

SEL-387-5, -6

**CURRENT DIFFERENTIAL RELAY
OVERCURRENT RELAY
DATA RECORDER
INTEGRATION STANDARD**

INSTRUCTION MANUAL

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



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.



CAUTION: The continuous rating of the current inputs is $3 \cdot I_{nom}$. If any currents in this test will exceed this rating, reduce the TAPn values as needed, to prevent possible damage to the input circuits.



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



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



DANGER: Contact with instrument terminals may cause electrical shock which can result in injury or death.



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



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



ATTENTION: La capacité, en régime permanent, des entrées de courant est $3 \cdot I_{nom}$. Si un courant d'essai dépassait cette valeur, réduire la prise TAPn pour prévenir les dommages aux circuits d'entrée.



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



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



DANGER: Le contact avec les bornes de l'instrument peut causer un choc électrique pouvant entraîner des blessures ou la mort.

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The English language manual is the only approved SEL manual.

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This product is covered by U.S. Patent Numbers: 5,041,737; 5,317,472; 5,479,315; 5,963,404 and U.S. Patent(s) Pending.

MANUAL CHANGE INFORMATION

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

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

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

Revision Date	Summary of Revisions
The Manual Change Information section has been created to begin a record of revisions to this manual. All changes will be recorded in this Summary of Revisions table.	
20001220	Updated Appendix A: Firmware Versions .
20001115	Added cautions, warnings, and dangers in English and French to reverse of title page, including a warning to change default passwords to private passwords at relay installation. Section 2: Installation added a caution about replacing the battery (page 2-17) affecting subsequent pagination. Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements corrected Figure 3.8: REF Enable/Block Logic (page 3-25) and Figure 3.9: REF Directional Element (page 3-26); added clarifying text under Top-Oil Temperature Limit (TOT1, TOT2) (page 3-42). Section 4: Control Logic and Section 5: Metering and Monitoring and Settings Sheets made typographical corrections. Section 7: Serial Port Communications and Commands made typographical changes and added warning to change default passwords to private passwords at relay installation (page 7-22). Section 8: Front-Panel Interface added warning to change default passwords to private passwords at relay installation (page 8-10), affecting subsequent pagination. Appendix A: Firmware Versions listed firmware that makes corrections and improvements to the SEL-387-5 and SEL-387-6 Relays, with and without DNP. Appendix D: Configuration, Fast Meter, and Fast Operate Commands corrected data in the A5C0 Relay Definition Block, affecting subsequent pagination. Appendix G: Distributed Network Protocol (DNP) 3.00 corrected DNP instruction list.
20000831	Added information about the SEL-387-6 Relay. Reorganized and reissued entire manual.

Revision Date	Summary of Revisions
20000621	Added Distributed Network Protocol (DNP) 3.00 resulting in changes to Section 6: Setting the Relay, Settings Sheets; Section 7: Serial Port Communications and Commands; Section 8: Front-Panel Interface; and Appendix A: Firmware Versions and creation of Appendix G: Distributed Network Protocol (DNP) 3.00. Corrected Figure 5.23: REF Enable/Block Logic, on p. 5-41 in Section 5: Protection and Control Logic Functions. Corrected Rows 48 and 49 in Table 5.8: SEL-387 Relay Word Bits and Locations in Section 5: Protection and Control Logic Functions. Changed formatting in Appendix A: Firmware Versions. Reordered steps in Appendix B: Firmware Upgrade Instructions. Corrected CHISTORY command explanation in Appendix E: Compressed ASCII Commands. Corrected name of Appendix F: Unsolicited SER Protocol.
20000203	Corrected typographical errors in Section 2: Installation; Section 4: Metering, Monitoring, and Reporting Functions; Section 7: Serial Port Communications and Commands; and Section 10: Testing and Troubleshooting.
991130	Added 24 Vdc and 110 Vdc control input voltage options (Section 1: Introduction and Specifications, page 1-4 and Section 2: Installation, page 2-5). Clarified Type Tests and Standards (Section 1: Introduction and Specifications, page 1-5). Added relay dimensions and drill plan drawing for panel-mount models (Section 2: Installation, Figure 2.2, page 2-2). Added rear-panel drawing of model 0387x1, terminal blocks (Section 2: Installation, Figure 2.3, page 2-3). Moved rear-panel drawing of model 0387xY Connectorized® (Section 2: Installation, Figure 2.4, page 2-4). Changed numbering of figures following Figure 2.2 (Section 2: Installation) because of the addition of two figures. Corrected an equation (Section 4: Metering, Monitoring, and Reporting Functions, page 4-11). Changed a reference to a figure in Section 2: Installation (Section 5: Protection and Control Logic Functions, page 5-37). Changed references to figures in Section 2: Installation (Section 6: Setting the Relay, pages 6-15, 6-22, 6-26, and 6-27). Corrected firmware date number (Appendix A: Firmware Versions, pages A-1–A-2).

Revision Date	Summary of Revisions
991029	Updated Appendix A: Firmware Versions .
991008	In Section 3: Differential and Overcurrent Elements, replaced IRT=1 with IRT=4 in discussion of Differential Element Operation, page 3-2. In Section 5: Protection and Control Logic Functions, inserted note about making latch bit settings with care (page 5-13); replaced and added text, added a figure (5.19), and updated figures 5.20, 5.21, 5.23, and 5.24 (pages 5-31 through 5-41); and added CTS to Row 14 of Table 5.8 (page 5-46) and Table 5.9 (page 5-51). In Section 7: Serial Port Communications and Commands, added discussion of STA C command (page 7-36). In Section 9: Event Reports and Sequence of Events Reporting, specified acceptable alias setting format and characters for alias names (pages 9-23 through 9-25). In Section 10: Testing and Troubleshooting, replaced label with updated version (page 10-2), replaced step 3 under Combined Overcurrent Elements (page 10-18; this affected pagination for the rest of the section). In relay command summary, added STA C command. In Appendix A: Firmware Versions, included updated firmware version.
990915	In Appendix A: Firmware Versions, included updated firmware version. In Appendix D: Configuration, Fast Meter, and Fast Operate Commands, added A5ED to Binary Message List (page D-1) and made typographical corrections throughout. In Appendix F: Unsolicited SOE Protocol, updated text throughout.
990721	Updated Appendix A: Firmware Versions .
990518	Initial release.

SEL-387-5, -6 INSTRUCTION MANUAL

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SECTION 1: INTRODUCTION AND SPECIFICATIONS

INTRODUCTION

Use this relay to protect two- to four-winding power transformers, buses, reactors, generators, large motors, or other multiterminal power apparatus. Three- or four-terminal applications permit separate connection of current transformers from two breakers connected to the same transformer winding, such as in ring-bus or breaker-and-a-half schemes. The relay settings permit you to use wye- or delta-connected current transformers with virtually any type of transformer winding connection.

INSTRUCTION MANUAL OVERVIEW

This instruction manual applies to the SEL-387 Relay. If you are unfamiliar with this relay, we suggest that you read the following sections in the outlined order.

Section 1: Introduction and Specifications for an introduction, instruction manual overview, relay functional overview, and specifications.

Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements to understand the protection elements and their associated settings.

Section 4: Control Logic to understand inputs, the Relay Word, outputs, and logic. Use this section to understand the settings necessary for implementing your logic.

Section 6: Setting the Relay to understand settings that are not described in ***Section 3*** or ***Section 5***, for default settings, and for settings sheets.

Section 7: Serial Port Communications and Commands for a description of the serial port commands used to set the relay for control, obtain target information, and obtain metering information, etc.

Section 8: Front-Panel Interface for a description of how to perform the serial port commands from the front panel.

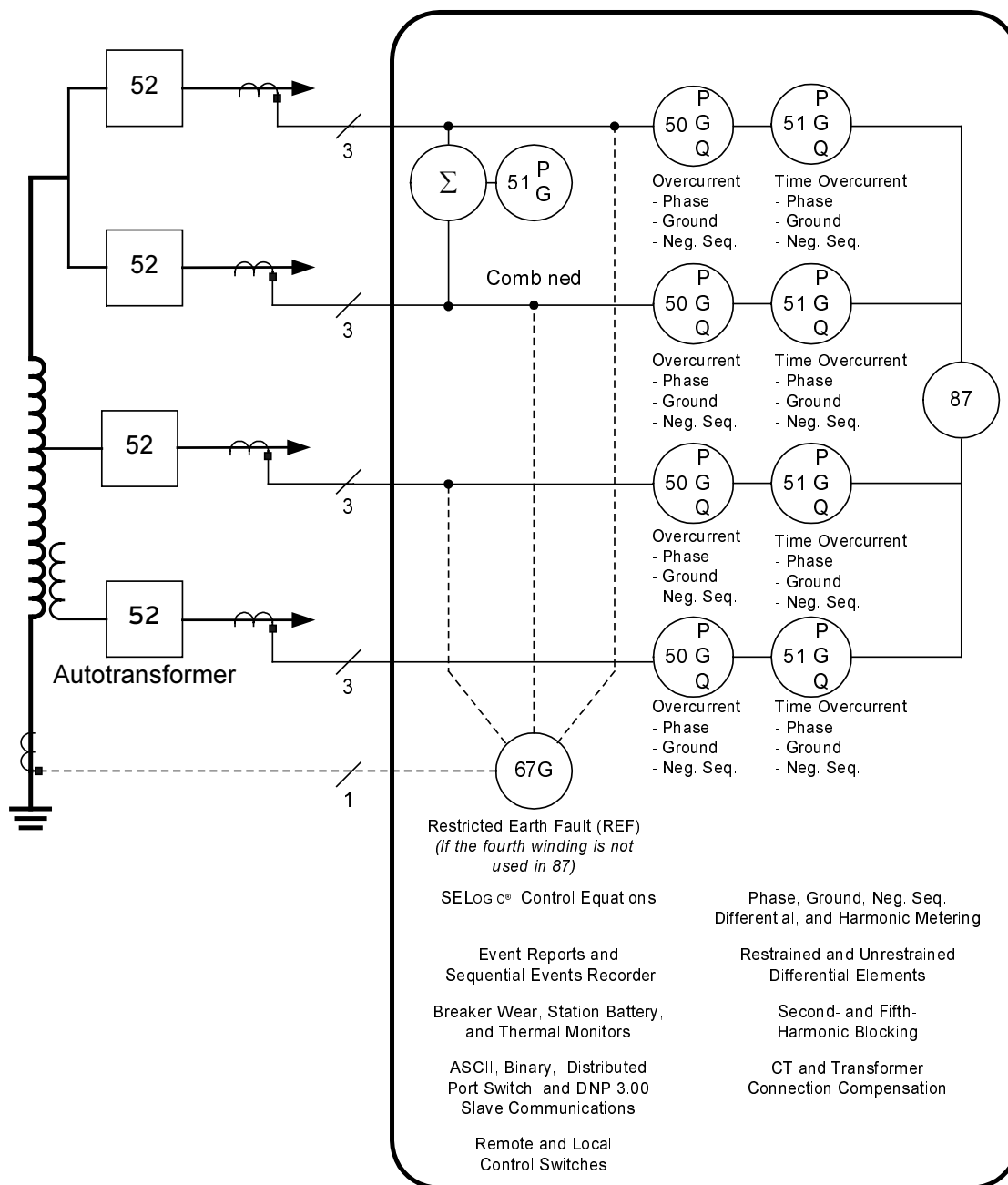
Section 5: Metering and Monitoring to learn how to retrieve operations data such as metering, dc battery monitor, breaker monitor, and relay status.

Section 9: Event Reports and SER for a description of event report and sequential events report generation, event report formats, sequential event reports, and report interpretation.

Section 2: Installation to learn how to configure, install, and wire your relay.

Section 10: Testing and Troubleshooting for test procedures and a troubleshooting guide. You can use this section as a tutorial to check your understanding of the relay's operation.

RELAY FUNCTIONS



DWG: M3871080

Figure 1.1: Functional Overview

Current Differential Protection

The SEL-387 Relay includes independent restrained and unrestrained current differential elements. The restrained element has a dual-slope, variable-percentage restraint characteristic. Where required, you can set second- and fifth-harmonic blocking functions to provide

differential element security for nonfault conditions. Second-harmonic blocking prevents false tripping during magnetizing inrush, and fifth-harmonic detection prevents operation during overexcitation. A separate unrestrained differential element provides faster clearance of high-magnitude, internal faults.

Restricted Earth Fault Protection

The SEL-387 Relay provides sensitive detection of internal ground faults via the Restricted Earth Fault (REF) protection element. The winding 4 inputs are used for introduction of neutral CT polarizing current. Operating current is derived from the residual current calculated for the protected winding. A directional element determines whether the fault is internal or external. Tripping is supervised by zero-sequence current thresholds and a positive-sequence current restraint setting. The REF function is applicable to a single grounded wye winding or an autotransformer with one breaker and set of CTs at one terminal and either one or two breakers and sets of CTs at the other terminal. Since the winding 4 inputs are used for the neutral CT, only three of the winding inputs may be used for normal differential or overcurrent protection purposes.

Thermal Protection (SEL-387-6 Relay)

The SEL-387-6 Relay provides a thermal element based on advanced transformer models. This thermal element calculates the operating temperature and insulation aging of mineral-oil-immersed power transformers being protected by the SEL-387-6 Relay. The element calculates operating temperature based on load currents, type of cooling system, and/or actual temperature inputs (ambient and top oil). It then uses operating temperature as a basis for calculating the insulation aging acceleration factor (FAA) and loss-of-life quantities. The thermal element asserts Relay Word bits to indicate alarm conditions when the following quantities exceed settable limits:

- Top-oil temperature
- Winding hot-spot temperature
- Insulation aging acceleration factor (FAA)
- Daily loss of life
- Total loss of life

Overcurrent Protection

The SEL-387 Relay provides nondirectional overcurrent elements for each winding/terminal:

- Phase Overcurrent: Three level instantaneous; definite time; inverse time
- Residual Overcurrent: Instantaneous; definite time; inverse time
- Negative-Sequence Overcurrent: Instantaneous; definite time; inverse time

In addition, the SEL-387 Relay has a special overcurrent function:

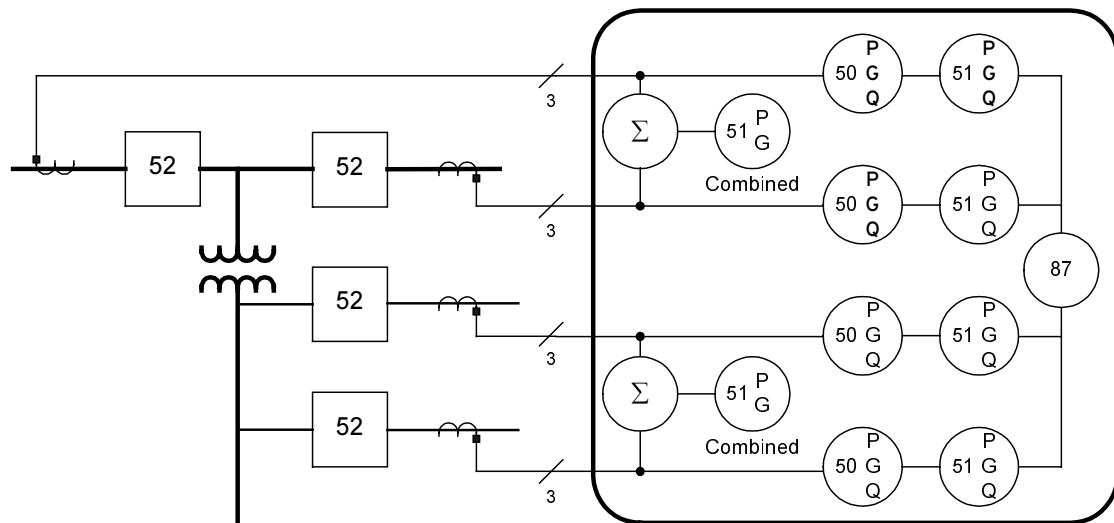
- Combined overcurrent (inverse time, phase and ground), for summed currents from windings 1 and 2 and windings 3 and 4

Overcurrent element pickup settings and operating characteristics are independent of the differential element settings. Most elements can be torque controlled.

Programmable Optoisolated Inputs and Output Contacts

The SEL-387 Relay is equipped with enhanced SELOGIC[®] control equations that allow you to design a custom tripping or control scheme. SELOGIC control equation functions include independent timers, tripping, event report triggering, and relay output contact control.

APPLICATION IDEAS



DWG: M3871073

Figure 1.2: Transformer and Overcurrent Protection

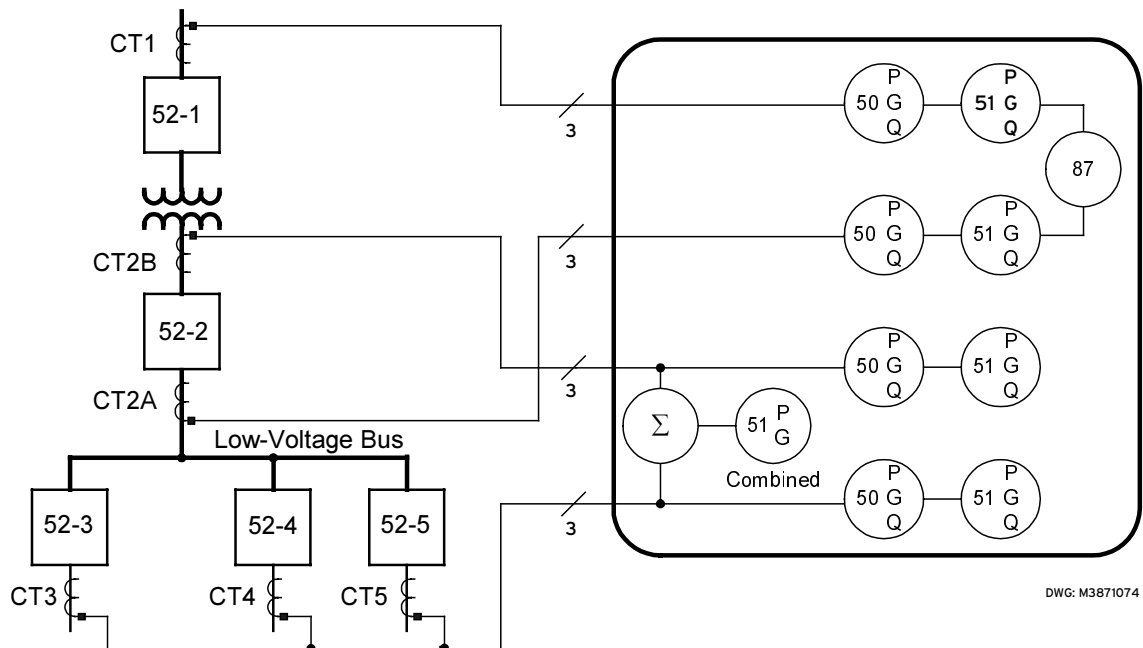


Figure 1.3: Transformer and Low-Voltage Bus Protection

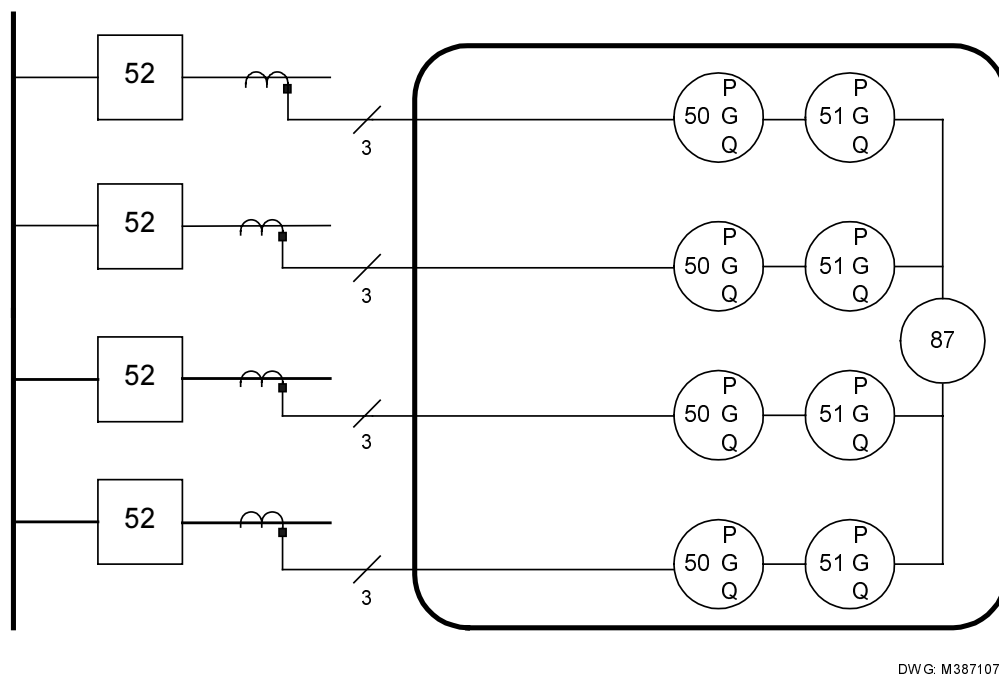


Figure 1.4: Bus and Feeder Protection

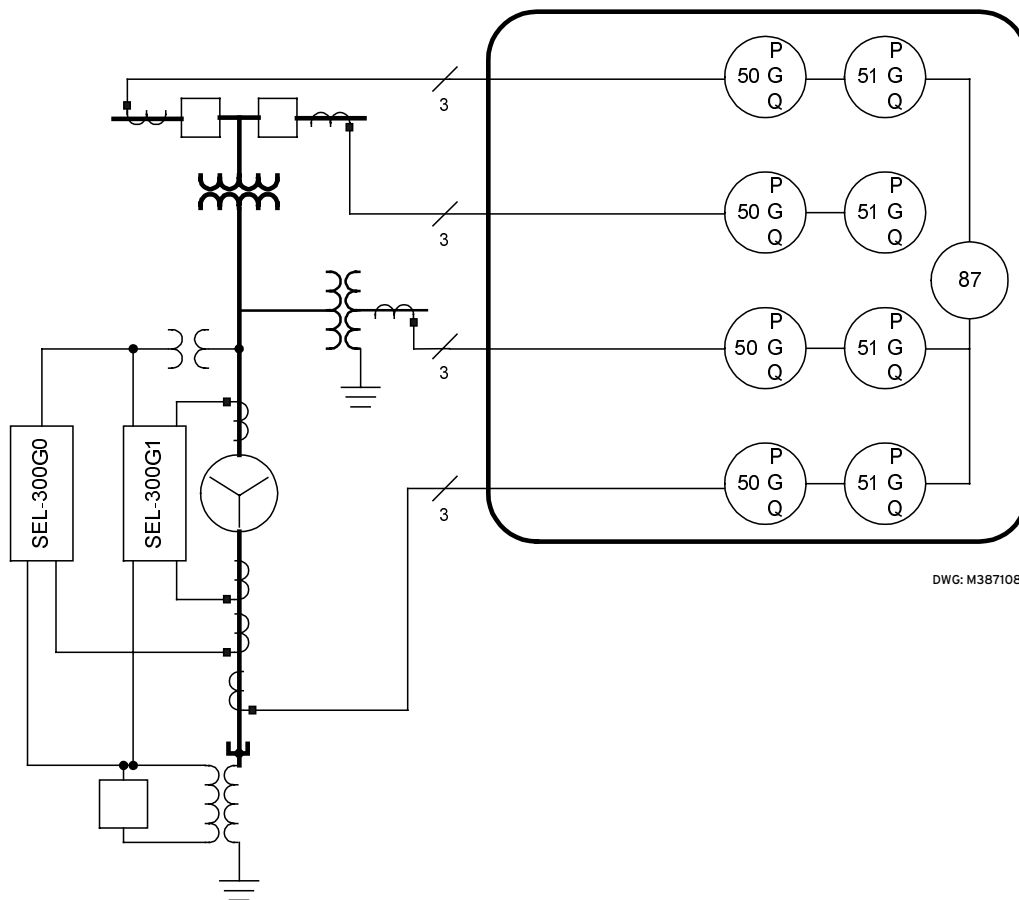


Figure 1.5: Unit Differential Protection

MODEL OPTIONS

SEL-387-0 Relay

The SEL-387-0 Relay has provided sophisticated and reliable service for many years. It continues to satisfy the needs of most of our customers. However, we recommend using the SEL-387-5 Relay or the SEL-387-6 Relay for new designs because of the enhanced features they provide. Use the SEL-387 Instruction Manual for the SEL-387-0 Relay.

SEL-387-5 Relay

The SEL-387-5 Relay includes all of the features of the SEL-387-0 Relay plus the following enhancements:

- Adds 16 local control switches
- Adds 8 latch control switches for a total of 16
- Adds binary SER

- Allows mismatched CTRs (CT ratios) in the combined current elements
- Adds DNP 3.00 Slave communications protocol

SEL-387-6 Relay

The SEL-387-6 Relay differs from the SEL-387-5 Relay in that it includes a transformer thermal model with protection elements and reporting functions.

Conventional Terminal Blocks

This model includes hardware that supports 12 current inputs, 6 optoisolated inputs, 7 programmable output contacts, 1 alarm contact, 3 EIA-232 ports, 1 EIA-485 port, and IRIG-B time code. It uses terminal blocks that support #6 ring terminals. This robust package meets or exceeds numerous industry standard type tests.

This relay is available in a 3.50" (2U) or 5.25" (3U) rack-mount package or 4.9" or 6.65" panel-mount package. Additional optoisolated inputs and programmable output contacts are available with the larger packages.

Plug-In Connectors (Connectorized®)

This model includes hardware that supports all of the features of the conventional terminal blocks model. It differs in its use of plug-in connectors instead of terminal blocks. In addition, it provides

- Quick connect/release hardware for rear-panel terminals
- Level-sensitive optoisolated inputs

This robust package meets or exceeds numerous industry standard type tests. It is available in a 5.25" (3U) rack-mount package or a 4.9" panel-mount package.

GENERAL SPECIFICATIONS

AC Current Inputs: 5 A nominal: 15 A continuous, 500 A for 1 s, linear to 100 A symmetrical.
1250 A for 1 cycle.
Burden: 0.27 VA at 5 A, 2.51 VA at 15 A.

1 A nominal: 3 A continuous, 100 A for 1 s, linear to 10 A symmetrical.
250 A for 1 cycle.
Burden: 0.13 VA at 1 A, 1.31 VA at 3 A.

Power Supply: 125/250 Vdc: Range: 85–350 Vdc or 85–264 Vac
Interruption: 30 ms at 125 Vdc
Ripple: 100%
24/48 Vdc: Range: 20–60 Vdc
Interruption: 30 ms at 48 Vdc
Ripple: 5%
Total Burden: Less than 15 W.

Note: Interruption and Ripple per IEC 60255-11 [IEC 255-11]: 1979.

Output Contacts: Standard:

Make: 30 A; Carry: 6 A; 1 s Rating: 100 A; MOV protected: 270 Vac, 360 Vdc, 40 J;
Pickup time: Less than 5 ms.

Breaking Capacity (10,000 operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycles/second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

High Current Interrupting Option:

Make: 30 A; Carry: 6 A; MOV protected: 330 Vdc, 40 J; Pickup time: Less than 5 ms;
Dropout time: Less than 8 ms, typical.

Breaking Capacity (10,000 operations):

24 V	10 A	L/R = 40 ms
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 in 1 second, followed by 2 minutes idle for thermal dissipation):

24 V	10 A	L/R = 40 ms
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 [IEC 255-23]: 1994.

<u>Optoisolated Inputs:</u>	250 Vdc: Pickup	200	–	300 Vdc; Dropout	150 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	15.0	–	30 Vdc.	

Note: 24, 48, 125 Vdc optoisolated inputs draw approximately 4 mA of current, 110 Vdc inputs draw approximately 8 mA of current, and 250 Vdc inputs draw approximately 5 mA of current. All current ratings are at nominal input voltage.

Routine Dielectric Strength: AC current inputs: 2500 Vac for 10 s; Power supply, optoisolated inputs, and output contacts: 3100 Vdc for 10 s.

Frequency and Rotation: System Frequency: 50 or 60 Hz; Phase Rotation: ABC or ACB.

Communications Ports: EIA-232: 1 front and 2 rear; EIA-485: 1 rear, 2100 Vdc isolation; Baud rate: 300–19200 baud.

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

Operating Temp: -40° to $+85^{\circ}\text{C}$ (-40° to $+185^{\circ}\text{F}$).

Relay Weight: 2U rack unit height: 15 lbs (6.8 kg); 3U rack unit height: 17.75 lbs (8 kg).

Type Tests:

- *Generic Emissions, Heavy Industrial: EN 50081-2: 1993, Class A
- *Generic Immunity, Heavy Industrial: EN 50082-2: 1995, Class A
- *Radiated and Conducted Emissions: EN 55011: 1998, Class A
- *Conducted Radio Frequency: EN 61000-4-6: 1996, ENV 50141: 1993, 10 Vrms
- Radiated Radio Frequency (900 MHz with modulation): ENV 50204: 1995, 10 V/m
- Cold: IEC 60068-2-1 [IEC 68-2-1]: 1990, EN 60068-2-1: 1993, Test Ad, 16 hours at -40°C
- Dry Heat: IEC 60068-2-2 [IEC 68-2-2]: 1974, EN 60068-2-2: 1993, Test Bd, 16 hours at $+85^{\circ}\text{C}$
- Damp Heat, Cyclic: IEC 60068-2-30 [IEC 68-2-30]: 1980, Test Db, 25° to 55°C , 6 cycles, 95% humidity
- Dielectric Strength: IEC 60255-5 [IEC 255-5]: 1977 and IEEE C37.90: 1989, 2500 Vac on analogs, contact inputs, and contact outputs; 3100 Vdc on power supply; 2200 Vdc on EIA-485 communications port
- Impulse: IEC 60255-5 [IEC 255-5]: 1977, 0.5 J, 5000 V
- Vibration: IEC 60255-21-1 [IEC 255-21-1]: 1988, Class 1
- Shock and Bump: IEC 60255-21-2 [IEC 255-21-2]: 1988, Class 1
- Seismic: IEC 60255-21-3 [IEC 255-21-3]: 1993, Class 2
- 1 MHz Burst Disturbance: IEC 60255-22-1 [IEC 255-22-1]: 1988, Class 3
- Electrostatic Discharge: IEC 60255-22-2 [IEC 255-22-2]: 1996, IEC 61000-4-2 [IEC 1000-4-2]: 1995, Level 4
- Radiated Radio Frequency: IEC 60255-22-3 [IEC 255-22-3]: 1989, ENV 50140: 1993, IEEE C37.90.2: 1995, 35 V/m

Fast Transient Disturbance:	IEC 60255-22-4 [IEC 255-22-4]: 1992, IEC 61000-4-4 [IEC 1000-4-4]: 1995 Level 4
Object Penetration:	IEC 60529 [IEC 529]: 1989, IP 30, IP54 from the front panel using the SEL-9103 front cover dust and splash protection (type test)
Surge Withstand Capability:	IEEE C37.90.1: 1989, 3000 V oscillatory, 5000 V fast transient
Note: * = Terminal Block version only.	

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

Processing

Specifications: 64 samples per power system cycle.

Metering Accuracy

5 A Model

Phase Currents:	$\pm 1.5\% \pm 0.10 \text{ A}$ and $\pm 1.5^\circ$
Sequence Currents:	$\pm 3.0\% \pm 0.10 \text{ A}$ and $\pm 2.0^\circ$
Differential Quantities:	$\pm 5.0\% \pm 0.10 \text{ A}$
2nd and 5th Harmonic:	$\pm 5.0\% \pm 0.10 \text{ A}$
Current Harmonics:	$\pm 5.0\% \pm 0.10 \text{ A}$

1 A Model

Phase Currents:	$\pm 1.5\% \pm 0.02 \text{ A}$ and $\pm 1.5^\circ$
Sequence Currents:	$\pm 3.0\% \pm 0.02 \text{ A}$ and $\pm 2.0^\circ$
Differential Quantities:	$\pm 5.0\% \pm 0.02 \text{ A}$
2nd and 5th Harmonic:	$\pm 5.0\% \pm 0.02 \text{ A}$
Current Harmonics:	$\pm 5.0\% \pm 0.02 \text{ A}$

Substation Battery Voltage Monitor

Pickup Range:	20–300 Vdc
Pickup Accuracy:	$\pm 2\%$ of setting

Differential Element

Pickup Accuracy (A secondary)

5 A Model:	$\pm 5\% \pm 0.10 \text{ A}$
1 A Model:	$\pm 5\% \pm 0.02 \text{ A}$

Unrestrained Element Pickup Time

(Min/Typ/Max): 0.8/1.0/1.9 cycles

Restrained Element Pickup Time

(Min/Typ/Max): 1.5/1.6/2.2 cycles

Harmonic Element

Pickup Accuracy (A secondary)

5 A Model:	$\pm 5\% \pm 0.10 \text{ A}$
1 A Model:	$\pm 5\% \pm 0.02 \text{ A}$

Time Delay Accuracy: $\pm 0.1\% \pm 0.25 \text{ cycle}$

Instantaneous/Definite-Time Overcurrent Elements (Winding)

Pickup Ranges (A secondary)
5A Model: 0.25–100.00 A
1 A Model: 0.05–20.00 A
Pickup Accuracies (A secondary)
5 A Model
Steady State: $\pm 3\% \pm 0.10$ A
Transient: $\pm 5\% \pm 0.10$ A
1 A Model:
Steady State: $\pm 3\% \pm 0.02$ A
Transient: $\pm 5\% \pm 0.02$ A
Note: For transient, $\pm 6\%$ for negative-sequence elements.
Pickup Time
(Typ/Max): 0.75/1.20 cycles
Time Delay Range: 0–16,000 cycles
Time Delay Accuracy: $\pm 0.1\% \pm 0.25$ cycle

Time-Overcurrent Elements (Winding and Combined Current)

Pickup Ranges (A secondary)
5A Model: 0.5–16.0 A
1 A Model: 0.1–3.2 A
Pickup Accuracies (A secondary)
5A Model
Steady State: $\pm 3\% \pm 0.10$ A
Transient: $\pm 5\% \pm 0.10$ A
1 A Model
Steady State: $\pm 3\% \pm 0.02$ A
Transient: $\pm 5\% \pm 0.02$ A
Note: For transient, $\pm 6\%$ for negative-sequence elements.
Curve
U1 = U.S. Moderately Inverse
U2 = U.S. Inverse
U3 = U.S. Very Inverse
U4 = U.S. Extremely Inverse
U5 = U.S. Short-Time Inverse
C1 = IEC Class A (Standard Inverse)
C2 = IEC Class B (Very Inverse)
C3 = IEC Class C (Extremely Inverse)
C4 = IEC Long-Time Inverse
C5 = IEC Short-Time Inverse
Time-Dial Range
US Curves: 0.50–15.00
IEC Curves: 0.05–1.00
Timing Accuracy: $\pm 4\% \pm 1.5$ cycles for current between 2 and 30 multiples of pickup. Curves operate on definite time for current greater than 30 multiples of pickup.
Note: For the combined current elements, 30 multiples of pickup is the sum of the currents in the two windings.
Reset Characteristic: Induction-disk reset emulation or 1 cycle linear reset.

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SECTION 2: INSTALLATION

Design your installation using the mounting and connection information in this section. Options include rack or panel mounting and terminal block or plug-in connector (Connectorized[®]) wiring. This section also includes information on configuring the relay for your application.

RELAY MOUNTING

Rack Mount

We offer the SEL-387 Relay in a rack-mount version that bolts easily into a standard 19-inch rack. From the front of the relay, insert four bolts (two on each side) through the holes on the relay mounting flanges, and use nuts to secure the relay to the rack. See Figure 2.1.

Panel Mount

We also offer the SEL-387 Relay in a panel-mount version for a clean look. Panel-mount relays have sculpted front panel molding that covers all installation holes. See Figure 2.1. Cut your panel and drill mounting holes according to the dimensions in Figure 2.1. Insert the relay into the cutout, aligning four relay mounting studs on the rear of the relay with the drilled holes in your panel, and use nuts to secure the relay to the panel.

PANEL MOUNT CHASSIS

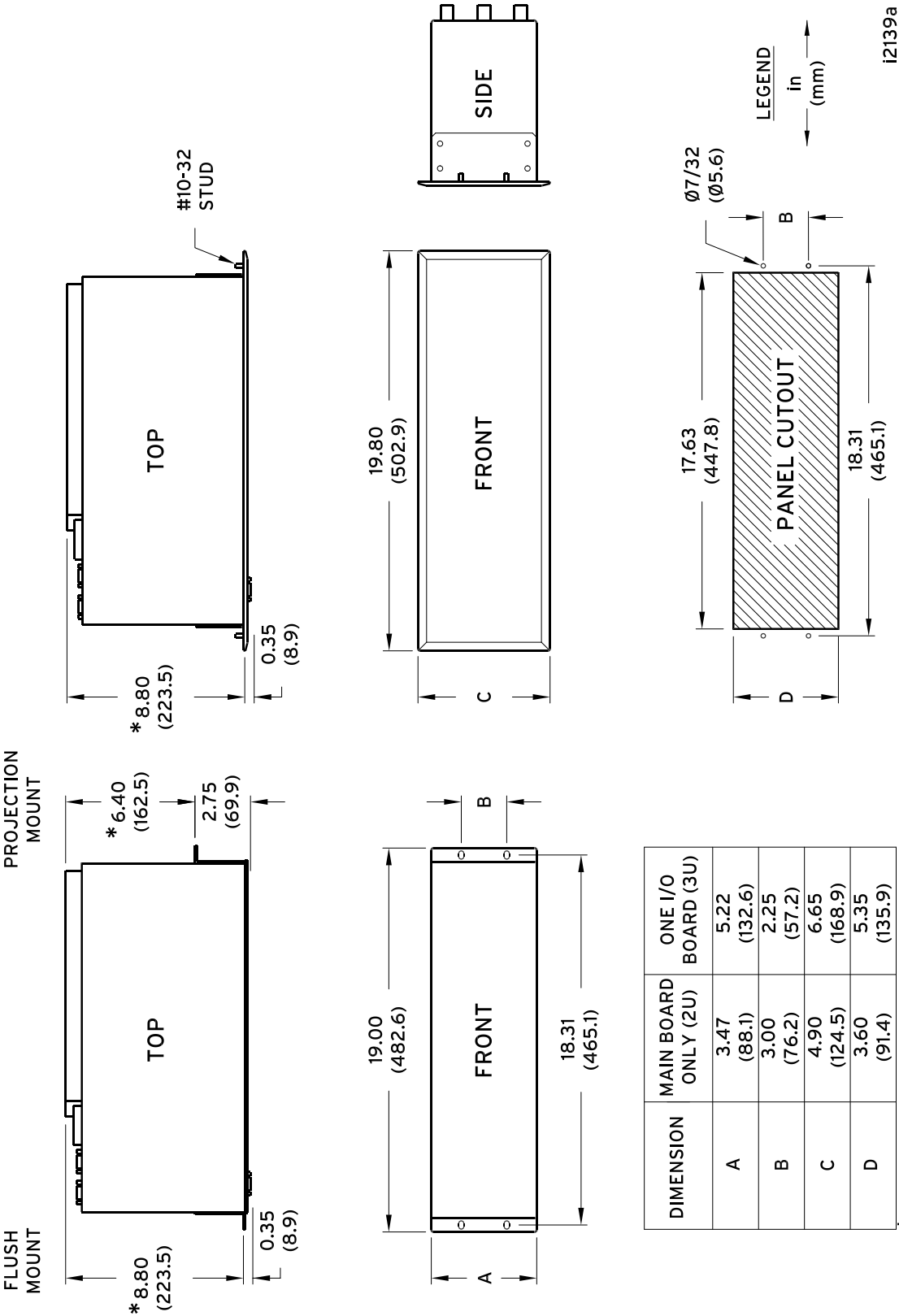
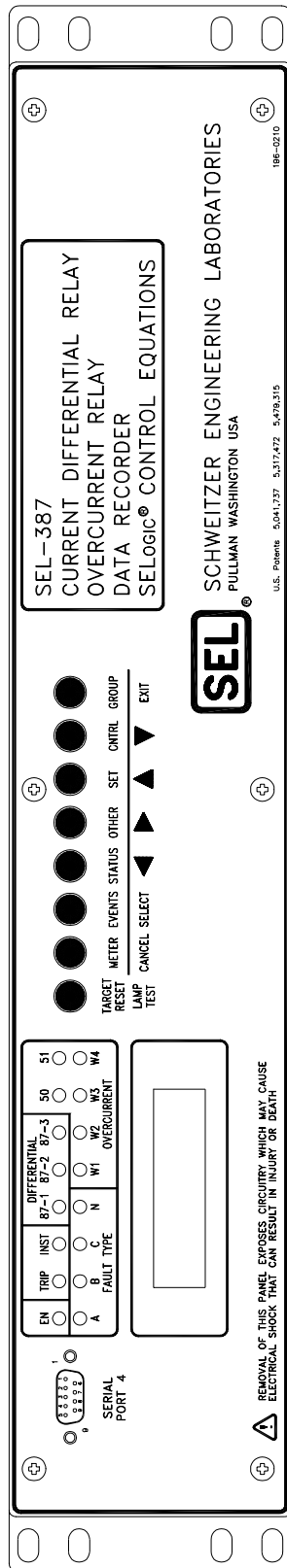
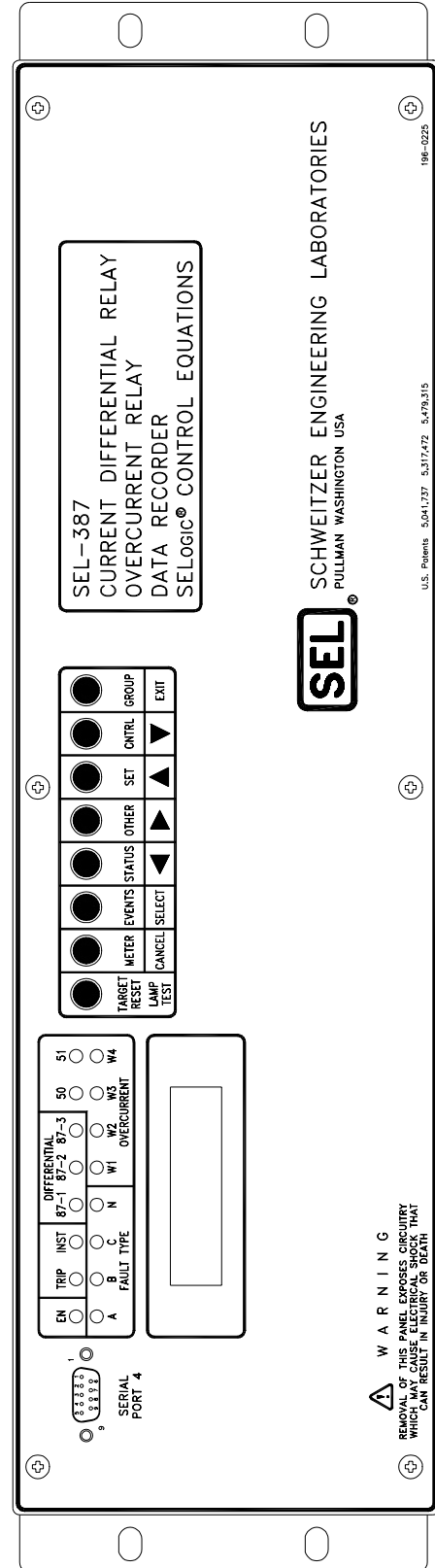


Figure 2.1: Relay Dimensions and Panel-Mount Cutout



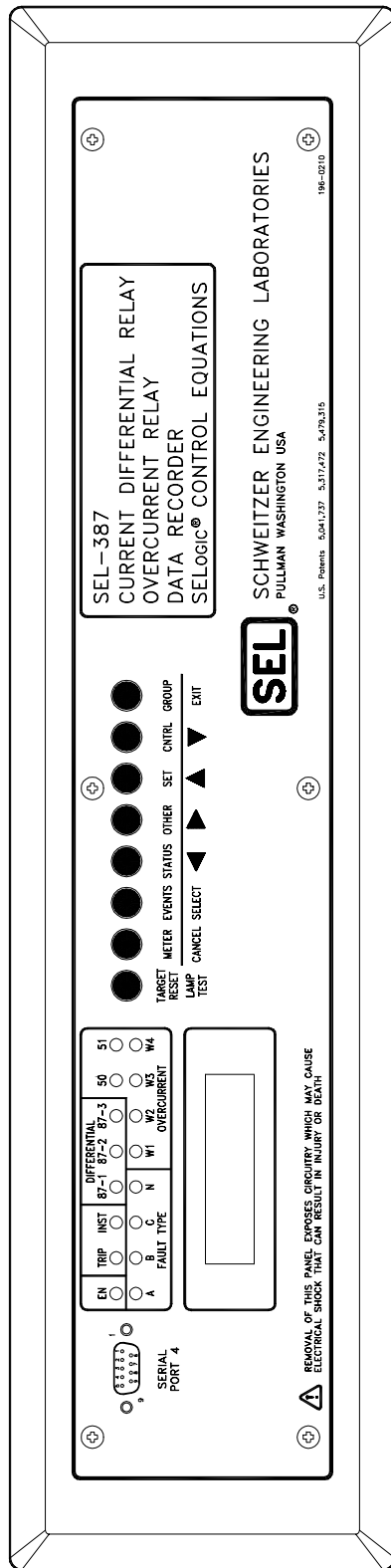
DWG. 11172



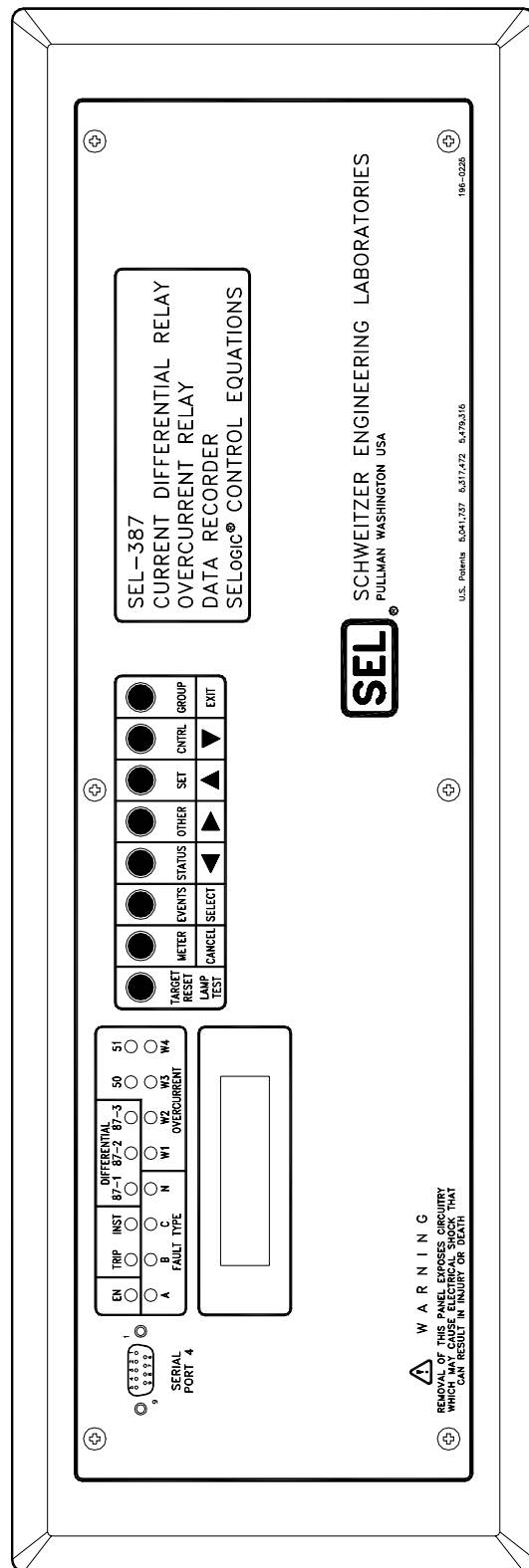
DWG. M3871087

DWG. 11184

Figure 2.2: Front-Panel Drawings—Models 0387x0xxxH and 0387x1xxxH



DWG: 11513



DWG: 11514

Figure 2.3: Front-Panel Drawings—Models 0387x0xxx3 and 0387x1xxx3

REAR-PANEL CONNECTIONS

We provide two options for secure connection of wiring to the relay rear panel. One of these is the conventional terminal block, in which you use size #6–32 screws to secure rear-panel wiring. The other option uses plug-in (Connectorized) connections that offer robust connections while minimizing installation and replacement time.

Connectorized rear-panel connections reduce repair time dramatically in the unlikely event that a relay should fail. These connections greatly simplify routine bench testing; connecting and disconnecting rear-panel wiring takes only a few minutes.

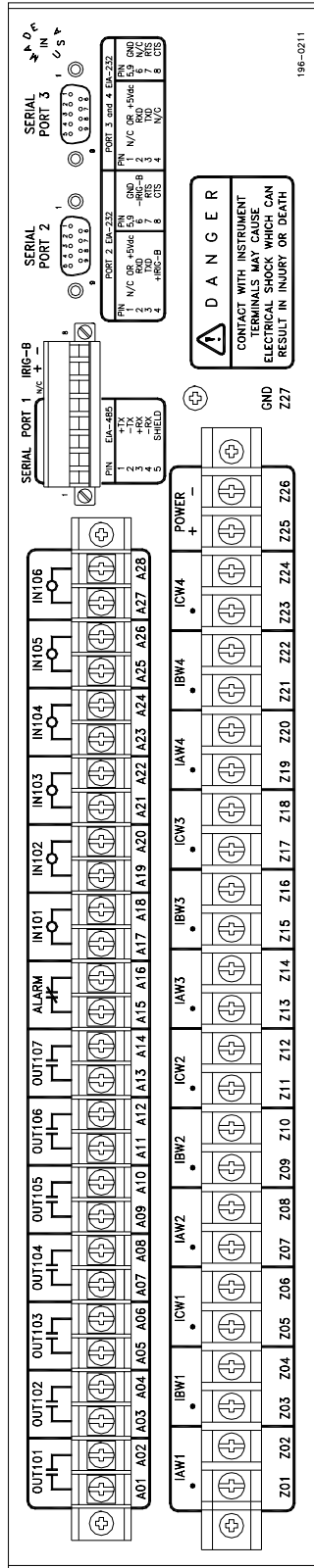
Connectorized relays use a current shorting connector for current inputs, a plug-in terminal block that provides maximum wiring flexibility for inputs and outputs, and a quick disconnect voltage-rated connector for voltage inputs. The manufacturers of these connectors have tested them thoroughly, and many industry applications have proven the performance of these connectors. In addition, we have tested these connectors thoroughly to ensure that they conform to our standards for protective relay applications.

Terminal Block

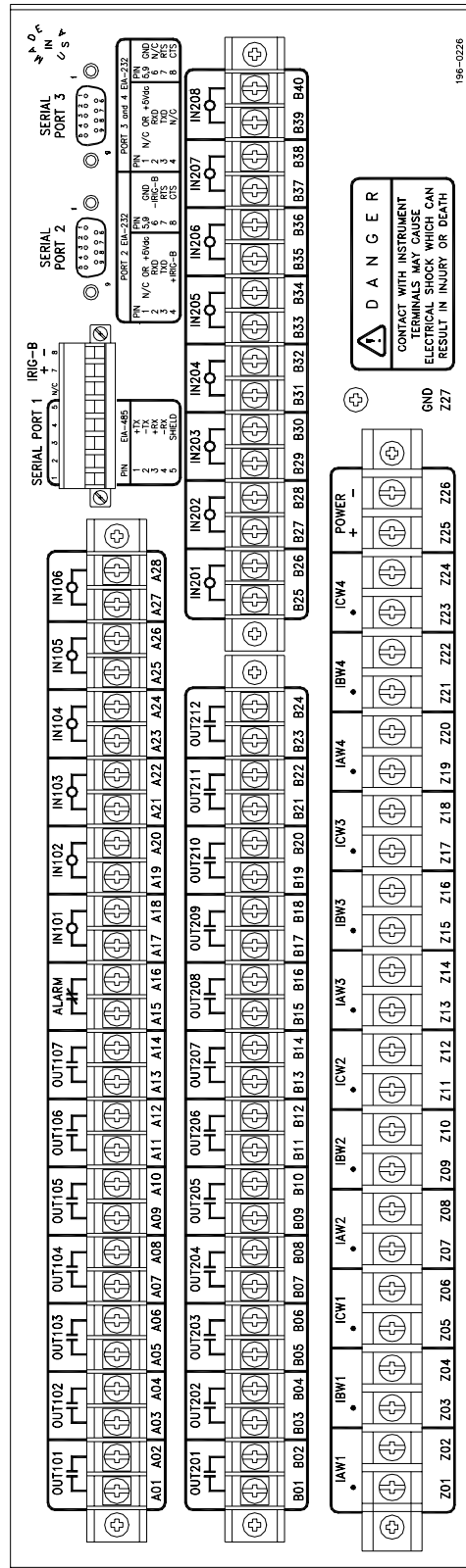
Make terminal block connections with size #6–32 screws using a Phillips or slotted screwdriver. You may request locking screws from the factory. Refer to Figure 2.4 and Figure 2.5 to make all terminal block connections.

Connectorized

To use the Connectorized version of the SEL-387 Relay, ask your SEL sales or customer service representative for the appropriate model option table and order wiring harness kit WA03870YxxxA, where x designates wire sizes and length. You can find the model option table on the SEL website at <http://www.selinc.com>. Refer to Figure 2.6 to make all Connectorized connections.



DWG: I1170



DWG: I1195

M3871085

Figure 2.4: Rear-Panel Drawings—Models 0387x0xxxxX and 0387x1xxxx2

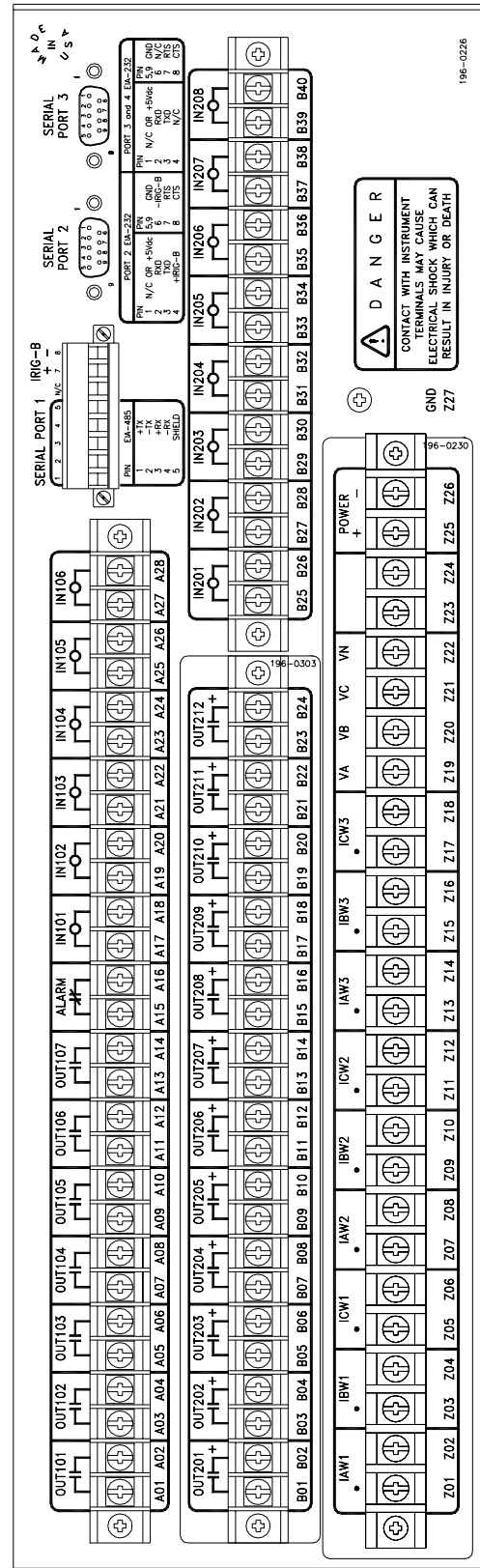
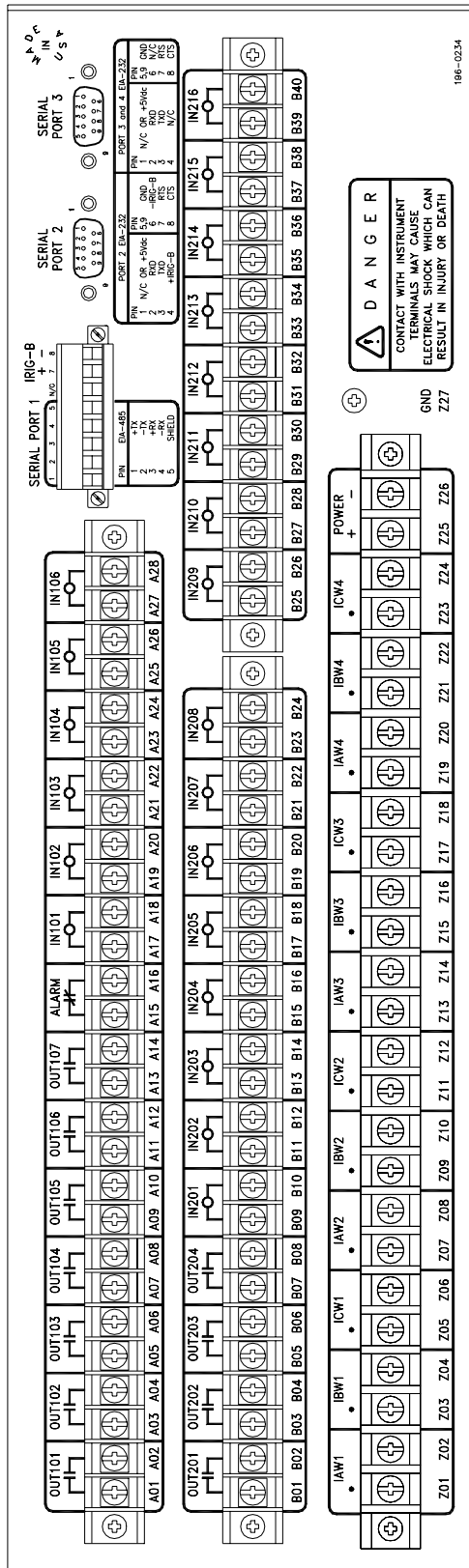
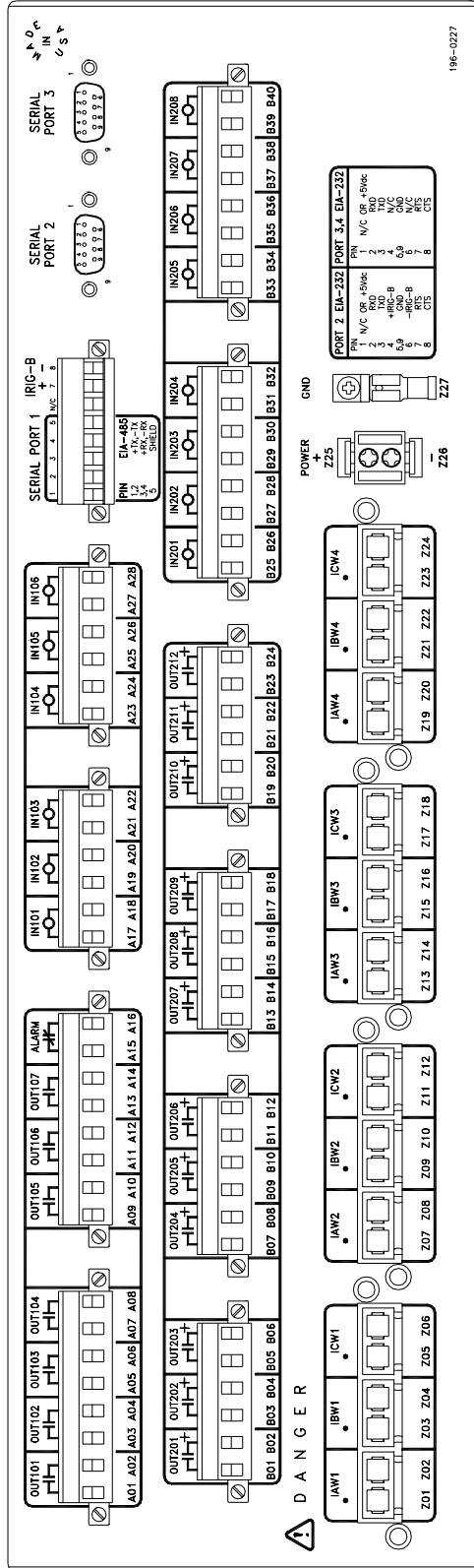
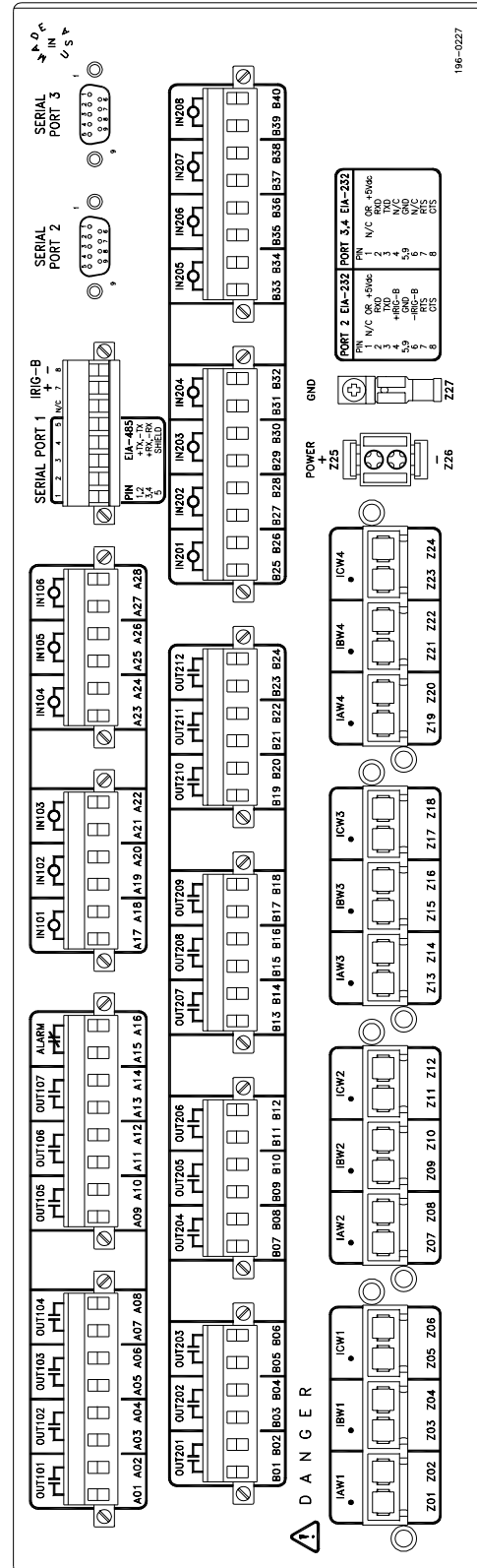


Figure 2.5: Rear-Panel Drawings—Models 0387x1xxxx4 and 0387x1xxxx6



DWG. 11361



DWG. M3871084

Figure 2.6: Rear-Panel Drawings—Models 0387xYxxxx6 and 0387xYxxxx2

Prewired Connectors

The wiring harness kit contains several prewired connectors for relay current inputs, power, and ground connections. These prewired connectors include the following:

- (4) six-position CT shorting connectors for current inputs IAW1, IBW1, and ICW1; IAW2, IBW2, and ICW2; IAW3, IBW3, and ICW3; and IAW4, IBW4, and ICW4. For these connectors select a wire size from AWG 16 to 10.
- (1) connector for POWER inputs (+ and –). For these connectors select a wire size from AWG 18 to 14.
- (1) spade connector for chassis GROUND connection.

Unwired Connectors

With the wiring harness kit are the following unwired connectors for the relay optoisolated inputs, contact outputs, and EIA-485 communications port connections:

- (2) eight-position female plug-in connectors for output contacts OUT101 through OUT104 and OUT105 through ALARM.
- (2) six-position female plug-in connectors for optoisolated inputs IN101 through IN103 and IN104 through IN106.
- (1) eight-position female plug-in connector for the EIA-485 serial port connection Port 1 and the demodulated IRIG-B input. Alternatively, you can bring IRIG-B through Port 2.
- (4) six-position female plug-in connectors for I/O board output contacts OUT201 through OUT203, OUT204 through OUT206, OUT207 through OUT209, and OUT210 through OUT212.
- (2) eight-position female plug-in connectors for I/O board optoisolated inputs IN201 through IN204 and IN205 through IN208.

Note: These unwired connectors accept wire sizes AWG 24 to 12. To install these connectors, you will need a wire stripping tool and small, slotted-tip screwdriver. Strip 0.31 inches (8 mm) insulation from the wires and install the wires in the connectors. Secure each connector to the relay chassis with the screws located on each connector end.

Connections

Frame Ground

For safety and performance, ground the relay chassis at terminal GND (Z27). Connectorized relays provide a 0.250-inch-by-0.023-inch spade connector for this connection. The grounding terminal of either relay version connects directly to relay chassis ground.

Power Supply

Connect rear-panel terminals marked + (Z25) and – (Z26) to a source of control voltage. Control power passes through these terminals to a fuse(s) and to the switching power supply. The control power circuitry is isolated from the frame ground. The 24/48 V power supply is polarity sensitive. Refer to **Section 1: Introduction and Specifications** for power supply voltage ranges.

Current Transformer Inputs

Connect current inputs to the four sets of current input terminals. Note that the CT shorting connectors providing current connections to Connectorized relays install in only one orientation. Note also that the current input terminals on both terminal block and Connectorized relays have a mark at one terminal per phase to indicate polarity. Each current input is independent of the other two inputs. Current inputs are designated IAW1, IBW1, ICW1; IAW2, IBW2, ICW2; IAW3, IBW3, ICW3; and IAW4, IBW4, and ICW4.

Note: When installing CT shorting connectors, ensure that you secure each connector to the relay chassis with the screws at each connector end. When removing a CT shorting connector, pull it straight away from the relay rear panel. Removing a shorting connector causes internal mechanisms within the connector to individually short out each power system current transformer.

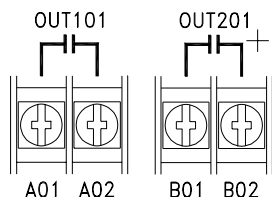
Optoisolated Inputs

Connect control input wiring to the six standard inputs IN101–IN106 and to any of the I/O board optoisolated inputs IN201–IN208 you need for your application.

All control inputs are dry optoisolated inputs and are not polarity dependent. Specify a nominal-rated control voltage of 48, 110, 125, or 250 Vdc for level-sensitive and 24 Vdc for nonlevel-sensitive when ordering. To assert an input, apply nominal-rated control voltage to the terminals assigned to that input. A terminal pair is brought out for each input. Refer to the **General Specifications** in **Section 1: Introduction and Specifications** for optoisolated input ratings. There are no internal connections between inputs. ON and OFF values are normally within one volt of each other, in the indicated range.

Output Contacts

Connect output wiring to the SEL-387 Relay main board eight standard independent output contacts, OUT101 through OUT107 and ALARM. Standard independent dry output contacts are not polarity dependent; the left side of Figure 2.7 shows these contacts as they would appear on a terminal block version.



DWG: M3871029

Figure 2.7: Standard Independent Output Contact Representation

Connect output wiring to any of the additional output contacts OUT201–OUT212 you need for your application. On the additional I/O board, you have the option of either standard or high current interrupting contacts. High current interrupting contacts are polarity dependent. A plus polarity mark next to the terminal requiring positive dc voltage identifies these contacts on a relay rear panel. The right side of Figure 2.7 shows this polarity mark for high current interrupting contacts. Ensure correct polarity; reversed polarity causes a short circuit to appear across the contact terminals.

Communications Port

Refer to Table 2.1 for a list of cables that you can purchase from SEL for various communication applications. Refer to **Section 7: Serial Port Communications and Commands** for detailed cable diagrams for selected cables.

Note: Listing of devices not manufactured by SEL is 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.

The relay rear panel provides pin definitions for Ports 1, 2, 3, and 4. Refer also to **Section 7: Serial Port Communications and Commands** for more serial port details. Port 1 is an EIA-485 protocol connection on the rear of the relay. Port 1 accepts a pluggable terminal block that supports wire sizes from 24 AWG to as large as 12 AWG. The connector comes with the relay. Ports 2, 3, and 4 are EIA-232 protocol connections with Ports 2 and 3 on the rear of the relay and Port 4 on the front of the relay. These female connectors are 9-pin, D-subminiature connectors. You can use any combination of these ports or all of them simultaneously for relay communication.

For example, to connect the SEL-387 Relay Ports 2, 3, or 4 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-387 Relay Port 2 to the SEL-2020 or SEL-2030 Communications Processor that supplies the communication link and the time-synchronization signal, order cable number C273A and specify the length needed. For connecting devices at more than 100 feet, fiber-optic transceivers are available. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long-distance signal transmission. Call the factory for further information on these products.

Table 2.1: SEL-387 Relay Communication Cable Numbers

SEL-387 Port #	Connect to Device (gender refers to the device)	SEL Cable #
2, 3, 4	PC, 25-Pin Male (DTE)	C227A
2, 3, 4	PC, 9-Pin Male (DTE)	C234A
2, 3	SEL-2020 or SEL-2030 without IRIG-B	C272A
2	SEL-2020 or SEL-2030 with IRIG-B	C273A
2	SEL-IDM, Ports 2 through 11	Requires a C254 and C257 cable
2, 3	Modem, 5 Vdc Powered (pin 10)	C220*
2, 3	Standard Modem, 25-Pin Female (DCE)	C222

* The 5 Vdc serial port jumper must be installed to power the Modem using C220 (see *EIA-232 Serial Port Jumpers* later in this section).

Clock Synchronization, IRIG-B

Refer to Table 2.1 for a list of cables that you can purchase from SEL for various time-synchronizing applications.

The SEL-387 Relay accepts a demodulated IRIG-B format signal for synchronizing an internal clock to some external source such as the SEL-2020 or SEL-2030 Communications Processor, SEL-IDM, or satellite time clock. Connect the IRIG-B source to the relay through the connectors for serial Ports 1 or 2. Refer to the port pin definition of each port for the appropriate connection.

TYPICAL AC/DC CONNECTIONS

Figure 2.8 and Figure 2.9 represent the ac and dc connections for a typical three-winding transformer application. The transformer is an autotransformer with a delta tertiary whose terminals fall within the differential zone of protection. Refer to Figure 2.8 and note that the current transformers for all windings are wye connected, with their polarity marks facing away from the transformer. The outputs of the CTs go to the polarity ends of the relay current inputs, with the nonpolarity ends of the inputs connected to the CT neutral and ground. You should use a single safety-ground point, as shown. (If current transformers are delta connected, the nonpolarity ends of the relay current inputs must be wired together and should be connected to the common ground point/neutral.)

As Figure 2.8 shows, this transformer has a neutral current CT connected to one of the three unused winding 4 current inputs. The Restricted Earth Fault (REF) protection function uses measured neutral current in conjunction with the residual current calculated from the winding 1 CTs. You can use the REF function only if CTs for the protected wye winding are themselves wye connected. Delta-connected CTs remove the zero-sequence components of the winding currents and provide no basis for comparison of residual and neutral currents.

We use this transformer example later for calculating relay settings; see **Section 6: Setting the Relay**. This example forms the basis for most of the factory default settings SEL stores in the relay before shipment.

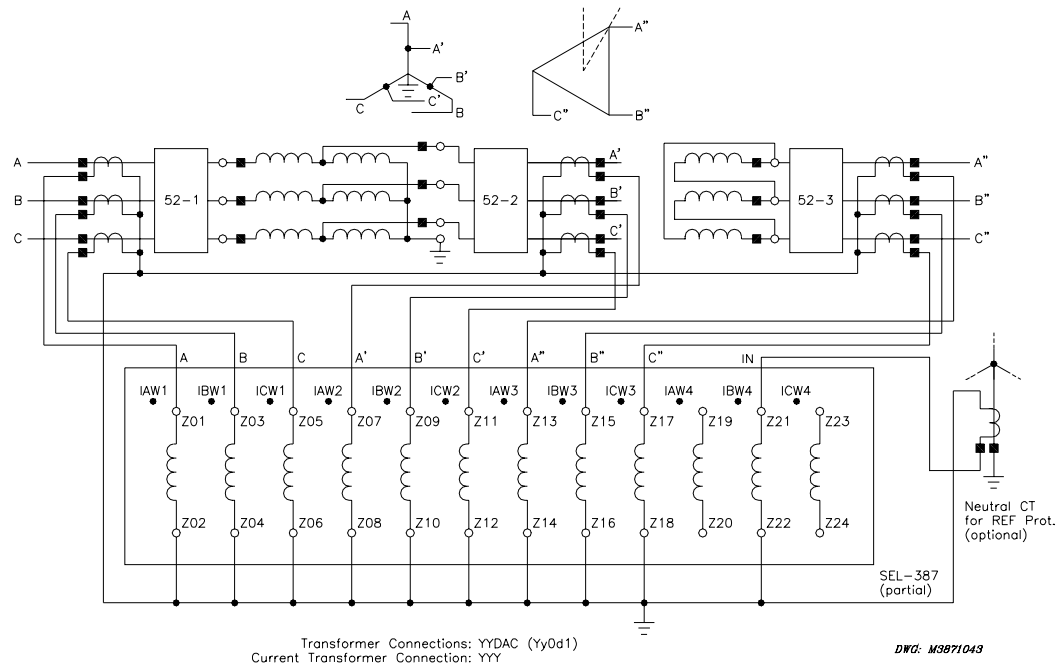


Figure 2.8: Example AC Connections (three-winding transformer)

The dc connection diagram, Figure 2.9, illustrates tripping control of the three power circuit breakers. The diagram includes three 52a input contacts to define breaker status (open or closed) and a separate 86 lockout relay for group tripping on a differential operation. Individual breaker trips occur for overcurrent operation.

The diagram also shows ALARM and annunciation functions. The ALARM contact comes factory-wired as a form-B contact, so that it closes under conditions of complete relay power failure. If breaker closing control were desired, we would use the Trip Annunciator contact (OUT105) as one of the three separate output contacts for connection to the breaker closing coils. That is, for this case the breaker trip and close functions together would require all seven standard output contacts.

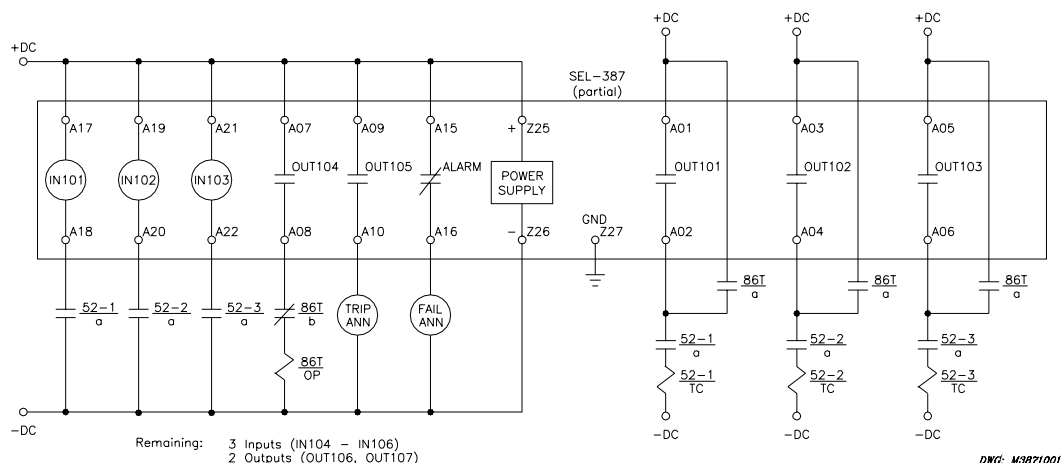


Figure 2.9: Example DC Connections (basic version)

CIRCUIT BOARD CONFIGURATION

In this section we describe (1) how to remove the relay circuit boards so you can change circuit board jumpers or replace the clock battery and (2) how to replace the circuit boards in the relay.

Accessing the Relay Circuit Boards

1. Deenergize the relay by removing the connections to rear-panel terminals + (Z25) and – (Z26). Accomplish this easily on Connectorized relays by removing the connector at rear-panel terminals + (Z25) and – (Z26).
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.



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.

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. An SEL-387 Relay Model 0387x0 has only a main board. A Model 0387x1 or 0387xY relay has an extra I/O board below the main board.
5. Disconnect circuit board cables as necessary so you can remove the board and drawout tray you want. To remove the extra I/O board, first remove the main board. Remove ribbon cables by pushing the extraction ears away from the connector. Remove the six-conductor power cable by grasping the wires near the connector 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. 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 you removed in step 5. Replace the relay front-panel cover.
9. Replace any cables previously connected to serial ports.
10. Reenergize the relay by reconnecting wiring to rear-panel terminals + (Z25) and – (Z26). On Connectorized versions, replace the power connector at rear-panel terminals + (Z25) and – (Z26).

Main Board

Output Contact Jumpers

Refer to Figure 2.10 to see the layout of the main board and locate the solder jumpers to the rear of the output contacts. Select the contact type for the output contacts. With a jumper in the A position, the corresponding output contact is an “a” output contact. An “a” output contact is open when the output contact coil is deenergized and closed when the output contact coil is energized. With a jumper in the B position, the corresponding output contact is a “b” output contact. A “b” output contact is closed when the output contact coil is deenergized and open when the output contact coil is energized. These jumpers are soldered in place but may be changed in the field.

Note that the ALARM output contact is a “b” contact and that the other output contacts are all “a” contacts. This is the normal configuration of these jumpers in a standard relay shipment. The additional I/O boards have slightly different layout locations for the jumpers relative to the corresponding output contacts.

Second ALARM Contact Jumper

Note the locations of main board jumper JMP23 and output contact OUT107 in Figure 2.10, and refer to Table 2.2 to understand the relationship between the jumper and output contact. The jumper JMP23 controls the operation of output contact OUT107. JMP23 provides the option of a second alarm output contact by changing the signal that drives output contact OUT107.

Table 2.2: SEL-387 Relay Second ALARM Contact Jumper Position

JMP23 Position	Output Contact OUT107 Operation
• Bottom (Pins 1 & 2)	Second Alarm output contact (operated by alarm logic/circuitry). Relay Word bit OUT107 has no effect on output contact OUT107 when jumper JMP23 is in this position.
• Top (Pins 2 & 3)	Regular output contact OUT107 (operated by Relay Word bit OUT107). Jumper JMP23 comes in this position in a standard relay shipment.
• Neither	Disable output contact OUT107. If JMP23 is not installed, output contact OUT107 is not functional and will remain in its deenergized state.

If jumper JMP23 is installed on the two bottom pins and both output contacts OUT107 and ALARM are the same output contact type (a or b), they will be in the same state (closed or open). If jumper JMP23 is installed on the two bottom pins and output contacts OUT107 and ALARM are different output contact types (one is an “a” and one is a “b”), they will be in opposite states (one is closed and one is open).

Password and Breaker Jumpers

Refer to Figure 2.10 and note the password and breaker jumpers identified as JMP6. To change these jumpers, remove the relay front panel and main board according to the steps outlined previously in *Accessing the Relay Circuit Boards*.

Put password jumper JMP6A (left-most jumper) in place to disable serial port and front-panel password protection. With the jumper removed, password security is enabled. View or set the passwords with the PASSWORD command (see *Section 7: Serial Port Communications and Commands*).

Put breaker jumper JMP6B in place to enable the serial port commands OPEN, CLOSE, and PULSE. The relay ignores these commands while you remove JMP6B. Use these commands primarily to assert output contacts for circuit breaker control or testing purposes (see *Section 7: Serial Port Communications and Commands*).

Do not install jumpers in position JMP6C or JMP6D. If a jumper is in position JMP6D and you lose dc power to the relay, the relay will power up in SELboot when power is restored. The front panel will show “SELboot” and then a warning to remove the jumper when you attempt serial port communication.

EIA-232 Serial Port Jumpers

Refer to Figure 2.10. Jumpers JMP1 and JMP2 are toward the rear of the main board, near the rear-panel EIA-232 serial communications ports. These jumpers connect or disconnect +5 Vdc to Pin 1 on the EIA-232 serial communications Ports 2 and 3. SEL normally ships relays with these jumpers removed (out of place) so that the +5 Vdc is not connected to Pin 1 on the EIA-232 serial communications ports. JMP1 controls the +5 Vdc for Port 3, and JMP2 controls the +5 Vdc for Port 2 (see Table 7.1 in *Section 7: Serial Port Communications and Commands*). If

these jumpers are installed, be certain not to short the power supply with an incorrect communication cable. The +5 Vdc connections supply current as high as 1 A.

Solder jumpers JMP3 and JMP4 allow connection of an IRIG-B source to Port 2. Removal of JMP3 and JMP4 will cause Port 2 to no longer accept an IRIG-B signal. The Port 1 connector always accepts an IRIG-B signal. Port 2 and Port 1 IRIG-B circuits are in parallel; therefore, connect only one IRIG-B source at a time.

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.

Other Jumpers

Additional main board jumpers JMP5A through JMP5D, located near JMP6, are not functional in the SEL-387 Relay. Originally they were installed for developmental testing purposes but are not used in the production version of the relay. Jumpers must not be installed in any JMP5 position.

Low-Level Analog Interface

SEL designed the SEL-387 Relay main board to accept low-level analog signals as an optional testing method. **Section 10: Testing and Troubleshooting** contains a more detailed discussion of the patented Low-Level Test Interface; and Figure 10.1 shows the pin configuration. The SEL-RTS (Relay Test System) interfaces with the relay through a ribbon cable connection on the main board. With the front panel removed, the low-level interface connector is on the front edge at the far right of the top board. Refer to Figure 2.10. Remove the ribbon cable from the main board (top board), and connect the SEL-RTS ribbon cable to the main board. This removes the connection from the transformers in the bottom of the relay chassis and connects the SEL-RTS system for low-level testing. Refer to the SEL-RTS Instruction Manual for system operation. For normal operation, be sure to properly reinstall the ribbon cable that connects the transformers in the bottom of the chassis to the main board.

Clock Battery

Refer to Figure 2.10 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. At room temperature (25°C) the battery will operate nominally for 10 years at rated load.

Because little self-discharge of the battery occurs when an external source powers the relay, battery life can extend well beyond the nominal 10 years. The battery cannot be recharged.

If the relay does not maintain the date and time after power loss, replace the battery. Follow the instructions previously described in **Accessing the Relay Circuit Boards** in this section to remove the relay main board.



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.

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 7: Serial Port Communications and Commands* or *Section 8: Front-Panel Interface*).

Additional Input/Output Board

We offer versions of the SEL-387 Relay in a taller case size (3U) to accommodate one additional circuit board. The additional board mounts below the main board and above the analog input (transformer) board.

Three I/O board types are available. Interface Board 2 has 12 standard output contacts and 8 optoisolated inputs. Interface Board 4 has 4 standard output contacts and 16 optoisolated inputs. Interface Board 6 has 12 hybrid high current interrupting output contacts and 8 optoisolated inputs. These latter contacts can interrupt as much as 10 A of dc current, as indicated in the *General Specifications* in *Section 1: Introduction and Specifications*.

Jumpers

As on the main board, the output contacts of Interface Boards 2 and 6 have solder jumpers for configuring the output as either a form-A (normally open) or form-B (normally closed) contact. When removing the board to change jumpers, follow the procedure outlined in *Accessing the Relay Circuit Boards*. Take precautions related to protection of components from damage due to electrostatic discharge (ESD).

Note: The level-sensitive optoisolated inputs on both I/O boards have no jumpers. You must specify control voltage at the time of order.

Board Layout

Figure 2.11, Figure 2.12, and Figure 2.13 show the layout of Interface Board 2, Interface Board 4, and Interface Board 6 (conventional terminal block), respectively. Figure 2.14 and Figure 2.15 show the layout of Interface Board 2 and Interface Board 6 (Connectorized), respectively. The only difference between the two is the row of electronic components that form the interruption circuits of the high current interrupting contacts on Interface Board 6.

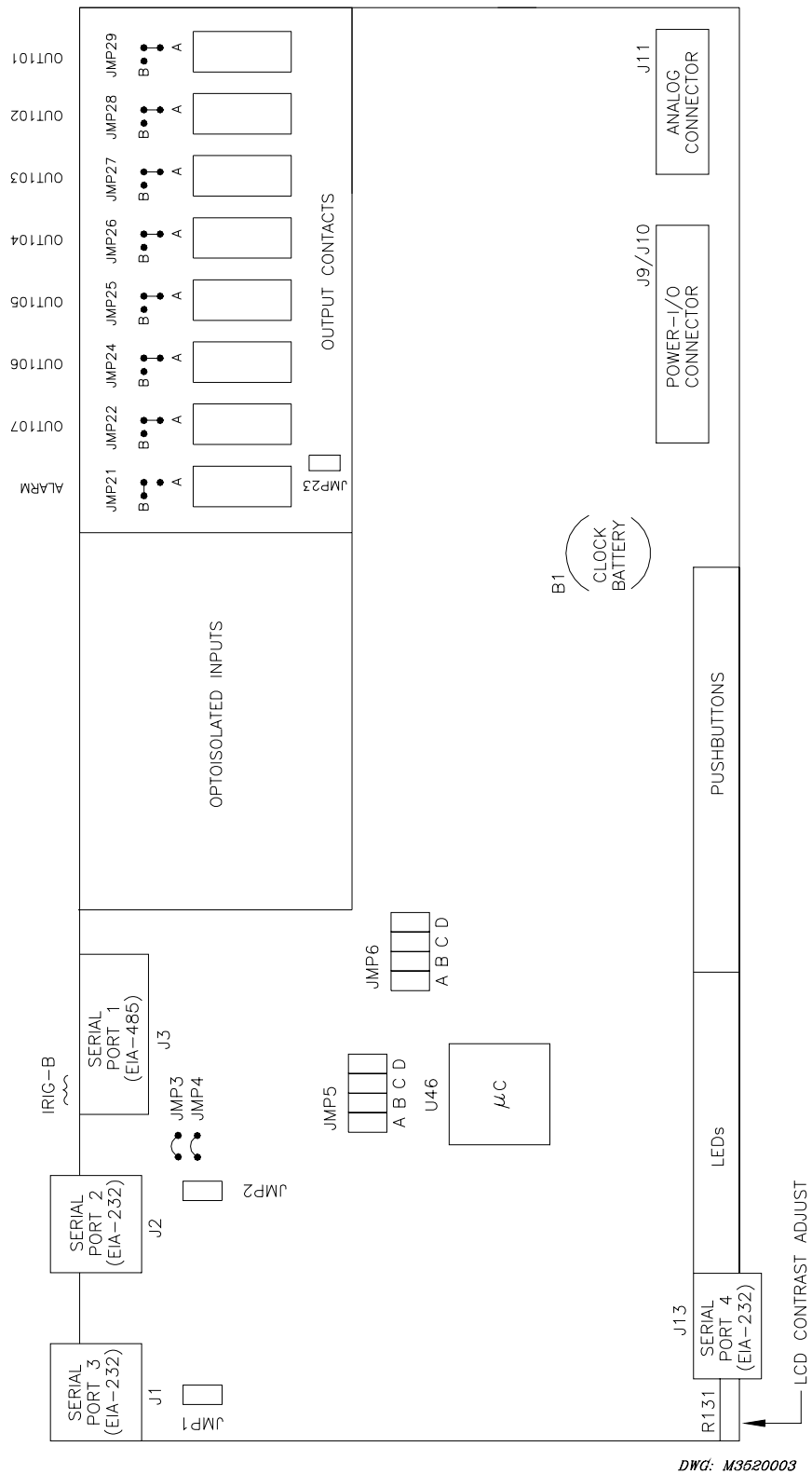
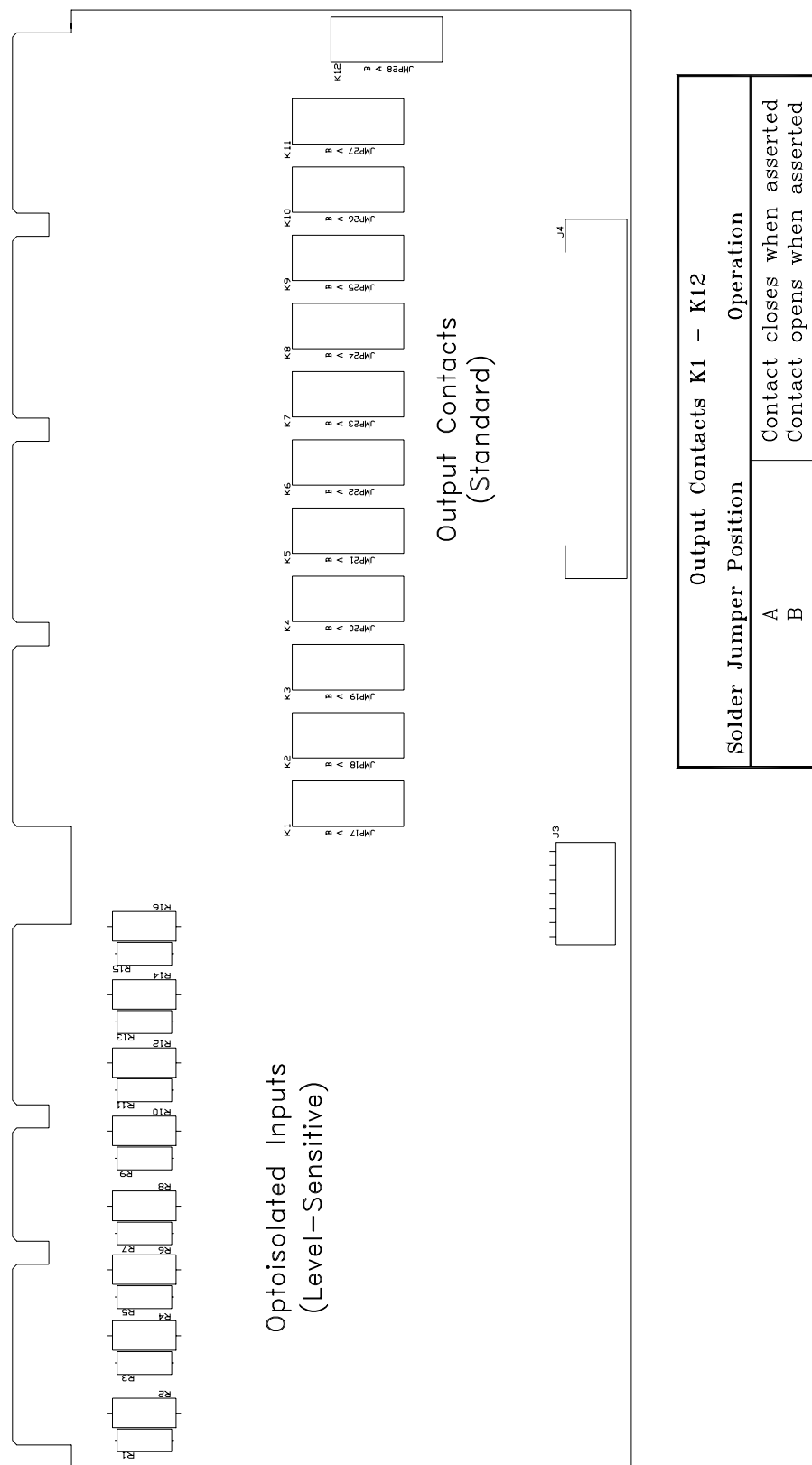
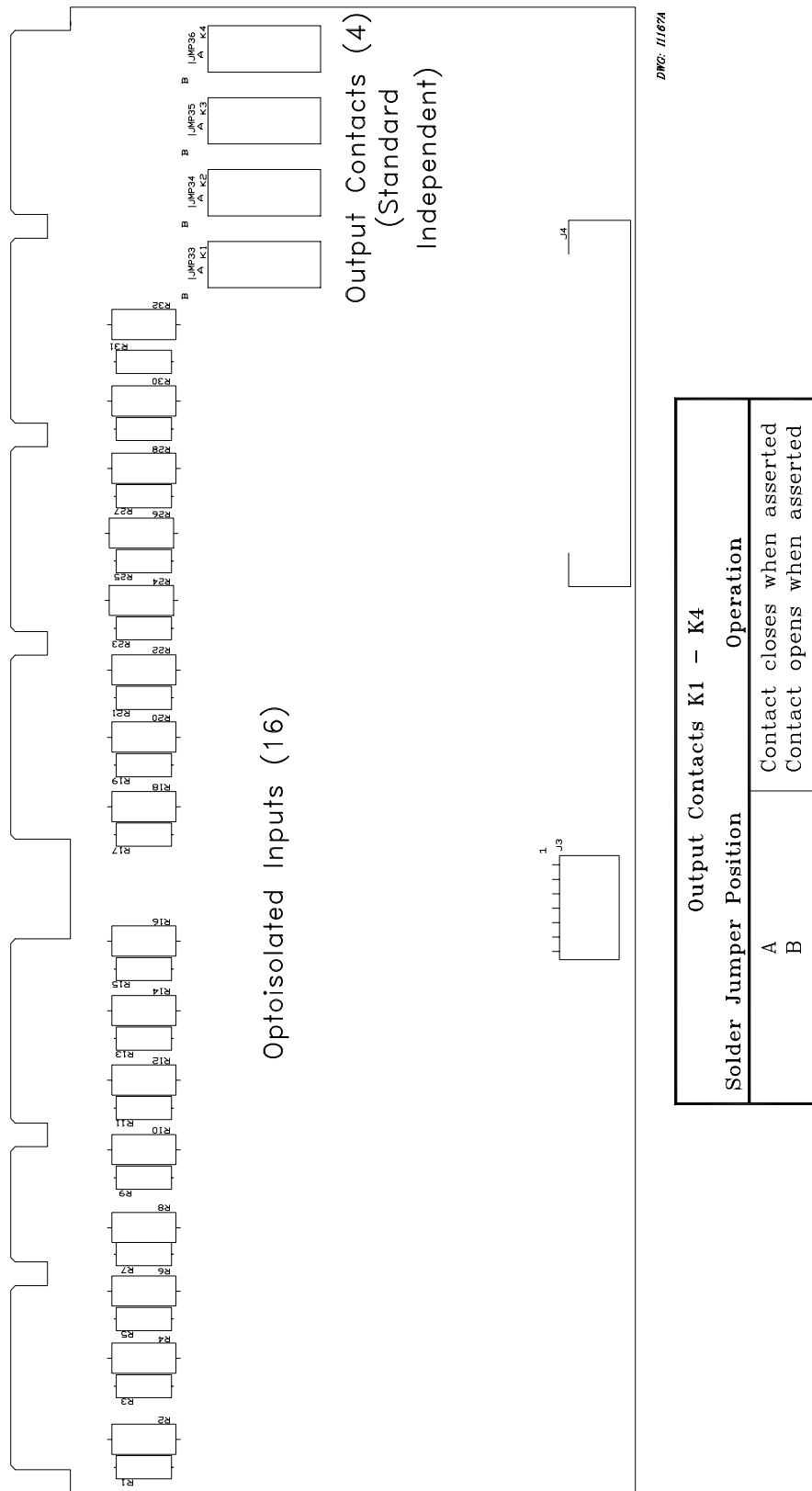


Figure 2.10: Main Board Jumper, Connections, and Battery Locations



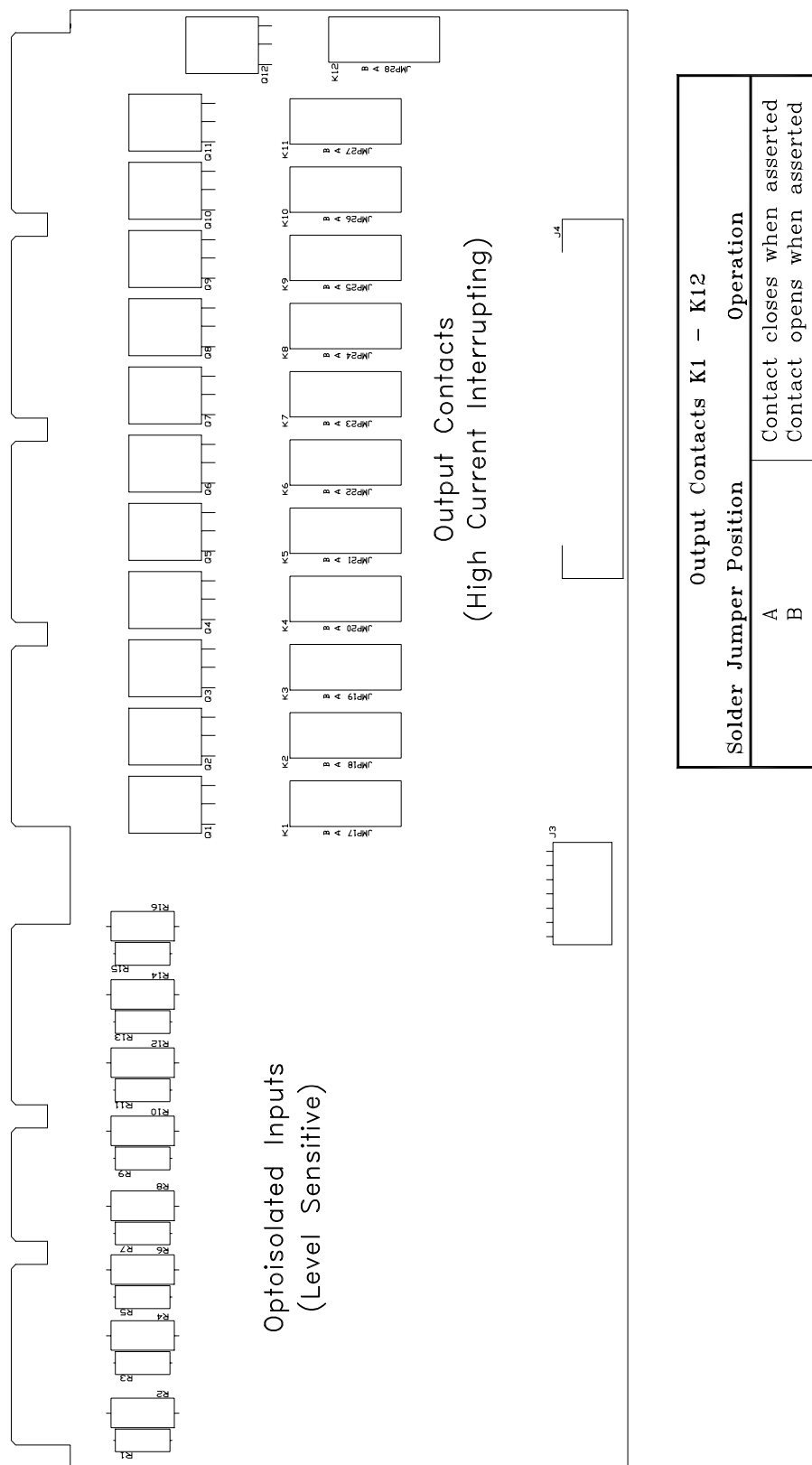
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Figure 2.11: Interface Board 2 Component Layout (Conventional Terminal Block)



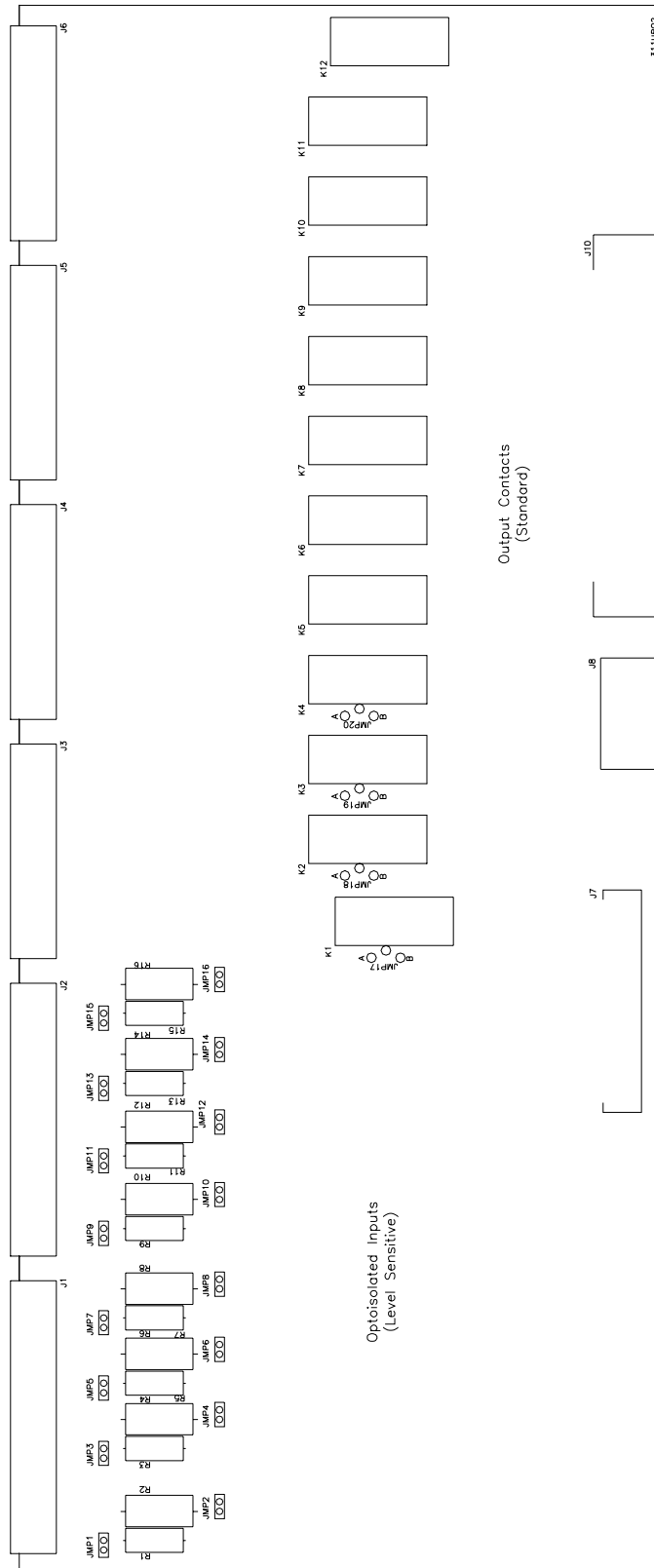
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Figure 2.12: Interface Board 4 Component Layout (Conventional Terminal Block)



DWG: M3871042

Figure 2.13: Interface Board 6 Component Layout (Conventional Terminal Block)



Output Contacts K1 - K4		
Solder Jumper Position		
A	Contact closes when asserted	
B	Contact opens when asserted	

DWG: M2871082

Figure 2.14: Interface Board 2 Component Layout (Connectorized)

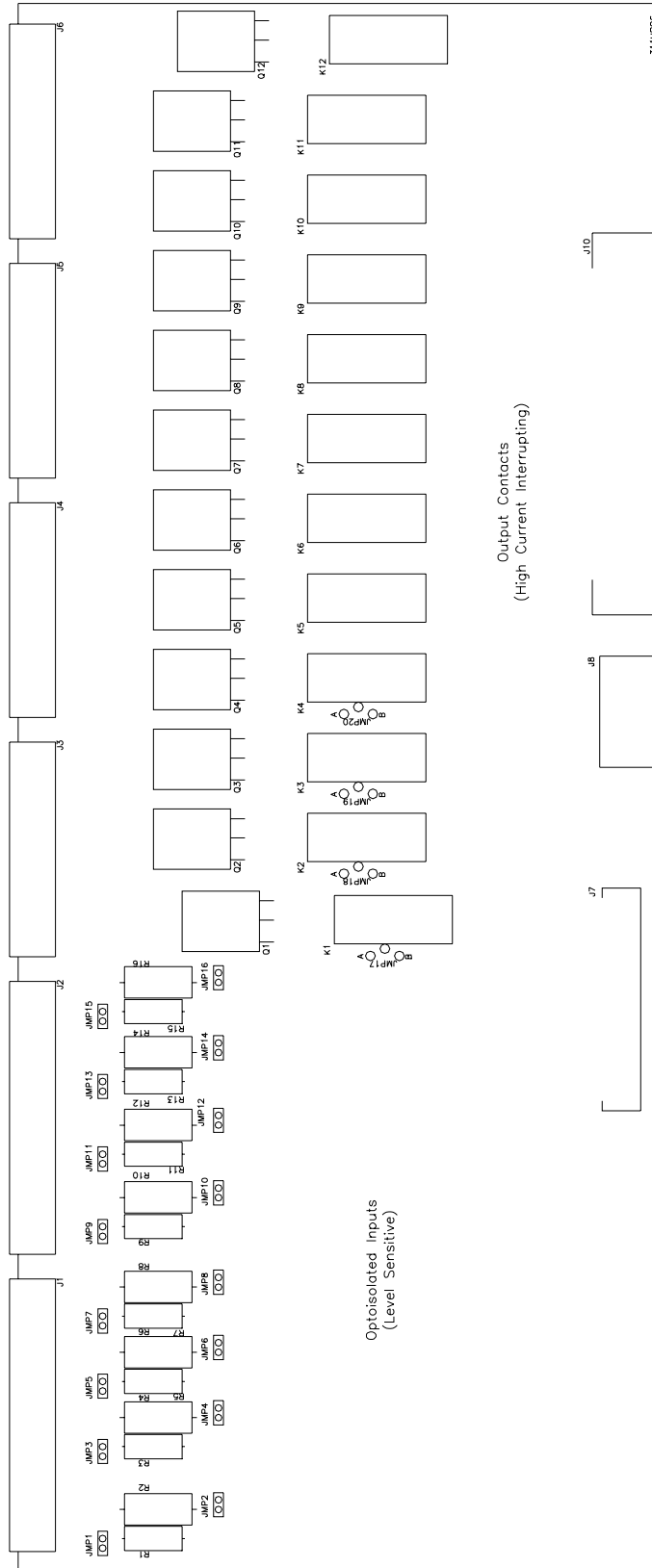


Figure 2.15: Interface Board 6 Component Layout (Connectorized)

Output Contacts K1 – K4	
Solder Jumper Position	
A	Contact closes when asserted
B	Contact opens when asserted

DWG: M387/083

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SECTION 3: DIFFERENTIAL, RESTRICTED EARTH FAULT, THERMAL, AND OVERCURRENT ELEMENTS

INTRODUCTION

This section describes general applications and operating characteristics for the current differential, restricted earth fault (REF), thermal, and overcurrent protection elements. The section also contains application guidelines for the differential and thermal elements and setting calculation information for the differential elements and restricted earth fault elements.

DIFFERENTIAL ELEMENT

Application Description

Protect your apparatus with dual-slope percentage differential protection. Percentage differential protection provides more sensitive and secure protection than traditional differential protection; the dual-slope characteristic compensates for CT ratio mismatches, CT ratio errors, CT saturation, and errors because of tap changing.

Operating Characteristic

The SEL-387 Relay has three differential elements (87R-1, 87R-2, and 87R-3). These elements employ Operate (IOP) and Restraint (IRT) quantities that the relay calculates from the winding input currents. The relay uses a characteristic such as that in Figure 3.1. You can set the characteristic as either a single-slope, percentage differential characteristic or as a dual-slope, variable-percentage differential characteristic. Tripping occurs if the Operate quantity is greater than the curve value for the particular restraint quantity. A minimum pickup level for the Operate quantity must also be satisfied. The four settings that define the characteristic are:

O87P = minimum IOP level required for operation

SLP1 = initial slope, beginning at origin and intersecting O87P at $IRT = O87P \cdot 100/SLP1$

IRS1 = limit of IRT for SLP1 operation; intersection where SLP2 begins

SLP2 = second slope, if used; must be greater than or equal to SLP1

By careful selection of these settings, the user can duplicate closely the characteristics of existing differential relays that have been in use for many years.

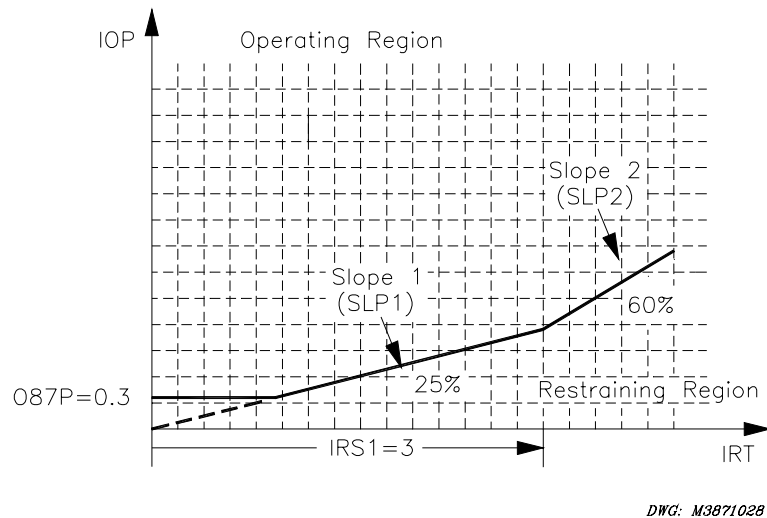


Figure 3.1: Percentage Restraint Differential Characteristic

Figure 3.2 illustrates the manner in which the differential element logic obtains Operate and Restraint quantities for use in the characteristic. The relay compensates the sets of three-phase currents for the phase angle and phase interaction effects introduced by the winding connection of the transformer and CTs. The relay then divides the currents by a tap value, determined on the same MVA basis for each winding, to reduce the currents to dimensionless multiples of tap.

The resulting A-phase, B-phase, and C-phase currents from each winding then go to the differential elements 87R-1, -2, and -3, respectively. In each element a phasor addition sums the winding currents. The magnitude of this result is IOP. The magnitudes of the winding currents are then summed in a simple scalar addition and divided by two. This result is IRT. For example, for a balanced through-load current of 4 amps, these calculations produce ideal results of $IOP = 0$ and $IRT = 4$.

Second- and fifth-harmonic elements supervise the restrained differential elements and block tripping if the specific harmonic content, as a percentage of fundamental operating current, exceeds a specified threshold. This prevents improper tripping during transformer inrush (second) or allowable overexcitation conditions (fifth). You can set the two thresholds, PCT2 and PCT5, independently. You can also specify whether the harmonic blocking of any element is to disable all elements or just the affected element. This setting, IHBL, stands for Independent Harmonic Blocking. If set to N (No), the setting will result in all elements being blocked if any is blocked. Set to Y (Yes), the setting disables only the blocked element.

There is also a set of unrestrained differential elements, 87U-1, -2, and -3. These simply compare the IOP quantity to a setting value (U87P), typically about 10 times tap, and trip if the IOP quantity exceeds this level. These elements essentially form an instantaneous unit set high enough that exceeding the pickup level could only indicate an internal fault.

An additional alarm function for fifth harmonic, to warn of overexcitation, employs a separate threshold (TH5P) and an adjustable timer (TH5D). This threshold and timer may be useful for transformer applications in or near generating stations.

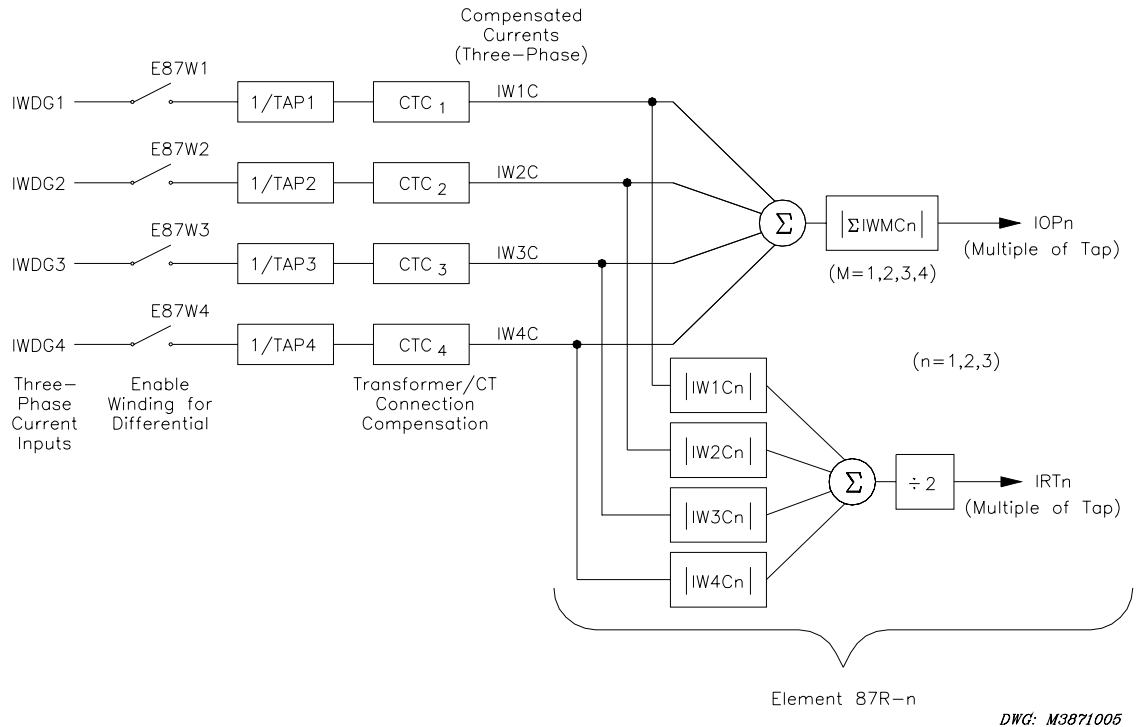


Figure 3.2: Differential Element Logic Current Quantities (Operate and Restraint)

Figure 3.2 shows the process of converting three-phase currents from as many as four windings into dimensionless quantities, which the logic sums in appropriate ways to produce three Operate values and three Restraint values.

The sets of three-phase currents enter the process at the left. IWDG1 represents the measurement of IAW1, IBW1, and ICW1 analog current quantities. IWDG2, IWDG3, and IWDG4 represent similar measurements for the other windings. If overcurrent units are enabled for a particular winding, the logic uses the three-phase currents directly for purposes of metering and determination of overcurrent unit operation.

For the differential units, you must take additional steps to adjust the current values and also take into account the relay application. The settings E87W1 through E87W4 tell the relay which sets of currents the differential calculation will use. These currents are those that represent the sum of all incoming and outgoing currents in the breakers serving the transformer. Overcurrent protection can use any relay winding inputs not associated specifically with summing of transformer winding current values; the differential calculation excludes these inputs.

The currents for use in the differential calculation must undergo two adjustments. They must be reduced to dimensionless multiples of tap values, and they must be adjusted for phase angle shift and sequence quantity changes produced by the transformer and/or CT winding connections.

Choosing the tap value for each winding occurs on a common MVA basis. This method of choosing tap values ensures that, for full-load through-current conditions, all incoming current multiples of tap sum to 1.0 and all outgoing current multiples of tap sum to -1.0, with a reference direction into the transformer windings.

Figure 3.2 indicates the adjustment for phase angle and sequence quantities as CTC_1 through CTC_4 . These processes use the values of settings $W1CTC$ through $W4CTC$ to determine the mathematical corrections necessary for the three-phase currents for a particular winding. The result is a different set of three-phase values. This set contains phases with altered magnitude, phase angle, and sequence content. $IW1C$ through $IW4C$, the letter C meaning “compensated,” indicate the phase-compensated currents in the figure. For the next step in the process these sets of three-phase compensated currents, again as multiples of tap, split again into phases.

The A-phase compensated current multiples go to differential element 87-1, B-phase multiples go to 87-2, and C-phase multiples go to 87-3. In each element the quantities are summed as phasors and the magnitude becomes the Operate quantity, IOP_n . For a through-current condition, IOP_n should calculate to about $1 + (-1) = 0$, at rated load. Calculation of the Restraint quantity, IRT_n , occurs through a summation of all current magnitudes and then division by two. For a through-current condition, this will calculate to about $(|1| + |-1|) / 2 = 2 / 2 = 1$, at rated load.

Figure 3.3 shows the decision phase of the process for the nth element.

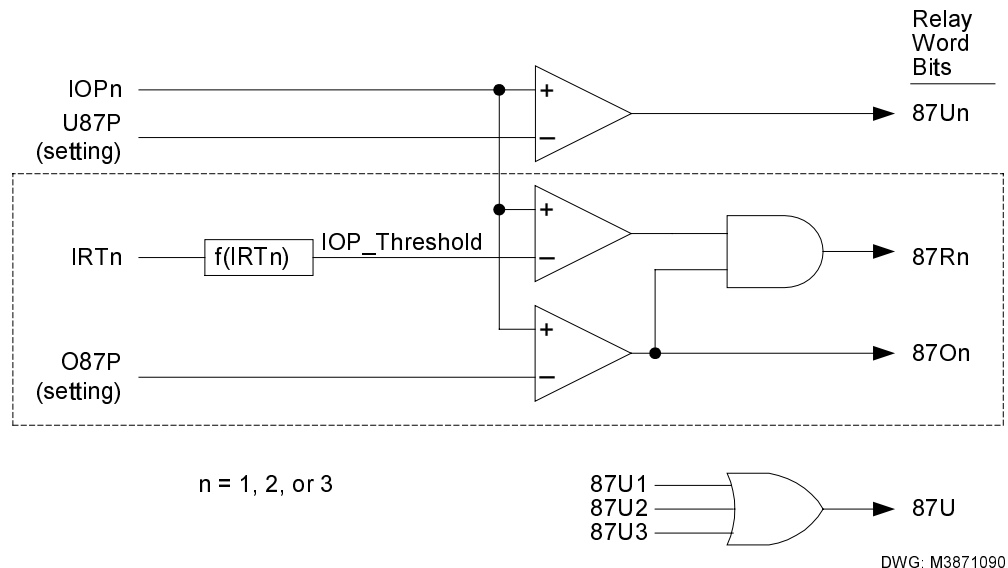


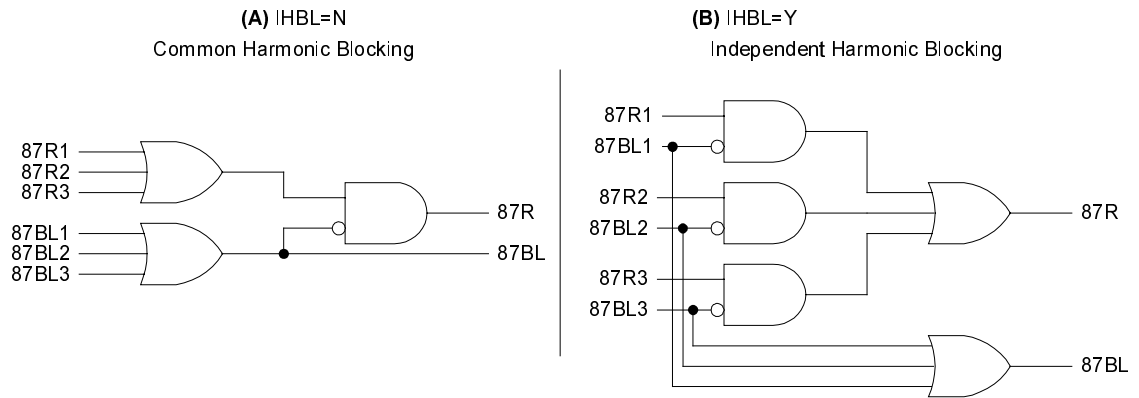
Figure 3.3: Differential Element Decision Logic

In element 87-1, for example, the IOP_n and IRT_n quantities determine whether the relay trips. The logic enclosed within the dotted line implements the Figure 3.1 characteristic. The differential element calculates an IOP threshold as a function of IRT_n . IOP_n must exceed this threshold to produce tripping. The function uses the $SLP1$, $SLP2$, and $IRS1$ setting values, along with IRT_n , to calculate the IOP value. The differential element decision logic compares the calculated value, denoted $f(IRT_n)$, to the actual IOP_n . If IOP_n is greater, one input of the AND gate at the right receives a logic 1. Comparison of IOP_n with the $O87P$ setting determines the second AND input. If IOP_n is greater than $O87P$, Relay Word bit $87O_n$ asserts. The AND gate condition then is satisfied, and Relay Word bit $87R_n$ asserts, indicating operation of the restrained differential element, n. This does not, as yet, produce a trip. The relay still needs the results of the harmonic blocking decision logic, which we describe later.

A simpler comparison also occurs in Figure 3.3. The logic outside and above the dotted line compares the value of IOP_n directly to the $U87P$ setting value. $U87P$ is set very high, such that an IOP of that magnitude could only imply a massive internal fault. If IOP exceeds $U87P$, the

87Un Relay Word bit asserts, indicating an unrestrained differential element trip. In the logic at lower right, the bits 87U1, 87U2, and 87U3 enter an OR gate, which asserts Relay Word bit 87U if any unrestrained element operates. Harmonic blocking is not performed on the unrestrained element.

Figure 3.4 shows the final stage of the decision process for the restrained differential elements.



DWG: M3871100

Figure 3.4: Differential Element Harmonic Blocking Logic

While the restrained differential elements are making decisions, a parallel decision process occurs regarding the magnitudes of specific harmonics in the IOP quantities. In element 87-1, if the magnitude of second harmonic divided by the magnitude of fundamental in IOP1 exceeds PCT2 percent, or if the magnitude of fifth harmonic divided by the magnitude of fundamental in IOP1 exceeds PCT5 percent, the Relay Word bit 87BL1 asserts. The 87-2 and 87-3 elements perform similar calculations. The final phase of the decision process depends on the setting of independent harmonic blocking (IHBL). This decision logic uses all three restrained element output bits, 87R1, 87R2, and 87R3, and all three blocking bits, 87BL1, 87BL2, and 87BL3.

If IHBL is set to N (No), the logic shown in Figure 3.4 to the left of the vertical line, IHBL = N, is enabled. In this case all 87Rn elements enter one OR gate, and all 87BLn elements enter another OR gate, whose output is negated at the upper AND gate. If the 87Rn OR output asserts but the 87BLn OR output does not, the 87R Relay Word bit asserts and tripping can take place. In other words, with IHBL = N, harmonic blocking within ANY differential element will prevent operation and tripping of ALL the restrained differential elements. Generally this is the preferred mode of operation.

If IHBL is set to Y (Yes), the logic shown in Figure 3.4 to the right of the vertical line, IHBL = Y, is enabled. Here, the logic pairs 87R1 with negated 87BL1, 87R2 with negated 87BL2, and 87R3 with negated 87BL3 at separate AND gates. In this logic harmonic blocking in a given element will only disable tripping of that element. In general, this mode of operation might only be used where three single-phase transformers are used to make up a three-phase bank, and independent-pole breaker operation is possible.

Relay Word bits 87R and 87U are high-speed elements that must trip all breakers. Our example assigns 87R and 87U to trip variable setting TR4. If either bit asserts, this variable asserts bit TRIP4, which drives contact OUT104. OUT104 connects to an 86 lockout device, which trips all breakers via multiple sets of contacts.

Setting Descriptions

Differential Element Enable (E87W1 through E87W4)

Range: Y, N

The SEL-387 Relay has four sets of three-phase current inputs. Depending on the application, you may not need all of these inputs for the differential zone of protection. You can configure any unused terminals for stand-alone overcurrent protection. The E87Wn setting specifies which of the terminals the relay is to include in the differential calculation. (An independent setting, EOCn, exists to enable the overcurrent and demand metering elements.) Selecting Y for E87Wn enables differential element settings for the corresponding winding. Selecting N for E87Wn disables differential element settings for the corresponding winding; the relay hides the settings, and they are unavailable for use.

CT Connection (W1CT through W4CT)

Range: D, Y

To perform calculations for TAPn values, the relay uses information on whether the CTs are connected in delta (D) or wye (Y) for each winding. If the CTs are connected in delta, the relay raises the TAP value by a factor of 1.732.

CT Ratio (CTR1 through CTR4)

Range: 1–50000

Determine the CT ratio by dividing the nominal primary CT current by the nominal secondary CT current. If, for example, the nominal primary CT current is 2000 A and the nominal secondary CT current is 5 A, the ratio is 2000/5 or 400. For this example, enter a value of 400.

Maximum Transformer Capacity, Three-Phase MVA (MVA)

Range: OFF, 0.2–5000 MVA, in 0.1 MVA steps

Use the highest expected transformer rating, such as the FOA (Forced Oil and Air cooled) rating or a higher emergency rating, when setting the maximum transformer capacity.

Internal Winding/CT Connection Compensation (ICOM)

Range: Y, N

This Yes/No variable defines whether the input currents need any correction, either to accommodate phase shifts in the transformer or CTs or to remove zero-sequence components from the secondary currents. If this setting is Yes, the relay permits the user, in the next group of settings, to define the amount of shift needed to properly align the secondary currents for the differential calculation.

Connection Compensation (W1CTC through W4CTC)

Range: 0, 1, ..., 12

These settings define the amount of compensation the relay applies to each set of winding currents to properly account for phase shifts in transformer winding connections and CT connections. For example, this correction is needed if both wye and delta power transformer windings are present, but all of the CTs are connected in wye. The effect of the compensation is to create phase shift and removal of zero-sequence current components.

Line-to-Line Voltage, kV (VWDG1 through VWDG4)

Range: 1–1000 kV, in 0.01 kV steps

Enter the nominal line-to-line transformer terminal voltages. If the transformer differential zone includes a load tap-changer, assume that it is in the neutral position. The setting units are kilovolts.

Current TAP (TAP1 through TAP4)

Range: 1A: 0.1–31 A, secondary, in 0.01 A steps

5A: 0.5–155 A, secondary, in 0.01 A steps

Note: TAP_{MAX}/TAP_{MIN} must be less than or equal to 7.5

When a value is entered in the MVA setting (i.e., MVA is not set to “OFF”), the relay uses the MVA, winding voltage, CT ratio, and CT connection settings you have entered and automatically calculates the “TAPn” values.

You can also directly enter tap values. Set MVA = OFF, and enter the TAP1 through TAP4 values directly, along with the other pertinent settings.

Restrained Element Operating Current Pickup (O87P)

Range: 0.1–1.0 · TAP

Note: 1A: $TAP_{MIN} \cdot O87P \geq 0.1 I_n$

5A: $TAP_{MIN} \cdot O87P \geq 0.5 I_n$

Set the operating current pickup at a minimum for increased sensitivity but high enough to avoid operation because of steady-state CT error and transformer excitation current.

Restraint Slope Percentage (SLP1, SLP2)

Range: 5–100%, in 1% steps

Use restraint slope percentage settings to discriminate between internal and external faults. Set SLP1 or SLP2 to accommodate current differences from power transformer tap-changer, CT saturation, CT errors, and relay error.

Restraint Current Slope 1 Limit (IRS1)

Range: 1.0–20.0, in 0.1 steps · TAP

Note: 1A: $TAP_{MAX} \cdot IRS1 \leq 31.0$

5A: $TAP_{MAX} \cdot IRS1 \leq 155.0$

A two-slope, or variable-percentage differential application, improves sensitivity in the region where CT error is less and increases security in the high-current region where CT error is greater. We must define both slopes, as well as the slope 1 limit or point IRS1, where SLP1 and SLP2 intersect.

Unrestrained Element Current Pickup (U87P)

Range: 1.0–20.0, in 0.1 steps · TAP

The purpose of the instantaneous unrestrained current element is to react quickly to very heavy current levels that clearly indicate an internal fault. Set the pickup level (U87P) to about 10 times tap. The unrestrained differential element only responds to the fundamental frequency component of the differential operating current. It is unaffected by the SLP1, SLP2, IRS1, PCT2, PCT5, or IHBL settings. Thus, you must set the element pickup level high enough so as not to react to large inrush currents.

Second-Harmonic Blocking Percentage of Fundamental (PCT2)

Range: OFF, 5–100%, in 1% steps

Energization of a transformer causes a temporary large flow of magnetizing inrush current into one terminal of a transformer, without other terminals seeing this current. Thus, it appears as a differential current that could cause improper relay operation. Magnetizing inrush currents contain greater amounts of second-harmonic current than do fault currents. This second-harmonic current can be used to identify the inrush phenomenon and to prevent relay misoperation. The SEL-387 Relay measures the amount of second-harmonic current flowing in the transformer. You can set the relay to block the percentage restrained differential element if the ratio of second-harmonic current to fundamental current (IF2/IF1) is greater than the PCT2 setting.

Fifth-Harmonic Blocking Percentage of Fundamental (PCT5)

Range: OFF, 5–100%, in 1% steps

According to industry standards (ANSI/IEEE C37.91, C37.102), overexcitation occurs when the ratio of the voltage to frequency (V/Hz) applied to the transformer terminals exceeds 1.05 per unit at full load or 1.1 per unit at no load. This ratio is a measure of the core flux density. Transformer overexcitation produces odd-order harmonics, which can appear as differential current to a transformer differential relay.

Unit-generator step-up transformers at power plants are the primary users of fifth-harmonic blocking. Transformer voltage and generator frequency may vary somewhat during startup, overexciting the transformers.

Fifth-Harmonic Alarm Threshold (TH5P)

Range: OFF, (0.02–3.2), in 0.01 steps · TAP

Note: 1A: $TAP_{MIN} \cdot TH5P \geq 0.05$
 $TAP_{MAX} \cdot TH5P \leq 31.0$

5A: $TAP_{MIN} \cdot TH5P \geq 0.25$
 $TAP_{MAX} \cdot TH5P \leq 155.0$

You may use the presence of fifth-harmonic differential current to assert an alarm output during startup. This alarm indicates that the rated transformer excitation current is exceeded. You may also consider triggering an event report if fifth-harmonic current exceeds the fifth-harmonic threshold that you set.

Fifth-Harmonic Alarm Time Delay Pickup (TH5D)

Range: 0–8000 cycles, in 0.125-cycle steps

With this pickup, you can delay assertion of an alarm for excessive fifth-harmonic differential current.

Independent Harmonic Blocking (IHBL)

Range: Y, N

Upon energization of a three-phase transformer, at least two phase currents will contain inrush harmonics. In traditional single-phase relays each relay compares the harmonic current flowing through the phase for that relay. The SEL-387 Relay performs harmonic blocking in two ways:

1. Independent Harmonic Blocking (IHBL = Y) blocks the percentage differential element for a particular phase if the harmonic (second or fifth) in that phase exceeds the block threshold. No blocking occurs on other differential elements.
2. Common Harmonic Blocking (IHBL = N) blocks all of the percentage differential elements if the harmonic magnitude of any one phase is greater than the blocking threshold.

Common Harmonic Blocking is more secure but may slightly delay percentage differential element operation because harmonics in all three phases must drop below the thresholds for the three phases.

Setting Calculation

General Discussion of Connection Compensation

The general expression for current compensation is as follows:

$$\begin{bmatrix} IAWnC \\ IBWnC \\ ICWnC \end{bmatrix} = [CTC(m)] \cdot \begin{bmatrix} IAWn \\ IBWn \\ ICWn \end{bmatrix}$$

where $IAWn$, etc., are the three-phase currents entering terminal “n” of the relay; $IAWnC$, etc., are the corresponding phase currents after compensation; and $[CTC(m)]$ is the three-by-three compensation matrix.

Setting $WnCTC = m$ specifies which $[CTC(m)]$ matrix the relay is to use. The setting values are 0, 1, 2, ..., 11, 12. These are discrete values “m” can assume in $[CTC(m)]$; the values physically represent the “m” number of increments of 30 degrees that a balanced set of currents with ABC phase rotation will be rotated in a counterclockwise direction when multiplied by $[CTC(m)]$. If a given set of such currents is multiplied by all 12 of the CTC matrices, the resulting compensated values would seem to move completely around the circle in a counterclockwise direction, returning to the original start position. This is the same as successively multiplying $[CTC(1)]$ times the original currents, then times each successive compensated result value, a total of 12 times.

If a balanced set of currents with ACB phase rotation undergoes the same exercise, the rotations by the $[CTC(m)]$ matrices are in the clockwise direction. This is because the compensation matrices, when performing phasor addition or subtraction involving B or C phases, will produce “mirror image” shifts relative to Phase A, when ACB phase rotation is used instead of ABC. In ACB phase rotation the three phases still rotate in a counterclockwise direction, but C-phase is in the 120-degree lagging position and B-phase leads by 120 degrees, relative to A-phase.

The discussions below assume ABC phase rotation, unless mentioned otherwise.

The “0” setting value is intended to create no changes at all in the currents and merely multiplies them by an identity matrix. Thus, for $WnCTC = 0$,

$$[CTC(0)] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

that is,

$$\begin{aligned} IAWnC &= IAWn \\ IBWnC &= IBWn \\ ICWnC &= ICWn \end{aligned}$$

The “1” setting performs a 30-degree compensation in the counterclockwise direction, as would a delta CT connection of type DAB (30-degree leading). The name for this connection comes from the fact that the polarity end of the A-phase CT connects to the nonpolarity end of the B-phase

CT, and so on, in forming the delta. Thus, for $W_nCTC = 1$, the relay uses the following [CTC(m)] matrix:

$$[CTC(1)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}$$

that is,

$$IAW_nC = \frac{(IAW_n - IBW_n)}{\sqrt{3}}$$

$$IBW_nC = \frac{(IBW_n - ICW_n)}{\sqrt{3}}$$

$$ICW_nC = \frac{(ICW_n - IAW_n)}{\sqrt{3}}$$

The “11” setting performs a 330-degree compensation ($11 \cdot 30$) in the counterclockwise direction, or a 30-degree compensation in the clockwise direction, as would a delta CT connection of type DAC (30-degree lagging). The name for this connection comes from the fact that the polarity end of the A-phase CT connects to the nonpolarity end of the C-phase CT, and so on, in forming the delta. Thus, for $W_nCTC = 11$, the relay uses the following [CTC(m)] matrix:

$$[CTC(11)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

that is,

$$IAW_nC = \frac{(IAW_n - ICW_n)}{\sqrt{3}}$$

$$IBW_nC = \frac{IBW_n - IAW_n}{\sqrt{3}}$$

$$ICW_nC = \frac{(ICW_n - IBW_n)}{\sqrt{3}}$$

The effect of each compensation on balanced three-phase currents is to rotate them $m \cdot 30^\circ$ without a magnitude change.

The compensation matrix [CTC(12)] is similar to [CTC(0)], in that it produces no phase shift (or, more correctly, 360 degrees of shift) in a balanced set of phasors separated by 120 degrees. However, it removes zero-sequence components from the winding currents, as do all of the matrices having non-zero values of m .

$$[CTC(12)] = \frac{1}{3} \cdot \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

that is,

$$IAW_{nC} = \frac{(+2 \cdot IAW_n - IBW_n - ICW_n)}{3}$$

$$IBW_{nC} = \frac{(-IAW_n + 2 \cdot IBW_n - ICW_n)}{3}$$

$$ICW_{nC} = \frac{(-IAW_n - IBW_n + 2 \cdot ICW_n)}{3}$$

We could use this type of compensation in applications having wye-connected transformer windings (no phase shift) with wye CT connections for each winding. Using $W_nCTC = 12$ for each winding removes zero-sequence components, just as connection of the CTs in delta would do, but without producing a phase shift. (One might also use $W_nCTC = 1$ or 11 for this same application, yielding compensation similar to that from connection of the CTs on both sides in DAB or DAC.)

The Complete List of Compensation Matrices (m = 1 to 12)

$$[CTC(1)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$[CTC(2)] = \frac{1}{3} \cdot \begin{bmatrix} 1 & -2 & 1 \\ 1 & 1 & -2 \\ -2 & 1 & 1 \end{bmatrix}$$

$$[CTC(3)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{bmatrix}$$

$$[CTC(4)] = \frac{1}{3} \cdot \begin{bmatrix} -1 & -1 & 2 \\ 2 & -1 & -1 \\ -1 & 2 & -1 \end{bmatrix}$$

$$[CTC(5)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix}$$

$$[CTC(6)] = \frac{1}{3} \cdot \begin{bmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{bmatrix}$$

$$[CTC(7)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix}$$

$$[CTC(8)] = \frac{1}{3} \cdot \begin{bmatrix} -1 & 2 & -1 \\ -1 & -1 & 2 \\ 2 & -1 & -1 \end{bmatrix}$$

$$[CTC(9)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix}$$

$$[CTC(10)] = \frac{1}{3} \cdot \begin{bmatrix} 1 & 1 & -2 \\ -2 & 1 & 1 \\ 1 & -2 & 1 \end{bmatrix}$$

$$[CTC(11)] = \frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

$$[CTC(12)] = \frac{1}{3} \cdot \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

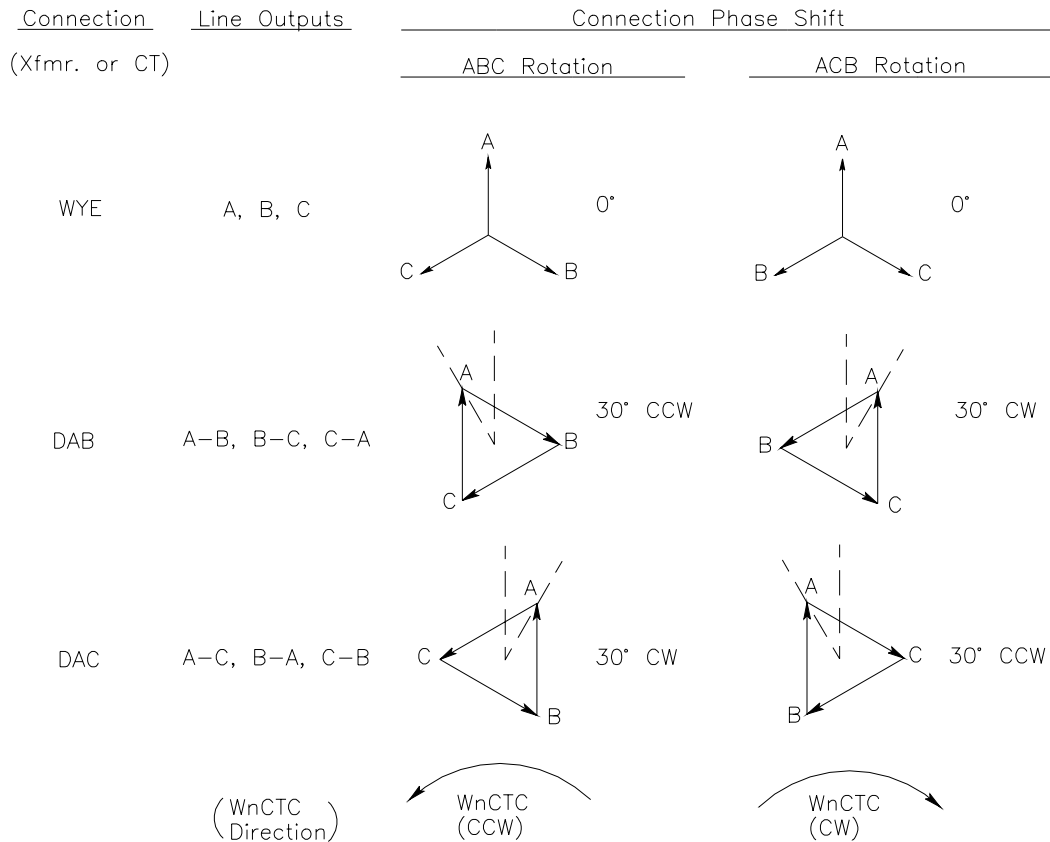
The matrices for odd values of m (1, 3, 5, 7, 9, 11) are similarly constructed, as are the matrices for even values of m (2, 4, 6, 8, 10, 12). Also, $[CTC(m)]$ equals the minus of $[CTC(m \pm 6)]$, because these matrices represent shifts separated by exactly 180 degrees.

Selecting the Correct Values of WnCTC for Each Winding

The process of choosing the correct WnCTC setting value for each winding involves a complete knowledge of the transformer winding connections and phase relationships, the CT connections, and the system phase rotation (ABC or ACB). The following brief review discusses the nature of various connections, their phase shifts, and the reference motion for selecting WnCTC based on system phase rotation.

Winding Connection Review

Figure 3.5 shows the three basic winding connections, consisting of a wye connection and the two possible delta connections.



DWG: M3871053

Figure 3.5: Winding Connections, Phase Shifts, and Compensation Direction

The wye connection consists of connecting one end of each winding to a common or neutral point, leaving the other ends of each winding for the line terminals. Because the windings do not interconnect at the line ends, the line current equals the respective winding current, A, B, or C,

and no phase shift occurs in the line currents with respect to the winding currents. The neutral point, if it is grounded, permits flow of zero-sequence current components in the windings and line outputs.

There are two possible delta connections. In determining WnCTC, it is essential to know not only that the CTs or transformer windings are connected in delta but in **which** delta. In this manual we call these delta connections DAB and DAC. In the DAB connection the polarity end of the A winding connects to the nonpolarity end of the B winding, and so on, to produce the delta. In the DAC connection the polarity end of the A winding connects to the nonpolarity end of the C winding, and so on, to produce the delta. In Figure 3.5 an arrowhead indicates the polarity end of each winding.

These arrangements involve a connection point between two windings at each line terminal; the line currents are not the same as the winding currents, but are in fact the phasor difference between the associated winding currents. Therefore, the line currents will shift in phase by some amount with respect to the winding currents. In the DAB connection the line currents from the A, B, and C line terminals are, respectively, A-B, B-C, and C-A in terms of the winding currents. In the DAC connection the line currents from the A, B, and C line terminals are, respectively, A-C, B-A, and C-B in terms of the winding currents. The phase shift produced by each physical type of delta depends on the system phase rotation.

Note: The terms “lead” and “lag” refer to the assumed counterclockwise (CCW) rotation of the phasors for both ABC and ACB phase rotation. “Lead” implies movement in the CCW direction; “lag” is movement in the clockwise (CW) direction.

In the ABC phase rotation B lags A by 120 degrees and C leads A by 120 degrees. The DAB connection line current at terminal A is A-B, which in this case is a phasor that leads A winding current by 30 degrees. For this reason, DAB is often referred to as the “leading connection.” However, DAB is the leading connection only for ABC phase rotation. In the ACB phase rotation C lags A by 120 degrees, and B leads A by 120 degrees. Terminal A line current is still A-B, but current now lags A winding current by 30 degrees.

The DAC connection produces opposite shifts to DAB. In the ABC phase rotation line current from terminal A is A-C, which lags A winding current by 30 degrees. In the ACB phase rotation line current A is still A-C, but this result leads A winding current by 30 degrees.

Five-Step Compensation Process

The process of determining WnCTC for each winding involves the following five basic steps. Two examples illustrate important points about the five steps.

1. Establish the phase direction for the terminal-A line current for each three-phase winding of the transformer. (This step requires transformer nameplate drawings and/or internal connection diagrams.)
2. Adjust the terminal-A line current direction by the phase shift (if any) of the current transformer connection. (Reference Figure 3.5 for this step.)
3. Select any one of the adjusted terminal-A directions from step 2, to serve as the reference direction. (The relay compensates all other windings to line up with this reference.)

4. Choose a setting for WnCTC for each set of winding input currents. This setting is the number of 30-degree increments needed to adjust each nonreference winding to line it up with the reference. This number will range from 0 to 12 increments. For ABC phase rotation, begin at the winding direction and proceed in a CCW direction until reaching the reference. For ACB phase rotation, begin at the winding direction and proceed in a CW direction until reaching the reference. Figure 3.5 shows these compensation directions.
5. If any winding needs no phase correction (zero degrees), but is a grounded-wye winding having wye-connected CTs, choose WnCTC=12 for that winding, rather than WnCTC=0. This setting will remove zero-sequence current components from the relay currents to prevent false differential tripping on external ground faults. (All non-zero values of WnCTC remove zero-sequence current.)

Example 1 for WnCTC Selection

Figure 3.6 illustrates the first example. This is a three-winding transformer with a DAB delta primary and two lower voltage secondaries connected in grounded wye. Two windings have wye-connected CTs. The higher voltage secondary winding has DAB delta-connected CTs. We assume ABC phase rotation. Using the “hour of the clock” convention for specifying transformer connections, the transformer is a “Dy1y9” connection. This means the transformer has a high-voltage delta whose reference is “noon,” a wye secondary winding whose direction is at “one o’clock,” and another whose direction is “9 o’clock” with respect to the direction of the delta. The CT currents go to relay winding inputs 1, 2, and 3, from left to right as Figure 3.6 illustrates.

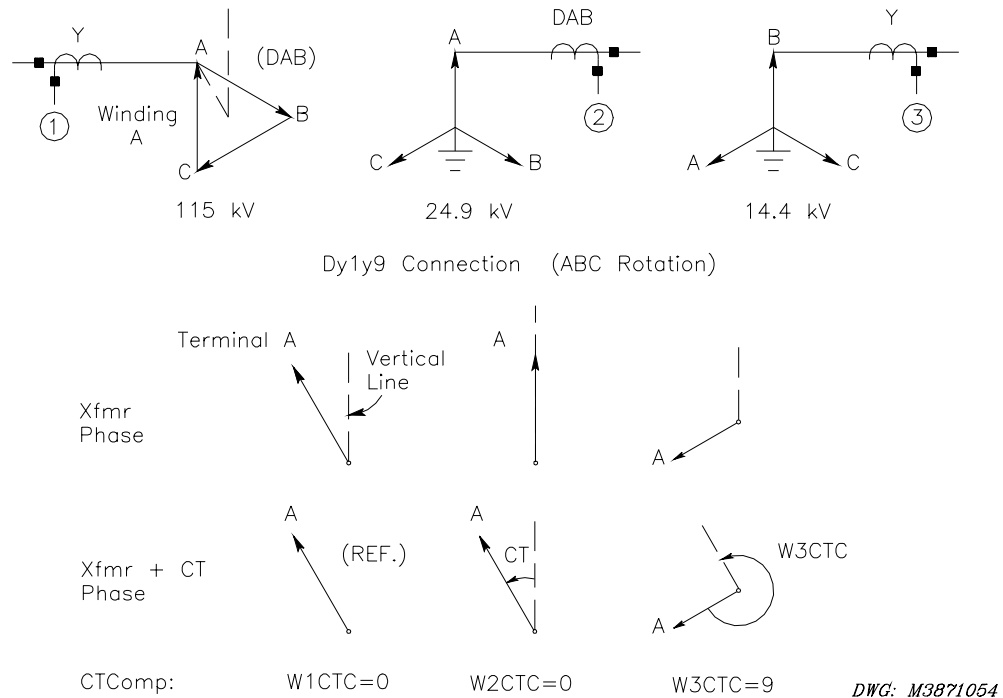


Figure 3.6: Example 1 for WnCTC Selection

The 115 kV delta primary and the 24.9 kV grounded-wye secondary, taken by themselves, represent a traditional “DABY” two-winding application. This application has wye CTs on the delta side and delta CTs on the wye side, using the same CT delta connection as the primary of the transformer. Perform the following simple steps to handle these traditional connections.

1. Establish the line terminal directions. Refer to the line following the transformer drawings in Figure 3.6 and note that the delta winding A line terminal direction is at 30 degrees CCW from the A winding direction (vertical), as we would expect for a DAB connection with ABC phase rotation. The A winding of the 24.9 kV winding is vertical. Figure 3.6 shows the A winding of the 14.4 kV winding at 120 degrees CCW from vertical, to make the example more interesting.
2. Adjust the CT connections. In this case the two windings with wye CTs need no adjustment. The 24.9 kV winding, with DAB CTs, needs a 30-degree correction in the CCW direction. Figure 3.6 shows this adjustment in the second line under the transformer drawings.
3. Select a reference direction for the transformer. You can use one of the three winding directions as the reference, but this need not be the case. You could establish any of the 12 possible directions, separated by 30 degrees around the complete circle of 360 degrees, as the reference. All three windings would then receive adjustments to correlate them with this reference. As Figure 3.6 illustrates, the primary winding direction serves as reference in the example.
4. Choose the WnCTC settings for all three windings. Because winding 1 is the reference, we need no adjustment; the setting is $W1CTC = 0$. Note that the adjusted winding 2 inputs coincide exactly with the reference direction; we need make no adjustment for the 24.9 kV winding either. Therefore, the setting is $W2CTC = 0$. As mentioned earlier, these two windings represent a classical DABY application. We can see this from the fact that the WnCTC setting is zero for both windings. The CT connections themselves perform exactly the right correction without additional help from the relay. The final winding inputs still reside at the “8 o’clock” position and need adjustment to the reference at “11 o’clock.” Beginning at the winding 3 direction, the compensation direction is CCW until arrival at the reference. This compensation requires nine increments of 30 degrees (or 9 “hours”) in the CCW direction. We therefore set $W3CTC = 9$. The process is nearly complete.
5. As a final step, ensure that no wye-connected winding having wye-connected CTs is set at $WnCTC = 0$ (uncompensated). Were this the case, zero-sequence currents could appear in these relay inputs but in no others, and a possible false trip could occur for external ground faults. Any non-zero value of WnCTC will eliminate the zero sequence. In this example the only wye winding with wye CTs is winding 3, which we have compensated by $W3CTC = 9$. The selection is complete. The relay receives the three settings as $W1CTC = 0$, $W2CTC = 0$, and $W3CTC = 9$.

Example 2 for WnCTC Selection

Figure 3.7 illustrates the second example. This is another three-winding transformer, for which we have chosen rather unusual winding phase relationships in order to show the flexibility of the winding compensation feature in the SEL-387 Relay.

The transformer has a 115 kV primary winding that is wye connected, with wye-connected CTs. The 34.5 kV secondary winding is DAB connected, but designated with the A line terminal at the “7 o’clock” position with respect to the primary A line terminal. It has wye-connected CTs. The 12.47 kV winding is another wye-connected winding, but with delta-connected CTs. The CTs connect in a DAC delta rather than DAB. However, this poses no problem for the relay. Figure 3.7 shows the A line terminal at the “4 o’clock” position with respect to the primary A line terminal. This transformer is therefore a “Yd7y4” connection type. We assume ABC phase rotation. The CT currents go to relay winding inputs 1, 2, and 3, from left to right as Figure 3.7 shows.

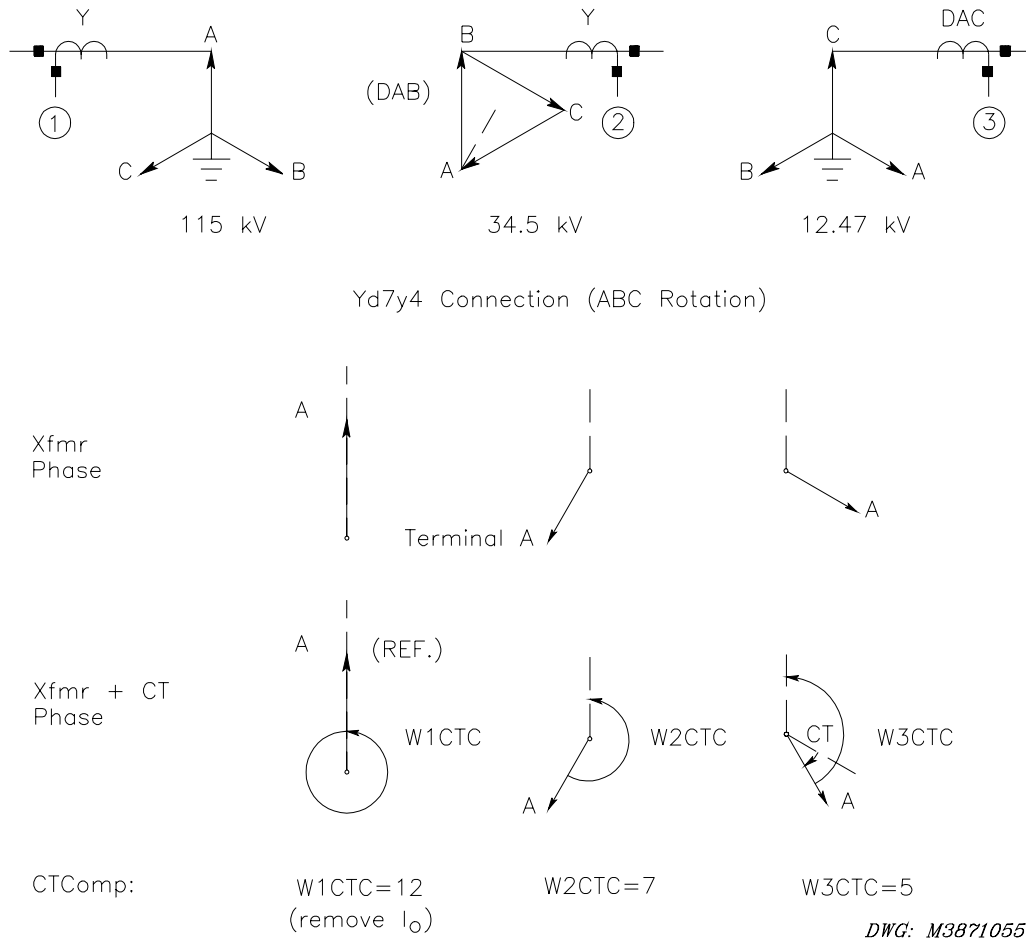


Figure 3.7: Example 2 for WnCTC Selection

1. Establish the phase direction for the three A line terminals. Figure 3.7 shows these phase directions in the first line below the transformer drawing. Based on the transformer designation, the terminal directions are shown at “noon,” “7 o’clock,” and “4 o’clock.”
2. Adjust the transformer winding directions based on the CT connections. Windings 1 and 2 need no correction, because they both have wye-connected CTs. Winding 3 has DAC delta-connected CTs and needs adjustment. Refer to Figure 3.5 and note that the DAC connection produces a 30-degree shift in the CW direction for ABC phase rotation. In

the second line under the transformer drawings, Figure 3.7 indicates this adjustment as a rotation of the winding 3 direction from the “4 o’clock” to the “5 o’clock” position.

3. Select a reference direction. In this example we have chosen the primary winding position at “noon.”
4. Select values of WnCTC for each winding. For the sake of later discussion, we have selected W1CTC = 0 as the setting for winding 1, the reference winding. Beginning at the winding 2 direction at “7 o’clock,” adjust the winding 2 position in the CCW direction until arrival at the “noon” reference direction. This procedure requires seven 30-degree increments, or seven “hours” of adjustment. Thus, we choose W2CTC = 7 as the setting. Similarly for winding 3, we need an adjustment of five “hours,” so we choose W3CTC = 5 as the setting. The process is almost complete, except for a final check.
5. Ensure that there will be no wye windings with wye CTs and a setting of WnCTC = 0. In this case the primary winding is wye-connected and has wye-connected CTs. In step 4 we set W1CTC at zero because winding 1 was the reference winding. However, this setting violates the condition that WnCTC not equal 0. Instead of a zero shift, we must shift winding 1 360 degrees by setting W1CTC = 12. This solves the zero-sequence current problem. The process is now complete. The relay receives the three settings as W1CTC = 12, W2CTC = 7, and W3CTC = 5.

Current TAP

The relay uses a standard equation to set TAP_n, based on settings entered for the particular winding. (n denotes the winding number.)

$$\text{TAP}_n = \frac{\text{MVA} \cdot 1000}{\sqrt{3} \cdot \text{VWDG}_n \cdot \text{CTR}_n} \cdot C$$

where:

C	=	1 if WnCT setting = Y (wye-connected CTs)
C	=	$\sqrt{3}$ if WnCT setting = D (delta-connected CTs)
MVA	=	maximum power transformer capacity setting (must be the same for all TAP _n calculations)
VWDG _n	=	winding line-to-line voltage setting, in kV
CTR _n	=	current transformer ratio setting

The relay calculates TAP_n with the following limitations:

- The tap settings are within the range $0.1 \cdot I_N$ and $31 \cdot I_N$
- The ratio $\text{TAP}_{\text{MAX}}/\text{TAP}_{\text{MIN}} \leq 7.5$

Operating Current Pickup

The O87P setting range is 0.1 to 1.0; we suggest an O87P setting of 0.3. The setting must be at a minimum for increased sensitivity but high enough to avoid operation because of steady-state CT error and transformer excitation current. The setting must also yield an operating current greater than or equal to $0.1 \cdot I_N$, when multiplied by the smallest of TAP1 through TAP4. Stated another way,

$$O87P_{MIN} \geq (0.1 \cdot I_N) / TAP_{MIN}$$

Restraint Slope Percentage

Example:

The current transformer error, e , is equal to ± 10 percent. In per unit:

$$e = 0.1$$

The voltage ratio variation of the power transformer load tap-changer, LTC, is from 90 percent to 110 percent. In per unit:

$$a = 0.1$$

In a through-current situation, the worst-case theoretical differential current occurs when all of the input currents are measured with maximum positive CT error, and all of the output currents are measured with maximum negative CT error as well as being offset by maximum LTC variation. Therefore, the maximum differential current expected for through-current conditions is:

$$Id_{max} = (1 + e) \cdot \sum_{"IN"} IW_n - \frac{(1 - e)}{(1 + a)} \cdot \sum_{"OUT"} IW_n$$

where the summation terms are the total input and output power transformer secondary currents, after tap compensation. Because these summations must be equal for external faults and load current, we can express the maximum differential current as a percentage of winding current:

$$(1 + e) - \frac{(1 - e)}{(1 + a)} = \frac{2 \cdot e + a + e \cdot a}{1 + a} \cdot 100\% = 28.18\%$$

In addition to the error calculated above, we have to consider additional errors from transformer excitation current ($\approx 3\%$) and relay measurement error ($\leq 5\%$). The maximum total error comes to 36 percent. Therefore, if we use only one slope, a conservative slope setting, SLP1, is about 40 percent. This represents a fixed percentage differential application and is a good average setting to cover the entire current range.

A two-slope, or variable-percentage differential application, improves sensitivity in the region where CT error is small and increases security in the high-current region where CT error is great. We must define both slopes, as well as the slope 1 limit or crossover point, IRS1. If we assume CT error to be only 1 percent, we can set SLP1 at about 25 percent. A good choice for IRS1 is about 3.0 per unit of tap, while the SLP2 setting should probably be in the 50 percent to 60 percent range to avoid problems with CT saturation at high currents. A 60 percent SLP2 setting covers CT error to as great as 20 percent.

Second-Harmonic Blocking

Transformer simulations show that magnetizing inrush current usually yields more than 30 percent of IF2/IF1 in the first cycle of the inrush. A setting of 15 percent usually provides a margin for security. However, some types of transformers, or the presence within the differential zone of equipment that draws a fundamental current of its own, may require setting the threshold as low as 7 percent. For example, the additional fundamental frequency charging current of a long cable run on the transformer secondary terminals could “dilute” the level of second harmonic seen at the primary to less than 15 percent.

Fifth-Harmonic Blocking

Fourier analysis of transformer currents during overexcitation indicates that a 35 percent fifth-harmonic setting is adequate to block the percentage differential element. To disable fifth-harmonic blocking, set PCT5 to OFF.

You may use the presence of fifth-harmonic differential current to assert an alarm output during startup. This alarm indicates that the rated transformer excitation current is exceeded. At full load, a TH5P setting of 0.1 corresponds to 10 percent of the fundamental current. A delay, TH5D, that can be set by the user prevents the relay from indicating transient presence of fifth-harmonic currents.

You may consider triggering an event report if transformer excitation current exceeds the fifth-harmonic threshold.

There are two criteria for setting TH5P:

- $TH5P \cdot TAP_{MIN} \geq 0.05 \cdot I_{nom}$, and
- $TH5P \cdot TAP_{MAX} \leq 31 \cdot I_{nom}$

where TAP_{MIN} and TAP_{MAX} are the least and greatest of the tap settings.

Example of Setting the SEL-387 Relay for a Three-Winding Transformer

In this section we use an example that forms the basis of the default differential settings we entered at the factory before shipping the relay. The example represents a typical three-winding transformer application and demonstrates the use of CT compensation settings and tap calculations.

Figure 2.8 in **Section 2: Installation** illustrates the application. The transformer is a 230 kV to 138 kV autotransformer with a 13.8 kV delta tertiary whose terminals we have brought out and included in the differential zone of protection. The transformer primary and secondary have a maximum rating of 100 MVA, while the tertiary has a rating of 30 MVA. All three windings have wye-connected current transformers, with ratios of 600/5 A at 230 kV, 1200/5 A at 138 kV, and 2000/5 A at 13.8 kV. We have connected the transformer per IEEE standards, with the low-voltage delta lagging the high-voltage wye by 30 degrees.

1. Set the appropriate enables. Because we need only three terminals for the differential zone, make the first settings as follows:

$$\text{E87W1} = \text{Y} \qquad \text{E87W2} = \text{Y} \qquad \text{E87W3} = \text{Y}$$

These settings enable windings 1, 2, and 3, leaving winding 4 available for stand-alone overcurrent duty.

2. Select settings for the current transformer connection and ratio for each winding. All CTs connect in wye. The ratios are equal to primary current divided by secondary current. The settings are as follows:

<u>230 kV</u>		<u>138 kV</u>		<u>13.8 kV</u>	
W1CT	= Y	W2CT	= Y	W3CT	= Y
CTR1	= 120	CTR2	= 240	CTR3	= 400

3. Set the transformer maximum rating. We use this rating for all windings in the later tap calculation:

$$\text{MVA} = 100$$

4. Decide whether to use internal CT compensation and determine compensation settings. Because there are both wye and delta transformer windings but only wye CTs, we must adjust for the phase angle shift. In the “traditional” differential relay connection the wye transformer windings would have their CTs connected in delta to produce a shift in the same direction as that produced in the transformer. In this case a “DAC” or “30-degree lagging” connection would have been used. This would not only shift the currents, but it would remove the zero-sequence current component by physically subtracting the appropriate phase currents via the delta connection. We achieve the same effect within the relay by using the selected compensation. The settings are:

$$\begin{aligned} \text{ICOM} &= \text{Y (choose to define the CT compensation)} \\ \text{W1CTC} &= 11 \qquad \text{W2CTC} = 11 \qquad \text{W3CTC} = 0 \end{aligned}$$

The relay will multiply the wye CT currents from the wye transformer windings by the matrix [CTC(11)] to give the same results as the physical DAC CT connection. Using the flexibility of the current compensation feature, another logical setting choice might have been to use the autotransformer windings as a reference and to adjust the delta tertiary currents. However, considering the need to remove zero-sequence current from the autotransformer CT outputs to the relay, the settings for this approach would be W1CTC = 12, W2CTC = 12, and W3CTC = 1. This is more burdensome, computationally, than the default settings indicated above.

5. Enter winding line-to-line voltages. The relay needs these voltages for the tap calculation. Voltages are in units of kV. For this example we enter the following values:

$$\text{VWDG1} = 230 \qquad \text{VWDG2} = 138 \qquad \text{VWDG3} = 13.8$$

The relay now calculates each tap current, using the formula stated previously:

$$TAPn = \frac{MVA \cdot 1000}{\sqrt{3} \cdot VWDGn \cdot CTRn} \cdot C \quad (C = 1 \text{ for wye CTs})$$

Thus, we have the following:

$$TAP1 = \frac{100MVA \cdot 1000}{\sqrt{3} \cdot 230kV \cdot 120} \cdot 1 \quad TAP1 = 2.09 \text{ A}$$

$$TAP2 = \frac{100MVA \cdot 1000}{\sqrt{3} \cdot 138kV \cdot 240} \cdot 1 \quad TAP2 = 1.74 \text{ A}$$

$$TAP3 = \frac{100MVA \cdot 1000}{\sqrt{3} \cdot 13.8kV \cdot 400} \cdot 1 \quad TAP3 = 10.46 \text{ A}$$

The relay calculates these taps automatically if MVA is given. If MVA is set to OFF, the user must calculate the taps and enter them individually.

The relay will check to see if a violation of the maximum tap ratio has occurred, and will notify the user of the violation. That is, it will divide the greatest TAPn, in this case 10.46, by the least TAPn, here 1.74, to get a ratio of 6.01. Because this is below 7.5, adjustment of the CT ratio is unnecessary.

6. Set the differential element characteristic. Select the settings according to our suggestions in the earlier setting descriptions. For this example, we have selected a two-slope, variable-percentage differential characteristic for maximum sensitivity at low currents and greater tolerance for CT saturation on external high-current faults. The settings are as follows:

O87P	=	0.3	(Operate current pickup in multiple of tap)
SLP1	=	25	(25% initial slope)
SLP2	=	50	(50% second slope)
IRS1	=	3.0	(limit of slope 1, Restraint current in multiple of tap)
U87P	=	10	(unrestrained differential Operate current level, multiple of tap)
PCT2	=	15	(block operation if second harmonic is above 15%)
PCT5	=	35	(block operation if fifth harmonic is above 35%)
TH5P	=	OFF	(no fifth-harmonic alarm)
IHBL	=	N	(no independent element blocking; any unit detecting second or fifth harmonic above PCT2 or PCT5 will block all units)

Remember that the O87P setting must yield an operating current value of at least $0.1 \cdot I_N$, at the least tap. In this case $O87P_{MIN} = (0.1 \cdot I_N) / TAP_{MIN} = 0.5 / 1.74 = 0.287$. Therefore, the O87P setting of 0.3 is valid.

The differential unit settings are complete for this specific application. At this point you can also choose to set backup overcurrent elements which we discuss at the end of this section.

Application Guideline

It is vital that you select adequate current transformers for a transformer differential application. Use the following procedure, based on ANSI/IEEE Standard C37.110: 1996, *IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes*.

CT Arrangements

Use separate relay restraint circuits for each power source to the relay. In the SEL-387 Relay you may apply two to four restraint inputs to the relay. You may connect CT secondary windings in parallel only if both circuits meet the following criteria:

- They are connected at the same voltage level.
- Both have CTs that are matched in ratio, C voltage ratings, and core dimensions.

CT Sizing

Sizing a CT to avoid saturation for the maximum asymmetrical fault current is ideal but not always possible. Such sizing requires CTs with C voltage ratings greater than $(1 + X/R)$ times the burden voltage for the maximum symmetrical fault current, where X/R is the reactance-to-resistance ratio of the primary system.

As a rule of thumb, CT performance will be satisfactory if the CT secondary maximum symmetrical external fault current multiplied by the total secondary burden in ohms is less than half of the C voltage rating of the CT. The following CT selection procedure uses this second guideline.

CT Ratio Selection for a Multiwinding Transformer

1. Determine the secondary side burdens in ohms for all current transformers connected to the relay.
2. Select the CT ratio for the highest-rated winding (e.g., CTR1) by considering the maximum continuous secondary current, I_{HS} , based on the highest MVA rating of the transformer. For wye-connected CTs, the relay current, I_{REL} , equals I_{HS} . For delta-connected CTs, I_{REL} equals $\sqrt{3} \cdot I_{HS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_N$ and $1.0 \cdot I_N$ A secondary, where I_N is the relay nominal secondary current, 1 A or 5 A.
3. Select the remaining CT ratios (e.g., CTR2–CTR4) by considering the maximum continuous secondary current, I_{LS} , for each winding. Typically, the CT ratio is based on the rated maximum MVA of the particular winding. If this rating is much smaller than the rating of the largest winding, you may violate the tap ratio limit for the SEL-387 Relay (see steps 4 and 5). As before, for wye-connected CTs I_{REL} equals I_{LS} . For delta-connected CTs I_{REL} equals $\sqrt{3} \cdot I_{LS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_N$ and $1.0 \cdot I_N$ A secondary.
4. The SEL-387 Relay calculates settings TAP1 through TAP4 if the ratio TAP_{MAX}/TAP_{MIN} is less than or equal to 7.5. When the relay calculates the tap settings, it reduces CT mismatch to less than 1 percent. Allowable tap settings are in the range $(0.1-31) \cdot I_N$.

5. If the ratio TAP_{MAX}/TAP_{MIN} is greater than 7.5, select a different CT ratio to meet the above conditions. You can often do this by selecting a higher CT ratio for the smallest rated winding, but you may need to apply auxiliary CTs to achieve the required ratio. Repeat steps 2 through 5.
6. Calculate the maximum symmetrical fault current for an external fault, and verify that the CT secondary currents do not exceed your utility standard maximum allowed CT current, typically $20 \cdot I_N$. If necessary, reselect the CT ratios and repeat steps 2 through 6.
7. For each CT, multiply the burdens calculated in step 1 by the magnitude, in secondary amperes, of the expected maximum symmetrical fault current for an external fault. Select a nominal accuracy class voltage for each CT that is greater than twice the calculated voltage. If necessary, select a higher CT ratio to meet this requirement, then repeat steps 2 through 7. This selection criterion helps reduce the likelihood of CT saturation for a fully offset fault current signal.

Please note that the effective C voltage rating of a CT is lower than the nameplate rating if a tap other than the maximum is used. Derate the CT C voltage rating by a factor of ratio used/ratio max.

RESTRICTED EARTH FAULT ELEMENT

Application Description

Use the Restricted Earth Fault (REF) element to provide sensitive protection against ground faults in your wye-connected transformer winding. The element is “restricted” in the sense that protection is restricted to ground faults within a zone defined by neutral and line CT placement.

Operating Characteristic

Restricted Earth Fault (REF) protection is a technique for sensitive detection of ground faults in a grounded wye-connected transformer winding. Because it employs a neutral CT at one end of the winding and the normal set of three CTs at the line end of the winding, REF protection can detect only ground faults within that particular wye-connected winding. For REF to function, the line-end CTs must also be connected in wye, because the technique uses comparison of zero-sequence currents. Delta-connected CTs cancel out all zero-sequence components of the currents, eliminating one of the quantities the REF element needs for comparison.

The REF implementation in the SEL-387 Relay uses a directional element (32I) that compares the direction of an operating current, derived from the line-end CTs, with the polarizing current, obtained from the neutral CT. A zero-sequence current threshold and positive-sequence restraint supervise tripping. You can apply REF to a single wye winding in a transformer or to an entire autotransformer winding with as many as three sets of line-end CT inputs. The neutral CT connects to one of the three current inputs for winding 4 (IAW4, IBW4, or ICW4), leaving only three three-phase winding inputs for normal differential or overcurrent protection purposes.

Figure 3.8 shows the REF simplified enable/block logic. The upper logic group determines whether to enable the REF directional element by assertion of the 32IE Relay Word bit. The two enabling quantities are assertion of the E32I equation and a magnitude of the neutral CT secondary current (IRW4) greater than the pickup setting, 50GP. The topmost part of this logic

is a blocking function. This function asserts if any of the winding residual currents used in the REF function are less than a positive-sequence current restraint factor, a_0 , times the positive-sequence current for their respective winding. Such a winding residual current value might occur with “false I_0 ” or if zero sequence current for that winding exceeds 50GP. False I_0 can occur in cases of CT saturation during heavy three-phase faults. If the blocking logic asserts, the CTS Relay Word bit asserts. To prevent 32IE assertion when CTS asserts, set the E32I setting = !CTS.

The lower logic group adjusts the winding residual currents to a common sensitivity level with the neutral CT, calculates a phasor sum of the appropriate currents, and compares this sum to the 50GP pickup value. If the sum is greater than the pickup level, Relay Word bit 50GC asserts. This bit indicates that the winding currents are present in sufficient magnitude.

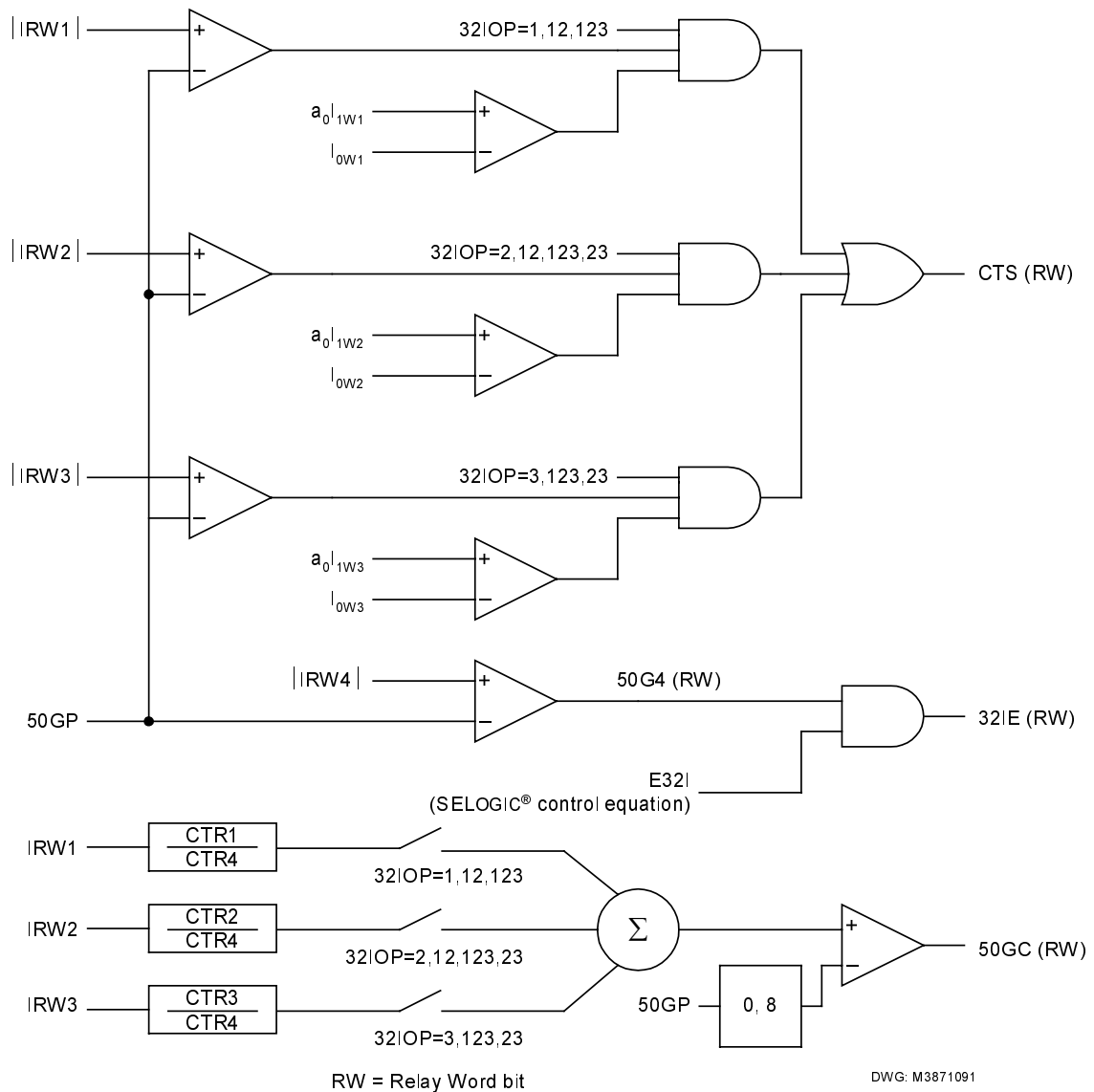


Figure 3.8: REF Enable/Block Logic

Figure 3.9 illustrates the logic of the REF directional element, 32I. It is at this stage that the element decides whether to operate.

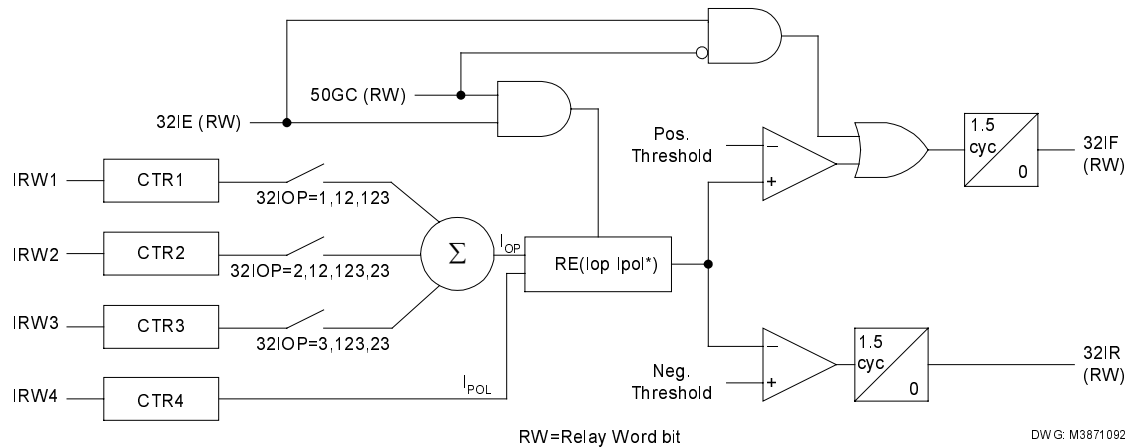


Figure 3.9: REF Directional Element

The relay enables the 32I directional element if the output of the AND gate at left-center in Figure 3.9 asserts. This will occur if the two Relay Word bits 32IE and 50GC assert.

The directional element compares the polarizing current to the operating current and indicates forward (internal) fault location or reverse (external) fault location. The internal/forward indication occurs if the fault is within the protected winding, between the line-end CTs and the neutral CT. The relay multiplies each current by the appropriate CT ratio to convert input currents to actual primary amps. This must be done to properly sum the currents in the autotransformer winding.

The polarizing current, IPOL, is simply the neutral CT current multiplied by the neutral CT ratio, CTR4, to produce a primary current value. The operating current, IOP, is the phasor sum of the winding residual currents, also on a primary basis. The 32IOP setting determines the appropriate IRWn, which the relay multiplies by the associated CTRn. The relay then sums the products. The 32I element calculates the real part of IOP times IPOL* (IPOL complex conjugate). This equates to |IOP| times |IPOL| times the cosine of the angle between them. The result is positive if the angle is within ± 90 degrees, indicating a forward or internal fault. The result is negative if the angle is greater than $+90$ or less than -90 degrees, indicating a reverse or external fault. The relay compares the output of the 32I element to positive and negative thresholds, to ensure security for very small currents or for an angle very near $+90$ or -90 degrees. If the 32I output exceeds the threshold test, it then must persist for at least 1.5 cycles before the Relay Word bit 32IF (forward) or 32IR (reverse) asserts. Assertion of 32IF constitutes a decision to trip by the REF function.

A second path can also assert the 32IF bit. This path comes from the three-position AND gate at the top-right of Figure 3.9. The gate asserts if 32IE is asserted. This assertion indicates that neutral current is above pickup but 50GC is not asserted, indicating no line-end current flow. This logic covers the situation of an internal wye-winding fault with the line-end breaker open.

You can perform tripping directly by inclusion of the Relay Word bit 32IF into one or more of the trip variables, TRn, as appropriate. If you want additional security, the relay is programmed to use 32IF to torque control an inverse-time curve for delayed tripping, as discussed below.

Figure 3.10 shows the output of the REF protection function. Timing is on an extremely inverse-time overcurrent curve (curve U4) at the lowest time-dial setting (0.5) and with 50GP as the pickup setting.

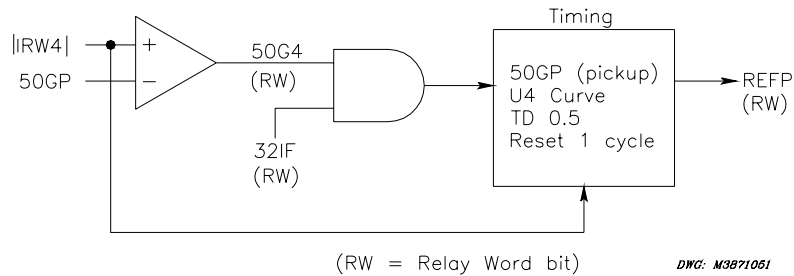


Figure 3.10: REF Protection Output (Extremely Inverse-Time O/C)

Relay Word bit 32IF (forward fault) torque controls the timing curve, and IRW4 operates the timing function. The curve resets in one cycle if current drops below pickup or if 32IF deasserts. When the curve times out, Relay Word bit REFP asserts. You can use this bit directly as an input to the appropriate trip variables, TRn, to trip the breaker or breakers that feed the fault.

Setting Descriptions

REF Directional Element Enable (E32I)

Range: SELOGIC® control equation

The setting E32I is a SELOGIC control equation setting that uses Relay Word bits to define the conditions under which the relay will enable REF. A logical state of 1 for this control equation enables the other REF settings and satisfies one of the conditions the REF element needs to activate. A logical state of 0 for this control equation disables the other REF settings; the relay hides these settings, and they are unavailable for use.

Operating Quantity from W1, W2, W3 (32IOP)

Range: 1, 2, 3, 12, 123

The setting 32IOP tells the relay which winding or combination of windings it should use in calculating residual current, which acts as the Operate quantity for the directional element.

Positive-Sequence Current Restraint Factor, I0/I1 (a0)

Range: 0.02–0.50, in 0.01 steps

For the relay to enable REF, the zero-sequence current at winding n must be greater than a_0 times the positive-sequence current at that input, or $|IRW_n| > a_0 \cdot |3I1W_n|$. This supervision provides security against “false I_0 ” that may occur because of CT saturation during heavy three-phase faults.

Residual Current Sensitivity Threshold (50GP)

Range: 1A: 0.05–3 A, in 0.01 A steps
5A: 0.25–15.00 A, in 0.01 A steps

You can set the residual current sensitivity threshold to as low as 0.05 times nominal current (0.25 A for 5 A nominal CT current), the minimum residual current sensitivity of the relay. However, the minimum acceptable value of 50GP must meet two criteria:

1. 50GP must be greater than any natural 3I0 imbalance caused by load conditions.
2. 50GP must be greater than a minimum value determined by the relationship of the CTRn values used in the REF function.

You must set the threshold setting, 50GP, at the greater of the two criteria values. Determine criterion 1 for load imbalance. The second criterion relates to the relative sensitivity of the winding CTs compared to the neutral CT.

Setting Calculation

Operating Quantity

Figure 3.11 depicts how to determine the Operate quantity, 32IOP, setting.

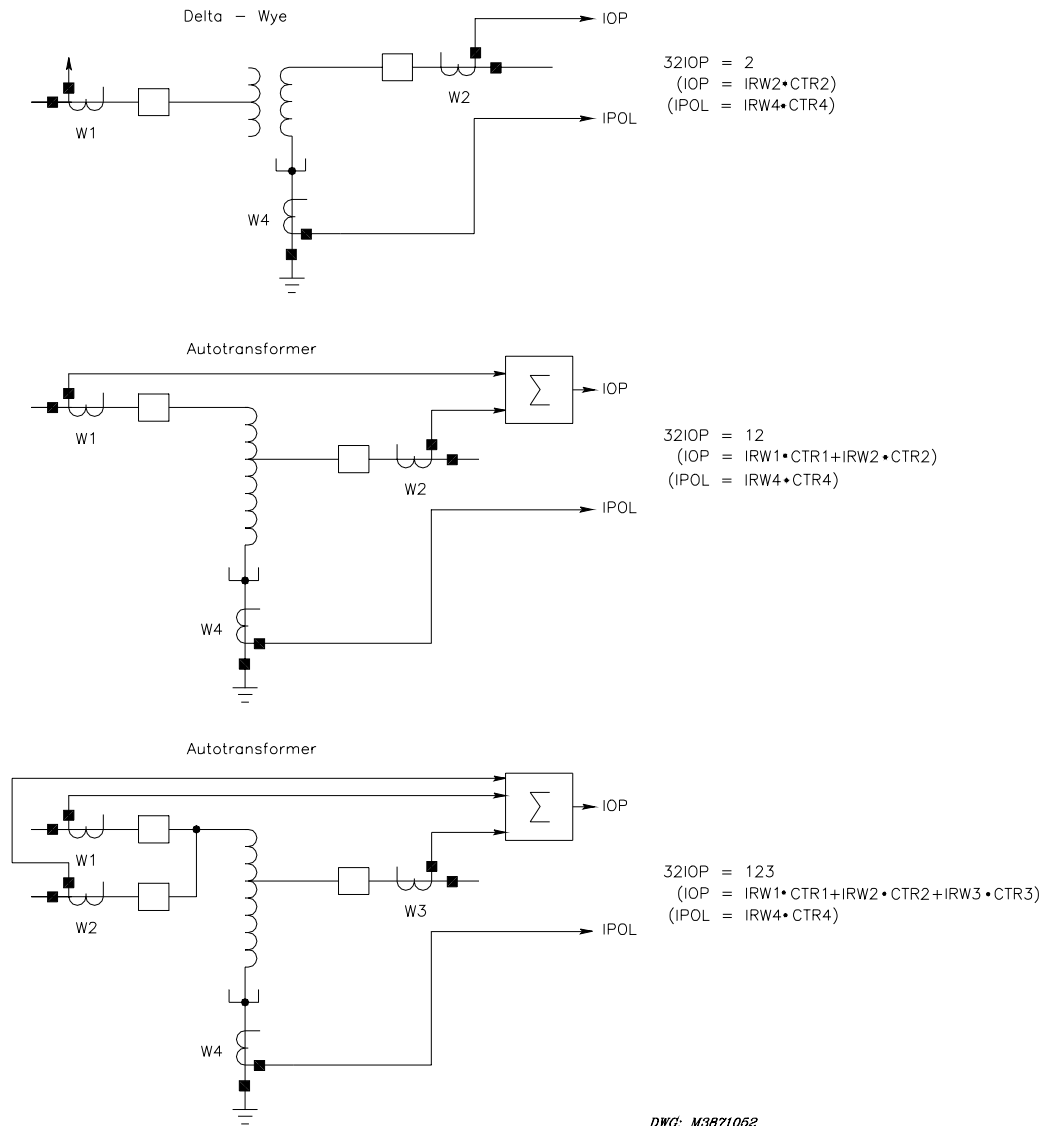


Figure 3.11: REF Function, 32IOP Setting Guide

If you want to protect a single wye winding in, for example, a delta-wye transformer, set 32IOP at 1, 2, or 3, which is the number of the relay winding input associated with the line-end CTs of the protected winding. The relay uses residual current from that single winding input as the Operate quantity. Figure 3.11 shows neutral CT input connected to the winding 4 input of the relay, as it must be for every case where REF protection is to be used.

If you want to protect an autotransformer, set 32IOP at 12 and connect the primary and secondary side CTs to relay winding inputs 1 and 2. You could also use this setting for the single winding mentioned above, if that winding had two breakers and two sets of CTs at the line end. You would also have to connect these CTs to winding inputs 1 and 2. Such a connection would be typical in ring-bus or breaker-and-a-half configurations. With 32IOP set at 12, the relay sums the residual currents from the winding 1 and winding 2 inputs to create the Operate quantity.

If you are protecting an autotransformer with two breakers and CT sets on one line end of the winding, set 32IOP at 123 and connect all three sets of CT inputs to the relay as indicated. The relay sums residual currents from the three winding inputs to create the Operate quantity. From the standpoint of the REF function, it does not matter which of the CT sets goes to which relay winding input. However, it is best to connect the two sets at the same transformer winding terminal to inputs 1 and 2, so that you have the option of using the Combined Overcurrent elements.

Calculation of the residual current at each relay winding input is as follows:

$$IRW_n = IAW_n + IBW_n + ICW_n \quad (n = 1, 2, 3, \text{ or } 4)$$

For the neutral CT connection, the relay uses only one of the three ABC inputs, e.g., IBW4, so the residual current for input 4 would be $IRW4 = 0 + IBW4 + 0 = IBW4$.

Residual Current Sensitivity Threshold

The second criterion of 50GP relates to the relative sensitivity of the winding CTs compared to the neutral CT. Use the following equation to determine the minimum second criterion for 50GP:

$$50GP_{\min} \geq 0.05 \cdot I_{\text{nom}} \cdot \frac{CTR_{\max}}{CTR4}$$

where CTR4 is the neutral CT ratio and CTRmax is the greatest CT ratio among the CTs being used for the REF function.

The 32IOP setting defines which line CTs the relay uses for REF. For example, if 32IOP = 12, CTRmax is the greatest of CTR1, CTR2, and CTR4.

An example 50GP calculation is as follows, assuming that $CTR4 = 40$, $CTR_{\max} = 160$, $I_{\text{nom}} = 5 \text{ A}$, and load imbalance is 10 percent:

$$50GP_{\min} \geq 0.05 \cdot 5\text{A} \cdot \frac{160}{40}$$

$$50GP_{\min} \geq 0.25\text{A} \cdot 4$$

$$50GP_{\min} \geq 1.0\text{A}$$

Criterion 2 minimum setting of 50GP is 1.0 A. With a 10 percent load imbalance, we can assume the criterion 1 value to be $0.1 \cdot 5 \text{ A}$, or 0.5 A. Because 50GP must be set at the greater of the two criteria values, we would select a setting of 1.0 A.

If you attempt to save a 50GP setting that is too low, the relay will respond (for a 5 A relay), “Out of Range.” The relay then will prompt you for a new setting.

The relay stores a default setting for the Residual Current Sensitivity Threshold of $50GP = 0.5 \text{ A}$.

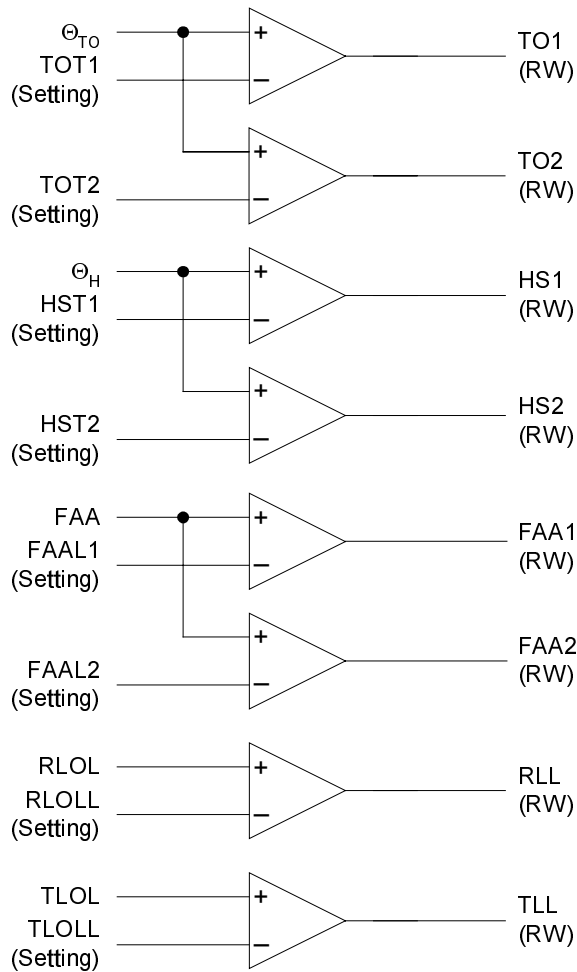
THERMAL ELEMENT (SEL-387-6)

Application Description

The SEL-387-6 Relay provides a thermal element based on IEEE Standard C57.91: 1995, *IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers*. Use this element to activate a control action or issue a warning or alarm when your transformer overheats or is in danger of excessive insulation aging or loss of life. Capture current hourly or daily data about your transformer using the thermal event report. The data acquisition interval is one minute, which constitutes the maximum element timing error. This very short time interval makes the element suitable for both thermal protection and control functions.

Operating Characteristic

The SEL-387 Relay thermal element compares top-oil, Θ_{TO} , and winding hot-spot, Θ_H , temperatures against thresholds beyond which a Relay Word bit will assert. You can use these bits to alarm for overheating of the transformer (Figure 3.12). Top-oil temperature is a calculation of the transformer oil temperature, while hot-spot temperature is a calculation of the hottest point on the transformer winding. The thermal element uses top-oil temperature and hot-spot temperature to calculate the insulation aging acceleration factor, FAA, daily rate of loss of life, RLOL, and total loss of life, TLOL. For each of these quantities you can set a threshold beyond which a Relay Word bit will assert (Figure 3.12).

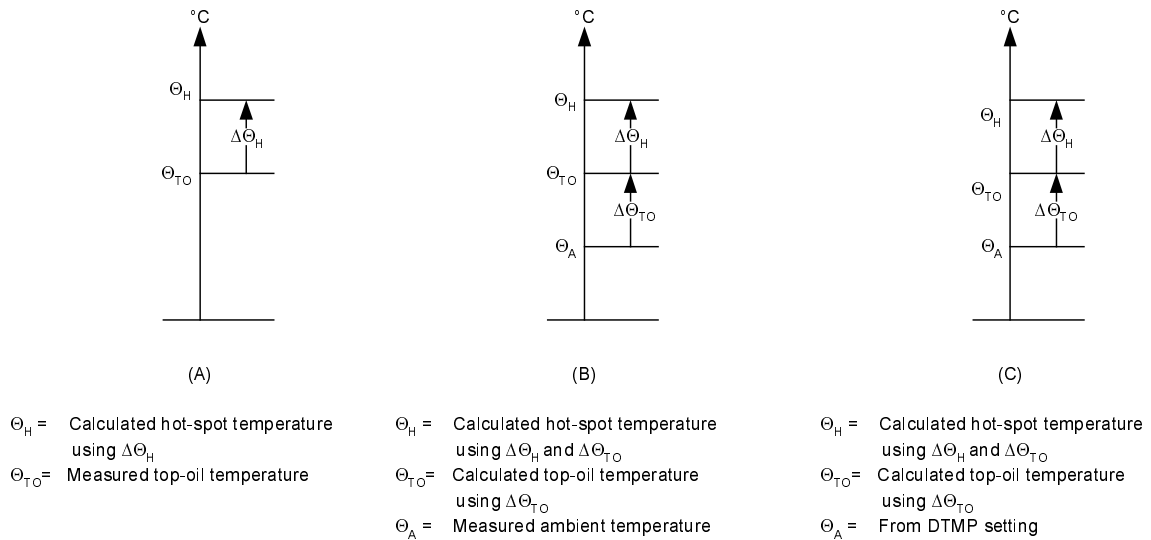


DWG: M3871094

Figure 3.12: Thermal Element Logic

The thermal element operates in one of three modes, depending upon the presence or lack of measured temperature inputs: measured ambient and top-oil temperature inputs, measured ambient temperature only, and no measured temperature inputs.

If the relay receives measured ambient and top-oil temperatures, the thermal element calculates hot-spot temperature (Figure 3.13 (A)). When the relay receives a measured ambient temperature but not a measured top-oil temperature, the thermal element calculates the top-oil temperature and hot-spot temperature Figure 3.13 (B)). In the absence of any measured ambient or top-oil temperatures, the thermal element uses a default ambient temperature setting (DTMP) that you select and calculates the top-oil and hot-spot temperatures Figure 3.13 (C)). Top-oil temperature is always calculated from the applied currents for the cooling system efficiency element.



DWG: M3871.095

Figure 3.13: Top-Oil and Hot-Spot Temperatures

Thermal Element With Ambient and Top-Oil Temperature Inputs

In this case the relay receives measured ambient and top-oil temperature inputs and uses the top-oil temperature to calculate the hot-spot temperature. The ambient temperature is reported in the thermal event reports.

For a single tank, three-phase transformer, you will have as many as two thermal inputs: the ambient temperature input and the top-oil input. For independent, single-phase transformers, normally you will have as many as four thermal inputs: an ambient temperature input and a top-oil input for each of the three tanks. During a fixed time interval, $\Delta t = 1$ minute, the relay calculates the winding hot-spot temperature at the end of the interval, according to the following expression:

$$\Theta_H = \Theta_{TO} + \Delta\Theta_H$$

where:

Θ_H = winding hot-spot temperature, °C

Θ_{TO} = top-oil temperature, °C

$\Delta\Theta_H$ = winding hot-spot rise over top-oil temperature, °C

The relay calculates winding hot-spot rise over top-oil temperature, $\Delta\Theta_H$, according to the following:

$$\Delta\Theta_H = (\Delta\Theta_{H,U} - \Delta\Theta_{H,i}) \cdot \left(1 - e^{\frac{-\Delta t}{60 \cdot T_{hs}}} \right) + \Delta\Theta_{H,i}$$

where:

$$\begin{aligned}\Delta\Theta_{H,U} &= \text{the ultimate hot-spot rise over top-oil temperature for any load, } ^\circ\text{C} \\ \Delta\Theta_{H,I} &= \text{initial hot-spot rise over top-oil temperature at the start time of the interval, } ^\circ\text{C} \\ T_{hs} &= \text{thermal time constant of hot spot, in hours (set from Table 3.2)} \\ \Delta t &= \text{one-minute temperature data acquisition interval} \\ \Delta\Theta_{H,U} &= K^{2 \cdot \text{EXPm}} \cdot \text{TH}_{gr}\end{aligned}$$

where:

$$\begin{aligned}K &= \text{load expressed in per unit of transformer nameplate rating according to the cooling system in service (phase current divided by the nominal current)} \\ \text{EXPm} &= \text{winding exponent (set from Table 3.2)} \\ \text{TH}_{gr} &= \text{rated winding hot-spot rise over top-oil at rated load, } ^\circ\text{C (set from Table 3.2)}\end{aligned}$$

Thermal Element With Ambient Temperature Input

In this case the relay receives a measured ambient temperature input and uses this input to calculate top-oil and hot-spot temperatures.

Where the relay has a measured ambient temperature input without a top-oil temperature input, you have one thermal input (for ambient temperature) regardless of whether you have a single three-phase transformer or independent single-phase transformers. The relay calculates winding hot-spot temperature, Θ_H , according to the equation in the earlier case:

$$\Theta_H = \Theta_{TO} + \Delta\Theta_H$$

and calculates top-oil temperature, Θ_{TO} , according to the following:

$$\Theta_{TO} = \Theta_A + \Delta\Theta_{TO}$$

where:

$$\begin{aligned}\Theta_A &= \text{ambient temperature, } ^\circ\text{C} \\ \Delta\Theta_{TO} &= \text{top-oil rise over ambient temperature, } ^\circ\text{C}\end{aligned}$$

The relay calculates top-oil rise over ambient temperature according to the following:

$$\Delta\Theta_{TO} = (\Delta\Theta_{TO,U} - \Delta\Theta_{TO,i}) \cdot \left(1 - e^{\frac{-\Delta t}{60T_o}} \right) + \Delta\Theta_{TO,i}$$

where:

$$\Delta\Theta_{TO,U} = \text{the ultimate top-oil rise over ambient temperature for any load, } ^\circ\text{C, and is a function of load and the values in Table 3.2}$$

$\Delta\Theta_{TO,i}$ = initial top-oil rise over ambient temperature at the start time of the interval, °C ($\Delta\Theta_{TO,i}$)

T_o = thermal top-oil time constant of transformer, in hours

The relay calculates the ultimate top-oil rise over ambient temperature, $\Delta\Theta_{TO,U}$, according to the following expression:

$$\Delta\Theta_{TO,U} = \left(\frac{(K^2 \cdot RATL + 1)}{(RATL + 1)} \right)^{EXPn} \cdot TH_{or}$$

where:

RATL = ratio of load loss at rated load to no-load loss (set from Table 3.2)

EXPn = oil exponent (set from Table 3.2)

TH_{or} = top-oil rise over ambient temperature at rated load, °C (set from Table 3.2)

For any EXPn (oil exponent) value and any load value, the relay calculates the thermal top-oil time constant according to the following expression:

$$T_o = OTR \cdot \left(\frac{\frac{\Delta\Theta_{TO,U}}{TH_{or}} - \frac{\Delta\Theta_{TO,i}}{TH_{or}}}{\left(\frac{\Delta\Theta_{TO,U}}{TH_{or}} \right)^{\frac{1}{EXPn}} - \left(\frac{\Delta\Theta_{TO,i}}{TH_{or}} \right)^{\frac{1}{EXPn}}} \right)$$

where:

OTR = thermal time constant in hours at rated load with initial top-oil temperature equal to ambient temperature (set from Table 3.2)

Thermal Element With No Measured Temperature Inputs

In this case, where your relay receives no measured ambient temperature or top-oil inputs, the relay uses a default ambient temperature value (DTMP setting) that you select and calculates a hot-spot temperature and top-oil temperature.

The relay calculates hot-spot temperature according to the following:

$$\Theta = \Theta_{TO} + \Delta\Theta$$

and the top-oil temperature according to the following:

$$\Theta_{TO} = \Theta_A + \Delta\Theta_{TO}$$

The relay has no measured ambient temperature input, so you must select an ambient temperature setting (DTMP) for the thermal element calculation of top-oil temperature as follows:

$$\Theta_{TO} = DTMP + \Delta\Theta_{TO}$$

where:

DTMP = user-selectable default ambient temperature

Top-Oil Temperature Comparison to Indicate Cooling System Efficiency

With measured top-oil temperatures available, top-oil temperatures are also calculated using measured currents and the two results compared. If the measured top-oil temperature exceeds the calculated top-oil temperature by a margin specified by the user (via the CSEPx setting), a Cooling System Efficiency (CSE) Relay Word bit is asserted. This bit can be programmed to any of the relay outputs to perform alarm or tripping functions. Assertion of the CSE bit indicates that the cooling system (fans and/or pumps) is operating below expected efficiency and may require maintenance.

CSEPx = Cooling System Efficiency Pickup setting, °C, where x = 1 if XTYPE = 3 and x = 1, 2, 3 if XTYPE = 1.

Serial Communications Failure

The COMFLG Relay Word bit is asserted under the following conditions:

- Serial communications link fails and NTHM setting > 0.
- Any of the received temperatures is not valid and the NTHM setting > 0. The range for valid measured temperatures is: -40°C to 350°C.

The COMFLG bit will never assert if the user configures the relay not to accept any temperatures by setting the NTHM setting to 0.

Insulation Loss of Life

Insulation Aging Acceleration Factor

The relay thermal element uses the hot-spot temperature to calculate an insulation aging acceleration factor, F_{AA} , which indicates how fast the transformer insulation is aging.

The relay calculates the insulation aging acceleration factor, F_{AA} , for each time interval, Δt , as follows:

$$F_{AA} = e^{\left[\frac{BFFA}{(\Theta_{H,R} + 273)} - \frac{BFFA}{(\Theta_H + 273)} \right]}$$

where:

F_{AA} = insulation aging acceleration factor

BFFA = is a design constant, typically 15000, °C (set from Table 3.2)

$\Theta_{H,R}$ = winding hot-spot temperature at rated load (95°C if THwr = 55°C, 110°C if THwr = 65°C)

THwr = average winding rise over ambient at rated load (setting)

Daily Rate of Loss of Life

The relay calculates daily rate of loss of life (RLOL, % loss of life per day) for a 24-hour period as follows:

$$RLOL = \frac{F_{EQA} \cdot 24}{ILIFE} \cdot 100$$

where:

RLOL = rate of loss of life in percent per day

ILIFE = expected normal insulation life in hours (set from Table 3.2)

The relay stores the RLOL value at midnight each day to provide the user with trend information on the loss of insulation life.

The equivalent life at the reference hot-spot temperature (95°C or 110°C) that will be consumed in a given time period for a given temperature cycle is:

$$F_{EQA} = \frac{\sum_{n=1}^N F_{AA_n} \cdot \Delta t_n}{\sum_{n=1}^N \Delta t_n}$$

where:

F_{EQA} = equivalent insulation aging factor for a total time period

n = index of the time interval, Δt

N = total number of time intervals for the time period

F_{AA_n} = insulation aging acceleration factor for the time interval, Δt_n

Δt = time interval (fixed at 1 minute)

During 24 hours, the total number of time intervals is:

$$N = \frac{24}{\left(\frac{\Delta t}{60}\right)} = \frac{1440}{\Delta t}$$

where:

Δt = time interval (fixed at 1 minute)

Because the time intervals and the total time period used in the thermal model will be constant, we can simplify the calculation of F_{EQA} to the following:

$$F_{EQA} = \frac{\sum_{n=1}^N F_{AA_n}}{N} \quad (\text{equivalent life in days})$$

Total Accumulated Loss of Life

The relay estimates the total accumulated loss of insulation life in percentage of normal insulation life by summing all of the daily RLOL values:

$$TLOL_d = RLOL_d + TLOL_{d-1}$$

where:

$TLOL_d$ = total accumulated loss of life, TLOL

$RLOL_d$ = most recent daily calculation

$TLOL_{d-1}$ = previous TLOL

The relay stores the TLOL value at midnight each day. You can use the THE P command to load an initial value of TLOL into the relay.

Estimated Time to Assert TLL Alarm

Estimated time to assert TLL bit:

$$TLLt = \frac{TLOLL - TLOL}{RLOL} \cdot 24$$

where:

$TLLt$ = estimated time to assert total loss-of-life alarm, in hours

$TLOLL$ = total loss-of-life limit setting

$TLOL$ = total accumulated loss of life, TLOL

$RLOL$ = most recent daily rate of loss-of-life calculation

Setting Descriptions

Thermal Element Enable (ETHER)

Range: Y, N

This setting enables or disables the thermal element. Set ETHER = Y to enable the thermal element or ETHER = N to disable the thermal element. If ETHER = N, the relay hides the following settings and they are unavailable to the user.

Thermal Model Winding Current (TMWDG)

Range: 1, 2, 3, 4, 12, 34

The TMWDG setting determines which power transformer winding corresponds with the measured currents the thermal element uses for calculations.

The measured currents the thermal element uses must represent the total current in or out of the power transformer. TMWDG allows selection of winding 1, winding 2, winding 3, winding 4, windings 1 and 2 (two currents added together), or windings 3 and 4 to be the current for the thermal element calculations. Refer to the two configuration settings, E87W and EOC, to determine which of the four windings are in use.

For a two-winding power transformer, current transformers located on either the high-voltage or low-voltage side would provide the correct current values. You can apply the thermal element on a three- or four-winding power transformer, provided that the TMWDG setting represents the total current in or out.

Winding LL Voltage (VWDG)

Range: 1–1000 kV, in 0.01 kV steps

Set VWDG to the rated phase-to-phase voltage for the winding you select in the TMWDG setting. The relay uses VWDG in conjunction with the power transformer MVA rating (see MCS setting) to calculate rated current. The relay then divides measured current by the rated current to determine K, which the relay uses in thermal element calculations.

Transformer Construction (XTYPE)

Range: 1, 3

A three-phase transformer may consist of one three-phase core and coil assembly in one physical enclosure or three physically separate single-phase transformers connected externally. Set XTYPE to either 3 (three-phase core and coil assembly in one physical enclosure) or 1 (three physically separate single-phase transformers connected externally).

Transformer Type (TRTYPE)

Range: D, Y

If the power transformer winding associated with the thermal element (see TMWDG setting) is delta connected OR if the current transformers associated with this winding are delta connected, set TRTYPE = D (delta). Set TRTYPE = Y (wye) only if both the power transformer winding AND current transformers are wye connected.

With TRTYPE = Y, the relay uses the measured currents for each phase in the thermal element calculations. This means that for a three-phase bank comprised of single-phase power transformers, the thermal element outputs may vary between phases because the phase currents may be different. With TRTYPE = D, the relay selects the highest magnitude phase current and sets the other two phase currents to that value to force a balanced condition. In this case the thermal element outputs for three single-phase transformers will be the same, assuming that each is operating at the same cooling stage and the thermal constants are set identically.

Winding Temp/Ambient Temp (THwr)

Range: 65, 55

Rated winding rise over ambient temperature is the difference in degrees Celsius of the winding temperature of a transformer above the ambient temperature. The actual winding temperature will be between the top-oil and hot-spot temperature.

Most power transformers manufactured in 1977 and later are rated for a 65°C rise over ambient. Power transformers manufactured prior to 1977 may be rated for a 55°C rise over ambient. Set THwr for either 55 or 65, based on the rating of the power transformer.

This setting determines which set of default transformer constants from Table 3.2 the relay will use if EDFTC = Y.

Number of Cooling Stages (NCS)

Range: 1–3

Power transformers generally have a self-cooled rating and one or two stages of forced cooling. Set NCS to the maximum number of cooling stages associated with the monitored power transformer.

Cooling Stage MVA Rating (MCSxy)

Range: 0.2–5000 MVA, in 0.1 MVA steps

Note: x designates the transformer and y designates the cooling stage.

The MVA rating for all types of transformers (XTYPE = 1 or 3) is taken as the nameplate MVA (MVA) rating and the line-to-line kilovolt (kV) values.

Table 3.1: Examples of Cooling Stages and MVA Ratings

XTYPE = 3			
Cooling Stage	MVA Rating		
CS1 (oil and air cooled)	MCS11 = 100		
CS2 (forced air cooled)	MCS12 = 140		
CS3 (forced oil and air cooled)	MCS13 = 170		
XTYPE = 1			
Cooling System	MVA Rating		
	Transformer 1	Transformer 2	Transformer 3
CS1 (oil and air cooled)	MCS11 = 100	MCS21 = 100	MCS31 = 100
CS2 (forced air cooled)	MCS12 = 140	MCS22 = 140	MCS32 = 140
CS3 (forced oil and air cooled)	MCS13 = 170	MCS13 = 170	MCS33 = 170

Cooling Stage 2 (or 3) (CSxyS)

Range: SELOGIC control equation

Note: x designates the transformer and y designates the cooling stage.

The thermal element uses the output of SELOGIC control equations to determine which cooling stage is active, so that thermal element calculations use the correct transformer constants. The settings XTYPE and NCS determine the number of SELOGIC control equations for which the relay will prompt the user.

The Csxys SELOGIC control equations can be set to any of the Relay Word bits except rows 0 and 1 of Table 5.8. However, it is critical that they be configured to accurately indicate which cooling system is active. In the simplest implementation, this will consist of one or two external contacts from the monitored power transformer connected to optoisolated inputs on the SEL-387 Relay with the Csxys SELOGIC control equations set to the corresponding digital input.

Default Ambient Temperature (DTMP)

Range: -40 to 85°C, in 1°C steps

Select a reasonable value for DTMP, even if your data acquisition system provides measurement of the ambient temperature (near the power transformer). In this case the thermal element calculations will use the DTMP setting, should the ambient temperature input not function on relay power up. If your data acquisition system cannot measure ambient temperature, then the thermal element calculations always use the DTMP value. The DTMP setting units are degrees Celsius.

Transformer Deenergized (TRDE)

Transformer heating consists of heating resulting from transformer losses and heating resulting from load. IEEE standard C57.91: 1995 assumes the transformer is energized and calculates an increase in oil and winding temperatures resulting from transformer losses. Relay Word TRDE provides the thermal element a way to distinguish between the deenergized and energized stages. For example, wire a “52b” (normally closed) circuit breaker auxiliary contact to input IN101 and enter the SELOGIC control equation $TRDE = IN101$. When IN101 asserts (circuit breaker main contacts open and the 52b auxiliary contacts closed), the thermal element considers the transformer deenergized and the ambient, top-oil, and hot-spot temperatures all have the same value.

It is the user's responsibility to make up an “effective external contact” from one or more 52a or 52b contacts (from one or more breakers) indicating that all the “source” breakers are open. If the user fails to assign a properly configured digital input to TRDE, then the top-oil and hot-spot temperatures will increase over the ambient temperature even when the power transformer is deenergized.

Number of Thermal Inputs (NTHM)

Range: 0–4

The maximum number of thermal inputs is four. The number of available thermal inputs depends on your data acquisition system and the construction of your transformer (XTYPE).

Thermal Function (THMz)

Range: AMB, OIL1, OIL2, OIL3

Note: $z = 0, 1, 2, \dots$ NTHM. There are as many THM settings as there are thermal inputs. Each thermal input must be properly designated.

This setting determines how the SEL-387 uses the thermal inputs it receives. The choices are AMB (ambient temperature), OIL1 (top-oil temperature 1), OIL2 (top-oil temperature 2), and OIL3 (top-oil temperature 3). If NTHM is set to 0, the relay assumes that it is not receiving any temperature inputs and will use only currents for its calculations. The COMFLG bit is cleared when NTHM is set to 0.

Top-Oil Temperature Limit (TOT1, TOT2)

Range: 50 to 150°C, in 1°C steps

One of the outputs the thermal element provides is top-oil temperature. TOT1 and TOT2 determine limits for top-oil temperature. If the top-oil temperature exceeds either limit, the corresponding TOT1 or TOT2 bit asserts. Using SELOGIC control equations, you can configure the TOT bits to close alarm contacts. When measured temperature inputs are available, the relay compares the TOT1 and TOT2 settings against the measured value. Should the measured value not be available (communication failure or lack of instrumentation), the relay compares the TOT1 and TOT2 settings against the calculated top-oil value.

With XTYPE = 1 and top-oil temperatures being measured or calculated for each of the three single-phase transformers, the TOT1 or TOT2 bits assert when any of the three values exceeds a limit. The thermal report will show which transformer exceeded the limits.

Hot-Spot Temperature Limit (HST1, HST2)

Range: 80 to 300°C, in 1°C steps

One of the outputs the thermal element provides is hot-spot temperature. HST1 and HST2 determine limits for hot-spot temperature. If the hot-spot temperature exceeds one of these limits, the corresponding HS1 or HS2 bit asserts. Using SELOGIC control equations, you can configure these bits to close alarm contacts.

With XTYPE = 1 and hot-spot temperatures being calculated for each of the three single-phase transformers, the HST1 or HST2 bits assert when any of the three values exceeds the limits. The thermal report will show which transformer exceeded the limits.

Aging Acceleration Factor Limits (FAAL1, FAAL2)

Range: 0–599.99, in 0.01 steps

A transformer subjected to overload or temperature greater than the normal transformer rating will age faster than the same transformer at rated load and temperature. One of the outputs the thermal element provides is a transformer insulation aging acceleration factor, which, when multiplied by elapsed time, provides an indication of the expected life remaining in the transformer. Should load and temperature be greater than normal, this factor is greater than 1. Should load and temperature be less than normal, the factor is less than 1. FAAL1 and FAAL2 determine limits for the aging acceleration factor. If the aging acceleration factor exceeds the limits, the FAA1 or FAA2 bit asserts. Using SELOGIC control equations, you can configure these bits to close alarm contacts.

With XTYPE = 1 and aging acceleration factors being calculated for each of the three single-phase transformers, the FAA1 or FAA2 bit asserts when any of the three values exceeds the limits. The thermal report will show which transformer was above the limits.

Daily Rate of Loss-of-Life Limit (RLOLL)

Range: 0–99%, in 0.01% steps

One of the outputs the thermal element provides is daily rate of loss of life. This output is a measure, in percent, of the life lost from the relay during a 24-hour period. RLOLL determines a limit for daily rate of loss of life. If the daily rate of loss of life exceeds the limit, a RLLOL bit asserts. Using SELOGIC control equations, you can configure the RLOLL bit to close an alarm contact.

With XTYPE = 1 and daily rate of loss of life being calculated for each of the three single-phase transformers, the RLL bit asserts when any of the three values exceeds the limit. The thermal report will show which transformer exceeded the limit.

Total Loss-of-Life Limit (TLOLL)

Range: 0–99%, in 0.01% steps

One of the outputs the thermal element provides is total loss of life, which is an estimate of the accumulated loss of transformer insulation life as a percentage of normal expected transformer insulation life. TLOLL determines a limit for total loss of life. If the total loss of life exceeds the limit, a TLL bit asserts. Using SELOGIC control equations, you can configure the TLL bit to close an alarm contact.

With XTYPE = 1 and aging acceleration factors being calculated for each of the three single-phase transformers, the TLL bit asserts when any of the three values exceeds the limit. The thermal report will show which transformer exceeded the limit.

Cooling System Efficiency Pickup (CSEPx)

Range: 5–100°C

Note: If XTYPE = 3, x = 1. If XTYPE = 1, x = 1, 2 and 3.

When a measured top-oil temperature is available via the serial port, measured currents are used to determine a calculated top-oil temperature. If the measured top-oil temperature is greater than the calculated top-oil temperature by the value of setting CSEPx, then a Cooling System Efficiency, CSE, bit in the Relay Word is asserted. Using SELOGIC control equations, the CSE bit can be configured to any of the relay outputs to perform alarm or tripping functions.

Assertion of the CSE bit indicates that the cooling system (fans and/or pumps) is operating below expected efficiency and may require maintenance.

With XTYPE = 1 and cooling system efficiency being calculated for each of the three single-phase transformers, the CSE bit is set when any of the three values exceeds the limit. The thermal report will show which transformer was above the setting.

General Cooling System Constants

Note: In the following settings x designates a transformer, and y designates the cooling system that the transformer uses. If XTYPE=3, x=1. If XTYPE=1, x=1, 2, and 3. For example, if the transformer is self-cooled, y=1. For a transformer cooled by forced air, y=2. For a transformer with both forced air and forced oil cooling, y=3.

Normal Insulation Life (ILIFE)

Range: 1000–999999 hr, in 1-hour steps

IEEE C57.91: 1995 suggests that normal transformer insulation life is 20.55 years or 180,000 hours. Table 3.2 lists this default value. You can select other values within a range of 1000–999999 hours.

Enable Default Constants (EDFTC)

Range: Y, N

Setting EDFTC enables or disables the default transformer constants in Table 3.2.

Table 3.2: Default Transformer Constants

		THwr = 55°C				THwr = 65°C	
IEEE C57.91: 1995	Setting	CS = 1	CS = 2	CS = 3	CS = 1	CS = 2	CS = 3
$\Delta\Theta_{TO,R}$	THor (°C)	45°	40°	37°	55°	50°	45°
$\Delta\Theta_{H,R}$	THgr (°C)	20°	25°	28°	25°	30°	35°
$\tau_{TO,R}$	OTR (hours)	3.0	2.0	1.25	3.0	2.0	1.25
R	RATL	3.0	3.5	5.0	3.2	4.5	6.5
n	EXPn	0.8	0.9	1.0	0.8	0.9	1.0
m	EXPm	0.8	0.8	1.0	0.8	0.8	1.0
τ_H	Ths (hours)	0.08					
B	BFFA	15000					
Normal Insulation Life	ILIFE	180000					

Note: THwr = average winding rise over ambient at rated load.

When EDFTC is set to Y (yes), the transformer constants shown in Table 3.2 are in effect, and the individual settings are not accessible. When EDFTC is set to N (no), the individual transformer constant settings are accessible.

Hot-Spot Thermal Time Constant (Thsx)

Range: 0.01–2.00 hours, in 0.01-hour steps

IEEE C57.91: 1995 section 7.2.6 states that the winding time constant, τ_H (Ths), is the time it takes the winding-temperature rise over oil-temperature rise to reach 63.2% of the difference between final rise and initial rise during a load change. The winding time constant may be estimated from the resistance cooling curve during thermal tests or calculated by the manufacturer using the mass of the conductor materials.

Constant to Calculate FAA (BFFAx)

Range: 0–100000, in steps of 1

IEEE C57.91: 1995 section 5.2 states that B (BFFA) is an empirical constant equal to 15000. Table 3.2 lists this value as the default. You can select other values from within a range of 0 to 100000. The thermal element uses this constant to calculate the transformer insulation aging acceleration factor (FAA).

Cooling Stage n Constants

Top-Oil Rise Over Ambient Temperature (THorxy)

Range: 0.1 to 100°C, in 0.1°C steps

Top-oil rise over ambient temperature is the difference in degrees Celsius of the top-oil temperature of a transformer above the ambient temperature.

The default values listed in Table 3.2 are from IEEE C57.92: 1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 100°C.

Hot-Spot Conductor Rise Over Top-Oil Temperature (THgrxy)

Range: 0.01 to 100°C, in 0.1°C steps

Hot-spot rise over top-oil temperature is the difference in degrees Celsius of the temperature of the hottest spot on the conductor winding over the top-oil temperature. If not provided, THgr may be calculated from the following equation:

$$THgr = THwr + \theta_{hswr} - THor$$

where:

THwr = average winding rise over ambient at rated load (55°C or 65°C)

θ_{hswr} = hot-spot winding rise over average winding rise

= (10°C if THwr = 55 or 15°C if THwr = 65)

Table 3.2 lists default values. The setting range for THgr is 0 to 100°C.

Ratio Losses (RATLxy)

Range: 0.1–100, in 0.1 steps

RATL is the ratio of load loss at rated load to no-load loss. The default values listed in Table 3.2 are from IEEE C57.92: 1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 100.

Oil Thermal Time Constant (OTRxy)

Range: 0.1–20 hours, in 0.1-hour steps

The oil thermal time constant is the time it takes the top-oil temperature rise over ambient temperature to reach 63.2% of the difference between final rise and initial rise during a load change. If not provided, OTR may be calculated from the following equation:

$$OTR = C \cdot \left[\frac{THor}{P_r} \right]$$

where:

$$\begin{aligned} C &= \text{transformer thermal capacity (watt-hours/degree)} \\ C &= 0.06 \times (\text{weight of core and coil assembly in pounds}) \\ &\quad + 0.04 \times (\text{weight of tank and fitting in pounds}) \\ &\quad + 1.33 \times (\text{gallons of oil}) \end{aligned}$$

or

$$\begin{aligned} C &= 0.0272 \times (\text{weight of core and coil assembly in kilograms}) \\ &\quad + 0.01814 \times (\text{weight of tank and fitting in kilograms}) \\ &\quad + 5.034 \times (\text{gallons of oil}) \\ P_r &= \text{total loss at rated load (watts)} \\ THor &= \text{top-oil rise over ambient at rated load} \end{aligned}$$

The default value from Table 3.2 is 0.08 hours. You can select other values from within a range of 0–2 hours. The default values listed in Table 3.2 are from IEEE C57.92: 1981, Tables 2 and 4.

Oil Exponent (EXPnxy)

Range: 0.1–5, in 0.1 steps

This exponent is a constant that the thermal element uses in calculating ultimate top-oil rise over ambient temperature ($\Delta\Theta_{TO}$).

The default values listed in Table 3.2 are from IEEE C57.92: 1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 5.

Winding Exponent (EXPmxy)

Range: 0.1–5, in 0.1 steps

This exponent is a constant that the thermal unit uses in calculating ultimate hot-spot conductor rise over top-oil temperature ($\Delta\Theta_{TO}$).

The default values listed in Table 3.2 are from IEEE C57.92: 1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 5.

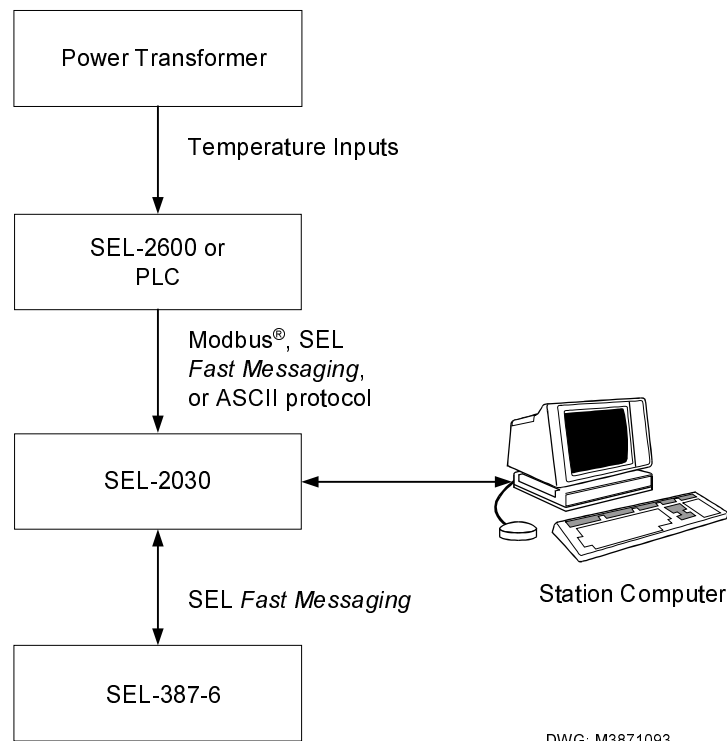
Application Guideline

The SEL-387-6 Relay obtains temperature information via one of its serial ports. The relay may receive data from as many as four temperature transducers: a single ambient temperature transducer and one transducer for top-oil temperature from each of three single-phase transformers.

These data could come from an SEL-2030 Communications Processor, which receives the temperature data from either an SEL-2600 Module or a PLC (see Figure 3.14). The SEL-2030

must receive the temperature data in Modbus®, SEL *Fast Messaging*, or ASCII protocol. The SEL-2030 passes these data on to the SEL-387-6 Relay in the form of an SEL *Fast Message*. While the SEL-387-6 Relay can receive temperature data at any rate, the thermal element uses these data only once a minute.

Please refer to *SEL Application Guide, “Connection and Configuration of SEL-2030 and SEL-2600 to Obtain Measured Ambient and Top-Oil Temperatures for SEL-387-6 Relay Thermal Element”* for information about how to set the SEL-2030 Communications Processor to communicate with the SEL-2600 Module and the SEL-387-6 Relay.



DWG: M3871093

Figure 3.14: Example System Block Diagram

OVERCURRENT ELEMENT

Application Description

The SEL-387 Relay provides numerous overcurrent elements, as many as 11 per winding, 44 total. Four levels of phase instantaneous/definite-time elements are available for single- or three-pole feeder protection, breaker failure protection, overcurrent phase selection for targeting, transformer backup protection, etc. Two levels of negative-sequence and residual instantaneous elements provide protection against unbalanced conditions and ground faults. A phase, negative-sequence, and residual time-overcurrent element are available for system backup protection.

Operating Characteristic

Each winding input of the SEL-387 Relay has 11 overcurrent elements (see Table 3.3). Nine of these 11 are torque-controlled elements, of which there is one definite-time element, one instantaneous element, and one inverse-time element per each of three categories. These categories are phase, negative-sequence, and residual current. Two of the 11 overcurrent elements, 50Pn3 and 50Pn4, are not torque controlled. These two elements are phase instantaneous overcurrent elements that provide output information per phase and, through an OR gate, assert a Relay Word bit if any one of the three phases asserts. These two elements primarily provide level detection, for applications such as trip unlatch logic or phase identification.

In addition to the 11 overcurrent elements, there are two sets of inverse-time overcurrent elements that use combined currents from two windings. These phase and residual current elements, one each for windings 1 and 2 and windings 3 and 4, remove circulating current components from two breakers that connect to the same physical transformer winding but whose CT inputs go to separate relay input terminals. These combined overcurrent elements permit more sensitive tripping in ring-bus or breaker-and-a-half schemes. These elements are not torque controlled.

Table 3.3: Overcurrent Element Summary

	Definite-Time Elements	Instantaneous Elements	Inverse-Time Elements
Phase (I_a , I_b , and I_c)			
Winding 1	50P11	50P12, 50P13, 50P14	51P1
Winding 2	50P21	50P22, 50P23, 50P24	51P2
Winding 3	50P31	50P32, 50P33, 50P34	51P3
Winding 4	50P41	50P42, 50P43, 50P44	51P4
Combined (Windings 1 and 2)			51PC1
Negative-Sequence ($I_Q = 3 \cdot I_2$)			
Winding 1	50Q11	50Q12	51Q1
Winding 2	50Q21	50Q22	51Q2
Winding 3	50Q31	50Q32	51Q3
Winding 4	50Q41	50Q42	51Q4
Residual ($I_R = I_a + I_b + I_c$)			
Winding 1	50N11	50N12	51N1
Winding 2	50N21	50N22	51N2
Winding 3	50N31	50N32	51N3
Winding 4	50N41	50N42	51N4
Combined (Windings 1 and 2)			51NC1

50Pn1 – Phase Definite-Time Element

Figure 3.15 shows the logic for the 50Pn1 element. The logic compares the magnitudes of phase input currents I_{A_n} , I_{B_n} , and I_{C_n} to pickup setting 50Pn1P. If one or more current magnitudes exceed the pickup level, a logic 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation 50Pn1TC determines the other AND input. If 50Pn1TC is true, Relay Word bit 50Pn1 asserts and starts the timer. After the time specified by delay setting 50Pn1D expires, a second Relay Word bit, 50Pn1T, asserts. This bit asserts only if the 50Pn1 bit remains asserted for the duration of 50Pn1D. When 50Pn1 deasserts, the timer resets without delay, along with 50Pn1T if it has asserted.

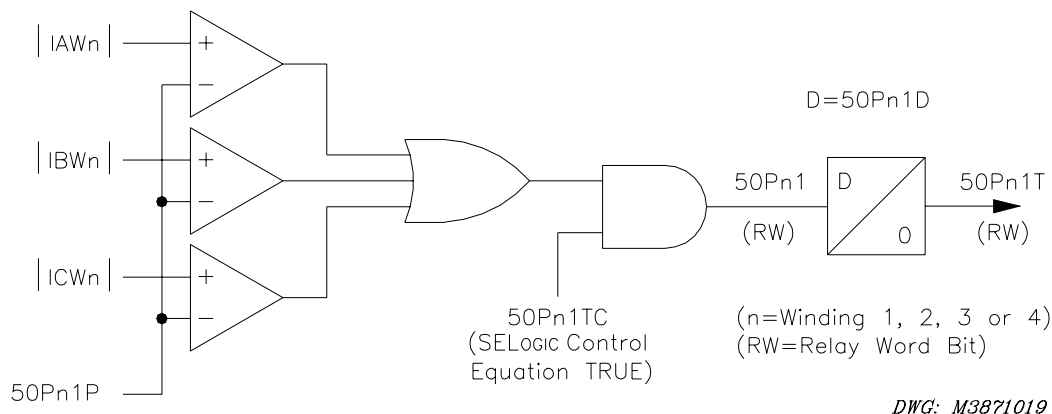


Figure 3.15: 50Pn1 Phase Definite-Time O/C Element, Torque Controlled

50Pn2 – Phase Instantaneous Element

Figure 3.16 shows the logic for the 50Pn2 element. The 50Pn2 element logic compares magnitudes of phase input currents I_{A_n} , I_{B_n} , and I_{C_n} to pickup setting 50Pn2P. If one or more current magnitudes exceed the pickup level, a logic 1 asserts at one input to the AND gate. The torque-control SELOGIC control equation 50Pn2TC determines the other AND input. If 50Pn2TC is true, Relay Word bit 50Pn2 asserts.

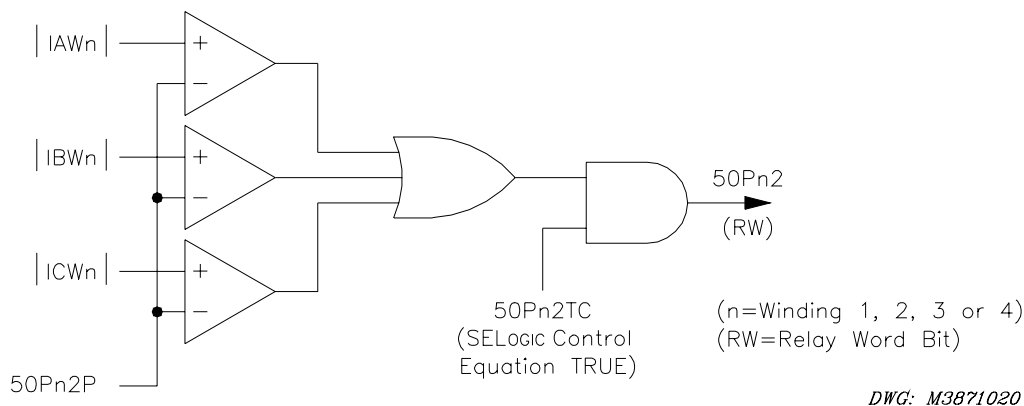


Figure 3.16: 50Pn2 Phase Instantaneous O/C Element, Torque Controlled

50Pn3 and 50Pn4 – Phase Instantaneous Element

Figure 3.17 shows the logic for the two nontorque-controlled phase instantaneous elements. The two elements find application primarily in level detection or phase identification. The logic compares magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pickup setting $50Pn3P(4P)$. Any phase current exceeding the pickup level will assert the appropriate phase-specific Relay Word bit, $50An3(4)$, $50Bn3(4)$, or $50Cn3(4)$. These bits enter an OR gate to assert Relay Word bit $50Pn3(4)$, indicating “any phase” pickup.

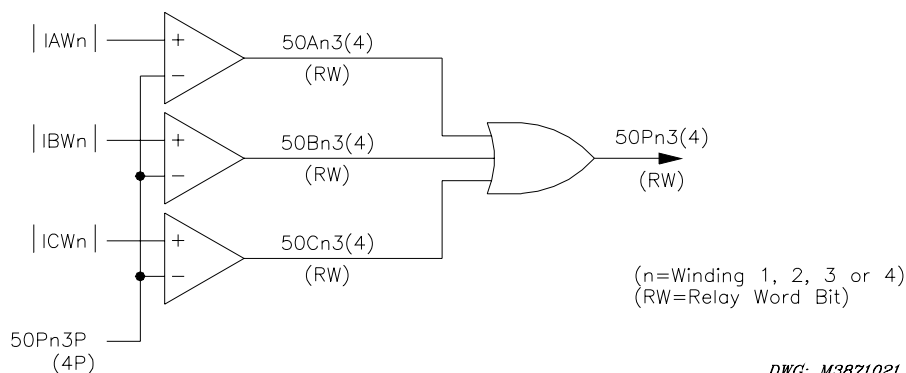


Figure 3.17: 50Pn3 and 50Pn4 Phase Instantaneous O/C Element, Nontorque Controlled

51Pn – Phase Inverse-Time Element

Figure 3.18 shows the logic for the 51Pn element. The logic compares the magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pickup setting $51PnP$. If one or more current magnitudes exceed the pickup level, a logical 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation $51PnTC$ determines the other AND input. If $51PnTC$ is true, Relay Word bit $51Pn$ asserts and the inverse curve begins timing.

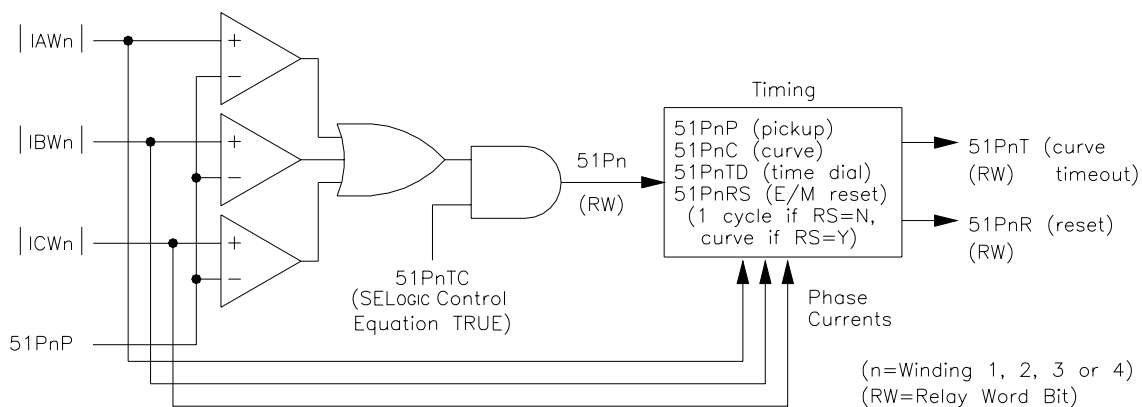


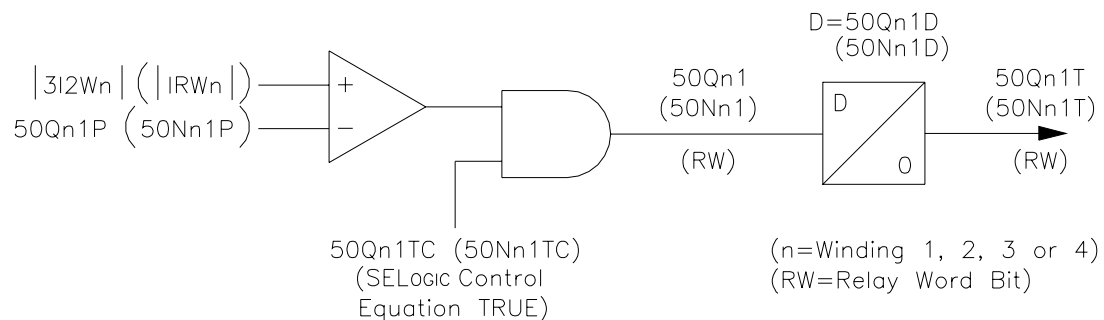
Figure 3.18: 51Pn Phase Inverse-Time O/C Element, Torque Controlled

Four settings define an inverse-time curve: the pickup setting, 51PnP, acts as a horizontal scaling factor, because the curve formula uses current multiple of pickup as an input; the curve setting, 51PnC, defines the particular curve equation, of which there are 10 (five U.S. and five IEC); the time-dial setting, 51PnTD, defines the time dial, which scales the curve in a vertical direction to vary the output timing for a given multiple of pickup; and the reset setting, 51PnRS, defines whether the curve resets slowly like an electromechanical disk or instantaneously when current drops below pickup. The phase inverse-time curve looks at all three phase current magnitudes and times on the basis of the greatest current of the three. It updates this maximum phase current selection every quarter-cycle.

If the curve times out, Relay Word bit 51PnT asserts. When all phase currents drop below pickup, with or without a curve time-out, 51Pn deasserts and the element resets according to setting 51PnRS. At the completion of the reset, Relay Word bit 51PnR asserts. This bit normally will be at logic state 1, when the element is at rest during normal system operation. Use the TAR command via a serial port or the front panel to verify the state of this bit. You can use the Level 2 serial port command RES or the front-panel RESET51 function under the OTHER button to force this bit to logical 1 during element testing. This saves time if you have chosen electromechanical reset.

50Qn1 and 50Nn1 – Sequence Current Definite-Time Element Logic

Figure 3.19 shows the logic for the definite-time 50Qn1 negative-sequence element and the definite-time 50Nn1 residual element.



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Figure 3.19: 50Qn1 and 50Nn1 Sequence Definite-Time O/C Element, Torque Controlled

50Qn1 Negative-Sequence Definite-Time Element

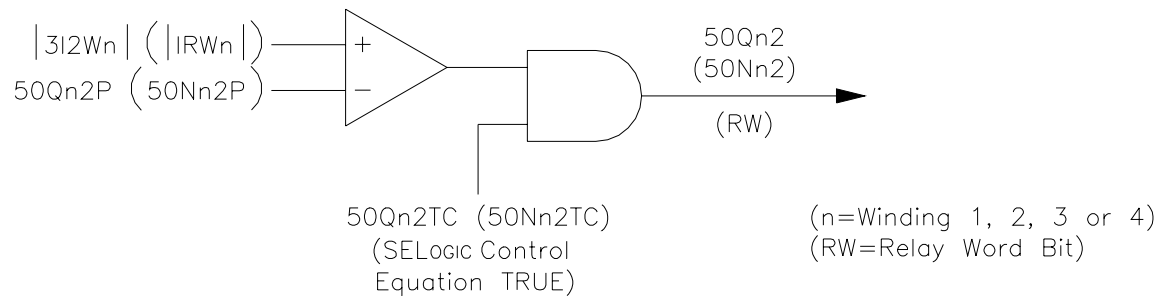
The 50Qn1 element logic compares the magnitude of calculated negative-sequence current 3I2Wn to pickup setting 50Qn1P. If the calculated negative-sequence current magnitude exceeds the pickup level, a logical 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation, 50Qn1TC, determines the other AND input. If 50Qn1TC is true, Relay Word bit 50Qn1 asserts and the timer starts. After the time specified by delay setting 50Qn1D has expired, a second Relay Word bit, 50Qn1T, asserts. The 50Qn1T bit asserts only if the 50Qn1 bit remains asserted for the duration of 50Qn1D. When 50Qn1 deasserts, the timer resets without delay, along with 50Qn1T if it has asserted.

50Nn1 Residual Definite-Time Element

The 50Nn1 element logic compares the magnitude of the calculated residual current, IRW_n , to the pickup setting, 50Nn1P. If the calculated residual current magnitude exceeds the pickup level, a logical 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation, 50Nn1TC, determines the other AND input. If 50Nn1TC is true, Relay Word bit 50Nn1 asserts and the timer starts. After the time specified by delay setting 50Nn1D has expired, a second Relay Word bit, 50Nn1T, asserts. The 50Nn1T bit asserts only if the 50Nn1 bit remains asserted for the duration of 50Nn1D. When 50Nn1 deasserts, the timer resets without delay, along with 50Nn1T if it has asserted.

50Qn2 and 50Nn2 – Sequence Instantaneous Element Logic

Figure 3.20 shows the logic for the instantaneous 50Qn2 negative-sequence element and the instantaneous 50Nn2 residual element



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Figure 3.20: 50Qn2 and 50Nn2 Sequence Instantaneous O/C Element, Torque Controlled

50Qn2 Negative-Sequence Instantaneous Element

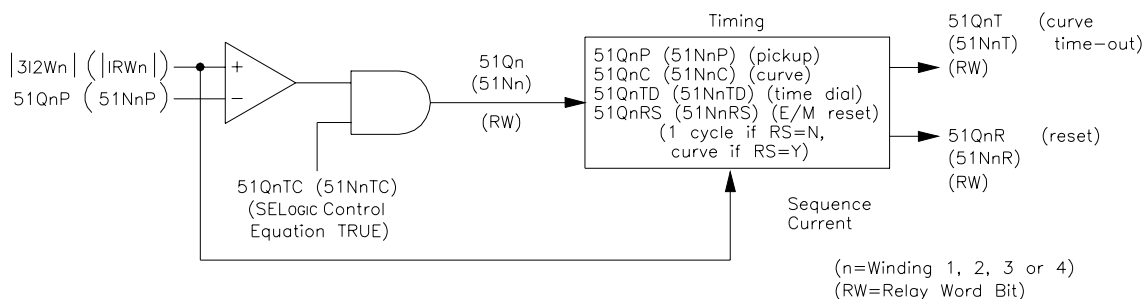
The 50Qn2 element compares the magnitude of the calculated negative-sequence current, $3I2W_n$, to the pickup setting, 50Qn2P. If the calculated negative-sequence current exceeds the pickup level, a logical 1 asserts at one input to the AND gate. The torque-control SELOGIC control equation, 50Qn2TC, determines the other AND input. If 50Qn2TC is true, Relay Word bit 50Qn2 asserts.

50Nn2 Residual Instantaneous Element

The 50Nn2 element compares the magnitude of the calculated residual current, IRW_n , to the pickup setting, 50Nn2P. If the calculated residual current exceeds the pickup level, a logical 1 asserts at one input to the AND gate. The torque-control SELOGIC control equation, 50Nn2TC, determines the other AND input. If 50Nn2TC is true, Relay Word bit 50Nn2 asserts.

51Qn and 51Nn – Sequence Inverse-Time Elements

Figure 3.21 shows the logic for the inverse-time 51Qn negative-sequence element and the instantaneous 51Nn residual element.



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Figure 3.21: 51Qn and 51Nn Sequence Inverse-Time O/C Element, Torque Controlled

51Qn Negative-Sequence Inverse-Time Element

The 51Qn element logic compares the magnitude of the calculated negative-sequence current, 3I2Wn, to the pickup setting, 51QnP. If the calculated negative-sequence current exceeds the pickup level, a logical 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation, 51QnTC, determines the other AND input. If 51QnTC is true, Relay Word bit 51Pn asserts and the inverse curve begins timing.

As with phase inverse-time element logic, four settings define the curve. In this case 51QnP is the pickup, 51QnC defines the curve equation, 51QnTD defines the time dial, and 51QnRS determines how the curve resets.

Curve time-out causes Relay Word bit 51QnT to assert. When the current drops below pickup, 51Qn deasserts and the element resets according to the setting for 51QnRS. At the completion of the reset, Relay Word bit 51QnR asserts. This bit normally is at logic state 1, when the element is at rest during normal system operation. You can use the TAR command to verify the state of the bit. You can use the Level 2 serial port command RES or the front-panel RESET51 function under the OTHER button to force the bit to a logical 1 during element testing. This saves time if you have chosen electromechanical reset.

51Nn Residual Inverse-Time Element

The 51Nn element compares the magnitude of the calculated residual current, IRWn, to the pickup setting, 51NnP. If calculated residual current exceeds the pickup level, a logical 1 asserts at one input to the AND gate at the center. The torque-control SELOGIC control equation, 51NnTC, determines the other AND input. If 51NnTC is true, Relay Word bit 51Nn asserts and the inverse curve begins timing.

The settings defining the curve in this case are 51NnP for the pickup setting, 51NnC for the particular curve equation, 51NnTD for the time dial, and 51NnRS for the curve reset.

Curve time-out causes Relay Word bit 51NnT to assert. When the current drops below pickup, 51Nn deasserts and the element resets according to the setting for 51NnRS. At the completion of

the reset, Relay Word bit 51NnR asserts. This bit normally is at logic state 1, when the element is at rest during normal system operation. You can use the TAR command to verify the state of the bit. You can use the Level 2 serial port command RES or the front-panel RESET51 function under the OTHER button to force the bit to a logical 1 during element testing.

51PCm and 51NCm Combined Overcurrent Element (m = 1, 2)

The combined overcurrent elements operate on summed input currents to two windings. Elements 51PC1 and 51NC1 use phase and residual current from windings 1 and 2, while 51PC2 and 51NC2 use these currents from windings 3 and 4; see Figure 3.22.

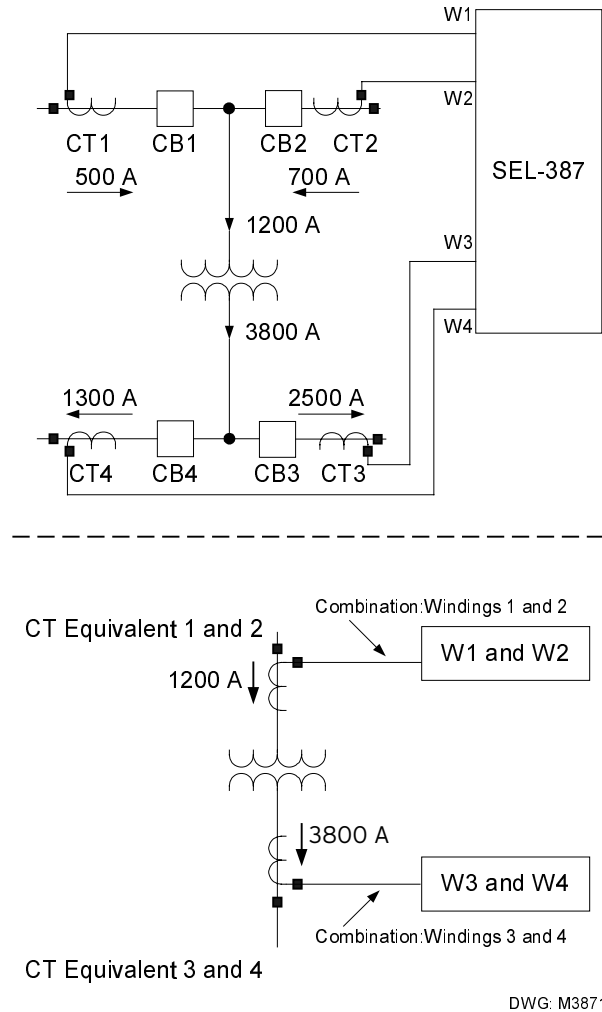


Figure 3.22: Combined Overcurrent Example

51PC1 and 51NC1 Element

Figure 3.23 shows the logic for the inverse-time combined overcurrent elements, 51PC1 and 51NC1.

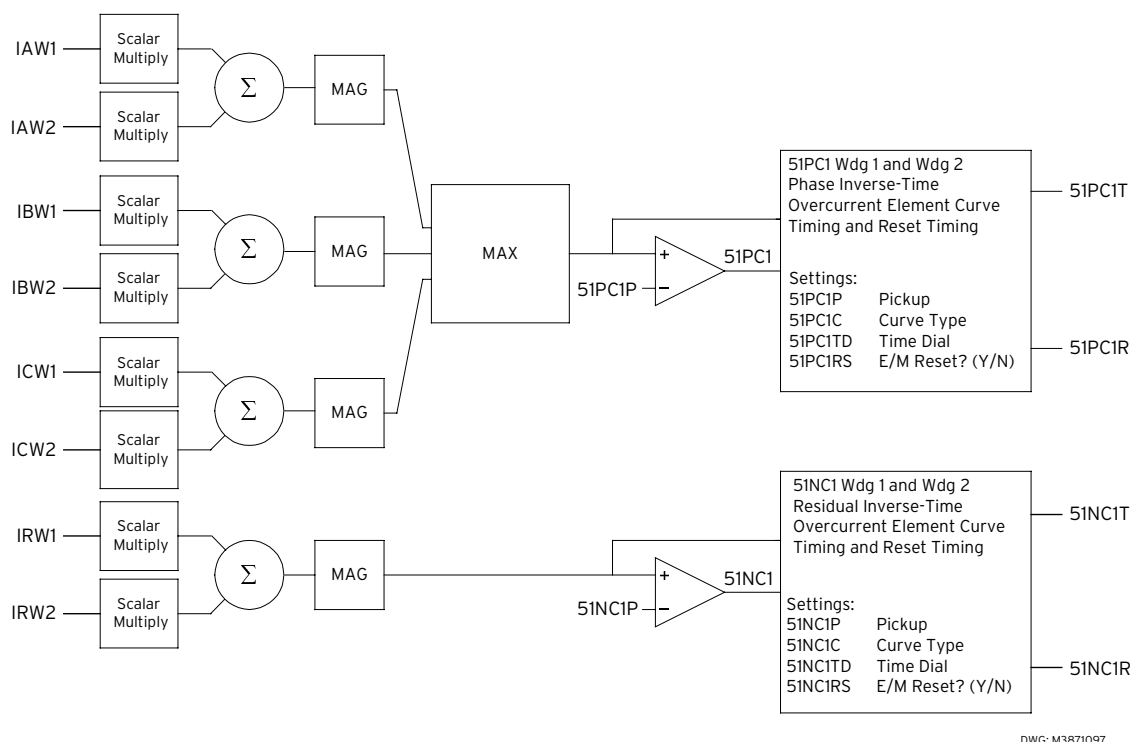


Figure 3.23: 51PC1 and 51NC1 Combined Inverse-Time O/C Elements

The relay determines whether to assert Relay Word bit 51PC1 by selecting the greater of the two CT ratios, using this ratio as a common base in calculating the combined secondary current, and then comparing this combined secondary current against the 51PC1P pickup setting. This pickup setting is a secondary quantity that the relay calculates by dividing the primary current pickup by the greater of the two CT ratios.

For $CTR1 < CTR2$, the relay performs the following operation on the secondary quantities it receives from the CTs:

$$(InW1 \cdot CTR1/CTR2) + InW2,$$

where n = Phase A, Phase B, or Phase C.

The following example illustrates the equivalent operation on the primary quantities entering the CTs:

Assume

$$\begin{aligned} CTR1 &= 600/5 = 120 \\ CTR2 &= 2000/5 = 400 \\ InW1 &= 2000 \text{ A (primary)} \\ InW2 &= 1000 \text{ A (primary)} \\ Pickup &= 8000 \text{ A (primary)} \end{aligned}$$

where n = Phase A, Phase B, or Phase C.

Then, converting the observed primary values to secondary values, we have

$$\frac{2000 \text{ A}}{400} + \frac{1000 \text{ A}}{400} = 7.5 \text{ A combined secondary current}$$

Note: Because CTR1 < CTR2, the relay uses CTR2 as the common base.

$$51PC1P = \frac{8000 \text{ A}}{400} = 20 \text{ A secondary}$$

The combined secondary current is less than the 51PC1P setting, so 51PC1 does not assert.

For CTR1 > CTR2, the relay performs the following operation on the secondary quantities it receives from the CTs:

$$InW1 + (InW2 \cdot CTR2/CTR1),$$

where n = Phase A, Phase B, or Phase C.

The following example illustrates the equivalent operation on the primary quantities entering the CTs:

Assume

$$\begin{aligned} CTR1 &= 1000/5 = 200 \\ CTR2 &= 500/5 = 100 \\ InW1 &= 3000 \text{ A (primary)} \\ InW2 &= 6000 \text{ A (primary)} \\ Pickup &= 8000 \text{ A (primary)} \end{aligned}$$

where n = Phase A, Phase B, or Phase C.

Then, converting the observed primary values to secondary values, we have

$$\frac{6000 \text{ A}}{200} + \frac{3000 \text{ A}}{200} = 45 \text{ A combined secondary current}$$

Note: Because CTR1 > CTR2, the relay uses CTR1 as the common base.

$$51PC1P = \frac{8000 \text{ A}}{200} = 40 \text{ A secondary}$$

The combined secondary current value is greater than the 51PC1P setting, so 51PC1 asserts and the time overcurrent curve begins timing.

The settings defining the curve in this case are 51PC1P for the pickup setting, 51PC1C for the particular curve equation, 51PC1TD for the time dial, and 51PC1RS for the curve reset.

Curve time-out causes the Relay Word bit 51PC1T to assert. When the current drops below pickup, 51PC1 deasserts and the element resets according to the setting 51PC1RS. At the completion of reset, Relay Word bit 51PC1R asserts. This bit normally is at logic state 1, when the element is at rest during normal system operation. You can use the TAR command to verify the state of the bit. You can use the Level 2 serial port command RES or the front-panel RESET51 function under the OTHER button to force the bit to 1 during element testing. This saves time if you have chosen electromechanical reset.

The relay determines whether to assert Relay Word bit 51NC1 by selecting the greater of the two CT ratios, using this ratio as a common base in calculating the combined secondary current and then comparing this combined secondary current against the 51NC1P pickup setting. This pickup setting is a secondary quantity that the relay calculates by dividing the primary current pickup by the greater of the two CT ratios.

For $CTR1 < CTR2$, the relay performs the following operation on the secondary quantities it receives from the CTs:

$$\left(\overrightarrow{IAW1} + \overrightarrow{IBW1} + \overrightarrow{ICW1} \right) \cdot \frac{CTR1}{CTR2} + \left(\overrightarrow{IAW2} + \overrightarrow{IBW2} + \overrightarrow{ICW2} \right)$$

Note: $\overrightarrow{XXXX}$ defines a vector quantity.

The following example illustrates the equivalent operation on the primary quantities entering the CTs:

Assume

$$\begin{aligned} CTR1 &= 500/5 = 100 \\ CTR2 &= 1000/5 = 200 \\ \text{Pickup} &= 400 \text{ A (primary)} \end{aligned}$$

Primary Currents

$$\begin{aligned} IAW1 &= 3000 \angle 2^\circ \text{ A} & IAW2 &= 1545 \angle 3^\circ \text{ A} \\ IBW1 &= 3010 \angle -122^\circ \text{ A} & IBW2 &= 1480 \angle -118^\circ \text{ A} \\ ICW1 &= 2950 \angle 117^\circ \text{ A} & ICW2 &= 1505 \angle 124^\circ \text{ A} \end{aligned}$$

Secondary Currents

$$\begin{aligned} IAW1 &= 30 \angle 2^\circ \text{ A} & IAW2 &= 7.725 \angle 3^\circ \text{ A} \\ IBW1 &= 30.1 \angle -122^\circ \text{ A} & IBW2 &= 7.4 \angle -118^\circ \text{ A} \\ ICW1 &= 29.5 \angle 117^\circ \text{ A} & ICW2 &= 7.525 \angle 124^\circ \text{ A} \end{aligned}$$

Then,

$$\begin{aligned} &\left(30 \angle 2^\circ \text{ A} + 30.1 \angle -122^\circ \text{ A} + 29.5 \angle 117^\circ \text{ A} \right) \cdot \frac{100}{200} \\ &+ \left(7.725 \angle 3^\circ \text{ A} + 7.4 \angle -118^\circ \text{ A} + 7.525 \angle 124^\circ \text{ A} \right) \\ &= 1.071 \angle 70.8^\circ \text{ A} \end{aligned}$$

Note: Because $CTR1 < CTR2$, the relay uses $CTR2$ as the common base.

$$51NC1P = \frac{400 \text{ A}}{200} = 2 \text{ A secondary}$$

The combined secondary current value is less than the 51NC1P setting, so 51NC1 does not assert.

For CTR1>CTR2, the relay performs the following operation on the secondary quantities it receives from the CTs:

$$\left(\overrightarrow{IAW1} + \overrightarrow{IBW1} + \overrightarrow{ICW1} \right) + \left(\overrightarrow{IAW2} + \overrightarrow{IBW2} + \overrightarrow{ICW2} \right) \cdot \frac{CTR2}{CTR1}$$

Note: $\overrightarrow{XXXX}$ defines a vector quantity.

The following example illustrates the equivalent operation on the primary quantities entering the CTs:

Assume

$$\begin{aligned} CTR1 &= 1000/5 = 200 \\ CTR2 &= 500/5 = 100 \\ \text{Pickup} &= 400 \text{ A (primary)} \end{aligned}$$

Primary Currents

$$\begin{aligned} IAW1 &= 3000 \angle 5^\circ \text{ A} & IAW2 &= 1545 \angle 3^\circ \text{ A} \\ IBW1 &= 3010 \angle -123^\circ \text{ A} & IBW2 &= 1480 \angle -118^\circ \text{ A} \\ ICW1 &= 2950 \angle 115^\circ \text{ A} & ICW2 &= 1505 \angle 124^\circ \text{ A} \end{aligned}$$

Secondary Currents

$$\begin{aligned} IAW1 &= 15 \angle 5^\circ \text{ A} & IAW2 &= 15.45 \angle 3^\circ \text{ A} \\ IBW1 &= 15.05 \angle -123^\circ \text{ A} & IBW2 &= 14.80 \angle -118^\circ \text{ A} \\ ICW1 &= 14.75 \angle 115^\circ \text{ A} & ICW2 &= 15.05 \angle 124^\circ \text{ A} \end{aligned}$$

Then,

$$\begin{aligned} & (15 \angle 5^\circ \text{ A} + 15.05 \angle -123^\circ \text{ A} + 14.75 \angle 115^\circ \text{ A}) + \\ & (15.45 \angle 3^\circ \text{ A} + 14.80 \angle -118^\circ \text{ A} + 15.05 \angle 124^\circ \text{ A}) \cdot \frac{100}{200} \\ & = 2.1164 \angle 76^\circ \text{ A} + 0.11370 \angle 73^\circ \text{ A} = 2.230 \angle 76^\circ \text{ A} \end{aligned}$$

Note: Because CTR1>CTR2, the relay uses CTR1 as the common base.

$$51NC1P = \frac{400 \text{ A}}{200} = 2 \text{ A secondary}$$

The combined secondary current value is greater than the 51NC1P setting, so 51NC1 asserts and the time overcurrent curve begins timing.

As with the phase current element, four settings define the curve: 51NC1P is the pickup setting, 51NC1C defines the curve equation, 51NC1TD defines the time dial, and 51NC1RS determines how the curve resets.

Curve time-out causes the Relay Word bit 51NC1T to assert. When the current drops below pickup, 51NC1 deasserts and the element resets according to the setting 51NC1RS. At the

completion of the reset, Relay Word bit 51NC1R asserts. This bit normally will be at logic state 1, when the element is at rest during normal system operation. You can verify the state of the bit using the TAR command via a serial port or the front panel. You can force this bit to 1 during element testing using the Level 2 serial port command RES or the front-panel RESET51 function under the OTHER button.

Note: These two overcurrent elements should not be used if the REF function is enabled. Neutral CT input to winding 4 may lead to false operation of 51PC1 or 51NC1. Set 51PC1P and 51NC1P to OFF for this situation.

51PC2 and 51NC2 Element Logic

Figure 3.24 shows the logic for the inverse-time combined overcurrent elements 51PC2 and 51NC2.

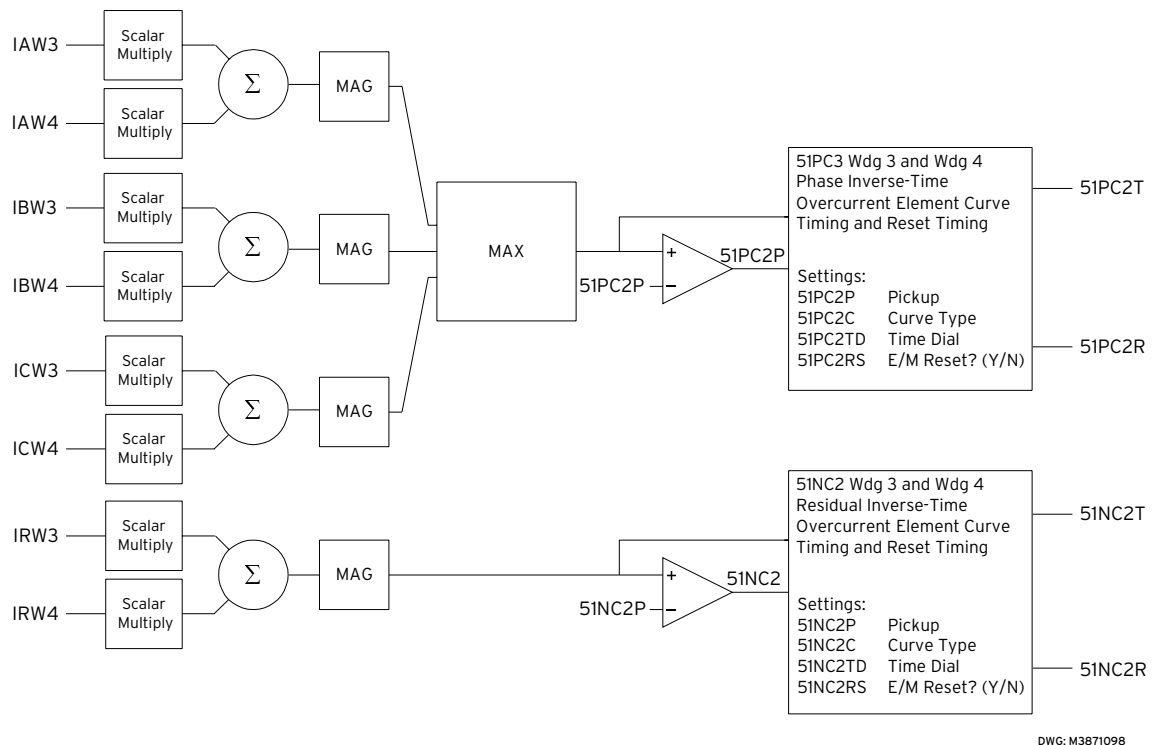


Figure 3.24: 51PC2 and 51NC2 Combined Inverse-Time O/C Elements

The relay determines whether 51PC2 and 51NC2 assert by performing calculations similar to those for determination of 51PC1 and 51NC1 assertion.

Setting Descriptions

This subsection contains setting names, setting ranges, and labels for the overcurrent elements associated with winding 1. Windings 2, 3, and 4 overcurrent element settings have similar names and labels. All windings have identical setting ranges.

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Winding n Overcurrent Element and Demand Threshold Enables (EOCn)

Range: Y, N

Set EOC1 = Y to enable overcurrent elements and demand thresholds for winding 1. The operation is identical for the other three windings. The relay default is for winding 1–3 overcurrent elements and demand thresholds to be enabled, while winding 4 overcurrent elements and demand thresholds are disabled (EOC4 = N).

Combined O/C Element Enable (EOCC)

Range: Y, N

Set EOCC = Y to enable combined overcurrent elements. A setting of EOCC = N disables the elements.

Instantaneous and Definite-Time Element Pickups (50PnP, 50QnP, 50NnP)

Range: 1A: OFF, (0.05–20), A secondary, in 0.01 A steps

5A: OFF, (0.25–100), A secondary, in 0.01 A steps

Set pickups for the current level above which you want the elements to assert. As the name of the instantaneous elements suggests, assertion occurs almost immediately after current exceeds the threshold you specify. A definite-time element asserts only after current exceeds the level you specify and after a time delay that you specify with the definite-time delay setting.

Definite-Time Element Delays (50PnD, 50QnD, 50NnD)

Range: 0–16000 cycles, in 0.25-cycle steps

Select a time in cycles that you want definite-time elements to wait before asserting.

Inverse-Time Element Pickups (51PnP, 51QnP, 51NnP, 51PCmP, 51NCmP)

Range: 1A: OFF, (0.1–3.2), A secondary, in 0.01 A steps

5A: OFF, (0.5–16), A secondary, in 0.01 A steps

Note: For combined winding element settings, m=1: W1+W2; m=2: W3+W4

The pickup setting acts as a horizontal scaling factor for an inverse-time curve, because the curve formula uses current multiple of pickup as an input.

Set pickups, and the following three settings defining the time overcurrent curve, to fit the practices of your organization, coordinate with upstream and downstream devices such as fuses and motors, and accommodate transient and fault conditions.

Curve Shape Settings (51P1C, 51Q1C, 51N1C, 51PCmC, 51NCmC)

Range: U1, U2, U3, U4, U5
C1, C2, C3, C4, C

Note: For the combined winding element settings, m=1: W1+W2; m=2: W3+W4

This setting defines a particular curve equation for an inverse-time curve from among five U.S. (U1–U5) and five IEC (C1–C5) curves.

Time-Dial Settings (51P1TD, 51Q1TD, 51N1TD, 51PCmTD, 51NCmTD)

Range: US 0.5–15, IEC 0.05–1, in 0.01 steps

Note: For the combined winding element settings, m=1: W1+W2; m=2: W3+W4

The time-dial setting acts to scale an inverse-time curve vertically, to vary the output timing for a given multiple of pickup.

Electromechanical Reset Settings (51P1RS, 51Q1RS, 51N1RS, 51PCmRS, 51NCmRS)

Range: Y, N

Note: For the combined winding element settings, m=1: W1+W2; m=2: W3+W4

This setting defines whether an inverse-time curve emulates an electromechanical disk and resets slowly or instantaneously when current drops below pickup. A setting of Y causes the relay to emulate an electromechanical disk. A setting of N causes full reset of the time-overcurrent element one cycle after current drops below the element pickup setting.

Torque-Control Settings (50PnTC, 50QnTC, 50NnTC, 51PnTC, 51QnTC, 51NnTC)

Range: SELOGIC control equation

The torque-control setting is an enable setting for which you have three options: a setting of logical 0 disables the associated definite-time element, a logical 1 permits the element to operate, and SELOGIC control equations allow conditional assertion of the element.

Time Overcurrent Curve Reference Information

tp = operating time in seconds

tr = electromechanical induction-disk emulation reset time in seconds
(if electromechanical reset setting is made)

TD = time-dial setting

M = applied multiples of pickup current [for operating time (tp), $M > 1$; for reset time (tr), $M \leq 1$]

U.S. Moderately Inverse Curve: U1

$$tp = TD \cdot \left[0.0226 + \frac{0.0104}{M^{0.02} - 1} \right]$$

$$tr = TD \cdot \left[\frac{1.08}{1 - M^2} \right]$$

U.S. Inverse Curve: U2

$$tp = TD \cdot \left[0.180 + \frac{5.95}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{5.95}{1 - M^2} \right]$$

U.S. Very Inverse Curve: U3

$$tp = TD \cdot \left[0.0963 + \frac{3.88}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{3.88}{1 - M^2} \right]$$

U.S. Extremely Inverse Curve: U4

$$tp = TD \cdot \left[0.0352 + \frac{5.67}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{5.67}{1 - M^2} \right]$$

U.S. Short-Time Inverse Curve: U5

$$tp = TD \cdot \left[0.00262 + \frac{0.00342}{M^{0.02} - 1} \right]$$

$$tr = TD \cdot \left[\frac{0.323}{1 - M^2} \right]$$

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

$$tp = TD \cdot \left[\frac{0.14}{M^{0.02} - 1} \right]$$

$$tr = TD \cdot \left[\frac{13.5}{1 - M^2} \right]$$

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

$$tp = TD \cdot \left[\frac{13.5}{M - 1} \right]$$

$$tr = TD \cdot \left[\frac{47.3}{1 - M^2} \right]$$

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

$$tp = TD \cdot \left[\frac{80.0}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{80.0}{1 - M^2} \right]$$

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

$$tp = TD \cdot \left[\frac{120.0}{M - 1} \right]$$

$$tr = TD \cdot \left[\frac{120.0}{1 - M} \right]$$

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

$$tp = TD \cdot \left[\frac{0.05}{M^{0.04} - 1} \right]$$

$$tr = TD \cdot \left[\frac{4.85}{1 - M^2} \right]$$

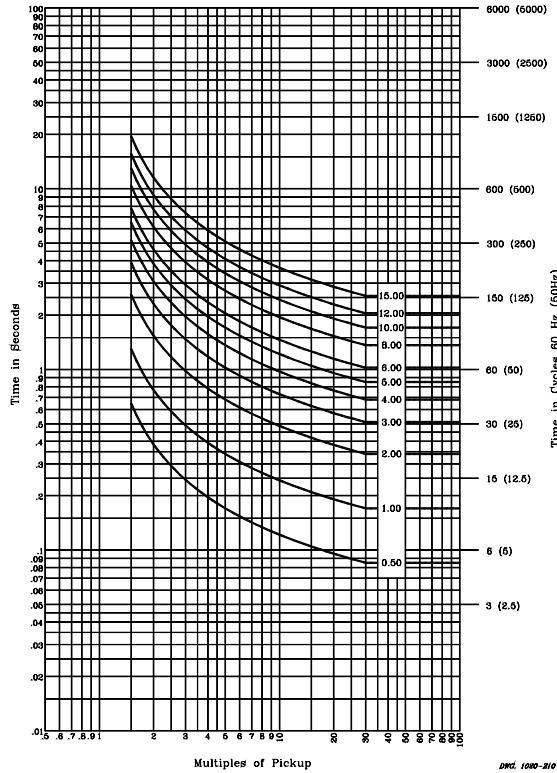


Figure 3.25: U.S. Moderately Inverse Curve: U1

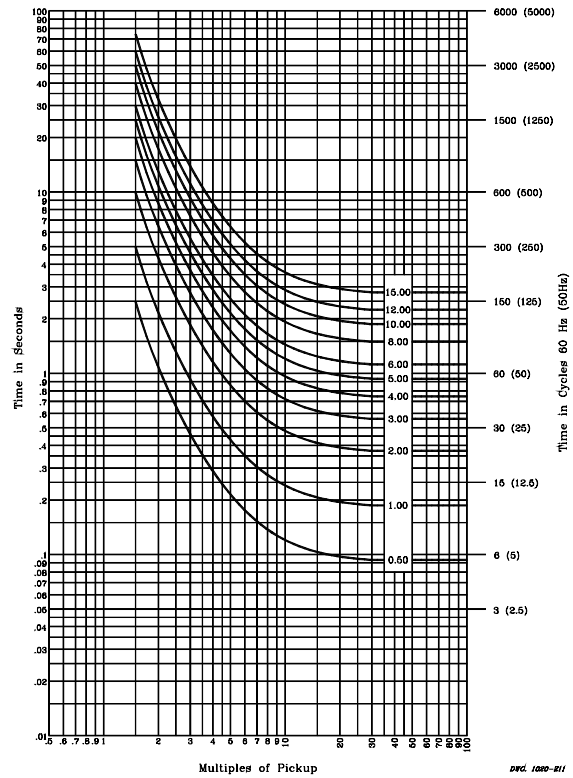


Figure 3.26: U.S. Inverse Curve: U2

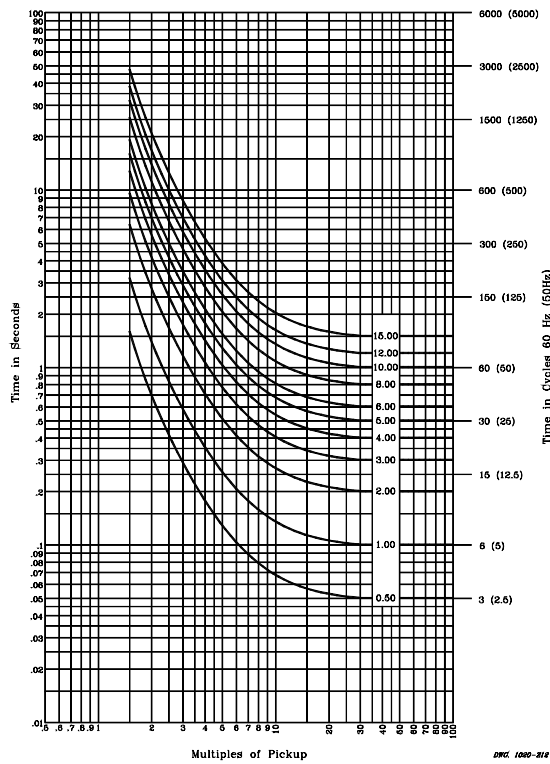


Figure 3.27: U.S. Very Inverse Curve: U3

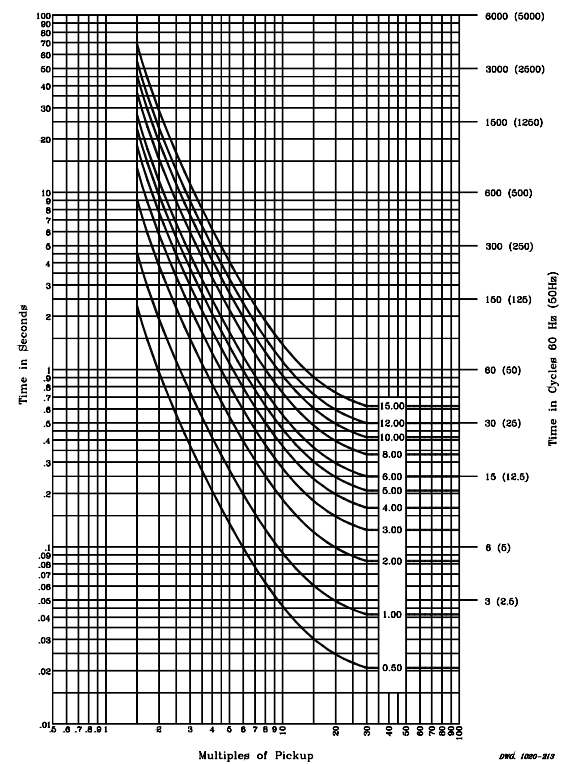


Figure 3.28: U.S. Extremely Inverse Curve: U4

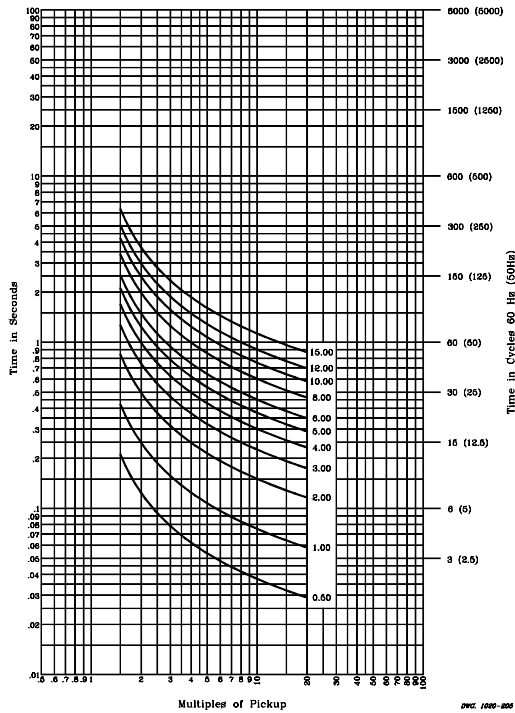


Figure 3.29: U.S. Short-Time Inverse Curve: U5

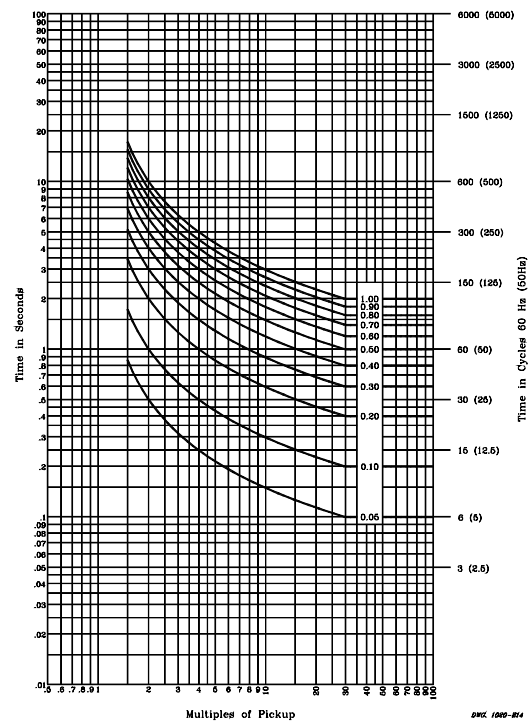


Figure 3.30: I.E.C. Class A Curve (Standard Inverse): C1

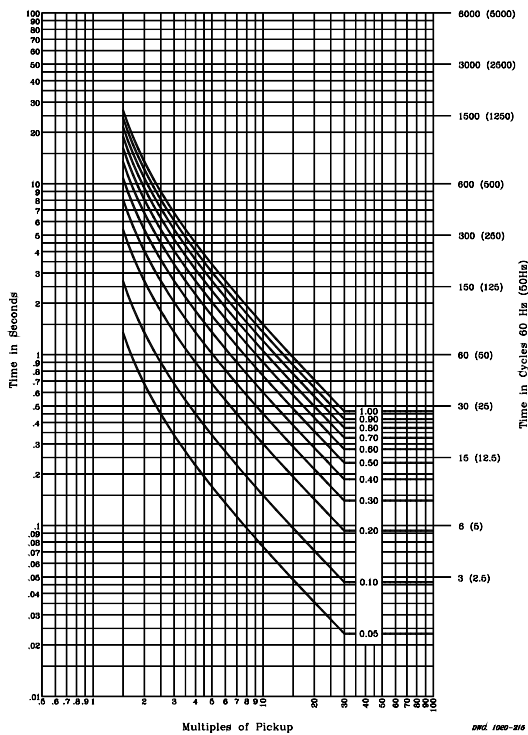


Figure 3.31: I.E.C. Class B Curve (Very Inverse): C2

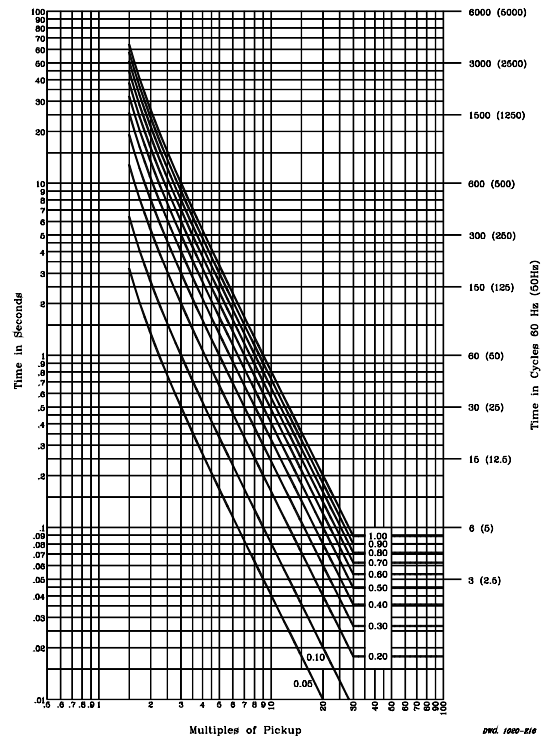


Figure 3.32: I.E.C. Class C Curve (Extremely Inverse): C3

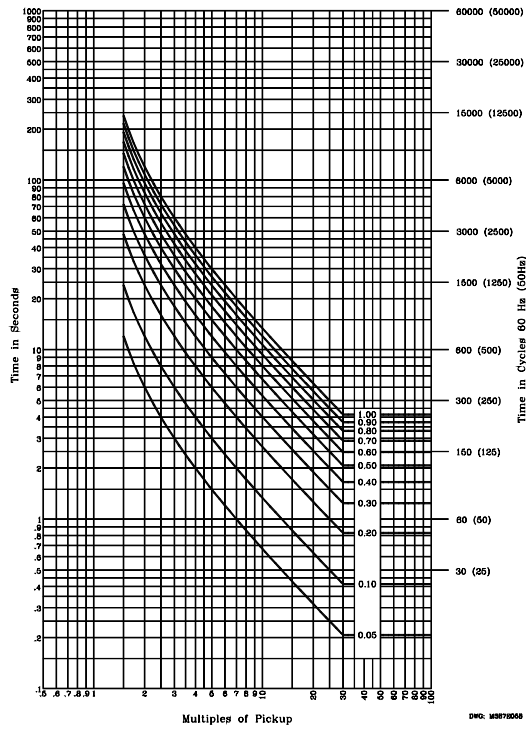


Figure 3.33: I.E.C. Long-Time Inverse Curve: C4

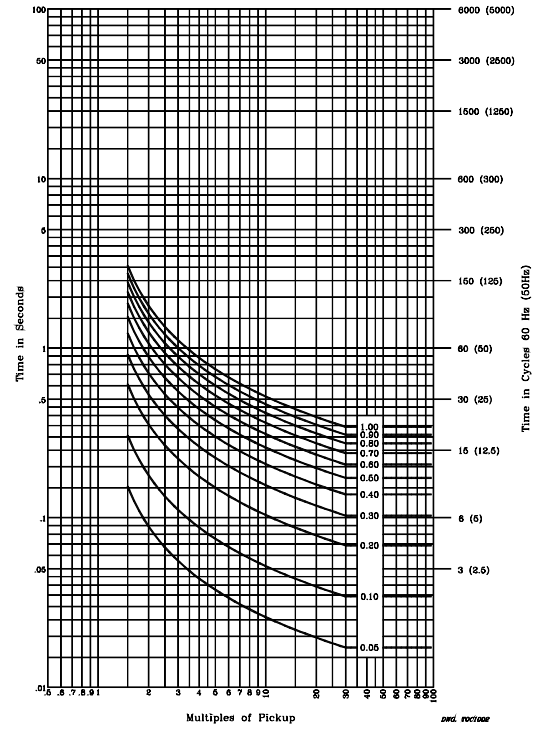


Figure 3.34: I.E.C. Short-Time Inverse Curve: C5

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SECTION 4: CONTROL LOGIC

This section explains the settings and operation of

Optoisolated inputs	(IN101–IN106, IN201–IN208)
Output contacts	(OUT101–OUT107, ALARM, OUT201–OUT212)
Remote control switches	(Remote Bits RB1 through RB16)
Multiple setting groups	(Group switching settings SS1 through SS6)
SELOGIC® control equation	
Sets (1 through 3) Variables	(Timed Variables and Latch Bits)
LED Targeting Logic	
Trip and Close Logic	
Differential Element Logic	
Overcurrent Element Logic	
SELOGIC control equations	(General Discussion)
Relay Word bits	

The above items constitute the principal logic functions of the relay. While the protective elements (overcurrent elements and the differential elements) have fixed internal logic, the availability of Relay Word bits and the use of SELOGIC control equations for many of the relay settings permit the user to customize how the protection functions interface with the user's control schemes and overall philosophy of operation.

Relay Word bits and SELOGIC control equation settings examples are used throughout this section. A complete listing of the Relay Word and explanation of the bit names are included at the end of this section, along with a discussion of SELOGIC control equations in general.

OPTOISOLATED INPUTS

Relay Word bits IN101 through IN106, and IN201 through IN208 (I/O board), follow the states of the optoisolated level-sensitive inputs having the same names. To assert an input, apply rated control voltage to the appropriate terminal pair. As noted in ***Section 1: Introduction and Specifications*** and ***Section 2: Installation***, these inputs have a specific voltage range for operation and a dropout voltage value below which the input will deassert. The inputs are not polarity sensitive; either terminal can be positive, the other negative.

Input Functions

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

IN101 =

IN102 =

Optoisolated inputs receive their function by how their corresponding Relay Word bits are used in SELOGIC control equations. Remember that any input Relay Word bit name will always appear on the right side of any SELOGIC control equation, as shown below.

Factory Settings Examples

Relay Word bit IN101 is used in the factory settings for the SELOGIC control equation circuit breaker status setting

$$52A1 = IN101$$

Connect input IN101 to a 52a circuit breaker auxiliary contact for the winding 1 breaker to provide the relay information on the position of the breaker's contacts.

If a 52b circuit breaker auxiliary contact were connected to input IN101, the setting could be changed to

$$52A1 = !IN101 \quad [!IN101 = \text{NOT}(IN101)]$$

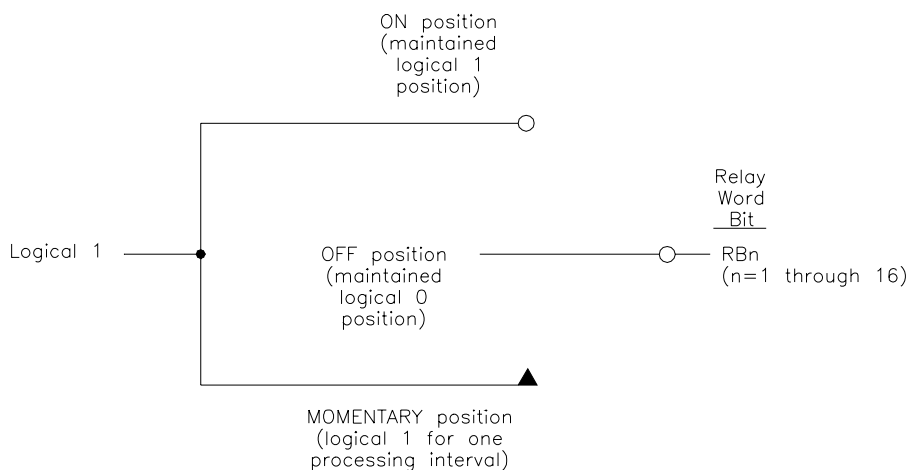
Input IN101 may also be used in other SELOGIC control equations. Any equation which requires information on the open or closed status of breaker 1 would use the IN101 Relay Word bit as this indication.

LOCAL CONTROL SWITCHES

The local control switch feature of this relay replaces traditional panel-mounted control switches. Operate the 16 local control switches using the front-panel keyboard/display (see **Section 8: Front-Panel Interface**).

REMOTE CONTROL SWITCHES

Remote control switches are operated via the serial communications port only (see **Section 7: Serial Port Communications and Commands**).



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

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

DWG: M3871013

Figure 4.1: Remote Control Switches Drive Remote Bits RB1 Through RB16

The outputs of the remote control switches in Figure 4.1 are Relay Word bits RBn (n = 1 to 16), called remote bits. Use these remote bits in SELOGIC control equations.

Any given remote control switch can be put in one of the following three positions via the serial port commands shown. Begin with the **CON n** (Control Remote Bit n) command, then specify

SRB n (Set Remote Bit n)	ON	(logical 1)
CRB n (Clear Remote Bit n)	OFF	(logical 0)
PRB n (Pulse Remote Bit n)	MOMENTARY	(logical 1 for one-eighth cycle)

Remote Bit Application

With SELOGIC control equations, the remote bits can be used in applications when you want to remotely enable or disable certain logic, depending on operating conditions of the system. Also, remote bits can be used in operating Latch Bit control switches in the additional SELOGIC control equation Sets 1 through 3. Pulse (momentarily operate) the remote bits for this application. Latch Bits are discussed later in this section.

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 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).

MULTIPLE SETTING GROUPS

The relay has six (6) independent setting groups. Each group contains Configuration Settings, General Data, Differential Elements, Overcurrent Elements, Miscellaneous Timers, SELOGIC Control Equation Sets 1 through 3, Trip Logic, Close Logic, Event Report Triggering, and Output Contact Logic. These settings can be viewed or changed via the SHO n and SET n commands. The settings for selecting which of the six groups is to be active is contained in the Global Settings area (SHO G/SET G commands).

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.

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

- SELOGIC control equation settings SS1 through SS6,
- The serial port GROUP n command (see *Section 7: Serial Port Communications and Commands*), or
- The front-panel GROUP pushbutton (see *Section 8: Front-Panel Interface*).

SELOGIC control equation settings SS1 through SS6 have priority over the serial port GROUP n command and the front-panel GROUP pushbutton in selecting the active setting group. Within the SS1 through SS6 settings, the currently active group setting SSn has priority over the other group SSn variables.

Operation of SELOGIC Control Equation Settings SS1 through SS6

The Global settings contain the set of SELOGIC control equation settings SS1 through SS6. If the SELOGIC control equation for setting SSn (n = 1 to 6) is TRUE (logical state 1), the relay is instructed to go to, or remain in, setting group n.

Table 4.1: Definitions for Active Setting Group Switching SELOGIC Control Equation Settings SS1 through SS6

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

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

Assume the active setting group starts out as setting group 3. Corresponding Relay Word bit SG3 is asserted to logical 1 as an indication that setting group 3 is the active setting group.

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 setting group 5 as the active setting group, after waiting for qualifying time setting TGR to expire:

TGR Group Change Delay Setting (settable from 0 to 900 seconds)

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 n 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 n 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 n command or the front-panel GROUP pushbutton can be used to switch the active setting group.

See *Section 7: Serial Port Communications and Commands* for more information on the serial port GROUP n command. See *Section 8: 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., latch bit states are retained during an active setting group change).

Active Setting Group Switching Example

Previous SEL relays (e.g., SEL-321 Relay and SEL-251 Relay) have multiple settings groups controlled by the assertion of three optoisolated inputs (e.g., IN101, IN102, and IN103) in different combinations as shown in Table 4.2.

Table 4.2: Active Setting Group Switching Input Logic

Input States			Active Setting Group
IN103	IN102	IN101	
0	0	0	Remote
0	0	1	Group 1
0	1	0	Group 2
0	1	1	Group 3
1	0	0	Group 4
1	0	1	Group 5
1	1	0	Group 6

The SEL-387 Relay can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-387 Relay. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in Figure 4.2.

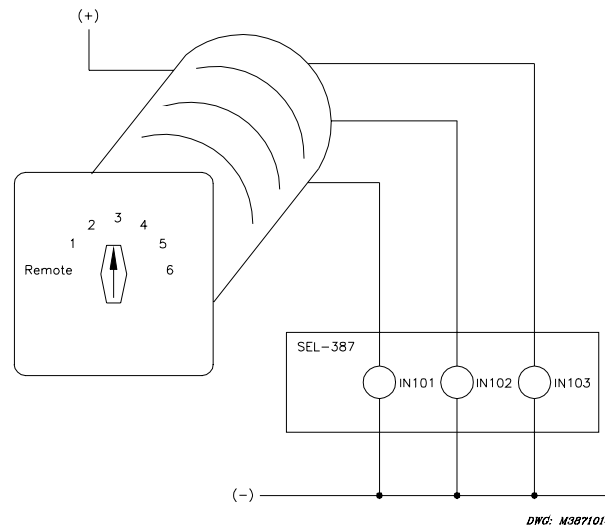


Figure 4.2: Rotating Selector Switch for Active Setting Group Selection

The selector switch has multiple internal contacts arranged to assert inputs IN101, IN102, and IN103, dependent on the switch position. As shown in Table 4.3, as the selector switch is moved from one position to another, a different setting group is activated. The logic in Table 4.2 is implemented in the SELOGIC control equation settings in Table 4.3.

Table 4.3: SELOGIC Control Equation Settings for Rotating Selector Switch

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

The REMOTE switch position deenergizes all relay inputs, thus placing all of the SS_n variables in state 0. With none of the SS_n variables asserted, the GRO n command, or the GROUP pushbutton on the front panel, can be used to change the setting group. With the switch in any other position, 1 through 6, the GRO n and GROUP functions will not effect a group change.

The setting TGR, the group change delay setting, should be set long enough so that the switch, as it is rotated from one position to another, will not remain at any intermediate position long enough to make any setting group change. For example, in rotating from position 1 to position 5, the switch must pass through positions 2, 3, and 4. It should not remain in 2, 3, or 4 for longer than TGR during this process, or it may produce multiple group changes before it finally gets to position 5.

The settings in Table 4.3 are made in the Global settings area.

CHSG Relay Word Bit Asserts During Setting Group Changes

The Relay Word bit CHSG is asserted whenever a setting group change is in process. It is defined in Table 4.9 and Table 4.10 as “Timing to change setting groups.” When group changes are initiated through one of the SS_n SELOGIC control equation settings, CHSG is asserted as soon as the new SS_n bit is asserted and the relay has made the decision to change groups. It deasserts when the SG_n bit for the new group agrees with the SS_n bit, indicating that the relay has changed to the newly requested group number. For example, assume the relay is in group 1. The active group bit SG1 equals one, while other SG_n bits are zero. All of the SS_n bits are also zero. SS4 is asserted, requesting a change to group 4. Since SS1 (same group as the active group) is not asserted, the group change process is initiated, and CHSG is asserted at the same time as SS4. After the group change is made, SG1 will deassert and SG4 will assert, indicating the relay is now in group 4. When this agreement of SS4 and SG4 occurs, CHSG will deassert to indicate the relay is no longer in the process of changing groups.

When the active group bit SG_n and its associated SS_n bit are both asserted, for example SG1 and SS1, the relay does not respond to the assertion of a new SS_n bit, such as SS3, and no group change will occur. Similarly, the CHSG bit will not assert along with SS3, since the SG1 and SS1 bits are in agreement. This agreement acts like a continuous “reset” applied to the CHSG bit.

In applications where a system-related condition requires that a change of setting groups must be done quickly and automatically, this would likely be accomplished via a contact input to the relay, which would assert an SS_n bit. In such cases, it may be desirable to immediately block some relay elements as soon as the change is needed to prevent misoperation. This could easily be done via the CHSG bit. CHSG could be used, for example, to supervise the tripping variable for differential trips. The default TR4 setting is $TR4 = 87R + 87U$; this could be changed to $TR4 = 87R * !CHSG + 87U * !CHSG$. CHSG optimizes (in this case minimizes) the amount of time to block TR4, since CHSG asserts exactly when the change of groups is needed, and deasserts exactly when the change has taken place.

For setting group changes that do not make use of the SS_n bits, namely those using the GRO n serial port command or the GROUP front-panel pushbutton, CHSG asserts about two cycles after the change command is received and deasserts shortly after the group change is made. For these cases, CHSG does not overlap the desired time period quite as precisely as when the SS_n bits are used, but group changes initiated manually through the serial port or front panel are inherently not as time critical, so a difference of a few cycles is not likely to matter as much, if at all.

Active Setting Group Retained for Power Loss, Settings Change

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.

If settings are changed (for the active setting group or one of the other setting groups), the active setting group is retained.

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

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

Note: Make Active Setting Group Switching Settings With Care

The active setting group is stored in nonvolatile memory so it can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of “writes” for all setting group changes. Exceeding the limit can result in an EEPROM self-test failure. An average of 1 setting group change per day can be made for a 25-year relay service life.

This requires that SELOGIC control equation settings SS1 through SS6 be set with some 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.

SELOGIC CONTROL EQUATION SETS (1 THROUGH 3) VARIABLES

Each Setting Group (1 through 6) has three sets of SELOGIC control equation variables for use in constructing SELOGIC control equations. In the SEL-387 these variables are of two types: timed variables and latch bits. The variables are processed in the order in which they appear in the Setting Sheets. If variables that appear earlier are used as input to later variables, the processing of both will occur within the same processing interval. If a later variable is an input to an earlier variable, the scheme output will be delayed one processing interval.

The SELOGIC control equation sets must be enabled by Group settings ESLS1, ESLS2, and/or ESLS3 in the configuration settings.

There are a total of 16 timed variables and 16 latch bits available to the user. The three SELOGIC control equation sets have different mixes of variable types, as shown below in Table 4.4.

Table 4.4: SELOGIC Control Equation Variable Mix by Set

SELOGIC Control Equation Set	Timers	Latch Bits
1	4	4
2	4	4
3	8	8

The format of the setting names for these variables is as follows:

Timed Variable Name:	SnVm	(n = Set Number; m = Variable Number)
Timer Pickup Delay:	SnVmPU	(cycles)
Timer Dropout Delay:	SnVmDO	(cycles)
Set Latch Bit:	SnSLTm	
Reset Latch Bit:	SnRLTm	(Reset takes precedence over Set)

Timers SnVmPU and SnVmDO have a setting range of about 4.63 hours:

0.00 through 999999.00 cycles in 0.125-cycle increments

The two types of variables are discussed in the following paragraphs.

Variables/Timers

Figure 4.3 shows the logic for the variables and timers. A SELOGIC control equation defines the variable SnVm. When this equation is true, the Relay Word bit SnVm is asserted. If SnVm remains true for the length of the SnVmPU setting, in cycles, the timer output asserts the Relay Word bit SnVmT (variable timed out). If SnVm deasserts, SnVmT will deassert SnVmDO cycles later.

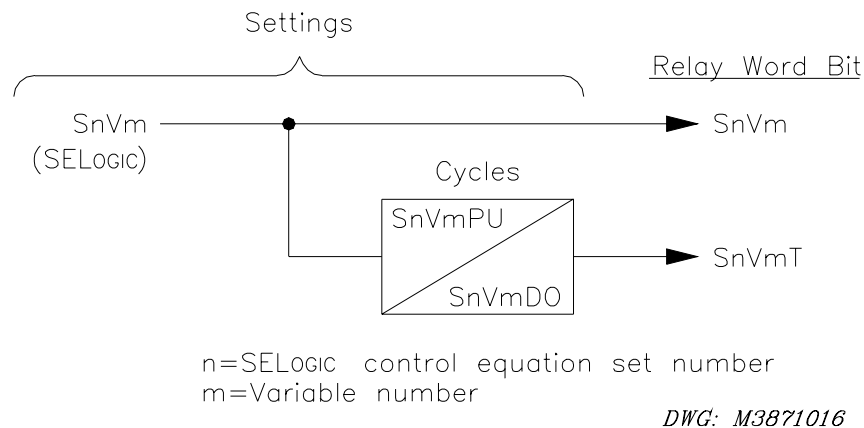


Figure 4.3: Timed Variables in SELOGIC Control Equation Sets

There are 16 variables of this type spread through the three SELOGIC control equation sets.

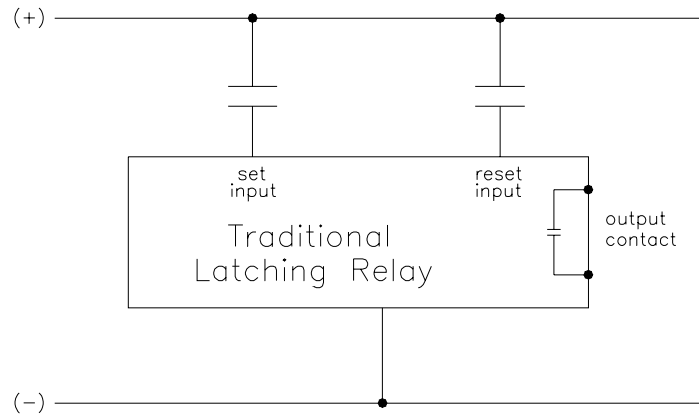
Timers Reset When Power Is Lost, Settings Are Changed, or Active Setting Group Is Changed

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 SnVm and SnVmT are reset to logical 0 and corresponding timer settings SnVmPU and SnVmDO load up again after power restoration, settings change, or active setting group switch.

Latch Control Switches

The SELOGIC control equation latch bit feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state—they are not dependent on dc voltage to maintain their output contact state. For example, if a latching relay output contact is closed and then dc voltage is lost to the panel, the latching relay output contact remains closed.

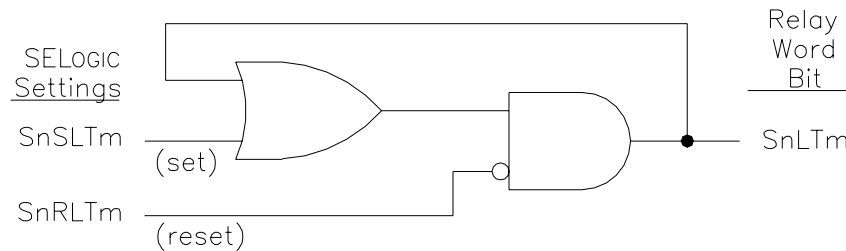
The state of a traditional latching relay output contact is changed by pulsing the latching relay inputs (see Figure 4.4). Pulse the set input to close (“set”) the latching relay output contact. Pulse the reset input to open (“reset”) the latching relay output contact. Often the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU, etc.).



DWG: M35174

Figure 4.4: Traditional Latching Relay

The latch bits in the SEL-387 Relay provide latching relay type functions (Figure 4.5).



n=SELOGIC control equation set number
m=Variable number

DWG: M3871015

Figure 4.5: Latch Bits in SELOGIC Control Equation Sets

The output of the latch bit logic is a Relay Word bit SnLTm. The bit is set by application of SnSLTm (Set latch bit), and reset by the application of SnRLTm (Reset latch bit). The Set/Reset values come from the logical state of the SELOGIC control equations stored for these two settings. These latch bits may be used in SELOGIC control equations, wherever a latching function is required.

If setting SnSLTm (Set) asserts to logical 1, latch bit SnLTm asserts to logical 1 and seals itself via the OR and AND gates. If setting SnRLTm (Reset) asserts to logical 1, the seal-in is broken and latch bit SnLTm deasserts to logical 0. If both settings SnSLTm and SnRLTm assert to logical 1, setting SnRLTm (Reset) takes precedence, and latch bit SnLTm deasserts to logical 0.

Latch Bit Behavior for Power Loss, Settings Change, Active Group Change

If power to the relay is lost and then restored, the states of the latch bits remain unchanged. This is done by retaining the latest states of the latch bits in EEPROM, where they can be recovered on power up of the relay.

If settings are changed in one of the nonactive setting groups, the states of the latch bits remain the same.

If settings are changed in the active setting group, or if a new setting group is selected to be the active group, the states of the latch bits may or may not change. When the active group changes are enabled in the relay, the latch bits will respond to the states of the SnSLTm (Set) and SnRLTm (Reset) equations, in the manner discussed above for Figure 4.5. The new latch bit states thus depend on the original state of the latch bit and on the effects of the user changes upon the set and reset equations.

The net effect is that the latch bits in the SEL-387 Relay behave exactly like traditional latching relays.

Note: Make Latch Bit 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 70 latch bit changes per day can be made for a 25-year relay service life.

OUTPUT CONTACTS

SELOGIC control equation settings OUT101 through OUT107 and OUT201 through OUT212 control Relay Word bits having the same names. These Relay Word bits in turn control the output contacts OUT101 through OUT107 and OUT201 through OUT212 (I/O board). Alarm logic/circuitry controls the ALARM output contact.

Factory Settings Example

In the factory SELOGIC control equation settings, all seven standard main board output contacts are used:

OUT101 = TRIP1	Used to trip breaker 1
OUT102 = TRIP2	Used to trip breaker 2
OUT103 = TRIP3	Used to trip breaker 3
OUT104 = TRIP4	Used to energize 86 device for tripping breakers 1 through 3
OUT105 = CLS1	Used to close breaker 1
OUT106 = CLS2	Used to close breaker 2
OUT107 = CLS3	Used to close breaker 3

Operation of Output Contacts for Different Output Contact Types

Output Contacts OUT101 through OUT107 and OUT201 through OUT212

The execution of the serial port command PULSE xxx (xxx = OUT101–OUT107, OUT201–OUT212), asserts the corresponding Relay Word bit (e.g., OUT104) to logical 1, for one or more seconds as defined by the user. The assertion of SELOGIC control equation setting OUTm (m = 101–107, 201–212) to logical 1 also asserts the corresponding Relay Word bit OUTm to logical 1.

The assertion of Relay Word bit OUT_m 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. 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. Solder jumpers JMP22 through JMP29 (main board) and JMP17 through JMP28 (I/O board) permit the user to configure any OUT_m contact to either an “a” or “b” type. OUT101 through OUT107 are factory-configured as type “a,” as are OUT201 through OUT212 if the additional I/O board is ordered.

The state of OUT_m remains the same while a setting change is in progress. However, once the new settings are enabled, the SELOGIC control equation setting for OUT_m will determine the new state of OUT_m.

OUT107 coil operation may be set to follow that of the ALARM contact by setting jumper JMP23 in the left position on the main board. OUT107 then will not respond to Relay Word bit OUT107. The OUT107 contact configuration can be set as “a” or “b,” as noted above. See **Section 2: Installation** for more information.

ALARM Output Contact

When the relay is functioning properly, the alarm logic/circuitry keeps the ALARM output contact coil energized. The type “b” ALARM output contact is normally held open. Solder jumper JMP21 may also be configured by the user for a type “a” contact, if desired.

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

The Relay Word bit !ALARM (not ALARM) is asserted to logical 1, and the ALARM output contact coil is energized, when the SEL-387 Relay is operating correctly. When the serial port command PULSE ALARM (or front panel CNTRL ALARM) is executed, the !ALARM Relay Word bit momentarily deasserts to logical 0. Also, when the relay enters Access Level 2 or Access Level B or a settings change is made, the !ALARM Relay Word bit momentarily deasserts to logical 0. When !ALARM is zero, the ALARM output contact coil is deenergized momentarily and the “b” contact falls closed. The ALARM contact also drops closed when a loss of power occurs.

ROTATING DEFAULT DISPLAY

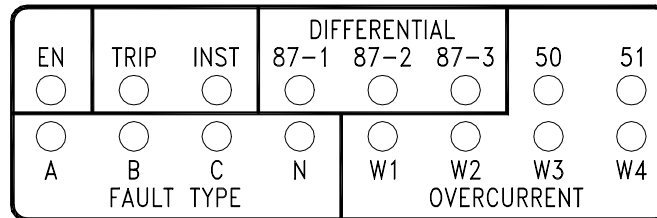
The rotating default display on the relay front panel replaces indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. See **Section 8: Front-Panel Interface** for details.

LED TARGETING LOGIC

The SEL-387 Relay has 16 LEDs on the front panel. One (EN) is dedicated to indication of the relay’s operational condition. Twelve are dedicated to specific targeting functions. Three (LEDA, LEDB, and LEDC) have default targeting logic but are fully programmable by the user.

The states of the 12 dedicated LEDs (all but EN, A, B, C) are stored in nonvolatile memory. If power is lost to the relay, these 12 targets will be restored to their last state when the relay power is restored. EN responds only to internal self-test routines, while A, B, and C respond to the present state of their respective Global SELOGIC control equation settings.

The array of LEDs is shown below in Figure 4.6.



DWG: 11172A

Figure 4.6: SEL-387 Relay Front-Panel LEDs

Table 4.5 describes the basic targeting functions associated with each of the 16 LEDs.

Table 4.5: LED Assignments

LED	Legend	Description
1	EN	Relay enabled
2	TRIP*	Relay trip
3	INST*	Instantaneous trip
4	87-1*	Differential element 1 asserted at, or 1 cycle after, rising edge of trip
5	87-2*	Differential element 2 asserted at, or 1 cycle after, rising edge of trip
6	87-3*	Differential element 3 asserted at, or 1 cycle after, rising edge of trip
7	50*	Instantaneous O/C element asserted at, or 1 cycle after, rising edge of trip
8	51*	Time O/C element asserted at, or 1 cycle after, rising edge of trip
9	A	A-phase involved in the fault (Programmable LEDA)
10	B	B-phase involved in the fault (Programmable LEDB)
11	C	C-phase involved in the fault (Programmable LEDC)
12	N*	Residual element asserted at, or 1 cycle after, rising edge of trip
13	W1*	Winding 1 overcurrent asserted at, or 1 cycle after, rising edge of trip
14	W2*	Winding 2 overcurrent asserted at, or 1 cycle after, rising edge of trip
15	W3*	Winding 3 overcurrent asserted at, or 1 cycle after, rising edge of trip
16	W4*	Winding 4 overcurrent asserted at, or 1 cycle after, rising edge of trip

* Indicates Nonvolatile Targets

The operation of each LED will be discussed in the following paragraphs.

LED 1 – EN – Relay Enabled

LED 1 illuminates only when the relay is fully enabled and ready for service. It will turn off if the relay should become disabled by certain critical failure or alarm conditions. LED 1 is the only green LED of the 16; the remaining LEDs are red.

LED 2 – TRIP – Relay Trip

LED 2 illuminates at the rising edge of any of the five trip elements, TRIP1 through TRIP5. It remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel, or via the serial port command TAR R.

LED 3 – INST – Instantaneous Trip

This LED will illuminate if any instantaneous element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Instantaneous elements include any of the overcurrent elements indicated as “50***,” the Restricted Earth Fault forward direction bit, 32IF, as well as the 87R and 87U differential elements. LED 3 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 4 – 87-1 – Differential Element 1

This LED will illuminate if the differential elements 87R or 87U are present in the TR1 through TR5 settings, and Relay Word bits 87R1 and 87R, or 87U1, are found to be asserted at the rising edge of any trip or one cycle later. If so, the 87E1 bit is also set. LED 4 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 5 – 87-2 – Differential Element 2

This LED will illuminate if the differential elements 87R or 87U are present in the TR1 through TR5 settings, and Relay Word bits 87R2 and 87R, or 87U2, are found to be asserted at the rising edge of any trip or one cycle later. If so, the 87E2 bit is also set. LED 5 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 6 – 87-3 – Differential Element 3

This LED will illuminate if the differential elements 87R or 87U are present in the TR1 through TR5 settings, and Relay Word bits 87R3 and 87R, or 87U3, are found to be asserted at the rising edge of any trip or one cycle later. If so, the 87E3 bit is also set. LED 6 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 7 – 50 – Instantaneous or Definite-Time Overcurrent Trip

This LED will illuminate if any instantaneous or definite-time overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the overcurrent elements indicated by Relay Word bits “50***” or “50***T” and the Restricted Earth Fault forward direction bit, 32IF. LED 7 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 8 – 51 – Inverse-Time Overcurrent Element Trip

This LED will illuminate if any inverse-time overcurrent element present in the TR1 through TR5 settings has timed out and is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the overcurrent elements indicated by Relay Word bits “51**(*)T,” which include the four combined overcurrent elements, as well as the REFP bit indicating time-out of the Restricted Earth Fault inverse-time curve. LED 8 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 9 – A – A-Phase Involved in the Fault (Programmable LEDA)

LED 9 is programmable via the LEDA SELOGIC control equations Global setting. It is updated each processing interval. If LEDA is true, LED 9 is illuminated. Otherwise, it is reset. The factory default setting is $LEDA = OCA + 87E1$.

Relay Word bit OCA indicates A-phase overcurrent during the fault. It is derived by first checking which winding “Wn” LED is lit, then asserting if the associated 50An4 overcurrent element bit is asserted, or if the magnitude of the IAWn phase current is greater than or equal to the magnitudes of IBWn and ICWn.

Relay Word bit 87E1 indicates differential element 87-1 operation and follows LED 4 operation (see LED 4 discussion).

LED 10 – B – B-Phase Involved in the Fault (Programmable LEDB)

LED 10 is programmable via the LEDB SELOGIC control equations Global setting. It is updated each processing interval. If LEDB is true, LED 10 is illuminated. Otherwise, it is reset. The factory default setting is $LEDB = OCB + 87E2$.

Relay Word bit OCB indicates B-phase overcurrent during the fault. It is derived by first checking which winding “Wn” LED is lit, then asserting if the associated 50Bn4 overcurrent element bit is asserted, or if the magnitude of the IBWn phase current is greater than or equal to the magnitudes of IAWn and ICWn.

Relay Word bit 87E2 indicates differential element 87-2 operation and follows LED 5 operation (see LED 5 discussion).

LED 11 – C – C-Phase Involved in the Fault (Programmable LEDC)

LED 11 is programmable via the LEDC SELOGIC control equations Global setting. It is updated each processing interval. If LEDC is true, LED 11 is illuminated. Otherwise, it is reset. The factory default setting is $LEDC = OCC + 87E3$.

Relay Word bit OCC indicates C-phase overcurrent during the fault. It is derived by first checking which winding “Wn” LED is lit, then asserting if the associated 50Cn4 overcurrent element bit is asserted, or if the magnitude of the ICWn phase current is greater than or equal to the magnitudes of IAWn and IBWn.

Relay Word bit 87E3 indicates differential element 87-3 operation and follows LED 6 operation (see LED 6 discussion).

LED 12 – N – Residual Overcurrent Element Trip

This LED will illuminate if any residual overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the winding overcurrent elements indicated by Relay Word bits “50N**,” “50N**T,” or “51N*T.” Also included are Combined Overcurrent elements indicated by Relay Word bits 51NC1T and 51NC2T and the Restricted Earth Fault bits, 32IF and REFP. LED 12 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 13 – W1 – Winding 1 Overcurrent Element Operation

This LED will illuminate if any winding 1 overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the 23 Relay Word bits associated with winding 1 overcurrent elements. LED 13 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 14 – W2 – Winding 2 Overcurrent Element Operation

This LED will illuminate if any winding 2 overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the 23 Relay Word bits associated with winding 2 overcurrent elements. LED 14 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 15 – W3 – Winding 3 Overcurrent Element Operation

This LED will illuminate if any winding 3 overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the 23 Relay Word bits associated with winding 3 overcurrent elements. LED 15 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

LED 16 – W4 – Winding 4 Overcurrent Element Operation

This LED will illuminate if any winding 4 overcurrent element present in the TR1 through TR5 settings is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the 23 Relay Word bits associated with winding 4 overcurrent elements. LED 16 remains lit until reset by the TRGTR element. TRGTR is asserted for one cycle either via the TARGET RESET pushbutton on the front panel or via the serial port command TAR R.

TRIP AND CLOSE LOGIC

The trip logic and close logic for the SEL-387 Relay operate in a similar manner. Each has a SELOGIC control equation setting to set or latch the logic and another SELOGIC control equation setting to reset or unlatch the logic. Each also has other elements or functions that will unlatch the logic. The output of each logic is a Relay Word bit which can be assigned to operate output contacts or in any other manner for which a Relay Word bit can be used. The specifics of each type of logic are discussed below.

Trip Logic

There are five specific sets of trip logic within the SEL-387 Relay. They are designed to operate when SELOGIC control equation trip variable setting TRm is asserted (m = 1, 2, 3, 4, 5) and to unlatch when SELOGIC control equation setting ULTRm is asserted. The output of the logic is Relay Word bit TRIPm. The logic operates much like the Latch Bit function in SELOGIC control equation Sets 1 through 3, with additional characteristics. In the trip logic, the set or latch function has priority over the reset or unlatch function.

Figure 4.7 shows the logic diagram for the TRIP1 logic. The remaining logic for TRIP2 through TRIP5 is identical, using variables TR2 through TR5 and ULTR2 through ULTR5, respectively.

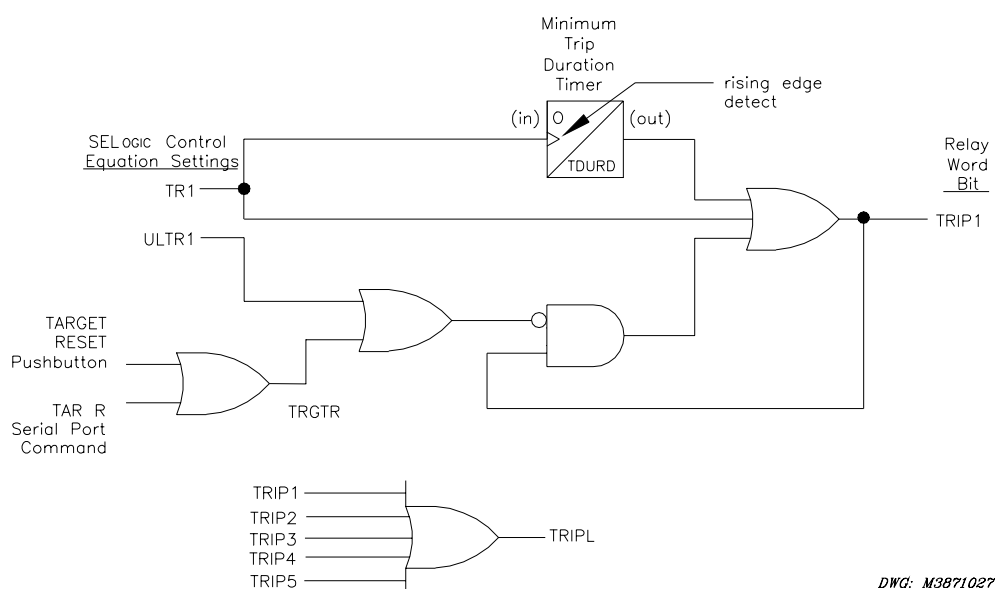


Figure 4.7: SEL-387 Relay Trip Logic (TRIP1)

The logic begins with the assertion of SELOGIC control equation TR1, one of the Group variables. In our example application, Relay Word bits representing three winding 1 overcurrent elements and the OPE 1 command are used to assert TR1. TR1 directly asserts TRIP1 via the three-input OR gate at the right.

However, TR1 may only assert briefly while a more lengthy assertion of TRIP1 is desired. There are two means to assure a longer TRIP1 assertion. At the top of the diagram is an Edge Trigger Timer. It detects the rising edge of TR1, and issues a second output to the OR gate. This second output will last the duration of Group setting TDURD (minimum trip duration timer). Once the rising edge has been detected and the timing started, the ongoing state of the TR1 input to the timer is ignored. Thus, TRIP1 will be asserted for a minimum of TDURD cycles, even if TR1 is asserted for as little as one processing interval, or if the unlatch portion of the logic is asserted before TDURD expires. The default setting of TDURD is nine cycles.

TRIP1 also seals itself in via the AND gate at the bottom. This AND gate receives the negated inputs from the unlatching functions. As long as no unlatch function is asserted, the seal of TRIP1 remains intact. TRIP1 is used to drive an output contact to initiate tripping of the breaker or breakers. In our example, $OUT101 = TRIP1$.

The unlatching of the trip logic is accomplished via three means. The first is the assertion of the SELOGIC control equation setting ULTR1. In our example, $ULTR1 = !50P13 = \text{NOT } 50P13$. This current element is set to pick up at 0.5 A. Thus, ULTR1 asserts when the currents in all three phases drop below 0.5 A, indicating successful three-pole opening of the breaker.

The other unlatching mechanism is manual, via pushing of the TARGET RESET pushbutton on the front panel or sending the TAR R serial port command to the relay. Either of these asserts the Relay Word bit TRGTR, which is also used to reset the LED targets on the front panel. In the trip logic, assertion of ULTR1 or TRGTR places a zero input on the AND gate and thereby breaks the TRIP1 seal-in loop.

With the deassertion of TRIP1, OUT101 opens, deenergizing the trip circuit. Presumably, the trip circuit current has already been interrupted by a breaker 52a contact in series with the trip coil. Should a failure to trip occur, followed by backup tripping of other breakers, the TR1 setting may deassert and the ULTR1 setting may assert, while the contact continues to carry dc trip circuit current. This could damage the contact as it tries to interrupt this current. The emergency nature of the situation might warrant this minor risk, but another choice might be to program into the ULTR1 setting not only removal of current but also indication that the breaker has opened.

Note that TRIP1 will always be asserted so long as TR1 is asserted, regardless of the action of ULTR1 or the TARGET RESET commands and that TRIP1 will be asserted for an absolute minimum of TDURD cycles no matter how short the length of time TR1 has been asserted. This is the essence of the trip logic.

At the bottom of Figure 4.7 is an additional OR gate. The five TRIPm Relay Word bits are all inputs to this gate, and the output is another Relay Word bit, TRIPL. TRIPL asserts for any trip output. It may be useful for other applications of SELOGIC control equations in the SEL-387 Relay.

Close Logic

There are four specific sets of close logic within the SEL-387 Relay. They are designed to operate when SELOGIC control equation close variable setting CL_m is asserted ($m = 1, 2, 3, 4$), and to unlatch when SELOGIC control equation setting ULCL_m is asserted. The output of the logic is Relay Word bit CLS_m. The logic operates much like the Latch Bit function in SELOGIC control equation Sets 1 through 3 with additional characteristics. In the close logic, the reset or unlatch function has priority over the set or latch function.

Figure 4.8 shows the logic diagram for the CLS1 logic. The remaining logic for CLS2 through CLS4 is identical, using variables CL2 through CL4 and ULCL2 through ULCL4, respectively.

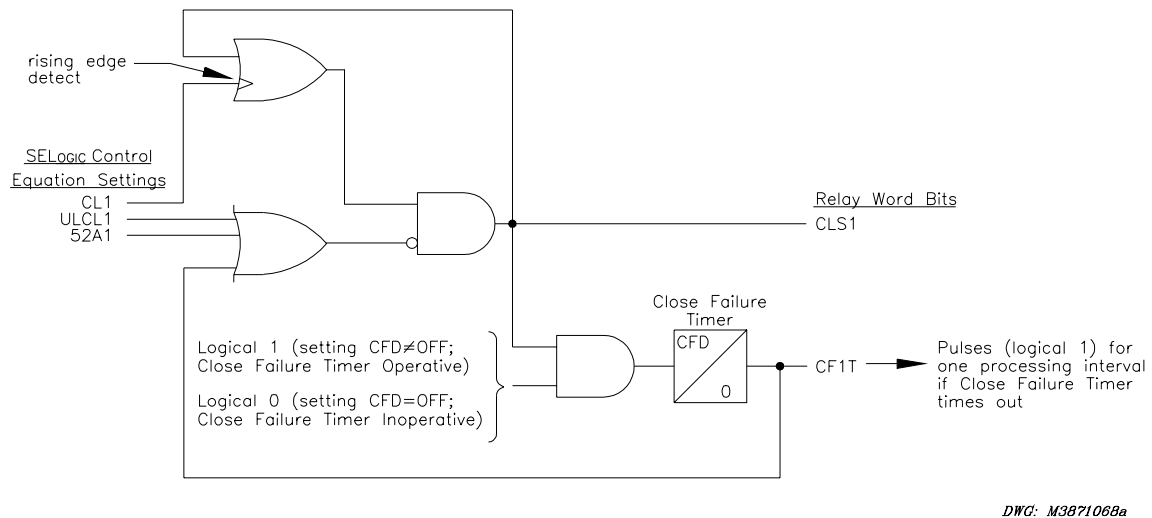


Figure 4.8: SEL-387 Relay Close Logic (CLS1)

The logic begins with the assertion of SELOGIC control equation CL1, one of the Group variables. In our example application, $CL1 = CC1 + /IN104$. Thus, CL1 will assert either if (1) a CLO 1 command has been sent to the relay via a serial port, or if (2) input IN104 has been energized via an external SCADA, recloser, or control switch contact, for example. CL1 does not directly assert CLS1 but acts as one input to the AND gate at the center. The other input to the AND gate is a negated OR gate output which asserts whenever any of the unlatching functions is in effect. Thus, unlatch elements take precedence over the close command elements.

Assuming no unlatch elements are asserted, assertion of CL1 produces assertion of the output Relay Word bit CLS1. CLS1 seals itself in via the OR gate at the top and begins to drive the output contact OUT105 (=CLS1), leading to the breaker one closing circuit. CLS1 can also be used in other SELOGIC control equations. CLS1 will remain asserted, and OUT105 will remain closed, until the close logic is unlatched by one of three means: assertion of the ULCL1 setting, closure of the breaker 52a auxiliary contact, or a Close Failure Detection. These three functions are inputs to the OR gate at the mid-left.

The ULCL1 SELOGIC control equation setting defines conditions for unlatching the close logic. If CL1 is not asserted when ULCL1 asserts, ULCL1 effectively “blocks” the close logic. If CL1 should assert after ULCL1 has been asserted, it effectively will be ignored, and CLS1 will not assert. If CL1 has asserted before ULCL1 and the closing process has begun, assertion of ULCL1 will unseal CLS1 and interrupt the process. In our example, $ULCL1 = TRIP1 + TRIP4$.

That is, if a winding 1 overcurrent trip, or a high-speed differential trip has been initiated, ULCL1 will prevent the close process from starting, or it will prevent it from going to completion if it has already begun.

Under normal circumstances, the second means of unlatching occurs. This is the closure of the Breaker 1 52a contact. The close logic setting 52A1 = IN101. When CLS1 asserts, OUT105 closes and the breaker begins to close. When the breaker closing is complete, the 52a contact closes, duplicating the operation of the breaker contacts themselves, and effectively indicating that the breaker is closed. The 52a contact is wired to IN101. When IN101 asserts, the equation 52A1 asserts and unlatches the close logic, deasserting CLS1 and opening OUT105. The close process is now complete. (Presumably, interruption of the current in the closing circuit has been accomplished via a breaker 52b contact, and not by OUT105.)

The third means of unlatching is a Close Failure Detection. This function can be set OFF if desired. This function is useful in the event the breaker does not close in response to energization of the closing circuit. This might be due to electrical problems or mechanical binding or breakage. With the breaker not moving, CLS1 will remain asserted and OUT105 will stay closed for an extended period, possibly resulting in an electrical fire, system damage, or injury to personnel. Within the logic when CLS1 asserts, an input is also sent to the AND gate at the bottom. The second AND input is 1 if the Close Failure detection timer (CFD) is set to some value, and 0 if CFD is set to OFF. In our example, we have selected CFD = 60 cycles (one second). With CFD set to some value, a timer is started. At the expiration of CFD, an output is asserted as Relay Word bit CFT1. This bit is pulsed for one processing interval. It is sent to the OR gate for the unlatch functions and interrupts the closing process. This prevents the closing circuit from being energized too long. It also creates the possibility that the OUT105 contact may be damaged by interrupting the closing circuit current flow. However, the emergency nature of the situation generally would be worth the risk. The CFT1 bit might also be used to set a SELOGIC control equation Latch Bit to close a contact, informing a SCADA system of the aborted closure attempt.

SELOGIC CONTROL EQUATIONS

Throughout this manual, reference is made to settings or variables which take the form of SELOGIC control equations. It is a convenient method for providing customized control logic to the relay, to enhance the relay performance for specific customer needs and practices.

While most users of SEL relays are at least somewhat familiar with SELOGIC control equations in a general sense, the capabilities of this logic, the types of logical operators, the number of allowable variables, and the construction rules of the equations have varied from one relay product to another. This portion of the manual is intended to inform the user of how SELOGIC control equations work in general and how they are implemented in the SEL-387 Relay.

SELOGIC Control Equations Fundamental Description

The basic building blocks of SELOGIC control equations are the Relay Word bits. A complete list of these bits is included at the end of this section of the manual. The Relay Word bits are simple digital quantities having a logical value of either 0 or 1. The terms “assert” or “asserted” refer to a Relay Word bit that has a value of 1 or is changing from 0 to 1. The terms “deassert” or “deasserted” refer to a Relay Word bit that has a value of 0 or is changing from 1 to 0. Relay

Word bits are asserted or deasserted by various elements within the relay, and are used in the fixed internal logic of the relay to make decisions, to interpret inputs, or to drive outputs. These same bits are made available to the user, so that the user can exercise flexibility in defining inputs or outputs, specifying control variables for internal logic, or for creating special customized logic through the use of SELOGIC control equations.

SELOGIC control equations use logic similar to Boolean algebra logic. A SELOGIC control equation consists of some combination of Relay Word bits and logical operators that define how the Relay Word bits are to be evaluated as a group or individually. The Relay Word bits take on their values of 0 or 1, the operators perform logical operations on these values, and the result is a logical value of 0 or 1 for the SELOGIC control equation itself. Thus, expressions of assertion or deassertion apply to the SELOGIC control equation as a whole, as well as to the individual components of the equation. In the end, the SELOGIC control equation itself is a simple digital variable having a value of 0 or 1.

SELOGIC Control Equation Logical Operators

In the SEL-387 Relay, there are six logical operators which can be used in SELOGIC control equations. These operators exist in a hierarchy, from the highest level operator to be processed to the lowest level operator. Table 4.6 lists these operators in their order of processing.

Table 4.6: SELOGIC Control Equation Operators

Operator	Logic Function
()	parentheses
!	NOT (negation)
/	rising edge detect
\	falling edge detect
*	AND
+	OR

Parentheses Operator ()

More than one set of parentheses can be used in a SELOGIC control equation. However, parentheses cannot be “nested,” that is you cannot have parentheses within parentheses. The following is an example:

$$S1V1 = (IN105 + RB3) * (87R + 87U)$$

The expressions within the parentheses are evaluated first. First, is IN105 OR RB3 asserted; next, is 87R OR 87U asserted. Assuming that at least one bit is asserted in each parentheses, the equation can now be evaluated: $S1V1 = 1 * 1 = 1$. The equation for S1V1 is thus asserted.

NOT Operator !

The ! operator performs a simple negation or inversion. On logic diagrams, it is represented by a small circle on an input or output line. Whatever the state of the logical quantity to which it is

applied, it simply reverses that state. For example, if 87R is a logical 1, then !87R is a logical 0. The ! operator can be applied to a parentheses containing several elements. The expression within the parentheses is evaluated first then the result is negated.

**Rising-Edge and Falling-Edge Operators / and **

These operators can be applied to individual Relay Word bits only. They cannot be used on groups in parentheses or on negated elements. They are not interested in the present value of that bit, as are most operators. Rather, they are only intended to detect a change of that value. The rising-edge operator “/” detects a change from a 0 state to a 1 state. The falling-edge operator “\” detects a change from a 1 state to a 0 state. Typical applications might include triggering an event report or unlatching internal logic. These two operators assert a 1 for a single processing interval, when they sense the change of state.

AND and OR Operators * and +

These operators produce an output state that combines the states of two or more inputs. The AND operator requires that every one of the inputs is a logical 1 before it issues a logical 1 output. For example, in the equation $S1V1 = 87R * IN103$, S1V1 will only assert if 87R=1 and IN103=1.

The OR operator only requires that one of the several inputs be a logical 1 in order to assert an output state of 1. For example, in this relay there is a Relay Word bit $TR1PL = TRIP1 + TRIP2 + TRIP3 + TRIP4 + TRIP5$. All TR1PL needs to assert is a 1 from any of the five Ored inputs. Thus, it is useful for indicating that “any trip” has occurred.

Ways of Setting SELOGIC Control Equation Relay Settings

Many of the Group and Global settings are defined as being SELOGIC control equations. A typical example would be the torque-control variables for the various overcurrent elements. For example, let us look at the setting 51P1TC for torque controlling the winding 1 phase inverse-time overcurrent element.

We could set 51P1TC to a single Relay Word bit. For example, $51P1TC = IN105$. This might be used for torque controlling by a contact input from some external device like a directional relay.

We could set 51P1TC to some combination of Relay Word bits. For example, $51P1TC = IN105 * !IN106$. Here, we might wish to supervise the element as before, from an external directional relay, but only if there is no input to IN106. IN106 could be a contact input from SCADA or a manual control switch, to disable the operation of the winding 1 inverse-time element. So long as voltage is applied to IN106, the 51P1 element will not operate, even if the directional relay gives permission.

We could set 51P1TC directly to 1. If $51P1TC = 1$, the 51P1 element is always ready to operate on current alone.

We could set 51P1TC directly to 0. If $51P1TC = 0$, the 51P1 element will never operate. This is one way, for example, to temporarily disable the 51P1 for some operational reason. It could be done using the SET command via a serial port from a remote location.

Limitations of SELOGIC Control Equations

Any single SELOGIC control equation setting is limited to 17 Relay Word bits that can be combined together with the SELOGIC control equation operators listed in Table 4.6. If this limit must be exceeded, use a SELOGIC control equation variable (SnVm) as an intermediate setting step.

For example, assume that a trip equation (SELOGIC control equation trip setting, TRn) needs more than 17 Relay Word bits in its equation setting. Instead of placing all Relay Word bits into TRn, program some of them into the SELOGIC control equation setting, SnVm. Next use the resultant SELOGIC control equation variable output (Relay Word bit SnVm) in the SELOGIC control equation trip setting, TRn.

The SELOGIC control equation settings in the Group settings are limited to no more than 441 (SEL-387-5 Relay) or 462 (SEL-387-6 Relay) elements and 74 (SEL-387-5 Relay) or 77 (SEL-387-6 Relay) rising-edge or falling-edge operators. In the Global settings, they are limited to no more than 81 elements and 14 rising-edge or falling-edge operators. Table 4.7 summarizes this information.

An attempt to set the relay with more than 17 operands will result in the message "Maximum of 17 elements allowed in a SELOGIC equation." The relay will then prompt the user to reenter the equation. An attempt to save Group settings with more than 441 (SEL-387-5 Relay) or 462 (SEL-387-6 Relay) Relay Word bits or Global settings with more than 81 Relay Word bits will result in the message "Overall SELOGIC setting size too large. Try simplifying equations." The relay will then return to the first nonhidden SELOGIC control equation for editing.

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 counts as one element.

After SELOGIC control equation settings have been made and the settings are saved, the SEL-387 Relay responds with the following message:

```
SCEUSE    xx.x
GRnCHK    yyyy
```

This message indicates that xx.x% of the maximum number of Relay Word bits are being used (SCEUSE = SELOGIC control equation use) and that the Global or Group n checksum (GBLCHK or GRnCHK) is yyyy. The relay provides use and checksum results for the GLOBAL and GROUP n settings.

Table 4.7: Maximums for SELOGIC Control Equations

	Group Setting Class	Global Setting Class
Relay Word bits per Equation	17	17
Relay Word bits per Setting Class	441 (SEL-387-5 Relay) 462 (SEL-387-6 Relay)	81
Equations per Setting Class (with two 16-output interface boards)	147 (SEL-387-5 Relay) 154 (SEL-387-6 Relay)	29
Rising- or Falling-Edge Operators per Setting Class	74 (SEL-387-5 Relay) 77 (SEL-387-6 Relay)	14

RELAY WORD BITS

The available Relay Word bits which can be used in SELOGIC control equations (except Row 0 or Row 1 target elements) are listed below in Table 4.8 through Table 4.10. Table 4.8 shows the names and locations in each row. The row number or bit name can be used when using the TAR command. Table 4.9 lists the Relay Word bit definitions, in their row order. Table 4.10 lists the Relay Word bits alphabetically to provide an easier method for looking for a specific bit.

Table 4.8: SEL-387 Relay Word Bits

Row	SEL-387 Relay Word Bits							
0	EN	TRIP	INST	87-1	87-2	87-3	50	51
1	A	B	C	N	W1	W2	W3	W4
2	50P11	50P11T	50P12	51P1	51P1T	51P1R	PDEM1	OCA
3	50A13	50B13	50C13	50P13	50A14	50B14	50C14	50P14
4	50N11	50N11T	50N12	51N1	51N1T	51N1R	NDEM1	OC1
5	50Q11	50Q11T	50Q12	51Q1	51Q1T	51Q1R	QDEM1	CC1
6	50P21	50P21T	50P22	51P2	51P2T	51P2R	PDEM2	OCB
7	50A23	50B23	50C23	50P23	50A24	50B24	50C24	50P24
8	50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
9	50Q21	50Q21T	50Q22	51Q2	51Q2T	51Q2R	QDEM2	CC2
10	50P31	50P31T	50P32	51P3	51P3T	51P3R	PDEM3	OCC
11	50A33	50B33	50C33	50P33	50A34	50B34	50C34	50P34
12	50N31	50N31T	50N32	51N3	51N3T	51N3R	NDEM3	OC3
13	50Q31	50Q31T	50Q32	51Q3	51Q3T	51Q3R	QDEM3	CC3
14	50P41	50P41T	50P42	51P4	51P4T	51P4R	PDEM4	CTS
15	50A43	50B43	50C43	50P43	50A44	50B44	50C44	50P44
16	50N41	50N41T	50N42	51N4	51N4T	51N4R	NDEM4	OC4
17	50Q41	50Q41T	50Q42	51Q4	51Q4T	51Q4R	QDEM4	CC4
18	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R
19	2HB1	2HB2	2HB3	5HB1	5HB2	5HB3	TH5	TH5T
20	87BL1	87BL2	87BL3	87BL	87E1	87E2	87E3	32IE
21	87O1	87O2	87O3	50GC	50G4	32IR	32IF	REFP
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2
23	51PC2	51PC2T	51PC2R	51NC2	51NC2T	51NC2R	DC3	DC4
24	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
25	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
26	SG1	SG2	SG3	SG4	SG5	SG6	CHSG	COMFLG+
27	*	*	IN106	IN105	IN104	IN103	IN102	IN101
28	IN208	IN207	IN206	IN205	IN204	IN203	IN202	IN201
29	IN216	IN215	IN214	IN213	IN212	IN211	IN210	IN209
30	IN308	IN307	IN306	IN305	IN304	IN303	IN302	IN301
31	IN316	IN315	IN314	IN313	IN312	IN311	IN310	IN309
32	S1V1	S1V2	S1V3	S1V4	S1V1T	S1V2T	S1V3T	S1V4T
33	S2V1	S2V2	S2V3	S2V4	S2V1T	S2V2T	S2V3T	S2V4T

Row	SEL-387 Relay Word Bits							
34	S3V1	S3V2	S3V3	S3V4	S3V5	S3V6	S3V7	S3V8
35	S3V1T	S3V2T	S3V3T	S3V4T	S3V5T	S3V6T	S3V7T	S3V8T
36	S1LT1	S1LT2	S1LT3	S1LT4	S2LT1	S2LT2	S2LT3	S2LT4
37	S3LT1	S3LT2	S3LT3	S3LT4	S3LT5	S3LT6	S3LT7	S3LT8
38	TLL+	RLL+	FAA1+	FAA2+	TO1+	TO2+	HS1+	HS2+
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2
40	BCWA3	BCWB3	BCWC3	BCW3	BCWA4	BCWB4	BCWC4	BCW4
41	TRIP1	TRIP2	TRIP3	TRIP4	TRIP5	TRIPL	CSE+	TRGTR
42	CLS1	CLS2	CLS3	CLS4	CF1T	CF2T	CF3T	CF4T
43	!ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101
44	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	OUT207	OUT208
45	OUT209	OUT210	OUT211	OUT212	OUT213	OUT214	OUT215	OUT216
46	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
47	OUT309	OUT310	OUT311	OUT312	OUT313	OUT314	OUT315	OUT316
48	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8
49	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16

*Reserved for future use.

+SEL-387-6 Relay only.

Rows 28–31 optoisolated inputs IN201–IN216 and IN301–IN316 may be available with an extra I/O board. The corresponding Relay Word bits are only operational with an extra I/O board. These rows will show asterisks in response to the TAR command, if an optional I/O board is not installed.

Row 38 thermal element Relay Word bits are only available in the SEL-387-6 Relay.

Rows 44–47 output contacts OUT201–OUT216 and OUT301–316 may be available with an extra I/O board. The corresponding Relay Word bits are only operational with an extra I/O board. These rows will show asterisks in response to the TAR command, if an optional I/O is not installed.

Table 4.9: Relay Word Bit Definitions

Row	Bit	Definition
0	All	LED targets - not usable in SELOGIC control equations
1	All	LED targets - not usable in SELOGIC control equations
2	50P11	Winding 1 phase definite-time O/C Level 1 element picked up
	50P11T	Winding 1 phase definite-time O/C Level 1 element timed out
	50P12	Winding 1 phase instantaneous O/C Level 2 element picked up
	51P1	Winding 1 phase inverse-time O/C element picked up
	51P1T	Winding 1 phase inverse-time O/C element timed out
	51P1R	Winding 1 phase inverse-time O/C 51P1 element is reset
	PDEM1	Winding 1 phase demand current threshold exceeded
	OCA	O/C element A-phase selection

Row	Bit	Definition
3	50A13	Winding 1 A-phase instantaneous O/C Level 3 element picked up
	50B13	Winding 1 B-phase instantaneous O/C Level 3 element picked up
	50C13	Winding 1 C-phase instantaneous O/C Level 3 element picked up
	50P13	50A13 + 50B13 + 50C13
	50A14	Winding 1 A-phase instantaneous O/C Level 4 element picked up
	50B14	Winding 1 B-phase instantaneous O/C Level 4 element picked up
	50C14	Winding 1 C-phase instantaneous O/C Level 4 element picked up
	50P14	50A14 + 50B14 + 50C14
4	50N11	Winding 1 residual definite-time O/C Level 1 element picked up
	50N11T	Winding 1 residual definite-time O/C Level 1 element timed out
	50N12	Winding 1 residual instantaneous O/C Level 2 element picked up
	51N1	Winding 1 residual inverse-time O/C element picked up
	51N1T	Winding 1 residual inverse-time O/C element timed out
	51N1R	Winding 1 residual inverse-time O/C 51N1 element is reset
	NDEM1	Winding 1 residual demand current threshold exceeded
	OC1	Breaker 1 OPEN command execution
5	50Q11	Winding 1 neg.-seq. definite-time O/C Level 1 element picked up
	50Q11T	Winding 1 neg.-seq. definite-time O/C element timed out
	50Q12	Winding 1 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q1	Winding 1 neg.-seq. inverse-time O/C element picked up
	51Q1T	Winding 1 neg.-seq. inverse-time O/C element timed out
	51Q1R	Winding 1 neg.-seq. inverse-time O/C 51Q1 element is reset
	QDEM1	Winding 1 neg.-seq. demand current threshold exceeded
	CC1	Breaker 1 CLOSE command execution
6	50P21	Winding 2 phase definite-time O/C Level 1 element picked up
	50P21T	Winding 2 phase definite-time O/C Level 1 element timed out
	50P22	Winding 2 phase instantaneous O/C Level 2 element picked up
	51P2	Winding 2 phase inverse-time O/C element picked up
	51P2T	Winding 2 phase inverse-time O/C element timed out
	51P2R	Winding 2 phase inverse-time O/C 51P2 element is reset
	PDEM2	Winding 2 phase demand current threshold exceeded
	OCB	O/C element B-phase selection

Row	Bit	Definition
7	50A23	Winding 2 A-phase instantaneous O/C Level 3 element picked up
	50B23	Winding 2 B-phase instantaneous O/C Level 3 element picked up
	50C23	Winding 2 C-phase instantaneous O/C Level 3 element picked up
	50P23	50A23 + 50B23 + 50C23
	50A24	Winding 2 A-phase instantaneous O/C Level 4 element picked up
	50B24	Winding 2 B-phase instantaneous O/C Level 4 element picked up
	50C24	Winding 2 C-phase instantaneous O/C Level 4 element picked up
	50P24	50A24 + 50B24 + 50C24
8	50N21	Winding 2 residual definite-time O/C Level 1 element picked up
	50N21T	Winding 2 residual definite-time O/C Level 1 element timed out
	50N22	Winding 2 residual instantaneous O/C Level 2 element picked up
	51N2	Winding 2 residual inverse-time O/C element picked up
	51N2T	Winding 2 residual inverse-time O/C element timed out
	51N2R	Winding 2 residual inverse-time O/C 51N2 element is reset
	NDEM2	Winding 2 residual demand current threshold exceeded
	OC2	Breaker 2 OPEN command execution
9	50Q21	Winding 2 neg.-seq. definite-time O/C Level 1 element picked up
	50Q21T	Winding 2 neg.-seq. definite-time O/C Level 1 element timed out
	50Q22	Winding 2 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q2	Winding 2 neg.-seq. inverse-time O/C element picked up
	51Q2T	Winding 2 neg.-seq. inverse-time O/C element timed out
	51Q2R	Winding 2 neg.-seq. inverse-time O/C 51Q2 element is reset
	QDEM2	Winding 2 neg.-seq. demand current threshold exceeded
	CC2	Breaker 2 CLOSE command execution
10	50P31	Winding 3 phase definite-time O/C Level 1 element picked up
	50P31T	Winding 3 phase definite-time O/C Level 1 element timed out
	50P32	Winding 3 phase instantaneous O/C Level 2 element picked up
	51P3	Winding 3 phase inverse-time O/C element picked up
	51P3T	Winding 3 phase inverse-time O/C element timed out
	51P3R	Winding 3 phase inverse-time O/C 51P3 element is reset
	PDEM3	Winding 3 phase demand current threshold exceeded
	OCC	O/C element C-phase selection

Row	Bit	Definition
11	50A33	Winding 3 A-phase instantaneous O/C Level 3 element picked up
	50B33	Winding 3 B-phase instantaneous O/C Level 3 element picked up
	50C33	Winding 3 C-phase instantaneous O/C Level 3 element picked up
	50P33	50A33 + 50B33 + 50C33
	50A34	Winding 3 A-phase instantaneous O/C Level 4 element picked up
	50B34	Winding 3 B-phase instantaneous O/C Level 4 element picked up
	50C34	Winding 3 C-phase instantaneous O/C Level 4 element picked up
	50P34	50A34 + 50B34 + 50C34
12	50N31	Winding 3 residual definite-time O/C Level 1 element picked up
	50N31T	Winding 3 residual definite-time O/C Level 1 element timed out
	50N32	Winding 3 residual instantaneous O/C Level 2 element picked up
	51N3	Winding 3 residual inverse-time O/C element picked up
	51N3T	Winding 3 residual inverse-time O/C element timed out
	51N3R	Winding 3 residual inverse-time O/C 51N3 element is reset
	NDEM3	Winding 3 residual demand current threshold exceeded
	OC3	Breaker 3 OPEN command execution
13	50Q31	Winding 3 neg.-seq. definite-time O/C Level 1 element picked up
	50Q31T	Winding 3 neg.-seq. definite-time O/C Level 1 element timed out
	50Q32	Winding 3 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q3	Winding 3 neg.-seq. inverse-time O/C element picked up
	51Q3T	Winding 3 neg.-seq. inverse-time O/C element timed out
	51Q3R	Winding 3 neg.-seq. inverse-time O/C 51Q3 element is reset
	QDEM3	Winding 3 neg.-seq. demand current threshold exceeded
	CC3	Breaker 3 CLOSE command execution
14	50P41	Winding 4 phase definite-time O/C Level 1 element picked up
	50P41T	Winding 4 phase definite-time O/C Level 1 element timed out
	50P42	Winding 4 phase instantaneous O/C Level 2 element picked up
	51P4	Winding 4 phase inverse-time O/C element picked up
	51P4T	Winding 4 phase inverse-time O/C element timed out
	51P4R	Winding 4 phase inverse-time O/C 51P4 element is reset
	PDEM4	Winding 4 phase demand current threshold exceeded
	CTS	Current transformer saturation

Row	Bit	Definition
15	50A43	Winding 4 A-phase instantaneous O/C Level 3 element picked up
	50B43	Winding 4 B-phase instantaneous O/C Level 3 element picked up
	50C43	Winding 4 C-phase instantaneous O/C Level 3 element picked up
	50P43	50A43 + 50B43 + 50C43
	50A44	Winding 4 A-phase instantaneous O/C Level 4 element picked up
	50B44	Winding 4 B-phase instantaneous O/C Level 4 element picked up
	50C44	Winding 4 C-phase instantaneous O/C Level 4 element picked up
	50P44	50A44 + 50B44 + 50C44
16	50N41	Winding 4 residual definite-time O/C Level 1 element picked up
	50N41T	Winding 4 residual definite-time O/C Level 1 element timed out
	50N42	Winding 4 residual instantaneous O/C Level 2 element picked up
	51N4	Winding 4 residual inverse-time O/C element picked up
	51N4T	Winding 4 residual inverse-time O/C element timed out
	51N4R	Winding 4 residual inverse-time O/C 51N4 element is reset
	NDEM4	Winding 4 residual demand current threshold exceeded
	OC4	Breaker 4 OPEN command execution
17	50Q41	Winding 4 neg.-seq. definite-time O/C element picked up
	50Q41T	Winding 4 neg.-seq. definite-time O/C element timed out
	50Q42	Winding 4 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q4	Winding 4 neg.-seq. inverse-time O/C element picked up
	51Q4T	Winding 4 neg.-seq. inverse-time O/C element timed out
	51Q4R	Winding 4 neg.-seq. inverse-time O/C 51Q4 element is reset
	QDEM4	Winding 4 neg.-seq. demand current threshold exceeded
	CC4	Breaker 4 CLOSE command execution
18	87U1	Unrestrained differential element 1 picked up
	87U2	Unrestrained differential element 2 picked up
	87U3	Unrestrained differential element 3 picked up
	87U	Unrestrained differential element picked up
	87R1	Restrained differential element 1 picked up
	87R2	Restrained differential element 2 picked up
	87R3	Restrained differential element 3 picked up
	87R	Restrained differential element picked up

Row	Bit	Definition
19	2HB1	Second-Harmonic block asserted for differential element 1
	2HB2	Second-Harmonic block asserted for differential element 2
	2HB3	Second-Harmonic block asserted for differential element 3
	5HB1	Fifth-Harmonic block asserted for differential element 1
	5HB2	Fifth-Harmonic block asserted for differential element 2
	5HB3	Fifth-Harmonic block asserted for differential element 3
	TH5	Fifth-Harmonic alarm threshold exceeded
	TH5T	Fifth-Harmonic alarm threshold exceeded for longer than TH5D
20	87BL1	Harmonic block asserted for differential element 1
	87BL2	Harmonic block asserted for differential element 2
	87BL3	Harmonic block asserted for differential element 3
	87BL	Harmonic block asserted for differential element
	87E1	Trip by differential element 1
	87E2	Trip by differential element 2
	87E3	Trip by differential element 3
	32IE	Internal enable for the 32I element
21	87O1	Restrained differential element 1 operating current above O87P
	87O2	Restrained differential element 2 operating current above O87P
	87O3	Restrained differential element 3 operating current above O87P
	50GC	Combined residual current sensitivity threshold exceeded
	50G4	W4 residual current sensitivity threshold exceeded
	32IR	32I element reverse (external) fault declaration
	32IF	32I element forward (internal) fault declaration
	REFP	Restricted Earth Fault inverse-time O/C element timed-out
22	51PC1	Windings 1 and 2 phase inverse-time O/C element picked up
	51PC1T	Windings 1 and 2 phase inverse-time O/C element timed out
	51PC1R	Windings 1 and 2 phase inverse-time O/C element is reset
	51NC1	Windings 1 and 2 residual inverse-time O/C element picked up
	51NC1T	Windings 1 and 2 residual inverse-time O/C element timed out
	51NC1R	Windings 1 and 2 residual inverse-time O/C element is reset
	DC1	DC battery voltage level 1 exceeded
	DC2	DC battery voltage level 2 exceeded

Row	Bit	Definition
23	51PC2	Windings 3 and 4 phase inverse-time O/C element picked up
	51PC2T	Windings 3 and 4 phase inverse-time O/C element timed out
	51PC2R	Windings 3 and 4 phase inverse-time O/C element is reset
	51NC2	Windings 3 and 4 residual inverse-time O/C element picked up
	51NC2T	Windings 3 and 4 residual inverse-time O/C element timed out
	51NC2R	Windings 3 and 4 residual inverse-time O/C element is reset
	DC3	DC battery voltage level 3 exceeded
	DC4	DC battery voltage level 4 exceeded
24	RB1	Remote bit RB1 asserted
	RB2	Remote bit RB2 asserted
	RB3	Remote bit RB3 asserted
	RB4	Remote bit RB4 asserted
	RB5	Remote bit RB5 asserted
	RB6	Remote bit RB6 asserted
	RB7	Remote bit RB7 asserted
	RB8	Remote bit RB8 asserted
25	RB9	Remote bit RB9 asserted
	RB10	Remote bit RB10 asserted
	RB11	Remote bit RB11 asserted
	RB12	Remote bit RB12 asserted
	RB13	Remote bit RB13 asserted
	RB14	Remote bit RB14 asserted
	RB15	Remote bit RB15 asserted
	RB16	Remote bit RB16 asserted
26	SG1	Setting group 1 is the active setting group
	SG2	Setting group 2 is the active setting group
	SG3	Setting group 3 is the active setting group
	SG4	Setting group 4 is the active setting group
	SG5	Setting group 5 is the active setting group
	SG6	Setting group 6 is the active setting group
	CHSG	Timing to change setting groups
	COMFLG	Asserted when communications fail or when out-of-range temperature data are received on the serial port used to obtain temperature data (SEL-387-6 Relay only)

Row	Bit	Definition
27	*	Reserved for future use
	*	Reserved for future use
	IN106	Input IN106 asserted
	IN105	Input IN105 asserted
	IN104	Input IN104 asserted
	IN103	Input IN103 asserted
	IN102	Input IN102 asserted
	IN101	Input IN101 asserted
28	IN208	Input IN208 asserted
	IN207	Input IN207 asserted
	IN206	Input IN206 asserted
	IN205	Input IN205 asserted
	IN204	Input IN204 asserted
	IN203	Input IN203 asserted
	IN202	Input IN202 asserted
	IN201	Input IN201 asserted
29	IN216	Input IN216 asserted
	IN215	Input IN215 asserted
	IN214	Input IN214 asserted
	IN213	Input IN213 asserted
	IN212	Input IN212 asserted
	IN211	Input IN211 asserted
	IN210	Input IN210 asserted
	IN209	Input IN209 asserted
30	IN308	Input IN308 asserted
	IN307	Input IN307 asserted
	IN306	Input IN306 asserted
	IN305	Input IN305 asserted
	IN304	Input IN304 asserted
	IN303	Input IN303 asserted
	IN302	Input IN302 asserted
	IN301	Input IN301 asserted

Row	Bit	Definition
31	IN316	Input IN316 asserted
	IN315	Input IN315 asserted
	IN314	Input IN314 asserted
	IN313	Input IN313 asserted
	IN312	Input IN312 asserted
	IN311	Input IN311 asserted
	IN310	Input IN310 asserted
	IN309	Input IN309 asserted
32	S1V1	Set 1 SELOGIC control equation variable S1V1 timer input asserted
	S1V2	Set 1 SELOGIC control equation variable S1V2 timer input asserted
	S1V3	Set 1 SELOGIC control equation variable S1V3 timer input asserted
	S1V4	Set 1 SELOGIC control equation variable S1V4 timer input asserted
	S1V1T	Set 1 SELOGIC control equation variable S1V1 timer output asserted
	S1V2T	Set 1 SELOGIC control equation variable S1V2 timer output asserted
	S1V3T	Set 1 SELOGIC control equation variable S1V3 timer output asserted
	S1V4T	Set 1 SELOGIC control equation variable S1V4 timer output asserted
33	S2V1	Set 2 SELOGIC control equation variable S2V1 timer input asserted
	S2V2	Set 2 SELOGIC control equation variable S2V2 timer input asserted
	S2V3	Set 2 SELOGIC control equation variable S2V3 timer input asserted
	S2V4	Set 2 SELOGIC control equation variable S2V4 timer input asserted
	S2V1T	Set 2 SELOGIC control equation variable S2V1 timer output asserted
	S2V2T	Set 2 SELOGIC control equation variable S2V2 timer output asserted
	S2V3T	Set 2 SELOGIC control equation variable S2V3 timer output asserted
	S2V4T	Set 2 SELOGIC control equation variable S2V4 timer output asserted
34	S3V1	Set 3 SELOGIC control equation variable S3V1 timer input asserted
	S3V2	Set 3 SELOGIC control equation variable S3V2 timer input asserted
	S3V3	Set 3 SELOGIC control equation variable S3V3 timer input asserted
	S3V4	Set 3 SELOGIC control equation variable S3V4 timer input asserted
	S3V5	Set 3 SELOGIC control equation variable S3V5 timer input asserted
	S3V6	Set 3 SELOGIC control equation variable S3V6 timer input asserted
	S3V7	Set 3 SELOGIC control equation variable S3V7 timer input asserted
	S3V8	Set 3 SELOGIC control equation variable S3V8 timer input asserted

Row	Bit	Definition
35	S3V1T	Set 3 SELOGIC control equation variable S3V1 timer output asserted
	S3V2T	Set 3 SELOGIC control equation variable S3V2 timer output asserted
	S3V3T	Set 3 SELOGIC control equation variable S3V3 timer output asserted
	S3V4T	Set 3 SELOGIC control equation variable S3V4 timer output asserted
	S3V5T	Set 3 SELOGIC control equation variable S3V5 timer output asserted
	S3V6T	Set 3 SELOGIC control equation variable S3V6 timer output asserted
	S3V7T	Set 3 SELOGIC control equation variable S3V7 timer output asserted
	S3V8T	Set 3 SELOGIC control equation variable S3V8 timer output asserted
36	S1LT1	Set 1 latch bit S1LT1 asserted
	S1LT2	Set 1 latch bit S1LT2 asserted
	S1LT3	Set 1 latch bit S1LT3 asserted
	S1LT4	Set 1 latch bit S1LT4 asserted
	S2LT1	Set 2 latch bit S2LT1 asserted
	S2LT2	Set 2 latch bit S2LT2 asserted
	S2LT3	Set 2 latch bit S2LT3 asserted
	S2LT4	Set 2 latch bit S2LT4 asserted
37	S3LT1	Set 3 latch bit S3LT1 asserted
	S3LT2	Set 3 latch bit S3LT2 asserted
	S3LT3	Set 3 latch bit S3LT3 asserted
	S3LT4	Set 3 latch bit S3LT4 asserted
	S3LT5	Set 3 latch bit S3LT5 asserted
	S3LT6	Set 3 latch bit S3LT6 asserted
	S3LT7	Set 3 latch bit S3LT7 asserted
	S3LT8	Set 3 latch bit S3LT8 asserted
38	TLL	Total accumulated loss-of-life alarm asserted (SEL-387-6 Relay only)
	RLL	Daily rate of loss-of-life alarm asserted (SEL-387-6 Relay only)
	FAA1	Insulation aging acceleration factor alarm level 1 asserted (SEL-387-6 Relay only)
	FAA2	Insulation aging acceleration factor alarm level 2 asserted (SEL-387-6 Relay only)
	TO1	Top-oil temperature alarm level 1 asserted (SEL-387-6 Relay only)
	TO2	Top-oil temperature alarm level 2 asserted (SEL-387-6 Relay only)
	HS1	Hot-spot temperature alarm level 1 asserted (SEL-387-6 Relay only)
	HS2	Hot-spot temperature alarm level 2 asserted (SEL-387-6 Relay only)

Row	Bit	Definition
39	BCWA1	A-phase breaker 1 contact wear threshold exceeded
	BCWB1	B-phase breaker 1 contact wear threshold exceeded
	BCWC1	C-phase breaker 1 contact wear threshold exceeded
	BCW1	BCWA1+BCWB1+BCWC1
	BCWA2	A-phase breaker 2 contact wear threshold exceeded
	BCWB2	B-phase breaker 2 contact wear threshold exceeded
	BCWC2	C-phase breaker 2 contact wear threshold exceeded
	BCW2	BCWA2+BCWB2+BCWC2
40	BCWA3	A-phase breaker 3 contact wear threshold exceeded
	BCWB3	B-phase breaker 3 contact wear threshold exceeded
	BCWC3	C-phase breaker 3 contact wear threshold exceeded
	BCW3	BCWA3+BCWB3+BCWC3
	BCWA4	A-phase breaker 4 contact wear threshold exceeded
	BCWB4	B-phase breaker 4 contact wear threshold exceeded
	BCWC4	C-phase breaker 4 contact wear threshold exceeded
	BCW4	BCWA4+BCWB4+BCWC4
41	TRIP1	Trip 1 logic asserted
	TRIP2	Trip 2 logic asserted
	TRIP3	Trip 3 logic asserted
	TRIP4	Trip 4 logic asserted
	TRIP5	Trip 5 logic asserted
	TRIPL	Any trip asserted
	CSE	Cooling system efficiency alarm asserted (SEL-387-6 Relay only)
	TRGTR	Target reset pushbutton/TAR R command
42	CLS1	Breaker 1 CLOSE output asserted
	CLS2	Breaker 2 CLOSE output asserted
	CLS3	Breaker 3 CLOSE output asserted
	CLS4	Breaker 4 CLOSE output asserted
	CF1T	Breaker 1 close failure timer timed out
	CF2T	Breaker 2 close failure timer timed out
	CF3T	Breaker 3 close failure timer timed out
	CF4T	Breaker 4 close failure timer timed out

Row	Bit	Definition
43	!ALARM	ALARM output not asserted
	OUT107	Output OUT107 asserted
	OUT106	Output OUT106 asserted
	OUT105	Output OUT105 asserted
	OUT104	Output OUT104 asserted
	OUT103	Output OUT103 asserted
	OUT102	Output OUT102 asserted
	OUT101	Output OUT101 asserted
44	OUT201	Output OUT201 asserted
	OUT202	Output OUT202 asserted
	OUT203	Output OUT203 asserted
	OUT204	Output OUT204 asserted
	OUT205	Output OUT205 asserted
	OUT206	Output OUT206 asserted
	OUT207	Output OUT207 asserted
	OUT208	Output OUT208 asserted
45	OUT209	Output OUT209 asserted
	OUT210	Output OUT210 asserted
	OUT211	Output OUT211 asserted
	OUT212	Output OUT212 asserted
	OUT213	Output OUT213 asserted
	OUT214	Output OUT214 asserted
	OUT215	Output OUT215 asserted
	OUT216	Output OUT216 asserted
46	OUT301	Output OUT301 asserted
	OUT302	Output OUT302 asserted
	OUT303	Output OUT303 asserted
	OUT304	Output OUT304 asserted
	OUT305	Output OUT305 asserted
	OUT306	Output OUT306 asserted
	OUT307	Output OUT307 asserted
	OUT308	Output OUT308 asserted

Row	Bit	Definition
47	OUT309	Output OUT309 asserted
	OUT310	Output OUT310 asserted
	OUT311	Output OUT311 asserted
	OUT312	Output OUT312 asserted
	OUT313	Output OUT313 asserted
	OUT314	Output OUT314 asserted
	OUT315	Output OUT315 asserted
	OUT316	Output OUT316 asserted
48	LB1	Local Bit 1 asserted
	LB2	Local Bit 2 asserted
	LB3	Local Bit 3 asserted
	LB4	Local Bit 4 asserted
	LB5	Local Bit 5 asserted
	LB6	Local Bit 6 asserted
	LB7	Local Bit 7 asserted
	LB8	Local Bit 8 asserted
49	LB9	Local Bit 9 asserted
	LB10	Local Bit 10 asserted
	LB11	Local Bit 11 asserted
	LB12	Local Bit 12 asserted
	LB13	Local Bit 13 asserted
	LB14	Local Bit 14 asserted
	LB15	Local Bit 15 asserted
	LB16	Local Bit 16 asserted

Table 4.10: Relay Word Bits Sorted Alphabetically

Bit	Definition	Row
All	LED targets - not usable in SELOGIC control equations.	0
All	LED targets - not usable in SELOGIC control equations.	1
!ALARM	ALARM output not asserted	43
2HB1	Second-Harmonic block asserted for differential element 1	19
2HB2	Second-Harmonic block asserted for differential element 2	19
2HB3	Second-Harmonic block asserted for differential element 3	19
32IE	Internal enable for the 32I element	20
32IF	32I element forward (internal) fault declaration	21
32IR	32I element reverse (external) fault declaration	21
50A13	Winding 1 A-phase instantaneous O/C Level 3 element picked up	3
50A14	Winding 1 A-phase instantaneous O/C Level 4 element picked up	3

Bit	Definition	Row
50A23	Winding 2 A-phase instantaneous O/C Level 3 element picked up	7
50A24	Winding 2 A-phase instantaneous O/C Level 4 element picked up	7
50A33	Winding 3 A-phase instantaneous O/C Level 3 element picked up	11
50A34	Winding 3 A-phase instantaneous O/C Level 4 element picked up	11
50A43	Winding 4 A-phase instantaneous O/C Level 3 element picked up	15
50A44	Winding 4 A-phase instantaneous O/C Level 4 element picked up	15
50B13	Winding 1 B-phase instantaneous O/C Level 3 element picked up	3
50B14	Winding 1 B-phase instantaneous O/C Level 4 element picked up	3
50B23	Winding 2 B-phase instantaneous O/C Level 3 element picked up	7
50B24	Winding 2 B-phase instantaneous O/C Level 4 element picked up	7
50B33	Winding 3 B-phase instantaneous O/C Level 3 element picked up	11
50B34	Winding 3 B-phase instantaneous O/C Level 4 element picked up	11
50B43	Winding 4 B-phase instantaneous O/C Level 3 element picked up	15
50B44	Winding 4 B-phase instantaneous O/C Level 4 element picked up	15
50C13	Winding 1 C-phase instantaneous O/C Level 3 element picked up	3
50C14	Winding 1 C-phase instantaneous O/C Level 4 element picked up	3
50C23	Winding 2 C-phase instantaneous O/C Level 3 element picked up	7
50C24	Winding 2 C-phase instantaneous O/C Level 4 element picked up	7
50C33	Winding 3 C-phase instantaneous O/C Level 3 element picked up	11
50C34	Winding 3 C-phase instantaneous O/C Level 4 element picked up	11
50C43	Winding 4 C-phase instantaneous O/C Level 3 element picked up	15
50C44	Winding 4 C-phase instantaneous O/C Level 4 element picked up	15
50G4	W4 residual current sensitivity threshold exceeded	21
50GC	Combined residual current sensitivity threshold exceeded	21
50N11	Winding 1 residual definite-time O/C Level 1 element picked up	4
50N11T	Winding 1 residual definite-time O/C Level 1 element timed out	4
50N12	Winding 1 residual instantaneous O/C Level 2 element picked up	4
50N21	Winding 2 residual definite-time O/C Level 1 element picked up	8
50N21T	Winding 2 residual definite-time O/C Level 1 element timed out	8
50N22	Winding 2 residual instantaneous O/C Level 2 element picked up	8
50N31	Winding 3 residual definite-time O/C Level 1 element picked up	12
50N31T	Winding 3 residual definite-time O/C Level 1 element timed out	12
50N32	Winding 3 residual instantaneous O/C Level 2 element picked up	12
50N41	Winding 4 residual definite-time O/C Level 1 element picked up	16
50N41T	Winding 4 residual definite-time O/C Level 1 element timed out	16
50N42	Winding 4 residual instantaneous O/C Level 2 element picked up	16
50P11	Winding 1 phase definite-time O/C Level 1 element picked up	2
50P11T	Winding 1 phase definite-time O/C Level 1 element timed out	2

Bit	Definition	Row
50P12	Winding 1 phase instantaneous O/C Level 2 element picked up	2
50P13	50A13 + 50B13 + 50C13	3
50P14	50A14 + 50B14 + 50C14	3
50P21	Winding 2 phase definite-time O/C Level 1 element picked up	6
50P21T	Winding 2 phase definite-time O/C Level 1 element timed out	6
50P22	Winding 2 phase instantaneous O/C Level 2 element picked up	6
50P23	50A23 + 50B23 + 50C23	7
50P24	50A24 + 50B24 + 50C24	7
50P31	Winding 3 phase definite-time O/C Level 1 element picked up	10
50P31T	Winding 3 phase definite-time O/C Level 1 element timed out	10
50P32	Winding 3 phase instantaneous O/C Level 2 element picked up	10
50P33	50A33 + 50B33 + 50C33	11
50P34	50A34 + 50B34 + 50C34	11
50P41	Winding 4 phase definite-time O/C Level 1 element picked up	14
50P41T	Winding 4 phase definite-time O/C Level 1 element timed out	14
50P42	Winding 4 phase instantaneous O/C Level 2 element picked up	14
50P43	50A43 + 50B43 + 50C43	15
50P44	50A44 + 50B44 + 50C44	15
50Q11	Winding 1 neg.-seq. definite-time O/C Level 1 element picked up	5
50Q11T	Winding 1 neg.-seq. definite-time O/C element timed out	5
50Q12	Winding 1 neg.-seq. instantaneous O/C Level 2 element picked up	5
50Q21	Winding 2 neg.-seq. definite-time O/C Level 1 element picked up	9
50Q21T	Winding 2 neg.-seq. definite-time O/C Level 1 element timed out	9
50Q22	Winding 2 neg.-seq. instantaneous O/C Level 2 element picked up	9
50Q31	Winding 3 neg.-seq. definite-time O/C Level 1 element picked up	13
50Q31T	Winding 3 neg.-seq. definite-time O/C Level 1 element timed out	13
50Q32	Winding 3 neg.-seq. instantaneous O/C Level 2 element picked up	13
50Q41	Winding 4 neg.-seq. definite-time O/C element picked up	17
50Q41T	Winding 4 neg.-seq. definite-time O/C element timed out	17
50Q42	Winding 4 neg.-seq. instantaneous O/C Level 2 element picked up	17
51N1	Winding 1 residual inverse-time O/C element picked up	4
51N1R	Winding 1 residual inverse-time O/C 51N1 element is reset	4
51N1T	Winding 1 residual inverse-time O/C element timed out	4
51N2	Winding 2 residual inverse-time O/C element picked up	8
51N2R	Winding 2 residual inverse-time O/C 51N2 element is reset	8
51N2T	Winding 2 residual inverse-time O/C element timed out	8
51N3	Winding 3 residual inverse-time O/C element picked up	12
51N3R	Winding 3 residual inverse-time O/C 51N3 element is reset	12

Bit	Definition	Row
51N3T	Winding 3 residual inverse-time O/C element timed out	12
51N4	Winding 4 residual inverse-time O/C element picked up	16
51N4R	Winding 4 residual inverse-time O/C 51N4 element is reset	16
51N4T	Winding 4 residual inverse-time O/C element timed out	16
51NC1	Windings 1 and 2 residual inverse-time O/C element picked up	22
51NC1R	Windings 1 and 2 residual inverse-time O/C element is reset	22
51NC1T	Windings 1 and 2 residual inverse-time O/C element timed out	22
51NC2	Windings 3 and 4 residual inverse-time O/C element picked up	23
51NC2R	Windings 3 and 4 residual inverse-time O/C element is reset	23
51NC2T	Windings 3 and 4 residual inverse-time O/C element timed out	23
51P1	Winding 1 phase inverse-time O/C element picked up	2
51P1R	Winding 1 phase inverse-time O/C 51P1 element is reset	2
51P1T	Winding 1 phase inverse-time O/C element timed out	2
51P2	Winding 2 phase inverse-time O/C element picked up	6
51P2R	Winding 2 phase inverse-time O/C 51P2 element is reset	6
51P2T	Winding 2 phase inverse-time O/C element timed out	6
51P3	Winding 3 phase inverse-time O/C element picked up	10
51P3R	Winding 3 phase inverse-time O/C 51P3 element is reset	10
51P3T	Winding 3 phase inverse-time O/C element timed out	10
51P4	Winding 4 phase inverse-time O/C element picked up	14
51P4R	Winding 4 phase inverse-time O/C 51P4 element is reset	14
51P4T	Winding 4 phase inverse-time O/C element timed out	14
51PC1	Windings 1 and 2 phase inverse-time O/C element picked up	22
51PC1R	Windings 1 and 2 phase inverse-time O/C element is reset	22
51PC1T	Windings 1 and 2 phase inverse-time O/C element timed out	22
51PC2	Windings 3 and 4 phase inverse-time O/C element picked up	23
51PC2R	Windings 3 and 4 phase inverse-time O/C element is reset	23
51PC2T	Windings 3 and 4 phase inverse-time O/C element timed out	23
51Q1	Winding 1 neg.-seq. inverse-time O/C element picked up	5
51Q1R	Winding 1 neg.-seq. inverse-time O/C 51Q1 element is reset	5
51Q1T	Winding 1 neg.-seq. inverse-time O/C element timed out	5
51Q2	Winding 2 neg.-seq. inverse-time O/C element picked up	9
51Q2R	Winding 2 neg.-seq. inverse-time O/C 51Q2 element is reset	9
51Q2T	Winding 2 neg.-seq. inverse-time O/C element timed out	9
51Q3	Winding 3 neg.-seq. inverse-time O/C element picked up	13
51Q3R	Winding 3 neg.-seq. inverse-time O/C 51Q3 element is reset	13
51Q3T	Winding 3 neg.-seq. inverse-time O/C element timed out	13
51Q4	Winding 4 neg.-seq. inverse-time O/C element picked up	17

Bit	Definition	Row
51Q4R	Winding 4 neg.-seq. inverse-time O/C 51Q4 element is reset	17
51Q4T	Winding 4 neg.-seq. inverse-time O/C element timed out	17
5HB1	Fifth-Harmonic block asserted for differential element 1	19
5HB2	Fifth-Harmonic block asserted for differential element 2	19
5HB3	Fifth-Harmonic block asserted for differential element 3	19
87BL	Harmonic block asserted for differential element	20
87BL1	Harmonic block asserted for differential element 1	20
87BL2	Harmonic block asserted for differential element 2	20
87BL3	Harmonic block asserted for differential element 3	20
87E1	Trip by differential element 1	20
87E2	Trip by differential element 2	20
87E3	Trip by differential element 3	20
87O1	Restrained differential element 1 operating current above O87P	21
87O2	Restrained differential element 2 operating current above O87P	21
87O3	Restrained differential element 3 operating current above O87P	21
87R	Restrained differential element picked up	18
87R1	Restrained differential element 1 picked up	18
87R2	Restrained differential element 2 picked up	18
87R3	Restrained differential element 3 picked up	18
87U	Unrestrained differential element picked up	18
87U1	Unrestrained differential element 1 picked up	18
87U2	Unrestrained differential element 2 picked up	18
87U3	Unrestrained differential element 3 picked up	18
BCW1	BCWA1+BCWB1+BCWC1	39
BCW2	BCWA2+BCWB2+BCWC2	39
BCW3	BCWA3+BCWB3+BCWC3	40
BCW4	BCWA4+BCWB4+BCWC4	40
BCWA1	A-phase breaker 1 contact wear threshold exceeded	39
BCWA2	A-phase breaker 2 contact wear threshold exceeded	39
BCWA3	A-phase breaker 3 contact wear threshold exceeded	40
BCWA4	A-phase breaker 4 contact wear threshold exceeded	40
BCWB1	B-phase breaker 1 contact wear threshold exceeded	39
BCWB2	B-phase breaker 2 contact wear threshold exceeded	39
BCWB3	B-phase breaker 3 contact wear threshold exceeded	40
BCWB4	B-phase breaker 4 contact wear threshold exceeded	40
BCWC1	C-phase breaker 1 contact wear threshold exceeded	39
BCWC2	C-phase breaker 2 contact wear threshold exceeded	39
BCWC3	C-phase breaker 3 contact wear threshold exceeded	40

Bit	Definition	Row
BCWC4	C-phase breaker 4 contact wear threshold exceeded	40
CC1	Breaker 1 CLOSE command execution	5
CC2	Breaker 2 CLOSE command execution	9
CC3	Breaker 3 CLOSE command execution	13
CC4	Breaker 4 CLOSE command execution	17
CF1T	Breaker 1 close failure timer timed out	42
CF2T	Breaker 2 close failure timer timed out	42
CF3T	Breaker 3 close failure timer timed out	42
CF4T	Breaker 4 close failure timer timed out	42
CHSG	Timing to change setting groups	26
CLS1	Breaker 1 CLOSE output asserted	42
CLS2	Breaker 2 CLOSE output asserted	42
CLS3	Breaker 3 CLOSE output asserted	42
CLS4	Breaker 4 CLOSE output asserted	42
COMFLG	Asserted when communications fail or when out-of-range temperature data are received on the serial port used to obtain temperature data (SEL-387-6 Relay only)	26
CSE	Cooling system efficiency alarm asserted (SEL-387-6 Relay only)	41
CTS	Current transformer saturation	14
DC1	DC battery voltage level 1 exceeded	22
DC2	DC battery voltage level 2 exceeded	22
DC3	DC battery voltage level 3 exceeded	23
DC4	DC battery voltage level 4 exceeded	23
FAA1	Insulation aging acceleration factor alarm level 1 asserted (SEL-387-6 Relay only)	38
FAA2	Insulation aging acceleration factor alarm level 2 asserted (SEL-387-6 Relay only)	38
HS1	Hot-spot temperature alarm level 1 asserted (SEL-387-6 Relay only)	38
HS2	Hot-spot temperature alarm level 2 asserted (SEL-387-6 Relay only)	38
IN101	Input IN101 asserted	27
IN102	Input IN102 asserted	27
IN103	Input IN103 asserted	27
IN104	Input IN104 asserted	27
IN105	Input IN105 asserted	27
IN106	Input IN106 asserted	27
IN201	Input IN201 asserted	28
IN202	Input IN202 asserted	28
IN203	Input IN203 asserted	28
IN204	Input IN204 asserted	28

Bit	Definition	Row
IN205	Input IN205 asserted	28
IN206	Input IN206 asserted	28
IN207	Input IN207 asserted	28
IN208	Input IN208 asserted	28
IN209	Input IN209 asserted	29
IN210	Input IN210 asserted	29
IN211	Input IN211 asserted	29
IN212	Input IN212 asserted	29
IN213	Input IN213 asserted	29
IN214	Input IN214 asserted	29
IN215	Input IN215 asserted	29
IN216	Input IN216 asserted	29
IN301	Input IN301 asserted	30
IN302	Input IN302 asserted	30
IN303	Input IN303 asserted	30
IN304	Input IN304 asserted	30
IN305	Input IN305 asserted	30
IN306	Input IN306 asserted	30
IN307	Input IN307 asserted	30
IN308	Input IN308 asserted	30
IN309	Input IN309 asserted	31
IN310	Input IN310 asserted	31
IN311	Input IN311 asserted	31
IN312	Input IN312 asserted	31
IN313	Input IN313 asserted	31
IN314	Input IN314 asserted	31
IN315	Input IN315 asserted	31
IN316	Input IN316 asserted	31
LB1	Local Bit 1 asserted	48
LB2	Local Bit 2 asserted	48
LB3	Local Bit 3 asserted	48
LB4	Local Bit 4 asserted	48
LB5	Local Bit 5 asserted	48
LB6	Local Bit 6 asserted	48
LB7	Local Bit 7 asserted	48
LB8	Local Bit 8 asserted	48
LB9	Local Bit 9 asserted	49
LB10	Local Bit 10 asserted	49

Bit	Definition	Row
LB11	Local Bit 11 asserted	49
LB12	Local Bit 12 asserted	49
LB13	Local Bit 13 asserted	49
LB14	Local Bit 14 asserted	49
LB15	Local Bit 15 asserted	49
LB16	Local Bit 16 asserted	49
NDEM1	Winding 1 residual demand current threshold exceeded	4
NDEM2	Winding 2 residual demand current threshold exceeded	8
NDEM3	Winding 3 residual demand current threshold exceeded	12
NDEM4	Winding 4 residual demand current threshold exceeded	16
OC1	Breaker 1 OPEN command execution	4
OC2	Breaker 2 OPEN command execution	8
OC3	Breaker 3 OPEN command execution	12
OC4	Breaker 4 OPEN command execution	16
OCA	O/C element A-phase selection	2
OCB	O/C element B-phase selection	6
OCC	O/C element C-phase selection	10
OUT101	Output OUT101 asserted	43
OUT102	Output OUT102 asserted	43
OUT103	Output OUT103 asserted	43
OUT104	Output OUT104 asserted	43
OUT105	Output OUT105 asserted	43
OUT106	Output OUT106 asserted	43
OUT107	Output OUT107 asserted	43
OUT201	Output OUT201 asserted	44
OUT202	Output OUT202 asserted	44
OUT203	Output OUT203 asserted	44
OUT204	Output OUT204 asserted	44
OUT205	Output OUT205 asserted	44
OUT206	Output OUT206 asserted	44
OUT207	Output OUT207 asserted	44
OUT208	Output OUT208 asserted	44
OUT209	Output OUT209 asserted	45
OUT210	Output OUT210 asserted	45
OUT211	Output OUT211 asserted	45
OUT212	Output OUT212 asserted	45
OUT213	Output OUT213 asserted	45
OUT214	Output OUT214 asserted	45

Bit	Definition	Row
OUT215	Output OUT215 asserted	45
OUT216	Output OUT216 asserted	45
OUT301	Output OUT301 asserted	46
OUT302	Output OUT302 asserted	46
OUT303	Output OUT303 asserted	46
OUT304	Output OUT304 asserted	46
OUT305	Output OUT305 asserted	46
OUT306	Output OUT306 asserted	46
OUT307	Output OUT307 asserted	46
OUT308	Output OUT308 asserted	46
OUT309	Output OUT309 asserted	47
OUT310	Output OUT310 asserted	47
OUT311	Output OUT311 asserted	47
OUT312	Output OUT312 asserted	47
OUT313	Output OUT313 asserted	47
OUT314	Output OUT314 asserted	47
OUT315	Output OUT315 asserted	47
OUT316	Output OUT216 asserted	47
PDEM1	Winding 1 phase demand current threshold exceeded	2
PDEM2	Winding 2 phase demand current threshold exceeded	6
PDEM3	Winding 3 phase demand current threshold exceeded	10
PDEM4	Winding 4 phase demand current threshold exceeded	14
QDEM1	Winding 1 neg.-seq. demand current threshold exceeded	5
QDEM2	Winding 2 neg.-seq. demand current threshold exceeded	9
QDEM3	Winding 3 neg.-seq. demand current threshold exceeded	13
QDEM4	Winding 4 neg.-seq. demand current threshold exceeded	17
RB1	Remote bit RB1 asserted	24
RB10	Remote bit RB10 asserted	25
RB11	Remote bit RB11 asserted	25
RB12	Remote bit RB12 asserted	25
RB13	Remote bit RB13 asserted	25
RB14	Remote bit RB14 asserted	25
RB15	Remote bit RB15 asserted	25
RB16	Remote bit RB16 asserted	25
RB2	Remote bit RB2 asserted	24
RB3	Remote bit RB3 asserted	24
RB4	Remote bit RB4 asserted	24
RB5	Remote bit RB5 asserted	24

Bit	Definition	Row
RB6	Remote bit RB6 asserted	24
RB7	Remote bit RB7 asserted	24
RB8	Remote bit RB8 asserted	24
RB9	Remote bit RB9 asserted	25
REFP	Restricted Earth Fault inverse-time O/C element timed-out	21
RLL	Daily rate of loss-of-life alarm asserted (SEL-387-6 Relay only)	38
S1LT1	Set 1 latch bit S1LT1 asserted	36
S1LT2	Set 1 latch bit S1LT2 asserted	36
S1LT3	Set 1 latch bit S1LT3 asserted	36
S1LT4	Set 1 latch bit S1LT4 asserted	36
S1V1	Set 1 SELOGIC control equation variable S1V1 timer input asserted	32
S1V1T	Set 1 SELOGIC control equation variable S1V1 timer output asserted	32
S1V2	Set 1 SELOGIC control equation variable S1V2 timer input asserted	32
S1V2T	Set 1 SELOGIC control equation variable S1V2 timer output asserted	32
S1V3	Set 1 SELOGIC control equation variable S1V3 timer input asserted	32
S1V3T	Set 1 SELOGIC control equation variable S1V3 timer output asserted	32
S1V4	Set 1 SELOGIC control equation variable S1V4 timer input asserted	32
S1V4T	Set 1 SELOGIC control equation variable S1V4 timer output asserted	32
S2LT1	Set 2 latch bit S2LT1 asserted	36
S2LT2	Set 2 latch bit S2LT2 asserted	36
S2LT3	Set 2 latch bit S2LT3 asserted	36
S2LT4	Set 2 latch bit S2LT4 asserted	36
S3LT1	Set 3 latch bit S2LT1 asserted	37
S3LT2	Set 3 latch bit S2LT2 asserted	37
S3LT3	Set 3 latch bit S2LT3 asserted	37
S3LT4	Set 3 latch bit S2LT4 asserted	37
S3LT5	Set 3 latch bit S2LT5 asserted	37
S3LT6	Set 3 latch bit S2LT6 asserted	37
S3LT7	Set 3 latch bit S2LT7 asserted	37
S3LT8	Set 3 latch bit S2LT8 asserted	37
S2V1	Set 2 SELOGIC control equation variable S2V1 timer input asserted	33
S2V1T	Set 2 SELOGIC control equation variable S2V1 timer output asserted	33
S2V2	Set 2 SELOGIC control equation variable S2V2 timer input asserted	33
S2V2T	Set 2 SELOGIC control equation variable S2V2 timer output asserted	33
S2V3	Set 2 SELOGIC control equation variable S2V3 timer input asserted	33
S2V3T	Set 2 SELOGIC control equation variable S2V3 timer output asserted	33
S2V4	Set 2 SELOGIC control equation variable S2V4 timer input asserted	33
S2V4T	Set 2 SELOGIC control equation variable S2V4 timer output asserted	33

Bit	Definition	Row
S3V1	Set 3 SELOGIC control equation variable S3V1 timer input asserted	34
S3V1T	Set 3 SELOGIC control equation variable S3V1 timer output asserted	35
S3V2	Set 3 SELOGIC control equation variable S3V2 timer input asserted	34
S3V2T	Set 3 SELOGIC control equation variable S3V2 timer output asserted	35
S3V3	Set 3 SELOGIC control equation variable S3V3 timer input asserted	34
S3V3T	Set 3 SELOGIC control equation variable S3V3 timer output asserted	35
S3V4	Set 3 SELOGIC control equation variable S3V4 timer input asserted	34
S3V4T	Set 3 SELOGIC control equation variable S3V4 timer output asserted	35
S3V5	Set 3 SELOGIC control equation variable S3V5 timer input asserted	34
S3V5T	Set 3 SELOGIC control equation variable S3V5 timer output asserted	35
S3V6	Set 3 SELOGIC control equation variable S3V6 timer input asserted	34
S3V6T	Set 3 SELOGIC control equation variable S3V6 timer output asserted	35
S3V7	Set 3 SELOGIC control equation variable S3V7 timer input asserted	34
S3V7T	Set 3 SELOGIC control equation variable S3V7 timer output asserted	35
S3V8	Set 3 SELOGIC control equation variable S3V8 timer input asserted	34
S3V8T	Set 3 SELOGIC control equation variable S3V8 timer output asserted	35
SG1	Setting group 1 is the active setting group	26
SG2	Setting group 2 is the active setting group	26
SG3	Setting group 3 is the active setting group	26
SG4	Setting group 4 is the active setting group	26
SG5	Setting group 5 is the active setting group	26
SG6	Setting group 6 is the active setting group	26
TH5	Fifth-Harmonic alarm threshold exceeded	19
TH5T	Fifth-Harmonic alarm threshold exceeded for longer than TH5D	19
TO1	Top-oil temperature alarm level 1 asserted (SEL-387-6 Relay only)	38
TO2	Top-oil temperature alarm level 2 asserted (SEL-387-6 Relay only)	38
TLL	Total accumulated loss-of-life alarm asserted (SEL-387-6 Relay only)	38
TRGTR	Target reset pushbutton/TAR R command	41
TRIP1	Trip 1 logic asserted	41
TRIP2	Trip 2 logic asserted	41
TRIP3	Trip 3 logic asserted	41
TRIP4	Trip 4 logic asserted	41
TRIP5	Trip 5 logic asserted	41
TRIPL	Any trip asserted	41

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SECTION 5: METERING AND MONITORING

INTRODUCTION

The SEL-387 Relay provides metering information in several report formats for each of the 4 three-phase winding current inputs and for the 3 differential elements. A DC Battery Monitor reports on the supply voltage to the relay and can be programmed to alarm for voltage excursions. There is also a Breaker Monitor function that keeps track of breaker trips, the cumulative current interrupted over time, and the amount of estimated contact wear. These functions and their associated reports are discussed in this section.

METERING FUNCTIONS

There are three types of fundamental frequency metering functions in the SEL-387 Relay: instantaneous, demand (thermal), and peak demand. Quantities metered include phase currents for all four winding inputs; positive-, negative-, and zero-sequence (residual) currents for all four winding inputs; and operate, restraint, second-harmonic, and fifth-harmonic currents for the three differential elements. There are several report formats, employing different groups of the above quantities, accessible by variants of the METER command through the relay serial port. This information is also available at the relay front panel via the LCD display.

There is also a specialized metering function, Harmonic Metering. It provides a snapshot of harmonic current magnitudes in the phase currents, fundamental through the fifteenth harmonic.

This section will discuss which quantities are used in each of the report formats and show the format for each of the METER command displays, as they would appear on the screen. The relay front-panel LCD displays the same quantities but requires several stages of keystrokes to select the data of interest. These displays are covered in *Section 8: Front-Panel Interface*.

All METER displays herein show the default Analog Input Labels (IAW1, IBW1, etc.). Relay displays show the user setting values of the Analog Input Labels.

Instantaneous Phase Current Meter Function (METER Command)

The **METER** or **MET** command, with no additional parameters, displays instantaneous magnitude values, in primary RMS amperes of the three-phase currents, the positive-sequence current, negative-sequence current, and residual current, for each of the four winding inputs. It also displays the value of the station battery dc supply voltage at the relay obtained from the Battery Voltage Monitor. If the command is typed as **MET m**, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode subsequent reports are not generated until the previous report has been completely sent. The format for the **MET** report is as follows:

=>METER						
XFMR 1		Date: MM/DD/YY		Time: HH:MM:SS.SSS		
STATION A						
		Phase Currents			Sequence Currents	
Wdg1	IAW1	IBW1	ICW1	3I1W1	3I2W1	IRW1
I (A,pri)	12345	12345	12345	12345	12345	12345
Wdg2	IAW2	IBW2	ICW2	3I1W2	3I2W2	IRW2
I (A,pri)	12345	12345	12345	12345	12345	12345
Wdg3	IAW3	IBW3	ICW3	3I1W3	3I2W3	IRW3
I (A,pri)	12345	12345	12345	12345	12345	12345
Wdg4	IAW4	IBW4	ICW4	3I1W4	3I2W4	IRW4
I (A,pri)	12345	12345	12345	12345	12345	12345
VDC (V)	123					

Demand Ammeter Function (METER D Command)

The SEL-387 Relay includes a thermal demand metering function for all four windings. In response to the MET D command, the individual phase demand currents, as well as the negative-sequence and residual demand currents for each winding, are displayed in primary RMS amperes. If the command is typed as MET D m, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode subsequent reports are not generated until the previous report has been completely sent. The format for the MET D report is as follows:

=>METER D						
XFMR 1		Date: MM/DD/YY		Time: HH:MM:SS.SSS		
STATION A						
		Phase Currents			Sequence Currents	
Wdg1	IAW1	IBW1	ICW1	3I2W1	IRW1	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Wdg2	IAW2	IBW2	ICW2	3I2W2	IRW2	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Wdg3	IAW3	IBW3	ICW3	3I2W3	IRW3	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Wdg4	IAW4	IBW4	ICW4	3I2W4	IRW4	
Dem I (A,pri)	12345	12345	12345	12345	12345	
LAST DEMAND RESET FOR		Wdg1:	mm/dd/yy	hh:mm:ss.sss		
		Wdg2:	mm/dd/yy	hh:mm:ss.sss		
		Wdg3:	mm/dd/yy	hh:mm:ss.sss		
		Wdg4:	mm/dd/yy	hh:mm:ss.sss		

The most recent demand resets for each winding are shown in the METER D report.

The Demand Ammeter function simulates the long-term heating effects of current at a particular level by accumulating the demand current on an exponential basis, using a thermal time constant setting, DATCn, for each winding (n = 1, 2, 3, 4). DATCn can be set over a range of 5 to 255 minutes (4 hrs 15 min). The demand values in secondary amperes are compared to user-defined thresholds, PDEMnP, QDEMnP, and NDEMnP. PDEMnP is compared to the greatest of the three individual phase current demands for winding n, while QDEMnP is compared to the

negative-sequence demand, and NDEMnP is compared to the residual demand. Relay Word bits PDEMn, QDEMn, or NDEMn are asserted if the appropriate demand exceeds the stated threshold. These bits can be used to initiate a display or to close an output contact, for alarming or tripping purposes.

The demand ammeter output for a step change in current of S amperes is a smoothly rising exponential that produces a demand change of 0.9 times S at time DATCn after the step change occurred (see Figure 5.1). For example, if the demand current has stabilized at some value I_{d0} before time zero and at $t = 0$ the current suddenly jumps to a new value I_{NEW} , the demand current as a function of time will have the equation

$$I_d(t) = I_{NEW} + (I_{d0} - I_{NEW}) \cdot e^{-[\ln(10)]t/DATCn}$$

The next function, the peak demand ammeter function, keeps track of the greatest value of $I_d(t)$ since the last reset of the peak demand registers.

Peak Demand Ammeter Function (METER P Command)

The peak demand ammeter function compares the value of the demand ammeter outputs for each winding, i.e., the largest of the phase current demands, the negative-sequence demand, and the residual demand, against registers containing the greatest demand value of each type since the last reset of the registers. This is done every two seconds. If the particular $I_d(t)$ exceeds the register value, it replaces the value in the register and becomes the new peak value. These peak values are time and date stamped.

In response to the **MET P** command, the phase current peak demands, as well as the negative-sequence and residual current peak demands for each winding, are displayed in primary amperes. If the command is typed as **MET P m**, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode, subsequent reports are not generated until the previous report has been completely sent. The format for the **MET P** report is as follows:

=>METER P				
XFMR 1		Date: MM/DD/YY	Time: HH:MM:SS.SSS	
STATION A				
	Peak Dem I (A, pri)	Date:	Time:	
Wdg 1	IAW1	12345	MM/DD/YY	HH:MM:SS.SSS
	IBW1	12345	MM/DD/YY	HH:MM:SS.SSS
	ICW1	12345	MM/DD/YY	HH:MM:SS.SSS
	3 I2W1	12345	MM/DD/YY	HH:MM:SS.SSS
	IRW1	12345	MM/DD/YY	HH:MM:SS.SSS
Wdg 2	IAW2	12345	MM/DD/YY	HH:MM:SS.SSS
	IBW2	12345	MM/DD/YY	HH:MM:SS.SSS
	ICW2	12345	MM/DD/YY	HH:MM:SS.SSS
	3 I2W2	12345	MM/DD/YY	HH:MM:SS.SSS
	IRW2	12345	MM/DD/YY	HH:MM:SS.SSS
Wdg 3	IAW3	12345	MM/DD/YY	HH:MM:SS.SSS
	IBW3	12345	MM/DD/YY	HH:MM:SS.SSS
	ICW3	12345	MM/DD/YY	HH:MM:SS.SSS
	3 I2W3	12345	MM/DD/YY	HH:MM:SS.SSS
	IRW3	12345	MM/DD/YY	HH:MM:SS.SSS
(continued on next page)				

(continued from previous page)				
Wdg 4	IAW4	12345	MM/DD/YY	HH:MM:SS.SSS
	IBW4	12345	MM/DD/YY	HH:MM:SS.SSS
	ICW4	12345	MM/DD/YY	HH:MM:SS.SSS
	3I2W4	12345	MM/DD/YY	HH:MM:SS.SSS
	IRW4	12345	MM/DD/YY	HH:MM:SS.SSS
LAST PEAK DEMAND RESET FOR				
	Wdg1:	MM/DD/YY	HH:MM:SS.SSS	
	Wdg2:	MM/DD/YY	HH:MM:SS.SSS	
	Wdg3:	MM/DD/YY	HH:MM:SS.SSS	
	Wdg4:	MM/DD/YY	HH:MM:SS.SSS	

The report for MET P contains the last reset times for the peak demand registers for each winding.

Differential Metering Function (METER DIF Command)

This metering function is performed on an element basis, not on a winding basis, due to the nature of the function. The relay has three differential elements, one per phase, denoted 87-1, 87-2, and 87-3. The “A-phase” currents for each winding are compensated for CT and transformer winding connections, then divided by the tap value for each winding, and entered into the calculations as dimensionless “multiples of tap.” These values are then summed in 87-1 on a phasor basis for determining operating current (IOPk) and on a scalar magnitude basis for the restraint current (IRTk) calculation (k = 1, 2, 3). The B-phase and C-phase values find their way to 87-2 and 87-3, respectively.

In response to the **MET DIF** command, the fundamental frequency Operate and Restraint currents for each differential element are displayed in multiples of tap. The second- and fifth-harmonic currents in each element are also shown in multiples of tap. These are calculated in the same way as the operate currents, using the harmonic current from each winding in a phasor addition. If the command is typed as **MET DIF m**, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode, subsequent reports are not generated until the previous report has been completely sent. The format for the **MET DIF** report is as follows:

=>METER DIF						
XFMR 1		Date: MM/DD/YY		Time: HH:MM:SS.SSS		
STATION A						
	Operate Currents			Restraint Currents		
	IOP1	IOP2	IOP3	IRT1	IRT2	IRT3
I (Mult. of Tap)	123.12	123.12	123.12	123.12	123.12	123.12
	Second Harmonic Currents			Fifth Harmonic Currents		
	I1F2	I2F2	I3F2	I1F5	I2F5	I3F5
I (Mult. of Tap)	123.12	123.12	123.12	123.12	123.12	123.12

The quantities I1F2/IOP1, I2F2/IOP2, I3F2/IOP3, and I1F5/IOP1, etc., form the basis for the harmonic blocking feature. To determine if blocking should take place, these ratios of harmonic to fundamental operating current (times 100%) are compared to the user-selected blocking threshold settings PCT2 and PCT5.

Phasor Current Metering Function (METER SEC Command)

The phasor current metering function is a useful tool for verifying proper phase rotation of input currents, for checking CT connections and polarities, and for checking that “in” currents are about 180° out-of-phase with “out” currents. With normal load currents on the transformer, the correctness (or lack thereof) of all the input connections becomes apparent.

In response to the **METER SEC** command, the separate phase currents, as well as the positive-sequence, negative-sequence, and residual currents for each winding, are shown in secondary amperes and at a calculated phase angle. The relay uses the sample data to calculate the RMS phasor magnitudes and instantaneous phase angles as a kind of “snapshot” of all the phasor currents at an instant in time. If the command is typed as **METER SEC m**, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode, subsequent reports are not generated until the previous report has been completely sent. The format for the **METER SEC** report is as follows:

=>METER SEC						
XFMR 1			Date: MM/DD/YY		Time: HH:MM:SS.SSS	
STATION A						
	Phase Currents			Sequence Currents		
Wdg1	IAW1	IBW1	ICW1	3I1W1	3I2W1	IRW1
I (A,sec)	123.12	123.12	123.12	123.12	123.12	123.12
Angle (deg)	±123.12	±123.12	±123.12	±123.12	±123.12	±123.12
Wdg2	IAW2	IBW2	ICW2	3I1W2	3I2W2	IRW2
I (A,sec)	123.12	123.12	123.12	123.12	123.12	123.12
Angle (deg)	±123.12	±123.12	±123.12	±123.12	±123.12	±123.12
Wdg3	IAW3	IBW3	ICW3	3I1W3	3I2W3	IRW3
I (A,sec)	123.12	123.12	123.12	123.12	123.12	123.12
Angle (deg)	±123.12	±123.12	±123.12	±123.12	±123.12	±123.12
Wdg4	IAW4	IBW4	ICW4	3I1W4	3I2W4	IRW4
I (A,sec)	123.12	123.12	123.12	123.12	123.12	123.12
Angle (deg)	±123.12	±123.12	±123.12	±123.12	±123.12	±123.12

The phase angles given are all referenced to current IAW1. That is, the full set of 24 calculated current phasors is rotated in a manner that brings IAW1 to an angle of zero degrees. However, if the magnitude of IAW1 is less than $0.05 \times I_{nom}$ (0.25A for a 5 A relay), the angles are listed according to the phasor calculation without further adjustment.

Demand Reset Functions (MET RD and MET RP Commands)

The demand ammeter function performs an integration of current over time and, as such, contains a “history” of the currents dating back minutes or hours from the present time. The peak demand ammeter function maintains registers with the highest recorded demands of each type over a period of time since the last reset of the registers. For both of these functions, it may be desirable to erase this “history.”

The **MET RD n** (Reset Demand) command returns the demand ammeter current values to zero. This is useful during testing, for example, so that previous test quantities do not appear as part of the metered values or in order to check the shape of the rising exponential for a fixed current over a period of time.

The **MET RP n** (Reset Peak demand) command stores the present values of the demands, along with their associated date/time stamps, in the registers used to store the values of the peaks. These become the new peaks of record until higher values occur. This function might typically be performed on a daily, weekly, or monthly basis to determine a peak demand profile of the equipment over time.

Both of the reset commands must be followed by a value for “n.” A value of 1, 2, 3, or 4 will produce a reset of all the demand or peak demand values for winding n. If the letter A is entered, reset will be done on all of the windings. Failure to enter a value will produce an “Invalid parameter” response from the relay. For valid n values, the relay will ask for a Yes/No verification of your request to reset. No reports are issued for either command.

Figure 5.1 is an overall diagram representative of the five demand ammeters for each winding n, and the relationship of the four related commands (MET D, MET P, MET RD, MET RP). The currents are indicated generically as IX, the demand of each as XD(t), the peak demand of each XD(t) as PXD, the three demand alarm thresholds as XDEMnP, and the associated Relay Word bit as XDEMn. The greatest of the XD(t) demands for IAWn, IBWn, and ICWn is compared to the phase threshold PDEMnP; if the threshold is exceeded, Relay Word bit PDEMn is set. Negative-sequence current demand is compared to QDEMnP, and Relay Word bit QDEMn is set if the threshold is exceeded. Residual current demand is compared to NDEMnP, and Relay Word bit NDEMn is set if the threshold is exceeded.

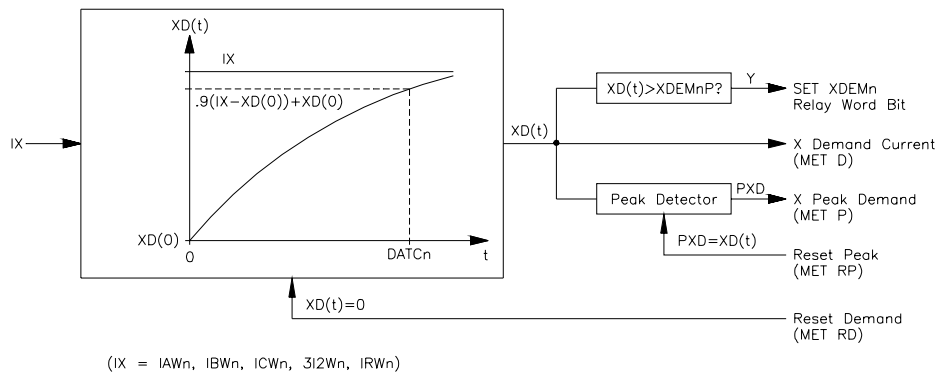


Figure 5.1: SEL-387 Relay Demand Ammeter Functions and Commands

Harmonic Metering Function (MET H Command)

The Harmonic Metering function, in response to the **MET H** command, retrieves 1 full cycle of unfiltered sample data, at 64 samples per cycle, from each of the 12 analog current inputs. Harmonic magnitudes are obtained using a fast Fourier transform method, which calculates a discrete Fourier transform, given by the following equation, for each harmonic from fundamental to fifteenth.

$$H_n = \sum_{k=0}^{N-1} h_k \cdot e^{j \frac{2\pi kn}{N}}$$

where,

N = samples per cycle = 64

n = order of the harmonic = 1, 2, ..., 15

h_k = sampled data for one full cycle at system frequency

k = summation index = 0, 1, ..., 63

H_n = result of the discrete Fourier transform calculation for the n^{th} harmonic

After the 15 H_n are calculated, they are adjusted to compensate for filter gain, and the resulting magnitudes are listed in secondary amperes:

```
=>MET H
processing harmonic spectrum .....
```

XFMR 1
STATION A

Date: 04/30/97 Time: 15:30:40.556

	Magnitudes of Harmonic Currents (Amps Sec)											
H	IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4
1	5.00	5.00	5.00	5.00	5.01	5.01	5.00	5.01	5.00	5.02	5.02	5.02
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
3	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

=>

The Analog Input Labels, IAW1, etc., will be listed as they are set in the Global settings section of the relay.

STATION DC BATTERY MONITOR

Use the station dc battery monitor in the SEL-387 Relay to alarm for undervoltage and overvoltage dc battery conditions and to view how station dc battery voltage fluctuates during tripping, closing, and other dc control functions. The monitor measures station dc battery voltage applied to the rear-panel terminals labeled Z25 (+) and Z26 (-). Access the station dc battery monitor settings (DC1P, DC2P, DC3P, and DC4P) with the SET G command.

Instantaneous Battery Voltage Values

The MET serial port command provides instantaneous values of the station dc battery voltage (Vdc). To obtain these values from the relay front panel, press the METER pushbutton, use the arrow pushbuttons to highlight VDC, and then press the SELECT pushbutton.

Undervoltage and Overvoltage Alarms

The flexibility of SELOGIC control equations lets you create battery warning and failure alarms that trigger when the station dc battery voltage falls below or exceeds voltage thresholds. Figure 5.2 shows the alarm logic and how Relay Word bits DC1 to DC4 can be used with DC1P, DC2P, DC3P, and DC4P threshold settings to create the alarms. Figure 5.3 shows the warning and alarm regions.

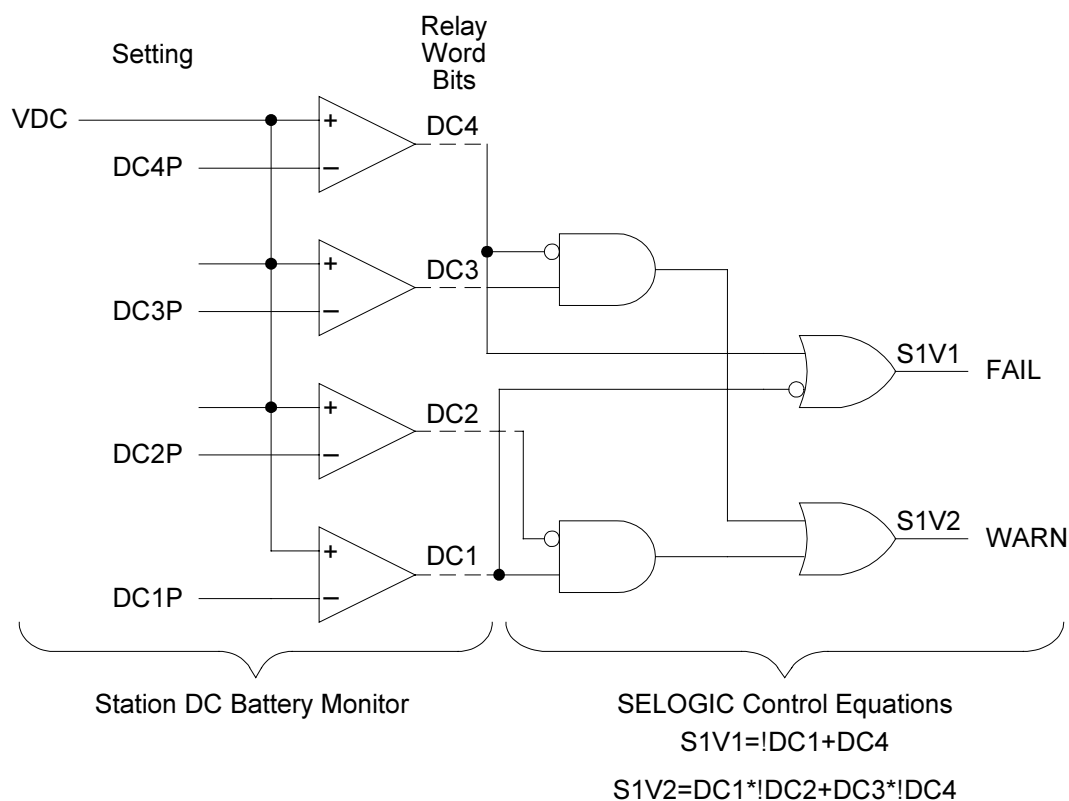


Figure 5.2: Station DC Battery Monitor Alarm Logic

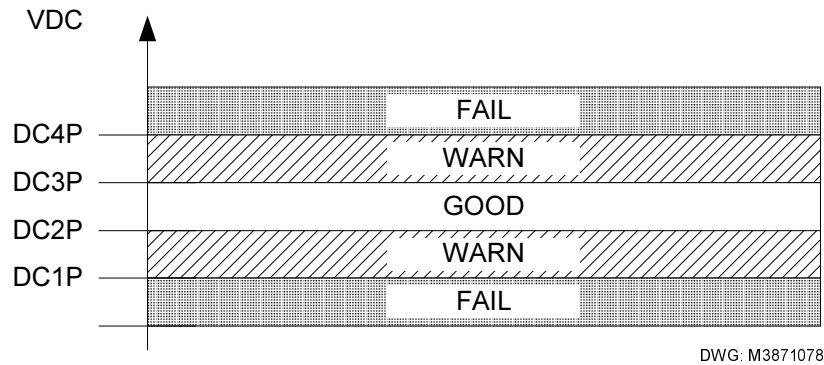


Figure 5.3: Undervoltage and Overvoltage Warning and Alarm Regions

From Figure 5.2 and Figure 5.3, you can see that no warning or alarm triggers so long as the battery dc voltage neither exceeds DC3P nor falls below DC2P. The relay triggers a warning for voltages exceeding DC3P or falling below DC2P. The relay triggers a failure alarm for voltages exceeding DC4P or falling below DC1P. For example, if the battery voltage exceeds the DC3P threshold, but falls below the DC4P threshold, the Relay Word bit DC3 asserts and the relay triggers a warning.

Detection of Voltage Dips in Event Reports

You can also use the battery monitor voltage threshold settings to detect momentary supply voltage fluctuations during periods of high demand on the station battery and charger system. The digital event report lists assertion of Relay Word bits DC1 through DC4. View this listing with the EVE D serial port command. To trigger an event report, include these bits in the SELOGIC control equation ER (event report trigger setting). Use the CEV command to retrieve a compressed event report containing the value of the station dc battery voltage during the event.

BREAKER MONITOR

The SEL-387 Relay breaker monitoring function is intended to capture information on the number of operations and total interrupted current for up to four breakers. These data are used to estimate the amount of contact wear per pole, based on a wear curve input by the user, and derived from the breaker manufacturer maintenance curves. Separate settings for each breaker determine under what conditions the monitoring function is initiated for that breaker. The breaker monitoring function is capable of differentiating between an internal trip, generated by units associated with the winding where the breaker is applied, and an external trip, initiated by another winding's units, another relay, or control contact. This information will assist the user in determining when to schedule maintenance of the breakers.

Breaker Monitor Description and Initiation Setting

The breaker monitor function has one initiation setting for each breaker. The BKMON1 through BKMON4 settings, in the Global/Relay settings area, are SELOGIC control equations, using Relay Word bits to initiate the monitor. The BKMONn settings look for rising edges (transition from logical 0 to logical 1) as an indication to read in current values. Currents are read 1.5 cycles after initiation as symmetrical RMS current and sent to the monitor IA, IB, and IC current accumulators. The trip counter is also advanced by one count. There are separate current accumulators and trip counters for internal and external trips.

An internal trip is defined as one initiated by the trip equation (TRn), which is associated with the particular Breaker n that BKMONn is monitoring. The monitor logic examines, for example, the status of the TRIP1 variable at the time the BKMON1 setting equation is asserted. If the TRIP1 variable is asserted when BKMON1 asserts, the trip count and the currents measured are recorded as internal. If TRIP1 is not asserted when BKMON1 asserts, the trip and currents are recorded as external. A trip initiated by any other winding elements (windings 2, 3, or 4) or the differential element is regarded as external, even though it originates within the same relay.

In our example transformer application, we want Breaker 1 to trip for its own overcurrent elements ($\text{OUT101} = \text{TRIP1}$; $\text{TR1} = 50\text{P11T} + 51\text{P1T} + 51\text{Q1T}$) or for a differential trip (86T device trip via $\text{OUT104} = \text{TRIP4}$; $\text{TR4} = 87\text{R} + 87\text{U}$). In this case, we set **BKMON1 = TRIP1 + TRIP4**. Winding 1 overcurrent trips (TRIP1) will be credited to the internal trip counter and current accumulators, and differential trips (TRIP4) will appear as external trips.

In order to capture trip information for other Breaker 1 trips initiated by devices other than the SEL-387 Relay, BKMONn must be set to sense these trips. This can be done, for example, by using an input to monitor the trip bus for the given breaker. This is illustrated in Figure 5.4, where IN106 is connected to the Breaker 1 trip bus and asserts for any trip from any source. Setting **BKMON1 = IN106** assures that the monitor will initiate for any Breaker 1 trip. The internal comparison with TRIP1 is then made to sort out internal versus external trips.

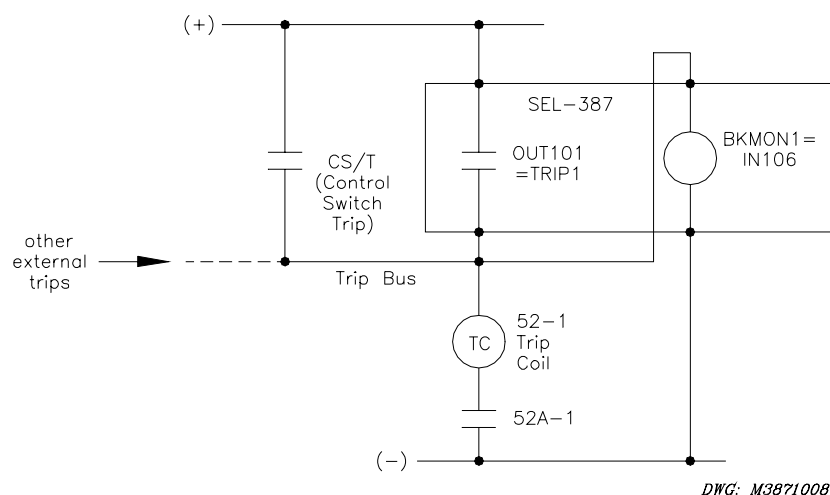


Figure 5.4: Trip Bus Sensing with Relay Input

Breaker Wear Curve Description and Settings

Based on maintenance curves supplied by manufacturers of the breakers, a contact wear curve for each breaker is constructed (Figure 5.5).

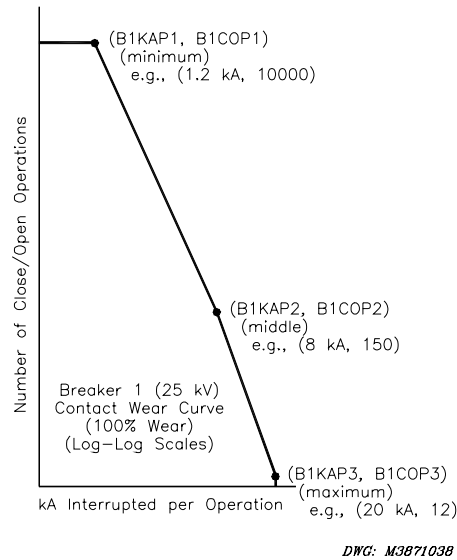


Figure 5.5: Breaker Contact Wear Curve

The curve is a plot of Close/Open operations versus interrupted current in kiloamperes (kA). The scales are logarithmic on both axes. For each Breaker n , three points are input in the Global setting area as relay settings. The points are defined by pairs of coordinates of current and operations. For Breaker n , these are the points $(BnKAP1, BnCOP1)$, $(BnKAP2, BnCOP2)$, and $(BnKAP3, BnCOP3)$. As shown in Figure 5.5, the point $(BnKAP1, BnCOP1)$ must represent the lowest current value, point $(BnKAP2, BnCOP2)$ an intermediate current value, and point $(BnKAP3, BnCOP3)$ the maximum current value. The relay will not accept the settings unless $BnKAP1 < BnKAP2 < BnKAP3$.

For values of current in kA (I) below $BnKAP1$, the number of operations is assumed to be the same as for $BnKAP1$. In this part of the curve, the number of operations may be governed more by the cumulative mechanical wear-and-tear on the breaker operating mechanism, rather than actual contact degradation. For values of I above $BnKAP3$, there is assumed to be no breaker capability to interrupt, and 100 percent contact wear is assumed. $BnKAP3$, then, is typically set at the maximum rated interrupting current for the particular breaker. $BnKAP1$ is set at a value approximating the continuous load current rating of the breaker. $BnKAP2$ is set at some intermediate value of current, chosen to provide the closest visual "fit" to the manufacturer's curve.

The two straight line segments of the curve between the three defined points define number of operations as a function of current in kiloamperes by an equation of the form:

$$O(I) = K \cdot I^{\alpha}$$

To determine the constants K and alpha for a given segment, any two current-operations pairs in that segment must be known. For any given pairs (I1, O1) and (I2, O2), the alpha constant is determined by the equation:

$$\alpha = \frac{\log_{10}\left(\frac{O1}{O2}\right)}{\log_{10}\left(\frac{I1}{I2}\right)}$$

The K constant can be found by back-substitution:

$$K = \frac{O1}{I1^\alpha} \quad \text{or} \quad K = \frac{O2}{I2^\alpha}$$

Here, we can use the endpoint pairs (BnKAP1, BnCOP1) and (BnKAP2, BnCOP2) to determine the equation that applies between these two input points and pairs (BnKAP2, BnCOP2) and (BnKAP3, BnCOP3) for the equation between the latter two points.

In Figure 5.5, for example, the two segments have the following equations:

$$O(I) = 14,972 \cdot I^{-2.214} \quad \text{and} \quad O(I) = 46,284 \cdot I^{-2.756}$$

For a particular value of I in kA, the calculated value O(I) represents 100 percent wear of the breaker contacts. Thus, the incremental percent wear for one trip operation at the defined current level is 100 / O(I) percent. For I < BnKAP1, O(I) = BnCOP1. For BnKAP1 < I < BnKAP2, O(I) is calculated by the first equation. For BnKAP2 < I < BnKAP3, O(I) is calculated by the second equation. For I > BnKAP3, O(I) = 0 and contact wear = 100 percent.

Since the breaker monitor calculates and accumulates current by phase, the wear for each pole of the breaker is calculated separately, using the same wear curve as a basis. Thus, over time, the cumulative percent wear for each of the three poles will be different. If a breaker already has some estimated wear when the relay is first applied, the user can preload a separate amount of wear for each pole of the breaker using the serial port command **BRE W n** (or **BRE n W**). Integer values of percent wear up to 100 percent are accepted by the relay. The incremental wear for the next interruption, and all subsequent interruptions, is added to the prestored value for a total wear value.

When the cumulative wear on any breaker pole reaches 100 percent, Relay Word bits are set to one for the particular pole, as well as for the breaker containing that pole. For example, for Breaker “n”, the Relay Word bits for the three poles are designated BCWAn, BCWBn, and BCWCn; for the breaker itself, Relay Word bit BCWn is set to one if any of the individual pole bits are set to one. These bits may be used for alarm or display purposes to alert the user that breaker inspection and maintenance may be required.

After breaker maintenance is performed or a new breaker installed, the breaker monitor operation counters, cumulative interrupted currents by pole, and percent wear by pole should be reset to zero. This can be done via the **BRE R n** (or **BRE n R**) serial port command or from the front panel via the OTHER pushbutton menu.

Both the **BRE W n** and **BRE R n** commands can be executed from Access Level B or 2.

Breaker Wear Example

A breaker having the wear curve of Figure 5.5 experiences a fault current interruption of 17,000 A. Previous accumulated wear is 44 percent.

The fault current falls between BnKAP2 (8 kA) and BnKAP3 (20 kA). The second equation is used to calculate O(I).

$$O(I) = 46,284 \cdot 17^{-2.756} = 46,284 \cdot 0.00041 = 18.81$$

$$\text{Incremental Percent Wear} = 100 / 18.81 = 5.32\%$$

$$\text{Cumulative Percent Wear} = 44 + 5.32 = 49.32\% \text{ (which appears as 49\% in BRE listing)}$$

Breaker Monitor Report Function (BRE Command)

The accumulators for each breaker can be reviewed either by a serial port command **BRE** or via the front-panel display, using the OTHER button menu.

The report lists all breakers, giving the number of internal and external trips for each breaker, the total accumulated RMS current by phase, and the Percent Wear by pole. The operation accumulators for each trip type have a maximum value of 65,000 trips. The current accumulators for each trip type have a maximum value of 99,999.00 kA RMS. Percent Wear never exceeds 100 percent. The accumulators can be reset by the serial port command **BRE n R** or via the OTHER front-panel pushbutton menu. The serial port report format is shown below.

```
=>BRE
XFMR 1                               Date: 04/21/97   Time: 14:52:14.179
STATION A

BREAKER 1
Int Trips=    0   IAW1=    0.00 IBW1=    0.00 ICW1=    0.00 kA(pri)
Ext Trips=    0   IAW1=    0.00 IBW1=    0.00 ICW1=    0.00 kA(pri)
Percent Wear: POLE1=    0 POLE2=    0 POLE3=    0

BREAKER 2
Int Trips=    0   IAW2=    0.00 IBW2=    0.00 ICW2=    0.00 kA(pri)
Ext Trips=    0   IAW2=    0.00 IBW2=    0.00 ICW2=    0.00 kA(pri)
Percent Wear: POLE1=    0 POLE2=    0 POLE3=    0

BREAKER 3
Int Trips=    0   IAW3=    0.00 IBW3=    0.00 ICW3=    0.00 kA(pri)
Ext Trips=    0   IAW3=    0.00 IBW3=    0.00 ICW3=    0.00 kA(pri)
Percent Wear: POLE1=    11 POLE2=    22 POLE3=    33

BREAKER 4
Int Trips=    0   IAW4=    0.00 IBW4=    0.00 ICW4=    0.00 kA(pri)
Ext Trips=    0   IAW4=    0.00 IBW4=    0.00 ICW4=    0.00 kA(pri)
Percent Wear: POLE1=    0 POLE2=    0 POLE3=    0

LAST BREAKER MONITOR RESET FOR   Bkr1: 04/21/97   14:35:15.742
                                   Bkr2: 04/21/97   14:35:15.821
                                   Bkr3: 04/21/97   14:35:15.898
                                   Bkr4: 04/21/97   14:35:15.975

==>>
```

THERMAL MONITOR (SEL-387-6 RELAY)

The thermal report functions provide information about the thermal status of the transformer(s) monitored by the SEL-387-6 Relay. There are four different types of thermal reports that display the present thermal status, event reports, hourly profile data, and daily profile data.

This section describes the quantities used in each of the reports and shows the format for each of the **THERM** command displays as they appear on the screen.

Thermal Monitor Report Function (THE command)

The **THERM** or **THE** command, with no additional parameters, displays the present thermal status of the transformer(s) monitored by the relay. If an alarm condition is detected (one or more of the thermal Relay Word bits are set), the relay saves a snapshot of the thermal status of the transformer to EEPROM. The format for the **THE** report is as follows:

Note: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 Relay displays only the values for Transformer 1; but when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 Relay displays the values for Transformer 1, Transformer 2, and Transformer 3.

```
=>>THE
XFMR 1                               Date: 05/21/00   Time: 14:17:35.045
STATION A
FID=SEL-387-6-Xxxx-V0-Z001001-Dxxxxxxxxx

Transformer 1
Thermal Element Condition      : NORMAL
Load(Per Unit)                 : 0.96
In Service Cooling Stage      : 1
Ambient (deg. C)              : 15.0
Calculated Top Oil (deg. C)   : 23.4
Measured Top Oil (deg. C)     : 400.0
Winding Hot Spot (deg. C)     : 46.7
Aging Acceleration Factor, FAA : 0.00
Rate of LOL (%/day)           : 0.00
Total Accumulated LOL (%)     : 0.00
Time-Assert TLL (hours)       : 0.00

Transformer 2
Thermal Element Condition      : NORMAL
Load(Per Unit)                 : 0.96
In Service Cooling Stage      : 1
Ambient (deg. C)              : 15.0
Calculated Top Oil (deg. C)   : 23.4
Measured Top Oil (deg. C)     : 400.0
Winding Hot Spot (deg. C)     : 46.7
Aging Acceleration Factor, FAA : 0.00
Rate of LOL (%/day)           : 0.00
Total Accumulated LOL (%)     : 0.00
Time-Assert TLL (hours)       : 0.00

                                (continued on next page)
```


(continued from previous page)	
Transformer 3	
Thermal Element Condition	: NORMAL
Load(Per Unit)	: 0.96
In Service Cooling Stage	: 1
Ambient (deg. C)	: 15.0
Calculated Top Oil (deg. C)	: 23.4
Measured Top Oil (deg. C)	: 400.0
Winding Hot Spot (deg. C)	: 46.6
Aging Acceleration Factor, FAA	: 0.00
Rate of LOL (%/day)	: 0.00
Total Accumulated LOL (%)	: 0.00
Time-Assert TLL (hours). . . .	: 0.00

Thermal Event Report Quantities

Thermal Element Conditions

The load condition value can be Normal, Warning 1, Warning 2, or Warning 3.

Table 5.1: Thermal Element Conditions

Value	Description
Normal	TO1, TO2, HS1, HS2, FAA1, FAA2, CSE, RLL, and TLL Relay Word bits are not asserted
Warning 1	TO1, HS1, FAA1, RLL, or TLL Relay Word bit is asserted.
Warning 2	TO2, HS2, FAA2 Relay Word bit is asserted.
Warning 3	CSE Relay Word bit is asserted.

Load Current

The load current is reported as a per-unit value based on the transformer rating.

In-Service Cooling Stage

The active cooling system is displayed. The displayed value is 1 for Cooling Stage 1, 2 for Cooling Stage 2, and 3 for Cooling Stage 3. The SEL-387-6 Relay selects the cooling stage with the aid of contact inputs or SELOGIC control equation expressions defined in settings. The settings are defined by SELOGIC control equations, using defined contact inputs or any Relay Word elements to switch transformer constants based on the cooling stage. Only one of the cooling stages may be active at a time.

Ambient Temperature

The value displayed (in degrees Celsius) is either the actual ambient temperature received from the serial port or the value of the default ambient temperature setting (DTMP), if actual temperatures are not received by the relay.

Calculated Top-Oil Temperature

The value displayed (in degrees Celsius) is the transformer's top-oil temperature computed using the load current. The maximum value displayed is 3276°C.

Measured Top-Oil Temperature

The value displayed (in degrees Celsius) is the transformer's top-oil temperature received from the serial port. If no data (or invalid data) are received from the serial port, the value displayed is -0-.

Winding Hot-Spot Temperature

The value displayed (in degrees Celsius) is the computed value of the winding hot-spot temperature using the actual ambient and top-oil temperatures or the load current. The maximum value displayed is 3276°C.

Aging Acceleration Factor

The value displayed is the active insulation aging acceleration factor (FAA). The maximum value of FAA is clamped at 9999.0.

Rate of Loss of Life

The value displayed is the computed daily rate of loss of life (%) accumulated in a 24-hour period. This value is updated at midnight daily.

Total Loss of Life

The value displayed represents the total accumulated loss of life (%) since last reset.

Time to Assert TLL

The value displayed represents the estimated time (in hours) to assert the total loss-of-life alarm (TLL Relay Word bit).

Thermal Event Report Function (THE n Command)

Whenever a thermal alarm condition is set (load conditions are Warning 1, Warning 2, or Warning 3), the SEL-387-6 Relay saves a snapshot of the thermal status of the transformer(s) in EEPROM. The five most recent thermal events are saved. If the command for retrieving the nth saved thermal event report is **THE n**, where n is a number from one to five, **THE 1** will display

the most recent event report while **THE 5** will display the oldest thermal event report. The format and data for the **THE n** report is the same as that for the **THE** report.

Thermal Profile Data Report Function (THE H and THE D Commands)

The SEL-387-6 Relay stores two types of trend data: one set on an hourly basis for the last 24 hours; a second set on a daily basis for the last 31 days. The format of the retrieved data report is suitable for display in Microsoft® Excel.

Hourly Profile Data Report (THE H Command)

The SEL-387-6 Relay stores the following data on an hourly basis for the last 24 hours. The data are stored at the beginning of each hour.

- One-hour average ambient temperature
- One-hour average calculated top-oil temperature
- One-hour average measured top-oil temperature
- One-hour average winding hot-spot temperature
- One-hour average per-unit load current
- One-hour average insulation aging acceleration factor (FAA)

The format for the **THE H** report is as follows:

Note: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 Relay displays only the values for Transformer 1; when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 Relay displays the values for Transformer 1, Transformer 2, and Transformer 3.

```

=>>THE H
XFMR 1                                Date: 04/24/00    Time: 13:20:03.956
STATION A
FID=SEL-387-6-X117-V0-Z001001-D20000419

Transformer 1
Date      Time      Ambient  Calc      Measured      Load
Top Oil   Top Oil   Hot Spot   Current   FAA
04/24/00 13:00* 15.0      32.5      -0-          32.7        0.04    0.0
04/24/00 12:00* 15.0      32.5      -0-          32.8        0.05    0.0

Transformer 2
Date      Time      Ambient  Calc      Measured      Load
Top Oil   Top Oil   Hot Spot   Current   FAA
04/24/00 13:00* 15.0      32.5      -0-          32.5        0.01    0.0
04/24/00 12:00* 15.0      32.5      -0-          32.5        0.02    0.0

Transformer 3
Date      Time      Ambient  Calc      Measured      Load
Top Oil   Top Oil   Hot Spot   Current   FAA
04/24/00 13:00* 15.0      32.5      -0-          32.7        0.05    0.0
04/24/00 12:00* 15.0      32.5      -0-          32.7        0.06    0.0
=>>

```

Daily Profile Data Report Function (THE D Command)

The relay stores the following on a daily basis (at midnight) for the last 30 days:

- Maximum ambient temperature
- Maximum calculated top-oil temperature
- Maximum measured top-oil temperature
- Maximum winding hot-spot temperature
- Maximum per-unit load
- Maximum insulation aging acceleration factor (FAA)
- Daily 24-hour accumulated loss of life (value of accumulated 24-hour loss of life at midnight)
- Total accumulated loss of life (sum of the daily 24-hour accumulated loss of life values)
- * showing a communication failure

The format for the **THE D** report is as follows:

Note: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 Relay displays only the values for Transformer 1; but when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 Relay displays the values for Transformer 1, Transformer 2, and Transformer 3.

```

=>THE D
XFMR 1                               Date: 04/25/00   Time: 00:00:43.248
STATION A
FID=SEL-387-6-X117-V0-Z001001-D20000419

Transformer 1
      Max      Max Calc Max Msd Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0    32.6    -0-   34.2    0.48    0.0    0.00    0.00

Transformer 2
      Max      Max Calc Max Msd Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0    32.6    -0-   34.2    0.48    0.0    0.00    0.00

Transformer 3
      Max      Max Calc Max Msd Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0    32.6    -0-   34.2    0.48    0.0    0.00    0.00
=>>

```

Retrieving Thermal Data Reports

Thermal data reports are accessed with the **THE** command in the following different ways:

Example THE

Serial Port

Commands

Format

THE

Enter **THE** command with no additional parameters to display the present status of the monitored transformer.

THE 1

Enter **THE** command followed by a number (1 in this example) to display the latest archived thermal event report.

THE D

Enter **THE** command followed by **D** and no additional parameters to display all available daily profile data records.

THE H

Enter **THE** command followed by an **H** but with no additional parameters to display all available hourly profile data records. The chronological progression through the report is down the page and in descending order.

THE H (or D) 3/30/00

Enter **THE H** (or **D**) followed by the date (**3/30/00** in this example) to display all records (if they exist) starting with that date and ending with the present date. The records display with the latest record at the beginning (top) of the report and the oldest record at the end (bottom) of the report. Chronological progression through the report is down the page and in descending order.

THE D (or H) 2/17/00 3/07/00

Enter **THE D** (or **H**) followed by two dates (**2/17/00** chronologically precedes **3/07/00** in this example) to display all the records (if they exist) between (and including) those dates. The records display with the latest record (**3/07/00**) at the beginning (top) of the report and the oldest record (**2/17/00**) at the end (bottom) of the report.

**THE D 3/07/00
2/17/00**

Enter **THE D** (or **H**) followed by two dates (**3/07/00** chronologically follows date **2/17/00** in this example) to display all records (if they exist) between (and including) those dates. The records display with the latest record (**3/07/00**) at the beginning (top) of the report and the oldest record (**2/17/00**) at the end (bottom) of the report.

The date entries in the examples for the **THE H** and **THE D** commands are dependent on the Date Format setting DATE_F. If setting DATE_F = MDY, enter the dates as in the above examples (Month/Day/Year). If setting DATE_F = YMD, enter the dates Year/Month/Day.

If the requested **THE** hourly or daily profile records do not exist, the relay responds: Invalid Record. If there is no data in the hourly or daily profile buffers, the relay responds: No Data Available.

Thermal Monitor Reset Functions (THE R, THE C, and THE P Commands)

The **THE C** (Clear Thermal Archives Function) command clears the daily profile archives, hourly profile archives, and the thermal event archives.

The **THE R** (Reset Thermal Function) command clears all the thermal archives (daily profile data, hourly profile data, and thermal event data) and resets the total accumulated loss-of-life value to its preset value (if it exists) or zero.

Using the **THE P n** (Load Preset Value of Total Loss of Life) command, the user can preset the initial loss-of-life values for each phase of the monitored transformer. The command must be followed by a value between zero and 100 percent. This command initializes the total loss-of-life value to the preset value entered by the user, clears all the thermal archive data, and restarts the thermal element.

STATUS MONITOR

The status monitor of the SEL-387 Relay is designed to provide information on the internal health of the relay's major components. The relay continuously runs a variety of self-tests. Some tests have warning and failure states; others only have failure states.

Status Monitor Report Function (STATUS Command)

The STATUS command displays a report of the self-test diagnostics. The relay automatically executes the STATUS command whenever the self-test software enters a warning or failure state.

If a warning or failure state occurs, the next time the STA command is issued, the warning state is reported. If a warning or failure occurs, it will not be cleared until relay power is cycled and the problem is fixed. Saving relay settings performs a warm boot of relay logic. This may clear some warnings. If warnings persist, contact the factory.

Below is the STATUS report format. All warnings are represented by a W in the status report, generate an automatic serial port message, and pulse the ALARM output contact for five seconds. All failures are represented by an F in the status report, generate an automatic serial

port message, display the failure on the front-panel display, and latch the ALARM output contact.

```
=>STA<ENTER>
```

XFMR 1	Date: 04/25/00		Time: 00:23:54.259				
STATION A							
FID=SEL-387-6-X117-V0-Z001001-D20000419 CID=2001							
SELF TESTS							
W=Warn F=Fail							
	IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	
OS	2	-0	2	1	1	1	
	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4	
OS	4	3	0	3	2	-0	
	+5V_PS	+5V_REG	-5V_REG	+12V_PS	-12V_PS	+15V_PS	-15V_PS
PS	4.95	5.00	-5.07	11.98	-12.17	14.92	-14.91
	TEMP	RAM	ROM	A/D	CR_RAM	EEPROM	IO_BRD
	41.1	OK	OK	OK	OK	OK	OK
Relay Enabled							

The quantities shown in the STATUS report are discussed below. The applicable limits for warning or failure of each self-test are summarized in Table 5.2.

The STATUS button on the front-panel interface can also be used to access the information in the report. See **Section 8: Front-Panel Interface**.

Channel Offset

The relay measures the dc offset (OS) voltage of each of the 12 analog current input channels and compares the value against a fixed limit of 30 mV. If an offset measurement is outside the fixed limit, the relay declares a warning.

Power Supply

The relay measures the internal power supply (PS) voltages and regulated +5 and -5 voltages, and compares the values against fixed limits. If a voltage measurement is outside the limits, the relay declares a warning or failure.

Temperature

The relay measures its internal temperatures (TEMP). If the relay measures a temperature less than -40°C or greater than +85°C, a warning is declared. If the relay measures a temperature less than -50°C or greater than +100°C, a failure is declared. The temperature warning does not pulse the ALARM output contact.

RAM

The relay checks the random-access memory (RAM). If a byte cannot be written to or read from, the relay declares a RAM failure. There is no warning state for this test.

Flash ROM

The relay checks the flash read-only memory (ROM) by computing a checksum. If the computed value does not agree with the stored value, the relay declares a ROM failure. There is no warning state for this test.

Analog-to-Digital Converter

The relay verifies the A/D converter function by checking the A/D conversion time. The test fails if conversion time is excessive or a conversion starts but does not finish. There is no warning state for this test.

Critical RAM

The particular area of RAM where the settings are stored is deemed Critical RAM. It is verified by computing a checksum. This must agree with a previously stored checksum value, or the relay will declare a Critical RAM (CR_RAM) failure. There is no warning for the test.

EEPROM

EEPROM is checked by computing a checksum. If the computed value does not agree with the stored value, the relay declares a EEPROM failure. There is no warning for the test.

I/O Boards

The relay checks the I/O board ID register against a stored value. If any values differ, the relay declares an I/O_BRD failure. There is no warning state for this test. Use the **INITIO** <ENTER> command to reset the stored value for the new I/O configuration.

Self-Test Alarm Limits

Table 5.2 summarizes the limits for issuing warning or failure alarms during self-testing. The power supply and temperature alarms list the lower values below which, and upper values above which, the stated alarm is issued.

Table 5.2: Self-Test Alarm Limits

Self-Test	Warning Limits	Failure Limits
Channel Offset	30 mVdc	NA
+5 V Power Supply	4.80/5.20 Vdc	4.65/5.40 Vdc
+5 V Regulated	4.75/5.20 Vdc	4.50/5.40 Vdc
–5 V Regulated	–4.75/–5.25 Vdc	–4.50/–5.40 Vdc
+12 V Power Supply	11.50/12.50 Vdc	11.20/14.00 Vdc
–12 V Power Supply	–11.50/–12.50 Vdc	–11.20/–14.00 Vdc
+15 V Power Supply	14.40/15.60 Vdc	14.00/16.00 Vdc
–15 V Power Supply	–14.40/–15.60 Vdc	–14.00/–16.00 Vdc
Temperature	–40/+85°C	–50/+100°C
RAM	NA	Cannot READ/WRITE
Flash ROM	NA	Bad Checksum
A/D	NA	Slow Conversion
Critical RAM	NA	Bad Checksum
EEPROM	NA	Bad Checksum
IO_BRD	NA	Incorrect I/O Board Value

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SECTION 6: SETTING THE RELAY

INTRODUCTION

Change or view settings with the SET and SHOWSET serial port commands and the front-panel SET pushbutton. Table 6.1 lists the serial port SET commands.

Table 6.1: Serial Port SET Commands

Command	Settings Type	Description
SET n	Relay	Overcurrent elements for settings group n (n = 1, 2, 3, 4, 5, 6).
SET G	Global	Battery and breaker monitors, etc.
SET R	SER	Sequential Events Recorder trigger conditions and Load Profile settings.
SET P n	Port	Serial port settings for Serial Port n (n = 1, 2, 3, or F).

View settings with the respective serial port SHOWSET commands (SHO, SHO G, SHO R, SHO P). See discussion of SHO commands in *Section 7: Serial Port Communications and Commands*. Settings Sheets are located at the end of this section.

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 8.8 in *Section 8: Front-Panel Interface* for information on front-panel settings.

SETTINGS CHANGES VIA THE SERIAL PORT

Note: In this manual commands you type appear in bold/uppercase: **SHOWSET**. You need to type only the first three letters of a command, for example, **SHO**. Computer keys you press appear in bold/uppercase/brackets: **<ENTER>**.

See *Section 7: Serial Port Communications and Commands* for information on serial port communications and relay access levels. The SET commands in Table 6.1 operate at Access Level 2 (screen prompt: =>>). To change a specific setting, enter the command:

SET n m s TERSE

where

n = L, G, R, T, or P (parameter n is not entered for the Relay settings).

M = group (1....6) or port (1....3). The relay selects the active group or port if m is not specified.

s = the name of the specific setting you wish to jump to and begin setting. If s is not entered, the relay starts at the first setting.

TERSE = instructs the relay to skip the SHOWSET display after the last setting. Use this parameter to speed up the SET command. If you wish to review the settings before saving, do not use the TERSE option.

When you issue the SET command, the relay presents a list of settings, one at a time. Enter a new setting or press <ENTER> to accept the existing setting. Editing keystrokes are shown in Table 6.2.

Table 6.2: SET Command Editing Keystrokes

Press Key(s)	Results
<ENTER>	Retains setting and moves to the next setting.
^ <ENTER>	Returns to previous setting.
< <ENTER>	Returns to previous setting.
> <ENTER>	Moves to next setting.
END<ENTER>	Exits editing session then prompts you to save the settings.
<CTRL> X	Aborts editing session without saving changes.

The relay checks each entry to ensure that it is within the setting range. If it is not, an "Out of Range" message is generated, and the relay prompts for the setting again.

When all the settings are entered, the relay displays the new settings and prompts for approval to enable them. Answer **Y**<ENTER> to enable the new settings. If changes are made to Global, SER, or Port settings (see Table 6.1), the relay is disabled while it saves the new settings. If changes are made to the Relay or Logic settings for the active setting group (see Table 6.1), the relay is disabled while it saves the new settings. The ALARM contact closes momentarily (for a "b" contact, opens for an "a") and the EN LED extinguishes while the relay is disabled. The relay is disabled for about one second. If Logic settings are changed for the active group, the relay can be disabled for 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 6.1), the relay is not disabled while it saves the new settings. The ALARM contact closes momentarily (for a "b" contact, opens for an "a") but the EN LED remains on while the new settings are saved.

ADDITIONAL RELAY SETTINGS

With the setting of the overcurrent elements, the protection-related settings of the relay are complete. However, this is not the end of the setting process. Other settings must be made to define the following:

1. Relay and Terminal Identification
2. System Parameters (Frequency, Phase Rotation)
3. Demand Metering

4. Additional special SELOGIC[®] control equations, if needed (Sets 1 through 3)
5. Assignment of Optoisolated Inputs and Contact Outputs
6. Trip and Close Logic
7. Event Report Triggering and Length Selection
8. Front-Panel Targeting and Displays
9. Sequential Events Recorder
10. Communications Ports
11. Setting Group Selection
12. Miscellaneous Hardware Settings
13. Breaker Monitor Settings
14. DC Battery Monitor Settings
15. Analog Input Labels

These settings are discussed below, as well as in other referenced instruction manual sections devoted more specifically to these topics.

Relay (RID) and Terminal (TID) Identification

The Relay Identifier (RID) and Terminal Identifier (TID) settings typically are used to identify the equipment protected by the relay or the identifier of the circuit breaker(s) controlled by the relay. The relay tags event reports with the Relay and Terminal Identifier Strings. This allows you to distinguish the event report as one generated for a specific breaker and substation. The RID setting is limited to 39 characters and the TID setting to 59 characters. For our example, we have selected RID=XFMR1 and TID=STATION A.

Demand Ammeter Settings (DATC, PDEM, QDEM, NDEM)

The relay provides demand ammeters for windings 1 through 4, for phase, negative-sequence, and residual currents. The relay saves time- and date-stamped peak demand readings for each of the quantities. View this information using the relay front panel or serial port METER commands.

The demand ammeters behave much like low-pass filters, responding to gradual trends in the current magnitude. The relay uses the demand ammeter time constant setting, DATCn, for all 5 demand ammeter calculations for winding “n.” The time constant is settable from 5 to 255 minutes. The demand ammeters operate such that if demand current is reset and a constant input current is applied, the demand current output will be 90 percent of the constant input current value DATCn minutes later.

Settable demand ammeter thresholds are available for all five demand ammeters in units of amps secondary. The thresholds are PDEMnP, QDEMnP, and NDEMnP for the phase (A, B, and C), negative-sequence, and residual demand ammeters, for winding “n.” If demand currents exceed the set threshold, the respective Relay Word bit **PDEMn**, **QDEMn**, or **NDEMn** asserts. You can use these Relay Word bits to alarm for phase overload and negative-sequence or residual current unbalance, for winding “n.” See *Section 5: Metering and Monitoring* for more information.

For our example, the Demand Ammeter function is enabled only for winding 1, the 230 kV primary winding, with the following settings: DATC1 = 15 minutes, PDEM1P = 7 A, QDEM1P = 1 A, and NDEM1P = 1 A.

The demand ammeter settings can be different in the six settings groups.

Instantaneous metering functions have no settings. These functions show primary phase, negative-sequence, and residual current magnitudes; secondary winding current magnitudes and angles; differential quantities (operate, restraint, second- and fifth-harmonics) in multiples of tap. Access is by the front panel or one of the communications ports.

Input and Output Assignments

Optoisolated inputs (IN101 through IN106) and contact outputs (OUT101 through OUT107) are fully programmable, with no numbered input or output specifically dedicated to a function. The one exception is the ALARM contact, factory-set as a form-B contact (normally closed), and dedicated to the alarm function. OUT107 can be made into an additional alarm contact that follows the normal ALARM contact via JMP23 on the main board (see **Section 2: Installation**). Standard SELOGIC control equations can be written to drive the output contacts. The inputs appear as elements of SELOGIC control equations. Examples of this are illustrated in the next discussion on Trip and Close Logic. These settings can be different in the six settings groups.

Trip and Close Logic

The Settings Sheets contain two specific areas highlighting the assignment of variables for the Trip Logic and Close Logic. These functions, along with those in the Output Contact Logic area, must be programmed in order for the relay to take action. Settings in all three areas are SELOGIC control equations.

There are five trip variables to define conditions under which a trip will be issued. These are named TR1 to TR5. This will cover trip conditions for four separate breakers, plus one extra for a general trip of all breakers. The settings for the example transformer application illustrate this.

In the example, TR1 through TR3 are set to respond to overcurrent elements specific to the winding associated with Breakers 1 to 3. For example, $TR1 = 50P11T + 51P1T + 51Q1T$. Complete operation of the phase definite-time or inverse-time elements, or the negative-sequence inverse-time element, will set the appropriate Relay Word bits 5xxxxT to one, and TR1 will respond to any of them. TR1 initiates the Trip Logic, producing output of the logic and setting of Relay Word bit TRIP1 to one. For tripping Breaker 2, $TR2 = 51P2T + 51Q2T$. For tripping Breaker 3, $TR3 = 50P31 + 51P3T$. Technically, 50P31T should have been used, since this would indicate that the definite-time element has timed out. However, since 50P31 is set for zero delay, or is instantaneous, there is no reason to wait. For group tripping of all three breakers, $TR4 = 87R + 87U$. This results in a tripping output to an external 86 lockout device, which then trips the three breakers with separate contacts. This takes place only if a differential operation, either restrained or unrestrained, is detected. TR5 is not used, and is set to zero.

In general, definition of the TR1 and TR5 variables should include only Relay Word bits which remain firmly asserted during a fault, but otherwise are not asserted. For this reason, rising-edge detection (/), falling-edge detection (\), and the NOT operator (!) should be avoided for the Relay Word bits used in these five settings. Exceptions might be bits used for opening the breaker by command during nonfault conditions, such as the OCn bits or the remote bits, RBn.

When the trip logic is activated, and one or more Relay Word bits TRIP1 to TRIP4 are set to one, a trip can take place. However, in order for this to happen an output contact must be assigned for each trip. These assignments are made on the Output Contact Logic setting sheet area. In this case, OUT101 = TRIP1, OUT102 = TRIP2, OUT103 = TRIP3, and OUT104 = TRIP4. OUT101 to OUT103 go directly to the three breaker trip coils, and OUT104 goes to the 86 operate coil. These connections are shown in Figure 2.9 in **Section 2: Installation**.

Corresponding to the five trip variables in the Trip Logic setting area are five unlatch variables. The variables ULTR1 to ULTR5 define the conditions to unlatch the seal-in of trip logic that takes place when TRn goes to one. They sense when it is appropriate to deenergize the trip circuit. In this case, the instantaneous overcurrent elements, 50Pn3, were set very low, and unlatch is defined as when the phase currents in all three phases drop below the setting. This is done with the NOT operator. That is, $ULTR1 = !50P13$, $ULTR2 = !50P23$ and $ULTR3 = !50P33$. $ULTR4 = !(50P13 + 50P23 + 50P33)$, and unlatches TRIP4 when all phase currents on all windings drop below the 0.5 A setting. ULTR5 is not used and is set to zero.

In the Close Logic setting area, inputs are defined to represent the 52a auxiliary contacts from the individual breakers. Defined as well are the four Close and four Unlatch Close variables, if the closing function is to be used.

In our example, inputs IN101 to IN103 are assigned to represent the 52a contacts. That is, $52A1 = IN101$, $52A2 = IN102$, and $52A3 = IN103$. (Note again that inputs appear in the right side of an equation, outputs on the left side.) $52A4$ is not used, and is set to zero. The connections for the 52a inputs are shown in Figure 2.9 in **Section 2: Installation**.

The four Close variables CL1 through CL4 are set up to define the conditions under which a closing can take place. In our example, these are set up to respond to a CLOSE n command from a communications port, or an external contact input from a SCADA RTU or other switch. Specifically, $CL1 = CC1 + /IN104$, $CL2 = CC2 + /IN105$, and $CL3 = CC3 + /IN106$, where “/” denotes detection of a “rising edge” for the input shown. CL4 is not used, and is set to zero. Within these SELOGIC control equations, inputs IN104 to IN106 have been defined as being related to the close initiation function for the specific breakers. The CLn variable initiates the close logic, resulting in Relay Word bit CLSn being set to one, unless the logic is disabled by an unlatch condition, discussed below. Note that connections for the closing function are not shown in Figure 2.9 in **Section 2: Installation**.

Closing can now take place, but only if an output contact has been assigned to this function. Returning to the Output Contact Logic setting area for our example, we set $OUT105 = CLS1$, $OUT106 = CLS2$, and $OUT107 = CLS3$. These contacts must be wired to the closing circuits of the individual breakers.

In the Close Logic setting area, four variables remain. ULCL1 to ULCL4 define the conditions for unlatching the close logic. These are set in our example to be the presence of any trip logic output. That is, $ULCL1 = TRIP1 + TRIP4$, $ULCL2 = TRIP2 + TRIP4$, and $ULCL3 = TRIP3 + TRIP4$. ULCL4 is not used and is set to zero. ULCLn will remove the seal-in of the close logic and return Relay Word bit CLSn to zero. A closed 52a contact or a Close Failure Detection will also unlatch the Close Logic. The output contact that follows the CLSn bit will open in response.

The Trip Logic and Close Logic settings can be set differently in the six setting groups. See **Section 4: Control Logic** for more information on Trip and Close Logic.

There are two additional miscellaneous timer settings that apply to the Trip and Close Logic. These are TDURD and CFD. TDURD is the minimum trip duration time and defines the minimum length of time the trip signal will be issued, regardless of other inputs to the Trip Logic. The default setting is 9 cycles. The CFD, or Close Failure Detection time delay, is an overriding timer to unlatch the close logic if the breaker has not yet closed. The default setting is 60 cycles.

Event Report Triggering (ER) and Length Selection (LER, PRE)

There are three settings for Event Reports: (1) ER, (2) LER, and (3) PRE.

The first, ER, defines in a SELOGIC control equation the conditions under which a report will be generated. In our example, $ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3$. Events will be generated from the pickup of the various overcurrent elements, whether they fully time out or not. This will yield reports for some external faults that do not result in tripping of the transformer breakers, but for which information might be useful. Winding 3 element pickup is used to detect external tertiary circuit faults that may be too weak to be detected by the winding 1 elements. Also, since tertiary circuits normally are short, probably only including the substation buses and auxiliary equipment, reports on faults of any kind would be of great interest.

The LER setting defines how long the overall report should be: 15, 30, or 60 cycles. The related setting PRE defines how much of that length should be “pre-trigger,” and can be set from one cycle to LER-1 cycles. We have selected the standard SEL report length of 15 for LER, with PRE set at 4, giving $15 - 4 = 11$ cycles of fault data. This is probably long enough to capture the entire event, for trips by high-speed elements (87R, 87U, 50Pxx), but may not be long enough for inverse-time trips. Since any trip will generate an Event Report, inverse-time trips may be captured on two reports, one generated by element pickup and the other by the eventual trip.

Event Report settings are Global settings, accessible with a SET G command from a communications port.

System Frequency (NFREQ) and Phase Rotation (PHROT)

The relay settings NFREQ and PHROT establish your basic system parameters for the SEL-387 Relay.

1. Set NFREQ equal to the nominal power system operating frequency, either 50 Hz or 60 Hz.
2. Set PHROT to the power system phase rotation, either ABC or ACB.

These are Global settings, set after issuing a SET G command from a communications port.

Miscellaneous (DATE F, SCROLL, FP TO, TGR)

There are four miscellaneous settings to complete the setting process. These are the Date Format, Front-Panel Time-Out, Scroll Data and Group Change Delay settings. These settings are Global settings, accessible with the SET G command from a communications port or the front panel.

The DATE_F setting permits the user to define either a Month-Day-Year (MDY) format or a Year-Month-Day (YMD) format for all relay date reporting. Default is MDY.

Use the display update rate (SCROLL or scroll data) setting to control how long each pair of display text messages is displayed on the front panel. Setting range is 1 to 60 seconds with a default of 2 seconds.

The front-panel time-out setting, FP_TO, defines the length of time before the panel returns to normal default scrolling displays and LED targeting. This feature is useful for preventing the panel from being accidentally left in a display state that was being used during testing or to confirm Relay Word bit status. It can be set from 0 to 30 minutes; default is 16 minutes.

The Group Change Delay timer setting, TGR, defines the amount of time that must pass before a new group of settings take effect. It requires the conditions to change to a new group to persist for time TGR before the relay enacts the new settings. The setting range is 0 through 900 seconds. The factory default value is 3 seconds. This function prevents the relay from jumping around from group to group in response to spurious fulfillment of the SS1 setting conditions and ensures that a request for change is real and justified.

DC Battery Monitor (DC1P–DC4P)

The DC Battery Monitor function is described in *Section 5: Metering and Monitoring*. You may choose one of four dc voltage thresholds, DC1P through DC4P, to assert Relay Word bits DC1 to DC4 when supply voltage to the relay exceeds the specific threshold. This allows the user to readily determine if the voltage is within certain limits and to alarm if the voltage goes too high or low. The four threshold settings are found in the Global setting area.

Breaker Monitor

The Breaker Monitor function is described fully in *Section 5: Metering and Monitoring*. There is one setting for each of four breakers, BKMON1 through BKMON4. This setting accepts a SELOGIC control equation using Relay Word elements to describe the triggering conditions for that particular monitor. When triggered, the monitor measures the three-phase currents 1.5 cycles after triggering, adds them to the total accumulated current for that breaker, and adds one to the external or internal trip counter, depending on whether the associated TRIP variable was asserted at time of triggering.

In addition, for each breaker there is a contact wear curve, defined by entering three operations versus current coordinate pairs. This curve is applied by pole to track and alarm when excessive contact wear is encountered. This helps the user schedule breaker maintenance intervals.

Analog Input Labels

In the Global setting area, the user is permitted to rename the 12 analog current inputs to suit local preferences. The present names, IAW1 through ICW4, can be replaced with other designations of not more than four characters. This function recognizes the desire of users to replace SEL designations with more familiar phase identifiers, such as “R, S, T,” “Red, Blue, Yellow,” and so forth.

The new labels will appear wherever the currents were identified by the existing labels, including the displays for serial port commands STATUS, BREAKER, EVENT, and METER, including the variants of each command. The new labels will also appear in the front-panel LCD displays for the STATUS and METER pushbutton menus.

Setting Group Selection

In the Global settings there are settings to define which of the six settings groups is to be the active group. Use the SET G command from a communications port to access settings SS1 to SS6. The front panel cannot be used to access or change these settings. The settings are defined by SELOGIC control equations, using defined contact inputs or any Relay Word elements to switch groups. The simplest method is to set a value of one for the SSn setting corresponding to the desired settings group “n.” The SELOGIC control equations permit greater user flexibility in defining when to switch setting groups. If any variable SS1 to SS6 is asserted, the GRO n serial port command and the front-panel GROUP pushbutton cannot be used to change setting groups.

Front-Panel Targeting, Displays, and Control

There are settings for elements of the front-panel display, if the user is interested in customizing an LED target or display for a specific function. Three of the 16 front-panel LEDs are fully programmable. These are the FAULT TYPE A, B, C LEDs in the second row. The default settings for these LEDs are based on phase selection logic for overcurrent trips or differential trips by a specific element. For example, the A-phase LED is programmed normally as follows: $LEDA = OCA + 87E1$. This means that the LED will come on if it is determined that A-phase was involved in an overcurrent trip or that differential element 1 issued a trip. The user may define any SELOGIC control equation to operate these targets by programming LEDA, LEDB, or LEDC.

There are 16 programmable Display Points, for creating customized messages on the LCD display. They appear in pairs and stay on screen for two seconds before scrolling to the next display. The variables DP1 through DP16 are defined by a SELOGIC control equation that at any time will have a logical value of 0 or 1. For each DPm there are two settings showing the display content. These are DPm_1 and DPm_0. The relay displays any nonblank DPm_1 or _0 values if the current logical value of DPm corresponds. The LED and Display Point settings are Global settings, accessible with the SET G command from a communications port.

Use local control to enable/disable schemes, trip/close breakers, and so on via the front panel. Local control asserts (sets to logical 1) or deasserts (sets to logical 0) local bits LB1 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC control equations.

For more information on the LEDs, Display Points, and Local Bits, see ***Section 8: Front-Panel Interface***.

Sequential Events Recorder

The SER, or Sequential Events Recorder, lists up to 512 events. This may help the user in determining the correct order of operation during a complicated event with multiple device operations within a short time interval. The settings for the SER are the trigger conditions and the Relay Word bit ALIAS names. Up to 96 total Relay Word bit names may be selected and

entered into settings SER1, SER2, SER3, and SER4, in any order, with a maximum of 24 bits in any SERn. Up to 20 Relay Word bits may be given ALIAS names to make the SER report more user friendly. For example, a given input may be given an ALIAS that designates a 52a input for a specific named breaker.

The SER settings are made after issuing the SET R command from a communications port. The SER operation and settings are described fully in ***Section 9: Event Reports and SER***.

Communications Ports

There are four communications ports on the SEL-387 Relay. Port 1 is an EIA-485 port on the rear panel. Ports 2 and 3, also on the rear panel, are EIA-232. Port 4 is an EIA-232 on the front panel. These ports are set via the SET P command. To identify the port by which one is presently communicating with the relay, issue the SHO P command, which will also list that port's settings.

Initial connection to the relay can be made with standard SEL protocol, at 2400 baud, 8 data bits, No parity, 1 stop bit, and VT100 emulation, using any standard communications program such as Microsoft® Windows® 95 HyperTerminal.

Complete information on the communications ports and necessary settings can be found in ***Section 7: Serial Port Communications and Commands***.

DEFAULT SETTINGS

SEL-387 Relay Default Settings (5A)

=>SH0
Group 1

RID =XFMR 1
TID =STATION A
E87W1 = Y E87W2 = Y
EOC1 = Y EOC2 = Y
EOCC = N ETHER = Y
ESLS3 = N

E87W3 = Y E87W4 = N
EOC3 = Y EOC4 = N
ESLS1 = N ESLS2 = N

W1CT = Y W2CT = Y W3CT = Y W4CT = Y
CTR1 = 120 CTR2 = 240 CTR3 = 400 CTR4 = 400
MVA = 100.0 ICOM = Y
W1CTC = 11 W2CTC = 11 W3CTC = 0
VWDG1 = 230.00 VWDG2 = 138.00 VWDG3 = 13.80

TAP1 = 2.09 TAP2 = 1.74 TAP3 = 10.46
O87P = 0.3 SLP1 = 25 SLP2 = 50 IRS1 = 3.0
U87P = 10.0 PCT2 = 15 PCT5 = 35
TH5P = OFF IHLB = N

E32I =0

Press RETURN to continue

50P11P = 20.00 50P11D = 5.00 50P11TC =1
50P12P = OFF
50P13P = 0.50 50P14P = 4.00
51P1P = 4.00 51P1C = U2 51P1TD = 3.00 51P1RS = Y
51P1TC =1

50Q11P = OFF 50Q12P = OFF
51Q1P = 6.00 51Q1C = U2 51Q1TD = 3.00 51Q1RS = Y
51Q1TC =1

50N11P = OFF 50N12P = OFF
51N1P = OFF
DATC1 = 15 PDEM1P = 7.00 QDEM1P = 1.00 NDEM1P = 1.00

50P21P = OFF 50P22P = OFF
50P23P = 0.50 50P24P = 3.50
51P2P = 3.50 51P2C = U2 51P2TD = 3.50 51P2RS = Y
51P2TC =1

Press RETURN to continue

50Q21P = OFF 50Q22P = OFF
51Q2P = 5.25 51Q2C = U2 51Q2TD = 3.50 51Q2RS = Y
51Q2TC =1

50N21P = OFF 50N22P = OFF
51N2P = OFF
DATC2 = 15 PDEM2P = 7.00 QDEM2P = 1.00 NDEM2P = 1.00

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50P31P = 7.00      50P31D = 0.00      50P31TC =1
50P32P = OFF
50P33P = 0.50      50P34P = 4.00
51P3P  = 4.00      51P3C  = U2        51P3TD = 1.30      51P3RS = Y
51P3TC =1

50Q31P = OFF      50Q32P = OFF
51Q3P  = OFF
50N31P = OFF      50N32P = OFF
51N3P  = OFF

Press RETURN to continue
DATC3  = 15      PDEM3P = 7.00      QDEM3P = 1.00      NDEM3P = 1.00

TMWDG  = 1      VWDG   = 230      XTYPE  = 3      TRTYPE = Y
THwr   = 65      NCS    = 1
MCS11  = 100.0
DTMP   = 15      TRDE   =0
NTHM   = 2      THM1   = AMB      THM2   = OIL1
TOT1   = 100     TOT2   = 100      HST1   = 200      HST2   = 200
FAAL1  = 50.00   FAAL2  = 50.00   RLOLL  = 50.00   TLOLL  = 50.00
CSEP1  = 15
ILIFE  = 180000  EDFTC  = Y
TDURD  = 9.000  CFD    = 60.000

TR1     =50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2     =51P2T + 51Q2T + OC2
TR3     =50P31 + 51P3T + OC3
TR4     =87R + 87U
TR5     =0
ULTR1   =!50P13
ULTR2   =!50P23

Press RETURN to continue
ULTR3   =!50P33
ULTR4   =!(50P13 + 50P23 + 50P33)
ULTR5   =0
52A1    =IN101
52A2    =IN102
52A3    =IN103
52A4    =0
CL1     =CC1 + LB4 + /IN104
CL2     =CC2 + /IN105
CL3     =CC3 + /IN106
CL4     =0
ULCL1   =TRIP1 + TRIP4
ULCL2   =TRIP2 + TRIP4
ULCL3   =TRIP3 + TRIP4
ULCL4   =0
ER      =/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101  =TRIP1
OUT102  =TRIP2
OUT103  =TRIP3
OUT104  =TRIP4

Press RETURN to continue
OUT105  =CLS1
OUT106  =CLS2
OUT107  =CLS3
```

SEL-387 Relay Default Settings (1A)

```
=>SH0 1
Group 1

RID      =XFMR 1
TID      =STATION A
E87W1    = Y      E87W2    = Y      E87W3    = Y      E87W4    = N
EOC1     = Y      EOC2     = Y      EOC3     = Y      EOC4     = N
EOCC     = N      ETHER    = Y      ESLS1    = N      ESLS2    = N
ESLS3    = N

W1CT     = Y      W2CT     = Y      W3CT     = Y      W4CT     = Y
CTR1     = 600    CTR2     = 1200   CTR3     = 2000   CTR4     = 2000
MVA      = 100.0  ICOM     = Y
W1CTC    = 11     W2CTC    = 11     W3CTC    = 0
VWDG1    = 230.00 VWDG2    = 138.00 VWDG3    = 13.80

TAP1     = 0.42   TAP2     = 0.35   TAP3     = 2.09
O87P     = 0.3    SLP1     = 25     SLP2     = 50     IRS1     = 3.0
U87P     = 10.0   PCT2     = 15     PCT5     = 35
TH5P     = OFF    IHBL     = N

E32I     =0

Press RETURN to continue

50P11P   = 4.00    50P11D   = 5.00    50P11TC  =1
50P12P   = OFF
50P13P   = 0.10    50P14P   = 0.80
51P1P    = 0.80    51P1C    = U2      51P1TD   = 3.00    51P1RS   = Y
51P1TC   =1

50Q11P   = OFF     50Q12P   = OFF
51Q1P    = 1.20    51Q1C    = U2      51Q1TD   = 3.00    51Q1RS   = Y
51Q1TC   =1

50N11P   = OFF     50N12P   = OFF
51N1P    = OFF
DATC1    = 15      PDEM1P   = 1.40    QDEM1P   = 0.20    NDEM1P   = 0.20

50P21P   = OFF     50P22P   = OFF
50P23P   = 0.10    50P24P   = 0.70
51P2P    = 0.70    51P2C    = U2      51P2TD   = 3.50    51P2RS   = Y
51P2TC   =1

Press RETURN to continue

50Q21P   = OFF     50Q22P   = OFF
51Q2P    = 1.05    51Q2C    = U2      51Q2TD   = 3.50    51Q2RS   = Y
51Q2TC   =1

50N21P   = OFF     50N22P   = OFF
51N2P    = OFF
DATC2    = 15      PDEM2P   = 1.40    QDEM2P   = 0.20    NDEM2P   = 0.20

50P31P   = 1.40    50P31D   = 0.00    50P31TC  =1
50P32P   = OFF
50P33P   = 0.10    50P34P   = 0.80
51P3P    = 0.80    51P3C    = U2      51P3TD   = 1.30    51P3RS   = Y
51P3TC   =1

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50Q31P = OFF 50Q32P = OFF
51Q3P = OFF
50N31P = OFF 50N32P = OFF
51N3P = OFF

Press RETURN to continue

DATC3 = 15 PDEM3P = 1.40 QDEM3P = 0.20 NDEM3P = 0.20

TMWDG = 1 VWDG = 230 XTYPE = 3 TRTYPE = Y
THwr = 65 NCS = 1
MCS11 = 100.0
DTMP = 15 TRDE = 0
NTHM = 2 THM1 = AMB THM2 = OIL1
TOT1 = 100 TOT2 = 100 HST1 = 200 HST2 = 200
FAAL1 = 50.00 FAAL2 = 50.00 RLOLL = 50.00 TLOLL = 50.00
CSEP1 = 15
ILIFE = 180000 EDFTC = Y
TDURD = 9.000 CFD = 60.000

TR1 = 50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2 = 51P2T + 51Q2T + OC2
TR3 = 50P31 + 51P3T + OC3
TR4 = 87R + 87U
TR5 = 0
ULTR1 = !50P13
ULTR2 = !50P23

Press RETURN to continue

ULTR3 = !50P33
ULTR4 = !(50P13 + 50P23 + 50P33)
ULTR5 = 0
52A1 = IN101
52A2 = IN102
52A3 = IN103
52A4 = 0
CL1 = CC1 + LB4 + /IN104
CL2 = CC2 + /IN105
CL3 = CC3 + /IN106
CL4 = 0
ULCL1 = TRIP1 + TRIP4
ULCL2 = TRIP2 + TRIP4
ULCL3 = TRIP3 + TRIP4
ULCL4 = 0
ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101 = TRIP1
OUT102 = TRIP2
OUT103 = TRIP3
OUT104 = TRIP4

Press RETURN to continue

OUT105 = CLS1
OUT106 = CLS2
OUT107 = CLS3

The Group settings shown above are the only settings which are different from the 5 A relay settings. The Global, Port, and SER settings remain the same.

SETTINGS SHEETS AND SETTINGS SHEETS EXAMPLE

The rest of this section consists of Settings Sheets and an example of how the sheets could be filled out.

You can photocopy the Settings Sheets and write your settings on the copy before you enter the settings in the relay. The Settings Sheets begin with the Group Settings (SET Command), followed by Global Settings (SET G Command), Sequential Events Recorder Settings (SET R Command), and Port Settings (SET P Command).

Following the Settings Sheets is an example of how the sheets could be filled out. As with the Settings Sheets, the example begins with the Group Settings (SET Command), followed by Global Settings (SET G Command), Sequential Events Recorder Settings (SET R Command), and Port Settings (SET P Command).

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

Page 1 of 29

Date _____

Group _____

CONFIGURATION SETTINGS

Relay Identifier (39 Characters)

RID = _____

Terminal Identifier (59 Characters)

TID = _____

Enable Winding 1 in Differential Element (Y, N)	E87W1	=	_____
Enable Winding 2 in Differential Element (Y, N)	E87W2	=	_____
Enable Winding 3 in Differential Element (Y, N)	E87W3	=	_____
Enable Winding 4 in Differential Element (Y, N)	E87W4	=	_____
Enable Winding 1 O/C Elements and Dmd Thresholds (Y, N)	EOC1	=	_____
Enable Winding 2 O/C Elements and Dmd Thresholds (Y, N)	EOC2	=	_____
Enable Winding 3 O/C Elements and Dmd Thresholds (Y, N)	EOC3	=	_____
Enable Winding 4 O/C Elements and Dmd Thresholds (Y, N)	EOC4	=	_____
Enable Combined O/C Elements (Y, N)	EOCC	=	_____
Enable Thermal Element (Y, N)	ETHER	=	_____
Enable SELOGIC [®] Control Equations Set 1 (Y, N)	ESLS1	=	_____
Enable SELOGIC Control Equations Set 2 (Y, N)	ESLS2	=	_____
Enable SELOGIC Control Equations Set 3 (Y, N)	ESLS3	=	_____

GENERAL DATA

Winding 1 CT Connection (D, Y)	W1CT	=	_____
Winding 2 CT Connection (D, Y)	W2CT	=	_____
Winding 3 CT Connection (D, Y)	W3CT	=	_____
Winding 4 CT Connection (D, Y)	W4CT	=	_____
Winding 1 CT Ratio (1–50000)	CTR1	=	_____
Winding 2 CT Ratio (1–50000)	CTR2	=	_____
Winding 3 CT Ratio (1–50000)	CTR3	=	_____
Winding 4 CT Ratio (1–50000)	CTR4	=	_____
Maximum Power Transformer Capacity (OFF, 0.2–5000 MVA)	MVA	=	_____
Define Internal CT Connection Compensation (Y, N)	ICOM	=	_____
Winding 1 CT Conn. Compensation (0, 1, ..., 12)	W1CTC	=	_____
Winding 2 CT Conn. Compensation (0, 1, ..., 12)	W2CTC	=	_____
Winding 3 CT Conn. Compensation (0, 1, ..., 12)	W3CTC	=	_____
Winding 4 CT Conn. Compensation (0, 1, ..., 12)	W4CTC	=	_____
Winding 1 Line-to-Line Voltage (1–1000 kV)	VWDG1	=	_____
Winding 2 Line-to-Line Voltage (1–1000 kV)	VWDG2	=	_____
Winding 3 Line-to-Line Voltage (1–1000 kV)	VWDG3	=	_____
Winding 4 Line-to-Line Voltage (1–1000 kV)	VWDG4	=	_____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

Page 2 of 29

Date _____

Group _____

DIFFERENTIAL ELEMENTS

Note: TAP1–TAP4 are auto-set by relay if MVA setting is not OFF.

Winding 1 Current Tap

(0.5–155.0 A secondary) (5 A)

(0.1–31.0 A secondary) (1 A)

TAP1 = _____

Winding 2 Current Tap

(0.5–155.0 A secondary) (5 A)

(0.1–31.0 A secondary) (1 A)

TAP2 = _____

Winding 3 Current Tap

(0.5–155.0 A secondary) (5 A)

(0.1–31.0 A secondary) (1 A)

TAP3 = _____

Winding 4 Current Tap

(0.5–155.0 A secondary) (5 A)

(0.1–31.0 A secondary) (1 A)

TAP4 = _____

Restrained Element Operating Current PU ((0.1–1.0) multiple of tap)

O87P = _____

Restraint Slope 1 Percentage (5–100%)

SLP1 = _____

Restraint Slope 2 Percentage (OFF, 25–200%)

SLP2 = _____

Restraint Current Slope 1 Limit ((1–20) multiple of tap)

IRS1 = _____

Unrestrained Element Current PU ((1–20) multiple of tap)

U87P = _____

Second-Harmonic Blocking Percentage (OFF, 5–100%)

PCT2 = _____

Fifth-Harmonic Blocking Percentage (OFF, 5–100%)

PCT5 = _____

Fifth-Harmonic Alarm Threshold (OFF, (0.02–3.20) multiple of tap)

TH5P = _____

Fifth-Harmonic Alarm TDPU (0–8000 cycles)

TH5D = _____

Independent Harmonic Blocking (Y, N)

IHBL = _____

RESTRICTED EARTH FAULT

Enable 32I (SELOGIC control equation)

E32I = _____

Operating Quantity from Wdg. 1, Wdg. 2, Wdg. 3 (1, 2, 3, 12, 23, 123) 32IOP = _____

Positive-Sequence Current Restraint Factor, I0/I1 (0.02–0.50) a0 = _____

Residual Current Sensitivity Threshold

(0.25–15.00 A secondary) (5 A)

(0.05–3.00 A secondary) (1 A)

50GP = _____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

Page 3 of 29

Date _____

Group _____

WINDING 1 O/C ELEMENTS

Winding 1 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P11P = _____

Phase Level 1 O/C Delay (0–16000 cycles)

50P11D = _____

50P11 Torque Control (SELOGIC control equation)

50P11TC = _____

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P12P = _____

50P12 Torque Control (SELOGIC control equation)

50P12TC = _____

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P13P = _____

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P14P = _____

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51P1P = _____

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P1C = _____

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P1TD = _____

Phase Inv.-Time O/C EM Reset (Y, N)

51P1RS = _____

51P1 Torque Control (SELOGIC control equation)

51P1TC = _____

Winding 1 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50Q11P = _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000 cycles)

50Q11D = _____

50Q11 Torque Control (SELOGIC control equation)

50Q11TC = _____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

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Date _____

Group _____

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50Q12P = _____

50Q12 Torque Control (SELOGIC control equation)

50Q12TC = _____

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51Q1P = _____

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)

51Q1C = _____

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51Q1TD = _____

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)

51Q1RS = _____

51Q1 Torque Control (SELOGIC control equation)

51Q1TC = _____

Winding 1 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50N11P = _____

Residual Level 1 O/C Delay (0–16000 cycles)

50N11D = _____

50N11 Torque Control (SELOGIC control equation)

50N11TC = _____

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50N12P = _____

50N12 Torque Control (SELOGIC control equation)

50N12TC = _____

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51N1P = _____

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N1C = _____

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51N1TD = _____

Residual Inv.-Time O/C EM Reset (Y, N)

51N1RS = _____

51N1 Torque Control (SELOGIC control equation)

51N1TC = _____

Winding 1 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

DATC1 = _____

Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

PDEM1P = _____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

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Date _____

Group _____

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

QDEM1P = _____

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

NDEM1P = _____

WINDING 2 O/C ELEMENTS

Winding 2 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P21P = _____

Phase Level 1 O/C Delay (0–16000 cycles)

50P21D = _____

50P21 Torque Control (SELOGIC control equation)

50P21TC = _____

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P22P = _____

50P22 Torque Control (SELOGIC control equation)

50P22TC = _____

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P23P = _____

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P24P = _____

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51P2P = _____

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P2C = _____

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P2TD = _____

Phase Inv.-Time O/C EM Reset (Y, N)

51P2RS = _____

51P2 Torque Control (SELOGIC control equation)

51P2TC = _____

Winding 2 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50Q21P = _____

SEL-387-5, -6 Relay Settings Sheet Group Settings (SET Command)

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Date _____

Group _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000 cycles) 50Q21D = _____

50Q21 Torque Control (SELOGIC control equation)

50Q21TC = _____

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50Q22P = _____

50Q22 Torque Control (SELOGIC control equation)

50Q22TC = _____

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A) 51Q2P = _____

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5) 51Q2C = _____

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51Q2TD = _____

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N) 51Q2RS = _____

51Q2 Torque Control (SELOGIC control equation)

51Q2TC = _____

Winding 2 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50N21P = _____

Residual Level 1 O/C Delay (0–16000 cycles) 50N21D = _____

50N21 Torque Control (SELOGIC control equation)

50N21TC = _____

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50N22P = _____

50N22 Torque Control (SELOGIC control equation)

50N22TC = _____

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A) 51N2P = _____

Residual Inv.-Time O/C Curve (U1–U5, C1–C5) 51N2C = _____

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51N2TD = _____

Residual Inv.-Time O/C EM Reset (Y, N) 51N2RS = _____

51N2 Torque Control (SELOGIC control equation)

51N2TC = _____

Winding 2 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min) DATC2 = _____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

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Date _____

Group _____

Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

PDEM2P = _____

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

QDEM2P = _____

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

(0.1–3.2 A secondary) (1 A)

NDEM2P = _____

WINDING 3 O/C ELEMENTS

Winding 3 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P31P = _____

Phase Level 1 O/C Delay (0–16000 cycles)

50P31D = _____

50P31 Torque Control (SELOGIC control equation)

50P31TC = _____

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P32P = _____

50P32 Torque Control (SELOGIC control equation)

50P32TC = _____

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P33P = _____

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50P34P = _____

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51P3P = _____

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P3C = _____

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P3TD = _____

Phase Inv.-Time O/C EM Reset (Y, N)

51P3RS = _____

51P3 Torque Control (SELOGIC control equation)

51P3TC = _____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command)

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Date _____

Group _____

Winding 3 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50Q31P = _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles)

50Q31D = _____

50Q31 Torque Control (SELOGIC control equation)

50Q31TC = _____

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50Q32P = _____

50Q32 Torque Control (SELOGIC control equation)

50Q32TC = _____

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51Q3P = _____

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)

51Q3C = _____

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51Q3TD = _____

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)

51Q3RS = _____

51Q3 Torque Control (SELOGIC control equation)

51Q3TC = _____

Winding 3 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50N31P = _____

Residual Level 1 O/C Delay (0–16000 cycles)

50N31D = _____

50N31 Torque Control (SELOGIC control equation)

50N31TC = _____

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50N32P = _____

50N32 Torque Control (SELOGIC control equation)

50N32TC = _____

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51N3P = _____

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N3C = _____

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51N3TD = _____

SEL-387-5, -6 Relay Settings Sheet Group Settings (SET Command)

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Date _____

Group _____

Residual Inv.-Time O/C EM Reset (Y, N) 51N3RS = _____
51N3 Torque Control (SELOGIC control equation)
51N3TC = _____

Winding 3 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min) DATC3 = _____
Phase Demand Ammeter Threshold
(0.5–16.0 A secondary) (5 A)
(0.1–3.2 A secondary) (1 A) PDEM3P = _____
Neg.-Seq. Demand Ammeter Threshold
(0.5–16.0 A secondary) (5 A)
(0.1–3.2 A secondary) (1 A) QDEM3P = _____
Residual Demand Ammeter Threshold
(0.5–16.0 A secondary) (5 A)
(0.1–3.2 A secondary) (1 A) NDEM3P = _____

WINDING 4 O/C ELEMENTS

Winding 4 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) 50P41P = _____
Phase Level 1 O/C Delay (0–16000 cycles) 50P41D = _____
50P41 Torque Control (SELOGIC control equation)
50P41TC = _____
Phase Inst. O/C Level 2 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) 50P42P = _____
50P42 Torque Control SELOGIC control equation)
50P42TC = _____
Phase Inst. O/C Level 3 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) 50P43P = _____
Phase Inst. O/C Level 4 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) 50P44P = _____
Phase Inv.-Time O/C PU
(OFF, 0.5–16.0 A secondary) (5 A)
(OFF, 0.1–3.2 A secondary) (1 A) 51P4P = _____
Phase Inv.-Time O/C Curve (U1–U5, C1–C5) 51P4C = _____
Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51P4TD = _____

SEL-387-5, -6 Relay Settings Sheet Group Settings (SET Command)

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Date _____

Group _____

Phase Inv.-Time O/C EM Reset (Y, N) 51P4RS = _____

51P4 Torque Control (SELOGIC control equation)

51P4TC = _____

Winding 4 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50Q41P = _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles) 50Q41D = _____

50Q41 Torque Control SELOGIC control equation)

50Q41TC = _____

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50Q42P = _____

50Q42 Torque Control (SELOGIC control equation)

50Q42TC = _____

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A) 51Q4P = _____

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5) 51Q4C = _____

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51Q4TD = _____

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N) 51Q4RS = _____

51Q4 Torque Control SELOGIC control equation)

51Q4TC = _____

Winding 4 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50N41P = _____

Residual Level 1 O/C Delay (0–16000 cycles) 50N41D = _____

50N41 Torque Control (SELOGIC control equation)

50N41TC = _____

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) 50N42P = _____

50N42 Torque Control (SELOGIC control equation)

50N42TC = _____

SEL-387-5, -6 Relay Settings Sheet Group Settings (SET Command)

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Date _____

Group _____

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51N4P = _____

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N4C = _____

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51N4TD = _____

Residual Inv.-Time O/C EM Reset (Y, N)

51N4RS = _____

51N4 Torque Control (SELOGIC control equation)

51N4TC = _____

Winding 4 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

DATC4 = _____

Phase Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

PDEM4P = _____

Neg.-Seq. Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

QDEM4P = _____

Residual Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

NDEM4P = _____

COMBINED O/C ELEMENTS

W1–W2 Phase O/C Element

W1-W2 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51PC1P = _____

W1-W2 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC1C = _____

W1-W2 Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51PC1TD = _____

W1-W2 Phase Inv.-Time O/C EM Reset (Y, N)

51PC1RS = _____

W1–W2 Residual O/C Element

W1-W2 Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51NC1P = _____

W1-W2 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC1C = _____

W1-W2 Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51NC1TD = _____

W1-W2 Residual Inv.-Time O/C EM Reset (Y, N)

51NC1RS = _____

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W3-W4 Phase O/C Element

W3-W4 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51PC2P* = _____

W3-W4 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC2C = _____

W3-W4 Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51PC2TD = _____

W3-W4 Phase Inv.-Time O/C EM Reset (Y, N)

51PC2RS = _____

* Must be OFF if Restricted Earth Fault is used.

W3-W4 Residual O/C Element

W3-W4 Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51NC2P* = _____

W3-W4 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC2C = _____

W3-W4 Residual Inv.-Time O/C Time-Dial (US 0.5-15.0, IEC 0.05-1.00)

51NC2TD = _____

W3-W4 Residual Inv.-Time O/C EM Reset (Y, N)

51NC2RS = _____

* Must be OFF if Restricted Earth Fault is used.

THERMAL ELEMENT (SEL-387-6 RELAY ONLY)

Thermal Model Winding Current (1, 2, 3, 4, 12, 34)

TMWDG = _____

Winding LL Voltage (1–1000 kV)

VWDG = _____

Transformer Construction (1, 3)

XTYPE = _____

Transformer Type (D, Y)

TRTYPE = _____

Winding Temp/Amb (65, 55)

THwr = _____

Number of Cooling Stages (1–3)

NCS = _____

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS11 = _____

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS21 = _____

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS31 = _____

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS12 = _____

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS22 = _____

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS32 = _____

Cooling System 2 (SELOGIC control equation)

CS12S = _____

Cooling System 2 (SELOGIC control equation)

CS22S = _____

Cooling System 2 (SELOGIC control equation)

CS32S = _____

Cooling Stage 3 Rating (0.2–5000.0 MVA)

MCS13 = _____

Cooling Stage 3 Rating (0.2–5000.0 MVA)

MCS23 = _____

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Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS33	=	_____
Cooling System 3 (SELOGIC control equation)			
CS13S =			_____
Cooling System 3 (SELOGIC control equation)			
CS23S =			_____
Cooling System 3 (SELOGIC control equation)			
CS33S =			_____
Default Ambient Temp. –40–85°C)	DTMP	=	_____
Deenergized Transformer (SELOGIC control equation)			
TRDE =			_____
Number Thermal Inputs (0–4)	NTHM	=	_____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM1	=	_____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM2	=	_____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM3	=	_____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM4	=	_____
Top-Oil Temp. Limit 1 (50–150°C)	TOT1	=	_____
Top-Oil Temp. Limit 2 (50–150°C)	TOT2	=	_____
Hot-Spot Limit 1 (80–300°C)	HST1	=	_____
Hot-Spot Limit 2 (80–300°C)	HST2	=	_____
Aging Acceleration Factor Limit 1 (0.00–599.99)	FAAL1	=	_____
Aging Acceleration Factor Limit 2 (0.00–599.99)	FAAL2	=	_____
Daily Loss-of-Life Limit (0.00–99.99%)	RLOLL	=	_____
Total Loss-of-Life Limit (0.00–99.99%)	TLOLL	=	_____
Cooling System Efficiency-Transformer 1 (5–100°C)	CSEP1	=	_____
Cooling System Efficiency-Transformer 2 (5–100°C)	CSEP2	=	_____
Cooling System Efficiency-Transformer 3 (5–100°C)	CSEP3	=	_____

General Cooling System Constants

Nominal Insulation Life (1000–999999 hr)	ILIFE	=	_____
Enable Default Constants (Y/N)	EDFTC	=	_____

Transformer 1

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths1	=	_____
Constant to Calc. FAA (0–100000)	BFFA1	=	_____
Cooling Stage 1 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor11	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr11	=	_____

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Group _____

Ratio Losses (0.0–100.0)	RATL11	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR11	=	_____
Oil Exponent (0.1–5)	EXPn11	=	_____
Winding Exponent (0.1–5)	EXPm11	=	_____
Cooling Stage 2 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor12	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr12	=	_____
Ratio Losses (0.0–100.0)	RATL12	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR12	=	_____
Oil Exponent (0.1–5)	EXPn12	=	_____
Winding Exponent (0.1–5)	EXPm12	=	_____
Cooling Stage 3 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor13	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr13	=	_____
Ratio Losses (0.0–100.0)	RATL13	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR13	=	_____
Oil Exponent (0.1–5)	EXPn13	=	_____
Winding Exponent (0.1–5)	EXPm13	=	_____
Transformer 2			
Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths2	=	_____
Constant to Calc. FAA (0–100000)	BFFA2	=	_____
Cooling Stage 1 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor21	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr21	=	_____
Ratio Losses (0.0–100.0)	RATL21	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR21	=	_____
Oil Exponent (0.1–5)	EXPn21	=	_____
Winding Exponent (0.1–5)	EXPm21	=	_____
Cooling Stage 2 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor22	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr22	=	_____
Ratio Losses (0.0–100.0)	RATL22	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR22	=	_____
Oil Exponent (0.1–5)	EXPn22	=	_____
Winding Exponent (0.1–5)	EXPm22	=	_____
Cooling Stage 3 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor23	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr23	=	_____
Ratio Losses (0.0–100.0)	RATL23	=	_____

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Oil Thermal Time Constant (0.1–20.0 hr)	OTR23	=	_____
Oil Exponent (0.1–5)	EXPn23	=	_____
Winding Exponent (0.1–5)	EXPm23	=	_____

Transformer 3

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths3	=	_____
Constant to Calc. FAA (0–100000)	BFFA3	=	_____

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor31	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr31	=	_____
Ratio Losses (0.0–100.0)	RATL31	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR31	=	_____
Oil Exponent (0.1–5)	EXPn31	=	_____
Winding Exponent (0.1–5)	EXPm31	=	_____

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor32	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr32	=	_____
Ratio Losses (0.0–100.0)	RATL32	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR32	=	_____
Oil Exponent (0.1–5)	EXPn32	=	_____
Winding Exponent (0.1–5)	EXPm32	=	_____

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor33	=	_____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr33	=	_____
Ratio Losses (0.0–100.0)	RATL33	=	_____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR33	=	_____
Oil Exponent (0.1–5)	EXPn33	=	_____
Winding Exponent (0.1–5)	EXPm33	=	_____

MISCELLANEOUS TIMERS

Minimum Trip Duration Time Delay (4–8000 cycles)	TDURD	=	_____
Close Failure Logic Time Delay (OFF, 0–8000 cycles)	CFD	=	_____

SELOGIC CONTROL EQUATIONS SET 1

Set 1 Variable 1 (SELOGIC control equation)

S1V1 = _____

S1V1 Timer Pickup (0–999999 cycles)	S1V1PU	=	_____

S1V1 Timer Dropout (0–999999 cycles)	S1V1DO	=	_____

Set 1 Variable 2 (SELOGIC control equation)

S1V2 = _____

S1V2 Timer Pickup (0–999999 cycles)	S1V2PU	=	_____

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Group _____

S1V2 Timer Dropout (0–999999 cycles) S1V2DO = _____

Set 1 Variable 3 (SELOGIC control equation)

S1V3 = _____

S1V3 Timer Pickup (0–999999 cycles) S1V3PU = _____

S1V3 Timer Dropout (0–999999 cycles) S1V3DO = _____

Set 1 Variable 4 (SELOGIC control equation)

S1V4 = _____

S1V4 Timer Pickup (0–999999 cycles) S1V4PU = _____

S1V4 Timer Dropout (0–999999 cycles) S1V4DO = _____

Set 1 Latch Bit 1 SET Input (SELOGIC control equation)

S1SLT1 = _____

Set 1 Latch Bit 1 RESET Input (SELOGIC control equation)

S1RLT1 = _____

Set 1 Latch Bit 2 SET Input (SELOGIC control equation)

S1SLT2 = _____

Set 1 Latch Bit 2 RESET Input (SELOGIC control equation)

S1RLT2 = _____

Set 1 Latch Bit 3 SET Input (SELOGIC control equation)

S1SLT3 = _____

Set 1 Latch Bit 3 RESET Input (SELOGIC control equation)

S1RLT3 = _____

Set 1 Latch Bit 4 SET Input (SELOGIC control equation)

S1SLT4 = _____

Set 1 Latch Bit 4 RESET Input (SELOGIC control equation)

S1RLT4 = _____

SELOGIC CONTROL EQUATIONS SET 2

Set 2 Variable 1 (SELOGIC control equation)

S2V1 = _____

S2V1 Timer Pickup (0–999999 cycles) S2V1PU = _____

S2V1 Timer Dropout (0–999999 cycles) S2V1DO = _____

Set 2 Variable 2 (SELOGIC control equation)

S2V2 = _____

S2V2 Timer Pickup (0–999999 cycles) S2V2PU = _____

S2V2 Timer Dropout (0–999999 cycles) S2V2DO = _____

Set 2 Variable 3 (SELOGIC control equation)

S2V3 = _____

S2V3 Timer Pickup (0–999999 cycles) S2V3PU = _____

S2V3 Timer Dropout (0–999999 cycles) S2V3DO = _____

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Group _____

Set 2 Variable 4 (SELOGIC control equation)

S2V4 = _____

S2V4 Timer Pickup (0–999999 cycles) S2V4PU = _____

S2V4 Timer Dropout (0–999999 cycles) S2V4DO = _____

Set 2 Latch Bit 1 SET Input (SELOGIC control equation)

S2SLT1 = _____

Set 2 Latch Bit 1 RESET Input (SELOGIC control equation)

S2RLT1 = _____

Set 2 Latch Bit 2 SET Input (SELOGIC control equation)

S2SLT2 = _____

Set 2 Latch Bit 2 RESET Input (SELOGIC control equation)

S2RLT2 = _____

Set 2 Latch Bit 3 SET Input (SELOGIC control equation)

S2SLT3 = _____

Set 2 Latch Bit 3 RESET Input (SELOGIC control equation)

S2RLT3 = _____

Set 2 Latch Bit 4 SET Input (SELOGIC control equation)

S2SLT4 = _____

Set 2 Latch Bit 4 RESET Input (SELOGIC control equation)

S2RLT4 = _____

SELOGIC CONTROL EQUATIONS SET 3

Set 3 Variable 1 (SELOGIC control equation)

S3V1 = _____

S3V1 Timer Pickup (0–999999 cycles) S3V1PU = _____

S3V1 Timer Dropout (0–999999 cycles) S3V1DO = _____

Set 3 Variable 2 (SELOGIC control equation)

S3V2 = _____

S3V2 Timer Pickup (0–999999 cycles) S3V2PU = _____

S3V2 Timer Dropout (0–999999 cycles) S3V2DO = _____

Set 3 Variable 3 (SELOGIC control equation)

S3V3 = _____

S3V3 Timer Pickup (0–999999 cycles) S3V3PU = _____

S3V3 Timer Dropout (0–999999 cycles) S3V3DO = _____

Set 3 Variable 4 (SELOGIC control equation)

S3V4 = _____

S3V4 Timer Pickup (0–999999 cycles) S3V4PU = _____

S3V4 Timer Dropout (0–999999 cycles) S3V4DO = _____

Set 3 Variable 5 (SELOGIC control equation)

S3V5 = _____

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Group _____

S3V5 Timer Pickup (0–999999 cycles)	S3V5PU	=	_____
S3V5 Timer Dropout (0–999999 cycles)	S3V5DO	=	_____
Set 3 Variable 6 (SELOGIC control equation)			
S3V6 =			_____
S3V6 Timer Pickup (0–999999 cycles)	S3V6PU	=	_____
S3V6 Timer Dropout (0–999999 cycles)	S3V6DO	=	_____
Set 3 Variable 7 (SELOGIC control equation)			
S3V7 =			_____
S3V7 Timer Pickup (0–999999 cycles)	S3V7PU	=	_____
S3V7 Timer Dropout (0–999999 cycles)	S3V7DO	=	_____
Set 3 Variable 8 (SELOGIC control equation)			
S3V8 =			_____
S3V8 Timer Pickup (0–999999 cycles)	S3V8PU	=	_____
S3V8 Timer Dropout (0–999999 cycles)	S3V8DO	=	_____
Set 3 Latch Bit 1 SET Input (SELOGIC control equation)			
S3SLT1 =			_____
Set 3 Latch Bit 1 RESET Input (SELOGIC control equation)			
S3RLT1 =			_____
Set 3 Latch Bit 2 SET Input (SELOGIC control equation)			
S3SLT2 =			_____
Set 3 Latch Bit 2 RESET Input (SELOGIC control equation)			
S3RLT2 =			_____
Set 3 Latch Bit 3 SET Input (SELOGIC control equation)			
S3SLT3 =			_____
Set 3 Latch Bit 3 RESET Input (SELOGIC control equation)			
S3RLT3 =			_____
Set 3 Latch Bit 4 SET Input (SELOGIC control equation)			
S3SLT4 =			_____
Set 3 Latch Bit 4 RESET Input (SELOGIC control equation)			
S3RLT4 =			_____
Set 3 Latch Bit 5 SET Input (SELOGIC control equation)			
S3SLT5 =			_____
Set 3 Latch Bit 5 RESET Input (SELOGIC control equation)			
S3RLT5 =			_____
Set 3 Latch Bit 6 SET Input (SELOGIC control equation)			
S3SLT6 =			_____

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Group _____

Set 3 Latch Bit 6 RESET Input (SELOGIC control equation)

S3RLT6 = _____

Set 3 Latch Bit 7 SET Input (SELOGIC control equation)

S3SLT7 = _____

Set 3 Latch Bit 7 RESET Input (SELOGIC control equation)

S3RLT7 = _____

Set 3 Latch Bit 8 SET Input (SELOGIC control equation)

S3SLT8 = _____

Set 3 Latch Bit 8 RESET Input (SELOGIC control equation)

S3RLT8 = _____

TRIP LOGIC

TR1 = _____

TR2 = _____

TR3 = _____

TR4 = _____

TR5 = _____

ULTR1 = _____

ULTR2 = _____

ULTR3 = _____

ULTR4 = _____

ULTR5 = _____

CLOSE LOGIC

52A1 = _____

52A2 = _____

52A3 = _____

52A4 = _____

CL1 = _____

CL2 = _____

CL3 = _____

CL4 = _____

ULCL1 = _____

ULCL2 = _____

ULCL3 = _____

ULCL4 = _____

EVENT REPORT TRIGGERING

ER = _____

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Group Settings (SET Command)

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OUTPUT CONTACT LOGIC (STANDARD OUTPUTS)

OUT101 = _____
OUT102 = _____
OUT103 = _____
OUT104 = _____
OUT105 = _____
OUT106 = _____
OUT107 = _____

OUTPUT CONTACT LOGIC (EXTRA INTERFACE BOARD 2 OR 6)

OUT201 = _____
OUT202 = _____
OUT203 = _____
OUT204 = _____
OUT205 = _____
OUT206 = _____
OUT207 = _____
OUT208 = _____
OUT209 = _____
OUT210 = _____
OUT211 = _____
OUT212 = _____

OUTPUT CONTACT LOGIC (EXTRA INTERFACE BOARD 4)

OUT201 = _____
OUT202 = _____
OUT203 = _____
OUT204 = _____

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RELAY SETTINGS

Length of Event Report (15, 30, 60 cycles)	LER	=	_____
Length of Pre-fault in Event Report (1 to (LER-1))	PRE	=	_____
Nominal Frequency (50, 60 Hz)	NFREQ	=	_____
Phase Rotation (ABC, ACB)	PHROT	=	_____
Date Format (MDY, YMD)	DATE_F	=	_____
Display Update Rate (1–60 seconds)	SCROLL	=	_____
Front Panel Time-out (OFF, 0–30 minutes)	FP_TO	=	_____
Group Change Delay (0–900 seconds)	TGR	=	_____

BATTERY MONITOR

DC Battery Voltage Level 1 (OFF, 20–300 Vdc)	DC1P	=	_____
DC Battery Voltage Level 2 (OFF, 20–300 Vdc)	DC2P	=	_____
DC Battery Voltage Level 3 (OFF, 20–300 Vdc)	DC3P	=	_____
DC Battery Voltage Level 4 (OFF, 20–300 Vdc)	DC4P	=	_____

BREAKER 1 MONITOR

BKR1 Trigger Equation (SELOGIC control equation)

BKMON1 = _____

Close/Open Set Point 1 max (1–65000 operations)	B1COP1	=	_____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B1KAP1	=	_____
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	=	_____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B1KAP2	=	_____
Close/Open Set Point 3 max (1–65000 operations)	B1COP3	=	_____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B1KAP3	=	_____

BREAKER 2 MONITOR

BKR2 Trigger Equation (SELOGIC control equation)

BKMON2 = _____

Close/Open Set Point 1 max (1–65000 operations)	B2COP1	=	_____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B2KAP1	=	_____
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	=	_____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B2KAP2	=	_____
Close/Open Set Point 3 max (1–65000 operations)	B2COP3	=	_____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B2KAP3	=	_____

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BREAKER 3 MONITOR

BKR3 Trigger Equation (SELOGIC control equation)

BKMON3 = _____

Close/Open Set Point 1 max (1–65000 operations)	B3COP1	=	_____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B3KAP1	=	_____
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	=	_____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B3KAP2	=	_____
Close/Open Set Point 3 max (1–65000 operations)	B3COP3	=	_____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B3KAP3	=	_____

BREAKER 4 MONITOR

BKR4 Trigger Equation (SELOGIC control equation)

BKMON4 = _____

Close/Open Set Point 1 max (1–65000 operations)	B4COP1	=	_____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B4KAP1	=	_____
Close/Open Set Point 2 max (1–65000 operations)	B4COP2	=	_____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B4KAP2	=	_____
Close/Open Set Point 3 max (1–65000 operations)	B4COP3	=	_____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B4KAP3	=	_____

ANALOG INPUT LABELS

Rename Current Input IAW1 (1–4 characters)	IAW1	=	_____
Rename Current Input IBW1 (1–4 characters)	IBW1	=	_____
Rename Current Input ICW1 (1–4 characters)	ICW1	=	_____
Rename Current Input IAW2 (1–4 characters)	IAW2	=	_____
Rename Current Input IBW2 (1–4 characters)	IBW2	=	_____
Rename Current Input ICW2 (1–4 characters)	ICW2	=	_____
Rename Current Input IAW3 (1–4 characters)	IAW3	=	_____
Rename Current Input IBW3 (1–4 characters)	IBW3	=	_____
Rename Current Input ICW3 (1–4 characters)	ICW3	=	_____
Rename Current Input IAW4 (1–4 characters)	IAW4	=	_____
Rename Current Input IBW4 (1–4 characters)	IBW4	=	_____
Rename Current Input ICW4 (1–4 characters)	ICW4	=	_____

SETTING GROUP SELECTION

Select Setting Group 1 (SELOGIC control equation)

SS1 = _____

Select Setting Group 2 (SELOGIC control equation)

SS2 = _____

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Select Setting Group 3 (SELOGIC control equation)

SS3 = _____

Select Setting Group 4 (SELOGIC control equation)

SS4 = _____

Select Setting Group 5 (SELOGIC control equation)

SS5 = _____

Select Setting Group 6 (SELOGIC control equation)

SS6 = _____

FRONT PANEL

Energize LEDA (SELOGIC control equation)

LEDA = _____

Energize LEDB (SELOGIC control equation)

LEDB = _____

Energize LEDC (SELOGIC control equation)

LEDC = _____

Show Display Point 1 (SELOGIC control equation)

DP1 = _____

DP1 Label 1 (16 characters) (Enter NA to Null) DP1_1 = _____

DP1 Label 0 (16 characters) (Enter NA to Null) DP1_0 = _____

Show Display Point 2 (SELOGIC control equation)

DP2 = _____

DP2 Label 1 (16 characters) (Enter NA to Null) DP2_1 = _____

DP2 Label 0 (16 characters) (Enter NA to Null) DP2_0 = _____

Show Display Point 3 (SELOGIC control equation)

DP3 = _____

DP3 Label 1 (16 characters) (Enter NA to Null) DP3_1 = _____

DP3 Label 0 (16 characters) (Enter NA to Null) DP3_0 = _____

Show Display Point 4 (SELOGIC control equation)

DP4 = _____

DP4 Label 1 (16 characters) (Enter NA to Null) DP4_1 = _____

DP4 Label 0 (16 characters) (Enter NA to Null) DP4_0 = _____

Show Display Point 5 (SELOGIC control equation)

DP5 = _____

DP5 Label 1 (16 characters) (Enter NA to Null) DP5_1 = _____

DP5 Label 0 (16 characters) (Enter NA to Null) DP5_0 = _____

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Global Settings (SET G Command)

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Show Display Point 6 (SELOGIC control equation)

DP6 = _____

DP6 Label 1 (16 characters) (Enter NA to Null) DP6_1 = _____

DP6 Label 0 (16 characters) (Enter NA to Null) DP6_0 = _____

Show Display Point 7 (SELOGIC control equation)

DP7 = _____

DP7 Label 1 (16 characters) (Enter NA to Null) DP7_1 = _____

DP7 Label 0 (16 characters) (Enter NA to Null) DP7_0 = _____

Show Display Point 8 (SELOGIC control equation)

DP8 = _____

DP8 Label 1 (16 characters) (Enter NA to Null) DP8_1 = _____

DP8 Label 0 (16 characters) (Enter NA to Null) DP8_0 = _____

Show Display Point 9 (SELOGIC control equation)

DP9 = _____

DP9 Label 1 (16 characters) (Enter NA to Null) DP9_1 = _____

DP9 Label 0 (16 characters) (Enter NA to Null) DP9_0 = _____

Show Display Point 10 (SELOGIC control equation)

DP10 = _____

DP10 Label 1 (16 characters) (Enter NA to Null) DP10_1 = _____

DP10 Label 0 (16 characters) (Enter NA to Null) DP10_0 = _____

Show Display Point 11 (SELOGIC control equation)

DP11 = _____

DP11 Label 1 (16 characters) (Enter NA to Null) DP11_1 = _____

DP11 Label 0 (16 characters) (Enter NA to Null) DP11_0 = _____

Show Display Point 12 (SELOGIC control equation)

DP12 = _____

DP12 Label 1 (16 characters) (Enter NA to Null) DP12_1 = _____

DP12 Label 0 (16 characters) (Enter NA to Null) DP12_0 = _____

Show Display Point 13 (SELOGIC control equation)

DP13 = _____

DP13 Label 1 (16 characters) (Enter NA to Null) DP13_1 = _____

DP13 Label 0 (16 characters) (Enter NA to Null) DP13_0 = _____

Show Display Point 14 (SELOGIC control equation)

DP14 = _____

DP14 Label 1 (16 characters) (Enter NA to Null) DP14_1 = _____

DP14 Label 0 (16 characters) (Enter NA to Null) DP14_0 = _____

SEL-387-5, -6 Relay Settings Sheet

Global Settings (SET G Command)

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Show Display Point 15 (SELOGIC control equation)

DP15 = _____

DP15 Label 1 (16 characters) (Enter NA to Null) DP15_1 = _____

DP15 Label 0 (16 characters) (Enter NA to Null) DP15_0 = _____

Show Display Point 16 (SELOGIC control equation)

DP16 = _____

DP16 Label 1 (16 characters) (Enter NA to Null) DP16_1 = _____

DP16 Label 0 (16 characters) (Enter NA to Null) DP16_0 = _____

TEXT LABELS

Local Bit LB1 Name (14 characters) (Enter NA to Null) NLB1 = _____

Clear Local Bit LB1 Label (7 characters) (Enter NA to Null) CLB1 = _____

Set Local Bit LB1 Label (7 characters) (Enter NA to Null) SLB1 = _____

Pulse Local Bit LB1 Label (7 characters) (Enter NA to Null) PLB1 = _____

Local Bit LB2 Name (14 characters) (Enter NA to Null) NLB2 = _____

Clear Local Bit LB2 Label (7 characters) (Enter NA to Null) CLB2 = _____

Set Local Bit LB2 Label (7 characters) (Enter NA to Null) SLB2 = _____

Pulse Local Bit LB2 Label (7 characters) (Enter NA to Null) PLB2 = _____

Local Bit LB3 Name (14 characters) (Enter NA to Null) NLB3 = _____

Clear Local Bit LB3 Label (7 characters) (Enter NA to Null) CLB3 = _____

Set Local Bit LB3 Label (7 characters) (Enter NA to Null) SLB3 = _____

Pulse Local Bit LB3 Label (7 characters) (Enter NA to Null) PLB3 = _____

Local Bit LB4 Name (14 characters) (Enter NA to Null) NLB4 = _____

Clear Local Bit LB4 Label (7 characters) (Enter NA to Null) CLB4 = _____

Set Local Bit LB4 Label (7 characters) (Enter NA to Null) SLB4 = _____

Pulse Local Bit LB4 Label (7 characters) (Enter NA to Null) PLB4 = _____

Local Bit LB5 Name (14 characters) (Enter NA to Null) NLB5 = _____

Clear Local Bit LB5 Label (7 characters) (Enter NA to Null) CLB5 = _____

Set Local Bit LB5 Label (7 characters) (Enter NA to Null) SLB5 = _____

Pulse Local Bit LB5 Label (7 characters) (Enter NA to Null) PLB5 = _____

Local Bit LB6 Name (14 characters) (Enter NA to Null) NLB6 = _____

Clear Local Bit LB6 Label (7 characters) (Enter NA to Null) CLB6 = _____

Set Local Bit LB6 Label (7 characters) (Enter NA to Null) SLB6 = _____

Pulse Local Bit LB6 Label (7 characters) (Enter NA to Null) PLB6 = _____

Local Bit LB7 Name (14 characters) (Enter NA to Null) NLB7 = _____

Clear Local Bit LB7 Label (7 characters) (Enter NA to Null) CLB7 = _____

Set Local Bit LB7 Label (7 characters) (Enter NA to Null) SLB7 = _____

Pulse Local Bit LB7 Label (7 characters) (Enter NA to Null) PLB7 = _____

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Global Settings (SET G Command)

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Local Bit LB8 Name (14 characters) (Enter NA to Null)	NLB8	=	_____
Clear Local Bit LB8 Label (7 characters) (Enter NA to Null)	CLB8	=	_____
Set Local Bit LB8 Label (7 characters) (Enter NA to Null)	SLB8	=	_____
Pulse Local Bit LB8 Label (7 characters) (Enter NA to Null)	PLB8	=	_____
Local Bit LB9 Name (14 characters) (Enter NA to Null)	NLB9	=	_____
Clear Local Bit LB9 Label (7 characters) (Enter NA to Null)	CLB9	=	_____
Set Local Bit LB9 Label (7 characters) (Enter NA to Null)	SLB9	=	_____
Pulse Local Bit LB9 Label (7 characters) (Enter NA to Null)	PLB9	=	_____
Local Bit LB10 Name (14 characters) (Enter NA to Null)	NLB10	=	_____
Clear Local Bit LB10 Label (7 characters) (Enter NA to Null)	CLB10	=	_____
Set Local Bit LB10 Label (7 characters) (Enter NA to Null)	SLB10	=	_____
Pulse Local Bit LB10 Label (7 characters) (Enter NA to Null)	PLB10	=	_____
Local Bit LB11 Name (14 characters) (Enter NA to Null)	NLB11	=	_____
Clear Local Bit LB11 Label (7 characters) (Enter NA to Null)	CLB11	=	_____
Set Local Bit LB11 Label (7 characters) (Enter NA to Null)	SLB11	=	_____
Pulse Local Bit LB11 Label (7 characters) (Enter NA to Null)	PLB11	=	_____
Local Bit LB12 Name (14 characters) (Enter NA to Null)	NLB12	=	_____
Clear Local Bit LB12 Label (7 characters) (Enter NA to Null)	CLB12	=	_____
Set Local Bit LB12 Label (7 characters) (Enter NA to Null)	SLB12	=	_____
Pulse Local Bit LB12 Label (7 characters) (Enter NA to Null)	PLB12	=	_____
Local Bit LB13 Name (14 characters) (Enter NA to Null)	NLB13	=	_____
Clear Local Bit LB13 Label (7 characters) (Enter NA to Null)	CLB13	=	_____
Set Local Bit LB13 Label (7 characters) (Enter NA to Null)	SLB13	=	_____
Pulse Local Bit LB13 Label (7 characters) (Enter NA to Null)	PLB13	=	_____
Local Bit LB14 Name (14 characters) (Enter NA to Null)	NLB14	=	_____
Clear Local Bit LB14 Label (7 characters) (Enter NA to Null)	CLB14	=	_____
Set Local Bit LB14 Label (7 characters) (Enter NA to Null)	SLB14	=	_____
Pulse Local Bit LB14 Label (7 characters) (Enter NA to Null)	PLB14	=	_____
Local Bit LB15 Name (14 characters) (Enter NA to Null)	NLB15	=	_____
Clear Local Bit LB15 Label (7 characters) (Enter NA to Null)	CLB15	=	_____
Set Local Bit LB15 Label (7 characters) (Enter NA to Null)	SLB15	=	_____
Pulse Local Bit LB15 Label (7 characters) (Enter NA to Null)	PLB15	=	_____
Local Bit LB16 Name (14 characters) (Enter NA to Null)	NLB16	=	_____
Clear Local Bit LB16 Label (7 characters) (Enter NA to Null)	CLB16	=	_____
Set Local Bit LB16 Label (7 characters) (Enter NA to Null)	SLB16	=	_____
Pulse Local Bit LB16 Label (7 characters) (Enter NA to Null)	PLB16	=	_____

SEL-387-5, -6 Relay Settings Sheet

Sequential Events Recorder Settings (SET R Command)

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TRIGGER CONDITIONS

Trigger SER (24 Relay Word bits per SERn equation, 96 total)

SER1 = _____
SER2 = _____
SER3 = _____
SER4 = _____

RELAY WORD BIT ALIASES

Syntax: 'Relay-Word Bit' 'Up to 15 characters'. Use NA to disable setting.

ALIAS1 = _____
ALIAS2 = _____
ALIAS3 = _____
ALIAS4 = _____
ALIAS5 = _____
ALIAS6 = _____
ALIAS7 = _____
ALIAS8 = _____
ALIAS9 = _____
ALIAS10 = _____
ALIAS11 = _____
ALIAS12 = _____
ALIAS13 = _____
ALIAS14 = _____
ALIAS15 = _____
ALIAS16 = _____
ALIAS17 = _____
ALIAS18 = _____
ALIAS19 = _____
ALIAS20 = _____

SEL-387-5, -6 Relay Settings Sheet

Port Settings (SET P Command)

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Note: RTSCTS setting does not appear if PROTO=LMD or DNP. LMD PREFIX, ADDR, and SETTLE do not appear if PROTO=SEL or DNP. See *Appendix C: SEL Distributed Port Switch Protocol (LMD)* for details on LMD protocol and see *Appendix G: Distributed Network Protocol (DNP) 3.00* for details on DNP protocol.

PORT 1 (SET P 1) REAR PANEL, EIA-485 PLUS IRIG-B

Port Protocol (SEL, LMD, DNP)	PROTO	=	_____
LMD Prefix (@, #, \$, %, &)	PREFIX	=	_____
LMD Address (1–99)	ADDR	=	_____
LMD Settling Time (0–30 seconds)	SETTLE	=	_____
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	_____
Data Bits (7, 8)	BITS	=	_____
Parity Odd, Even, or None (O, E, N)	PARITY	=	_____
Stop Bits (1, 2)	STOP	=	_____
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	_____
Send auto messages to port (Y, N)	AUTO	=	_____
Enable hardware handshaking (Y, N)	RTSCTS	=	_____
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	_____

PORT 2 (SET P 2) REAR PANEL, EIA-232 WITH IRIG-B

Port Protocol (SEL, LMD, DNP)	PROTO	=	_____
LMD Prefix (@, #, \$, %, &)	PREFIX	=	_____
LMD Address (1–99)	ADDR	=	_____
LMD Settling Time (0–30 seconds)	SETTLE	=	_____
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	_____
Data Bits (7, 8)	BITS	=	_____
Parity Odd, Even, or None (O, E, N)	PARITY	=	_____
Stop Bits (1, 2)	STOP	=	_____
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	_____
Send auto messages to port (Y, N)	AUTO	=	_____
Enable hardware handshaking (Y, N)	RTSCTS	=	_____
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	_____

SEL-387-5, -6 Relay Settings Sheet

Port Settings (SET P Command)

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PORT 3 (SET P 3) REAR PANEL, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	_____
LMD Prefix (@, #, \$, %, &)	PREFIX	=	_____
LMD Address (1–99)	ADDR	=	_____
LMD Settling Time (0–30 seconds)	SETTLE	=	_____
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	_____
Data Bits (7, 8)	BITS	=	_____
Parity Odd, Even, or None (O, E, N)	PARITY	=	_____
Stop Bits (1, 2)	STOP	=	_____
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	_____
Send auto messages to port (Y, N)	AUTO	=	_____
Enable hardware handshaking (Y, N)	RTSCTS	=	_____
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	_____

PORT 4 (SET P 4) FRONT PANEL, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	_____
LMD Prefix (@, #, \$, %, &)	PREFIX	=	_____
LMD Address (1–99)	ADDR	=	_____
LMD Settling Time (0–30 seconds)	SETTLE	=	_____
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	_____
Data Bits (7, 8)	BITS	=	_____
Parity Odd, Even, or None (O, E, N)	PARITY	=	_____
Stop Bits (1, 2)	STOP	=	_____
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	_____
Send auto messages to port (Y, N)	AUTO	=	_____
Enable hardware handshaking (Y, N)	RTSCTS	=	_____
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	_____

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Group _____

CONFIGURATION SETTINGS

Relay Identifier (39 Characters)

RID = XFMR 1

Terminal Identifier (59 Characters)

TID = STATION A

Enable Winding 1 in Differential Element (Y, N)	E87W1	=	<u>Y</u>
Enable Winding 2 in Differential Element (Y, N)	E87W2	=	<u>Y</u>
Enable Winding 3 in Differential Element (Y, N)	E87W3	=	<u>Y</u>
Enable Winding 4 in Differential Element (Y, N)	E87W4	=	<u>N</u>
Enable Winding 1 O/C Elements and Dmd Thresholds (Y, N)	EOC1	=	<u>Y</u>
Enable Winding 2 O/C Elements and Dmd Thresholds (Y, N)	EOC2	=	<u>Y</u>
Enable Winding 3 O/C Elements and Dmd Thresholds (Y, N)	EOC3	=	<u>Y</u>
Enable Winding 4 O/C Elements and Dmd Thresholds (Y, N)	EOC4	=	<u>N</u>
Enable Combined O/C Elements (Y, N)	EOCC	=	<u>N</u>
Enable Thermal Element (Y, N)	ETHER	=	<u>Y</u>
Enable SELOGIC [®] Control Equations Set 1 (Y, N)	ESLS1	=	<u>N</u>
Enable SELOGIC Control Equations Set 2 (Y, N)	ESLS2	=	<u>N</u>
Enable SELOGIC Control Equations Set 3 (Y, N)	ESLS3	=	<u>N</u>

GENERAL DATA

Winding 1 CT Connection (D, Y)	W1CT	=	<u>Y</u>
Winding 2 CT Connection (D, Y)	W2CT	=	<u>Y</u>
Winding 3 CT Connection (D, Y)	W3CT	=	<u>Y</u>
Winding 4 CT Connection (D, Y)	W4CT	=	<u>Y</u>
Winding 1 CT Ratio (1–50000)	CTR1	=	<u>120; 600*</u>
Winding 2 CT Ratio (1–50000)	CTR2	=	<u>240; 1200*</u>
Winding 3 CT Ratio (1–50000)	CTR3	=	<u>400; 2000*</u>
Winding 4 CT Ratio (1–50000)	CTR4	=	<u>400; 2000*</u>
Maximum Power Transformer Capacity (OFF, 0.2–5000 MVA)	MVA	=	<u>100</u>
Define Internal CT Connection Compensation (Y, N)	ICOM	=	<u>Y</u>
Winding 1 CT Conn. Compensation (0, 1, ..., 12)	W1CTC	=	<u>11</u>
Winding 2 CT Conn. Compensation (0, 1, ..., 12)	W2CTC	=	<u>11</u>
Winding 3 CT Conn. Compensation (0, 1, ..., 12)	W3CTC	=	<u>0</u>
Winding 4 CT Conn. Compensation (0, 1, ..., 12)	W4CTC	=	<u>0</u>
Winding 1 Line-to-Line Voltage (1–1000 kV)	VWDG1	=	<u>230</u>
Winding 2 Line-to-Line Voltage (1–1000 kV)	VWDG2	=	<u>138</u>
Winding 3 Line-to-Line Voltage (1–1000 kV)	VWDG3	=	<u>13.8</u>
Winding 4 Line-to-Line Voltage (1–1000 kV)	VWDG4	=	<u>13.8</u>

*The first value applies to a 5 A relay, the second value applies to a 1 A relay.

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Group _____

DIFFERENTIAL ELEMENTS

Note: TAP1–TAP4 are auto-set by relay if MVA setting is not OFF.

Winding 1 Current Tap

(0.5–155.0 A secondary) (5 A)	TAP1	=	<u>2.09</u>
(0.1–31.0 A secondary) (1 A)		=	<u>0.42</u>

Winding 2 Current Tap

(0.5–155.0 A secondary) (5 A)	TAP2	=	<u>1.74</u>
(0.1–31.0 A secondary) (1 A)		=	<u>0.35</u>

Winding 3 Current Tap

(0.5–155.0 A secondary) (5 A)	TAP3	=	<u>10.46</u>
(0.1–31.0 A secondary) (1 A)		=	<u>2.09</u>

Winding 4 Current Tap

(0.5–155.0 A secondary) (5 A)	TAP4	=	<u>10.46</u>
(0.1–31.0 A secondary) (1 A)		=	<u>2.09</u>

Restrained Element Operating Current PU ((0.1–1.0) multiple of tap)	O87P	=	<u>0.3</u>

Restraint Slope 1 Percentage (5–100%)	SLP1	=	<u>25</u>

Restraint Slope 2 Percentage (OFF, 25–200%)	SLP2	=	<u>50</u>

Restraint Current Slope 1 Limit ((1–20) multiple of tap)	IRS1	=	<u>3</u>

Unrestrained Element Current PU ((1–20) multiple of tap)	U87P	=	<u>10</u>

Second-Harmonic Blocking Percentage (OFF, 5–100%)	PCT2	=	<u>15</u>

Fifth-Harmonic Blocking Percentage (OFF, 5–100%)	PCT5	=	<u>35</u>

Fifth-Harmonic Alarm Threshold (OFF, (0.02–3.20) multiple of tap)	TH5P	=	<u>OFF</u>

Fifth-Harmonic Alarm TDPU (0–8000 cycles)	TH5D	=	<u>30</u>

Independent Harmonic Blocking (Y, N)	IHBL	=	<u>N</u>

RESTRICTED EARTH FAULT

Enable 32I (SELOGIC control equation)

E32I = 0

Operating Quantity from Wdg. 1, Wdg. 2, Wdg. 3 (1, 2, 3, 12, 23, 123)	32IOP	=	<u>1</u>

Positive-Sequence Current Restraint Factor, I0/I1 (0.02–0.50)	a0	=	<u>0.10</u>

Residual Current Sensitivity Threshold

(0.25–15.00 A secondary) (5 A)	50GP	=	<u>0.50</u>

(0.05–3.00 A secondary) (1 A)		=	<u>0.10</u>

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Group _____

WINDING 1 O/C ELEMENTS

Winding 1 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P11P = 20.00(OFF, 0.05–20.00 A secondary) (1 A) = 4.00Phase Level 1 O/C Delay (0–16000 cycles) 50P11D = 5

50P11 Torque Control (SELOGIC control equation)

50P11TC = 1

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P12P = OFF(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50P12 Torque Control (SELOGIC control equation)

50P12TC = 1

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P13P = 0.50(OFF, 0.05–20.00 A secondary) (1 A) = 0.10

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P14P = 4.00(OFF, 0.05–20.00 A secondary) (1 A) = 0.80

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51P1P = 4.00(OFF, 0.1–3.2 A secondary) (1 A) = 0.80Phase Inv.-Time O/C Curve (U1–U5, C1–C5) 51P1C = U2Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51P1TD = 3.00Phase Inv.-Time O/C EM Reset (Y, N) 51P1RS = Y

51P1 Torque Control (SELOGIC control equation)

51P1TC = 1

Winding 1 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50Q11P = OFF(OFF, 0.05–20.00 A secondary) (1 A) = OFFNeg.-Seq. Level 1 O/C Delay (0.5–16000 cycles) 50Q11D = 5

50Q11 Torque Control (SELOGIC control equation)

50Q11TC = 1

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Date _____

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Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50Q12P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50Q12 Torque Control (SELOGIC control equation)

50Q12TC = 1

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51Q1P = 6.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 1.2

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)

51Q1C = U2

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51Q1TD = 3.00

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)

51Q1RS = Y

51Q1 Torque Control (SELOGIC control equation)

51Q1TC = 1

Winding 1 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50N11P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

Residual Level 1 O/C Delay (0–16000 cycles)

50N11D = 5

50N11 Torque Control (SELOGIC control equation)

50N11TC = 1

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50N12P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50N12 Torque Control (SELOGIC control equation)

50N12TC = 1

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51N1P = OFF

(OFF, 0.1–3.2 A secondary) (1 A)

= OFF

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N1C = U2

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51N1TD = 1.00

Residual Inv.-Time O/C EM Reset (Y, N)

51N1RS = Y

51N1 Torque Control (SELOGIC control equation)

51N1TC = 1

Winding 1 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

DATC1 = 15

Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

PDEM1P = 7.0

(0.1–3.2 A secondary) (1 A)

= 1.4

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Group _____

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

QDEM1P = 1.0

(0.1–3.2 A secondary) (1 A)

= 0.2

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

NDEM1P = 1.0

(0.1–3.2 A secondary) (1 A)

= 0.2

WINDING 2 O/C ELEMENTS

Winding 2 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

Phase Level 1 O/C Delay (0–16000 cycles)

50P21D = 5

50P21 Torque Control (SELOGIC control equation)

50P21TC = 1

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50P22 Torque Control (SELOGIC control equation)

50P22TC = 1

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P23P = 0.50

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.10

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P24P = 3.50

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.70

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51P2P = 3.5

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.7

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P2C = U2

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P2TD = 3.50

Phase Inv.-Time O/C EM Reset (Y, N)

51P2RS = Y

51P2 Torque Control (SELOGIC control equation)

51P2TC = 1

Winding 2 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50Q21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

SEL-387-5, -6 Relay Settings Sheet
Group Settings (SET Command) Example

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Group _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000 cycles) 50Q21D = 5

50Q21 Torque Control (SELOGIC control equation)

50Q21TC = 1

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50Q22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50Q22 Torque Control (SELOGIC control equation)

50Q22TC = 1

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51Q2P = 5.25

(OFF, 0.1–3.2 A secondary) (1 A) = 1.05

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5) 51Q2C = U2

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51Q2TD = 3.50

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N) 51Q2RS = Y

51Q2 Torque Control (SELOGIC control equation)

51Q2TC = 1

Winding 2 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50N21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

Residual Level 1 O/C Delay (0–16000 cycles) 50N21D = 5

50N21 Torque Control (SELOGIC control equation)

50N21TC = 1

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50N22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50N22 Torque Control (SELOGIC control equation)

50N22TC = 1

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51N2P = OFF

(OFF, 0.1–3.2 A secondary) (1 A) = OFF

Residual Inv.-Time O/C Curve (U1–U5, C1–C5) 51N2C = U2

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51N2TD = 1.00

Residual Inv.-Time O/C EM Reset (Y, N) 51N2RS = Y

51N2 Torque Control (SELOGIC control equation)

51N2TC = 1

Winding 2 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min) DATC2 = 15

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Group Settings (SET Command) Example

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Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

PDEM2P = 7.0

(0.1–3.2 A secondary) (1 A)

= 1.4

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

QDEM2P = 1.0

(0.1–3.2 A secondary) (1 A)

= 0.2

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

NDEM2P = 1.0

(0.1–3.2 A secondary) (1 A)

= 0.2

WINDING 3 O/C ELEMENTS

Winding 3 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P31P = 7.00

(OFF, 0.05–20.00 A secondary) (1 A)

= 1.40

Phase Level 1 O/C Delay (0–16000 cycles)

50P31D = 0

50P31 Torque Control (SELOGIC control equation)

50P31TC = 1

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P32P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50P32 Torque Control (SELOGIC control equation)

50P32TC = 1

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P33P = 0.50

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.10

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P34P = 4.00

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.80

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51P3P = 4.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.8

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P3C = U2

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P3TD = 1.30

Phase Inv.-Time O/C EM Reset (Y, N)

51P3RS = Y

51P3 Torque Control (SELOGIC control equation)

51P3TC = 1

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Group Settings (SET Command) Example

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Winding 3 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50Q31P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles) 50Q31D = 5

50Q31 Torque Control (SELOGIC control equation)

50Q31TC = 1

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50Q32P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50Q32 Torque Control (SELOGIC control equation)

50Q32TC = 1

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51Q3P = OFF

(OFF, 0.1–3.2 A secondary) (1 A) = OFF

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5) 51Q3C = U2

Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51Q3TD = 3.00

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N) 51Q3RS = Y

51Q3 Torque Control (SELOGIC control equation)

51Q3TC = 1

Winding 3 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50N31P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

Residual Level 1 O/C Delay (0–16000 cycles) 50N31D = 5

50N31 Torque Control (SELOGIC control equation)

50N31TC = 1

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50N32P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50N32 Torque Control (SELOGIC control equation)

50N32TC = 1

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51N3P = OFF

(OFF, 0.1–3.2 A secondary) (1 A) = OFF

Residual Inv.-Time O/C Curve (U1–U5, C1–C5) 51N3C = U2

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) 51N3TD = 1.00

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Group Settings (SET Command) Example

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Residual Inv.-Time O/C EM Reset (Y, N) 51N3RS = Y

51N3 Torque Control (SELOGIC control equation)

51N3TC = 1

Winding 3 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min) DATC3 = 15

Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A) PDEM3P = 7.0

(0.1–3.2 A secondary) (1 A) = 1.4

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A) QDEM3P = 1.0

(0.1–3.2 A secondary) (1 A) = 0.2

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A) NDEM3P = 1.0

(0.1–3.2 A secondary) (1 A) = 0.2

WINDING 4 O/C ELEMENTS

Winding 4 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P41P = 20.00

(OFF, 0.05–20.00 A secondary) (1 A) = 4.00

Phase Level 1 O/C Delay (0–16000 cycles) 50P41D = 5

50P41 Torque Control (SELOGIC control equation)

50P41TC = 1

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P42P = OFF

(OFF, 0.05–20.00 A secondary) (1 A) = OFF

50P42 Torque Control SELOGIC control equation)

50P42TC = 1

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P43P = 0.50

(OFF, 0.05–20.00 A secondary) (1 A) = 0.10

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A) 50P44P = 4.00

(OFF, 0.05–20.00 A secondary) (1 A) = 0.80

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A) 51P4P = 4.0

(OFF, 0.1–3.2 A secondary) (1 A) = 0.8

Phase Inv.-Time O/C Curve (U1–U5, C1–C5) 51P4C = U2

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Group Settings (SET Command) Example

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Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51P4TD	=	<u>3.00</u>
Phase Inv.-Time O/C EM Reset (Y, N)	51P4RS	=	<u>Y</u>
51P4 Torque Control (SELOGIC control equation)			
51P4TC =	<u>1</u>		

Winding 4 Negative-Sequence O/C Elements

Note: All negative-sequence element pickup settings are in terms of $3I_2$.

Neg.-Seq. Def.-Time O/C Level 1 PU			
(OFF, 0.25–100.00 A secondary) (5 A)	50Q41P	=	<u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		=	<u>OFF</u>
Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles)	50Q41D	=	<u>5</u>
50Q41 Torque Control SELOGIC control equation)			
50Q41TC =	<u>1</u>		
Neg.-Seq. Inst. O/C Level 2 PU			
(OFF, 0.25–100.00 A secondary) (5 A)	50Q42P	=	<u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		=	<u>OFF</u>
50Q42 Torque Control (SELOGIC control equation)			
50Q42TC =	<u>1</u>		
Neg.-Seq. Inv.-Time O/C PU			
(OFF, 0.5–16.0 A secondary) (5 A)	51Q4P	=	<u>6.0</u>
(OFF, 0.1–3.2 A secondary) (1 A)		=	<u>1.2</u>
Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)	51Q4C	=	<u>U2</u>
Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51Q4TD	=	<u>3.00</u>
Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)	51Q4RS	=	<u>Y</u>
51Q4 Torque Control SELOGIC control equation)			
51Q4TC =	<u>1</u>		

Winding 4 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU			
(OFF, 0.25–100.00 A secondary) (5 A)	50N41P	=	<u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		=	<u>OFF</u>
Residual Level 1 O/C Delay (0–16000 cycles)	50N41D	=	<u>5</u>
50N41 Torque Control (SELOGIC control equation)			
50N41TC =	<u>1</u>		
Residual Inst. O/C Level 2 PU			
(OFF, 0.25–100.00 A secondary) (5 A)	50N42P	=	<u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		=	<u>OFF</u>
50N42 Torque Control (SELOGIC control equation)			
50N42TC =	<u>1</u>		

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51N4P = OFF

(OFF, 0.1–3.2 A secondary) (1 A)

= OFF

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N4C = U2

Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51N4TD = 1.00

Residual Inv.-Time O/C EM Reset (Y, N)

51N4RS = Y

51N4 Torque Control (SELOGIC control equation)

51N4TC = 1

Winding 4 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

DATC4 = 15

Phase Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

PDEM4P = 7.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 1.4

Neg.-Seq. Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

QDEM4P = 1.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

Residual Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

NDEM4P = 1.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

COMBINED O/C ELEMENTS

W1–W2 Phase O/C Element

W1-W2 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51PC1P = 4.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.8

W1-W2 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC1C = U2

W1-W2 Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51PC1TD = 3.00

W1-W2 Phase Inv.-Time O/C EM Reset (Y, N)

51PC1RS = Y

W1–W2 Residual O/C Element

W1-W2 Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51NC1P = 1.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

W1-W2 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC1C = U2

W1-W2 Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51NC1TD = 3.00

W1-W2 Residual Inv.-Time O/C EM Reset (Y, N)

51NC1RS = Y

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Group Settings (SET Command) Example

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W3-W4 Phase O/C Element

W3-W4 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51PC2P* = 4.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.8

W3-W4 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC2C = U2

W3-W4 Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51PC2TD = 3.00

W3-W4 Phase Inv.-Time O/C EM Reset (Y, N)

51PC2RS = Y

* Must be OFF if Restricted Earth Fault is used.

W3-W4 Residual O/C Element

W3-W4 Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51NC2P* = 1.00

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

W3-W4 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC2C = U2

W3-W4 Residual Inv.-Time O/C Time-Dial (US 0.5-15.0, IEC 0.05-1.00)

51NC2TD = 3.00

W3-W4 Residual Inv.-Time O/C EM Reset (Y, N)

51NC2RS = Y

* Must be OFF if Restricted Earth Fault is used.

THERMAL ELEMENT (SEL-387-6 RELAY ONLY)

Thermal Model Winding Current (1, 2, 3, 4, 12, 34)

TMWDG = 1

Winding LL Voltage (1–1000 kV)

VWDG = 230

Transformer Construction (1, 3)

XTYPE = 1

Transformer Type (D, Y)

TRTYPE = Y

Winding Temp/Amb (65, 55)

THwr = 65

Number of Cooling Stages (1–3)

NCS = 3

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS11 = 100.0

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS21 = 100.0

Cooling Stage 1 Rating (0.2–5000.0 MVA)

MCS31 = 100.0

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS12 = 140.0

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS22 = 140.0

Cooling Stage 2 Rating (0.2–5000.0 MVA)

MCS32 = 140.0

Cooling System 2 (SELOGIC control equation)

CS12S = 0

Cooling System 2 (SELOGIC control equation)

CS22S = 0

Cooling System 2 (SELOGIC control equation)

CS32S = 0

Cooling Stage 3 Rating (0.2–5000.0 MVA)

MCS13 = 170.0

Cooling Stage 3 Rating (0.2–5000.0 MVA)

MCS23 = 170.0

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Group Settings (SET Command) Example

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Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS33	=	<u>170.0</u>
Cooling System 3 (SELOGIC control equation)			
CS13S =			<u>0</u>
Cooling System 3 (SELOGIC control equation)			
CS23S =			<u>0</u>
Cooling System 3 (SELOGIC control equation)			
CS33S =			<u>0</u>
Default Ambient Temp. (–40–85°C)	DTMP	=	<u>15</u>
Deenergized Transformer (SELOGIC control equation)			
TRDE =			<u>0</u>
Number Thermal Inputs (0–4)	NTHM	=	<u>4</u>
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM1	=	<u>AMB</u>
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM2	=	<u>OIL1</u>
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM3	=	<u>OIL2</u>
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM4	=	<u>OIL3</u>
Top-Oil Temp. Limit 1 (50–150°C)	TOT1	=	<u>100</u>
Top-Oil Temp. Limit 2 (50–150°C)	TOT2	=	<u>100</u>
Hot-Spot Limit 1 (80–300°C)	HST1	=	<u>200</u>
Hot-Spot Limit 2 (80–300°C)	HST2	=	<u>200</u>
Aging Acceleration Factor Limit 1 (0.00–599.99)	FAAL1	=	<u>50.00</u>
Aging Acceleration Factor Limit 2 (0.00–599.99)	FAAL2	=	<u>50.00</u>
Daily Loss-of-Life Limit (0.00–99.99%)	RLOLL	=	<u>50.00</u>
Total Loss-of-Life Limit (0.00–99.99%)	TLOLL	=	<u>50.00</u>
Cooling System Efficiency-Transformer 1 (5–100°C)	CSEP1	=	<u>15</u>
Cooling System Efficiency-Transformer 2 (5–100°C)	CSEP2	=	<u>15</u>
Cooling System Efficiency-Transformer 3 (5–100°C)	CSEP3	=	<u>15</u>

General Cooling System Constants

Nominal Insulation Life (1000–999999 hr)	ILIFE	=	<u>180000</u>
Enable Default Constants (Y/N)	EDFTC	=	<u>Y</u>

Transformer 1

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths1	=	<u>0.08</u>
Constant to Calc. FAA (0–100000)	BFFA1	=	<u>150000</u>
Cooling Stage 1 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor11	=	<u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr11	=	<u>25.0</u>

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Group Settings (SET Command) Example

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Group _____

Ratio Losses (0.0–100.0)	RATL11	=	<u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR11	=	<u>3.0</u>
Oil Exponent (0.1–5)	EXPn11	=	<u>0.8</u>
Winding Exponent (0.1–5)	EXPm11	=	<u>0.8</u>
Cooling Stage 2 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor12	=	<u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr12	=	<u>30.0</u>
Ratio Losses (0.0–100.0)	RATL12	=	<u>4.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR12	=	<u>2.0</u>
Oil Exponent (0.1–5)	EXPn12	=	<u>0.9</u>
Winding Exponent (0.1–5)	EXPm12	=	<u>0.9</u>
Cooling Stage 3 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor13	=	<u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr13	=	<u>35.0</u>
Ratio Losses (0.0–100.0)	RATL13	=	<u>6.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR13	=	<u>1.3</u>
Oil Exponent (0.1–5)	EXPn13	=	<u>1.0</u>
Winding Exponent (0.1–5)	EXPm13	=	<u>1.0</u>
Transformer 2			
Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths2	=	<u>0.08</u>
Constant to Calc. FAA (0–100000)	BFFA2	=	<u>150000</u>
Cooling Stage 1 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor21	=	<u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr21	=	<u>25.0</u>
Ratio Losses (0.0–100.0)	RATL21	=	<u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR21	=	<u>3.0</u>
Oil Exponent (0.1–5)	EXPn21	=	<u>0.8</u>
Winding Exponent (0.1–5)	EXPm21	=	<u>0.8</u>
Cooling Stage 2 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor22	=	<u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr22	=	<u>30.0</u>
Ratio Losses (0.0–100.0)	RATL22	=	<u>4.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR22	=	<u>2.0</u>
Oil Exponent (0.1–5)	EXPn22	=	<u>0.9</u>
Winding Exponent (0.1–5)	EXPm22	=	<u>0.9</u>
Cooling Stage 3 Constants			
Top-Oil Rise/Amb (0.1–100.0°C)	THor23	=	<u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr23	=	<u>35.0</u>
Ratio Losses (0.0–100.0)	RATL23	=	<u>6.5</u>

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Group Settings (SET Command) Example

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Group _____

Oil Thermal Time Constant (0.1–20.0 hr)	OTR23	=	<u>1.3</u>
Oil Exponent (0.1–5)	EXPn23	=	<u>1.0</u>
Winding Exponent (0.1–5)	EXPm23	=	<u>1.0</u>

Transformer 3

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths3	=	<u>0.08</u>
Constant to Calc. FAA (0–100000)	BFFA3	=	<u>150000</u>

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor31	=	<u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr31	=	<u>25.0</u>
Ratio Losses (0.0–100.0)	RATL31	=	<u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR31	=	<u>3.0</u>
Oil Exponent (0.1–5)	EXPn31	=	<u>0.8</u>
Winding Exponent (0.1–5)	EXPm31	=	<u>0.8</u>

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor32	=	<u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr32	=	<u>30.0</u>
Ratio Losses (0.0–100.0)	RATL32	=	<u>4.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR32	=	<u>2.0</u>
Oil Exponent (0.1–5)	EXPn32	=	<u>0.9</u>
Winding Exponent (0.1–5)	EXPm32	=	<u>0.9</u>

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor33	=	<u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr33	=	<u>35.0</u>
Ratio Losses (0.0–100.0)	RATL33	=	<u>6.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR33	=	<u>1.3</u>
Oil Exponent (0.1–5)	EXPn33	=	<u>1.0</u>
Winding Exponent (0.1–5)	EXPm33	=	<u>1.0</u>

MISCELLANEOUS TIMERS

Minimum Trip Duration Time Delay (4–8000 cycles)	TDURD	=	<u>9</u>
Close Failure Logic Time Delay (OFF, 0–8000 cycles)	CFD	=	<u>60</u>

SELOGIC CONTROL EQUATIONS SET 1

Set 1 Variable 1 (SELOGIC control equation)

S1V1 = 0S1V1 Timer Pickup (0–999999 cycles) S1V1PU = 0S1V1 Timer Dropout (0–999999 cycles) S1V1DO = 0

Set 1 Variable 2 (SELOGIC control equation)

S1V2 = 0S1V2 Timer Pickup (0–999999 cycles) S1V2PU = 0

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Group Settings (SET Command) Example

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Date _____

Group _____

S1V2 Timer Dropout (0–999999 cycles) S1V2DO = 0

Set 1 Variable 3 (SELOGIC control equation)

S1V3 = 0

S1V3 Timer Pickup (0–999999 cycles) S1V3PU = 0

S1V3 Timer Dropout (0–999999 cycles) S1V3DO = 0

Set 1 Variable 4 (SELOGIC control equation)

S1V4 = 0

S1V4 Timer Pickup (0–999999 cycles) S1V4PU = 0

S1V4 Timer Dropout (0–999999 cycles) S1V4DO = 0

Set 1 Latch Bit 1 SET Input (SELOGIC control equation)

S1SLT1 = 0

Set 1 Latch Bit 1 RESET Input (SELOGIC control equation)

S1RLT1 = 0

Set 1 Latch Bit 2 SET Input (SELOGIC control equation)

S1SLT2 = 0

Set 1 Latch Bit 2 RESET Input (SELOGIC control equation)

S1RLT2 = 0

Set 1 Latch Bit 3 SET Input (SELOGIC control equation)

S1SLT3 = 0

Set 1 Latch Bit 3 RESET Input (SELOGIC control equation)

S1RLT3 = 0

Set 1 Latch Bit 4 SET Input (SELOGIC control equation)

S1SLT4 = 0

Set 1 Latch Bit 4 RESET Input (SELOGIC control equation)

S1RLT4 = 0

SELOGIC CONTROL EQUATIONS SET 2

Set 2 Variable 1 (SELOGIC control equation)

S2V1 = 0

S2V1 Timer Pickup (0–999999 cycles) S2V1PU = 0

S2V1 Timer Dropout (0–999999 cycles) S2V1DO = 0

Set 2 Variable 2 (SELOGIC control equation)

S2V2 = 0

S2V2 Timer Pickup (0–999999 cycles) S2V2PU = 0

S2V2 Timer Dropout (0–999999 cycles) S2V2DO = 0

Set 2 Variable 3 (SELOGIC control equation)

S2V3 = 0

S2V3 Timer Pickup (0–999999 cycles) S2V3PU = 0

S2V3 Timer Dropout (0–999999 cycles) S2V3DO = 0

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Group Settings (SET Command) Example

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Set 2 Variable 4 (SELOGIC control equation)

S2V4 = 0

S2V4 Timer Pickup (0–999999 cycles)

S2V4PU = 0

S2V4 Timer Dropout (0–999999 cycles)

S2V4DO = 0

Set 2 Latch Bit 1 SET Input (SELOGIC control equation)

S2SLT1 = 0

Set 2 Latch Bit 1 RESET Input (SELOGIC control equation)

S2RLT1 = 0

Set 2 Latch Bit 2 SET Input (SELOGIC control equation)

S2SLT2 = 0

Set 2 Latch Bit 2 RESET Input (SELOGIC control equation)

S2RLT2 = 0

Set 2 Latch Bit 3 SET Input (SELOGIC control equation)

S2SLT3 = 0

Set 2 Latch Bit 3 RESET Input (SELOGIC control equation)

S2RLT3 = 0

Set 2 Latch Bit 4 SET Input (SELOGIC control equation)

S2SLT4 = 0

Set 2 Latch Bit 4 RESET Input (SELOGIC control equation)

S2RLT4 = 0

SELOGIC CONTROL EQUATIONS SET 3

Set 3 Variable 1 (SELOGIC control equation)

S3V1 = 0

S3V1 Timer Pickup (0–999999 cycles)

S3V1PU = 0

S3V1 Timer Dropout (0–999999 cycles)

S3V1DO = 0

Set 3 Variable 2 (SELOGIC control equation)

S3V2 = 0

S3V2 Timer Pickup (0–999999 cycles)

S3V2PU = 0

S3V2 Timer Dropout (0–999999 cycles)

S3V2DO = 0

Set 3 Variable 3 (SELOGIC control equation)

S3V3 = 0

S3V3 Timer Pickup (0–999999 cycles)

S3V3PU = 0

S3V3 Timer Dropout (0–999999 cycles)

S3V3DO = 0

Set 3 Variable 4 (SELOGIC control equation)

S3V4 = 0

S3V4 Timer Pickup (0–999999 cycles)

S3V4PU = 0

S3V4 Timer Dropout (0–999999 cycles)

S3V4DO = 0

Set 3 Variable 5 (SELOGIC control equation)

S3V5 = 0

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Group Settings (SET Command) Example

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S3V5 Timer Pickup (0–999999 cycles)	S3V5PU	= <u>0</u>
S3V5 Timer Dropout (0–999999 cycles)	S3V5DO	= <u>0</u>
Set 3 Variable 6 (SELOGIC control equation)		
S3V6 = <u>0</u>		
S3V6 Timer Pickup (0–999999 cycles)	S3V6PU	= <u>0</u>
S3V6 Timer Dropout (0–999999 cycles)	S3V6DO	= <u>0</u>
Set 3 Variable 7 (SELOGIC control equation)		
S3V7 = <u>0</u>		
S3V7 Timer Pickup (0–999999 cycles)	S3V7PU	= <u>0</u>
S3V7 Timer Dropout (0–999999 cycles)	S3V7DO	= <u>0</u>
Set 3 Variable 8 (SELOGIC control equation)		
S3V8 = <u>0</u>		
S3V8 Timer Pickup (0–999999 cycles)	S3V8PU	= <u>0</u>
S3V8 Timer Dropout (0–999999 cycles)	S3V8DO	= <u>0</u>
Set 3 Latch Bit 1 SET Input (SELOGIC control equation)		
S3SLT1 = <u>0</u>		
Set 3 Latch Bit 1 RESET Input (SELOGIC control equation)		
S3RLT1 = <u>0</u>		
Set 3 Latch Bit 2 SET Input (SELOGIC control equation)		
S3SLT2 = <u>0</u>		
Set 3 Latch Bit 2 RESET Input (SELOGIC control equation)		
S3RLT2 = <u>0</u>		
Set 3 Latch Bit 3 SET Input (SELOGIC control equation)		
S3SLT3 = <u>0</u>		
Set 3 Latch Bit 3 RESET Input (SELOGIC control equation)		
S3RLT3 = <u>0</u>		
Set 3 Latch Bit 4 SET Input (SELOGIC control equation)		
S3SLT4 = <u>0</u>		
Set 3 Latch Bit 4 RESET Input (SELOGIC control equation)		
S3RLT4 = <u>0</u>		
Set 3 Latch Bit 5 SET Input (SELOGIC control equation)		
S3SLT5 = <u>0</u>		
Set 3 Latch Bit 5 RESET Input (SELOGIC control equation)		
S3RLT5 = <u>0</u>		
Set 3 Latch Bit 6 SET Input (SELOGIC control equation)		
S3SLT6 = <u>0</u>		

SEL-387-5, -6 Relay Settings Sheet

Group Settings (SET Command) Example

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Set 3 Latch Bit 6 RESET Input (SELOGIC control equation)

S3RLT6 = 0

Set 3 Latch Bit 7 SET Input (SELOGIC control equation)

S3SLT7 = 0

Set 3 Latch Bit 7 RESET Input (SELOGIC control equation)

S3RLT7 = 0

Set 3 Latch Bit 8 SET Input (SELOGIC control equation)

S3SLT8 = 0

Set 3 Latch Bit 8 RESET Input (SELOGIC control equation)

S3RLT8 = 0

TRIP LOGIC

TR1 = 50P11T + 51P1T + 51Q1T + OC1 + LB3

TR2 = 51P2T + 51Q2T + OC2

TR3 = 50P31 + 51P3T + OC3

TR4 = 87R + 87U

TR5 = 0

ULTR1 = !50P13

ULTR2 = !50P23

ULTR3 = !50P33

ULTR4 = !(50P13 + 50P23 + 50P33)

ULTR5 = 0

CLOSE LOGIC

52A1 = IN101

52A2 = IN102

52A3 = IN103

52A4 = 0

CL1 = CC1 + LB4 + /IN104

CL2 = CC2 + /IN105

CL3 = CC3 + /IN106

CL4 = 0

ULCL1 = TRIP1 + TRIP4

ULCL2 = TRIP2 + TRIP4

ULCL3 = TRIP3 + TRIP4

ULCL4 = 0

EVENT REPORT TRIGGERING

ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3

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Group Settings (SET Command) Example

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OUTPUT CONTACT LOGIC (STANDARD OUTPUTS)

OUT101	=	TRIP1
OUT102	=	TRIP2
OUT103	=	TRIP3
OUT104	=	TRIP4
OUT105	=	CLS1
OUT106	=	CLS2
OUT107	=	CLS3

OUTPUT CONTACT LOGIC (EXTRA INTERFACE BOARD 2 OR 6)

OUT201	=	0
OUT202	=	0
OUT203	=	0
OUT204	=	0
OUT205	=	0
OUT206	=	0
OUT207	=	0
OUT208	=	0
OUT209	=	0
OUT210	=	0
OUT211	=	0
OUT212	=	0

OUTPUT CONTACT LOGIC (EXTRA INTERFACE BOARD 4)

OUT201	=	0
OUT202	=	0
OUT203	=	0
OUT204	=	0

SEL-387-5, -6 Relay Settings Sheet

Global Settings (SET G Command) Example

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RELAY SETTINGS

Length of Event Report (15, 30, 60 cycles)	LER	=	<u>15</u>
Length of Pre-fault in Event Report (1 to (LER-1))	PRE	=	<u>4</u>
Nominal Frequency (50, 60 Hz)	NFREQ	=	<u>60 or 50</u>
Phase Rotation (ABC, ACB)	PHROT	=	<u>ABC or ACB</u>
Date Format (MDY, YMD)	DATE_F	=	<u>MDY</u>
Display Update Rate (1–60 seconds)	SCROLD	=	<u>2</u>
Front Panel Time-out (OFF, 0–30 minutes)	FP_TO	=	<u>15</u>
Group Change Delay (0–900 seconds)	TGR	=	<u>3</u>

BATTERY MONITOR

DC Battery Voltage Level 1 (OFF, 20–300 Vdc)	DC1P	=	<u>OFF</u>
DC Battery Voltage Level 2 (OFF, 20–300 Vdc)	DC2P	=	<u>OFF</u>
DC Battery Voltage Level 3 (OFF, 20–300 Vdc)	DC3P	=	<u>OFF</u>
DC Battery Voltage Level 4 (OFF, 20–300 Vdc)	DC4P	=	<u>OFF</u>

BREAKER 1 MONITOR

BKR1 Trigger Equation (SELOGIC control equation)

BKMON1 = TRIP1 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B1COP1	=	<u>10000</u>
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B1KAP1	=	<u>1.2</u>
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	=	<u>150</u>
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B1KAP2	=	<u>8.0</u>
Close/Open Set Point 3 max (1–65000 operations)	B1COP3	=	<u>12</u>
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B1KAP3	=	<u>20.0</u>

BREAKER 2 MONITOR

BKR2 Trigger Equation (SELOGIC control equation)

BKMON2 = TRIP2 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B2COP1	=	<u>10000</u>
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B2KAP1	=	<u>1.2</u>
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	=	<u>150</u>
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B2KAP2	=	<u>8.0</u>
Close/Open Set Point 3 max (1–65000 operations)	B2COP3	=	<u>12</u>
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B2KAP3	=	<u>20.0</u>

SEL-387-5, -6 Relay Settings Sheet

Global Settings (SET G Command) Example

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BREAKER 3 MONITOR

BKR3 Trigger Equation (SELOGIC control equation)

BKMON3 = TRIP3 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B3COP1	=	<u>10000</u>
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B3KAP1	=	<u>1.2</u>
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	=	<u>150</u>
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B3KAP2	=	<u>8.0</u>
Close/Open Set Point 3 max (1–65000 operations)	B3COP3	=	<u>12</u>
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B3KAP3	=	<u>20.0</u>

BREAKER 4 MONITOR

BKR4 Trigger Equation (SELOGIC control equation)

BKMON4 = 0

Close/Open Set Point 1 max (1–65000 operations)	B4COP1	=	<u>10000</u>
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B4KAP1	=	<u>1.2</u>
Close/Open Set Point 2 max (1–65000 operations)	B4COP2	=	<u>150</u>
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B4KAP2	=	<u>8.0</u>
Close/Open Set Point 3 max (1–65000 operations)	B4COP3	=	<u>12</u>
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B4KAP3	=	<u>20.0</u>

ANALOG INPUT LABELS

Rename Current Input IAW1 (1–4 characters)	IAW1	=	<u>IAW1</u>
Rename Current Input IBW1 (1–4 characters)	IBW1	=	<u>IBW1</u>
Rename Current Input ICW1 (1–4 characters)	ICW1	=	<u>ICW1</u>
Rename Current Input IAW2 (1–4 characters)	IAW2	=	<u>IAW2</u>
Rename Current Input IBW2 (1–4 characters)	IBW2	=	<u>IBW2</u>
Rename Current Input ICW2 (1–4 characters)	ICW2	=	<u>ICW2</u>
Rename Current Input IAW3 (1–4 characters)	IAW3	=	<u>IAW3</u>
Rename Current Input IBW3 (1–4 characters)	IBW3	=	<u>IBW3</u>
Rename Current Input ICW3 (1–4 characters)	ICW3	=	<u>ICW3</u>
Rename Current Input IAW4 (1–4 characters)	IAW4	=	<u>IAW4</u>
Rename Current Input IBW4 (1–4 characters)	IBW4	=	<u>IBW4</u>
Rename Current Input ICW4 (1–4 characters)	ICW4	=	<u>ICW4</u>

SETTING GROUP SELECTION

Select Setting Group 1 (SELOGIC control equation)

SS1 = 0

Select Setting Group 2 (SELOGIC control equation)

SS2 = 0

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Global Settings (SET G Command) Example

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Select Setting Group 3 (SELOGIC control equation)

SS3 = 0

Select Setting Group 4 (SELOGIC control equation)

SS4 = 0

Select Setting Group 5 (SELOGIC control equation)

SS5 = 0

Select Setting Group 6 (SELOGIC control equation)

SS6 = 0

FRONT PANEL

Energize LEDA (SELOGIC control equation)

LEDA = OCA + 87E1

Energize LEDB (SELOGIC control equation)

LEDB = OCB + 87E2

Energize LEDC (SELOGIC control equation)

LEDC = OCC + 87E3

Show Display Point 1 (SELOGIC control equation)

DP1 = IN101

DP1 Label 1 (16 characters) (Enter NA to Null) DP1_1 = BREAKER 1 CLOSED

DP1 Label 0 (16 characters) (Enter NA to Null) DP1_0 = BREAKER 1 OPEN

Show Display Point 2 (SELOGIC control equation)

DP2 = IN102

DP2 Label 1 (16 characters) (Enter NA to Null) DP2_1 = BREAKER 2 CLOSED

DP2 Label 0 (16 characters) (Enter NA to Null) DP2_0 = BREAKER 2 OPEN

Show Display Point 3 (SELOGIC control equation)

DP3 = IN103

DP3 Label 1 (16 characters) (Enter NA to Null) DP3_1 = BREAKER 3 CLOSED

DP3 Label 0 (16 characters) (Enter NA to Null) DP3_0 = BREAKER 3 OPEN

Show Display Point 4 (SELOGIC control equation)

DP4 = 0

DP4 Label 1 (16 characters) (Enter NA to Null) DP4_1 = _____

DP4 Label 0 (16 characters) (Enter NA to Null) DP4_0 = _____

Show Display Point 5 (SELOGIC control equation)

DP5 = 0

DP5 Label 1 (16 characters) (Enter NA to Null) DP5_1 = _____

DP5 Label 0 (16 characters) (Enter NA to Null) DP5_0 = _____

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Global Settings (SET G Command) Example

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Group _____

Show Display Point 6 (SELOGIC control equation)

DP6 = 0

DP6 Label 1 (16 characters) (Enter NA to Null) DP6_1 = _____

DP6 Label 0 (16 characters) (Enter NA to Null) DP6_0 = _____

Show Display Point 7 (SELOGIC control equation)

DP7 = 0

DP7 Label 1 (16 characters) (Enter NA to Null) DP7_1 = _____

DP7 Label 0 (16 characters) (Enter NA to Null) DP7_0 = _____

Show Display Point 8 (SELOGIC control equation)

DP8 = 0

DP8 Label 1 (16 characters) (Enter NA to Null) DP8_1 = _____

DP8 Label 0 (16 characters) (Enter NA to Null) DP8_0 = _____

Show Display Point 9 (SELOGIC control equation)

DP9 = 0

DP9 Label 1 (16 characters) (Enter NA to Null) DP9_1 = _____

DP9 Label 0 (16 characters) (Enter NA to Null) DP9_0 = _____

Show Display Point 10 (SELOGIC control equation)

DP10 = 0

DP10 Label 1 (16 characters) (Enter NA to Null) DP10_1 = _____

DP10 Label 0 (16 characters) (Enter NA to Null) DP10_0 = _____

Show Display Point 11 (SELOGIC control equation)

DP11 = 0

DP11 Label 1 (16 characters) (Enter NA to Null) DP11_1 = _____

DP11 Label 0 (16 characters) (Enter NA to Null) DP11_0 = _____

Show Display Point 12 (SELOGIC control equation)

DP12 = 0

DP12 Label 1 (16 characters) (Enter NA to Null) DP12_1 = _____

DP12 Label 0 (16 characters) (Enter NA to Null) DP12_0 = _____

Show Display Point 13 (SELOGIC control equation)

DP13 = 0

DP13 Label 1 (16 characters) (Enter NA to Null) DP13_1 = _____

DP13 Label 0 (16 characters) (Enter NA to Null) DP13_0 = _____

Show Display Point 14 (SELOGIC control equation)

DP14 = 0

DP14 Label 1 (16 characters) (Enter NA to Null) DP14_1 = _____

DP14 Label 0 (16 characters) (Enter NA to Null) DP14_0 = _____

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Global Settings (SET G Command) Example

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Group _____

Show Display Point 15 (SELOGIC control equation)

DP15 = 0

DP15 Label 1 (16 characters) (Enter NA to Null) DP15_1 = _____

DP15 Label 0 (16 characters) (Enter NA to Null) DP15_0 = _____

Show Display Point 16 (SELOGIC control equation)

DP16 = 0

DP16 Label 1 (16 characters) (Enter NA to Null) DP16_1 = _____

DP16 Label 0 (16 characters) (Enter NA to Null) DP16_0 = _____

TEXT LABELS

Local Bit LB1 Name (14 characters) (Enter NA to Null) NLB1 = _____

Clear Local Bit LB1 Label (7 characters) (Enter NA to Null) CLB1 = _____

Set Local Bit LB1 Label (7 characters) (Enter NA to Null) SLB1 = _____

Pulse Local Bit LB1 Label (7 characters) (Enter NA to Null) PLB1 = _____

Local Bit LB2 Name (14 characters) (Enter NA to Null) NLB2 = _____

Clear Local Bit LB2 Label (7 characters) (Enter NA to Null) CLB2 = _____

Set Local Bit LB2 Label (7 characters) (Enter NA to Null) SLB2 = _____

Pulse Local Bit LB2 Label (7 characters) (Enter NA to Null) PLB2 = _____

Local Bit LB3 Name (14 characters) (Enter NA to Null) NLB3 = MANUAL TRIP 1

Clear Local Bit LB3 Label (7 characters) (Enter NA to Null) CLB3 = RETURN

Set Local Bit LB3 Label (7 characters) (Enter NA to Null) SLB3 = _____

Pulse Local Bit LB3 Label (7 characters) (Enter NA to Null) PLB3 = TRIP

Local Bit LB4 Name (14 characters) (Enter NA to Null) NLB4 = MANUAL CLOSE 1

Clear Local Bit LB4 Label (7 characters) (Enter NA to Null) CLB4 = RETURN

Set Local Bit LB4 Label (7 characters) (Enter NA to Null) SLB4 = _____

Pulse Local Bit LB4 Label (7 characters) (Enter NA to Null) PLB4 = CLOSE

Local Bit LB5 Name (14 characters) (Enter NA to Null) NLB5 = _____

Clear Local Bit LB5 Label (7 characters) (Enter NA to Null) CLB5 = _____

Set Local Bit LB5 Label (7 characters) (Enter NA to Null) SLB5 = _____

Pulse Local Bit LB5 Label (7 characters) (Enter NA to Null) PLB5 = _____

Local Bit LB6 Name (14 characters) (Enter NA to Null) NLB6 = _____

Clear Local Bit LB6 Label (7 characters) (Enter NA to Null) CLB6 = _____

Set Local Bit LB6 Label (7 characters) (Enter NA to Null) SLB6 = _____

Pulse Local Bit LB6 Label (7 characters) (Enter NA to Null) PLB6 = _____

Local Bit LB7 Name (14 characters) (Enter NA to Null) NLB7 = _____

Clear Local Bit LB7 Label (7 characters) (Enter NA to Null) CLB7 = _____

Set Local Bit LB7 Label (7 characters) (Enter NA to Null) SLB7 = _____

Pulse Local Bit LB7 Label (7 characters) (Enter NA to Null) PLB7 = _____

SEL-387-5, -6 Relay Settings Sheet **Global Settings (SET G Command) Example**

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Group _____

Local Bit LB8 Name (14 characters) (Enter NA to Null)	NLB8	=	_____
Clear Local Bit LB8 Label (7 characters) (Enter NA to Null)	CLB8	=	_____
Set Local Bit LB8 Label (7 characters) (Enter NA to Null)	SLB8	=	_____
Pulse Local Bit LB8 Label (7 characters) (Enter NA to Null)	PLB8	=	_____
Local Bit LB9 Name (14 characters) (Enter NA to Null)	NLB9	=	_____
Clear Local Bit LB9 Label (7 characters) (Enter NA to Null)	CLB9	=	_____
Set Local Bit LB9 Label (7 characters) (Enter NA to Null)	SLB9	=	_____
Pulse Local Bit LB9 Label (7 characters) (Enter NA to Null)	PLB9	=	_____
Local Bit LB10 Name (14 characters) (Enter NA to Null)	NLB10	=	_____
Clear Local Bit LB10 Label (7 characters) (Enter NA to Null)	CLB10	=	_____
Set Local Bit LB10 Label (7 characters) (Enter NA to Null)	SLB10	=	_____
Pulse Local Bit LB10 Label (7 characters) (Enter NA to Null)	PLB10	=	_____
Local Bit LB11 Name (14 characters) (Enter NA to Null)	NLB11	=	_____
Clear Local Bit LB11 Label (7 characters) (Enter NA to Null)	CLB11	=	_____
Set Local Bit LB11 Label (7 characters) (Enter NA to Null)	SLB11	=	_____
Pulse Local Bit LB11 Label (7 characters) (Enter NA to Null)	PLB11	=	_____
Local Bit LB12 Name (14 characters) (Enter NA to Null)	NLB12	=	_____
Clear Local Bit LB12 Label (7 characters) (Enter NA to Null)	CLB12	=	_____
Set Local Bit LB12 Label (7 characters) (Enter NA to Null)	SLB12	=	_____
Pulse Local Bit LB12 Label (7 characters) (Enter NA to Null)	PLB12	=	_____
Local Bit LB13 Name (14 characters) (Enter NA to Null)	NLB13	=	_____
Clear Local Bit LB13 Label (7 characters) (Enter NA to Null)	CLB13	=	_____
Set Local Bit LB13 Label (7 characters) (Enter NA to Null)	SLB13	=	_____
Pulse Local Bit LB13 Label (7 characters) (Enter NA to Null)	PLB13	=	_____
Local Bit LB14 Name (14 characters) (Enter NA to Null)	NLB14	=	_____
Clear Local Bit LB14 Label (7 characters) (Enter NA to Null)	CLB14	=	_____
Set Local Bit LB14 Label (7 characters) (Enter NA to Null)	SLB14	=	_____
Pulse Local Bit LB14 Label (7 characters) (Enter NA to Null)	PLB14	=	_____
Local Bit LB15 Name (14 characters) (Enter NA to Null)	NLB15	=	_____
Clear Local Bit LB15 Label (7 characters) (Enter NA to Null)	CLB15	=	_____
Set Local Bit LB15 Label (7 characters) (Enter NA to Null)	SLB15	=	_____
Pulse Local Bit LB15 Label (7 characters) (Enter NA to Null)	PLB15	=	_____
Local Bit LB16 Name (14 characters) (Enter NA to Null)	NLB16	=	_____
Clear Local Bit LB16 Label (7 characters) (Enter NA to Null)	CLB16	=	_____
Set Local Bit LB16 Label (7 characters) (Enter NA to Null)	SLB16	=	_____
Pulse Local Bit LB16 Label (7 characters) (Enter NA to Null)	PLB16	=	_____

SEL-387-5, -6 Relay Settings Sheet

Sequential Events Recorder Settings

(SET R Command) Example

Page 27 of 29

Date _____

Group _____

TRIGGER CONDITIONS

Trigger SER (24 Relay Word bits per SERn equation, 96 total)

SER1	=	IN101 IN102 IN103 IN104 IN105 IN106
SER2	=	OUT101 OUT102 OUT103 OUT104 OUT105 OUT106 OUT107
SER3	=	0
SER4	=	0

RELAY WORD BIT ALIASES

Syntax: 'Relay-Word Bit' 'Up to 15 characters'. Use NA to disable setting.

ALIAS1	=	NA
ALIAS2	=	NA
ALIAS3	=	NA
ALIAS4	=	NA
ALIAS5	=	NA
ALIAS6	=	NA
ALIAS7	=	NA
ALIAS8	=	NA
ALIAS9	=	NA
ALIAS10	=	NA
ALIAS11	=	NA
ALIAS12	=	NA
ALIAS13	=	NA
ALIAS14	=	NA
ALIAS15	=	NA
ALIAS16	=	NA
ALIAS17	=	NA
ALIAS18	=	NA
ALIAS19	=	NA
ALIAS20	=	NA

SEL-387-5, -6 Relay Settings Sheet

Port Settings (SET P Command) Example

Page 28 of 29

Date _____

Group _____

Note: RTSCTS setting does not appear if PROTO=LMD or DNP. LMD PREFIX, ADDR, and SETTLE do not appear if PROTO=SEL or DNP. See *Appendix C: SEL Distributed Port Switch Protocol (LMD)* for details on LMD protocol and see *Appendix G: Distributed Network Protocol (DNP) 3.00* for details on DNP protocol.

PORT 1 (SET P 1) REAR PANEL, EIA-485 PLUS IRIG-B

Port Protocol (SEL, LMD, DNP)	PROTO	=	<u>SEL</u>
LMD Prefix (@, #, \$, %, &)	PREFIX	=	<u> </u>
LMD Address (1–99)	ADDR	=	<u> </u>
LMD Settling Time (0–30 seconds)	SETTLE	=	<u> </u>
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	<u>2400</u>
Data Bits (7, 8)	BITS	=	<u>8</u>
Parity Odd, Even, or None (O, E, N)	PARITY	=	<u>N</u>
Stop Bits (1, 2)	STOP	=	<u>1</u>
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	<u>15</u>
Send auto messages to port (Y, N)	AUTO	=	<u>N</u>
Enable hardware handshaking (Y, N)	RTSCTS	=	<u>N</u>
Fast Operate Enable (Y, N)	FASTOP	=	<u>N</u>

PORT 2 (SET P 2) REAR PANEL, EIA-232 WITH IRIG-B

Port Protocol (SEL, LMD, DNP)	PROTO	=	<u>SEL</u>
LMD Prefix (@, #, \$, %, &)	PREFIX	=	<u> </u>
LMD Address (1–99)	ADDR	=	<u> </u>
LMD Settling Time (0–30 seconds)	SETTLE	=	<u> </u>
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	<u>2400</u>
Data Bits (7, 8)	BITS	=	<u>8</u>
Parity Odd, Even, or None (O, E, N)	PARITY	=	<u>N</u>
Stop Bits (1, 2)	STOP	=	<u>1</u>
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	<u>15</u>
Send auto messages to port (Y, N)	AUTO	=	<u>N</u>
Enable hardware handshaking (Y, N)	RTSCTS	=	<u>N</u>
Fast Operate Enable (Y, N)	FASTOP	=	<u>N</u>

SEL-387-5, -6 Relay Settings Sheet

Port Settings (SET P Command)

Page 29 of 29

Date _____

Group _____

PORT 3 (SET P 3) REAR PANEL, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	<u>SEL</u>
LMD Prefix (@, #, \$, %, &)	PREFIX	=	<u> </u>
LMD Address (1–99)	ADDR	=	<u> </u>
LMD Settling Time (0–30 seconds)	SETTLE	=	<u> </u>
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	<u>2400</u>
Data Bits (7, 8)	BITS	=	<u>8</u>
Parity Odd, Even, or None (O, E, N)	PARITY	=	<u>N</u>
Stop Bits (1, 2)	STOP	=	<u>1</u>
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	<u>15</u>
Send auto messages to port (Y, N)	AUTO	=	<u>N</u>
Enable hardware handshaking (Y, N)	RTSCTS	=	<u>N</u>
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	<u>N</u>

PORT 4 (SET P 4) FRONT PANEL, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	<u>SEL</u>
LMD Prefix (@, #, \$, %, &)	PREFIX	=	<u> </u>
LMD Address (1–99)	ADDR	=	<u> </u>
LMD Settling Time (0–30 seconds)	SETTLE	=	<u> </u>
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	<u>2400</u>
Data Bits (7, 8)	BITS	=	<u>8</u>
Parity Odd, Even, or None (O, E, N)	PARITY	=	<u>N</u>
Stop Bits (1, 2)	STOP	=	<u>1</u>
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	<u>15</u>
Send auto messages to port (Y, N)	AUTO	=	<u>N</u>
Enable hardware handshaking (Y, N)	RTSCTS	=	<u>N</u>
<i>Fast Operate</i> Enable (Y, N)	FASTOP	=	<u>N</u>

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SECTION 7: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

The SEL-387 Relay is equipped with four serial ports: one EIA-232 port on the front, two EIA-232 ports on the rear, and one EIA-485 port on the rear. Establish communication by connecting a terminal to one of the serial ports with the appropriate cable. Connect computers, modems, protocol converters, printers, an SEL-2020 or an SEL-2030 Communications Processor, an SEL-2885, a SCADA serial port, and/or RTUs for local or remote communications.

Use one of the SEL protocols for communication. The SEL ASCII commands and structure are defined in detail in this section. Other SEL protocols used for interfacing other intelligent electronic devices for automated communication are described in detail in the appendices.

ESTABLISH COMMUNICATION

Establish communication with the SEL-387 Relay through one of its serial ports by using standard “off-the-shelf” software and the appropriate cable connections, depending on the device.

Software

Use any system that emulates a standard terminal system. Such PC-based terminal emulation programs include: Procomm[®] Plus, Relay/Gold, Microsoft[®] Windows[®] Terminal, Microsoft[®] Windows[®] 95 HyperTerminal, Smartcom, and CROSSTALK[®]. Many terminal emulation programs will work with the SEL-387 Relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default communication settings for the serial ports follow:

Baud Rate = 2400
Data Bits = 8
Parity = N
Stop Bits = 1
RTS/CTS = N

Change the port settings using the front panel or the **SET P <ENTER>** command.

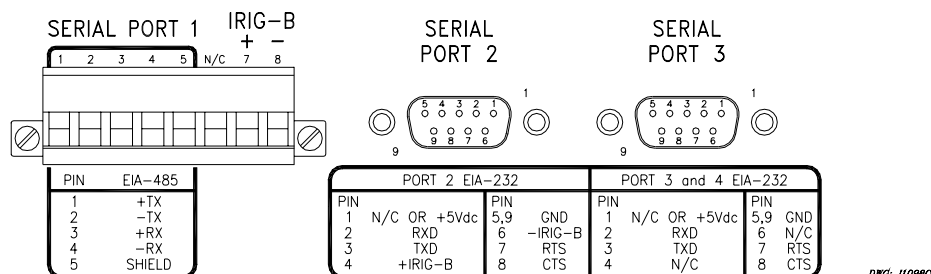
Port Identification

If there is ever uncertainty about the number of the port to which you are connected (1–4), use the command **SHO P <ENTER>**. The relay will respond with a message identifying the port number, and will list the settings for that port. The SHO P command is discussed later in more detail.

Cables

Connect the SEL-387 Relay to another device using the appropriate cable. The pin definitions for Ports 1, 2, 3, and 4 are given on the relay rear panel and detailed in Table 7.1.

A 9-pin port connector drawing and pin definitions appear in Figure 7.1.



(female chassis connectors as viewed from outside panel)

Figure 7.1: SEL-387 Relay Serial Port Connectors

Pinouts for EIA-232 and EIA-485 ports follow:

Table 7.1: Serial Port Pin Definitions

Pin Number	Port 1 Rear EIA-485	Port 2 Rear EIA-232 with IRIG-B	Port 3 Rear EIA-232	Port 4 Front EIA-232
1	+TX (Out)	N/C or +5 Vdc*	N/C or +5 Vdc*	N/C
2	-TX (Out)	RXD (In)	RXD (In)	RXD (In)
3	+RX (In)	TXD (Out)	TXD (Out)	TXD (Out)
4	-RX (In)	N/C or +IRIG-B*	N/C	N/C
5	Shield	GND	GND	GND
6	N/C	N/C or -IRIG-B*	N/C	N/C
7	+IRIG-B	RTS (Out)	RTS (Out)	RTS (Out)
8	-IRIG-B	CTS (In)	CTS (In)	CTS (In)
9	NA	GND	GND	GND

* Install a jumper to use the 5 V connection, and remove a solder jumper to disable the IRIG-B input. See **Section 2: Installation** for more information.

Port 1 is an EIA-485 protocol connection on the rear of the relay. It accepts a pluggable terminal block that supports wire sizes from 24 AWG up to 12 AWG. The connector is supplied with the relay. Ports 2, 3, and 4 are EIA-232 protocol connections with Ports 2 and 3 on the rear of the relay and Port 4 on the front of the relay. These female connectors are 9-pin, D-subminiature

connectors. Any combination of these ports or all of them may be used for relay communication. Table 7.2 lists cables that can be purchased from SEL for various communication applications.

Note: Listing of devices not manufactured by SEL is 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.

Table 7.2: SEL-387 Relay Communication Cable Numbers

SEL-387 Port #	Connect to Device (gender refers to device)	SEL Cable #
2, 3, 4	PC, 25-Pin Male (DTE)	C227A
2, 3, 4	PC, 9-Pin Male (DTE)	C234A
2, 3	SEL-2020 or SEL-2030 without IRIG-B	C272A
2	SEL-2020 or SEL-2030 with IRIG-B	C273A
2	SEL-IDM, Ports 2 through 11	Requires a C254 and C257 cable
2, 3	Modem, 5 Vdc Powered (pin 10)	C220*
2, 3	Standard Modem, 25-Pin Female (DCE)	C222

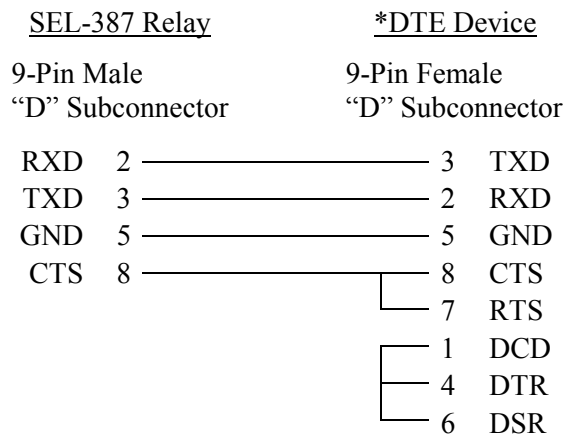
* The 5 Vdc serial port jumper must be installed to power the Modem using C220. See **Section 2: Installation**.

For example, to connect the SEL-387 Relay Ports 2, 3, or 4 to the 9-pin male connector on a laptop, order cable number C234A and specify the length needed. To connect the SEL-387 Relay Port 2 to the SEL-2020 or SEL 2030 Communications Processor that supplies the communication link and the time synchronization signal, order cable number C273A, and specify the length needed. For connecting devices at over 100 feet, fiber-optic transceivers are available. The SEL-2800 and SEL-2810 provide fiber-optic links between devices for electrical isolation and long-distance signal transmission. Call the factory for further information on these products.

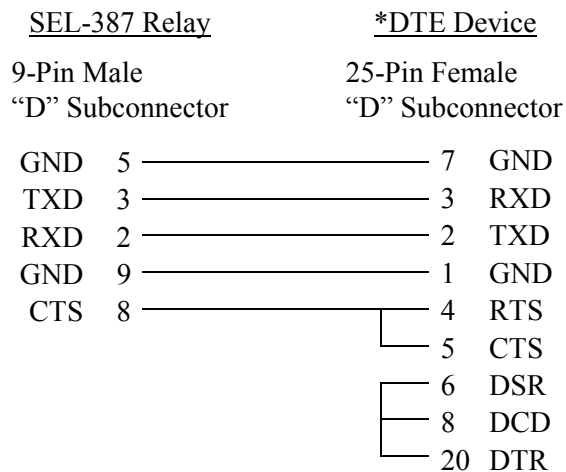
The following cable diagrams show several types of EIA-232 serial communications cables. These and other cables are available from SEL. Contact the factory for more information.

SEL-387 Relay to Computer

Cable C234A

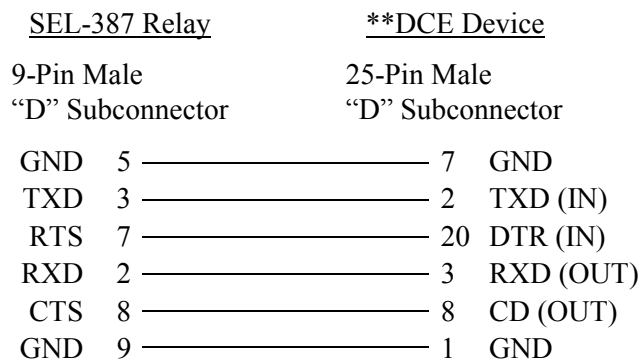


Cable C227A

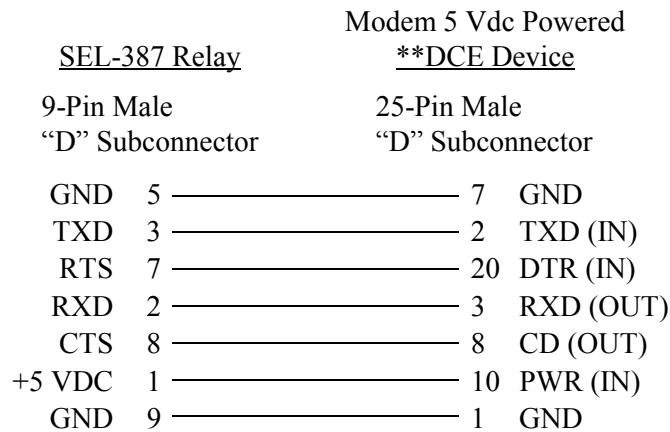


SEL-387 Relay to Modem

Cable C222

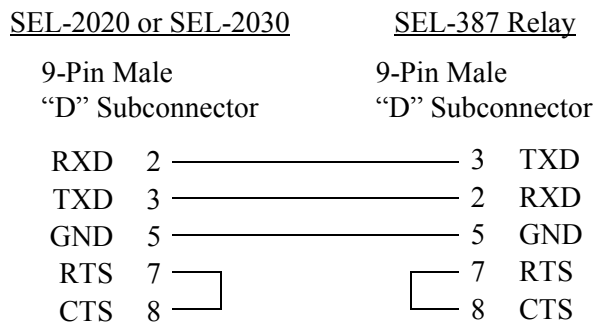


Cable C220

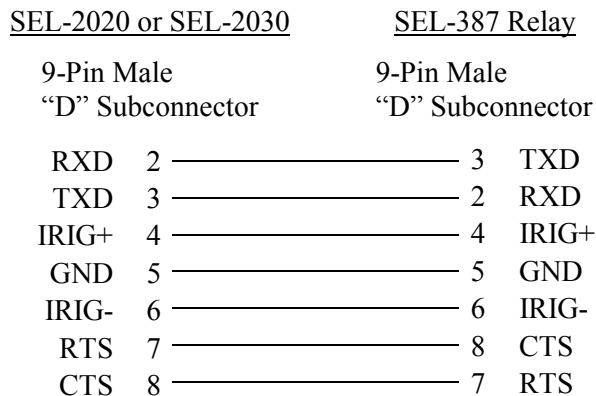


SEL-387 Relay to SEL-2020 or SEL-2030

Cable 272A



Cable 273A



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

Table 7.3: Serial Communications Port Pin Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
+(-)IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Shielded Ground
RTS	Request to Send
CTS	Clear to Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

COMMUNICATIONS PROTOCOL

This section explains the serial port communications protocol used by the SEL-387 Relay. You set and operate the SEL-387 Relay via the serial communications ports.

Note: In this document, commands you type appear in bold/uppercase: **OTTER**. Keys you press appear in bold/uppercase/brackets: **<ENTER>**.

Relay output appears boxed and in the following format:

```
XFMR 1                      Date: 02/01/97   Time: 11:03:25.180
```

The communications protocol consists of hardware and software features.

Hardware Protocol

All EIA-232 serial ports support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 serial port.

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 Protocol

Software protocols consist of standard SEL ASCII, SEL Distributed Port Switch (LMD), SEL Distributed Network Protocol (DNP), SEL *Fast Meter*, SEL *Fast Operate*, and SEL Compressed

ASCII. Based on the port PROTOCOL setting, the relay activates SEL ASCII, SEL LMD, or SEL DNP protocol. SEL *Fast Meter* and SEL Compressed ASCII commands are always active.

SEL ASCII Protocol

The following software protocol is designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

<command><CR> or <command><CR><LF>

A command transmitted to the relay should consist of the following:

- A command followed by either a carriage return or a carriage return and line feed.
 - You must separate arguments from the command by spaces, commas, semicolons, colons, or slashes.
 - You may truncate commands to the first three characters. **EVENT 1** <ENTER> would become **EVE 1** <ENTER>.
 - Upper and lower case characters may be used without distinction, except in passwords.
2. The relay transmits all messages in the following format:

```
<STX><CR><LF>
<MESSAGE LINE 1><CR><LF>
<MESSAGE LINE 2><CR><LF>
.
.
.
<LAST MESSAGE LINE><CR><LF>
<ETX> <PROMPT>
```

Each message begins with the start-of-transmission character STX (ASCII character 02) and ends with the end-of-transmission character ETX (ASCII character 03).

3. The relay indicates how full its receive buffer is through an XON/XOFF protocol.

The relay transmits XON (ASCII hex 11) when the buffer drops below 40 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is over 80 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 an XON/XOFF procedure to control the relay during data transmission. When the relay receives an XOFF command during transmission, it pauses until it receives an XON command. If there is no message in progress when the relay receives an XOFF command, it blocks transmission of any message presented to its buffer.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

5. Control characters can be sent from most keyboards with the following keystrokes:

XON: <CTRL>Q (hold down the Control key and press Q)

XOFF:	<CTRL>S	(hold down the Control key and press S)
CAN:	<CTRL>X	(hold down the Control key and press X)

SEL Distributed Port Switch Protocol

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. Select the protocol by setting **PROTOCOL = LMD**, a SET P setting. See *Appendix C: SEL Distributed Port Switch Protocol (LMD)* for more information.

SEL Distributed Network Protocol

SEL Distributed Network Protocol (DNP) meets DNP 3.00 Level 2 requirements. Select the protocol by setting **PROTOCOL = DNP**, a SET P setting. See *Appendix G: Distributed Network Protocol (DNP) 3.00* for more information.

SEL Fast Meter Protocol

SEL *Fast Meter* protocol supports binary messages to transfer metering messages. SEL *Fast Meter* protocol is always available on any serial port. The protocol is described in *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*.

SEL Fast Operate Protocol

SEL *Fast Operate* protocol supports binary messages to control Relay Word bits. SEL *Fast Operate* protocol is available on any serial port. Turn it off by setting **FAST_OP = N**, a SET P setting. The protocol is described in *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. SEL Compressed ASCII protocol is always available on any serial port. The protocol is described in *Appendix E: Compressed ASCII Commands*.

SEL Unsolicited Sequential Events Recorder (SER) Protocol

SEL Unsolicited Sequential Events Recorder (SER) Protocol provides SER events to an automated data collection system. SEL Unsolicited SER Protocol is available on any serial port. The protocol is described in *Appendix F: Unsolicited SER Protocol*.

SEL ASCII PROTOCOL DETAILS

Automatic Messages

The SEL-387 Relay generates automatic messages and sends them out the serial port(s) with the SET P setting **AUTO = Y**. Four different automatic messages can be displayed:

- Relay startup message
- Setting group change message

- Relay self-test warning or failure
- Event summary message

Startup Message

Immediately after power is applied, the relay transmits the following automatic message:

```

XFMR 1                                     Date: 03/13/97   Time: 14:26:22.324
STATION A
SEL-387
=

```

Group Switch Message

The SEL-387 Relay has six different setting groups for the SET settings. The active group is selected by the SS1 through SS6 SELOGIC[®] control equation variable bits, or by the GRO n serial port command or the front-panel GROUP pushbutton. At the moment when the active group is changed, the following automatic message is generated.

```

XFMR 1                                     Date: 03/13/97   Time: 14:33:49.109
STATION A

Active Group = 2
=>>

```

- RID and TID settings for the new active group
- Date and time of group change
- Active setting group now being used

Note: the SET G settings SS1 through SS6 take precedence over the GRO n command.

Status Report

The relay automatically generates a status report whenever the self-tests declare a failure state and some warning states.

```

XFMR 1                                     Date: 04/21/00   Time: 21:29:42.829
STATION A

FID=SEL-387-6-X117-V0-Z001001-D20000419  CID=2001
SELF TESTS

W=Warn   F=Fail

OS      IAW1   IBW1   ICW1   IAW2   IBW2   ICW2
        0      -0      -0      1      0      1
OS      IAW3   IBW3   ICW3   IAW4   IBW4   ICW4
        0      0      -0      1      0      -1
PS      +5V_PS +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
        4.93   4.99   -5.07   11.90  -12.08  14.96  -14.90
        TEMP   RAM    ROM    A/D    CR_RAM  EEPROM  IO_BRD
        32.1   OK     OK     OK     OK     OK     OK

```

```
Relay Enabled
=>
```

- RID and TID settings for the active group
- Date and time the failure or warning was detected
- Firmware identification string
- Individual self-test results
- Relay protection enabled or disabled indication

Summary Event Report

An automatic message is generated each time an event is triggered. The message is a summary of the event.

```
XFMR 1                      Date: 03/13/97    Time: 15:03:53.409
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 2 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 3 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 4 Currents (A Sec), ABC:  0.0  0.0  0.0

=>>
```

- RID and TID settings for the active group
- Date and time the event was triggered
- The event type
- Target information
- Phase currents for all four windings

Access Levels

Commands can be issued to the relay via the serial port to view metering values, change relay settings, etc. The available ASCII serial port commands are listed in Figure 7.2, and summarized by level in **Section 12: SEL-387-5, -6 Relay Command Summary**. A multilevel password system provides security against unauthorized access. This access scheme allows you to give personnel access to only those functions they require.

The relay supports four access levels. Each level has an associated screen prompt and password. Below are the access level hierarchy, the access level prompts, and the default, as-shipped, passwords:

<u>Access Level</u>	<u>Prompt</u>	<u>Commands Allowed</u>	<u>Password</u>
0 (lowest)	=	0	
1	=>	0, 1	OTTER
B	==>	0, B	EDITH
2 (highest)	=>>	0, 1, B, 2	TAIL

Figure 7.2 summarizes the access levels, passwords, prompts, and commands available from each access level, and commands for moving between access levels.

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 or if a command is not followed by the correct number or letter.

Access Level 0

Once serial port communications are established with the relay, the Access Level 0 prompt (=) appears. If a different prompt appears, the relay was left in a different access level or the terminal emulation you are using is translating the characters differently. VT-100 emulation is recommended.

The only commands that can be executed at Access Level 0 are the ACC and QUI commands (see Figure 7.2). Enter the ACC command at the Access Level 0 prompt to go to Access Level 1.

Access Level 1

After issuing the ACC command and entering the password, if it is required (default is “OTTER”), the relay is in Access Level 1. The prompt for Access Level 1 appears (=>).

Many commands can be executed from Access Level 1 for viewing relay information. The 2AC command allows the relay to go to Access Level 2. The BAC command allows the relay to go to Access Level B.

Access Level B (Breaker Level)

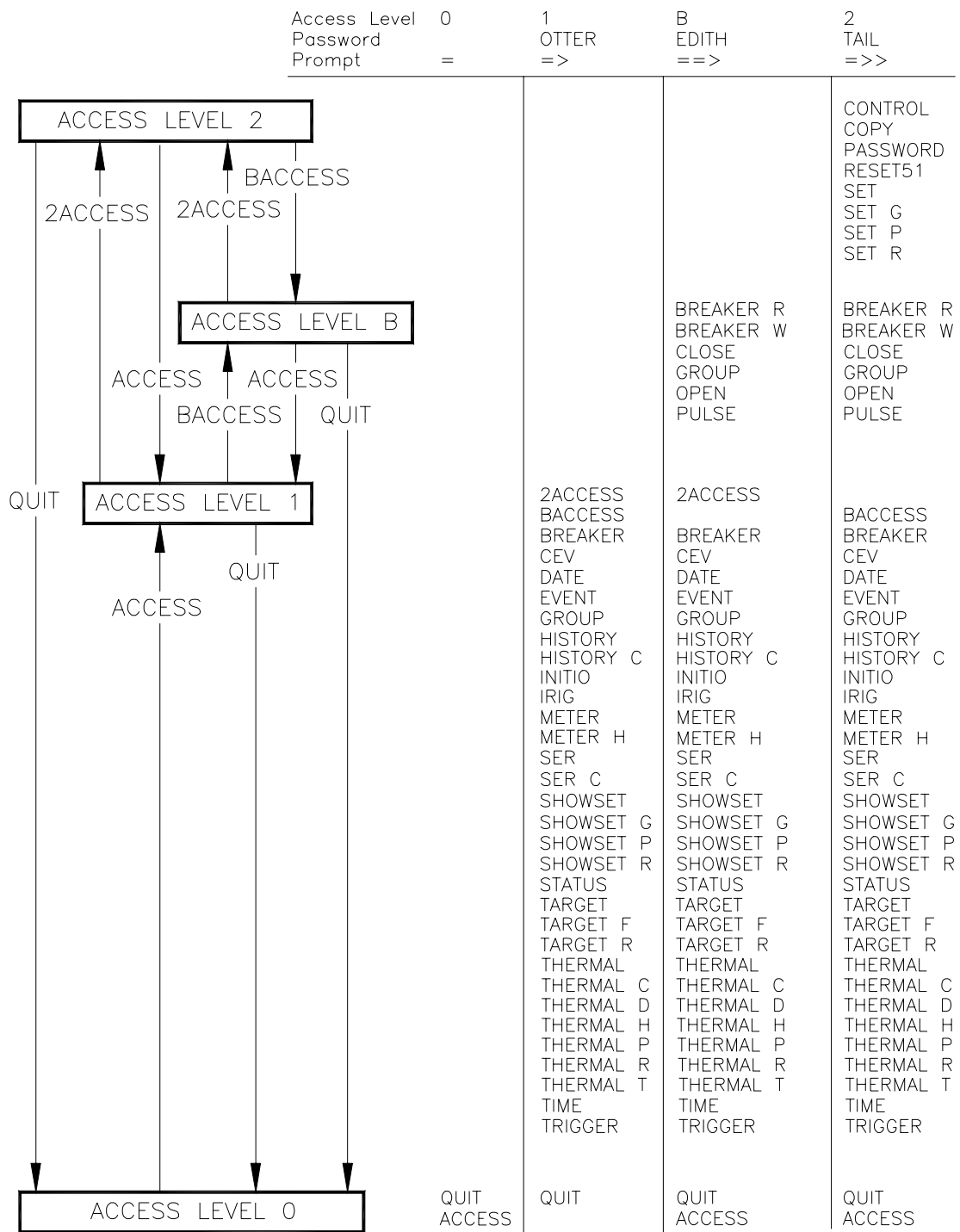
After issuing the BAC command and entering the password, if it is required (default is “EDITH”), the relay pulses the ALARM contact and is in Access Level B (breaker access level). The Access Level B prompt appears (==>).

Many commands can be executed from Access Level B for viewing relay information, and controlling the breaker. While in Access Level B, any of the commands available in the lower Access Levels 0 and 1 can be executed.

Access Level 2

After issuing the 2AC command and entering the password, if it is required (default is “TAIL”), the relay pulses the ALARM contact and is in Access Level 2. The Access Level 2 prompt appears (=>>).

This is the highest access level. All commands listed in this manual, for any access level, can be executed from Access Level 2 for viewing relay information, controlling the breaker, and changing settings. Firmware upgrades to Flash memory (see *Appendix B: Firmware Upgrade Instructions*) are also performed from this level.



DWG: M3871089

Figure 7.2: Access Level Relationships

Command Definitions

SEL ASCII commands require three characters and some commands require certain parameters. Each command is defined in alphabetical order. Examples are shown for some commands following their definitions. Text you type appears in bold, and keyboard keys you push appear in bold with brackets. For example, to enter Access Level 1 from Access Level 0 type **ACC<ENTER>**.

2AC (Access Level 2)

Access Levels 1, B

Use the 2ACCESS command to enter Access Level 2. The default password at this level is set by SEL to TAIL. Use the PASSWORD command from Access Level 2 to change passwords. Install main board jumper JMP6A to disable password protection. With JMP6A installed, the relay will not display a request for the password, but will immediately execute the command.

The following display indicates successful access to Level 2:

```
=>2AC<ENTER>
Password: ? TAIL<ENTER>

XFMR 1                      Date: 11/09/96   Time: 14:23:41.758
STATION A

Level 2
=>>
```

You may use any command from the “=>>” prompt. The relay pulses the ALARM contact for one second after any Level 2 access attempt unless an alarm condition already exists.

ACC (Access Level 1)

Access Levels 0, B, 2

Use the ACCESS command to enter Access Level 1. The default password is set by SEL to OTTER. Use the PASSWORD command from Access Level 2 to change passwords. Install main board jumper JMP6A to disable password protection.

The following display indicates successful access to Level 1:

```
=ACC<ENTER>
Password: ? OTTER<ENTER>

XFMR 1                      Date: 11/09/96   Time: 14:23:41.758
STATION A

Level 1
=>
```

BAC (Access Level B)

Access Levels 1, 2

Use the BACCESS command to enter Access Level B. The default password is set by SEL to EDITH. Use the PASSWORD command from Access Level 2 to change this password. Install main board jumper JMP6A to disable password protection.

The following display indicates successful access to Level B:

```
=>BAC<ENTER>
Password: ?  EDITH<ENTER>

XFMR 1                      Date: 11/11/96   Time: 14:04:51.251
STATION A

Breaker Level
==>
```

The relay pulses the ALARM contact closed for one second after any Level B access attempt unless an alarm condition already exists.

BRE (Breaker Report)

Access Levels 1, B, 2

Use the BREAKER command to display a report of breaker operation information. The breaker report provides trip counter and trip current information for up to four breakers. The summary of the operations provides valuable breaker diagnostic information at a glance. An example breaker report follows. Refer to **Section 5: Metering and Monitoring** for further information. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

```
=>>BRE

XFMR 1                      Date: 06/19/97   Time: 21:04:30.973
STATION A

BREAKER 1
Int Trips=    4  IAW1=    0.01  IBW1=    0.01  ICW1=    0.02 kA(pri)
Ext Trips=   15  IAW1=    1.04  IBW1=    0.50  ICW1=    0.16 kA(pri)
Percent Wear:  POLE1=    0  POLE2=    0  POLE3=    0

BREAKER 2
Int Trips=    3  IAW2=   59.31  IBW2=    0.09  ICW2=    0.08 kA(pri)
Ext Trips=   14  IAW2=  160.91  IBW2=    1.70  ICW2=    0.33 kA(pri)
Percent Wear:  POLE1=   88  POLE2=    0  POLE3=    0

BREAKER 3
Int Trips=   11  IAW3=  316.47  IBW3=    0.33  ICW3=    0.46 kA(pri)
Ext Trips=    6  IAW3=    6.32  IBW3=    3.03  ICW3=    0.24 kA(pri)
Percent Wear:  POLE1=  100  POLE2=    0  POLE3=    0

BREAKER 4
Int Trips=    0  IAW4=    0.00  IBW4=    0.00  ICW4=    0.00 kA(pri)
Ext Trips=    0  IAW4=    0.00  IBW4=    0.00  ICW4=    0.00 kA(pri)
Percent Wear:  POLE1=    0  POLE2=    0  POLE3=    0

(continued on next page)
```

```

                                (continued from previous page)
LAST BREAKER MONITOR RESET FOR  Bkr1: 06/12/97      16:02:07.407
                                Bkr2: 06/12/97      16:02:07.533
                                Bkr3: 06/12/97      16:02:07.651
                                Bkr4: 06/12/97      16:02:07.758

=>>

```

BRE R n (Breaker Reset)

Access Levels B, 2

The BRE R n command resets the trip counter, trip current data and contact wear percentages for breaker “n.” Issue BRE R A to reset all Breaker Monitors at one time. Use the BRE command to verify resetting of the data.

BRE W n (Breaker Wear Pre-Set)

Access Levels B, 2

This command is used to pre-set the amount of contact wear for breaker n, on the assumption that the breaker has already experienced some fault duty before the relay is installed. The command prompts for percentage wear for each pole of the breaker. These must be entered as integer values, from 0 to 100 percent. Values over 100 will not be accepted. The data is stored in EEPROM and is nonvolatile. The procedure is shown below.

```

=>>BRE W 1
Breaker Wear Percent Preload

Breaker 1: Pole 1 % = 0 ? 15
Breaker 1: Pole 2 % = 0 ? 20
Breaker 1: Pole 3 % = 0 ? 10
Are you sure (Y/N) ? Y
=>>

```

After entering the values, use the BRE command to verify that the data has been accepted properly.

CEV (Compressed Event)

Access Levels 1, B, 2

The SEL-5601 Analytic Assistant software is available for graphical analysis of event reports. The CEV command is a compressed (no formatting) version of the EVE command. Use the CEV command to download events for the SEL-5601 Analytic Assistant Program.

The CEV command can generate both winding and differential reports.

The command syntax is CEV [DIF R][n Sx Ly[-[w]] C]. All parameters are optional. Enter them in any order.

DIF specifies generation of the differential element report in compressed form. Otherwise, the winding report will be produced.

R specifies “raw,” or unfiltered analog data, in a format [1.5 cycles + Ly].

Letter “n” specifies the event number.

Sx specifies samples per cycle. The x value can be 4, 8, 16, 32, or 64 for raw reports (default is 16) or 4, 8 for filtered reports (default is 4). Digital elements will be displayed at the resolution specified by Sx, up to a maximum of eight samples per cycle.

Ly specifies the report length in cycles. The y value can be from 1 to the LER setting. Default is 15 cycles. “Ly-” specifies reporting from cycle y to the end of the report. “Ly-w” specifies reporting from cycle y to cycle w.

C specifies using the eight samples per cycle compressed format for compatibility with the SEL-2020 or SEL-2030 and is equivalent to using the EVE C command.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

Refer to *Appendix E: Compressed ASCII Commands* for a complete description of the command, as well as additional Compressed ASCII commands CAS, CBR, CHI, CST, and CTA.

CLO n (Close)

Access Levels B, 2

The CLO n command asserts the CCn Relay Word bit. This bit must be included in the CLn Close Logic setting for breaker n, in order for closing to take place. This logic is described in *Section 4: Control Logic*.

To close the circuit breaker with this command, type **CLOSE n<ENTER>**. The prompting message “Close Breaker n (Y/N) ?” is displayed. Then “Are you sure (Y/N)?” Typing **N<ENTER>** after either of the above prompts aborts the closing operation with the message “Command Aborted.” If both questions are answered **Y<ENTER>**, the breaker will be closed, an automatic message summarizing the close operation will be sent, and an Event Report will be created.

If the main board jumper JMP6B is not in place, the relay responds: “Aborted: Breaker Jumper Not in Place.”

CON n (Control RBn)

Access Level 2

This command is used to control the Relay Word bit RBn, or Remote Bit n, n having a value of 1 to 16. The relay responds with CONTROL RBn. The user must then respond with one of the following: **SRB n<ENTER>** (Set Remote Bit n), or **CRB n<ENTER>** (Clear Remote Bit n), or **PRB n<ENTER>** (Pulse Remote Bit n). The latter asserts RBn for one processing interval, one-eighth cycle. The Remote Bits permit design of SELOGIC control equations that can be set, cleared, or momentarily activated via a remote command.

COP m n (Copy Settings)

Access Level 2

The COPY command copies settings and logic from setting Group m to Group n (m and n can be any combination of 1 through 6). After entering the settings into one setting group with the SET command, copy it to the other groups with the COPY command. Use the SET command to modify copied setting groups. The ALARM output contact closes momentarily when you change settings in an active setting group but not in an inactive setting group.

```
=>>COP 1 3<ENTER>
COPY 1 to 3
Are you sure (Y/N) ? Y<ENTER>

Please wait...
Settings copied
=>>
```

DAT (Date)

Access Levels 1, B, 2

The DATE command displays or sets the date stored by the internal calendar/clock. Simply typing DAT<ENTER> displays the date. Set the date by typing **DATE d1<ENTER>** where d1 is either mm/dd/yy or yy/mm/dd depending on the SET G date format setting DATE_F. The following example views the current date, verifies the DATE_F setting, and changes the date. Note that single-digit numbers may be entered without leading zeros like the 9 in 11/9/96.

```
=>>DAT<ENTER>
11/11/96
=>>SHO G DATE_F<ENTER>

RELAY SETTINGS
DATE_F = MDY      FP_TO = 5      TGR      = 5

=>>DAT 11/9/96<ENTER>
11/09/96
=>>
```

Note: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

EVE (Event Reports)

Access Levels 1, B, 2

Use the EVENT command to view event reports. See *Section 9: Event Reports and SER* for further details on retrieving event reports.

GRO and GRO n (Setting Group)

Access Levels 1, B, 2

The “GROUP” command, at Access Level 1, displays the setting group variable for the currently active setting group. Changing the variable is not permitted. The “GROUP n” command, at Levels B and 2, designates what the setting group variable is to be (n = 1 to 6), thereby asking the relay to change to the setting group so designated. The relay will only make the change if the setting group selection SELOGIC control equations (SS1 through SS6) are not assigned or are not asserted. The following example verifies the existing group variable, changes it, and then waits for the automatic message when the setting group changes. The variable must be changed for a certain number of seconds as specified by the TGR setting (under SET G) before the new settings are enabled.

```
=>>GRO<ENTER>
Active Group = 1
=>>GRO 2<ENTER>
Change to Group 2
Are you sure (Y/N) ? Y<ENTER>
=>>
```

The GROUP command does not clear the event report buffer. If the active group is changed, the relay pulses the ALARM output contacts and generates the following automatic message:

```
XFMR 1                                Date: 03/13/97    Time: 14:33:49.109
STATION A

Active Group = 2
=>>
```

Note: The relay will be disabled momentarily while the change in groups takes place.

HIS (History of Events)

Access Levels 1, B, 2

The HISTORY command displays the 80 most recent event summaries in reverse chronological order (most recent event at the top, with lowest event number “#”). The number of full Event Reports completely saved in Flash memory depends on the SET G setting LER as follows:

<u>LER Setting</u>	<u>Number of Event Reports Stored</u>
15 cycles	18–21
30 cycles	12–14
60 cycles	7

Each summary shows the date, time, event type, active setting group at the time of the event, and relay targets.

Event types, in decreasing order of precedence, are: TRIPn (n = 1 to 5), CLSm (m = 1 to 4), ER (SELOGIC control equation event trigger), PULSE (user-initiated momentary contact operation), and TRIG (user-initiated triggering of an Event Report). If more than one event type occurs

during the same event, the type with highest precedence will be displayed in the EVENT field of each line of the display.

Enter **HIS n**, where n is a positive number (1 through 80), to limit the history report to the most recent n events. The history is stored in nonvolatile memory, so it is retained through power failures.

The date and time is saved to the nearest millisecond and referenced to the trigger row of data in the Event Report.

An example of the display appears below. In this example seven events have occurred since the history was last cleared:

=>HIS<ENTER>

XFMR 1

STATION A

Date: 6/1/96

Time: 01:16:24

#	DATE	TIME	EVENT	GRP	TARGETS
1	01/06/96	00:18:10.333	TRIP1	1	
2	01/04/96	09:08:20.058	TRIG	1	
3	01/04/96	08:53:55.429	TRIP3	1	50 A B W3
4	01/01/96	00:18:10.258	TRIP1	1	
5	01/01/96	00:18:08.095	TRIP3	1	50 A B W3
6	12/09/95	22:41:33.108	ER	1	
7	12/09/95	22:27:47.870	TRIP3	1	50 A B W3

=>

If an event has not occurred since the history was last cleared, the headings are displayed with the message: History Buffer Empty.

HIS C (Clear History and Events)

Access Levels 1, B, 2

HIS C command clears the history and events associated with them from nonvolatile Flash memory. The clearing process may take up to 30 seconds under normal operation. It may be even longer if the relay is busy processing a fault or other protection logic. The following is an example of the HIS C command. The relay will pause after the word “Clearing” until the buffer is completely clear, and then it will display the rest of the information.

```
=>HIS C<ENTER>
```

Clear History Buffer	
Are you sure (Y/N) ?	Y<ENTER>
Clearing Complete	Relay pauses after the word Clearing

```
=>
```

Note: Clear the Event Buffer With Care

Automated clearing of the event buffer should be limited to reduce the possibility of wearing out the nonvolatile memory. Limit automated HIS C commands to once per week or less.

INI (Initialize I/O)

Access Levels 1, B, 2

The INITIO command reports the number and type of I/O boards in the relay from Access Levels 1 and B. If the number or type of I/O boards has changed since last power up, INITIO will confirm that the I/O boards present are correct from Access Level 2.

```
=>>INI<ENTER>
I/O BOARD      INPUTS    OUTPUTS
Main           6          7
1              No Board Connected
2              No Board Connected

=>>
```

IRI (IRIG-B Synchronization)

Access Levels 1, B, 2

The IRIG command forces the relay to read the demodulated IRIG-B time-code input at the time of the command.

If the relay reads the time code successfully, it updates the internal clock/calendar time and date to the time-code reading. The relay then transmits a message with relay settings RID and TID, and the date and time.

```
=>IRI<ENTER>

XFMR 1                      Date: 02/01/96   Time: 01:45:40.762
STATION A
=>
```

If no IRIG-B signal is present or the code cannot be read successfully, the relay sends the error message "IRIG-B DATA ERROR."

Note: Normally, it is not necessary to synchronize using this command because the relay automatically synchronizes approximately once a minute. The IRIG command is provided to prevent delays during testing and installation checkout.

MET (Metering Report)

Access Levels 1, B, 2

The METER command displays currents, demand currents, peak demand currents, or differential data, depending on the command statement. There are several choices for the MET command, listed briefly below. Refer to **Section 5: Metering and Monitoring** for a complete description of the metering reports.

MET	Displays winding current metering data, in primary amperes
MET D	Displays winding demand ammeter data, in primary amperes

MET DIF	Displays differential metering data, in multiples of tap
MET H	Displays harmonic spectrum of currents (see MET H below)
MET P	Displays peak demand ammeter data, in primary amperes
MET RD n	Resets demand ammeter for winding n (n = 1, 2, 3, 4, A)
MET RP n	Resets peak demand ammeter values for winding n (n = 1, 2, 3, 4, A)
MET SEC	Displays winding current metering data, with magnitude and phase angle, in secondary amperes

Use the MET XXX n command, where n is a positive integer, to repeat the MET XXX report n times. For example, to display a series of eight meter readings, type **MET 8 <ENTER>**.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

MET H (Harmonic Metering)

Access Levels 1, B, 2

The METER H command is different from the normal metering functions, in that it uses 1 full cycle of unfiltered data, at 64 samples per cycle, to provide a snapshot of total harmonic content of all 12 analog current inputs. It uses a fast Fourier transform technique to provide secondary current values for all harmonics from 1 (fundamental) to 15.

This function is explained more fully in *Section 5: Metering and Monitoring* where a sample report also is shown. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

OPE n (Open)

Access Levels B, 2

The OPE n command asserts the OCn Relay Word bit. This bit must be included in the TRn trip logic setting for breaker n, in order for opening to take place. This logic is described in *Section 4: Control Logic*.

To open circuit breaker n by this command, type **OPE n<ENTER>**. The prompt “Open Breaker n (Y/N) ?” is displayed. Then “Are you sure (Y/N) ?” is displayed. Typing **N <ENTER>** after either of the above prompts aborts the opening operation with the message “Command Aborted.” If both questions are answered **Y<ENTER>**, the breaker will be opened, an automatic message summarizing the trip will be sent, an Event Report will be created, and the TRIP LED on the front panel will light. This must be turned off by a TAR R command or by the TARGET RESET pushbutton on the front panel.

If the main board jumper JMP6B is not in place, the relay responds: “Aborted: Breaker Jumper Not in Place.”

PAS (Passwords)

Access Level 2

The PASSWORD command allows you to inspect or change existing passwords. Use **PAS<ENTER>** to inspect passwords. The password for Levels 1, B, and 2 are displayed.

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



WARNING

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

To change a password use the following syntax:

PAS n newpas<ENTER>

The two parameters are required:

- **n** specifies the Access Level (1, B, or 2).
- **newpas** specifies the new password.

Note: If **newpas** is **DISABLE** (must be upper case), the password prompt and password protection for the **n** level are disabled. The relay responds with “Password Disabled.” This permits the user to temporarily suspend password protection, without installing jumper JMP6A.

Designate which access level password to change with the **n = 1, B, or 2**. The new password designated by **newpas** can be up to six characters. The following example changes the level one password to BIKE. The passwords are case sensitive.

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

The relay sets the password, pulses the ALARM relay closed for approximately one second, and transmits the response “Set” to the display.

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

Passwords may contain up to six characters and include any combination of letters, numbers, periods, or hyphens. Upper- and lower-case letters are treated as different characters. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner

are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

Ot3579 A24.68 lh2dcs 4u-lwg .387.

If the passwords are lost or you wish to operate the relay completely without password protection, install main board jumper JMP6A. With no password protection, you may gain access without knowing the passwords, and view or change active passwords and settings.

PUL n (Pulse)

Access Levels B, 2

The PULSE n k command asserts the selected output contact n for k seconds. The k parameter is optional. If k is not specified the output contact is pulsed for 1 second. Main board breaker jumper JMP6B must be in place. After issuing the PULSE command, the relay asks for confirmation of the operation, and then asks if you are sure. An invalid output contact name or incorrect k value produces an error message.

Parameter n may be any existing output contact element name such as OUT107. Parameter k must be a number ranging from 1 to 30 seconds.

Note: The PUL command is useful during testing to verify operation of output contacts, but it should not be used while the relay is in service. During the entire time the specified output contact is being pulsed, all other output contacts are frozen in their existing state and are not permitted to change. This could prevent a trip or other critical output from being issued during the specified PUL time interval.

```
=>>PUL OUT107 3<ENTER>
Pulse contact OUT107 for 3 second(s) (Y/N) ? Y<ENTER>
Are you sure (Y/N) ? Y<ENTER>
=>>
```

QUI (Quit)

Access Levels 0, 1, B, 2

The QUIT command returns the relay to Access Level 0 from Level 1, B, or 2. The command displays the relay settings RID, TID, date, and time of QUIT command execution.

Use the QUI command when you finish communicating with the relay to prevent unauthorized access. The relay automatically returns to Access Level 0 after a certain inactivity time dependent on the SET P setting T_OUT.

```
==>QUI<ENTER>

XFMR 1                      Date: 02/01/93    Time: 15:15:32.161
STATION A

=
```

RES (RESET51–Reset Inverse-Time O/C Elements)

Access Level 2

The RESET51 command clears the inverse-time overcurrent element accumulators (phase, negative-sequence, and residual) for all four windings. It also clears the four combined overcurrent phase and residual inverse-time elements. This command is useful in testing of the inverse-time elements, because it mimics the action of immediately returning an electromechanical disk to the starting position. This command can save time in waiting for some units to reset according to their electromechanical reset equations in **Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements**.

The relay will ask “Reset 51 Elements (Y/N) ?” when given the RES command. If No, it will abort the command. If Yes, it will respond “All Time-Overcurrent Element Accumulators Cleared.” This command is not likely to have much use in normal in-service relay operation.

SER (Sequential Events Recorder)

Access Levels 1, B, 2

The SER command displays the last 512 SER records. To limit the number of records displayed, use number or date parameters with the SER command. SER d1 shows only events triggered on the date specified by d1. SER d1 d2 shows only events triggered on or between the specified dates. SER m shows the most recent m events. SER m n shows event records m through n. The following is an example of the SER report. See **Section 9: Event Reports and SER** for a complete description of the report.

```

=>SER 2/26/97 2/27/97<ENTER>

XFMR 1                                     Date: 03/13/97    Time: 18:27:42.091
STATION A

FID=SEL-387-X104-V-D970311
#      DATE      TIME      ELEMENT      STATE
4      2/26/97   10:33:54.873  TRIP3      Asserted
3      2/26/97   10:33:55.373  TRIP3      Deasserted
2      2/27/97   10:34:06.872  CLS3      Asserted
1      2/27/97   10:34:07.372  CLS3      Deasserted

=>

```

SER C (Clear Sequential Events Recorder)

Access Levels 1, B, 2

Clear the sequential event records from relay memory with the SER C command. The process may take up to 30 seconds under normal operation or longer if the relay is busy processing a fault or protection logic.


```
=>>SER C<ENTER>  
Clear the SER  
Are you sure (Y/N) ? Y  
Clearing Complete  
  
=>>
```

Note: Clear the SER Buffer With Care

Automated clearing of the SER buffer should be limited to reduce the possibility of wearing out the nonvolatile memory. Limit automated SER C commands to once per week or less.

SET (Edit Group 1 through 6 Settings)

Access Level 2

Configure the relay using the SET command. The entire syntax of the SET command follows:

SET n *Setting* TERSE<ENTER>

All parameters are optional and perform the following functions:

- **n** specifies the setting group (1 through 6). The default is the active setting group.
- ***Setting*** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the group settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

If a setting is hidden because that section of the settings is turned OFF, you cannot jump to that setting. TERSE is very useful when making small changes to the settings. For example, the following procedure is recommended when making a change to one setting:

Change the CTR1 Setting

```

=>>SET CTR1 TE <ENTER>
Group 1

GENERAL DATA
Wdg 1 CT Ratio (1-50000)          CTR1   = 120      ? 160<ENTER>
Wdg 2 CT Ratio (1-50000)          CTR2   = 240      ? END<ENTER>
Save Changes? Y<ENTER>
Settings saved

```

Verify the CTR1 Setting

```

=>>SHO CTR1<ENTER>
Group 1

GENERAL DATA
CTR1   = 160      CTR2   = 240      CTR3   = 400      CTR4   = 400
MVA    = 100.0    ICOM   = Y
W1CTC  = 11       W2CTC  = 11       W3CTC  = 0
VWDG1  = 230.00   VWDG2  = 138.00   VWDG3  = 13.80

```

Issue <CTRL> X to Stop Scrolling

```

=>>

```

Table 7.4 lists the editing keys that you can use with the SET command.

Table 7.4: Editing Keys for SET Commands

Press Key(s)	Results
^ <ENTER>	Moves to previous entry in a setting category until you get to the first entry in the category, and then it moves to previous category.
< <ENTER>	Moves to previous settings category when making group settings.
> <ENTER>	Moves to next settings category when making group settings.
<ENTER>	Moves to next entry.
END <ENTER>	Exits editing session and displays all settings (if TERSE not used). Prompts: “SAVE CHANGES (Y/N)?” Type Y <ENTER> to save changes and exit, N <ENTER> to exit without saving.
<CONTROL> X	Aborts editing session without saving changes.
OFF <ENTER>	Flags a setting as not applicable. Only applies to certain settings.

After you enter a setting, you are prompted for the next setting. Press <ENTER> to move from setting to setting. The settings are arranged into families of related settings to simplify setting changes. You can start at a specific setting by entering the setting name as a parameter.

The relay checks each entry to ensure that it is within the allowable input range. If it is not, an “Out of Range” message is generated, and the relay prompts for the setting again.

When you have made all the necessary setting changes, it is not necessary to scroll through the remaining settings. Type **END<ENTER>** at the next setting prompt to display the new settings and request confirmation.

Answer **Y<ENTER>** to the confirmation request to approve the new settings. If you violate a rule for setting relationships, a fail message is displayed, and the settings prompt moves to the first setting that affects the failure. While the active settings are updated, the relay is disabled, the ALARM output contacts close, and all timers and relay elements reset. The relay logic is fully functional while editing settings. The relay is only disabled for approximately one second when settings are saved.

Refer to *Section 6: Setting the Relay* for all default settings and setting worksheets.

SET G (Edit Global Settings)

Access Level 2

Configure the relay global settings using the SET G command. The global settings include Event Report parameters, frequency, phase rotation, date format, front-panel time-out, rotating display update rate, the group switching time delay, DC battery monitor thresholds, breaker monitor settings, analog input labels, SSn setting group variables, and definition of front-panel programmable LED and Display Point variables. The entire syntax of the SET G command follows:

SET G *Setting* TERSE<ENTER>

The two parameters are optional and perform the following functions:

- ***Setting*** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the global settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

The SET G procedure works just like the SET procedure. Table 7.4 lists the editing keys that you can use with the SET command.

Refer to *Section 6: Setting the Relay* for all default settings and setting worksheets.

SET P (Edit Port Settings)

Access Level 2

Configure the relay port settings using the SET P command. The port settings include the communication and protocol settings. The entire syntax of the SET P command follows:

SET P *n Setting* TERSE<ENTER>

The two parameters are optional and perform the following functions:

- ***n*** specifies the serial port number (1, 2, 3, or 4). Default is the port issuing the command.
- ***Setting*** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the port settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

The SET P procedure works just like the SET procedure. Table 7.4 lists the editing keys that you can use with the SET command.

The settings for each communication port are:

- PROTO:** protocol can be SEL, LMD, or DNP.
- PREFIX:** If PROTO is LMD, prefix can be @, #, \$, %, or &.
- ADDR:** If PROTO is LMD, ADDR can be any integer 1 through 99.
- SETTLE:** If PROTO is LMD, the settling time can be 0 to 30 seconds.
- SPEED:** baud can be set to 300, 1200, 2400, 4800, 9600, or 19200.
- BITS:** data can be 7 or 8 bits.
- PARITY:** can be O, E, or N (Odd, Even, None).
- STOP:** bits can be 1 or 2.
- T_OUT:** port inactivity time-out can be 0 through 30 minutes. T_OUT = 0 setting means port will never time out. Time-out returns port to Access Level 0.
- AUTO:** send auto messages to the port; Yes or No.
- RTSCTS:** enable hardware handshaking; Yes or No (only if PROTO=SEL).
- FASTOP:** enable *Fast Operate* function; Yes or No.

Refer to **Section 6: Setting the Relay** for all default settings and setting worksheets.

SET R (Edit SER Settings)

Access Level 2

Configure the Sequential Events Recorder settings using the SET R command. The settings are the four sequential events recorder trigger conditions (SER1 to SER4) and the ALIAS1 to ALIAS20 settings for re-naming Relay Word bits for the SER report. The entire syntax of the SET R command follows:

SET R *Setting* TERSE<ENTER>

The two parameters are optional and perform the following functions:

- ***Setting*** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the new settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

The SET R procedure works just like the SET procedure. Table 7.4 lists the editing keys that you can use with the SET command.

Refer to **Section 6: Setting the Relay** for setting worksheets. Refer to **Section 9: Event Reports and SER** for more details on default settings and data retrieval.

Note: 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, SER3, or SER4 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 1 state change every 3 minutes can be made for a 25-year relay service life.

SHO (Show Group 1 through 6 Settings)

Access Levels 1, B, 2

SHOWSET displays the relay settings of the currently selected group. The entire syntax of the SHO command follows:

SHO n *Setting* A<ENTER>

- **n** specifies the setting group (1 through 6). The default is the active setting group.
- ***Setting*** specifies the setting name with which to begin. The default is the first setting.
- If ***Setting* = A**, then hidden settings are shown in addition to the regular settings.

Control characters provide control over the scrolling of the data:

Temporarily Stop Scrolling:	<CTRL>Q	(hold down the Control key and press Q)
Restart Scrolling:	<CTRL>S	(hold down the Control key and press S)
Cancel Scrolling Completely:	<CTRL>X	(hold down the Control key and press X)

Settings cannot be entered or modified with this command. Change settings with the SET command from Access Level 2. Refer to **Section 6: Setting the Relay** for information on all settings. The following example demonstrates the report for the SHO command.

=>>SHO 2<ENTER>

Group 2

RID	=XFMR 1				
TID	=STATION A				
E87W1	= Y	E87W2	= Y	E87W3	= Y
EOC1	= Y	EOC2	= Y	EOC3	= Y
EOCC	= N	ETHER	= Y	ESLS1	= N
ESLS3	= N			ESLS2	= N
W1CT	= Y	W2CT	= Y	W3CT	= Y
CTR1	= 120	CTR2	= 240	CTR3	= 400
MVA	= 100.0	ICOM	= Y	W4CT	= Y
W1CTC	= 11	W2CTC	= 11	CTR4	= 400
VWDG1	= 230.00	VWDG2	= 138.00	W3CTC	= 0
		VWDG3	= 13.80		
TAP1	= 2.09	TAP2	= 1.74	TAP3	= 10.46
O87P	= 0.3	SLP1	= 25	SLP2	= 50
U87P	= 10.0	PCT2	= 15	PCT5	= 35
TH5P	= OFF	IHBL	= N	IRS1	= 3.0

E32I =0

Press RETURN to continue

50P11P	= 20.00	50P11D	= 5.00	50P11TC	=1
50P12P	= OFF				
50P13P	= 0.50	50P14P	= 4.00		
51P1P	= 4.00	51P1C	= U2	51P1TD	= 3.00
51P1TC	=1			51P1RS	= Y
50Q11P	= OFF	50Q12P	= OFF		
51Q1P	= 6.00	51Q1C	= U2	51Q1TD	= 3.00
51Q1TC	=1			51Q1RS	= Y
50N11P	= OFF	50N12P	= OFF		
51N1P	= OFF				
DATC1	= 15	PDEM1P	= 7.00	QDEM1P	= 1.00
				NDEM1P	= 1.00
50P21P	= OFF	50P22P	= OFF		
50P23P	= 0.50	50P24P	= 3.50		
51P2P	= 3.50	51P2C	= U2	51P2TD	= 3.50
51P2TC	=1			51P2RS	= Y

Press RETURN to continue

50Q21P	= OFF	50Q22P	= OFF		
51Q2P	= 5.25	51Q2C	= U2	51Q2TD	= 3.50
51Q2TC	=1			51Q2RS	= Y
50N21P	= OFF	50N22P	= OFF		
51N2P	= OFF				
DATC2	= 15	PDEM2P	= 7.00	QDEM2P	= 1.00
				NDEM2P	= 1.00
50P31P	= 7.00	50P31D	= 0.00	50P31TC	=1
50P32P	= OFF				
50P33P	= 0.50	50P34P	= 4.00		
51P3P	= 4.00	51P3C	= U2	51P3TD	= 1.30
51P3TC	=1			51P3RS	= Y

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50Q31P = OFF 50Q32P = OFF
51Q3P = OFF
50N31P = OFF 50N32P = OFF
51N3P = OFF

Press RETURN to continue

DATC3 = 15 PDEM3P = 7.00 QDEM3P = 1.00 NDEM3P = 1.00

TMWDG = 1 VWDG = 230 XTYPE = 3 TRTYPE = Y
THwr = 65 NCS = 1
MCS11 = 100.0
DTMP = 15 TRDE = 0
NTHM = 2 THM1 = AMB THM2 = OIL1
TOT1 = 100 TOT2 = 100 HST1 = 200 HST2 = 200
FAAL1 = 50.00 FAAL2 = 50.00 RLOLL = 50.00 TLOLL = 50.00
CSEP1 = 15
ILIFE = 180000 EDFTC = Y
TDURD = 9.000 CFD = 60.000

TR1 = 50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2 = 51P2T + 51Q2T + OC2
TR3 = 50P31 + 51P3T + OC3
TR4 = 87R + 87U
TR5 = 0
ULTR1 = !50P13
ULTR2 = !50P23

Press RETURN to continue

ULTR3 = !50P33
ULTR4 = !(50P13 + 50P23 + 50P33)
ULTR5 = 0
52A1 = IN101
52A2 = IN102
52A3 = IN103
52A4 = 0
CL1 = CC1 + LB4 + /IN104
CL2 = CC2 + /IN105
CL3 = CC3 + /IN106
CL4 = 0
ULCL1 = TRIP1 + TRIP4
ULCL2 = TRIP2 + TRIP4
ULCL3 = TRIP3 + TRIP4
ULCL4 = 0
ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101 = TRIP1
OUT102 = TRIP2
OUT103 = TRIP3
OUT104 = TRIP4

Press RETURN to continue

OUT105 = CLS1
OUT106 = CLS2
OUT107 = CLS3
=>>

SHO G (Show Global Settings)

Access Levels 1, B, 2

SHOWSET G displays the relay global settings of the currently selected group. The global settings include Event Report parameters, frequency, phase rotation, date format, front-panel

time-out, the group switching time delay, DC battery monitor thresholds, breaker monitor settings, analog input labels, SSn setting group variables, and definition of front-panel programmable LED and Display Point variables. The syntax of the SHO G command follows:

SHO G *Setting*<ENTER>

- *Setting* specifies the setting name with which to begin. The default is the first setting.

Settings cannot be entered or modified with this command. Change settings with the SET G command from Access Level 2. Refer to **Section 6: Setting the Relay** for information on all settings. The following example demonstrates the report for the SHO G command.

```

=>>SHO G<ENTER>

LER      = 15      PRE      = 4      NFREQ    = 60      PHROT    = ABC
DATE_F   = MDY     SCROLLD  = 2      FP_TO    = 15      TGR      = 3
DC1P     = OFF     DC2P     = OFF     DC3P     = OFF     DC4P     = OFF

BKM0N1   =TRIP1 + TRIP4
B1COP1   = 10000    B1KAP1   = 1.2
B1COP2   = 150      B1KAP2   = 8.0
B1COP3   = 12       B1KAP3   = 20.0

BKM0N2   =TRIP2 + TRIP4
B2COP1   = 10000    B2KAP1   = 1.2
B2COP2   = 150      B2KAP2   = 8.0
B2COP3   = 12       B2KAP3   = 20.0

BKM0N3   =TRIP3 + TRIP4
B3COP1   = 10000    B3KAP1   = 1.2
B3COP2   = 150      B3KAP2   = 8.0
B3COP3   = 12       B3KAP3   = 20.0

BKM0N4   =0

IAW1     =IAW1      (NOTE: This part of the listing shows the Analog Input Labels,
IBW1     =IBW1      which can be up to four characters long)
ICW1     =ICW1
IAW2     =IAW2
IBW2     =IBW2
ICW2     =ICW2
IAW3     =IAW3
IBW3     =IBW3
ICW3     =ICW3
IAW4     =IAW4
IBW4     =IBW4
ICW4     =ICW4

SS1      =0
SS2      =0
SS3      =0
SS4      =0
SS5      =0
SS6      =0

LEDA     =OCA + 87E1
LEDB     =OCB + 87E2
LEDC     =OCC + 87E3

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```


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```

DP1      =IN101
DP1_1    =BREAKER 1 CLOSED DP1_0 =BREAKER 1 OPEN
DP2      =IN102
DP2_1    =BREAKER 2 CLOSED DP2_0 =BREAKER 2 OPEN
DP3      =IN103
DP3_1    =BREAKER 3 CLOSED DP3_0 =BREAKER 3 OPEN
DP4      =0
DP4_1    =          DP4_0 =
DP5      =0
DP5_1    =          DP5_0 =
DP6      =0
DP6_1    =          DP6_0 =
DP7      =0
DP7_1    =          DP7_0 =
DP8      =0
DP8_1    =          DP8_0 =
DP9      =0
DP9_1    =          DP9_0 =
DP10     =0
DP10_1   =          DP10_0 =
DP11     =0
DP11_1   =          DP11_0 =
DP12     =0
DP12_1   =          DP12_0 =
DP13     =0
DP13_1   =          DP13_0 =
DP14     =0
DP14_1   =          DP14_0 =
DP15     =0
DP15_1   =          DP15_0 =
DP16     =0
DP16_1   =          DP16_0 =

```

Text Labels:

```

NLB1 =          CLB1 =          SLB1 =          PLB1 =
NLB2 =          CLB2 =          SLB2 =          PLB2 =
NLB3 = MANUAL TRIP 1 CLB3 = RETURN SLB3 =          PLB3 = TRIP
NLB4 = MANUAL CLOSE 1 CLB4 = RETURN SLB4 =          PLB4 = CLOSE
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 =

```

=>>

SHO P (Show Port Settings)

Access Levels 1, B, 2

SHOWSET P displays the relay serial port settings. The port settings include the communications and protocol settings. The syntax of the SHO P command follows:

SHO P n *Setting*<ENTER>

The two parameters are optional and perform the following functions:

- **n** specifies the serial port number (1, 2, 3, or 4). Default is the port issuing the command.
- **Setting** specifies the setting name with which to begin. The default is the first setting.

Entering **SHO P<ENTER>** is an easy way to identify the port to which you are presently connected.

Settings cannot be entered or modified with this command. Change settings with the SET P command from Access Level 2. The following example shows the factory default settings. Refer to **Section 6: Setting the Relay** for Settings Sheets.

```
=>>SHO P<ENTER>
Port 2

PROTO  = SEL
SPEED  = 19200      BITS   = 8      PARITY  = N      STOP    = 1
T_OUT  = 0          AUTO   = Y      RTSCTS  = N      FASTOP  = N
=>>
```

SHO R (Show SER Settings)

Access Levels 1, B, 2

SHOWSET R displays the Sequential Events Recorder settings. The syntax of the SHO R command follows:

SHO R *Setting* <ENTER>

- **Setting** specifies the setting name with which to begin. The default is the first setting.

Settings cannot be entered or modified with this command. Change settings with the SET R command from Access Level 2. Refer to **Section 6: Setting the Relay** for information on all settings. Following is an example of the display for the SHO R command.

```
=>>SHO R<ENTER>

SER1    =IN101, IN102, IN103, IN104, IN105, IN106
SER2    =OUT101, OUT102, OUT103, OUT104, OUT105, OUT106, OUT107
SER3    =0
SER4    =0
ALIAS1  =OUT101 B1TRIP
ALIAS2  =OUT105 B1CLOSE
ALIAS3  =OUT102 B2TRIP
ALIAS4  =OUT106 B2CLOSE
ALIAS5  =OUT103 B3TRIP
ALIAS6  =OUT107 B3CLOSE
ALIAS7  =NA
ALIAS8  =NA
ALIAS9  =NA
ALIAS10 =NA

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```

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```
ALIAS11 =NA
ALIAS12 =NA
ALIAS13 =NA
ALIAS14 =NA
ALIAS15 =NA
ALIAS16 =NA
ALIAS17 =NA
ALIAS18 =NA
ALIAS19 =NA
ALIAS20 =NA
```

=>>

STA (Status Report)

Access Levels 1, B, 2

The STATUS command displays a report of the self-test diagnostics. The relay automatically executes the STATUS command whenever the self-test software enters a warning or failure state. You may repeat the STA command by appending a number as a repeat count parameter. Type **STA 4<ENTER>** to view the status information four times.

If a warning or failure state occurs, the next time the STA command is issued, the warning state is reported. If a warning or failure occurs, it will not be cleared until relay power is cycled and the problem is fixed. Saving relay settings performs a warm boot of relay logic. This may clear some warnings, but do not ignore warnings; contact the factory.

The **STA C<ENTER>** command clears any out-of-tolerance condition from the status report and reboots the relay. Do not ignore warnings; contact the factory.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set. The STATUS report format appears below:

```
XFMR 1                               Date: 04/21/00   Time: 21:29:42.829
STATION A

FID=SEL-387-6-X117-V0-Z001001-D20000419  CID=2001
SELF TESTS

W=Warn    F=Fail

   IAW1    IBW1    ICW1    IAW2    IBW2    ICW2
OS      0      -0      -0      1      0      1

   IAW3    IBW3    ICW3    IAW4    IBW4    ICW4
OS      0      0      -0      1      0      -1

   +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      4.93  4.99  -5.07  11.90 -12.08  14.96 -14.90

   TEMP    RAM     ROM     A/D     CR_RAM  EEPROM  IO_BRD
        32.1    OK     OK     OK     OK     OK     OK

Relay Enabled

=>
```

TAR (Show Relay Word Targets On-Screen)

Access Levels 1, B, 2

The TARGET command displays the default row of the Relay Word showing the Relay Word bit names and their value, which is either a logical 1 (asserted) or logical 0 (deasserted). The syntax of the TAR command follows:

TAR n k X<ENTER>

- **n** specifies a new default Relay Word row by entering the row number or the specific Relay Word bit name (except names of target elements in rows 0 and 1). If n is not specified, the last default row is displayed.
- **k** specifies a repeat count for the command. The default is 1.
- **X** allows viewing a Relay Word row without changing the default row.

The default row number can also be changed by the TAR F command, but each serial port has independent defaults. The default row number returns to 0 when the port times out, the QUIT command is executed, TAR 0 command is executed, or the TAR R command is executed.

The TARGET command does not remap the front-panel LEDs. See the TAR F command.

The following examples demonstrate the TARGET command:

```
=>>TAR<ENTER>                                Default Row is 0
EN      TRIP  INST  87-1  87-2  87-3  50    51
1        0      0      0      0      1      0      0

=>>TAR 8<ENTER>                                Display and Change Default to Row 8
50N21  50N21T 50N22  51N2  51N2T  51N2R  NDEM2  OC2
0        0      0      0      0      1      0      0

=>>TAR<ENTER>                                Default Row is 8
50N21  50N21T 50N22  51N2  51N2T  51N2R  NDEM2  OC2
0        0      0      0      0      1      0      0

=>>TAR 8 5<ENTER>                             Display Row 8 Five Times
50N21  50N21T 50N22  51N2  51N2T  51N2R  NDEM2  OC2
0        0      0      0      0      1      0      0
0        0      0      0      0      1      0      0
0        0      0      0      0      1      0      0
0        0      0      0      0      1      0      0
0        0      0      0      0      1      0      0

=>>TAR RB4 X<ENTER>                             Display Row 24 (RB4) But Do Not Change Default
RB1    RB2    RB3    RB4    RB5    RB6    RB7    RB8
0        0      0      0      1      0      0      0

=>>TAR<ENTER>
50N21  50N21T 50N22  51N2  51N2T  51N2R  NDEM2  OC2
0        0      0      0      0      1      0      0

=>>TAR R<ENTER>                                Reset Default to Row 0
EN      TRIP  INST  87-1  87-2  87-3  50    51
1        0      0      0      0      0      0      0

=>>
```

Refer to *Section 4: Control Logic* for a list of the Relay Word and the corresponding rows.

TAR F n (Show Relay Word Targets on Front-Panel LEDs)

Access Levels 1, B, 2

The TARGET F command works like the TARGET command, but it also remaps the second row of target LEDs on the front-panel to follow the default row. This may be useful, for example, in testing situations where a display on the relay front-panel LEDs of element pickup or operation may be desired. The syntax of the TAR F command follows:

TAR F n k X<ENTER>

- **n** specifies a new default Relay Word row by entering the number or the specific Relay Word bit name. If n is not specified, the last default row is displayed.
- **k** specifies a repeat count for the command for the serial port display. The default is 1.
- **X** allows remapping the LEDs to a Relay Word row without changing the default row.

The default row number returns to 0 when the serial port times out, the QUIT command is executed, TAR 0 command is executed, or the TAR R command is executed.

The front-panel LEDs remain remapped until the front panel times out, the TAR R command is executed, or the <TARGET RESET> button is pushed.

Refer to *Section 4: Control Logic* for a list of the Relay Word and the corresponding rows.

TAR R (Reset Targets)

Access Levels 1, B, 2

The TARGET R command resets the default row for the TAR and TAR F commands to 0, and remaps the second row of front-panel LEDs to display Row 1, which is the standard target display. It also resets any tripping front-panel targets.

Use the TAR R command to return the front-panel LEDs to the standard targets when you are done using the TAR or TAR F command for testing.

THE (Thermal Report) (SEL-387-6 Relay only)

Access Levels 1, B, 2

The THERM command displays temperature inputs, thermal event reports, hourly profile data or daily profile data, depending on the command statement. There are several choices for the THE command, listed briefly below. Refer to *Section 5: Metering and Monitoring* for a complete description of the thermal monitoring reports.

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer
THE C	Clears the hourly profile, daily profile, and thermal event data archives

THE D x y	Retrives daily profile data from day x to day y If x and y are omitted, retrieves entire profile data If x or y is omitted, retrieves profile from day x (y) to present
THE H x y	Retrives hourly profile data from day x to day y If x and y are omitted, retrieves entire profile data If x or y is omitted, retrives profile from day x (y) to present
THE n	Displays saved thermal monitor report n where n = 1 is the most recently saved report
THE P n	Loads preset value of accumulated insulation loss of life
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values
THE T	Displays the four temperature inputs received from an SEL-2020 or an SEL-2030

TIM (Time)

Access Levels 1, B, 2

The TIME command displays or sets the time stored by the internal clock. The time is set or displayed on a 24-hour clock basis, not a.m./p.m. View the current time with **TIM<ENTER>**. To set the clock, type **TIM t1<ENTER>** where t1 is the new time in h:m:s; the seconds are optional. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. The following example sets the clock to 23:30:00:

```
=>TIM 23:30:00<ENTER>
23:30:00
=>
```

A quartz crystal oscillator provides the time base for the internal clock. You can also set the time clock automatically through the relay time-code input using a source of demodulated IRIG-B time-code.

Note: After setting the time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

TRI (Trigger an Event)

Access Levels 1, B, 2

The TRIGGER command generates an event record. The command is a convenient way to record all inputs and outputs from the relay at any time you desire (e.g., testing or commissioning). The event type is recorded as TRIG any time the TRI command is issued.

```

=>>TRI<ENTER>
Triggered

=>>

XFMR 1                                Date: 03/13/97    Time: 18:49:21.586
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 2 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 3 Currents (A Sec), ABC:  0.0  0.0  0.0
Winding 4 Currents (A Sec), ABC:  0.0  0.0  0.0

=>>

```

Alarm Conditions

The SEL-387 Relay asserts the ALARM output during power up until all self-tests pass and whenever a diagnostic test fails. In addition to these, the ALARM output pulses for one second with the commands and conditions shown in Table 7.5.

Table 7.5: Commands With Alarm Conditions

Command	Condition
2AC	Entering Access Level 2 or Three wrong password attempts into Access Level 2
ACC	Three wrong password attempts into Access Level 1
BAC	Entering Breaker Access Level or Three wrong password attempts into Breaker Access Level
COP m n	Copying a setting group to the active setting group
GRO n	Changing the active setting group
PAS n newpas	Any password is changed
SET commands	Changing the SET G settings, the SET R settings, or the active group SET settings (SET P does not alarm)

Main Board Jumpers

Installing and removing certain main board jumpers affects execution of some commands. Table 7.6 lists all jumpers you should be concerned with and their effects.

Table 7.6: Main Board Jumpers

Jumper	Comment
JMP6A	Disables password protection when installed
JMP6B	Enables CLO, OPE, and PUL commands when installed

SEL-387-5, -6 RELAY COMMAND SUMMARY

ACCESS LEVEL 0 COMMANDS

**Access
Level 0
Commands**

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

- ACC Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.
- QUI Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.

ACCESS LEVEL 1 COMMANDS

**Access
Level 1
Commands**

The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>

- 2AC Enter Access Level 2. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.
- BAC Enter Access Level B. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level B password in order to enter Access Level B.
- BRE Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
- CEV n Show compressed winding event report number n, at 1/4 cycle resolution.
Attach DIF for compressed differential element report, at 1/4 cycle resolution.
Attach R for compressed raw winding data report, at 1/16 cycle resolution.
Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)
- DAT Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE D n Show digital data event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE DIF1 n Show differential element 1 event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE DIF2 n Show differential element 2 event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.

EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
STA C	Clear relay status report from memory and reboot the relay.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.

TAR n k Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen.
Append F to display targets on the front panel, second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE Displays a thermal monitor report that indicates the present thermal status of the transformer.

THE C Clears the hourly profile, daily profile, and thermal event data archives.

THE D x y Retrives daily profile data from day x to day y.
 If x and y are omitted, retrieves entire profile data.
 If x or y is omitted, retrieves profile from day x (y) to present.

THE H x y Retrives hourly profile data from day x to day y.
 If x and y are omitted, retrieves entire profile data.
 If x or y is omitted, retrives profile from day x (y) to present.

THE n Displays saved thermal monitor report n where n = 1 is the most recently saved report.

THE P n Loads preset value of accumulated insulation loss of life.

THE R Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.

THE T Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.

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 The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>

ACC Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.

2AC Enter Access Level 2. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.

BRE Breaker report shows trip counters, trip currents, and wear data for up to four breakers.

BRE R n Reset trip counters, trip currents, and wear data for breaker n (n = 1, 2, 3, 4, A).

BRE W n Pre-set the percent contact wear for each pole of breaker n (n = 1, 2, 3, or 4).

CEV n Show compressed winding event report number n, at ¼ cycle resolution.
Attach DIF for compressed differential element report, at ¼ cycle resolution.
Attach R for compressed raw winding data report, at 1/16 cycle resolution.
Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)

CLO n	Assert the CCn Relay Word bit. Used to close breaker n if CCn is assigned to an output contact. JMP24B has to be in place to enable this command.
DAT	Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE D n	Show digital data event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF1 n	Show differential element 1 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF2 n	Show differential element 2 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
GRO n	Switch to Setting Group n. (Will not function if any SSn Relay Word bit is asserted.)
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
OPE n	Assert the OCn Relay Word bit. Used to open breaker n if OCn is assigned to an output contact. JMP24B has to be in place to enable this command.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number k to pulse for k seconds [k = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP24B has to be in place to enable this command.

QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
TAR n k	Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen. Append F to display targets on the front panel second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D x y	Retrives daily profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE H x y	Retrives hourly profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE n	Displays saved thermal monitor report n where n = 1 is the most recently saved report.
THE P n	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.

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 2 COMMANDS

Access Level 2 Commands	The Access Level 2 commands primarily allow the user to change settings or operate relay parameters and output contacts. All Access Level 1 commands can also be executed from Access Level 2. The screen prompt is: =>>
ACC	Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.
BAC	Enter Access Level B. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level B password in order to enter Access Level B.
BRE	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
BRE R n	Reset trip counters, trip currents, and wear data for breaker n (n = 1, 2, 3, 4, A).
BRE W n	Pre-set the percent contact wear for each pole of breaker n (n = 1, 2, 3, or 4).
CEV n	Show compressed winding event report number n, at ¼ cycle resolution. Attach DIF for compressed differential element report, at ¼ cycle resolution. Attach R for compressed raw winding data report, at 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)
CLO n	Assert the CCn Relay Word bit. Used to close breaker n if CCn is assigned to an output contact. JMP24B has to be in place to enable this command.
CON n	Control Relay Word bit RBn (Remote Bit n; n = 1 through 16). Execute CON n and the relay responds: CONTROL RBn. 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 one processing interval (1/8 cycle)].
COPY m n	Copy settings and logic from setting Group m to Group n.
DAT	Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE D n	Show digital data event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.

EVE DIF1 n	Show differential element 1 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF2 n	Show differential element 2 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
GRO n	Switch to Setting Group n. (Will not function if any SSn Relay Word bit is asserted.)
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay. In Access Level 2, confirms that I/O boards are correct.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
OPE n	Assert the OCn Relay Word bit. Used to open breaker n if OCn is assigned to an output contact. JMP24B has to be in place to enable this command.
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.
	If xxxxxx is DISABLE (upper case), password for selected level is disabled.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number k to pulse for k seconds [k = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP24B has to be in place to enable this command.
QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
RES	RESET51 command resets all inverse-time O/C elements for the four windings, including the Combined Overcurrent elements.

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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SET n	Change relay group settings (overcurrent, differential, etc.). For the SET commands, parameter n is the setting name at which to begin editing settings. If parameter n is not entered, setting editing starts at the first setting.
SET G	Change global settings.
SET P n	Change port settings.
SET R	Change Sequential Events Recorder (SER) settings.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
TAR n k	Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen. Append F to display targets on the front panel, second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D x y	Retrieves daily profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE H x y	Retrieves hourly profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE n	Displays saved thermal monitor report n where n = 1 is the most recently saved report.
THE P n	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.
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.

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SECTION 8: FRONT-PANEL INTERFACE

FRONT-PANEL OPERATION

A close-up view of the user interface portion of the SEL-387 Relay front panel is shown in Figure 8.1. It includes a two-line, 16-character LCD display; 16 LED target indicators; and eight pushbuttons for local communication.

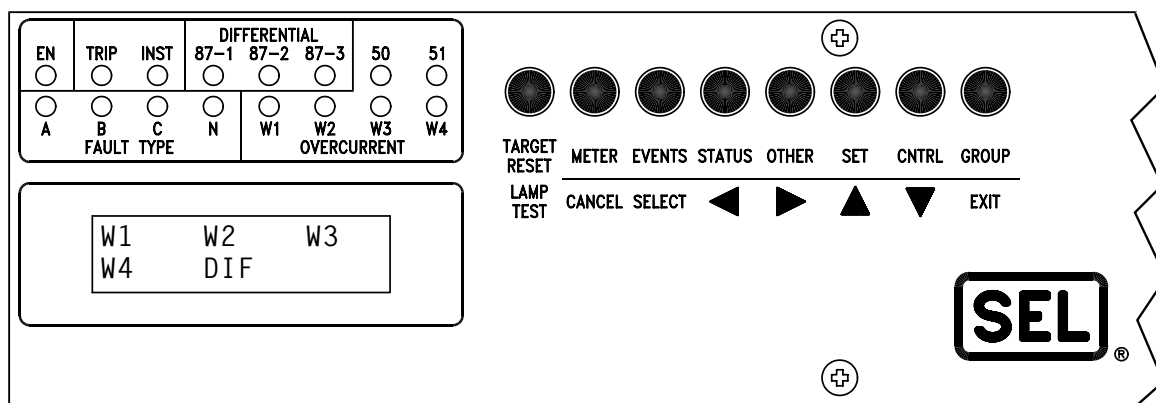


Figure 8.1: SEL-387 Relay Front-Panel User Interface

The LCD display shows event, metering, setting, and relay self-test status information. The display is controlled with the eight multifunction pushbuttons. The target LEDs display relay target information as described by the legend. The bottom row can be remapped to display a Relay Word row of bits, in response to the TAR F serial port command.

Time-Out

If no buttons are pressed on the front panel, the relay waits a time period specified in the SET G setting FP_TO (Front-Panel Time-Out) and then takes the following actions:

- The front-panel LCD display resets to the default display.
- The front-panel access level reverts to Access Level 1.
- The LCD back lighting is turned off.
- Any routine being executed via a front-panel command is interrupted.
- The target LEDs (lower row) revert to the default targets.

FP_TO is factory-set to 15 minutes and can be set from 0 to 30 minutes. If zero is selected, the front panel will never time out. A zero setting is useful when testing, but do not leave the time-out set at zero. The back light will fail if lit for prolonged periods of time, and the target LEDs that may have been changed using the TAR F command will not be reset to the default targets. Reset FP_TO to some nonzero value, then **push any button** — the relay will not revert to the new value of FP_TO until a button has been pushed.

Displays

The LCD display is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed Display Points. Display Points and LCD scrolling controls are discussed at the end of this section in more detail. The default display is a scroll through any active, nonblank Display Points. If none are active, the relay scrolls through up to four two-line displays of the A-, B-, and C-phase currents in the four windings in primary amperes. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the display as set. The two-line current display for a winding “n” is turned off if both of the settings E87Wn and EOCn are set to “N.” Each display remains for Global setting SCROLLD (seconds), before scrolling continues. Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The <EXIT> button returns the display to the default display, if some other front-panel function is being performed.

Error messages such as self-test failures are displayed on the LCD in place of the default display when they occur. Do not power down the relay if this occurs; refer to **Section 10: Testing and Troubleshooting** for further instructions.

During power up and when executing the R_S command to reset factory default settings, the LCD displays “Initializing.” It will then scroll through the winding current displays until the relay is again enabled. When the EN LED indicates the relay is enabled, the active Display Points will be scrolled.

Menu choices on the LCD display are listed horizontally on the second line. The first character of the menu choice is underlined. The left and right arrow buttons move the underline to the adjacent menu selection. Once the underline indicates your selection, use the <SELECT> button to proceed.

Target LEDs

The target LEDs are an indication of what the relay has detected on the power system and how the relay has reacted. The front-panel legend gives a brief description of each target, but **Section 4: Control Logic** describes each target LED in detail.

The only times the target LEDs do not illuminate according to their labels is when (1) LEDA, LEDB, or LEDC has been reprogrammed by the user to respond to a SELOGIC® control equation or (2) the TAR F command is issued through one of the serial ports. The TAR F command remaps the second row of LEDs to follow a particular row in the Relay Word bits, such that a Relay Word bit that is asserted will light the corresponding LED position. Refer to **Section 7: Serial Port Communications** for a complete description of the TAR F command.

The states of the 12 dedicated LEDs (all but EN, A, B, C) are stored in nonvolatile memory. If power to the relay is lost, these 12 targets will return to their last state when power is restored. EN responds only to internal self-test routines, while A, B, and C respond to the present state of their Global settings, which are SELOGIC control equations.

Password Access

Commands that are at Access Level 2 (2AC) or the Breaker Access Level (BAC) are password protected from the front panel. Access Level 1 commands are not password protected. The front panel is normally active at Access Level 1. If you issue a command from the front panel that requires a Level B or Level 2 password, the relay prompts you for a password. After you enter the password for the higher access level, you remain at that access level only until the front panel times out from inactivity or you EXIT from the specific command. When you EXIT the command, the front panel returns to Access Level 1.

If the password jumper, JMP6A, is installed, there is no password protection, and you will not be prompted for a password. If a particular level password has been disabled with serial port command **PAS n DISABLE<ENTER>**, you will not be prompted for a password.

When prompted for a password, enter the BAC or 2AC password, depending on the requirements of the command. All commands are available using the 2AC password. The front-panel request for password shows a display of six characters, shown initially as ABCDEF, with the A underscored. Use the up/down arrow keys to scroll and set the first character of the password. Passwords are case sensitive; be sure you use upper or lower case letters as needed. Use the right arrow key to move to the second character, and adjust it using the up/down arrows as before. Continue this process until **all six** characters are filled. If the password has less than six characters, fill the remaining slots with a “blank,” found between the numeral 9 and the lower case “a” in the character scroll. When the password is complete, push **<SELECT>** to enter it. If the password is correct, the relay will change to the higher level and permit you to perform that level’s commands. If it is incorrect, the relay will declare an “Invalid Password,” and allow another attempt. After three incorrect attempts, the relay will pulse the ALARM contact for one second and the front panel will exit the command you are trying to access.

PUSHBUTTONS

Eight multifunction pushbuttons control the front-panel display. The button legend defines the primary function in the top row and the secondary function in the bottom row. The primary functions are for command selection and the secondary functions are for cursor movements and specific commands within dialogues. The eight pushbutton primary functions will be discussed in the order in which they appear from left to right on the front panel.

Primary Function Review

TARGET RESET / LAMP TEST

The left-most button is dedicated to the **<TARGET RESET>** function. Except while viewing or editing settings, pressing **<TARGET RESET>** causes the front-panel LEDs to illuminate for a two-second lamp test and then clears all target LEDs except for the EN LED, which is illuminated if the relay is enabled. While viewing or editing settings, the **<TARGET RESET>** button acts as a Help function, showing specific information about the displayed setting.

METER

The **<METER>** button performs all of the MET serial port commands, via a multilevel menu structure. The METER display is updated every two seconds.

When **<METER>** is pushed, the seven dual-function buttons revert to their secondary functions. The first METER menu prompts the user to select **W1**, **W2**, **W3**, **W4**, **DIF**, or **VDC** metering display. W1 to W4 are winding displays, DIF is the differential element display, and VDC is the Battery Monitor display. Use any arrow button to highlight the choice. Then push **<SELECT>**.

If DIF is selected, the relay scrolls through the instantaneous multiple of tap values for Operate, Restraint, and harmonic quantities.

If VDC is selected, the relay displays “Station Battery” and “VDC= nnn.n.”

If a winding has been selected, a second menu appears prompting the user to select the type of metering to display. The choices are **INST**antaneous, **DEMAND**, **PKD** peak demand, or **SECON**dary. Use the right/left arrows to choose, then push **<SELECT>**. **Note:** The harmonic spectrum metering function, the MET H serial port command, is not available from the front panel.

If INST or SEC is selected, the relay scrolls through the primary current magnitudes or secondary current magnitudes and angles for the selected winding. If DEM or PKD are selected, a third menu appears prompting the user to select to either **DISPLAY** the demand information or to **RESET** the demand accumulators. **Note:** RESET of the DEM or PKD is a Level 1 function and is not password protected from the front panel. Use the right/left arrows and **<SELECT>** to choose. If RESET is chosen, the relay will prompt for a Yes/No verification of the choice. Use the right/left arrows and **<SELECT>** to choose. If DISPLAY is chosen, the relay will scroll through the demand values.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the displays as set.

While within the METER menu structure, the **<CANCEL>** button will take the user back up to the previous menu. The **<EXIT>** button will take the user out of METER and back to the default display.

While METER information is being scrolled every two seconds, the scroll can be stopped by pushing **<SELECT>**. The user may then manually scroll through the displays with the up/down arrow keys. This facilitates writing down the displayed information by hand, for example. Pushing **<SELECT>** again will resume the scroll.

Figure 8.5, at the end of this section, shows the full METER menu and display structure.

EVENTS

Push the **<EVENTS>** button to display short event summaries, comparable to the HIS serial port command.

If no EVENT records exist, the display states “No Fault Data” and terminates the command.

If there are records to view, use the right/left arrows to review data within an event record and the up/down arrows to move between event records. Information displayed for a given event are

the event number, date/time, active setting group, fault targets, and the winding secondary current magnitudes (IA, IB, IC). The currents only appear if the entire event report still resides in relay memory. The Analog Input Label names are not used in this display. Current information is simply listed, for example, as “**W1**” followed by “**A B C**” and the magnitudes. There may be up to 80 event summaries in the history buffer, but a much smaller number of full event reports. The **EVENTS** command will display everything but the currents for the older, incomplete history summaries. Use **<CANCEL>** or **<EXIT>** to return to the default display.

Figure 8.6, at the end of this section, shows the **EVENTS** display structure.

STATUS

The **<STATUS>** button displays the relay status information in similar fashion to the serial port **STA** command. When **<STATUS>** is pushed, the initial display shows:

STATUS: [OK/WARN/FAIL]

FID=SEL-387-R103 (e.g., the first 12 characters of the FID string)

The **STATUS** line shows the worst state of the several parameters examined. The right/left arrow keys can be used to view the rest of the FID string.

The up/down arrow keys are then used to manually scroll through the diagnostic fields, showing the analog channel offsets, power supply voltages, internal temperature, RAM (OK/FAIL), etc. The display remains in this scroll sequence until either **<CANCEL>** or **<EXIT>** are pushed.

OTHER

The **<OTHER>** button is used to access several miscellaneous functions, and mimics the corresponding serial port commands for these functions. Pushing **<OTHER>** provides a menu that prompts the user to select **DATE**, **TIME**, **TARget**, **BKR**(breaker), **RESET51**, or **LCD**. These perform the same functions as the serial port commands **DAT**, **TIM**, **TAR**, **BRE**, and **RES**. Use any arrow key and **<SELECT>** to choose the function. These **OTHER** subfunctions are discussed below in alphabetical order.

BKR

This function displays the breaker monitor accumulator values for internal and external trips, the accumulated interrupted currents by pole, the percent contact wear, and the time/date of last reset, for the selected breaker.

When **BKR** is selected, a second menu appears to prompt the user to select **Bk1**, **Bk2**, **Bk3**, or **Bk4**. Use the right/left arrow keys and **<SELECT>** to choose. Another menu appears, asking whether **DISPLAY** or **RESET** is desired. Use the right/left arrow keys and **<SELECT>** to choose.

If **DISPLAY** is selected, the display scrolls automatically, showing the Internal and External trip counters for the breaker chosen, the phase currents accumulated for each type of trip, and the percent contact wear by breaker pole. The first two-line display shows **P1**, the second **P2**, and the third **P3**. The fourth display shows “**% wear**” for each of the three poles, in integer values of 100 or less. The fifth display shows “**Last Reset From**” and the date/time of last reset. Pushing

<SELECT> will toggle between stop-scroll and resume-scroll, to facilitate hand-recording of data values.

Push <CANCEL> to return to the OTHER main menu. Push <EXIT> to return to the default display.

Figure 8.7, at the end of this section, shows the full OTHER/BKR menu and display structure.

DATE

The DATE function is used to change the date stored in the relay. It is identical to the serial port DATE command.

When selected, a two-line display appears with the current date on the first line and a prompt to **Set** or **Cancel** on the second. Use the right/left arrows and <SELECT> to choose. The date display will follow whichever format was selected by the DATE_F setting, either MDY or YMD. If Set is selected, a second display appears prompting the user to change the date. Since this is a Level 1 command, it is not password protected from the front panel. Use the right/left arrows to move between the MM/DD/YY fields, and the up/down arrows to scroll to the number selected for the field. When the date is shown correctly, push <SELECT> to enter it. Push <CANCEL> to return to the OTHER main menu. Push <EXIT> to return to the default display.

Note: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

LCD

The rotating default display can be locked on a single screen. Access the scroll lock control with the OTHER pushbutton.

DATE	TIME	TAR
BKR	RESET51	LCD

Select LCD for Scroll Lock Control mode. The rotating display will then appear, and the scroll mode reminder screen will appear every eight seconds for one second as a reminder that the display is in Scroll Lock Control mode.

Scroll lock OFF SELECT to Lock

Stop Scrolling (Lock)

When in the Scroll Lock Control mode, press the SELECT key to stop display rotation. Scrolling can be stopped on any of the display point screens. While rotation is stopped, the active display is updated continuously so that the display point changes can be seen. If no button is pressed for eight seconds, the reminder message will appear for one second followed by the active screen.

Scroll lock ON SELECT to Unlock

Restart Scrolling (Unlock)

The SELECT key unlocks the modified rotating display.

Single Step

From the Scroll Locked state, single-step through the display screens by pressing the SELECT key twice. Wait for the first press to display the next screen as the active display, then press the SELECT key a second time to freeze scrolling.

Exit

Press the EXIT key to leave Scroll Lock Control and return the rotating display to normal operation.

Cancel

Press the CANCEL key to return to the OTHER menu.

DATE	TIME	TAR
BKR	RESET51	LCD

RESET51

This command exactly equates to the RES serial port command. RESET51 clears all time accumulators of all the inverse-time overcurrent elements, both for separate windings and for the combined overcurrent elements. RESET51 may be useful for saving time in testing the relay overcurrent elements but is not likely to be used while the relay actually is in service.

If RESET51 is selected, a password screen will appear if password protection is in force. Next, a **Reset 51? Yes No** screen appears. Use the right/left arrows to underscore Yes or No, then push **<SELECT>**. Yes will reset the accumulators and exit the command. No will abort the command and return to the OTHER main menu; or, simply push **<CANCEL>** to return to the OTHER main menu. Push **<EXIT>** to return to the default display.

TAR

This command is roughly equivalent to the TAR F serial port command. When TAR is selected in the OTHER main menu, the display shows **TAR 0**, the first row of the Relay Word bits, with **EN** shown in the second row (relay enabled). The up/down arrow keys may be used to scroll through the remaining rows of the Relay Word bits. For these rows, the asserted Relay Word bit names will be listed in the second row of the display, and the corresponding LED positions will be lit in the target area above the display. If more bits are asserted than will fit in the display, the right/left arrow keys may be used to see the off-screen names.

Push **<CANCEL>** to return to the OTHER main menu. Push **<EXIT>** to return to the default display.

TIME

This command works like the DATE command above and is equivalent to the TIME serial port command.

When selected, a two-line display appears, with the current time on the first line and a prompt to **Set** or **Cancel** on the second. Use the right/left arrows and **<SELECT>** to choose. Since this is a Level 1 command, it is not password protected from the front panel. If Set is selected, a second display appears prompting the user to change the time. Use the right/left arrows to move between the HH:MM:SS fields and the up/down arrows to scroll to the number selected for the field. When the time is shown correctly, push **<SELECT>** to enter it. Push **<CANCEL>** to return to the OTHER main menu. Push **<EXIT>** to return to the default display.

Note: After setting the time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

SET

The SET function has the most elaborate menu and display structure of all the pushbutton functions. Only numeric value settings or settings having fixed Character string values can be displayed or changed on the display. Settings which are SELOGIC control equations cannot be displayed or changed.

To show or set relay settings, press the **<SET>** button. There are four set/show options: **GROUP**, **GLOBAL**, **PORT**, and **PASS**. Use the right/left arrow keys and **<SELECT>** to choose. These will be discussed in alphabetical order.

Figure 8.8, at the end of this section, shows the essential menu and display structure for the SET button. It does not show anything below the setting section (subgroup) level, since this would be too cumbersome.

GLOBAL

This command is roughly equivalent to the SHO G and SET G serial port commands. When GLOBAL is selected, a menu appears for selecting whether to **Set** or **Show** the settings. If Set, a password entry screen appears if password protection is in force.

The next screen is either the **Set GLOBAL** or **Show GLOBAL** display, in which a message scrolls across the second line, reminding the user to “Press TARGET RESET for help during set/show routine.” This special use for the TARGET RESET button provides the user with a short description of the setting and the range of values, should the user not recognize the setting by its Character string name.

The next menus to appear allow the user to enter a specific section of the GLOBAL settings, rather than having to scroll through all GLOBAL settings. The sections are **RELAY SETTINGS**, **BATTERY MONITOR**, **BKRn MONITOR**, **ANALOG INPUT LABELS**, **SETTING GROUP SElection**, and **FRONT PANEL**. Use any arrow key to move to the desired section, then push **<SELECT>** to enter that section.

For example, if we select RELAY SETTINGS, the first setting **LER=15** appears in the second line of the display. If the user does not recognize this setting, he can push the TARGET RESET

button, and a single scroll across the first line will inform him that this is the “Length of Event Report (15, 30, 60 Cycles)” setting.

If we are in the Show mode, we can only observe the value. The <SELECT> button acts like a down arrow, to move to the next setting. The up/down arrows themselves can be used to move within the list of settings.

If in the Set mode, we can choose to change the value by pushing <SELECT>. An underscore will appear under the first character of the value. If it has discrete values, like LER, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at the new value, push <SELECT> to enter the change.

When the complete list of settings has been shown or set, the display returns to the level of selection of which section to Set or Show. <CANCEL> may also be used to move to this level from within the section of settings. <EXIT> , in the Set mode, brings the display to a **Save Changes? Y/N** selection point. In the Show mode, it returns to the default display.

GROUP

This command is roughly equivalent to the SHO and SET serial port commands. When GROUP is selected, a menu appears for selecting which of the six setting groups to Show or Set. Use the right/left arrow keys and <SELECT> to choose. The next screen asks the user if he intends to **Set** or **Show** the settings. If Set, a password entry screen appears, if password protection is in force.

The next screen is either the **Set GROUP n** or **Show GROUP n** display (n = the group number), in which a message scrolls across the second line, reminding the user to “Press TARGET RESET for help during set/show routine.” This special use for the TARGET RESET button provides the user with a short description of the setting and the range of values, should the user not recognize the setting by its Character string name.

The next menus to appear are to allow the user to enter a specific section of the GROUP settings, rather than having to scroll through all GROUP settings. The sections are **CONFIG. SETTINGS**, **GENERAL DATA**, **DIFF ELEMS**, **RESTRICTED EARTH**, **WINDING n ELEMS**, **COMBINED ELEMS**, and **MISC. TIMERS**. Four additional section titles appear after **MISC. TIMERS**. These are **TRIP LOGIC**, **CLOSE LOGIC**, **EVENT TRIGGER**, and **OUTPUT CONTACT Logic**. These sections are entirely SELOGIC control equations, and cannot be viewed or changed from the front panel. Use an arrow key to scroll past these latter sections. Use any arrow key to move to the desired section, then push <SELECT> to enter that section.

For example, if we select CONFIG. SETTINGS, the first setting **E87W1=Y** appears in the second line of the display. If the user doesn’t recognize this setting, he can push the TARGET RESET button and a single scroll across the first line will inform him that this is the “Enable Wdg1 in Differential Element (Y, N)” setting.

If we are in the Show mode, we can only observe the value. The <SELECT> button acts like a down arrow to move to the next setting. The up/down arrows themselves can be used to move within the list of settings.

If in the Set mode, we can choose to change the value by pushing <SELECT>. An underscore will appear under the first character of the value. If it has discrete values, like E87W1, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at its new value, push <SELECT> to enter the change.

When the complete list of settings has been shown or set, the display returns to the menu level of selection of which section to Set or Show. <CANCEL> may also be used to move to this level from within the section of settings. <EXIT>, in the Set mode, brings the display to a **Save Changes? Y/N** selection point. In the Show mode it returns to the default display.

PASSWORD



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.

This command is like the password setting feature of the PAS serial port command. You cannot view the list of passwords from the front panel; you can only enter existing passwords where required or change them to some other value with this front-panel command.

If PASSWORD is selected, the first display requires you to enter the existing Level 2 password, if password protection is in force.

The next display asks the level of access for which you are changing the password. These are **ACC**, **BAC**, and **2AC**, corresponding to the Level 1, Level B, and Level 2 serial port access request commands. Use the right/left arrow keys and <SELECT> to choose.

The third display permits setting of the new password for the level selected. This is done in the same manner as for normal entering of the password. To set it, Push <SELECT> when the new password is displayed fully.

<CANCEL> may be used to return to an earlier menu. <EXIT> will abort the PASSWORD command and return to the default display.

PORT

This command is roughly equivalent to the SET P and SHO P serial port commands. When PORT is selected, a menu appears for selecting which of the four port setting groups to Show or Set. Use the right/left arrow keys and <SELECT> to choose. The next screen asks the user if he intends to **Set** or **Show** the settings. If Set, a password entry screen appears, if password protection is in force.

The next screen is either the **Set PORT n** or **Show PORT n** display (n = the port number), in which a message scrolls across the second line reminding the user to "Press TARGET RESET for help during set/show routine." This special use for the TARGET RESET button provides the user with a short description of the setting and the range of values, should the user not recognize

the setting by its Character string name. After the scroll, the first setting for the selected port appears in the second line of the display.

For example, the first setting **PROTO=SEL** appears. If the user does not recognize this setting, he can push the TARGET RESET button, and a single scroll across the first line will inform him that this is the “Protocol (SEL, LMD, DNP)” setting.

If we are in the Show mode, we can only observe the value. The **<SELECT>** button acts like a down arrow to move to the next setting. The up/down arrows themselves can be used to move within the list of settings.

If in the Set mode, we can choose to change the value by pushing **<SELECT>**. An underscore will appear under the first character of the value. If it has discrete values, like PROTO, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at the new value, push **<SELECT>** to enter the change.

When the complete list of settings has been shown or set, the display prompts for a **Save Changes? Y/N** choice. After the choice, it exits the PORT command and returns to the default display. **<CANCEL>** may be used to return to an earlier menu. **<EXIT>** will abort the PORT command and return to the default display.

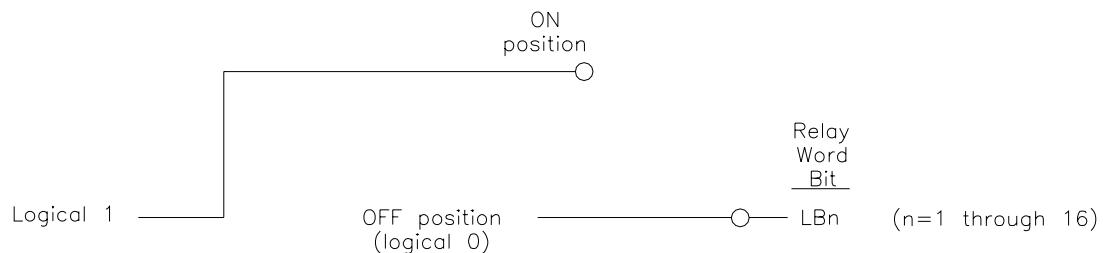
CNTRL

Use local control to enable/disable schemes, trip/close breakers, and so on, via the front panel.

Local Control

In more specific terms, local control asserts (sets to logical 1) or deasserts (sets to logical 0) local control switches referred to as local bits LB1 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC control equations.

Local control can emulate the following switch types in Figure 8.2 through Figure 8.4.



DWG. M351245

Figure 8.2: Local Control Switch Configured as an ON/OFF Switch

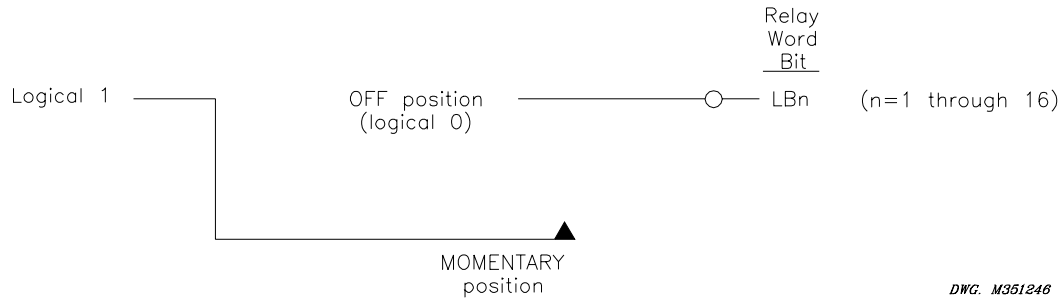


Figure 8.3: Local Control Switch Configured as an OFF/MOMENTARY Switch

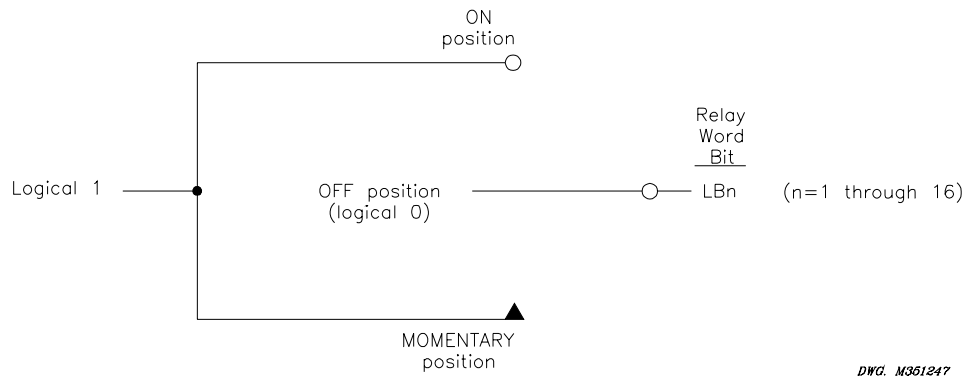


Figure 8.4: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Local control switches are created by making corresponding switch position label settings. These text label settings are set with the SET command or viewed with the SHO command via the serial port. Refer to ***SHO Command (Show/View Settings)*** in **Section 7: Serial Port Communications and Commands**.

Table 8.1: Correspondence Between Local Control Switch Positions and Label Settings

Switch Position	Label Setting	Setting Definition	Logic State
not applicable	NLBn	Name of Local Control Switch	not applicable
ON	SLBn	“Set” Local bit LBn	logical 1
OFF	CLBn	“Clear” Local bit LBn	logical 0
MOMENTARY	PLBn	“Pulse” Local bit LBn	logical 1 for one processing interval

Note the first setting in Table 8.1 (NLBn) is the overall switch name setting.

**Table 8.2: Correspondence Between Local Control Switch Types
and Required Label Settings**

Local Switch Type	Label NLBn	Label CLBn	Label SLBn	Label PLBn
ON/OFF	X	X	X	
OFF/MOMENTARY	X	X		X
ON/OFF/MOMENTARY	X	X	X	X

Disable local control switches by “nulling out” all the label settings for that switch. The local bit associated with this disabled local control switch is then fixed at logical 0.

Factory Settings Examples:

Local bits LB3 and LB4 are used in a few of the factory SELOGIC control equation settings for manual trip and close functions. Their corresponding local control switch position labels are set to configure the switches as OFF/MOMENTARY switches:

<u>Local Bit</u>	<u>Label Settings</u>	<u>Function</u>
LB3	NLB3 = MANUAL TRIP 1	trips breaker and drives reclosing relay to lockout
	CLB3 = RETURN	OFF position (“return” from MOMENTARY position)
	SLB3 =	ON position – not used (left “blank”)
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE 1	closes breaker, separate from automatic reclosing
	CLB4 = RETURN	OFF position (“return” from MOMENTARY position)
	SLB4 =	ON position – not used (left “blank”)
	PLB3 = CLOSE	MOMENTARY position

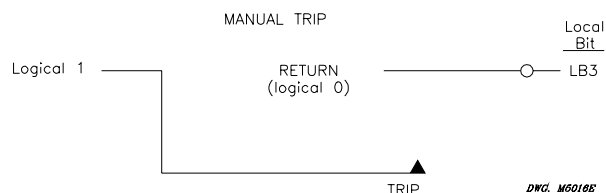
View Local Control (With Factory Settings)

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

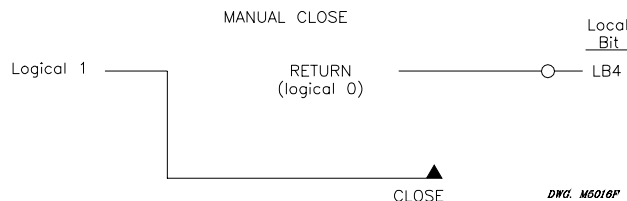
Press the CNTRL pushbutton, and the first set local control switch displays (shown here with factory default settings).

MANUAL TRIP 1 ←→
Position: RETURN



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

MANUAL CLOSE 1 ←→
Position: RETURN



The MANUAL TRIP 1: RETURN/TRIP and MANUAL CLOSE 1: RETURN/CLOSE switches are both OFF/MOMENTARY switches (see Figure 8.4).

There are no more local control switches in the factory default settings. Press the right arrow pushbutton and scroll to the “output contact testing” function.

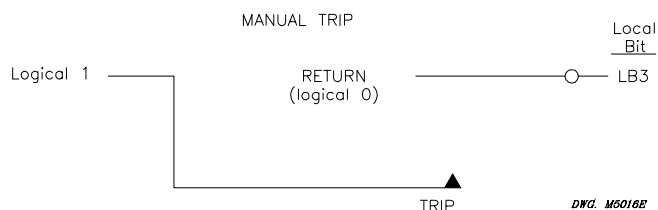
Output Contact ←→
Testing

This front-panel function provides the same function as the serial port PUL command.

Operate Local Control (With Factory Settings)

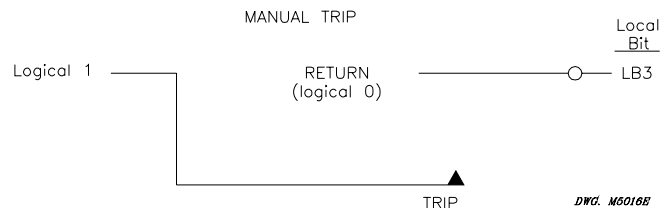
Press the right arrow pushbutton and scroll back to the first set local control switch in the factory default settings.

MANUAL TRIP 1 ←→
Position: RETURN

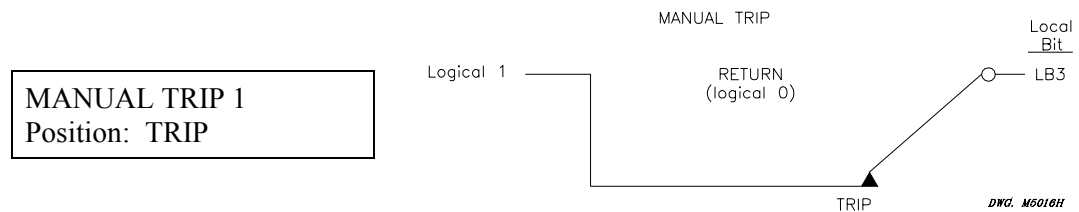


Press the SELECT pushbutton to display the operate option for the displayed local control switch.

MANUAL TRIP 1
TRIP ? Yes No ←→

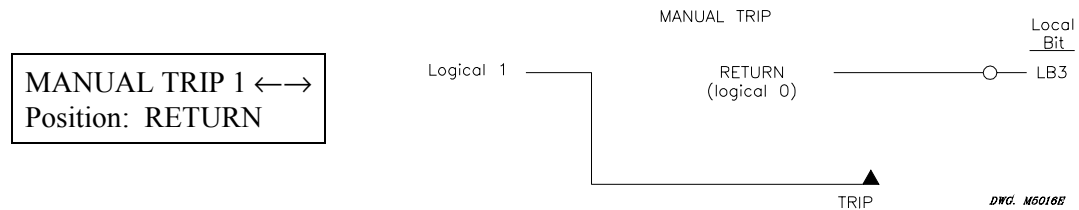


Scroll left with the left arrow button and then select “Yes” to show the new local control switch position.



Because this is an OFF/MOMENTARY type switch, the MANUAL TRIP 1 switch returns to the RETURN position after momentarily being in the TRIP position. Technically, the MANUAL TRIP 1 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 1 switch shows in the TRIP position for two seconds (long enough to be seen), and then it returns to the RETURN position.

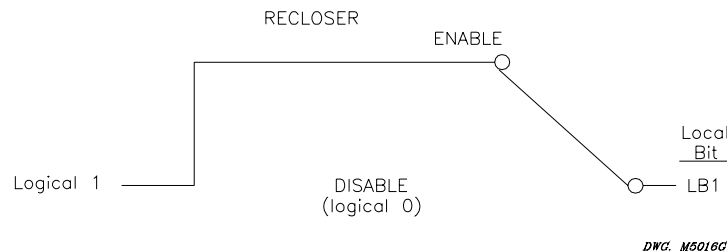


The MANUAL CLOSE 1 switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP 1 switch, and operates similarly.

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 8.2).



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

Pulse Output Contacts

Use the control button **<CTRL>** to mimic the **PULse**, **OPEn**, and **CLOse** serial port commands. This is useful during relay checkout to verify that output contacts actually function in response to a command.

Pulse Output Contacts are available in the **CTRL** menu after the Local Bit pushbutton functions. The screen will prompt for “**Pulse Close Open.**” Use the right/left arrow keys and **<SELECT>** to choose.

If **Pulse** is selected, the next screen will prompt for the output to be pulsed. These are **OUT101** to **OUT107** and **ALARM**. Use the up/down arrow keys and **<SELECT>** to choose. The display will follow with a Yes/No verification request. Again, use the up/down arrow keys and **<SELECT>** to choose.

The relay will pulse the output contact for one second then return to the contact selection screen in case there are more contacts to test. **<CANCEL>** will return to the main CNTRL menu. **<EXIT>** will abort the command and return to the default display.

Note: The CNTRL function, while useful during testing, should not be used while the relay is actually in service. During the one-second interval while contact OUT10X is being pulsed, all other OUT10Y contacts are frozen in their existing state and are not permitted to change. This could prevent a trip or other vital output from being issued during the pulse interval.

If **Close** is selected, the next screen prompts for the breaker (Bk1 to Bk4) to be closed. Use the right/left arrow keys and **<SELECT>** to choose, for example Bk1. The relay then asks “**Close Bkr 1? Yes No.**” Use the right/left arrow keys and **<SELECT>** to choose. If Yes, the relay asserts the CC1 Relay Word bit. If CC1 has been assigned to the CL1 Close Logic setting, the breaker will close. If No is selected, the relay returns to the Close menu.

If **Open** is selected, a sequence exactly like the one for Close takes place. If Yes is selected, the relay asserts Relay Word bit OC1 for Bkr 1, and if this bit has been assigned to the TR1 Trip Logic setting, the breaker will open. The **TRIP** front-panel LED will also light. It can be turned off by pushing the TARGET RESET button or by the TAR R serial port command.

Since all three CNTRL functions are legitimate event types, an Event Report will be triggered whenever any is activated. An automatic message will be sent to any port set to receive messages. If the contact outputs are listed as SER triggers, the contact assertion and deassertion will appear in the SER report, with time tags. Contact operate timing can thus be easily analyzed.

GROUP

The GROUP function is identical to the GRO and GRO n (n = 1 to 6) serial port commands.

When you select the **<GROUP>** button, the relay display shows “Active Group 1” (for example), and asks whether you wish to **Change** or **Exit**. Use the right/left arrow keys and **<SELECT>** to choose.

If Change is selected, the display shows **Change to Group** in the first line, and the present group number in the second line. Use the up/down arrows and **<SELECT>** to choose another group.

The relay will ask for a Yes/No verification of the change. Use the right/left arrow keys and **<SELECT>** to choose. The change will be made and the ALARM contact pulsed for one second if Yes is chosen, and if SS1 through SS6 are not asserted or not assigned. These group selection settings always take precedence over the Group command function.

<CANCEL> may be used to return to an earlier menu. **<EXIT>** will abort the command and return to the default display.

Secondary Function Review

The secondary button functions come into effect as soon as one of the buttons for the above primary functions has been pushed. These secondary functions remain in effect until a primary function has been completed, aborted, or exited and the display has returned to the default display. They will be discussed in the left to right order in which they appear on the front panel, below the horizontal line. The first button, TARGET RESET / LAMP TEST, has no secondary function except as a HELP key, explained earlier under the SET primary function.

CANCEL

The **<CANCEL>** button returns the display to the previous menu within a primary function. Use the **<CANCEL>** button to go back after issuing a **<SELECT>**. If there is no previous menu, the default display is shown. If the **<CANCEL>** button is pushed while in the default display mode, the relay interprets the button as the **<METER>** button.

SELECT

The **<SELECT>** button is used within primary function dialogues to select a menu choice. Once the choice has been identified with the arrow buttons, use the **<SELECT>** button to select that choice. If the **<SELECT>** button is pushed while in the default display mode, the relay interprets the button as the **<EVENTS>** button.

Arrows

The arrow buttons are used throughout the front-panel primary function displays for scrolling through lists of items, identifying menu choices by moving the cursor, and scrolling to the left or right for more information. If one of the arrow buttons is pushed while in the default display mode, the relay interprets the button according to the primary function. That is:

“left” = **<STATUS>**, “right” = **<OTHER>**, “up” = **<SET>**, and “down” = **<CNTRL>**.

EXIT

If you push the **<EXIT>** button at any time within one of the dialogues, the procedure is aborted and the display reverts to the default display. If the **<EXIT>** button is pushed while in the default display mode, the relay interprets the button as the **<GROUP>** button.

Pushbutton / Serial Port Equivalents

Table 8.3 summarizes the pushbutton functions and their approximate equivalents in serial port commands.

Table 8.3: Front-Panel Button Serial Port Equivalents

Button	Similar SEL-387 Serial Port Commands
TARGET RESET / LAMP TEST	TAR R
METER	MET, MET (D, DIF, P, SEC, RD, RP)
EVENTS	HIS
STATUS	STA
OTHER	DAT, TIM, TAR F, BRE, BRE R, RES
SET	SET, SET G, SET P, SHO, SHO G, SHO P, PAS
CNTRL	PUL, CLO, OPE
GROUP	GRO, GRO n

PROGRAMMABLE LEDA, LEDB, LEDC

Three of the LEDs in the second row may be programmed by the user by use of SELOGIC control equations. These settings appear under the FRONT PANEL section of the Global settings, accessible by the SHO G and SET G serial port commands. These settings can neither be seen nor changed from the front panel itself.

The factory default settings are as follows:

$$\mathbf{LEDA} = \mathbf{OCA} + 87\mathbf{E1} \quad \mathbf{LEDB} = \mathbf{OCB} + 87\mathbf{E2} \quad \mathbf{LEDC} = \mathbf{OCC} + 87\mathbf{E3}$$

The Relay Word bits OCA, OCB, and OCC indicate selection of Phase A, B, or C by the overcurrent elements for those respective phases. The Relay Word bits 87E1, 87E2, and 87E3 indicate Trips initiated by Differential Elements 1, 2, or 3, respectively. These correspond, essentially, to Phases A, B, and C. Thus, LEDA, LEDB, and LEDC are factory set to indicate either an overcurrent or differential selection of their respective phases as the ones involved in a fault. They are therefore labeled as “FAULT TYPE” LEDs.

It is probably best to leave these settings in place when the relay is in service so that observers of the front-panel labels will not be confused by seeing the LEDs lit for apparently no reason and being unable to verify why they are lit without having a serial port connection to the relay. For testing or other purposes, however, these programmable LEDs may be very helpful for identifying conditions, defined by SELOGIC control equations, which are of interest to the user.

ROTATING DEFAULT DISPLAY

Rotating default displays on the relay front panel replace indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as circuit breaker open/closed.

Traditional Indicating Panel Lights Replaced With Rotating Default Display

The indicating panel lights are not needed if the rotating default display feature in the SEL-387 Relay is used.

There are 16 of these default displays available in the SEL-387 Relay. Referred to as Display Points, each default display has available two complementary screens (e.g., BREAKER CLOSED and BREAKER OPEN). The settings for these Display Points are located in the FRONT PANEL area of the Global settings. They are viewable and settable from the serial ports, via the SHO G or SET G commands. Since they include SELOGIC control equations and variable text, they cannot be accessed from the front panel.

General Operation of Rotating Default Display Settings

SELOGIC control equations display point setting DPn (n = 1 through 16) controls the display of corresponding, complementary text settings:

DPn_1 (displayed when DPn = logical 1)

DPn_0 (displayed when DPn = logical 0)

Make each text setting through the serial port using the command **SET G**. View these text settings using the serial port command **SHO G**. These text settings are displayed in pairs on the SEL-387 Relay front-panel display in rotation. Global setting SCROLLD determines how long each pair is displayed. They must not be longer than 16 characters maximum. Any active Display Points take precedence as the default display over the standard scroll through the winding current values. Relay-generated messages, however, take precedence over the Display Points.

Below are some examples of how the Display Points may be used.

Circuit Breaker Status Indication Example

Make SELOGIC control equations display point setting DP2:

DP2 = IN102 (IN102 is assigned to the 52A2 function for Breaker 2)

Make corresponding, complementary text settings:

DP2_1 = BREAKER 2 CLOSED

DP2_0 = BREAKER 2 OPEN

Display point setting DP2 controls the display of the text settings.

Circuit Breaker Closed

The optoisolated input IN102 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

$$DP2 = IN102 = \text{logical } 1$$

This results in the display of corresponding text setting DP2_1 on the front-panel display.

BREAKER 2 CLOSED

Circuit Breaker Open

The optoisolated input IN1 is deenergized when the 52a circuit breaker auxiliary contact is open, resulting in:

$$DP2 = IN102 = \text{logical } 0$$

This results in the display of corresponding text setting DP2_0 on the front-panel display.

BREAKER 2 OPEN

Display Only One Message Example

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 = IN102	(52a circuit breaker auxiliary contact connected to input IN102)
DP2_1 = BREAKER 2 CLOSED	(displays when DP2 = logical 1)
DP2_0 =	(blank)

Circuit Breaker Closed

The optoisolated input IN102 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

$$DP2 = IN102 = \text{logical } 1$$

This results in the display of corresponding text setting DP2_1 on the front-panel display.

BREAKER 2 CLOSED

Circuit Breaker Open

The optoisolated input IN102 is deenergized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = IN102 = logical 0

Corresponding text setting DP2_0 is not set (it is “blank”), so no message is displayed on the front-panel display.

Scroll Lock Control of Front-Panel LCD

Select Scroll Lock

The rotating default display can be locked on a single screen. Access the scroll lock control with the OTHER pushbutton.

DATE	TIME	79
TAR BRK_MON LCD		

Select LCD for Scroll Lock Control mode. The rotating display will then appear, and the scroll mode reminder screen will appear every eight seconds for one second as a reminder that the display is in Scroll Lock Control mode.

Scroll lock OFF
SELECT to Lock

Stop Scrolling (Lock)

When in the Scroll Lock Control mode, press the SELECT key to stop display rotation. Scrolling can be stopped on any of the display point screens or on the current-meter display screen. While rotation is stopped, the active display is updated continuously so that current or display point changes can be seen. If no button is pressed for eight seconds, the reminder message will appear for one second, followed by the active screen.

Scroll lock ON
SELECT to Lock

Restart Scrolling (Unlock)

The SELECT key unlocks the LCD and resumes the rotating display.

Single Step

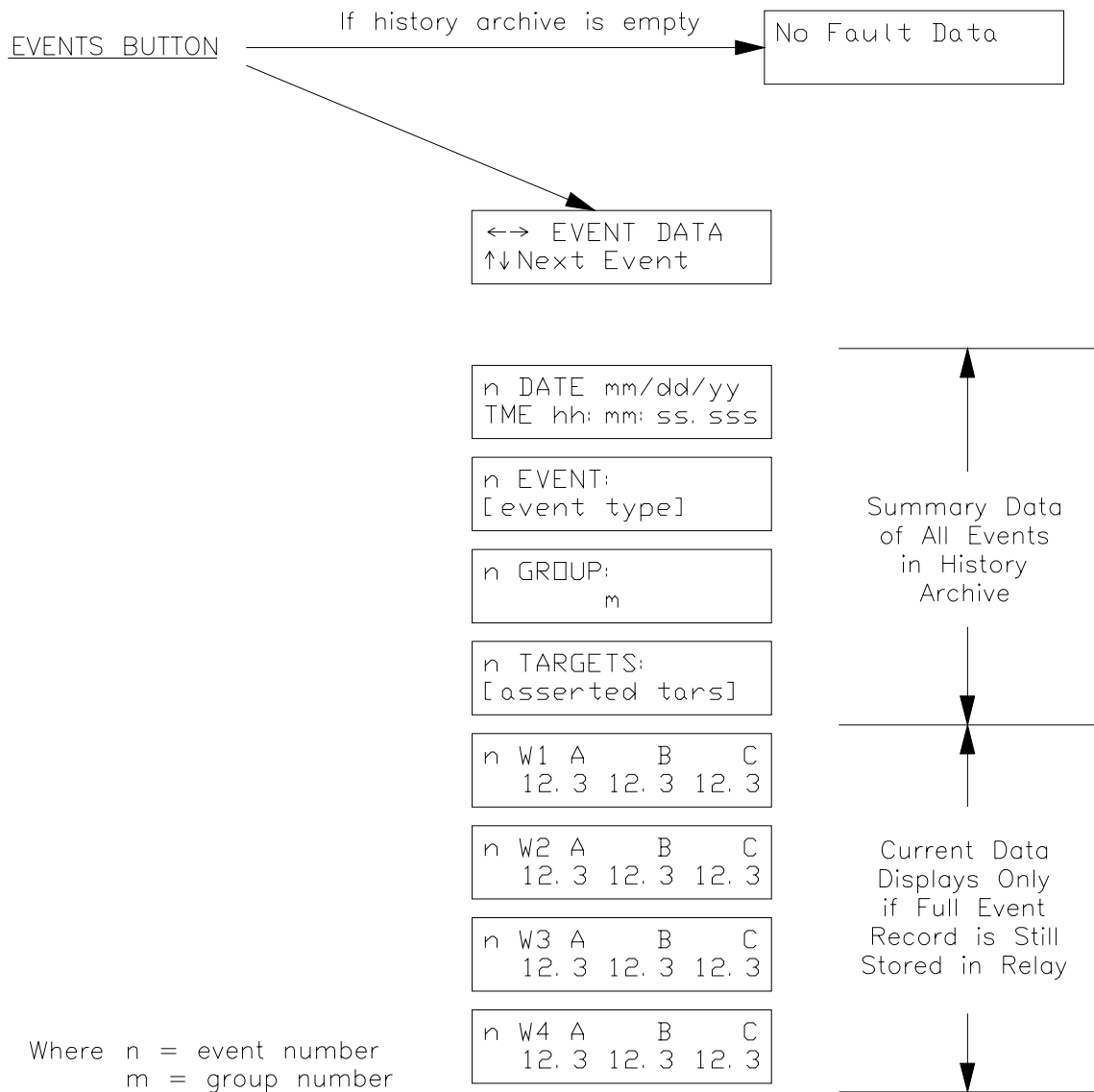
From the Scroll Locked state, single-step through the display screens by pressing the SELECT key twice. Wait for the first press to display the next screen as the active display, then press the SELECT key a second time to freeze scrolling.

Exit

Press the EXIT key to leave Scroll Lock Control and return the rotating display to normal operation.

The diagram illustrates the W1 Meter menu structure and its associated data screens. The main menu 'W1: Meter' is divided into four sections: INST, DEM, PKD, and SEC. The INST section displays various current and voltage readings (IAW1, IBW1, ICW1, 3I1W1, 3I2W1, IRW1). The DEM section is further divided into Demand and Peak Dem, each with a DISPLAY RESET option and a confirmation screen (W1 Reset Dem? and W1 Reset Peak). The SEC section shows the Station Battery VDC reading. The PKD section displays the Diff Quantity in Multiples of Tap, which includes various parameters like IOP1, IOP2, IOP3, IRT1, IRT2, IRT3, I1F2, I2F2, I3F2, I1F5, I2F5, I3F5. The diagram also shows a METER BUTTON at the top left and a W1 W4 box at the top right.

Figure 8.5: METER Menu and Display Structure



Where n = event number
m = group number

Note: If secondary currents > 99.9, drop the decimal place.

DWG: M3871010

Figure 8.6: EVENTS Display Structure

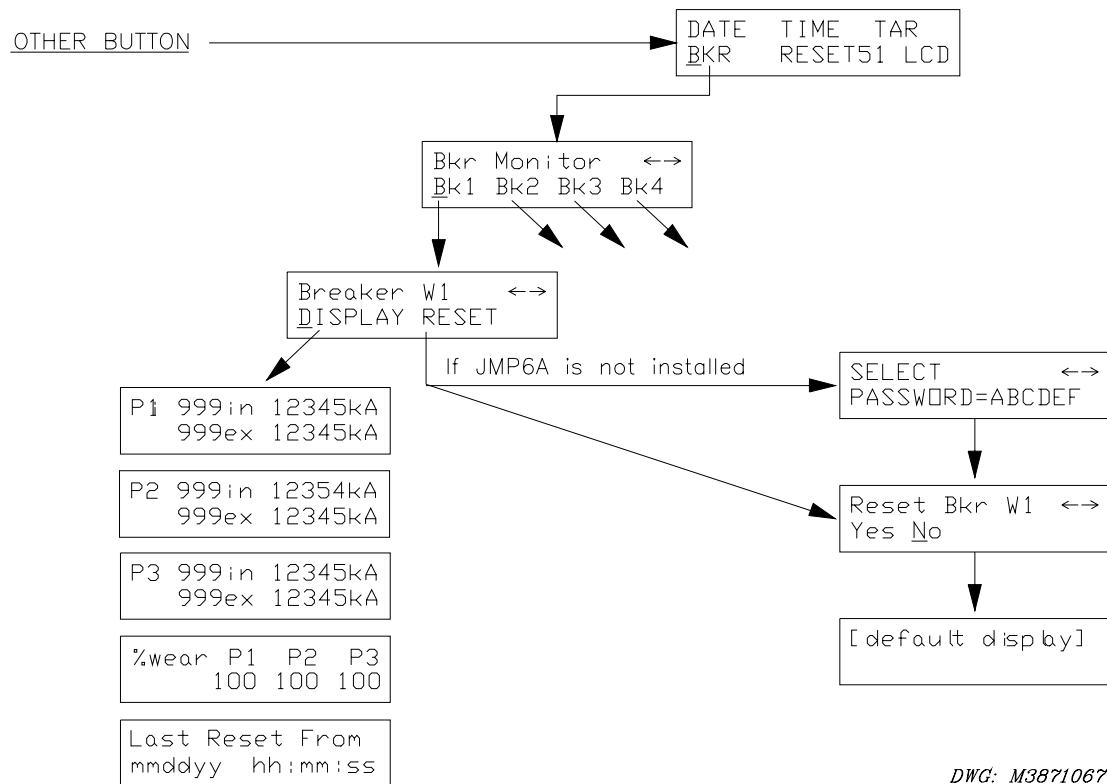


Figure 8.7: OTHER / BKR Menu and Display Structure

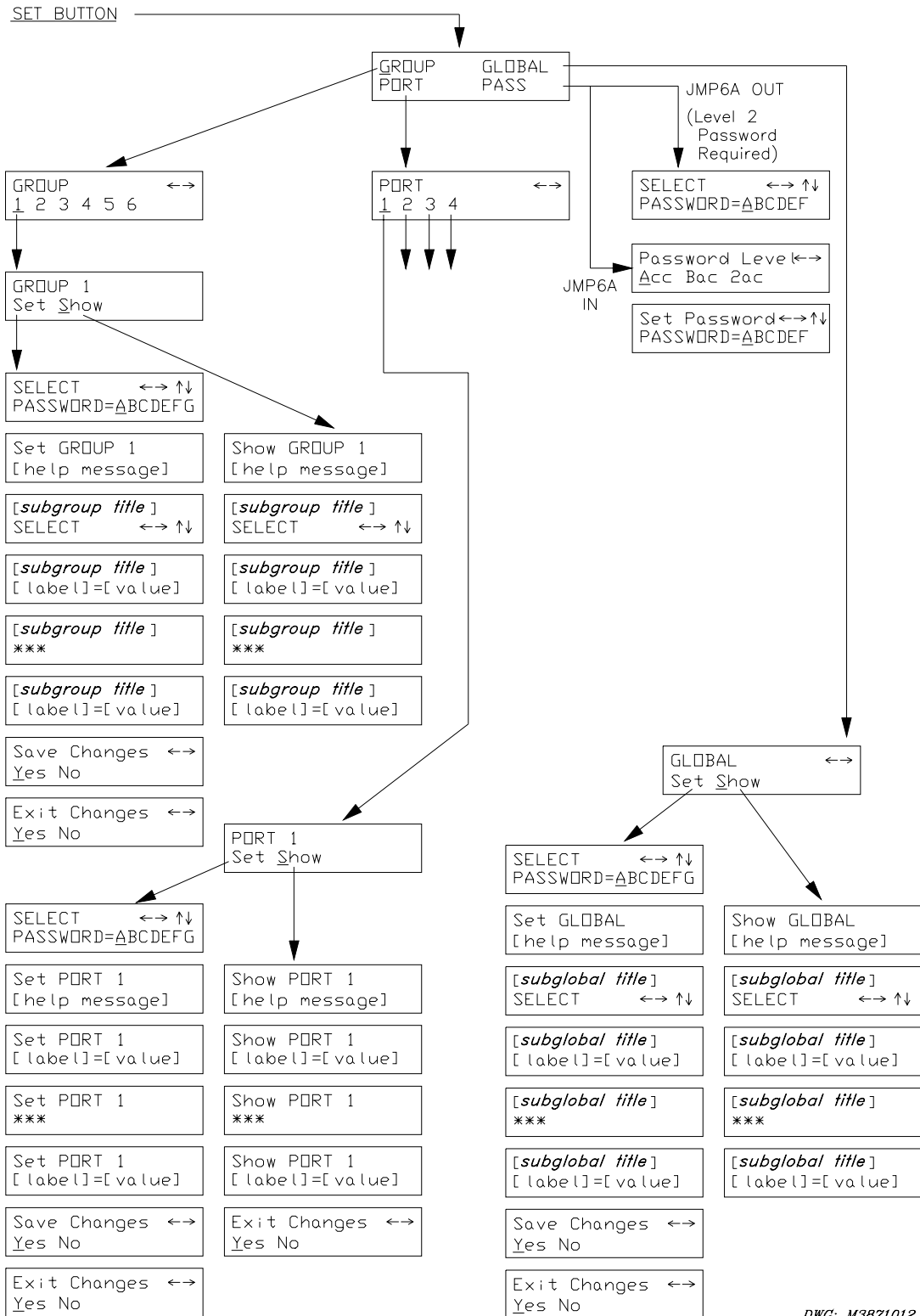


Figure 8.8: SET Menu and Display Structure

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SECTION 9: EVENT REPORTS AND SER

INTRODUCTION

The SEL-387 Relay offers two styles of event reports:

- Standard 15-, 30-, or 60-cycle event reports
- Sequential Events Recorder (SER) report

These event reports contain date, time, current, relay element, optoisolated input, and output contact information.

The relay generates (triggers) standard 15-, 30-, or 60-cycle event reports by fixed and programmable conditions. These reports show information for 15, 30, or 60 continuous cycles depending on the Global setting LER. The length of the pre-fault data contained in the event report is determined by the Global setting PRE. This setting allows for 1 to (LER-1) cycles of pre-fault data in each event report. The number of event reports stored in nonvolatile memory depends on the LER setting as follows:

<u>LER</u>	<u>Number of Event Reports Saved</u>
15	18–21
30	12–14
60	7

The number of events saved will be fewer if mixed lengths (e.g., LER = 60 for 3 event reports and then changed to LER = 30) are stored together or if the relay is subjected to frequent power-down/power-up cycles.

If the relay nonvolatile memory is full and another event is triggered, the latest event report will overwrite the oldest event report, and the oldest event report will be lost. See Figure 9.2 for an example standard 15-cycle event report.

The relay adds lines in the Sequential Events Recorder (SER) report by programmable conditions only. 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 9.8 for an example SER report.

STANDARD 15-, 30-, OR 60-CYCLE EVENT REPORTS

Event Report Length (Settings LER and PRE)

The SEL-387 Relay provides user-programmable event report length and pre-fault length. Event report length is set at 15, 30, or 60 cycles, using the Global setting LER. Pre-fault length ranges from 1 to (LER-1) cycles. Set the pre-fault length with the Global setting PRE. The LER and PRE settings are accessible either via the SET G serial port command or via the SET/GLOBAL front-panel pushbuttons.

Changing the LER and/or PRE settings has no effect on previously stored nonvolatile reports.

Standard Event Report Triggering

The relay triggers (generates) a standard 15-, 30-, or 60-cycle event report when any of the following occur:

- Relay Word bits TRIP1 through TRIP5 assert
- Relay Word bits CLS1 through CLS4 assert
- Programmable SELOGIC[®] control equation setting ER asserts to logical 1
- PULSE serial port/front-panel command executed for output contact OUT101 through OUT107 or other OUTnnn contacts if available
- TRIGGER serial port command executed

Relay Word Bits TRIP1–TRIP5, CLS1–CLS4

Relay Word bits TRIP_n ($n = 1, 2, 3, 4, \text{ or } 5$) usually would be assigned to an output contact for tripping a circuit breaker (e.g., setting OUT101 = TRIP1). SELOGIC control equation settings TR_n initiate the Trip Logic and control the assertion of Relay Word bits TRIP_n (see Figure 4.7). The Relay Word bit OC_m ($m = 1, 2, 3, 4$), initiated by the “Open breaker m ” serial port command OPE m or the front-panel CNTRL/Open command, normally would be assigned to TR_m.

Similarly, Relay Word bits CLS_m ($m = 1, 2, 3, 4$) would be assigned to an output contact for closing a circuit breaker (e.g., setting OUT105 = CLS1). SELOGIC control equations settings CL_m initiate the Close Logic and control the assertion of Relay Word bits CLS_m (see Figure 4.8). The Relay Word bit CC_m, initiated by the “Close breaker m ” serial port command CLO m or the front-panel CNTRL/Close command, normally would be assigned to CL_m.

Any condition that is set to trip in setting TR_n, or to close in setting CL_m, does not have to be entered in SELOGIC control equations setting ER. The assertion of Relay Word bit TRIP_n or CLS_m automatically triggers a standard 15-, 30-, or 60-cycle event report.

Programmable SELOGIC Control Equation Setting ER

The SELOGIC control equation setting ER is set to trigger standard 15-, 30-, or 60-cycle event reports for conditions other than tripping or closing conditions already listed in settings TR_n or CL_m. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if it is not already generating a report that encompasses the new transition). The factory setting is:

$$ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3$$

ER is factory-set with definite-time and inverse-time overcurrent element pickups for phase- and negative-sequence quantities on windings 1, 2, and 3. Thus, at the inception of a fault, which-ever pickup asserts first will trigger a standard 15-, 30-, or 60-cycle event report.

Note the rising-edge operator symbol (/) in front of each of these elements. See **Section 4: Control Logic** 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, then generating another event report later if a breaker trips on some time-delayed element.

PULSE and TRIGGER Commands

The PULSE serial port/front-panel command is used to assert the output contacts for testing purposes or for remote control. If an output contact OUT101–OUT107 or an available I/O board contact OUTnnn is asserted with the PULSE command, a standard 15-, 30-, or 60-cycle event report is also generated. Since the PUL command generates an event report, precautions should be taken to retrieve and store any existing event reports of interest that presently may be in the relay before testing the output contacts with the PUL command. Failure to do so may result in some or all of the existing reports being overwritten when PUL commands are issued.

The sole function of the TRIGGER serial port command is to generate standard 15-, 30-, or 60-cycle event reports primarily for testing purposes. Simply type **TRI<ENTER>** to execute the command.

See *Section 7: Serial Port Communications and Commands* for more information on serial port commands TRIGGER and PULSE.

Standard Event Report Summary

Each time the relay generates a standard 15-, 30-, or 60-cycle event report, it also generates a corresponding event summary (see Figure 9.1). Event summaries contain the following information:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Front-panel targets at the time of trip
- Phase (IA, IB, IC) currents for the four (4) winding inputs

This event summary information is also contained in the corresponding standard 15-, 30-, or 60-cycle event report. The identifiers, date, and time information is at the top of the standard 15-, 30-, or 60-cycle event report, and the other information follows at the end. See Figure 9.2.

The example event summary in Figure 9.1 corresponds to the full-length standard 15-cycle event report in Figure 9.2.

```
XFMR 1                      Date: 02/28/97    Time: 06:28:38.888
STATION A

Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4
```

Figure 9.1: Example Event Summary

Note: The relay sends event summaries to all serial ports with setting AUTO = Y each time an event triggers.

The latest 80 event summaries are stored in nonvolatile memory and are accessed by the HISTORY command. The HIS C command clears the event summaries and corresponding full-length standard event reports from nonvolatile memory. See the *HIS and HIS C Commands (History and History Clear)* in *Section 7: Serial Port Communications and Commands* for more information.

Event Type

The “Event:” field shows the event type. The possible event types and their descriptions are shown in Table 9.1. Note the correspondence to the preceding event report triggering conditions (see *Standard Event Report Triggering* in this section).

Table 9.1: Event Types

Event	Event Triggered by:
TRIP1	Assertion of Relay Word bit TRIP1
TRIP2	Assertion of Relay Word bit TRIP2
TRIP3	Assertion of Relay Word bit TRIP3
TRIP4	Assertion of Relay Word bit TRIP4
TRIP5	Assertion of Relay Word bit TRIP5
CLS1	Assertion of Relay Word bit CLS1
CLS2	Assertion of Relay Word bit CLS2
CLS3	Assertion of Relay Word bit CLS3
CLS4	Assertion of Relay Word bit CLS4
ER	SELOGIC control equations setting ER
PULSE	Execution of PULSE serial port command
TRIG	Execution of TRIGGER serial port command

The order of precedence for listing the event type in the summary is: TRIP, CLOSE, ER, PULSE, TRIG (as implied by the table). If more than one type of report trigger occurs within the same report period, the type of highest precedence will be shown in the “Event:” field of the report summary.

Targets

The target field shows all front-panel targets that were illuminated at the end of the triggered event report. The targets include: TRIP, INST, 87-1, 87-2, 87-3, 50, 51, A, B, C, N, W1, W2, W3, and W4.

Winding Currents

The “Winding n Currents (A Sec), ABC:” (n=1, 2, 3, or 4) field shows each winding input current present in the event report row containing the maximum secondary phase current. The standard 15-, 30-, or 60-cycle event report will mark the reference row used in the summary report with an asterisk. The listed currents for each of the four (4) winding inputs are:

Phase (A = channel IA, B = channel IB, C = channel IC)

Retrieving Full-Length Standard Event Reports

Any given event report has four different ways it can be displayed, depending on the particular serial port command issued to the relay. The command choices are shown below.

<u>Serial Port Command</u>	<u>Format</u>
EVENT	Winding event report.
EVENT C	Compressed ASCII event report.
EVENT D	Digital event report.
EVENT DIF	Differential event report.
EVENT R	Raw (unfiltered) winding event report.

Event (Winding Event Report)

The winding event report contains secondary phase currents for each of the four winding inputs as well as the status of the eight digital outputs and six optoisolated inputs.

Use the EVENT command to retrieve winding event reports. There are several options to customize the report format. The general command format is:

EVE [n, Sx, Ly[-[w]]] (parameters in [] are optional)

where:

- n = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx = Displays x samples per cycle (4 or 8); defaults to 4 if not listed
- Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed
- Ly- = Displays from cycle y to end of report
- Ly-w = Displays from cycle y to cycle w

Refer to Figure 9.2 for an example winding event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE<ENTER>** command.

XFMR 1												Date: 02/28/97		Time: 06:28:38.888	
STATION A															
FID=SEL-387-R102-V#####-D970226															
Winding 1			Winding 2			Winding 3			Winding 4			OUT	IN		
Amps Sec			Amps Sec			Amps Sec			Amps Sec			1357	135		
IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4	246A	246		
[1]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
[2]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	>....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	*....	...		
.	.	.	.	.	.	.	.	.	.	.	.	.	.		
[15]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5															
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4															
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4															

Figure 9.2: Example Winding Event Report

The trigger row includes a ‘>’ character following immediately after the last analog column to indicate the trigger point. A ‘*’ character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The ‘*’ character takes precedence over the ‘>’ character when both conditions occur for the same row.

Table 9.2 summarizes the event report current columns. The column headings shown are the default headings, corresponding to the designations on terminals Z01 to Z24. If the Analog Input Labels settings have been changed within the Global setting area, these will appear in the report as set.

Table 9.2: Winding Event Report Current Columns

Column Heading	Definition
IAW1	Current measured by winding 1 input channel IA (Amps, secondary)
IBW1	Current measured by winding 1 input channel IB (Amps, secondary)
ICW1	Current measured by winding 1 input channel IC (Amps, secondary)
IAW2	Current measured by winding 2 input channel IA (Amps, secondary)
IBW2	Current measured by winding 2 input channel IB (Amps, secondary)
ICW2	Current measured by winding 2 input channel IC (Amps, secondary)

Column Heading	Definition
IAW3	Current measured by winding 3 input channel IA (Amps, secondary)
IBW3	Current measured by winding 3 input channel IB (Amps, secondary)
ICW3	Current measured by winding 3 input channel IC (Amps, secondary)
IAW4	Current measured by winding 4 input channel IA (Amps, secondary)
IBW4	Current measured by winding 4 input channel IB (Amps, secondary)
ICW4	Current measured by winding 4 input channel IC (Amps, secondary)

The following table summarizes the winding event report output and input columns.

Table 9.3: Winding Event Report Output and Input Columns

Column Heading	Symbol	Definition
All	.	All indication deasserted
OUT 12	1 2 b	Output contact OUT101 asserted Output contact OUT102 asserted Both OUT101 and OUT102 asserted
OUT 34	3 4 b	Output contact OUT103 asserted Output contact OUT104 asserted Both OUT103 and OUT104 asserted
OUT 56	5 6 b	Output contact OUT105 asserted Output contact OUT106 asserted Both OUT105 and OUT106 asserted
OUT 7A	7 A b	Output contact OUT107 asserted Output contact ALARM asserted Both OUT107 and ALARM asserted
IN 12	1 2 b	Optoisolated input IN101 asserted Optoisolated input IN102 asserted Both IN101 and IN102 asserted
IN 34	3 4 b	Optoisolated input IN103 asserted Optoisolated input IN104 asserted Both IN103 and IN104 asserted
IN 56	5 6 b	Optoisolated input IN105 asserted Optoisolated input IN106 asserted Both IN105 and IN106 asserted

Event D (Digital Event Report)

The digital event report contains the status of the instantaneous, definite-time, and inverse-time overcurrent phase, single-phase, calculated residual, and negative-sequence overcurrent elements and the demand current thresholds for phase, calculated residual, and negative-sequence for each

of the four winding inputs. The status of the Relay Word bits TRIPn (n = 1, 2, 3, 4, and 5) as well as the status of the eight digital outputs and six optoisolated inputs are also included.

Use the EVENT D command to retrieve digital event reports. There are several options to customize the report format. The general command format is:

EVE D [n, Sx, Ly[-[w]]] (parameters in [] are optional)

where:

- n = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx = Displays x samples per cycle (4 or 8); defaults to 4 if not listed
- Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed
- Ly- = Displays from cycle y to end of report
- Ly-w = Displays from cycle y to cycle w

Refer to Figure 9.3 for an example digital event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE D<ENTER>** command.

```

XFMR 1                                     Date: 02/28/97  Time: 06:28:38.888
STATION A

FID=SEL-387-R102-V#####-D970226

Overcurrent Elements
Winding 1   Winding 2   Winding 3   Winding 4
50          51 50      51 50          51 50          51 51  DC TRP DEM   OUT IN
PPABCNNQQPNQ PPABCNNQQPNQ PPABCNNQQPNQ PPABCNNQQPNQ PNPNN PPNNQQ
123331212    123331212    123331212    123331212    CCCC 13 135 131313 1357 135
      444      444      444      444      1122 24 24 242424 246A 246
[1]
.....
.....
.....
.....
[2]
.....>
.....
.....*
.
.
.
[15]
.....
.....
.....
.....

Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4

```

Figure 9.3: Example Digital Event Report

The trigger row includes a ‘>’ character following immediately after the last digital column to indicate the trigger point. A ‘*’ character following immediately after the last digital column denotes that the designated row was used for the Event Summary currents. The ‘*’ character takes precedence over the ‘>’ character when both conditions occur for the same row.

The following table summarizes the digital event report columns.

Table 9.4: Digital Event Report Column Description

Column Heading	Symbol	Definition
All	.	All indication deasserted
Wdg 1 50P1	1 T	50P11 asserted 50P11T asserted
Wdg 1 50P2	2	50P12 asserted
Wdg 1 50A34	3 4 b	50A13 asserted 50A14 asserted 50A13 and 50A14 asserted
Wdg 1 50B34	3 4 b	50B13 asserted 50B14 asserted 50B13 and 50B14 asserted
Wdg 1 50C34	3 4 b	50C13 asserted 50C14 asserted 50C13 and 50C14 asserted
Wdg 1 50N1	1 T	50N11 asserted 50N11T asserted
Wdg 1 50N2	2	50N12 asserted
Wdg 1 50Q1	1 T	50Q11 asserted 50Q11T asserted
Wdg 1 50Q2	2	50Q12 asserted
Wdg 1 51P	p T r l .	51P1 asserted 51P1T asserted Timing to reset (51P1RS=Y) Timing to reset after 51P1T assertion (51P1RS=N) 51P1R asserted
Wdg 1 51N	p T r l .	51N1 asserted 51N1T asserted Timing to reset (51N1RS=Y) Timing to reset after 51N1T assertion (51N1RS=N) 51N1R asserted

Column Heading	Symbol	Definition
Wdg 1 51Q	p T r l .	51Q1 asserted 51Q1T asserted Timing to reset (51Q1RS=Y) Timing to reset after 51Q1T assertion (51Q1RS=N) 51Q1R asserted
Use same logic for overcurrent elements in Wdg 2, Wdg 3, and Wdg 4		
51PC1	p T r l .	51PC1 asserted 51PC1T asserted Timing to reset (51PC1RS=Y) Timing to reset after 51PC1T assertion (51PC1RS=N) 51PC1R asserted
51NC1	p T r l .	51NC1 asserted 51NC1T asserted Timing to reset (51NC1RS=Y) Timing to reset after 51NC1T assertion (51NC1RS=N) 51NC1R asserted
51PC2	p T r l .	51PC2 asserted 51PC2T asserted Timing to reset (51PC2RS=Y) Timing to reset after 51PC2T assertion (51PC2RS=N) 51PC2R asserted
51NC2	p T r l .	51NC2 asserted 51NC2T asserted Timing to reset (51NC2RS=Y) Timing to reset after 51NC2T assertion (51NC2RS=N) 51NC2R asserted
DC 12	1 2 b	DC1 asserted DC2 asserted DC1 and DC2 asserted
DC34	3 4 b	DC3 asserted DC4 asserted DC3 and DC4 asserted
TRP 12	1 2 b	TRIP1 asserted TRIP2 asserted TRIP1 and TRIP2 asserted
TRP 34	3 4 b	TRIP3 asserted TRIP4 asserted TRIP3 and TRIP4 asserted
TRP 5	5	TRIP5 asserted

Column Heading	Symbol	Definition
DEM P12	1 2 b	PDEM1 asserted PDEM2 asserted PDEM1 and PDEM2 asserted
DEM P34	3 4 b	PDEM3 asserted PDEM4 asserted PDEM3 and PDEM4 asserted
DEM N12	1 2 b	NDEM1 asserted NDEM2 asserted NDEM1 and NDEM2 asserted
DEM N34	3 4 b	NDEM3 asserted NDEM4 asserted NDEM3 and NDEM4 asserted
DEM Q12	1 2 b	QDEM1 asserted QDEM2 asserted QDEM1 and QDEM2 asserted
DEM Q34	3 4 b	QDEM3 asserted QDEM4 asserted QDEM3 and QDEM4 asserted
OUT 12	1 2 b	Output contact OUT101 asserted Output contact OUT102 asserted Both OUT101 and OUT102 asserted
OUT 34	3 4 b	Output contact OUT103 asserted Output contact OUT104 asserted Both OUT103 and OUT104 asserted
OUT 56	5 6 b	Output contact OUT105 asserted Output contact OUT106 asserted Both OUT105 and OUT106 asserted
OUT 7A	7 A b	Output contact OUT107 asserted Output contact ALARM asserted Both OUT107 and ALARM asserted
IN 12	1 2 b	Optoisolated input IN101 asserted Optoisolated input IN102 asserted Both IN101 and IN102 asserted
IN 34	3 4 b	Optoisolated input IN103 asserted Optoisolated input IN104 asserted Both IN103 and IN104 asserted
IN 56	5 6 b	Optoisolated input IN105 asserted Optoisolated input IN106 asserted Both IN105 and IN106 asserted

Event DIF (Differential Event Report)

The differential event report contains the operate and restraint currents in a given differential element along with the second- and fifth-harmonic content of the current. The status of the restrained and unrestrained differential elements, the fifth-harmonic alarm, the REF function, the Relay Word bits TRIPn (n = 1, 2, 3, 4, and 5), the SELOGIC control equation Timed Variables and Latch Bits, eight of the 16 Remote Bits, the eight digital outputs, and the six optoisolated inputs are shown.

Use the EVENT DIF command to retrieve differential event reports. There are several options to customize the report format. The general command format is:

EVE DIFz [n, Sx, Ly[-[w]]] (parameters in [] are optional)

where:

- z = Displays results for differential element z (z=1, 2, or 3)
- n = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx = Displays x samples per cycle (4 or 8); defaults to 4 if not listed
- Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed
- Ly- = Displays from cycle y to end of report
- Ly-w = Displays from cycle y to cycle w

Refer to Figure 9.4 for an example differential event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE DIF1<ENTER>** command.

XFMR 1				Date: 02/28/97 Time: 06:28:38.888											
STATION A															
FID=SEL-387-R102-V####-D970226															
				Differential				Set 1		Set 2		Set 3			
Differential Quantities				87	87B	HB	TR	TRP	LT	LT				OUT	IN
Multiples of TAP				R			HE	135	VVVV13	VVVV13	VVVVVVVV	1357	135		
IOP1	IRT1	IIF2	IIF5	U123	123	123	5F	24	123424	123424	12345678	246A	246		
[1]				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
[2]				123.12	123.12	123.12	123.12>	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12*	....	...	...	...	...	...	...	...
				.											
				.											
[15]				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
				123.12	123.12	123.12	123.12	....	...	...	...	...	...	...	...
Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5															
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4															
Winding 1 Currents (A Sec), ABCPQN:				123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4		
Winding 2 Currents (A Sec), ABCPQN:				123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4		
Winding 3 Currents (A Sec), ABCPQN:				123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4		
Winding 4 Currents (A Sec), ABCPQN:				123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4	123.4		

Figure 9.4: Example Differential Event Report

The trigger row includes a ‘>’ character following immediately after the last analog column to indicate the trigger point. A ‘*’ character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The ‘*’ character takes precedence over the ‘>’ character when both conditions occur for the same row.

The following table summarizes the event report current columns.

Table 9.5: Differential Event Report Current Columns

Column Heading	Definition
IOP1	Operate current for differential element 1 (multiples of tap)
IRT1	Restraint current for differential element 1 (multiples of tap)
IIF2	Second-harmonic current for differential element 1 (multiples of tap)
IIF5	Fifth-harmonic current for differential element 1 (multiples of tap)

The following table summarizes the digital event report columns.

Table 9.6: Differential Event Report Element Columns

Column	Symbol	Definition
All	.	All indication deasserted
Dif EI 87RU	R U b	87R asserted 87U asserted 87R and 87U asserted
Dif EI 87 1	R U b	87R1 asserted 87U1 asserted 87R1 and 87U1 asserted
Dif EI 87 2	R U b	87R2 asserted 87U2 asserted 87R2 and 87U2 asserted
Dif EI 87 3	R U b	87R3 asserted 87U3 asserted 87R3 and 87U3 asserted
Dif EI 87B 1	1 .	87BL1 asserted 87BL1 not asserted
Dif EI 87B 2	1 .	87BL2 asserted 87BL2 not asserted
Dif EI 87B 3	1 .	87BL3 asserted 87BL3 not asserted
Dif EI HB 1	2 5 b	2HB1 asserted 5HB1 asserted 2HB1 and 5HB1 asserted
Dif EI HB 2	2 5 b	2HB2 asserted 5HB2 asserted 2HB2 and 5HB2 asserted
Dif EI HB 3	2 5 b	2HB3 asserted 5HB3 asserted 2HB3 and 5HB3 asserted
TH5	p T	TH5 asserted TH5 asserted longer than TH5D
REF	p T 1 .	32IF*50G4*!REFP asserted (timing to trip) 32IF*50G4*REFP asserted (timed out) Timing 1 cycle to reset after REFP assertion Reset
TRP 12	1 2 b	TRIP1 asserted TRIP2 asserted TRIP1 and TRIP2 asserted

Column	Symbol	Definition
TRP 34	3 4 b	TRIP3 asserted TRIP4 asserted TRIP3 and TRIP4 asserted
TRP 5	5	TRIP5 asserted
Set 1 V1 V2 V3 V4	p T d	S1Vn asserted (timing to output) S1VnT asserted (timed out); S1Vn asserted S1VnT asserted, S1Vn deasserted (timing to reset)
Set 1 LT 12	1 2 b	Latch Bit 1 Latched Latch Bit 2 Latched Latch Bit 1 and Latch Bit 2 Latched
Set 1 LT 34	3 4 b	Latch Bit 3 Latched Latch Bit 4 Latched Latch Bit 3 and Latch Bit 4 Latched
Set 2 V1 V2 V3 V4	p T d	S2Vn asserted (timing to output) S2VnT asserted (timed out); S2Vn asserted S2VnT asserted, S2Vn deasserted (timing to reset)
Set 2 LT 12	1 2 b	Latch Bit 1 Latched Latch Bit 2 Latched Latch Bit 1 and Latch Bit 2 Latched
Set 2 LT 34	3 4 b	Latch Bit 3 Latched Latch Bit 4 Latched Latch Bit 3 and Latch Bit 4 Latched
Set 3 V1 V2 V3 V4 V5 V6 V7 V8	p T d	S3Vn asserted (timing to output) S3VnT asserted (timed out); S3Vn asserted S3VnT asserted, S3Vn deasserted (timing to reset)
RB 12	1 2 b	RB1 asserted RB2 asserted RB1 and RB2 asserted
RB 34	3 4 b	RB3 asserted RB4 asserted RB3 and RB4 asserted

Column	Symbol	Definition
RB 56	5 6 b	RB5 asserted RB6 asserted RB5 and RB6 asserted
RB 78	7 8 b	RB7 asserted RB8 asserted RB7 and RB8 asserted
OUT 12	1 2 b	OUT101 asserted OUT102 asserted OUT101 and OUT102 asserted
OUT 34	3 4 b	OUT103 asserted OUT104 asserted OUT103 and OUT104 asserted
OUT 56	5 6 b	OUT105 asserted OUT106 asserted OUT105 and OUT106 asserted
OUT 7A	7 A b	OUT107 asserted ALARM asserted OUT107 and ALARM asserted
IN 12	1 2 b	IN101 asserted IN102 asserted IN101 and IN102 asserted
IN 34	3 4 b	IN103 asserted IN104 asserted IN103 and IN104 asserted
IN 56	5 6 b	IN105 asserted IN106 asserted IN105 and IN106 asserted

Event R (Raw Winding Event Report)

The raw winding event report contains secondary phase currents for each of the four winding inputs as well as the status of the eight digital outputs and six optoisolated inputs. The SEL-387 Relay samples the analog ac input currents 64 times per power system cycle. The relay filters the samples to remove transient signals. The relay operates on the filtered values and reports them in most event reports. The raw or unfiltered event report allows for viewing the samples before digital filtering occurs.

Use the EVENT R command to retrieve raw winding event reports. There are several options to customize the report format. The general command format is:

EVE R [n, Sx, Ly[-[w]]] (parameters in [] are optional)

where:

- n = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx = Displays x samples per cycle (4, 8, 16, 32, or 64); defaults to 16 if not listed
- Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed
- Ly- = Displays from cycle y to end of report
- Ly-w = Displays from cycle y to cycle w

Refer to Figure 9.5 for an example raw winding event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE R S4<ENTER>** command. The raw event report always shows 1.5 cycles of pretrigger data, in this case six samples instead of four.

XFMR 1												Date: 02/28/97		Time: 06:28:38.888	
STATION A															
FID=SEL-387-R100-V#####-D970226															
Winding 1			Winding 2			Winding 3			Winding 4			OUT	IN		
Amps Sec			Amps Sec			Amps Sec			Amps Sec			1357	135		
IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4	246A	246		
[0]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
[1]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234>	....		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234*	....		
[2]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....		
.	.	.	.	.	.	.	.	.	.	.	.	.	.		
[15]															
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5															
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4															
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4															
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4															

Figure 9.5: Example Raw Winding Event Report

The trigger row includes a ‘>’ character following immediately after the last analog column to indicate the trigger point. A ‘*’ character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The ‘*’ character takes precedence over the ‘>’ character when both conditions occur for the same row.

The following table summarizes the raw event report current columns. The column headings shown are the default headings, corresponding to the designations on terminals Z01 to Z24. If the Analog Input Labels settings have been changed within the Global setting area, these will appear in the report as set.

Table 9.7: Raw Winding Event Report Current Columns

Column Heading	Definition
IAW1	Current measured by winding 1 input channel IA (Amps, secondary)
IBW1	Current measured by winding 1 input channel IB (Amps, secondary)
ICW1	Current measured by winding 1 input channel IC (Amps, secondary)
IAW2	Current measured by winding 2 input channel IA (Amps, secondary)
IBW2	Current measured by winding 2 input channel IB (Amps, secondary)
ICW2	Current measured by winding 2 input channel IC (Amps, secondary)
IAW3	Current measured by winding 3 input channel IA (Amps, secondary)
IBW3	Current measured by winding 3 input channel IB (Amps, secondary)
ICW3	Current measured by winding 3 input channel IC (Amps, secondary)
IAW4	Current measured by winding 4 input channel IA (Amps, secondary)
IBW4	Current measured by winding 4 input channel IB (Amps, secondary)
ICW4	Current measured by winding 4 input channel IC (Amps, secondary)

The following table summarizes the raw winding event report output and input columns.

Table 9.8: Raw Winding Event Report Outputs and Inputs

Column Heading	Symbol	Definition
All	.	All indication deasserted
OUT 12	1 2 b	Output contact OUT101 asserted Output contact OUT102 asserted Both OUT101 and OUT102 asserted
OUT 34	3 4 b	Output contact OUT103 asserted Output contact OUT104 asserted Both OUT103 and OUT104 asserted
OUT 56	5 6 b	Output contact OUT105 asserted Output contact OUT106 asserted Both OUT105 and OUT106 asserted

Column Heading	Symbol	Definition
OUT 7A	7	Output contact OUT107 asserted
	A	Output contact ALARM asserted
	b	Both OUT107 and ALARM asserted
IN 12	1	Optoisolated input IN101 asserted
	2	Optoisolated input IN102 asserted
	b	Both IN101 and IN102 asserted
IN 34	3	Optoisolated input IN103 asserted
	4	Optoisolated input IN104 asserted
	b	Both IN103 and IN104 asserted
IN 561	5	Optoisolated input IN105 asserted
	6	Optoisolated input IN106 asserted
	b	Both IN105 and IN106 asserted

Compressed ASCII Event Reports

The SEL-387 Relay provides compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 or the SEL-2030 Communications Processor and the SEL-5601 Analytic Assistant software take advantage of the compressed ASCII format. Use the EVE C command or the CEVENT command to display compressed ASCII event reports. See the CEVENT command discussion in *Appendix E: Compressed ASCII Commands* for further information.

Extracting RMS Phasor Data from Filtered Event Reports

Figure 9.6 and Figure 9.7 look in detail at one cycle of A-phase current (channel IA) from a typical filtered Event Report. Figure 9.6 shows how the event report ac current column data relates to the actual sampled waveform and RMS magnitude values. Figure 9.7 shows how the event report current column data can be converted to phasor RMS values.

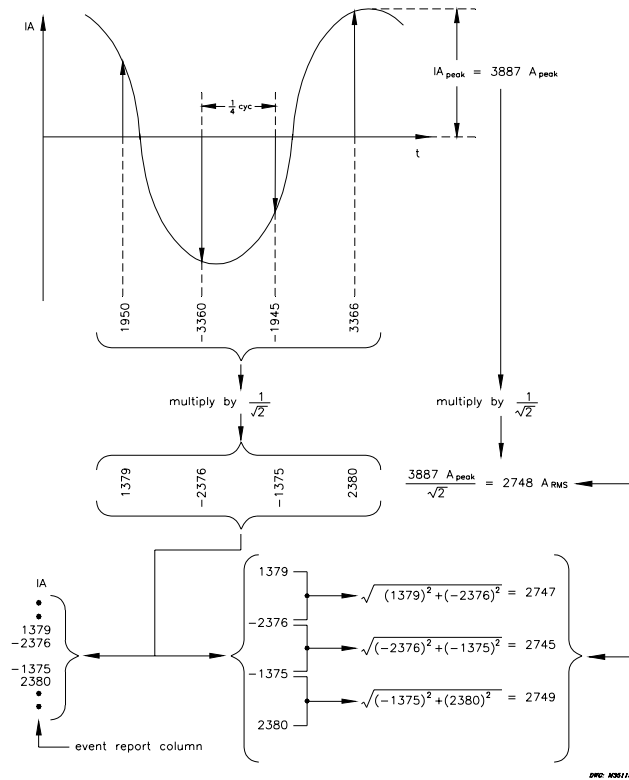


Figure 9.6: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In Figure 9.6, note that any two rows of current data from the event report that are one-quarter cycle apart, can be used to calculate RMS current values. One-quarter cycle represents 90 electrical degrees, hence the two samples are effectively perpendicular to each other and can be treated as rectangular components of the phasor quantity. By using the normal method of taking the square root of the sum of the squares of the samples, the magnitude of the phasor can be extracted. Since the actual sample values have been divided by the square root of two (multiplied by $1/\sqrt{2}$ in the drawing) before being entered into the report column, no further adjustment is needed after doing the magnitude calculation. In the example in Figure 9.6, successive pairs of samples result in magnitude calculations very close to the true value of 2748 A, RMS. The true RMS value is shown as $I_{A\_peak} \text{ times } 1/\sqrt{2} = 3887 \cdot 0.707 = 2748 \text{ A}$.

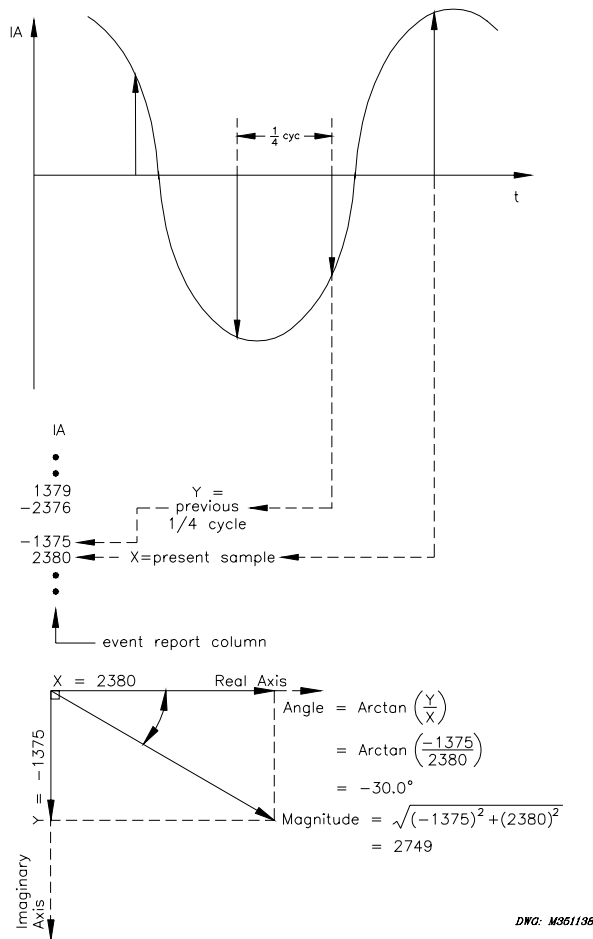


Figure 9.7: Derivation of Phasor RMS Current Values From Event Report Current Values

In Figure 9.7, note that two rows of current data one-quarter cycle apart can be used to calculate phasor RMS current values. At the time of interest, the present sample is used as the Real Axis, or “X” component, while the value from one-quarter cycle before is used as the Imaginary Axis, or “Y” component. Plotting the components as shown, and noting that the angle of the phasor is $\text{Arctan}(Y/X)$, the complete phasor quantity can be derived and compared with other current phasors calculated from other current pairs selected from the same two rows of the Event Report. In Figure 9.7 at the present sample the phasor RMS current value is:

$$IA = 2749 \text{ A } \angle -30.0^\circ$$

The present sample ($IA = 2380 \text{ A}$) is a real RMS current value that relates to the phasor RMS current value:

$$2749 \text{ A} \cdot \cos(-30.0^\circ) = 2380 \text{ A}$$

A calculation of the phasor using the previous pair, $X = -1375$ and $Y = -2376$, yields a calculation of:

$$IA = 2745 \text{ A } \angle -120.0^\circ$$

Thus, the phasor rotates in a counterclockwise direction in 90-degree increments, as expected, when successive pairs of samples are used for making the calculation.

SEQUENTIAL EVENTS RECORDER (SER) EVENT REPORT

Figure 9.8 demonstrates an example SER event report.

=>SER 2/26/97 2/27/97<ENTER>				
XFMR 1		Date: 03/13/97		Time: 18:27:42.091
STATION A				
FID=SEL-387-R102-V-D970226				
#	DATE	TIME	ELEMENT	STATE
4	2/26/97	10:33:54.873	TRIP3	Asserted
3	2/26/97	10:33:55.373	TRIP3	Deasserted
2	2/27/97	10:34:06.872	CLS3	Asserted
1	2/27/97	10:34:07.372	CLS3	Deasserted
=>				

Figure 9.8: Example SER Event Report

SER Event Report Row Triggering and ALIAS Settings

The relay triggers (generates) a row in the SER event report for any change of state in any one of the elements listed in the SER1, SER2, SER3, or SER4 trigger settings. Use port command SHO R to view the settings, or SET R to set them. The factory default settings are:

SER1 = IN101, IN102, IN103, IN104, IN105, IN106
SER2 = OUT101, OUT102, OUT103, OUT104, OUT105, OUT106, OUT107
SER3 = 0
SER4 = 0

The elements are Relay Word bits from Tables 4.7 to 4.9. Each element is looked at individually to see if it asserts or deasserts. Any assertion or deassertion of a listed element triggers a row in the SER event report. For example, setting SER1 contains all six of the optoisolated inputs. Any time dc voltage is applied to, or removed from, one of these inputs, a row is triggered in the SER event report.

In the SER settings are 20 settings by which the user can redefine the names of Relay Word bits in the SER report, to make the entries more readily identifiable to the user. The settings are ALIAS1 to ALIAS20. If they are not set, they are listed as, for example, ALIAS1=NA.

To rename a Relay Word bit with an ALIASn setting, use SET R to access the settings. For each “ALIASn =” setting, list the bit name; a separator, which can be one of the following characters: = ; : ‘ , / \ ? “; and then the desired name, which can include as many as 15 characters. For example, one setting might be ALIAS2 = CLS1 BKR1CLOSE. In the report instead of CLS1 being listed, the name BKR1CLOSE will appear, indicating a breaker 1 close operation was performed.

Note: Alias names can consist of all printable characters (including spaces).

In addition to the SERn trigger settings, if the relay is newly powered up or a settings change is made, a row is triggered in the SER event report with the message:

Relay newly powered up or settings changed

Each entry in the SER includes SER row number, date, time, element name, and element state. Generally, the rows are listed from top to bottom in chronological order, oldest first, to facilitate analyzing the sequence. The newest records have the lowest row numbers, the oldest records the highest row numbers.

Making SER Event Report Trigger Settings

Each SER trigger setting (SER1, SER2, SER3, or SER4) can be set with up to 24 elements (Relay Word bits from Tables 4.7 to 4.9). Thus, up to 96 total elements can be monitored for SER event report row triggering.

The SER settings can be made using spaces or commas as delimiters between elements. For example, if setting SER1 is made as follows:

SER1 = IN101,IN102 IN103,,IN104 , IN105, , IN106

The relay displays the settings as:

SER1 = IN101,IN102,IN103,IN104,IN105,IN106

Retrieving SER Event Report Rows

The latest 512 rows of the SER event report are stored in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. These lines are accessed with the SER command in the following different ways:

**Example SER
Serial Port
Commands**

Format

SER	If SER is entered with no numbers following it, all available rows are displayed (up to row number 512). They display with the oldest row at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 17	If SER is entered with a single number following it (17 in this example), the first 17 rows are displayed, if they exist. They display with the oldest row (row 17) at the beginning (top) of the report and the latest row (row 1) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 10 33	If SER is entered with two numbers following it (10 and 33 in this example; $10 < 33$), all the rows between (and including) rows 10 and 33 are displayed, if they exist. They display with the oldest row (row 33) at the beginning (top) of the report and the latest row (row 10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 47 22	If SER is entered with two numbers following it (47 and 22 in this example; $47 > 22$), all the rows between (and including) rows 47 and 22 are displayed, if they exist. They display with the newest row (row 22) at the beginning (top) of the report and the oldest row (row 47) at the end (bottom) of the report. <u>Reverse</u> chronological progression through the report is down the page and in ascending row number.
SER 3/30/96	If SER is entered with one date following it (date 3/30/96 in this example), all the rows on that date are displayed, if they exist. They display with the oldest row at the beginning (top) of the report and the latest row at the end (bottom) of the report, for the given date. Chronological progression through the report is down the page and in descending row number.
SER 2/17/96 3/23/96	If SER is entered with two dates following it (date 2/17/96 chronologically <u>precedes</u> date 3/23/96 in this example), all the rows between (and including) dates 2/17/96 and 3/23/96 are displayed, if they exist. They display with the oldest row (date 2/17/96) at the beginning (top) of the report and the latest row (date 3/23/96) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.

SER 3/16/96 1/5/96 If SER is entered with two dates following it (date 3/16/96 chronologically follows date 1/5/96 in this example), all the rows between (and including) dates 1/5/96 and 3/16/96 are displayed, if they exist. They display with the latest row (date 3/16/96) at the beginning (top) of the report and the oldest row (date 1/5/96) 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:

Invalid Record

If there are no rows in the SER event report buffer, the relay responds:

No SER data

Clearing SER Event Report Buffer

If the SER C command is entered, the relay prompts the operator for confirmation:

Clear SER Buffer
Are you sure (Y/N)?

If “Y” is entered, the relay clears the SER event reports from nonvolatile memory. If “N” is entered, no reports are cleared, and the relay responds:

Canceled

Note: Clear the SER Buffer With Care

Automated clearing of the SER buffer should be limited to reduce the possibility of wearing out the nonvolatile memory. Limit automated SER C commands to once per week or less.

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SECTION 10: TESTING AND TROUBLESHOOTING

INTRODUCTION

The Testing section should be used for determining and establishing test routines for the SEL-387 Relay. Included are discussions on testing philosophies, methods, and tools. Example test procedures are shown for the overcurrent elements, differential elements, harmonic blocking functions, Restricted Earth Fault protection, and metering. Relay troubleshooting procedures are shown at the end of the section.

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 in the test complexity.

The paragraphs below describe when each type of test is performed, 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.

TESTING METHODS AND TOOLS

Test Features Provided by the Relay

The following features assist you during relay testing.

METER Command	The METER command shows the currents presented to the relay in primary values. Compare these quantities against other devices of known accuracy.
EVENT Command	The relay generates an event report in response to faults or disturbances. Each report contains current information, relay element states, and input/output contact information. If you question the relay response or your test method, use the EVENT command to display detailed information.
TARGET, TARGET F Command	Use the TARGET n command to view the state of relay control inputs, relay outputs, and relay elements individually during a test.
SER Command	Use the Sequential Events Recorder for timing tests by setting the SER trigger settings (SER1, SER2, SER3, or SER4) to trigger for specific elements asserting or deasserting. View the SER with the SER command.
Programmable Outputs	Programmable outputs allow you to isolate individual relay elements. Refer to the SET command.

For more information on these features and commands, see *Section 7: Serial Port Communications and Commands*.

Low-Level Test Interface

The SEL-387 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: conventionally, by applying ac current signals to the relay inputs; 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 10.1 shows the low-level interface connections. 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 V peak-to-peak to the low-level test interface. Figure 10.1 shows the signal scaling factors.



CAUTION

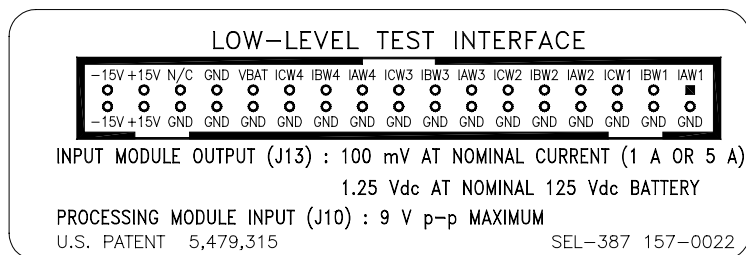
The relay contains devices that are sensitive to Electrostatic Discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

You can test the input module two different ways:

Measure the outputs from the input module with an accurate voltmeter and compare the readings to accurate instruments in the relay input circuits;

or

Replace the ribbon cable, press the front-panel <METER> button, and compare the relay readings to other accurate instruments in the relay input circuits.



DWG: M3871071

Figure 10.1: Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements using one of three methods: front-panel target LCD/LED indication, output contact operation, or the Sequential Events Recorder (SER).

Target LED Illumination

During testing use target LED illumination to determine relay element status. Using the TAR F command, set the front-panel targets to display the element under test. Monitor element pickup and dropout by observing the target LEDs.

For example, the winding 1 phase definite-time overcurrent element 50P11 appears in Relay Word Row 2. When you type the command **TAR F 50P11 <ENTER>**, the terminal displays the labels and status for each bit in the Relay Word row (2) and the LEDs display their status. Thus, with these new targets displayed, if the winding 1 phase definite-time overcurrent element (50P11) asserts, the far left LED illuminates. See **Section 4: Control Logic** for a list of all Relay Word elements.

Be sure to reset the front-panel targets to the default targets after testing before returning the relay to service. This can be done by pressing the front-panel **<TARGET RESET>** button or by issuing the **TAR R** command from the serial port.

Output Contact Operation

To test using this method, set one programmable output contact to assert when the element under test picks up. With the SET n command, enter the Relay Word bit name of the element under test.

For an “a” contact, when the condition asserts, the output contact closes. When the condition deasserts, the output contact opens.

For a “b” contact, when the condition asserts, the output contact opens. When the condition deasserts, the output contact closes.

Programmable contacts can be changed to “a” or “b” contacts with a solder jumper. Refer to **Section 2: Installation** for jumper locations. Using contact operation as an indicator, you can measure element operating characteristics, stop timers, etc.

Tests in this section assume an “a” output contact.

Sequential Events Recorder (SER)

To test using this method, set the SER to trigger for the element under test. With the SET R command, put the element name in the SER1, SER2, SER3, or SER4 setting.

Whenever an element asserts or deasserts, a time stamp is recorded. View the SER report with the SER command. The SER report will list the actual element name (Relay Word bit), unless this bit has been renamed using one of the ALIASn settings, in which case the ALIAS will appear in the report. Clear the SER report with the SER C command.

ACCEPTANCE TESTING

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

Goal:

- a) Ensure 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.

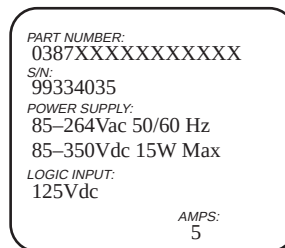
Equipment Required

The following equipment is necessary to perform all of the acceptance tests:

1. A terminal or computer with terminal emulation with EIA-232 serial interface
2. Interconnecting data cable between terminal and relay
3. Source of relay control power
4. Source of two currents at nominal frequency
5. Source of one current at two times and/or five times nominal frequency
6. Ohmmeter or contact opening/closing sensing device

Initial Checkout

- 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: Verify requirements for relay logic inputs, control power voltage level, and voltage and current inputs.
Method: Refer to the information sticker on the rear panel of the relay. Figure 10.2 provides an example. Check the information on this sticker before applying power to the relay or starting tests. Be sure your dc supply is correctly adjusted for the control and logic input requirements.



DWG: M3871072

Figure 10.2: Relay Part Number and Hardware Identification Sticker

Power Supply

- Step 1.** Purpose: Establish control power connections.
- Method: Connect a frame ground to terminal marked GND on the rear panel and connect rated control power to terminals marked + and -. Relays supplied with 125 or 250 V power supplies may be powered from a 115 Vac wall receptacle for testing. Other power supplies require dc voltage and are polarity sensitive.
- Step 2.** Purpose: Verify that +5 Vdc is presented on Ports 2 and 3. This voltage is sometimes required by external devices that include a dc powered modem.
- Method:
1. Execute the STATUS command from the serial port or front panel, and inspect the voltage readings for the power supply.
 2. Verify that JMP1 is installed for Serial Port 3 and JMP2 is installed for Serial Port 2. Refer to **Section 2: Installation** for further information about the jumpers.
 3. Use a voltmeter to read the +5 V output. Pin 1 of each port should have +5 Vdc on it when the jumpers mentioned above are installed.
 4. Compare the +5 V readings from the status report and voltmeter. The voltage difference should be less than 50 mV (0.05 V), and both readings should be within ± 0.15 V of 5 V.

Serial Communications

- Step 1.** Purpose: Verify the communications interface setup.
- Method: Connect a computer terminal to Ports 2, 3, or 4 of the relay.
- Communication Parameters: 2400 Baud, 8 Data Bits, 1 Stop Bit, N Parity
- Cables: SEL-C234A for 9-pin male computer connections
SEL-C227A for 25-pin male computer connections
- Step 2.** Purpose: Apply control voltage to the relay, and start Access Level 0 communications.
- Method: Apply control voltage to the relay. The enable target (EN) LED should illuminate. If not, be sure that power is present. Type **<ENTER>** from your terminal to get the Access Level 0 response from the relay. The = prompt should appear, indicating that you have established communications at Access Level 0.
- The ALARM relay should pull in, holding its “b” contacts open.
- If the relays pull in but your terminal does not respond with the equals sign, check the terminal configuration. If neither occurs, turn off the power, and refer to the Troubleshooting Guide later in this section.

The = prompt indicates that communications with the relay are at Access Level 0, the first of four possible levels. The only command accepted at this level is **ACC <ENTER>**, which opens communications on Access Level 1.

Note: If you are using a battery simulator, be sure the simulator voltage level is stabilized before turning the relay on.

Step 3. Purpose: Establish Access Level 1 communications.

Method: Type **ACC <ENTER>**. At the prompt, enter the Access Level 1 password **OTTER** and press **<ENTER>**. The => prompt should appear, indicating that you have established communications at Access Level 1.

Step 4. Purpose: Verify relay self-test status.

Method: Type **STA <ENTER>**. The following display should appear on the terminal: (**Note:** The current input names shown are the default values; any inputs renamed in the Analog Input Labels settings will appear as set.)

Step 5. Purpose: View factory settings entered before shipment.

Method: The relay is shipped with factory settings; type **SHO <ENTER>** to view the settings. **Section 6: Setting the Relay** includes a complete description of the settings. The terminal display should look similar to the following:

```

SHO<ENTER>
Group 1

RID      =XFMR 1
TID      =STATION A
E87W1    = Y      E87W2    = Y      E87W3    = Y      E87W4    = N
EOC1     = Y      EOC2     = Y      EOC3     = Y      EOC4     = N
EOCC     = N      ETHER    = Y      ESLS1    = N      ESLS2    = N
ESLS3    = N

W1CT     = Y      W2CT     = Y      W3CT     = Y      W4CT     = Y
CTR1     = 120    CTR2     = 240    CTR3     = 400    CTR4     = 400
MVA      = 100.0  ICOM     = Y
W1CTC    = 11     W2CTC    = 11     W3CTC    = 0
VWDG1    = 230.00 VWDG2    = 138.00 VWDG3    = 13.80

TAP1     = 2.09   TAP2     = 1.74   TAP3     = 10.46
O87P     = 0.3    SLP1     = 25     SLP2     = 50     IRS1     = 3.0
U87P     = 10.0   PCT2     = 15     PCT5     = 35
TH5P     = OFF    IHBL     = N

E32I     =0

Press RETURN to continue

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50P11P = 20.00 50P11D = 5.00 50P11TC = 1
50P12P = OFF
50P13P = 0.50 50P14P = 4.00
51P1P = 4.00 51P1C = U2 51P1TD = 3.00 51P1RS = Y
51P1TC = 1

50Q11P = OFF 50Q12P = OFF
51Q1P = 6.00 51Q1C = U2 51Q1TD = 3.00 51Q1RS = Y
51Q1TC = 1

50N11P = OFF 50N12P = OFF
51N1P = OFF
DATC1 = 15 PDEM1P = 7.00 QDEM1P = 1.00 NDEM1P = 1.00

50P21P = OFF 50P22P = OFF
50P23P = 0.50 50P24P = 3.50
51P2P = 3.50 51P2C = U2 51P2TD = 3.50 51P2RS = Y
51P2TC = 1

Press RETURN to continue

50Q21P = OFF 50Q22P = OFF
51Q2P = 5.25 51Q2C = U2 51Q2TD = 3.50 51Q2RS = Y
51Q2TC = 1

50N21P = OFF 50N22P = OFF
51N2P = OFF
DATC2 = 15 PDEM2P = 7.00 QDEM2P = 1.00 NDEM2P = 1.00

50P31P = 7.00 50P31D = 0.00 50P31TC = 1
50P32P = OFF
50P33P = 0.50 50P34P = 4.00
51P3P = 4.00 51P3C = U2 51P3TD = 1.30 51P3RS = Y
51P3TC = 1

50Q31P = OFF 50Q32P = OFF
51Q3P = OFF
50N31P = OFF 50N32P = OFF
51N3P = OFF

Press RETURN to continue

DATC3 = 15 PDEM3P = 7.00 QDEM3P = 1.00 NDEM3P = 1.00

TMWDG = 1 VWDG = 230 XTYPE = 3 TRTYPE = Y
THwr = 65 NCS = 1
MCS11 = 100.0
DTMP = 15 TRDE = 0
NTHM = 2 THM1 = AMB THM2 = OIL1
TOT1 = 100 TOT2 = 100 HST1 = 200 HST2 = 200
FAAL1 = 50.00 FAAL2 = 50.00 RLOLL = 50.00 TLOLL = 50.00
CSEP1 = 15
ILIFE = 180000 EDFTC = Y
TDURD = 9.000 CFD = 60.000

TR1 = 50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2 = 51P2T + 51Q2T + OC2
TR3 = 50P31 + 51P3T + OC3
TR4 = 87R + 87U
TR5 = 0

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ULTR1 =!50P13
ULTR2 =!50P23

Press RETURN to continue

ULTR3 =!50P33
ULTR4 =!(50P13 + 50P23 + 50P33)
ULTR5 =0
52A1 =IN101
52A2 =IN102
52A3 =IN103
52A4 =0
CL1 =CC1 + LB4 + /IN104
CL2 =CC2 + /IN105
CL3 =CC3 + /IN106
CL4 =0
ULCL1 =TRIP1 + TRIP4
ULCL2 =TRIP2 + TRIP4
ULCL3 =TRIP3 + TRIP4
ULCL4 =0
ER =/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101 =TRIP1
OUT102 =TRIP2
OUT103 =TRIP3
OUT104 =TRIP4

Press RETURN to continue

OUT105 =CLS1
OUT106 =CLS2
OUT107 =CLS3

OUT201 =0
OUT202 =0
OUT203 =0
OUT204 =0
OUT205 =0
OUT206 =0
OUT207 =0
OUT208 =0
OUT209 =0
OUT210 =0
OUT211 =0
OUT212 =0

SCEUSE 47.1
GR1CHK 9FAE

Outputs

- Step 1.** Purpose: Verify that contact outputs operate when you execute the PULSE command.
- Method:
1. Isolate all circuitry connected to the output contacts.
 2. Set the target LEDs to display the contact outputs by typing **TAR F OUT101 <ENTER>**. The front-panel LEDs should now follow Row 41 of the Relay Word where OUT101 is listed.
 3. Execute the PULSE n command for each output contact. Verify that the corresponding target LED illuminates and output contact closes for approximately one second. For example, type **PUL OUT101 <ENTER>** to test output contact OUT101.
 4. Repeat this step for each output. Use the TARGET F command to display the appropriate output elements.
- Step 2.** Purpose: Verify externally connected circuitry is operational.
- Method:
1. Isolate all circuitry connected to the output contacts except the circuit under test.
 2. Set the target LEDs to display the contact outputs by typing **TAR F OUT101 <ENTER>**. The bottom row of the front-panel LEDs will follow Row 41 of the Relay Word where OUT101 is listed.
 3. Execute the PULSE n command for each output contact. Verify that the corresponding target LED illuminates and output contact closes for approximately one second. For example, type **PUL OUT101 <ENTER>** to test output contact 101.
 4. Repeat this step for each output. Use the TARGET F command to display the appropriate output elements. Verify that the connected circuitry operates as expected.

Inputs

- Step 1.** Purpose: Verify that logic inputs assert when control voltage is applied across the respective terminal pair.
- Method:
1. Set the target LEDs to display the level-sensitive inputs by typing **TAR F IN101 <ENTER>**. The bottom row of the front-panel LEDs will follow logic inputs IN101 through IN106, which is Relay Word Row 27.
 2. Apply the appropriate control voltage to each input and make sure the corresponding target LED turns on.
 3. Repeat this step for each input. Use the TARGET F command to display the appropriate output elements.

Metering

- Step 1.** Purpose: Connect simulated power system secondary current sources to the relay.
- Method: Turn power off to the relay and connect current sources. If three current sources are available, connect them to the relay in a full three-phase connection, as shown in Figure 10.3. If only two current sources are available, connect the sources as shown in Figure 10.4 to generate balanced positive-sequence currents:
- Connect the A-phase and B-phase current sources to the dotted A and B current input terminals.
 - Connect both undotted A and B current input terminals to the undotted C current input terminal.
 - Connect the dotted C current input terminal to both the A and B current source returns.
- Set the current sources to deliver one ampere with A-phase at 0 degrees, B-phase lagging A-phase by 120 degrees, and C-phase leading A phase by 120 degrees.
- Step 2.** Purpose: Verify correct current levels.
- Method: Turn relay power on, and use the METER command to measure the currents applied in step 1. With applied currents of one ampere per phase and a current transformer ratio of 120:1 (**SHO CTR1 <ENTER>** displays the CT ratios for each winding, **<CTRL> X** cancels scrolling), the displayed line currents should be the applied current, 120 amperes $\pm 3\%$, ± 12 amperes.
- Step 3.** Purpose: Verify phase rotation.
- Method: Verify that residual (IR) and negative-sequence (3I2) quantities are approximately zero. If IR equals three times the applied current, all three phases have the same angle. If 3I2 equals three times the applied current, the phase rotation is reversed. Turn the current sources off.

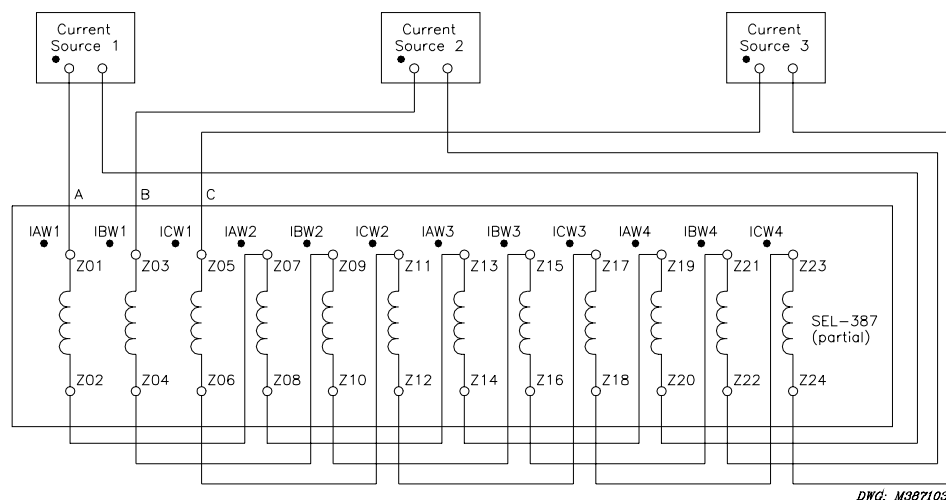


Figure 10.3: Test Connections for Balanced Load With Three-Phase Current Sources

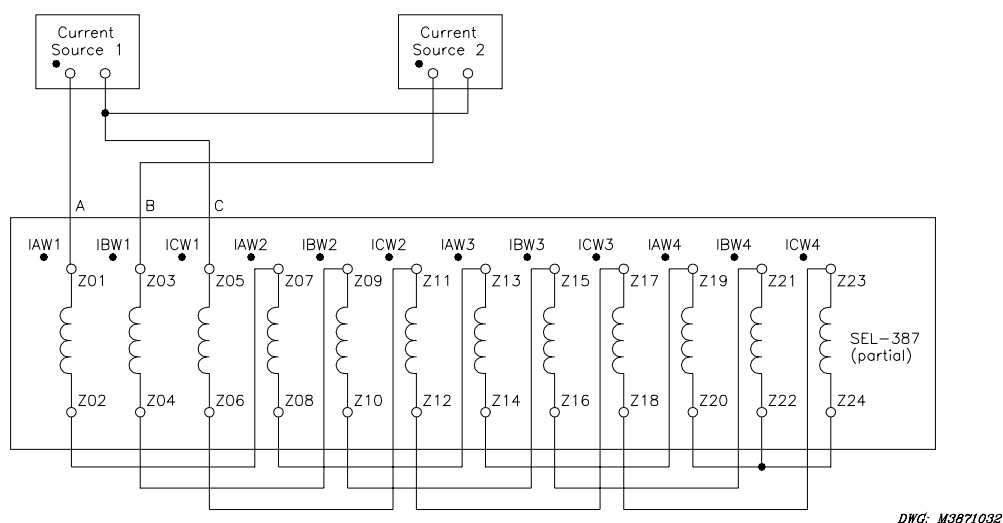


Figure 10.4: Test Connections for Balanced Load With Two-Phase Current Sources

Winding Overcurrent

Each winding overcurrent element that is to be tested must be enabled. Enable the overcurrent elements for a particular winding with the EOC1, EOC2, EOC3, and EOC4 settings for windings 1, 2, 3, and 4 respectively. By setting these to “Y” the overcurrent elements are enabled for the corresponding winding. The pickup settings for each overcurrent element must also be set to a pickup value. If they are not set to a value but are set to “OFF,” that particular overcurrent element is disabled.

Instantaneous Overcurrent Elements

Note: This example tests the winding 1 50P11 phase overcurrent element. Use the same procedure to test all instantaneous overcurrent elements for each winding.

- Step 1.** Purpose: Determine the expected instantaneous overcurrent element pickup value.
Method: Execute the SHO command via the relay front panel or serial port and verify the setting (i.e., **SHO 50P11P<ENTER>**).
- Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
Method: Execute the TARGET command (i.e., **TAR F 50P11<ENTER>**). The SEL-387 Relay now displays the state of several winding 1 overcurrent elements on the bottom row of front-panel LEDs.
- Step 3.** Purpose: Connect and apply a single current test source until the appropriate LED illuminates.
Method: Connect a single current test source (i.e., source 1) as shown in Figure 10.5. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the appropriate element asserts (i.e., 50P11), causing the LED to illuminate (i.e., left-most). Note the magnitude of the current applied. It should equal the 50P1P setting $\pm 5\%$ of the setting $\pm 0.02 I_{nom}$ (negative-sequence elements are $\pm 6\%$ of the setting $\pm 0.02 I_{nom}$).
- Step 4.** Purpose: Repeat test for each instantaneous overcurrent element for each winding.
Method: Repeat steps 1 through 3 for each instantaneous overcurrent element listed in Table 10.1 for each winding. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the TAR F command is issued.

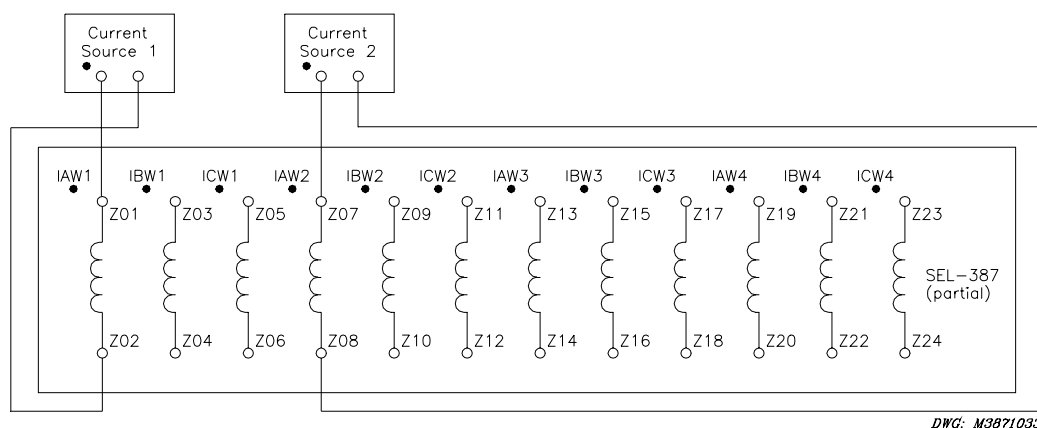


Figure 10.5: Test Connections for Two Single Current Test Sources

Table 10.1: Instantaneous Overcurrent Elements and Corresponding Settings

	Winding 1		Winding 2		Winding 3		Winding 4	
	Bit	Setting	Bit	Setting	Bit	Setting	Bit	Setting
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P	50P41	50P41P
Phase Level 2	50P12	50P12P	50P22	50P22P	50P32	50P32P	50P42	50P42P
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P	51P4	51P4P
A-Phase Level 3	50A13	50P13P	50A23	50P23P	50A33	50P33P	50A43	50P43P
B-Phase Level 3	50B13		50B23		50B33		50B43	
C-Phase Level 3	50C13		50C23		50C33		50C43	
Phase Level 3	50P13		50P23		50P33		50P43	
A-Phase Level 4	50A14	50P14P	50A24	50P24P	50A34	50P34P	50A44	50P44P
B-Phase Level 4	50B14		50B24		50B34		50B44	
C-Phase Level 4	50C14		50C24		50C34		50C44	
Phase Level 4	50P14		50P24		50P34		50P44	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P	50N41	50N41P
Residual Level 2	50N12	50N12P	50N22	50N22P	50N32	50N32P	50N42	50N42P
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P	51N4	51N4P
Neg-Seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P	50Q41	50Q41P
Neg-Seq Level 2	50Q12	50Q12P	50Q22	50Q22P	50Q32	50Q32P	50Q42	50Q42P
Neg-Seq Inverse-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P	51Q4	51Q4P

Definite-Time and Inverse-Time Overcurrent Elements

Note: This example tests the winding 1 51P1 phase inverse-time overcurrent element. Use the same procedure to test all definite-time and inverse-time overcurrent elements for each winding.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

- Method:
1. Execute the SHO command via the relay front panel or serial port and verify the time delay settings (i.e., **SHO 51P1<ENTER>**). The delay settings will follow the pickup settings when they are displayed.
 2. Calculate the time delay to pickup (tp). Definite-time elements will be equal to the delay setting (i.e., 50P11D setting for the 50P11 element). Inverse-time elements are calculated using three element settings and the operating time equations shown in **Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements**. TD is the time-dial setting (i.e., 51P1TD), and M is the applied multiple of pickup current.

For example, if 51P1P = 2.2 A, 51P1C = U3, and 51P1TD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M·51P1P = 6.6 A):

$$tp = TD \cdot \left(0.0963 + \frac{3.88}{M^2 - 1} \right)$$

$$tp = 2.33 \text{ seconds}$$

- Step 2.** Purpose: Set the Sequential Events Recorder to record the element timing.
- Method: Use **SET R SER1<ENTER>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 51P1, 51P1T). When prompted, set SER2, SER3, and SER4 to NA. Save the settings.
- Step 3.** Purpose: Connect and apply a single current test source at a level that is M times greater than the pickup (i.e., $2.2 \cdot M = 6.6 \text{ A}$ for this example).
- Method: Connect a single current test source as shown in Figure 10.5. Turn on the single current test source for the winding under test at the desired level.
- Step 4.** Purpose: Verify the operation times.
- Method: Type **SER<ENTER>** to view the SER. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings is recorded. Subtract the time from the assertion of the pickup (i.e., 51P1) to the assertion of the time-delayed element (i.e., 51P1T). SER C clears the SER records.
- Step 5.** Purpose: Repeat the test for each definite-time and inverse-time overcurrent element, for each winding.
- Method: Repeat steps 1 through 4 for each time element listed in Table 10.2 for each winding. Remember to set the SER for the appropriate elements and apply current to the appropriate winding.
- Note:** If the time-overcurrent element induction-disk reset emulation is enabled (i.e., 51P1RS= Y), the element under test may take some time to reset fully. If the element is not fully reset when you run a second test, the time to trip will be lower than expected. To reset all time-overcurrent elements before running additional tests, enter the **RESET <ENTER>** command from the relay serial port.

Table 10.2: Time-Delayed Overcurrent Elements and Corresponding Settings

	Winding 1		Winding 2		Winding 3		Winding 4	
	Bit	Setting	Bit	Setting	Bit	Setting	Bit	Setting
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P	50P41	50P41P
Definite-Time	50P11T	50P11D	50P21T	50P21D	50P31T	50P31D	50P41T	50P41D
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P	51P4	51P4P
Curve		51P1C		51P2C		51P3C		51P4C
Time-Dial		51P1TD		51P2TD		51P3TD		51P4TD
Time-Out	51P1T		51P2T		51P3T		51P4T	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P	50N41	50N41P
Definite-Time	50N11T	50N11D	50N21T	50N21D	50N31T	50N31D	50N41T	50N41D
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P	51N4	51N4P
Curve		51N1C		51N2C		51N3C		51N4C
Time-Dial		51N1TD		51N2TD		51N3TD		51N4TD
Time-Out	51N1T		51N2T		51N3T		51N4T	
Neg-Seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P	50Q41	50Q41P
Definite-Time	50Q11T	50Q11D	50Q21T	50Q21D	50Q31T	50Q31D	50Q41T	50Q41D
Neg-Seq Inv-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P	51Q4	51Q4P
Curve		51Q1C		51Q2C		51Q3C		51Q4C
Time-Dial		51Q1TD		51Q2TD		51Q3TD		51Q4TD
Time-Out	51Q1T		51Q2T		51Q3T		51Q4T	

Phase Overcurrent Elements

The SEL-387 Relay has many phase overcurrent elements. They all operate based on a comparison between the phase current directly applied to the winding inputs and the phase overcurrent setting. The elements that have a P as the third character of the element name operate when any one of the three phase currents exceed the phase current setting threshold. The elements that have an A, B, or C as the third character in the element name operate based on that phase current.

Test the instantaneous and time-delayed phase overcurrent elements by applying current to the inputs and comparing relay operation to the phase overcurrent settings. These tests were previously outlined in this section.

Negative-Sequence Overcurrent Elements

The SEL-387 Relay has 12 negative-sequence overcurrent elements. They all operate based on a comparison between a negative-sequence calculation of the three-phase inputs and the negative-sequence overcurrent setting. The negative-sequence calculation that is performed on the three-phase inputs is as follows:

$$3I_2 = A\text{-phase} + B\text{-phase (shifted by } -120^\circ) + C\text{-phase (shifted by } 120^\circ)$$

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $3I_2 = 0$ (load conditions).

For testing purposes, apply a single-phase current to the relay and the negative-sequence overcurrent elements will operate. For example, assume one ampere on A-phase and zero on B- and C-phases:

$$3I_2 = 1 + 0 \text{ (shifted } -120^\circ) + 0 \text{ (shifted } 120^\circ) = 1 \text{ (simulated ground fault condition)}$$

Test the instantaneous and time-delayed negative-sequence overcurrent elements by applying current to the inputs and comparing relay operation to the negative-sequence overcurrent settings. These tests were previously outlined in this section.

Residual Overcurrent Elements

The SEL-387 Relay has many residual overcurrent elements. They all operate based on a comparison between a residual calculation of the three-phase inputs and the residual overcurrent setting. The residual calculation that is performed on the three-phase inputs is as follows:

$$I_R = A\text{-phase} + B\text{-phase} + C\text{-phase (all angles are considered as well)}$$

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $I_R = 0$ (load conditions) because the currents cancel one another.

For testing purposes, apply a single-phase current to the relay and the residual overcurrent elements will operate. For example, assume one ampere on A-phase and zero on B- and C-phases:

$$I_R = 1 + 0 \text{ (shifted } 120^\circ) + 0 \text{ (shifted } -120^\circ) = 1 \text{ (simulated ground fault condition)}$$

Test the instantaneous and time-delayed residual overcurrent elements by applying current to the inputs and comparing relay operation to the residual overcurrent settings. These tests were previously outlined in this section.

Torque Control

SELOGIC[®] control equations are provided for various overcurrent elements (i.e., 51P1TC) that provide a torque control (required to be true for element operation). Follow the following procedure to test the torque-control equations.

- Step 1.** Purpose: Set the torque-control equation for the desired condition.
- Method: Execute the SET command via the relay serial port and set the desired torque-control equation to the desired condition. For a test example a digital input is used. Enter **SET 51P1TC<ENTER>**. When prompted, set 51P1TC to IN101. Note that the 51P1TC may be set to 1 (always asserted) or 0 (always deasserted) for testing instead of asserting an input.
- Step 2.** Purpose: Assert the torque-control equation.
- Method: Apply the appropriate conditions to assert the torque-control equation. For this test example, apply control voltage to IN101.
- Step 3.** Purpose: Display the appropriate Relay Word bit to verify the torque-control equation.
- Method: Execute the TARGET command (i.e., **TAR F IN101<ENTER>**). The SEL-387 Relay now displays the state of the six input elements in the second row of the front-panel LEDs. If multiple elements are used in the torque-control equation, several TARGET commands must be issued to view the individual elements.
- Step 4.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs for the desired overcurrent element.
- Method: Execute the TARGET command (i.e., **TAR F 51P1<ENTER>**). The SEL-387 Relay now displays the state of several overcurrent elements in the second row of the front-panel LEDs. The 51P1 bit is the fourth LED from the left.
- Step 5.** Purpose: Execute and verify an overcurrent test.
- Method: Referring to the overcurrent tests previously outlined in this section, execute an overcurrent test and verify its operation.
- Step 6.** Purpose: Verify that the torque-control equation disables the overcurrent element when deasserted.
- Method: Remove the torque-control conditions to deassert the torque-control equation. For this test example, remove control voltage from IN101. Reexecute the same overcurrent test and verify that it does not operate.

Combined Overcurrent Elements

The SEL-387 Relay has two sets of combined overcurrent elements. Set EOCC = Y to enable them. One set uses the sum of currents from windings 1 and 2, the other the sum of currents from windings 3 and 4. Each set has a phase overcurrent and a residual overcurrent element, both of which are inverse-time elements using the same curves as the similar winding 51 elements. The first set, for windings 1 and 2, consists of units 51PC1 and 51NC1; the other set, for windings 3 and 4, has units 51PC2 and 51NC2.

The test for the combined overcurrent elements is intended to simulate the application for these elements, namely a ring-bus or breaker-and-a-half scheme where two sets of CT inputs from two breakers are brought to the relay. These two inputs are for the same physical winding, whose current is the phasor sum of the two inputs.

The test configuration is that shown in Figure 10.5, with two sources delivering current to the same phase of windings 1 and 2, or windings 3 and 4.

The test below is for element 51PC1, utilizing windings 1 and 2 inputs. Set the pickup, curve, and time-dial values for this element as desired. The pickup should be set fairly low, at about one or two amperes. Disable the complementary 51NC1 element by setting 51NC1P to OFF.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

Method: Execute the SHO command via the relay front panel or serial port and verify the element settings (i.e., **SHO 51PC1P <ENTER>**). The pickup is 51PC1P, the curve type is 51PC1C, and the time dial is 51PC1TD.

Calculate the time delay to pickup (tp). Inverse-time elements are calculated using three element settings and the operating time equations shown in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements*. TD is the time-dial setting (i.e., 51PC1TD), and M is the applied multiple of pickup current.

For example, if 51PC1P = 2.2 A, 51PC1C = U3, and 51PC1TD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M·51PC1P = 6.6 A):

$$tp = TD \cdot \left(0.0963 + \frac{3.88}{M^2 - 1} \right)$$
$$tp = 2.33 \text{ seconds}$$

Step 2. Purpose: Set the Sequential Events Recorder to record the element timing.

Method: Use **SET R SER1<ENTER>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 51PC1, 51PC1T). When prompted, set SER2, SER3, and SER4 to NA. Save the settings.

Step 3. (For CTR1<CTR2).

Purpose: Connect and apply two single current test sources to create sufficient current to operate the 51PC1 element.

Method: Connect two single current test sources as shown in Figure 10.5. Set the IAW2 current at some fixed value, such as 10 A at angle zero degrees. Set the IAW1 current to a value equal to IAW2 · CTR2/CTR1 at 180 degrees. Since the phasor sum is zero, nothing will happen.

Execute the **TAR F 22** command. Relay Word bits 51PC1 and 51PC1T will appear in the second row of LEDs, in the A and B positions, during the tests. Before the test, LED C should be lit, representing bit 51PC1R (reset).

Slowly reduce IAW1 until the unit picks up, indicated by LED A. This should happen when $IAW1 \text{ equals } CTR2/CTR1 \cdot (IAW2 - 51PC1P)$. After verifying pickup, increase IAW1 back to $IAW2 \cdot CTR2/CTR1$. LED A will extinguish. Wait for LED C to reappear, indicating reset. Or, issue command RES to force a reset.

Suddenly reduce the current IAW1 to a value equal to $CTR2/CTR1 \cdot (IAW2 - M \cdot 51PC1P)$, where M is the desired multiple of pickup. Allow the unit to proceed to time-out, indicated by the lighting of LED B. (LED A will also be lit.)

(For $CTR2 < CTR1$).

Purpose: Connect and apply two single current test sources to create sufficient current to operate the 51PC1 element.

Method: Connect two single current test sources as shown in Figure 10.5. Set the IAW1 current at some fixed value, such as 10 A at angle zero degrees. Set the IAW2 current to a value equal to $IAW1 \cdot CTR1/CTR2$ at 180 degrees. Since the phasor sum is zero, nothing will happen.

Execute the **TAR F 22** command. Relay Word bits 51PC1 and 51PC1T will appear in the second row of LEDs, in the A and B positions, during the tests. Before the test, LED C should be lit, representing bit 51PC1R (reset).

Slowly reduce IAW2 until the unit picks up, indicated by LED A. This should happen when $IAW2 \text{ equals } CTR1/CTR2 \cdot (IAW1 - 51PC1P)$. After verifying pickup, increase IAW2 back to $IAW1 \cdot CTR1/CTR2$. LED A will extinguish. Wait for LED C to reappear, indicating reset. Or, issue command RES to force a reset.

Suddenly reduce the current IAW2 to a value equal to $CTR1/CTR2 \cdot (IAW1 - M \cdot 51PC1P)$, where M is the desired multiple of pickup. Allow the unit to proceed to time-out, indicated by the lighting of LED B. (LED A will also be lit.)

Step 4. **Purpose:** Verify the operation time.

Method: Type SER<ENTER> to view the SER records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings is recorded. Subtract the time of the assertion of the pickup (i.e., 51PC1) from the assertion time of the time-out bit (i.e., 51PC1T). This is the operate time. SER C clears the SER records.

Step 5. Purpose: Repeat the test for 51NC1, 51PC2, and 51NC2.

Method: Repeat steps 1 through 4 for the other elements. Remember to set the SER for the appropriate elements and apply current to the appropriate windings. Also remember to disable the pickup of the complementary element in each set, so that only the phase or residual element is being tested at one time.

Restricted Earth Fault (REF) Function

The test for the REF function is similar to that for the combined overcurrent element — using two current sources to inject current into two different windings. Small currents are used to demonstrate the sensitivity of the element to internal ground faults. The test assumes a 5 A relay is being used.

The settings for the REF function are these:

E32I = Enabling SELOGIC control equations. Set E32I = 1.

32IOP = Winding(s) for obtaining the Operate quantity. Set 32IOP = 1.

a0 = Positive-sequence restraint factor. Use default setting, a0 = 0.1.

50GP = Residual current sensitivity level. Use default setting, 50GP = 0.5A.

Recall that the default CT ratio settings are: CTR1 = 120, and CTR4 = 400.

Note: To use the setting 50GP = 0.5, be sure that the ratio CTRmax/CTR4 is not more than 2.0, where CTRmax is the greater of CTR1 or CTR4. Using the default CT ratio settings, CTRmax = CTR4, so the ratio CTRmax/CTR4 = 1. Therefore, the 50GP setting can remain at 0.5 A.

If the ratio CTRmax/CTR4 is greater than 2.0, set 50GP equal to 0.25 A times the actual ratio of CTRmax/CTR4.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

Method: Execute the SHO command via the relay front panel or serial port and verify the element settings (i.e., **SHO E32I <ENTER>**).

Calculate the time delay to pickup (tp). Inverse-time elements are calculated using three element settings and the operating time equations shown in **Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements**. TD is the time-dial setting, and M is the applied multiple of pickup current.

For example, 50GP = 0.5 A. The REF curve is type U4, extremely inverse. The time dial is fixed at 0.5. Only the IRW4 current is used for the time curve calculation. Setting IRW4 at 1 A represents a multiple of pickup of M = 2.0. We can use the equation below to calculate the expected operating time for curve U4 at M = 2, TD = 0.5:

$$t_p = TD \cdot \left(0.0352 + \frac{5.67}{M^2 - 1} \right)$$

$t_p = 0.963$ seconds

Step 2. Purpose: Set the Sequential Events Recorder to record the element timing.

Method: Use **SET R SER1<ENTER>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 50G4, 32IF, and REFP). When prompted, set SER2, SER3, and SER4 to NA. Save the settings.

Step 3. Purpose: Connect and apply two single current test sources to test the REF element.

Method: Connect two single current test sources as shown in Figure 10.5, but with source current 2 connected to one of the winding 4 inputs (e.g., IAW4). Set the IAW1 current magnitude to:

$$IAW1 \geq 2 \cdot 50GP \cdot CTR4/CTR1$$

Using the default CT ratios, IAW1 should be set to at least $2 \cdot 0.5 \text{ A} \cdot 400/120$, or 3.33 A. Set the magnitude of IAW1 to 4 A; set the angle of IAW1 to 180 degrees.

Set the IAW4 current at 1 A at zero degrees. Since the currents are opposite in phase, nothing should happen. Verify this as follows:

Execute the **TAR 21** command. Relay Word bits 50G4, 32IR, 32IF, and REFP are all in this row. With the currents applied as above, 50G4 should be 1, and REFP should remain at 0. Bit 32IR should be 1, indicating an external (reverse) fault. Bit 32IF should be 0.

Change the angle of IAW1 to zero degrees, or any value within about ± 80 degrees of IAW4. The REF element should function. Verify this as follows:

Execute the **TAR 21** command again. 50G4 should still be 1, REFP should be 1 (indicating time-out), 32IR should be 0, and 32IF should be 1 (indicating an internal, or forward, fault).

Step 4. Purpose: Verify the operation time.

Method: Type **SER<ENTER>** to view the SER records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings is recorded. Subtract the time of assertion of the directional element (32IF) from the assertion time of the time-out bit (REFP). This is the operate time, which should be about one second, as calculated above. (50G4 will have remained asserted from earlier in the test, since no change was made to the IAW4 current.) **SER C** clears the SER records.

Differential

The SEL-387 Relay has several components to its differential element. Figure 10.6 gives a representation of the differential characteristic and the plot of each test. Each test only uses winding 1 and winding 2 inputs. Any combination of two winding inputs may be used for the test. The differential elements for each winding must be enabled for each winding under test with the E87W1, E87W2, E87W3, and E87W4 settings. Set each setting equal to “Y” to enable the corresponding differential element.

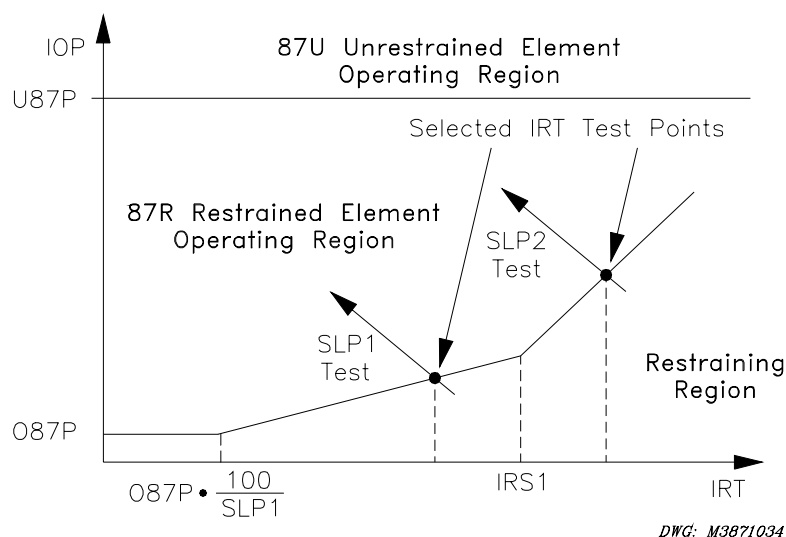


Figure 10.6: Percentage Restraint Differential Characteristic

U87P Unrestrained Differential Element

- Step 1.** Purpose: Verify the expected unrestrained differential element pickup setting.
- Method: Execute the SHO command via the relay front panel or serial port and verify the setting (i.e., **SHO U87P<ENTER>**). **Note:** This value is in per unit of tap.
- Step 2.** Purpose: Calculate the required current to pick up the unrestrained differential element.
- Method: Calculate the expected pickup for the 87U element by multiplying the U87P setting by the TAP1, TAP2, TAP3, or TAP4 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC, W2CTC, W3CTC, and W4CTC determine the A constant for the calculations. Use the corresponding TAPn and WnCTC settings for the winding under test.



CAUTION

The continuous rating of the current inputs is $3 \cdot I_{nom}$. For this test, it may be desirable to choose low values of U87P and TAPn, in order to limit the required test current to a safe value.

- Step 3.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the TARGET command (i.e., **TAR F 87U<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87U bit is the fourth from the left.
- Step 4.** Purpose: Connect and ramp a single current test source until the appropriate LED illuminates.
- Method: Connect a single current test source as shown in Figure 10.5. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87U element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 2, $\pm 5\% \pm 0.02 I_{nom}$.
- Step 5.** Purpose: Repeat the test for each phase for each winding if desired.
- Method: Repeat steps 1 through 4 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the TAR F command is issued.

Table 10.3: Connection Compensation Factor

WnCTC Setting	A
0	1
Odd: 1, 3, 5, 7, 9, 11	$\sqrt{3}$
Even: 2, 4, 6, 8, 10, 12	1.5

O87P Differential Element Pickup

- Step 1.** Purpose: Verify the expected restrained differential element minimum pickup setting.
- Method: Execute the SHO command via the relay front panel or serial port and verify the setting (i.e., **SHO O87P<ENTER>**). **Note:** This value is in per unit of tap.
- Step 2.** Purpose: Calculate the required current to pick up the restrained differential element.
- Method: Calculate the expected pickup for the 87R element by multiplying the O87P setting by the TAP1, TAP2, TAP3, or TAP4 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC, W2CTC, W3CTC, and W4CTC determine the A constant for the calculations. Use the corresponding TAPn and WnCTC settings for the winding under test.

- Step 3.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the TARGET command (i.e., **TAR F 87R<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.
- Step 4.** Purpose: Connect and ramp a single current test source until the appropriate LED illuminates.
- Method: Connect a single current test source as shown in Figure 10.5. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 2, $\pm 5\% \pm 0.02 I_{nom}$.
- Step 5.** Purpose: Repeat the test for each phase for each winding if desired.
- Method: Repeat steps 1 through 4 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the TAR F command is issued.

SLP1 Restrained Differential Threshold

- Step 1.** Purpose: Verify the differential characteristic settings and set winding compensation.
- Method: Execute the **SHO TAP1<ENTER>** command via the relay front panel or serial port and verify the (TAPn) settings, the Restraint Slope 1 Percentage (SLP1) setting, the Restraint Slope 2 Percentage (SLP2) setting, the restraint current slope 1 limit (IRS1) setting, and the O87P minimum pickup setting.
- Execute the **SET W1CTC<ENTER>** command and set the WnCTC settings for the two windings to be used to the same value (0, 1, ..., 12). Save the settings.
- Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the TARGET command (i.e., **TAR F 87R<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

Step 3. Purpose: Select a test point on the percentage differential curve in Figure 10.6.

Method: Decide where you want to cross the differential characteristic by picking a restraint value IRT which is a vertical line on the graph. Since this test is for the SLP1 threshold, select a point above the O87P intersection point and below IRS1. If SLP2 = OFF, IRS1 and SLP2 are not functional.

$$O87P \cdot 100 / SLP1 < \mathbf{IRT} < IRS1$$

The value of IOP corresponding to the selected IRT equals the following:

$$IOP = \frac{SLP1}{100} \cdot IRT$$

Both IRT and IOP are in multiples of tap.

Step 4. Purpose: Calculate the expected current for winding 1 and winding 2 at the restrained differential element SLP1 threshold for the test point selected above.

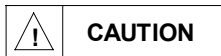
Method: Calculate the winding 1 current for the test using the following formula:

$$IAW1 = IRT \cdot \left(1 + \frac{SLP1}{200} \right) \cdot TAP1 \cdot A$$

Calculate the winding 2 current for the test using the following formula:

$$IAW2 = IRT \cdot \left(1 - \frac{SLP1}{200} \right) \cdot TAP2 \cdot A$$

The A connection compensation constant is based on Table 10.3. Since the windings have the same WnCTC setting, the A constant will be the same for both windings. The A constant must be used to achieve the exact curve point on which we have based the calculations. The TAPn settings can be different for the two windings.



CAUTION

The continuous rating of the current inputs is $3 \cdot I_{nom}$. If any currents in this test will exceed this rating, reduce the TAPn values as needed, to prevent possible damage to the input circuits.

Step 5. Purpose: Calculate the initial current for winding 2 for this test.

Method: Calculate the winding 2 initial current for the test using the following formula:

$$IAW2 = IAW1 \cdot \frac{TAP2}{TAP1}$$

This formula determines the current necessary for $IOP = 0$ given the IAW1 calculated above.

- Step 6.** Purpose: Connect a single current test source to A-phase of winding 1 and a single current test source to A-phase of winding 2. Ramp down winding 2 current until the appropriate LED illuminates.
- Method: Connect the two current test sources as shown in Figure 10.5. Turn on the current test source for A-phase of winding 1 (IAW1) at the value calculated above, **and set the phase angle at zero degrees**. Turn on the current test source for A-phase of winding 2 (IAW2) at the calculated initial current **and set the phase angle at 180 degrees**. Slowly decrease the magnitude of IAW2 until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 4 $\pm 5\% \pm 0.02 I_{nom}$.
- Step 7.** Purpose: Repeat the test for each phase for each winding if desired.
- Method: Repeat steps 1 through 6 for each phase. Remember to view the appropriate TARget and apply currents to the appropriate windings. The computer terminal will display the LED labels from left to right when the TAR F command is issued.

Note: IRS1 must be greater than $\frac{100}{SLP1} \cdot 087P7$ if SLP2 is not set to OFF.

SLP2 Restrained Differential Threshold

- Step 1.** Purpose: Verify the differential characteristic settings and set winding compensation.
- Method: Execute the **SHO TAP1<ENTER>** command via the relay front panel or serial port and verify the (TAPn) settings, the Restraint Slope 1 Percentage (SLP1) setting, the Restraint Slope 2 Percentage (SLP2) setting, and the restraint current slope 1 limit (IRS1) setting.
- Execute the **SET W1CTC<ENTER>** command and set the WnCTC settings for the two windings to be used to the same value. Save the settings.
- Note:** For this test, use only WnCTC=0 or WnCTC= an odd-numbered setting (1, 3, 5, 7, 9, 11). Depending on the value of IRT selected in step 3 below, the even-numbered settings may produce 87R outputs from 87R-2 and 87R-3 before the calculated slope 2 current (below) reaches the curve value for 87R-1. This could lead to erroneous conclusions about the accuracy of the 87R elements.
- Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the TARGET command (i.e., **TAR F 87R<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

Step 3. Purpose: Select a test point on the percentage differential curve in Figure 10.6.

Method: Decide where you want to cross the differential characteristic by picking a restraint value IRT which is a vertical line on the graph. Since this test is for the SLP2 threshold, select a point above the IRS1 setting.

$$\mathbf{IRT > IRS1}$$

The value of IOP that corresponds to the selected IRT is as follows:

$$IOP = \frac{SLP2}{100} \cdot IRT + IRS1 \cdot \left(\frac{SLP1 - SLP2}{100} \right)$$

Both IRT and IOP are in multiples of tap.

Step 4. Purpose: Calculate the expected current for winding 1 and winding 2 at the restrained differential element SLP2 threshold for the test point selected above.

Method: Calculate the winding 1 current for the test using the following formula:

$$IAW1 = \left(IRT \cdot \left(1 + \frac{SLP2}{200} \right) + IRS1 \cdot \left(\frac{SLP1 - SLP2}{200} \right) \right) \cdot TAP1 \cdot A$$

Calculate the winding 2 current for the test using the following formula:

$$IAW2 = \left(IRT \cdot \left(1 - \frac{SLP2}{200} \right) - IRS1 \cdot \left(\frac{SLP1 - SLP2}{200} \right) \right) \cdot TAP2 \cdot A$$

The A connection compensation constant is based on Table 10.3. Since the windings have the same WnCTC setting, the A constant will be the same for both windings. The A constant must be used to achieve the exact curve point on which we have based the calculations. The TAPn settings can be different for the two windings.



CAUTION

The continuous rating of the current inputs is $3 \cdot I_{nom}$. If any currents in this test will exceed this rating, reduce the TAPn values as needed, to prevent possible damage to the input circuits.

Step 5. Purpose: Calculate the initial current for winding 2 for this test.

Method: Calculate the winding 2 initial current by multiplying the winding 2 expected current calculated above by 110 percent.

$$IAW2 \text{ (initial)} = 1.1 \cdot IAW2 \text{ (from step 4)}$$

- Step 6.** Purpose: Connect a single current test source to A-phase of winding 1 and a single current test source to A-phase of winding 2. Ramp down winding 2 current until the appropriate LED illuminates.
- Method: Connect the two current test sources as shown in Figure 10.5. Turn on the current test source for A-phase of winding 1 (IAW1) at the value calculated above **and set the phase angle to zero degrees**. Turn on the current test source for A-phase of winding 2 (IAW2) at the calculated starting current **and set the phase angle at 180 degrees**. Slowly decrease the magnitude of current IAW2 until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 4 $\pm 5\% \pm 0.02 I_{nom}$.
- Step 7.** Purpose: Repeat the test for each phase for each winding combination if desired.
- Method: Repeat steps 1 through 6 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the TAR F command is issued.

Second-Harmonic Blocking

Note: This test requires a current source capable of generating second-harmonic current. This example tests the second-harmonic blocking function.

- Step 1.** Purpose: Verify the second-harmonic restraint percentage.
- Method: Execute the SHOW command via the relay front panel or serial port and verify the percentage of fundamental current that the magnitude of second-harmonic current must exceed for differential restraint. Enter **SHO PCT2<ENTER>**.
- Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.
- Method: Execute the TARGET command (i.e., **TAR F 87R<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.
- Step 3.** Purpose: Connect two current test sources to one phase of one winding input.
- Method: Connect a current source to the IAW1 input. Connect a second current source in parallel with the first source to the IAW1 input as shown in Figure 10.7.
- Step 4.** Purpose: Apply fundamental current to pick up the 87R element.
- Method: Turn on the first current test source connected to the winding 1 input (IAW1) equal to the TAP1 setting multiplied by the connection constant A shown in Table 10.3. The 87R LED will illuminate once current is applied to the relay.

Step 5. Purpose: Apply and ramp second-harmonic current to dropout the 87R element.

Method: Turn on the second current source for second-harmonic current (120 Hz for NFREQ = 60 and 100 Hz for NFREQ = 50). Starting at zero current, slowly increase the magnitude of this second current source until the 87R element deasserts, causing the 87R LED to completely extinguish. Note the value of the applied current from the second test source. The current from the second-harmonic source should equal the PCT2 setting divided by 100, multiplied by the magnitude of the fundamental current source, $\pm 5\%$ and $\pm 0.02 I_{nom}$.

$$IAW1 (\text{second harmonic}) = \frac{PCT2}{100} \cdot IAW1 (\text{fundamental}), \pm 5\% \pm 0.02 I_{nom}$$

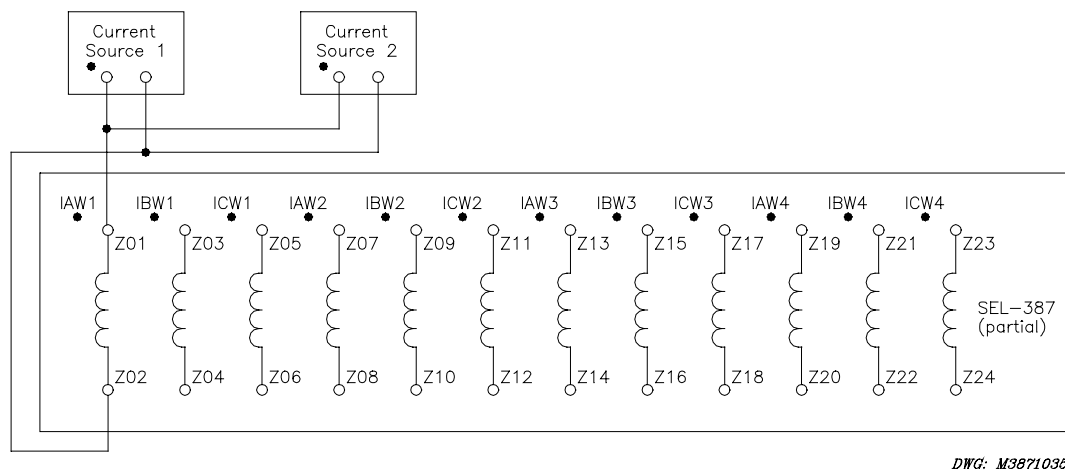


Figure 10.7: Test Connections for Parallel Current Sources

Fifth-Harmonic Blocking

Note: This test requires a current source capable of generating fifth-harmonic current. This example tests the fifth-harmonic blocking function.

Step 1. Purpose: Verify the fifth-harmonic restraint percentage.

Method: Execute the SHOW command via the relay front panel or serial port and verify the percentage of fundamental current that the magnitude of fifth-harmonic current must exceed for differential restraint. Enter **SHO PCT5<ENTER>**.

Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the TARGET command (i.e., **TAR F 87R<ENTER>**). The SEL-387 Relay now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

- Step 3.** Purpose: Connect two current test sources to one phase of one winding input.
- Method: Connect a current source to the IAW1 input. Connect a second current source in parallel with the first source to the IAW1 input as shown in Figure 10.7.
- Step 4.** Purpose: Apply fundamental current to pick up the 87R element.
- Method: Turn on the first current test source connected to the winding 1 input (IAW1) equal to the TAP1 setting multiplied by the connection constant A shown in Table 10.3. The 87R LED will illuminate once current is applied to the relay.
- Step 5.** Purpose: Apply and ramp fifth-harmonic current to dropout the 87R element.
- Method: Turn on the second current source for fifth-harmonic current (300 Hz for NFREQ = 60 and 250 Hz for NFREQ = 50). Starting at zero current, slowly increase the magnitude of this second current source until the 87R element deasserts, causing the 87R LED to completely extinguish. Note the value of the applied current from the second test source. The current from the fifth-harmonic source should equal the PCT5 setting divided by 100, multiplied by the magnitude of the fundamental current source, $\pm 5\%$ and $\pm 0.02 I_{nom}$.

$$IAW1 \text{ (fifth harmonic)} = \frac{PCT5}{100} \cdot IAW1 \text{ (fundamental)}, \pm 5\% \pm 0.02 I_{nom}$$

Time-Code Input (IRIG-B)

- Purpose: Verify operation of the IRIG-B clock input for Serial Port 2 and the connector of Serial Port 1.
- Method:
1. Connect a source of demodulated IRIG-B time code to the relay Serial Port 2 (pins 4 and 6) in series with a resistor to monitor the current. Adjust the source to obtain an “ON” current of about 10 mA.
 2. Execute the IRIG command. Make sure the relay clock displays the correct date and time.
 4. Optional. Connect the demodulated IRIG-B time code to the relay as in step 1, but through the Serial Port 1 connector (pins 7 and 8).

Thermal Element

The SEL-387 thermal element provides information on power transformer insulation aging at present loading and temperatures. Ambient temperature is either measured or fixed via a setting. Top-oil temperatures are either calculated from the applied current or measured. All measured temperatures are obtained via a serial port using a specific data format. Measured temperatures are not used in the following test.

Certain Thermal Element outputs are calculated once per minute. Other outputs are calculated once per hour (on the hour) or once per day (at midnight). To limit the elapsed test time to one hour, only the outputs that are calculated once per minute are tested.

Step 1. Starting with all settings at the default values, verify or change to the values listed below:

CTR1	=	1000/IN	VWDG1	=	100
W1CT	=	Y			
ETHER	=	Y			
TMWDG	=	1	VWDG	=	100
XTYPE	=	3	TRTYPE	=	Y
THwr	=	65	NCS	=	1
MCS11	=	100	DTMP	=	40
TRDE	=	IN101	NTHM	=	0
TOT1	=	50	TOT2	=	52
HST1	=	130	HST2	=	135
FAAL1	=	15	FAAL2	=	20
EDFTC	=	Y			

Configure an external contact wired to IN101 such that IN101 is asserted (contact closed) to simulate a “deenergized” power transformer prior to the start of the test. This contact must be configured to open (power transformer “energized”) at the instant when the test is started (current is applied), and to stay open while the test is in progress.

Use the SET R command to configure the sequential events recorder SER1 trigger conditions to:

SER1 =IN101,TO1,TO2,HS1,HS2,FAA1,FAA2

The relay’s sequential events recorder will be used to establish the time for the TO1, TO2, HS1, HS2, FAA1, and FAA2 bits to assert.

Step 2. Initialize the thermal element.

With the relay turned on and the contact wired to IN101 closed, issue the THE R command to initialize the thermal element.

Step 3. Start the test.

Simultaneously open the contact wired to IN101 and apply ($1.2 * I_N$) amps to IAW1 (Z01–Z02). The test starts, $t = 0$, when input IN101 is deasserted (external contact opens). The expected operating times (in minutes) from $t = 0$ are:

TO1 = 10
TO2 = 12
HS1 = 14
HS2 = 17
FAA1 = 19
FAA2 = 22

Acceptable values are ± 1 minute of the above times. The following is a typical SER report for this test.

06/09/00	07:27:39.752	IN101	Deasserted
06/09/00	07:37:16.315	T01	Asserted
06/09/00	07:39:16.689	T02	Asserted
06/09/00	07:41:16.436	HS1	Asserted
06/09/00	07:44:16.448	HS2	Asserted
06/09/00	07:46:17.062	FAA1	Asserted
06/09/00	07:49:16.316	FAA2	Asserted

COMMISSIONING TESTING

When: When installing a new protection system.

- Goal:
- 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 current 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 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 DIF command to record the measured operate and restraint values for through-load currents. Use the PULSE command to verify relay output contact operation.

Use the SEL-387 Relay Commissioning Test Worksheet, located at the end of this section, to verify correct CT connections and settings when placing the relay in service. The worksheet shows how using software commands or the front-panel display can replace the need for the traditional phase angle meter and ammeter.

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's 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 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 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 and current differential element 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.

RELAY TROUBLESHOOTING

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to the Troubleshooting Procedure.

1. Do not turn the relay off.
2. Check to see that the power is on.
3. Measure and record the power supply voltage at the power input terminals.
4. Measure and record the voltage at all control inputs.
5. Measure and record the state of all output relays.

Troubleshooting Procedure

All Front-Panel LEDs Dark

1. Power is off.
2. Blown power supply fuse.
3. Input power not present.
4. Self-test failure.
5. TAR F command improperly set.

Note: For 1, 2, 3, and 4 the ALARM relay contacts should be closed.

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) Press any front-panel button. The relay should turn on the LCD back lighting.
 - b) Locate the contrast adjust hole behind the front panel beside the serial port. (This requires unscrewing and removing the front-panel plate.)
 - c) Insert a small screwdriver in this hole to adjust the contrast.

Relay Does Not Respond to Commands From Device Connected to Serial Port

1. Communications device not connected to relay.
2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.
3. System is processing event record. Wait several seconds.
4. System is attempting to transmit information, but cannot due to handshake line conflict. Check communications cabling.
5. System is in the XOFF state, halting communications. Type <CTRL>Q to put system in XON state.
6. If the serial port or front-panel interface that does not respond was working before, steps 1 through 5 above have been tried, and the MET command was the last issued command, the Digital Signal Processor may have failed, and you should call the factory.

Relay Does Not Respond to Faults

1. Relay improperly set. Review your settings with SET and SET G commands.
2. Improper test settings.
3. Current transformer connection wiring error.
4. Analog input cable between transformer-termination and main board loose or defective.
5. Check self-test status with STA command.
6. Check input voltages and currents with MET command and TRI and EVE sequence.

Time Command Displays the Same Time for Successive Commands

1. The digital signal processor has failed; contact the factory.

Tripping Output Relay Remains Closed Following Fault

1. Auxiliary contact inputs improperly wired.
2. Output relay contacts burned closed.
3. Interface board failure.

“SELboot” on Front Display at Power-Up; Serial Port Warning to Remove Link

1. A jumper has been installed at position JMP6D. Power down, remove the jumper, and power up the relay again.

No Prompting Message Issued to Terminal Upon Power Up

1. Terminal not connected to system.
2. Wrong baud rate.
3. Terminal improperly connected to system.
4. SET P AUTO setting set to N (factory default).
5. Main board or interface board failure.

Terminal Displays Meaningless Characters

1. Baud rate set incorrectly.
2. Check terminal configuration. See *Section 7: Serial Port Communications and Commands*.

Self-Test Failure: +5 V PS

1. Power supply +5 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: +5 V REG

1. Regulated +5 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: –5 V REG

1. Regulated –5 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: +12 V PS

1. Power supply +12 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: –12 V PS

1. Power supply –12 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: +15 V PS

1. Power supply +15 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: –15 V PS

1. Power supply –15 V output out-of-tolerance. See STATUS command.
2. A/D converter failure.

Self-Test Failure: Offset

1. Offset drift.
2. A/D converter drift.
3. Loose ribbon cable between transformers and main board.

Self-Test Failure: ROM

1. Memory failure. Contact the factory.

Self-Test Failure: RAM

1. Failure of static RAM IC. Contact the factory.

Self-Test Failure: A/D Converter

1. A/D converter failure.
2. RAM error not detected by RAM test.

Self-Test Failure: IO_BRD

1. I/O board has been changed. Execute the INITIO command.
2. Ribbon cable disconnected between upper I/O board and main board. Reconnect and execute INITIO command. Step 2 only applies to the upper I/O board in a relay which has two I/O boards.
3. Interface board failure.

Self-Test Failure: CR_RAM, EEPROM, and IO_BRD

1. Self-test detected setting location movement due to Flash firmware upgrade. Execute R_S command.
2. Main board failure, contact the factory.

Alarm Contacts Closed

1. Power is off.
2. Blown fuse.
3. Power supply failure.
4. Main board or interface board failure.
5. Other self-test failure.

Self-Test Failure: Temp After R_S Command

1. Record STA command and state of all outputs. Call the factory. Powering down the relay will reset the logic.

RELAY CALIBRATION

The SEL-387 Relay is factory-calibrated. If you suspect that the relay is out of calibration, please contact the factory.

FACTORY ASSISTANCE

The employee-owners of Schweitzer Engineering Laboratories are dedicated to making electric power safer, more reliable, and more economical.

We appreciate your interest in SEL products, and we are committed to making sure you are satisfied. If you have any questions, please contact us at:

Schweitzer Engineering Laboratories
2350 NE Hopkins Court
Pullman, WA USA 99163-5603
Tel: (509) 332-1890
Fax: (509) 332-7990

We guarantee prompt, courteous, and professional service.

We appreciate receiving any comments and suggestions about new products or product improvements that would help us make your job easier.

COMMISSIONING TEST WORKSHEET

SEL-387-5, -6 Relay

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SYSTEM INFORMATION

System Settings

RID (Relay identification) = _____

TID (Terminal identification) = _____

MVA (Maximum transformer rating) = _____

	<u>Winding 1</u>	<u>Winding 2</u>	<u>Winding 3</u>	<u>Winding 4</u>
Current transformer connection:	W1CT = _____	W2CT = _____	W3CT = _____	W4CT = _____
Current transformer ratio:	CTR1 = _____	CTR2 = _____	CTR3 = _____	CTR4 = _____
Connection compensation:	W1CTC = _____	W2CTC = _____	W3CTC = _____	W4CTC = _____
Nominal line-to-line voltage (kV):	VWDG1 = _____	VWDG2 = _____	VWDG3 = _____	VWDG4 = _____
TAP calculation:	TAP1 = _____	TAP2 = _____	TAP3 = _____	TAP4 = _____

Differential Settings

O87P = _____ SLP1 = _____ SLP2 = _____ IRS1 = _____ U87P = _____

Metered Load (Data taken from substation panel meters, not the SEL-387 Relay)

± Readings from meters	<u>Winding 1</u>	<u>Winding 2</u>	<u>Winding 3</u>	<u>Winding 4</u>
Megawatts:	MW1 = _____	MW2 = _____	MW3 = _____	MW4 = _____
Megavars:	MVAR1 = _____	MVAR2 = _____	MVAR3 = _____	MVAR4 = _____
MVA calculation:				
$MVA_n = \sqrt{MW_n^2 + MVAR_n^2}$	MVA1 = _____	MVA2 = _____	MVA3 = _____	MVA4 = _____

Calculated Relay Load

	<u>Winding 1</u>	<u>Winding 2</u>	<u>Winding 3</u>	<u>Winding 4</u>
Primary Amperes calculation:				
$I_{npri} = \frac{MVA_n \cdot 1000}{\sqrt{3} \cdot VWDG_n}$	I1pri = _____	I2pri = _____	I3pri = _____	I4pri = _____
Secondary Amperes calculation:				
$W_nCT = Y, I_{nsec} = \frac{I_{npri}}{CTR_n}$	I1sec = _____	I2sec = _____	I3sec = _____	I4sec = _____
$W_nCT = D, I_{nsec} = \frac{I_{npri} \cdot \sqrt{3}}{CTR_n}$				

COMMISSIONING TEST WORKSHEET

SEL-387-5, -6 Relay

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CONNECTION CHECK

Differential Connection (issue **MET DIF<ENTER>** to serial port or front panel)

Note: System load conditions should be higher than 0.1 A secondary. 0.5 A secondary is recommended for the best results.

Operate Current: IOP1 = _____ IOP2 = _____ IOP3 = _____

Restraint Current: IRT1 = _____ IRT2 = _____ IRT3 = _____

Mismatch Calculation:

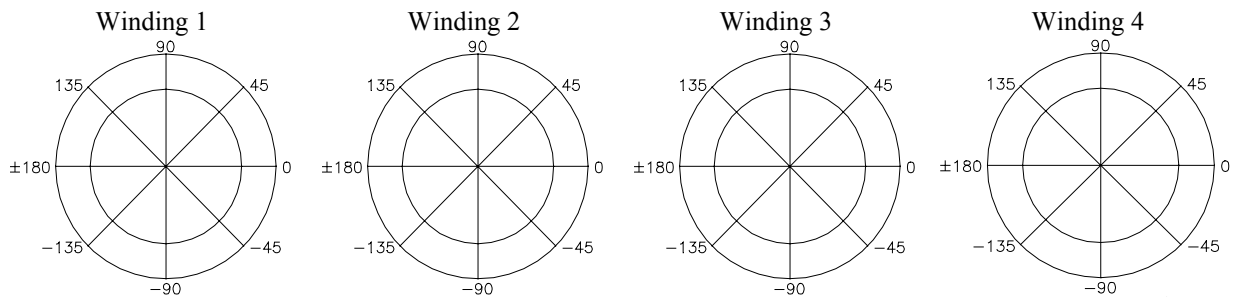
$MM_n = \frac{IOP_n}{IRT_n}$ MM1 = _____ MM2 = _____ MM3 = _____

Check individual current magnitudes, phase angles, and operate and restraint currents in an event report if mismatch is not less than 0.10.

MAGNITUDE, ANGLE, AND PHASE ROTATION CHECK

(issue **MET SEC<ENTER>** to the serial port or front panel)

	<u>Winding 1</u>	<u>Winding 2</u>	<u>Winding 3</u>	<u>Winding 4</u>
A-Phase Secondary Amperes:	IAW1 = _____	IAW2 = _____	IAW3 = _____	IAW4 = _____
A-Phase Angle:	_____	_____	_____	_____
B-Phase Secondary Amperes:	IBW1 = _____	IBW2 = _____	IBW3 = _____	IBW4 = _____
B-Phase Angle:	_____	_____	_____	_____
C-Phase Secondary Amperes:	ICW1 = _____	ICW2 = _____	ICW3 = _____	ICW4 = _____
C-Phase Angle:	_____	_____	_____	_____



1. Calculated relay amperes match MET SEC amperes?
2. Phase rotation is as expected for each winding?
3. Do angular relationships among windings correspond to expected results? (Remember that secondary current values for load current flowing out of a winding will be 180° out of phase with the reference phase position for that winding. The reason is that CT polarity marks normally face away from the transformer on all windings.)

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APPENDIX A: FIRMWARE VERSIONS

To find the firmware revision number in your relay, view the status report using the serial port STATUS command or the front-panel STATUS pushbutton. For firmware versions prior to October 4, 1999, the status report displays the Firmware Identification (FID) label:

FID=SEL-387-5-Rxxx-Vx-Dxxxxxx

For firmware versions with the date code of October 4, 1999, or later, the FID label will appear as follows with the Part/Revision number in bold:

FID=SEL-387-5-Rxxx-Vx-Z001001-Dxxxxxxx

The firmware revision number is after the “R” and the release date is after the “D”.

This manual covers SEL-387-5 and SEL-387-6 Relays that contain firmware bearing the following part numbers and revision numbers (most recent firmware listed at top):

Firmware Part/Revision No.	Description of Firmware
SEL-387-5-R407-V0-Z101101-D20001220 SEL-387-6-R402-V0-Z101101-D20001220	– Corrected Object 32 in DNP versions (SEL-387-5-R407 and SEL-387-6-R402)
SEL-387-5-R406-V0-Z101101-D20001121 SEL-387-5-R306-V0-Z001001-D20001121 SEL-387-6-R401-V0-Z101101-D20001121 SEL-387-6-R301-V0-Z001001-D20001121	– Corrected A5C0 message to include DNP on DNP versions (SEL-387-5-R406 and SEL-387-6-R401) – Corrected Event Report formatting error (SEL-387-5-R406 and SEL-387-5-R306) – Improve THE command output (SEL-387-6-R401 and SEL-387-6-R301) – Improve thermal element response to measured top-oil values (SEL-387-6-R401 and SEL-387-6-R301) – Improve REF functionality (SEL-387-5-R406 and SEL-387-5-R306; SEL-387-6-R401 and SEL-387-6-R301)
SEL-387-6-R400-V0-Z101101-D20000831 SEL-387-6-R300-V0-Z001001-D20000831	Supports the PROTO=DNP protocol setting option. Does not support the PROTO=DNP protocol setting option. – Initial SEL-387-6 Relay release.

SEL-387-5-R405-V0-Z101101-D20000621 SEL-387-5-R305-V0-Z001001-D20000621	Supports the PROTO=DNP protocol setting option. Does not support the PROTO=DNP protocol setting option. This firmware differs from previous versions as follows: – Created version which supports DNP 3.00 Level 2 Slave protocol. – Added “n” command option to the CHI command. “CHI n” will now return the last n items contained in the history. – Added DS1302 battery-backed clock support. – Fixed the 50GP setting so it does not accept a violation of: $50GP_{min} \geq 0.05 \cdot Inom \cdot CTR_{max} / CTR_4$.
SEL-387-5-R304-V0-Z001001-D19991029	This firmware differs from previous versions as follows: – Fixed TID problem. – Fixed OPEN/CLOSE command display error. – Added CID to STA Command. – Updated FID string to include four-digit year.
SEL-387-5-R303-V0-Z001001-D19991004	This firmware differs from previous versions as follows: – Added capability of using mismatched CTRs in the combined current elements. – Added CT Saturation (CTS) Relay Word bit in the REF Decision Logic (See Figure 5.23: REF Enable/Block Logic). – Added "23" combination for REF Directional Element (See Figure 5.24: REF Directional Element). – Added characters (= ; ',^?) that can be separators in the SER triggering. – Fixed the CEV report to show the correct input and outputs and to show the correct number of rows being displayed in the report header. – Fixed front-panel LCD time-out to time-out regardless of whether a front-panel pushbutton is being pressed or not. – Fixed SER to record RB (Remote Bits) and TRGTR (Target Reset) transitions. – Added the STA C (Status Clear) command option. – Increased character usage in ALIAS settings.

	– Changed the TAP setting response from error to warning. – Improved the harmonic supervision logic. – Closed a timing window where events triggered after midnight January 1 show the incorrect time. – Fixed the rising-edge timers so they are always initialized correctly. – Changed the CASCII command to level 0. – Fixed the SG (Set Group) bits so they assert correctly when changing groups quickly using the serial port or front panel. – Removed “*” from accepted Relay Word bits. – Enabled serial port timeouts to reset front-panel target index.
SEL-387-5-R302-V-D990914	This firmware differs from previous versions as follows: – Fixed SOE lockup problem.
SEL-387-5-R301-V-D990721	This firmware differs from previous versions as follows: – Fixed Alias problem in the unsolicited SER protocol.
SEL-387-5-R300-V-D990621	Original Firmware Release.

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE INSTRUCTIONS

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The SEL-387 Relay stores firmware in FLASH memory; therefore, changing physical components is not necessary. A firmware loader program called SELboot resides in the SEL-387 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 reentered. 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., Procomm[®] Plus, Relay/Gold, Microsoft[®] Windows[®] Terminal and HyperTerminal, SmartCOM, or CROSSTALK[®]).
- 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-387 Relay contains History (HIS) data, Event (EVE) data, Metering (MET) data, or Sequential Events Recorder (SER) data that you want to retain, retrieve this information 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 4, and enter Access Level 2 by issuing the **ACC** and **2AC** commands.

Note: 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 Relay, Global, Port, and SER settings, use the following Show commands to retrieve the necessary settings: **SHO 1, SHO 2, SHO 3, SHO 4, SHO 5, SHO 6, SHO G, SHO P 1, SHO P 2, SHO P 3, SHO P 4, and SHO R.**

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. Issue the **L_D <ENTER>** command to the relay (L underscore D ENTER) to start the SELboot program.
5. 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 the SELboot prompt **!>**.

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.

6. Issue **HEL <ENTER>** to list the commands available in SELboot.
7. Set up your communication connection to the highest possible baud rate. The relay will support speeds up to 38400 baud. Use the **BAU** command (e.g., **BAU 38400 <ENTER>**) to change the SPEED setting to the desired baud rate.
8. Make a copy of the firmware presently 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 1 MB of free disk space.

Issue the Send (**SEN <ENTER>**) 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., 387R104.S19). After the transfer, the relay will respond: “Download completed successfully!”

9. Begin the transfer of the new firmware to the relay by issuing the Receive (**REC <ENTER>**) command to instruct the relay to receive new firmware.

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.)

10. 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.
11. 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.

12. 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: The file transfer takes approximately 6 minutes at 38400 baud using the 1k-XMODEM protocol. After the transfer completes, the relay will reboot and return to Access Level 0. The following screen capture shows the entire process.

```
=>>L_D <ENTER>
Disable relay to send or receive firmware(Y/N) ? Y <ENTER>
Are you sure (Y/N) ? Y <ENTER>
Relay Disabled
!>SEN <ENTER>
Download completed successfully!

!>REC <ENTER>
Caution! - This command erases the relay's firmware.
If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.

Are you sure you wish to erase the existing firmware? (Y/N)Y
Erasing
Erase successful
Press any key to begin transfer, then start transfer at the PC <ENTER>

Upload completed successfully. Attempting a restart
```

13. 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 14; 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 13a.

If the relay does not display the level 0 “ = ” prompt, the Relay baud rate has reverted to the factory default of 2400 baud. Go to self-test failure: **CR_RAM**, **EEPROM**, and **IO_BRD**, step 13d.

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 ten seconds, 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. For a 1 Amp relay, type **R_S 1**. This takes about two minutes, after which time 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 with each of the following commands: **SET 1**, **SET 2**, **SET 3**, **SET 4**, **SET 5**, **SET 6**, **SET G**, **SET P 1**, **SET P 2**, **SET P 3**, **SET P 4**, **SET R**.
- h. Use the **PAS** command to set the original relay passwords you saved earlier in step 3.

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 any FAIL codes show on the Relay LCD, see **Section 10: Testing and Troubleshooting**.

14. 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. (To change the calibration settings, you will need to first enter the calibration access level by typing **CAL** <**ENTER**>, and the password **CLARKE** <**ENTER**>.)
15. Execute the Status (**STA**) command to verify that all relay self-test parameters are within tolerance.
16. Apply current and voltage signals to the relay. Issue the **MET** command and 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 (LMD)

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 which 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 command terminates the connection. If no data are sent to the relay before the port timeout period, it automatically terminates the connection.
6. Enter the sequence CTRL-X QUIT <CR> before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

Note: You can use the front-panel SET pushbutton to change the port settings to return to SEL protocol.

APPENDIX D: CONFIGURATION, FAST METER, AND FAST OPERATE COMMANDS

INTRODUCTION

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long 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-387 Relay.

MESSAGE LISTS

Binary Message List

<u>Request to Relay (hex)</u>	<u>Response From Relay</u>
A5C0	Relay Definition Block
A5C1	<i>Fast Meter</i> Configuration Block
A5D1	<i>Fast Meter</i> Data Block
A5B9	<i>Fast Meter</i> Status Clear Command
A5C2	Demand <i>Fast Meter</i> Configuration Block
A5D2	Demand <i>Fast Meter</i> Data Message
A5C3	Peak Demand <i>Fast Meter</i> Configuration Block
A5D3	Peak Demand <i>Fast Meter</i> Data Message
A5CE	<i>Fast Operate</i> Configuration Block
A5E0	<i>Fast Operate</i> Remote Bit Control
A5E3	<i>Fast Operate</i> Breaker Control
A5ED	<i>Fast Operate</i> Reset Command
A546	Temperature Data Block

ASCII Configuration Message List

<u>Request to Relay (ASCII)</u>	<u>Response From Relay</u>
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNB	ASCII Names of bits in the <i>Fast Meter</i> Status Byte

MESSAGE DEFINITIONS

A5C0 Relay Definition Block

In response to the A5C0 request, the relay sends the following block:

<u>Data</u>	<u>Description</u>
A5C0	Command
40	Message length (64 bytes)
42	Message length (66 bytes (DNP versions only))
02	Support SEL, LMD
03	Support DNP (DNP versions only)
03	Support fast meter, fast demand, and fast peak
05	Status flag commands supported: Warn, Fail, Group or Settings change
A5C1	Fast meter configuration
A5D1	Fast meter message
A5C2	Fast demand configuration
A5D2	Fast demand message
A5C3	Fast peak configuration
A5D3	Fast peak message
0002	Self-test warning bit
5354410D0000 (STA<CR>)	Check status
0003	Self-test failure bit
5354410D0000 (STA<CR>)	Check status
0004	Settings change bit
A5C100000000	Reconfigure fast meter on settings change
0004	Settings change bit
53484F0D0000 (SHO<CR>)	Check the settings
0004	
53484F20470D (SHO G<CR>)	Check the Global settings
0300	SEL protocol, <i>Fast Meter</i> and fast message
301	LMD protocol, <i>Fast Operate</i> and fast message
0005	DNP protocol (DNP versions only)
00	Reserved
xx	Checksum

A5C1 Fast Meter Configuration Block

In response to the A5C1 request, the relay sends the following block:

<u>Data</u>	<u>Description</u>
A5C1	Fast Meter command
D2	Message length (210 bytes)
01	One status flag byte
01	Scale factors in configuration message
04	# scale factors
0C	# analog input channels
02	# samples per channel
32	# digital banks (50 bytes)

04	# calculation blocks
0004	Analog channel data offset
0034	Time stamp offset (52) bytes
003C	Digital data offset (60) bytes
494157310000 (IAW1)	Analog channel name
00	Analog channel type (integer)
01	Scale factor type (4-byte float)
00C0	Scale factor offset (winding 1)
494257310000 (IBW1)	
00	
01	
00C0	
494357310000 (ICW1)	
00	
01	
00C0	
494157320000 (IAW2)	
00	
01	
00C4	(winding 2)
494257320000 (IBW2)	
00	
01	
00C4	
494357320000 (ICW2)	
00	
01	
00C4	
494157330000 (IAW3)	
00	
01	
00C8	(winding 3)
494257330000 (IBW3)	
00	
01	
00C8	
494357330000 (ICW3)	
00	
01	
00C8	
494157340000 (IAW4)	
00	
01	
00CC	(winding 4)
494257340000 (IBW4)	
00	
01	
00CC	
494357340000 (ICW4)	
00	

01	
00CC	
xx	Connection byte -- Based on PHROT and W1CT settings (Calculation block #1)
03	Current calculation only
FFFF	No skew adjustment
FFFF	No RS offset
FFFF	No XS offset
00	IAW1
01	IBW1
02	ICW1
FF	NA
FF	NA
FF	NA
xx	Connection byte -- Based on PHROT and W2CT settings (Calculation block #2)
03	Current calculation only
FFFF	No skew adjustment
FFFF	No RS offset
FFFF	No XS offset
03	IAW2
04	IBW2
05	ICW2
FF	NA
FF	NA
FF	NA
xx	Connection byte -- Based on PHROT and W3CT settings (Calculation block #3)
03	Current calculation only
FFFF	No skew adjustment
FFFF	No RS offset
FFFF	No XS offset
06	IAW3
07	IBW3
08	ICW3
FF	NA
FF	NA
FF	NA
xx	Connection byte -- Based on PHROT and W4CT settings (Calculation block #4)
03	Current calculation only
FFFF	No skew adjustment
FFFF	No RS offset
FFFF	No XS offset
09	IAW4
0A	IBW4
0B	ICW4
FF	NA
FF	NA
FF	NA

xxxxxxx	Scale factor (200 * Inom) * CTR1 winding 1
xxxxxxx	Scale factor (200 * Inom) * CTR2 winding 2
xxxxxxx	Scale factor (200 * Inom) * CTR3 winding 3
xxxxxxx	Scale factor (200 * Inom) * CTR4 winding 4
00	Reserved
xx	Checksum

A5D1 Fast Meter Data Block

In response to the A5D1 request, the relay sends the following block:

<u>Data</u>	<u>Description</u>								
A5D1	Command								
70	Message length (112 bytes)								
xx	Status byte								
	<table> <tr> <th><u>Bit</u></th><th><u>Usage</u></th></tr> <tr> <td>2</td><td>Self-test warning</td></tr> <tr> <td>3</td><td>Self-test failure</td></tr> <tr> <td>4</td><td>Settings change</td></tr> </table>	<u>Bit</u>	<u>Usage</u>	2	Self-test warning	3	Self-test failure	4	Settings change
<u>Bit</u>	<u>Usage</u>								
2	Self-test warning								
3	Self-test failure								
4	Settings change								
48 bytes	Integers for the following: IAW1, IBW1, ICW1, IAW2, IBW2, ICW2, IAW3, IBW3, ICW3, IAW4, IBW4, ICW4 (Imaginary values first, followed by Real values)								
8 bytes	Time stamp								
50 bytes	Digital banks -- targets 0 through 49								
00	Reserved								
xx	Checksum								

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the SEL-387 Relay clears the Settings change (STSET) bit in the Status Byte of the *Fast Meter* messages (A5D1, A5D2, and A5D3). 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 to determine if the scale factors or line configuration parameters have been modified. No return response is given to the A5B9 request.

A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages

In response to the A5C2 or A5C3 request, the relay sends the following block:

<u>Data</u>	<u>Description</u>
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
DA	Message length (218 bytes)
00	No status byte
01	Scale factors in fast meter configuration
00	No scale factors used
14	20 analog input channels
01	One sample per channel

00	No digital banks
00	No calculations
0004	Analog channel offset
FFFF	No time stamp
FFFF	No digital data
494157310000 (IAW1)	Analog channel name
02	Analog channel type -- double precision float
FF	No scale factor
0000	No scale factor offset
494257310000 (IBW1)	
02	
FF	
0000	
494357310000 (ICW1)	
02	
FF	
0000	
334932573100 (3I2W1)	
02	
FF	
0000	
495257310000 (IRW1)	
02	
FF	
0000	
494157320000 (IAW2)	
02	
FF	
0000	
494257320000 (IBW2)	
02	
FF	
0000	
494357320000 (ICW2)	
02	
FF	
0000	
334932573200 (3I2W2)	
02	
FF	
0000	
495257320000 (IRW2)	
02	
FF	
0000	
494157330000 (IAW3)	
02	
FF	
0000	

```

494257330000 (IBW3)
02
FF
0000
494357330000 (ICW3)
02
FF
0000
334932573300 (3I2W3)
02
FF
0000
495257330000 (IRW3)
02
FF
0000
494157340000 (IAW4)
02
FF
0000
494257340000 (IBW4)
02
FF
0000
494357340000 (ICW4)
02
FF
0000
334932573400 (3I2W4)
02
FF
0000
495257340000 (IRW4)
02
FF
0000
00          Reserved
xx          Checksum

```

A5D2/A5D3 Demand/Peak Demand *Fast Meter* Message

In response to the A5D2 or A5D3 request, the relay sends the following block:

<u>Data</u>	<u>Description</u>
A5D2 or A5D3	Command
A6	Message length (166 bytes)
00	Reserved

160 bytes	Demand meter values in double floats in the same order as channel listings in A5C2.
00	Reserved
xx	Checksum

A5CE Fast Operate Configuration Block

In response to the A5CE request, the relay sends the following block:

<u>Data</u>	<u>Description</u>
A5CE	Command
42	Message length, #bytes (66)
04	# circuit breakers supported
0010	16 remote bits
01	Remote bit pulse supported
00	Reserved
31	Open breaker 1
11	Close breaker 1
32	Open breaker 2
12	Close breaker 2
33	Open breaker 3
13	Close breaker 3
34	Open breaker 4
14	Close breaker 4
00	Clear remote bit RB1
20	Set remote bit RB1
40	Pulse remote bit RB1
01	Clear remote bit RB2
21	Set remote bit RB2
41	Pulse remote bit RB2
02	Clear remote bit RB3
22	Set remote bit RB3
42	Pulse remote bit RB3
03	Clear remote bit RB4
23	Set remote bit RB4
43	Pulse remote bit RB4
04	Clear remote bit RB5
24	Set remote bit RB5
44	Pulse remote bit RB5
05	Clear remote bit RB6
25	Set remote bit RB6
45	Pulse remote bit RB6
06	Clear remote bit RB7
26	Set remote bit RB7
46	Pulse remote bit RB7
07	Clear remote bit RB8
27	Set remote bit RB8
47	Pulse remote bit RB8
08	Clear remote bit RB9

28	Set remote bit RB9
48	Pulse remote bit RB9
09	Clear remote bit RB10
29	Set remote bit RB10
49	Pulse remote bit RB10
0A	Clear remote bit RB11
2A	Set remote bit RB11
4A	Pulse remote bit RB11
0B	Clear remote bit RB12
2B	Set remote bit RB12
4B	Pulse remote bit RB12
0C	Clear remote bit RB13
2C	Set remote bit RB13
4C	Pulse remote bit RB13
0D	Clear remote bit RB14
2D	Set remote bit RB14
4D	Pulse remote bit RB14
0E	Clear remote bit RB15
2E	Set remote bit RB15
4E	Pulse remote bit RB15
0F	Clear remote bit RB16
2F	Set remote bit RB16
4F	Pulse remote bit RB16
00	Reserved pad
xx	Checksum

A5E0 Fast Operate Remote Bit Control

The external device sends the following message to perform a remote bit operation (set, clear, pulse):

<u>Data</u>	<u>Description</u>
A5E0	Command
06	Message length
xx	Operate code (0-F, 20-2F, 40-4F for remote bit clear, set or pulse)
xx	Operate validation: $4 * \text{operate code} + 1$
xx	Checksum

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval.

A5E3 Fast Operate Breaker Control

The external device sends the following message to perform a fast breaker open/close of breakers 1 through 4:

<u>Data</u>	<u>Description</u>
A5E3	Command
06	Message length

xx	Operate code (hex 31-34 open, hex 11-14 close breakers 1 through 4)
xx	Operate validation: $4 * \text{operate code} + 1$
xx	Checksum

A5CD Fast Operate Reset Definition Block

In response to an A5CD request, the relay sends the configuration block for the *Fast Operate* Reset message

<u>Data</u>	<u>Description</u>
A5CD	Command
0E	Message length
01	The number of <i>Fast Operate</i> reset codes supported
00	Reserved for future use
	Per <i>Fast Operate</i> reset code, repeat:
00	<i>Fast Operate</i> reset code (e.g., “00” for target reset)
54415220520000	<i>Fast Operate</i> reset description string (e.g., “TAR R”)
xx	Checksum

A5ED Fast Operate Reset Command

The *Fast Operate* Reset commands take the following form:

<u>Data</u>	<u>Description</u>
A5ED	Command
06	Message Length - always 6
00	Operate Code (e.g., “00” for target reset, “TAR R”)
01	Operate Validation - $(4 + \text{Operate Code}) + 1$
xx	Checksum

A546 Temperature Data Block

The SEL-387-6 Relay understands the contents of the following binary data packet from an external device, which may be an SEL-2020 or SEL-2030 Communications Processor:

<u>Data</u>	<u>Description</u>
A546	Unsolicited Message Identifier
xx	Message Length
0000000000	Routing Value (0)
00	Status Byte
20	Function Code
00	Sequence Byte
00	Response Number Byte
00	Database Address (4 bytes)
Xxxx	Register Count = N where N can have a value between 1–4.
xx . . xx	Temperature data (N bytes)
xxxx	CRC-16 data block check code

ID Command

In response to the ID command, the relay sends the firmware ID, the relay TID setting, and the Modbus™ device code, as described below.

```
<STX>      (STX character, 02)
"FID STRING ENCLOSED IN QUOTES","yyyy"<CR>
"ID SETTING ENCLOSED IN QUOTES","yyyy"<CR>
32,"yyyy"<CR>
<ETX>      (ETX character, 03)
```

where yyyy is the 4-byte ASCII representation of the hex checksum for the line.
 32 is the device code used by the SEL-2020 to identify the relay to Modbus™ users.

DNA Command

In response to the DNA command, the relay sends names of the Relay Word bits, as described below:

```
<STX>      (STX character, 02)
"xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","yyyy"<CR>
... (49 more, where xxxxxx is a relay word element name)
<ETX>      (ETX character, 03)
```

where xxxxxx are each name in ASCII. "*" indicates an unused bit position. The labels shall appear in order from Most Significant Bit (MSB) to Least Significant Bit (LSB).
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

BNA Command

In response to the BNA command, the relay sends the names of the bits transmitted in the Status Byte of the *Fast Meter* messages (A5D1, A5D2, and A5D3) as shown below:

```
<STX> (STX character, 02)
"*","*","*","STSET","STFAIL","STWARN","*","*","yyyy"<CR>
<ETX> (ETX character, 03)
```

where yyyy is the 4-byte ASCII representation of the hex checksum for the line.

The bits named are defined as follows:

- STSET Set when a power-up or settings change has occurred. It is cleared by the A5B9 request (see earlier in this Appendix).
- STFAIL One or more of the monitored status quantities is in a FAIL state.
- STWARN One or more of the monitored status quantities is in a WARN state.

SNS Message

In response to the SNS command, the relay sends the name string of the SER (SER1, SER2, SER3, and SER4) 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, SER3, and SER4.

For example: If SER1 = 50P11 OUT101; SER2 = 87U1 32IF; SER3 = OUT102 52A, SER4 = 0; the name string will be "50P11","OUT101"," 87U1"," 32IF","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 less than eight strings.

The ALIAS settings are ignored for the SNS command (i.e., if ALIAS1 = OUT101 CL_BKR_1, SNS includes "OUT101", **not** the custom label). Refer to *Settings* in **Section 6: Setting the Relay**.

SNS message for the SEL-387-5 is:

```
<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
      "xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
      "xxxx","xxxx","xxxx",<CR><ETX>
```

where: xxxx is a string from the settings in SER (SER1, SER2, SER3, and SER4)
 yyyy is the 4-byte ASCII representation of the checksum

APPENDIX E: COMPRESSED ASCII COMMANDS

INTRODUCTION

The SEL-387 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-387 Relay provides the following Compressed ASCII commands:

<u>Command</u>	<u>Description</u>
<u>CASCII</u>	Configuration message
<u>CBREAKER</u>	Breaker report
<u>CEVENT</u>	Event report (Winding)
<u>CEVENT DIF</u>	Event report (Differential)
<u>CHISTORY</u>	History report
<u>CSTATUS</u>	Status report
<u>CTARGET</u>	Target display
<u>CTHERMAL</u>	Thermal report
<u>CTHERMAL D 1</u>	Transformer 1 daily thermal report
<u>CTHERMAL D 2</u>	Transformer 2 daily thermal report
<u>CTHERMAL D 3</u>	Transformer 3 daily thermal report
<u>CTHERMAL H 1</u>	Transformer 1 hourly thermal report
<u>CTHERMAL H 2</u>	Transformer 2 hourly thermal report
<u>CTHERMAL H 3</u>	Transformer 3 hourly thermal report
<u>CTHERMAL T</u>	RTD input report

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 <ENTER>

The relay sends:

```
<STX> "CAS",n,"yyyy" <CR>
"COMMAND 1",l1,"yyyy" <CR>
"#H","xxxxx","xxxxx",.....,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
"COMMAND 2",l1,"yyyy" <CR>
"#h","ddd","ddd",.....,"ddd","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
.
.
.
"COMMAND n",l1,"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.

l1 is the minimum access level (e.g., 1, or B, or 2) 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 ASCII representation of the hex checksum for the line.

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>
```



```

"60D","F","F","F","F","F","F","F","F","F","F","F","F","F","1S","96S","yyyy"<CR>

"CEV C",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","35S","yyyy"<CR>
"7H","MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
"1D","I","I","I","I","I","I","I","I","yyyy"<CR>
"5H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
"1D","F","I","I","F","7S","yyyy"<CR>
"15H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","NAMES OF ELEMENTS IN ALL RELAY WORD ROWS",
"yyyy"<CR>
"120D","F","F","F","F","F","F","F","F","F","F","F","F","F","1S","96S","yyyy"<CR>

"CEV S64 R",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","35S","yyyy"<CR>
"7H","MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
"1D","I","I","I","I","I","I","I","I","yyyy"<CR>
"5H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
"1D","F","I","I","F","7S","yyyy"<CR>
"15H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","NAMES OF ELEMENTS IN ALL RELAY WORD ROWS",
"yyyy"<CR>
"1056D","F","F","F","F","F","F","F","F","F","F","F","F","F","1S","96S","yyyy"<CR>

"CTA",1,"yyyy"<CR>
"8h","6S","6S","6S","6S","6S","6S","6S","6S","yyyy"<CR>
"1D","I","I","I","I","I","I","I","I","yyyy"<CR>
<ETX>

```

where yyyy is the 4-byte ASCII representation of the hex checksum for the line.

#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.

#D identifies a data format line, ‘#’ is the maximum number of subsequent data lines, each format field contains one of the following type designators:

I	Integer data
F	Floating point data
mS	String of max ‘m’ characters (e.g., 10S for a 10 char string)

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>
```


Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input Labels global settings, they will appear in the above report as set.

CBREAKER Command

Display the SEL-387 Relay compressed ASCII breaker report by sending:

CBR <ENTER>

The relay sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"BREAKER","INT_TRIPS","IAW","IBW","ICW","EXT_TRIPS","IAW","IBW","ICW",
"POLE1","POLE2","POLE3","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
<ETX>
```

where The data is a summation of breaker information collected since the last summary clear.
 xxxx are the data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

CEVENT Command

The CEV report contains every analog and digital element found in an EVE report, and displays the information in compressed ASCII format by sending:

CEV [DIF R] [n Sx Ly[-[w]] C] <ENTER>

The command parameters, all optional, can be entered in any order. They are:

Report Types:

DIF	Display differential information for the all elements
R	Displays raw (unfiltered) analog data and raw station battery
	Displays preceding 1.5 cycles (including reports with 'L' options)
	Allows S4, S8, S16, S32, and S64
	Defaults to S16 samples/cycle
(default)	Display cosine filtered fundamental currents on all windings and station battery averaged for 1 cycle

Report Options:

n	Event number Default to 1
Sx	Samples per cycle x = 4 or 8 (See 'R' option) Default to 4 if Sx not specified
Ly	Display first y cycles of event report y = 1 - LER Default to L15 if Ly not specified
Ly-	Displays event report from cycle y to end of report
Ly-w	Displays event report from cycle y to cycle w
C	Default to 8 samples/cycle (same as EVE C)

Note: If Sx and/or Ly are given, they override all other parameters.

Note: The L and U parameters are supported for consistency with the SEL-321Relay. The C parameter is used for SEL-2020 compatibility.

CEVENT Winding Report (Default)

If DIF is not specified in the command line, the default report is the winding currents report. To obtain a report, send the following:

CEV <ENTER>

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS"<CR>
... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>
```

Note: "DIGITAL_ELEMENT_NAMES" consists of the text strings representing the names for the relay word bits from the element store visible to the user, excluding the first 2 front panel rows.

where:

xxxx	are the data values corresponding to the first line labels.
yyyy	is the 4-byte ASCII representation of the hex checksum for the line.
z	is ">" to mark where the event was triggered, "*" to mark the maximum current for the event, with the "*" overriding the ">"

RLY_BITS relay element data, in hex ASCII, corresponding to the
DIGITAL_ELEMENT_NAMES

SETTINGS text refers to the current settings of the relay as described in the event report
section.

Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input
Labels global settings, they will appear in the above report as set.

CEVENT Differential Report

If DIF is specified in the command line, the report on differential element quantities is provided.
To obtain the report, send the following:

CEV DIF <ENTER>

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IOP1","IRT1","I1F2","I1F5","IOP2","IRT2","I2F2","I2F5","IOP3","IRT3","I3F2","I3F5",
"TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS","yyyy"
<CR> ... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>
```

Note: "DIGITAL_ELEMENT_NAMES" consists of the text strings representing the names for
the relay word bits from the element store visible to the user, excluding the first 2 front
panel rows.

where:

xxxx are the data values corresponding to the first line labels.

yyyy is the 4-byte ASCII representation of the hex checksum for the line.

z is ">" to mark where the event was triggered, "*" to mark the maximum current
for the event, with the "*" overriding the ">"

RLY_BITS relay element data, in hex ASCII, corresponding to the
DIGITAL_ELEMENT_NAMES

SETTINGS text refers to the current settings of the relay as described in the event report
section.

CHISTORY Command

Display the SEL-387 Relay compressed ASCII history report by sending:

CHI <ENTER>

or display the last “n” items in the SEL-387 Relay compressed ASCII history report by sending:

CHI n<ENTER>

The relay responds to the CHI<Enter> command by sending the following:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"GROUP","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx","xxxx","xxxx","yyyy"<CR>
... (continue previous line until all events are listed -- max 80)
<ETX>
```

where The data is a list of all events since the last history clear.
 xxxx are the data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

CSTATUS Command

Display the SEL-387 Relay compressed ASCII status report by sending:

CST <ENTER>

The relay sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","+5V_PS","+5V_REG",-5V_REG","+12V_PS",-12V_PS","+15V_PS",
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","yyyy"<CR>
<ETX>
```

where xxxx are the data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input Labels global settings, they will appear in the above report as set.

CTARGET Command

Display the SEL-387 Relay compressed ASCII target display by sending:

CTA N <ENTER>

where N is one of the target numbers or element names accepted by the TAR command. If N is omitted, 0 is used.

The relay responds:

```
<STX>
"LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","yyyy"<CR>
x,x,x,x,x,x,x,x,"yyyy"<CR>
<ETX>
```

where LLLL are the labels for the given target.
x is 0 or 1 corresponding to the first line labels.

yyyy is the 4-byte ASCII representation of the hex checksum for the line.

SEL-387-6 RELAY

CASCI Command

Display the SEL-387 Relay compressed ASCII configuration message by sending:

CAS <ENTER>

SEL-387-5 Relays send information on the CST, CBR, CHI, CEV, CEV C, CEV S64 R, and CTA compressed ASCII commands. SEL-387-6 Relays send the same information as SEL-387-5 Relays plus information on the CTH, CTH D 1, CTH D 2, CTH D 3, CTH H 1, CTH H 2, CTH H3, and CTH T compressed ASCII thermal commands. A sample SEL-387-6 Relay response is shown below:

```
<STX>  
"CAS",15,"yyyy"<CR>  
"CST",1,"yyyy"<CR>  
"1H","FID","yyyy"<CR>  
"1D","40S","yyyy"<CR>  
"7H","MONTH_","DAY_","YEAR_","HOURL_","MIN_","SEC_","MSEC_","yyyy"<CR>  
"1D","I","I","I","I","I","I","I","yyyy"<CR>  
"26H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",  
"IBW4","ICW4","+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>  
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",  
"9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S"  
"CBR",1,"yyyy"<CR>  
"1H","FID","yyyy"<CR>  
"1D","40S","yyyy"<CR>  
"7H","MONTH_","DAY_","YEAR_","HOURL_","MIN_","SEC_","MSEC_","yyyy"<CR>
```



```

"12H","MONTH_","DAY_","YEAR_","HOUR_","MIN_","CommError","Ambient","Calc
TopOil","Msrd TopOil","Hot Spot","Load","FAA","yyyy"<CR>
24D","I","I","I","I","I","1S","F","F","F","F","F","F"yyyy"<CR>

"CTH T",1,"yyyy"<CR>
"7H","MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
"1D","I","I","I","I","I","I","I","yyyy"<CR>
"2H","Input #","Temp","yyyy"<CR>
"4D","I","I","I","yyyy"<CR>
<ETX>

```

where yyyy is the 4-byte ASCII representation of the hex checksum for the line.

#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.

#D identifies a data format line, ‘#’ is the maximum number of subsequent data lines, each format field contains one of the following type designators:

I	Integer data
F	Floating point data
mS	String of max ‘m’ characters (e.g., 10S for a 10 char string)

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>
```

Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input Labels global settings, they will appear in the above report as set.

CBREAKER Command

Display the SEL-387 Relay compressed ASCII breaker report by sending:

CBR <ENTER>

The relay sends:

```

<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"BREAKER","INT_TRIPS","IAW","IBW","ICW","EXT_TRIPS","IAW","IBW","ICW",
"POLE1","POLE2","POLE3","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
"yyyy"<CR>

```



```

xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx"yyyy"<CR>
<ETX>

```

where The data is a summation of breaker information collected since the last summary clear.
 xxxxx are the data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

CEVENT Command

The CEV report contains every analog and digital element found in an EVE report, and displays the information in compressed ASCII format by sending:

CEV [DIF R] [n Sx Ly[-[w]] C] <ENTER>

The command parameters, all optional, can be entered in any order. They are:

Report Types:

DIF	Display differential information for the all elements
R	Displays raw (unfiltered) analog data and raw station battery Displays preceding 1.5 cycles (including reports with 'L' options) Allows S4, S8, S16, S32, and S64 Defaults to S16 samples/cycle
(default)	Display cosine filtered fundamental currents on all windings and station battery averaged for 1 cycle

Report Options:

n	Event number Default to 1
Sx	Samples per cycle x = 4 or 8 (See 'R' option) Default to 4 if Sx not specified
Ly	Display first y cycles of event report y = 1 - LER Default to L15 if Ly not specified
Ly-	Displays event report from cycle y to end of report
Ly-w	Displays event report from cycle y to cycle w
C	Default to 8 samples/cycle (same as EVE C)

Note: If Sx and/or Ly are given, they override all other parameters.

Note: The L and U parameters are supported for consistency with the SEL-321Relay.
 The C parameter is used for SEL-2020 compatibility.

CEVENT Winding Report (Default)

If DIF is not specified in the command line, the default report is the winding currents report. To obtain a report, send the following:

CEV <ENTER>

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS"<CR>
... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>
```

Note: "DIGITAL_ELEMENT_NAMES" consists of the text strings representing the names for the relay word bits from the element store visible to the user, excluding the first 2 front panel rows.

where:

xxxx	are the data values corresponding to the first line labels.
yyyy	is the 4-byte ASCII representation of the hex checksum for the line.
z	is ">" to mark where the event was triggered, "*" to mark the maximum current for the event, with the "*" overriding the ">"
RLY_BITS	relay element data, in hex ASCII, corresponding to the DIGITAL_ELEMENT_NAMES
SETTINGS	text refers to the current settings of the relay as described in the event report section.

Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input Labels global settings, they will appear in the above report as set.

CEVENT Differential Report

If DIF is specified in the command line, the report on differential element quantities is provided. To obtain the report, send the following:

CEV DIF <ENTER>

The relay responds:

```
<STX>
"FID","yyyy"<CR>
```

```

"FID=SEL-387-XXXX-V0-ZXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IOP1","IRT1","I1F2","I1F5","IOP2","IRT2","I2F2","I2F5","IOP3","IRT3","I3F2","I3F5",
"TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS","yyyy"
<CR> ... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>

```

Note: "DIGITAL_ELEMENT_NAMES" consists of the text strings representing the names for the relay word bits from the element store visible to the user, excluding the first 2 front panel rows.

where:

xxxx	are the data values corresponding to the first line labels.
yyyy	is the 4-byte ASCII representation of the hex checksum for the line.
z	is ">" to mark where the event was triggered, "*" to mark the maximum current for the event, with the "*" overriding the ">"
RLY_BITS	relay element data, in hex ASCII, corresponding to the DIGITAL_ELEMENT_NAMES
SETTINGS	text refers to the current settings of the relay as described in the event report section.

CHISTORY Command

Display the SEL-387 Relay compressed ASCII history report by sending:

CHI <ENTER>

or display the last “n” items in the SEL-387 Relay compressed ASCII history report by sending:

CHI n<ENTER>

The relay responds to the CHI<Enter> command by sending the following:

```

<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"GROUP","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,"xxxx","yyyy"<CR>
... (continue previous line until all events are listed -- max 99)
<ETX>

```

where The data is a list of all events since the last history clear.
 xxxx are the data values corresponding to the first line labels.

yyyy is the 4-byte ASCII representation of the hex checksum for the line.

CSTATUS Command

Display the SEL-387 Relay compressed ASCII status report by sending:

CST <ENTER>

The relay sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS",
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","yyyy"<CR>
<ETX>
```

where xxxx are the data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

Note: If the analog current input names (IAW1, etc.) have been changed via the Analog Input Labels global settings, they will appear in the above report as set.

CTARGET Command

Display the SEL-387 Relay compressed ASCII target display by sending:

CTA N <ENTER>

where N is one of the target numbers or element names accepted by the TAR command. If N is omitted, 0 is used.

The relay responds:

```
<STX>
"LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","yyyy"<CR>
x,x,x,x,x,x,x,x,"yyyy"<CR>
<ETX>
```

where LLLL are the labels for the given target.
 x is 0 or 1 corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the hex checksum for the line.

CTH Thermal Report Command

Display the following thermal reports in Compressed ASCII format by sending:

CTH [H D T] [phase] <ENTER>

Report types:

(Default)	Display all archived thermal event reports.
H	Display all archived hourly profile data for specified phase ([phase] option)
D	Display all archived daily profile data for specified phase ([phase] option)
T	Display Temperature input data

Report Options: (only for H and D report types)

Phase: Phase A, B or C.

CTH Event Report

If no parameters are specified on the command line, all archived thermal event reports are displayed. To obtain thermal event reports, send the following:

CTH <ENTER>

<STX>

"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy" <CR>

"Event#", "Phase", "MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "Load
Cond", "Cool Sys", "Load", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot",
"FAA", "RLOL", "TLOL", "TLL", "yyyy" <CR>
x,x,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,, "xxxxxxxx", "xxxxxxxxxx",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,x
xxx,xxxx,xxxx, "yyyy" <CR>
...(previous line repeated until all archived events are listed)
<ETX>

If no data is available, the relay replies:

"No Data Available", "0668" <CR>

where: xxxx are data values corresponding to the first line labels.
yyyy is the 4-byte ASCII representation of the checksum for the line.

CTH Daily Profile Data Report

If D is specified in the command line, the report on daily profile data is provided. To obtain the report for Phase A, send the following:

CTH D 1 <ENTER>

<STX>

"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy" <CR>

```
"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", ",", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

To obtain the report for Phase B, send the following:

CTH D 2 <ENTER>

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>

"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", ",", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

To obtain the report for Phase C, send the following:

CTH D 3 <ENTER>

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>

"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", ",", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

If no data is available, the relay replies:

```
"No Data Available", "0668"<CR>
```

where: xxxx are data values corresponding to the first line labels.
 yyyy is the 4-byte ASCII representation of the checksum for the line.

CTH Hourly Profile Data Report

If H is specified in the command line, the report on hourly profile data is provided. To obtain the report for Phase A, send the following:

CTH H 1<ENTER>

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx, "yyyy"<CR>
MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "CommError", "Ambient", "Calc
TopOil", "Msrd TopOil", "Hot Spot", "Load", "FAA", "yyyy"<CR>
```

xxxx,xxxx,xxxx,xxxx,xxxx,"x",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>

To obtain the report for Phase B, send the following:

CTH H 2 <ENTER>

<STX>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>

"MONTH_","DAY_","YEAR_","HOUR_","MIN_","CommError","Ambient","Calc
TopOil","Msrd TopOil","Hot Spot","Load", "FAA",
,"yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,"x",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>

To obtain the report for Phase C, send the following:

CTH H 3 <ENTER>

<STX>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
MONTH_","DAY_","YEAR_","HOUR_","MIN_","ComError","Ambient","Calc TopOil","Msrd
TopOil","Hot Spot","Load","FAA","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,"x",xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>

If no data is available, the relay replies:

"No Data Available","0668"<CR>

where: xxxx are data values corresponding to the first line labels.
yyyy is the 4-byte ASCII representation of the checksum for the line.

CTH Temperature Input Data Report

<STX>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxx,xxxx,"yyyy"<CR>
"Input#","Temp","yyyy"<CR>
xxxx,xxxx,"yyyy"<CR>
...(previous line repeated for each input available)
<ETX>

If no data available the relay replies:

"No Data Available","0668"<CR>

where: xxxx are data values corresponding to the first line labels.

yyyy is the 4-byte ASCII representation of the checksum for the line.

APPENDIX F: UNSOLICITED SER PROTOCOL

INTRODUCTION

This appendix describes special binary Sequential Events Recorder (SER) messages that are not included in **Section 9: Event Reports and SER** of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from the SEL-387 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 use of a single communications channel 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 at the other end of the link requires software that uses the separate data streams. A device that does not interleave the data streams can also access the binary commands and ASCII commands.

Note: 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, SER3, or SER4 trigger settings. Nonvolatile memory stores the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory stores a finite number of “writes.” Exceeding the limit can result in an EEPROM self-test failure. An average of 1 state change every 3 minutes can be made for a 25-year relay service life.

RECOMMENDED MESSAGE USAGE

Use the following sequence of commands to enable unsolicited binary SER messaging in the SEL-387 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 binary SER messages. Send the "Enable Unsolicited Data Transfer" message to enable the SEL-387 Relay to transmit unsolicited binary SER messages.
2. When SER records are triggered in the SEL-387, the relay responds with an unsolicited binary SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as that contained in the original message. The relay will wait about 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited 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 unsolicited 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.

0x01 - Function Code: Enable Unsolicited Data Transfer

Upon power-up, the SEL-387 Relay disables its own unsolicited transmissions. This function enables the SEL-387 Relay to begin sending unsolicited data to the device which sent the enable message, if the SEL-387 has such data to transfer. The message format for function code 0x01 is shown below.

<u>Data</u>	<u>Description</u>
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (0x18 – unsolicited SER messages)
0000	Reserved for future use as function code data
nn	Maximum number of SOE records per message, 01 - 20 hex)
cccc	Two byte CRC-16 check code for message

The SEL-387 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 unsolicited SER message and transmits it. If there are more than "nn" new records available, or if the first and last records 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 records 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, SER3, and SER4 are all

set to NA), the unsolicited SER messages are still enabled, but the only SER records generated result from settings changes and power being applied to the relay. If the SER1, SER2, SER3, or SER4 settings subsequently change to any non-NA value and SER entries trigger, unsolicited SER messages will generate with the new SER records.

0x02 - Function Code: Disable Unsolicited Data Transfer

This function disables the SEL-387 Relay from transferring unsolicited data. The message format for function code 0x02 is shown below.

<u>Data</u>	<u>Description</u>
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (0x18 = Unsolicited SER)
00	Reserved for future use as function code data
cccc	Two byte CRC-16 check code for message

The SEL-387 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.

0x18 - Function: Unsolicited Sequence-of-Events Response

The function 0x18 is used for the transmission of unsolicited Sequential Events Recorder (SER) data from the SEL-387 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 unsolicited data should be enabled or disabled. The message format for function code 0x18 is shown below.

<u>Data</u>	<u>Description</u>
A546	Message header
ZZ	Message length (As many as $34 + 4 \cdot nn$ decimal, where nn is the maximum number of SER records allowed per message as indicated in the "Enable Unsolicited Data Transfer" message.)
0000000000	Five bytes reserved for future use as a routing address

YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address
dddd	Two-byte day of year (1 - 366)
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the SNS command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
.	
.	
.	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.
FFFFFFFE	Four-byte end-of-records flag
sssssss	Packed four-byte element status for up to 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the relay determines that SER records have been lost, it sends a message with the following format:

<u>Data</u>	<u>Description</u>
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...)
00000000	Four bytes reserved for future use as a return routing address
dddd	Two-byte day of year (1 - 366) of overflow message generation
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex) of overflow message generation.
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFE	Four-byte end-of-records flag
00000000	Element status (unused)
cccc	Two-byte CRC-16 checkcode for message

Acknowledge Message

The acknowledge message is constructed and transmitted for every received message which contains a status byte with the LSB set (except another acknowledge message) and which passes all other checks, including the CRC. The acknowledge message format is shown below.

<u>Data</u>	<u>Description</u>
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.
cccc	Two-byte CRC-16 checkcode for message

The SEL-387 supports the following response codes:

RR	Response
00	Success
01	Function code not recognized

Examples

1. Successful acknowledge for "Enable Unsolicited Data Transfer" message from a relay with at least one of SER1, SER2, or SER3 not set to NA:
A5 46 0E 00 00 00 00 00 00 81 00 XX cc cc
(XX is the 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 the 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 "Enable Unsolicited Data Transfer" message:
A5 46 0E 00 00 00 00 00 00 82 00 XX cc cc
(XX is the same as the response number in the "Disable Unsolicited Data Transfer" message to which it responds.)

5. Successful acknowledge message from the master for an unsolicited SER message:
A5 46 0E 00 00 00 00 00 98 00 XX cccc
(XX is the same as the response number in the unsolicited 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 0xFE indicates that the SER record is due to power up. An element index of 0xFF indicates that the SER record is due to setting change. An element index of 0xFD 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 of 32 records and the data may span a time period of no more than 16 seconds. The master may limit the number of 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 an SER packet with less than the requested number of records, if the record time stamps span more than 16 seconds.

The relay always requests acknowledgment in unsolicited SER messages (LSB of the status byte is set).

Unsolicited SER messages can be enabled on multiple ports simultaneously.

APPENDIX G: DISTRIBUTED NETWORK PROTOCOL (DNP) 3.00

OVERVIEW

Some versions of the SEL-387 family of relays 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-387 supports DNP point remapping and virtual terminal object.

CONFIGURATION

To configure a port for DNP, set the port PROTO setting to DNP. Although DNP may be selected on any of the available ports, DNP may not be enabled on more than one port at a time. The following information is required to configure a port for DNP operation:

Label	Description	Default
SPEED	Baud rate (300–19200)	2400
T_OUT	Port time-out (0–30 minutes)	5
DNPADR	DNP Address (0–65534)	0
MODEM	Modem connected to port (Y, N)	N
MSTR	Modem startup string (up to 30 characters)	E0X0&D0S0=2
PH_NUM	Phone number to dial-out to (up to 30 characters)	
MDTIME	Time to attempt dial (5–300 seconds)	60
MDRETI	Time between dial-out attempts (5–3600 seconds)	120
MDRETN	Number of dial-out attempts (0–5)	3
ECLASSA	Class for Analog event data (0 for no event, 1–3)	2
ECLASSB	Class for Binary event data (0 for no event, 1–3)	1
ECLASSC	Class for Counter event data (0 for no event, 1–3)	0
DECPLA	Currents scaling (0–3 decimal places)	1
TIMERQ	Time-set request interval (0–32767 min.)	0
STIMEO	Select/operate time-out (0.0–30.0 sec.)	1.0
DTIMEO	Data link time-out (0–5 sec.)	1
MINDLY	Minimum time from DCD to TX (0.00–1.00 sec.)	0.05
MAXDLY	Maximum time from DCD to TX (0.00–1.00 sec.)	0.10
PREDLY	Settle time from RTS on to TX (OFF, 0.00–30.00 sec.)	0
PSTDLY	Settle time after TX to RTS off (0.00–30.00 sec.)	0
ANADBA	Analog reporting dead band (0–32767 counts)	100
ETIMEO	Event data confirmation time-out (0.1–50.0 sec)	2.0
DRETRY	Data link retries (0–15)	3
UNSOL	Enable unsolicited reporting (Y, N)	N
PUNSOL	Enable unsolicited reporting at power-up (Y, N)	N
REPADR	DNP Address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Age of oldest event to transmit on (0–60 sec.)	2.0

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 deasserted. 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-387 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-387 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-387 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-387 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 were 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-387 decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-387 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-387 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 choose a method for retrieving data on the DNP connection. The following table summarizes the main options, listed from least to most efficient, and indicates corresponding key related settings.

Table G.1: Data Access Methods

Data Retrieval Method	Description	Relevant SEL-387 Settings
Polled Static	The master polls for static (Class 0) data only.	Set CLASS = 0, Set UNSOL = N.
Polled Report-by-Exception	The master polls frequently for event data and occasionally for static data.	Set CLASS to a non-zero value, Set UNSOL = N.
Unsolicited Report-by-Exception	The slave devices send unsolicited event data to the master and the master occasionally sends integrity polls for static data.	Set CLASS 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 CLASS to a non-zero value, Set UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.

DEVICE PROFILE

The following is the device profile as specified in the ***DNP 3.00 Subset Definitions*** document:

DNP 3.00 DEVICE PROFILE DOCUMENT This document must be accompanied by a table having the following headings: Object Group Request Function Codes Response Function Codes Object Variation Request Qualifiers Response Qualifiers Object Name (optional)		
Vendor Name: Schweitzer Engineering Laboratories, Inc.		
Device Name: SEL-387		
Highest DNP Level Supported: For Requests Level 2 For Responses Level 2	Device Function: ☐ Master ☒ Slave	
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): <u>Supports enabling and disabling of unsolicited reports on a class basis.</u> <u>Supports Virtual Terminal.</u>		

Maximum Data Link Frame Size (octets): Transmitted <u> 292 </u> Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted <u> 2048 </u> (if >2048, must be configurable) Received <u> 2048 </u> (must be >249)																																																							
Maximum Data Link Re-tries: ☐ None ☐ Fixed at _____ ☒ Configurable, range <u> 0 </u> to <u> 15 </u>	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? <u> by settings. </u>																																																								
Requires Application Layer Confirmation: ☐ Never ☐ Always (not recommended) ☒ When reporting Event Data (Slave devices only) ☐ When sending multi-fragment responses (Slave devices only) ☐ Sometimes If 'Sometimes', when? _____ ☐ Configurable If 'Configurable', how? _____																																																								
Time-outs while waiting for: <table style="width: 100%; border: none;"> <tr> <td>Data Link Confirm</td> <td>☐ None</td> <td>☐ Fixed at _____</td> <td>☐ Variable</td> <td>☒ Configurable</td> </tr> <tr> <td>Complete Appl. Fragment</td> <td>☒ None</td> <td>☐ Fixed at _____</td> <td>☐ Variable</td> <td>☐ Configurable</td> </tr> <tr> <td>Application Confirm</td> <td>☐ None</td> <td>☐ Fixed at _____</td> <td>☐ Variable</td> <td>☒ Configurable</td> </tr> <tr> <td>Complete Appl. Response</td> <td>☒ None</td> <td>☐ Fixed at _____</td> <td>☐ Variable</td> <td>☐ Configurable</td> </tr> </table> Others _____ Attach explanation if 'Variable' or 'Configurable' was checked for any time-out.		Data Link Confirm	☐ None	☐ Fixed at _____	☐ Variable	☒ Configurable	Complete Appl. Fragment	☒ None	☐ Fixed at _____	☐ Variable	☐ Configurable	Application Confirm	☐ None	☐ Fixed at _____	☐ Variable	☒ Configurable	Complete Appl. Response	☒ None	☐ Fixed at _____	☐ Variable	☐ Configurable																																			
Data Link Confirm	☐ None	☐ Fixed at _____	☐ Variable	☒ Configurable																																																				
Complete Appl. Fragment	☒ None	☐ Fixed at _____	☐ Variable	☐ Configurable																																																				
Application Confirm	☐ None	☐ Fixed at _____	☐ Variable	☒ Configurable																																																				
Complete Appl. Response	☒ None	☐ Fixed at _____	☐ Variable	☐ Configurable																																																				
Sends/Executes Control Operations: <table style="width: 100%; border: none;"> <tr> <td>WRITE Binary Outputs</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>SELECT/OPERATE</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>DIRECT OPERATE</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>DIRECT OPERATE - NO ACK</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Count > 1</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Pulse On</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Pulse Off</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Latch On</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Latch Off</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Queue</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Clear Queue</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> </table> Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.		WRITE Binary Outputs	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	SELECT/OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	DIRECT OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	DIRECT OPERATE - NO ACK	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable	Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Latch On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Latch Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable	Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
WRITE Binary Outputs	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
SELECT/OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
DIRECT OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
DIRECT OPERATE - NO ACK	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																				
Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
Latch On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
Latch Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																				
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																				
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																				

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 <u>20</u> ☐ Default variation <u>6</u> ☐ 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 of a configurable item within the device profile, the item is controlled by SEL-387 settings.

OBJECT TABLE

The following object table lists supported objects, functions, and qualifier code combinations.

Table G.2: SEL-387 DNP Object Table

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
1	0	Binary Input–All Variations	1	0,1,6,7,8		
1	1	Binary Input	1	0,1,6,7,8	129	0,1,7,8
1	2*	Binary Input With Status	1	0,1,6,7,8	129	0,1,7,8
2	0	Binary Input Change–All Variations	1	6,7,8		
2	1	Binary Input Change Without Time	1	6,7,8	129	17,28
2	2*	Binary Input Change With Time	1	6,7,8	129,130	17,28
2	3	Binary Input Change With Relative Time	1	6,7,8	129	17,28
10	0	Binary Output–All Variations	1	0,1,6,7,8		
10	1	Binary Output				
10	2*	Binary Output Status	1	0,1,6,7,8	129	0,1
12	0	Control Block–All Variations				
12	1	Control Relay Output Block	3,4,5,6	17,28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter–All Variations	1	0,1,6,7,8		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0,1,6,7,8	129	0,1,7,8
20	6*	16-Bit Binary Counter Without Flag	1	0,1,6,7,8	129	0,1,7,8
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter–All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event--All Variations	1	6,7,8		
22	1	32-Bit Counter Change Event Without Time	1	6,7,8	129	17,28
22	2*	16-Bit Counter Change Event Without Time	1	6,7,8	129,130	17,28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6,7,8	129	17,28
22	6	16-Bit Counter Change Event With Time	1	6,7,8	129	17,28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event--All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input--All Variations	1	0,1,6,7,8		
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	3	32-Bit Analog Input Without Flag	1	0,1,6,7,8	129	0,1,7,8
30	4*	16-Bit Analog Input Without Flag	1	0,1,6,7,8	129	0,1,7,8
31	0	Frozen Analog Input--All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
32	0	Analog Change Event--All Variations	1	6,7,8		
32	1	32-Bit Analog Change Event Without Time	1	6,7,8	129	17,28
32	2*	16-Bit Analog Change Event Without Time	1	6,7,8	129,130	17,28
32	3	32-Bit Analog Change Event With Time	1	6,7,8	129	17,28
32	4	16-Bit Analog Change Event With Time	1	6,7,8	129	17,28
33	0	Frozen Analog Event--All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
40	0	Analog Output Status--All Variations	1	0,1,6,7,8		
40	1	32-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8
40	2*	16-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8
41	0	Analog Output Block--All Variations				
41	1	32-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
50	0	Time and Date--All Variations				
50	1	Time and Date	1,2	7,8 index = 0	129	07, quantity=1
50	2	Time and Date With Interval				
51	0	Time and Date CTO--All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quantity=1
52	0	Time Delay--All Variations				
52	1	Time Delay Coarse				
52	2	Time Delay Fine			129	07, quantity=1
60	0	All Classes of Data	1,20,21	6		
60	1	Class 0 Data	1	6		
60	2	Class 1 Data	1,20,21	6,7,8		
60	3	Class 2 Data	1,20,21	6,7,8		
60	4	Class 3 Data	1,20,21	6,7,8		
70	1	File Identifier				
80	1	Internal Indications	2	0,1 index = 7		
81	1	Storage Object				
82	1	Device Profile				

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
112	All	Virtual Terminal Output Block	2	6		
113	All	Virtual Terminal Event Data	1,20,21	6	129,130	17,28
No object			13,14,23			

DATA MAP

The following is the default object map supported by the SEL-387 for both wye-connected CTs and delta-connected CTs (see **Appendix A: Firmware Versions in This Manual**).

Table G.3: SEL-387-Wye/Delta DNP Data Map

DNP Object Type	Index	Description
01,02	000–799	Relay Word, where OCA is 0 and TRIP1 is 319.
01,02	800–1599	Relay Word from the SER, encoded same as inputs 000–799 with 800 added.
01,02	1600–1615	Relay front-panel targets, where 1615 is A, 1608 is W4, 1607 is EN and 1600 is 51.
01,02	1616	Relay Disabled.
01,02	1617	Relay diagnostic failure.
01,02	1618	Relay diagnostic warning.
01,02	1619	New relay event available.
01,02	1620	Settings change or relay restart.
10,12	00–15	Remote bits RB1–RB16.
10,12	16	Pulse Open breaker 1 command OC.
10,12	17	Pulse Close breaker 1 command CC.

DNP Object Type	Index	Description
10,12	18	Pulse Open breaker 2 command OC.
10,12	19	Pulse Close breaker 2 command CC.
10,12	20	Pulse Open breaker 3 command OC.
10,12	21	Pulse Close breaker 3 command CC.
10,12	22	Pulse Open breaker 4 command OC.
10,12	23	Pulse Close breaker 4 command CC.
10,12	24–31	Remote bit pairs RB1–RB16.
10,12	32	Open/Close pair for breaker 1.
10,12	33	Open/Close pair for breaker 2.
10,12	34	Open/Close pair for breaker 3.
10,12	35	Open/Close pair for breaker 4.
10,12	36	Reset demands.
10,12	37	Reset demand peaks.
10,12	39	Reset breaker monitor.
10,12	40	Reset front-panel targets.
10,12	41	Read next relay event.
20,22	00	Active settings group.
20,22	01	Internal breaker trips1.
20,22	02	Internal breaker trips 2.
20,22	03	Internal breaker trips 3.
20,22	04	Internal breaker trips 4.
20,22	05	External breaker trips 1.
20,22	06	External breaker trips 2.
20,22	07	External breaker trips 3.
20,22	08	External breaker trips 4.
30,32	00,01	IA magnitude and angle for Wdg. 1.
30,32	02,03	IB magnitude and angle for Wdg. 1.
30,32	04,05	IC magnitude and angle for Wdg. 1.
30,32	06,07	3I1 magnitude and angle for Wdg. 1.
30,32	08,09	3I2 magnitude and angle for Wdg. 1.
30,32	10,11	IRW magnitude and angle for Wdg. 1.

DNP Object Type	Index	Description
30,32	12,13	IA magnitude and angle for Wdg. 2.
30,32	14,15	IB magnitude and angle for Wdg. 2.
30,32	16,17	IC magnitude and angle for Wdg. 2.
30,32	18,19	3I1 magnitude and angle for Wdg. 2.
30,32	20,21	3I2 magnitude and angle for Wdg. 2.
30,32	22,23	IRW magnitude and angle for Wdg. 2.
30,32	24,25	IA magnitude and angle for Wdg. 3.
30,32	26,27	IB magnitude and angle for Wdg. 3.
30,32	28,29	IC magnitude and angle for Wdg. 3.
30,32	30,31	3I1 magnitude and angle for Wdg. 3.
30,32	32,33	3I2 magnitude and angle for Wdg. 3.
30,32	34,35	IRW magnitude and angle for Wdg. 3.
30,32	36,37	IA magnitude and angle for Wdg. 4.
30,32	38,39	IB magnitude and angle for Wdg. 4.
30,32	40,41	IC magnitude and angle for Wdg. 4.
30,32	42,43	3I1 magnitude and angle for Wdg. 4.
30,32	44,45	3I2 magnitude and angle for Wdg. 4.
30,32	46,47	IRW magnitude and angle for Wdg. 4.
30,32	48	IOP1 Operate Current.
30,32	49	IOP2 Operate Current.
30,32	50	IOP3 Operate Current.
30,32	51	IRT1 Restraint Current.
30,32	52	IRT2 Restraint Current.
30,32	53	IRT3 Restraint Current.
30,32	54	I1F2 Second-Harmonic Current.
30,32	55	I2F2 Second-Harmonic Current.
30,32	56	I3F2 Second-Harmonic Current.
30,32	57	I1F5 Fifth-Harmonic Current.
30,32	58	I2F5 Second-Harmonic Current.
30,32	59	I3F5 Second-Harmonic Current.
30,32	60	VDC.
30,32	61–65	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 1.
30,32	66–70	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 2.
30,32	71–75	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 3.
30,32	76–80	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 4.

DNP Object Type	Index	Description
30,32	81	Peak demand IA mag. for Wdg.1.
30	82–84	Peak demand IA time in DNP format for Wdg.1.
30,32	85	Peak demand IB mag. for Wdg.1.
30	86–88	Peak demand IB time in DNP format for Wdg.1.
30,32	89	Peak demand IC mag. for Wdg.1.
30	90–92	Peak demand IC time in DNP format for Wdg.1.
30,32	93	Peak demand 312 mag. for Wdg.1.
30	94–96	Peak demand 312 time in DNP format for Wdg.1.
30,32	97	Peak demand IR mag. for Wdg.1.
30	98–100	Peak demand IR time in DNP format for Wdg.1.
30,32	101	Peak demand IA mag. for Wdg.2.
30	102–104	Peak demand IA time in DNP format for Wdg.2.
30,32	105	Peak demand IB mag. for Wdg.2.
30	106–108	Peak demand IB time in DNP format for Wdg.2.
30,32	109	Peak demand IC mag. for Wdg.2.
30	110–112	Peak demand IC time in DNP format for Wdg.2.
30,32	113	Peak demand 312 mag. for Wdg.2.
30	114–116	Peak demand 312 time in DNP format for Wdg.2.
30,32	117	Peak demand IR mag. for Wdg.2.
30	118–120	Peak demand IR time in DNP format for Wdg.2.
30,32	121	Peak demand IA mag. for Wdg.3.
30	122–124	Peak demand IA time in DNP format for Wdg.3.
30,32	125	Peak demand IB mag. for Wdg.3.
30	126–128	Peak demand IB time in DNP format for Wdg.3.
30,32	129	Peak demand IC mag. for Wdg.3.
30	130–132	Peak demand IC time in DNP format for Wdg.3.
30,32	133	Peak demand 312 mag. for Wdg.3.
30	134–136	Peak demand 312 time in DNP format for Wdg.3.
30,32	137	Peak demand IR mag. for Wdg.3.
30	138–140	Peak demand IR time in DNP format for Wdg.3.
30,32	141	Peak demand IA mag. for Wdg.4.
30	142–144	Peak demand IA time in DNP format for Wdg.4.
30,32	145	Peak demand IB mag. for Wdg.4.
30	146–148	Peak demand IB time in DNP format for Wdg.4.
30,32	149	Peak demand IC mag. for Wdg.4.

DNP Object Type		Index	Description		
30		150–152	Peak demand IC time in DNP format for Wdg.4.		
30,32		153	Peak demand 312 mag. for Wdg.4.		
30		154–156	Peak demand 312 time in DNP format for Wdg.4.		
30,32		157	Peak demand IR mag. for Wdg.4.		
30		158–160	Peak demand IR time in DNP format for Wdg.4.		
30,32		161–163	Breaker contact wear percentage (A, B, C) for Wdg. 1.		
30,32		164–166	Breaker contact wear percentage (A, B, C) for Wdg. 2.		
30,32		167–169	Breaker contact wear percentage (A, B, C) for Wdg. 3.		
30,32		170–172	Breaker contact wear percentage (A, B, C) for Wdg. 4.		
SEL-387-5			SEL-387-6		
Type	Index	Description	Type	Index	Description
30,32	173	Event type (See Event Cause table, following)	30,32	173	Ambient temperature.
30,32	174	Fault Targets (bit 15:EN, bit 8:51, and bit 7:A-bit 0:W4).	30,32	174–176	Thermal Load (A, B, C).
30,32	175–186	Fault currents (all windings, all phases).	30,32	177–179	In-Service Cooling System (A, B, C).
			30,32	180–182	Calculated Top-Oil Temperature (A, B, C).
			30,32	183–185	Measured Top-Oil Temperature (A, B, C).*
30,32	187	Fault settings group.	30,32	186–188	Hot-Spot Temperature (A, B, C).
30,32	188-190	Fault time in DNP format (high, middle, and low 16 bits).	30,32	189–191	Aging Acceleration Factor, FAA (A, B, C).
30,32	191-218	Not applicable.	30,32	192–194	Rate of Loss-of-Life (A, B, C).
			30,32	195–197	Total Loss-of-Life (A, B, C).
			30,32	198–200	Time to assert TLL (A, B, C).**
			30,32	201	Event Type (See Event Cause table, following).
			30,32	202	Fault Targets (bit 15:EN, bit 8:51, and bit 7:A-bit 0:W4).

SEL-387-5			SEL-387-6		
Type	Index	Description	Type	Index	Description
40,41	00	Active settings group.	30,32	203–214	Fault currents (all windings, all phases).
			30,32	215	Fault settings group.
			30	216–218	Fault time in DNP format (high, middle, and low 16 bits).
			40,41	00	Active settings group.

*Error code = 400 (when measured top-oil temperature is not available).

**Infinite marker = –1 (when RLOL = 0).

Binary inputs (objects 1 and 2) are supported as defined by the previous table. Binary inputs 0–799 and 1600–1619 are scanned approximately once every 128 ms 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, see the Binary Input Lookup Table. It is derived from the Relay Word Bits tables in **Section 5: Protection and Control Logic Functions**. 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 800–1599 are derived from the Sequential Events Recorder (SER) and carry the time stamp of actual occurrence. Add 800 to the Binary Input Point column to get the point mapping for points 800–1599. Static reads from these inputs will show the same data as a read from the corresponding index in the 0–799 group. Only points that are actually in the SER list (SET R) will generate events in the 800–1599 group.

Analog Inputs (objects 30 and 32) are supported as defined by the preceding table. The values are reported in primary units. Current magnitudes are scaled according to the DECPLA setting. If DECPLA is 3, then its value is multiplied by 1000. VDC is not scaled. Event-class messages are generated whenever an input changes beyond the value given by the ANADBA setting. The dead-band check is done after any scaling is applied. The angles 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 ANADBA setting. Analog inputs are scanned at approximately a ½-second rate, except for analogs 204–221. During a scan, all events generated will use the time the scan was initiated. Analogs 204–221 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 204 is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	ER element
8	Trip 5
16	Trip 4
32	Trip 3
64	Trip 2
128	Trip 1

If Analog 204 is 0, fault information has not been read and the related analogs (205–221) 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. If either the Trip or Close bit is set, one of the other control field bits must be set as well. The control field is interpreted as follows:

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–15	Set	Clear	Set	Clear	Pulse	Clear
16–23	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1
33	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2
34	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3
35	Pulse CC4	Pulse OC4	Pulse CC4	Pulse OC4	Pulse CC4	Pulse OC4
36–41	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing

If the Trip bit is set, a Latch Off operation is performed, and if the Close bit is set, a Latch On operation is performed on the specified index. 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.

Table G.4: SEL-387-5 Relay Binary Input Lookup Table

	SEL-387 Relay Word Bits								Binary Input Point
Row									
2	50P11	50P11T	50P12	51P1	51P1T	51P1R	PDEM1	OCA	7–0
3	50A13	50B13	50C13	50P13	50A14	50B14	50C14	50P14	15–8
4	50N11	50N11T	50N12	51N1	51N1T	51N1R	NDEM1	OC1	23–16
5	50Q11	50Q11T	50Q12	51Q1	51Q1T	51Q1R	QDEM1	CC1	31–24
6	50P21	50P21T	50P22	51P2	51P2T	51P2R	PDEM2	OCB	39–32
7	50A23	50B23	50C23	50P23	50A24	50B24	50C24	50P24	47–40
8	50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2	55–48
9	50Q21	50Q21T	50Q22	51Q2	51Q2T	51Q2R	QDEM2	CC2	63–56
10	50P31	50P31T	50P32	51P3	51P3T	51P3R	PDEM3	OCC	71–64
11	50A33	50B33	50C33	50P33	50A34	50B34	50C34	50P34	79–72
12	50N31	50N31T	50N32	51N3	51N3T	51N3R	NDEM3	OC3	87–80
13	50Q31	50Q31T	50Q32	51Q3	51Q3T	51Q3R	QDEM3	CC3	95–88
14	50P41	50P41T	50P42	51P4	51P4T	51P4R	PDEM4	CTS	103–96
15	50A43	50B43	50C43	50P43	50A44	50B44	50C44	50P44	111–104
16	50N41	50N41T	50N42	51N4	51N4T	51N4R	NDEM4	OC4	119–112
17	50Q41	50Q41T	50Q42	51Q4	51Q4T	51Q4R	QDEM4	CC4	127–120
18	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R	135–128
19	2HB1	2HB2	2HB3	5HB1	5HB2	5HB3	TH5	TH5T	143–136
20	87BL1	87BL2	87BL3	87BL	87E1	87E2	87E3	32IE	151–144
21	87O1	87O2	87O3	50GC	50G4	32IR	32IF	REFP	159–152
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2	167–160
23	51PC2	51PC2T	51PC2R	51NC2	51NC2T	51NC2R	DC3	DC4	175–168
24	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8	183–176
25	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16	191–184
26	SG1	SG2	SG3	SG4	SG5	SG6	CHSG	COMFLG+	199–192
27	–	–	IN106	IN105	IN104	IN103	IN102	IN101	207–200
28	IN208	IN207	IN206	IN205	IN204	IN203	IN202	IN201	215–208
29	IN216	IN215	IN214	IN213	IN212	IN211	IN210	IN209	223–216
30	IN308	IN307	IN306	IN305	IN304	IN303	IN302	IN301	231–224
31	IN316	IN315	IN314	IN313	IN312	IN311	IN310	IN309	239–232
32	S1V1	S1V2	S1V3	S1V4	S1V1T	S1V2T	S1V3T	S1V4T	247–240
33	S2V1	S2V2	S2V3	S2V4	S2V1T	S2V2T	S2V3T	S2V4T	255–248
34	S3V1	S3V2	S3V3	S3V4	S3V5	S3V6	S3V7	S3V8	263–256
35	S3V1T	S3V2T	S3V3T	S3V4T	S3V5T	S3V6T	S3V7T	S3V8T	271–264
36	S1LT1	S1LT2	S1LT3	S1LT4	S2LT1	S2LT2	S2LT3	S2LT4	279–272

Row	SEL-387 Relay Word Bits								Binary Input Point
37	S3LT1	S3LT2	S3LT3	S3LT4	S3LT5	S3LT6	S3LT7	S3LT8	287–280
38	TLL+	RLL+	FAA1+	FAA2+	TO1+	TO2+	HS1+	HS2+	295–288
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2	303–296
40	BCWA3	BCWB3	BCWC3	BCW3	BCWA4	BCWB4	BCWC4	BCW4	311–304
41	TRIP1	TRIP2	TRIP3	TRIP4	TRIP5	TRIPL	CSE+	TRGTR	319–312
42	CLS1	CLS2	CLS3	CLS4	CF1T	CF2T	CF3T	CF4T	327–320
43	!ALARM	OUT107	OUT106	OUT105	OUT104	OUT103	OUT102	OUT101	335–328
44	OUT201	OUT202	OUT203	OUT204	OUT205	OUT206	OUT207	OUT208	343–336
45	OUT209	OUT210	OUT211	OUT212	OUT213	OUT214	OUT215	OUT216	351–344
46	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308	359–352
47	OUT309	OUT310	OUT311	OUT312	OUT313	OUT314	OUT315	OUT316	367–360
48	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	375–368
49	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16	383–376

+SEL-387-6 Relay only.

Relay Summary Event Data

Whenever there is unread relay event summary data (fault data), binary input point 1619 will be set. In order to load the next available relay event summary, the master should pulse binary output point 41. This will cause the event summary analogs (points 204–221) 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 204) to be set to 0.

POINT REMAPPING

Introduction

The DNP command is available to view and remap the DNP data. This command is available at level 1 for viewing data, but only from level 2 can it be used to remap the DNP map.

Inputs

Command Syntax: DNP [A|B|S|T]

 DNP [AI|AO|BI|BO|C] [VIEW]

The DNP analog input, analog output, counter, binary output, and binary input points may be remapped via the DNP command. The map is composed of five lists of indices: one for the analog inputs (30 and 32), one for the binary inputs (1 one 2), one for the binary outputs (10 and 12), one for the analog outputs (40 and 41), and the other for the counters (20 and 22). The indices correspond to those given by the relay's DNP data map. The order in which they occur in

the list determines the index that the corresponding value is reported to the DNP master. If a value is not in the list, it is not available to the DNP master. All points of the corresponding type may be included in the list, but must only occur once. The maps are stored in nonvolatile memory and are protected with a checksum. The DNP command is only available if DNP has been selected on one of the ports.

If the DNP command is issued without parameters, the relay displays all of the maps with the following format:

```
=>DNP<ENTER>

Binary Inputs  = Default Map
Binary Outputs = Default Map
Counters       = Default Map
Analog Inputs  = 112 28 17 35 1 56 57 58 59 60 61 62 63 64 65 \
                  66 67 100 101 102 103
Analog Outputs = Off

=>
```

If the DNP command is issued with an object type specified (AI, AO, BI, BO, C) and the VIEW parameter, the relay displays only the corresponding map. The S parameter is equivalent to AI VIEW and the T parameter is equivalent to BI VIEW; they are available for consistency with the older products. If the map checksum is determined to be invalid, the map will be reported as corrupted during a display command, as follows:

```
=>DNP BI VIEW<ENTER>

Binary Inputs  = Map Corrupted

=>
```

If the DNP command is issued with just an object type specifier (AI, AO, BI, BO, C) at level 2 or greater, the relay asks the user to enter indices for the corresponding list. (The A parameter is the same as AI and B is the same as BI; these parameters are available for consistency with older products.) 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 map). If a single entry of OFF or NA is entered, all objects of that type will be disabled. For example, the first example remap could be produced with the following commands:


```

==>DNP AI<ENTER>

Enter the new DNP Analog Input map
112 28 17 \<ENTER>
35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102 \<ENTER>
103<ENTER>

Save Settings (Y/N)? Y<ENTER>

==>DNP BI<ENTER>

Enter the new DNP Binary Input map
<ENTER>

Save Settings (Y/N)? Y<ENTER>

==>DNP AO<ENTER>

Enter the new DNP Analog Output map
OFF<ENTER>

Save Settings (Y/N)? Y<ENTER>

==>

```

The DNP command will report an error if an index is used twice, an invalid index is used, or nonnumeric data is entered:

```

xx is referenced more than once, changes not saved

xx is not a valid index, changes not saved

Invalid format, changes not saved

```

Custom Scaling

In addition to remapping, these commands can be used on analog inputs to create custom scaling and dead-bands per point. Scaling is done by adding a semicolon and scaling factor to a point reference. The base value will be multiplied by the scaling factor before reporting it. This is done instead of the DECPLA setting that would normally apply. Dead-bands are added using a colon and dead-band count. This dead-band will override the ANADBA setting. For example:

```

==>DNP AI<ENTER>

Enter the new DNP Analog Input map
112;5 28;0.2 17:10 1;1:15<ENTER>

==>

```

These settings will cause the value at index 112 (now at index 0) to be multiplied by five before it is reported. Similarly, the value at index 28 (now at index 1) will be multiplied by 0.2 before it is reported. Both of these values will use the default dead-band. The value at index 17 (now at index 2) is left for default scaling, but uses a dead-band of +/- 10 counts. Similarly, the value that was at index 1 (now at index 3) is now scaled by 1 and uses a dead-band of +/- 15 counts.

Modem Support

The modem handling will only be applied when the port settings include the following:

PROTOCOL = DNP

MODEM = Y

On power-up and settings change, the relay shall initialize the modem by issuing the string "+++AT" followed by the MSTR string and <CR>. This will initialize the modem. The MSTR (modem string) is a port setting visible only when the protocol setting is DNP. The MSTR setting is a series of ASCII characters that initialize the modem by sending the modem a series of commands.

If someone calls in, the modem will send "RING" and "CONNECT" messages to the relay. These messages, as well as all messages received while DCD is low, shall be ignored. All DNP messages received while connected shall be treated normally.

If the relay needs to send an unsolicited message and it is not currently connected, it must attempt to make a connection by sending the string "+++ATDT" followed by the phone number and <CR>. It shall then wait for a "CONNECT" message. Once "CONNECT" is received and CTS is asserted, the relay can consider itself connected and continue its transaction. If connection is not achieved within MDTIME seconds of initiating the phone call, the relay shall issue the command "+++ATH<CR>" and wait at least MDRETI seconds before trying again and try MDRETN times before giving up. If it fails to connect in the first try, it will try again at a later time every six hours.

If the relay initiates a connection, it shall disconnect once there have been no transactions for TIMEOUT time, using the disconnect command "+++ATH<CR>". Also, if an outside caller connects to the modem in the SEL-387, the SEL-387 will disconnect the modem if there have been no transactions for the TIMEOUT time.

Note 1: Because of the connection requirements described here, it will not be possible to use hardware flow control (RTSCTS) with the modem. This means that it is important to select a port baud rate low enough that the modem connection will not end up slower, or there will be a high likelihood of losing characters.

Note 2: The CTS signal shall be treated as a data carrier detect (DCD). This means that the message may only be transmitted while DCD is asserted. (Normally, a modem will be connected with a C220 or C222 cable that ties the DCD of the modem to the CTS.)

Virtual Terminal

The purpose of this Virtual Terminal (VT) Protocol is to allow ASCII data transfers between a master and an SEL relay over a DNP port. DNP3.0 objects 112 and 113 are used for embedding the ASCII communications over the DNP port. At the master each slave channel is assigned a Virtual Port number. Only one channel, with a Virtual Port number of "0" (for ASCII), is supported in the relay.

Object 112 is used with the Function code Write (FC=2) to send data from the Master side to the Slave side (IED) of the link.

Object 113 is used to send data from the relay side to the Master side of the link. Master devices may use only Function codes Read (FC=1). The relay uses only Function codes Response (FC=129).

The procedure for accessing these objects is as follows. Master devices transmit data to relay devices by writing one or more of object 112 to a relay using the Virtual Port number as the DNP point number. Relays send information to the Master using the Virtual Port number by responding to a Master READ (FC=1) request of object 113. Messages can flow in either direction at any time, however the relay sends messages only at the request of the Master. There are no explicit procedures for the initiation or conclusion of a VT session (i.e., implicit connections exist by the mere presence of a VT-compatible Slave IED).

Virtual terminal supports all ASCII commands listed in the **Command Summary** at the end of **Section 7: Serial Port Communications and Commands**. You do not need a password to login to a virtual terminal session through a DNP port, but you will need the appropriate access levels for setting changes and breaker operations. A virtual terminal session times out in the same way as an ASCII session.

SEL-387-5, -6 RELAY DNP PORT – SET P SETTINGS SHEET

Port Protocol (SEL, LMD, DNP)	PROTO	=	DNP
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	
DNP Address (0–65534)	DNPADR	=	
Port Time-out (0–30 minutes)	T_OUT	=	
Modem connected to port (Y, N)	MODEM	=	
Modem startup string (up to 30 characters)	MSTR	=	
Phone number to dial-out to (up to 30 characters)	PH_NUM	=	
Time to attempt dial (5–300 seconds)	MDTIME	=	
Time between dial-out attempts (5–3600 seconds)	MDRETI	=	
Number of dial-out attempts (0–5)	MDRETN	=	
Class for Analog event data (0 for no event, 1–3)	ECLASSA	=	
Class for Binary event data (0 for no event, 1–3)	ECLASSB	=	
Class for Counter event data (0 for no event, 1–3)	ECLASSC	=	
Time-set request interval, minutes (0 for never, 1–32767)	TIMERQ	=	
Currents scaling (0–3 decimal places)	DECPLA	=	
Select/Operate time-out interval, seconds (0.0–30.0)	STIMEO	=	
Number of data-link retries (0 for no confirm, 1–15)	DRETRY	=	
Data link time-out interval, seconds (0–5)	DTIMEO	=	
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	MINDLY	=	
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	MAXDLY	=	
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	PREDLY	=	
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	PSTDLY	=	
Analog reporting dead band (0–32767 counts)	ANADBA	=	
Event Data Confirmation time-out (0.1–50.0 sec)	ETIMEO	=	
Allow Unsolicited reporting (Y, N)	UNSOL	=	
Enable unsolicited messages on power-up (Y, N)	PUNSOL	=	
Address of master to report to (0–65534)	REPADR	=	

Number of events to transmit on (1–200)

NUMEVE = _____

Age of oldest event to force transmit on, seconds
(0.0–60.0)

AGEEVE = _____

SEL-387-5, -6 RELAY COMMAND SUMMARY

ACCESS LEVEL 0 COMMANDS

Access Level 0 Commands

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

- ACC Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.
- QUI Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.

ACCESS LEVEL 1 COMMANDS

Access Level 1 Commands

The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>

- 2AC Enter Access Level 2. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.
- BAC Enter Access Level B. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level B password in order to enter Access Level B.
- BRE Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
- CEV n Show compressed winding event report number n, at 1/4 cycle resolution.
Attach DIF for compressed differential element report, at 1/4 cycle resolution.
Attach R for compressed raw winding data report, at 1/16 cycle resolution.
Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)
- DAT Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE D n Show digital data event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE DIF1 n Show differential element 1 event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.
- EVE DIF2 n Show differential element 2 event report number n, with 1/4 cycle resolution.
Attach S8 for 1/8 cycle resolution.

EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
STA C	Clear relay status report from memory and reboot the relay.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.

TAR n k Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen.
Append F to display targets on the front panel, second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE Displays a thermal monitor report that indicates the present thermal status of the transformer.

THE C Clears the hourly profile, daily profile, and thermal event data archives.

THE D x y Retrives daily profile data from day x to day y.
 If x and y are omitted, retrieves entire profile data.
 If x or y is omitted, retrieves profile from day x (y) to present.

THE H x y Retrives hourly profile data from day x to day y.
 If x and y are omitted, retrieves entire profile data.
 If x or y is omitted, retrives profile from day x (y) to present.

THE n Displays saved thermal monitor report n where n = 1 is the most recently saved report.

THE P n Loads preset value of accumulated insulation loss of life.

THE R Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.

THE T Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.

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 The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>

ACC Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.

2AC Enter Access Level 2. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 2 password in order to enter Access Level 2.

BRE Breaker report shows trip counters, trip currents, and wear data for up to four breakers.

BRE R n Reset trip counters, trip currents, and wear data for breaker n (n = 1, 2, 3, 4, A).

BRE W n Pre-set the percent contact wear for each pole of breaker n (n = 1, 2, 3, or 4).

CEV n Show compressed winding event report number n, at ¼ cycle resolution.
Attach DIF for compressed differential element report, at ¼ cycle resolution.
Attach R for compressed raw winding data report, at 1/16 cycle resolution.
Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)

CLO n	Assert the CCn Relay Word bit. Used to close breaker n if CCn is assigned to an output contact. JMP24B has to be in place to enable this command.
DAT	Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE D n	Show digital data event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF1 n	Show differential element 1 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF2 n	Show differential element 2 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
GRO n	Switch to Setting Group n. (Will not function if any SSn Relay Word bit is asserted.)
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
OPE n	Assert the OCn Relay Word bit. Used to open breaker n if OCn is assigned to an output contact. JMP24B has to be in place to enable this command.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number k to pulse for k seconds [k = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP24B has to be in place to enable this command.

QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
TAR n k	Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen. Append F to display targets on the front panel second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D x y	Retrives daily profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE H x y	Retrives hourly profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE n	Displays saved thermal monitor report n where n = 1 is the most recently saved report.
THE P n	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.

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 2 COMMANDS

Access Level 2 Commands	The Access Level 2 commands primarily allow the user to change settings or operate relay parameters and output contacts. All Access Level 1 commands can also be executed from Access Level 2. The screen prompt is: =>>
ACC	Enter Access Level 1. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level 1 password in order to enter Access Level 1.
BAC	Enter Access Level B. If the main board password jumper (JMP24A) is not in place, the relay prompts for the entry of the Access Level B password in order to enter Access Level B.
BRE	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
BRE R n	Reset trip counters, trip currents, and wear data for breaker n (n = 1, 2, 3, 4, A).
BRE W n	Pre-set the percent contact wear for each pole of breaker n (n = 1, 2, 3, or 4).
CEV n	Show compressed winding event report number n, at ¼ cycle resolution. Attach DIF for compressed differential element report, at ¼ cycle resolution. Attach R for compressed raw winding data report, at 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4 or 8 for filtered data; m = 4, 8, 16, 32, or 64 for raw data)
CLO n	Assert the CCn Relay Word bit. Used to close breaker n if CCn is assigned to an output contact. JMP24B has to be in place to enable this command.
CON n	Control Relay Word bit RBn (Remote Bit n; n = 1 through 16). Execute CON n and the relay responds: CONTROL RBn. 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 one processing interval (1/8 cycle)].
COPY m n	Copy settings and logic from setting Group m to Group n.
DAT	Show date presently in the relay.
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 standard event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE D n	Show digital data event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.

EVE DIF1 n	Show differential element 1 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF2 n	Show differential element 2 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE DIF3 n	Show differential element 3 event report number n, with 1/4 cycle resolution. Attach S8 for 1/8 cycle resolution.
EVE R n	Show raw analog data event report number n, with 1/16 cycle resolution. Attach Sm for 1/m cycle resolution. (m = 4, 8, 32, 64)
GRO	Display active setting group number.
GRO n	Switch to Setting Group n. (Will not function if any SSn Relay Word bit is asserted.)
HIS n	Show brief summary of the n latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
INI	INITIO command reports the number and type of I/O boards in the relay. In Access Level 2, confirms that I/O boards are correct.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET k	Display metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET D k	Display demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET DIF k	Display differential metering data, in multiples of TAP. Enter number k to scroll metering k times on screen.
MET P k	Display peak demand metering data, in primary amperes. Enter number k to scroll metering k times on screen.
MET RD n	Reset demand metering values. (n = 1, 2, 3, 4, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 4, A)
MET SEC k	Display metering data (magnitude and phase angle), in secondary amperes. Enter number k to scroll metering k times on screen.
OPE n	Assert the OCn Relay Word bit. Used to open breaker n if OCn is assigned to an output contact. JMP24B has to be in place to enable this command.
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.
	If xxxxxx is DISABLE (upper case), password for selected level is disabled.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number k to pulse for k seconds [k = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP24B has to be in place to enable this command.
QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
RES	RESET51 command resets all inverse-time O/C elements for the four windings, including the Combined Overcurrent elements.

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 for 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	Clear the Sequential Events Recorder (SER) event reports from memory.
SET n	Change relay group settings (overcurrent, differential, etc.). For the SET commands, parameter n is the setting name at which to begin editing settings. If parameter n is not entered, setting editing starts at the first setting.
SET G	Change global settings.
SET P n	Change port settings.
SET R	Change Sequential Events Recorder (SER) settings.
SHO n	Show relay group n settings. Shows active group if n is not specified.
SHO G	Show relay global settings.
SHO P	Show port settings and identification of port to which user is connected.
SHO P n	Show port settings for port n (n = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
TAR n k	Show Relay Word row n status (n = 0 through 41). Enter number k to scroll Relay Word row n status k times on screen. Append F to display targets on the front panel, second row of LEDs.

All commands that begin THE apply to the SEL-387-6 Relay:

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D x y	Retrieves daily profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE H x y	Retrieves hourly profile data from day x to day y. If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE n	Displays saved thermal monitor report n where n = 1 is the most recently saved report.
THE P n	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2020 or an SEL-2030 Communications Processor.
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.