SEL-387E

CURRENT DIFFERENTIAL AND VOLTAGE PROTECTION RELAY

INSTRUCTION MANUAL

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

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

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

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

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.

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.

CAUTION: The continuous rating of the current inputs is $3 \cdot I_{nom}$. For this test, you may want to choose low values of U87P and TAPn, in order to limit the required test current to a safe value.

ATTENTION: La limite, en régime permanent, des entrées de courant est $3 \cdot I_{nom}$. Pour ce test, vous pourriez choisir de valeurs peu élevées pour U87P et TAPn, de façon à limiter le courant de test à une valeur sécuritaire.

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

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

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

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

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

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

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.

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

PM387E-01

MANUAL CHANGE INFORMATION

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

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

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

Revision Date	Summary of Revisions
The ***Manual Change Information*** section has been created to begin a record of revisions to this manual. All changes will be recorded in this Summary of Revisions table.	
20020218	• Updated ***Appendix A: Firmware Versions*** (firmware change corresponds with instruction manual edits with date code of 20020129).
20020129	• Clarified the tightening torque information, corrected values in AC Current Inputs and Power Supply, and added power supply rated 48/125 Vdc or 125 Vac in ***Specifications***, ***Section 1: Introduction and Specifications***. • Updated front- and rear-panel drawings in ***Section 2: Installation***. • Added harmonic restraint function necessitating changes to text and figures in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements***, the Relay Word bit tables in ***Section 4: Control Logic***, text in ***Settings Sheets and Settings Sheets Example*** in ***Section 6: Setting the Relay***, text in ***Section 10: Testing and Troubleshooting***, and the Binary Input Table in ***Appendix G: Distributed Network Protocol (DNP) 3.00***. • Corrected typographical errors in ***Section 3***. • Added information about energy metering in ***Section 5: Metering and Monitoring***, ***Section 7: Serial Port Communications and Commands***, ***SEL-387E Relay Command Summary***, and ***Section 8: Front-Panel Interface***. • Clarified settings for Three-Phase Voltage Input and Phase Potential Connection in ***Section 6***. • Updated figures in ***Section 8***. • Removed remote bits from ***Table 9.6 Differential Event Report Element Columns*** in ***Section 9: Event Reports and Sequential Events Reporting***. • Corrected typographical errors in ***Section 10***. • Updated ***Appendix A: Firmware Versions***.

Revision Date	Summary of Revisions
20020129 (*continued*)	• Replaced ***Appendix B: Firmware Upgrade Instructions*** with a revised, more comprehensive ***Appendix B: SEL-300 Series Relays Firmware Upgrade Instructions***. • Made typographical corrections to ***Appendix D: Configuration, Fast Meter, and Fast Operate Commands***. • Changed Relay Word bit !ALARM to NOTALM necessitating changes in the Relay Word bit table and text in ***Section 4*** and in the Binary Input Table in ***Appendix G***.
20010906	• Removed 32IOP as input to "REF Directional Element" logic AND gate. With 32IOP removed as an input, the AND gate only uses 32IE and 50GC as inputs. Changed 50GP multiplier from 0.9 to 0.8 in 50GC logic (***Figure 3.8*** and ***Figure 3.9*** in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements***). • Clarified voltage settings in ***Section 3***. • Updated ***Appendix A: Firmware Versions***.
20010521	• Manual reissue. • Made typographical changes under ***Model Options*** and in ***Specification***, both in ***Section 1: Introduction and Specifications***. • Updated front- and rear-panel drawings, rearranged some text, added description of a four-position prewired connector for PT wiring in ***Section 2: Installation***. • Changed the title of ***Section 3*** to ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements***; moved overcurrent element application guidelines and descriptions of differential and overcurrent elements from ***Section 6*** to ***Section 3***; rearranged order of text and figures. • Changed ***Section 4*** to ***Section 4: Control Logic*** and changed ***Section 5*** to ***Section 5: Metering and Monitoring***. • Added figures illustrating the station dc battery monitor alarm logic and the undervoltage and overvoltage warning and alarm regions to ***Section 5: Metering and Monitoring.*** • Changed the title of ***Section 6*** to ***Section 6: Setting the Relay***; moved information on differential elements and overcurrent elements and application guidelines for overcurrent elements to ***Section 3***. Made typographical corrections to ***Settings Sheets*** and ***Settings Sheets Example***. • Made text changes throughout ***Section 7: Serial Port Communications and Commands*** to advise the user to change default passwords to private, strong passwords at installation.

Revision Date	Summary of Revisions
20010521 (*continued*)	• Made typographical changes in ***Section 8: Front-Panel Interface***, ***Section 9: Event Reports and Sequential Events Reporting***, and ***Section 10: Testing and Troubleshooting***; added information about Compressed ASCII event reports to ***Section 9***. • Changed the title of ***Appendix A*** to ***Appendix A: Firmware Versions***; in ***Appendix E: Compressed ASCII Commands*** replaced specific Relay Word bit names in examples of CASCII messages with "*NAMES OF ELEMENTS IN ALL RELAY WORD ROWS*"; in ***Appendix F: Unsolicited SER Protocol*** added Function Disabled to list of response codes in Acknowledge Message; ***Appendix G: Distributed Network Protocol (DNP) 3.00*** reordered rows in SET P Settings Sheet to match order in relay.
20010130	• Deleted unavailable power supply option from ***Specifications*** in ***Section 1: Introduction and Specifications***.
20010102	• Updated ***Appendix A: Firmware Versions in This Manual*** and ***Appendix G: Distributed Network Protocol (DNP) 3.00***.
20001116	• Added Distributed Network Protocol (DNP) 3.00 resulting in changes to ***Section 6: Additional Settings and Settings Sheets***; ***Section 7: Serial Port Communications and Commands***; ***Section 8: Front-Panel Interface***; and ***Appendix A: Firmware Versions in This Manual*** and creation of ***Appendix G: Distributed Network Protocol (DNP) 3.00***. • Added cautions, warnings, and dangers in English and French to the reverse of the title page. • Restructured introduction; corrected ***Figure 1.1: SEL-387E Relay Functional Overview***; added information about restricted earth fault protection, overvoltage and undervoltage protection, and frequency protection; and made typographical corrections to specifications in ***Section 1: Introduction and Specifications***. • Made typographical corrections in ***Section 3: Differential, Overcurrent, Voltage, and Frequency Elements***. • Corrected format for the **METER** report in ***Section 4: Metering, Monitoring, and Reporting Functions***. • Added clarifying information about local control switches; moved text; corrected note on page 5-9 to indicate that only one setting group change per day should be made; added note about making latch bit settings with care on page 5-12; corrected ***Figure 5.7: SEL-387E Relay Trip Logic (TRIP1)*** on page 5-17; clarified ***Limitations of SELOGIC® Control Equations*** subsection starting on page 5-24; corrected tables 5.8, 5.9, and 5.10 to add Relay Word bit rows 48 and 49 in ***Section 5: Control Logic Functions***.

Revision Date	Summary of Revisions
20001116 (*continued*)	Included ***SEL-387 Relay Command Summary***; corrected table 7.2 on page 7-3; deleted information about cable connection SEL-PRTU to SEL-387E and added information about connection of Cable 272A between SEL-2020/2030 and SEL-387E Relay on page 7-5; added warning about changing default passwords to private passwords at relay installation on pages 7-22 and 8-10; added notes about taking care when setting the date and time on pages 7-17 and 7-32; added note about making SER settingswith care on page 7-28 in ***Section 7: Serial Port Communications and Commands***. • Added notes about taking care when setting the date and time on pages 8-6 and 8-7; added Winding 1 and 2 current sum for power calculations in ***Section 8: Front-Panel Interface***. • Made typographical corrections in ***Appendix D: Configuration, Fast Meter, and Fast Operate Commands*** and ***Appendix E: Compressed ASCII Commands***.
20000728	• Corrected equation in ***Section 3: Differential, Overcurrent, Voltage, and Frequency Elements***, page 3-25. • Added detailed information about differential element application and setting and overcurrent protection in ***Section 6: Additional Settings and Settings Sheets***.
20000606	• Corrected ***Figure 3.4: Differential Element Harmonic Blocking Logic*** and ***Figure 3.6: REF Enable/Block Logic*** and made typographical corrections in ***Section 3: Differential, Overcurrent, Voltage, and Frequency Elements***. • Made typographical corrections in ***Settings Sheets*** and ***Settings Sheets Example*** in ***Section 6: Additional Settings and Settings Sheets***. • Added firmware SEL-387E-R101-V0-Z001001-D20000606, ***Appendix A: Firmware Versions in This Manual*** to correct second-harmonic and fifth-harmonic elements' failure to block when required.
20000414	• Clarified PT connections in ***Figure 2.16: Example AC Connections (three-winding transformer; open-delta-connected voltages)*** in ***Section 2: Installation***. • Clarified independent harmonic blocking selection in ***Figure 3.4: Differential Element Harmonic Blocking Logic***; rearranged data in ***Table 3.3: Overcurrent Element Summary***; corrected 50Qn1, 50Nn1, 51Qn, and 51Nn logic and text to show the elements use $3I_2$ and I_R instead of I_2 and I_0, respectively; corrected ***Figure 3.12: Combined Overcurrent Example***; and made other minor miscellaneous changes in ***Section 3: Differential, Overcurrent, Voltage, and Frequency Elements***. • Added information on settings changes via the front panel and serial port, added missing settings descriptions, and consolidated settings sheets in ***Section 6: Additional Settings and Settings Sheets***.

Revision Date	Summary of Revisions
20000414 *(continued)*	• ***Made*** minor miscellaneous changes to ***Section 9: Event Reports and Sequential Events Reporting***.
20000216	New Manual Release.

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SECTION 1: INTRODUCTION AND SPECIFICATIONS

INTRODUCTION

Use this relay to protect two- to three-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.

The SEL-387E Differential Relay provides three differential elements with dual slope characteristics. The second slope provides security against CT saturation for heavy through faults. Be sure to conduct detailed analysis of CT performance under worst-case saturation conditions to set the relay characteristic correctly for bus protection applications. For assistance with CT selection, obtain ***SEL Application Guide 99-07 Bus Protection Using a Four-Winding Low-Impedance Percentage Differential Relay*** from the SEL Web site (www.selinc.com).

INSTRUCTION MANUAL OVERVIEW

This instruction manual applies to the SEL-387E 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, Overcurrent, Voltage, and Frequency 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 4***, 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 Sequential Events Reporting 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

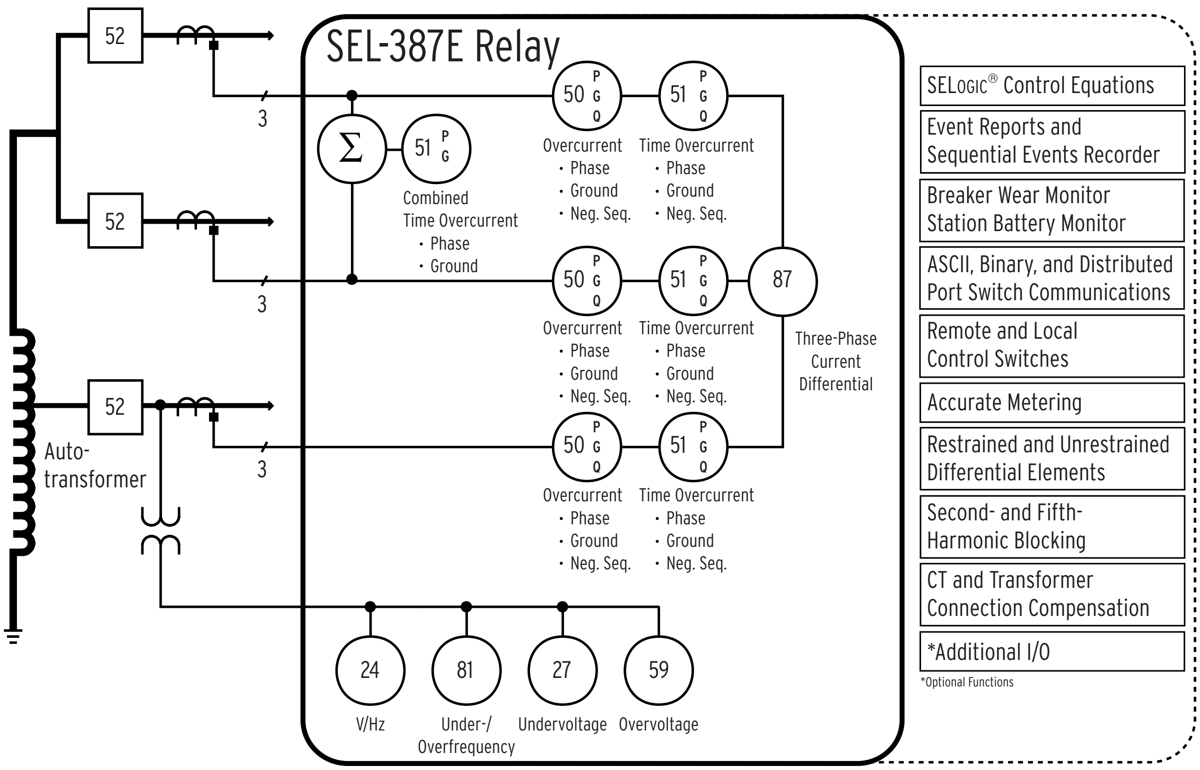

Figure 1.1: SEL-387E Relay Functional Overview

Current Differential Protection

The SEL-387E Relay includes independent restrained and unrestrained current differential elements. The restrained element has a dual-slope, variable-percentage restraint characteristic. Use the fifth-harmonic element to prevent relay misoperation during allowable overexcitation conditions. Even-harmonic elements (second and fourth harmonic) provide security against inrush currents during transformer energization, complemented by the dc element which measures the dc offset. The even-harmonic element offers the choice between harmonic blocking and harmonic restraint. In the blocking mode, the user selects either blocking on an individual phase basis or on a common basis, as per application and philosophy. The second-, fourth-, and fifth-harmonic thresholds are set independently, and the dc blocking and harmonic restraint features are enabled independently. A separate unrestrained differential element provides faster clearance of high-magnitude internal faults.

Restricted Earth Fault Protection

The SEL-387E Relay provides sensitive detection of internal ground faults via the Restricted Earth Fault (REF) protection element. The Winding 3 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 one breaker and set of CTs at the other terminal. Since the Winding 3 inputs are used for the neutral CT, only two of the winding inputs may be used for normal differential or overcurrent protection purposes.

Overcurrent Protection

The SEL-387E 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-387E Relay has two special overcurrent functions:

- Combined overcurrent (inverse time, phase, and ground) for summed currents from Windings 1 and 2
- Restricted Earth Fault (REF) protection for sensitive ground fault detection in grounded wye-connected windings

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

Volts-per-Hertz Protection

The SEL-387E Relay provides sensitive dual-level elements to detect voltage overexcitation. Level 1 volts-per-hertz elements provide instantaneous and definite-time operation for alarm or trip. Level 2 elements provide one of three selectable inverse-time/definite-time composite characteristics, or one user-definable inverse-time characteristic, for alarm or trip. Both volts-per-hertz protection levels may be torque controlled.

Overvoltage and Undervoltage Protection

The SEL-387E Relay provides eight overvoltage and undervoltage elements. Elements include phase undervoltage and overvoltage elements, phase-to-phase undervoltage and overvoltage elements, as well as positive sequence, negative sequence, and residual overvoltage elements. Phase and phase-to-phase elements operate when any individual phase exceeds the respective setting. Combine these elements with SELOGIC control equations to provide time delays for up to 999999 cycles. The elements have many applications in protection, control, and indication.

Frequency Protection

The SEL-387E Relay provides six levels of under-/overfrequency elements. Each element can operate as either an underfrequency or as an overfrequency element, depending on its pickup setting. Should any phase voltage fall below a user-defined value, the relay disables all frequency elements, providing security against loss-of-potential conditions. The relay tracks the system frequency from 40.1 to 65 Hz to provide measurement of frequency excursions over a wide range. Apply the elements readily to underfrequency load shedding and restoration control systems.

Programmable Optoisolated Inputs and Output Contacts

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

MODEL OPTIONS

Conventional Terminal Blocks

This model includes hardware that supports nine current inputs, three voltage inputs, six optoisolated inputs, seven programmable output contacts, one alarm contact, three EIA-232 ports, one 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.

SPECIFICATIONS

General

Terminal Connections:

Rear Screw-Terminal Tightening Torque
Terminal Block:
Minimum: 8 in-lb (0.9 Nm)
Maximum: 12 in-lb (1.4 Nm)

Connectorized (for further information, see ***SEL Application Guide 2001-03, Installing and Servicing Connectors for Connectorized® Relays***):
Minimum: 4.4 in-lb (0.5 Nm)
Maximum: 8.8 in-lb (1.0 Nm)

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

AC Current Inputs:

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

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

AC Voltage Inputs:

300 V_{L-N}, three-phase, four-wire connection
300 V continuous (connect any voltage from 0 to 300 Vac)
600 V for 10 s
Burden: 0.03 VA @ 67 V; 0.06 VA @ 120 V; 0.8 VA @ 300 V

Power Supply:

Rated: 125/250 Vdc or Vac
Range: 85–350 Vdc or 85–264 Vac
Burden: <25 W
Interruption: 45 ms at 125 Vdc
Ripple: 100%

Rated: 48/125 Vdc or 125 Vac
Range: 38–200 Vdc or 85–140 Vac
Burden: <25 W
Interruption: 160 ms at 125 Vdc
Ripple: 100%

Rated: 24/48 Vdc
Range: 18–60 Vdc polarity dependent
Burden: <25 W
Interruption: 110 ms at 48 Vdc
Ripple: 100%

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

Output Contacts:

Standard:
Make: 30A; Carry: 6 A continuous carry at 70°C, 4 A continuous carry at 85°C;
1 s rating: 50 A; MOV protected: 270 Vac, 360 Vdc, 40 J;
Pickup time: Less than 5 ms; Dropout time: Less than 5 ms, typical

Breaking Capacity (10000 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: 30A; Carry: 6 A continuous carry at 70°C, 4 A continuous carry at 85°C;
1 s rating: 50 A; MOV protected: 330 Vdc, 40 J;
Pickup time: Less than 5 ms; Dropout time: Less than 8 ms, typical

Breaking Capacity (10000 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.

Optoisolated Inputs:

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, and 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: V, I inputs, optoisolated inputs, output contacts: 2500 Vac for 10 s; Power supply: 3100 Vdc for 10 s; EIA-485 communications port: 2200 Vdc

Frequency and Rotation: System Frequency: 50 or 60 Hz; Phase Rotation: ABC or ACB; Frequency Tracking Range: 40.1–65.0 Hz

Note: V_A required for frequency tracking.

Communications Ports: EIA-232: 1 front and 2 rear; EIA-485: 1 rear, 2100 Vdc isolation; Baud rate: 300–19200 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°C (–40° to +185°F)

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
*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 –40ºC
Dry Heat:	IEC 60068-2-2 [IEC 68-2-2]: 1974, EN 60068-2-2: 1993, Test Bd, 16 hours at +85ºC
Damp Heat, Cyclic:	IEC 60068-2-30 [IEC 68-2-30]: 1980, Test Db, 25° to 55ºC, 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, no keying test, frequency element accurate to 0.1 Hz
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, IP30
Protection Against Dust and Splashing Water:	IEC 60529 [IEC 529]: 1989, IP54 from the front panel using the SEL-9103
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.
UL Listed
CSA Certified

Sampling: 64 samples per power system cycle

Processing: Differential elements, optoisolated inputs, and contact outputs are processed at 1/8-cycle.
Overcurrent elements are processed at 1/8-cycle.

Metering Accuracy

Accuracy Range:

5 A Model

Phase Currents:	±1.5% ±0.10 A and ±1.5°
Sequence Currents:	±3.0% ±0.10 A and ±2.0°
Differential Quantities:	±5.0% ±0.10 A
2nd and 5th Harmonic:	±5.0% ±0.10 A
Current Harmonics:	±5.0% ±0.10 A

1 A Model
Phase Currents: ±1.5% ±0.02 A and ±1.5°
Sequence Currents: ±3.0% ±0.02 A and ±2.0°
Differential Quantities: ±5.0% ±0.02 A
2nd and 5th Harmonic: ±5.0% ±0.02 A
Current Harmonics: ±5.0% ±0.02 A

Phase Voltages: ±1.5% ±0.10 V and ±1.5°
Sequence Voltages: ±3.0% ±0.10 V and ±2.0°
Power Quantities: ±3.0% and ±3.0° for balanced currents and voltages

Station DC Battery Monitor

Pickup Range: 20–300 Vdc, 1 Vdc steps
Pickup Accuracy: ±2.0% ±2 Vdc

Differential Element

Unrestrained
Pickup Range: 1–20 in per unit of tap

Restrained
Pickup Range: 0.1–1.0 in per unit of tap

Pickup Accuracy (A secondary)
5 A Model: ±5% ±0.10 A
1 A Model: ±5% ±0.02 A

Unrestrained Element Pickup Time
(Min/Typ/Max): 0.8/1.0/1.9 cycles

Restrained Element (with harmonic blocking)
Pickup Time
(Min/Typ/Max): 1.5/1.6/2.2 cycles

Restrained Element (with harmonic restraint)
Pickup Time
(Min/Typ/Max): 2.62/2.72/2.86 cycles

Harmonic Element

Pickup Range
(% of fundamental) 5–100%

Pickup Accuracy (A secondary)
5 A Model: ±5% ±0.10 A
1 A Model: ±5% ±0.02 A

Time Delay Accuracy: ±0.1% ±0.25 cycle

Instantaneous/Definite-Time Overcurrent Elements (Winding)

Pickup Range (A secondary)
5 A Model: 0.25–100.00 A
1 A Model: 0.05–20.00 A

Pickup Accuracy (A secondary)
5 A Model
Steady State: ±3% ±0.10 A
Transient: ±5% ±0.10 A
Transient for 50Q: ±6% ±0.10 A

1 A Model:
Steady State: ±3% ±0.02 A
Transient: ±5% ±0.02 A
Transient for 50Q: ±6% ±0.02 A

Pickup Time (Typ/Max):	0.75/1.20 cycles
Time Delay Range:	0–16000 cycles
Time Delay Accuracy:	±0.1% ±0.25 cycle

Time Overcurrent Elements (Winding and Combined Current)

Pickup Range (A secondary)	
5 A Model:	0.50–16.00 A
1 A Model:	0.10–3.20 A
Pickup Accuracy (A secondary)	
5 A Model	
Steady State:	±3% ±0.10 A
Transient:	±5% ±0.10 A
Transient for 50Q:	±6% ±0.10 A
1 A Model	
Steady State:	±3% ±0.02 A
Transient:	±5% ±0.02 A
Transient for 50Q:	±6% ±0.02 A
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:	±4% ±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

Over-/Undervoltage Elements

Pickup Range:	0.00–300.00 V, 0.01 V steps
Steady-State Pickup Accuracy:	±5% ±2 V
Transient Overreach:	±5% of pickup

Frequency Element

Pickup Range:	40.10–65.00 Hz, 0.01 Hz steps
Steady-State plus Transient Overshoot:	±0.01 Hz
Time Delay:	0.04–300.00 s, 0.01 s steps
Timer Accuracy:	±0.1% ±0.0042 s
Frequency change caused by temperature:	$\Delta f_{sys} = f_{sys} \bullet (0.04 \bullet 10^{-6}) (T-25°C)^2$ where T = temperature of relay via **STATUS** command

Volts/Hertz Element

Definite-Time Element

Pickup Range:	100–200%
Steady-State Pickup Accuracy:	±1%
Pickup Time:	25 ms @ 60 Hz (Max)
Time-Delay Range:	0.00–400.00 s
Time-Delay Accuracy:	±0.1% ±4.2 ms @ 60 Hz
Reset Time Range:	0.00–400.00 s

Inverse-Time Element

Pickup Range:	100–200%
Steady-State Pickup Accuracy:	±1%
Pickup Time:	25 ms @ 60 Hz (Max)
Curve:	0.5, 1.0, or 2.0
Factor:	0.1–10.0 s
Timing Accuracy:	±4% ±25 ms @ 60 Hz, for V/Hz above 1.05 multiples (Curve 0.5 and 1.0) or 1.10 multiples (Curve 2.0) of pickup setting, and for operating times greater than 4 s
Reset Time Range:	0.00–400.00 s

Composite-Time Element:

Combination of Definite-Time and Inverse-Time specifications

User-Definable Curve Element

Pickup Range:	100–200%
Steady-State Pickup Accuracy:	±1%
Pickup Time:	25 ms @ 60 Hz (Max)
Reset Time Range:	0.00–400.00 s

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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

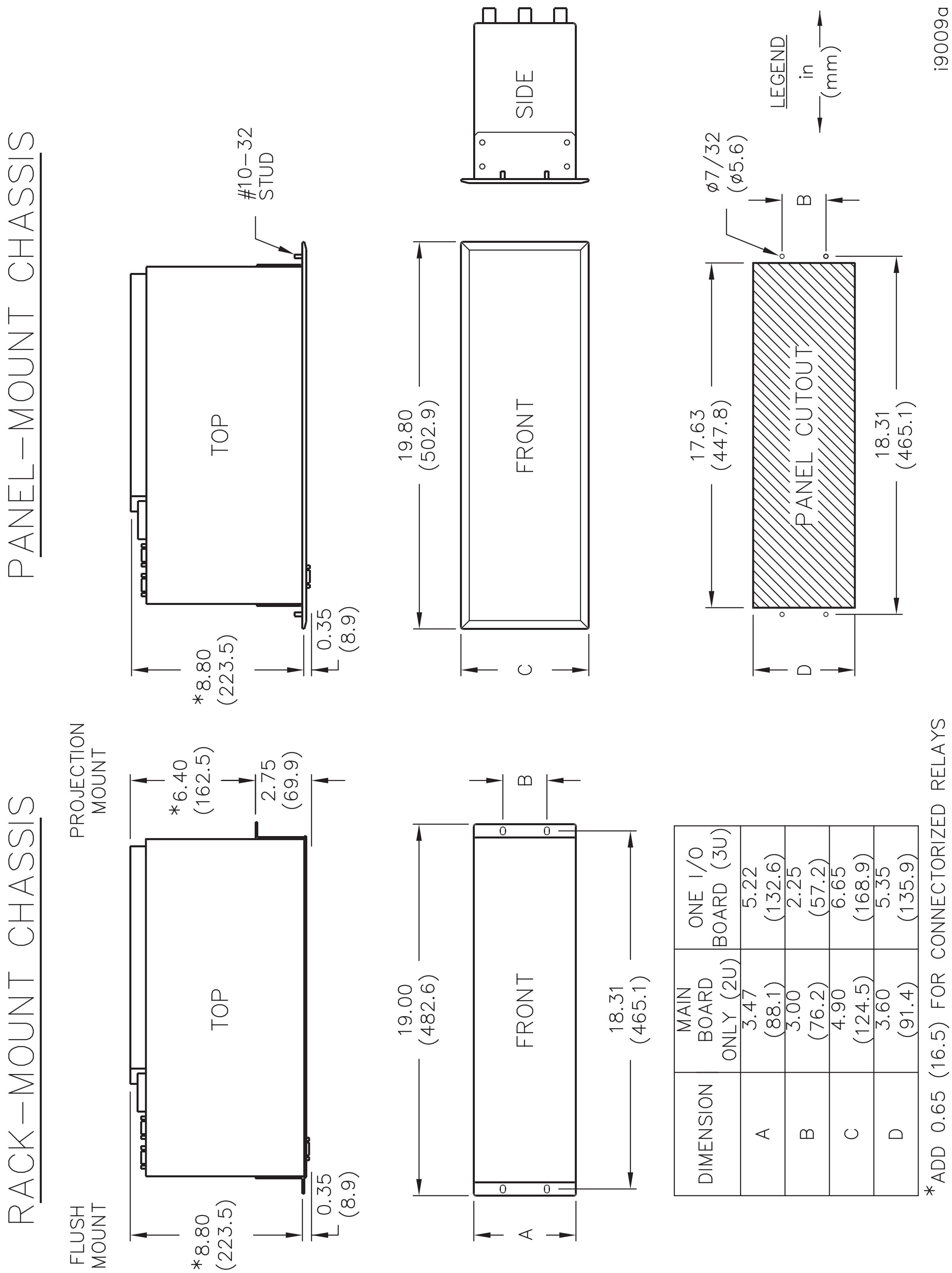
Rack Mount

We offer the SEL-387E Relay in a rack-mount version that bolts easily into a standard 19-inch rack. See Figure 2.2. 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-387E 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 2.3. 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.

Dimensions and Cutout



DIMENSION	MAIN BOARD ONLY (2U)	ONE I/O BOARD (3U)
A	3.47 (88.1)	5.22 (132.6)
B	3.00 (76.2)	2.25 (57.2)
C	4.90 (124.5)	6.65 (168.9)
D	3.60 (91.4)	5.35 (135.9)

*ADD 0.65 (16.5) FOR CONNECTORIZED RELAYS

Figure 2.1: Relay Dimensions and Panel-Mount Cutout

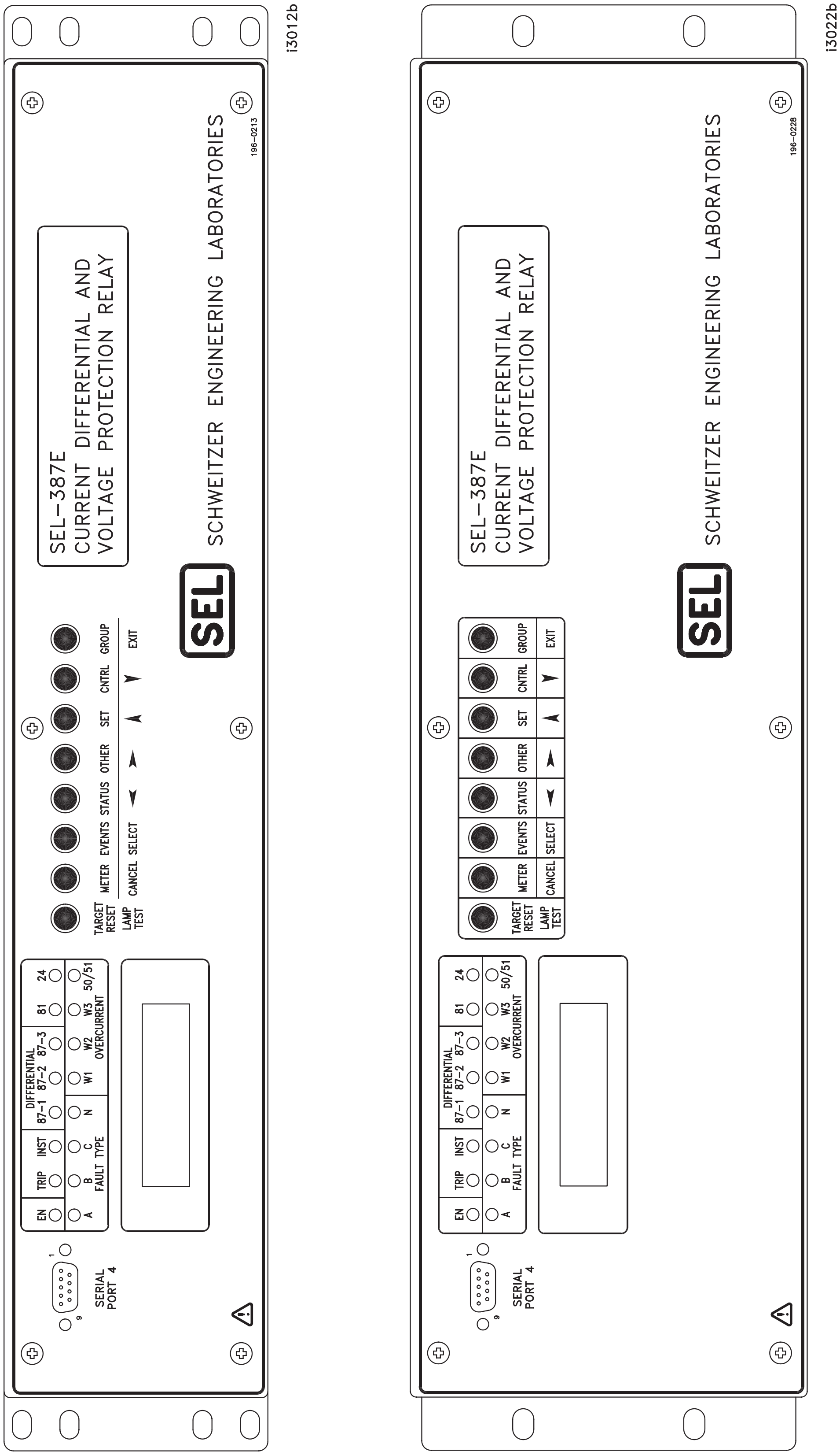


Figure 2.2: Front-Panel Drawings–Models 0387Ex0xxxH and 0387Ex1xxxH

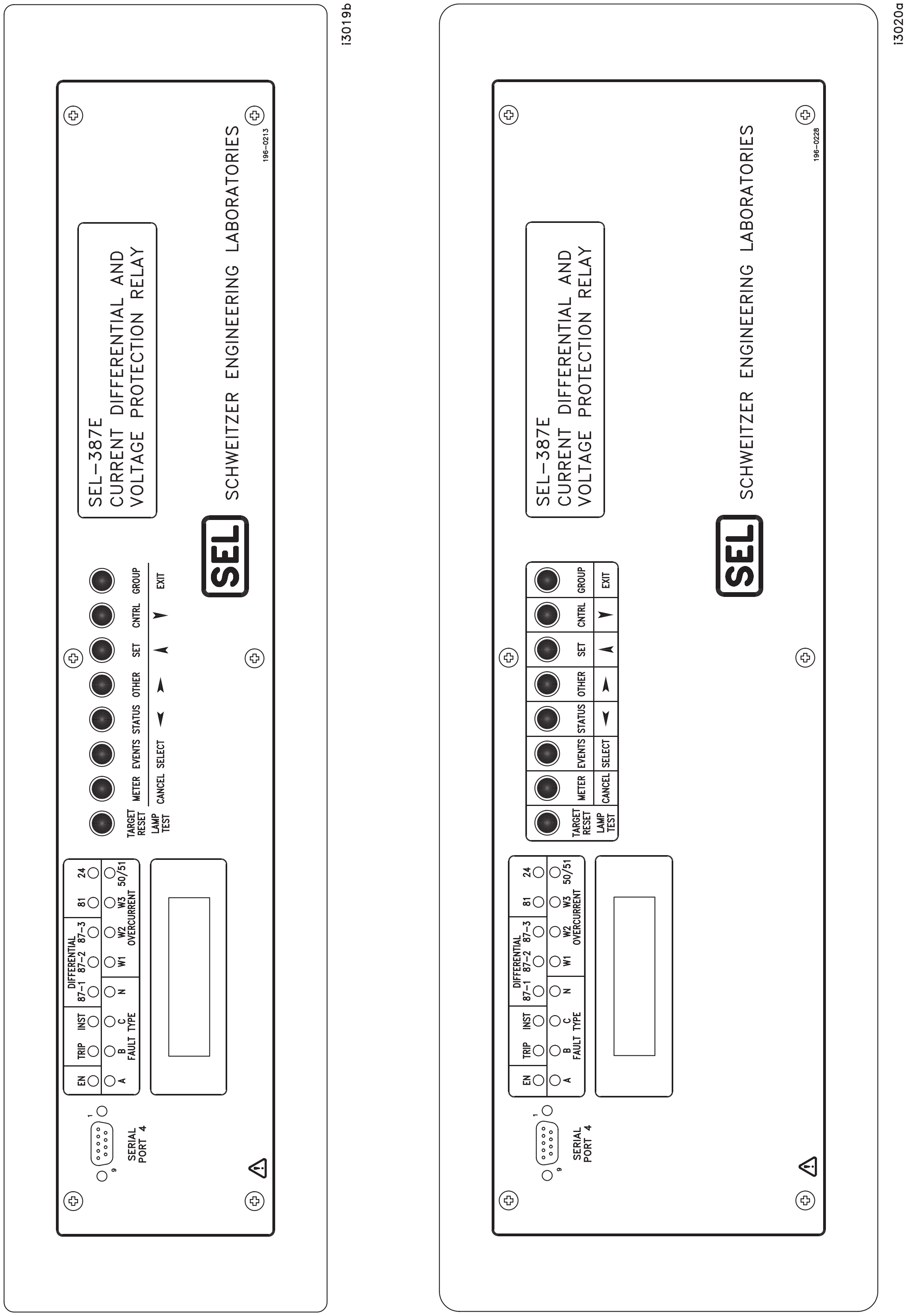


Figure 2.3: Front-Panel Drawings–Models 0387Ex0xxx3 and 0387Ex1xxx3

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-387E Relay, ask your SEL sales or customer service representative for the appropriate model option table and order wiring harness kit WA0387E0YxxxA, where x designates wire sizes and length. You can find the model option table on the SEL Web site at http://www.selinc.com. Refer to Figure 2.6 to make all Connectorized connections.

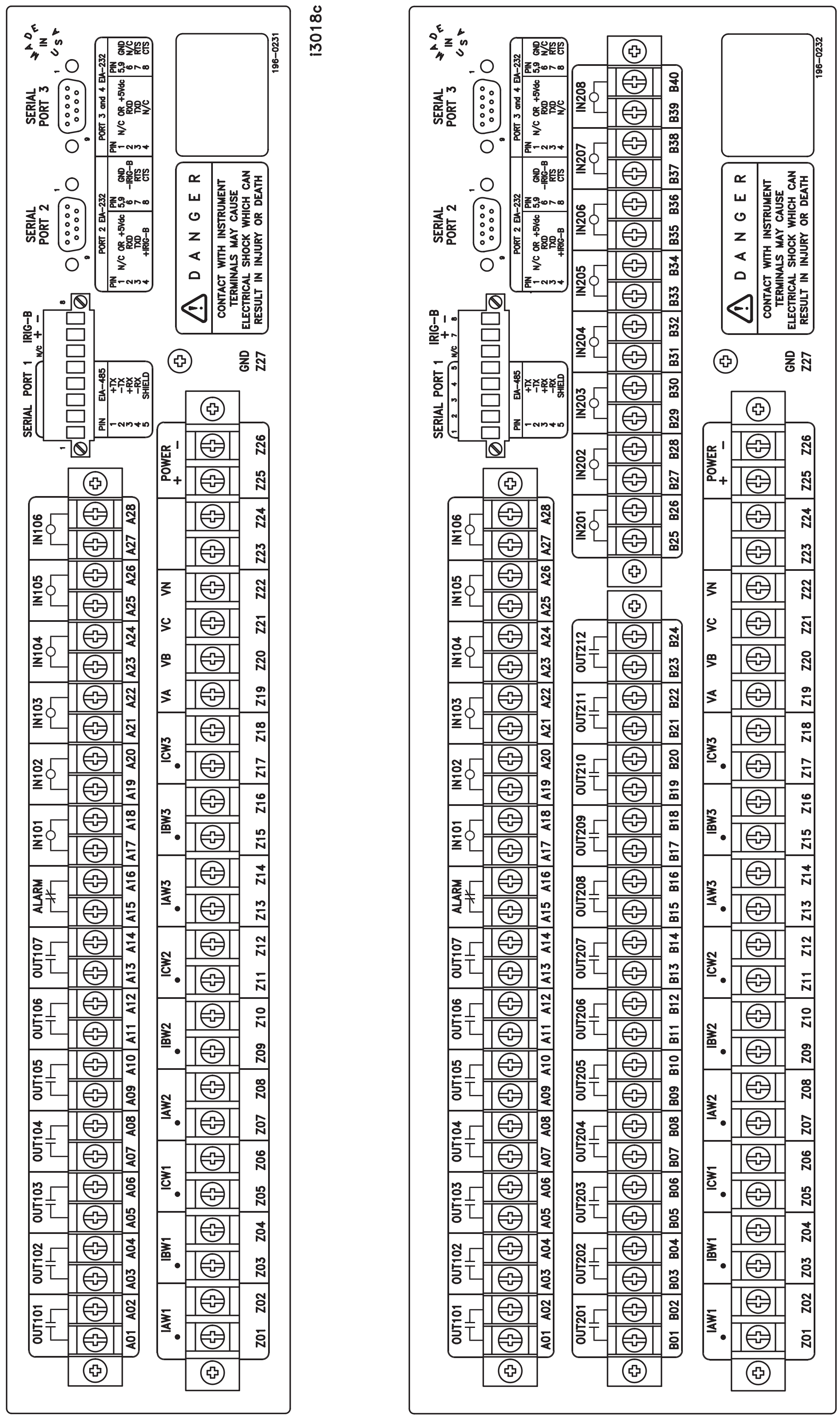
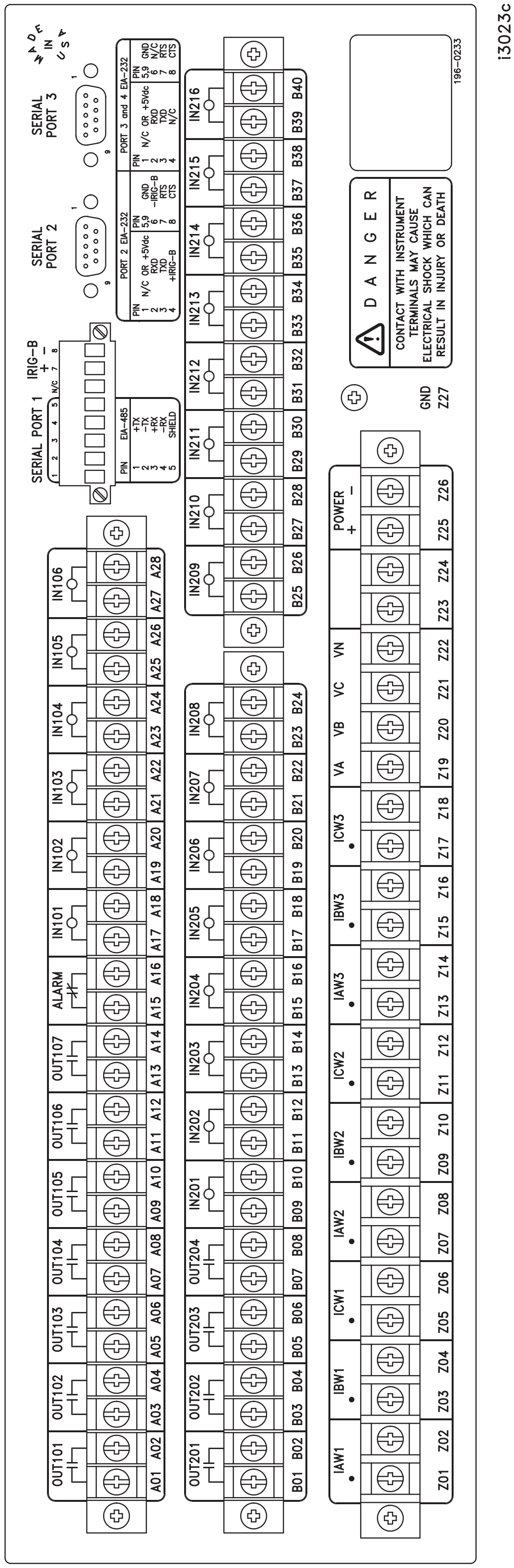


Figure 2.4: Rear Panel Drawings–Models 0387Ex0xxxxX and 0387Ex1xxxx2



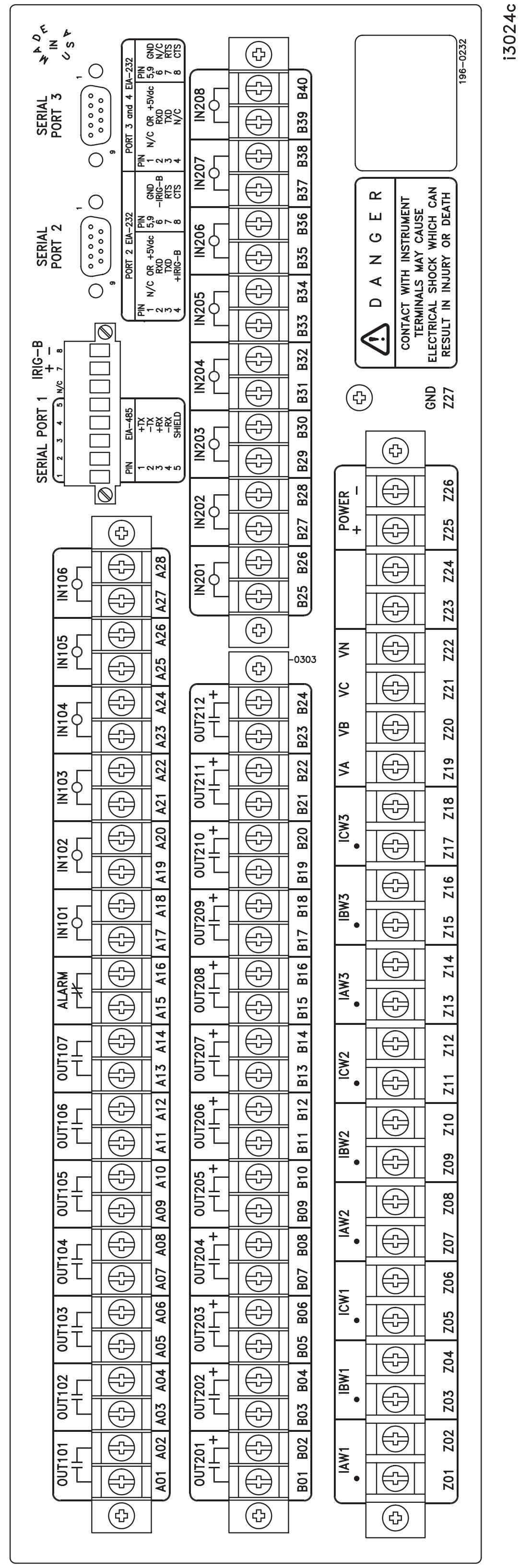
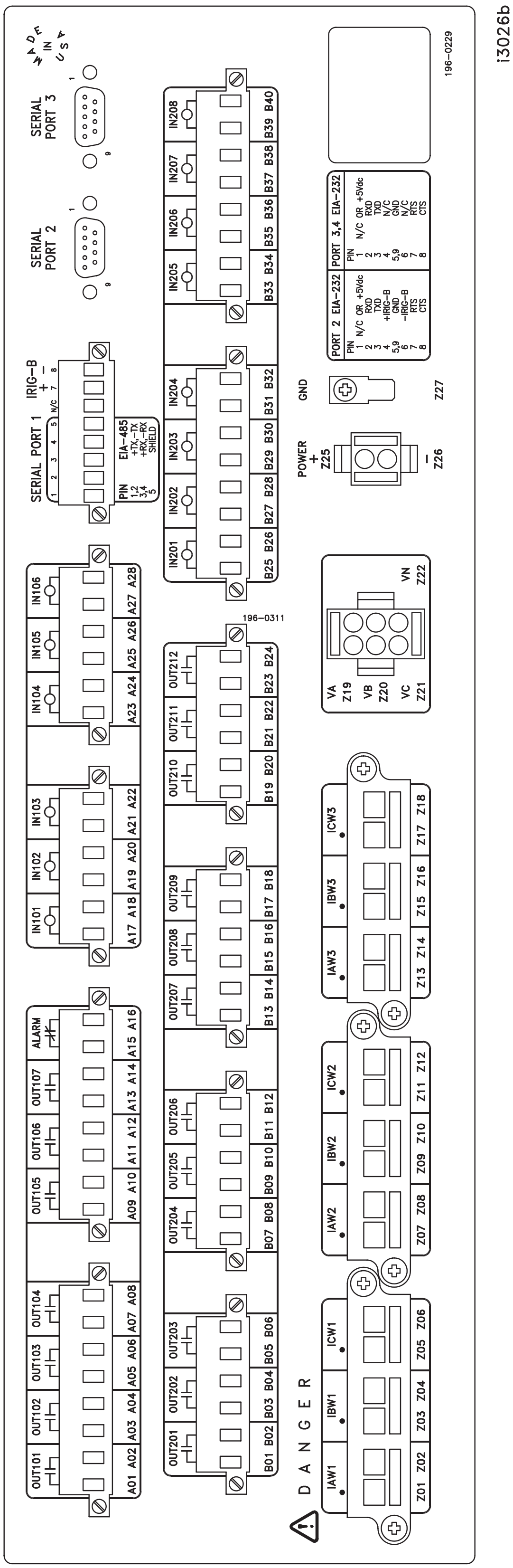


Figure 2.5: Rear-Panel Drawings–Models 0387Ex1xxxx4 and 0387Ex1xxxx6



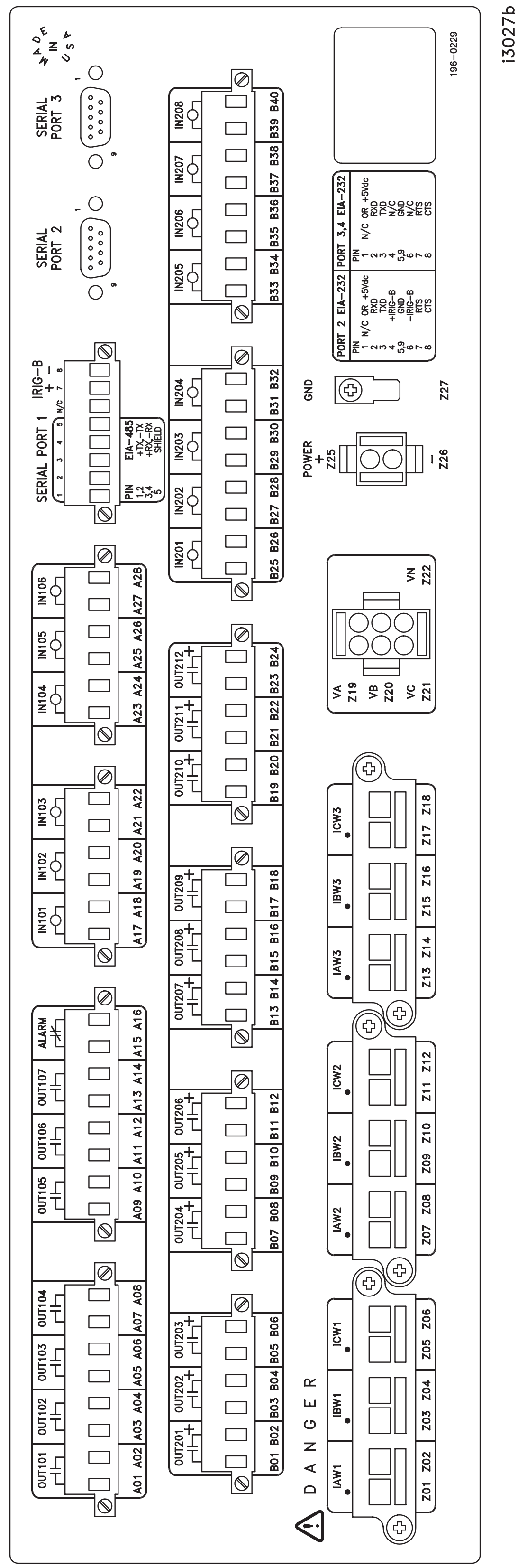


Figure 2.6: Rear-Panel Drawings–Models 0387ExYxxxx2 and 0387ExYxxxx6

Prewired Connectors

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

- (3) six-position CT shorting connectors for current inputs IAW1, IBW1, and ICW1; IAW2, IBW2, and ICW2; and IAW3, IBW3, and ICW3. For these connectors select a wire size from AWG 16 to 10.
- (1) four-position connector for PT wiring. Plug the connector into terminals Z19 through Z22. The connector is keyed uniquely and locks in place upon insertion.
- (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, output contacts, 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 interface board output contacts OUT201 through OUT203, OUT204 through OUT206, OUT207 through OUT209, and OUT210 through OUT212.
- (2) eight-position female plug-in connectors for interface 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. If the tab on the chassis is removed, the chassis ground connection can be made with the size #6-32 screw. 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 three 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; and IAW3, IBW3, ICW3.

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.

Potential Transformer Inputs

Any of the single-phase voltage inputs (i.e., VA-N, VB-N, or VC-N) can be connected to voltages up to 300 V RMS continuous. Figure 2.8 shows an example of wye-connected voltages. Frequency is determined from the voltages connected to terminal VA-N. Volts/hertz is determined from the largest per-winding volts/hertz measurement (see ***Volts/Hertz Element Specifications*** in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements***).

Note the signal labels (VA, VB, VC, N) on terminals Z19 through Z22. Figure 2.8 shows the internal connection for terminals VA, VB, VC, and VN.

Optoisolated Inputs

Connect control input wiring to the six standard inputs IN101–IN106 and to any of the interface 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 normally are within one volt of each other, in the indicated range.

Output Contacts

Connect output wiring to the SEL-387E 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.

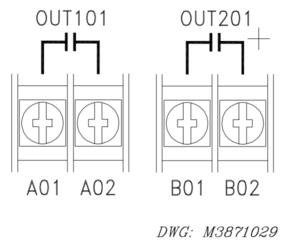


Figure 2.7: Standard Independent Output Contact Representation

Connect output wiring to any of the additional output contacts OUT201–OUT212 you need for your application. On the additional interface 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-387E 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-387E 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-387E Relay Communication Cable Numbers

SEL-387E 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-387E 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 Connection Diagrams

Figure 2.8 and Figure 2.12 represent the ac and dc connections for a typical three-winding transformer application. The transformer is an autotransformer with a delta tertiary whose terminals also have been brought out through bushings and are included in the differential zone of protection. Referring to Figure 2.8, the current transformers for all windings are wye connected, with their polarity marks facing away from the transformer. Their outputs are taken to the polarity ends of the relay current inputs, with the nonpolarity ends of the inputs connected to the CT neutral and ground. A single safety-ground point should be used, 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.)

This transformer example is used later for calculating relay settings; see ***Section 6: Setting the Relay***. This example forms the basis for most of the factory default settings stored in the relay before shipment.

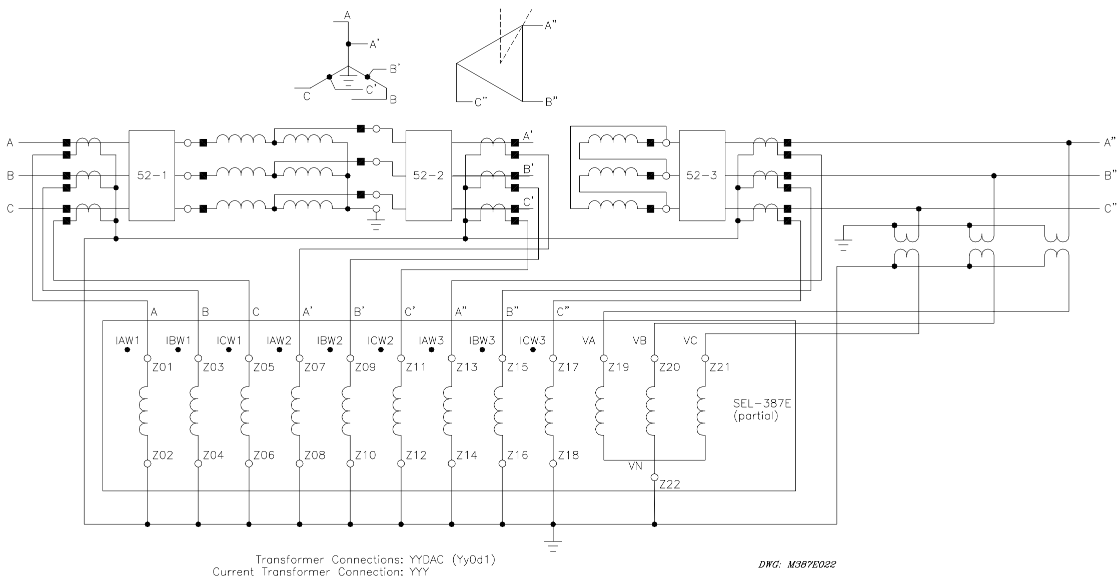


Figure 2.8: Example AC Connections (three-winding transformer; wye-connected voltages)

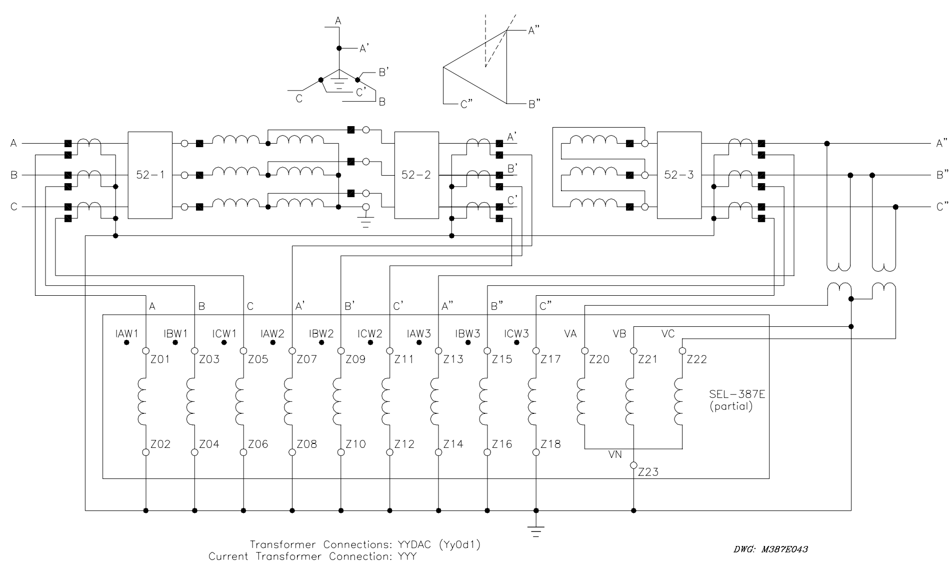


Figure 2.9: Example AC Connections (three-winding transformer; open-delta-connected voltages)

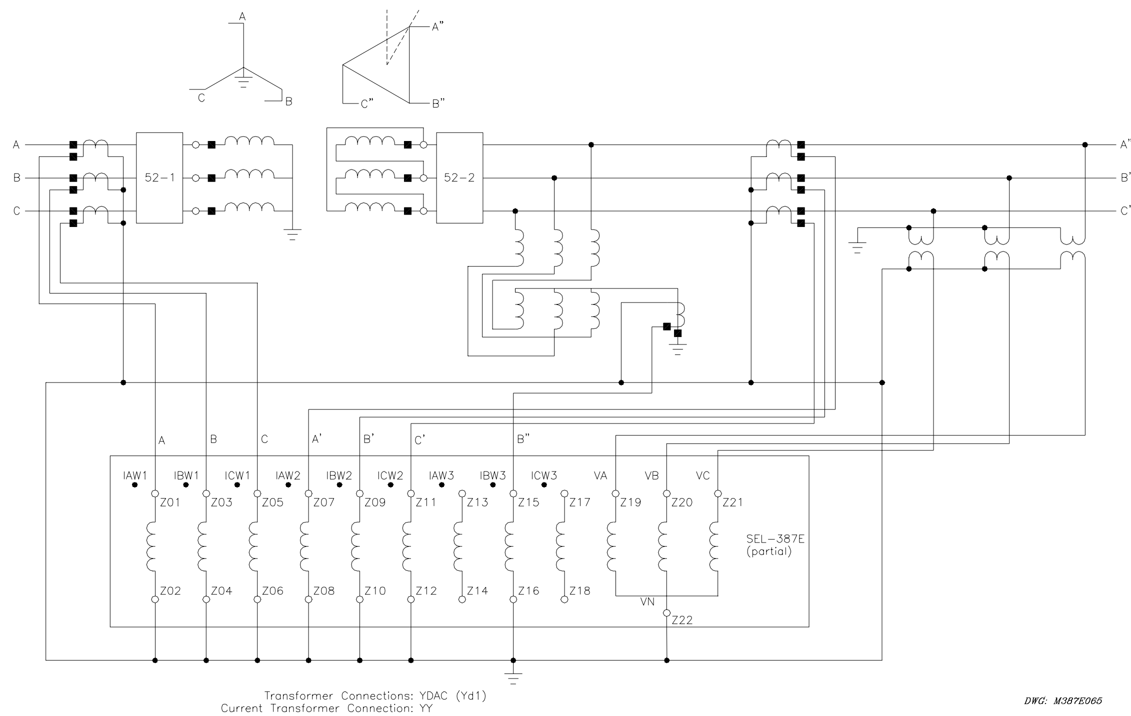


Figure 2.10: Example AC Connections (two-winding transformer; REF with LV compensated earthing; wye-connected voltages)

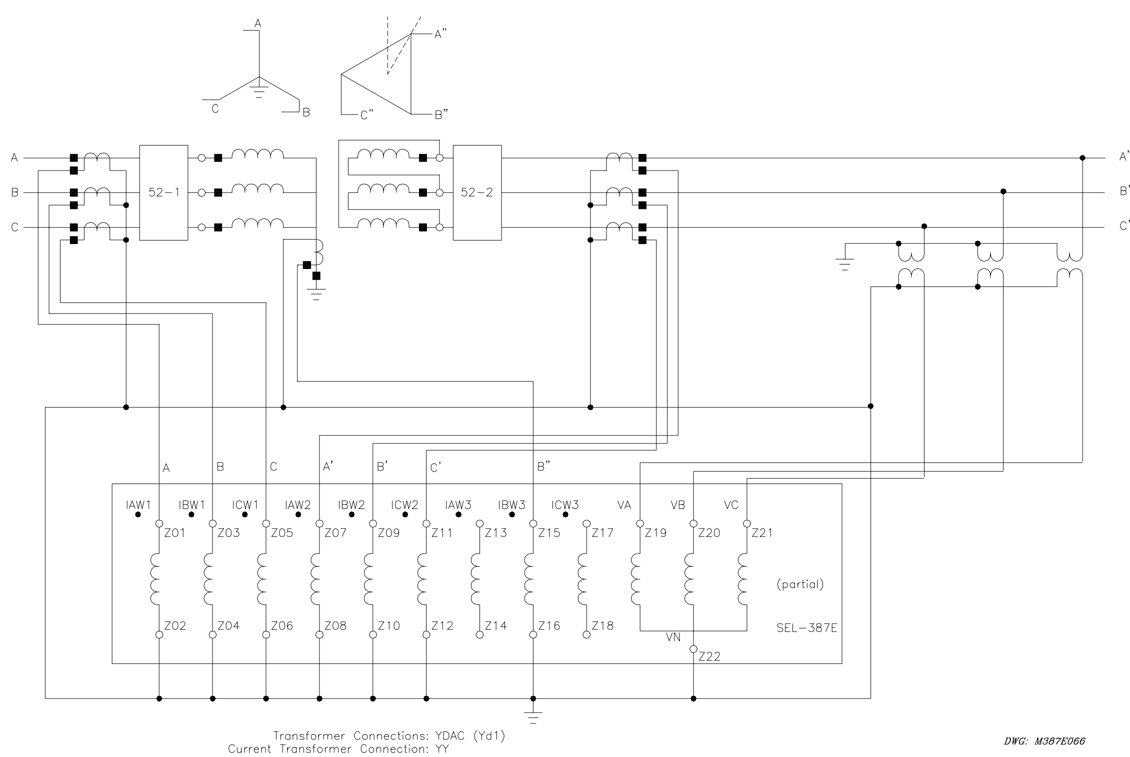


Figure 2.11: Example AC Connections (two-winding transformer; HV REF; wye-connected voltages)

In the dc connection diagram, Figure 2.12, tripping control of the three power circuit breakers is illustrated. This 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.

ALARM and annunciation functions are also shown. ALARM is factory wired as a form b contact, so that it closes under conditions of complete relay power failure. If breaker closing control were desired, the Trip Annunciator contact (OUT105) would be one of the three separate output contacts used 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.

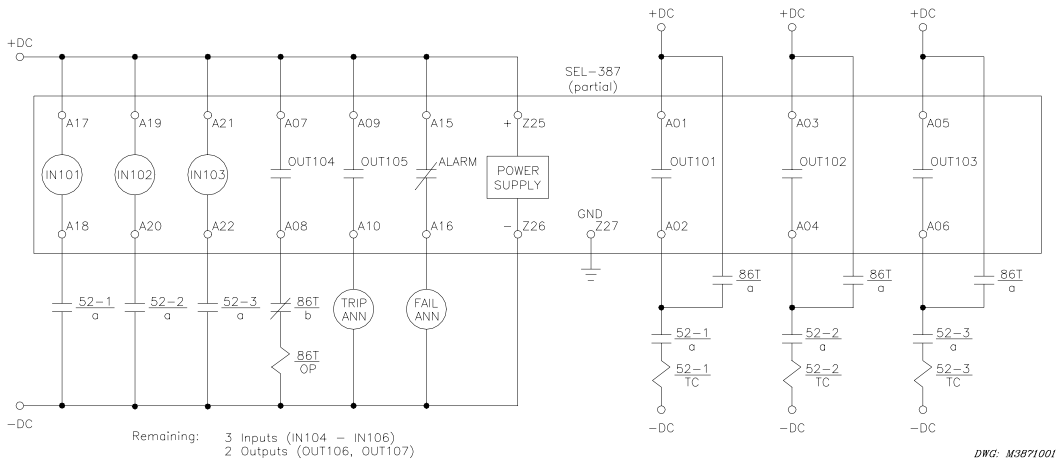


Figure 2.12: Example DC Connections (basic version)

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. De-energize 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.

!	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.

4. Each circuit board corresponds to a row of rear-panel terminal blocks or connectors and is affixed to a draw-out tray. Identify which draw-out tray needs to be removed. An SEL-387E

Relay Model 0387Ex0 has only a main board. A Model 0387Ex1 or 0387ExY relay has an extra interface board below the main board.

5. Disconnect circuit board cables as necessary so you can remove the board and draw-out tray you want. To remove the extra interface 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 draw-out 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 draw-out 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 2.13 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 de-energized 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 de-energized 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 interface 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 2.13, 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-387E 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 de-energized 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 2.13 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 2.13. 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 fuse 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-387E 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-387E 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 2.13. 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 2.13 for clock battery B1 location. This lithium battery powers the relay clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell. 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.

⚠ 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.

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 Interface Board

We offer versions of the SEL-387E 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 interface 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 interface boards have no jumpers. You must specify control voltage at the time of order.

Board Layout

Figure 2.14, Figure 2.15, and Figure 2.16 show the layout of Interface Board 2, Interface Board 4, and Interface Board 6 (conventional terminal block), respectively. Figure 2.17 and Figure 2.18 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.

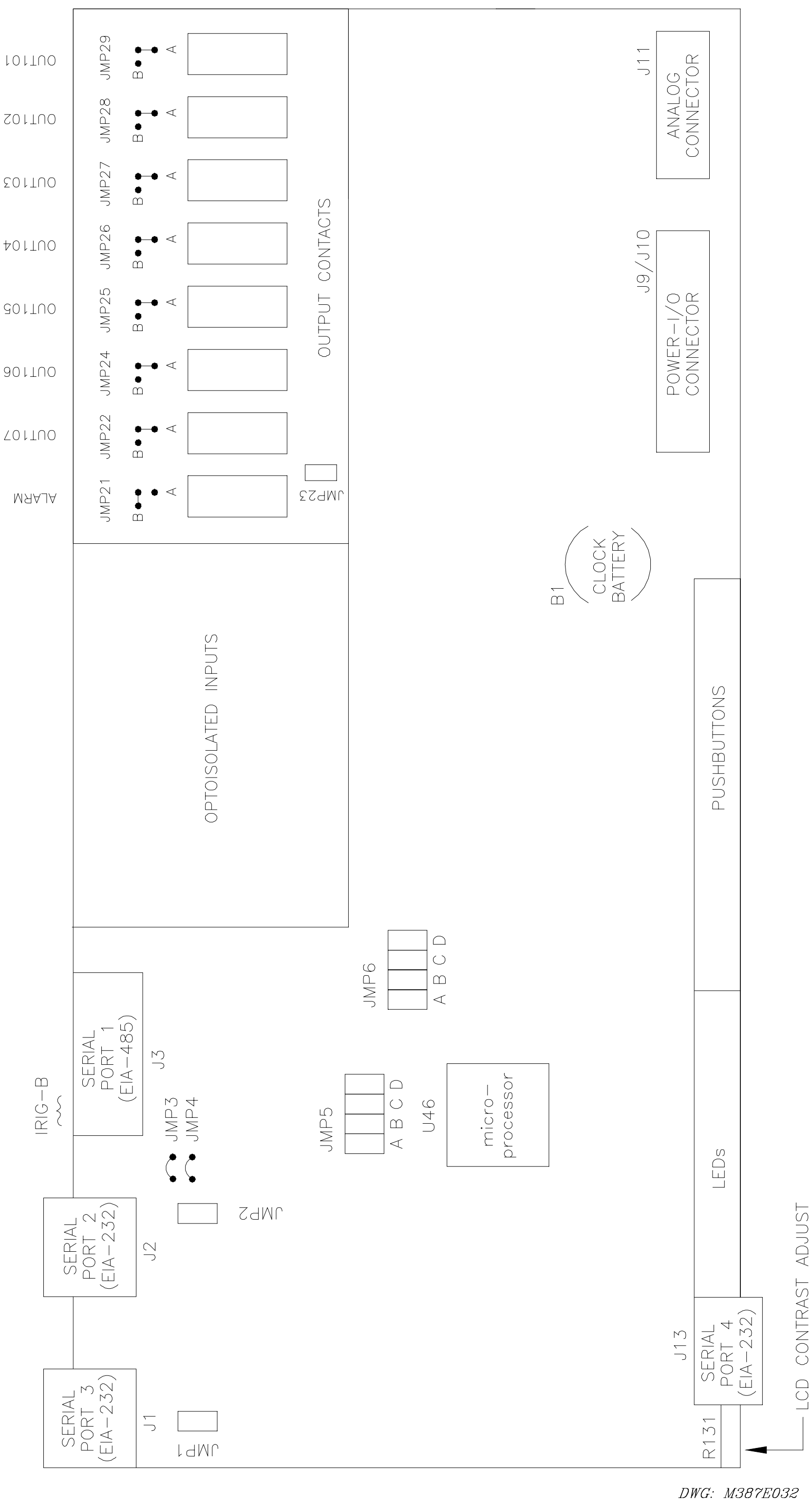
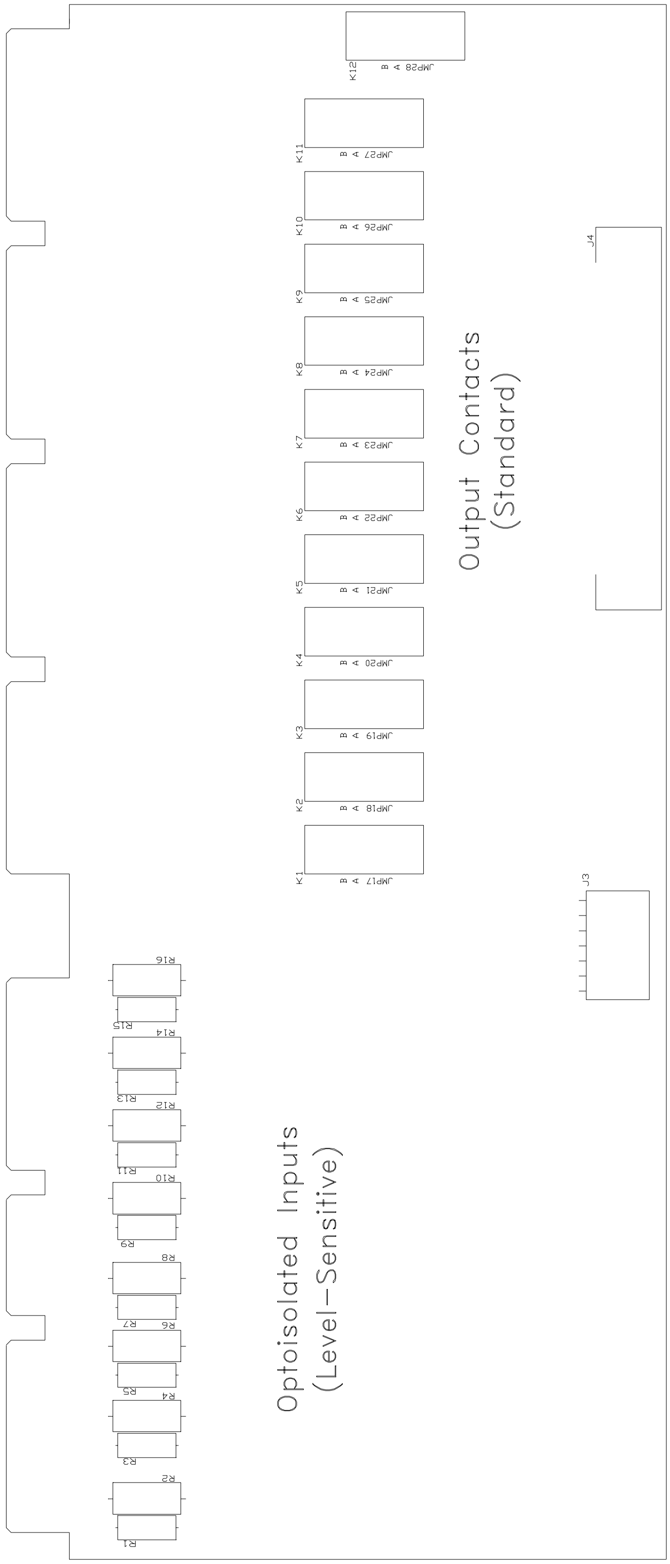


Figure 2.13: Main Board Jumpers, Connections, and Battery Locations



Output Contacts K1 – K12

Solder Jumper Position	Operation
A	Contact closes when asserted
B	Contact opens when asserted

Figure 2.14: Interface Board 2 Component Layout (Conventional Terminal Block)

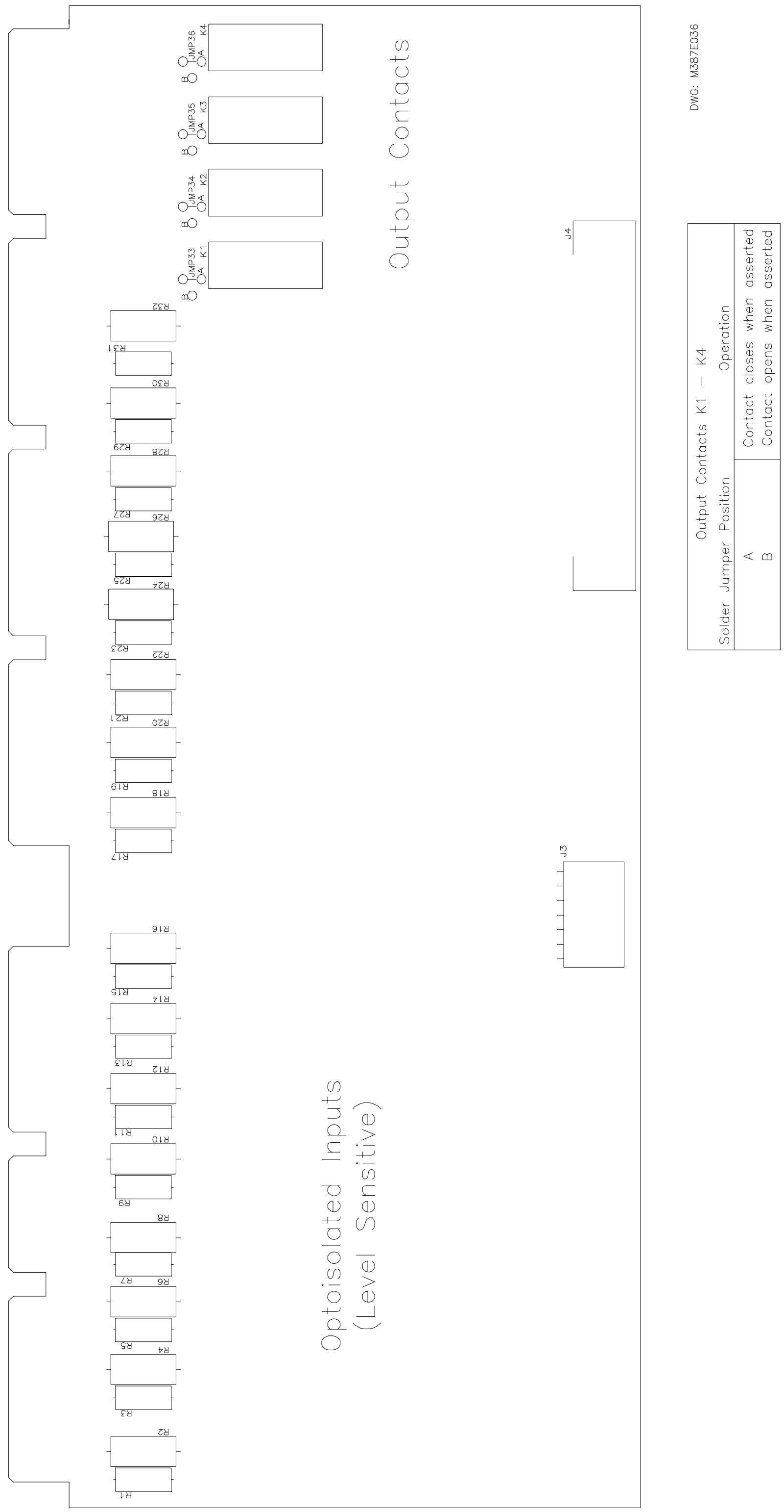


Figure 2.15: Interface Board 4 Component Layout (Conventional Terminal Block)

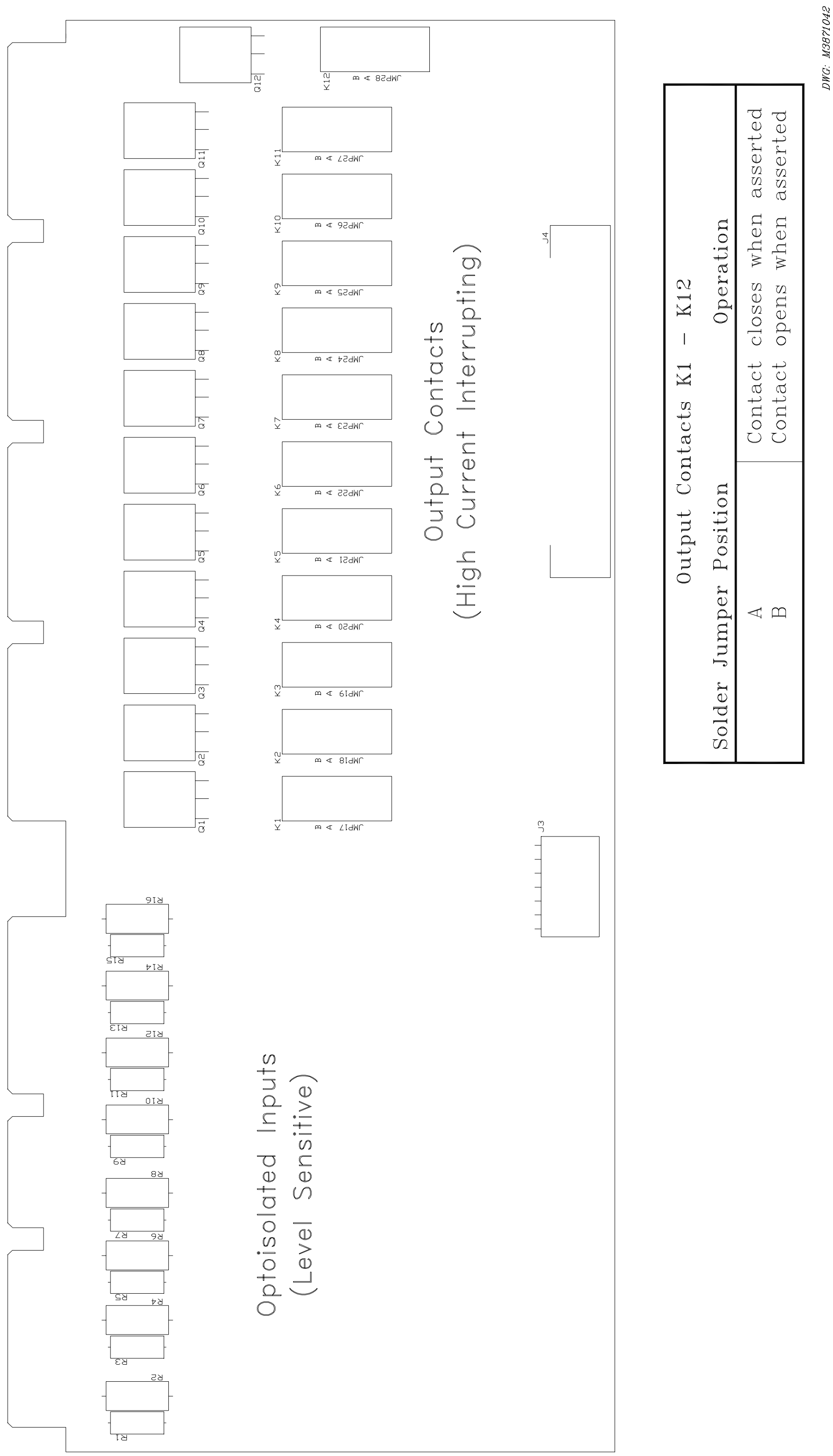


Figure 2.16: Interface Board 6 Component Layout (Conventional Terminal Block)

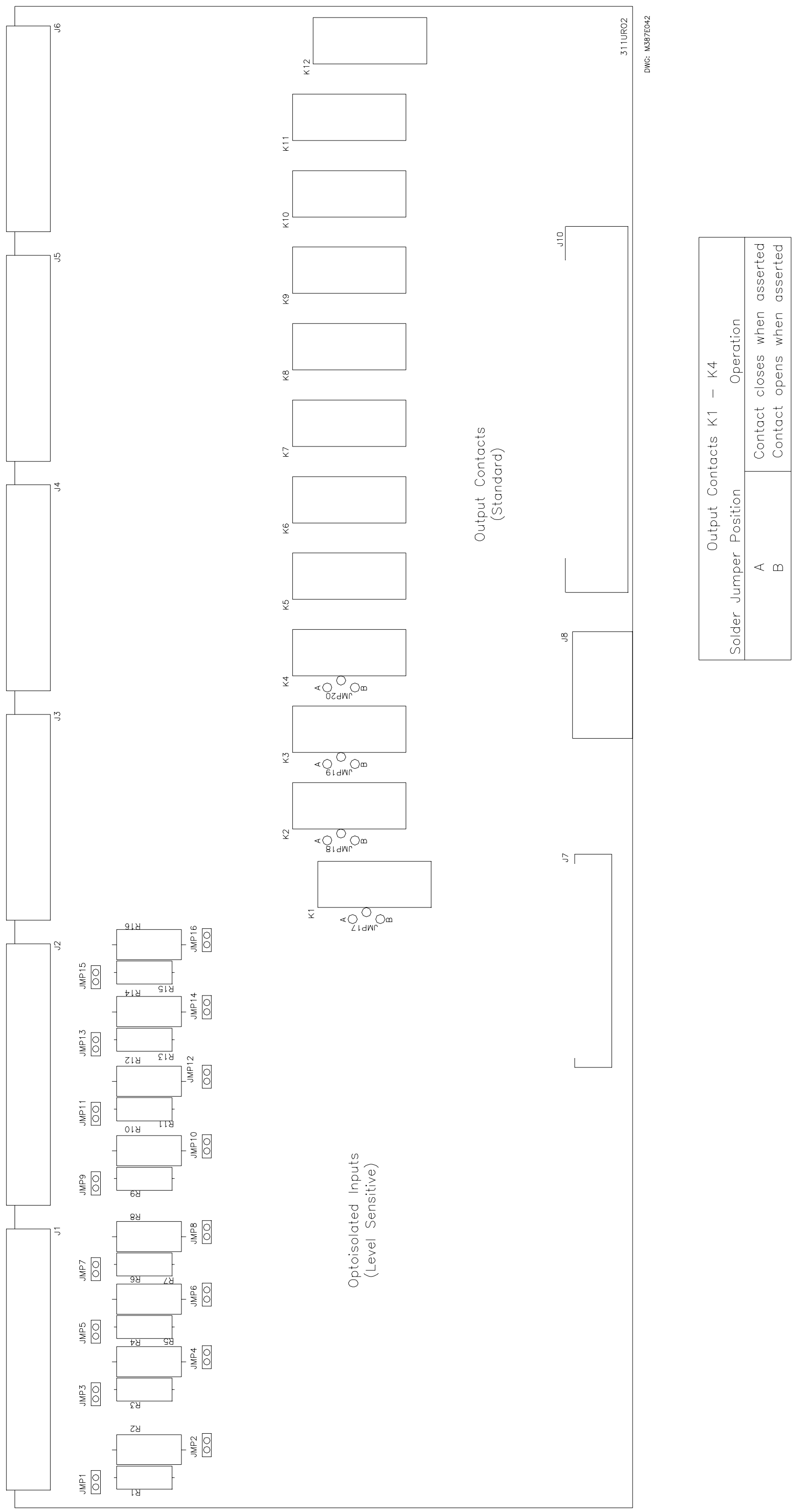


Figure 2.17: Interface Board 2 Component Layout (Connectorized)

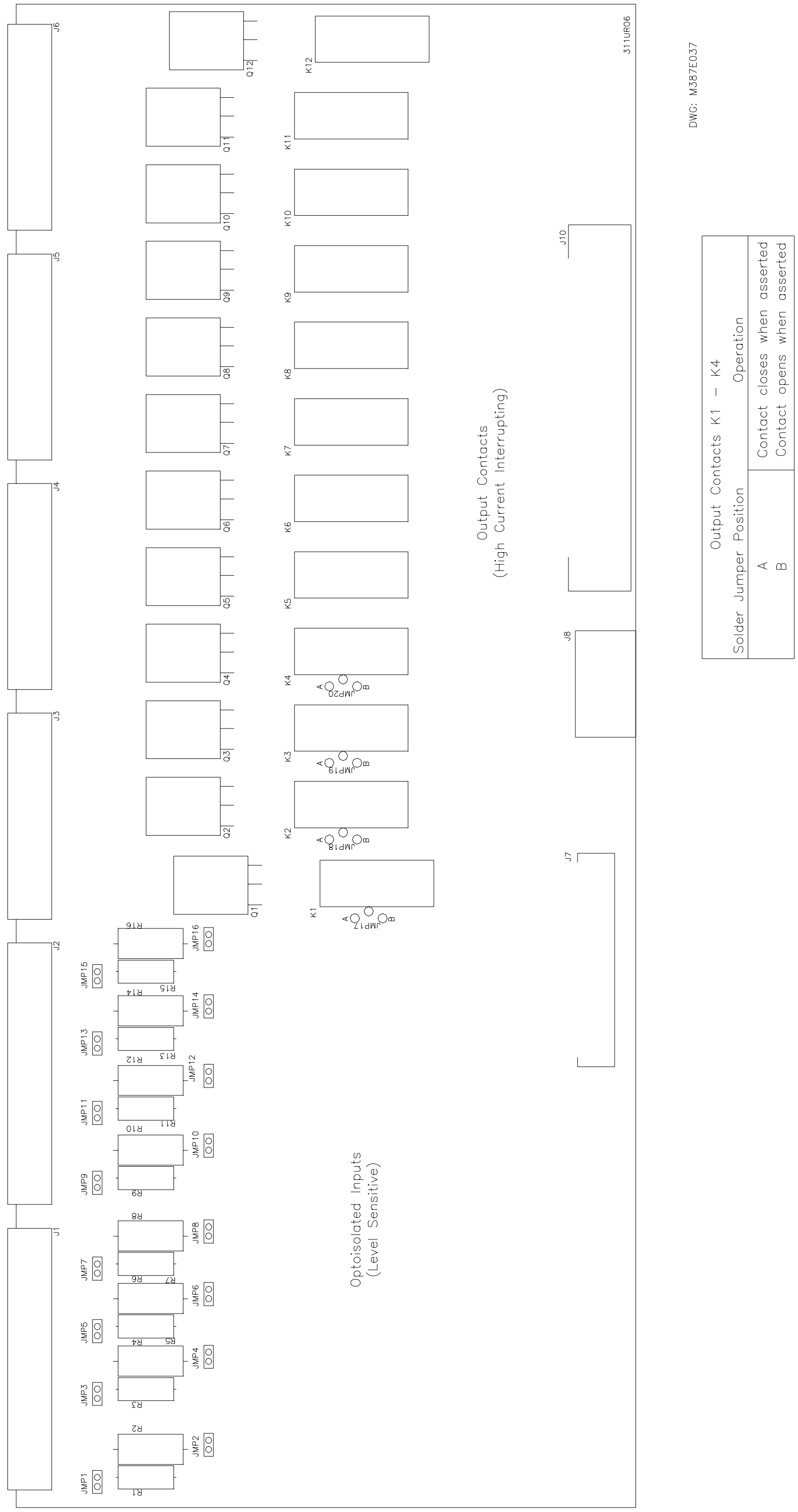


Figure 2.18: Interface Board 6 Component Layout (Connectorized)

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SECTION 3: DIFFERENTIAL, RESTRICTED EARTH FAULT, OVERCURRENT, VOLTAGE, AND FREQUENCY ELEMENTS

INTRODUCTION

This section describes general applications and operating characteristics for the current differential, restricted earth fault (REF), overcurrent, over- and undervoltage, frequency, and volts/hertz protection elements. The section also contains application guidelines for the differential and overcurrent 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.

The relay provides a choice between harmonic blocking and harmonic restraint, both providing stability during transformer inrush conditions. Even-numbered harmonics (second and fourth), augmented by dc blocking provide security during energization, while fifth harmonic blocking provides security for overexitation conditions.

Operating Characteristic

The SEL-387E 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. Figure 3.1 shows the relay characteristic. 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 the origin and intersecting O87P at IRT = O87P · 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.

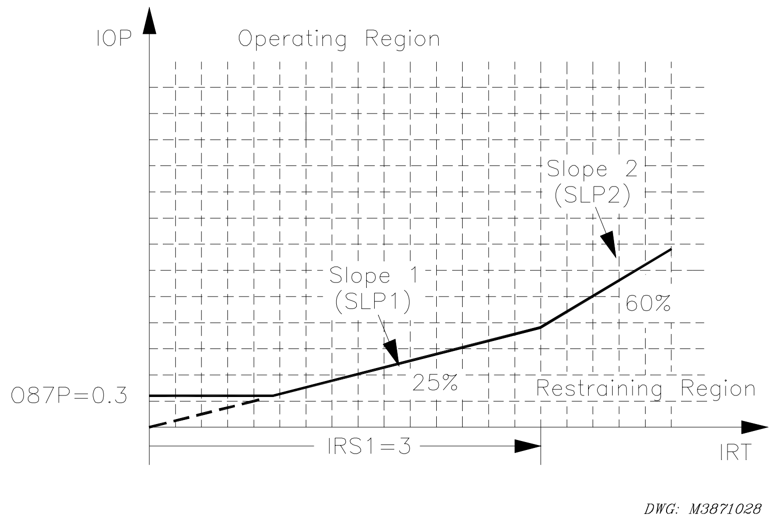


Figure 3.1: Percentage Restraint Differential Characteristic

Figure 3.2, Figure 3.3, and Figure 3.4 illustrate how input currents are acquired and used in the unrestrained and restrained differential element. Data acquisition, filtering, tap scaling, and transformer and CT connection compensation for Winding 1 are shown in Figure 3.2.

Four digital band-pass filters extract the fundamental, second, fourth, and fifth (not shown) harmonics of the input currents. A dc filter (not shown) forms one-cycle sums of the positive and negative values.

Using the transformer MVA rating as a common reference point, TAP scaling converts all secondary currents entering the relay from the three windings to per-unit values, thus changing the ampere values into dimensionless multiples of TAP. Throughout the text, the term "TAP" refers to the per-unit value common to all three windings, whereas "TAPn" refers to the ampere value of a particular winding(s); TAPmin and TAPmax refer to the least and greatest of the three TAPn values. This method 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.

Transformer and CT connection compensation adjusts the sets of three-phase currents for the phase angle and phase interaction effects introduced by the winding connection of the transformer and CTs. Settings W1CTC through W3CTC determine the mathematical corrections to the three-phase currents for Winding 1 through Winding 3, respectively. CTC1 is shown in Figure 3.2 as the phase angle and sequence quantity adjustment for Winding 1.

I1W1C1, I2W1C1, and I3W1C1 are the fundamental frequency A-phase, B-phase, and C-phase compensated currents for Winding 1. Similarly, I1W1C2, I2W1C2, and I3W1C2 are the second-harmonic compensated currents for Winding 1. The dc, fourth-harmonic, and fifth-harmonic compensated currents use similar names. The I1 compensated currents are used with differential element 87-1, I2 with element 87-2, and I3 with element 87-3.

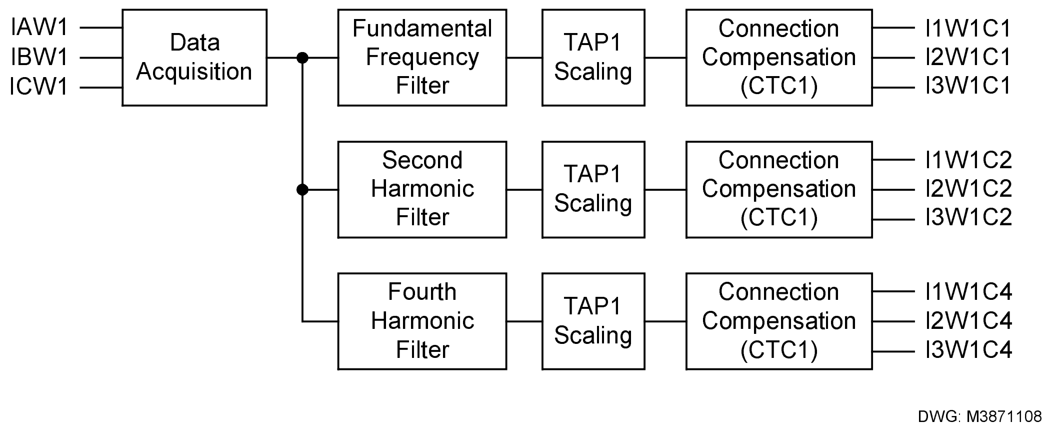


Figure 3.2: Winding 1 Compensated Currents

Figure 3.3 illustrates how the IOP1 (operate), IRT1 (restraint), IHRT1 (harmonic restraint), I1HB2 (second harmonic), and I1HB4 (fourth harmonic) quantities are calculated for the 87-1 element. IOP1 is generated by summing the winding currents in a phasor addition. IRT1 is generated by summing the magnitudes of the winding currents in a simple scalar addition and dividing by two. The 87-2 and 87-3 quantities are calculated in a similar manner.

For each restraint element (87R-1, 87R-2, 87R-3), the quantities are summed as phasors and the magnitude becomes the Operate quantity (IOPn). For a through-current condition, IOPn should calculate to about $1 + (-1) = 0$, at rated load. Calculation of the Restraint quantity (IRTn) 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.

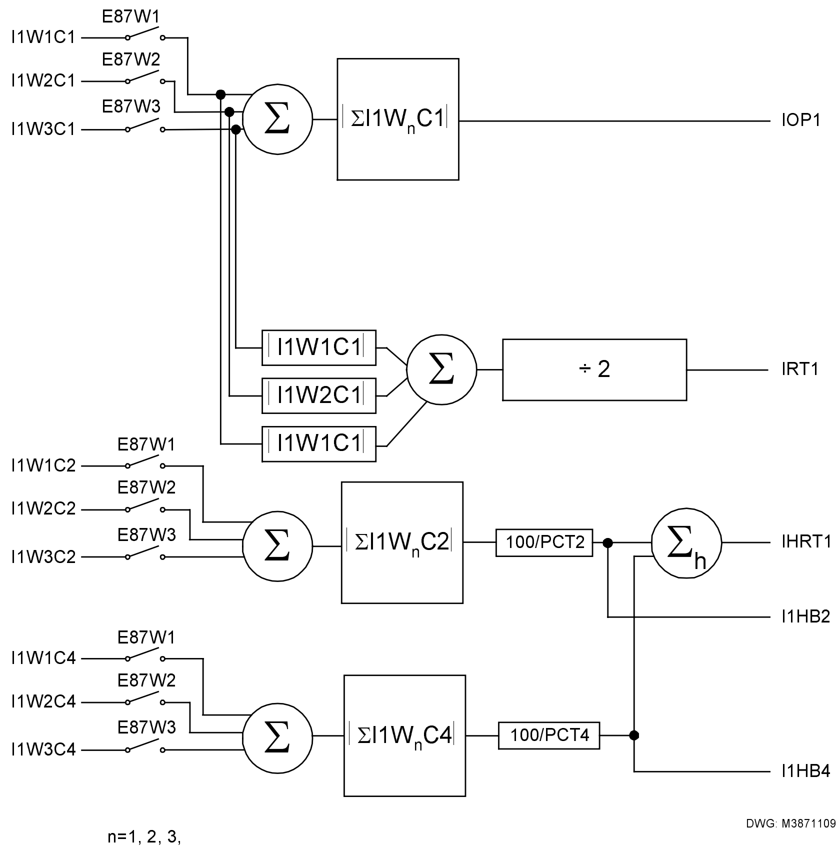


Figure 3.3: Differential Element (87-1) Quantities

Figure 3.4 shows how the differential element quantities are used to generate the unrestrained 87Un (87U1, 87U2, 87U3) and restrained 87Rn (87R1, 87R2, 87R3) elements. These elements are combined to form differential element targets (87-1, 87-2, 87-3).

Unrestrained elements (87U1, 87U2, and 87U3) compare the IOP quantity to a setting value (U87P), typically about 10 times TAP, and trip if this level is exceeded. Elements 87U1, 87U2, and 87U3 are combined to form element 87U as shown in the lower right corner of Figure 3.4. Harmonic blocking is not performed on the unrestrained elements. Use these elements to protect your transformer bushings and end windings while maintaining security for inrush and through-fault conditions. Operating current elements 87On (87O1, 87O2, 87O3) are provided for testing purposes.

Restrained elements (87R1, 87R2, and 87R3) determine whether the IOP quantity is greater than the restraint quantity using the differential characteristic shown in Figure 3.1. Set HRSTR=Y (harmonic restraint) to modify this characteristic as a function of the second- and fourth-harmonic content in the input currents.

In element 87Rn, for example, the IOPn and IRTn quantities determine whether the relay trips. The logic enclosed within the dotted line of Figure 3.4 implements the Figure 3.1 characteristic. The differential element calculates a threshold as a function of IRTn. IOPn must exceed this threshold to produce tripping. The function uses the SLP1, SLP2, and IRS1 setting values, along with IRTn, to calculate the IOP value. The differential element decision logic compares the calculated value, denoted f(IRTn), to the actual IOPn. If IOPn is greater, one input of the AND gate at the right receives a logic 1. Comparison of IOPn with the O87P setting determines the second AND input. If IOPn is greater than O87P, Relay Word bit 87On asserts. The AND gate condition then is satisfied, and Relay Word bit 87Rn 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 and dc blocking decision logic, which is described later.

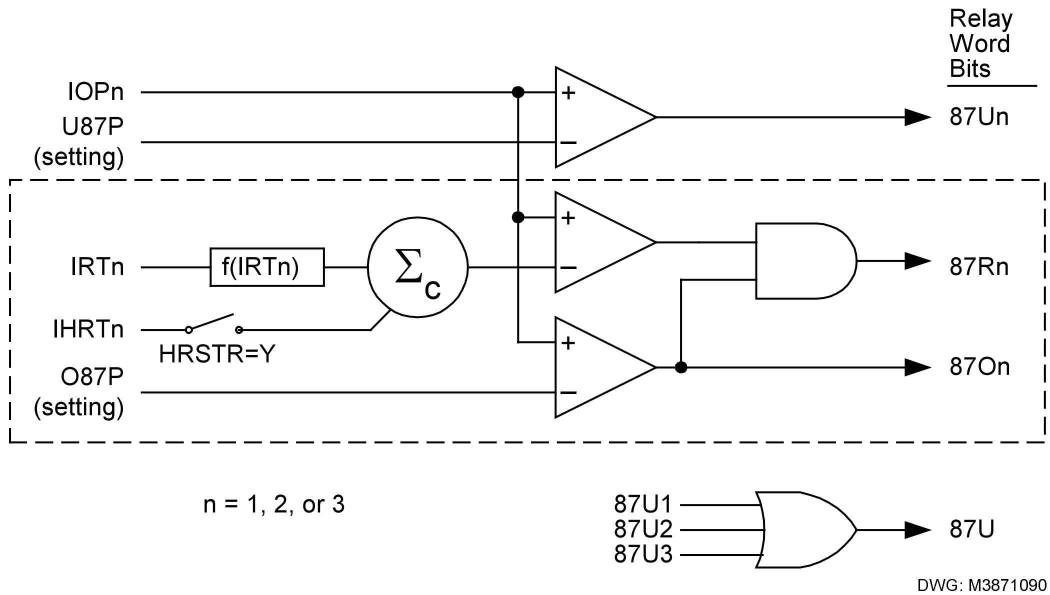


Figure 3.4: Differential Element Decision Logic

Harmonic Restraint

Consider the harmonic restraint feature (HRSTR=Y) if your practices require independent harmonic restraint. This feature disables common harmonic blocking (IHBL=Y). It also disables second- and fourth-harmonic blocking since it adds the second- and fourth-harmonic quantities to the differential characteristic restraint quantity. Blocking features are discussed in more detail later in this section.

For harmonic blocking, the harmonic content of the differential current must exceed the individual (PCT2 or PCT4) threshold values, i.e., the thresholds are independent measurements of each harmonic value. For harmonic restraint, the values of the second- and fourth-harmonic currents are summed, and that value is used in the relay characteristic. Consider, for example, the simple case of Slope 1, i.e., a straight line through the origin. The general equation for a line is:

$$y = m \bullet x + c$$

More specifically, in the SEL-387E Relay:

$$IOP = SLP1 \bullet IRT + c$$

Because the line starts at the origin, the value of c is normally zero. The sum of the second- and fourth-harmonic currents now forms the constant c in the equation, raising the relay characteristic proportionally to the harmonic values.

Blocking

While the restrained differential elements are making decisions, a parallel blocking decision process occurs regarding the magnitudes of specific harmonics in the IOP quantities.

Common (Cross) or Independent Blocking

Use common or independent blocking elements (87BL1, 87BL2, and 87BL3) to supervise the restrained differential elements. Common blocking disables all restrained elements if any blocking element is picked up. Figure 3.5 shows how independent blocking disables the restrained element associated with the blocking element.

If IHBL is set to N (No), the logic shown in Figure 3.5 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, blocking within ANY differential element will prevent operation and tripping of ALL the restrained differential elements.

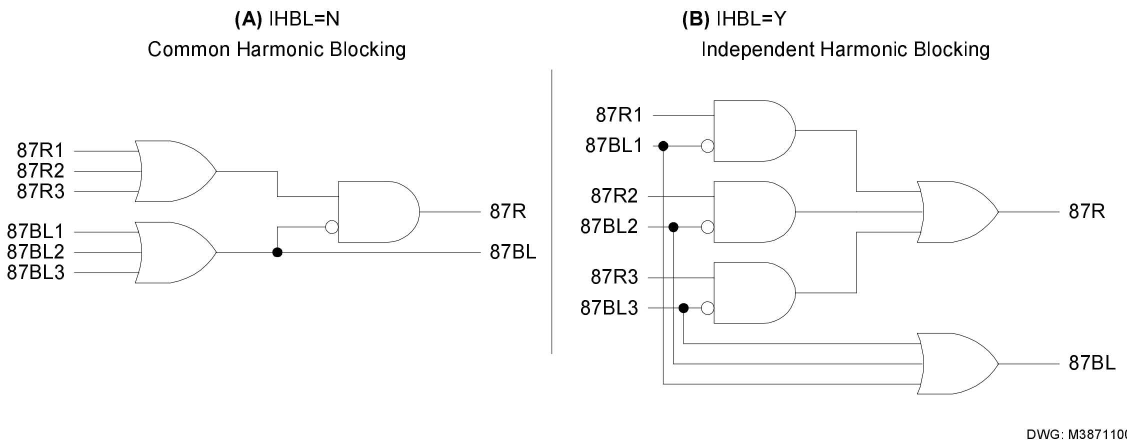


Figure 3.5: Differential Element Harmonic Blocking Logic

If IHBL is set to Y (Yes), the logic shown in Figure 3.5 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, 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, in the harmonic blocking mode. When harmonic restraint is selected, the relay operates only in the individual blocking mode.

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.

Harmonic Blocking

Figure 3.6 shows how the 87BL1 blocking element will pick up if the second-, fourth-, or fifth-harmonic operating current, as a percentage of fundamental operating current, are above the 2PCT, 4PCT, or 5PCT setting thresholds, respectively. The blocking element will also pick up if the ratio of positive and negative dc exceeds a threshold as shown in Figure 3.7. The blocking prevents improper tripping during transformer inrush or allowable overexcitation conditions.

Elements 4HB1, 4HB2, and 4HB3 are combined to form element 4HBL as shown at the bottom of Figure 3.6. 4HBL is available as a Relay Word bit but elements 4HB1, 4HB2, and 4HB3 are not.

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.

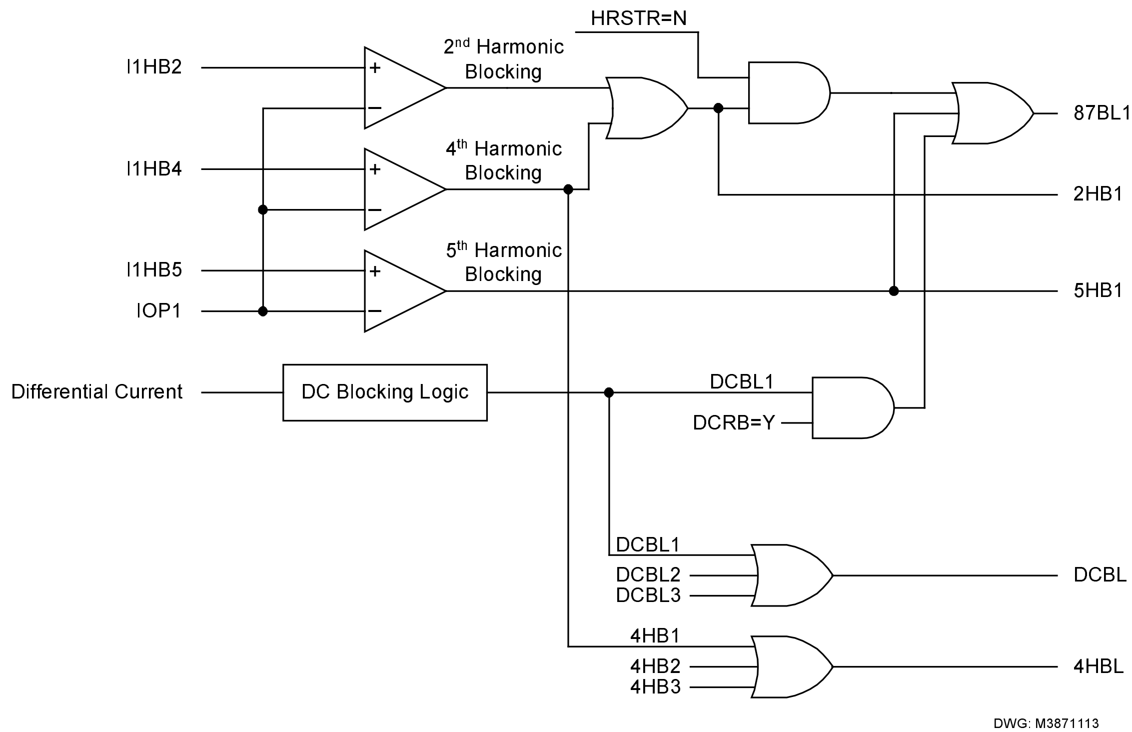


Figure 3.6: Differential Element (87BL1) Blocking Logic

DC Ratio Blocking

Figure 3.7 shows the dc blocking logic for Winding 1. Elements DCBL1, DCBL2, and DCBL3 are combined to form element DCBL as shown at the bottom of Figure 3.6. DCBL is available as a Relay Word bit but elements DCBL1, DBL2, and DCBL3 are not.

The dc ratio blocking feature applies to inrush cases with little harmonic content, but a high dc offset. The measurement principle is that of wave shape recognition, distinguishing between the time constants for inrush current that typically are longer than the time constants for an internal fault.

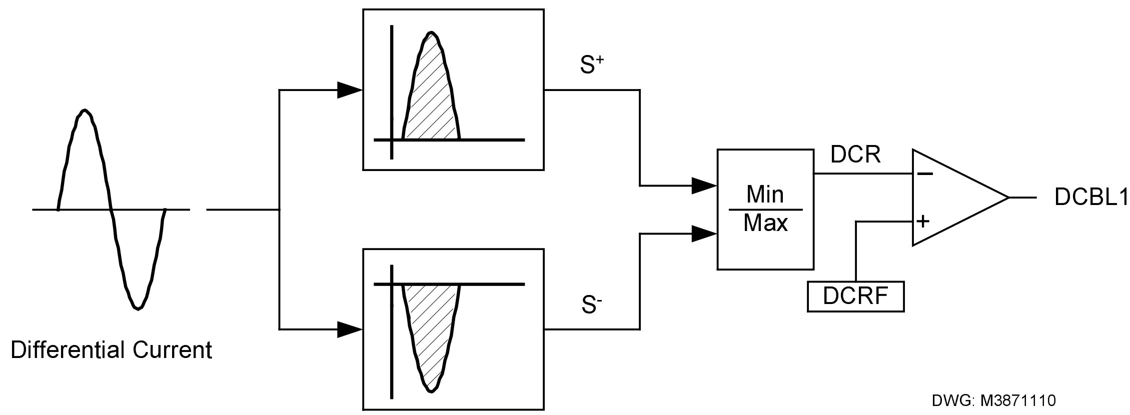


Figure 3.7: DC Blocking (DCBL1) Logic

Setting Descriptions

Differential Element Enable (E87W1 through E87W3)

Range: Y, N, Y1

The SEL-387E Relay has three 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.

Selecting Y1 makes the fourth-harmonic (PCT4), dc ratio blocking (DCRB), and harmonic restraint (HRSTR) settings available. This is the only difference between Y and Y1 selection.

CT Connection (W1CT through W3CT)

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 CTR3)

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 W3CTC)

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 VWDG3)

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 TAP3)

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

5 A: 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 TAP3 values directly, along with the other pertinent settings.

Restrained Element Operating Current Pickup (O87P)

Range: 0.10–1.00 • TAP

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

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: SLP1: 5–100%, in 1% steps; SLP2: OFF, 25–200%

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

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

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-387E 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.

Fourth-Harmonic Blocking Percentage of Fundamental (PCT4)

Range: OFF, 5–100%, in 1% steps

Set E87Wx=Y1 to make the fourth-harmonic, (PCT4), dc ratio blocking (DCRB), and harmonic restraint (HRSTR) settings available. 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 even-harmonic current than do fault currents. This even-harmonic current can be used to identify the inrush phenomenon and to prevent relay misoperation. The SEL-387E Relay measures the amount of fourth-harmonic current flowing in the transformer. You can set the relay to block the percentage restrained differential element if the ratio of fourth-harmonic current to fundamental current (IF4/IF1) is greater than the PCT4 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: 1 A: $TAP_{MIN} \cdot TH5P \geq 0.05$
$TAP_{MAX} \cdot TH5P \leq 31.0$

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

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.

DC Ratio Blocking (DCRB)

Set E87Wx=Y1 to make the fourth-harmonic, (PCT4), dc ratio blocking (DCRB), and harmonic restraint (HRSTR) settings available. Some magnetizing inrush cases contain very little harmonic content but contain a dc offset. The SEL-387E Relay can detect the dc offset and use it in the blocking (not restraint) logic. Enable this function by setting DCRB = Y.

Harmonic Restraint (HRSTR)

Set E87Wx=Y1 to make the fourth-harmonic, (PCT4), dc ratio blocking (DCRB), and harmonic restraint (HRSTR) settings available. Even harmonics (second and fourth) can be used to provide security against magnetizing inrush currents during transformer energization. Choose between harmonic blocking and harmonic restraint. Harmonic blocking treats the second and fourth harmonics independently and blocks the relay when the second- or fourth-harmonic content (harmonic current as a percentage of the fundamental current) exceeds the PCT2 or PCT4 setting, respectively. For example, assume the following:

PCT2 = PCT4 = 20 percent, and the harmonics in the differential current are:
second harmonic = 15 percent, fourth harmonic = 7 percent

In this case, the relay does not block because neither harmonic content exceeds its particular setting. But when the second-harmonic content increases to 21 percent, the relay blocks, regardless of the value of the fourth-harmonic content present in the differential current. Increasing the fourth-harmonic content to exceed the PCT4 setting while the second-harmonic content remains lower than the PCT2 setting yields the same result.

Harmonic restraint is more secure than harmonic blocking since it adds the values of the second- and fourth-harmonic currents together and raises the relay characteristic by the sum of the two values. In the example, second-harmonic content + fourth-harmonic content = 15 percent + 7 percent = 22 percent and relay tripping is restrained when it would not have been blocked.

Set HRSTR = Y to select the harmonic restraint function and automatically enable Independent Harmonic Blocking (IHBL).

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-387E 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:

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

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,

IAWnC = IAWn
IBWnC = IBWn
ICWnC = ICWn

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 WnCTC = 1, the relay uses the following [CTC(m)] matrix:

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

that is,

$$IAWnC = \frac{(IAWn - IBWn)}{\sqrt{3}}$$

$$IBWnC = \frac{(IBWn - ICWn)}{\sqrt{3}}$$

$$ICWnC = \frac{(ICWn - IAWn)}{\sqrt{3}}$$

The "11" setting performs a 330-degree compensation (11 • 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 WnCTC = 11, the relay uses the following [CTC(m)] matrix:

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

that is,

$$IAWnC = \frac{(IAWn - ICWn)}{\sqrt{3}}$$

$$IBWnC = \frac{IBWn - IAWn}{\sqrt{3}}$$

$$ICWnC = \frac{(ICWn - IBWn)}{\sqrt{3}}$$

The effect of each compensation on balanced three-phase currents is to rotate them m • 30° 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.

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

that is,

$$IAWnC = \frac{\left(+2 \bullet IAWn - IBWn - ICWn\right)}{3}$$

$$IBWnC = \frac{\left(-IAWn + 2 \bullet IBWn - ICWn\right)}{3}$$

$$ICWnC = \frac{\left(-IAWn - IBWn + 2 \bullet ICWn\right)}{3}$$

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 WnCTC = 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 WnCTC = 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)

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

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

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

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

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

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

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

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

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

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

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

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

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±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 3.8 shows the three basic winding connections, consisting of a wye connection and the two possible delta connections.

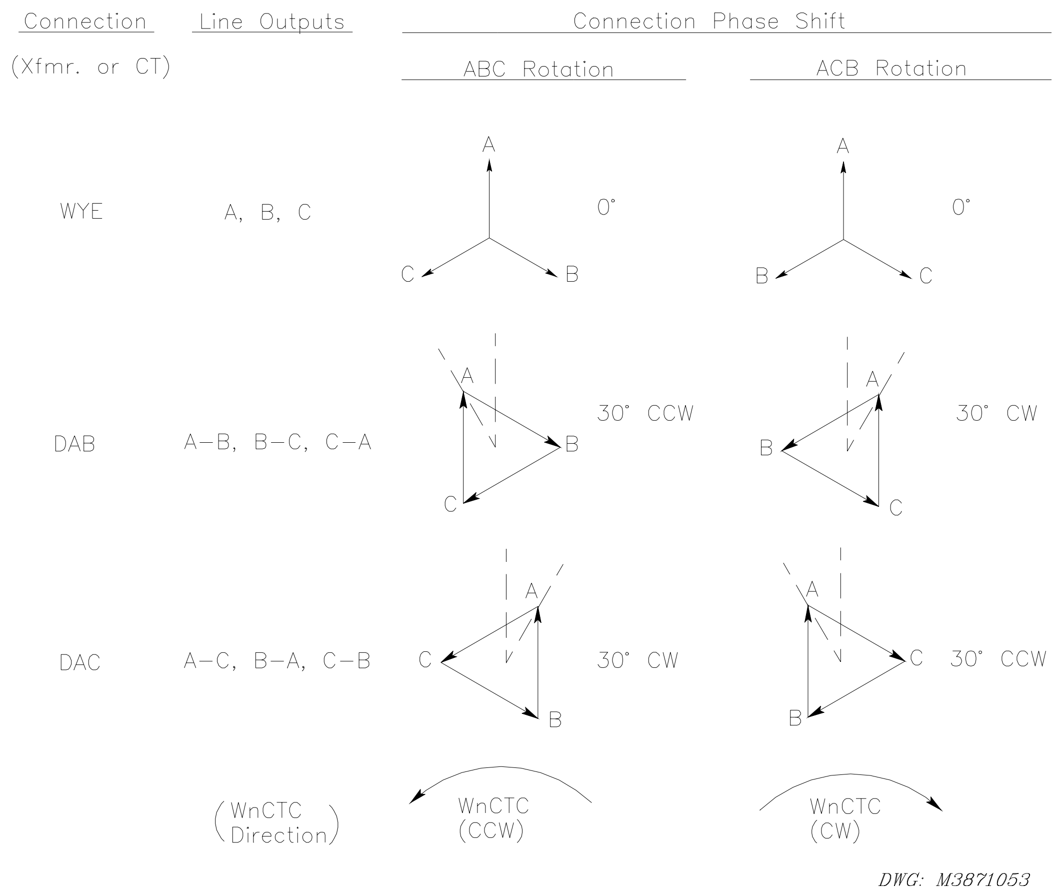


Figure 3.8: Winding Connections, Phase Shifts, and Compensation Direction

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 3.8 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 3.8 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 3.8 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 3.9 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 3.9 illustrates.

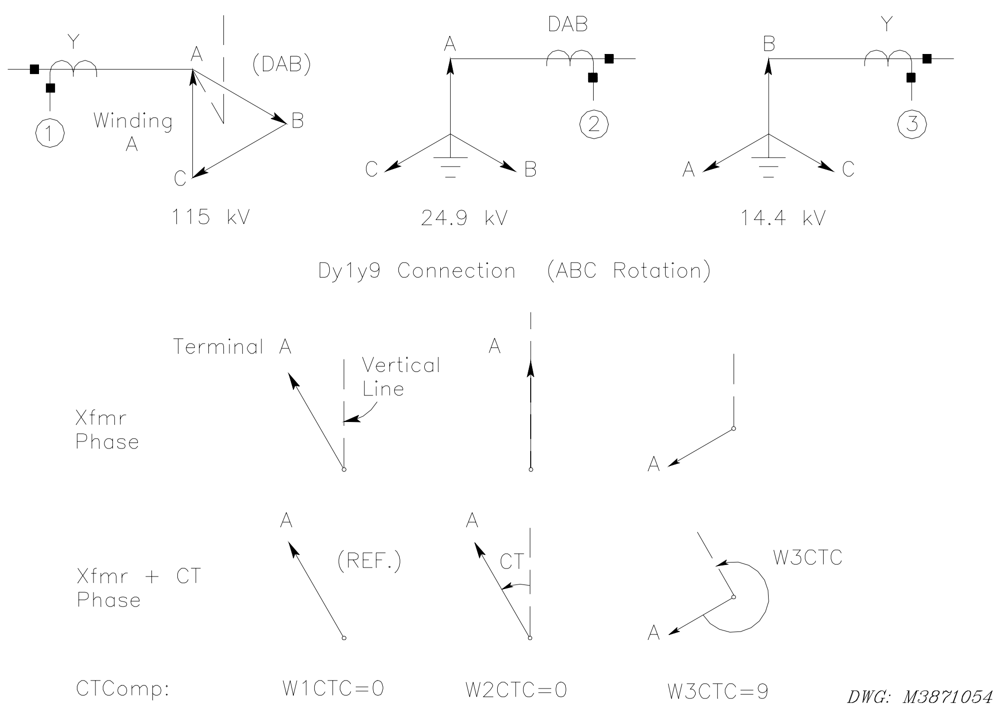


Figure 3.9: Example 1 for WnCTC Selection

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 3.9 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 3.9 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 3.9 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 3.9 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 3.10 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-387E 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 3.10 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 3.10 shows.

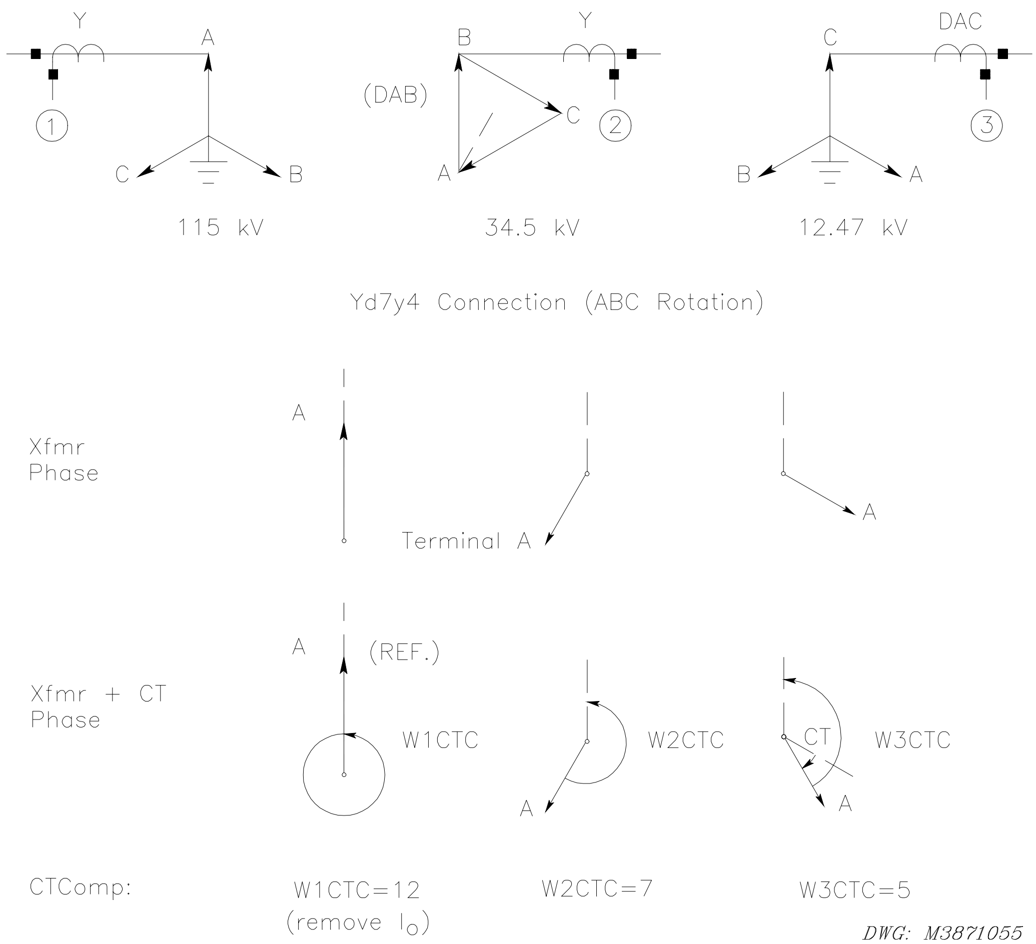


Figure 3.10: Example 2 for WnCTC Selection

1. Establish the phase direction for the three A line terminals. Figure 3.10 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 3.8 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 3.10 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.

Winding Line-to-Line Voltages

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

Current TAP

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

$$\text{TAPn} = \frac{\text{MVA} \cdot 1000}{\sqrt{3} \bullet \text{VWDGn} \cdot \text{CTRn}} \bullet \text{C}$$

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 TAPn calculations)
VWDGn	=	winding line-to-line voltage setting, in kV
CTRn	=	current transformer ratio setting

The relay calculates TAPn with the following limitations:

- The tap settings are within the range $0.1 \bullet I_N$ and $31 \bullet I_N$
- The ratio $TAP_{MAX}/TAP_{MIN} \leq 7.5$

Restrained Element 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 $0.1 \bullet I_N$, when multiplied by the smallest of TAP1 through TAP3. Stated another way,

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

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:

$$\text{Id max} = (1+e) \bullet \sum_{\text{"IN"}} \text{IWn} - \frac{(1-e)}{(1+a)} \bullet \sum_{\text{"OUT"}} \text{IWn}$$

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:

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

In addition to the error calculated above, we have to consider additional errors from transformer excitation current (≈3 percent) and relay measurement error (≤5 percent). 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.

Unrestrained Element Current Pickup

The instantaneous unrestrained current element is intended 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 not affected by the SLP1, SLP2, IRS1, PCT2, PCT5, or IHBL settings. Thus, it must be set high enough so as not to react to large inrush currents.

Note: U87P must be set lower than 31 • I_{nom}/TAP_{max}, where TAP_{max} is the largest of the TAP settings.

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.

Fourth-Harmonic Blocking

Transformer magnetizing inrush currents are generated during transformer energization when the current contains a dc offset due to point-on-wave switching. Inrush conditions typically are detected using even harmonics and are used to prevent misoperations due to inrush. The largest even-harmonic current component is usually second harmonic followed by fourth harmonic. Use fourth-harmonic blocking to provide additional security against inrush conditions; set PCT4 less than PCT2.

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:

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

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

Independent Harmonic Blocking Element (IHBL)

When a three-phase transformer is energized, inrush harmonics are present in at least two phase currents. In traditional single-phase relays, each relay performs a comparison of the harmonic current flowing through its phase. The SEL-387E Relay can perform harmonic blocking two ways:

- Independent Harmonic Blocking (IHBL = Y) blocks the percentage differential element for a particular phase if the harmonic (second or fifth) in that phase is above the block threshold. Other differential elements are not blocked.

- Common Harmonic Blocking (IHBL = N) blocks all of the percentage differential elements if any one phase has a harmonic magnitude above the blocking threshold.

Common Harmonic Blocking is a more secure scheme but may slightly delay percentage differential element operation since harmonics in all three phases must drop below their thresholds.

Example of Setting the SEL-387E 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:

E87W1	=	Y	E87W2	=	Y	E87W3	=	Y

   These settings enable Windings 1, 2, and 3.

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:

230 kV			138 kV			13.8 kV		
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:

   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:

ICOM	=	Y (choose to define the CT compensation)						
W1CTC	=	11	W2CTC	=	11	W3CTC	=	0

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:

VWDG1	=	230	VWDG2	=	138	VWDG3	=	13.8

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

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

Thus, we have the following:

$$\text{TAP 1} = \frac{100\ \text{MVA} \bullet 1000}{\sqrt{3} \bullet 230\ \text{kV} \bullet 120} \bullet 1 \qquad \text{TAP1} = 2.09\ \text{A}$$

$$\text{TAP 2} = \frac{100\ \text{MVA} \bullet 1000}{\sqrt{3} \bullet 138\ \text{kV} \bullet 240} \bullet 1 \qquad \text{TAP2} = 1.74\ \text{A}$$

$$\text{TAP 3} = \frac{100\ \text{MVA} \bullet 1000}{\sqrt{3} \bullet 13.8\ \text{kV} \bullet 400} \bullet 1 \qquad \text{TAP3} = 10.46\ \text{A}$$

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 percent initial slope)
SLP2	=	50	(50 percent 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)
PCT4	=	15	(block operation if fourth harmonic is above 15 percent)
PCT5	=	35	(block operation if fifth harmonic is above 35 percent)
TH5P	=	OFF	(no fifth-harmonic alarm)
DCRB	=	N	(dc ratio blocking disabled)
HRSTR	=	N	(harmonic restraint disabled)

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

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-387E 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 $\sqrt{3} \bullet I_{HS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \bullet I_N$ and $1.0 \bullet I_N$ 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–CTR3) 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-387E Relay (see steps 4 and 5). As before, for wye-connected CTs I_{REL} equals I_{LS}. For delta-connected CTs I_{REL} equals $\sqrt{3} \bullet I_{LS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \bullet I_N$ and $1.0 \bullet I_N$ A secondary.

4. The SEL-387E Relay calculates settings TAP1 through TAP3 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 $(0.1–31) \bullet I_N$.

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 $20 \bullet I_N$. 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-387E 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 3 (IAW3, IBW3, or ICW3), leaving only two three-phase winding inputs for normal differential or overcurrent protection purposes.

Figure 3.11 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 (IRW3) 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, a0, times the positive-sequence current for their respective winding. Such a winding residual current value might occur with "false Io" or if zero sequence current for that winding exceeds 50GP. False Io 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.

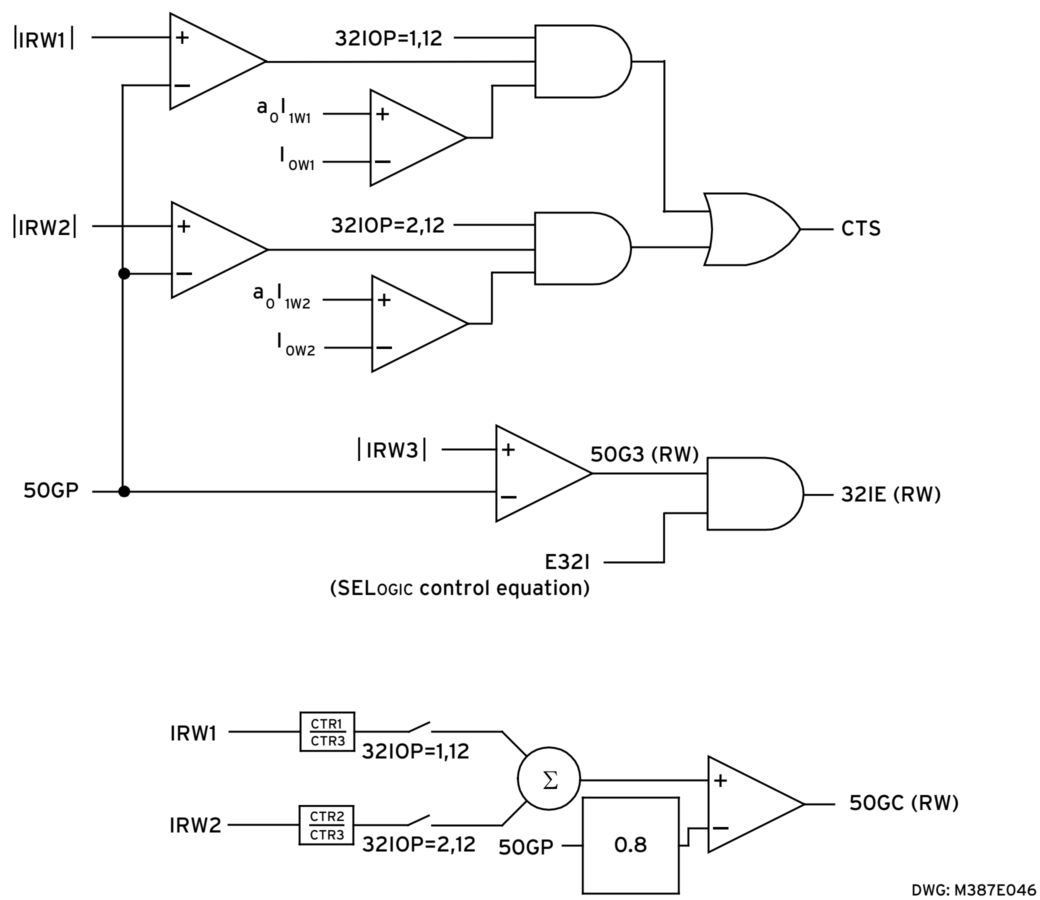


Figure 3.11: REF Enable/Block Logic

Figure 3.12 illustrates the logic of the REF directional element, 32I. It is at this stage that the element decides whether to operate.

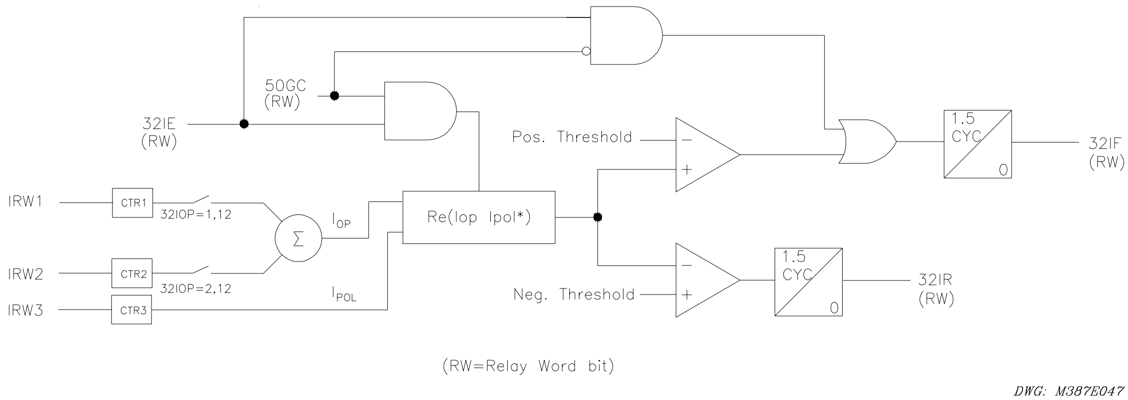


Figure 3.12: REF Directional Element

The relay enables the 32I directional element if the output of the AND gate at left-center in Figure 3.12 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, CTR3, 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 3.12. 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 3.13 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.

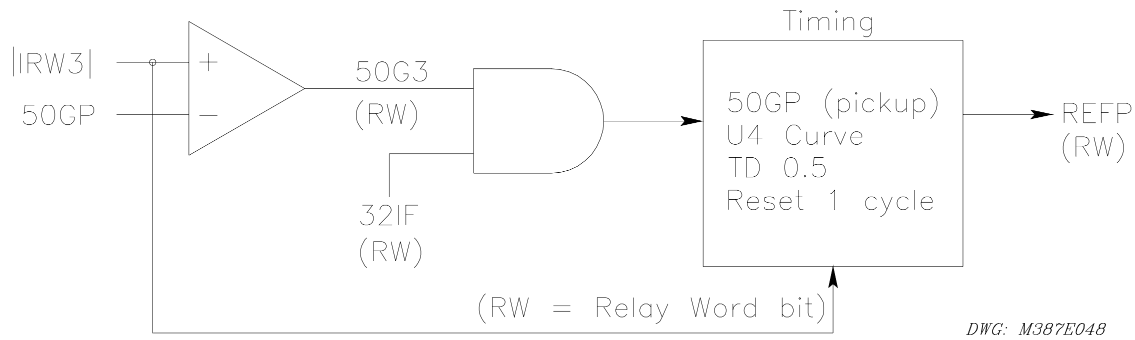


Figure 3.13: REF Protection Output (Extremely Inverse-Time O/C)

Relay Word bit 32IF (forward fault) torque controls the timing curve, and IRW3 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 (32IOP)

Range: 1, 2, 12

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 a0 times the positive-sequence current at that input, or |IRWn| > a0 • |3I1Wn|. This supervision provides security against “false Io” that may occur because of CT saturation during heavy three-phase faults.

Residual Current Sensitivity Threshold (50GP)

Range: 1 A: 0.05–3 A, in 0.01 A steps

5 A: 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 3.14 depicts how to determine the Operate quantity, 32IOP, setting.

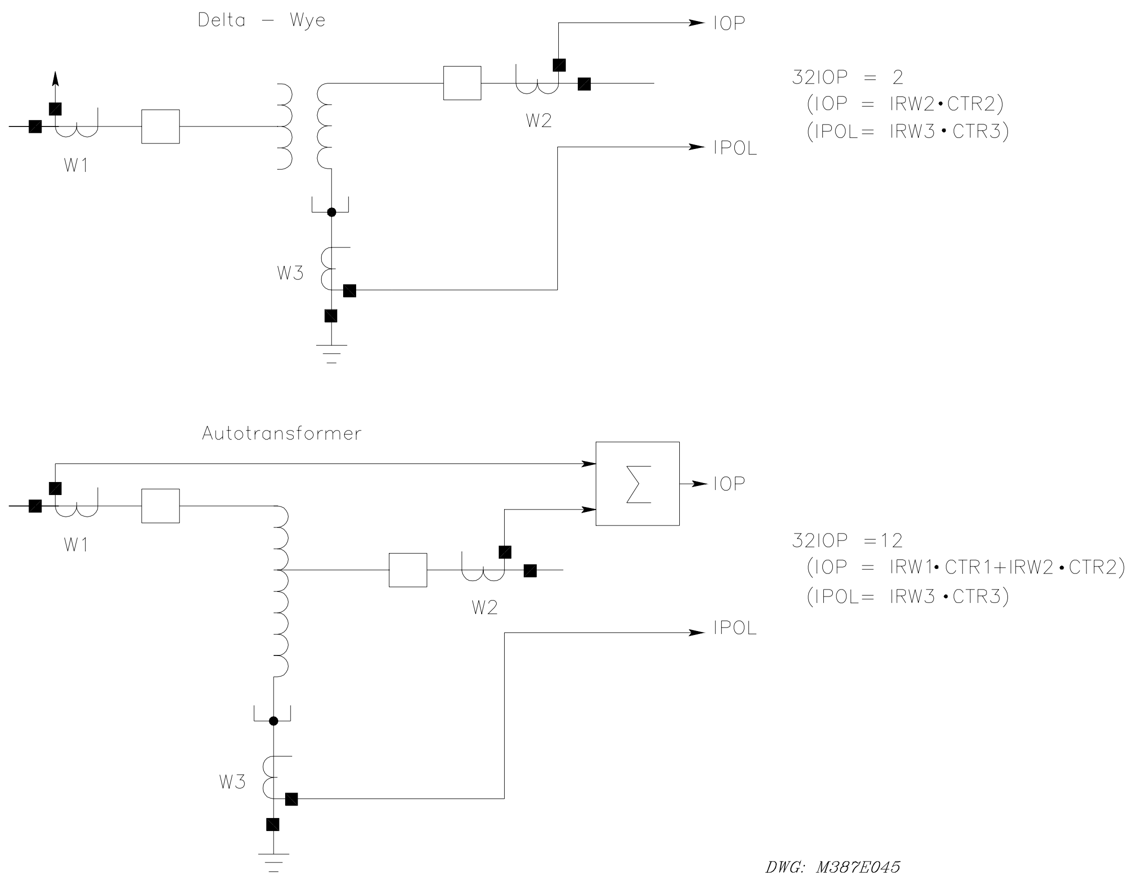


Figure 3.14: REF Function, 32IOP Setting Guide

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 3.14 shows neutral CT input connected to the Winding 3 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.

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

$$IRWn = IAWn + IBWn + ICWn \quad (n = 1, 2)$$

For the neutral CT connection, the relay uses only one of the three ABC inputs, e.g., IBW3, so the residual current for input 3 would be IRW3 = 0 + IBW3 + 0 = IBW3.

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:

$$50\,\text{GP}\min \geq 0.05 \cdot I_{\text{nom}} \bullet \frac{\text{CTRmax}}{\text{CTR}\,3}$$

where CTR3 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 or CTR2.

An example 50GP calculation is as follows, assuming that CTR3 = 40, CTRmax = 160, I_{nom} = 5 A, and load imbalance is 10 percent:

$$50\,\text{GP}\min \geq 0.05 \bullet 5\text{ A} \bullet \frac{160}{40}$$

$$50\,\text{GP}\min \geq 0.25\text{ A} \bullet 4$$

$$50\,\text{GP}\min \geq 1.0\text{ A}$$

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 • 5 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), "Minimum 50GP sensitivity is CTRmax/CTR3 • 0.25." The relay then will prompt you for a new setting.

The relay stores a default setting for the Residual Current Sensitivity Threshold of 5OGP = 0.5 A.

Overcurrent Element

Application Description

The SEL-387E Relay provides numerous overcurrent elements, as many as 11 per winding, 33 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-387E Relay has 11 overcurrent elements (see Table 3.1). 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 is one set 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, 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 3.1: Overcurrent Element Summary

	Definite-Time Elements	Instantaneous Elements	Inverse-Time Elements
Phase (Ia, Ib, and Ic)			
Winding 1	50P11	50P12, 50P13, 50P14	51P1
Winding 2	50P21	50P22, 50P23, 50P24	51P2
Winding 3	50P31	50P32, 50P33, 50P34	51P3
Combined (Windings 1 and 2)			51PC1
Negative-Sequence (IQ = 3 • I_2)			
Winding 1	50Q11	50Q12	51Q1
Winding 2	50Q21	50Q22	51Q2
Winding 3	50Q31	50Q32	51Q3
Residual (IR = Ia + Ib +Ic)			
Winding 1	50N11	50N12	51N1
Winding 2	50N21	50N22	51N2
Winding 3	50N31	50N32	51N3
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 IAWn, IBWn, and ICWn 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.

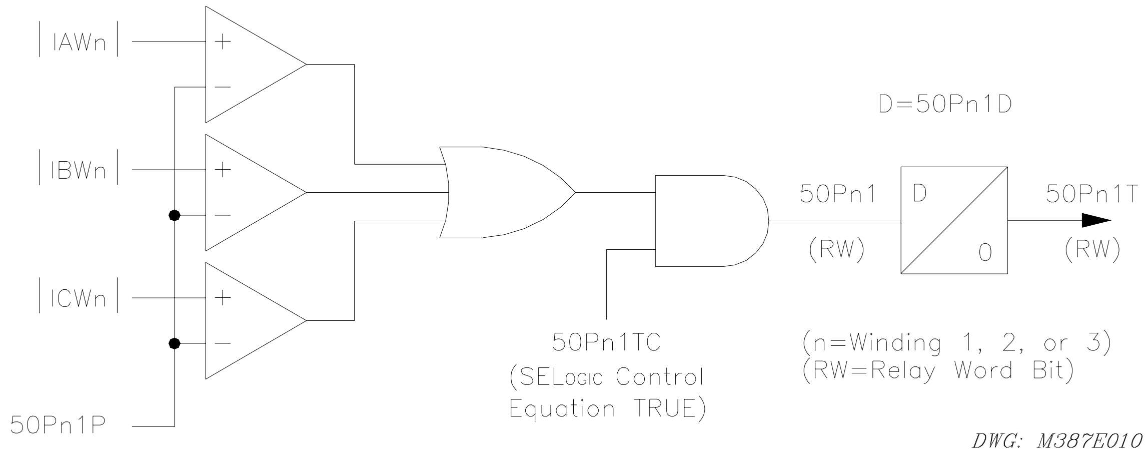


Figure 3.15: 50Pn1 Phase Definite-Time O/C Element, Torque Controlled

50Pn2 – Phase Instantaneous Element

Figure 3.16 shows the logic for the 50Pn2 element. The 50Pn2 element logic compares magnitudes of phase input currents IAWn, IBWn, and ICWn 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.

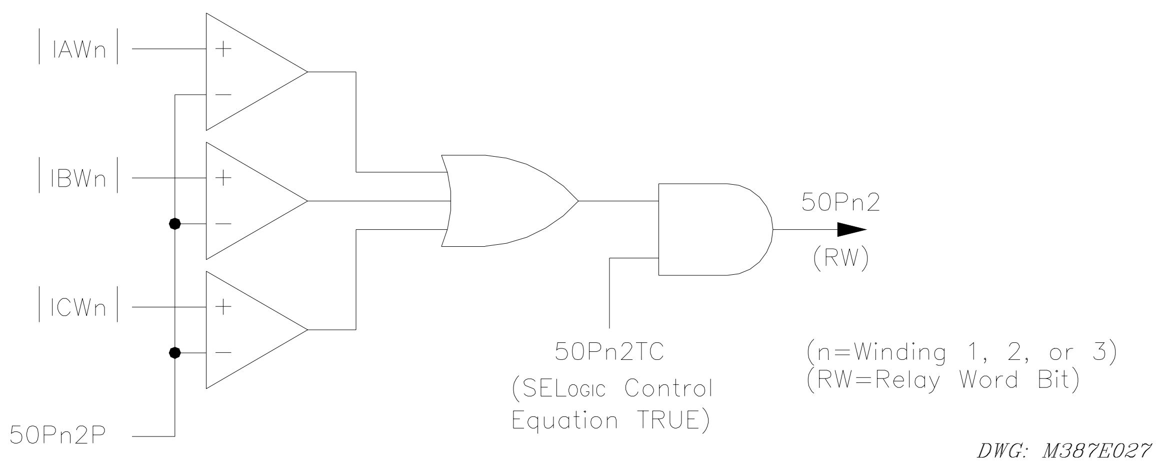


Figure 3.16: 50Pn2 Phase Instantaneous O/C Element, Torque Controlled

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 IAWn, IBWn, and ICWn 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.

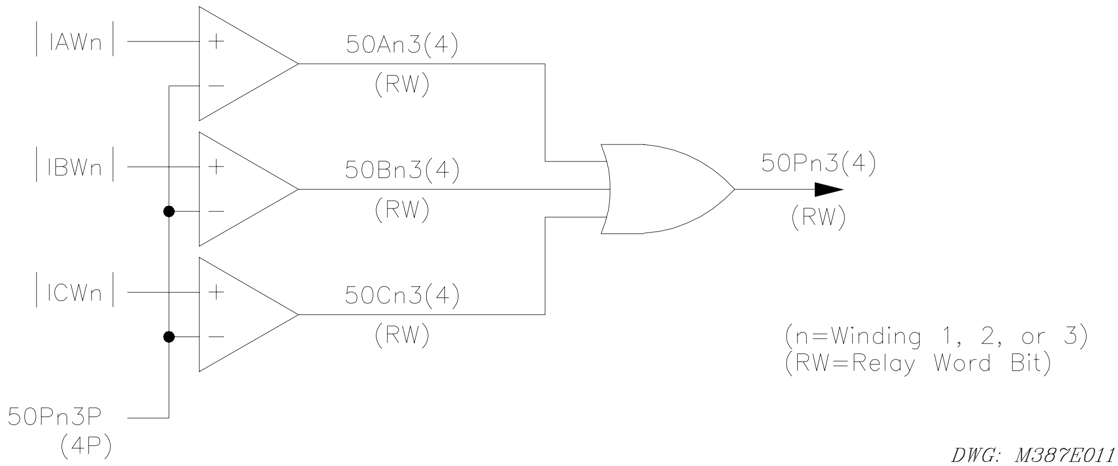


Figure 3.17: 50Pn3 and 50Pn4 Phase Instantaneous O/C Element, Nontorque Controlled

51Pn – Phase Inverse-Time Element

Figure 3.18 shows the logic for the 51Pn element. The logic compares the magnitudes of phase input currents IAWn, IBWn, and ICWn 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.

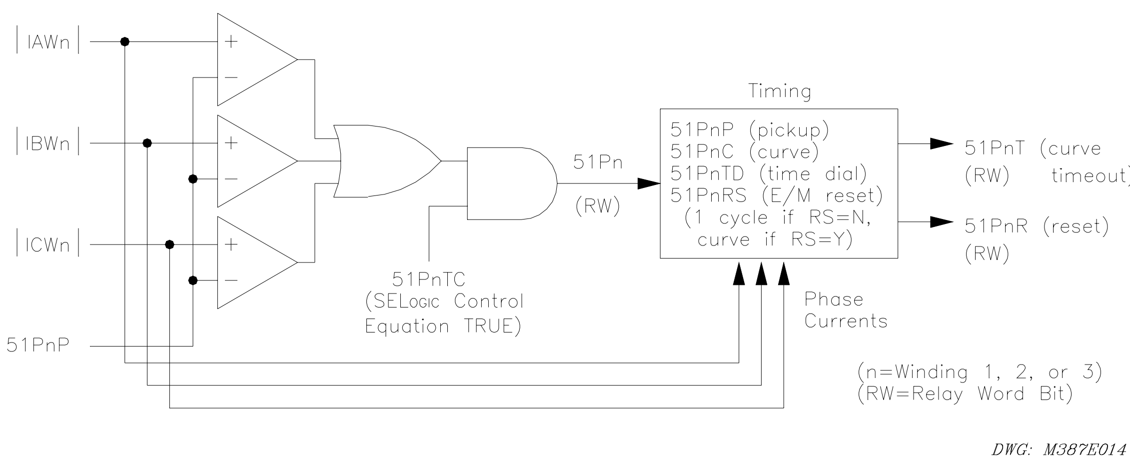


Figure 3.18: 51Pn Phase Inverse-Time O/C Element, Torque Controlled

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.

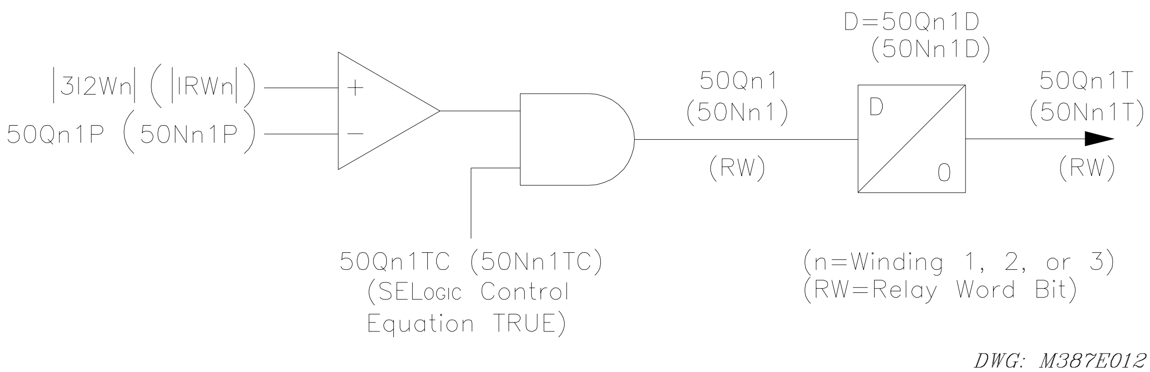


Figure 3.19: 50Qn1 and 50Nn1 Sequence Definite-Time O/C Element, Torque Controlled

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, IRWn, 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

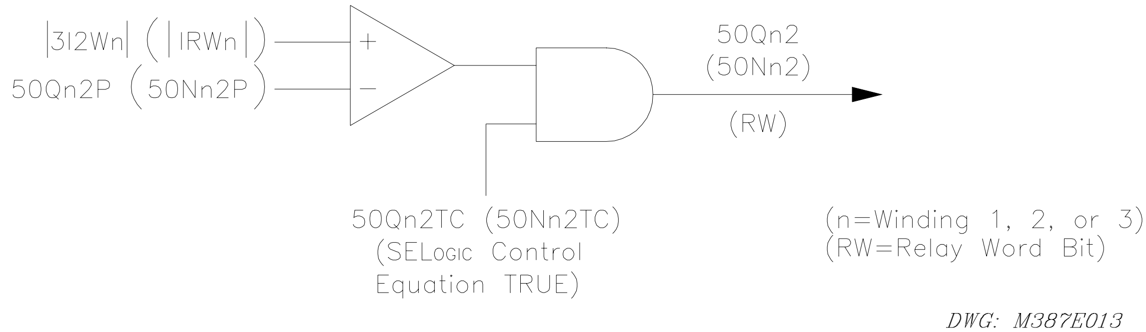


Figure 3.20: 50Qn2 and 50Nn2 Sequence Instantaneous O/C Element, Torque Controlled

50Qn2 Negative-Sequence Instantaneous Element

The 50Qn2 element compares the magnitude of the calculated negative-sequence current, 3I2Wn, 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, IRWn, 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.

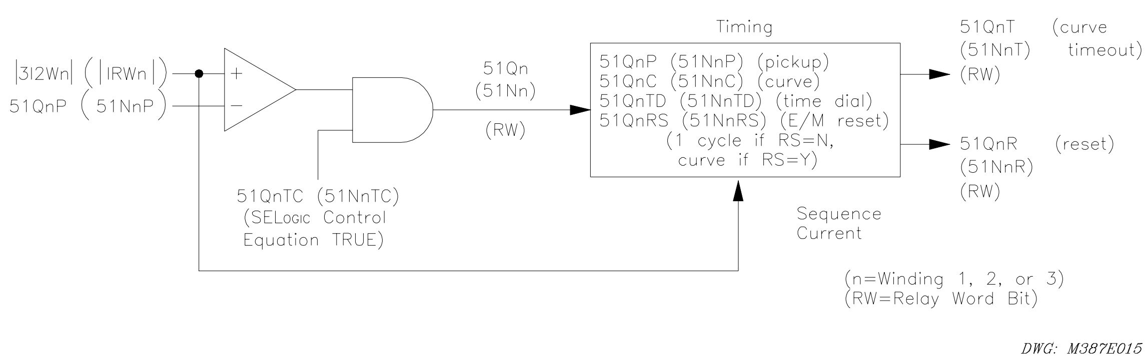


Figure 3.21: 51Qn and 51Nn Sequence Inverse-Time O/C Element, Torque Controlled

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.

51PC1 and 51NC1 Combined Overcurrent Elements

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. See Figure 3.22.

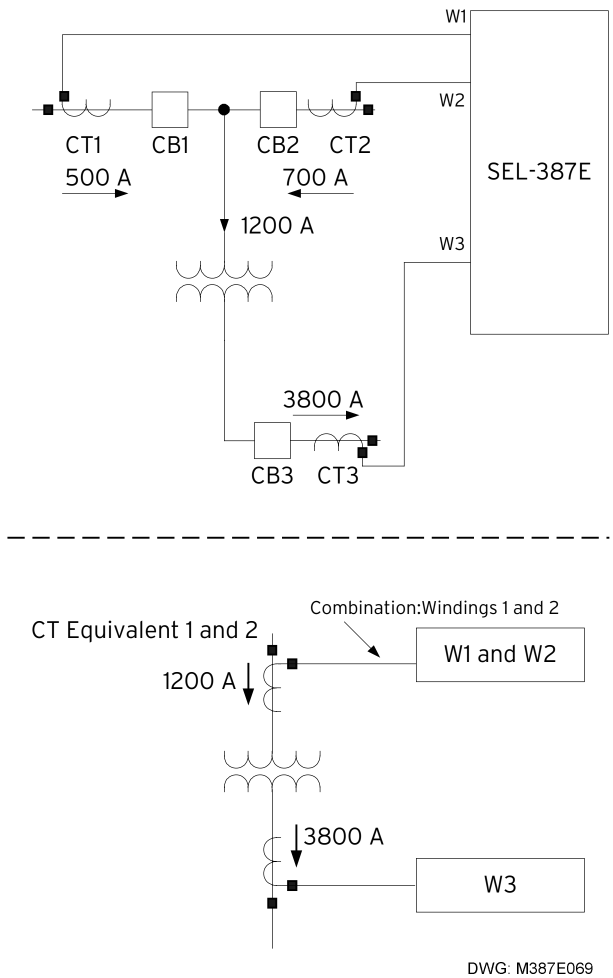


Figure 3.22: Combined Overcurrent Example

51PC1 and 51NC1 Element Logic

The logic for the inverse-time combined overcurrent elements 51PC1 and 51NC1 is shown in Figure 3.23.

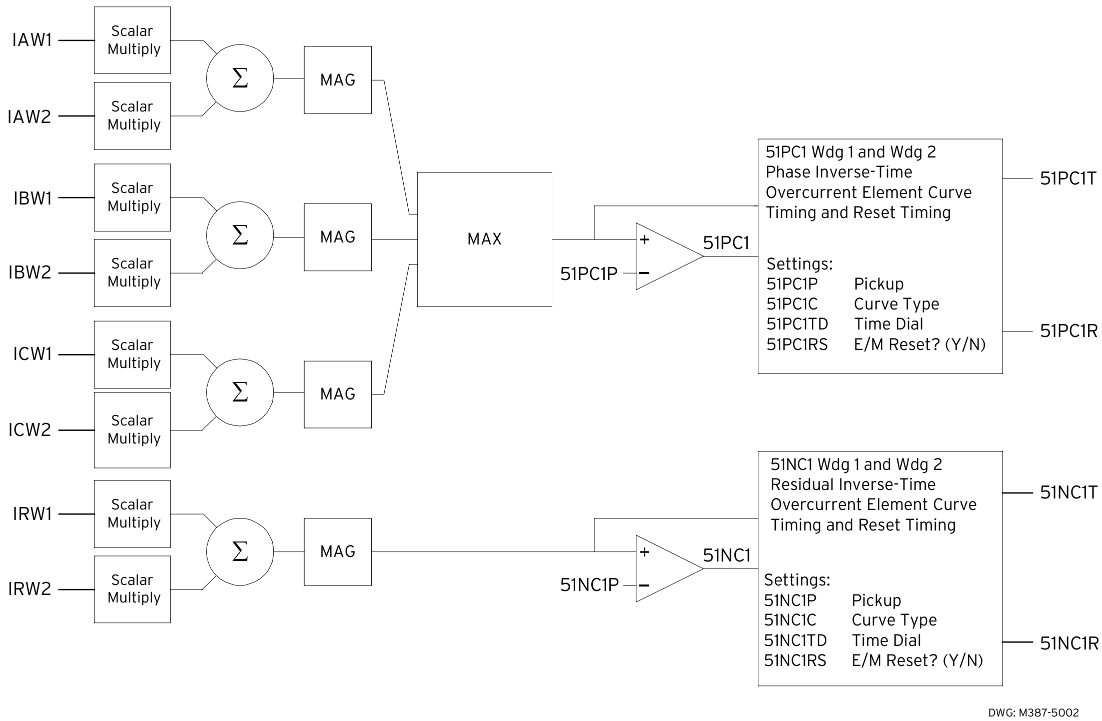


Figure 3.23: 51PC1 and 51NC1 Combined Inverse-Time O/C Elements

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 • 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

CTR1	=	600/5 = 120
CTR2	=	2000/5 = 400
InW1	=	2000 A (primary)
InW2	=	1000 A (primary)
Pickup	=	8000 A (primary)

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

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

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

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

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

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 • 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

CTR1	=	1000/5 = 200
CTR2	=	500/5 = 100
InW1	=	3000 A (primary)
InW2	=	6000 A (primary)
Pickup	=	8000 A (primary)

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

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

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

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

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

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:

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

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

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

Assume

CTR1	=	500/5	=	100
CTR2	=	1000/5	=	200
Pickup	=	400 A (primary)		

Primary Currents

IAW1	=	3000∠2° A	IAW2	=	1545∠3° A
IBW1	=	3010∠–122° A	IBW2	=	1480∠–118° A
ICW1	=	2950∠117° A	ICW2	=	1505∠124° A

Secondary Currents

IAW1	=	30∠2° A	IAW2	=	7.725∠3° A
IBW1	=	30.1∠–122° A	IBW2	=	7.4∠–118° A
ICW1	=	29.5∠117° A	ICW2	=	7.525∠124° A

Then,

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

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:

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

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

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

Assume

CTR1	=	1000/5	=	200
CTR2	=	500/5	=	100
Pickup	=	400 A (primary)		

Primary Currents

IAW1	=	3000∠5° A	IAW2	=	1545∠3° A
IBW1	=	3010∠–123° A	IBW2	=	1480∠–118° A
ICW1	=	2950∠115° A	ICW2	=	1505∠124° A

Secondary Currents

IAW1	=	15∠5° A	IAW2	=	15.45∠3° A
IBW1	=	15.05∠–123° A	IBW2	=	14.80∠–118° A
ICW1	=	14.75∠115° A	ICW2	=	15.05∠124° A

Then,

$$\left(15\angle 5^\circ\ A+15.05\angle -123^\circ\ A+14.75\angle 115^\circ\ A\right)+$$
$$\left(15.45\angle 3^\circ\ A+14.80\angle -118^\circ\ A+15.05\angle 124^\circ\ A\right)\bullet\frac{100}{200}$$

$$=2.1164\angle 76^\circ\ A+0.11370\angle 73^\circ\ A=2.230\angle 76^\circ\ A$$

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

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

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.

Setting Descriptions

This subsection contains setting names, setting ranges, and labels for the overcurrent elements associated with Winding 1. Windings 2 and 3 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.

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 (50PnmP, 50QnmP, 50NnmP)

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

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

Note: n = Winding 1, 2, or 3; m = Level 1, 2, 3, or 4.

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 (50Pn1D, 50Qn1D, 50Nn1D)

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, 51PC1P, 51NC1P)

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

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

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 (51PnC, 51QnC, 51NnC, 51PC1C, 51NC1C)

Range: U1, U2, U3, U4, U5
C1, C2, C3, C4, C5

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 (51PnTD, 51QnTD, 51NnTD, 51PC1TD, 51NC1TD)

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

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 (51PnRS, 51QnRS, 51NnRS, 51PC1RS, 51NC1RS)

Range: Y, N

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 (50PnmTC, 50QnmTC, 50NnmTC, 51PnTC, 51QnTC, 51NnTC)

Range: SELOGIC control equation

Note: n = Winding 1, 2, or 3; m = Level 1, 2, 3, or 4.

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.

Application Guidelines

Transformer Overcurrent Protection

Instantaneous overcurrent elements typically provide high-speed protection for high-current, internal transformer faults and coordinated backup protection for faults on the adjacent bus and/or feeders. You may use inverse-time overcurrent elements to prevent transformer damage due to excessive through currents caused by slow clearing external faults. Thermal and mechanical damage curves should be available from the transformer manufacturer for specific transformer designs. You can consult several references, including the IEEE C37.91, *Guide for Protective Relay Applications to Power Transformers*, that provide generic through-current limitations for various classes of transformers.

Set the SEL-387E Relay instantaneous overcurrent elements to detect high-current faults within the transformer differential protection zone. Use definite-time and time-overcurrent elements to detect lower current faults inside and outside the transformer differential protection zone. Use appropriate delays to coordinate with upstream and downstream protection.

Conventional instantaneous overcurrent elements must be set sufficiently high to avoid tripping on transformer magnetizing inrush current, where peak currents may be many times the transformer full load current. Transformer magnetizing inrush current contains substantial second-harmonic and fourth-harmonic current and often contains a significant dc component. Unlike conventional electromechanical overcurrent elements, the SEL-387E Relay overcurrent elements ignore all but the fundamental frequency current, making them insensitive to the off-fundamental-frequency content of the magnetizing inrush current. The SEL-387E Relay instantaneous, definite-time, and time-overcurrent elements need only be set with regard to expected load and fault conditions.

Where the SEL-387E Relay is applied to a distribution substation transformer serving load centers, expected load conditions include steady-state load as well as transient conditions caused by hot and cold load pickup.

Hot load pickup inrush occurs when a distribution circuit is energized shortly after being de-energized, such as in a feeder trip-reclose cycle. Hot load pickup inrush current that the SEL-387E Relay may see consists primarily of starting current from motor loads, incandescent and fluorescent lighting load inrush, and resistive heating element inrush. The overall effect is an inrush current several times the normal load current that may last for several seconds.

Cold load pickup inrush occurs when a distribution circuit is energized after being de-energized for a relatively long period of time. The cold load pickup includes many of the same inrush characteristics as hot load pickup but is usually more severe and longer lasting because more thermostatically controlled systems need to satisfy their heating or cooling requirements after the prolonged outage.

For these reasons, overcurrent protection must be tailored to meet the protection requirements for the specific transformer, avoid tripping for various types of nonfault transient conditions, and coordinate with upstream and downstream protection devices. These factors constrain the selection of settings and characteristics for the applied overcurrent protection.

Overcurrent Element Operating Quantities

The SEL-387E Relay phase overcurrent elements respond to the maximum phase current magnitude, Ip, where Ip is the largest value of $|Ia|$, $|Ib|$, and $|Ic|$. Set phase overcurrent element pickup settings above the highest expected load current to avoid tripping on normal load current. You may set the pickup lower if you use torque control.

Since you can use the negative-sequence overcurrent elements to detect phase-to-phase faults, you can set the phase overcurrent elements for three-phase fault detection only. This setting selection improves the ratio of the minimum phase fault current to maximum load current required for secure phase overcurrent relay application.

The negative-sequence elements respond to $|3I_2|$ current, where $3I_2 = Ia + Ib \bullet (1\angle 240) + Ic \bullet (1\angle 120)$. The negative-sequence overcurrent elements are uniquely suited to detect phase-to-phase faults and are not sensitive to balanced load.

For a phase-to-phase fault:

$$|I_2| = \left(\sqrt{3}/3\right) \bullet |I_P|$$
$$3 \bullet |I_2| = \sqrt{3} \bullet |I_P|$$
$$\therefore |3I_2| / |I_P| = 1.73$$

where Ip is the maximum phase current

Thus, the negative-sequence element is 1.73 times more sensitive to phase-to-phase faults than a phase overcurrent element with the same pickup setting.

While negative-sequence overcurrent elements do not respond to balanced load, they do detect the negative-sequence current present in unbalanced load. For this reason, select an element pickup setting above the maximum $3I_2$ current expected due to load unbalance.

When applied on the delta side of a delta-wye transformer, negative-sequence relay elements also provide sensitive fault protection for ground faults on the wye side of the transformer. This is not possible using only phase and residual overcurrent elements.

The residual element responds to $3I_0$ current, where $3I_0 = Ia + Ib + Ic$. Residual overcurrent elements detect ground faults and do not respond to balanced load. The residual element is sensitive to unbalanced load, however, and should be set above the maximum $3I_0$ current expected due to load unbalance.

When applied on the delta side of a delta-wye transformer, residual overcurrent elements are insensitive to any type of fault on the wye side of the transformer, and can only detect ground faults on the delta side. This eliminates any coordination constraints with protection devices on the wye side of the transformer, permitting very sensitive residual overcurrent element pickup settings.

Time-Overcurrent Element Settings

The SEL-387E Relay includes time-overcurrent elements for phase, negative-sequence, and residual current. Each element operates using measured current and five settings that define:

- Pickup current, in secondary amperes
- Operating time curve
- Operating time dial
- Element reset characteristic
- Element external torque-control

To disable a time-overcurrent element, set that element pickup setting = OFF. When the pickup setting is OFF, the relay disables the element and you are not required to enter any remaining settings associated with the element.

The residual overcurrent elements are automatically disabled if the CT for the associated winding is connected in delta (WnCT = D). The residual element is disabled because the delta connected CT cannot deliver any residual operating current.

Time-Overcurrent Pickup

Set the phase time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for balanced and unbalanced fault conditions. Use the negative-sequence time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for unbalanced fault conditions including phase-to-phase, phase-to-ground and phase-to-phase-to-ground faults. Set the residual time-overcurrent element to provide sensitive detection and coordinated time-overcurrent protection for phase-to-ground faults.

Time-Overcurrent Curve and Time-Dial

Select the element curve and time-dial settings individually to coordinate with downstream phase, negative-sequence, and residual time-overcurrent elements. Refer to the time-overcurrent equations and curves in this section for the specific time-overcurrent characteristic equations.

Time-Overcurrent Element Reset Characteristic

You can set the relay time-overcurrent element to emulate an induction disk relay reset characteristic by setting the 51xnRS (x = P, Q, or N; n = winding number) setting equal to Y. With this setting, the relay emulates the spring-torque-governed disk reset action of an induction time-overcurrent unit. Make this setting when the SEL-387E Relay time-overcurrent element must coordinate with upstream electromechanical time-overcurrent relays during trip-reclose cycles.

When you set 51xnRS = N, the relay fully resets the time-overcurrent element one cycle after current drops below the element pickup setting. Make this setting when the relay time-overcurrent element must coordinate with upstream static or microprocessor-based time-overcurrent elements that have fast reset characteristics.

Instantaneous and Definite-Time Overcurrent Elements

The SEL-387E Relay includes instantaneous and definite-time overcurrent elements for phase, negative-sequence and residual current. There are three separate phase instantaneous elements, which can be used for various tripping or supervisory functions defined by the user. Each element operates using measured current, a pickup setting and, for the definite-time elements, a time delay setting.

Instantaneous and Definite-Time Element Pickup and Time Delay Settings

Use the instantaneous overcurrent elements to provide fast tripping for heavy internal transformer faults. Set the element pickup settings high enough to prevent tripping for faults outside the protection zone. Both definite-time and instantaneous phase overcurrent elements are sensitive to load, but should, based on other setting constraints, be set well above the maximum expected loading.

Use the definite-time delayed overcurrent elements to provide fast backup protection for downstream instantaneous elements. Allow sufficient time delay to coordinate with downstream breakers, reclosers, or other protection.

Overcurrent Element External Torque-Control

The SEL-387E Relay allows you to either enable or block selected overcurrent elements using a SELOGIC control equation. You may wish, for example, to control an overcurrent element using an external contact from a toggle switch, control switch, external directional relay, or recloser. Or, you may wish to use some combination of relay elements to enable or block the overcurrent element. These choices are easily accomplished by creating a SELOGIC control equation that describes what is needed, and storing the equation as the setting for the specific overcurrent unit's torque-control variable. For example, to torque control the inverse-time phase overcurrent unit for Winding 1, an equation is needed for the setting 51PTC. A few simple possibilities might include:

To enable the unit with an external contact input IN104, set 51PTC = IN104.

To block the unit with this same input, set 51PTC = !IN104 (i.e., NOT IN104).

To enable the unit with IN104, but only if Breaker 3 is open, set 51PTC = IN104*!IN106 (i.e., IN104 AND NOT IN106, where IN106 was previously defined as representing the 52a-3 contact input)

To enable the unit continuously (default setting), set 51PTC = 1.

Overcurrent Settings for Example Application

The differential settings for the example transformer application (see Figure 2.15 in ***Section 2: Installation***) were defined earlier. Overcurrent settings were chosen to complete the protection settings package. These settings are listed at the end of this section of the instruction manual.

Before setting of any overcurrent elements can occur, these must be enabled by the configuration settings EOC1 through EOC3. EOC1, EOC2, and EOC3 are set to Y.

For the 230 kV primary winding (Winding 1), three elements are set for overcurrent tripping of 230 kV Breaker 1. The phase definite-time element, 50P11, is set for 20 A secondary, with a five-cycle trip delay time. The phase and negative-sequence inverse-time elements, 51P1 and 51Q1, are set to pick up at 4 A and 6 A, respectively, both using the U2 or U.S. Inverse curve, on Time-Dial 3, with electromechanical reset characteristics. One of the phase instantaneous elements, 50P13, is set very low at 0.5 A, along with 50P23 and 50P33 on the other two windings. These elements are employed in a supervisory mode for the Unlatch Trip function, effectively defining when the breaker has opened by the dropping of phase current below the element setting. The 50P14 phase instantaneous element has been set at 4 A, and is used in an internal supervision function (LED targeting).

For the 138 kV secondary winding (Winding 2), tripping is set for the phase and negative-sequence inverse-time elements, 51P2 and 51Q2. These are set at lower pickup values of 3.5 and 5.25 A secondary, using the same curves as Winding 1, but at a higher Time Dial of 3.5. Tripping is done for the 138 kV Breaker 2. Phase instantaneous elements 50P23 and 50P24 are used for supervision, as with Winding 1, set at 0.5 A and 3.5 A, respectively.

For the 13.8 kV tertiary, Winding 3, tripping is by the definite-time element, 50P31, set as an instantaneous element at 7 A and zero time delay, and by the phase inverse time element 51P3. 51P3 is set for 4 A, at Time Dial 1.3 of the U2 inverse curve, with electromechanical reset. Tripping is for the 13.8 kV Breaker 3. The 50P33 and 50P34 phase instantaneous elements are used for supervision, set at 0.5 A and 4 A.

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≤1]

U.S. Moderately Inverse Curve: U1

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

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

U.S. Inverse Curve: U2

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

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

U.S. Very Inverse Curve: U3

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

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

U.S. Extremely Inverse Curve: U4

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

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

U.S. Short-Time Inverse Curve: U5

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

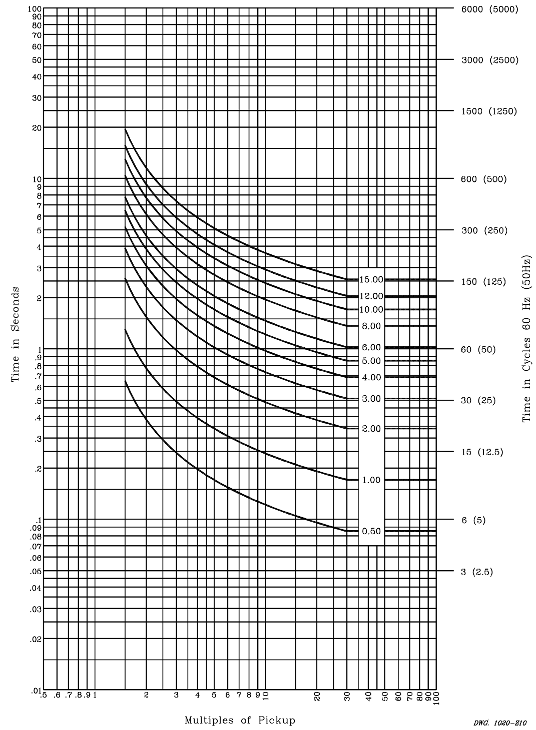


Figure 3.24: U.S. Moderately Inverse Curve: U1

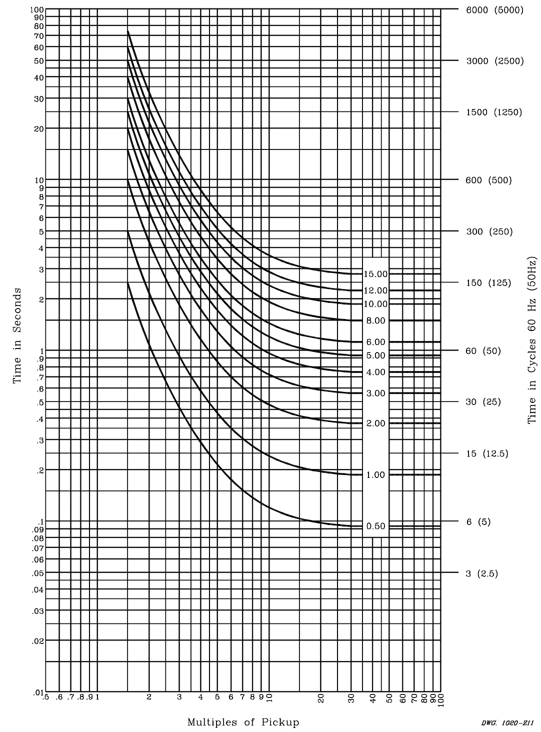


Figure 3.25: U.S. Inverse Curve: U2

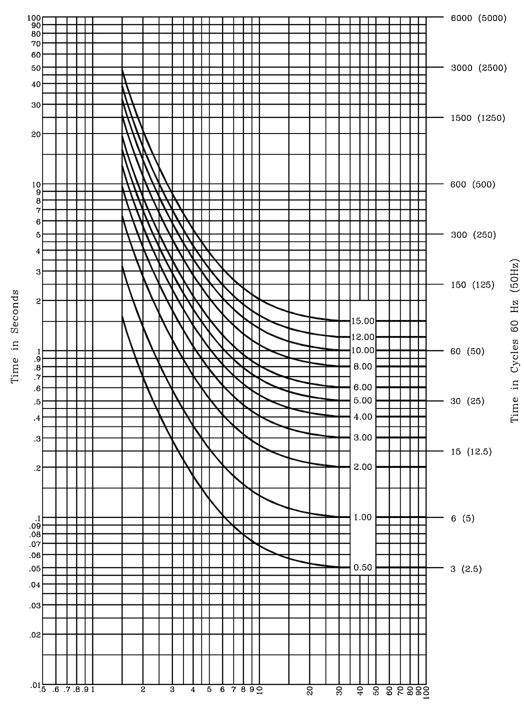


Figure 3.26: U.S. Very Inverse Curve: U3

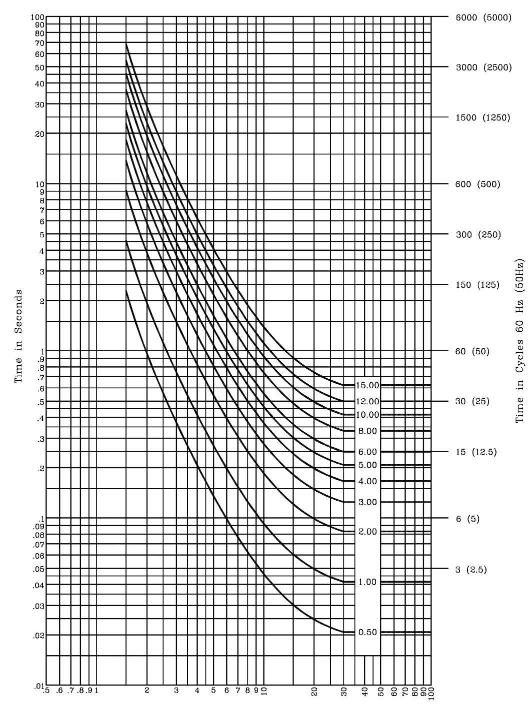


Figure 3.27: U.S. Extremely Inverse Curve: U4

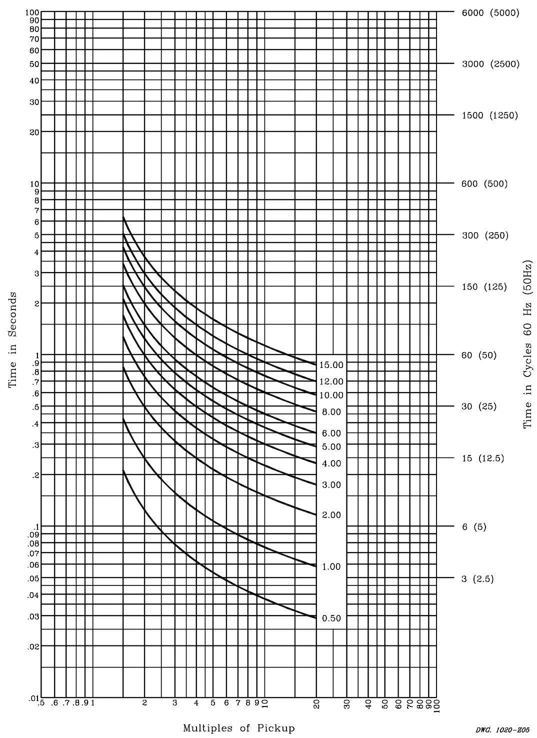


Figure 3.28: U.S. Short-Time Inverse Curve: U5

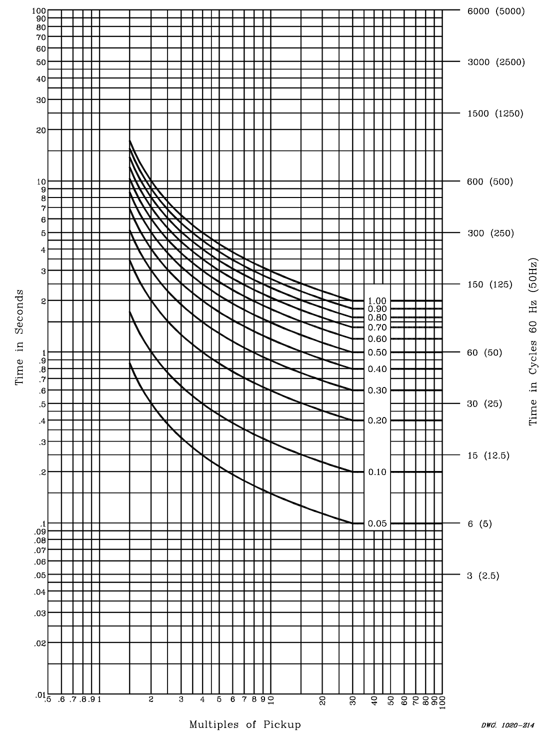


Figure 3.29: I.E.C. Class A Curve (Standard Inverse): C1

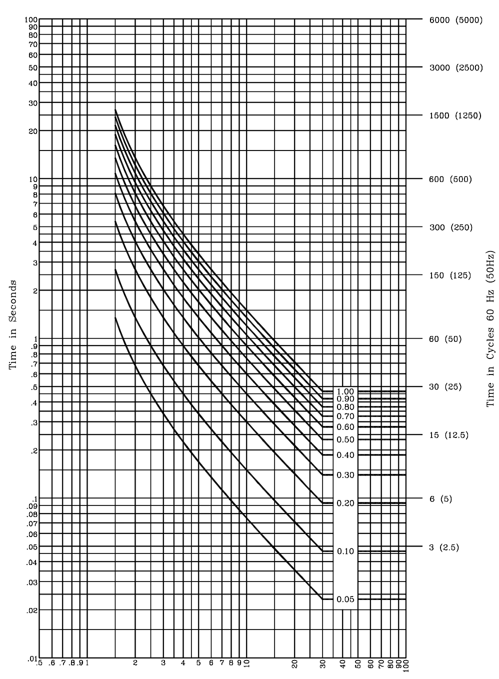


Figure 3.30: I.E.C. Class B Curve (Very Inverse): C2

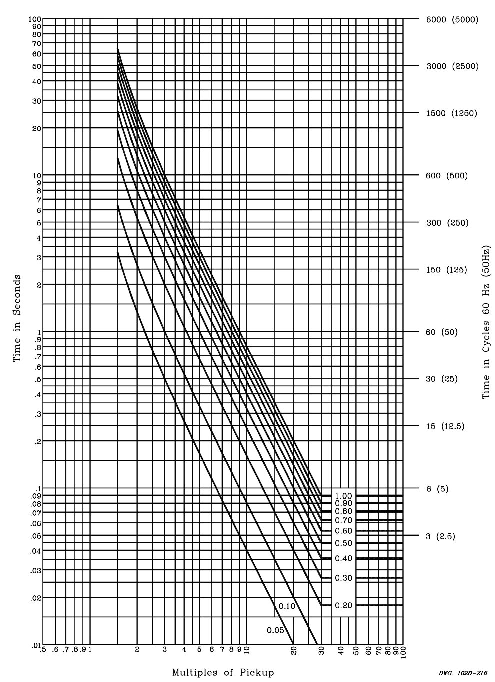


Figure 3.31: I.E.C. Class C Curve (Extremely Inverse): C3

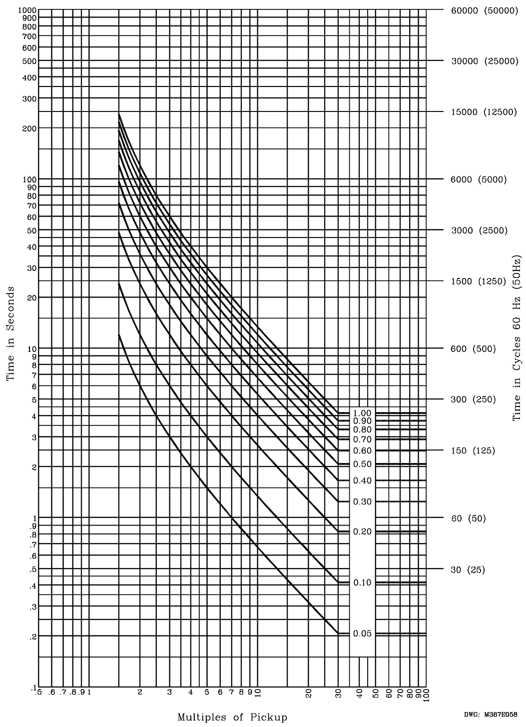


Figure 3.32: I.E.C. Long-Time Inverse Curve: C4

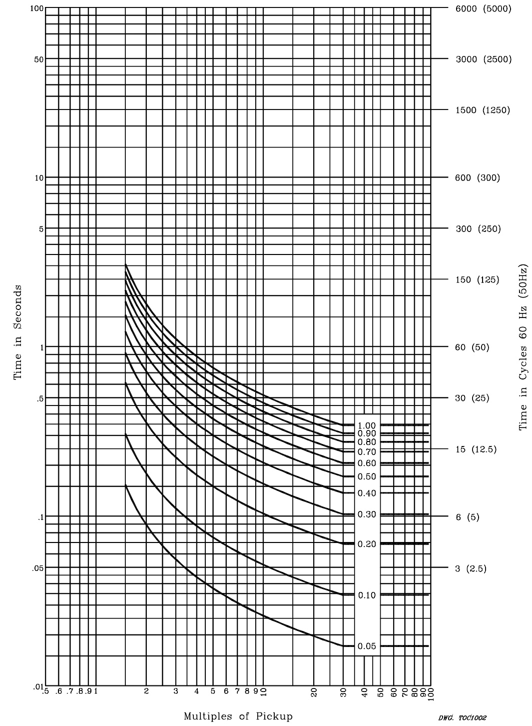


Figure 3.33: I.E.C. Short-Time Inverse Curve: C5

Over-/Undervoltage Element

Application Description

The SEL-387E Relay offers the following overvoltage and undervoltage elements for protection, indication, and control functions:

- Two levels of phase undervoltage
- Two levels of phase-to-phase undervoltage
- One level of positive-sequence undervoltage (V1)
- Two levels of phase overvoltage
- Two levels of residual overvoltage (3V0)
- One level of negative-sequence overvoltage (V2)
- One level of positive-sequence overvoltage
- Two levels of phase-to-phase overvoltage

Operating Characteristic

Phase overvoltage elements operate using the maximum of the measured phase voltage magnitudes. Residual overvoltage elements operate using the sum of the three-phase voltage (3V0) measurements. The positive- (V1) and negative-sequence (V2) overvoltage elements operate when their respective measurements exceed their set thresholds. The phase-to-phase overvoltage element operates when the maximum phase-to-phase voltage exceeds the set threshold.

Phase undervoltage elements operate using the minimum of the measured phase voltage magnitudes, operating if any single-phase measurement falls below the set threshold. The phase-to-phase undervoltage element operates using the minimum of the measured phase-to-phase voltages. The positive-sequence (V1) undervoltage element operates when the measured positive-sequence voltage falls below the set threshold.

Figure 3.34 and Figure 3.35, respectively, diagram the logic for the overvoltage and undervoltage elements.

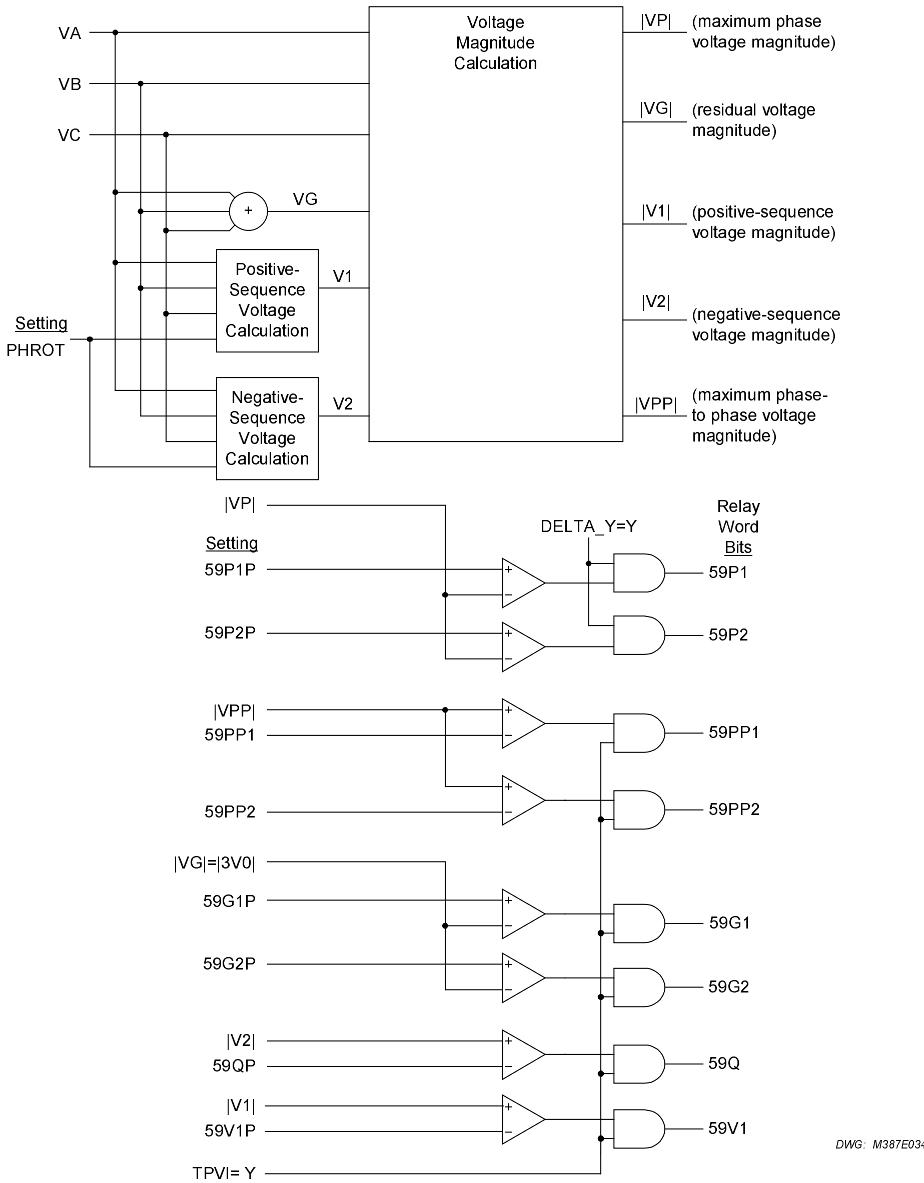


Figure 3.34: Overvoltage Element Logic Diagram

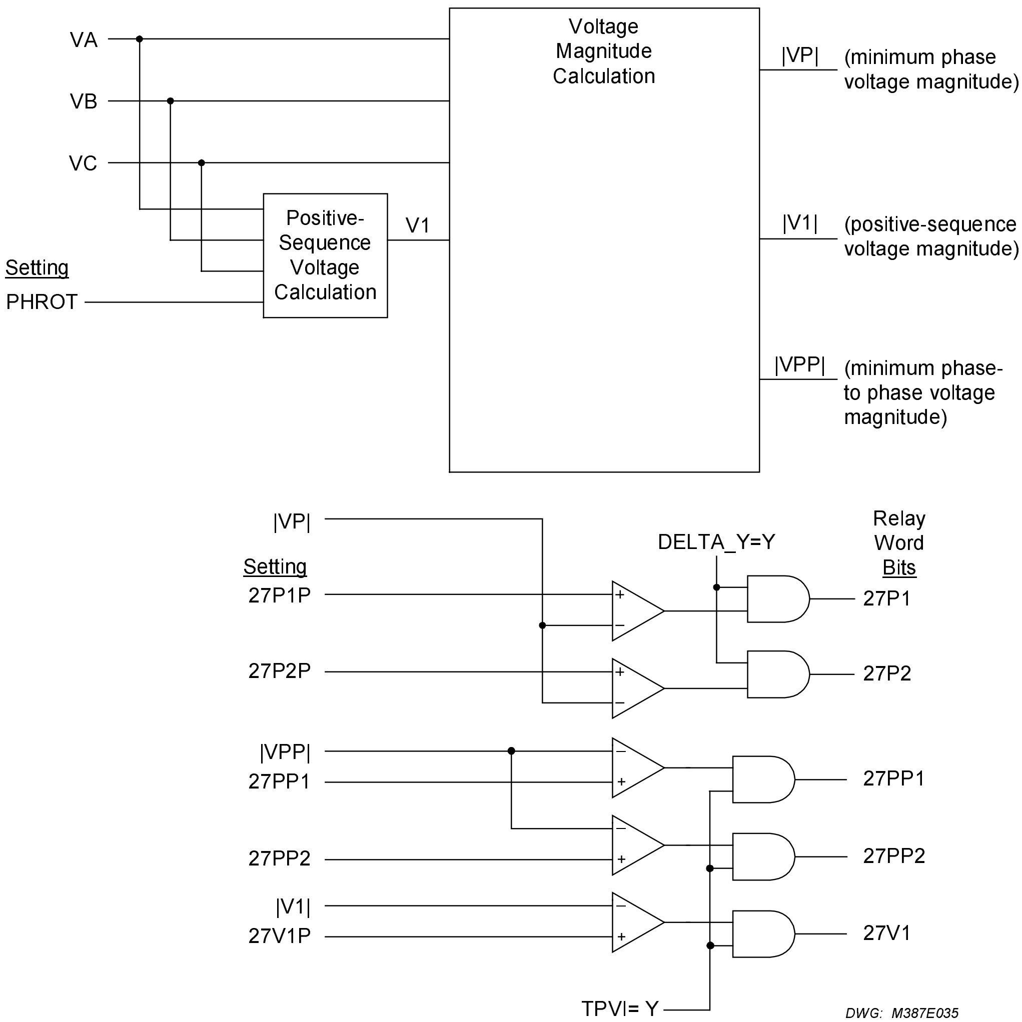


Figure 3.35: Undervoltage Element Logic Diagram

Setting Descriptions

Undervoltage Element Enable (E27)

Range: Y, N

Set E27 = Y to enable the 27P1, 27P2, 27PP1, 27PP2, and 27V1 undervoltage elements. If you do not need these elements, set E27 = N. When E27 = N, the relay hides the undervoltage elements and you do not need to enter the pickup settings. Settings DELTA_Y and TPVI also affect whether these elements are available.

Overvoltage Element Enable (E59)

Range: Y, N

Set E59 = Y to enable the 59P1, 59P2, 59G1, 59G2, 59Q, 59V1, 59PP1, and 59PP2 overvoltage elements. If you do not need any of these elements, set E59 = N. When E59 = N, the relay hides the overvoltage elements and you do not need to enter the pickup settings. Settings DELTA_Y and TPVI also affect whether these elements are available.

Phase Undervoltage Element Pickups (27PnP)

Range: OFF, 0.1–300.0 V

Set pickups for the phase voltage value below which you want the elements to assert. Note that n represents one of two pickup levels, 1 or 2.

Phase-Phase Undervoltage Element Pickups (27PPn)

Range: OFF, 0.1–520.0 V

Set pickups for the phase-to-phase voltage value below which you want the elements to assert. Note that n represents one of two pickup levels, 1 or 2.

Positive-Sequence Undervoltage Element Pickup (27V1P)

Range: OFF, 0.1–100.0 V

Set the pickup for the positive-sequence voltage value below which you want the element to assert.

Phase Overvoltage Element Pickups (59PnP)

Range: OFF, 0.0–300.0 V

Set pickups for the phase voltage value above which you want the elements to assert. Note that n represents one of two pickup levels, 1 or 2.

Residual Overvoltage Element Pickups (59GnP)

Range: OFF, 0.0–300.0 V

Set pickups for the residual voltage value above which you want the elements to assert. Note that n represents one of two pickup levels, 1 or 2.

Negative-Sequence Overvoltage Element Pickup (59QP)

Range: OFF, 0.0–100.0 V

Set the pickup for the negative-sequence voltage value above which you want the element to assert.

Phase-Phase Overvoltage Element Pickups (59PPn)

Range: OFF, 0.0–520.0 V

Set pickups for the phase-to-phase voltage value above which you want the elements to assert. Note that n represents one of two pickup levels, 1 or 2.

Positive-Sequence Overvoltage Element Pickup (59V1P)

Range: OFF, 0.0–100.0 V

Set the pickup for the positive-sequence voltage value above which you want the element to assert.

Definite-Time Characteristic

None of the elements is equipped with a definite-time delay. If you want a definite-time characteristic, use a SELOGIC control equation variable and corresponding built-in time-delay pickup and dropout timers.

FREQUENCY ELEMENT

Application Description

The SEL-387E Relay provides six levels of over-/underfrequency elements. Each element can operate as an overfrequency or as an underfrequency element, depending on its pickup setting. If the element pickup setting is less than the nominal system frequency setting, NFREQ, the element operates as an underfrequency element, picking up if measured frequency is less than the set point. If the pickup setting is greater than NFREQ, the element operates as an overfrequency element, picking up if measured frequency is greater than the set point.

Operating Characteristic

The SEL-387E Relay determines system frequency using the A-phase voltage.

Note: All frequency elements are disabled if any phase voltage is less than a settable voltage, 27B81P. Use the relay frequency elements for simple abnormal frequency protection.

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

E81 = N (none), 1 through 6

as shown in Figure 3.36. Frequency is determined from the voltage connected to voltage terminals VA-N.

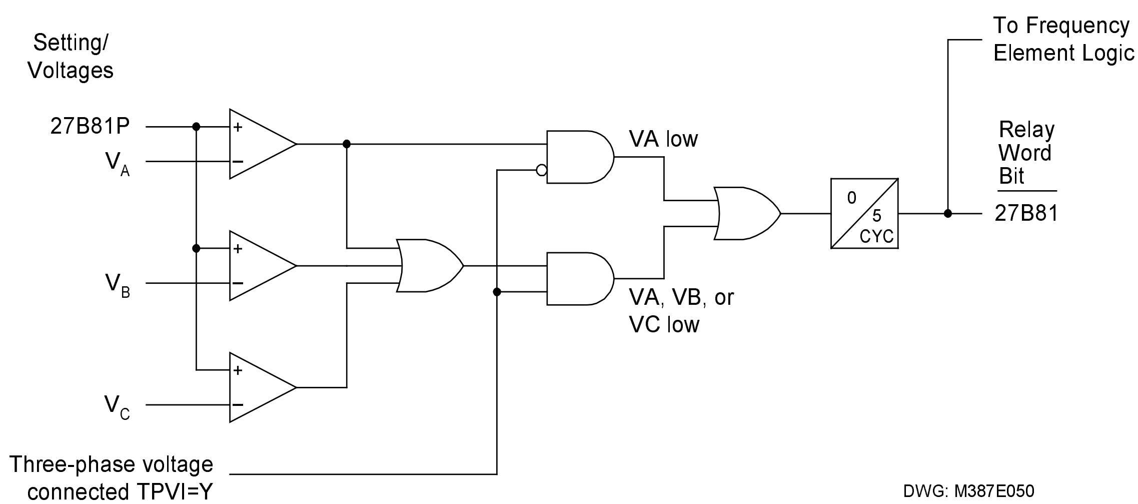


Figure 3.36: Undervoltage Block for Frequency Elements

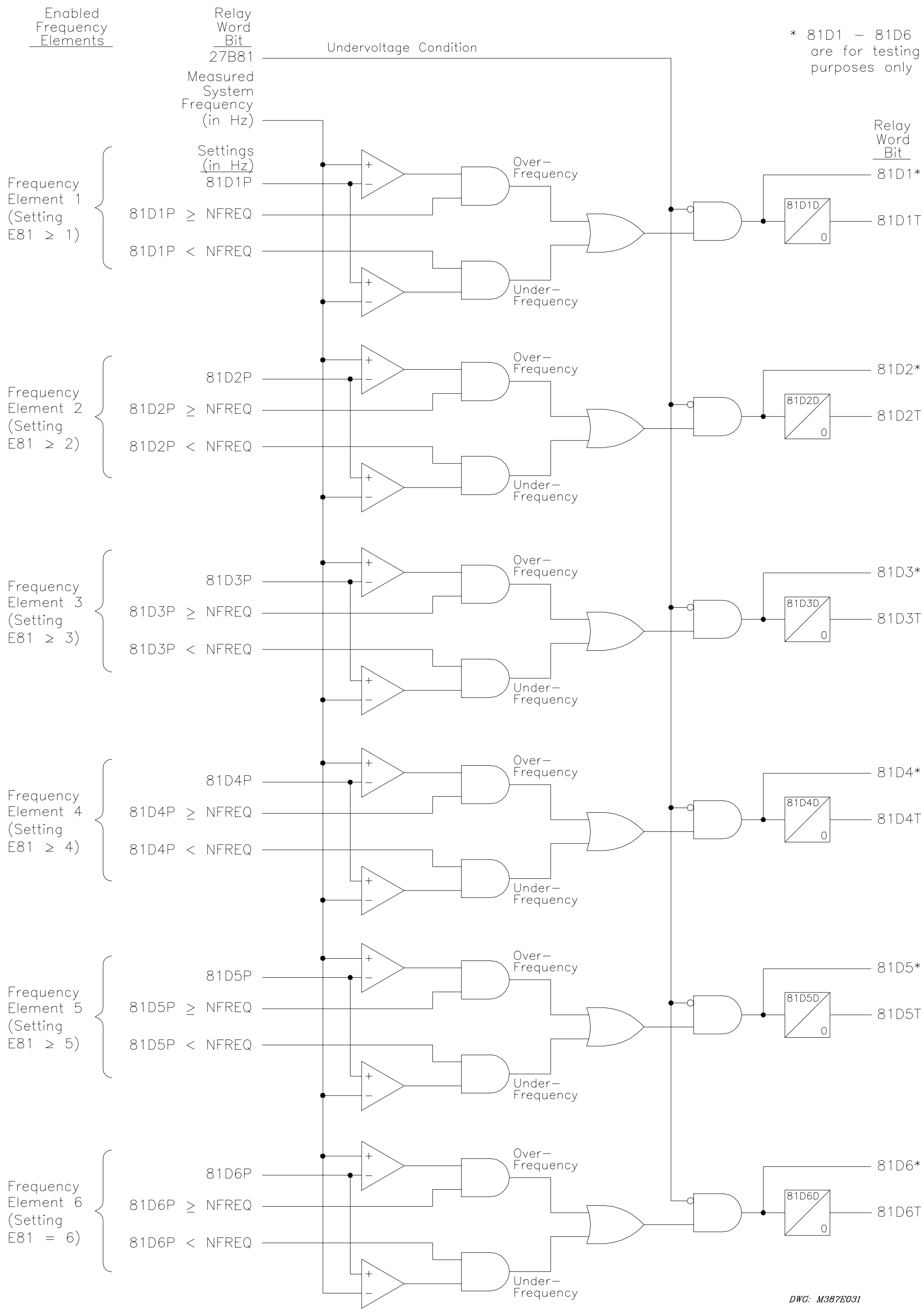


Figure 3.37: Frequency Element Logic

Note: Instantaneous frequency element Relay Word bits 81D1–81D6 should not be used for applications other than testing.

Setting Descriptions

Frequency Element Enable (E81)

Range: N, 1–6

Set E81 to enable as many as six over-/underfrequency elements. When E81 = N, the relay disables the frequency elements and hides corresponding settings; you do not need to enter these hidden settings.

Phase Undervoltage Block (27B81P)

Range: 20.00–150.00 Vsec

Set the phase voltage value below which all frequency elements will be disabled.

Frequency Element Pickups (81DnP)

Range: OFF, 40.10–65.00 Hz

Set the value at which you want the frequency element for each of six levels to assert. For a value of 81DnP less than the nominal system frequency of 60 Hz, the element operates as an underfrequency element. For a value greater than 60 Hz, the element operates as an overfrequency element. Note that n can be one of six levels, 1–6.

Frequency Element Time Delays (81DnD)

Range: 0.04–300.00 seconds

Select a time in seconds that you want frequency elements to wait before asserting. Note that n can be one of six levels, 1–6.

Volts/Hertz Element

Application Description

Overexcitation occurs when a transformer magnetic core becomes saturated. When this happens, stray flux is induced in nonlaminated components, causing overheating. In the SEL-387E Relay a volts/hertz element detects overexcitation. The SEL-387E Relay provides a sensitive definite-time volts/hertz element, plus a tripping element with a composite operating time. The relay calculates the present transformer volts/hertz as a percent of nominal, based on the present and nominal voltages and frequencies. The settings VNOM and NFREQ define the nominal transformer voltage and frequency, respectively.

Operating Characteristic

If the torque-control 24TC SELOGIC control equation is true and the present volts/hertz exceed the 24D1P setting, the relay asserts the 24D1 Relay Word bit and starts the 24P1D timer. If the condition remains for 24P1D seconds, the relay asserts the 24D1T Relay Word bit. Typically, you should apply this element as an overexcitation alarm.

For volts/hertz tripping the relay provides a time-integrating element with a settable operating characteristic. You can set the element to operate as an inverse-time element; a user-defined curve element (using the SEL-5806 PC Software); a composite element with an inverse-time characteristic and a definite-time characteristic; or as a dual-level, definite-time element. In any case, the element provides a linear reset characteristic with a settable reset time. This element also is supervised by the 24TC torque-control setting.

The volts/hertz tripping element has a percent-travel operating characteristic similar to that employed by an induction-disk time-overcurrent element. This characteristic coincides well with the heating effect that overexcitation has on transformer components.

The element compares the three phase voltages and uses the highest of the values for the volts/hertz magnitude calculations. The relay tracks the frequency over the range 40.1 to 65 Hz, but only on the A-phase voltage.

Volts/hertz tripping elements are usually used to trip the transformer breaker. Volts/hertz logic is discussed in the following section. For more detail and for examples of tripping SELOGIC control equations, refer to ***Section 4: Control Logic.***

Figure 3.38, following, diagrams the logic of the volts/hertz elements.

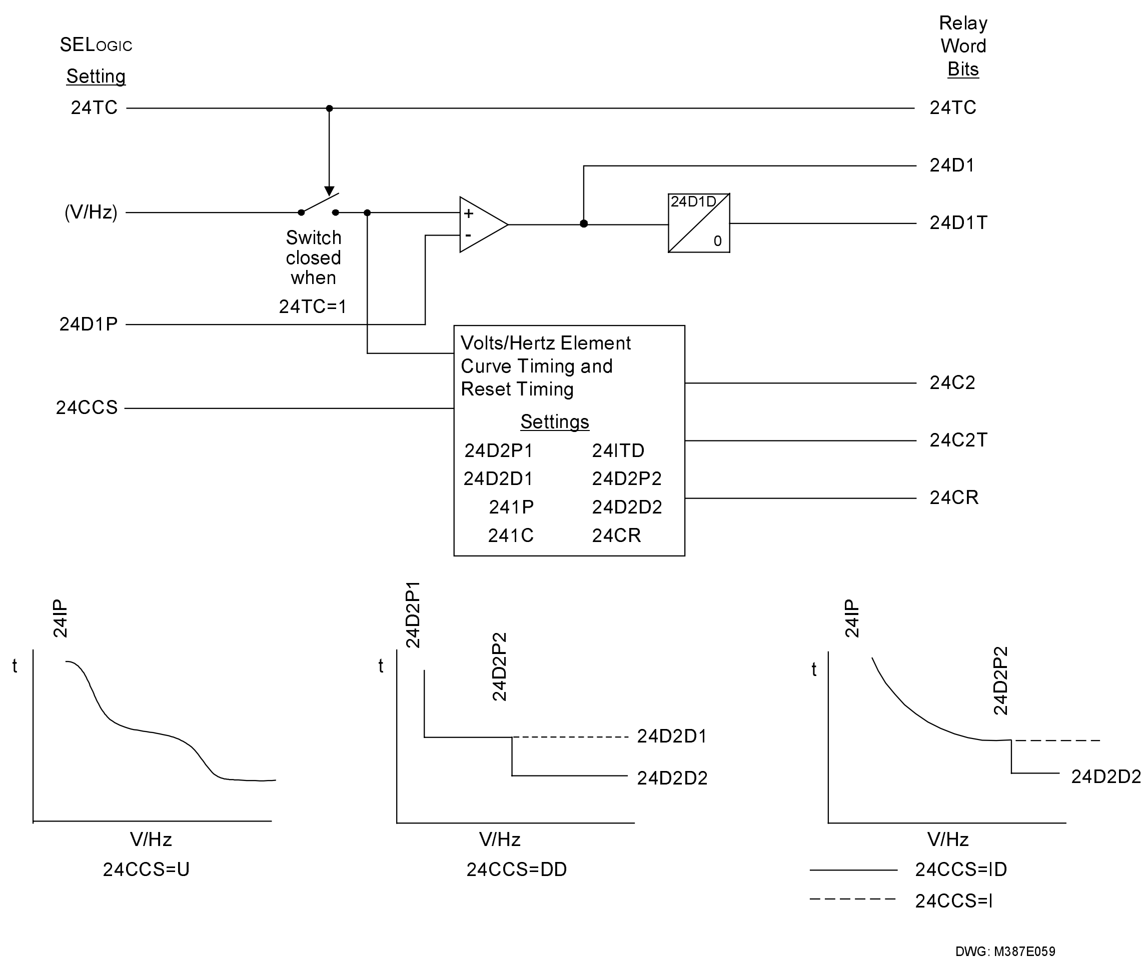


Figure 3.38: Volts/Hertz Element Logic Diagram

The figures below are similar to *IEEE C37.102 : 1987 IEEE Guide for AC Generator Protection Figure 4.5.4-1 and Figure 4.5.4-2*.

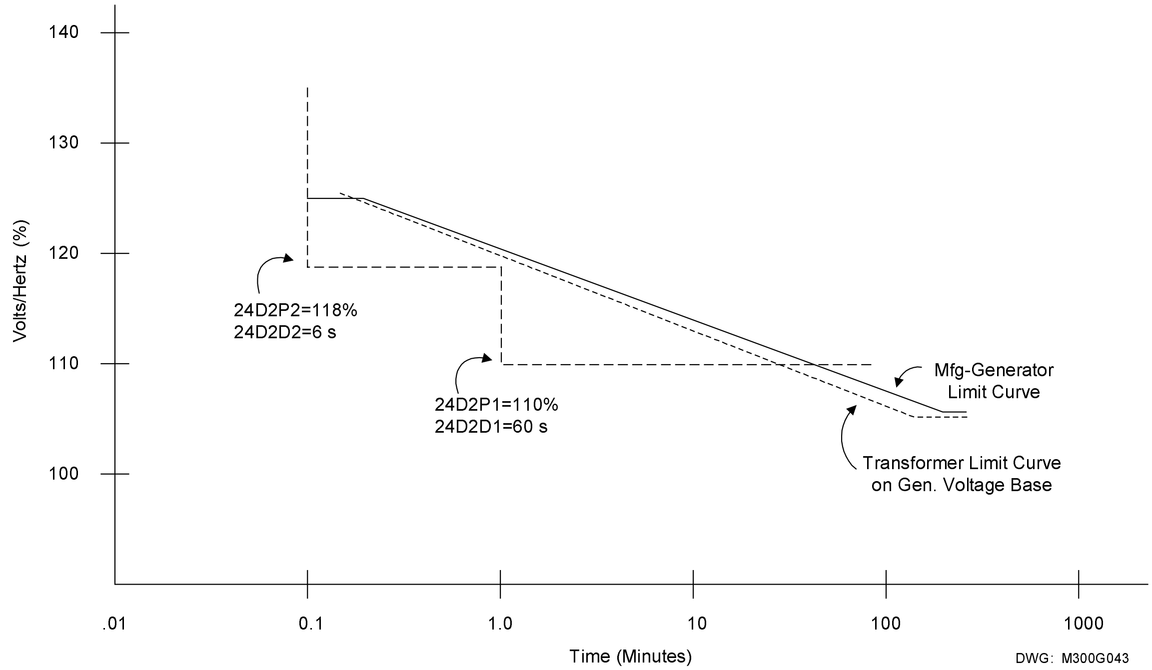


Figure 3.39: Dual-Level Volts/Hertz Time-Delay Characteristic 24CCS=DD

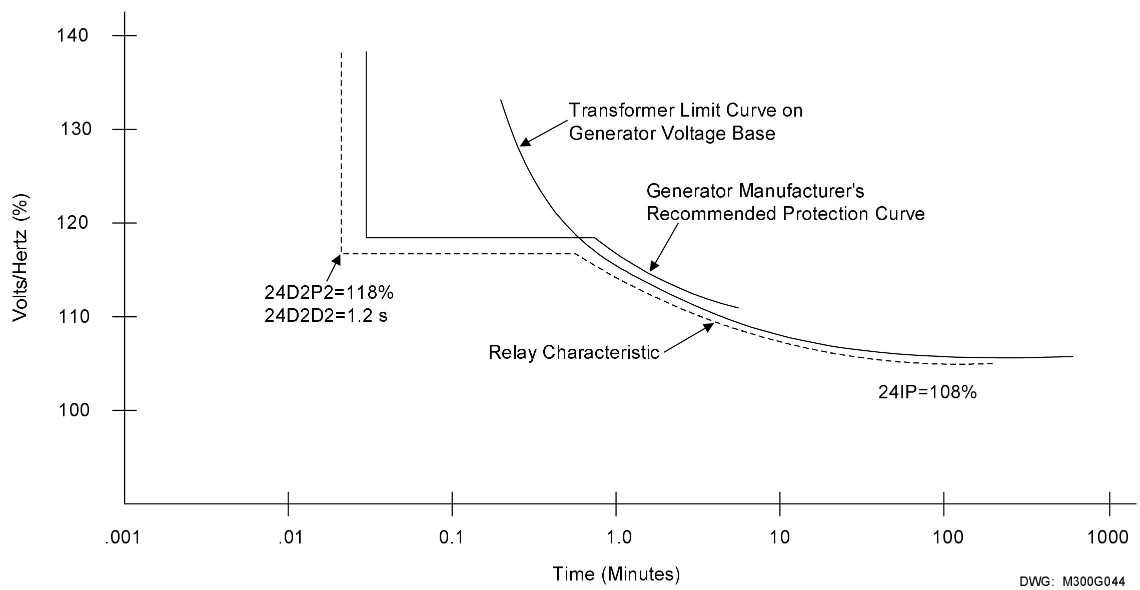


Figure 3.40: Composite Inverse/Definite-Time Overexcitation Characteristic, 24CCS=ID

Setting Descriptions

Recommendations

Collect this information before calculating volts/hertz element settings:

- Transformer manufacturer's overexcitation limit curve
- Transformer nominal phase-phase voltage

Select the transformer winding that is most likely to suffer overexcitation. The relay voltage input should be from a source that most reliably reflects that winding voltage.

Use the Level 1 volts/hertz element as an overexcitation alarm. Set 24D1P equal to or greater than 105 percent, but less than the minimum pickup of the Level 2 element. Use a 24D1D time delay of 1.0 second to allow time for correction of an overexcitation condition prior to an alarm.

Use the Level 2 volts/hertz element as an overexcitation tripping element. Select the dual level, composite inverse, simple inverse, or user-defined operating time characteristic (using the SEL-5806 Curve Designer Software) to conform to the transformer manufacturer's recommendations.

Phase Potential Connection (DELTA_Y)

Use **SET G <ENTER>** to access the DELTA_Y setting. Set DELTA_Y = D for open-delta PT connections (Figure 2.16), otherwise, set it to Y. See ***Phase Potential Connection (DELTA_Y)*** in ***Section 6: Setting the Relay*** for more information on this type of PT connection.

Volts/Hertz Protection Enable (E24)

Range: (Y, N)

Set E24 = Y to enable volts/hertz protection elements. If you do not need volts/hertz protection, set E24 = N. When E24 = N, the 24TC, 24D1, 24D1T, 24C2, 24C2T, and 24CR Relay Word bits are inactive. The relay hides corresponding settings; you do not need to enter these settings.

Protected Winding Line-to-Line Voltage (VNOM)

Range: (0.20 – 800.00 kV)

VNOM is the rated transformer line-to-line voltage in kV at the protected winding. Consider the transformer tap when determining this setting. For example, a 345 kV transformer set on the 327.75 kV TAP would have VNOM = 327.75.

Power Transformer Winding Connection (24WDG)

Range: (D, Y)

When three PTs are available, the most common PT winding connection is to connect both HV and LV sides in wye, leaving the power transformer winding connections as the only variable. For wye-connected power transformer windings, the power transformer phase-to-neutral voltage is readily measured through wye-wye connected PTs. Set 24WDG = Y. When the power transformer windings are delta connected, the relay cannot measure the phase voltage directly, but needs to calculate the voltage values. The relay calculates the differences between the voltages presented to the relay from the wye-wye connected PTs and thus the voltage connected to the power transformer windings. Set 24WDG = D. Thus, voltage values selection to calculate the volts/hertz protection and sequence components is based on the 24WDG selection; phase to phase for 24WDG = D and phase-to-neutral for 24WDG = Y.

Level 1 Volts/Hertz Element Pickup (24D1P)

Range: 100–200%

Apply the Level 1 element as an overexcitation alarm. The 24D1P setting defines the percent volts/hertz alarm pickup. The 24D1 Relay Word bit asserts without time delay when the measured transformer volts/hertz exceeds the 24D1P setting.

Level 1 Time Delay (24D1D)

Range: 0.04–400.00 s

The 24D1T Relay Word bit asserts 24D1D seconds after 24D1 assertion if the measured volts/hertz remains above the 24D1P setting.

Level 2 Composite Curve Shape (24CCS)

Range: OFF, DD, ID, I, U

The 24CCS setting defines the overexcitation tripping element time-delay characteristic or disables the element when set to OFF.

Set 24CCS = OFF if you do not require Level 2 volts/hertz protection. When 24CCS = OFF, the other Level 2 settings are hidden and do not need to be entered.

When 24CCS = DD:

The element operates with a dual-level, definite-time characteristic.

Level 2 Pickups (24D2P1 and 24D2P2)

Range: 100–200% (for 24D2P1)

Range: 101–200% (for 24D2P2)

The SEL-387E Relay asserts the 24C2 Relay Word bit without time delay when the transformer volts/hertz exceeds either the 24D2P1 or 24D2P2 setting.

Level 2 Time-Delays (24D2D1 and 24D2D2)

Range: 0.04–400.00 s

If the volts/hertz percentage is greater than the 24D2P1 setting, but less than the 24D2P2 setting, the relay asserts the 24C2T Relay Word bit in 24D2D1 seconds.

When the volts/hertz percentage is greater than the 24D2P2 setting, the relay asserts the 24C2T Relay Word bit in 24D2D2 seconds. The setting 24D2P1 must be less than the setting for 24D2P2.

When 24CCS = ID:

The element operates with a composite inverse-time and definite-time characteristic.

Level 2 Inverse-Time Pickup (24IP)

Range: 100–200%

The 24IP setting defines the pickup point of the inverse-time portion of the operating time curve. The SEL-387E Relay asserts the 24C2 Relay Word bit without time delay when the transformer volts/hertz exceeds the 24IP setting.

Level 2 Inverse-Time Curve (24IC)

Range: 0.5, 1.0, 2.0

The 24IC setting defines the element operating time curve shape.

Level 2 Inverse-Time Factor (24ITD)

Range: 0.10–10.0 s

The 24ITD setting defines the inverse element operate time in seconds when the transformer volts/hertz equals 200 percent.

Level 2 Pickup Two (24D2P2)

Range: 101–200%

Level 2 Time-Delay Two (24D2D2)

Range: 0.04–400.00 s

The 24D2P2 and 24D2D2 settings define the pickup and definite operating time of the definite-time portion of the composite curve. The relay asserts the 24C2T Relay Word bit in time defined by the inverse curve when the measured apparatus volts/hertz is less than the 24D2P2 setting.

The relay asserts the 24C2T Relay Word bit in time defined by the 24D2D2 definite-time settings when the measured apparatus volts/hertz is greater than the 24D2P2 setting. The setting for 24IP must be less than the setting for 24D2P2.

When 24CCS = I:

The element operates with a simple inverse-time characteristic, depending on the 24IC setting.

The relay asserts the 24C2T Relay Word bit in time defined by the inverse curve when the measured apparatus volts/hertz exceeds the 24IP setting.

Level 2 Inverse-Time Pickup (24IP)

Range: 100–200%

The 24IP setting defines the pickup point of the inverse-time portion of the operating time curve. The SEL-387E Relay asserts the 24C2 Relay Word bit without time delay when the measured apparatus volts/hertz exceeds the 24IP setting.

Level 2 Inverse-Time Curve (24IC)

Range: 0.5, 1.0, 2.0

The 24IC setting defines the curve shape.

Level 2 Inverse-Time Factor (24ITD)

Range: 0.10–10.0 s

The 24ITD setting defines the inverse element operate time in seconds when the transformer volts/hertz equals 200 percent.

When 24CCS = U:

The element operates with a user-defined inverse-time characteristic. The user curve should be set using SEL-5806 PC software. This program handles individual mapping of points to make a curve that matches any transformer characteristic. It also handles all relay communication by either uploading the current curve or programming a new curve.

Level 2 Inverse-Time Pickup (24IP)

Range: 100–200%

The 24IP setting defines the pickup point of the user-defined operating time curve. The SEL-387E Relay asserts the 24C2 Relay Word bit without time delay when the transformer volts/hertz exceeds the 24IP setting. The relay asserts the 24C2T Relay Word bit in time defined by the user-defined curve when the measured apparatus volts/hertz exceeds the user-defined setting.

When 24CCS = DD, ID, I, or U:

Level 2 Reset Time (24CR)

Range: 0.04–400.00 s

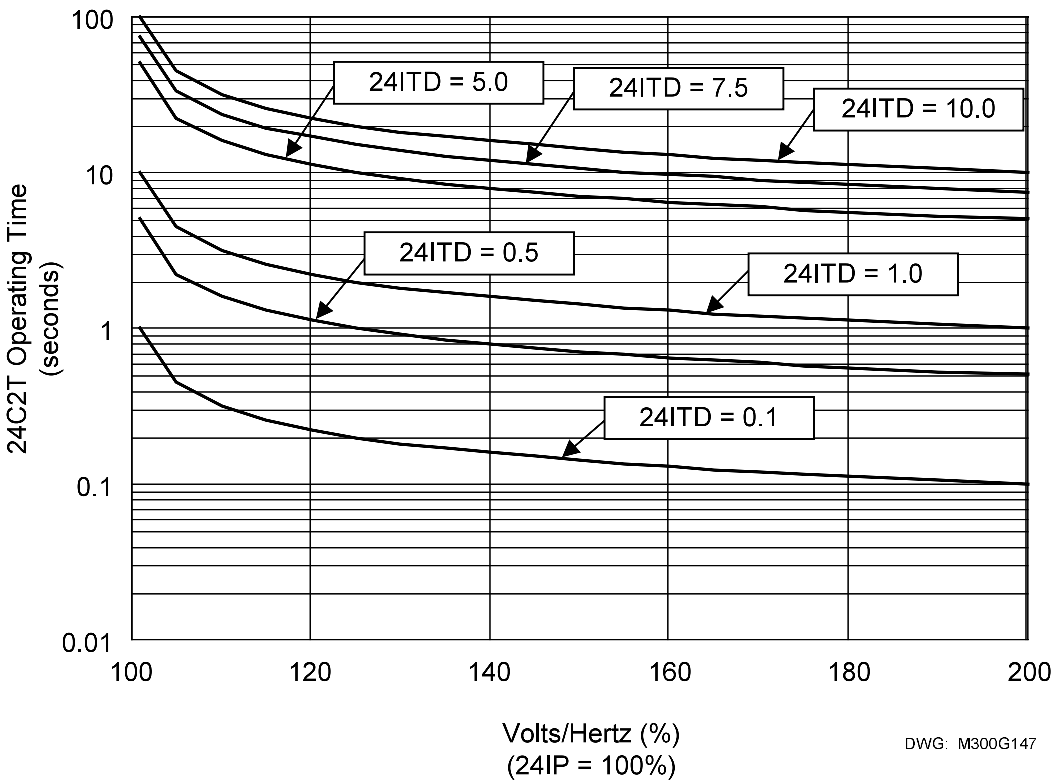
The 24CR setting defines the composite element reset time. When the element times out to trip, it will fully reset 24CR seconds after the applied volts/hertz drops below the element pickup setting. The element reset characteristic is linear, so if the element times 60 percent toward a trip, it will fully reset (0.6 • 24CR) seconds after the applied volts/hertz drops below the element pickup setting. When the element is reset, the relay asserts the 24CR Relay Word bit.

24 Element Torque Control (24TC)

Range: SELOGIC control equation

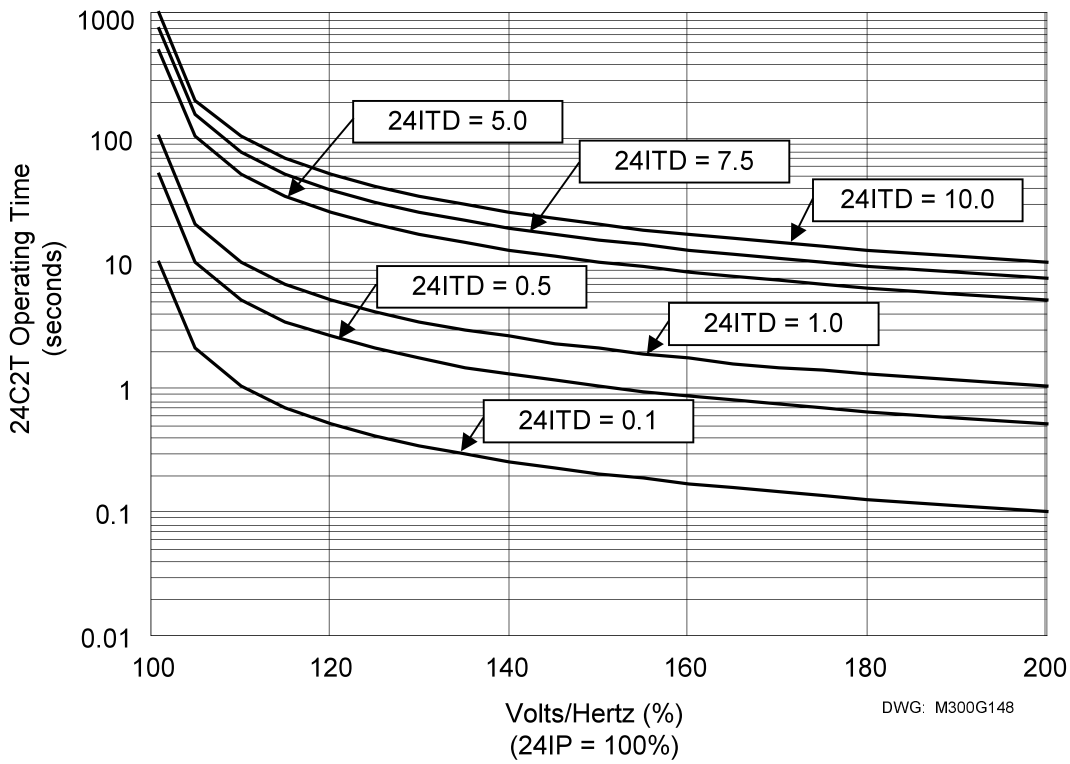
Both volts/hertz elements are disabled when the 24TC SELOGIC control equation equals logical 0. The elements are allowed to operate when the 24TC SELOGIC control equation equals logical 1, the default setting. You can add other supervisory conditions if you need these for your application.

Volts/Hertz Setting Reference Information



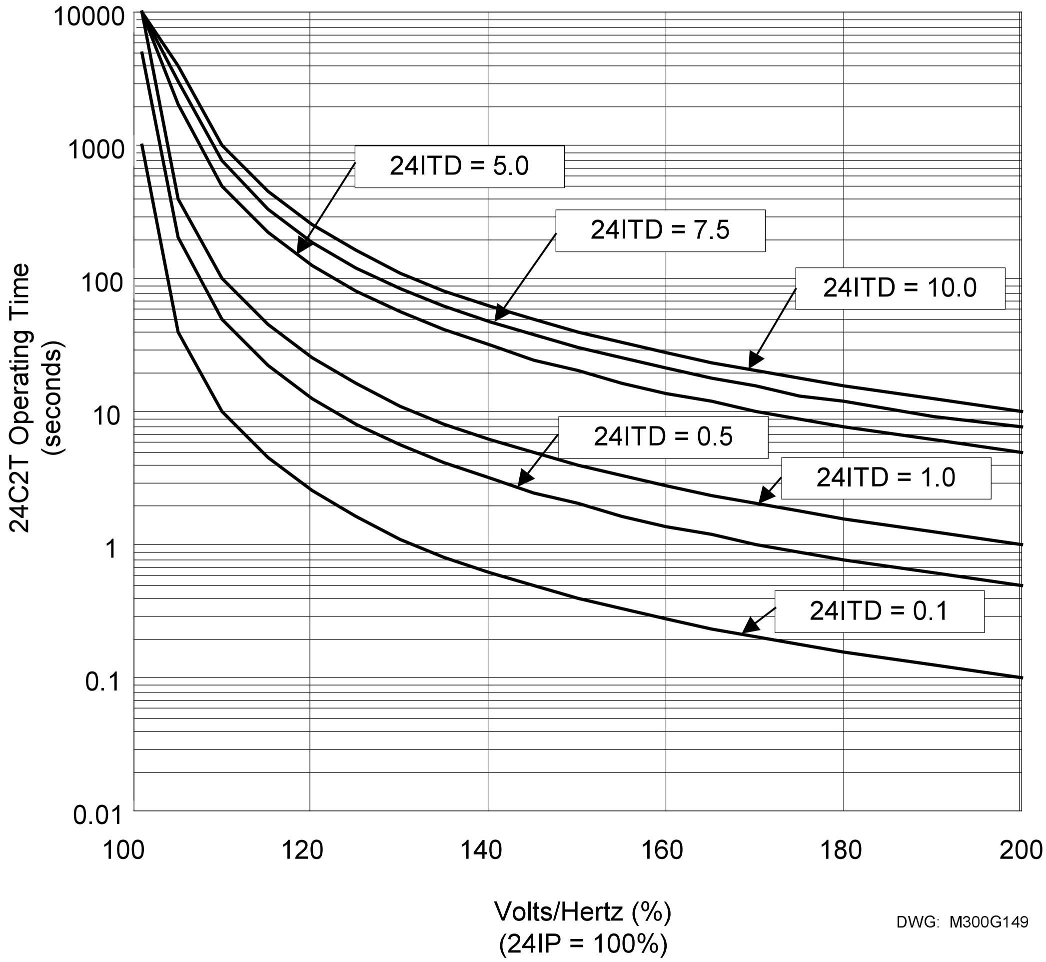
$$t_p = \frac{24\,\text{ITD}}{\left(\dfrac{\left(\dfrac{\sqrt{3}\bullet V_{sec}\bullet \text{PTR}}{\text{freq}}\bullet\dfrac{\text{NFREQ}}{\text{VNOM}\cdot 10^{3}}\right)}{\dfrac{24\,\text{IP}}{100\%}}-1\right)^{0.5}}\ \text{seconds}$$

Figure 3.41: Volts/Hertz Inverse-Time Characteristic, 24IC = 0.5



$$t_p = \frac{24\ \text{ITD}}{\left(\dfrac{\left(\dfrac{\sqrt{3} \bullet V_{sec} \bullet \text{PTR}}{\text{freq}} \bullet \dfrac{\text{NFREQ}}{\text{VNOM} \cdot 10^{3}}\right)}{\dfrac{24\ \text{IP}}{100\%}} - 1\right)^{1}}\ \text{seconds}$$

Figure 3.42: Volts/Hertz Inverse-Time Characteristic, 24IC = 1



$$t_p = \frac{24\ \text{ITD}}{\left(\dfrac{\left(\dfrac{\sqrt{3} \bullet V_{sec} \bullet \text{PTR}}{\text{freq}} \bullet \dfrac{\text{NFREQ}}{\text{VNOM} \cdot 10^3}\right)}{\dfrac{24\ \text{IP}}{100\%}} - 1\right)^2} \text{ seconds}$$

Figure 3.43: Volts/Hertz Inverse-Time Characteristics, 24IC = 2

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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	
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 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–IN106 and IN201–IN208 (interface 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 [!IN101 = 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***).

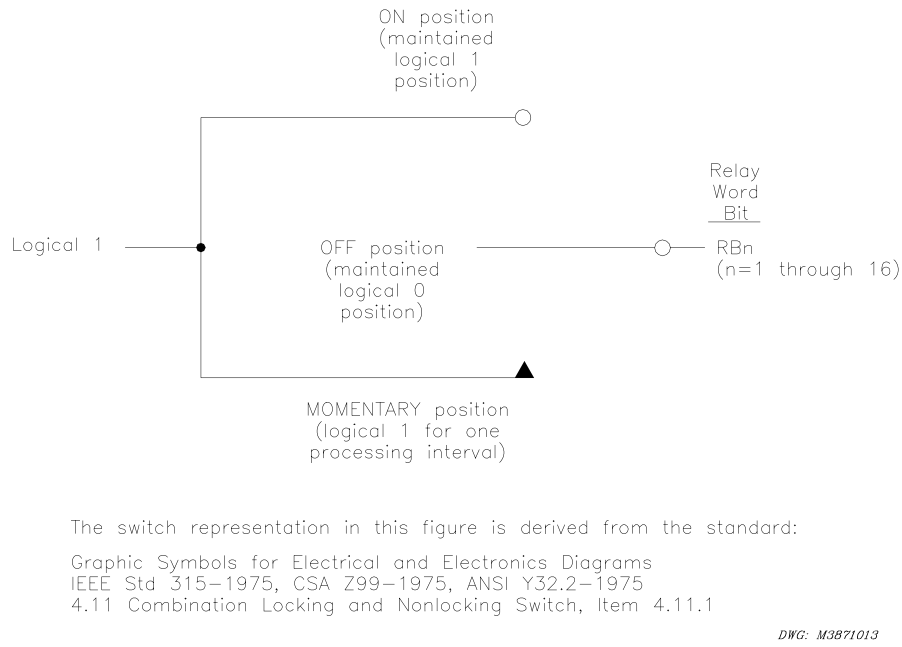

Figure 4.1: Remote Control Switches Drive Remote Bits RB1 Through RB16

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 where you want certain logic to be remotely enabled or disabled, 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, Voltage Elements, Volts-per-Hertz Elements, Frequency 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 **GRO 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 **GRO 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 **GRO 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 **GRO 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 **GRO 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 **GRO 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 power system cycles** 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.

Active Setting Group Switching Example

Previous SEL relays (e.g., SEL-321 Relay and SEL-251 Relay) have had 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-387E Relay can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-387E Relay. In this example optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in Figure 4.2.

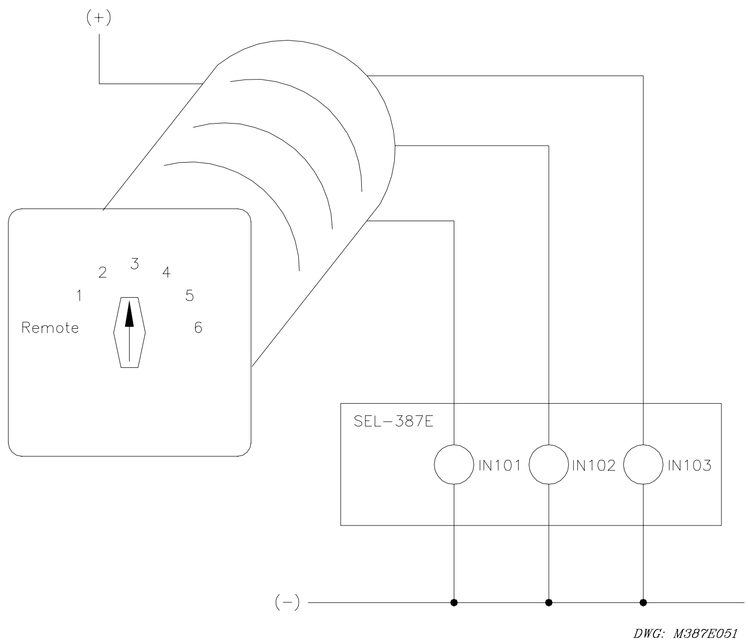

Figure 4.2: Rotating Selector Switch for Active Setting Group Selection

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 de-energizes all relay inputs, thus placing all of the SSn variables in state 0. With none of the SSn 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 SSn SELOGIC control equation settings, CHSG is asserted as soon as the new SSn bit is asserted and the relay has made the decision to change groups. It deasserts when the SGn bit for the new group agrees with the SSn 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 SGn bits are zero. All of the SSn bits are also zero. SS4 is asserted, requesting a change to Group 4. Because 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 SGn and its associated SSn bit are both asserted, for example SG1 and SS1, the relay does not respond to the assertion of a new SSn 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 SSn bit. In such cases, you may want 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 SSn 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 SSn bits are used, but group changes initiated manually through the serial port or front panel are inherently not as time critical, so a few cycles difference 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 control equations. In the SEL-387E these variables are of two types: timed variables and latch bits. The variables are processed in the order in which they appear in the Settings Sheets. If variables that appear earlier are used as inputs 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	Timed Variables	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 999,999 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 timed variables. 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.

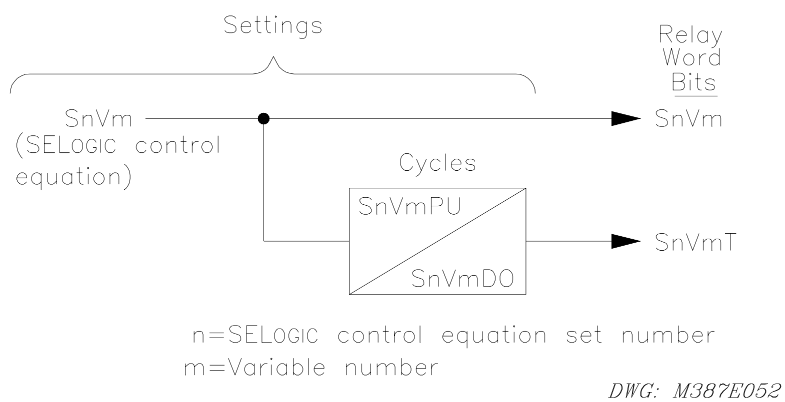

Figure 4.3: Timed Variables in SELOGIC Control Equation Sets

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 equations 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.).

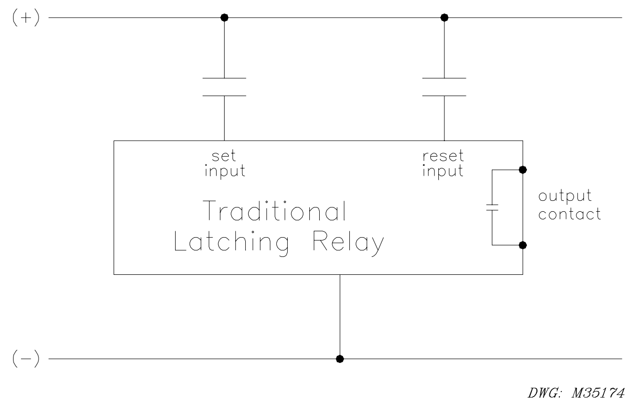

Figure 4.4: Traditional Latching Relay

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

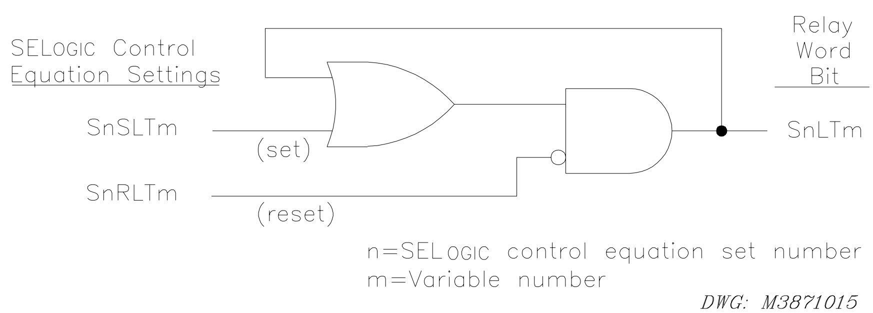

Figure 4.5: Latch Bits in SELOGIC Control Equation Sets

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 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-387E 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 control Relay Word bits having the same names. These Relay Word bits in turn control the output contacts (interface 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

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 OUTm to logical 1 causes the energization of the corresponding output contact OUTm 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 de-energized and closed when the output contact coil is energized. A "b" type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized. Solder jumpers JMP22 through JMP29 (main board) and JMP17 through JMP28 (interface board) permit the user to configure any OUTm 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 interface board is ordered.

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

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 de-energizes the ALARM output contact coil.

The Relay Word bit NOTALM (not ALARM) is asserted to logical 1, and the ALARM output contact coil is energized, when the SEL-387E Relay is operating correctly. When the serial port command **PULSE ALARM** (or front-panel CNTRL ALARM) is executed, the NOTALM 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 NOTALM Relay Word bit momentarily deasserts to logical 0. When NOTALM is zero, the ALARM output contact coil is de-energized momentarily and the "b" contact closes. The ALARM contact also closes 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-387E 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.

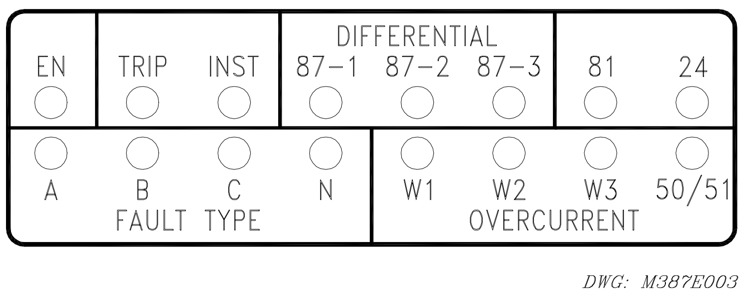

Figure 4.6: SEL-387E Relay Front-Panel LEDs

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	81*	O/U frequency element asserted at, or 1 cycle after, rising edge of trip
8	24*	Volts/hertz element asserted at, or 1 cycle after, rising edge of trip
9	A	A-phase involved in the fault (Programmable LEDA)

LED	Legend	Description
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	50*/51*	O/C element 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 four trip elements, TRIP1 through TRIP4. 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 TR4 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 volts/hertz elements 24D1 and 24C2, and the frequency elements 81Dn ($1 \leq n \leq 6$), 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 TR4 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 TR4 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 TR4 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 – 81 – Over-/Underfrequency Element Trip

This LED will illuminate if any over-/underfrequency element present in the TR1 through TR4 settings is asserted at the rising edge of any trip or one cycle later. Over-/underfrequency elements include 81Dn and 81DnT ($1 \leq n \leq 6$). 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 8 – 24 – Volts-per-Hertz Element

This LED will illuminate if any volts/hertz element present in the TR1 through TR4 settings is asserted at the rising edge of any trip or one cycle later. Volts/hertz elements include 24D1, 24D1T, 24C2, and 24C2T. 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 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 equation 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 TR4 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." The combined overcurrent element indicated by Relay Word bit 51NC1T is also included. 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 TR4 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 TR4 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 TR4 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– 50/51 – Overcurrent Trip

This LED will illuminate if any overcurrent element present in the TR1 through TR4 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***”, “50***T”, or “51**(*)T. 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-387E 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 that 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 four specific sets of trip logic within the SEL-387E Relay. They are designed to operate when SELOGIC control equation trip variable setting TRm is asserted (m = 1, 2, 3, 4), 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 TRIP4 is identical, using variables TR2 through TR4 and ULTR2 through ULTR4, respectively.

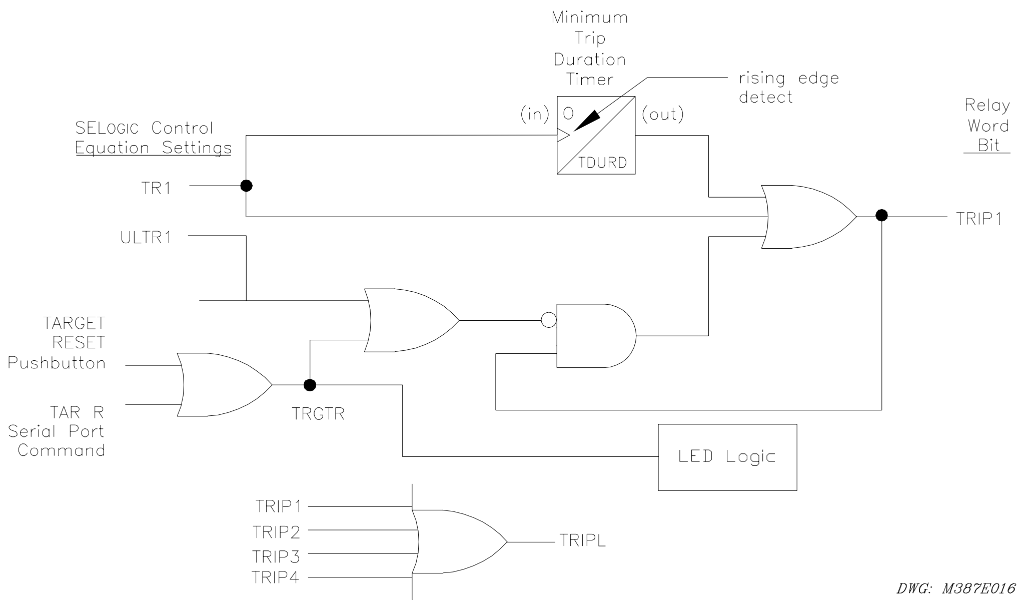

Figure 4.7: SEL-387E Relay Trip Logic (TRIP1)

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 assert more briefly than is needed. There are two means to ensure 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-in itself 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.

There are three means of unlatching the trip logic. The first is the assertion of the SELOGIC control equation setting ULTR1. In our example ULTR1 = !50P13 = 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 as 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 a 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 four 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-387E Relay.

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 four trip variables, TR1 to TR4, to define conditions under which a trip will be issued. This will cover trip conditions for three 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 one to three. 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, because this would indicate that the definite-time element has timed out. However, because 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.

In general, definition of the TR1 and TR4 variables should include only Relay Word bits that 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 four 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 logical 1, 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 2.19 in ***Section 2: Installation***.

Four unlatch variables, ULTR1 to ULTR4, correspond to the four trip variables in the Trip Logic setting area. ULTR1 to ULTR4 define the conditions to unlatch the seal-in of trip logic that takes place when TRn goes to logical 1. They sense when it is appropriate to de-energize 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.

TDURD, or minimum trip duration time, is an additional miscellaneous timer setting for trip logic. TDURD 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.

Close Logic

There are three specific sets of close logic within the SEL-387E Relay. They are designed to operate when SELOGIC control equation close variable setting CLm is asserted (m = 1, 2, 3) and to unlatch when SELOGIC control equation setting ULCLm is asserted. The output of the logic is Relay Word bit CLSm. 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 CLS3 is identical, using variables CL2 through CL3 and ULCL2 through ULCL3, respectively.

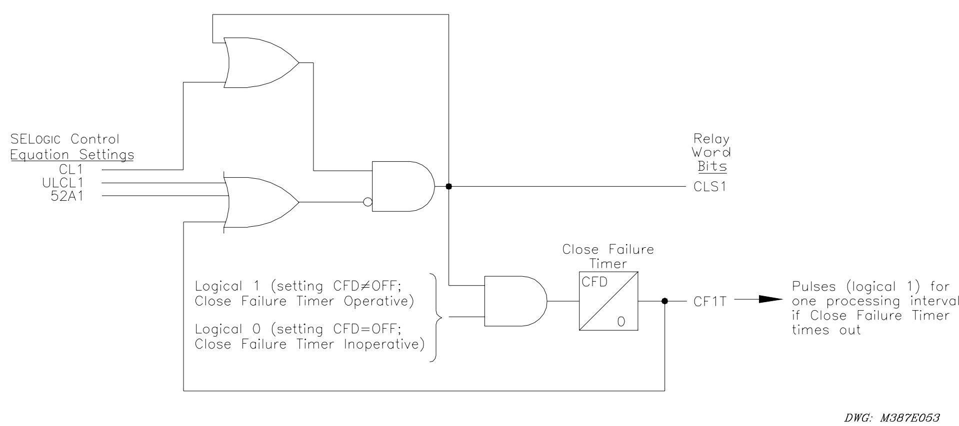

Figure 4.8: SEL-387E Relay Close Logic (CLS1)

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 1 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, the logic will effectively ignore CL1 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 will prevent the close process from going to completion if it has already begun.

Under normal circumstances, the second means of unlatching, closure of the Breaker 1 52a contact, occurs. 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 to OFF but 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 CF1T. This bit is pulsed for one processing interval and sent to the OR gate for the unlatch functions, where it interrupts the closing process. This interruption prevents the closing circuit from being energized too long but 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 warrants 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.

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.) The connections for the 52a inputs are shown in Figure 2.19 in ***Section 2: Installation***.

The three Close variables, CL1 through CL3, 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. 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 logical 1, unless the logic is disabled by an unlatch condition, discussed below. Note that connections for the closing function are not shown in Figure 2.19 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 three variables remain. ULCL1 to ULCL3 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. 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.

CFD, or Close Failure Detection time delay, is an additional miscellaneous timer setting for close logic. CFD is an overriding timer to unlatch the close logic if the breaker has not yet closed. The default setting is 60 cycles.

SELOGIC CONTROL EQUATIONS

This manual refers throughout to settings or variables that take the form of SELOGIC control equations. These equations are convenient for customizing control logic to the relay and enhancing relay performance for specific customer needs and practices.

While most users of SEL relays are familiar with SELOGIC control equations, the capabilities of this logic, types of operators, number of variables, and equation syntax have varied from one relay product to another. We intend in this manual to explain how SELOGIC control equations work in general and how we implement these equations in the SEL-387E Relay.

SELOGIC Control Equations Fundamental Description

Relay Word bits are the basic building blocks of SELOGIC control equations. The end of this section of the manual contains a complete list of these bits. 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. Various relay elements cause assertion or deassertion of Relay Word bits, which the fixed internal logic of the relay uses to make decisions, to interpret inputs, or to drive outputs. You have access to these bits and can use them to 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 equations 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-387E Relay, there are six logical operators that 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”; you cannot have parentheses within parentheses. The following is an example:

S1V1 = (IN105 + RB3) * (87R + 87U)

The expressions within the parentheses are evaluated first. The logic determines whether IN105 OR RB3 is asserted and then whether 87R OR 87U is asserted. Assuming that at least one bit asserts for each pair of 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, a small circle on an input or output line represents this inversion. 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 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. Instead of detecting the present value of Relay Word bits, as do most operators, these operators are only intended to detect a change of 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 TRIPL = TRIP1 + TRIP2 + TRIP3 + TRIP4. All TRIPL needs to assert is a 1 from any of the four 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 402 elements and 67 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 402 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-387E 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	402	81
Equations per Setting Class (with two 16–output interface boards)	134	29
Rising- or Falling-Edge Operators per Setting Class	67	14

RELAY WORD BITS

The Relay Word bits available for use 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-387E Relay Word Bits and Locations

Row	SEL-387E Relay Word Bits							
0	EN	TRIP	INST	87-1	87-2	87-3	24	81
1	A	B	C	N	W1	W2	W3	50/51
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	*	27V1	27PP2	27PP1	27P2	27P1	*	CTS
15	59Q	59G2	59G1	59V1	59PP2	59PP1	59P2	59P1
16	81D1	81D2	81D3	81D4	81D5	81D6	*	27B81
17	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	*	*
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	24D1	24D1T	24C2	24C2T	24CR
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2
23	*	*	*	*	*	*	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	*
27	4HBL	DCBL	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-387E 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	*	*	*	50GC	50G3	32IR	32IF	REFP
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2
40	BCWA3	BCWB3	BCWC3	BCW3	*	*	*	*
41	TRIP1	TRIP2	TRIP3	TRIP4	*	TRIPL	*	TRGTR
42	CLS1	CLS2	CLS3	*	CF1T	CF2T	CF3T	*
43	NOTALM	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.

** These rows will show asterisks in response to **TAR** command, if optional interface board 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	*	Reserved for future use
	27V1	Positive-sequence undervoltage picked up
	27PP2	Level 2 phase-phase undervoltage picked up
	27PP1	Level 1 phase-phase undervoltage picked up
	27P2	Level 2 phase undervoltage picked up
	27P1	Level 1 phase undervoltage picked up
	*	Reserved for future use
	CTS	Current transformer saturation

Row	Bit	Definition
15	59Q	Negative-sequence overvoltage picked up
	59G2	Level 2 residual overvoltage picked up
	59G1	Level 1 residual overvoltage picked up
	59V1	Positive-sequence overvoltage picked up
	59PP2	Level 2 phase-phase overvoltage picked up
	59PP1	Level 1 phase-phase overvoltage picked up
	59P2	Level 2 phase overvoltage picked up
	59P1	Level 1 phase overvoltage picked up
16	81D1	Level 1 frequency element
	81D2	Level 2 frequency element
	81D3	Level 3 frequency element
	81D4	Level 4 frequency element
	81D5	Level 5 frequency element
	81D6	Level 6 frequency element
	*	Reserved for future use
	27B81	Undervoltage element for frequency blocking
17	81D1T	Level 1 definite-time frequency element
	81D2T	Level 2 definite-time frequency element
	81D3T	Level 3 definite-time frequency element
	81D4T	Level 4 definite-time frequency element
	81D5T	Level 5 definite-time frequency element
	81D6T	Level 6 definite-time frequency element
	*	Reserved for future use
	*	Reserved for future use
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
	24D1	Level 1 Volts/Hertz instantaneous pickup
	24D1T	Level 1 Volts/Hertz definite-time element timed out
	24C2	Level 2 Volts/Hertz composite element pickup
	24C2T	Level 2 Volts/Hertz composite element timed out
	24CR	Level 2 Volts/Hertz element fully reset
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	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	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
	*	Reserved for future use

Row	Bit	Definition
27	4HBL	Fourth-harmonic block asserted
	DCBL	DC block asserted
	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	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	50GC	Combined residual current sensitivity threshold exceeded
	50G3	W3 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

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
	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
	*	Reserved for future use
41	TRIP1	Trip 1 logic asserted
	TRIP2	Trip 2 logic asserted
	TRIP3	Trip 3 logic asserted
	TRIP4	Trip 4 logic asserted
	*	Reserved for future use
	TRIPL	Any trip asserted
	*	Reserved for future use
	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
	*	Reserved for future use
	CF1T	Breaker 1 close failure timer timed out
	CF2T	Breaker 2 close failure timer timed out
	CF3T	Breaker 3 close failure timer timed out
	*	Reserved for future use

Row	Bit	Definition
43	NOTALM	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
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
4HBL	Fourth-Harmonic element asserted	27
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
24C2	Level 2 Volts/Hertz composite element pickup	21

Bit	Definition	Row
24C2T	Level 2 Volts/Hertz composite element timed out	21
24CR	Level 2 Volts/Hertz element fully reset	21
24D1	Level 1 Volts/Hertz instantaneous pickup	21
24D1T	Level 1 Volts/Hertz definite-time element timed out	21
27B81	Undervoltage element for frequency blocking	16
27P1	Level 1 phase undervoltage picked up	14
27P2	Level 2 phase undervoltage picked up	14
27PP1	Level 1 phase-phase undervoltage picked up	14
27PP2	Level 2 phase-phase undervoltage picked up	14
27V1	Positive-sequence undervoltage picked up	14
32IE	Internal enable for the 32I element	20
32IF	32I element forward (internal) fault declaration	38
32IR	32I element reverse (external) fault declaration	38
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
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
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
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
50G3	W3 residual current sensitivity threshold exceeded	38
50GC	Combined residual current sensitivity threshold exceeded	38
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

Bit	Definition	Row
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
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
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
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
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
51N3T	Winding 3 residual inverse-time O/C element timed out	12
51NC1	Windings 1 and 2 residual inverse-time O/C element picked up	22

Bit	Definition	Row
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
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
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
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. instantaneous O/C Level 1 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
59G1	Level 1 residual overvoltage picked up	15
59G2	Level 2 residual overvoltage picked up	15
59P1	Level 1 phase overvoltage picked up	15
59P2	Level 2 phase overvoltage picked up	15
59PP1	Level 1 phase-phase overvoltage picked up	15
59PP2	Level 2 phase-phase overvoltage picked up	15
59Q	Negative-sequence overvoltage picked up	15
59V1	Positive-sequence overvoltage picked up	15
81D1	Level 1 frequency element	16
81D2	Level 2 frequency element	16
81D3	Level 3 frequency element	16
81D4	Level 4 frequency element	16
81D5	Level 5 frequency element	16
81D6	Level 6 frequency element	16
81D1T	Level 1 definite-time frequency element	17

Bit	Definition	Row
81D2T	Level 2 definite-time frequency element	17
81D3T	Level 3 definite-time frequency element	17
81D4T	Level 4 definite-time frequency element	17
81D5T	Level 5 definite-time frequency element	17
81D6T	Level 6 definite-time frequency element	17
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	Retrained differential element 1 operating current above O87P	21
87O2	Retrained differential element 2 operating current above O87P	21
87O3	Retrained 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
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
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
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
CC1	Breaker 1 CLOSE command execution	5
CC2	Breaker 2 CLOSE command execution	9
CC3	Breaker 3 CLOSE command execution	13

Bit	Definition	Row
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
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
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
DCBL	DC block asserted	27
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
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

Bit	Definition	Row
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
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
NOTALM	ALARM output not asserted	43
OC1	Breaker 1 OPEN command execution	4
OC2	Breaker 2 OPEN command execution	8
OC3	Breaker 3 OPEN command execution	12
OCA	O/C element A-phase selection	2
OCB	O/C element B-phase selection	6

Bit	Definition	Row
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
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

Bit	Definition	Row
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
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
RB1	Remote bit RB1 asserted	24
RB2	Remote bit RB2 asserted	24
RB3	Remote bit RB3 asserted	24
RB4	Remote bit RB4 asserted	24
RB5	Remote bit RB5 asserted	24
RB6	Remote bit RB6 asserted	24
RB7	Remote bit RB7 asserted	24
RB8	Remote bit RB8 asserted	24
RB9	Remote bit RB9 asserted	25
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
REFP	Restricted earth fault inverse-time O/C element timed-out	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

Bit	Definition	Row
S2LT2	Set 2 latch bit S2LT2 asserted	36
S2LT3	Set 2 latch bit S2LT3 asserted	36
S2LT4	Set 2 latch bit S2LT4 asserted	36
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
S3LT1	Set 3 latch bit S3LT1 asserted	37
S3LT2	Set 3 latch bit S3LT2 asserted	37
S3LT3	Set 3 latch bit S3LT3 asserted	37
S3LT4	Set 3 latch bit S3LT4 asserted	37
S3LT5	Set 3 latch bit S3LT5 asserted	37
S3LT6	Set 3 latch bit S3LT6 asserted	37
S3LT7	Set 3 latch bit S3LT7 asserted	37
S3LT8	Set 3 latch bit S3LT8 asserted	37
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

Bit	Definition	Row
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
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
TRIPL	Any trip asserted	41

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SECTION 5: METERING AND MONITORING

INTRODUCTION

The SEL-387E Relay provides metering information in several report formats, for each of the three three-phase winding current inputs and three voltage inputs, and for the three 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-387E Relay: instantaneous, demand (thermal), and peak demand. Quantities metered include one set of phase voltage and phase currents for each winding input; positive-, negative-, and zero-sequence (residual) voltages and currents for all current and voltage 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.

There is also a specialized metering function, harmonic metering. This function provides a snapshot of harmonic magnitudes of all analog inputs, fundamental through the 15th 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 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 Meter Function (METER Command)

The **METER** (**MET**) command, with no additional parameters, displays instantaneous current, voltage, and power magnitudes, in primary quantities. Phase, positive-sequence, negative-sequence, and residual currents and voltages are displayed for each of the three winding and voltage inputs. Power is calculated from the supplied voltages and currents and displayed in real, reactive, and apparent power quantities. Frequency, percent volts per hertz, and the value of the station battery dc supply voltage at the relay are also included. The station battery voltage is 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.

Note: If current or voltage transformers are connected delta (DELTA_Y = D, WnCT = D) or only one voltage is connected (TPVI = N), only total power (MW, MVAR, MVA) will display in the METER report. This restricted calculation assumes balanced load conditions. Setting the current voltage winding setting (VIWDG) to 12 combines the current in Winding 1 and Winding 2 and displays their sum in the METER report.

The format for the METER report is as follows:

```
=>>METER<ENTER>

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)        123       123       123            123       123       123
Wdg2            IAW2      IBW2      ICW2          3I1W2     3I2W2      IRW2
I (A,pri)        123       123       123            123       123       123
Wdg3            IAW3      IBW3      ICW3          3I1W3     3I2W3      IRW3
I (A,pri)        123       123       123            123       123       123
Wdg1&2         IAW12     IBW12     ICW12          IRW12
I (A,pri)        123       123       123            123
                  Phase Voltages                    Sequence Voltages
WdgX            VAWX      VBWX      VCWX          3V1WX     3V2WX      VRWX
V (KV,pri)      123.12    123.12    123.12        123.12    123.12     123.12
                  Power Quantities
                  MW        MWA       MWB       MWC
P (MW,pri)      123.12    123.12    123.12    123.12
                MVAR      MVRA      MVRB      MVRC
Q (MVar,pri)    123.12    123.12    123.12    123.12
                 MVA      MVAA      MVAB      MVAC
S (MVa,pri)     123.12    123.12    123.12    123.12

FREQ (Hz)      12.12
V/Hz (percent) 12.12
VDC (V)        123.1
=>>
```

Demand Ammeter Function (METER D Command)

The SEL-387E Relay includes a thermal demand metering function for all three current windings. In response to the **METER D** (**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 METER D report is as follows:

```
=>>METER D<ENTER>
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


    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

=>>
```

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). DATCn can be set over a range of 5 to 255 minutes (4 hours 15 minutes). The demand values in secondary amperes are compared to user-defined thresholds, PDEMnP, QDEMnP, and NDEMnP. PDEMnP is compared to the largest 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 Id_0 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:

$$Id(t) = I_{NEW} + \left(Id_0 - I_{NEW}\right) \bullet e^{-[\ln(10)]^{-t/DATCn}}$$

The next function, the peak demand ammeter function, keeps track of the largest value of Id(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 current winding, i.e., the largest of the phase current demands, the negative-sequence demand, and the residual demand, against registers containing the largest demand value of each type since the last reset of the registers. This happens every two seconds. If the particular Id(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 **METER P** (**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 METER P report is as follows:

```
=>>METER P<ENTER>
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
                 3I2W1        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
                 3I2W2        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
                 3I2W3        12345         MM/DD/YY          HH:MM:SS.SSS
                  IRW3        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

=>>
```

The report for METER 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, because of 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, divided by the tap value for each winding, and then 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 ways to 87-2 and 87-3, respectively.

In response to the **METER DIF** (**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 METER DIF report is as follows:

```
=>>METER DIF<ENTER>
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 Metering Function (METER SEC Command)

The phasor 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** (**MET 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 **MET 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<ENTER>
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
                  Phase Voltages                   Sequence Voltages
WdgX            VAWX      VBWX      VCWX          3V1WX     3V2WX      VRWX
V (V,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 VAWX. That is, the full set of 24 calculated phasors is rotated in a manner that brings VAWX to an angle of zero degrees. However, if the magnitude of VAWX is less than 0.0975 • V_{nom} (13 V for a 120 V relay), the angles are listed according to the phasor calculation, without further adjustment.

Demand Reset Functions (METER RD and METER RP Commands)

The demand ammeter function performs an integration of current over time and 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, you may want to erase this "history."

The **METER RD** (**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 **METER RP** (**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, or 3 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.

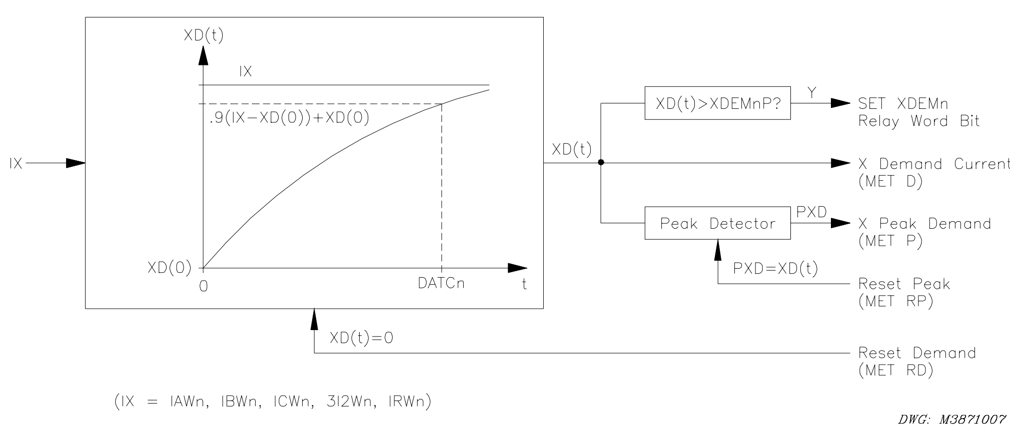

Figure 5.1: SEL-387E Relay Demand Ammeter Functions and Commands

Harmonic Metering Function (METER H Command)

The harmonic metering function, in response to the **METER H** (**MET H**) command, retrieves one full cycle of unfiltered sample data (64 samples) from each of the 12 analog 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 15th.

$$H_n = \sum_{k=0}^{N-1} h_k \bullet e^{j \bullet \frac{2\pi kn}{N}}$$

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 nth harmonic

After all harmonics are calculated, they are adjusted to compensate for filter gain, and the resulting magnitudes are listed in secondary quantities:

```
=>>METER H<ENTER>
processing harmonic spectrum ...........


XFMR 1            Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

      Magnitudes of Harmonic Currents (Amps Sec, Volts Sec)
   H  IAW1   IBW1   ICW1    IAW2    IBW2    ICW2    IAW3    IBW3    ICW3    VAWX    VBWX    VCWX

   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
   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
   3  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   4  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   5  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   6  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   7  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   8  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
   9  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
  10  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
  11  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
  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
  13  123.12 123.12 123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12  123.12
  14  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

=>>
```

The Analog Input Labels, IAW1, etc., will be listed as they are set in the Global Settings section of the relay.

Energy Metering Function (METER E Command)

The energy metering function, in response to the **METER E**, (**MET E**) command, provides energy quantities as follows:

```
=>MET E<ENTER>

XFMR 1                                Date: 10/30/01    Time: 11:09:48.362
STATION A
              MWh3P            MWhA            MWhB            MWhC
IN    123456789012.1 123456789012.1 123456789012.1 123456789012.1
OUT   123456789012.1 123456789012.1 123456789012.1 123456789012.1

            MVARh3P          MVARhA          MVARhB          MVARhC
IN    123456789012.1 123456789012.1 123456789012.1 123456789012.1
OUT   123456789012.1 123456789012.1 123456789012.1 123456789012.1

LAST ENERGY RESET         11/25/00         10:15:17.235

=>
```

The element runs every second, using the average value of the last 16 cycles of the previous second to calculate the energy quantities. The element calculates the real (cosine of the angle between current and voltage) and reactive powers (sine of the angle between current and voltage), as well as the direction of the flow, as referenced below:

Table 5.1: Energy Metering Data

Sign of Cosine	Sign of Sine	Direction
Positive	Positive	A-phase, B-phase, and C-phase outgoing real power Three-phase outgoing real power A-phase, B-phase, and C-phase outgoing reactive power Three-phase outgoing reactive power
Positive	Negative	A-phase, B-phase, and C-phase outgoing real power Three-phase outgoing real power A-phase, B-phase, and C-phase incoming reactive power Three-phase incoming reactive power
Negative	Positive	A-phase, B-phase, and C-phase incoming real power Three-phase incoming real power A-phase, B-phase, and C-phase outgoing reactive power Three-phase outgoing reactive power
Negative	Negative	A-phase, B-phase, and C-phase incoming real power Three-phase incoming real power A-phase, B-phase, and C-phase incoming reactive power Three-phase incoming reactive power

Use the **METER RE** (**MET RE**) to reset the energy data. In response to the **METER RE** command, the relay displays the following message:

```
Reset Energies (Y/N)?
```

If the prompt is confirmed, the relay resets all energy values and records the date, otherwise the relay responds with the command aborted message.

STATION DC BATTERY MONITOR

Use the station dc battery monitor in the SEL-387E 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.

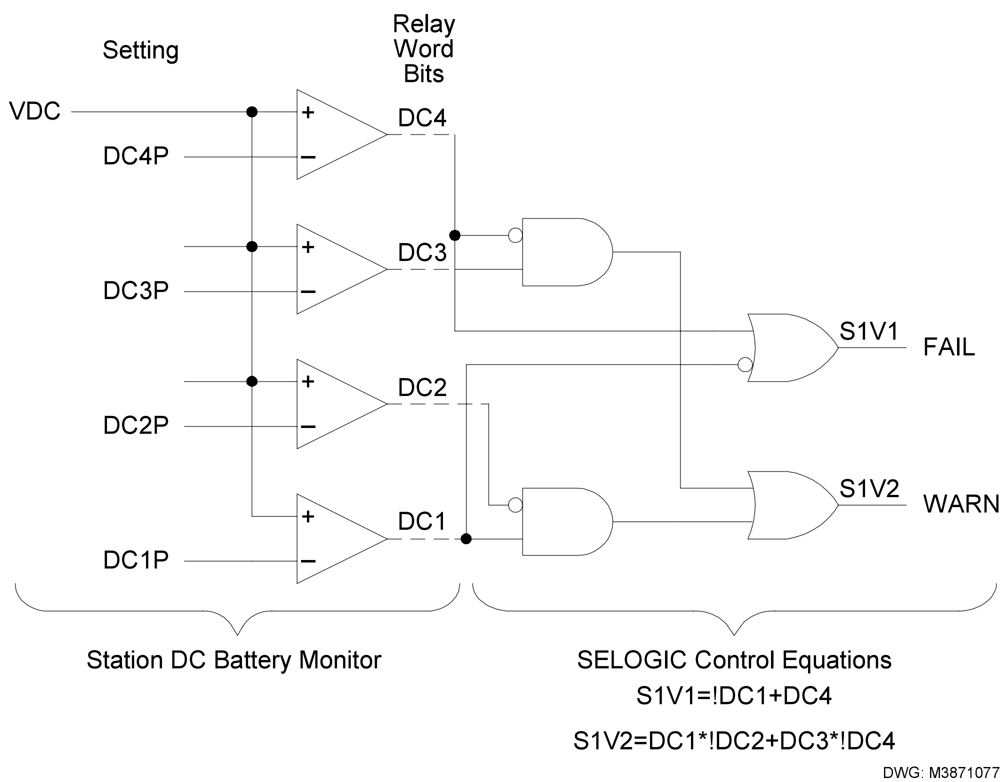

Figure 5.2: Station DC Battery Monitor Alarm Logic

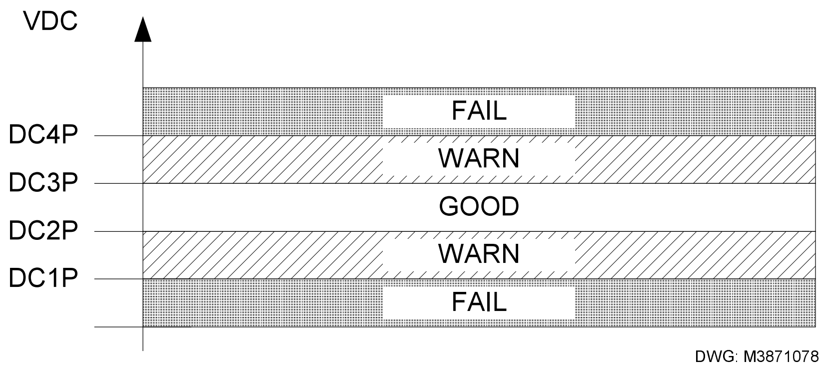

Figure 5.3: Undervoltage and Overvoltage Warning and Alarm Regions

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-387E Relay breaker monitoring function captures information on the number of operations and total interrupted current for as many as three breakers. These data are used to estimate the amount of contact wear per pole, based on wear curve information the user derives from breaker manufacturer maintenance curves and enters into the relay. Separate settings for each breaker determine under what conditions the monitoring function initiates 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 BKMON3 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 or 3) 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 (OUT101 = TRIP1; TR1 = 50P11T+51P1T+51Q1T) or for a differential trip (86T device trip via OUT104 = TRIP4; TR4 = 87R+87U). 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-387E 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** ensures that the monitor will initiate for any Breaker 1 trip. The monitor then compares IN106 with TRIP1 to sort internal and external trips.

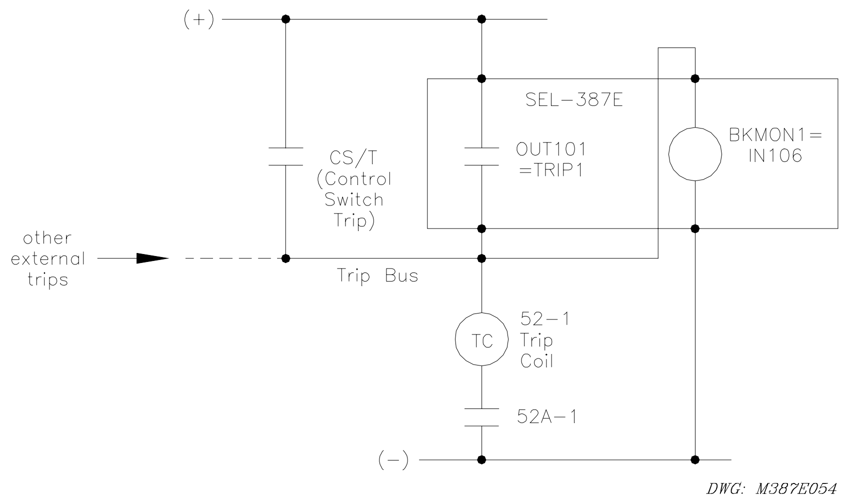

Figure 5.4: Trip Bus Sensing With Relay Input

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).

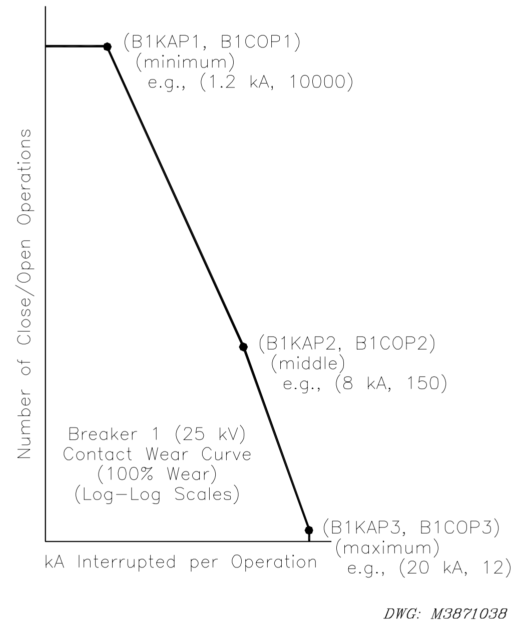

Figure 5.5: Breaker Contact Wear Curve

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 current in kA 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 the number of operations as a function of current in kiloamperes by an equation of the form:

$$O(I) = K \bullet I^{\alpha}$$

To determine the constants K and α 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:

$$K = \frac{O1}{I1^{\alpha}}\text{, or} \qquad K = \frac{O2}{I2^{\alpha}}$$

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:

$$O(I) = 14972 \bullet I^{-2.214} \qquad \text{and} \qquad O(I) = 46284 \bullet I^{-2.756}$$

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.

Because 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 logical 1 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 logical 1 if any of the individual pole bits is set to logical 1. 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 17000 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).

$$O(I) = 46284 \bullet 17^{-2.756} = 46284 \bullet 0.00041 = 18.81$$

Incremental Percent Wear = 100/18.81 = 5.32%

Cumulative Percent Wear = 44 + 5.32 = 49.32% (which appears as 49% in BRE listing)

Breaker Monitor Reporting

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 65000 trips. The current accumulators for each trip type have a maximum value of 99999.00 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.

```
=>>BREAKER<ENTER>

XFMR 1                                   Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

BREAKER 1
Int Trips=     12345   IAW1=     12345  IBW1=    12345  ICW1=    12345 kA(pri)
Ext Trips=     12345   IAW1=     12345  IBW1=    12345  ICW1=    12345 kA(pri)
Percent Wear:          POLE1=      123  POLE2=     123  POLE3=     123

BREAKER 2
Int Trips=     12345   IAW2=     12345  IBW2=    12345  ICW2=    12345 kA(pri)
Ext Trips=     12345   IAW2=     12345  IBW2=    12345  ICW2=    12345 kA(pri)
Percent Wear:         POLE1=      123  POLE2=     123  POLE3=     123

BREAKER 3
Int Trips=     12345   IAW3=     12345  IBW1=     12345  ICW3=     12345 kA(pri)
Ext Trips=     12345   IAW3=     12345  IBW1=     12345  ICW3=     12345 kA(pri)
Percent Wear:          POLE1=      123  POLE2=      123  POLE3=      123

LAST BREAKER MONITOR RESET FOR     Bkr1:  MM/DD/YY      HH:MM:SS.SSS
                                   Bkr2:  MM/DD/YY      HH:MM:SS.SSS
                                   Bkr3:  MM/DD/YY      HH:MM:SS.SSS

=>>
```

Status Monitor

The status monitor of the SEL-387E 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** (**STA**) command displays a report of the self-test diagnostics. The relay automatically executes the **STA** command whenever the self-test software enters a warning or failure state.

If a warning or failure state occurs, the warning state is reported the next time the **STA** command is issued. 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. Warnings 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. Failures generate an automatic serial port message, display the failure on the front-panel display, and latch the ALARM output contact.

```
=>>STATUS<ENTER>

XFMR 1                              Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A
FID=SEL-387E-R-V-D
SELF TESTS
W=Warn    F=Fail

       IAW1     IBW1     ICW1     IAW2     IBW2     ICW2
OS     1234     1234     1234     1234     1234     1234

       IAW3     IBW3     ICW3     VAWX      VBWX     VCWX
OS     1234     1234     1234     1234     1234     1234

       +5V_PS   +5V_REG  -5V_REG  +12V_PS  -12V_PS  +15V_PS  -15V_PS
PS      1.12     1.12     -1.12     12.12   -12.12   12.12     -12.12

       TEMP     RAM      ROM      A/D      CR_RAM   EEPROM   IO_BRD
       123.1    OK       OK       OK       OK       OK       OK

Relay Enabled
=>>
```

To reset the self-test status, use the **STA C** command from Access Level 2.

The relay responds:

```
Reboot the relay and clear status
Are you sure (Y/N) ?
```

If you select “N” or “n”, the relay displays:

```
Canceled
```

and aborts the command.

If you select “Y”, the relay displays:

```
Rebooting the relay
```

The relay then restarts (just like powering down and then powering up the relay), and all diagnostics are rerun before the relay is 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 internal dc offset (OS) voltage of each of the nine current and three voltage input channels and compares each measured 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 an EEPROM failure. There is no warning for the test.

Interface Boards

The relay checks the interface 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 interface board 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 values below or 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 Interface 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 monitor, analog input label, setting group control, programmable LED, display point, and local control switch settings.
SET R	SER	Sequential Events Recorder trigger condition 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 8.9 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/upper case: **SHOWSET**. You need to type only the first three letters of a command, for example, **SHO**. Computer keys you press appear in bold/upper case/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 = G, R, 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

The following explanations are for settings that are not discussed in earlier sections.

Relay (RID) and Terminal (TID) Identification

The Relay Identifier (RID) and Terminal Identifier (TID) settings are typically used to identify the equipment protected by the relay or 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.

Potential Transformer Ratio (PTR)

The relay uses the potential transformer ratio (PTR) to convert measured secondary phase-to-neutral voltages into primary phase-phase voltages for display in the meter report. For example, a 230 kV phase-phase line has a primary phase-to-neutral voltage of 230 kV / √3= 132.8 kV. Since the secondary phase-to-neutral voltage is 67 V the PTR = 132.8 kV / 67 V ≈ 2000.

Compensation Angle (COMPANG)

This adjusts the power metering to account for angular differences between around-the-clock CT connections and delta or wye PT connections.

Voltage-Current Winding (VIWDG)

Use this setting to tell the relay which winding current to use when calculating power for the meter report. The configuration for a breaker-and-a-half application has typically two sets of current transformers, the sum of whose currents supply the power transformer. For power calculations requiring the sum through two sets of current transformers, select the WDG12 option. With this selection, the relay vectorially adds the currents from Windings 1 and 2 and uses the resultant for further calculations.

Three-Phase Voltage Input (TPVI)

Set TPVI=Y if you have a three-phase set of PTs or open-delta connected PTs. Set TPVI=N if you have only one PT. With TPVI=Y, the relay uses the highest of the three voltages in the V/Hz calculation; when TPVI=N, the relay uses the A-phase voltage. A setting of TPVI=Y enables the phase-phase, residual (ground), negative-sequence, and positive-sequence voltage elements; enables display of three-phase and single-phase power measurements in the meter report; and enables three-phase under-voltage blocking (Relay Word bit 27B81) of the frequency elements. The relay uses VAB, VBC, and VCA in place of VA, VB, and VC respectively for the 27B81 logic when the PT connections are connected open-delta and DELTA_Y=D. A setting of TPVI=N disables and hides all voltage elements but the phase-ground elements; removes single-phase power measurements from the meter report; and modifies the under-voltage blocking of the frequency elements so that it only uses VA. The three-phase power calculation assumes a balanced three-phase system when TPVI=N. The TPVI=N selection supports the V/Hz element when only a single PT is available, connected to the A phase.

Demand Ammeter (DATC, PDEM, QDEM, NDEM)

The relay provides demand ammeters for Windings 1 through 3, 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 five 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 imbalance 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. Access is by the front panel or one of the communications ports.

Assignment of Optoisolated Inputs and Output Contacts

Optoisolated inputs (IN101 through IN106) and output contacts (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 "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.

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, regardless of whether they fully time out. 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, because 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, 29, 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. Because 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-387E 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.

Phase Potential Connection (DELTA_Y)

Select D if your potential transformers (PTs) are connected in open-delta. A setting of Y enables the phase-ground voltage elements and enables display of three-phase and single-phase power measurements in the meter report. A setting of D removes the √3 multiplication from the V/Hz calculation that normally accounts for the difference between phase-to-neutral and phase-to-phase voltages, disables and hides the phase-ground voltage elements, and removes single-phase power measurements from the meter report.

Measured phase-to-phase voltages (VAB, VCB) from open-delta PTs are converted to calculated phase-to-phase voltages (VAB, VBC, VCA) when DELTA_Y=D. These voltages are used for various elements. The meter report converts the calculated phase-to-phase voltages (VAB, VBC, VCA) into phase-to-neutral voltages (VA, VB, VC) by dividing the phase-to-phase voltages by √3. Phase-to-phase voltages can only be converted to phase-to-neutral voltages using the √3 factor when the system is balanced. Relabel VA, VB, and VC to VAB, VBC, and VCA, respectively, using the **SET G** command and increase your PTR setting by a factor of √3 using the **SET** command to display phase-to-phase voltages rather than phase-to-neutral voltages. However, increasing the PTR by √3 also increases the V/Hz measurement by √3. To adjust for this V/Hz increase, multiply the VNOM setting by √3. For example, consider the following default settings:

VNOM =230

PTR =2000

To display phase-to-phase voltages and adjust the V/Hz calculation, apply the following settings:

VNOM =230•√3 = 398.4

PTR =2000•√3 = 3464

The values of the final affected measurements, 3V1 and 3V2, cannot be adjusted but remain increased by √3. You do not need to change the VNOM and PTR settings if the display of phase voltages is acceptable.

Miscellaneous (DATE_F, SCROLD, 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 (SCROLD 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 is settable 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 takes 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***. Four settable dc voltage thresholds, DC1P through DC4P, 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 three breakers, BKMON1 through BKMON3. 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 to 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 VWCX, 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** (**STA**), **BREAKER** (**BRE**), **EVENT** (**EVE**), and **METER** (**MET**), including the variants of each command. The new labels will also appear in the front-panel LCDs for the STATUS and METER pushbutton menus.

Front-Panel Displays

Fault type targets A, B, and C can be redefined using SELOGIC control equations LEDA, LEDB, and LEDC, respectively.

There are 16 programmable Display Points, for creating customized messages on the LCD. 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.

For more information on the LEDs and Display Points, see ***Section 8: Front-Panel Interface.***

Sequential Events Reporting

The SER, or Sequential Events Recorder, lists up to 512 events. This listing may help the user determine within a short time interval the correct order of operation during a complicated event with multiple device operations. The settings for the SER are the trigger conditions and the Relay Word bit ALIAS names. As many as 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. As many as 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 Sequential Events Reporting.***

Communications Ports

There are four communications ports on the SEL-387E 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 port 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 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-387E Relay SHO G (Show Global Settings)

```
=>>SHO G<ENTER>
LER     = 15        PRE     = 4         NFREQ   = 60        PHROT   = ABC
DELTA_Y = Y
DATE_F  = MDY       SCROLD  = 2         FP_TO   = 16        TGR     = 3
DC1P    = OFF       DC2P    = OFF       DC3P    = OFF       DC4P    = OFF

BKMON1  =TRIP1 + TRIP4
B1COP1  = 10000     B1KAP1  = 1.2
B1COP2  = 160       B1KAP2  = 8.0
B1COP3  = 12        B1KAP3  = 20.0

BKMON2  =TRIP2 + TRIP4
B2COP1  = 10000     B2KAP1  = 1.2
B2COP2  = 160       B2KAP2  = 8.0
B2COP3  = 12        B2KAP3  = 20.0

BKMON3  =TRIP3 + TRIP4
B3COP1  = 10000     B3KAP1  = 1.2
B3COP2  = 160       B3KAP2  = 8.0
B3COP3  = 12        B3KAP3  = 20.0

IAW1    =IAW1
IBW1    =IBW1
ICW1    =ICW1
IAW2    =IAW2
IBW2    =IBW2
ICW2    =ICW2
IAW3    =IAW3
IBW3    =IBW3
ICW3    =ICW3
VAWX    =VAWX
VBWX    =VBWX
VCWX    =VCWX

SS1     =0
SS2     =0
SS3     =0
SS4     =0
SS5     =0
SS6     =0
LEDA    =OCA + 87E1
LEDB    =OCB + 87E2
LEDC    =OCC + 87E3

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
```

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```
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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
SCEUSE                 47.8
GBLCHK                 68EB
=>>
```

Note: SCEUSE is the percent of SELOGIC control equations used in Global settings. GBLCHK is the Global setting checksum used by the relay's diagnostics.

SEL-387E Relay SHO P (Show Port Settings)

```
=>>SHO P<ENTER>
Port F

PROTO   = SEL
SPEED   = 19200     BITS    = 8         PARITY  = N         STOP    = 1
T_OUT   = 15        AUTO    = N         RTSCTS  = N         FASTOP  = N

=>>
```

SEL-387E Relay SHO R (Show SER Settings)

```
=>>SHO R<ENTER>

SER1    =IN101,IN102,IN103,IN104,IN105,IN106
SER2    =OUT101,OUT102,OUT103,OUT104,OUT105,OUT106,OUT107
SER3    =0
SER4    =0

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-387E Relay Default Settings (5 A)

```
=>>SHO<ENTER>
Group 1


RID     =XFMR 1
TID     =STATION A
E87W1   = Y         E87W2   = Y         E87W3   = Y
EOC1    = Y         EOC2    = Y         EOC3    = Y         EOCC    = N
E24     = Y         E27     = Y         E59     = Y
E81     = N
ESLS1   = N         ESLS2   = N         ESLS3   = N

W1CT    = Y         W2CT    = Y         W3CT    = Y
CTR1    = 120       CTR2    = 240       CTR3    = 400
MVA     = 100.0     ICOM    = Y
W1CTC   = 11        W2CTC   = 11        W3CTC   = 0

VWDG1   = 230.00    VWDG2   = 138.00    VWDG3   = 13.80
PTR     = 2000      COMPANG = 0         VIWDG   = 1         TPVI    = Y

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

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

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
DATC3   = 15        PDEM3P  = 7.00      QDEM3P  = 1.00      NDEM3P  = 1.00
```

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```
VNOM    = 230.00    24WDG   = Y         24D1P   = 105       24D1D   = 1.00
24CCS   = ID        24IP    = 105       24IC    = 2.0       24ITD   = 0.1
24D2P2  = 176       24D2D2  = 3.00      24CR    = 240.00
24TC    =1

27P1P   = 20.0      27P2P   = 0.0
27PP1   = 35.0      27PP2   = 0.0       27V1P   = 0.0

59P1P   = 74.0      59P2P   = OFF
59G1P   = 20.0      59G2P   = OFF       59QP    = OFF
59PP1   = 128.0     59PP2   = OFF       59V1P   = OFF
TDURD   = 9.000     CFD     = 60.000

TR1     =50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2     =51P2T + 51Q2T + OC2
TR3     =50P31 + 51P3T + OC3

TR4     =87R + 87U
ULTR1   =!50P13
ULTR2   =!50P23
ULTR3   =!50P33
ULTR4   =!(50P13 + 50P23 + 50P33)
52A1    =IN101
52A2    =IN102
52A3    =IN103
CL1     =CC1 + LB4 + /IN104
CL2     =CC2 + /IN105
CL3     =CC3 + /IN106
ULCL1   =TRIP1 + TRIP4
ULCL2   =TRIP2 + TRIP4
ULCL3   =TRIP3 + TRIP4
ER      =/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101  =TRIP1
OUT102  =TRIP2
OUT103  =TRIP3
OUT104  =TRIP4
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     47.8
GR1CHK     68EB
=>>
```

Note: SCEUSE is the percent of SELOGIC control equations used in this setting group. GRnCHK is the Group setting checksum used by the relay's diagnostics.

SEL-387E Relay Default Settings (1 A)

```
=>>SHO<ENTER>
Group 1


RID     =XFMR 1
TID     =STATION A
E87W1   = Y         E87W2   = Y         E87W3   = Y
EOC1    = Y         EOC2    = Y         EOC3    = Y         EOCC    = N
E24     = Y         E27     = Y         E59     = Y
E81     = N
ESLS1   = N         ESLS2   = N         ESLS3   = N

W1CT    = Y         W2CT    = Y         W3CT    = Y
CTR1    = 600       CTR2    = 1200      CTR3    = 2000
MVA     = 100.0     ICOM    = Y

W1CTC   = 11        W2CTC   = 11        W3CTC   = 0
VWDG1   = 230.00    VWDG2   = 138.00    VWDG3   = 13.80
PTR     = 2000      COMPANG = 0         VIWDG   = 1         TPVI    = Y

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

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

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
DATC3   = 15        PDEM3P  = 1.40      QDEM3P  = 0.20      NDEM3P  = 0.20

VNOM    = 230.00    24WDG   = Y         24D1P   = 105       24D1D   = 1.00
24CCS   = ID        24IP    = 105       24IC    = 2.0       24ITD   = 0.1
24D2P2  = 176       24D2D2  = 3.00      24CR    = 240.00
24TC    =1

27P1P   = 20.0      27P2P   = 0.0
27PP1   = 35.0      27PP2   = 0.0       27V1P   = 0.0

59P1P   = 74.0      59P2P   = OFF
59G1P   = 20.0      59G2P   = OFF       59QP    = OFF
59PP1   = 128.0     59PP2   = OFF       59V1P   = OFF

TDURD   = 9.000     CFD     = 60.000

TR1     =50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2     =51P2T + 51Q2T + OC2
TR3     =50P31 + 51P3T + OC3
TR4     =87R + 87U
ULTR1   =!50P13
ULTR2   =!50P23
ULTR3   =!50P33
ULTR4   =!(50P13 + 50P23 + 50P33)
52A1    =IN101
52A2    =IN102
52A3    =IN103
CL1     =CC1 + LB4 + /IN104
CL2     =CC2 + /IN105
CL3     =CC3 + /IN106
ULCL1   =TRIP1 + TRIP4
ULCL2   =TRIP2 + TRIP4
ULCL3   =TRIP3 + TRIP4
ER      =/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101  =TRIP1
OUT102  =TRIP2
OUT103  =TRIP3
OUT104  =TRIP4
OUT105  =CLS1
OUT106  =CLS2
OUT107  =CLS3

OUT201  =0
OUT202  =0
OUT203  =0
OUT204  =0
OUT205  =0
OUT206  =0
OUT207  =0
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                                        (continued from previous page)
OUT208  =0
OUT209  =0
OUT210  =0
OUT211  =0
OUT212  =0



SCEUSE     47.8
GR1CHK     6804
=>>
```

Note: SCEUSE is the percent of SELOGIC control equations used in this setting group. GRnCHK is the Group setting checksum used by the relay's diagnostics.

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

The following Settings Sheets may be photocopied, filled out, and used as reference when you are entering settings. Refer to ***Section 1: Introduction and Specifications*** for information on 5 A nominal and 1 A nominal ordering options and how they influence overcurrent element setting ranges and accuracies.

SEL-387E Settings Sheets
Group Settings (SET Command)

Configuration Settings

Relay Identifier (39 Characters)

RID = ____________________

Terminal Identifier (59 Characters)

TID = ____________________

Enable Winding 1 in Differential Element (Y, N, Y1)	E87W1	=	______
Enable Winding 2 in Differential Element (Y, N, Y1)	E87W2	=	______
Enable Winding 3 in Differential Element (Y, N, Y1)	E87W3	=	______
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 Combined O/C Elements (Y, N)	EOCC	=	______
Enable Volts/Hertz Protection (Y, N)	E24	=	______
Enable Undervoltage Protection (Y, N)	E27	=	______
Enable Overvoltage Protection (Y, N)	E59	=	______
Enable Frequency Protection (N, 1–6)	E81	=	______
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 1 CT Ratio (1–50000)	CTR1	=	______
Winding 2 CT Ratio (1–50000)	CTR2	=	______
Winding 3 CT Ratio (1–50000)	CTR3	=	______
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 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	=	________
PT Ratio (1–6500)	PTR	=	________
Compensation Angle (0–360 degrees)	COMPANG	=	________
Voltage-Current Winding (1, 2, 3, 12)	VIWDG	=	________
Three-Phase Voltage Input (Y, N)	TPVI	=	________

Differential Elements

Note: TAP1–TAP3 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	=	________
Restrained Element Operating Current PU ((0.10–1.00) 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	=	________
Fourth-Harmonic Blocking Percentage (OFF, 5–100%)	PCT4	=	________
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	=	________
DC Ratio Blocking (Y, N)	DCRB	=	________
Harmonic Restraint (Y, N)	HRSTR	=	________
Independent Harmonic Blocking (Y, N)	IHBL	=	________

Restricted Earth Fault

Enable 32I (SELogic control equation)

E32I = ____

Operating Quantity from W 1, W 2 (1, 2, 12) 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 = ________

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 = ________________________________

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 = ________

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 = ________

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	=	________
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 = ____

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 = ________

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	=	________

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	=	________

24 Elements

Protected Winding L-L Voltage (0.20–800.00 kV primary)	VNOM	=	________
Transformer Winding Connection (D, Y)	24WDG	=	________
Level 1 Volts/Hertz Pickup (100–200%)	24D1P	=	________

Level 1 Time Delay (0.04–400.00 seconds)	24D1D	=	________
Level 2 Composite Curve Shape (OFF, DD, ID, I, U)	24CCS	=	________
Level 2 Inv.-Time Pickup (100–200%)	24IP	=	________
Level 2 Inv.-Time Curve (0.5, 1.0, 2.0)	24IC	=	________
Level 2 Inv.-Time Factor (0.1–10.0 seconds)	24ITD	=	________
Level 2 Pickup One (100–200%)	24D2P1	=	________
Level 2 Time Delay One (0.04–400.00 seconds)	24D2D1	=	________
Level 2 Pickup Two (101–200%)	24D2P2	=	________
Level 2 Time Delay Two (0.04–400.00 seconds)	24D2D2	=	________
Level 2 Reset Time (0.00–400.00 seconds)	24CR	=	________

24 Element Torque-Control (SELOGIC control equation)

24TC = ____

27 Elements

Level 1 Phase U/V PU (OFF, 0.1–300.0 V secondary)	27P1P	=	________
Level 2 Phase U/V PU (OFF, 0.1–300.0 V secondary)	27P2P	=	________
Level 1 Phase-Phase U/V PU (OFF, 0.1–520.0 V secondary)	27PP1	=	________
Level 2 Phase-Phase U/V PU (OFF, 0.1–520.0 V secondary)	27PP2	=	________
Pos.-Seq. U/V PU (OFF, 0.1–100.0 V secondary)	27V1P	=	________

59 Elements

Level 1 Phase O/V PU (OFF, 0.0–300.0 V secondary)	59P1P	=	________
Level 2 Phase O/V PU (OFF, 0.0–300.0 V secondary)	59P2P	=	________
Level 1 Residual O/V PU (OFF, 0.0–300.0 V secondary)	59G1P	=	________
Level 2 Residual O/V PU (OFF, 0.0–300.0 V secondary)	59G2P	=	________
Neg.-Seq. U/V PU (OFF, 0.0–100.0 V secondary)	59QP	=	________
Level 1 Phase-Phase O/V PU (OFF, 0.0–520.0 V secondary)	59PP1	=	________
Level 2 Phase-Phase O/V PU (OFF, 0.0–520.0 V secondary)	59PP2	=	________
Pos.-Seq.(V1) O/V PU (OFF, 0.0–100.0 V secondary)	59V1P	=	________

81 Elements

Undervoltage Block (20.0–150.0 V secondary)	27B81P	=	________
Level 1 Pickup (OFF, 40.10–65.00 Hz)	81D1P	=	________
Level 1 Time Delay (0.04–300.00 seconds)	81D1D	=	________
Level 2 Pickup (OFF, 40.10–65.00 Hz)	81D2P	=	________

Level 2 Time Delay (0.04–300.00 seconds)	81D2D	=	______
Level 3 Pickup (OFF, 40.10–65.00 Hz)	81D3P	=	______
Level 3 Time Delay (0.04–300.00 seconds)	81D3D	=	______
Level 4 Pickup (OFF, 40.10–65.00 Hz)	81D4P	=	______
Level 4 Time Delay (0.04–300.00 seconds)	81D4D	=	______
Level 5 Pickup (OFF, 40.10–65.00 Hz)	81D5P	=	______
Level 5 Time Delay (0.04–300.00 seconds)	81D5D	=	______
Level 6 Pickup (OFF, 40.10–65.00 Hz)	81D6P	=	______
Level 6 Time Delay (0.04–300.00 seconds)	81D6D	=	______

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	=	______
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 = ________

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 = ____________________

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 = ____________________

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 = ____________________

ULTR1 = ____________________

ULTR2 = ____________________

ULTR3 = ____________________

ULTR4 = ____________________

Close Logic

52A1 = ____________________

52A2 = ____________________

52A3 = ____________________

CL1 = ____________________

CL2 = ____________________

CL3 = ____________________

ULCL1 = ____________________

ULCL2 = ____________________

ULCL3 = ____________________

Event Report Triggering

ER = ______________________________

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 = ______________________________

SEL-387E Relay Settings Sheet
Global Settings (SET G Command)

Relay Settings

Length of Event Report (15, 29, 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	=	______
Phase Potential Connection (D, Y)	DELTA_Y	=	______
Date Format (MDY, YMD)	DATE_F	=	______
Display Update Rate (1–60 seconds) (1–60)	SCROLD	=	______
Front Panel Time-out (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 primary)	B1KAP1	=	______
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	=	______
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B1KAP2	=	______
Close/Open Set Point 3 max (1–65000 operations)	B1COP3	=	______
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	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 primary)	B2KAP1	=	______
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	=	______
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B2KAP2	=	______

Close/Open Set Point 3 max (1–65000 operations)	B2COP3	=	________
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	B2KAP3	=	________

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 primary)	B3KAP1	=	________
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	=	________
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B3KAP2	=	________
Close/Open Set Point 3 max (1–65000 operations)	B3COP3	=	________
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	B3KAP3	=	________

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 Voltage Input VAWX (1–4 characters)	VAWX	=	________
Rename Voltage Input VBWX (1–4 characters)	VBWX	=	________
Rename Voltage Input VCWX (1–4 characters)	VCWX	=	________

Setting Group Selection

Select Setting Group 1 (SELOGIC control equation)

SS1 = ________________________________

Select Setting Group 2 (SELOGIC control equation)

SS2 = ________________________________

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 = ____________

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	=	________

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	=	
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-387E Relay Settings Sheet
Sequential Events Recorder Settings
(SET R Command)

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 = ____________________

Note: RTSCTS setting does not appear if PROTO=LMD or DNP. 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	=	________
Fast Operate 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	=	________
Fast Operate Enable (Y, N)	FASTOP	=	________

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	=	________
Fast Operate 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	=	________
Fast Operate Enable (Y, N)	FASTOP	=	________

SEL-387E Relay Settings Sheet
Group Settings (SET Command) Example

Date _______

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, Y1)	E87W1	=	Y
Enable Winding 2 in Differential Element (Y, N, Y1)	E87W2	=	Y
Enable Winding 3 in Differential Element (Y, N, Y1)	E87W3	=	Y
Enable Winding 1 O/C Elements and Dmd Thresholds (Y, N)	EOC1	=	Y
Enable Winding 2 O/C Elements and Dmd Thresholds (Y, N)	EOC2	=	Y
Enable Winding 3 O/C Elements and Dmd Thresholds (Y, N)	EOC3	=	Y
Enable Combined O/C Elements (Y, N)	EOCC	=	N
Enable Volts/Hertz Protection (Y, N)	E24	=	Y
Enable Undervoltage Protection (Y, N)	E27	=	Y
Enable Overvoltage Protection (Y, N)	E59	=	Y
Enable Frequency Protection (N, 1–6)	E81	=	N
Enable SELOGIC® Control Equations Set 1 (Y, N)	ESLS1	=	N
Enable SELOGIC Control Equations Set 2 (Y, N)	ESLS2	=	N
Enable SELOGIC Control Equations Set 3 (Y, N)	ESLS3	=	N

General Data

Winding 1 CT Connection (D, Y)	W1CT	=	Y
Winding 2 CT Connection (D, Y)	W2CT	=	Y
Winding 3 CT Connection (D, Y)	W3CT	=	Y
Winding 1 CT Ratio (1–50000)	CTR1	=	120; 600*
Winding 2 CT Ratio (1–50000)	CTR2	=	240; 1200*
Winding 3 CT Ratio (1–50000)	CTR3	=	400; 2000*
Maximum Power Transformer Capacity (OFF, 0.2–5000 MVA)	MVA	=	100
Define Internal CT Connection Compensation (Y, N)	ICOM	=	Y
Winding 1 CT Conn. Compensation (0, 1, …, 12)	W1CTC	=	11
Winding 2 CT Conn. Compensation (0, 1, …, 12)	W2CTC	=	11
Winding 3 CT Conn. Compensation (0, 1, …, 12)	W3CTC	=	0
Winding 1 Line-to-Line Voltage (1–1000 kV)	VWDG1	=	230

*The first value applies to a 5 A relay, the second value applies to a 1 A relay.

Winding 2 Line-to-Line Voltage (1–1000 kV)	VWDG2	=	138
Winding 3 Line-to-Line Voltage (1–1000 kV)	VWDG3	=	13.8
PT Ratio (1–6500)	PTR	=	2000
Compensation Angle (0–360 degrees)	COMPANG	=	0
Voltage-Current Winding (1, 2, 3, 12)	VIWDG	=	1
Three-Phase Voltage Input (Y, N)	TPVI	=	Y

Differential Elements

Note: TAP1–TAP3 are auto-set by relay if MVA setting is not OFF.

Winding 1 Current Tap			
(0.5–155.0 A secondary) (5 A)	TAP1	=	2.09
(0.1–31.0 A secondary) (1 A)			0.42
Winding 2 Current Tap			
(0.5–155.0 A secondary) (5 A)	TAP2	=	1.74
(0.1–31.0 A secondary) (1 A)			0.35
Winding 3 Current Tap			
(0.5–155.0 A secondary) (5 A)	TAP3	=	10.46
(0.1–31.0 A secondary) (1 A)			2.09
Restrained Element Operating Current PU ((0.10-1.00) multiple of tap)	O87P	=	0.30
Restraint Slope 1 Percentage (5–100%)	SLP1	=	25
Restraint Slope 2 Percentage (OFF, 25–200%)	SLP2	=	50
Restraint Current Slope 1 Limit ((1–20) multiple of tap)	IRS1	=	3
Unrestrained Element Current PU ((1–20) multiple of tap)	U87P	=	10
Second-Harmonic Blocking Percentage (OFF, 5–100%)	PCT2	=	15
Fourth-Harmonic Blocking Percentage (OFF, 5–100%)	PCT4	=	15
Fifth-Harmonic Blocking Percentage (OFF, 5–100%)	PCT5	=	35
Fifth-Harmonic Alarm Threshold (OFF, (0.02–3.20) multiple of tap)	TH5P	=	OFF
Fifth-Harmonic Alarm TDPU (0–8000 cycles)	TH5D	=	30
DC Ratio Blocking (Y, N)	DCRB	=	N
Harmonic Restraint (Y, N)	HRSTR	=	Y
Independent Harmonic Blocking (Y, N)	IHBL	=	N

Restricted Earth Fault

Enable 32I (SELOGIC control equation)

E32I = 0

Operating Quantity from W 1, W 2 (1, 2, 12)	32IOP	=	1
Positive-Sequence Current Restraint Factor, I0/I1 (0.02–0.50)	a0	=	0.10
Residual Current Sensitivity Threshold			
(0.25–15.00 A secondary) (5 A)	50GP	=	0.10
(0.05–3.00 A secondary) (1 A)			0.10

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)			4.00
Phase 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)			0.80
Phase Inv.-Time O/C Curve (U1–U5, C1–C5)	51P1C	=	U2
Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51P1TD	=	3.00
Phase 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)			OFF
Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles)	50Q11D	=	5

50Q11 Torque Control (SELOGIC control equation)

50Q11TC = 1

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	=	6.00
(OFF, 0.1–3.2 A secondary) (1 A)			1.20
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	=	7.00
(0.1–3.2 A secondary) (1 A)			1.40
Neg.-Seq. Demand Ammeter Threshold			
(0.5–16.0 A secondary) (5 A)	QDEM1P	=	1.00
(0.1–3.2 A secondary) (1 A)			0.20
Residual Demand Ammeter Threshold			
(0.5–16.0 A secondary) (5 A)	NDEM1P	=	1.00
(0.1–3.2 A secondary) (1 A)			0.20

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	=	3.50
(OFF, 0.1–3.2 A secondary) (1 A)			0.70
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
Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 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
Phase Demand Ammeter Threshold			
(0.5–16.0 A secondary) (5 A)	PDEM2P	=	7.00
(0.1–3.2 A secondary) (1 A)			1.40
Neg.-Seq. Demand Ammeter Threshold			
(0.5–16.0 A secondary) (5 A)	QDEM2P	=	1.00
(0.1–3.2 A secondary) (1 A)			0.20
Residual Demand Ammeter Threshold			
(0.5–16.0 A secondary) (5 A)	NDEM2P	=	1.00
(0.1–3.2 A secondary) (1 A)			0.20

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	=	4.00
(OFF, 0.1–3.2 A secondary) (1 A)			0.80
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			

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
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	= 7.00
(0.1–3.2 A secondary) (1 A)		1.40
Neg.-Seq. Demand Ammeter Threshold		
(0.5–16.0 A secondary) (5 A)	QDEM3P	= 1.00
(0.1–3.2 A secondary) (1 A)		0.20
Residual Demand Ammeter Threshold		
(0.5–16.0 A secondary) (5 A)	NDEM3P	= 1.00
(0.1–3.2 A secondary) (1 A)		0.20

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	= 4.00
(OFF, 0.1–3.2 A secondary) (1 A)		0.80
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	= 1.00
(OFF, 0.1–3.2 A secondary) (1 A)		0.20
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

24 Elements

Protected Winding L-L Voltage (0.20–800.00 kV primary)	VNOM	= 230.00
Transformer Winding Connection (D, Y)	24WDG	= Y
Level 1 Volts/Hertz Pickup (100–200%)	24D1P	= 105

Level 1 Time Delay (0.04–400.00 seconds)	24D1D	= 1.00
Level 2 Composite Curve Shape (OFF, DD, ID, I, U)	24CCS	= ID
Level 2 Inv.-Time Pickup (100–200%)	24IP	= 105
Level 2 Inv.-Time Curve (0.5, 1.0, 2.0)	24IC	= 2.0
Level 2 Inv.-Time Factor (0.1–10.0 seconds)	24ITD	= 0.1
Level 2 Pickup One (100–200%)	24D2P1	= 175
Level 2 Time Delay One (0.04–400.00 seconds)	24D2D1	= 3.00
Level 2 Pickup Two (101–200%)	24D2P2	= 176
Level 2 Time Delay Two (0.04–400.00 seconds)	24D2D2	= 3.00
Level 2 Reset Time (0.00–400.00 seconds)	24CR	= 240.00

24 Element Torque-Control (SELOGIC control equation)

24TC = 1

27 Elements

Level 1 Phase U/V PU (OFF, 0.1–300.0 V secondary)	27P1P	= 20.0
Level 2 Phase U/V PU (OFF, 0.1–300.0 V secondary)	27P2P	= 0.0
Level 1 Phase-Phase U/V PU (OFF, 0.1–520.0 V secondary)	27PP1	= 35.0
Level 2 Phase-Phase U/V PU (OFF, 0.1–520.0 V secondary)	27PP2	= 0.0
Pos.-Seq. U/V PU (OFF, 0.1–100.0 V secondary)	27V1P	= 0.0

59 Elements

Level 1 Phase O/V PU (OFF, 0.0–300.0 V secondary)	59P1P	= 74.0
Level 2 Phase O/V PU (OFF, 0.0–300.0 V secondary)	59P2P	= OFF
Level 1 Residual O/V PU (OFF, 0.0–300.0 V secondary)	59G1P	= 20.0
Level 2 Residual O/V PU (OFF, 0.0–300.0 V secondary)	59G2P	= OFF
Neg.-Seq. U/V PU (OFF, 0.0–100.0 V secondary)	59QP	= OFF
Level 1 Phase-Phase O/V PU (OFF, 0.0–520.0 V secondary)	59PP1	= 128.0
Level 2 Phase-Phase O/V PU (OFF, 0.0–520.0 V secondary)	59PP2	= OFF
Pos.-Seq.(V1) O/V PU (OFF, 0.0–100.0 V secondary)	59V1P	= OFF

81 Elements

Undervoltage Block (20.0–150.0 V secondary)	27B81P	= 40.00
Level 1 Pickup (OFF, 40.10–65.00 Hz)	81D1P	= OFF
Level 1 Time Delay (0.04–300.00 seconds)	81D1D	= 300.00
Level 2 Pickup (OFF, 40.10–65.00 Hz)	81D2P	= OFF

Level 2 Time Delay (0.04–300.00 seconds)	81D2D	= 300.00
Level 3 Pickup (OFF, 40.10–65.00 Hz)	81D3P	= OFF
Level 3 Time Delay (0.04–300.00 seconds)	81D3D	= 300.00
Level 4 Pickup (OFF, 40.10–65.00 Hz)	81D4P	= OFF
Level 4 Time Delay (0.04–300.00 seconds)	81D4D	= 300.00
Level 5 Pickup (OFF, 40.10–65.00 Hz)	81D5P	= OFF
Level 5 Time Delay (0.04–300.00 seconds)	81D5D	= 300.00
Level 6 Pickup (OFF, 40.10–65.00 Hz)	81D6P	= OFF
Level 6 Time Delay (0.04–300.00 seconds)	81D6D	= 300.00

Miscellaneous Timers

Minimum Trip Duration Time Delay (4–8000 cycles)	TDURD	= 9
Close Failure Logic Time Delay (OFF, 0–8000 cycles)	CFD	= 60

SELogic Control Equations Set 1

Set 1 Variable 1 (SELogic control equation)

S1V1 = 0

S1V1 Timer Pickup (0–999999 cycles)	S1V1PU	= 0
S1V1 Timer Dropout (0–999999 cycles)	S1V1DO	= 0

Set 1 Variable 2 (SELogic control equation)

S1V2 = 0

S1V2 Timer Pickup (0–999999 cycles)	S1V2PU	= 0
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

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

S3V5 Timer Pickup (0–999999 cycles) S3V5PU = 0

S3V5 Timer Dropout (0–999999 cycles) S3V5DO = 0

Set 3 Variable 6 (SELOGIC control equation)

S3V6 = 0

S3V6 Timer Pickup (0–999999 cycles) S3V6PU = 0

S3V6 Timer Dropout (0–999999 cycles) S3V6DO = 0

Set 3 Variable 7 (SELOGIC control equation)

S3V7 = 0

S3V7 Timer Pickup (0–999999 cycles) S3V7PU = 0

S3V7 Timer Dropout (0–999999 cycles) S3V7DO = 0

Set 3 Variable 8 (SELOGIC control equation)

S3V8 = 0

S3V8 Timer Pickup (0–999999 cycles) S3V8PU = 0

S3V8 Timer Dropout (0–999999 cycles) S3V8DO = 0

Set 3 Latch Bit 1 SET Input (SELOGIC control equation)

S3SLT1 = 0

Set 3 Latch Bit 1 RESET Input (SELOGIC control equation)

S3RLT1 = 0

Set 3 Latch Bit 2 SET Input (SELOGIC control equation)

S3SLT2 = 0

Set 3 Latch Bit 2 RESET Input (SELOGIC control equation)

S3RLT2 = 0

Set 3 Latch Bit 3 SET Input (SELOGIC control equation)

S3SLT3 = 0

Set 3 Latch Bit 3 RESET Input (SELOGIC control equation)

S3RLT3 = 0

Set 3 Latch Bit 4 SET Input (SELOGIC control equation)

S3SLT4 = 0

Set 3 Latch Bit 4 RESET Input (SELOGIC control equation)

S3RLT4 = 0

Set 3 Latch Bit 5 SET Input (SELOGIC control equation)

S3SLT5 = 0

Set 3 Latch Bit 5 RESET Input (SELOGIC control equation)

S3RLT5 = 0

Set 3 Latch Bit 6 SET Input (SELOGIC control equation)

S3SLT6 = 0

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
TR2	=	51P2T+51Q2T+OC2
TR3	=	50P31+51Q3T+OC3
TR4	=	87R+87U+24C2T
ULTR1	=	!50P13
ULTR2	=	!50P23
ULTR3	=	!50P33
ULTR4	=	!(50P13+50P23+50P33)

Close Logic

52A1	=	IN101
52A2	=	IN102
52A3	=	IN103
CL1	=	CC1+/IN104
CL2	=	CC2+/IN105
CL3	=	CC3+/IN106
ULCL1	=	TRIP1+TRIP4
ULCL2	=	TRIP2+TRIP4
ULCL3	=	TRIP3+TRIP4

Event Report Triggering

ER	=	/50P11+/51P1+/51Q1+/51P2+/51Q2+/51P3

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

Relay Settings

Length of Event Report (15, 29, 60 cycles)	LER	=	15
Length of Pre-fault in Event Report (1 to (LER-1))	PRE	=	4
Nominal Frequency (50, 60 Hz)	NFREQ	=	60 or 50
Phase Rotation (ABC, ACB)	PHROT	=	ABC or ACB
Phase Potential Connection (D, Y)	DELTA_Y	=	Y
Date Format (MDY, YMD)	DATE_F	=	MDY
Display Update Rate (1–60 seconds) (1–60)	SCROLD	=	2
Front Panel Time-out (0–30 minutes)	FP_TO	=	15
Group Change Delay (0–900 seconds)	TGR	=	3

Battery Monitor

DC Battery Voltage Level 1 (OFF, 20–300 Vdc)	DC1P	=	OFF
DC Battery Voltage Level 2 (OFF, 20–300 Vdc)	DC2P	=	OFF
DC Battery Voltage Level 3 (OFF, 20–300 Vdc)	DC3P	=	OFF
DC Battery Voltage Level 4 (OFF, 20–300 Vdc)	DC4P	=	OFF

Breaker 1 Monitor

BKR1 Trigger Equation (SELOGIC control equation)

BKMON1 = TRIP1 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B1COP1	=	10000
kA Interrupted Set Point 1 min (0.1–999.0 kA primary)	B1KAP1	=	1.2
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	=	150
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B1KAP2	=	8.0
Close/Open Set Point 3 max (1–65000 operations)	B1COP3	=	12
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	B1KAP3	=	20.0

Breaker 2 Monitor

BKR2 Trigger Equation (SELOGIC control equation)

BKMON2 = TRIP2 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B2COP1	=	10000
kA Interrupted Set Point 1 min (0.1–999.0 kA primary)	B2KAP1	=	1.2
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	=	150
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B2KAP2	=	8.0

Close/Open Set Point 3 max (1–65000 operations)	B2COP3	=	12
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	B2KAP3	=	20.0

Breaker 3 Monitor

BKR3 Trigger Equation (SELogic control equation)

BKMON3 = TRIP3 + TRIP4

Close/Open Set Point 1 max (1–65000 operations)	B3COP1	=	10000
kA Interrupted Set Point 1 min (0.1–999.0 kA primary)	B3KAP1	=	1.2
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	=	150
kA Interrupted Set Point 2 min (0.1–999.0 kA primary)	B3KAP2	=	8.0
Close/Open Set Point 3 max (1–65000 operations)	B3COP3	=	12
kA Interrupted Set Point 3 min (0.1–999.0 kA primary)	B3KAP3	=	20.0

Analog Input Labels

Rename Current Input IAW1 (1–4 characters)	IAW1	=	IAW1
Rename Current Input IBW1 (1–4 characters)	IBW1	=	IBW1
Rename Current Input ICW1 (1–4 characters)	ICW1	=	ICW1
Rename Current Input IAW2 (1–4 characters)	IAW2	=	IAW2
Rename Current Input IBW2 (1–4 characters)	IBW2	=	IBW2
Rename Current Input ICW2 (1–4 characters)	ICW2	=	ICW2
Rename Current Input IAW3 (1–4 characters)	IAW3	=	IAW3
Rename Current Input IBW3 (1–4 characters)	IBW3	=	IBW3
Rename Current Input ICW3 (1–4 characters)	ICW3	=	ICW3
Rename Voltage Input VAWX (1–4 characters)	VAWX	=	VAWX
Rename Voltage Input VBWX (1–4 characters)	VBWX	=	VBWX
Rename Voltage Input VCWX (1–4 characters)	VCWX	=	VCWX

Setting Group Selection

Select Setting Group 1 (SELogic control equation)

SS1 = 0

Select Setting Group 2 (SELogic control equation)

SS2 = 0

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 = ________

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	=	

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	=	________
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-387E Relay Settings Sheet
Sequential Events Recorder Settings
(SET R Command) Example

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

Note: **RTSCTS setting does not appear if PROTO=LMD or DNP. 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	=	SEL
LMD Prefix (@, #, $, %, &)	PREFIX	=	
LMD Address (1–99)	ADDR	=	
LMD Settling Time (0–30 seconds)	SETTLE	=	
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	2400
Data Bits (7, 8)	BITS	=	8
Parity Odd, Even, or None (O, E, N)	PARITY	=	N
Stop Bits (1, 2)	STOP	=	1
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	5
Send auto messages to port (Y, N)	AUTO	=	N
Enable hardware handshaking (Y, N)	RTSCTS	=	N
Fast Operate Enable (Y, N)	FASTOP	=	N

Port 2 (SET P 2) Rear Panel, EIA-232 with IRIG-B

Port Protocol (SEL, LMD, DNP)	PROTO	=	SEL
LMD Prefix (@, #, $, %, &)	PREFIX	=	
LMD Address (1–99)	ADDR	=	
LMD Settling Time (0–30 seconds)	SETTLE	=	
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	2400
Data Bits (7, 8)	BITS	=	8
Parity Odd, Even, or None (O, E, N)	PARITY	=	N
Stop Bits (1, 2)	STOP	=	1
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	5
Send auto messages to port (Y, N)	AUTO	=	N
Enable hardware handshaking (Y, N)	RTSCTS	=	N
Fast Operate Enable (Y, N)	FASTOP	=	N

Port 3 (SET P 3) Rear Panel, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	SEL
LMD Prefix (@, #, $, %, &)	PREFIX	=	
LMD Address (1–99)	ADDR	=	
LMD Settling Time (0–30 seconds)	SETTLE	=	
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	2400
Data Bits (7, 8)	BITS	=	8
Parity Odd, Even, or None (O, E, N)	PARITY	=	N
Stop Bits (1, 2)	STOP	=	1
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	5
Send auto messages to port (Y, N)	AUTO	=	N
Enable hardware handshaking (Y, N)	RTSCTS	=	N
Fast Operate Enable (Y, N)	FASTOP	=	N

Port 4 (SET P 4) Front Panel, EIA-232

Port Protocol (SEL, LMD, DNP)	PROTO	=	SEL
LMD Prefix (@, #, $, %, &)	PREFIX	=	
LMD Address (1–99)	ADDR	=	
LMD Settling Time (0–30 seconds)	SETTLE	=	
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	2400
Data Bits (7, 8)	BITS	=	8
Parity Odd, Even, or None (O, E, N)	PARITY	=	N
Stop Bits (1, 2)	STOP	=	1
Time-out (for inactivity) (0–30 minutes)	T_OUT	=	5
Send auto messages to port (Y, N)	AUTO	=	N
Enable hardware handshaking (Y, N)	RTSCTS	=	N
Fast Operate Enable (Y, N)	FASTOP	=	N

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SECTION 7: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

The SEL-387E 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, 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-387E 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-387E 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.

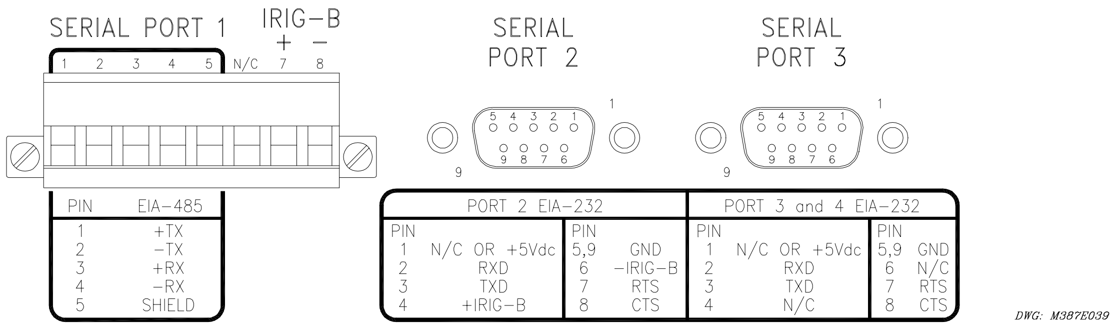
Port Identification

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-387E 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 drawing of the 9-pin port connector and pin definitions appears in Figure 7.1.



(female chassis connectors as viewed from outside panel)

Figure 7.1: SEL-387E 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 gives a list of 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-387E Relay Communication Cable Numbers

SEL-387E 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-387E 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-387E Relay Port 2 to the SEL-2020 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-387E Relay to Computer

Cable C234A

SEL-387E Relay 9-Pin Male "D" Subconnector			*DTE Device 9-Pin Female "D" Subconnector	
RXD	2	—	3	TXD
TXD	3	—	2	RXD
GND	5	—	5	GND
CTS	8	—	8	CTS
			7	RTS
			1	DCD
			4	DTR
			6	DSR

Cable C227A

SEL-387E Relay 9-Pin Male "D" Subconnector			*DTE Device 25-Pin Female "D" Subconnector	
GND	5	—	7	GND
TXD	3	—	3	RXD
RXD	2	—	2	TXD
GND	9	—	1	GND
CTS	8	—	4	RTS
			5	CTS
			6	DSR
			8	DCD
			20	DTR

SEL-387E Relay to Modem

Cable C222

SEL-387E Relay 9-Pin Male "D" Subconnector			**DCE Device 25-Pin Male "D" Subconnector	
GND	5	—	7	GND
TXD	3	—	2	TXD (IN)
RTS	7	—	20	DTR (IN)
RXD	2	—	3	RXD (OUT)
CTS	8	—	8	CD (OUT)
GND	9	—	1	GND

Cable C220

SEL-387E Relay 9-Pin Male "D" Subconnector			Modem 5 Vdc Powered **DCE Device 25-Pin Male "D" Subconnector	
GND	5	——	7	GND
TXD	3	——	2	TXD (IN)
RTS	7	——	20	DTR (IN)
RXD	2	——	3	RXD (OUT)
CTS	8	——	8	CD (OUT)
+5 VDC	1	——	10	PWR (IN)
GND	9	——	1	GND

SEL-387E Relay to SEL-2020 or SEL-2030

Cable C272A

SEL-2020 or SEL-2030 9-Pin Male "D" Subconnector			SEL-387E Relay 9-Pin Male "D" Subconnector	
RXD	2	——	3	TXD
TXD	3	——	2	RXD
GND	5	——	5	GND
RTS	7 ┐		┌ 7	RTS
CTS	8 ┘		└ 8	CTS

Cable C273A

SEL-2020 9-Pin Male "D" Subconnector			SEL-387E Relay 9-Pin Male "D" Subconnector	
RXD	2	——	3	TXD
TXD	3	——	2	RXD
IRIG+	4	——	4	IRIG+
GND	5	——	5	GND
IRIG-	6	——	6	IRIG-
RTS	7	——	8	CTS
CTS	8	——	7	RTS

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

Table 7.3: Serial Communications Port Pin Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc	5 Vdc Power Connection
+12 Vdc	12 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
CD	Carrier Detect
PWR	5 Vdc

COMMUNICATIONS PROTOCOL

This section explains the serial port communications protocol used by the SEL-387E Relay. You set and operate the SEL-387E Relay via the serial communications ports.

Note: In this document, commands you type appear in bold/upper case: **STATUS**. Keys you press appear in bold/upper case/brackets: **<ENTER>**.

Relay output appears boxed and in the following format:

```
XFMR 1                        Date: MM/DD/YY    Time: HH:MM:SS.SSS
```

The communications protocol consists of hardware and software features.

Hardware Protocol

The following hardware protocol is designed for manual and automatic communications.

1. If the SET P setting “RTS_CTS” = N, RTS will always be asserted.
2. If the SET P setting “RTS_CTS” = Y, RTS asserts while the communication buffer is less than 87 percent full, and RTS deasserts when the communications port buffer is greater than 87 percent full.
3. If the SET P setting “RTS_CTS” = 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 (LMD)

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-387E 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

Relay Startup Message

Immediately after power is applied, the relay transmits the following automatic message:

```
XFMR 1                                  Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A
SEL-387E
=
```

Setting Group Change Message

The SEL-387E 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: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

Active Group = N
=>>
```

- 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.

Relay Self-Test Warning or Failure

The relay automatically generates a status report whenever the self-tests declare a failure state and some warning states.

```
XFMR 1                                  Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D
SELF TESTS

W=Warn    F=Fail

       IAW1     IBW1     ICW1     IAW2     IBW2     ICW2
OS      123      123      123      123      123      123

       IAW3     IBW3     ICW3     VAWX     VBWX     VCWX
OS      123      123      123      123      123      123

       +5V_PS   +5V_REG  -5V_REG  +12V_PS  -12V_PS  +15V_PS  -15V_PS
PS      1.12     1.12    -1.12    12.12    -12.12    12.12    -12.12

       TEMP     RAM      ROM      A/D      CR_RAM   EEPROM   IO_BRD
       123.1    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

Event Summary Message

An automatic message is generated each time an event is triggered. The message is a summary of the event.

```
XFMR 1                                  Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:   123.0   123.0   123.0
Winding 2 Currents (A Sec), ABC:   123.0   123.0   123.0
Winding 3 Currents (A Sec), ABC:   123.0   123.0   123.0
Winding X Voltages (V Sec), ABC:   123.0   123.0   123.0
Volts/Hertz Percent:  0.0
=>>
```

- RID and TID settings for the active group
- Date and time the event was triggered
- The event type
- Target information
- All phase currents and voltages

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-387E 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. The relay is shipped with the default factory passwords shown in the table under ***PAS (Passwords)*** later in this section. Below are the access level hierarchy, the access level prompts, and commands allowed in each of the four access levels:

Access Level	Prompt	Commands Allowed
0 (lowest)	=	0
1	=>	0, 1
B	==>	0, B
2 (highest)	=>>	0, 1, B, 2

Figure 7.2 summarizes the access levels, 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 with "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 you issue the **ACC** command and enter the password, if it is required [see ***PAS (Passwords)*** for default factory passwords], the relay will be 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 **BAC** command allows the relay to go to Access Level B. The **2AC** command allows the relay to go to Access Level 2.

Access Level B (Breaker Level)

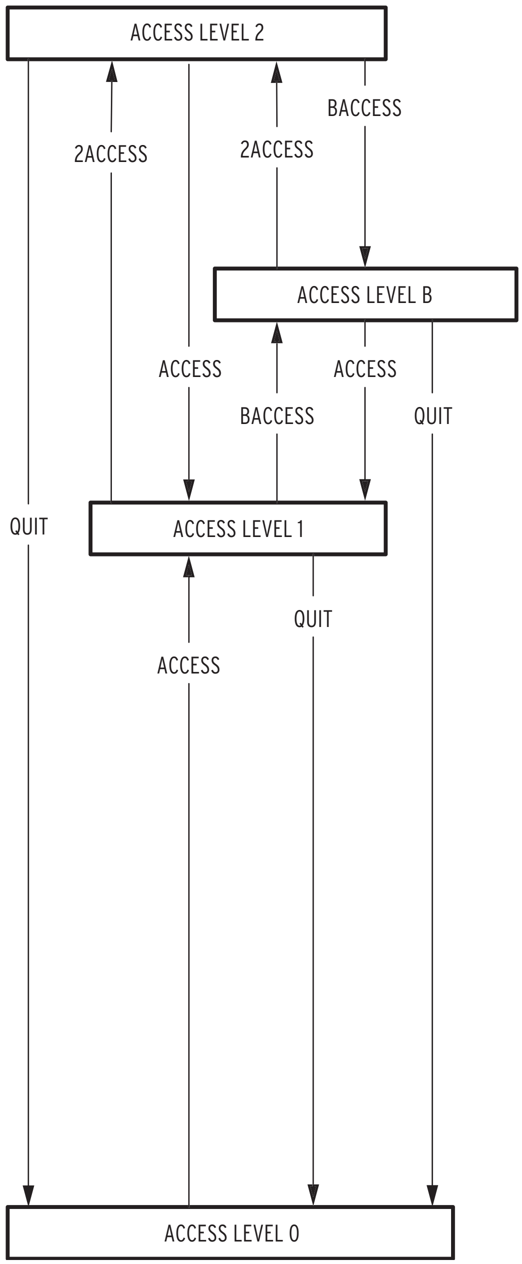
After you issue the **BAC** command and enter the password, if it is required [see ***PAS (Passwords)*** for default factory passwords], the relay pulses the ALARM contact and will be in Access Level B (breaker access level). The Access Level B prompt appears (==>).

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 you issue the **2AC** command and enter the password, if it is required [see ***PAS (Passwords)*** for default factory passwords], the relay pulses the ALARM contact and will be 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: SEL-300 Series Relays Firmware Upgrade Instructions***) are also performed from this level.



Access Level	0	1	B	2
Prompt	=	=>	==>	=>>
				CONTROL
				COPY
				PASSWORD
				RESET51
				SET
				SET G
				SET P
				SET R
			BREAKER R	BREAKER R
			BREAKER W	BREAKER W
			CLOSE	CLOSE
			GROUP	GROUP
			OPEN	OPEN
			PULSE	PULSE
		2ACCESS	2ACCESS	
		BACCESS		BACCESS
		BREAKER	BREAKER	BREAKER
		CEV	CEV	CEV
		DATE	DATE	DATE
		EVENT	EVENT	EVENT
		GROUP	GROUP	GROUP
		HISTORY	HISTORY	HISTORY
		HISTORY C	HISTORY C	HISTORY C
		INITIO	INITIO	INITIO
		IRIG	IRIG	IRIG
		METER	METER	METER
		METER E	METER E	METER E
		METER H	METER H	METER H
		SER	SER	SER
		SER C	SER C	SER C
		SHOWSET	SHOWSET	SHOWSET
		SHOWSET G	SHOWSET G	SHOWSET G
		SHOWSET P	SHOWSET P	SHOWSET P
		SHOWSET R	SHOWSET R	SHOWSET R
		STATUS	STATUS	STATUS
		TARGET	TARGET	TARGET
		TARGET F	TARGET F	TARGET F
		TARGET R	TARGET R	TARGET R
		TIME	TIME	TIME
		TRIGGER	TRIGGER	TRIGGER
	QUIT	QUIT	QUIT	QUIT
	ACCESS		ACCESS	ACCESS

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 **2AC** command to enter Access Level 2. The default password for Level 2 is shown in the table under ***PAS (Passwords)*** later in this section. Use the **PAS** 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: ? @@@@@

XFMR 1                            Date: MM/DD/YY    Time: HH:MM:SS.SSS
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 **ACC** command to enter Access Level 1. The default password for Level 1 is shown in the table under ***PAS (Passwords)*** later in this section. Use the **PAS** 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: ? @@@@@<ENTER>

XFMR 1                                  Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A


Level 1
=>
```

BAC (Access Level B)

Access Levels 1, 2

Use the **BAC** command to enter Access Level B. The default password for Level B is shown in the table under ***PAS (Passwords)*** later in this section. Use the **PAS** 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: ?  @@@@@<ENTER>

XFMR 1                           Date: MM/DD/YY    Time: HH:MM:SS.SSS
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 **BRE** command to display a report of breaker operation information. The breaker report provides trip counter and trip current information for up to three 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<ENTER>

XFMR 1                                 Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

BREAKER 1
Int Trips=     12345   IAW1=     12345  IBW1=    12345  ICW1=    12345 kA(pri)
Ext Trips=     12345   IAW1=     12345  IBW1=    12345  ICW1=    12345 kA(pri)
Percent Wear:          POLE1=      123  POLE2=     123  POLE3=     123

BREAKER 2
Int Trips=     12345   IAW2=     12345  IBW2=    12345  ICW2=    12345 kA(pri)
Ext Trips=     12345   IAW2=     12345  IBW2=    12345  ICW2=    12345 kA(pri)
Percent Wear:         POLE1=      123  POLE2=     123  POLE3=     123

BREAKER 3
Int Trips=     12345   IAW3=     12345  IBW1=     12345  ICW3=     12345 kA(pri)
Ext Trips=     12345   IAW3=     12345  IBW1=     12345  ICW3=     12345 kA(pri)
Percent Wear:          POLE1=      123  POLE2=      123  POLE3=      123


LAST BREAKER MONITOR RESET FOR     Bkr1:  MM/DD/YY       HH:MM:SS.SSS
                                   Bkr2:  MM/DD/YY       HH:MM:SS.SSS
                                   Bkr3:  MM/DD/YY       HH:MM:SS.SSS

=>>
```

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 experienced some fault duty before the relay was installed. The command prompts for percentage wear for each pole of the breaker. Percentage wear information must be entered as integer values, from 0 to 100 percent. Values over 100 will not be accepted. The data are stored in EEPROM and are nonvolatile. The procedure is shown below.

```
=>>BRE W 1<ENTER>
Breaker Wear Percent Preload

Breaker 1: Pole 1 % = 123 ?
Breaker 1: Pole 2 % = 123 ?
Breaker 1: Pole 3 % = 123 ?
Are you sure (Y/N) ?
=>>
```

After entering the values, use the **BRE** command to verify that the data have 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 [n Sx C]**. All parameters are optional. Enter them in any order.

Letter n specifies the event number.

Sx specifies samples per cycle. The x value can be 64 for raw reports. Digital elements will be displayed at the resolution specified by Sx, up to a maximum of eight samples per cycle.

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 **CLO 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 **COP m n** 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 **COP** 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 **DAT** 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, as in 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 Sequential Events Reporting*** for further details on retrieving event reports.

GRO and GRO n (Setting Group)

Access Levels 1, B, 2

The **GRO** command, at Access Level 1, displays the setting group variable for the currently active setting group. Changing the variable is not permitted. The **GRO 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 = N
=>>GRO 2<ENTER>
Change to Group 2
Are you sure (Y/N) ? Y<ENTER>
=>>
```

The **GRO** 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 **HIS** command displays the 99 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:

LER Setting	Number of Event Reports Stored
15 cycles	18–21
29 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 4), CLSm (m = 1 to 4), ER (SELOGIC control equations 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 99), 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 are saved (time 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                                      Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

#       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    50/51 A B W3
4     01/01/96  00:18:10.258  TRIP1    1
5     01/01/96  00:18:08.095  TRIP3    1    50/51 A B W3
6     12/09/95  22:41:33.108  ER       1
7     12/09/95  22:27:47.870  TRIP3    1    50/51 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

The **HIS C** command clears the history and associated events 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 Interface Board)

Access Levels 1, B, 2

The **INI** command reports the number and type of interface boards in the relay from Access Levels 1 and B. If the number or type of interface boards has changed since last power up, INI will confirm from Access Level 2 that the interface boards present are correct.

```
=>>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 **IRI** 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: MM/DD/YY    Time: HH:MM:SS.SSS
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 **MET** command displays currents, voltages, 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 voltage and current metering data, in primary amperes

MET D Displays winding demand ammeter data, in primary amperes

MET DIF Displays differential current metering data, in multiples of tap

MET E Display energy metering data (see **MET E** below)

MET H Displays harmonic spectrum of currents and voltages (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, A)
MET RP n	Resets peak demand ammeter values for Winding n (n = 1, 2, 3, A)
MET SEC	Displays winding current metering data, with magnitude and phase angle, in secondary and voltage quantities

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 E (Energy Metering)

Access Levels 1, B, 2

The **MET E** command initiates the energy metering function. The element runs every second, using the average value of the last 16 cycles of the previous second to calculate energy quantities. This function is explained more fully in ***Section 5: Metering and Monitoring***, where a sample report also is shown.

MET H (Harmonic Metering)

Access Levels 1, B, 2

The **MET H** command is different from the normal metering functions, in that it uses one full cycle of unfiltered data, at 64 samples per cycle, to provide a snapshot of total harmonic content of all 12 analog inputs. It uses a Fast Fourier Transform technique to provide secondary quantities 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)

⚠ WARNING

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

Access Level 2

The **PAS** command allows you to inspect or change existing passwords. The factory default passwords for Access Levels 1, B, and 2 are:

Access Level	Factory Default Password
1	OTTER
B	EDITH
2	TAIL

Use **PAS<ENTER>** to inspect passwords. The passwords for Levels 1, B, and 2 are displayed.

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

To change a password, use the following syntax:

PAS n newpas<ENTER>

The following 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 Ot3579. The passwords are case sensitive.

```
=>>PAS 1 Ot3579<ENTER>
Set
=>>
```

The relay sets the password, pulses the ALARM relay closed for approximately one second, and transmits the response "Set" to the display.

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 Ih2dcs 4u-Iwg .0387.

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

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 **PUL 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 one second. Main board breaker jumper JMP6B must be in place. After issuing the **PUL** 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 states 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 **QUI** 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 **QUI** 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: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

=
```

RES (RESET51 -- Reset Inverse-Time O/C Elements)

Access Level 2

The **RES** command clears the inverse-time overcurrent element accumulators (phase, negative-sequence, and residual) for all three windings. It also clears the combined overcurrent phase and residual inverse-time elements. This command is useful in testing 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, Overcurrent, Voltage, and Frequency 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 sequential events 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 Sequential Events Reporting*** for a complete description of the report.

```
=>>SER 2/26/97 2/27/97<ENTER>

XFMR 1                                    Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D
#      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 events 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
MVA     = 100.0     ICOM    = Y
W1CTC   = 11        W2CTC   = 11        W3CTC   = 0
VWDG1   = 230.00    VWDG2   = 138.00    VWDG3   = 13.80
PTR     = 100       VIWDG   = 1         TPVI    = Y
```

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 disabled for approximately one second when settings are saved.

Refer to individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

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, 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 individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

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 individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

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 record trigger conditions (SER1 to SER4) and the ALIAS1 to ALIAS20 settings for renaming 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 Sequential Events Reporting*** 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. <u>An average of 1 state change every 3 minutes can be made for a 25-year relay service life.</u>

SHO (Show Group 1 through 6 Settings)

Access Levels 1, B, 2

SHO 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 individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

SHO G (Show Global Settings)

Access Levels 1, B, 2

SHO 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 individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

SHO P (Show Port Settings)

Access Levels 1, B, 2

SHO 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 R (Show SER Settings)

Access Levels 1, B, 2

SHO 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 individual elements in ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** and to ***Section 6: Setting the Relay*** for information on settings.

STA (Status Report)

Access Levels 1, B, 2

The **STA** command displays a report of the self-test diagnostics. The relay automatically executes the **STA** 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 also warm boots relay logic. This may clear some warnings, but do not ignore warnings; contact the factory.

The **STA C<ENTER>** command also clears any out-of-tolerance condition from the status report and reboots the relay. Do not ignore the warning; contact the factory.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set. For the STA report format see the example following ***Status Reporting Function*** in ***Section 5: Metering and Monitoring***.

TAR (Show Relay Word Targets On Screen)

Access Levels 1, B, 2

The **TAR** 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 **QUI** command is executed, **TAR 0** command is executed, or the **TAR R** command is executed.

The **TAR** command does not remap the front-panel LEDs. See the **TAR F** command.

The following examples demonstrate the **TAR** command:

```
=>>TAR<ENTER>                        Default Row is 0

EN      TRIP    INST    87-1    87-2    87-3    24      81
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    24      81
1       0       0       0       0       0       0       0
=>>
```

Refer to ***Section 4: Control Logic*** for a list of the Relay Word bits and their corresponding rows.

TAR F n (Show Relay Word Targets on Front-Panel LEDs)

Access Levels 1, B, 2

The **TAR F** command works like the **TAR** 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 of the command for the serial port display. The default is 1.
- **X** allows remapping of 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 **QUI** 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 bits and their corresponding rows.

TAR R (Reset Targets)

Access Levels 1, B, 2

The **TAR 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.

TIM (Time)

Access Levels 1, B, 2

The **TIM** 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 hours:minutes:seconds; 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 **TRI** command generates an event record. The command is a convenient way to record all inputs and outputs from the relay any time you want (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: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding 2 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding 3 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding X Voltages (V Sec), ABC:   123.1   123.1   123.1
Volts/Hertz Percent:   123.1
=>>
```

Alarm Conditions

The SEL-387E 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-387E RELAY COMMAND SUMMARY

ACCESS LEVEL 0 COMMANDS

Access Level 0 <u>Commands</u>	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 (JMP6A) 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 <u>Commands</u>	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: =>
ACC	Enter Access Level 1. If the main board password jumper (JMP6A) 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 (JMP6A) 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 (JMP6A) 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 three 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 DAT m/d/y DAT y/m/d	Show date presently in the relay. Enter date in this manner if Date Format setting DATE_F = MDY. 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	Reports the number and type of interface 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 E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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.

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.
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 <u>Commands</u>	The Access Level B commands allow the user to control breakers and output contacts. 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 (JMP6A) 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 (JMP6A) 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, A).
BRE W n	Pre-set the percent contact wear for each pole of Breaker n (n = 1, 2, 3).
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)
CLO n	Assert the CCn Relay Word bit. Used to close Breaker n if CCn is assigned to an output contact. JMP6B 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	Reports the number and type of interface 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 E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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. JMP6B 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. JMP6B 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.
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 (JMP6A) 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 (JMP6A) 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 three breakers.
BRE R n	Reset trip counters, trip currents, and wear data for Breaker n (n = 1, 2, 3, A).
BRE W n	Pre-set the percent contact wear for each pole of Breaker n (n = 1, 2, 3).
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)
CLO n	Assert the CCn Relay Word bit. Used to close Breaker n if CCn is assigned to an output contact. JMP6B 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)].
COP 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	Reports the number and type of interface boards in the relay. In Access Level 2, confirms that interface 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 DIF k	Display differential metering data, in multiples of tap. Enter number k to scroll metering k times on screen.
MET E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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. JMP6B 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. JMP6B 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.
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-387E Relay front panel is shown in Figure 8.1. It includes a two-line, 16-character LCD; 16 LED target indicators; and eight pushbuttons for local communication.

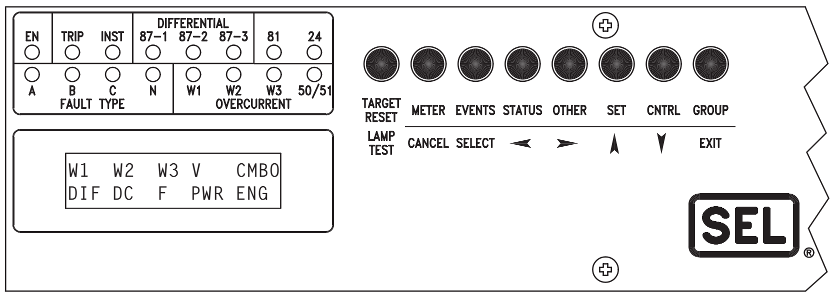


Figure 8.1: SEL-387E Relay Front-Panel User Interface

The LCD 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 for a period specified in the SET G setting FP_TO (Front-Panel Time-Out) and then takes the following actions:

- The front-panel LCD 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 1 to 99 minutes.

Displays

The LCD is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed Display Points. These Display Points 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 four two-line displays of the A-, B-, and C-phase currents and voltages in primary quantities. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the display as set. Each display remains for two 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 happens, but refer to ***Section 10: Testing and Troubleshooting*** for further instructions.

During power up the LCD displays "Initializing." It will then scroll through the winding current and voltage 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 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. ***Section 4: Control Logic*** describes each target LED in detail.

The only times the target LEDs do not illuminate according to their labels are when (1) the user has reprogrammed LEDA, LEDB, or LEDC 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 assertion of a Relay Word bit will light the corresponding LED position. Refer to ***Section 7: Serial Port Communications and Commands*** 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 the power is lost to the relay, these 12 targets will be restored 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 have no password protection. The front panel normally is 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 fewer 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 the commands of that level. 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, while 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 clear 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.

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.

When **<METER>** is pushed, the seven dual-function buttons revert to their secondary functions. The first METER menu prompts the user to select the **W1**, **W2**, **W3**, **V**, **CMBO**, **DIF**, **DC**, **F**, **PWR**, or **ENG** metering display. W1 to W3 are winding displays, V is the voltage input display, CMBO is W1 and W2 combined current, DIF is the differential element display, DC is the battery monitor display, F is the measured system frequency, PWR is the calculated power display, and ENG is the energy metering display. Use any arrow button to highlight the choice. Then push **<SELECT>**.

Windings (W1, W2, W3)

If a winding has been selected, a second menu prompts the user to select the type of metering to display. The choices are **INST**antaneous, **DEM**and, **PKD** peak demand, or **SEC**ondary. 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 is selected, a third menu appears, prompting the user to select either to **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.

Voltage (V)

If V is selected, a second menu prompts the user to select the type of metering to display. The choices are **INST**antaneous, or **SEC**ondary. 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 voltage magnitudes, or secondary voltage magnitudes and angles, for the selected voltage. Use the right/left arrows and **<SELECT>** to choose.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the displays as set.

Differential Element (DIF)

If DIF is selected, the relay scrolls through the instantaneous multiple of tap values for Operate, Restraint, and harmonic quantities.

Battery Monitor (DC)

If DC is selected, the relay displays “Station Battery” and “VDC= nnn.n.”

Frequency (F)

If F is selected, the relay displays "System Frequency" and "FREQ = xx.xx."

Power (PWR)

If PWR is selected, the relay scrolls through real (MW), reactive (MVAR), and apparent (MVA) power values. If the current and voltage transformers are wye connected (DELTA_Y = Y, WnCT = Y) along with all three phase voltages connected to the relay (TPVI = Y), all phase quantities are displayed. Otherwise, only total power values appear, assuming balanced load conditions.

Energy (ENG)

If ENG is selected, a second screen giving the user a choice of Energy DISPLAY or RESET appears. If DISPLAY is chosen, the relay scrolls through real (MWh) and reactive (MVARh) quantities.

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. The information displayed for a given event is: 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 as many as 99 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 8.8, 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-387E-R10 (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>** is pushed.

OTHER

The **<OTHER>** button is used to access several miscellaneous functions; it mimics the corresponding serial port commands for these functions. Pushing **<OTHER>** provides a menu that prompts the user to select **DATE**, **TIME**, **TAR**get, **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, or Bk3. 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 8.9, 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 prompts the user to change the date. Because 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.

RESET51

This command equates exactly 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. Because 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 that 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 8.10, 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, because 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 are to 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 SE**lection**,** and **FRONT PANEL**. Use any arrow key to move to the section you want, 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 users do not recognize this setting, they can push the TARGET RESET button, and a single scroll across the first line will inform them that this is the "Length of Event Report (15, 29, 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 at which the user selects 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, <**EXIT**> returns you 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 whether the user 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 to remind 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**, **WINDING n ELEMS**, **COMBINED**

ELEMS, **24 ELEMS, 27 ELEMS, 59 ELEMS, 81 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; they 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 section you want, 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 users do not recognize this setting, they can push the TARGET RESET button, and a single scroll across the first line will inform them 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 changing a discrete values, such as E87W1, the up/down arrows can be used to scroll through the available choices. If changing a numerical variable, the digits change 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 at which the user selects 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, <**EXIT**> returns you to the default display.

PASSWORD

⚠ 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.

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 a new password, 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 whether the user 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 to remind 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 users do not recognize this setting, they can push the TARGET RESET button, and a single scroll across the first line will inform them 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 changing a discrete value, such as PROTO, the up/down arrows can be used to scroll through the available choices. If changing a numerical variable, change the digits 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 Bits

In more specific terms, local control asserts (sets to logical 1) or deasserts (sets to logical 0) what are called local bits LB1 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC control equations.

Local control can emulate the following switch types in Figure 8.2 through Figure 8.4.

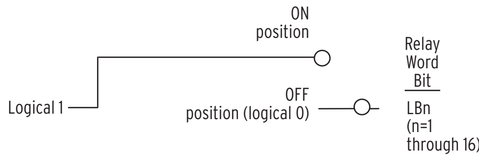


Figure 8.2: Local Control Switch Configured as an ON/OFF Switch

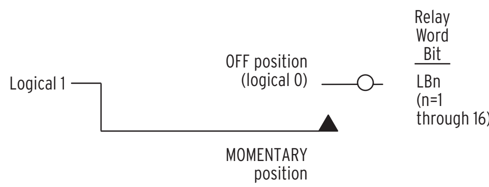


Figure 8.3: Local Control Switch Configured as an OFF/MOMENTARY Switch

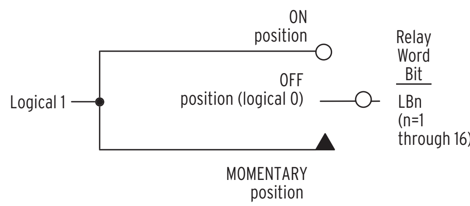


Figure 8.4: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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 P (Show Port 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 that 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:

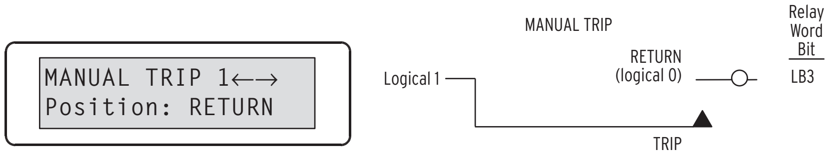
Local Bit	Label Settings	Function
LB3	NLB3 = MANUAL TRIP 1	trips breaker and drives reclosing relay to lockout
	CLB3 = RETURN	OFF position ("return" from MOMENTARY position)
	SLB3 =	ON position – not used (left "blank")
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE 1	closes breaker, separate 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)

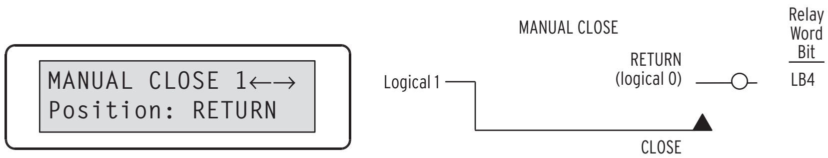
Access local control via the CNTRL pushbutton. If local control switches exist (i.e., corresponding switch position label settings were made), the following message displays with the rotating default display messages.

```
Press CNTRL for
Local Control
```

Press the CNTRL pushbutton, and the first set local control switch displays (shown here with factory default settings).

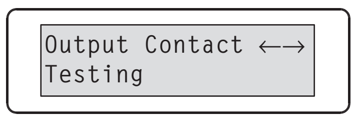


Press the right arrow pushbutton and scroll to the next set local control switch.



The MANUAL TRIP 1: RETURN/TRIP and MANUAL CLOSE 1: RETURN/CLOSE switches are both OFF/MOMENTARY switches (see Figure 8.4).

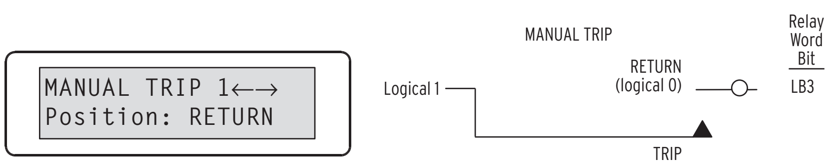
There are no more local control switches in the factory default settings. Press the right arrow pushbutton and scroll to the "output contact testing" function.



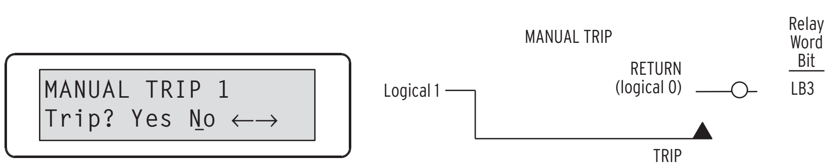
This front-panel function provides the same function as the serial port **PUL** command.

Operate Local Control (With Factory Settings)

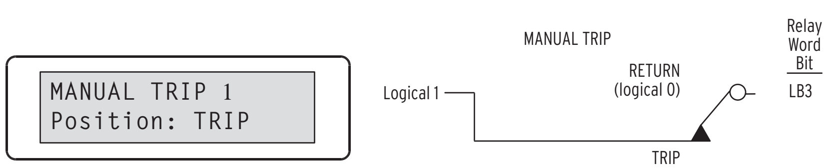
Press the right arrow pushbutton, and scroll back to the first set local control switch in the factory default settings.



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

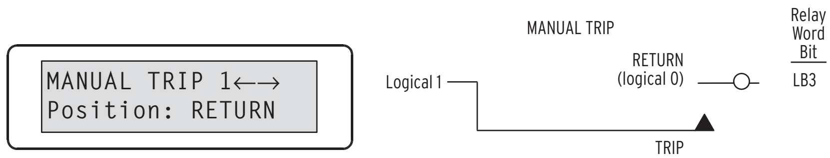


Scroll left with the left arrow button and then select “Yes.” The display then shows the new local control switch position.



Because this is an OFF/MOMENTARY type switch, the MANUAL TRIP 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 is shown to be in the TRIP position for two seconds (long enough to be seen), and then it returns to the RETURN position.

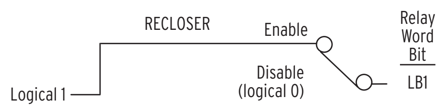


The MANUAL CLOSE 1 switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP 1 switch, and operates similarly.

Local Control State Retained When Relay De-energized

Local bit states are stored in nonvolatile memory, so when power to the relay is turned off, the local bit states are retained.

For example, suppose the local control switch with local bit output LB1 is configured as an ON/OFF type switch (see Figure 11.5).



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 again, 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 after the outage when power is restored.

Pulse Output Contacts

Use the control button **<CTRL>** to mimic the **PUL**se, **OPE**n, and **CLO**se serial port commands. This is useful during relay checkout, to verify that output contacts actually function in response to a command.

Under the **CTRL** menu, use local bit pushbutton functions to select whether to PULSE, CLOSE, or OPEN individual local bits. 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.

Because 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 output contacts 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 inquires whether you want 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, <u>and if SS1 through SS6 are not asserted or assigned</u>. 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-387E 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 through 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:

LEDA = OCA + 87E1 **LEDB** = OCB + 87E2 **LEDC** = OCC + 87E3

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. Otherwise, observers of the front-panel labels might be confused by seeing the LEDs lit for apparently no reason; determining why the LEDs are lit would be impossible without 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 that are of interest to the user.

Programmable Default Display Points

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-387E Relay is used.

There are 16 of these default displays available in the SEL-387E 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. Because 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-387E Relay front-panel display on a two-second rotation. They must not be longer than 16 characters. 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 = 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 de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

DP2 = IN102 = 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 = 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 de-energized 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.

FIGURES OF SELECTED FRONT-PANEL MENU STRUCTURES

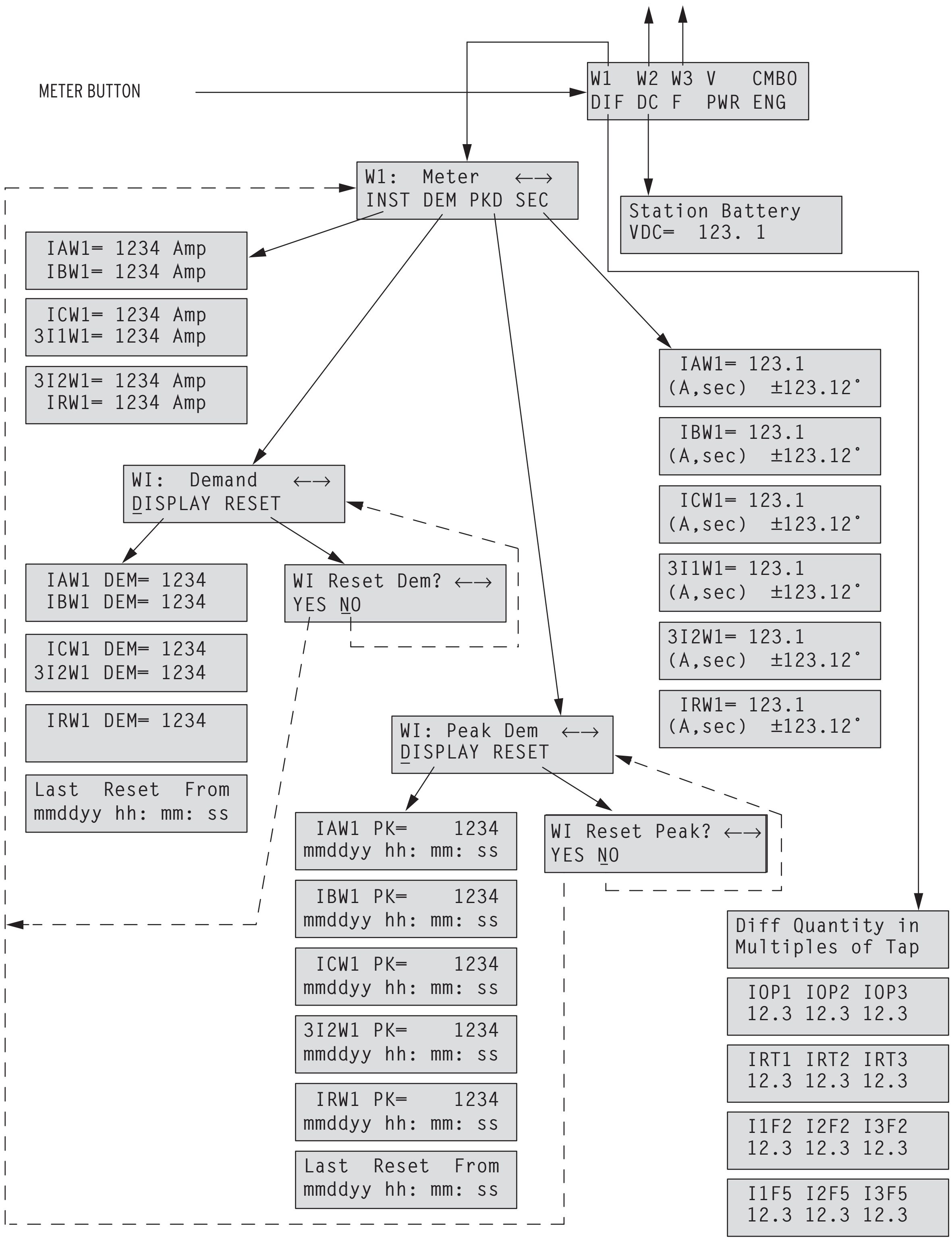


Figure 8.5: METER Menu and Display Structure

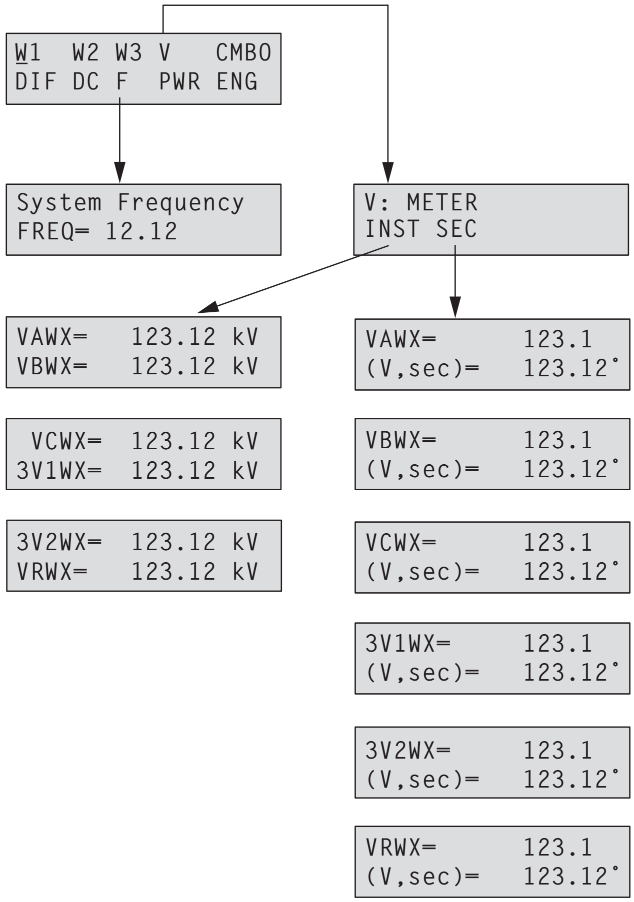


Figure 8.6: METER Menu and Display Structure (*continued*)

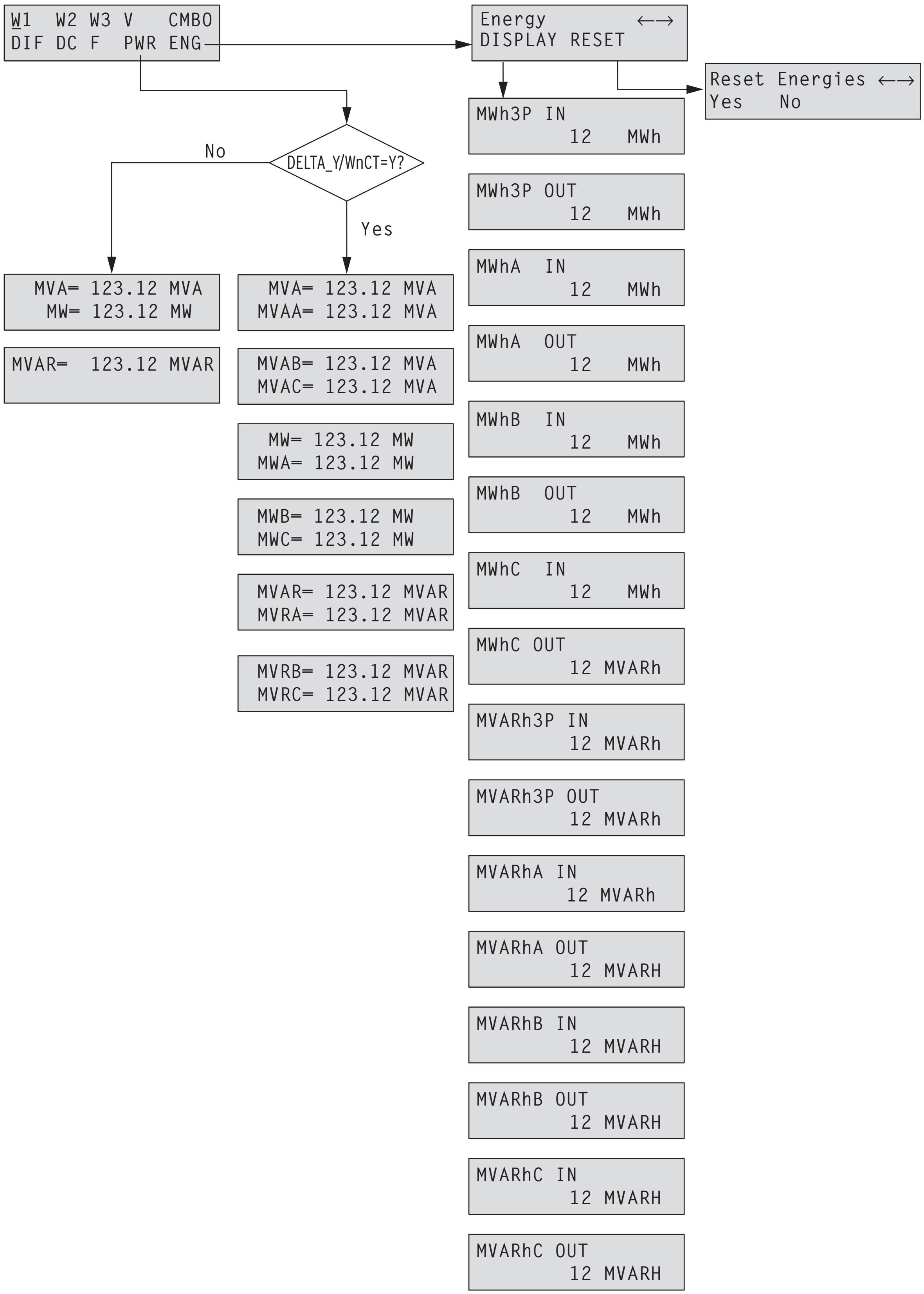
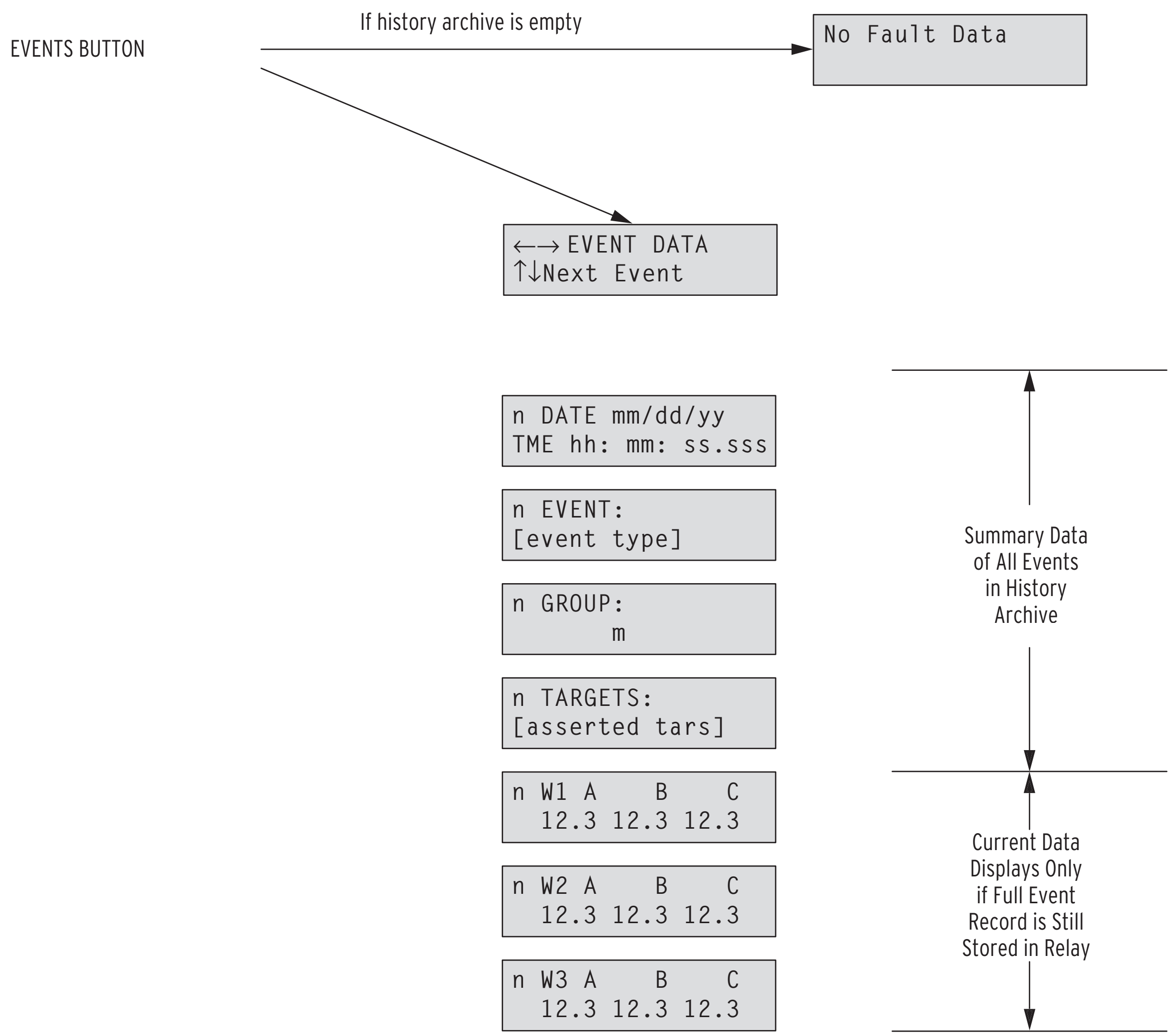


Figure 8.7: METER Menu and Display Structure (*continued*)



Where n = event number
m = group number

Note: If secondary currents > 99.9, drop the decimal place.

Figure 8.8: EVENTS Display Structure

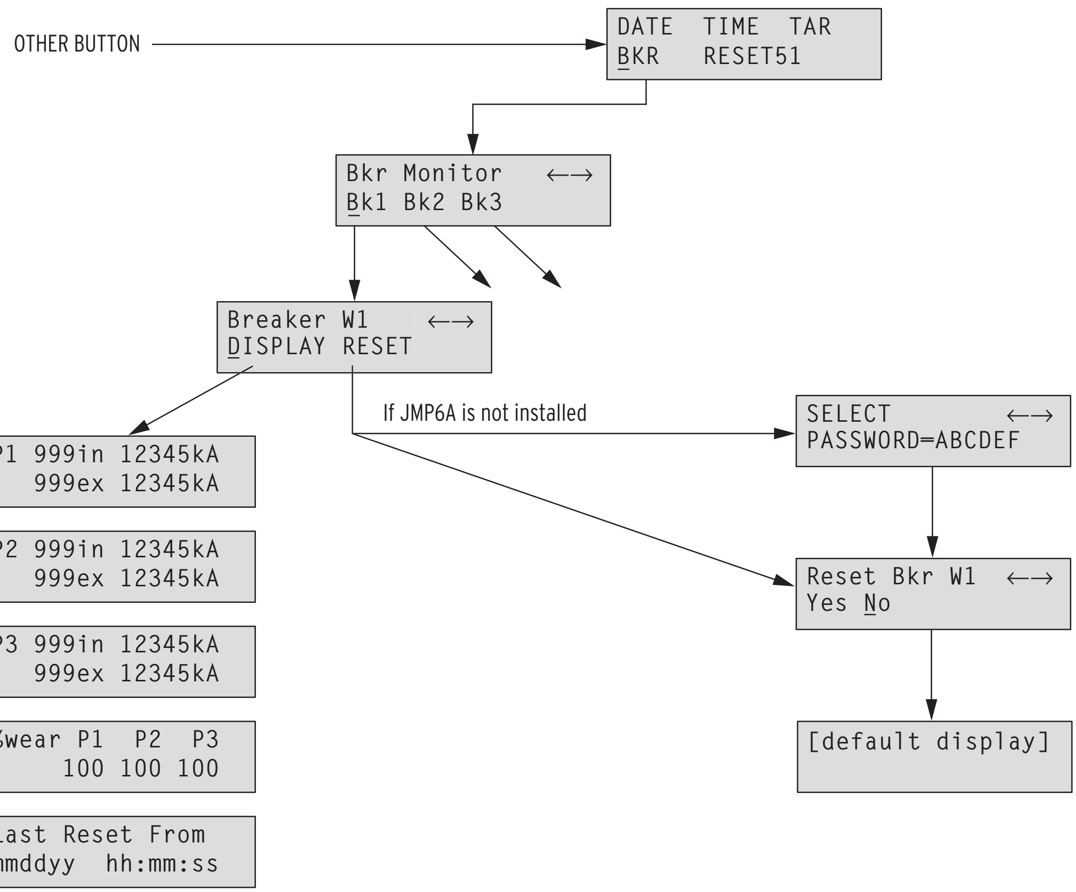


Figure 8.9: OTHER / BKR Menu and Display Structure

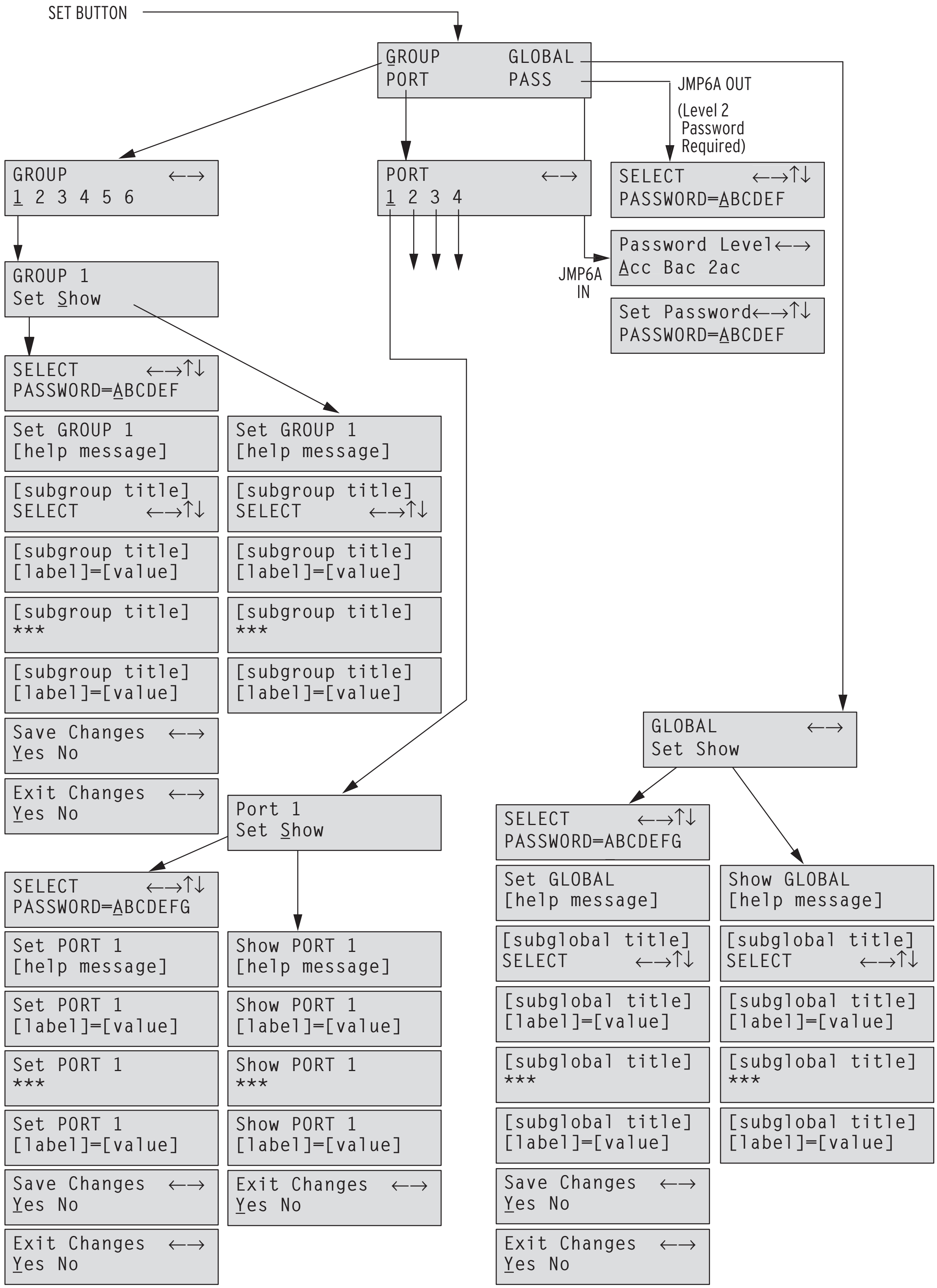


Figure 8.10: SET Menu and Display Structure

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SECTION 9: EVENT REPORTS AND SEQUENTIAL EVENTS REPORTING

INTRODUCTION

The SEL-387E Relay offers two styles of event reports:

- Standard 15-, 29-, 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-, 29-, or 60-cycle event reports by fixed and programmable conditions. These reports show information for 15, 29, 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:

LER	Number of Event Reports Saved
15	18–21
29	12–14
60	7

The number of events saved will be fewer if mixed lengths (e.g., LER = 60 for three event reports and then changed to LER = 29) 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-, 29-, OR 60-CYCLE EVENT REPORTS

Event Report Length (Settings LER and PRE)

The SEL-387E Relay provides user-programmable event report length and pre-fault length. Event report length is set at 15, 29, 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-, 29-, or 60-cycle event report when any of the following occurs:

- Relay Word bits TRIP1 through TRIP4 assert
- Relay Word bits CLS1 through CLS3 assert
- Programmable SELOGIC® control equation setting ER asserts to logical 1
- **PULSE** serial port/front-panel command executed for output contacts
- **TRIGGER** serial port command executed

Relay Word Bits TRIP1–TRIP4, CLS1–CLS3

Relay Word bits TRIPn (n = 1, 2, 3, or 4) would usually be assigned to an output contact for tripping a circuit breaker (e.g., setting OUT101 = TRIP1). SELOGIC control equation settings TRn initiate the Trip Logic and control the assertion of Relay Word bits TRIPn (see Figure 5.7). The Relay Word bit OCm (m = 1, 2, 3), initiated by the "Open breaker m" serial port command **OPE m** or the front-panel CNTRL/Open command, would normally be assigned to TRm.

Similarly, Relay Word bits CLSm (m = 1, 2, 3) would be assigned to an output contact for closing a circuit breaker (e.g., setting OUT105 = CLS1). SELOGIC control equation settings CLm initiate the Close Logic and control the assertion of Relay Word bits CLSm (see Figure 5.8). The Relay Word bit CCm, initiated by the "Close breaker m" serial port command **CLO m** or the front-panel CNTRL/Close command, would normally be assigned to CLm.

Any condition that is set to trip in setting TRn, or to close in setting CLm, does not have to be entered in SELOGIC control equation setting ER. The assertion of Relay Word bit TRIPn or CLSm automatically triggers a standard 15-, 29-, or 60-cycle event report.

Programmable SELOGIC Control Equation Setting ER

The SELOGIC control equation setting ER is set to trigger standard 15-, 29-, or 60-cycle event reports for conditions other than tripping or closing conditions already listed in settings TRn or CLm. 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, whichever pickup asserts first will trigger a standard 15-, 29-, 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 **PUL** serial port/front-panel command is used to assert the output contacts for testing purposes or for remote control. If an output contact is asserted with the **PUL** command, a standard 15-, 29-, or 60-cycle event report is also generated. Because 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 **TRI** serial port command is to generate standard 15-, 29-, 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 the serial port commands **TRI** and **PUL**.

Standard Event Report Summary

Each time the relay generates a standard 15-, 29-, 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 three (3) current winding inputs
- Phase (VA, VB, VC) voltage inputs
- Percent volts/hertz

This event summary information is also contained in the corresponding standard 15-, 29-, or 60-cycle event report. The identifiers, date, and time information is at the top of the standard 15-, 29-, 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: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding 2 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding 3 Currents (A Sec), ABC:   123.1   123.1   123.1
Winding X Voltages (V Sec), ABC:   123.1   123.1   123.1
Volts/Hertz Percent:   123.1
=>>
```

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 99 event summaries are stored in nonvolatile memory and are accessed by the **HIS** command. The **HIS C** command clears the event summaries and corresponding full-length standard event reports from nonvolatile memory. See ***HIS (History of Events)*** and ***HIS C (Clear History and Events)*** 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
CLS1	Assertion of Relay Word bit CLS1
CLS2	Assertion of Relay Word bit CLS2
CLS3	Assertion of Relay Word bit CLS3
ER	SELOGIC control equation setting ER
PULSE	Execution of **PUL** serial port command
TRIG	Execution of **TRI** 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, 24, 50/51, 81, A, B, C, N, W1, W2, and W3.

Winding Currents

The "Winding n Currents (A Sec), ABC:" (n = 1, 2, or 3) field shows each winding input current present in the event report row containing the maximum secondary phase current. The standard 15-, 29-, 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 three (3) winding inputs are:

Phase (A = channel IA, B = channel IB, C = channel IC)

Voltages

The "Winding n Voltages (V Sec), ABC:" (n = 1, 2, or 3) field shows each winding input voltage present in the event report row containing the maximum secondary phase current. The standard 15-, 29-, or 60-cycle event report will mark the reference row used in the summary report with an asterisk. The listed voltages for each of the three (3) winding inputs are:

Phase (A = channel VA, B = channel VB, C = channel VC)

Percent Volts/Hertz

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.

Serial Port Command	Format
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 three current winding inputs and secondary phase voltages for the voltage winding inputs, as well as the status of the eight digital outputs and six optoisolated inputs.

Use the **EVE** command to retrieve winding event reports. There are several options for customizing 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 Display x samples per cycle (4 or 8); defaults to 4 if not listed.

Ly Display y cycles of data (1 to LER); defaults to LER if not listed.

Ly- Display from cycle y to end of report.

Ly-w Display 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; it was retrieved with the **EVE<ENTER>** command.

```
=>>EVE<ENTER>

XFMR 1                              Date: MM/DD/YY  Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D

Winding 1        Winding 2        Winding 3       Winding X          OUT  IN
    Amps Sec         Amps Sec         Amps Sec        Volts Sec      1357 135
 IAW1  IBW1  ICW1  IAW2  IBW2  ICW2  IAW3  IBW3  ICW3  VAWX  VBWX  VCWX  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  .... ...
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 [2]
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 [15]
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+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
Targets: TRIP INST 87-1 87-2 87-3 24 81 A B C N W1 W2 W3 50/51
Winding 1 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 2 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 3 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding X Voltages (V Sec), ABC:  123.1   123.1   123.1
Volts/Hertz Percent:  123.1
=>>
```

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 Z21. 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)
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)
VAWX	Voltage measured by Winding x input channel VA (Volts, secondary)
VBWX	Voltage measured by Winding x input channel VB (Volts, secondary)
VCWX	Voltage measured by Winding x input channel VC (Volts, 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

Column Heading	Symbol	Definition
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 overcurrent elements (instantaneous, definite-time and inverse-time overcurrent phase, single-phase, calculated residual, and negative-sequence overcurrent elements), combined current overcurrent elements, voltage and frequency elements, dc battery monitor, and the demand current thresholds (phase, calculated residual, and negative-sequence for each of the three winding inputs). The status of the Relay Word bits TRIPn (n = 1, 2, 3, and 4), as well as the status of the eight digital outputs and six optoisolated inputs, is also included.

Use the **EVE D** command to retrieve digital event reports. There are several options for customizing 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 Display x samples per cycle (4 or 8); defaults to 4 if not listed.

Ly Display y cycles of data (1 to LER); defaults to LER if not listed.

Ly- Display from cycle y to end of report.

Ly-w Display 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; it was retrieved with the **EVE D<ENTER>** command.

```
=>>EVE D<ENTER>

XFMR 1                                  Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D

     Overcurrent Elements               Voltage/Freq
Winding 1    Winding 2    Winding 3       Elements             D
5        5   5        5   5        5   5  2  2  5    8   T     E      O
O        1   O        1   O        1   1  4  7  9    1   R  D  M      U    I
PPABCNNQQPNQ PPABCNNQQPNQ PPABCNNQQPNQ PN DC PVPPVPGQ    P  C  PPNNQQ T    N
123331212    123331212    123331212    CC 12  1P 1P  135 13 13 131313 1357 135
  444          444          444        11            246 24 24 2 2 2  246A 246
[1]
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Event: TRIP1 TRIP2 TRIP3 TRIP4

Targets: TRIP INST 87-1 87-2 87-3 24 81 A B C N W1 W2 W3 50/51
Winding 1 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 2 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 3 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding X Voltages (V Sec), ABC:  123.1   123.1   123.1
Volts/Hertz Percent: 123.1
=>>
```

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 1 .	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 1 .	51N1 asserted 51N1T asserted Timing to reset (51N1RS=Y) Timing to reset after 51N1T assertion (51N1RS=N) 51N1R asserted
Wdg 1 51Q	p T r 1 .	51Q1 asserted 51Q1T asserted Timing to reset (51Q1RS=Y) Timing to reset after 51Q1T assertion (51Q1RS=N) 51Q1R asserted

Column Heading	Symbol	Definition
Use same logic for overcurrent elements in Wdg 2 and Wdg 3.		
51PC1	p T r 1 .	51PC1 asserted 51PC1T asserted Timing to reset (51PC1RS=Y) Timing to reset after 51PC1T assertion (51PC1RS=N) 51PC1R asserted
51NC1	p T r 1 .	51NC1 asserted 51NC1T asserted Timing to reset (51NC1RS=Y) Timing to reset after 51NC1T assertion (51NC1RS=N) 51NC1R asserted
24D1	1 D	24D1 element picked up 24D1 element picked up; timer timed out on pickup time; timer output 24D1T asserted
24C2	2 C r	24C2 element picked up and timing 24C2 element timed out 24C2 element fully reset
27P	1 2 b	L 1 instantaneous phase undervoltage element picked up L 2 instantaneous phase undervoltage element picked up Both Level 1 and Level 2 phase undervoltage elements picked up
27V1	V	27V1 positive-sequence undervoltage element picked up
27PP	1 2 b	Level 1 phase-to-phase undervoltage element picked up Level 2 phase-to-phase undervoltage element picked up Both Level 1 and Level 2 phase-to-phase undervoltage elements picked up
59P	1 2 b	L 1 instantaneous phase overvoltage element picked up L 2 instantaneous phase overvoltage element picked up Both Level 1 and Level 2 phase overvoltage elements picked up
59V1	V	Positive-sequence instantaneous overvoltage element 59V1 picked up
59PP	1 2 b	Level 1 phase-to-phase instantaneous overvoltage element picked up Level 2 phase-to-phase instantaneous overvoltage element picked up Both phase-to-phase instantaneous overvoltage elements picked up

Column Heading	Symbol	Definition
59G	1 2 b	Level 1 instantaneous residual overvoltage element picked up Level 2 instantaneous residual overvoltage element picked up Both Level 1 and Level 2 residual overvoltage elements picked up
59Q	Q	Negative-sequence instantaneous overvoltage element 59Q picked up
81D 12	1 2 b	Frequency element 81D1 asserted Frequency element 81D2 asserted Both frequency elements asserted
81D 34	3 4 b	Frequency element 81D3 asserted Frequency element 81D4 asserted Both frequency elements asserted
81D 56	5 6 b	Frequency element 81D5 asserted Frequency element 81D6 asserted Both frequency elements 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
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
DEM P12	1 2 b	PDEM1 asserted PDEM2 asserted PDEM1 and PDEM2 asserted
DEM P3	3	PDEM3 asserted
DEM N12	1 2 b	NDEM1 asserted NDEM2 asserted NDEM1 and NDEM2 asserted
DEM N3	3	NDEM3 asserted

Column Heading	Symbol	Definition
DEM Q12	1 2 b	QDEM1 asserted QDEM2 asserted QDEM1 and QDEM2 asserted
DEM Q3	3	QDEM3 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 restricted earth fault function, the Relay Word bits TRIPn (n = 1, 2, 3, and 4), 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 **EVE 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 Display 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 Display x samples per cycle (4 or 8); defaults to 4 if not listed.

Ly Display y cycles of data (1 to LER); defaults to LER if not listed.

Ly- Display from cycle y to end of report.

Ly-w Display 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; it was retrieved with the **EVE DIF1<ENTER>** command.

```
=>>EVE DIF1<ENTER>

XFMR 1                                Date: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-Z-D
                             Differential       Set 1  Set 2  Set 3
    Differential Quantities  87   87B HB  TR TRP    LT     LT         OUT  IN
       Multiples of TAP      R            HE 13 VVVV13 VVVV13 VVVVVVVV 1357 135
   IOP1   IRT1   I1F2   I1F5 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
Targets: TRIP INST 87-1 87-2 87-3 24 81 A B C N W1 W2 W3 50/51
Winding 1 Currents (A Sec), ABC: 123.1 123.1 123.1
Winding 2 Currents (A Sec), ABC: 123.1 123.1 123.1
Winding 3 Currents (A Sec), ABC: 123.1 123.1 123.1
Winding X Voltages (V Sec), ABC: 123.1 123.1 123.1
Volts/Hertz Percent: 123.1
=>>
```

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)
I1F2	Second-harmonic current for differential element 1 (multiples of tap)
I1F5	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 El 87RU	R U b	87R asserted 87U asserted 87R and 87U asserted
Dif El 87 1	R U b	87R1 asserted 87U1 asserted 87R1 and 87U1 asserted
Dif El 87 2	R U b	87R2 asserted 87U2 asserted 87R2 and 87U2 asserted
Dif El 87 3	R U b	87R3 asserted 87U3 asserted 87R3 and 87U3 asserted
Dif El 87B 1	1 .	87BL1 asserted 87BL1 not asserted
Dif El 87B 2	1 .	87BL2 asserted 87BL2 not asserted
Dif El 87B 3	1 .	87BL3 asserted 87BL3 not asserted
Dif El HB 1	2 5 b	2HB1 asserted 5HB1 asserted 2HB1 and 5HB1 asserted
Dif El HB 2	2 5 b	2HB2 asserted 5HB2 asserted 2HB2 and 5HB2 asserted
Dif El HB 3	2 5 b	2HB3 asserted 5HB3 asserted 2HB3 and 5HB3 asserted

Column	Symbol	Definition
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
TRP 34	3 4 b	TRIP3 asserted TRIP4 asserted TRIP3 and TRIP4 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

Column	Symbol	Definition
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)
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 three winding inputs, secondary phase voltages for one of the three windings, as well as the status of the eight digital outputs and six optoisolated inputs. The SEL-387E 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 viewing of the samples before digital filtering occurs.

Use the **EVE R** command to retrieve raw winding event reports. There are several options for customizing 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** Display x samples per cycle (4, 8, 16, 32, or 64); defaults to 16 if not listed.
- **Ly** Display y cycles of data (1 to LER); defaults to LER if not listed.
- **Ly-** Display from cycle y to end of report.
- **Ly-w** Display 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; it 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.

```
EVE R S4<ENTER>

XFMR 1                                  Date: MM/DD/YY  Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D

Winding 1         Winding 2         Winding 3        Winding X          OUT  IN
    Amps Sec          Amps Sec          Amps Sec         Volts Sec       1357 135
 IAW1  IBW1  ICW1  IAW2  IBW2  ICW2  IAW3  IBW3  ICW3  VAWX  VBWX  VCWX  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  .... ...
[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
Targets: TRIP INST 87-1 87-2 87-3 24 81 50/51 A B C N W1 W2 W3
Winding 1 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 2 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding 3 Currents (A Sec), ABC:  123.1   123.1   123.1
Winding X Voltages (V Sec), ABC:  123.1   123.1   123.1
Volts/Hertz Percent: 123.1
=>>
```

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 Z21. 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)
VAWX	Voltage measured by Winding x input channel VA (Volts, secondary)
VBWX	Voltage measured by Winding x input channel VB (Volts, secondary)
VCWX	Voltage measured by Winding x input channel VC (Volts, 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 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

Compressed ASCII Event Reports

The SEL-387E Relay provides Compressed ASCII event reports to facilitate event report storage and display. The SEL-2020 or 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 relate 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.

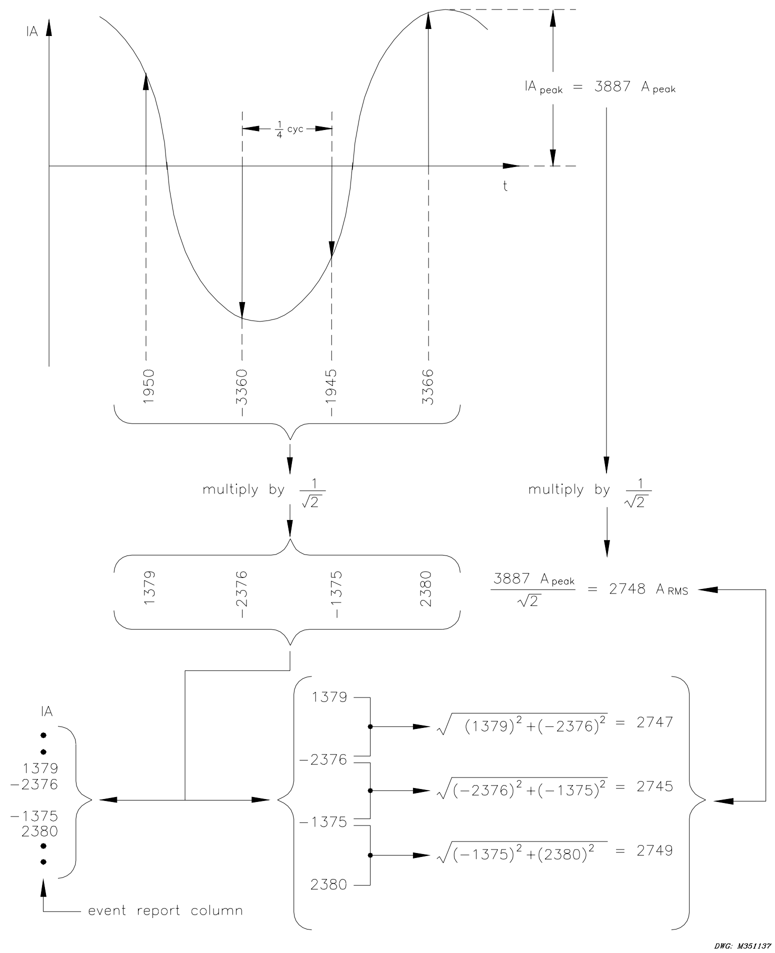

Figure 9.6: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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; therefore, 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. Because 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 IA_{peak} times 1/sqrt(2) = 3887 • 0.707 = 2748 A.

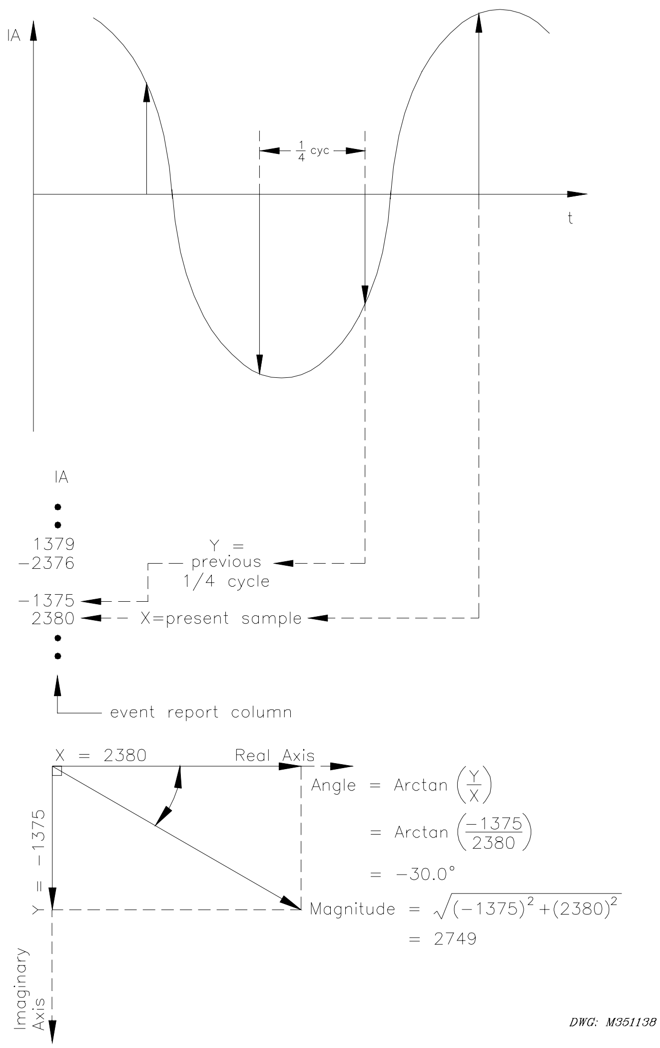

Figure 9.7: Derivation of Phasor RMS Current Values From Event Report Current Values

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 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 A ∠-30.0°

The present sample (IA = 2380 A) is a real RMS current value that relates to the phasor RMS current value:

2749 A • cos(-30.0°) = 2380 A

A calculation of the phasor using the previous pair, X = -1375 and Y = -2376, yields a calculation of:

IA = 2745 A $\angle$-120.0°

Thus, the phasor rotates in a counter-clockwise 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: MM/DD/YY    Time: HH:MM:SS.SSS
STATION A

FID=SEL-387E-R-V-D
#      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 5.7 to 5.9. 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, then a space, then the desired name, which can contain any combination of 15 letters, numbers, and underscores. 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 only consist of letters (capital or lower-case), numbers, and the underscore character; they cannot contain spaces or any other type of character.

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 as many as 24 elements (Relay Word bits from Tables 5.7 to 5.9). Thus, as many as 96 total elements can be monitored for SER event report row triggering.

You can make SER settings 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. Reverse 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 precedes 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

The process of clearing SER event reports may take up to 30 seconds under normal operation or longer if the relay is busy processing a fault or protection logic.

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

Use this section for determining and establishing test routines for the SEL-387E Relay. This section includes discussions on testing philosophies, methods, and tools. It also shows example test procedures for metering, overcurrent elements, differential elements, and harmonic blocking functions. Relay troubleshooting procedures are 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 by the complexities of the tests.

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 and voltages presented to the relay in primary values. Compare these quantities against other devices of known accuracy.
METER SEC Command	The **METER SEC** command shows the currents, voltages, and phase angles presented to the relay in secondary 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-387E Relay has a low-level test interface between the calibrated input module and the separately calibrated processing module. You may test the relay in either of two ways: by applying ac current and voltage 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.

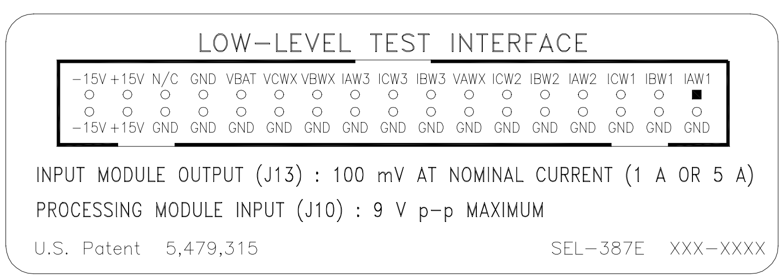
⚠ CAUTION	The relay contains devices that are sensitive to electrostatic discharge. When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.

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. M387E001

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, and 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. Reset these targets 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 that 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. Source of variable three-phase voltage adjustable from 40 to 70 Hz
7. Ohmmeter or contact opening/closing sensing device

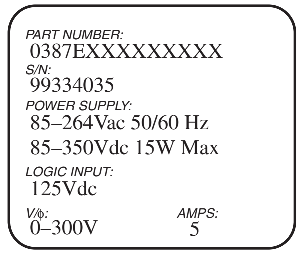
Initial Checkout

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: M387E017

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 equal 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 and press **<ENTER>** [see ***PAS (PASSWORDS)*** in ***Section 7: Serial Port Communications and Commands*** for a table of factory default passwords]. 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>**. A display similar to the screen capture following 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.) To view a relay status report, see the example following the discussion of ***Status Reporting Function*** in ***Section 5: Metering and Monitoring***.

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: Settings the Relay*** includes a complete description of the settings.

Outputs

Step 1. Purpose: Verify that output contacts 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 output contacts, 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 the 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 (TAR F)** command to display the appropriate output elements.

Step 2. Purpose: Verify that 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 output contacts 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 (TAR 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 that the corresponding target LED turns on.
3. Repeat this step for each input. Use the **TARGET F (TAR F)** command to display the appropriate output elements.

Metering

Current Metering

Step 1. Purpose: Connect simulated power system secondary current sources to the relay.

Method: Turn relay power off 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:

a. Connect the A-phase and B-phase current sources to the dotted A and B current input terminals.

b. Connect both undotted A and B current input terminals to the undotted C current input terminal.

c. 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 ±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, then all three phases have the same angle. If 3I2 equals three times the applied current, then the phase rotation is reversed. Turn the current sources off.

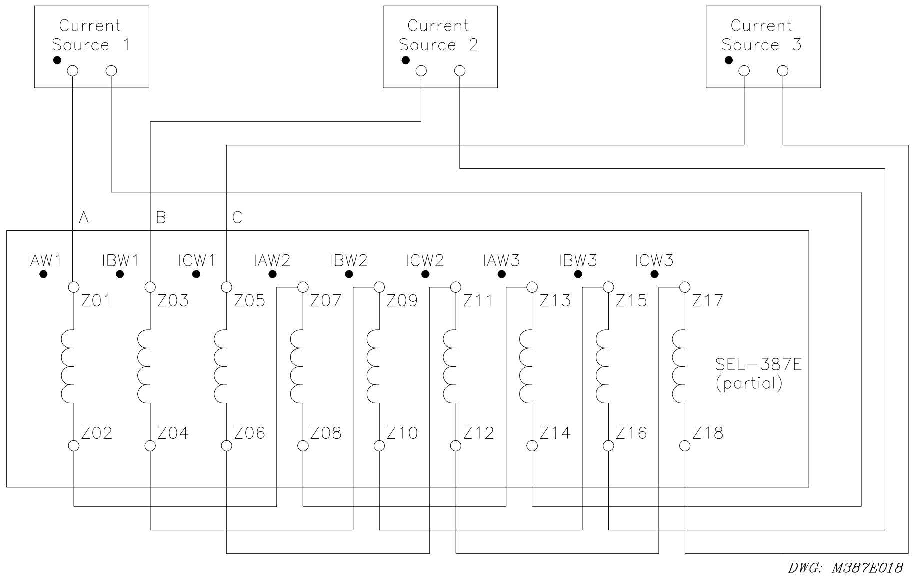


Figure 10.3: Test Connections for Balanced Load With Three-Phase Current Sources

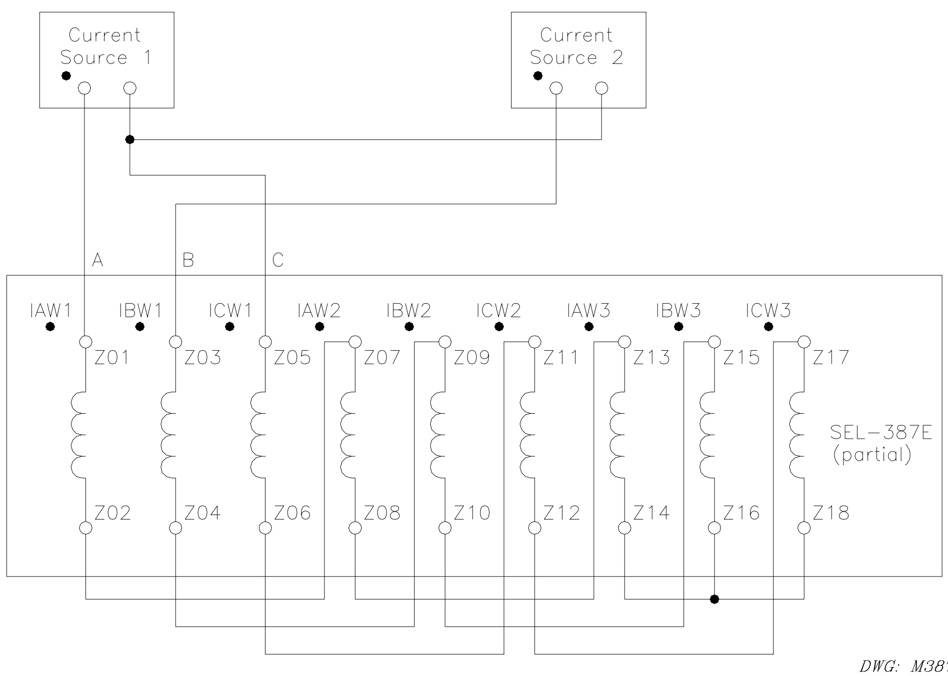


Figure 10.4: Test Connections for Balanced Load With Two-Phase Current Sources

Voltage Metering

Step 1. Purpose: Connect simulated power system secondary voltage sources to the relay.

Method: Connect a source of variable three-phase voltage to the relay as shown in Figure 10.5. Set the voltage sources to deliver 67 Volts with A-phase at 0 degrees, B-phase lagging A-phase by 120 degrees, and C-phase leading A-phase by 120 degrees.

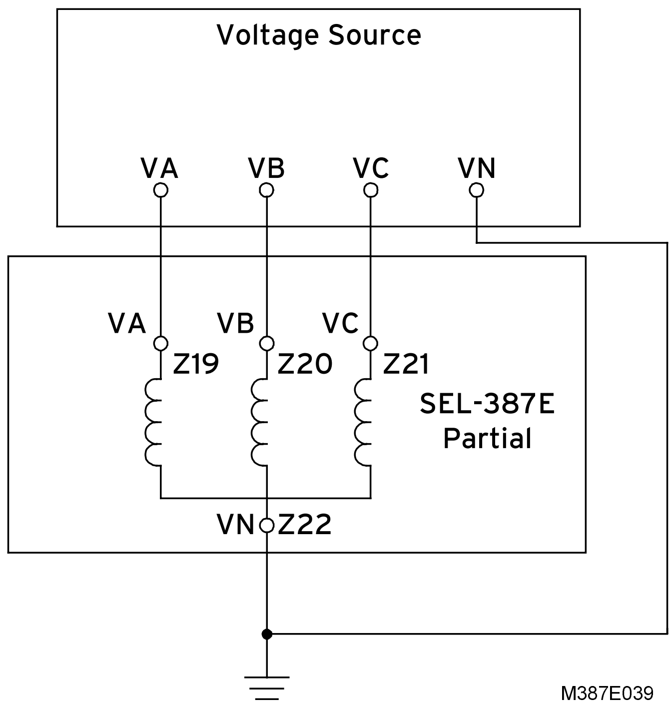


Figure 10.5: Voltage Test Connection

Step 2. Purpose: Verify correct voltage levels.

Method: Turn relay power on, and use the **METER** command to measure the voltages applied in Step 1. With applied voltages of 67 Volts per phase and a voltage transformer ratio of 2000:1 (**SHO PTR <ENTER>** displays the PT ratios, **<CTRL> X** cancels scrolling), the displayed line voltages should be the applied voltage, 134 kV ±2 kV and ±5% of applied voltage times PTR.

Step 3. Purpose: Verify phase rotation.

Method: Verify that residual (VRWx) and negative-sequence (3V2Wx) quantities are approximately zero. If VRWx equals three times the applied voltage, then all three phases have the same angle. If 3V2Wx equals three times the applied voltage, then the phase rotation is reversed.

Frequency Metering

Step 1. Purpose: Verify frequency metering.

Method: Use the **METER** command to measure the frequency applied in Voltage Metering Step 1. The displayed frequency should equal the applied frequency ±0.01 Hz.

Volts/Hertz Metering

Step 1. Purpose: Verify volts/hertz metering

Method: Use the **METER** command to measure the volts/hertz applied in Voltage Metering Step 1. The displayed volts/hertz should equal the following ±1%:

$$\text{Volts / Hertz} = \frac{\sqrt{3} \bullet V_{sec} \bullet \text{PTR} \bullet \text{NFREQ}}{10 \bullet \text{freq} \bullet V_{nom}}$$

V_{sec}	=	Secondary Voltage (applied)
PTR	=	Potential transformer ratio (Setting)
Freq	=	Frequency (applied)
NFREQ	=	Nominal Frequency (Setting)
V_{nom}	=	Nominal Voltage in kV (Setting)

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, and EOC3 settings for Windings 1, 2, and 3, respectively. Setting these to “Y” enables the overcurrent elements 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 **SHOWSET** 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-387E 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 10.6. 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 ±5% of the setting ±0.02 I_{nom} (negative-sequence elements are ±6% of the setting ±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.

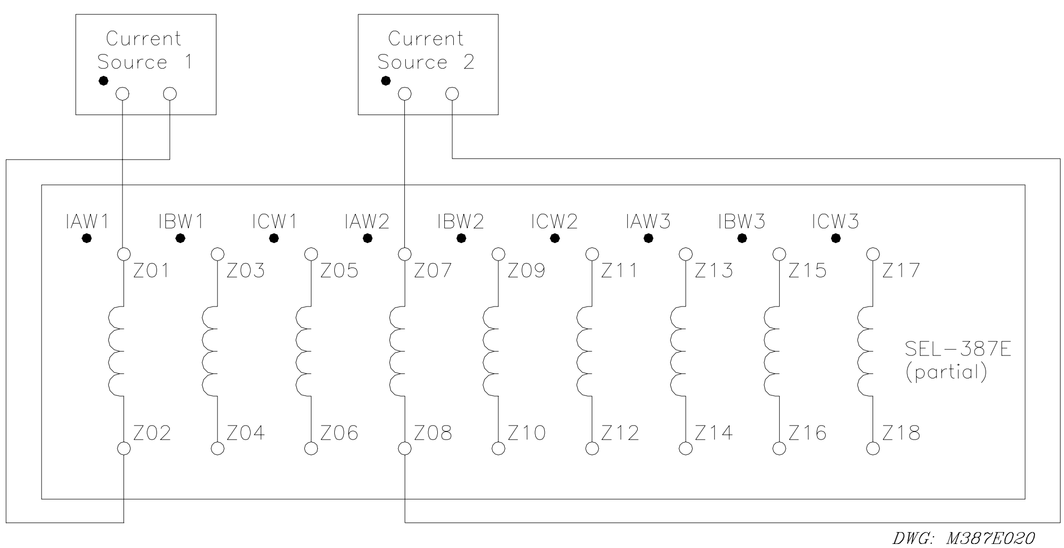


Figure 10.6: Test Connections for Two Single-Current Test Sources

Table 10.1: Instantaneous Overcurrent Elements and Corresponding Settings

	Winding 1		Winding 2		Winding 3	
	Bit	**Setting**	**Bit**	**Setting**	**Bit**	**Setting**
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P
Phase Level 2	50P12	50P12P	50P22	50P22P	50P32	50P32P
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P
A-Phase Level 3	50A13	50P13P	50A23	50P23P	50A33	50P33P
B-Phase Level 3	50B13		50B23		50B33	
C-Phase Level 3	50C13		50C23		50C33	
Phase Level 3	50P13		50P23		50P33	
A-Phase Level 4	50A14	50P14P	50A24	50P24P	50A34	50P34P
B-Phase Level 4	50B14		50B24		50B34	
C-Phase Level 4	50C14		50C24		50C34	
Phase Level 4	50P14		50P24		50P34	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P
Residual Level 2	50N12	50N12P	50N22	50N22P	50N32	50N32P
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P
Neg-Seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P
Neg-Seq Level 2	50Q12	50Q12P	50Q22	50Q22P	50Q32	50Q32P
Neg-Seq Inverse-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P

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 **SHOWSET** 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, Overcurrent, Voltage, and Frequency 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):

$$tp = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1} \right)$$

$$tp = 2.33 \text{ seconds}$$

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 • M = 6.6 A for this example).

Method: Connect a single-current test source as shown in Figure 10.6. 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 sequential events records. 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 sequential events 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	
	Bit	**Setting**	**Bit**	**Setting**	**Bit**	**Setting**
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P
Definite-Time	50P11T	50P11D	50P21T	50P21D	50P31T	50P31D
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P
Curve		51P1C		51P2C		51P3C
Time-Dial		51P1TD		51P2TD		51P3TD
Time-Out	51P1T		51P2T		51P3T	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P
Definite-Time	50N11T	50N11D	50N21T	50N21D	50N31T	50N31D
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P
Curve		51N1C		51N2C		51N3C
Time-Dial		51N1TD		51N2TD		51N3TD
Time-Out	51N1T		51N2T		51N3T	
Neg-seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P
Definite-Time	50Q11T	50Q11D	50Q21T	50Q21D	50Q31T	50Q31D
Neg-seq Inv-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P
Curve		51Q1C		51Q2C		51Q3C
Time-Dial		51Q1TD		51Q2TD		51Q3TD
Time-Out	51Q1T		51Q2T		51Q3T	

Phase Overcurrent Elements

The SEL-387E 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 exceeds 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 outlined earlier in this section.

Negative-Sequence Overcurrent Elements

The SEL-387E 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:

I2 = (A-phase + B-phase (shifted by -120°) + C-phase (shifted by 120°))/3

This means that if balanced positive-sequence currents are applied to the relay, the relay reads:

I2 = 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:

I2 = (1 + 0 (shifted -120°) + 0 (shifted 120°))/3 = 1/3 (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 outlined earlier in this section.

Residual Overcurrent Elements

The SEL-387E 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_0 = (A-phase + B-phase + C-phase)/3 (all angles are considered as well)

This means that if balanced positive-sequence currents are applied to the relay, the relay reads I_0 = 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_0 = (1 + 0 (shifted 120°) + 0 (shifted -120°))/3 = 1/3 (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 outlined earlier 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). 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. For an alternate way of testing, use the relay serial port to set the 51P1TC to 1 (always asserted) or 0 (always deasserted), 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-387E 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-387E 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-387E Relay has one set of combined overcurrent elements. Set EOCC = Y to enable this set, which uses the sum of currents from Windings 1 and 2. The 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. This set consists of units 51PC1 and 51NC1.

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 10.6, with two sources delivering current to the same phase of Windings 1 and 2.

The test below is for element 51PC1, using 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 **SHOWSET** 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, Overcurrent, Voltage, and Frequency 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):

$$tp = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1} \right)$$

$$tp = 2.33 \text{ seconds}$$

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. 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 10.6. Set the IAW1 current at some fixed value, such as 10 A at angle zero degrees. Set the IAW2 current at 10 A at 180 degrees. Because 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 equals 10 - 51PC1P. After verifying pickup, increase IAW2 back to 10 A. 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 10 - M • 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 sequential events records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings are 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 sequential events records.

Step 5. Purpose: Repeat the test for 51NC1.

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 winding. 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 = 0.5 A.

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/CTR3 is not more than 2.0, where CTRmax is the larger of CTR1 and CTR3. Using the default CT ratio settings, CTRmax = CTR3, so the ratio CTRmax/CTR3 = 1. Therefore, the 50GP setting can remain at 0.5A.

If the ratio CTRmax/CTR3 is greater than 2.0, set 50GP equal to 0.25 A times the actual ratio of CTRmax/CTR3.

Step 1. Purpose: Determine the expected time delay for the restricted earth fault function.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the element settings (i.e., **SHO E321<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, Overcurrent, Voltage, and Frequency 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 IRW3 current is used for the time curve calculation. Setting IRW3 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:

$$tp = TD \bullet \left(0.0352 + \frac{5.67}{M^2 - 1} \right)$$

$$tp = 0.963 \text{ seconds}$$

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., 50G3, 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 10.6, but with Source Current 2 connected to one of the Winding 3 inputs (e.g., IAW3). Set the IAW1 current magnitude to:

$$IAW1 \geq 2 \bullet 50GP \bullet \frac{CTR3}{CTR1}$$

Using the default CT ratios, IAW1 should be set to at least 2 • 0.5 A • 400/120, or 3.33 A. Set the magnitude of IAW1 to 4 A; set the angle of IAW1 to 180 degrees.

Set the IAW3 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 50G3, 32IR, 32IF, and REFP are all in this row. With the currents applied as above, 50G3 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 IAW3. The REF element should function. Verify this as follows:

Execute the **TAR 21** command again. 50G3 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. (50G3 will have remained asserted from earlier in the test, since no change was made to the IAW3 current.) **SER C** clears the SER records.

Differential

The SEL-387E Relay has several components to its differential element. Figure 10.7 gives a representation of the differential characteristic and the plot of each test. Each test only uses Winding 1 and 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, and E87W3 settings. Set each setting equal to "Y" to enable the corresponding differential element.

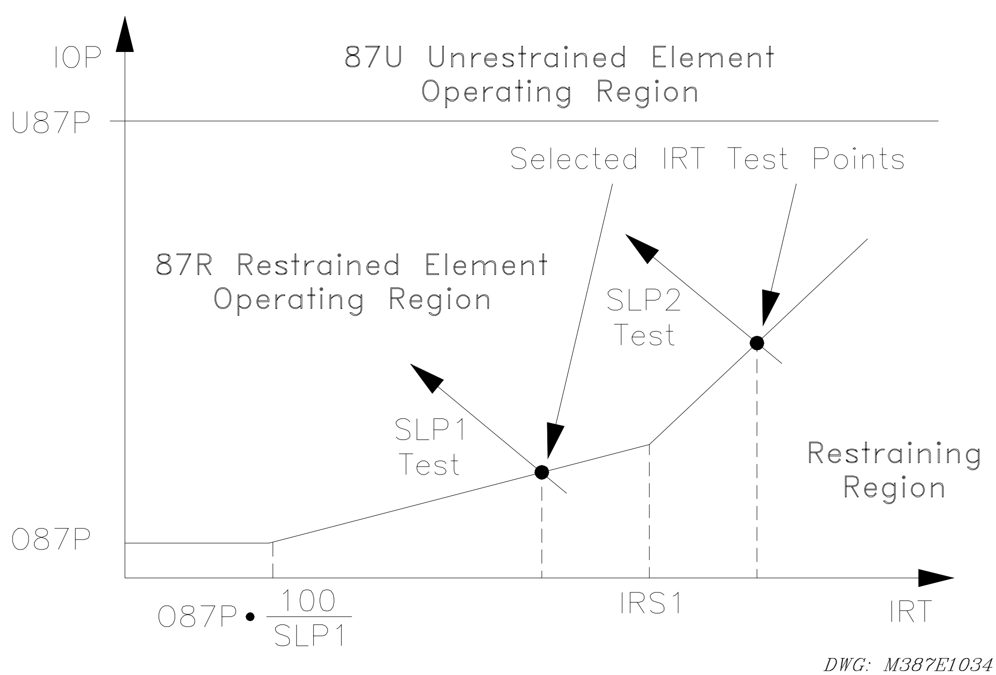


Figure 10.7: Percentage Restraint Differential Characteristic

U87P Unrestrained Differential Element

Step 1. Purpose: Verify the expected unrestrained differential element pickup setting.

Method: Execute the **SHOWSET** 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, or TAP3 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC, W2CTC, and W3CTC 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 • I_{nom}. For this test, you may want 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-387E 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 10.6. 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, ±5% ±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 **SHOWSET** 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, or TAP3 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC, W2CTC, and W3CTC 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-387E 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 10.6. 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, ±5% ±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-387E 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 10.7.

Method: Decide where you want to cross the differential characteristic by picking a restraint value IRT, which is a vertical line on the graph. Because 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.

$$O87P \bullet \frac{100}{SLP1} < IRT < IRS1$$

The value of IOP corresponding to the selected IRT equals the following:

$$IOP = \frac{SLP1}{100} \bullet IRT$$

Both IRT and IOP are in multiples of tap.

Step 4. Purpose: Calculate the expected current for Windings 1 and 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:

$$IAW1 = IRT \bullet \left(1 + \frac{SLP1}{200}\right) \bullet TAP1 \bullet A$$

Calculate the Winding 2 current for the test using the following formula:

$$IAW2 = IRT \bullet \left(1 - \frac{SLP1}{200}\right) \bullet TAP2 \bullet A$$

The A connection compensation constant is based on Table 10.3. Because 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 $3 \bullet I_{nom}$. 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:

$$IAW2 = IAW1 \bullet \frac{TAP2}{TAP1}$$

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 10.6. 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 ±5% ±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 $\frac{100}{\text{SLP1}} \bullet 087\text{P}$ 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-387E 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 10.7.

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.

IRT > IRS1

The value of IOP that corresponds to the selected IRT is as follows:

$$\text{IOP} = \frac{\text{SLP2}}{100} \bullet \text{IRT} + \text{IRS1} \bullet \left(\frac{\text{SLP1} - \text{SLP2}}{100} \right)$$

Both IRT and IOP are in multiples of tap.

Step 4. Purpose: Calculate the expected current for Winding 1 and 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:

$$\text{IAW1} = \left(\text{IRT} \bullet \left(1 + \frac{\text{SLP2}}{200} \right) + \text{IRS1} \bullet \left(\frac{\text{SLP1} - \text{SLP2}}{200} \right) \right) \bullet \text{TAP1} \bullet \text{A}$$

Calculate the Winding 2 current for the test using the following formula:

$$\text{IAW2} = \left(\text{IRT} \bullet \left(1 - \frac{\text{SLP2}}{200} \right) - \text{IRS1} \bullet \left(\frac{\text{SLP1} - \text{SLP2}}{200} \right) \right) \bullet \text{TAP2} \bullet \text{A}$$

The A connection compensation constant is based on Table 10.3. Because 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 $3 \bullet I_{nom}$. 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 (initial) = 1.1•IAW2 (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 10.6. 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 ±5% ±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 **SHOWSET** 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-387E 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 10.8.

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, ±5% and ±0.02 I_{nom}.

$$IAW1\,(\text{second harmonic}) = \frac{PCT2}{100} \bullet IAW1\ \ (\text{fundamental}),$$

$\pm 5\%\ \pm 0.02\ I_{nom}$

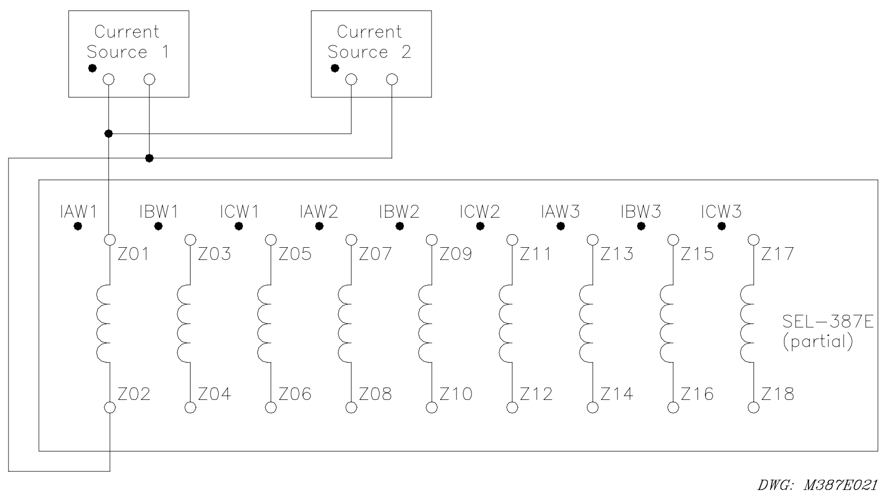


Figure 10.8: Test Connections for Parallel Current Sources

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 **SHOWSET** 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-387E 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 10.8.

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, and multiplied by the magnitude of the fundamental current source, ±5% and ±0.02 I_{nom}.

$$\text{IAW1}(\text{fifth harmonic}) = \frac{\text{PCT5}}{100} \bullet \text{IAW1 (fundamental)}, \pm 5\% \pm 0.02\ I_{nom}$$

Harmonic Restraint

Note: This test requires a current source capable of generating second- and fourth-harmonic current. This example tests the second-harmonic restraint function. Test the fourth-harmonic restraint function in a similar way.

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-387E 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 10.8.

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.

The following test applies to a single-harmonic injection at a time, i.e., only the second or the fourth harmonic, not both. Set E87W1 = E87W2 = Y1, and HRSTR = Y. Set the second current source for second-harmonic current (120 Hz for NFREQ = 60 and 100 Hz for NFREQ = 50). Turn on the second current test source connected to the Winding 1 input (IAW1). Starting at zero current, slowly increase the magnitude of applied current until the 87R element deasserts, causing the 87R LED to extinguish completely. Note the value of the applied current from the second test source. The general equation to calculate the percentage of harmonic content for a single slope is: (±5% ±0.10 A (5 A relay) or ±5% ±0.02 A (1 A relay)):

$$I1F2 = \left[IOP1 - IRT1 \bullet f\left(SLP\right)\right] \bullet \frac{PCT2}{100} \quad \text{and}$$

$$\%\ \text{harmonic} = \frac{I1F2}{IOP1} \bullet 100\ (\text{percent})$$

For inrush conditions, current normally is applied to one side of the transformer, and the equation simplifies to the following:

$$\%\ \text{harmonic} = PCT2\left(1 - \frac{SLP1}{200}\right)$$

where

PCT2 = second-harmonic setting in percent

SLP1 = slope 1 setting

For example

SLP1 = 50 percent

PCT2 = 20 percent

$$\%\ \text{harmonic} = 20\left(1 - \frac{50}{200}\right) = 15\ \text{percent}$$

For values on the second slope, use the following equation:

$$\%\ \text{harmonic} = \left(\frac{PCT2}{200}\right) \bullet \left(200 - SLP2 - \frac{IRS1}{IRT}\left(SLP1 - SLP2\right)\right)$$

where:

PCT2 = second-harmonic setting in percent

SLP1 = slope 1 setting

SLP2 = slope 2 setting

IRS1 = intersection where SLP2 begins

IRT = restraint quantity at which the calculation is carried out

For example:

Slope 1 = 25 percent

Slope 2 = 60 percent

PCT2 = 20 percent

IRS1 = 3, and choose IRT = 6

$$\% \text{ harmonic} = \left(\frac{20}{200}\right) \bullet \left(200 - 60 - \frac{3}{6}(25 - 60)\right) = 15.75 \text{ percent}$$

Note: The second and fourth harmonics are combined to form the restraint quantity.

Over-/Undervoltage Elements

Purpose: Verify the operation of over- and undervoltage elements.

Verify the operation of overvoltage elements.

Step 1. Connect a source of variable three-phase voltage to the relay as shown in Figure 10.5.

Step 2. Purpose: Verify the expected phase overvoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 59P1P<ENTER>**).

Step 3. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 59P1<ENTER>**). The SEL-387E Relay now displays the state of the overvoltage elements on the bottom row of front-panel LEDs.

Step 4. Purpose: Apply balanced three-phase voltage below the setting and raise one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5, adjusted to a value below the **59P1P** setting. Raise one phase voltage until the **59P1** LED illuminates. The voltage should equal the **59P1P** setting ±2 V and ±5% of setting. Repeat the test for the other two phases.

Step 5. Purpose: Repeat the test for each phase overvoltage element.

Method: Repeat Steps 1–4 for the **59P2** overvoltage element.

Step 6. Purpose: Verify the expected phase-to-phase overvoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 59PP1<ENTER>**).

Step 7. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 59PP1<ENTER>**). The SEL-387E Relay now displays the state of the overvoltage elements on the bottom row of front-panel LEDs.

Step 8. Purpose: Apply balanced three-phase voltage above the setting and raise one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5, adjusted to a value below the **59PP1** setting. Raise one phase voltage until the **59PP1** LED illuminates. The phase-to-phase voltage should equal the **59PP1** setting ±2 V and ±5% of setting. Repeat the test for the other two phase-to-phase voltages.

Step 9. Purpose: Repeat the test for each phase-to-phase overvoltage element.

Method: Repeat Steps 6–8 for each **59PP2** overvoltage element.

Step 10. Purpose: Verify the expected positive-sequence overvoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 59V1P<ENTER>**).

Step 11. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 59V1<ENTER>**). The SEL-387E Relay now displays the state of the overvoltage elements on the bottom row of front-panel LEDs.

Step 12. Purpose: Apply balanced three-phase voltage below the setting and raise one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Raise one phase voltage until the **59V1** LED illuminates. The positive sequence voltage, **V1**, may be calculated as (VA + VB +VC)/3 if the voltages are 120 degrees apart in proper phase rotation.

Step 13. Purpose: Verify the expected negative-sequence overvoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 59QP<ENTER>**).

Step 14. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 59Q<ENTER>**). The SEL-387E Relay now displays the state of the overvoltage elements on the bottom row of front-panel LEDs.

Step 15. Purpose: Apply balanced three-phase voltage below the setting and raise one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Raise one phase voltage until the **59Q** LED illuminates. The negative-sequence voltage, **V2**, should equal the **59QP** setting ±2 V and ±5% of setting. The negative-sequence voltage may be calculated as $(VA + a^2VB + aVC)/3$ where $a = 1 \angle 120$.

Step 16. Purpose: Verify the expected residual overvoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 59G1P<ENTER>**).

Step 17. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 59G1<ENTER>**). The SEL-387E Relay now displays the state of the overvoltage elements on the bottom row of front-panel LEDs.

Step 18. Purpose: Apply balanced three-phase voltage below the setting and raise one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Raise one phase voltage until the **59G1** LED illuminates. The residual voltage,**V0**, should equal the **59G1P** setting ±2 V and ±5% of setting. The residual voltage may be calculated as the vector sum $(VA + VB + VC)/3$.

Step 19. Purpose: Repeat the test for each residual overvoltage element.

Method: Repeat Steps 16–18 for the **59G2** overvoltage element.

Verify the operation of undervoltage elements.

Step 1. Connect a source of variable three-phase voltage to the relay as shown in Figure 10.5.

Step 2. Purpose: Verify the expected phase undervoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 27P1P<ENTER>**).

Step 3. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 27P1<ENTER>**). The SEL-387E Relay now displays the state of the undervoltage elements on the bottom row of front-panel LEDs.

Step 4. Purpose: Apply balanced three-phase voltage above the setting and reduce one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5, adjusted to a value above the **27P1P** setting. Reduce one phase voltage until the **27P1** LED illuminates. The voltage should equal the **27P1P** setting ±2 V and ±5% of setting. Repeat the test for the other two phases.

Step 5. Purpose: Repeat the test for each phase undervoltage element.

Method: Repeat Steps 1–4 for the **27P2** undervoltage element.

Step 6. Purpose: Verify the expected phase-to-phase undervoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 27PP1<ENTER>**).

Step 7. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 27PP1<ENTER>**). The SEL-387E Relay now displays the state of the undervoltage elements on the bottom row of front-panel LEDs.

Step 8. Purpose: Apply balanced three-phase voltage above the setting and reduce one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5, adjusted to a value above the **27PP1** setting. Reduce one phase voltage until the **27PP1** LED illuminates. The phase-to-phase voltage should equal the **27PP1** setting ±2 V and ±5% of setting. Repeat the test for the other two phase-to-phase voltages.

Step 9. Purpose: Repeat the test for each phase-to-phase undervoltage element.

Method: Repeat Steps 6–8 for the **27PP2** undervoltage element.

Step 10. Purpose: Verify the expected positive sequence undervoltage pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 27V1P<ENTER>**).

Step 11. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 27V1<ENTER>**). The SEL-387E Relay now displays the state of the undervoltage elements on the bottom row of front-panel LEDs.

Step 12. Purpose: Apply balanced three-phase voltage above the setting and reduce one phase voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5, adjusted to a value above the **27V1P** setting. Reduce one phase voltage until the **27V1** LED illuminates. The positive-sequence voltage should equal the **27V1P** setting ±2 V and ±5% of setting. The positive-sequence voltage, **V1**, may be calculated as (VA + VB +VC)/3 if the voltages are 120 degrees apart in proper phase rotation.

Frequency Elements

Purpose: Verify the operation of frequency elements.

Step 1. Connect a source of variable three-phase voltage and frequency to the relay as shown in Figure 10.5.

Step 2. Purpose: Verify the expected frequency pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 81D1P<ENTER>**).

Step 3. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 81D1<ENTER>**). The SEL-387E Relay now displays the state of the frequency elements on the bottom row of front-panel LEDs.

Step 4. Purpose: Apply balanced three-phase voltage and change the frequency until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the frequency to a value above (below) the **81D1P** setting until the **81D1** LED illuminates. The frequency should equal the **81D1P** setting ±0.01 Hz.

Step 5. Purpose: Repeat the test for each frequency element.

Method: Repeat Steps 1–4 for **81D2P** through **81D6P** elements.

Step 6. Purpose: Verify the expected frequency time delay setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 81D1D<ENTER>**).

Step 7. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 81D1T<ENTER>**). The SEL-387E Relay now displays the state of the frequency time-delayed elements on the bottom row of front-panel LEDs.

Step 8. Purpose: Apply balanced three-phase voltage and change the frequency until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the frequency to a value above (below) the **81D1P** setting. The **81D1T** LED should illuminate **81D1D** seconds later, within ±0.0042 seconds and ±0.1% of setting.

Step 9. Purpose: Repeat the test for each frequency element.

Method: Repeat Steps 6–8 for the **81D2D** through **81D6D** frequency time-delayed element.

Volts/Hertz Elements

Purpose: Verify the operation of volts/hertz elements.

Step 1. Method: Connect a source of variable three-phase voltage and frequency to the relay as shown in Figure 10.5.

Step 2. Purpose: Verify the Level 1 volts/hertz pickup setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24D1P<ENTER>**).

Step 3. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24D1<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 4. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D1P** setting until the **24D1** LED illuminates. The **24D1** pickup should be ±1% of setting. Calculate pickup voltage as:

$$V_{sec} = \frac{10 \bullet 24D1P \bullet freq \bullet V_{nom}}{\sqrt{3} \bullet PTR \bullet NFREQ}$$

V_{sec} = Secondary Voltage (applied)

PTR = Potential transformer ratio (Setting)

freq = Frequency (applied)

NFREQ= Nominal Frequency (Setting)

V_{nom} = Nominal Voltage in kV (Setting)

Step 5. Purpose: Verify the Level 1 volts/hertz delay setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24D1D<ENTER>**).

Step 6. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24DT<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 7. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D1P** setting. The **24D1T** LED should illuminate **24D1D** seconds later, ±0.1% of setting ±4.2 ms (at 60 Hz).

Step 8. Purpose: Verify the Level 2 volts/hertz pickup setting, **24D2P1**.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24D2P1<ENTER>**).

Step 9. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24C2<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 10. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D2P1** setting until the **24C2** LED illuminates. The **24C2** pickup should be ±1% of setting. Calculate pickup voltage as:

$$V_{sec} = \frac{10 \bullet 24D2P1 \bullet freq \bullet V_{nom}}{\sqrt{3} \bullet PTR \bullet NFREQ}$$

V_{sec} = Secondary Voltage (applied)

PTR = Potential transformer ratio (Setting)

freq = Frequency (applied)

NFREQ= Nominal Frequency (Setting)

V_{nom} = Nominal Voltage in kV (Setting)

Step 11. Purpose: Verify the Level 2 Volts/Hertz delay setting, when **24CCS = DD** and **24D2D1 < 24D2D2**.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24CCS<ENTER, SHO 24D2D1<ENTER>**). **24CCS** should be set to **DD; 24D2D1** should be less than **24D2D2.**

Step 12. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24C2T<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 13. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D2P1** setting. The **24C2T** LED should illuminate **24D2D1** seconds later, within ±0.1% of setting ±4.2 ms (at 60 Hz).

Step 14. Purpose: Verify the Level 2 volts/hertz delay setting, when **24CCS = DD** and **24D2D2 < 24D2D1**.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24CCS<ENTER, SHO 24D2D2<ENTER>**). **24CCS** should be set to **DD; 24D2D2** should be less than **24D2D1.**

Step 15. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24C2T<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 16. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D2P2** setting. The **24C2T** LED should illuminate **24D2D2** seconds later, within ±0.1% of setting ±4.2 ms (at 60 Hz).

Step 17. Purpose: Verify the Level 2 volts/hertz delay settings, when **24CCS = ID**.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24CCS<ENTER**).

Step 18. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24C2T<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 19. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24IP** setting and below the **24D2P2** setting until the **24C2T** LED illuminates. Refer to ***Section 3: Differential, Restricted Earth Fault, Overcurrent, Voltage, and Frequency Elements*** for the maximum inverse-time timing error. Calculate pickup time as:

$$24C2T = \frac{24ITD}{\left(\frac{\frac{\sqrt{3} \bullet V_{sec} \bullet PTR}{freq} \bullet \frac{NFREQ}{V_{nom} \bullet 10^3}}{\frac{24IP}{100\%}} - 1\right)^{24IC}}$$

V_{sec}	=	Secondary voltage (applied)
PTR	=	Potential transformer ratio (Setting)
Freq	=	Frequency (applied)
NFREQ	=	Nominal Frequency (Setting)
V_{nom}	=	Nominal Voltage in kV (Setting)
24ITD	=	Inverse time factor (Setting)
24IP	=	Inverse time pickup (Setting)
24IC	=	Inverse time curve (Setting)

Step 20. Purpose: Verify the **24D2P2** setting and **24D2D2** delay.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage from a value below the **24IP** setting to a value above the **24D2P2** setting. The **24C2T** LED should illuminate **24D2D2** seconds later.

Step 21. Purpose: Verify the Level 2 volts/hertz delay settings, when **24CCS = I**.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24CCS<ENTER>**).

Step 22. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24C2T<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 23. Purpose: Apply balanced three-phase voltage and change the voltage until the appropriate LED illuminates.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24IP** setting until the **24C2T** LED illuminates. Refer to ***3: Differential, Overcurrent, Voltage, and Frequency Elements*** for the maximum inverse-time timing error. Calculate pickup time as:

$$24C2T = \frac{24ITD}{\left(\dfrac{\dfrac{\sqrt{3} \bullet V_{sec} \bullet PTR}{freq} \bullet \dfrac{NFREQ}{V_{nom} \bullet 10^{3}}}{\dfrac{24IP}{100\%}} - 1 \right)^{24IC}}$$

V_{sec}	=	Secondary voltage (applied)
PTR	=	Potential transformer ratio (Setting)
Freq	=	Frequency (applied)
NFREQ	=	Nominal Frequency (Setting)
V_{nom}	=	Nominal Voltage in kV (Setting)
24ITD	=	Inverse time factor (Setting)
24IP	=	Inverse time pickup (Setting)
24IC	=	Inverse time curve (Setting)

Step 24. Purpose: Verify the Level 2 volts/hertz delay reset setting.

Method: Execute the **SHOWSET** command via the relay front panel or serial port and verify the setting (i.e., **SHO 24CR<ENTER>**).

Step 25. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 24CR<ENTER>**). The SEL-387E Relay now displays the state of the volts/hertz elements on the bottom row of front-panel LEDs.

Step 26. Purpose: Verify the **24CR** setting.

Method: Apply balanced three-phase voltages as shown in Figure 10.5. Change the voltage to a value above the **24D2P1** setting for an elapsed time of **24D2D2/**2 seconds, then change the voltage to a value below the **24D2P1** setting. The **24CR** front-panel LED should illuminate after **24CR/**2 seconds, within ±0.1% of setting ±4.2 ms (at 60 Hz).

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.
3. 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).

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-387E 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 utility dependence on routine maintenance testing.

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

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

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

Because SEL relays are microprocessor based, their operating characteristics do not change over time. Time-overcurrent 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 because of handshake line conflict. Check communications cabling.
5. System is in the XOFF state, halting communications. Type **<CTRL>Q** to put system in XON state.

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.
2. 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.

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 ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
2. A/D converter failure.

Self-Test Failure: +5 V REG

1. Regulated +5 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***..
2. A/D converter failure.

Self-Test Failure: -5 V REG

1. Regulated -5 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
2. A/D converter failure.

Self-Test Failure: +12 V PS

1. Power supply +12 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
2. A/D converter failure.

Self-Test Failure: -12 V PS

1. Power supply -12 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
2. A/D converter failure.

Self-Test Failure: +15 V PS

1. Power supply +15 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
2. A/D converter failure.

Self-Test Failure: -15 V PS

1. Power supply -15 V output out-of-tolerance. See ***STA (Status Report)***, ***Section 7: Serial Port Communications and Commands***.
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.
2. Contact the factory.

Self-Test Failure: RAM

1. Failure of static RAM IC.
2. 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. Interface board has been changed. Execute the **INITIO** command.
2. Ribbon cable disconnected between upper interface board and main board. Reconnect and execute **INITIO** command. Step 2 only applies to the upper interface board in a relay that has more than one I/O board.
3. Interface board failure.

Self-Test Failure: CR_RAM, EEPROM, and IO_BRD

1. Self-test detected EEPROM or CR_RAM reconfiguration because of 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

1. Record **STA** command and state of all outputs.
2. Contact the factory. Powering down the relay will reset the logic.

Relay Calibration

The SEL-387E Relay is factory calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Factory Assistance

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA USA 99163-5603
Tel: (509) 332-1890
Fax: (509) 332-7990
Internet: www.selinc.com

Commissioning Test Worksheet
SEL-387E Relay

System Information

System Settings

RID (Relay identification) = ______________________________

TID (Terminal identification) = ______________________________

MVA (Maximum transformer rating) = ______________________________

	Winding 1	Winding 2	Winding 3
Current transformer connection:	W1CT = ________	W2CT = ________	W3CT = ________
Current transformer ratio:	CTR1 = ________	CTR2 = ________	CTR3 = ________
Connection compensation:	W1CTC = ________	W2CTC = ________	W3CTC= ________
Nominal line-to-line voltage (kV):	VWDG1 = ________	VWDG2= ________	VWDG3= ________
Tap calculation:	TAP1 = ________	TAP2 = ________	TAP3 = ________

Differential Settings

O87P = ________ SLP1 = ________ SLP2 = ________ IRS1 = ________ U87P = ________

Metered Load (Data taken from substation panel meters, not the SEL-387E Relay)

± Readings from meters	Winding 1	Winding 2	Winding 3
Megawatts:	MW1 =________	MW2 =________	MW3 =________
Megavars:	MVAR1=________	MVAR2=________	MVAR3=________
MVA calculation: $MVAn = \sqrt{MWn^2 + MVARn^2}$	MVA1=________	MVA2=________	MVA3=________

Calculated Relay Load

	Winding 1	Winding 2	Winding 3
Primary Amperes calculation: $Inpri = \dfrac{MVAn \cdot 1000}{\sqrt{3} \cdot VWDGn}$	I1pri =________	I2pri =________	I3pri =________
Secondary Amperes calculation: $WnCT = Y,\ Insec = \dfrac{Inpri}{CTRn}$ $WnCT = D,\ Insec = \dfrac{Inpri \cdot \sqrt{3}}{CTRn}$	I1sec=________	I2sec=________	I3sec =________

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:

$$MMn = \frac{IOPn}{IRTn}$$

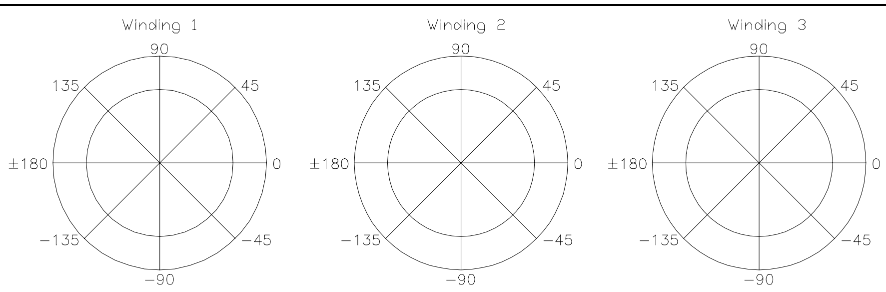
MM1 = ______ MM2 = ______ MM3 = ______

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)

	Winding 1	**Winding 2**	**Winding 3**
A-Phase Secondary Amperes:	IAW1 = ______	IAW2 = ______	IAW3 = ______
A-Phase Angle:	______	______	______
B-Phase Secondary Amperes:	IBW1 = ______	IBW2 = ______	IBW3 = ______
B-Phase Angle:	______	______	______
C-Phase Secondary Amperes:	ICW1 = ______	ICW2 = ______	ICW3 = ______
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, because 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. The status report displays the FID label with the Part/Revision number in bold:

FID=**SEL-387E-R100-V0-Z . . .**

The SEL-387E Relay provides a means of interpreting Firmware Identification Data (FID). The FID string is included near the top of each long event report, and is also available using the **STA** or **SER** serial port commands. Part of it is available using the STATUS pushbutton, as noted above. The string format follows:

FID = [PN] - R[RN] - V[VO] - Z[ES]- D[RD],

Where:

[PN] = Product Name (e.g., SEL-387E)
[RN] = Revision Number (e.g., 103)
[VO] = Version Options (none available at this time)
[ES] = External Software Version (e.g., 003002, 006009)
[RD] = Release Date of Firmware (e.g., yyyymmdd = 20000229)

For the SEL-387E Relay, version options are interpreted as follows:

[VO] = Version Options (none available at this time)

This manual covers SEL-387E 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-387E-R601-V0-Z002002-D20020218	– Added support for new DSP. – Added support for faster CPU. – Added harmonic restraint function. – Added dc ratio blocking feature. – Added energy metering with the **MET E** and **MET RE** commands. – Added DC Battery Voltage (VDC) to *Fast Meter*. – Added **EVE T** that displays short event summary. – Changed front-panel breaker monitor display scroll time from 0.5 second to 2 seconds. – Increased O87P setting range resolution.

Firmware Part/Revision No.	Description of Firmware
	– Changed !ALARM Relay Word bit to NOTALM. – Corrected ADC power up. – Corrected minimum pickup using 24IP setting in Volts/Hertz user-defined curve.
SEL-387E-R205-V0-Z101101-D20020214 SEL-387E-R104-V0-Z001001-D20020214	Supports PROTO=DNP protocol setting option. Does not support POTO=DNP protocol setting option. This firmware differs from the previous version as follows: – Corrected minimum pickup using 24IP setting in Volts/Hertz user-defined curve.
SEL-387E-R204-V0-Z101101-D20010906 SEL-387E-R103-V0-Z001001-D20010906	Supports PROTO=DNP protocol setting option. Does not support POTO=DNP protocol setting option. This firmware differs from the previous version as follows: – Removed 32IOP as input to "REF Directional Element" logic AND gate. With 32IOP removed as an input, the AND gate only uses 32IE and 50GC as inputs. Changed 50GP multiplier from 0.9 to 0.8 in 50GC logic. This change only affects R103 (without DNP) since R203 (with DNP) already incorporated the change. – Corrected front-panel PWR meter display to properly scroll to the bottom of the list of power quantities when the up arrow is used and VIWDG is set to either 1 or 2. – Corrected front-panel METER display to support PWR when TPVI=N, WnCT=D, and VIWDG=N.
SEL-387E-R203-V0-Z101101-D20010102	Supports the PROTO=DNP protocol setting option. This firmware differs from the previous version as follows: – Included W1, W2 combination in

Firmware Part/Revision No.	Description of Firmware
	combined overcurrent metering. – Enhanced Object 32. – Removed 32IOP as input to "REF Directional Element" logic AND gate. With 32IOP removed as an input, the AND gate only uses 32IE and 50GC as inputs. Changed 50GP multiplier from 0.9 to 0.8 in 50GC logic.
SEL-387E-R202-V0-Z101101-D20001116 SEL-387E-R102-V0-Z001001-D20001116	Supports the PROTO=DNP protocol setting option. Does not support the PROTO=DNP protocol setting option. This firmware differs from the previous version as follows: – Different checksum.
SEL-387E-R101-V0-Z001001-D20000606	This firmware differs from the previous version as follows: – Fixed the second- and fifth-harmonic blocking elements. – Added DS1302 battery-backed clock support.
SEL-387E-R100-V0-Z001001-D20000216	Original General-Release Firmware

APPENDIX B: SEL-300 SERIES RELAYS FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE OVERVIEW

Note: These firmware upgrade instructions apply to all SEL-300 series relays except the SEL-321 series relays (which use EPROM instead of Flash).

SEL may occasionally offer firmware upgrades to improve the performance of your relay. The relay stores firmware in Flash memory; therefore, changing physical components is not necessary. A firmware loader program called SELBOOT resides in the relay. These instructions give a step-by-step procedure to upgrade the relay firmware by uploading a file from a personal computer to the relay via a serial port.

Note: SEL strongly recommends that you perform the firmware upgrade at the location of the relay and with a direct connection from the personal computer to one of the serial ports of the relay. Do not attempt to load firmware from a remote location because problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the relay through an SEL-2020 or SEL-2030 Communications Processor.

Perform the firmware upgrade process in the following sequence:

A. Prepare the Relay
B. Establish a Terminal Connection
C. Save Settings and Other Data
D. Start SELBOOT
E. Download Existing Firmware
F. Upload New Firmware
G. Check Relay Self-Tests
H. Verify Calibration, Status, Breaker Wear, and Metering
I. Return Relay to Service

Required Equipment

- Personal computer
- Terminal emulation software that supports the XMODEM/CRC protocol (these instructions use HyperTerminal from a Microsoft® Windows® operating system)
- Serial communications cable (SEL-C234A or equivalent)
- Disk containing firmware upgrade file

Upgrade Procedure

A. Prepare the Relay

Step 1. If the relay is in service, change settings, or disconnect external voltage sources or output contact wiring to disable relay control functions.

Step 2. Power up your relay.

Step 3. From the relay front panel, press the **{SET}** pushbutton.

Step 4. Use the arrow pushbuttons to navigate to PORT.

Step 5. Press the **{SELECT}** pushbutton.

Step 6. Use the arrow pushbuttons to navigate to the relay serial port you plan to use.

Step 7. Press the **{SELECT}** pushbutton.

Step 8. With SHOW selected, press the **{SELECT}** pushbutton.

Step 9. Press the down arrow pushbutton to scroll through the port settings and keep a written record of the value for each setting. Many of these you will use later in the upgrade procedure.

Step 10. At the Exit Settings prompt, be certain "Yes" is highlighted and press the **{SELECT}** pushbutton.

Step 11. Connect an SEL-C234A (or equivalent) serial communications cable to the relay serial port you identified earlier.

B. Establish Terminal Connection

To establish communication between your relay and a personal computer, you must be able to modify your serial communications parameters (data transmission rate, data bits, parity, etc.), disable any hardware or software flow control in your computer terminal emulation software, and transfer files with the XMODEM protocol.

Step 1. Connect a serial communications cable to the serial port.

a. Check the back of your computer for a label identifying the serial communications ports

b. Choose a port and connect an SEL-C234A (or equivalent) serial communications cable to the personal computer serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you may later have to change this computer serial port to establish communication between your relay and your computer.

Step 2. Disconnect any other serial port connection.

Step 3. Open HyperTerminal (on a personal computer running Windows, you would typically click the **Start** button, point to Programs, and point to Accessories).

Step 4. Enter a name, select any icon, and click **OK** (Figure B.1).

Step 5. Determine the computer serial port you will use to communicate with the relay (Figure B.2) and click **OK**.

Step 6. Establish serial port communications parameters.

Note that these settings for your computer (Figure B.3) must match the settings you recorded earlier for the relay (hardware and software flow control settings, for example, should match what you recorded earlier for the relay RTSCTS setting). If computer settings do not match relay settings, change the computer settings to match relay settings.

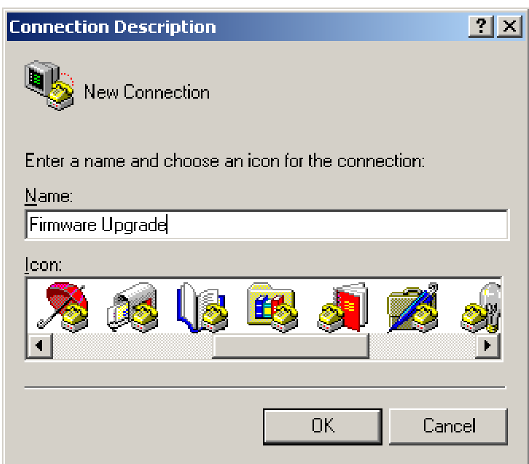

Figure B.1: Establishing a Connection

Figure B.2: Determining the Computer Serial Port

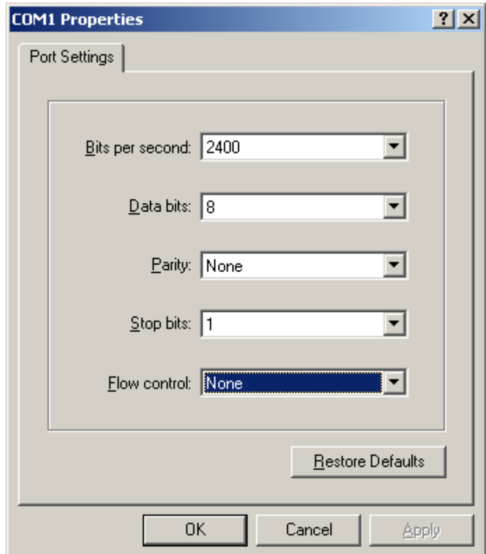

Figure B.3: Determining Communications Parameters for the Computer

Step 7. Click **OK** and press **<Enter>**.

You should see a screen and prompt similar to that in Figure B.4. The prompt does not appear unless you press **<Enter>**.

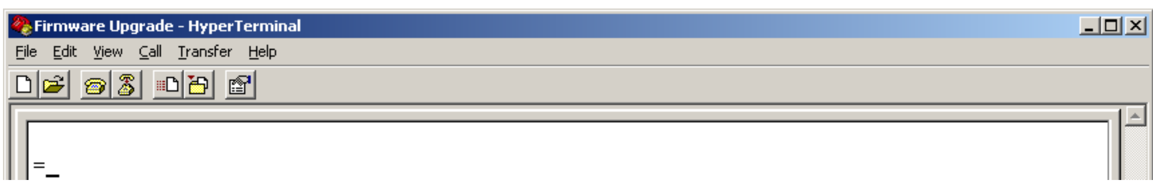

Figure B.4: Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the "=" prompt, press **<Enter>** again. If you still do not see the "=" prompt, you have either selected the incorrect serial communications port on your computer or the computer speed setting does not match the data transmission rate of your relay. Perform the following steps to reattempt a connection.

Step 1. Terminate communication by pressing the icon illustrating a phone off the hook.

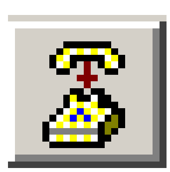

Figure B.5: Terminating Communication

Step 2. Correct your port setting.

a. From the File menu, choose Open.

You should see a dialog box similar to Figure B.6.

b. Select a different port in the "Connect using:" list box and click **OK**.

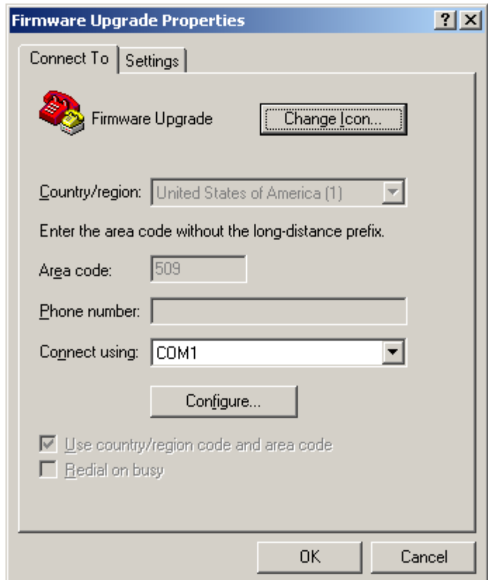

Figure B.6: Correcting Port Setting

Step 3. Correct communications parameters.

a. From the File menu, choose Properties.

b. Choose Configure to see a dialog box similar to Figure B.3.

Step 4. Change settings in the appropriate list boxes and click **OK**.

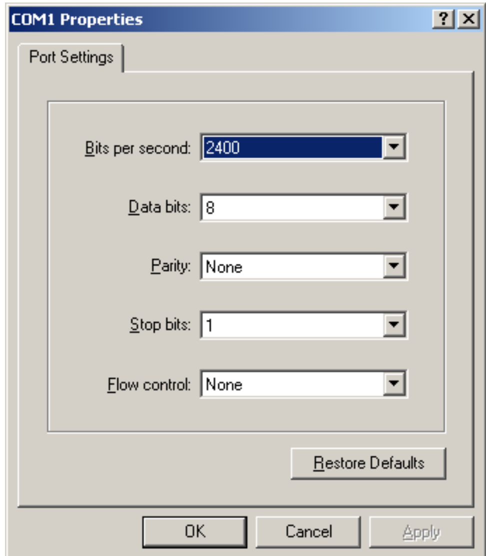

Figure B.7: Correcting Communications Parameters

Step 5. After you have corrected settings, reestablish communication by pressing the icon showing the phone back on the hook (Figure B.8).

Step 6. Press **<Enter>** to obtain the "=" prompt.

Figure B.8: Establishing Communication

C. Save Settings and Other Data

The firmware upgrade procedure may result in lost relay settings. If the relay contains History (HIS), Event (EVE), Metering (MET), Breaker Wear Monitor (BRE), or Sequential Events Recorder (SER) data that you want to retain, retrieve and record this information prior to performing the firmware upgrade. If you have either SEL-5010 Relay Assistant Software or SEL-5030 ACSELERATOR® Software available for your relay, use this software to record existing relay settings and proceed to ***Start SELBOOT*** on page B-7. Otherwise, carefully perform the following steps to minimize the chance of inadvertently losing relay settings.

Step 1. From the "=" prompt, use the **ACCESS** (**ACC**) and **2ACCESS** (**2AC**) commands to enter Access Level 2.

Step 2. Under the Transfer menu in HyperTerminal, select Capture Text.

Step 3. Enter a directory and file name for a text file in which you will record existing relay settings.

Step 4. Click **Start**.

Note that the Capture Text command causes the terminal emulation program to copy to the text file all information you retrieve and all key strokes you type until you send the command to stop capturing text.

Step 5. Use the **SHOW CALIBRATION** (**SHO C**) command to retrieve the relay calibration settings.

If you do not already have copies of other relay settings (Group, Global, Port, Logic, Text label, SER, and Channel, depending upon your relay), use the **SHOW** (**SHO n**) command to retrieve necessary settings, where n can be 1–6, G, P, L, T, R, X, or Y. Also, use the **PASSWORD** (**PAS**) command to save the original password settings in case you need these later.

Normally, the relay will preserve the settings during the firmware upgrade. However, depending on the previously installed firmware version and the use of relay memory, this cannot be ensured. Saving settings is always recommended.

Step 6. Under the Transfer menu in HyperTerminal, select Capture Text and click **Stop**.

Step 7. Print the text file you created in steps 4 through 6 and save this record for later reference.

Step 8. Take note of the present relay data transmission setting for later use in the upgrade procedure.

This value should be the same as the value for the SPEED setting you recorded earlier in ***Prepare the Relay*** on page B-2.

D. Start SELBOOT

Step 1. To start the SELBOOT program, use the **L_D** command (to obtain the underscore, type **<Shift>**, then the hyphen (-) key).

Step 2. Type **Y <Enter>** at the prompt asking whether you want to disable the relay.

Step 3. Type **Y <Enter>** at the "Are you sure (Y/N)?" prompt.

The relay will send the SELBOOT prompt "!>". Note that the relay sometimes takes a few minutes to start SELBOOT.

Commands Available in SELBOOT

To list the commands available in SELBOOT, use the **HELP** (**HEL**) command. The relay displays a list similar to the following:

```
!>HELP <Enter>
SELboot-3xx-R100

bau "rate"  ; Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, or 38400 baud
era         ; Erase the existing relay firmware
exi         ; Exit this program and restart the device
fid         ; Print the relays firmware id
rec         ; Receive new firmware for the relay using xmodem
sen         ; Send the relays firmware to a pc using xmodem
hel         ; Print this list

FLASH Type : 040         Checksum = 370E  OK
```

Set Relay Data Transmission Rate

Step 1. Set the relay baud rate to the highest possible data transmission rate for the relay.

In SELBOOT, the relay supports firmware upload and download speeds as fast as 38400 baud.

Step 2. Use the **BAUD (BAU)** command to change the data transmission rate in the relay.

```
!>BAU 38400 <Enter>
```

Match Computer Communications Speed to the Relay

Step 1. In HyperTerminal, terminate communication (Figure B.5).

Step 2. On the File menu, choose Properties.

Step 3. Choose Configure.

Step 4. Change your computer communications speed to match the new data transmission rate in the relay (Figure B.9).

Step 5. Click **OK** twice.

Note that you should not have to reestablish communication; HyperTerminal reestablishes communication automatically the second time you click OK.

Step 6. Press **<Enter>**.

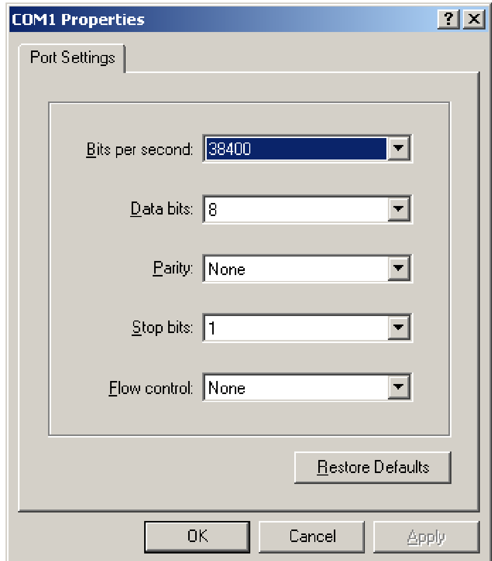

Figure B.9: Matching Computer to Relay Parameters

E. Download Existing Firmware

Copy the firmware presently in the relay, in case the new firmware upload is unsuccessful. To make a backup of the firmware, you will need as much as 3 MB of free disk space. This backup procedure takes between 5 and 10 minutes at 38400 bps.

Step 1. From the Transfer menu in HyperTerminal, select Receive File.

You should see a dialog box similar to Figure B.10.

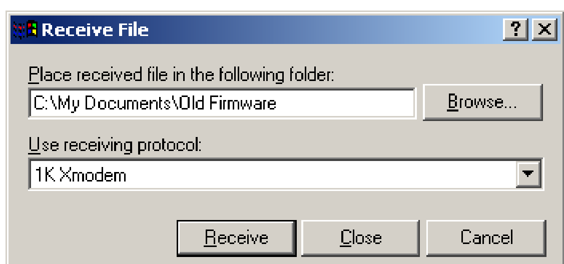

Figure B.10: Example Receive File Dialog box

Step 2. Choose a filename that clearly identifies your existing firmware version.

SEL generally lists the firmware revision number first, then the product number. All such files have an .s19 extension (r100387.s19, for example).

Note: After beginning the following procedure, you will need to enter this information quickly before the relay times out.

Step 3. Enter the pathname of a folder on your computer hard drive in which you want to record the existing relay firmware, and select “1K Xmodem” if you have this protocol available on your PC. Otherwise, choose “Xmodem.”

Step 4. Use the **SEND** (**SEN**) command to the relay at the SELBOOT prompt to initiate the firmware transfer from the relay to your computer.

```
!>SEN <Enter>
```

You will see no activity on the PC screen because the relay is waiting for the PC to request the first Xmodem data packet.

Note: You have about one minute to complete the following procedure before the relay times out. If the relay should time out, use the **SEND** command again and restart the Receive File process.

Step 5. Reopen the Receive File dialog box from the Transfer menu in the terminal emulation program and select Receive.

You should see a dialog box similar to Figure B.11.

Step 6. Provide the filename that you chose earlier and click **OK**.

For a successful download, you should see a dialog box similar to Figure B.12. After the transfer, the relay will respond: “Download completed successfully!”

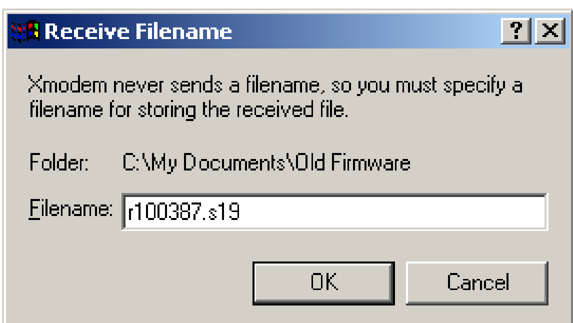

Figure B.11: Example Filename Identifying Old Firmware Version

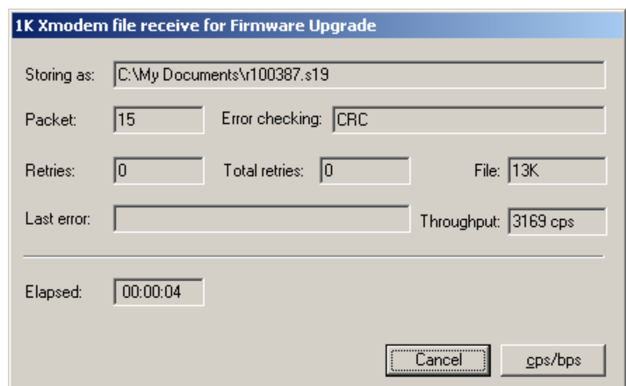

Figure B.12: Downloading of Old Firmware

F. Upload New Firmware

Step 1. Insert the disk containing the new firmware into the appropriate disk drive on your computer.

Notes: This example shows upload of new firmware directly from the floppy disk. For a faster upload (and less potential for file corruption), copy the new firmware to your local hard drive and upload the new firmware from your hard drive.

Some firmware may be in self-extracting compressed files (files with .exe extensions). If you have firmware in such files, double-click on the file you want from Windows Explorer and select a directory on your local hard drive into which you want to download the uncompressed files. Ensure that these uncompressed files have an .s19 extension.

Step 2. Use the **RECEIVE** (**REC**) command at the SELBOOT prompt to instruct the relay to receive new firmware.

The relay will prompt whether you want to erase the existing firmware.

```
!>REC <Enter>
Caution! -  This command erases the relays firmware.
If you erase the firmware, new firmware must be loaded into the relay
before it can be put back into service.
```

Note: If the relay power fails during a firmware receive and after the old firmware is erased, the relay will restart in SELBOOT but the relay baud rate will default to 2400 baud. (If this happens, connect to the relay at 2400 baud, type **BAU 38400 <Enter>** at the SELBOOT prompt, and verify that computer communications settings match the relay settings [***Match Computer Communications Speed to the Relay*** on B-8]. Restart the firmware receive.)

Step 3. Type **Y** to erase the existing firmware and load new firmware. To abort, press **<Enter>**.

```
Are you sure you wish to erase the existing firmware? (Y/N)
Erasing
Erase successful
```

Note: The relay prompts you to press a key (e.g., **<Enter>**) and begin the transfer. After you press a key to begin the transfer, you have about one minute to complete the following procedure before the relay times out. 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 within about one minute, the relay times out and responds, "Upload failed – Communications failed!" If this happens, use the **REC** command again and restart the transfer.

Step 4. Start the file transfer by pressing any key and selecting Send File under the Transfer menu in HyperTerminal.

```
Press any key to begin transfer, then start transfer at the PCCCC <Enter>
```

Step 5. For Filename, type in the location of your new firmware or use the browse button to select the firmware file (Figure B.13).

Step 6. For Protocol, select "1K Xmodem" if you have this protocol available. Otherwise, select "Xmodem."

Step 7. Click **Send** to send the file containing the new firmware (e.g., r103387e.s19).

You should see a dialog box similar to that in Figure B.14. Incrementing numbers in the Packet box and a bar advancing from left to right in the File box indicate a transfer in progress.

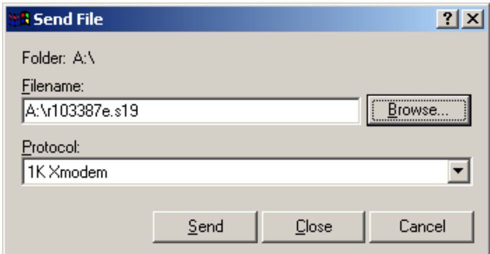

Figure B.13: Selecting the New Firmware to Send to the Relay

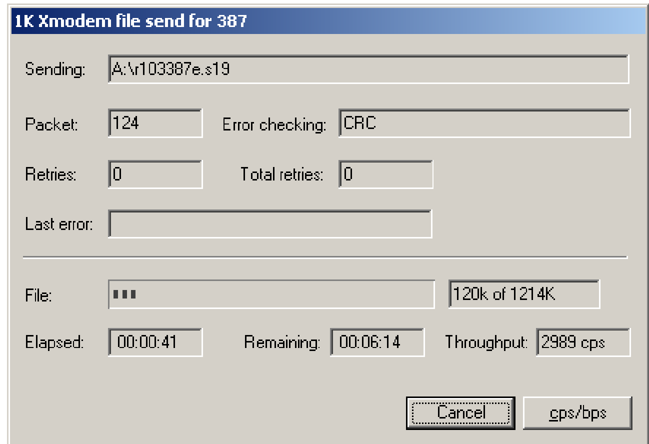

Figure B.14: Transfer of New Firmware to the Relay

Note: If you use "1K Xmodem," the file transfer takes between 5 and 15 minutes at 38400 baud. If you see no indication of a transfer in progress within a few minutes after clicking Send, use the **REC** command again and reattempt the transfer. Remember to press any key after the relay erases existing firmware and prior to your selecting Send File. After the transfer completes, the relay displays the following:

```
Upload completed successfully. Attempting a restart
```

G. Check Relay Self-Tests

The relay EN front-panel LED should illuminate if the relay retained original relay settings through the upload (LED illumination may be delayed as long as two minutes). Press **<Enter>** to see if the Access Level 0 prompt "=" appears on your terminal screen.

EN LED Illuminated and Access Level 0 Prompt Visible

If the EN LED is illuminated and the Access Level 0 prompt is visible, use the **ACC** and **2AC** commands to enter Access Level 2 and proceed to ***Verify Calibration, Status, Breaker Wear, and Metering*** on page B-14.

EN LED Illuminated But No Access Level 0 Prompt

If the EN LED is illuminated and the Access Level 0 prompt does not appear, the relay data transmission rate has reverted to the value you recorded in ***Prepare the Relay*** on page B-2.

Step 1. As you did earlier in ***Match Computer Communications Speed to the Relay*** on page B-8, change the computer communications speed to match.

Step 2. Use the **ACC** and **2AC** commands to enter Access Level 2 and proceed to ***Verify Calibration, Status, Breaker Wear, and Metering*** on page B-14.

EN LED Not Illuminated

If the EN LED does not illuminate, the relay can display various self-test fail status messages. Press **{STATUS}** on the relay front panel and use the up and down pushbuttons to scroll through the various status messages.

If the relay displays only an IO_BRD fail status message, the relay data transmission rate has reverted to the value you recorded in ***Prepare the Relay*** on page B-2.

Step 1. As you did in ***Match Computer Communications Speed to the Relay*** on page B-8, change the computer communications speed to match.

Step 2. Use the **ACC** and **2AC** commands to enter Access Level 2 and proceed to ***IO_BRD Fail Status Message***, Step 1.

If fail status messages display for any combination of CR_RAM, EEPROM, and IO_BRD, the relay baud rate has reverted to the factory default of 2400 baud. Go to ***CR_RAM, EEPROM, and IO_BRD Fail Status Messages***, Step 1.

IO_BRD Fail Status Message

Step 1. Use the **INITIALIZE** (**INI**) command to reinitialize the I/O board(s). If this command is not available, go to ***CR_RAM, EEPROM, and IO_BRD Fail Status Messages***, Step 1.

Step 2. Answer **Y <Enter>** to the question: "Are the new I/O board(s) correct (Y/N)?"

After a brief interval (as long as a minute), the EN LED will illuminate. Verify that the relay retained the original settings.

Step 3. Enter Access Level 2 by issuing the **ACC** and **2AC** commands.

Step 4. Go to ***Verify Calibration, Status, Breaker Wear, and Metering*** on page B-14.

CR_RAM, EEPROM, and IO_BRD Fail Status Messages

Step 1. As you did earlier in ***Match Computer Communications Speed to the Relay*** on page B-8, terminate communication.

Step 2. Change communications software settings to 2400 baud, 8 data bits, 1 stop bit.

Step 3. Reestablish communication.

Step 4. Press **<Enter>** to have the Access Level 0 prompt "=" appear on your terminal screen.

Step 5. Enter Access Level 2 by issuing the **ACC** and **2AC** commands, (the factory default passwords, as shown under the **PAS** command in your instruction manual, will be in effect).

Step 6. Use the **RESTORE SETTINGS** (**R_S**) command to restore factory default settings in the relay (use the **R_S 1** command for a 1 Amp SEL-387-type or 1 Amp SEL-352-type relay).

The relay will prompt whether you want to restore default settings. If your relay does not accept the **R_S** (or **R_S 1**) command, contact the factory for assistance.

Step 7. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the EN LED illuminates.

Note: If the relay prompts you to enter a part number, use either the number from the label on the disk containing your firmware or the number from the new part number sticker (if supplied).

Step 8. Press **<Enter>** to have the Access Level 0 prompt "=" appear on your terminal screen.

Step 9. Use the **ACC** and **2AC** commands to reenter Access Level 2.

Factory default passwords will be in effect.

Step 10. Restore original settings and passwords.

a. If you have SEL-5010 software or SEL-5030 ACSELERATOR Software, restore original settings as necessary.

b. If you do not have either SEL-5010 software or SEL-5030 ACSELERATOR Software, restore original settings by issuing the necessary **SET n** commands, where n can be 1–6, G, P, L, T, R, X, or Y, and the **PAS** command to set original relay passwords.

Use the **PAS** command as shown in the following example: Type **PAS 1: Ot3579 <Enter>** to set the Access Level 1 password to Ot3579. Use a similar format for other password levels. The **PAS** command is case sensitive, so the relay treats lower-case and upper-case letters differently.

Step 11. If any failure codes still appear on the relay display, see the testing and troubleshooting section in your relay instruction manual or contact the factory for assistance.

H. Verify Calibration, Status, Breaker Wear, and Metering

Step 1. To verify relay calibration settings, use the **SHO C** command. If the settings do not match those contained in the text file you recorded in ***Save Settings and Other Data*** on page B-6, contact the factory for assistance.

Note: Some relays support the **VERSION** (**VER**) command that you use to obtain a part number. Compare this number against the part number from the label on the disk containing your firmware.

a. If the label on the disk matches the part number on the screen, proceed to Step 2.

b. If the label on the disk does not match the part number on the screen, type **PAR<Enter>**, type the number from the disk label, and press **<Enter>**.

c. If the relay reinitializes after saving the changes, reenter Access Level 2 and proceed to Step 3.

Step 2. Use the **STATUS** (**STA**) command to verify that all relay self-test parameters are within tolerance.

Step 3. If you used the Breaker Wear Monitor, use the **BRE** command to check the data and see if the relay retained breaker wear data through the upgrade procedure.

If the relay did not retain these data, use the **BRE Wn** command to reload the percent contact wear values for each pole of Circuit Breaker n (n = 1, 2, 3, or 4) you recorded in ***Save Settings and Other Data*** on page B-6.

Step 4. Apply current and voltage signals to the relay.

Step 5. Use the **METER** (**MET**) command and verify that the current and voltage signals are correct.

Step 6. Use the **TRIGGER** (**TRI**) and **EVENT** (**EVE**) commands to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report.

If these values do not match, check the relay settings and wiring.

I. Return Relay to Service

Reenable relay control functions.

Note: If an SEL-2020 or SEL-2030 Communications Processor is connected to the relay, re-autoconfigure the SEL-20x0 port. Failure to do so may cause automatic data collection failure if power to the communications processor is cycled.

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 that does not occur in the course of other communications with the relay. Valid choices are one of the following: "@", "#", "$", "%", "&". The default is "@."

ADDR: Two character ASCII address. The range is "01" to "99." The default is "01."

SETTLE: Time in seconds that transmission is delayed after the request to send (RTS line) asserts. This delay accommodates transmitters with a slow rise time.

OPERATION

1. The relay ignores all input from this port until it detects the prefix character and the two-byte address.
2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
3. Wait until you receive a prompt before entering commands in order 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 time-up 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. To exploit this feature, the device connected to the other end of the link must have software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

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-387E Relay.

MESSAGE LISTS

Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	*Fast Meter* Configuration Block
A5D1	*Fast Meter* Data Block
A5B9	*Fast Meter* Status Clear Command
A5C2	Demand *Fast Meter* Configuration Block
A5D2	Demand *Fast Meter* Data Message
A5C3	Peak Demand *Fast Meter* Configuration Block
A5D3	Peak Demand *Fast Meter* Data Message
A5CE	*Fast Operate* Configuration Block
A5E0	*Fast Operate* Remote Bit Control
A5E3	*Fast Operate* Breaker Control
A5ED	*Fast Operate* Reset Command

ASCII Configuration Message List

Request to Relay (ASCII)	Response From Relay
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the *Fast Meter* Status Byte

Message Definitions

A5C0 Relay Definition Block

In response to the A5C0 request, the relay sends the following block:

Data	Description
A5C0	Command
40	Message length (64 bytes)
02	Support SEL and LMD protocols
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 Group settings
0300	SEL protocol has *Fast Operate*
0301	LMD protocol has *Fast Operate*
00	Reserved
1-byte	Checksum

A5C1 *Fast Meter* Configuration Block

In response to the A5C1 request, the relay sends the following block:

Data	Description
A5C1	*Fast Meter* command
E0	Message length (224 bytes)
01	One status flag byte
01	Scale factors in configuration message
05	# scale factors
0D	# analog input channels
02	# samples per channel
32	# digital banks (50 bytes)
04	# calculation blocks
0004	Analog channel data offset
0038	Time stamp offset (56 bytes)

0040	Digital data offset (64 bytes)
494157310000 (IAW1)	Analog channel name
00	Analog channel type (integer)
01	Scale factor type (4-byte float)
00CA	Scale factor offset (Winding 1)
494257310000 (IBW1)	
00	
01	
00CA	
494357310000 (ICW1)	
00	
01	
00CA	
494157320000 (IAW2)	
00	
01	
00CE	(Winding 2)
494257320000 (IBW2)	
00	
01	
00CE	
494357320000 (ICW2)	
00	
01	
00CE	
494157330000 (IAW3)	
00	
01	
00D2	(Winding 3)
494257330000 (IBW3)	
00	
01	
00D2	
494357330000 (ICW3)	
00	
01	
00D2	
564157580000 (VAWX)	
00	
01	
00D6	(voltages)
564257580000 (VBWX)	
00	
01	
00D6	
564357580000 (VCWX)	
00	
01	
00D6	

564443000000 (VDC)	
00	
01	
00DA	
1-byte	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
1-byte	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
1-byte	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
1-byte	Connection byte–Based on PHROT and DELTA_Y settings (Calculation block #4)
00	For VIWDG=1 or 2 or 3
02	For VIWDG=12
FFFF	No skew adjustment
FFFF	No RS offset
FFFF	No XS offset
xx	00 if VIWDG=1; 03 if VIWDG=2; 06 if VIWDG=3; FF if VIWDG=12
xx	01 if VIWDG=1; 04 if VIWDG=2; 07 if VIWDG=3; FF if VIWDG=12

xx	02 if VIWDG=1; 05 if VIWDG=2; 08 if VIWDG=3; FF if VIWDG=12
09	VAWX
0A	VBWX
0B	VCWX
4-bytes	Scale factor (200 · I_{nom}) · CTR1 Winding 1
4-bytes	Scale factor (200 · I_{nom}) · CTR2 Winding 2
4-bytes	Scale factor (200 · I_{nom}) · CTR2 Winding 3
xxxxxxxx	Scale factor 100 · PTR voltage
3C23D70A	Scale factor (1/100)
1-byte	Reserved
1-byte	Checksum

A5D1 *Fast Meter* Data Block

In response to the A5D1 request, the relay sends the following block:

Data	Description
A5D1	Command
76	Message length (116 bytes)
1-byte	Status byte

Bit	Usage
2	Self-test warning
3	Self-test failure
4	Settings change

52-bytes	Integers for the following: IAW1, IBW1, ICW1, IAW2, IBW2, ICW2, IAW3, IBW3, ICW3, VAWX, VBWX, VCWX, VDC (Imaginary values first, followed by Real values). Note: the imaginary value for VDC is always zero.
8-bytes	Time stamp
50-bytes	Digital banks -- targets 0 through 49
1-byte	Reserved
1-byte	Checksum

A5B9 *Fast Meter* Status Acknowledge Message

In response to the A5B9 request, the SEL-387E 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:

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
A8	Message length (168 bytes)

00	No status byte
01	Scale factors in *Fast Meter* configuration
00	No scale factors used
0F	15 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	
1-byte	Reserved
1-byte	Checksum

A5D2/A5D3 Demand/Peak Demand *Fast Meter* Message

In response to the A5D2 or A5D3 request, the relay sends the following block:

Data	Description
A5D2 or A5D3	Command
7E	Message length (126 bytes)
1-byte	Reserved
120-bytes	Demand meter values in double floats in the same order as channel listings in A5C2.
1-byte	Reserved
1-byte	Checksum

A5CE *Fast Operate* Configuration Block

In response to the A5CE request, the relay sends the following block:

Data	Description
A5CE	Command
40	Message length, #bytes (64)
03	# 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
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
1-byte	Reserved
1-byte	Checksum

A5E0 *Fast Operate* Remote Bit Control

The external device sends the following message to perform a remote bit operation (set, clear, pulse):

Data	Description
A5E0	Command
06	Message length
1-byte	Operate code (0-F, 20-2F, 40-4F for remote bit clear, set or pulse)
1-byte	Operate validation: 4 * operate code + 1
1-byte	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:

Data	Description
A5E3	Command
06	Message length
1-byte	Operate code (hex 31-33 open, hex 11-13 close breakers 1 through 3)
1-byte	Operate validation: 4 * operate code + 1
1-byte	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

Data	Description
A5CD	Command
0E	Message length
01	The number of *Fast Operate* reset codes supported
1-byte	Reserved for future use
	Per *Fast Operate* reset code, repeat:
00	*Fast Operate* reset code (e.g., "00" for target reset)
54415220520000	*Fast Operate* reset description string (e.g., "TAR R")
1-byte	Checksum

A5ED *Fast Operate* Reset Command

The *Fast Operate* Reset commands take the following form:

Data	Description
A5ED	Command
06	Message length–always 6
00	Operate Code (e.g., "00 for target reset, "TAR R")
00	Operate Validation–(4 + Operate Code) +1
1-byte	Checksum

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>
"THE CHECKSUM OF THE ROM CODE","yyyy"<CR>
"THE TERMINAL ID AS SET BY THE TID SETTING","yyyy"<CR>
"DEVCODE=42","yyyy"<CR>
"PARTNO=0387EXXXXXXXXXp","yyyy"<CR>
"CONFIG=111100","0387"<CR>
<ETX> (ETX character, 03)

where yyyy is the 4-byte ASCII representation of the hex checksum for the line.
42 is the device code used by the SEL-2020 to identify the relay to Modbus users.
PARTNO reports the part number. The last digit of the part number (p) indicates whether the firmware supports DNP communication or not. For p = 1, the communications protocol will be Standard plus DNP 3.00 Level 2 Slave; for p = X, it will be Standard with no DNP.

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. The **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","OUT02","52A".

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and cartridge return. The last row may have fewer than eight strings.

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-387E 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-387E 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-387E Relay provides the following Compressed ASCII commands:

Command	Description
CASCII	Configuration message
CBREAKER	Breaker report
CEVENT	Event report (Winding)
CEVENT **DIF**	Event report (Differential)
CHISTORY	History report
CSTATUS	Status report
CTARGET	Target display

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",ll,"yyyy" <CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy" <CR>
"COMMAND 2",ll,"yyyy" <CR>
"#h","ddd","ddd",......,"ddd","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy" <CR>
    •
    •
    •
"COMMAND n",ll,"yyyy" <CR>
"#H","xxxxx","xxxxx",......,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",......,"ddd","yyyy" <CR><ETX>
```

where n is the number of Compressed ASCII command descriptions to follow.

COMMAND is the ASCII name for the Compressed ASCII command as sent by the requesting device. The naming convention for the Compressed ASCII commands is a

'C' preceding the typical command. For example, **CSTATUS** (abbreviated to CST) is the compressed **STATUS** command.

ll is the minimum access level (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>

CASCII Command – SEL-387E Relay

Display the SEL-387E Relay Compressed ASCII configuration message by sending:

CAS <ENTER>

The relay sends:

<STX>
"**CAS**",7,"yyyy"<CR>
"**CST**",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"," yyyy"<CR>
"26H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","VAWX",
"VBWX","VCWX","+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"," yyyy"<CR>

"**CBR**",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"," yyyy"<CR>
"19H","BREAKER","INT_TRIPS","IAW","IBW","ICW","EXT_TRIPS","IAW","IBW","ICW",
"POLE1","POLE2","POLE3","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC",
" yyyy"<CR>
"3D","I","I","F","F","F","I","F","F","F","I","I","I","I","I","I","I","I","I","I"," yyyy"<CR>

"**CHI**",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"," yyyy"<CR>
"11H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"GROUP","TARGETS"," yyyy"<CR>
"99D","I","I","I","I","I","I","I","I","7S","I","52S"," yyyy"<CR>

"**CEV**",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"," yyyy"<CR>
"5H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT"," yyyy"<CR>
"1D","F","I","I","F","7S"," yyyy"<CR>
"16H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","VAWX",
"VBWX","VCWX","VDC","FREQ","TRIG","***NAMES OF ELEMENTS IN ALL RELAY WORD ROWS*** "," yyyy"<CR>
"60D","F","F","F","F","F","F","F","F","F","F","F","F","F","F","1S","88S"," 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"," yyyy"<CR>
"5H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT"," yyyy"<CR>
"1D","F","I","I","F","7S"," yyyy"<CR>
"16H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","VAWX",
"VBWX","VCWX","VDC","FREQ","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","F","1S","88S"," 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"," yyyy"<CR>
"5H","FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT"," yyyy"<CR>
"1D","F","I","I","F","7S"," yyyy"<CR>

"16H","IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","VAWX","VBWX","VCWX","VDC","FREQ","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","F","1S","88S"," 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-387E Relay Compressed ASCII breaker report by sending:

CBR <ENTER>

The relay sends:

<STX>
"FID","yyyy"<CR>
"FID=SEL-387E-XXXX-V-ZXXXXXX-DXXXXXXXX","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"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 are 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-321 Relay. 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-387E-XXXX-V-ZXXXXXX-DXXXXXXXX","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>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","VAWX",
"VBWX","VCWX","VDC","TRIG","FREQ","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,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-387E-XXXX-V-ZXXXXXX-DXXXXXXXX","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-387E Relay Compressed ASCII history report by sending:

CHI <ENTER>

The relay sends:

<STX>
"FID","yyyy"<CR>
"FID=SEL-387E-XXXX-V-ZXXXXXX-DXXXXXXXX","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 comprise 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-387E Relay Compressed ASCII status report by sending:

CST <ENTER>

The relay sends:

<STX>
"FID","yyyy"<CR>
"FID=SEL-387E-XXXX-V-ZXXXXXX-DXXXXXXXX","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", "VAWX",
"VBWX","VCWX",
"+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS",
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx", "xxxx",
"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-387E 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.

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 Sequential Events Reporting*** of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from the SEL-387E Relay.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data. To exploit this feature, the device connected to the other end of the link requires software that uses the separate data streams. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

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 four state changes per minute can be made for a 25-year relay service life.

RECOMMENDED MESSAGE USAGE

Use the following sequence of commands to enable unsolicited binary SER messaging in the SEL-387E 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-387E Relay to transmit unsolicited binary SER messages.
2. When SER records are triggered in the SEL-387E, 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 contained in the original message. The relay will wait approximately 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited 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-387E Relay disables its own unsolicited transmissions. This function enables the SEL-387E Relay to begin sending unsolicited data to the device which sent the enable message, if the SEL-387E has such data to transfer. The message format for function code 0x01 is shown below.

Data	Description
A546	Message header
12	Message length in bytes (18 decimal)
0000000000	Five bytes reserved for future use as a routing address
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
01	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 00, 01...).
18	Function to enable (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-387E 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 are due to settings changes and power being applied to the relay. If the SER1, SER2, SER3, or SER4 settings are subsequently changed to any non-NA value and SER entries are triggered, unsolicited SER messages will be generated with the new SER records.

0x02 - Function Code: Disable Unsolicited Data Transfer

This function disables the SEL-387E Relay from transferring unsolicited data. The message format for function code 0x02 is shown below.

Data	Description
A546	Message header
10	Message length (16 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status byte (LSB = 1 indicates an acknowledge is requested)
02	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
18	Function to disable (0x18 = Unsolicited SER)
00	Reserved for future use as function code data
cccc	Two byte CRC-16 check code for message

The SEL-387E 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 Sequential Events Response

The function 0x18 is used for the transmission of unsolicited Sequential Events Recorder (SER) data from the SEL-387E 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.

Data	Description
A546	Message header
ZZ	Message length (Up to 34 + 4 • nn decimal, where nn is the maximum number of SER records allowed per message as indicated in the "Enable Unsolicited Data Transfer" message.)

0000000000	Five bytes reserved for future use as a routing address
YY	Status Byte (01 = need acknowledgment; 03 = settings changed and need acknowledgment)
18	Function code
C0	Sequence byte (Always C0. Other values are reserved for future use in multiple frame messages.)
XX	Response number (XX = 00, 01, 02, 03, 01, 02...)
00000000	Four bytes reserved for future use as a return routing address
dddd	Two-byte day of year (1 - 366)
yyyy	Two-byte, four-digit year (e.g., 1999 or 07CF hex)
mmmmmmmm	Four-byte time of day in milliseconds since midnight
XX	1st element index (match with the response to the **SNS** command; 00 for 1st element, 01 for second element, and so on)
uuuuuu	Three-byte time tag offset of 1st element in microseconds since time indicated in the time of day field.
XX	2nd element index
uuuuuu	Three-byte time tag offset of 2nd element in microseconds since time indicated in the time of day field.
.	
.	
.	
xx	last element index
uuuuuu	Three-byte time tag offset of last element in microseconds since time indicated in the time of day field.
FFFFFFFE	Four-byte end-of-records flag
ssssssss	Packed four-byte element status for up to 32 elements (LSB for the 1st element)
cccc	Two-byte CRC-16 checkcode for message

If the relay determines that SER records have been lost, it sends a message with the following format:

Data	Description
A546	Message header
22	Message length (34 decimal)
0000000000	Five bytes reserved for future use as a routing address.
YY	Status Byte (01 = need 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.

Data	Description
A546	Message header
0E	Message length (14 decimal)
0000000000	Five bytes reserved for future use as a routing address
00	Status byte (always 00)
XX	Function code, echo of acknowledged function code with MSB set.
RR	Response code (see below)
XX	Response number (XX = 00, 01, 02, 03, 00, 01, ...) must match response number from message being acknowledged.
cccc	Two-byte CRC-16 checkcode for message

The SEL-387E supports the following response codes:

RR	Response
00	Success
01	Function code not recognized
02	Function disabled

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 "Disable 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 00 98 00 XX cc cc
   (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-387E family of relays support Distributed Network Protocol (DNP) 3.00 L2 Slave protocol. This includes access to metering data, protection elements (Relay Word), contact I/O, targets, Sequential Events Recorder, breaker monitor, relay summary event reports, settings groups, and time synchronization. The SEL-387E 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
DECPLV	Voltage scaling (0–3 decimal places)	1
DECPLM	Misc. 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	Current analog reporting dead band (0–32767 counts)	100
ANADBV	Voltage analog reporting dead band (0–32767 counts)	100
ANADBM	Misc. 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

Label	Description	Default
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-387E 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-387E 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-387E 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-387E 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-387E decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-387E 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-387E 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-387E 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-387E**

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):

Supports enabling and disabling of unsolicited reports on a class basis.

Supports Virtual Terminal.

Maximum Data Link Frame Size (octets): Transmitted 292 Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted 2048 (if >2048, must be configurable) Received 2048 (must be >249)
Maximum Data Link Re-tries: ❒ None ❒ Fixed at ____ ☑ Configurable, range 0 to 15	Maximum Application Layer Re-tries: ☑ None ❒ Configurable, range ____ to ____ (Fixed is not permitted)

Requires Data Link Layer Confirmation:

❒ Never
❒ Always
❒ Sometimes If 'Sometimes', when? ____
☑ Configurable If 'Configurable', how? by settings.

Requires Application Layer Confirmation:

❒ Never
❒ Always (not recommended)
☑ When reporting Event Data (Slave devices only)
❒ When sending multi-fragment responses (Slave devices only)
❒ Sometimes If 'Sometimes', when? ____
❒ Configurable If 'Configurable', how? ____

Time-outs while waiting for:

Data Link Confirm	❒ None	❒ Fixed at ____	❒ Variable	☑ Configurable
Complete Appl. Fragment	☑ None	❒ Fixed at ____	❒ Variable	❒ Configurable
Application Confirm	❒ None	❒ Fixed at ____	❒ Variable	☑ Configurable
Complete Appl. Response	☑ None	❒ Fixed at ____	❒ Variable	❒ Configurable

Others ____

Attach explanation if 'Variable' or 'Configurable' was checked for any time-out.

Sends/Executes Control Operations:

WRITE Binary Outputs	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
SELECT/OPERATE	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
DIRECT OPERATE	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
DIRECT OPERATE - NO ACK	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Count > 1	☑ Never	❒ Always	❒ Sometimes	❒ Configurable
Pulse On	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Pulse Off	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Latch On	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Latch Off	❒ Never	☑ Always	❒ Sometimes	❒ Configurable
Queue	☑ Never	❒ Always	❒ Sometimes	❒ Configurable
Clear Queue	☑ Never	❒ Always	❒ Sometimes	❒ Configurable

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

- ❒ Either time-tagged or non-time-tagged for a single event
- ❒ Both time-tagged and non-time-tagged for a single event
- ❒ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY

Reports Binary Input Change Events when no specific variation requested:

- ❒ Never
- ❒ Only time-tagged
- ☑ Only non-time-tagged
- ❒ Configurable to send both, one or the other (attach explanation)

Reports time-tagged Binary Input Change Events when no specific variation requested:

- ☑ Never
- ❒ Binary Input Change With Time
- ❒ Binary Input Change With Relative Time
- ❒ Configurable (attach explanation)

Sends Unsolicited Responses:

- ❒ Never
- ☑ Configurable (attach explanation)
- ❒ Only certain objects
- ❒ Sometimes (attach explanation)

☑ ENABLE/DISABLE UNSOLICITED

Function codes supported

Sends Static Data in Unsolicited Responses:

- ☑ Never
- ❒ When Device Restarts
- ❒ When Status Flags Change

No other options are permitted.

Default Counter Object/Variation:	Counters Roll Over at:
❒ No Counters Reported ❒ Configurable (attach explanation) ☑ Default object 20 ❒ Default variation 6 ❒ Point-by-point list attached	❒ 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-387E settings.

Object Table

The following object table lists supported objects, functions, and qualifier code combinations.

Table G.2: SEL-387E 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				

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0,1,6,7,8	129	0,1,7,8
20	6*	16-Bit Binary Counter Without Flag	1	0,1,6,7,8	129	0,1,7,8
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter–All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event–All Variations	1	6,7,8		
22	1	32-Bit Counter Change Event Without Time	1	6,7,8	129	17,28
22	2*	16-Bit Counter Change Event Without Time	1	6,7,8	129,130	17,28
22	3	32-Bit Delta Counter Change Event Without Time				
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				

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input–All Variations	1	0,1,6,7,8		
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8
30	3	32-Bit Analog Input Without Flag	1	0,1,6,7,8	129	0,1,7,8
30	4*	16-Bit Analog Input Without Flag	1	0,1,6,7,8	129	0,1,7,8
31	0	Frozen Analog Input–All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
32	0	Analog Change Event–All Variations	1	6,7,8		
32	1	32-Bit Analog Change Event Without Time	1	6,7,8	129	17,28
32	2*	16-Bit Analog Change Event Without Time	1	6,7,8	129,130	17,28
32	3	32-Bit Analog Change Event With Time	1	6,7,8	129	17,28
32	4	16-Bit Analog Change Event With Time	1	6,7,8	129	17,28
33	0	Frozen Analog Event–All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
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	129	07,

Object			Request (supported)		Response (may generate)	
Obj.	*default Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
				index = 0		quantity=1
50	2	Time and Date With Interval				
51	0	Time and Date CTO–All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quantity=1
52	0	Time Delay–All Variations				
52	1	Time Delay Coarse				
52	2	Time Delay Fine			129	07, quantity=1
60	0	All Classes of Data	1,20,21	6		
60	1	Class 0 Data	1	6		
60	2	Class 1 Data	1,20,21	6,7,8		
60	3	Class 2 Data	1,20,21	6,7,8		
60	4	Class 3 Data	1,20,21	6,7,8		
70	1	File Identifier				
80	1	Internal Indications	2	0,1 index = 7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
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-387E Relay (see ***Appendix A***: ***Firmware Versions***).

Table G.3: SEL-387E-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 50/51, 1607 is EN, and 1600 is 24.
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.
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	22–29	Remote bit pairs RB1–RB16.
10,12	30	Open/Close pair for breaker 1.
10,12	31	Open/Close pair for breaker 2.
10,12	32	Open/Close pair for breaker 3.
10,12	33	Reset demands.
10,12	34	Reset demand peaks.
10,12	35	Reset breaker monitor.
10,12	36	Reset front-panel targets.
10,12	37	Read next relay event.
10,12	38	Reset energy metering.
20,22	00	Active settings group.

DNP Object Type	Index	Description
20,22	01	Internal breaker trips 1.
20,22	02	Internal breaker trips 2.
20,22	03	Internal breaker trips 3.
20,22	04	External breaker trips 1.
20,22	05	External breaker trips 2.
20,22	06	External breaker trips 3.
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.
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	VA magnitude and angle.
30,32	38,39	VB magnitude and angle.
30,32	40,41	VC magnitude and angle.
30,32	42,43	3V1 magnitude and angle.
30,32	44,45	3V2 magnitude and angle.
30,32	46,47	3V0 magnitude and angle.
30,32	48–51	MW 3-phase, A,B,C.
30,32	52–55	MVAR 3-phase, A,B,C.
30,32	56–59	MVA 3-phase, A,B,C.

DNP Object Type	Index	Description
30,32	60	IOP1 Operate Current.
30,32	61	IOP2 Operate Current.
30,32	62	IOP3 Operate Current.
30,32	63	IRT1 Restraint Current.
30,32	64	IRT2 Restraint Current.
30,32	65	IRT3 Restraint Current.
30,32	66	I1F2 Second Harmonic Current.
30,32	67	I2F2 Second Harmonic Current.
30,32	68	I3F2 Second Harmonic Current.
30,32	69	I1F5 Fifth Harmonic Current.
30,32	70	I2F5 Fifth Harmonic Current.
30,32	71	I3F5 Fifth Harmonic Current.
30,32	72	Volts/Hertz.
30,32	73	Frequency.
30,32	74	VDC.
30,32	75–79	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 1.
30,32	80–84	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 2.
30,32	85–89	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 3.
30,32	90	Peak demand IA mag. for Wdg. 1.
30	91–93	Peak demand IA time in DNP format for Wdg. 1.
30,32	94	Peak demand IB mag. for Wdg. 1.
30	95–97	Peak demand IB time in DNP format for Wdg. 1.
30,32	98	Peak demand IC mag. for Wdg. 1.
30	99–101	Peak demand IC time in DNP format for Wdg. 1.
30,32	102	Peak demand 3I2 mag. for Wdg. 1.
30	103–105	Peak demand 3I2 time in DNP format for Wdg. 1.
30,32	106	Peak demand IR mag. for Wdg. 1.
30	107–109	Peak demand IR time in DNP format for Wdg. 1.
30,32	110	Peak demand IA mag. for Wdg. 2.
30	111–113	Peak demand IA time in DNP format for Wdg. 2.
30,32	114	Peak demand IB mag. for Wdg. 2.
30	115–117	Peak demand IB time in DNP format for Wdg. 2.
30,32	118	Peak demand IC mag. for Wdg. 2.
30	119–121	Peak demand IC time in DNP format for Wdg. 2.

DNP Object Type	Index	Description
30,32	122	Peak demand 3I2 mag. for Wdg. 2.
30	123–125	Peak demand 3I2 time in DNP format for Wdg. 2.
30,32	126	Peak demand IR mag. for Wdg. 2.
30	127–129	Peak demand IR time in DNP format for Wdg. 2.
30,32	130	Peak demand IA mag. for Wdg. 3.
30	131–133	Peak demand IA time in DNP format for Wdg. 3.
30,32	134	Peak demand IB mag. for Wdg. 3.
30	135–137	Peak demand IB time in DNP format for Wdg. 3.
30,32	138	Peak demand IC mag. for Wdg. 3.
30	139–141	Peak demand IC time in DNP format for Wdg. 3.
30,32	142	Peak demand 3I2 mag. for Wdg. 3.
30	143–145	Peak demand 3I2 time in DNP format for Wdg. 3.
30,32	146	Peak demand IR mag. for Wdg. 3.
30	147–149	Peak demand IR time in DNP format for Wdg. 3.
30,32	150–152	Breaker contact wear percentage (A, B, C) for Wdg. 1.
30,32	153–155	Breaker contact wear percentage (A, B, C) for Wdg. 2.
30,32	156–158	Breaker contact wear percentage (A, B, C) for Wdg. 3.
30,32	159	Event Type.
30,32	160	Fault Targets.
30,32	161–172	Fault values (all windings, all phases).
30,32	173	Volts/Hertz.
30,32	174	Fault settings group.
30	175–177	Fault time in DNP format (high, middle, and low 16 bits).
30,32	178,179	3-phase MWhr in and out.
30,32	180,181	A-phase MWhr in and out.
30,32	182,183	B-phase MWhr in and out.
30,32	184,185	C-phase MWhr in and out.
30,32	186,187	3-phase MVARhr in and out.
30,32	188,189	A-phase MVARhr in and out.
30,32	190,191	B-phase MVARhr in and out.
30,32	192,193	C-phase MVARhr in and out.
30	194–196	Last reset time in DNP format.
40,41	00	Active settings group.

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 4: Control Logic***. 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, voltage magnitudes by DECPLV, and other magnitudes by DECPLM. For example, if DECPLx is 3, then its value is multiplied by 1000. Event-class messages are generated whenever an input changes beyond the value given by the appropriate analog dead-band setting (ANADBA, ANADBV, ANADBM). 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 dead-band setting. Analog inputs are scanned at approximately a half-second rate, except for analogs 159–177. During a scan, all events generated will use the time the scan was initiated. Analogs 159–177 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 159 is defined as follows:

Value	Event Cause
1	**Trigger** command
2	**Pulse** command
4	ER element
16	Trip 4
32	Trip 3
64	Trip 2
128	Trip 1

If Analog 159 is 0, no more new events are available (i.e., all events have been read).

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
16–21	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
22	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
23	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
24	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
25	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
26	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
27	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
28	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
29	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
30	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1
31	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2
32	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3
33–37	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-387E Relay Binary Input Lookup Table

Row	SEL-387 Relay Word Bits								Binary Input Point
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	*	27V1	27PP2	27PP1	27P2	27P1	*	CTS	103–96
15	59Q	59G2	59G1	59V1	59PP2	59PP1	59P2	59P1	111–104
16	81D1	81D2	81D3	81D4	81D5	81D6	*	27B81	119–112
17	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	*	*	127–120
18	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R	135–128

Row	SEL-387 Relay Word Bits								Binary Input Point
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	24D1	24D1T	24C2	24C2T	24CR	159–152
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2	167–160
23	*	*	*	*	*	*	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	*	199–192
27	4HBL	DCBL	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
37	S3LT1	S3LT2	S3LT3	S3LT4	S3LT5	S3LT6	S3LT7	S3LT8	287–280
38	*	*	*	50GC	50G3	32IR	32IF	REFP	295–288
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2	303–296
40	BCWA3	BCWB3	BCWC3	BCW3	*	*	*	*	311–304
41	TRIP1	TRIP2	TRIP3	TRIP4	*	TRIPL	*	TRGTR	319–312
42	CLS1	CLS2	CLS3	*	CF1T	CF2T	CF3T	*	327–320
43	NOTALM	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

* Reserved for future use.

** These rows will show asterisks in response to **TAR** command, if optional interface board is not installed.

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 159–177) 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 159) 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
```

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, ANADBV, or ANADBM 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-387E, the SEL-387E 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. DNP 3.0 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 this instruction manual. 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-387E Relay DNP Port – SET P Settings Sheet

Port Protocol (SEL, LMD, DNP)	PROTO	=	DNP
Baud (300, 1200, 2400, 4800, 9600, 19200)	SPEED	=	
Port Time-out (0–30 minutes)	T_OUT	=	
DNP Address (0–65534)	DNPADR	=	
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	=	
Currents scaling (0–3 decimal places)	DECPLA	=	
Voltage scaling (0–3 decimal places)	DECPLV	=	
Misc. scaling (0–3 decimal places)	DECPLM	=	
Time-set request interval, minutes (0 for never, 1–32767)	TIMERQ	=	
Select/Operate time-out interval, seconds (0.0–30.0)	STIMEO	=	
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	=	
Analog reporting dead band (0–32767 counts)	ANADBV	=	
Analog reporting dead band (0–32767 counts)	ANADBM	=	
Event Data Confirmation time-out (0.1–50.0 sec)	ETIMEO	=	

Number of data-link retries (0 for no confirm, 1–15)	DRETRY	=	________
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-387E RELAY COMMAND SUMMARY

ACCESS LEVEL 0 COMMANDS

Access Level 0 <u>Commands</u>	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 (JMP6A) 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 <u>Commands</u>	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: =>
ACC	Enter Access Level 1. If the main board password jumper (JMP6A) 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 (JMP6A) 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 (JMP6A) 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 three 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 DAT m/d/y DAT y/m/d	Show date presently in the relay. Enter date in this manner if Date Format setting DATE_F = MDY. 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	Reports the number and type of interface 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 E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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.

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.
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 output contacts. 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 (JMP6A) 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 (JMP6A) 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, A).
BRE W n	Pre-set the percent contact wear for each pole of Breaker n (n = 1, 2, 3).
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)
CLO n	Assert the CCn Relay Word bit. Used to close Breaker n if CCn is assigned to an output contact. JMP6B 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	Reports the number and type of interface 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 E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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. JMP6B 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. JMP6B 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.
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 (JMP6A) 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 (JMP6A) 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 three breakers.
BRE R n	Reset trip counters, trip currents, and wear data for Breaker n (n = 1, 2, 3, A).
BRE W n	Pre-set the percent contact wear for each pole of Breaker n (n = 1, 2, 3).
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)
CLO n	Assert the CCn Relay Word bit. Used to close Breaker n if CCn is assigned to an output contact. JMP6B 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)].
COP 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	Reports the number and type of interface boards in the relay. In Access Level 2, confirms that interface 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 DIF k	Display differential metering data, in multiples of tap. Enter number k to scroll metering k times on screen.
MET E	Display energy metering data.
MET H	Generate harmonic spectrum report for all input currents, showing first to 15th 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, A)
MET RP n	Reset peak demand metering values. (n = 1, 2, 3, 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. JMP6B 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. JMP6B 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.
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.