

SEL-387-0, -5, -6 Relay

Current Differential Overcurrent Relay Data Recorder

Instruction Manual

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PM387-01

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Preface

Manual Overview

The SEL-387 Relay Instruction Manual describes common aspects of the application and use of this relay. It includes the necessary information to install, set, test, and operate the relay and more detailed information about settings and commands.

If you are unfamiliar with this relay, we suggest that you read the following sections in the outlined order.

Section 1: Introduction and Specifications. Provides an introduction, relay functional overview, and specifications.

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

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

Section 6: Setting the Relay. Describes methods for setting the device, settings not explained in *Section 3* or *Section 4*, and default settings. Provides *Settings Sheets* with examples.

Section 7: Serial Port Communications and Commands. Explains the serial port commands necessary for setting the relay for such functions as control, obtaining target information, and obtaining metering information.

Section 8: Front-Panel Interface. Describes use of the front panel to perform the actions of serial port commands.

Section 5: Metering and Monitoring. Explains how to retrieve such operations data as metering results, dc battery status, breaker wear, through-fault event data, and relay status.

Section 9: Event Reports and SER. Reviews event report and sequential events report generation, event report formats, sequential event reports, and report interpretation.

Section 2: Installation. Provides information necessary for configuring, installing, and wiring your relay.

Section 10: Testing and Troubleshooting. Includes test procedures and a troubleshooting guide. Can serve as a tutorial and as a check of your understanding of relay operation.

The appendices in this instruction manual provide helpful reference material.

Appendix A: Firmware and Manual Versions. Lists the present and previous versions of relay firmware and explains differences. Provides a record of changes to the manual since the initial release.

Appendix B: SEL-300 Series Relays Firmware Upgrade Instructions. Describes the procedure to update the firmware stored in flash memory.

Appendix C: SEL Distributed Port Switch Protocol (LMD). Describes the use of this protocol.

Appendix D: Configuration, Fast Meter, and Fast Operate Commands.

Describes use of these commands in communicating ASCII and binary messages over a single communications channel.

Appendix E: Compressed ASCII Commands. Describes commands that produce machine-readable relay data for export to an external device.

Appendix F: Unsolicited SER Protocol. Describes a protocol certain devices can use in receiving unsolicited binary data from the relay.

Appendix G: Distributed Network Protocol. Describes DNP3 protocol.

Appendix H: Protection Application Examples. Describes transformer winding and CT connection compensation settings examples.

Appendix I: PC Software. Describes PC software solutions that support SEL devices.

SEL-387 Relay Command Summary. Summarizes the serial port commands fully described in *Section 7*.

Safety Information

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

DANGER

Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

WARNING










Indicates a potentially hazardous situation that, if not avoided, **could** result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

Safety Symbols

The following symbols are often marked on SEL products.

	 CAUTION Refer to accompanying documents.	 ATTENTION Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d'instructions

Safety Marks

The following statements apply to this device.

General Safety Marks

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
⚠ 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. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Ray-O-Vac® no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.

Other Safety Marks

⚠ DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠ DANGER Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠ 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.
⚠ WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠ AVERTISSEMENT Avant de travailler sur un circuit TC, placez d'abord un court-circuit sur l'enroulement secondaire du TC.
⚠ WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠ AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠ 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 appareil 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 peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.
⚠ WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠ AVERTISSEMENT L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠ 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.
⚠ 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 relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.	⚠ ATTENTION Le relais contient des pièces sensibles aux décharges électrostatiques. Quand on travaille sur le relais avec les panneaux avant ou du dessus enlevés, toutes les surfaces et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

General Information

Typographic Conventions

- There are three ways to communicate with the SEL-387:
- Using a command line interface on a PC terminal emulation window, such as Microsoft® HyperTerminal®.
 - Using the front-panel menus and pushbuttons.
 - Using ACSELERATOR QuickSet® SEL-5030 Software

The instructions in this manual indicate these options with specific font and formatting attributes. The following table lists these conventions:

Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
{CLOSE}	Relay front-panel pushbuttons.
ENABLE	Relay front- or rear-panel labels.
MAIN > METER	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.
SELOGIC control equations	SEL trademarks and registered trademarks contain the appropriate symbol on first reference in a section. In the SEL-387 Instruction Manual, certain SEL trademarks appear in small caps. These include SELOGIC control equations.
Modbus®	Registered trademarks of other companies include the registered trademark symbol with the first occurrence of the term in a section.

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-387. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-387.

Section 1

Introduction and Specifications

Overview

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

The SEL-387 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 website (selinc.com).

Relay Functions

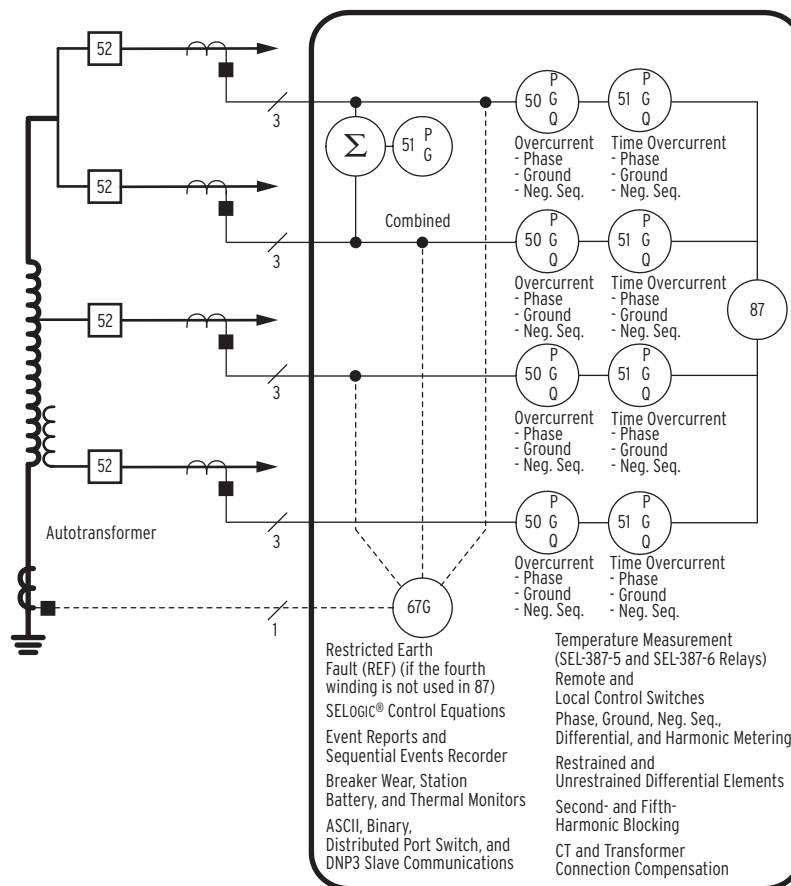


Figure 1.1 Functional Overview

Current Differential Protection

The SEL-387 includes independent restrained and unrestrained current differential elements. The restrained element has a dual-slope, variable-percentage restraint characteristic. A separate unrestrained differential element provides faster clearance of high-magnitude, internal faults.

SEL-387-0 Relay

The relay provides security against conditions that may cause relay misoperation, resulting from both system and transformer events. Use the fifth-harmonic element to prevent relay misoperation during allowable overexcitation conditions. Even-harmonic elements (second) provide security against inrush currents during transformer energization. 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- and fifth-harmonic thresholds are set independently.

SEL-387-5 Relay and SEL-387-6 Relay

These relays also provide security against conditions that may cause relay misoperation, resulting from both system and transformer events. 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 that 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.

Restricted Earth Fault Protection

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

Thermal Protection (SEL-387-6 Relay)

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

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

Overcurrent Protection

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

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

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

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

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

Through-Fault Event Monitor (SEL-387-5 and SEL-387-6)

Through faults are a major cause of transformer damage and failure. Fault currents cause cumulative mechanical damage by displacing transformer windings every time a fault occurs. Thermal stress from fault currents damages insulation. The SEL-387-5 and the SEL-387-6 provide a through-fault event monitor to gather fault current level, duration, and date/time for each through fault. The monitor performs a simple I^2t calculation and cumulatively stores calculation results for each phase. Use these through-fault event data to schedule proactive maintenance for transformers and to help justify possible system enhancements to mitigate through faults.

Programmable Optoisolated Inputs and Output Contacts

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

Application Ideas

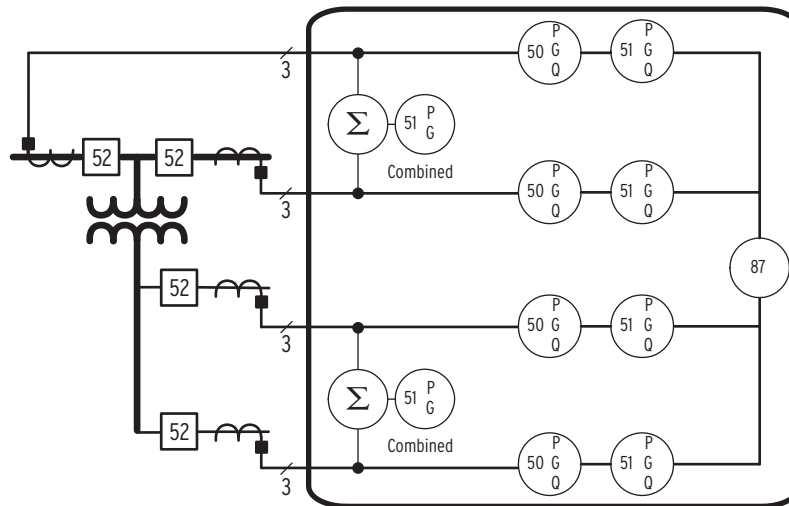


Figure 1.2 Transformer and Overcurrent Protection

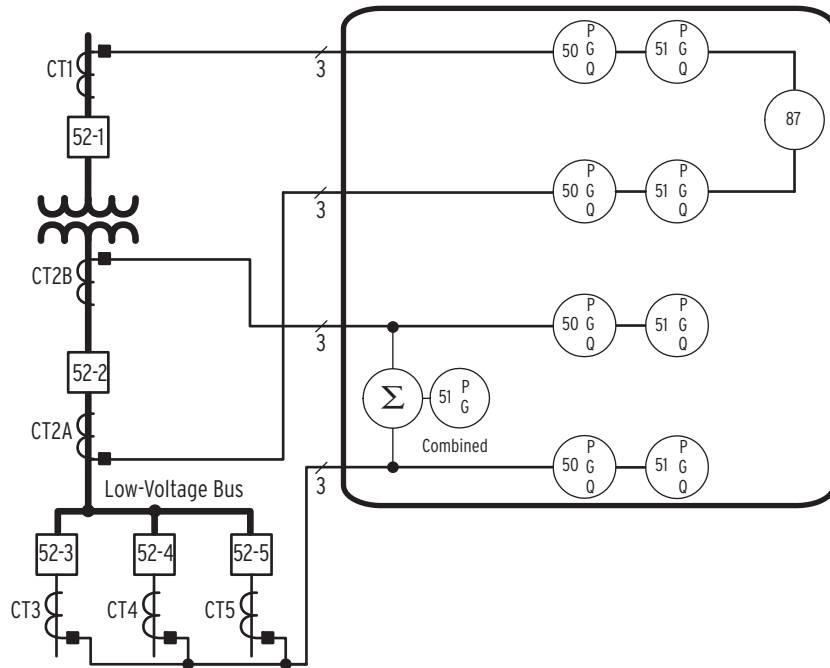


Figure 1.3 Transformer and Low-Voltage Bus Protection

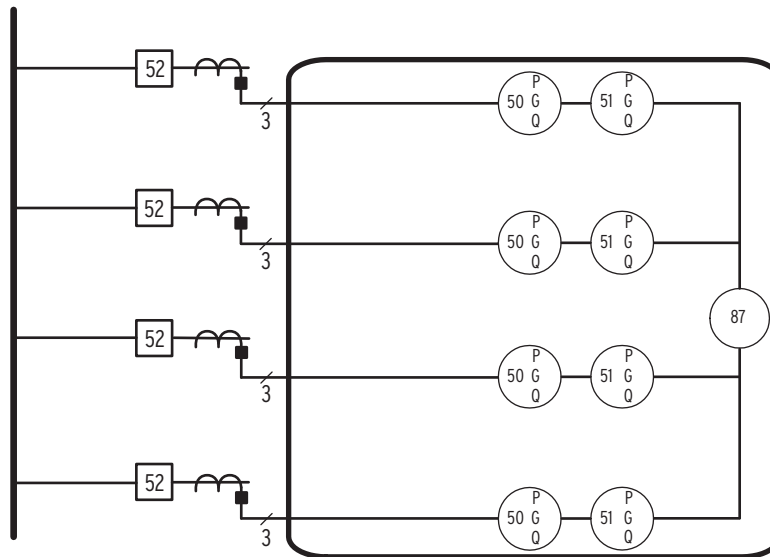


Figure 1.4 Bus and Feeder Protection

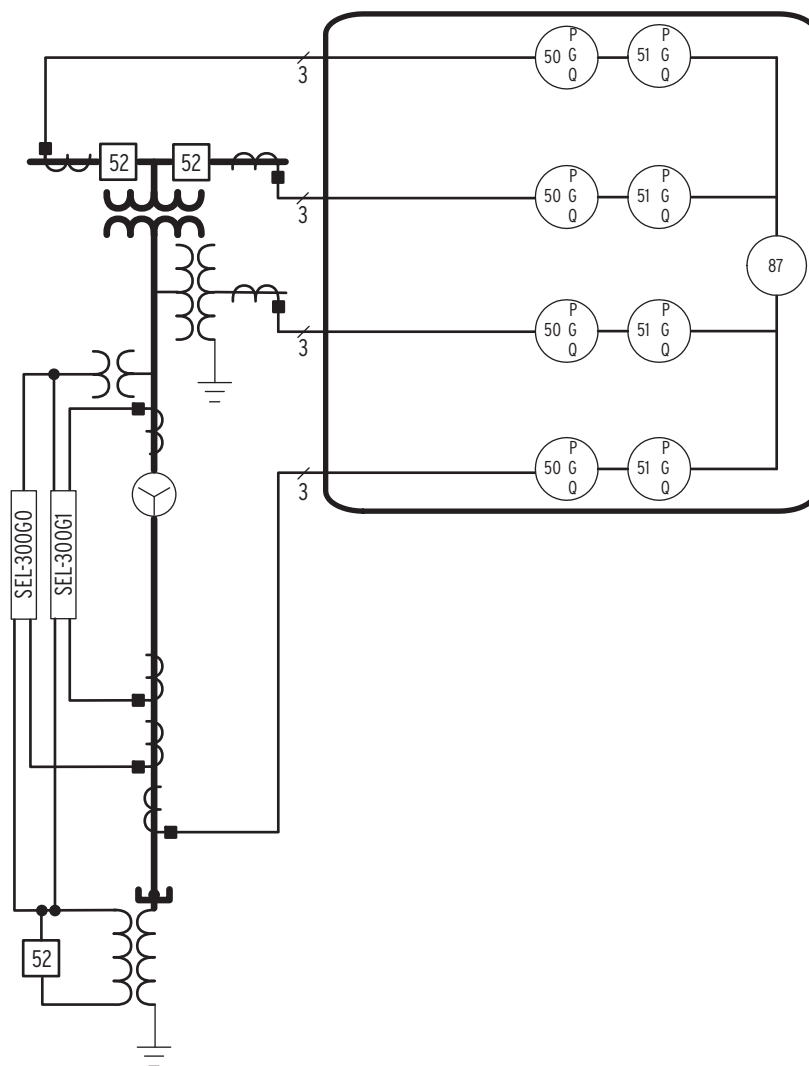


Figure 1.5 Unit Differential Protection

Model Options

SEL-387-0 Relay

The SEL-387-0 (Model 03870xxxx) has provided sophisticated and reliable service for many years. It continues to satisfy the needs of most of our customers. However, we recommend using the SEL-387-5 or the SEL-387-6 for new designs because of the enhanced features they provide.

SEL-387 Relay

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

- Adds 16 local control switches
- Adds 8 latch control switches for a total of 16
- Adds DNP3 Level 2 Slave communications protocol

SEL-387-6 Relay

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

Conventional Terminal Blocks

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

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

Plug-In Connectors (Connectorized)

This model includes hardware that supports all of the features of the conventional terminal blocks model. It differs in its use of plug-in connectors (Connectorized®) 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

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)

CE Mark

RCM Mark

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

General

AC Current Inputs

5 A nominal:	15 A continuous, 500 A for 1 s, linear to 100 A symmetrical, 1250 A for 1 cycle
Burden:	0.27 VA at 5 A 2.51 VA at 15 A
1 A nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical, 250 A for 1 cycle
Burden:	0.13 VA at 1 A 1.31 VA at 3 A

Power Supply

125/250 Vdc or Vac	
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Interruption:	45 ms at 125 Vdc
Ripple:	100%
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%
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 60255-11:1979.

Output Contacts

Standard:	
Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	270 Vac/360 Vdc; 130 J

Pickup Time:	<5 ms		
Dropout Time:	<5 ms, typical		
Breaking Capacity (10,000 Operations):			
24 V	0.75 A	L/R = 40 ms	
48 V	0.50 A	L/R = 40 ms	
125 V	0.30 A	L/R = 40 ms	
250 V	0.20 A	L/R = 40 ms	

Cyclic Capacity (2.5 Cycles/Second):		
24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

High-Current Interrupting Option:

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C

1 s Rating:	50 A		
MOV Protection:	330 Vdc; 130 J		
Pickup Time:	<5 ms		
Dropout Time:	<8 ms, typical		
Breaking Capacity (10,000 Operations):			
24 V	10 A	L/R = 40 ms	
48 V	10 A	L/R = 40 ms	
125 V	10 A	L/R = 40 ms	
250 V	10 A	L/R = 20 ms	

Cyclic Capacity (4 Cycles in 1 Second Followed by 2 Minutes Idle for Thermal Dissipation):

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

Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.
Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Optoisolated Inputs

Contact inputs have a fixed, 1/4-cycle debounce time

250 Vdc:	Pickup 200–300 Vdc; Dropout 150 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout 132 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout 75 Vdc
110 Vdc:	Pickup 88–132 Vdc; Dropout 66 Vdc
48 Vdc:	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
24 Vdc:	Pickup 15.0–30 Vdc

Note: 24, 48, and 125 Vdc optoisolated inputs draw approx. 4 mA of current; 110 Vdc inputs draw approx. 8 mA of current; and 220 and 250 Vdc inputs draw approx. 5 mA of current. All current ratings are at nominal input voltage.

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC or ACB

Communications Ports

EIA-232:	1 front and 2 rear
EIA-485:	1 rear, 2100 Vdc isolation
Baud Rate:	300–19200 bps

Operating Temperature

−40° to +85°C (−40° to +185°F)

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.

Tightening Torque

Terminal Block

Minimum:	9 in-lb (1.1 Nm)
Maximum:	12 in-lb (1.3 Nm)

Connectorized (for further information, see SEL Application Guide 2001-03, *Installing and Servicing Connectors for Connectorized® Relays*)

Minimum:	5 in-lb (0.6 Nm)
Maximum:	7 in-lb (0.8 Nm)

Terminal Connections

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

Routine Dielectric Strength

AC current inputs:	2500 Vac for 10 s
Power supply, optoisolated inputs, and output contacts:	3100 Vdc for 10 s

Weight

2U rack unit height:	6.8 kg (15 lb)
3U rack unit height:	8 kg (17.75 lb)

Type Tests

Emissions

*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

Note: * = Terminal Block version only.

Environmental Tests

Cold:	IEC 60068-2-1:1990 [EN 60068-2-1:1993] Test Ad; 16 hr at −40°C
Damp Heat Cyclic:	IEC 60068-2-30:1980 Test Db; 25° to 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:1974 [EN 60068-2-2:1993] Test Bd: 16 hr at +85°C

Dielectric Strength and Impulse Tests

Dielectric:	IEC 60255-5:1977 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
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Impulse:	IEC 60255-5:1977 0.5 J, 5000 V
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Electrostatic Discharge Test

ESD:	IEC 60255-22-2:1996 IEC 61000-4-2:1995 Level 4
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RFI and Interference Tests

1 MHz Burst Disturbance:	IEC 60255-22-1:1988 Class 3
Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 61000-4-4:1995 Level 4
Radiated EMI:	IEC 60255-22-3:1989 ENV 50140:1993 IEEE C37.90.2-1995 35 V/m
Surge Withstand:	IEEE C37.90.1-1989 3.0 kV oscillatory; 5.0 kV fast transient

Vibration and Shock Tests

Shock and Bump:	IEC 60255-21-2:1988 Class 1
Seismic	IEC 60255-21-3:1993 Class 2
Sinusoidal Vibration:	IEC 60255-21-1:1988 Class 1

Object Penetration

Object Penetration:	IEC 60529:1989 IP 30, IP 54 from the front panel using the optional SEL-9103 front-cover dust and splash protection
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Processing Specifications

64 samples per power system cycle

Metering Accuracy

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

Substation Battery Voltage Monitor

Pickup Range:	20–300 Vdc
Pickup Accuracy:	±2% of setting

Relay Elements

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:	$\pm 5\% \pm 0.10$ A
1 A Model:	$\pm 5\% \pm 0.02$ A
Unrestrained Element Pickup Time:	0.8/1.0/1.9 cycles (Min/Typ/Max)
Restrained Element (with harmonic blocking) Pickup Time:	1.5/1.6/2.2 cycles (Min/Typ/Max)
Restrained Element (with harmonic restraint) Pickup Time:	2.62/2.72/2.86 cycles (Min/Typ/Max)

Harmonic Element

Pickup Range (% of fundamental):	5–100%
Pickup Accuracy (A secondary)	
5 A Model:	$\pm 5\% \pm 0.10$ A
1 A Model:	$\pm 5\% \pm 0.02$ A
Time Delay Accuracy:	$\pm 0.1\% \pm 0.25$ cycle

Winding Instantaneous/Definite-Time Overcurrent Elements

Pickup Ranges (A secondary)	
5 A Model:	0.25–100.00 A
1 A Model:	0.05–20.00 A
Pickup Accuracies (A secondary)	
5 A Model:	
Steady State:	$\pm 3\% \pm 0.10$ A
Transient:	$\pm 5\% \pm 0.10$ A
1 A Model:	
Steady State:	$\pm 3\% \pm 0.02$ A
Transient:	$\pm 5\% \pm 0.02$ A
Note: For transient, $\pm 6\%$ for negative-sequence elements.	
Pickup Time:	0.75/1.20 cycles (Typ/Max)
Time Delay Range:	0–16000 cycles
Time Delay Accuracy:	$\pm 0.1\% \pm 0.25$ cycle

Winding and Combined Current Time-Overcurrent Elements

Pickup Ranges (A secondary)	
5 A Model:	0.5–16.0 A
1 A Model:	0.1–3.2 A
Pickup Accuracies (A secondary)	
5 A Model:	
Steady State:	$\pm 3\% \pm 0.10$ A
Transient:	$\pm 5\% \pm 0.10$ A
1 A Model:	
Steady State:	$\pm 3\% \pm 0.02$ A
Transient:	$\pm 5\% \pm 0.02$ A
Note: For transient, $\pm 6\%$ for negative-sequence elements.	

Curve	
U1 =	U.S. Moderately Inverse
U2 =	U.S. Inverse
U3 =	U.S. Very Inverse
U4 =	U.S. Extremely Inverse
U5 =	U.S. Short-Time Inverse
C1 =	IEC Class A (Standard Inverse)
C2 =	IEC Class B (Very Inverse)
C3 =	IEC Class C (Extremely Inverse)
C4 =	IEC Long-Time Inverse
C5 =	IEC Short-Time Inverse

Time-Dial Range	
US Curves:	0.50–15.00
IEC Curves:	0.05–1.00
Timing Accuracy:	$\pm 4\% \pm 1.5$ cycles for current between 2 and 30 multiples of pickup

Note: For the combined current elements, 30 multiples of pickup is the sum of the currents in the two windings.

Reset Characteristic:	Induction-disk reset emulation or 1 cycle linear reset
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Section 2

Installation

Overview

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

Relay Mounting

Rack Mount

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

Reverse the relay mounting flanges to cause the relay to project 2.75 inches (69.9 mm) from the front of your mounting rack and provide additional space at the rear of the relay for applications where the relay might otherwise be too deep to fit.

Panel Mount

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

The projection panel-mount option covers all installation holes and maintains the sculpted look of the panel-mount option; the relay projects 2.75 inches (69.9 mm) from the front of your panel. This ordering option increases space at the rear of the relay for applications where the relay would ordinarily be too deep to fit your cabinet.



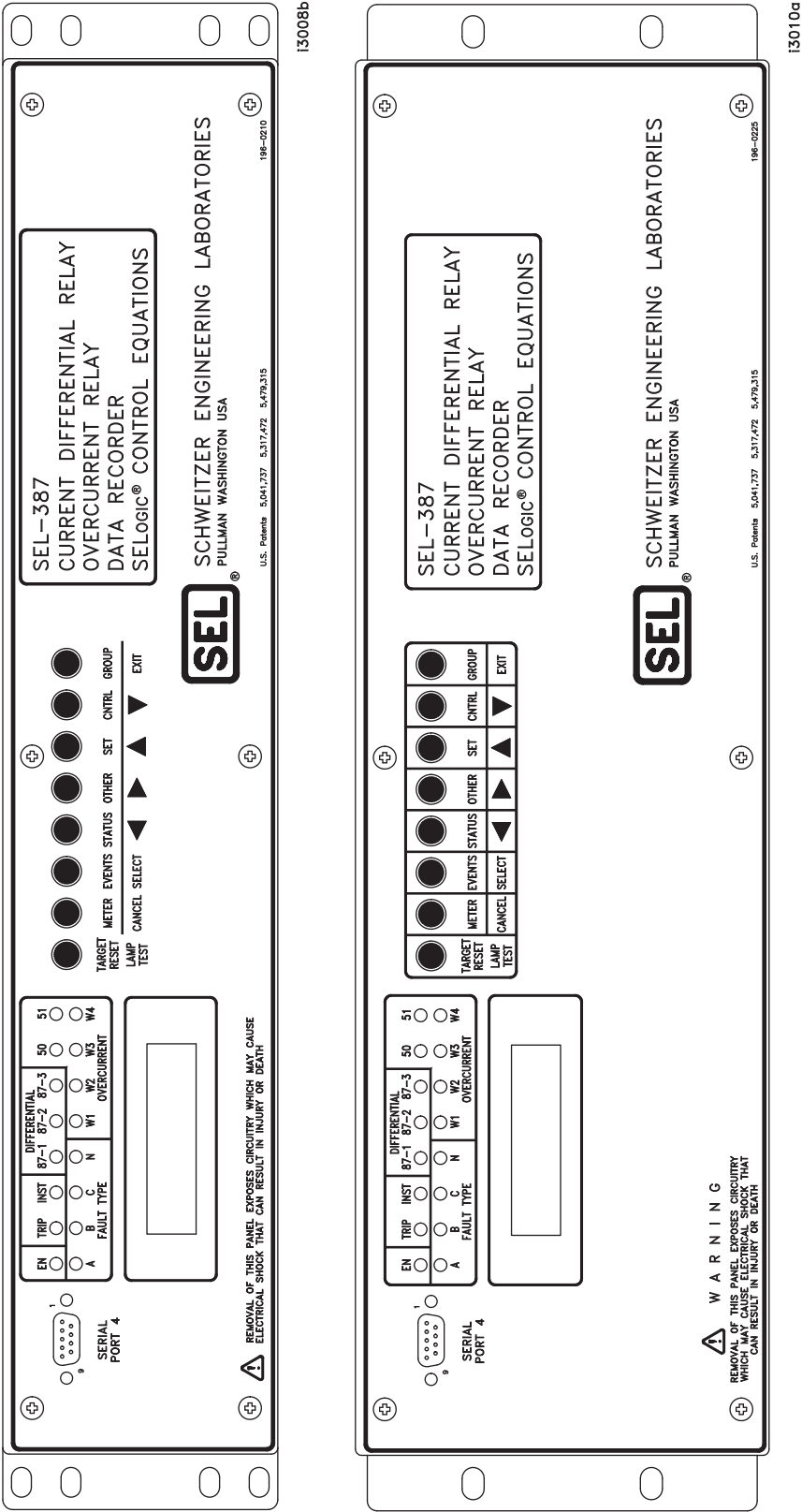


Figure 2.2 Front-Panel Drawings-Models 0387x0xxxH and 0387x1xxxH

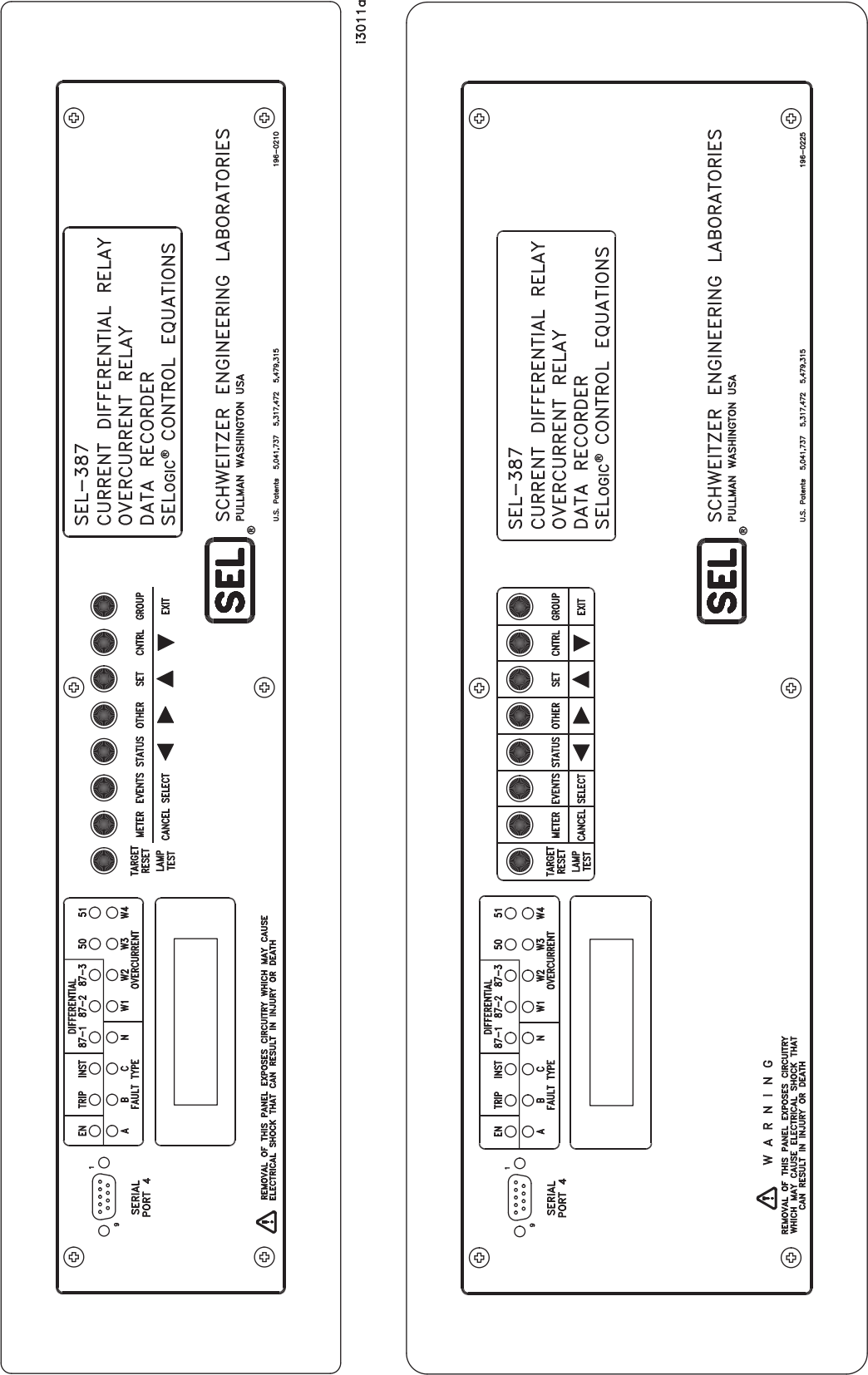


Figure 2.3 Front-Panel Drawings-Models 0387x0xxx3 and 0387x1xxx3

Rear-Panel Connections

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

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

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

Terminal Block

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

Connectorized

To use the Connectorized version of the SEL-387, ask your SEL sales or customer service representative for the appropriate model option table and order wiring harness kit WA03870Y $_{xxx}$ A, where x designates wire sizes and length. You can find the model option table on the SEL website at selinc.com. Refer to *Figure 2.6* to make all Connectorized connections.

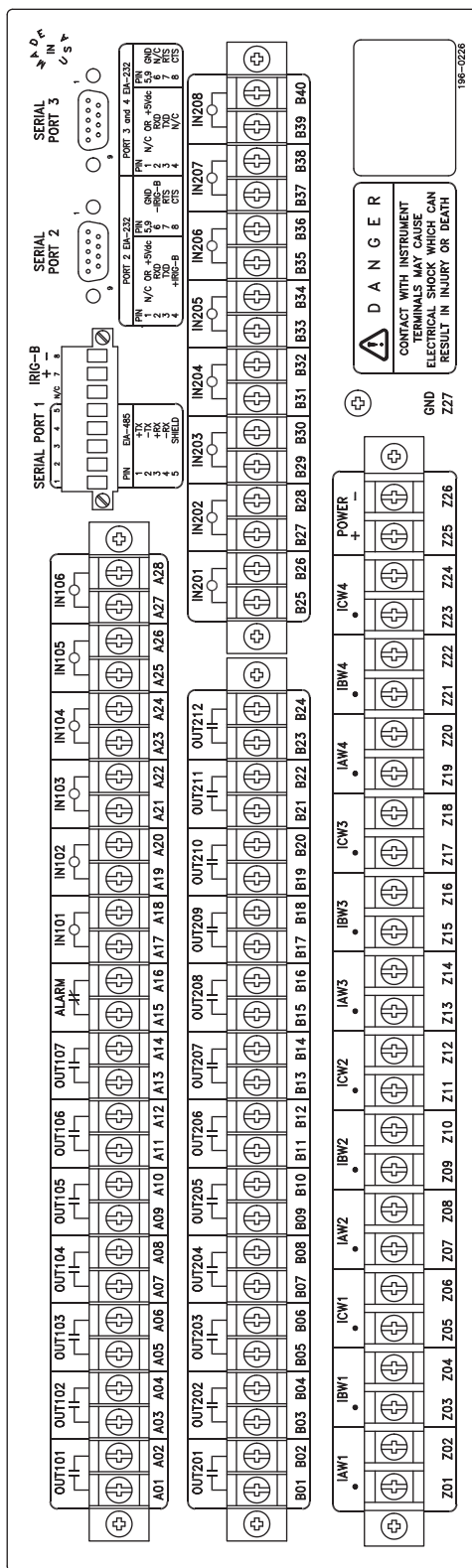
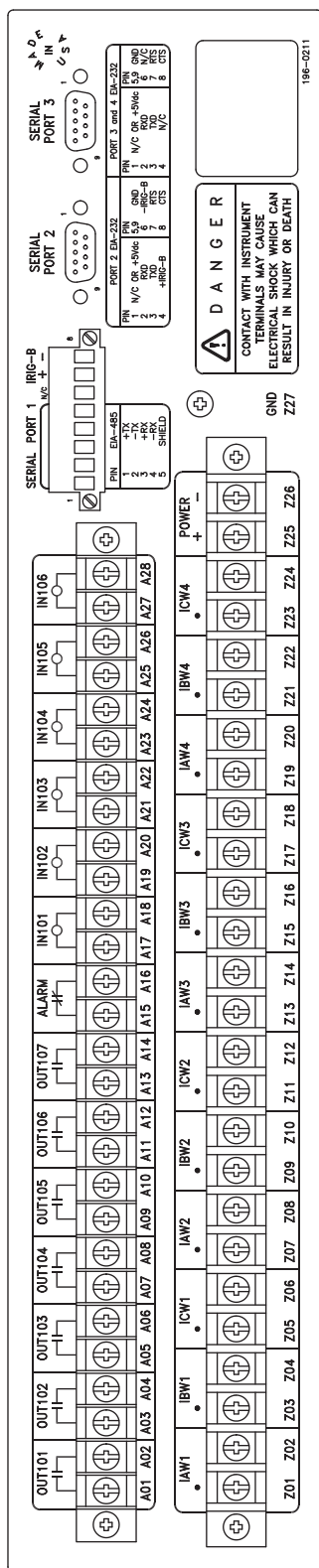


Figure 2.4 Rear-Panel Drawings-Models 0387x0xxxxX and 0387x1xxxx2

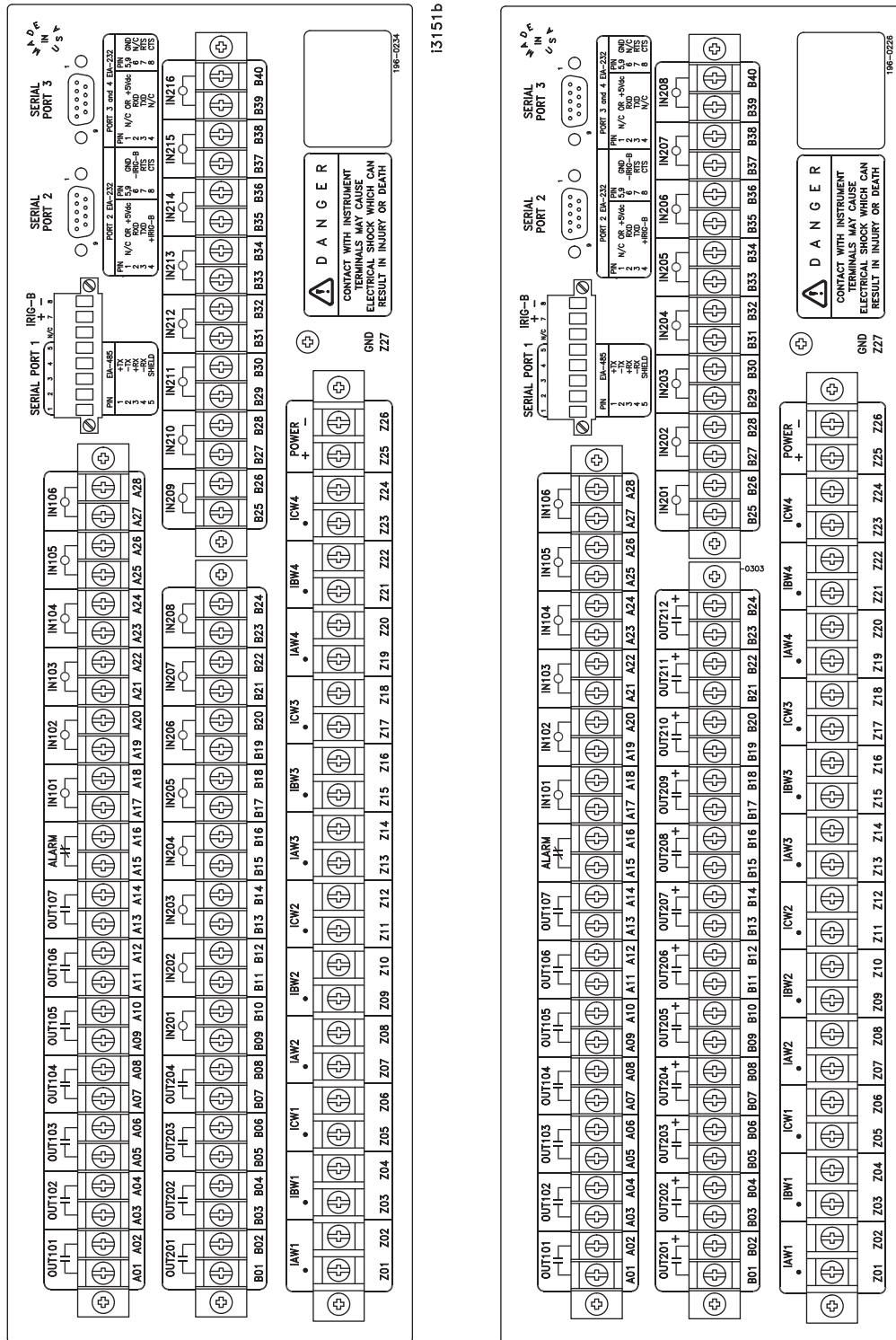
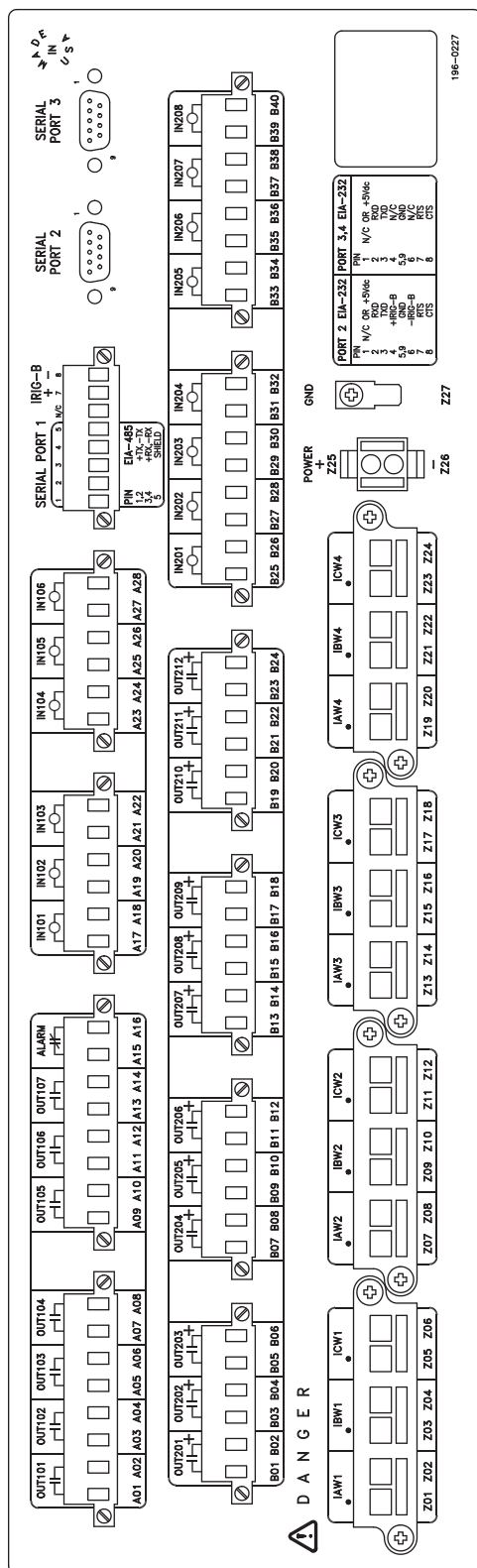


Figure 2.5 Rear-Panel Drawings-Models 0387x1xxxx4 and 0387x1xxxx6



Prewired Connectors

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

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

Unwired Connectors

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.

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

- (2) eight position female plug-in connectors for output contacts **OUT101** through **OUT104** and **OUT105** through **ALARM**.
- (2) six position female plug-in connectors for optoisolated inputs **IN101** through **IN103** and **IN104** through **IN106**.
- (1) eight position female plug-in connector for the EIA-485 serial port connection **SERIAL PORT 1** and the demodulated IRIG-B input. Alternatively, you can bring IRIG-B through **SERIAL 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**.

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

⚠ WARNING

Before working on a CT circuit, first apply a short to the secondary winding of the CT.

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.

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

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, 220, 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 *General on page 1.8* for optoisolated input ratings. There are no internal connections between inputs. ON and OFF values are normally within one volt of each other, in the indicated range.

Output Contacts

Connect output wiring to the SEL-387 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.

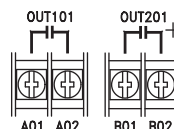


Figure 2.7 Standard Independent Output Contact Representation

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

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.

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.

The relay rear panel provides pin definitions for **SERIAL PORTS 1, 2, 3, and 4**. Refer also to *Section 7: Serial Port Communications and Commands* for more serial port details. **SERIAL PORT 1** is an EIA-485 protocol connection on the rear of the relay. **SERIAL 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. **SERIAL PORTS 2, 3, and 4** are EIA-232 protocol connections with **SERIAL PORTS 2 and 3** on the rear of the relay and **SERIAL PORT 4** on the front of the relay. These female connectors are 9-pin, D-subminiature connectors. You can use any combination of these ports or all of them simultaneously for relay communication.

For example, to connect the SEL-387 **SERIAL PORTS 2, 3, or 4** to the 9-pin male connector on a laptop computer, order cable number SEL-C234A and specify the length needed. Standard length is eight feet. To connect the SEL-387 **SERIAL PORT 2** to the SEL-2032, SEL-2030, or SEL-2020 Communications Processor that supplies the communication link and the time synchronization signal, order cable number SEL-C273A and specify the length needed. For connecting devices at more than 100 feet, fiber-optic transceivers are available. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long distance signal transmission. Call the factory for further information on these products.

Table 2.1 SEL-387 Communication Cable Numbers

SEL-387 Port #	Connect to Device (gender refers to the device)	SEL Cable #
2, 3, 4	PC, 25-Pin Male (DTE)	SEL-C227A
2, 3, 4	PC, 9-Pin Male (DTE)	SEL-C234A
2, 3	SEL-2032, SEL-2030, or SEL-2020 without IRIG-B	SEL-C272A
2	SEL-2032, SEL-2030, or SEL-2020 with IRIG-B	SEL-C273A
2	SEL IDM, Ports 2 through 11	Requires an SEL-C254 and SEL-C257 cable
2, 3	Modem, 5 Vdc Powered (pin 10)	SEL-C220 ^a
2, 3	Standard Modem, 25-Pin Female (DCE)	SEL-C222

^a The 5 Vdc serial port jumper must be installed to power the Modem using SEL-C220 (see *EIA-232 Serial Port Jumpers on page 2.16*).

Clock Synchronization, IRIG-B

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

The SEL-387 accepts a demodulated IRIG-B format signal for synchronizing an internal clock to some external source such as the SEL-2032, SEL-2030, or SEL-2020 Communications Processor, SEL IDM, or satellite time clock. Connect the IRIG-B source to the relay through the connectors for serial **SERIAL PORTS 1 or 2**. Refer to the port pin definition of each port for the appropriate connection.

Typical AC/DC Connections

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

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

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

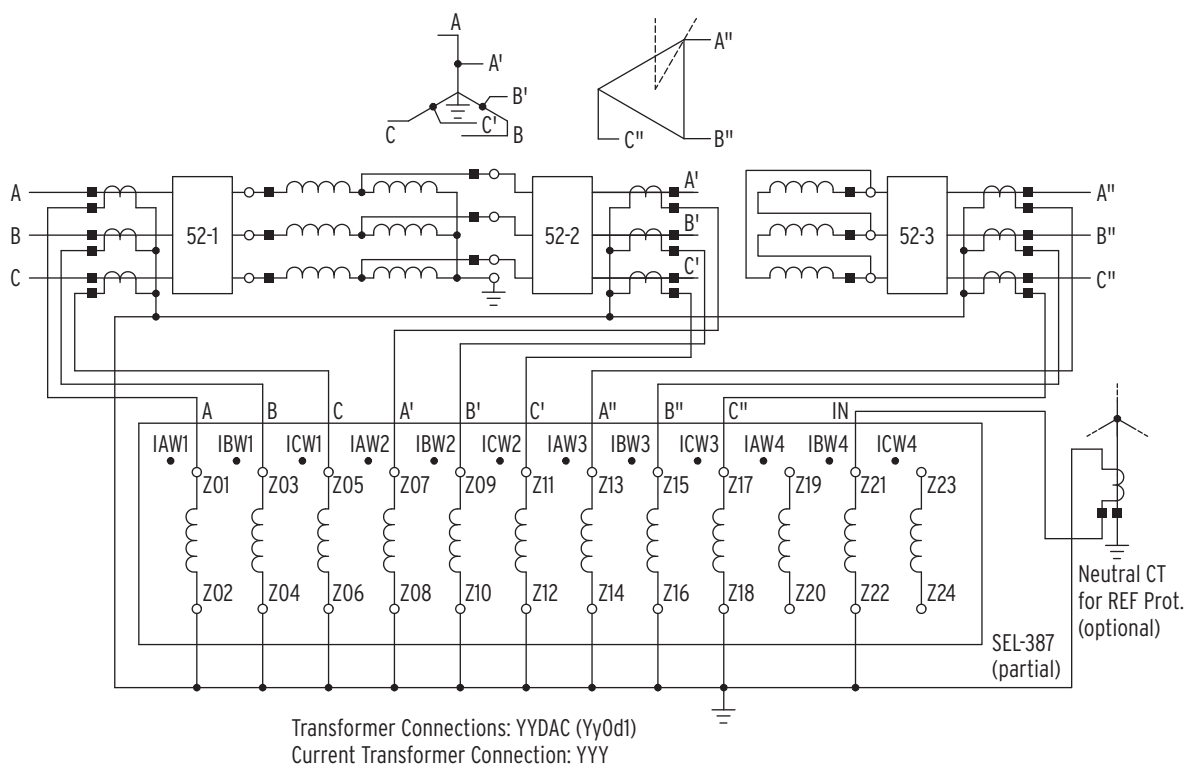


Figure 2.8 Example AC Connections (Three-Winding Transformer)

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

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

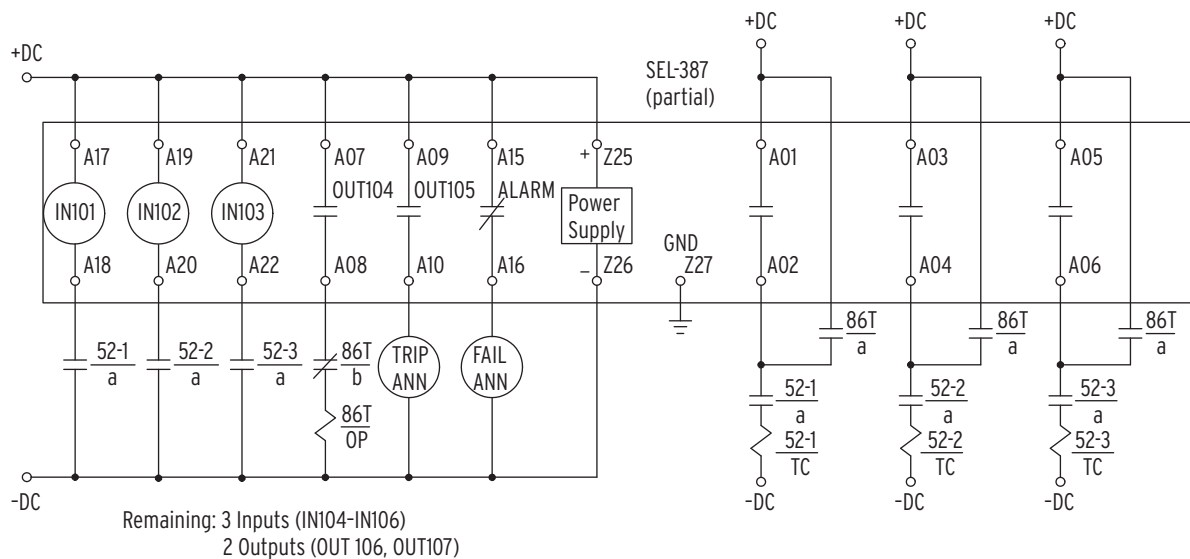


Figure 2.9 Example DC Connections (Basic Version)

Circuit Board Configuration

In this section we describe the following:

- How to remove the relay circuit boards so you can change circuit board jumpers or replace the clock battery
- How to replace the circuit boards in the relay

Accessing the Relay Circuit Boards

⚠ CAUTION

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

Step 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).

Step 2. Remove any cables connected to serial ports on the front and rear panels.

Step 3. Loosen the six front-panel screws (they remain attached to the front panel) and remove the relay front panel.

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

Model 0387x0 has only a main board. A Model 0387x1 or 0387xY relay has an extra interface board below the main board.

- Step 5. Disconnect circuit board cables as necessary so you can remove the board and drawout 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.

Step 6. Grasp the drawout assembly of the board and pull the assembly from the relay chassis.

Step 7. Locate the jumper(s) or battery to be changed. Make the desired changes.

Note that the output contact jumpers are soldered in place.

Step 8. When finished, slide the drawout assembly into the relay chassis.

- Reconnect the cables you removed in *Step 5*.
- Replace the relay front-panel cover.

Step 9. Replace any cables previously connected to serial ports.

Step 10. Re-energize the relay by reconnecting wiring to rear-panel terminals + (Z25) and - (Z26).

On Connectorized versions, replace the power connector at rear-panel terminals + (Z25) and - (Z26).

Main Board

Output Contact Jumpers




Refer to *Figure 2.10* to see the layout of the main board and locate the solder jumpers to the rear of the output contacts. Select the contact type for the output contacts. With a jumper in the A position, the corresponding output contact is an a output contact. An a output contact is open when the output contact coil is 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 2.10*, and refer to *Table 2.2* to understand the relationship between the jumper and output contact. The jumper JMP23 controls the operation of output contact **OUT107**. JMP23 provides the option of a second alarm output contact by changing the signal that drives output contact **OUT107**.

Table 2.2 SEL-387 Second ALARM Contact Jumper Position

JMP 23 Position	Output Contact OUT 107 Operation
 <p>Bottom (Pins 1 and 2)</p>	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.
 <p>Top (Pins 2 and 3)</p>	Regular output contact OUT107 (operated by Relay Word bit OUT107). Jumper JMP23 comes in this position in a standard relay shipment.
 <p>Neither</p>	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 2.10* and note the password and breaker jumpers identified as JMP6. To change these jumpers, remove the relay front panel and main board according to the steps outlined previously in *Accessing the Relay Circuit Boards* on page 2.13.

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 turn on in SELBOOT when power is restored. The front panel will show **SELBOOT** and then a warning to remove the jumper when you attempt serial port communication.

EIA-232 Serial Port Jumpers

Refer to *Figure 2.10*. Jumpers JMP1 and JMP2 are toward the rear of the main board, near the rear-panel EIA-232 serial communications ports. These jumpers connect or disconnect +5 Vdc to Pin 1 on the EIA-232 serial communications **SERIAL 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 **SERIAL PORT 3**, and JMP2 controls the +5 Vdc for **SERIAL PORT 2** (see *Table 7.1*). 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 **SERIAL PORT 2**. Removal of JMP3 and JMP4 will cause **SERIAL PORT 2** to no longer accept an IRIG-B signal. The **SERIAL PORT 1** connector always accepts an IRIG-B signal. **SERIAL PORT 2** and **SERIAL 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-387. Originally they were installed for developmental testing purposes but are not used in the production version of the relay. Jumpers must not be installed in any JMP5 position.

Low-Level Analog Interface

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

Clock Battery

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. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

Refer to *Figure 2.10* for clock battery B1 location. This lithium battery powers the relay clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell. At room temperature (25°C) the battery will operate nominally for 10 years at rated load.

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

If the relay does not maintain the date and time after power loss, replace the battery. Follow the instructions previously described in *Accessing the Relay Circuit Boards* on page 2.13 to remove the relay main board.

Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up. Reassemble the relay as described in *Accessing the Relay Circuit Boards*. Set the relay date and time via serial communications port or front panel (see *Section 7: Serial Port Communications and Commands* or *Section 8: Front-Panel Interface*).

Additional Interface Board

We offer versions of the SEL-387 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 *General* on page 1.8.

Jumpers

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

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).

Board Layout

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

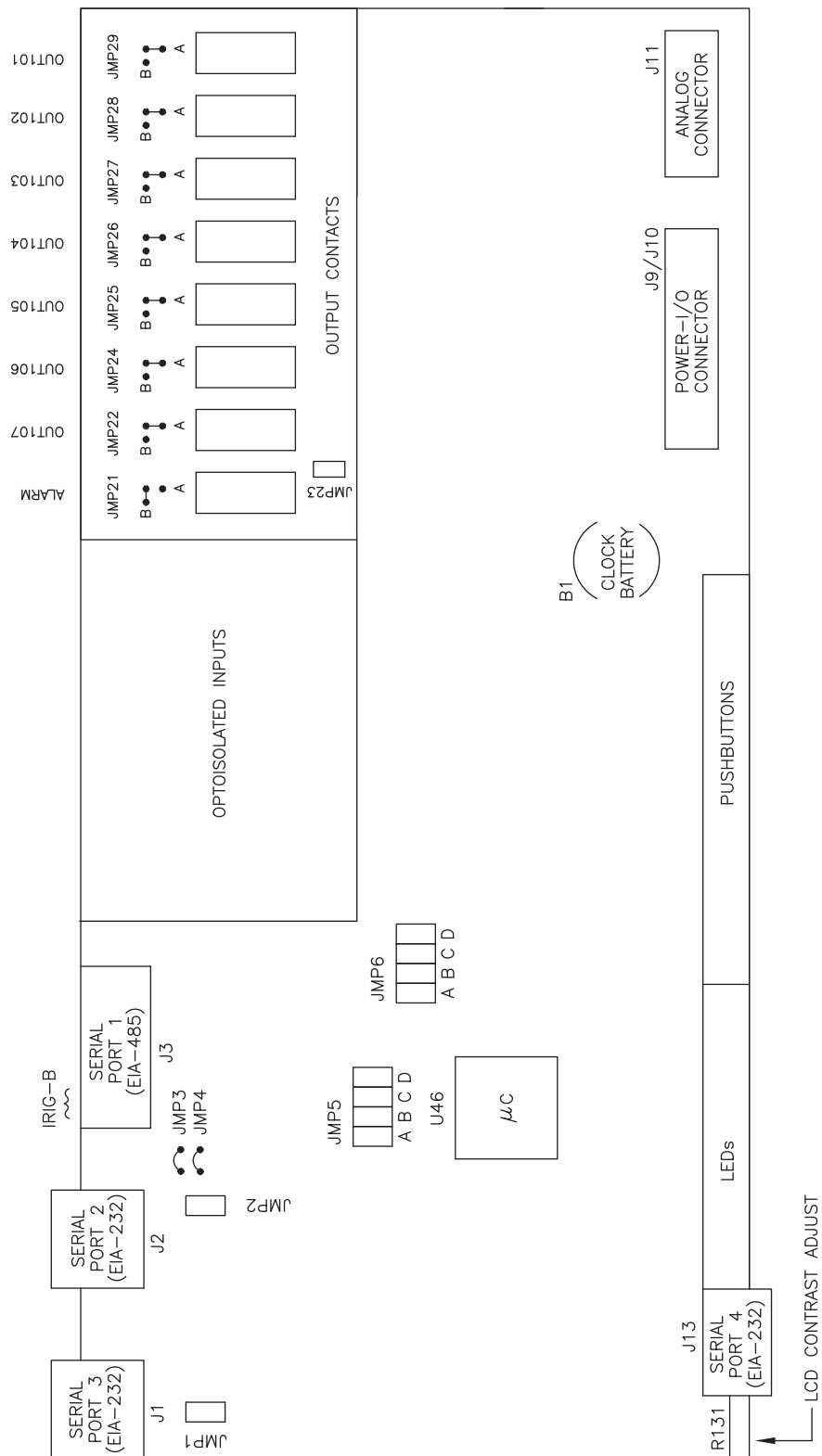


Figure 2.10 Main Board Jumpers, Connections, and Battery Locations

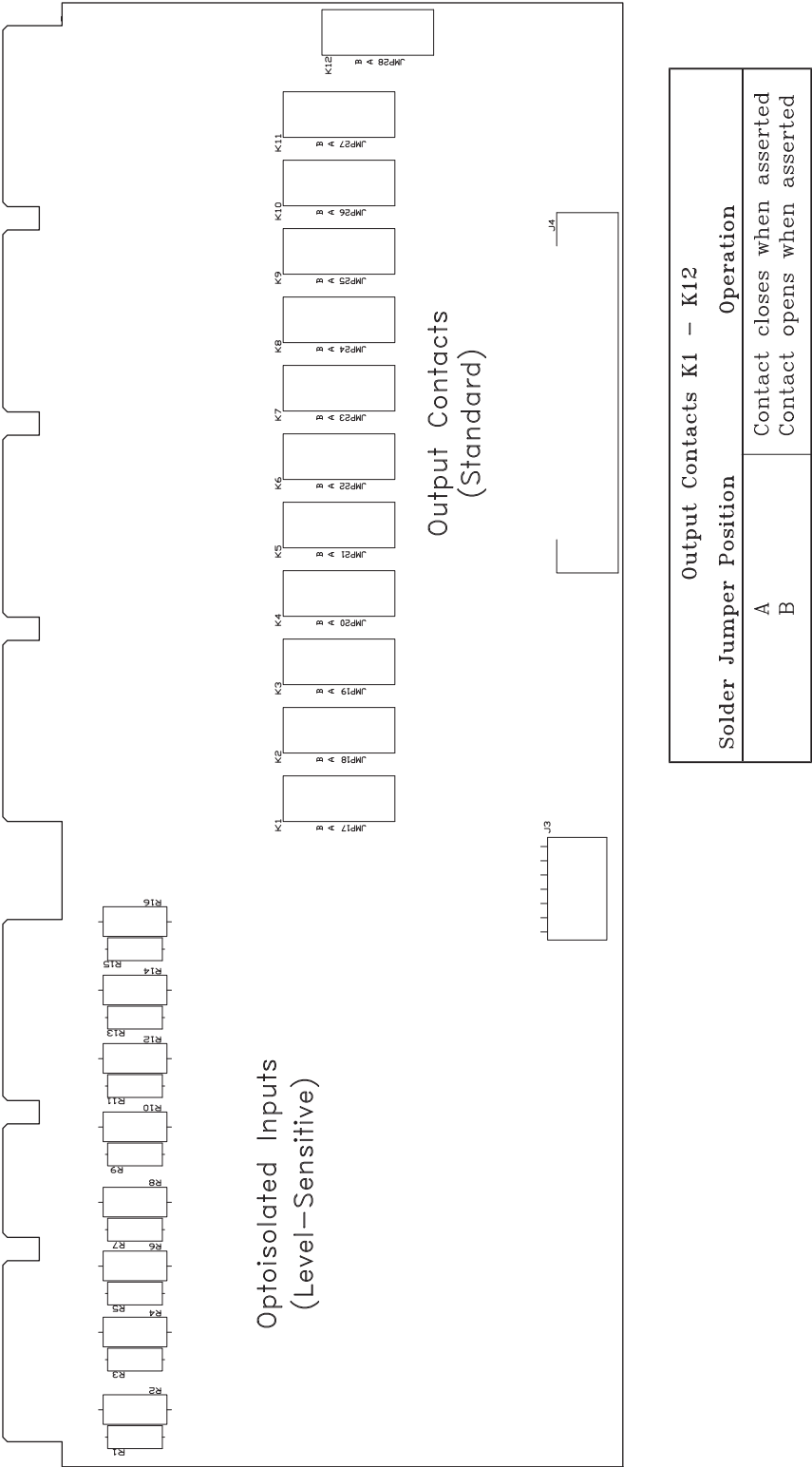


Figure 2.11 Interface Board 2 Component Layout (Conventional Terminal Block)

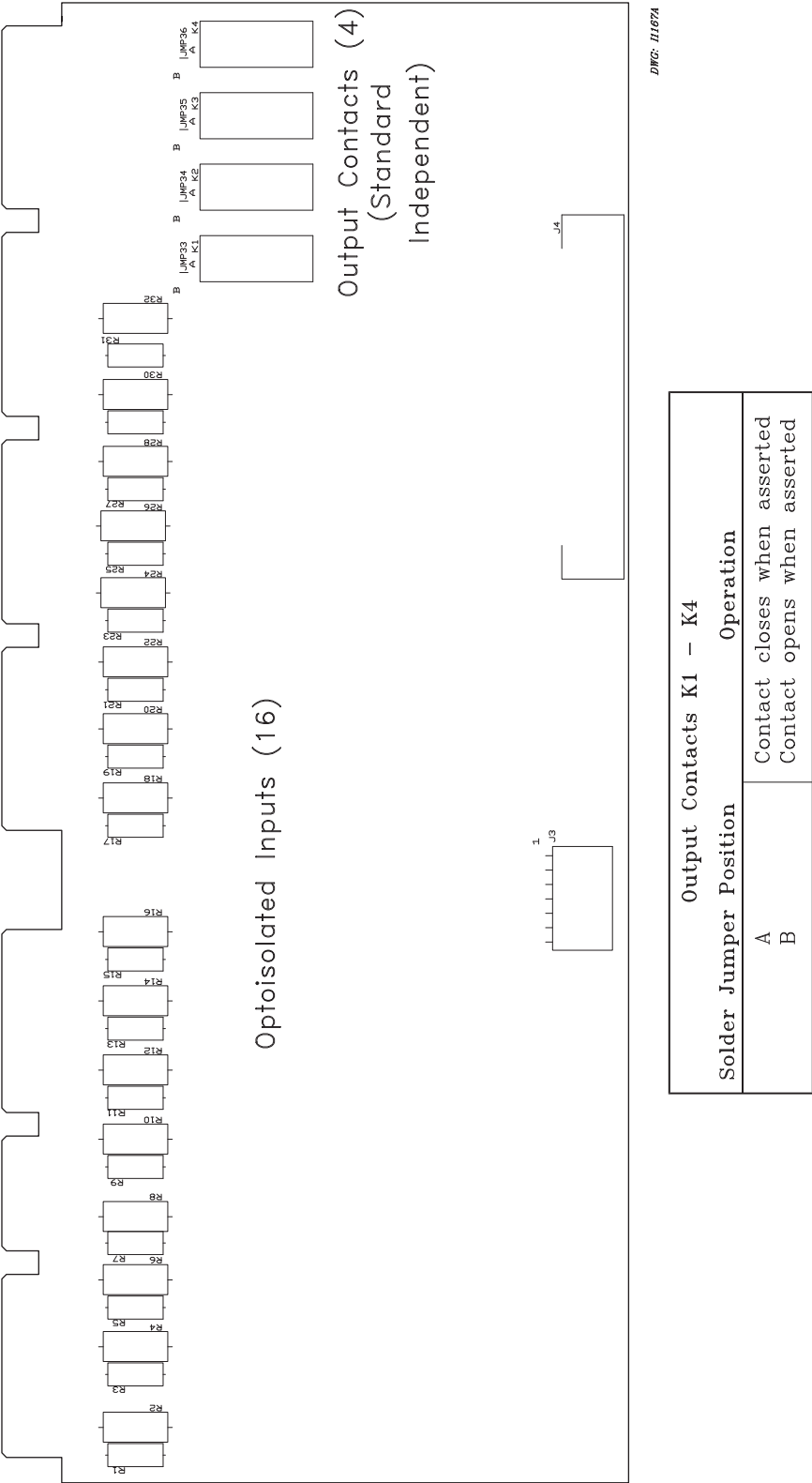


Figure 2.12 Interface Board 4 Component Layout (Conventional Terminal Block)

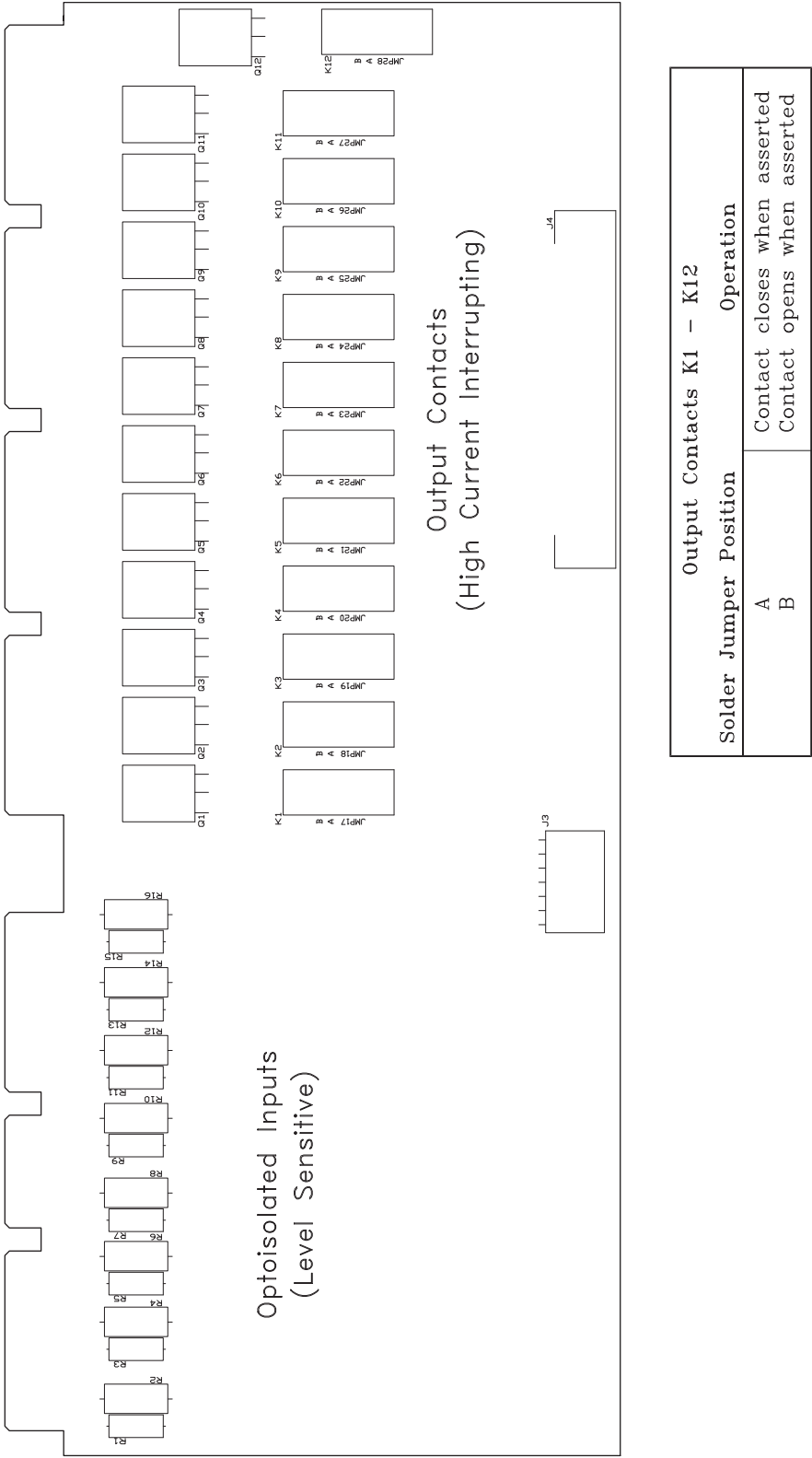


Figure 2.13 Interface Board 6 Component Layout (Conventional Terminal Block)

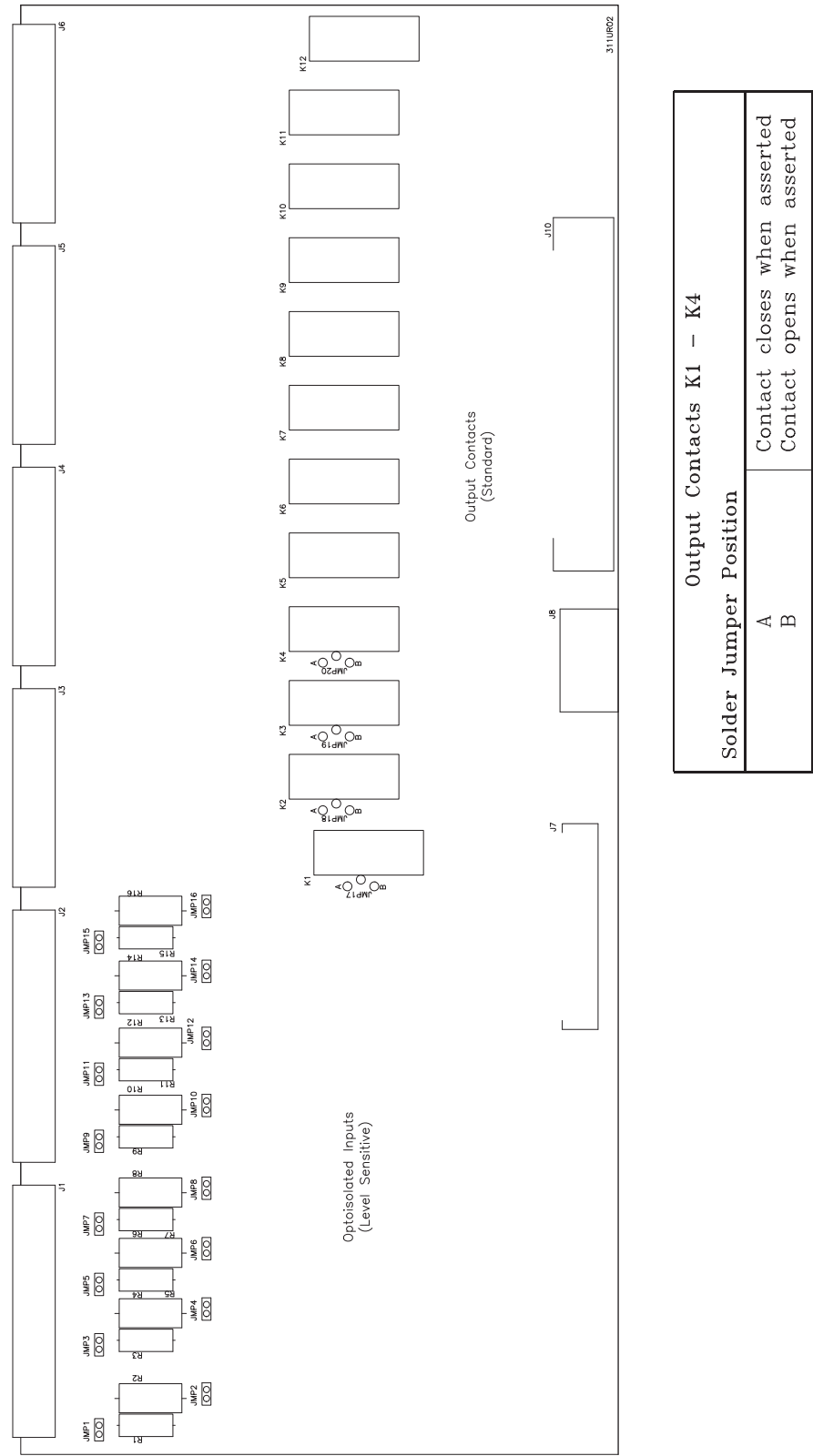


Figure 2.14 Interface Board 2 Component Layout (Connectorized)

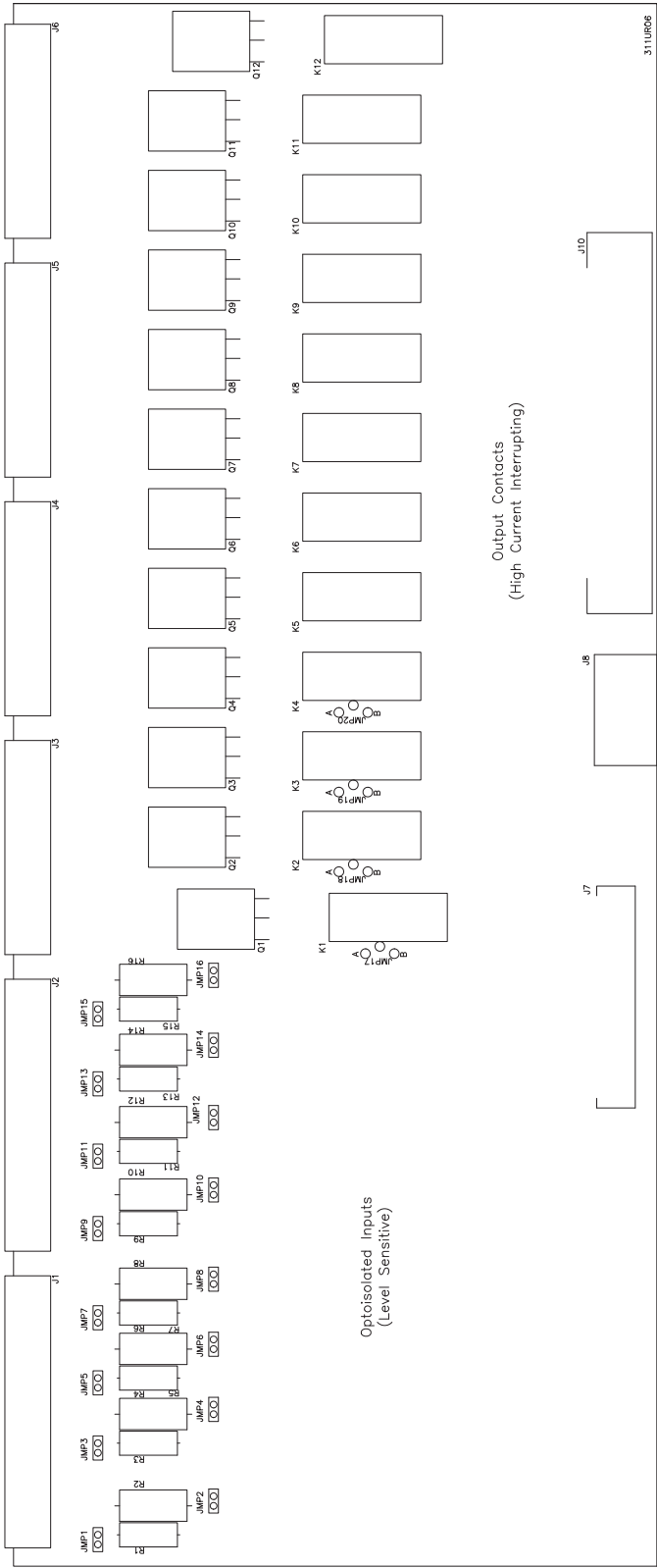


Figure 2.15 Interface Board 6 Component Layout (Connectorized)

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

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Section 3

Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements

Overview

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

Differential Element

Application Description

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

All relays but the SEL-387-0 Relay offer the choice between harmonic blocking and harmonic restraint to secure relay 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 overexcitation conditions.

Operating Characteristic

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

- O87P = minimum IOP level required for operation
- SLP1 = initial slope, beginning at origin and intersecting O87P at $IRT = O87P \cdot 100/SLP1$
- IRS1 = limit of IRT for SLP1 operation; intersection where SLP2 begins
- SLP2 = second slope, if used; must be greater than or equal to SLP1

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

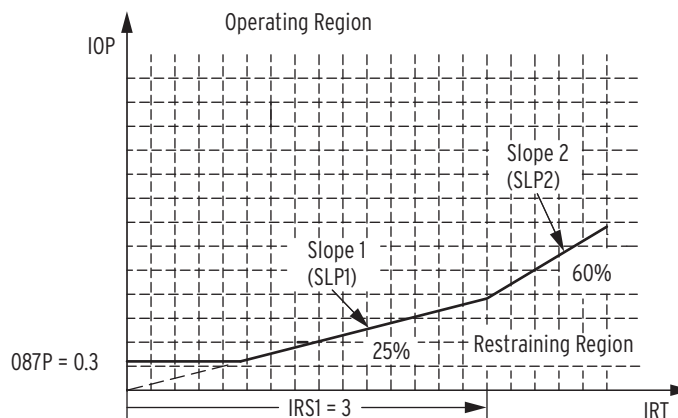


Figure 3.1 Percentage Restraint Differential Characteristic

Figure 3.2, Figure 3.3, Figure 3.4, and Figure 3.5 illustrate how input currents are acquired and used in the unrestrained and restrained differential elements. 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 (all but SEL-387-0), 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 four 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 four windings, whereas “TAP_n” refers to the ampere value of a particular winding(s); TAP_{min} and TAP_{max} refer to the least and greatest of the four TAP_n 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 W4CTC determine the mathematical corrections to the three-phase currents for Winding 1 through Winding 4, 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.

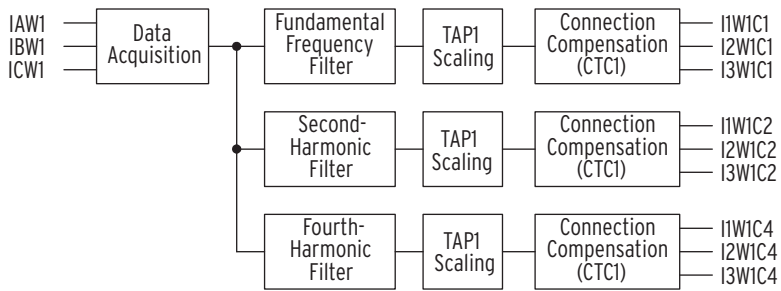


Figure 3.2 Winding 1 Compensated Currents

Figure 3.3 and Figure 3.4 illustrate how the IOP1 (operate), IRT1 (restraint), IHRT1 (harmonic restraint, all but SEL-387-0 Relay), I1HB2 (second harmonic), and I1HB4 (fourth harmonic, all but SEL-387-0) 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 (IOP_n). For a through-current condition, IOP_n should calculate to about $1 + (-1) = 0$, at rated load. Calculation of the Restraint quantity (IRT_n) occurs through a summation of all current magnitudes and then division by two. For a through-current condition, this will calculate to about $(|1| + |-1|) / 2 = 2 / 2 = 1$, at rated load.

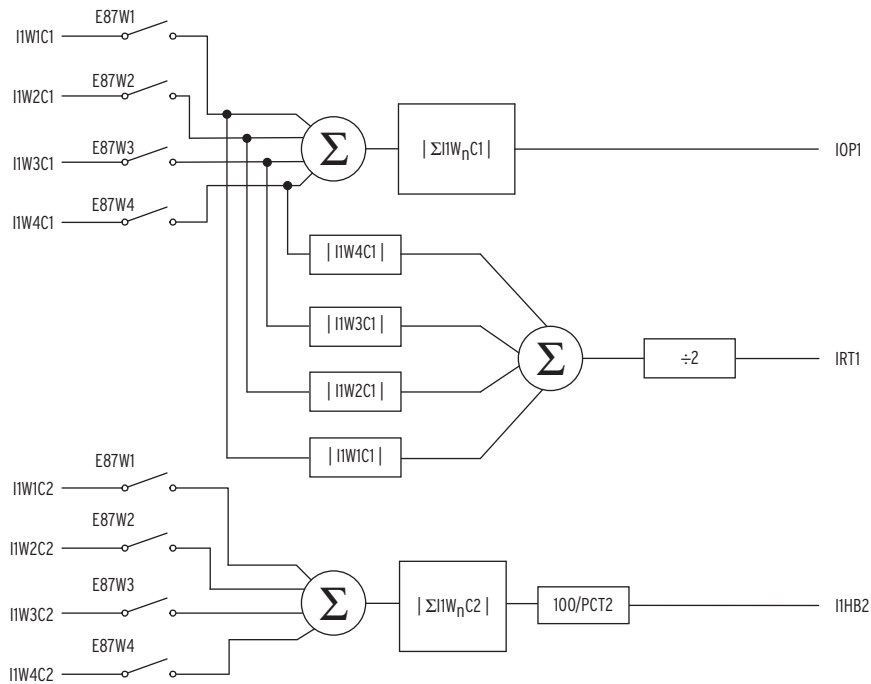


Figure 3.3 Differential Element (87-1) Quantities (SEL-387-0)

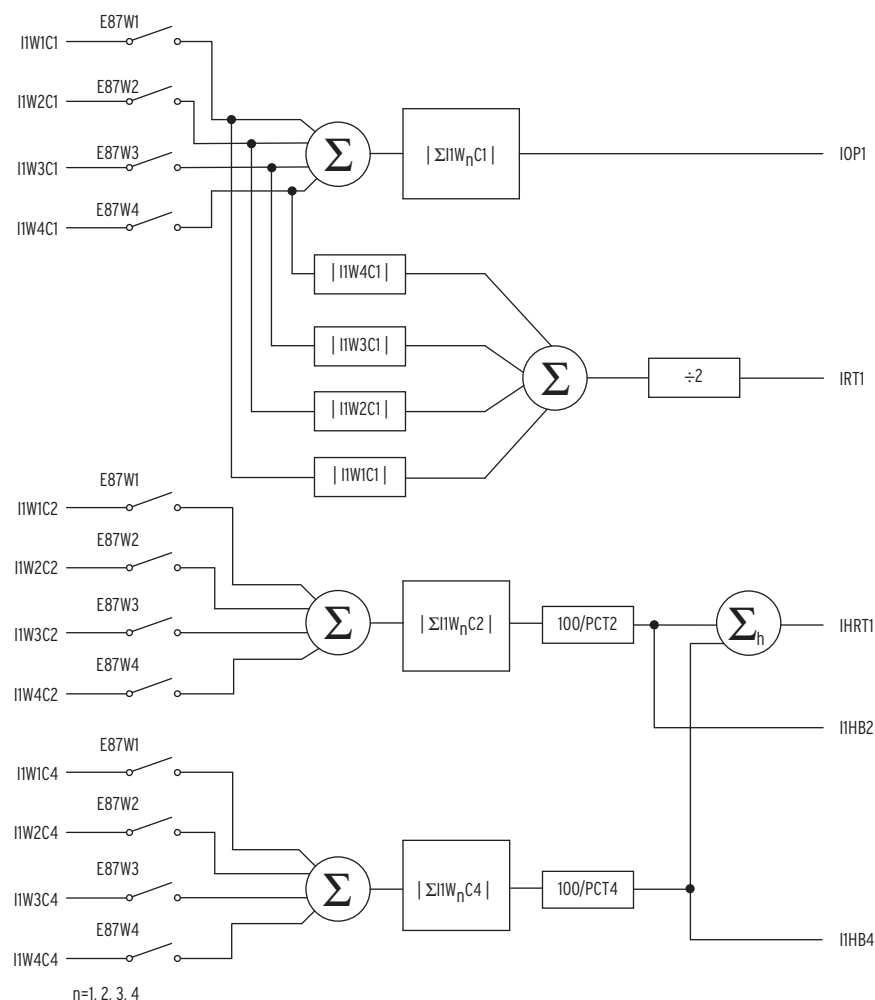


Figure 3.4 Differential Element (87-1) Quantities (All But SEL-387-0)

Figure 3.5 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 3.5. Harmonic blocking or restraint 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, all but SEL-387-0) 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 3.5 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 IRT_n , to calculate the IOP value. The differential element decision logic compares the calculated value, denoted $f(IRT_n)$, to the actual IOP_n . If IOP_n is greater, one input of the AND gate at the right receives a logic 1. Comparison of IOP_n with the O87P setting determines the second AND input. If IOP_n is greater than O87P, Relay Word bit 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.

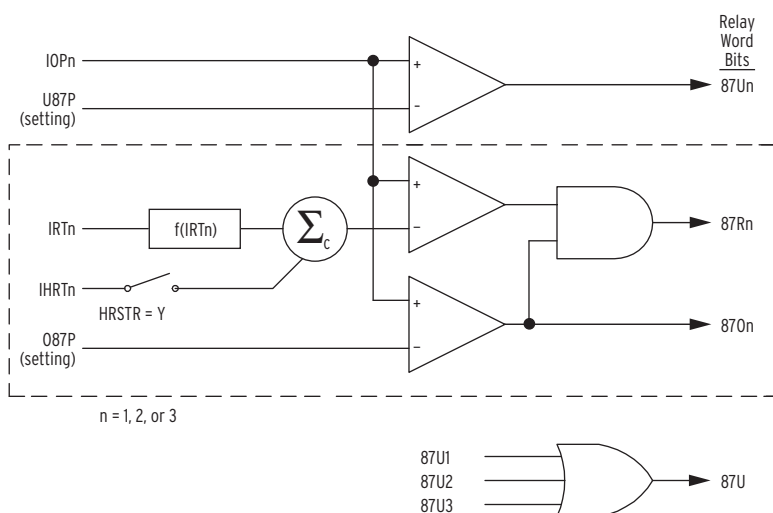


Figure 3.5 Differential Element Decision Logic

Harmonic Restraint (All But SEL-387-0)

Consider the harmonic restraint feature (HRSTR = Y) if your practices require independent harmonic restraint. This feature automatically applies harmonic restraint to each phase independently. The harmonic blocking setting IHBL is not used. It also disables second- and fourth-harmonic blocking since it adds the second- and fourth-harmonic quantities ($IHRT_n$) to the differential characteristic restraint quantity (see *Figure 3.4* and *Figure 3.5*). 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 treated as independent measurements of each harmonic value. For harmonic restraint, the values of the second- and fourth-harmonic currents are scaled by the respective PCT2 or PCT4 setting before being summed and added to the relay restraint characteristic (IRT_n). Consider, for example, the simple case of Slope 1, i.e., a straight line through the origin. The general equation for a line is:

$$y = m \cdot x + c \quad \text{Equation 3.1}$$

More specifically, in the SEL-387:

$$IOP = SLP1 \cdot IRT + c \quad \text{Equation 3.2}$$

where:

$$c = (100/PCT2 \cdot \Sigma I W_n C2) + (100/PCT4 \cdot \Sigma I W_n C4)$$

when:

$$HRSTR = Y$$

Because the line starts at the origin, the value of c normally is zero. When harmonic restraint is used, the sum of the scaled second- and fourth-harmonic currents from the enabled windings of the relay now forms the constant c in the equation, raising the relay restraint slope characteristic proportionally to the harmonic values.

For this reason, it is important not to set the PCT2 and PCT4 settings to OFF when using the harmonic restraint function ($HRSTR = Y$). Doing so will effectively remove all harmonic restraint from the relay.

Increasing the values used for PCT2 and PCT4 settings decreases the respective harmonic content that is added to the IOP characteristic of the relay. This is a result of the inverse relationship created by the $100/PCT2$ and $100/PCT4$ multipliers on the respective harmonic content. Use the default values for these settings to provide secure differential element operation for inrush conditions.

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 3.6* 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 3.6* in the top drawing, $IHBL = N$, is enabled. In this case all 87R n elements enter one OR gate, and all 87BL n elements enter another OR gate, whose output is negated at the upper AND gate. If the 87R n OR output asserts but the 87BL n 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.

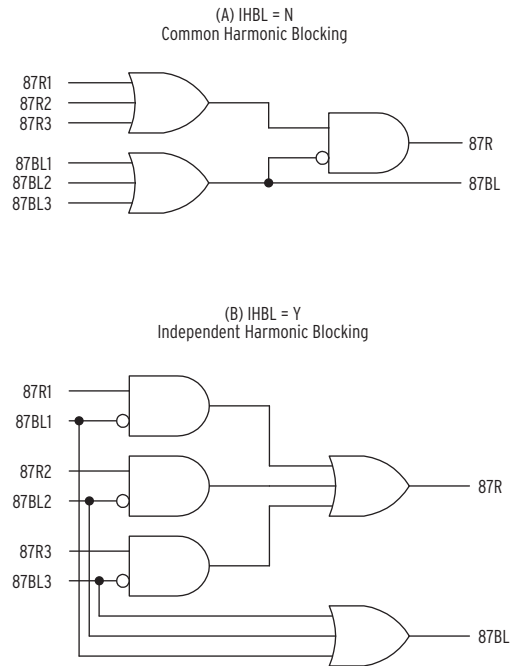


Figure 3.6 Differential Element Harmonic Blocking Logic

If IHBL is set to Y (Yes), the logic shown in *Figure 3.6* in the bottom drawing, 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 3.7 (SEL-387-0) and *Figure 3.8* (all but SEL-387-0) show how the 87BL1 blocking element will pick up if the second-, fourth-, or fifth-harmonic operating current, as a percentage of fundamental operating current, is above the PCT2, PCT4, or PCT5 setting threshold, respectively. The blocking element will also pick up if the ratio of positive and negative dc exceeds a threshold as shown in *Figure 3.9*. 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 3.8*. 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.

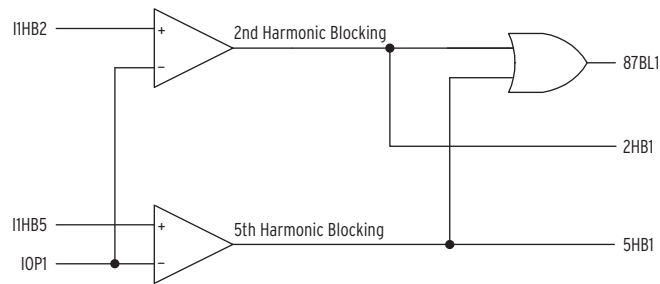


Figure 3.7 Differential Element (87BL1) Blocking Logic (SEL-387-0)

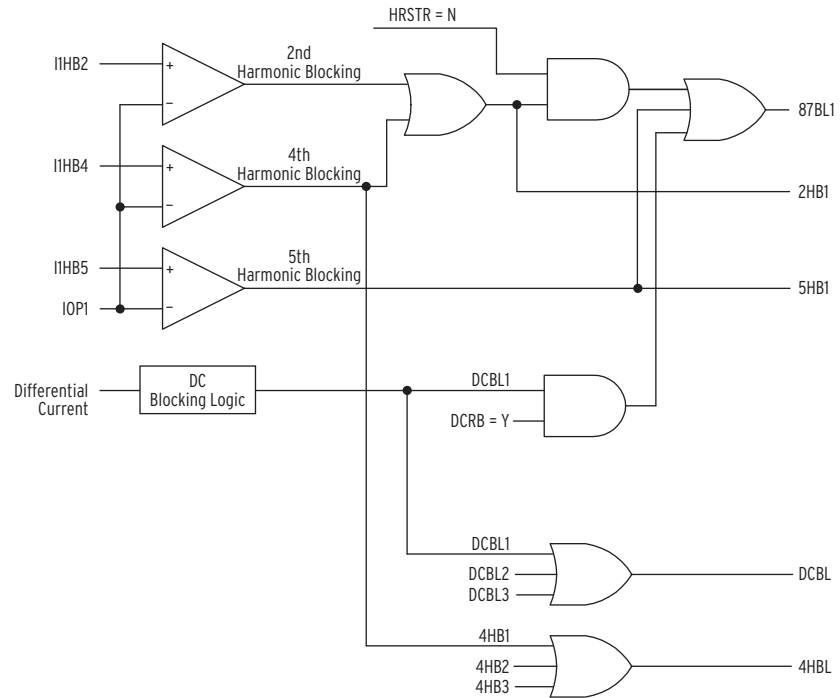


Figure 3.8 Differential Element (87BL1) Blocking Logic (All But SEL-387-0)

DC Ratio Blocking (All But SEL-387-0)

Figure 3.9 shows the dc blocking logic for Differential Element 1. Elements DCBL1, DCBL2, and DCBL3 are combined to form element DCBL as shown at the bottom of Figure 3.8. 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 waveshape recognition, distinguishing between the time constants for inrush current that typically are longer than the time constants for an internal fault.

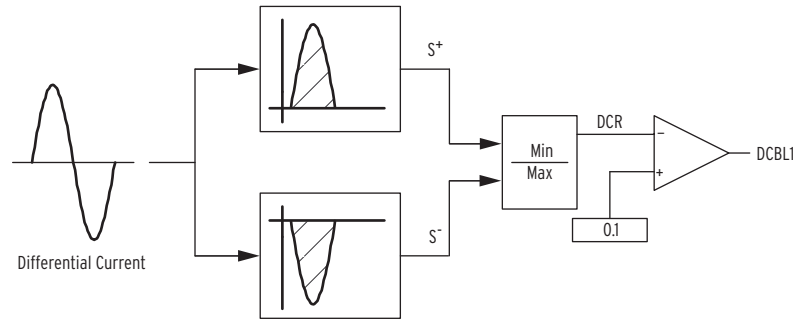


Figure 3.9 DC Blocking (DCBL1) Logic (All But SEL-387-0)

Setting Descriptions

Differential Element Enable (E87W1–E87W4)

Range: Y, N, Y1

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

For all relays but the SEL-387-0, selecting Y1 makes the fourth-harmonic (PCT4), dc ratio blocking (DCRB), and harmonic restraint (HRSTR) settings available on all enabled (Y or Y1) windings. This is the only difference between Y and Y1 selection.

CT Connection (W1CT–W4CT)

Range: D, Y

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

Also, if the CTs on a particular winding “n” are connected in delta (WnCT = D), then the secondary currents into the corresponding SEL-387 current inputs (IAWn, IBWn, and ICWn) are modified before being displayed or used in:

- breaker monitoring (**BRE** command)
- instantaneous metering (**METER** command)
- demand metering (**METER D** and **METER P** commands)
- through-fault event monitoring (**TFE** command)

For delta-connected CTs, the secondary currents into the SEL-387 current inputs are phase-phase difference currents (e.g., phase-phase difference current $I_A - I_B$ flows into current input IAWn). To create a pseudo phase-neutral value for display or use in algorithms, these phase-phase difference currents are divided by $\sqrt{3}$ (divided by 1.732).

CT Ratio (CTR1–CTR4)

Range: 1–50000

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

Maximum Transformer Capacity, Three-Phase MVA (MVA)

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

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

Internal Winding/CT Connection Compensation (ICOM)

Range: Y, N

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

Connection Compensation (W1CTC–W4CTC)

Range: 0, 1, ..., 12

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

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

Range: 1–1000 kV, in 0.01 kV steps

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

Current TAP (TAP1–TAP4)

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 “TAP_n” values.

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

Restrained Element Operating Current Pickup (O87P)

Range: 0.1–1.0 • TAP

Note: 1 A: $\text{TAP}_{\text{MIN}} \cdot \text{O87P} \geq 0.1 \cdot I_n$

5 A: $\text{TAP}_{\text{MIN}} \cdot \text{O87P} \geq 0.1 \cdot I_n$

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: $\text{TAP}_{\text{MAX}} \cdot \text{IRS1} \leq 31.0$

5 A: $\text{TAP}_{\text{MAX}} \cdot \text{IRS1} \leq 155.0$

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 even-harmonic current can be used to identify the inrush phenomenon and to prevent relay misoperation. The SEL-387 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.

When using harmonic restraint ($HRSTR = Y$), use the PCT2 setting to scale the amount of second-harmonic content that will be added to the restraint slope characteristic. The larger the PCT2 setting, the smaller the increase on the restraint slope as a result of the measured second-harmonic content. See *Figure 3.4* for details.

Fourth-Harmonic Blocking Percentage of Fundamental (PCT4) (All But SEL-387-0)

Range: OFF, 5–100%, in 1% steps

For all relays but the SEL-387-0, 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-387 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.

When using harmonic restraint ($HRSTR = Y$), use the PCT4 setting to scale the amount of fourth-harmonic content that will be added to the restraint slope characteristic. The larger the PCT4 setting, the smaller the increase on the restraint slope as a result of the measured fourth-harmonic content. See *Figure 3.4* for details.

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.

The fifth-harmonic blocking is independent of the harmonic restraint setting (HRSTR), and does not affect the restraint slope characteristic.

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

NOTE: The relay permits the setting of values smaller than $TH5P \cdot TAP_{MIN} \geq 0.05 \cdot I_{NOM}$, but alerts the user with the message "Settings times minimum TAP should be ≥ 0.25 ." If the setting is not changed to a value within the limits, the relay performance may be outside the element specification.

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) (All But SEL-387-0)

For all relays but the SEL-387-0, 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-387 can detect the dc offset and use it in the blocking (not restraint) logic. Enable this function by setting $DCRB = Y$.

Harmonic Restraint (HRSTR) (All But SEL-387-0)

For all relays but the SEL-387-0, 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 effectively raises the relay restraint slope characteristic by the sum of the scaled second and fourth-harmonic values. See *Figure 3.4* and *Figure 3.5* for details.

Set $HRSTR = Y$ to select the harmonic restraint function. The relay automatically applies harmonic restraint to each phase independently. When $HRSTR = Y$, the relay setting IHL is not used.

Independent Harmonic Blocking (IHBL)

Range: Y, N

The setting IHBL is not used when HRSTR = Y. When HRSTR = N, this setting specifies how the relay will apply harmonic blocking to the relay differential elements. Upon energization of a three-phase transformer, at least two phase currents will contain inrush harmonics. In traditional single-phase relays each relay compares the harmonic current flowing through the phase for that relay. The SEL-387 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

Connection Compensation Settings

The relay offers connection compensation settings, W_nCTC ($n = 1, 2, 3$, or 4), to compensate for the phase shift across the transformer. These settings offer a range, 0–12, that represents 3x3 matrices, CTC(0)–CTC(12), permitting compensation from 0 degrees to 360 degrees, in increments of 30 degrees, respectively. The general expression for current compensation is as follows:

$$\begin{bmatrix} I1WnC \\ I2WnC \\ I3WnC \end{bmatrix} = [CTC(m)] \bullet \begin{bmatrix} IAWn \\ IBWn \\ ICWn \end{bmatrix}$$

where $IAWn$, $IBWn$, and $ICWn$ are the three-phase currents entering terminal “n” of the relay; $I1WnC$, $I2WnC$, and $I3WnC$ are the corresponding phase currents after compensation the relay uses to calculate the operate and restraint quantities; and $CTC(m)$ is the three-by-three compensation matrix corresponding to the W_nCTC setting. The complete list of compensation matrices ($m = 0–12$) and the corresponding correction compensation they result in are shown in *Table 3.1*.

Table 3.1 WnCTC Setting: Corresponding Phase and Direction of Correction (Sheet 1 of 2)

WnCTC Setting ^a	Matrix	Compensation Matrices	Amount and Direction of Correction	
			ABC Phase Rotation	ACB Phase Rotation
0	CTC(0)	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	0°	0°
1	CTC(1)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}$	30° CCW	30° CW
2	CTC(2)	$\frac{1}{3} \cdot \begin{bmatrix} 1 & -2 & 1 \\ 1 & 1 & -2 \\ -2 & 1 & 1 \end{bmatrix}$	60° CCW	60° CW
3	CTC(3)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{bmatrix}$	90° CCW	90° CW
4	CTC(4)	$\frac{1}{3} \cdot \begin{bmatrix} -1 & -1 & 2 \\ 2 & -1 & -1 \\ -1 & 2 & -1 \end{bmatrix}$	120° CCW	120° CW
5	CTC(5)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix}$	150° CCW	150° CW
6	CTC(6)	$\frac{1}{3} \cdot \begin{bmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{bmatrix}$	180° CCW	180° CW
7	CTC(7)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix}$	210° CCW	210° CW
8	CTC(8)	$\frac{1}{3} \cdot \begin{bmatrix} -1 & 2 & -1 \\ -1 & -1 & 2 \\ 2 & -1 & -1 \end{bmatrix}$	240° CCW	240° CW

Table 3.1 WnCTC Setting: Corresponding Phase and Direction of Correction (Sheet 2 of 2)

WnCTC Setting ^a	Matrix	Compensation Matrices	Amount and Direction of Correction	
			ABC Phase Rotation	ACB Phase Rotation
9	CTC(9)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix}$	270° CCW	270° CW
10	CTC(10)	$\frac{1}{3} \cdot \begin{bmatrix} 1 & 1 & -2 \\ -2 & 1 & 1 \\ 1 & -2 & 1 \end{bmatrix}$	300° CCW	300° CW
11	CTC(11)	$\frac{1}{\sqrt{3}} \cdot \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$	330° CCW	330° CW
12	CTC(12)	$\frac{1}{3} \cdot \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$	0° (360°) CCW	0° (360°) CW

^a n = 1, 2, 3, 4.

Compensation matrix CTC(0) is intended to create no changes at all in the currents and merely multiplies them by an identity matrix. 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 current, as do all of the matrices with non-zero values of *m*.

Use the following guidelines to determine correct compensation settings for each winding.

- Step 1. Determine the phase shift as seen by the relay. The following information is required to accurately determine this phase shift.
 - Transformer winding connection diagram (transformer nameplate)
 - Three-line connection diagram showing: (1) system phase-to-transformer bushing connections, (2) current transformer (CT) connections, and (3) CT-to-relay connections
- Step 2. Choose one of the relay current inputs as the reference winding.
 - If a delta winding exists and is wired into the relay, choose it as the reference. Select matrix CTC(0) for the compensation of the delta winding.
 - If a delta winding does not exist, select matrix CTC(11) for the compensation of one of the wye windings.

- Step 3. With the winding in *Step 2* as reference, determine the required compensation settings for all other windings. Use odd matrices for compensating wye windings. Avoid the use of even matrices when possible.

Refer to *Appendix H: Protection Application Examples* for more details on application of these guidelines in determining correct compensation settings.

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 TAP_n , based on settings entered for the particular winding. (n denotes the winding number.)

$$TAP_n = \frac{MVA \cdot 1000}{\sqrt{3} \cdot VWDG_n \cdot CTR_n} \cdot C \quad \text{Equation 3.3}$$

where:

$C = 1$ if W_nCT setting = Y (wye-connected CTs)

$C = \sqrt{3}$ if W_nCT setting = D (delta-connected CTs)

MVA = maximum power transformer capacity setting
(must be the same for all TAP_n calculations)

$VWDG_n$ = winding line-to-line voltage setting, in kV

CTR_n = current transformer ratio setting

The relay calculates TAP_n with the following limitations:

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

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 $0.1 \cdot I_N$, when multiplied by the smallest of TAP_1 through TAP_4 . Stated another way,

$$O87P_{MIN} \geq \frac{(0.1 \cdot I_N)}{TAP_{MIN}} \quad \text{Equation 3.4}$$

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:

$$I_{dmax} = (1 + e) \cdot \sum_{\text{"IN"}} IW_n - \frac{(1 - e)}{(1 + a)} \cdot \sum_{\text{"OUT"}} IW_n \quad \text{Equation 3.5}$$

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

$$(1 + e) - \frac{(1 - e)}{(1 + a)} = \frac{2 \cdot e + a + e \cdot a}{1 + a} \cdot 100\% = 28.18\% \quad \text{Equation 3.6}$$

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

NOTE: U87P must be set lower than $31 \cdot I_{NOM}/TAP_{MAX}$, where TAP_{MAX} is the largest of the TAP settings.

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.

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 (PCT2) 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 (All But SEL-387-0 Relay)

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:

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

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

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-387 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-387 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 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.

- Step 1. Enable the differential settings as follows:

E87W1 = Y

E87W2 = Y

E87W3 = Y

These settings enable Windings 1, 2, and 3, leaving Winding 4 available for stand-alone overcurrent duty.
- Step 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

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

MVA = 100
- Step 4. Determine compensation settings.

Because the CTs on either side of the transformer (wye and delta sides) are wye-connected, we must adjust for the phase angle shift. In the “traditional” differential relay connection, the wye transformer windings have their CTs connected in delta to produce a shift in the same direction as that produced in the transformer. Using the guidelines in *Steps to Determine the Compensation Settings (WnCTC)* on page H.5, it can be determined that the phase-to-transformer bushing connections are standard. The primary delta current Ia lags the system primary wye current IA by 30 degrees. The CT connections are standard, which results in IAW3 leading IAW1 and IAW2 by 150 degrees as seen by the relay. Primary currents and secondary currents as measured by the relay are shown in Figure 3.10. For simplicity, only Terminal 1 and Terminal 3 currents are shown. Terminal 2 currents are the same as Terminal 1.

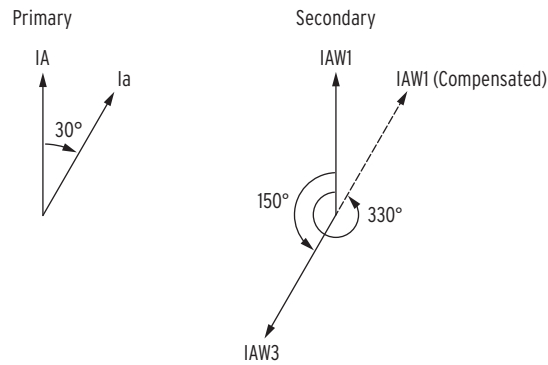


Figure 3.10 Primary Currents and Secondary Currents as Measured by the Relay

Further, select the delta winding as the reference. The delta current is connected to Terminal W3 of the SEL-387 Relay. Therefore, set W3CTC = 0. The wye currents are connected to Terminal W1 and W2 of the SEL-387 Relay, so W1CTC and W2CTC must be determined. IAW1 and IAW2 must be rotated 330 degrees (11 multiples of 30 degrees) in the counterclockwise direction for a system with an ABC phase rotation to be 180 degrees out-of-phase with IAW3. Therefore, set W1CTC = 11 and W2CTC = 11. The resulting compensation settings are:

ICOM = **Y** (choose to define the CT compensation)

W1CTC = **11**

W2CTC = **11**

W3CTC = **0**

The relay multiplies the wye CT currents from the wye transformer windings by the CTC(11) matrix to give the same results as the physical DAC CT connection.

- Step 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:

$$TAP_n = \frac{MVA \cdot 1000}{\sqrt{3} \cdot VWDG_n \cdot CTR_n} \cdot C$$

(C = 1 for wye CTs)

Equation 3.7

Thus, we have the following:

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

$$TAP1 = 2.09 \text{ A}$$

Equation 3.8

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

$$TAP2 = 1.74 \text{ A}$$

Equation 3.9

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

$$TAP3 = 10.46 \text{ A}$$

Equation 3.10

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 TAP_n, in this case 10.46, by the least TAP_n, here 1.74, to get a ratio of 6.01. Because this is below 7.5, adjustment of the CT ratio is unnecessary.

Step 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)

CT2 = **15** (block operation if second harmonic is above 15 percent)

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)

IHBL = **N** (no independent element blocking; any unit detecting second or fifth harmonic above PCT2 or PCT5 will block all units)

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

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

Application Guideline

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

CT Arrangements

Use separate relay restraint circuits for each power source to the relay. In the SEL-387 you can apply two to four restraint inputs to the relay. You can 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.
- The paralleled CTs are applied on outgoing radial loads.

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

Step 1. Determine the secondary side burdens in ohms for all current transformers connected to the relay.

Step 2. Select the CT ratio for the highest-rated winding (e.g., CTR1) by considering the maximum continuous secondary current, I_{HS} , based on the highest MVA rating of the transformer.

For wye-connected CTs, the relay current, I_{REL} , equals I_{HS} . For delta-connected CTs, I_{REL} equals $\sqrt{3} \cdot I_{HS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_N$ and $1.0 \cdot I_N$ A secondary, where I_N is the relay nominal secondary current, 1 A or 5 A.

Step 3. Select the remaining CT ratios (e.g., CTR2–CTR4) by considering the maximum continuous secondary current, I_{LS} , for each winding.

Typically, the CT ratio is based on the rated maximum MVA of the particular winding. If this rating is much smaller than the rating of the largest winding, you can violate the tap ratio limit for the SEL-387 (see *Step 4* and *Step 5*). As before, for wye-connected CTs I_{REL} equals I_{LS} . For delta-connected CTs I_{REL} equals $\sqrt{3} \cdot I_{LS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_N$ and $1.0 \cdot I_N$ A secondary.

- Step 4. The SEL-387 calculates settings TAP1 through TAP4 if the ratio TAP_{MAX}/TAP_{MIN} is less than or equal to 7.5. When the relay calculates the tap settings, it reduces CT mismatch to less than 1 percent. Allowable tap settings are in the range $(0.1-31) \cdot I_N$.
- Step 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 *Step 2* through *Step 5*.
- Step 6. Calculate the maximum symmetrical fault current for an external fault, and verify that the CT secondary currents do not exceed your utility standard maximum allowed CT current, typically $20 \cdot I_N$. If necessary, reselect the CT ratios and repeat *Step 2* through *Step 6*.
- Step 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 *Step 2* through *Step 7*. This selection criterion helps reduce the likelihood of CT saturation for a fully offset fault current signal.

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

Restricted Earth Fault Element

Application Description

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

Operating Characteristic

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

The REF implementation in the SEL-387 uses a directional element (32I) that compares the direction of an operating current, derived from the line-end CTs, with the polarizing current, obtained from the neutral CT. A zero-sequence current threshold and positive-sequence restraint supervise tripping. You can apply REF to a single wye winding in a transformer or to an entire autotransformer winding with as many as three sets of line-end CT inputs. The neutral CT connects to one of the three current inputs for Winding 4 (IAW4, IBW4, or ICW4), leaving only 3 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 (IRW4) greater than the pickup setting, 50GP. The topmost part of this logic is a blocking function. This function asserts if any of the winding residual currents used in the REF function are less than a positive-sequence current restraint factor, a0, times the positive-sequence current for their respective winding. Such a winding residual current value might occur with “false I0” or if zero sequence current for that winding exceeds 50GP. False I0 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. Note that the SEL-387-0 Relay prior to firmware version R602 does not support the CTS Relay Word bit.

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.

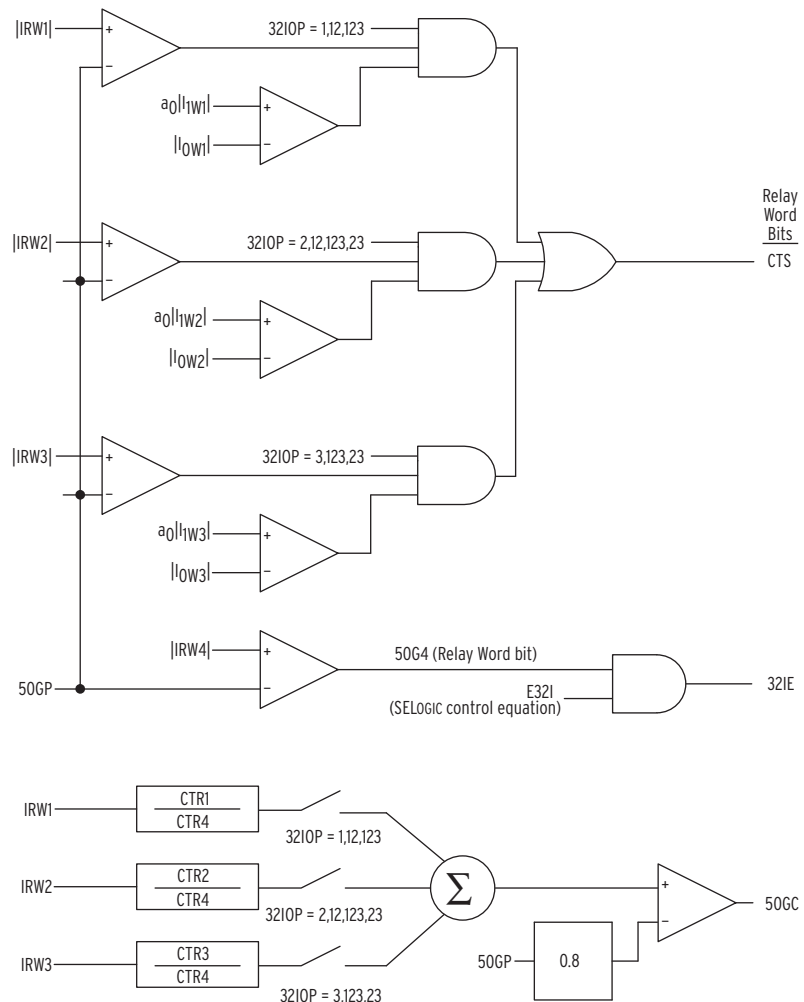


Figure 3.11 REF Enable/Block Logic

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

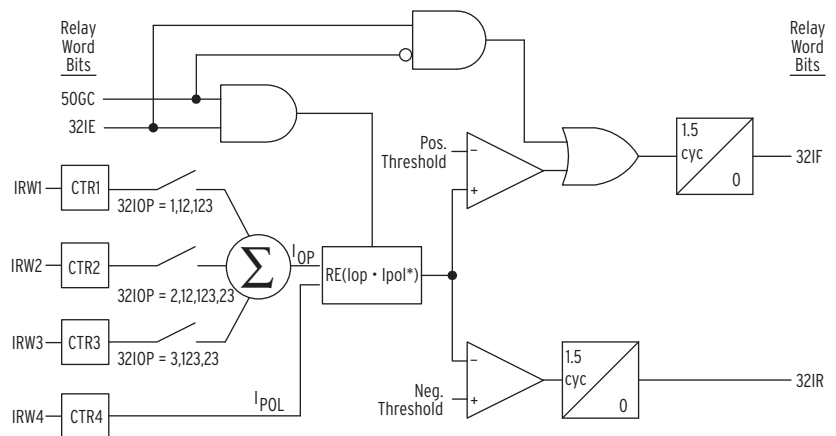


Figure 3.12 REF Directional Element

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 amperes. This must be done to properly sum the currents in the autotransformer winding.

The polarizing current, IPOL, is simply the neutral CT current multiplied by the neutral CT ratio, CTR4, to produce a primary current value. The operating current, IOP, is the phasor sum of the winding residual currents, also on a primary basis. The 32IOP setting determines the appropriate IRW_n, which the relay multiplies by the associated CTR_n. 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 two-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, TR_n, 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.

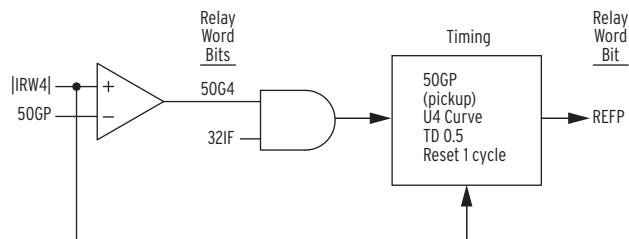


Figure 3.13 REF Protection Output (Extremely Inverse-Time O/C)

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

Setting Descriptions

REF Directional Element Enable (E32I)

Range: SELOGIC® control equation

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

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

Range: 1, 2, 3, 12, 23, 123

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

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

Range: 0.02–0.50, in 0.01 steps

For the relay to enable REF, the zero-sequence current at Winding n must be greater than $a0$ times the positive-sequence current at that input, or $I0Wn > a0 \cdot I1Wn$. This supervision provides security against “false I0” that can 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:

- 50GP must be greater than any natural 3I0 unbalance caused by load conditions.
- 50GP must be greater than a minimum value determined by the relationship of the CTR_n 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 unbalance. 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.

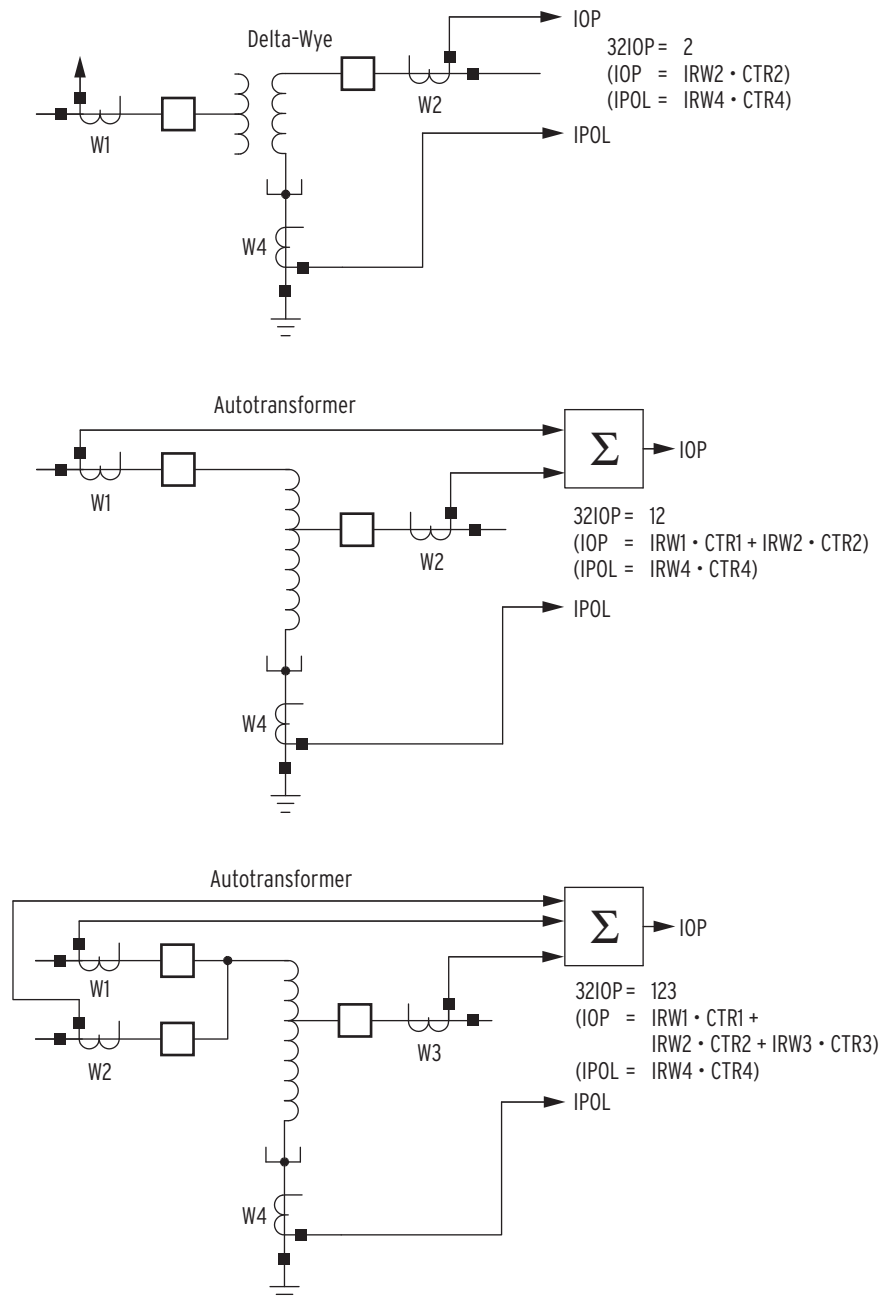


Figure 3.14 REF Function, 32IOP Setting Guide

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 4 input of the relay, as it must be for every case where REF protection is to be used.

If you want to protect an autotransformer, set 32IOP at 12 and connect the primary and secondary side CTs to relay winding inputs 1 and 2. You could also use this setting for the single winding mentioned above, if that winding had two breakers and two sets of CTs at the line end. You would also have to connect these CTs to winding inputs 1 and 2. Such a connection would be

typical in ring-bus or breaker-and-a-half configurations. With 32IOP set at 12, the relay sums the residual currents from the Winding 1 and Winding 2 inputs to create the Operate quantity.

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

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

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

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

Residual Current Sensitivity Threshold

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

$$50GP_{min} \geq 0.05 \cdot I_{NOM} \cdot \frac{CTR_{max}}{CTR4} \quad \text{Equation 3.11}$$

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

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

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

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

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

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

Equation 3.12

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

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

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

Temperature Measurement (SEL-387-5 and SEL-387-6 Relays)

For temperature measurement purposes, the SEL-387 accepts RTD inputs from the SEL-2600A RTD Module via any one of the serial ports. Set the RTD enable and the RTD alarm and trip settings under group settings. Set the RTD configuration under the port settings. A discussion of these settings follows.

Setting Descriptions

RTD Enable (E49A, E49B)

Range: Y, N

The relay can accept 12 RTD inputs from each of two SEL-2600A RTD Modules (total of 24 RTD inputs). The two groups of RTD inputs are labeled “49A” and “49B,” respectively.

RTD Alarm and Trip Settings (49A01A-49T12A and 49A01B-49T12B)

Range: OFF, 32–482°F; OFF, 0–250°C

Set the temperature value for alarm and trip operations.

The relay can accept 12 RTD inputs from each of two SEL-2600A RTD Modules (total of 24 RTD inputs). Configure the SEL-387 and SEL-2600A communication with the port setting SET P n ($n = 1, 2, 3, \text{ or } 4$).

Temperature Preference (TMPREFA, TMPREFB)

Range: C, F

Located under the Global settings, TMPREFA, TMPREFB select the preferred temperature units: C for Celsius or F for Fahrenheit. The relay automatically recalculates all 49-element temperature values.

The SEL-387 can report a different RTD alarm or trip temperature than the temperature you entered for settings 49A01A–49T12A and 49A01B–49T12B. The relay rounds digits after the decimal point, processes the rounded values, and reports temperature in unit-precision (e.g., 25, 72). The rounded result can differ from the temperature setting especially when settings TMPREFA or TMPREFB are F (Fahrenheit). The relay converts Fahrenheit scale settings to the Celsius scale for processing, and then reconverts these temperatures to the Fahrenheit scale for reporting. For example, if setting 49A01A is 101°F, the relay reports 100°F.

$$\begin{aligned} \frac{\text{Setting } 49A01A \text{ } ^\circ\text{F}-32^\circ}{1.8} &= \frac{101^\circ\text{F}-32^\circ}{1.8} \\ &= 38.3^\circ\text{C internal relay processing} \\ &\quad \text{temperature, rounded to } 38^\circ\text{C} \end{aligned}$$

Equation 3.13

$$38^\circ\text{C} \cdot 1.8 + 32^\circ = 100.4^\circ\text{F} = 100^\circ\text{F reported temperature, rounded to } 100^\circ\text{F}.$$

Protocol Setting (PROTO)

Range: SEL, LMD, RTDA, RTDB, DNP

Select the RTDA or RTDB protocol under the Port settings (SET P n , $n = 1-4$), to enable communication with the SEL-2600A.

Number of RTDs in Use (RTDNUMA, RTDNUMB)

Range: 0 . . 12

Enter the number of RTDs to be used for Group A. Group B has a similar setting.

Type of RTDs (RTD1TA-RTD12TA)

Range: NA, PT100, NI100, NI120, CU10

Enter the type of metal: platinum, nickel, or copper. Based on the RTD n TA setting (where n is the RTD number), the data for the specified RTD type will be used to update the associated RTD temperature value.

Type of RTDs (RTD1TB-RTD12TB)

Range: NA, PT100, NI100, NI120, CU10

Enter the type of metal: platinum, nickel, or copper. Based on the RTD n TB setting (where n is the RTD number), the data for the specified RTD type will be used to update the associated RTD temperature value.

Thermal Element (SEL-387-6 Relay)

Application Description

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

Operating Characteristic

The SEL-387 thermal element compares top-oil, Θ_{TO} , and winding hot-spot, Θ_H , temperatures against thresholds beyond which a Relay Word bit will assert. You can use these bits to alarm for overheating of the transformer (*Figure 3.15*). Top-oil temperature is a calculation of the transformer oil temperature, while hot-spot temperature is a calculation of the hottest point on the transformer winding. The thermal element uses top-oil temperature and hot-spot temperature to calculate the insulation aging acceleration factor, FAA, daily rate of loss of life, RLOL, and total loss of life, TLOL. For each of these quantities you can set a threshold beyond which a Relay Word bit will assert (*Figure 3.15*).

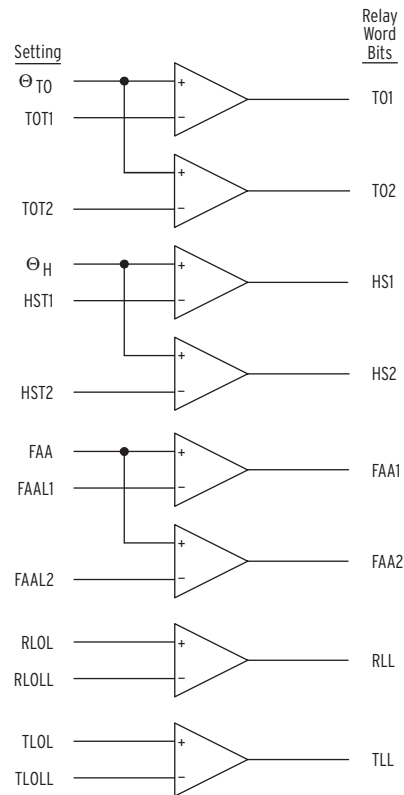


Figure 3.15 Thermal Element Logic

The thermal element operates in one of three modes, depending upon the presence or lack of measured temperature inputs:

- Measured ambient and top-oil temperature inputs
- Measured ambient temperature only
- No measured temperature inputs

If the relay receives measured ambient and top-oil temperatures, the thermal element calculates hot-spot temperature (*Figure 3.16 (A)*). When the relay receives a measured ambient temperature but not a measured top-oil temperature, the thermal element calculates the top-oil temperature and hot-spot temperature (*Figure 3.16 (B)*). In the absence of any measured ambient or top-oil temperatures, the thermal element uses a default ambient temperature setting (DTMP) that you select and calculates the top-oil and hot-spot temperatures (*Figure 3.16 (C)*). Top-oil temperature is always calculated from the applied currents for the cooling system efficiency element.

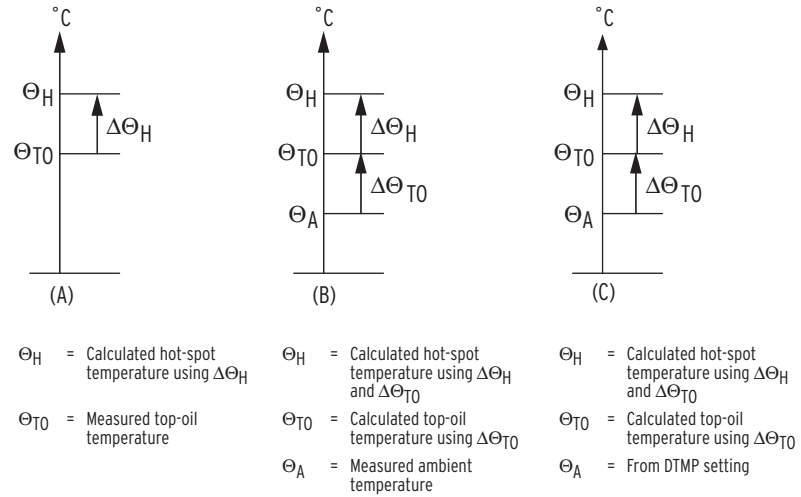


Figure 3.16 Top-Oil and Hot-Spot Temperatures

Thermal Element With Ambient and Top-Oil Temperature Inputs

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

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

$$\Theta_H = \Theta_{TO} + \Delta\Theta_H \quad \text{Equation 3.14}$$

where:

Θ_H = winding hot-spot temperature, °C

Θ_{TO} = top-oil temperature, °C

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

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

$$\Delta\Theta_H = (\Delta\Theta_{H,U} - \Delta\Theta_{H,i}) \cdot \left(1 - e^{\frac{-\Delta t}{60 \cdot T_{hs}}} \right) + \Delta\Theta_{H,i} \quad \text{Equation 3.15}$$

where:

$\Delta\Theta_{H,U}$ = the ultimate hot-spot rise over top-oil temperature for any load, °C

$\Delta\Theta_{H,i}$ = initial hot-spot rise over top-oil temperature at the start time of the interval, °C

T_{hs} = thermal time constant of hot spot, in hours (set from Table 3.3)

Δt = one-minute temperature data acquisition interval

$$\Delta\Theta_{H,U} = K^{2 \cdot EXPm} \cdot TH_{gr} \quad \text{Equation 3.16}$$

where:

K = load expressed in per unit of transformer nameplate rating according to the cooling system in service (phase current divided by the nominal current)

$EXPm$ = winding exponent (set from *Table 3.3*)

TH_{gr} = rated winding hot-spot rise over top-oil at rated load, °C (set from *Table 3.3*)

Thermal Element With Ambient Temperature Input

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

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

$$\Theta_H = \Theta_{TO} + \Delta\Theta_H \quad \text{Equation 3.17}$$

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

$$\Theta_{TO} = \Theta_A + \Delta\Theta_{TO} \quad \text{Equation 3.18}$$

where:

Θ_A = ambient temperature, °C

$\Delta\Theta_{TO}$ = top-oil rise over ambient temperature, °C

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

$$\Delta\Theta_{TO} = (\Delta\Theta_{TO,U} - \Delta\Theta_{TO,i}) \cdot \left(1 - e^{\frac{-\Delta t}{60T_o}} \right) + \Delta\Theta_{TO,i} \quad \text{Equation 3.19}$$

where:

$\Delta\Theta_{TO,U}$ = the ultimate top-oil rise over ambient temperature for any load, °C, and is a function of load and the values in *Table 3.3*

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

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

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

$$\Delta\Theta_{TO,U} = \left(\frac{(K^2 \cdot RATL + 1)}{(RATL + 1)} \right)^{EXPn} \cdot TH_{or} \quad \text{Equation 3.20}$$

where:

RATL = ratio of load loss at rated load to no-load loss (set from *Table 3.3*)

EXPn = oil exponent (set from *Table 3.3*)

TH_{or} = top-oil rise over ambient temperature at rated load, °C (set from *Table 3.3*)

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

$$T_o = OTR \cdot \left(\frac{\frac{\Delta\Theta_{TO,U}}{TH_{or}} - \frac{\Delta\Theta_{TO,i}}{TH_{or}}}{\frac{1}{\left(\frac{\Delta\Theta_{TO,U}}{TH_{or}}\right)^{EXPn}} - \frac{1}{\left(\frac{\Delta\Theta_{TO,i}}{TH_{or}}\right)^{EXPn}}} \right) \quad \text{Equation 3.21}$$

where:

OTR = thermal time constant in hours at rated load with initial top-oil temperature equal to ambient temperature (set from *Table 3.3*)

Thermal Element With No Measured Temperature Inputs

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

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

$$\Theta_H = \Theta_{TO} + \Delta\Theta_H \quad \text{Equation 3.22}$$

and the top-oil temperature according to the following:

$$\Theta_{TO} = \Theta_A + \Delta\Theta_H \quad \text{Equation 3.23}$$

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

$$\Theta_{TO} = DTMP + \Delta\Theta_{TO} \quad \text{Equation 3.24}$$

where:

DTMP = user-selectable default ambient temperature

Top-Oil Temperature Comparison to Indicate Cooling System Efficiency

With measured top-oil temperatures available, top-oil temperatures are also calculated using measured currents and the two results compared. If the measured top-oil temperature exceeds the calculated top-oil temperature by a margin specified by the user (via the CSEPx setting), a Cooling System Efficiency (CSE) Relay Word bit is asserted. This bit can be programmed to

any of the relay outputs to perform alarm or tripping functions. Assertion of the CSE bit indicates that the cooling system (fans and/or pumps) is operating below expected efficiency and may require maintenance.

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

Serial Communications Failure

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

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

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

Insulation Loss of Life

Insulation Aging Acceleration Factor

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

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

$$F_{AA} = e^{\left[\frac{BFFA}{(\Theta_{H,R} + 273)} - \frac{BFFA}{(\Theta_H + 273)} \right]} \quad \text{Equation 3.25}$$

where:

F_{AA} = insulation aging acceleration factor

BFFA = a design constant, typically 15000, °C (set from *Table 3.3*)

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

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

Daily Rate of Loss of Life

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

$$RLOL = \frac{F_{EQA} \cdot 24}{ILIFE} \cdot 100 \quad \text{Equation 3.26}$$

where:

RLOL = rate of loss of life in percent per day

ILIFE = expected normal insulation life in hours (set from *Table 3.3*)

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

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

$$F_{EQA} = \frac{\sum_{n=1}^N F_{AA_n} \cdot \Delta t_n}{\sum_{n=1}^N \Delta t_n} \quad \text{Equation 3.27}$$

where:

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

n = index of the time interval, Δt

N = total number of time intervals for the time period

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

Δt = time interval (fixed at 1 minute)

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

$$N = \frac{24}{\left(\frac{\Delta t}{60}\right)} = \frac{1440}{\Delta t} \quad \text{Equation 3.28}$$

where:

Δt = time interval (fixed at 1 minute)

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

$$F_{EQA} = \frac{\sum_{n=1}^N F_{AA_n}}{N} \quad (\text{equivalent life in days}) \quad \text{Equation 3.29}$$

Total Accumulated Loss of Life

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

$$TLOL_d = RLOL_d + TLOL_{d-1} \quad \text{Equation 3.30}$$

where:

$TLOL_d$ = total accumulated loss of life, TLOL

$RLOL_d$ = most recent daily calculation

$TLOL_{d-1}$ = previous TLOL

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

Estimated Time to Assert TLL Alarm

Estimated time to assert TLL bit:

$$TLL_t = \frac{TLOLL - TLOL}{RLOL} \cdot 24 \quad \text{Equation 3.31}$$

where:

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

TLOLL = total loss-of-life limit setting

TLOL = total accumulated loss of life, TLOL

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

Setting Descriptions

Thermal Element Enable (ETHER)

Range: Y, N

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

Thermal Model Winding Current (TMWDG)

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

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

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

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

Winding LL Voltage (VWDG)

Range: 1–1000 kV, in 0.01 kV steps

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

Transformer Construction (XTYPE)

Range: 1, 3

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

Transformer Type (TRTYPE)

Range: D, Y

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

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

Winding Temp/Ambient Temp (THwr)

Range: 65, 55

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

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

This setting determines which set of default transformer constants from *Table 3.3* the relay will use if EDFTC = Y.

Number of Cooling Stages (NCS)

Range: 1–3

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

Cooling Stage MVA Rating (MCSxy)

Range: 0.2–5000 MVA, in 0.1 MVA steps

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

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

Table 3.2 Examples of Cooling Stages and MVA Ratings

XTYPE = 3			
Cooling Stage	MVA Rating		
CS1 (oil and air cooled)	MCS11 = 100		
CS2 (forced air cooled)	MCS12 = 140		
CS3 (forced oil and air cooled)	MCS13 = 170		
XTYPE = 1			
Cooling System	MVA Rating		
	Transformer 1	Transformer 2	Transformer 3
CS1 (oil and air cooled)	MCS11 = 100	MCS21 = 100	MCS31 = 100
CS2 (forced air cooled)	MCS12 = 140	MCS22 = 140	MCS32 = 140
CS3 (forced oil and air cooled)	MCS13 = 170	MCS23 = 170	MCS33 = 170

Cooling Stage 2 (or 3) (CSxyS)

Range: SELOGIC control equation

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

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

The CsxyS SELOGIC control equations can be set to any of the Relay Word bits except rows 0 and 1 of *Table 4.9*. However, it is critical that they be configured to accurately indicate which cooling system is active. In the simplest implementation, this will consist of one or two external contacts from the monitored power transformer connected to optoisolated inputs on the SEL-387 with the CsxyS SELOGIC control equations set to the corresponding digital input.

Default Ambient Temperature (DTMP)

Range: –40 to 85°C, in 1°C steps

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

Transformer De-Energized (TRDE)

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

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

Number of Thermal Inputs (NTHM)

Range: 0–4

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

Thermal Function (THMz) (SEL-387-6 Relays With Firmware Versions R404 and Earlier)

Range: AMB, OIL1, OIL2, OIL3

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

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

NOTE: Thermal Model temperature inputs assigned as RTD inputs require temperature inputs from the SEL-2600 RTD Module via one of the SEL-387 serial ports.

Thermal Model temperature inputs assigned as THM inputs require an external device, such as an SEL-2030, communicating thermal information directly to the SEL-387 via the relay serial port. For more information on using the THM type thermal inputs, see SEL Application Guide AG2006-05 “Connection and Configuration of an SEL Communications Processor and an SEL-2410 I/O Processor to Obtain Measured Ambient and Top-Oil Temperatures for the SEL-387-6 Relay Thermal Element”.

Ambient Temperature Input (AMB) (SEL-387-6 Relays With Firmware Versions R606 and Later)

Range: THM1... THM4, RTD1A...RTD12A, RTD1B ...RTD12B

This setting assigns one of the selected temperature inputs to the ambient temperature variable in the SEL-387-6 thermal model.

Top-Oil 1 Temperature Input (OIL1) (SEL-387-6 Relays With Firmware Versions R606 and Later)

Range: THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B

This setting assigns the selected temperature input to the Top-Oil 1 temperature variable in the SEL-387-6 thermal model. Use this setting for single tank, three phase transformers, or as one of three top-oil inputs for single tank, single-phase transformers.

Top-Oil 2 Temperature Input (OIL2) (SEL-387-6 Relays With Firmware Versions R606 and Later)

Range: THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B

This setting assigns the selected temperature input to the Top-Oil 2 temperature variable in the SEL-387-6 thermal model. Use this setting for two of three top-oil inputs for single tank and single-phase transformers.

Top-Oil 3 Temperature Input (OIL3) (SEL-387-6 Relays With Firmware Versions R606 and Later)

Range: THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B

This setting assigns the selected temperature input to the Top-Oil 3 temperature variable in the SEL-387-6 thermal model. Use this setting for the third of three top-oil inputs for single tank and single-phase transformers.

Top-Oil Temperature Limit (TOT1, TOT2)

Range: 50 to 150°C, in 1°C steps

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

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

Hot-Spot Temperature Limit (HST1, HST2)

Range: 80 to 300°C, in 1°C steps

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

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

Aging Acceleration Factor Limits (FAAL1, FAAL2)

Range: 0–599.99, in 0.01 steps

A transformer subjected to overload or temperature greater than the normal transformer rating will age faster than the same transformer at rated load and temperature. One of the outputs the thermal element provides is a transformer

insulation aging acceleration factor, which, when multiplied by elapsed time, provides an indication of the expected life remaining in the transformer. Should load and temperature be greater than normal, this factor is greater than 1. Should load and temperature be less than normal, the factor is less than 1. FAAL1 and FAAL2 determine limits for the aging acceleration factor. If the aging acceleration factor exceeds the limits, the FAA1 or FAA2 bit asserts. Using SELOGIC control equations, you can configure these bits to close alarm contacts.

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

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

Range: 0–99%, in 0.01% steps

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

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

Total Loss-of-Life Limit (TLOLL)

Range: 0–99%, in 0.01% steps

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

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

Cooling System Efficiency Pickup (CSEPx)

Range: 5–100°C

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

When a measured top-oil temperature is available via the serial port, measured currents are used to determine a calculated top-oil temperature. If the measured top-oil temperature is greater than the calculated top-oil temperature by the value of setting CSEPx, then a Cooling System Efficiency, CSE, bit in the Relay Word is asserted. Using SELOGIC control equations, the CSE bit can be configured to any of the relay outputs to perform alarm or tripping functions. Assertion of the CSE bit indicates that the cooling system (fans and/or pumps) is operating below expected efficiency and may require maintenance.

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

General Cooling System Constants

Normal Insulation Life (ILIFE)

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

IEEE C57.91: 1995 suggests that normal transformer insulation life is 20.55 years or 180000 hours. *Table 3.3* lists this default value. You can select other values within a range of 1000–999999 hours.

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

Enable Default Constants (EDFTC)

Range: Y, N

Setting EDFTC enables or disables the default transformer constants in *Table 3.3*.

Table 3.3 Default Transformer Constants

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

^a THwr = average winding rise over ambient at rated load.

When EDFTC is set to Y (yes), the transformer constants shown in *Table 3.3* are in effect, and the individual settings are not accessible. When EDFTC is set to N (no), the individual transformer constant settings are accessible.

Hot-Spot Thermal Time Constant (Thsx)

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

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

Constant to Calculate FAA (BFFAx)

Range: 0–100000, in steps of 1

IEEE C57.91-1995 section 5.2 states that B (BFFA) is an empirical constant equal to 15000. *Table 3.3* lists this value as the default. You can select other values from within a range of 0 to 100000. The thermal element uses this constant to calculate the transformer insulation aging acceleration factor (FAA).

Cooling Stage n Constants

Top-Oil Rise Over Ambient Temperature (THorxy)

Range: 0.1 to 100°C, in 0.1°C steps

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

The default values listed in *Table 3.3* are from IEEE C57.92-1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 100°C.

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

Range: 0.01 to 100°C, in 0.1°C steps

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

$$THgr = THwr + \theta_{hswr} - THor \quad \text{Equation 3.32}$$

where:

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

θ_{hswr} = hot-spot winding rise over average winding rise
 = (10°C if THwr = 55 or 15°C if THwr = 65)

Table 3.3 lists default values. The setting range for THgr is 0 to 100°C.

Ratio Losses (RATLxy)

Range: 0.1–100, in 0.1 steps

RATL is the ratio of load loss at rated load to no-load loss. The default values listed in *Table 3.3* are from IEEE C57.92-1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 100.

Oil Thermal Time Constant (OTR_{xy})

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

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

$$\text{OTR} = C \cdot \left[\frac{\text{THor}}{P_r} \right] \quad \text{Equation 3.33}$$

where:

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

or

C = $0.1323 \cdot (\text{weight of core and coil assembly in kilograms})$
 + $0.0882 \cdot (\text{weight of tank and fitting in kilograms})$
 + $0.3513 \cdot (\text{liters of oil})$

P_r = total loss at rated load (watts)

THor = top-oil rise over ambient at rated load

where:

1 kg = 2.2046 pounds

1 gallon = 3.785 liters

The default value from *Table 3.3* is 0.08 hours. You can select other values from within a range of 0–2 hours. The default values listed in *Table 3.3* are from IEEE C57.92-1981, Tables 2 and 4.

Oil Exponent (EXP_{nxy})

Range: 0.1–5, in 0.1 steps

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

The default values listed in *Table 3.3* are from IEEE C57.92-1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 5.

Winding Exponent (EXP_{mxy})

Range: 0.1–5, in 0.1 steps

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

The default values listed in *Table 3.3* are from IEEE C57.92-1981, Tables 2 and 4. If specific values for a particular transformer are known, you can enter values from within a range of 0 to 5.

Application Guideline, Using the SEL-2030 to Send Temperature Data to the SEL-387-6

While the SEL-387-5, SEL-387-6 relays can communicate directly with the SEL-2600A for gathering temperature readings, some applications may use the SEL-2030 communications processor for retrieving the temperature data from the SEL-2600A.

The SEL-387-6 obtains temperature information via one of its serial ports. The relay may receive data from as many as four temperature transducers: a single ambient temperature transducer and one transducer for top-oil temperature from each of three single-phase transformers. These data could come from an SEL-2032 or an SEL-2030 Communications Processor, which receives the temperature data from either an SEL-2600A RTD Module or a PLC (see *Figure 3.17*). The SEL communications processor must receive the temperature data in Modbus®, SEL Fast Messaging, or ASCII protocol. The SEL communications processor passes these data on to the SEL-387-6 in the form of an SEL Fast Message. While the SEL-387-6 can receive temperature data at any rate, the thermal element uses these data only once a minute.

Please refer to *SEL Application Guide 2000-07, Connection and Configuration of an SEL Communications Processor and SEL-2600A to Obtain Measured Ambient and Top-Oil Temperatures for SEL-387-6 Relay Thermal Element* for information about how to set the SEL communications processor to communicate with the SEL-2600A RTD Module and the SEL-387-6.

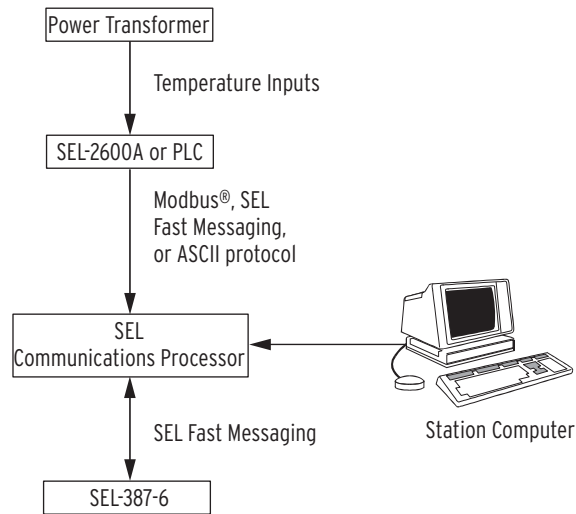


Figure 3.17 Example System Block Diagram

Overcurrent Element

Application Description

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

Operating Characteristic

Each winding input of the SEL-387 has 11 overcurrent elements (see *Table 3.4*). Nine of these 11 are torque-controlled elements, of which there are one definite-time element, one instantaneous element, and one inverse-time element per each of three categories. These categories are phase, negative-sequence, and residual current. Two of the 11 overcurrent elements, 50Pn3 and 50Pn4, are not torque-controlled. These two elements are phase instantaneous overcurrent elements that provide output information per phase

and, through an OR gate, assert a Relay Word bit if any one of the three phases asserts. These two elements primarily provide level detection, for applications such as trip unlatch logic or phase identification.

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

Table 3.4 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
Winding 4	50P41	50P42, 50P43, 50P44	51P4
Combined (Windings 1 and 2)			51PC1
Negative-Sequence ($I_Q = 3 \cdot I_2$)			
Winding 1	50Q11	50Q12	51Q1
Winding 2	50Q21	50Q22	51Q2
Winding 3	50Q31	50Q32	51Q3
Winding 4	50Q41	50Q42	51Q4
Residual ($I_R = I_a + I_b + I_c$)			
Winding 1	50N11	50N12	51N1
Winding 2	50N21	50N22	51N2
Winding 3	50N31	50N32	51N3
Winding 4	50N41	50N42	51N4
Combined (Windings 1 and 2)			51NC1
Combined (Windings 3 and 4)			51NC2

50Pn1-Phase Definite-Time Element

Figure 3.18 shows the logic for the 50Pn1 element. The logic compares the magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pick up 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.

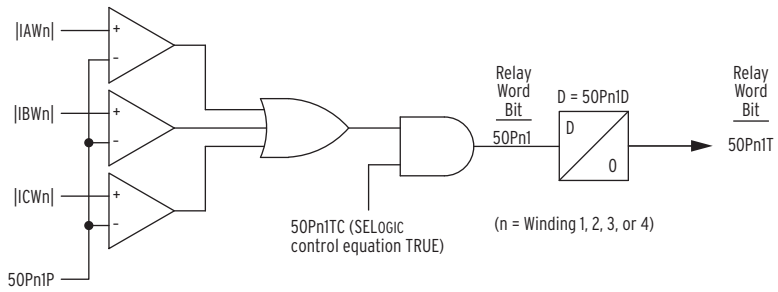


Figure 3.18 50Pn1 Phase Definite-Time O/C Element, Torque-Controlled

50Pn2-Phase Instantaneous Element

Figure 3.19 shows the logic for the 50Pn2 element. The 50Pn2 element logic compares magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pick up 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.

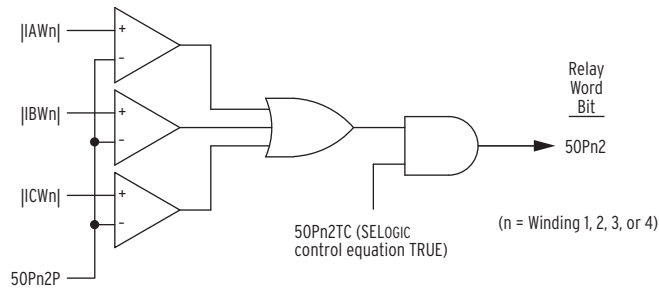


Figure 3.19 50Pn2 Phase Instantaneous O/C Element, Torque-Controlled

50Pn3 and 50Pn4-Phase Instantaneous Element

Figure 3.20 shows the logic for the two nontorque-controlled phase instantaneous elements. The two elements find application primarily in level detection or phase identification. The logic compares magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pick up 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.

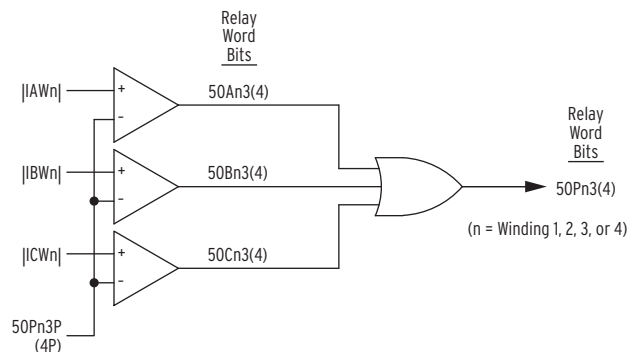


Figure 3.20 50Pn3 and 50Pn4 Phase Instantaneous O/C Element, Nontorque-Controlled

51Pn-Phase Inverse-Time Element

Figure 3.21 shows the logic for the 51Pn element. The logic compares the magnitudes of phase input currents I_{AWn} , I_{BWn} , and I_{CWn} to pick up 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.

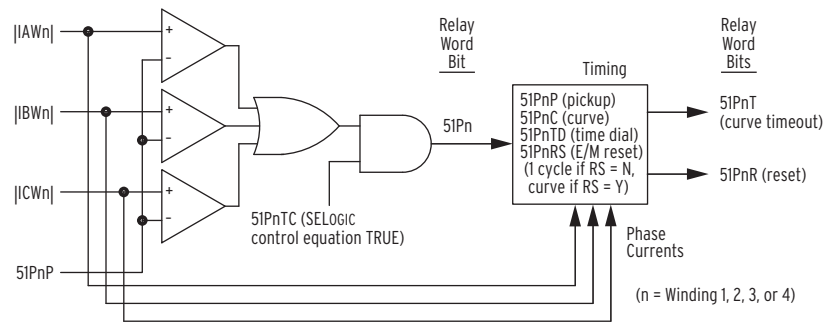


Figure 3.21 51Pn Phase Inverse-Time O/C Element, Torque-Controlled

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} pushbutton 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 3.22 shows the logic for the definite-time 50Qn1 negative-sequence element and the definite-time 50Nn1 residual element.

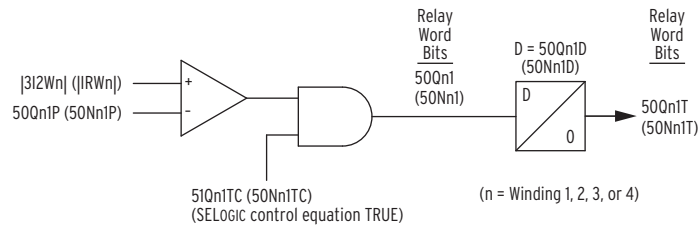


Figure 3.22 50Qn1 and 50Nn1 Sequence Definite-Time O/C Element, Torque Controlled

50Qn1 Negative-Sequence Definite-Time Element

The 50Qn1 element logic compares the magnitude of calculated negative-sequence current 3I2Wn to pick up 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, IIRWn, 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 3.23 shows the logic for the instantaneous 50Qn2 negative-sequence element and the instantaneous 50Nn2 residual element.

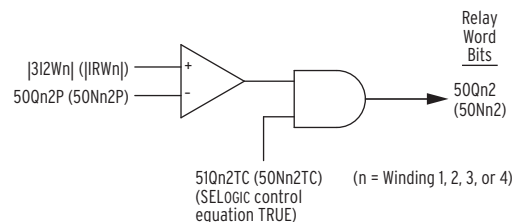


Figure 3.23 50Qn2 and 50Nn2 Sequence Instantaneous O/C Element, Torque-Controlled

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

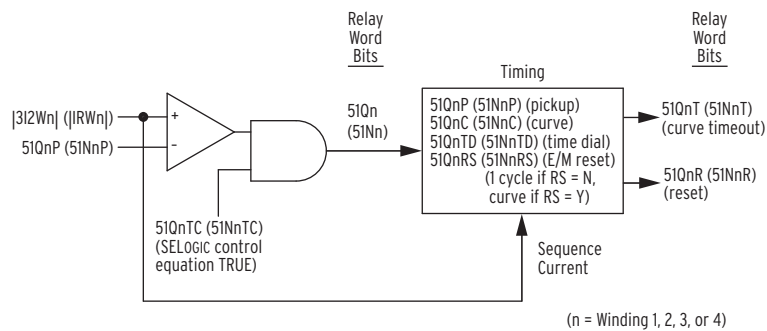


Figure 3.24 51Qn and 51Nn Sequence Inverse-Time O/C Element, Torque Controlled

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} pushbutton 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, 51N n TC, determines the other AND input. If 51N n TC is true, Relay Word bit 51N n asserts and the inverse curve begins timing.

The settings defining the curve in this case are 51N n P for the pickup setting, 51N n C for the particular curve equation, 51N n TD for the time dial, and 51N n RS for the curve reset.

Curve time-out causes Relay Word bit 51N n T to assert. When the current drops below pickup, 51N n deasserts and the element resets according to the setting for 51N n RS. At the completion of the reset, Relay Word bit 51N n R 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} pushbutton to force the bit to a logical 1 during element testing.

51PC m and 51NC m Combined Overcurrent Element ($m = 1, 2$)

The combined overcurrent elements operate on summed input currents to two windings. Elements 51PC1 and 51NC1 use phase and residual current from Windings 1 and 2, while 51PC2 and 51NC2 use these currents from Windings 3 and 4; see *Figure 3.25*.

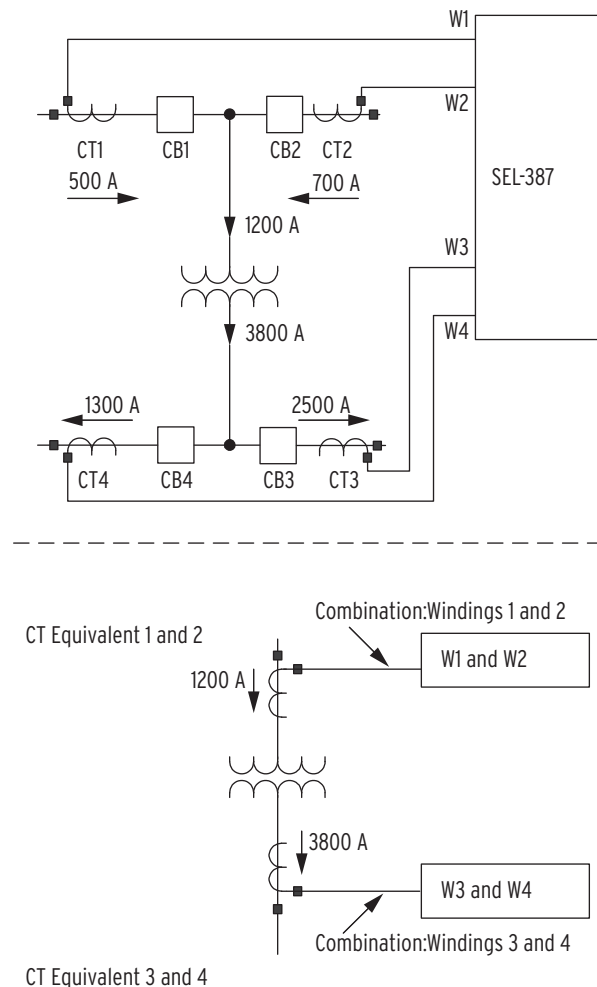


Figure 3.25 Combined Overcurrent Example

51PC1 and 51NC1 Element

Figure 3.26 shows the logic for the inverse-time combined overcurrent elements, 51PC1 and 51NC1.

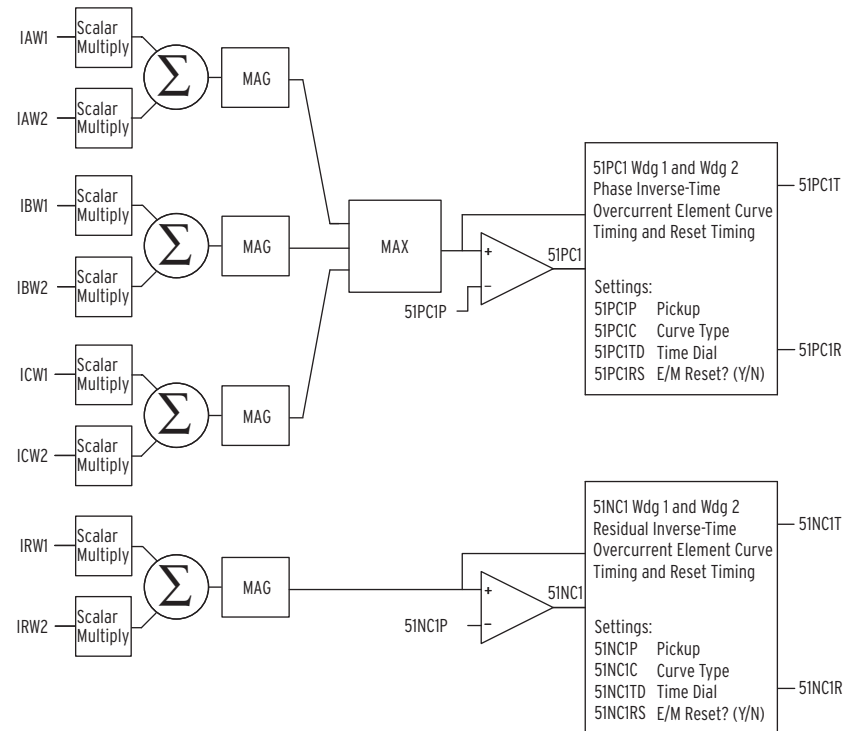


Figure 3.26 51PC1 and 51NC1 Combined Inverse-Time O/C Elements

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:

$$\left(I_{nW1} \cdot \frac{CTR1}{CTR2} \right) + I_{nW2} \quad \text{Equation 3.34}$$

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

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

$$CTR1 = 600/5 = 120$$

$$CTR2 = 2000/5 = 400$$

$$I_{nW1} = 2000 \text{ A (primary)}$$

$$I_{nW2} = 1000 \text{ A (primary)}$$

$$\text{Pickup} = 8000 \text{ A (primary)}$$

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

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

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

Equation 3.35

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

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

Equation 3.36

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:

$$InW1 + \left(InW2 \cdot \frac{CTR2}{CTR1} \right)$$

Equation 3.37

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

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

$$CTR1 = 1000/5 = 200$$

$$CTR2 = 500/5 = 100$$

$$InW1 = 3000 \text{ A (primary)}$$

$$InW2 = 6000 \text{ A (primary)}$$

$$\text{Pickup} = 8000 \text{ A (primary)}$$

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

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

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

Equation 3.38

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

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

Equation 3.39

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}** pushbutton 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:

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

Equation 3.40

\overrightarrow{XXXX} defines a vector quantity.

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

$$CTR1 = 500/5 = 100$$

$$CTR2 = 1000/5 = 200$$

$$\text{Pickup} = 400 \text{ A (primary)}$$

Primary Currents	
IAW1 =	3000 $\angle 2^\circ$ A
IAW2 =	1545 $\angle 3^\circ$ A
IBW1 =	3010 $\angle -122^\circ$ A
IBW2 =	1480 $\angle -118^\circ$ A
ICW1 =	2950 $\angle 117^\circ$ A
ICW2 =	1505 $\angle 124^\circ$ A

Secondary Currents	
IAW1 =	30 $\angle 2^\circ$ A
IAW2 =	7.725 $\angle 3^\circ$ A
IBW1 =	30.1 $\angle -122^\circ$ A
IBW2 =	7.4 $\angle -118^\circ$ A
ICW1 =	29.5 $\angle 117^\circ$ A
ICW2 =	7.525 $\angle 124^\circ$ A

Then

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

$$= 1.071 \angle 70.8^\circ \text{ A}$$

Equation 3.41

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

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

Equation 3.42

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:

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

Equation 3.43

\overrightarrow{XXXX} defines a vector quantity.

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

$$CTR1 = 1000/5 = 200$$

$$CTR2 = 500/5 = 100$$

$$\text{Pickup} = 400 \text{ A (primary)}$$

Primary Currents	
IAW1 =	3000 $\angle 5^\circ$ A
IAW2 =	1545 $\angle 3^\circ$ A
IBW1 =	3010 $\angle -123^\circ$ A
IBW2 =	1480 $\angle -118^\circ$ A
ICW1 =	2950 $\angle 115^\circ$ A
ICW2 =	1505 $\angle 124^\circ$ A

Secondary Currents	
IAW1 =	15 $\angle 5^\circ$ A
IAW2 =	15.45 $\angle 3^\circ$ A
IBW1 =	15.05 $\angle -123^\circ$ A
IBW2 =	14.80 $\angle -118^\circ$ A
ICW1 =	14.75 $\angle 115^\circ$ A
ICW2 =	15.05 $\angle 124^\circ$ A

Then

$$\begin{aligned} & (15 \angle 5^\circ \text{ A} + 15.05 \angle -123^\circ \text{ A} + 14.75 \angle 115^\circ \text{ A}) \\ & + (15.45 \angle 3^\circ \text{ A} + 14.80 \angle -118^\circ \text{ A} + 15.05 \angle 124^\circ \text{ A}) \cdot \frac{100}{200} \\ & = 2.1164 \angle 76^\circ \text{ A} + 0.11270 \angle 73^\circ \text{ A} = 2.230 \angle 76^\circ \text{ A} \end{aligned}$$

Equation 3.44

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

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

Equation 3.45

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.

NOTE: These two overcurrent elements should not be used if the REF function is enabled. Neutral CT input to Winding 4 may lead to false operation of 51PC2 or 51NC2. Set 51PC2P and 51NC2P to OFF for this situation.

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} pushbutton.

51PC2 and 51NC2 Element

Figure 3.27 shows the logic for the inverse-time combined overcurrent elements 51PC2 and 51NC2.

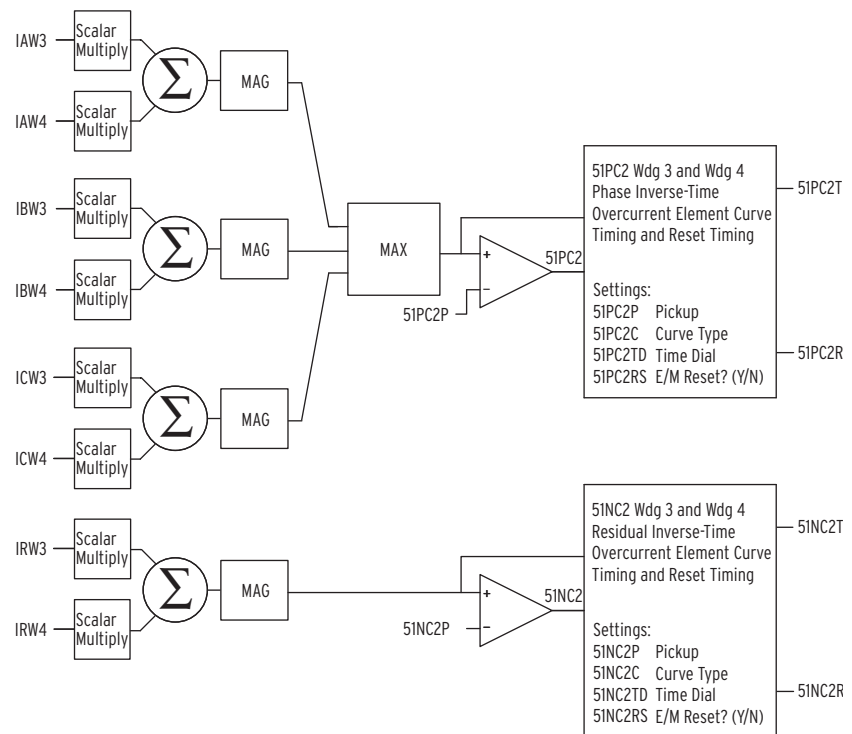


Figure 3.27 51PC2 and 51NC2 Combined Inverse-Time O/C Elements

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

Setting Descriptions

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

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

Winding n Overcurrent Element and Demand Threshold Enables (EOCn)

Range: Y, N

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

Combined O/C Element Enable (EOCC)

Range: Y, N

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

Instantaneous and Definite-Time Element Pickups (50PnmP, 50QnmP, 50NnmP)

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

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

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

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

Definite-Time Element Delays (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, 51PCmP, 51NCmP)

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

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

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, 51PCmC, 51NCmC)

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

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

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

Time-Dial Settings (51PnTD, 51QnTD, 51NnTD, 51PCmTD, 51NCmTD)

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

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, 51PCmRS, 51NCmRS)

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

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)

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

Range: SELOGIC control equation

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

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 can 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-387 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 can be 30 times the transformer full load current. Transformer magnetizing inrush current contains substantial second-harmonic current and often contains a significant dc component. Unlike conventional electromechanical overcurrent elements, the SEL-387 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-387 instantaneous, definite-time, and time-overcurrent elements need only be set with regard to expected load and fault conditions.

Where the SEL-387 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-387 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 can 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-387 phase overcurrent elements respond to the maximum phase current magnitude, I_p , where I_p is the largest value of $|I_a|$, $|I_b|$, and $|I_c|$. Set phase overcurrent element pickup settings above the highest expected load current to avoid tripping on normal load current. You can 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 $3I_2 = I_a + I_b \cdot (1 \angle 240) + I_c \cdot (1 \angle 120)$. 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:

$$\begin{aligned} |I_2| &= \left(\frac{\sqrt{3}}{3}\right) \cdot |I_p| \\ 3 \cdot |I_2| &= \sqrt{3} \cdot |I_p| \\ \therefore \frac{|3I_2|}{|I_p|} &= 1.73 \end{aligned} \quad \text{Equation 3.46}$$

where I_p 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 as a result of 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 $3I_0 = I_a + I_b + I_c$. 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 as a result of 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-387 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 at the end of 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 $51xnRS$ ($x = P, Q, \text{ or } N$; $n = \text{winding number}$) setting equal to Y . With this setting, the relay emulates the spring-torque-governed disk reset action of an induction time-overcurrent element. Make this setting when the SEL-387 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-387 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-387 allows you to either enable or block selected overcurrent elements using a SELOGIC control equation. You may want, 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 want 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 torque-control variable of the specific overcurrent element. For

example, to torque control the inverse-time phase overcurrent element for Winding 1, an equation is needed for the setting 51PTC. A few simple possibilities might include:

To enable the element with an external contact input **IN104**, set
 $51PTC = IN104$.

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

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

Overcurrent Settings for Example Application

The differential settings for the example transformer application (see *Figure 2.8*) 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 Curves

Standard Inverse-Time Characteristic Curves

The information in *Table 3.5* and *Table 3.6* describes the curve timing for the curve and time-dial settings made for the time-overcurrent elements. The time-overcurrent curves in *Figure 3.28* through *Figure 3.37* conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Where:

T_p = Operating time in seconds

T_R = Electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)

TD = Time-dial setting

M = Applied multiples of pickup current [for operating time (T_p), $M > 1$; for reset time (T_R), $M \leq 1$]

Table 3.5 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$T_p = TD \cdot \left(0.0226 + \frac{0.0104}{M^{0.02} - 1} \right)$	$T_R = TD \cdot \left(\frac{1.08}{1 - M^2} \right)$	<i>Figure 3.28</i>
U2 (Inverse)	$T_p = TD \cdot \left(0.180 + \frac{5.95}{M^2 - 1} \right)$	$T_R = TD \cdot \left(\frac{5.95}{1 - M^2} \right)$	<i>Figure 3.29</i>
U3 (Very Inverse)	$T_p = TD \cdot \left(0.0963 + \frac{3.88}{M^2 - 1} \right)$	$T_R = TD \cdot \left(\frac{3.88}{1 - M^2} \right)$	<i>Figure 3.30</i>
U4 (Extremely Inverse)	$T_p = TD \cdot \left(0.0352 + \frac{5.67}{M^2 - 1} \right)$	$T_R = TD \cdot \left(\frac{5.67}{1 - M^2} \right)$	<i>Figure 3.31</i>
U5 (Short-Time Inverse)	$T_p = TD \cdot \left(0.00262 + \frac{0.00342}{M^{0.02} - 1} \right)$	$T_R = TD \cdot \left(\frac{0.323}{1 - M^2} \right)$	<i>Figure 3.32</i>

Table 3.6 Equations Associated With IEC Curves (Sheet 1 of 2)

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$T_p = TD \cdot \frac{0.14}{M^{0.02} - 1}$	$T_R = TD \cdot \left(\frac{13.5}{1 - M^2} \right)$	<i>Figure 3.33</i>
C2 (Very Inverse)	$T_p = TD \cdot \frac{13.5}{M - 1}$	$T_R = TD \cdot \left(\frac{47.3}{1 - M^2} \right)$	<i>Figure 3.34</i>
C3 (Extremely Inverse)	$T_p = TD \cdot \frac{80}{M^2 - 1}$	$T_R = TD \cdot \left(\frac{80}{1 - M^2} \right)$	<i>Figure 3.35</i>

Table 3.6 Equations Associated With IEC Curves (Sheet 2 of 2)

Curve Type	Operating Time	Reset Time	Figure
C4 (Long-Time Inverse)	$T_p = TD \cdot \frac{120}{M - 1}$	$T_R = TD \cdot \left(\frac{120}{1 - M} \right)$	Figure 3.36
C5 (Short-Time Inverse)	$T_p = TD \cdot \frac{0.05}{M^{0.04} - 1}$	$T_R = TD \cdot \left(\frac{4.85}{1 - M^2} \right)$	Figure 3.37

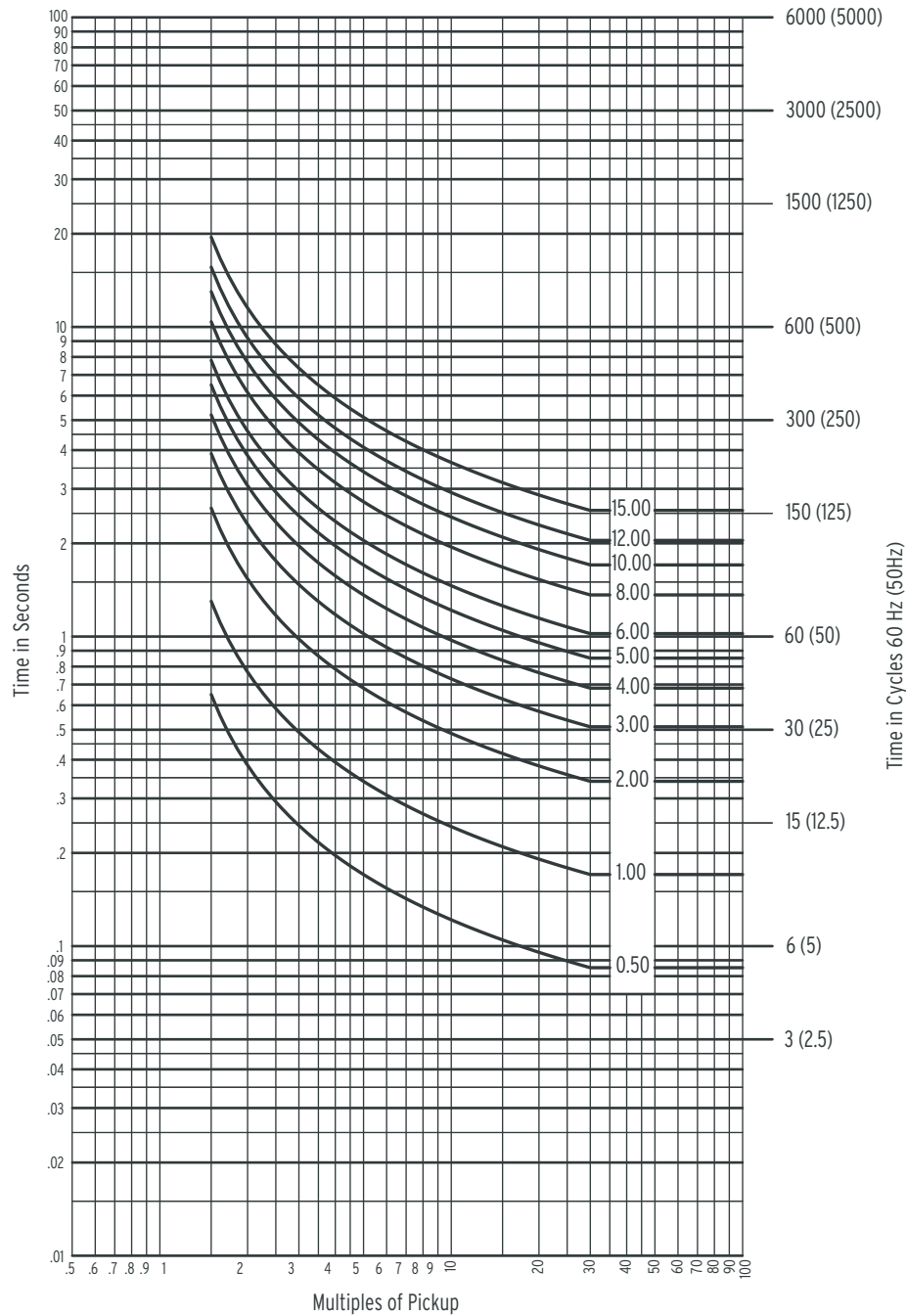


Figure 3.28 U. S. Moderately Inverse Curve: U1

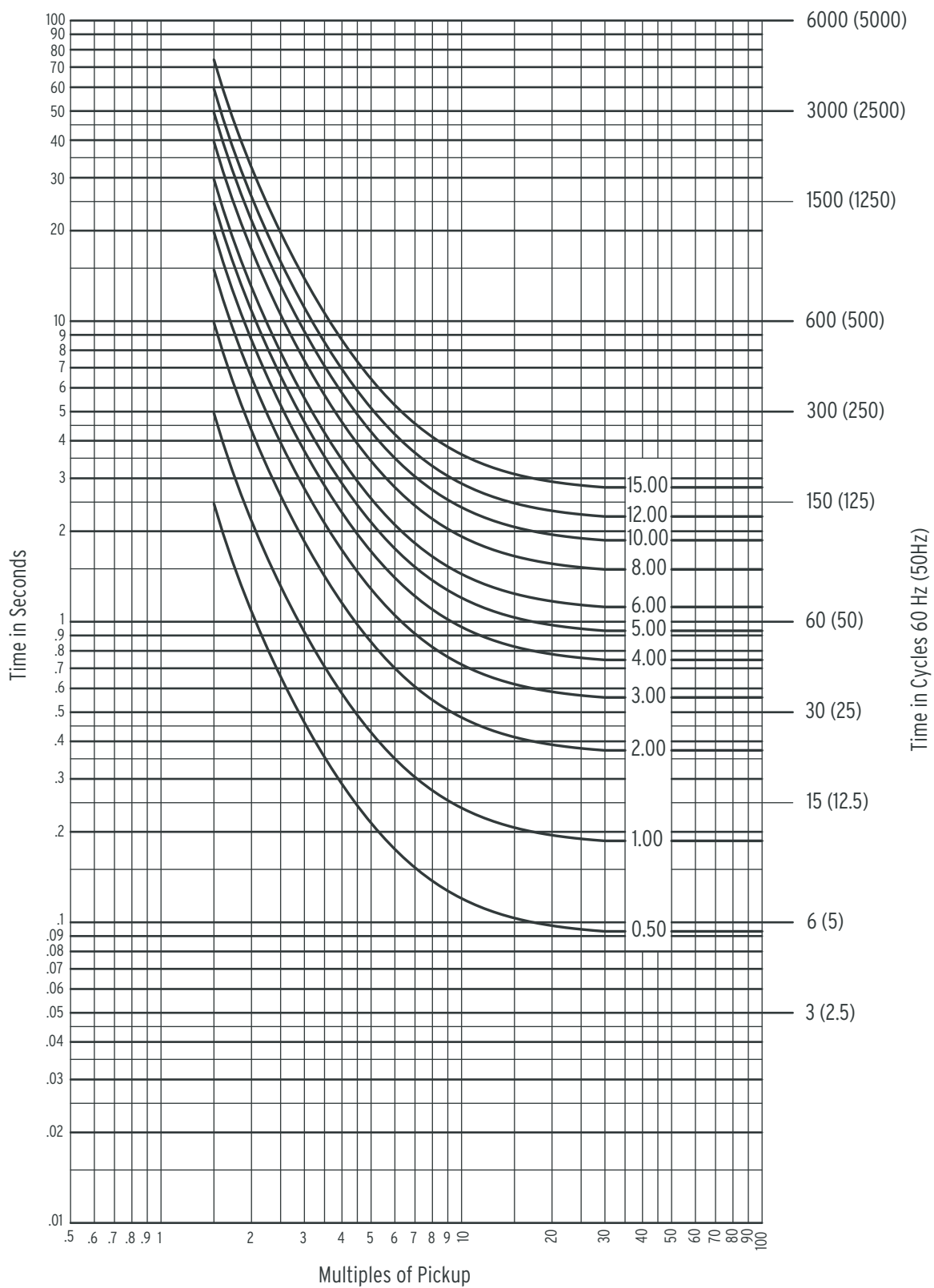


Figure 3.29 U.S. Inverse Curve: U2

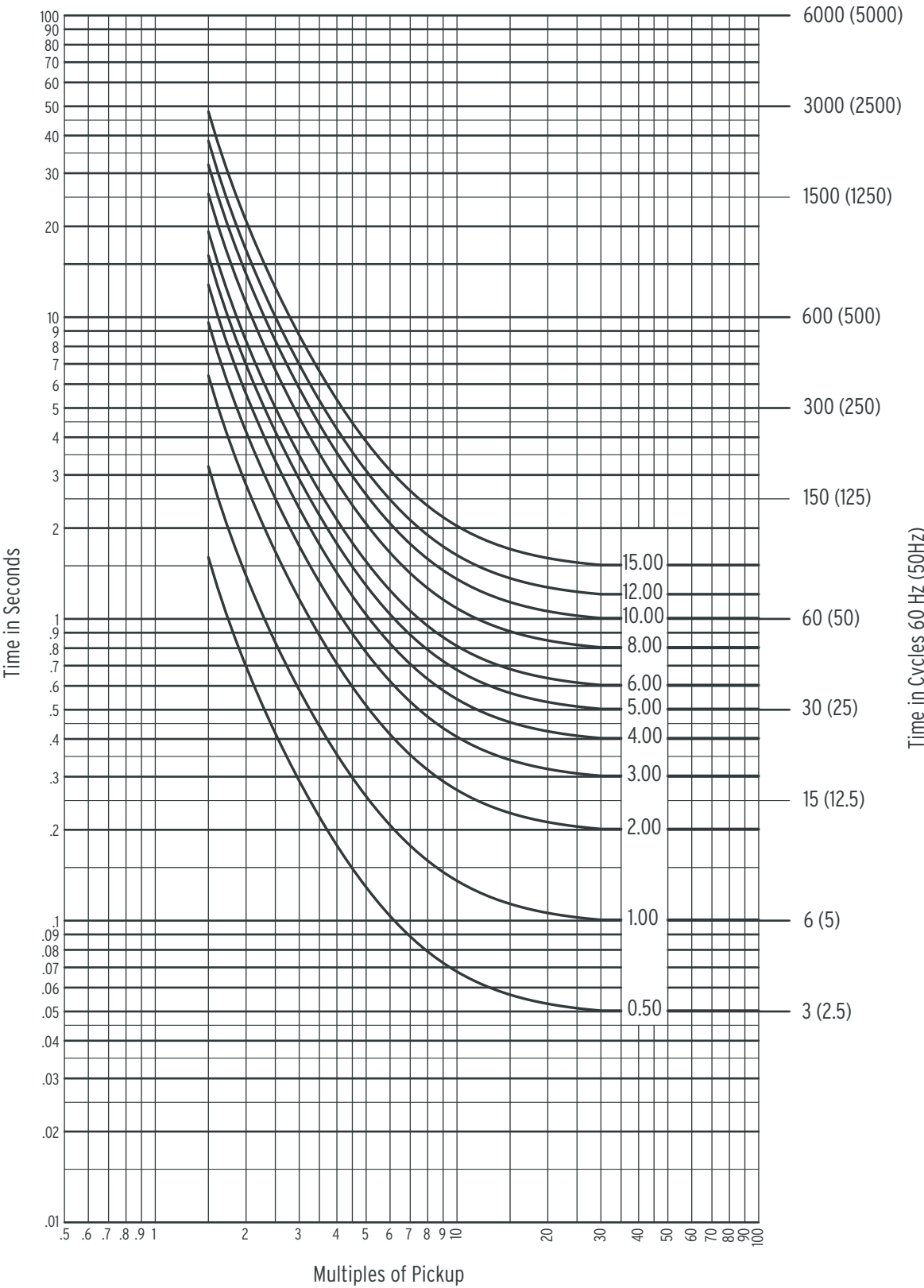


Figure 3.30 U.S. Very Inverse Curve: U3

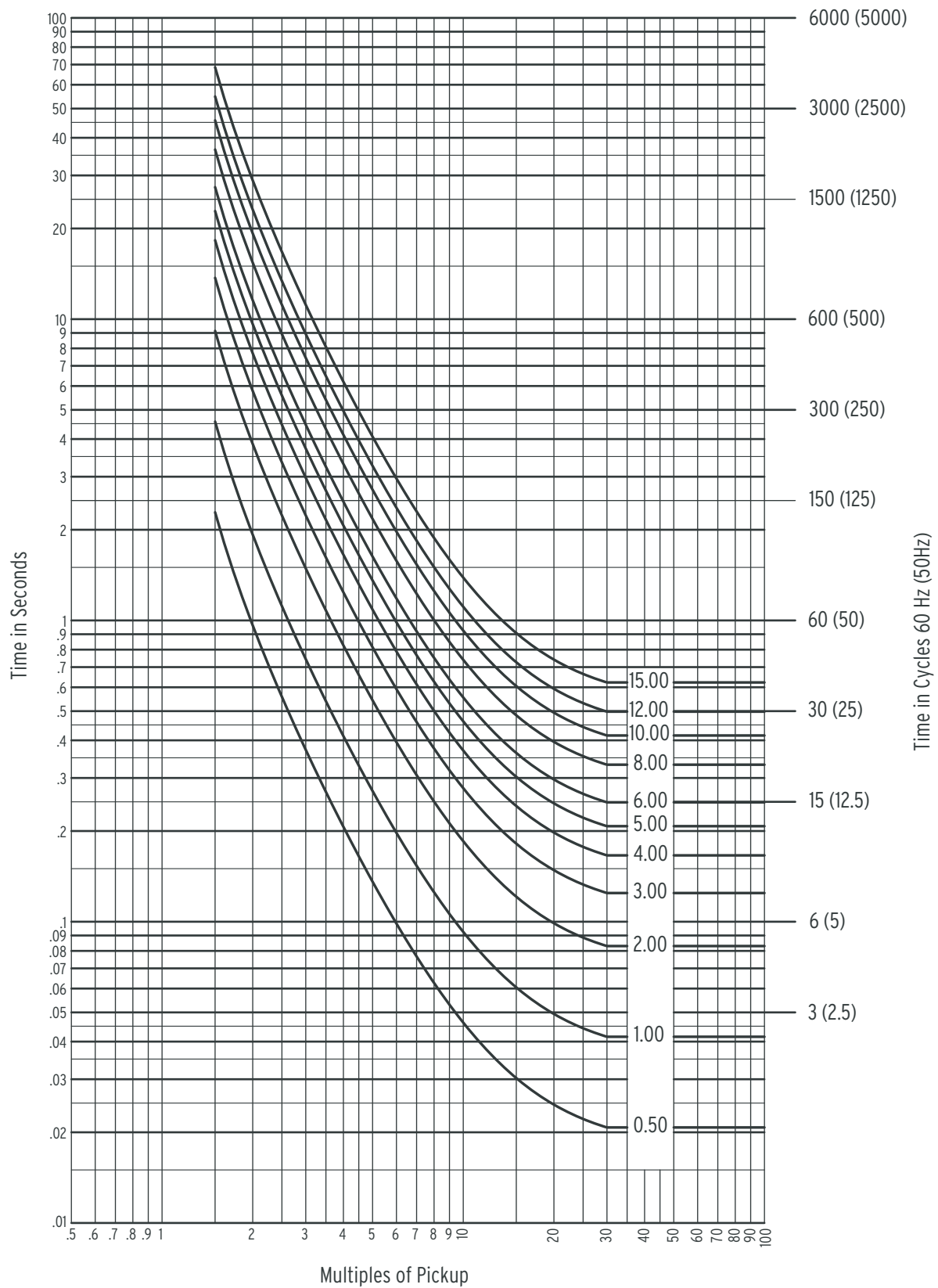


Figure 3.31 U.S. Extremely Inverse Curve: U4

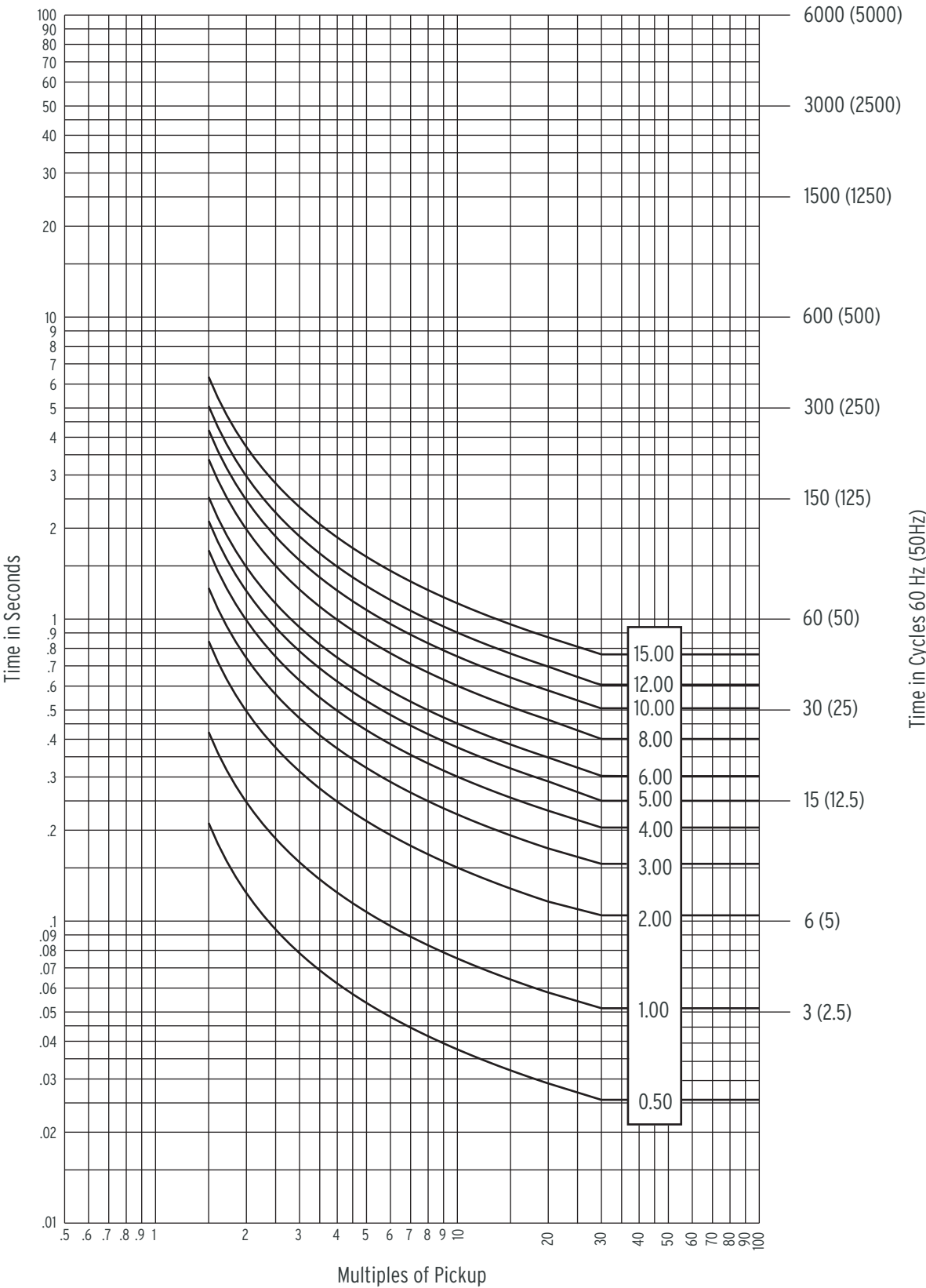


Figure 3.32 U.S. Short-Time Inverse Curve: U5

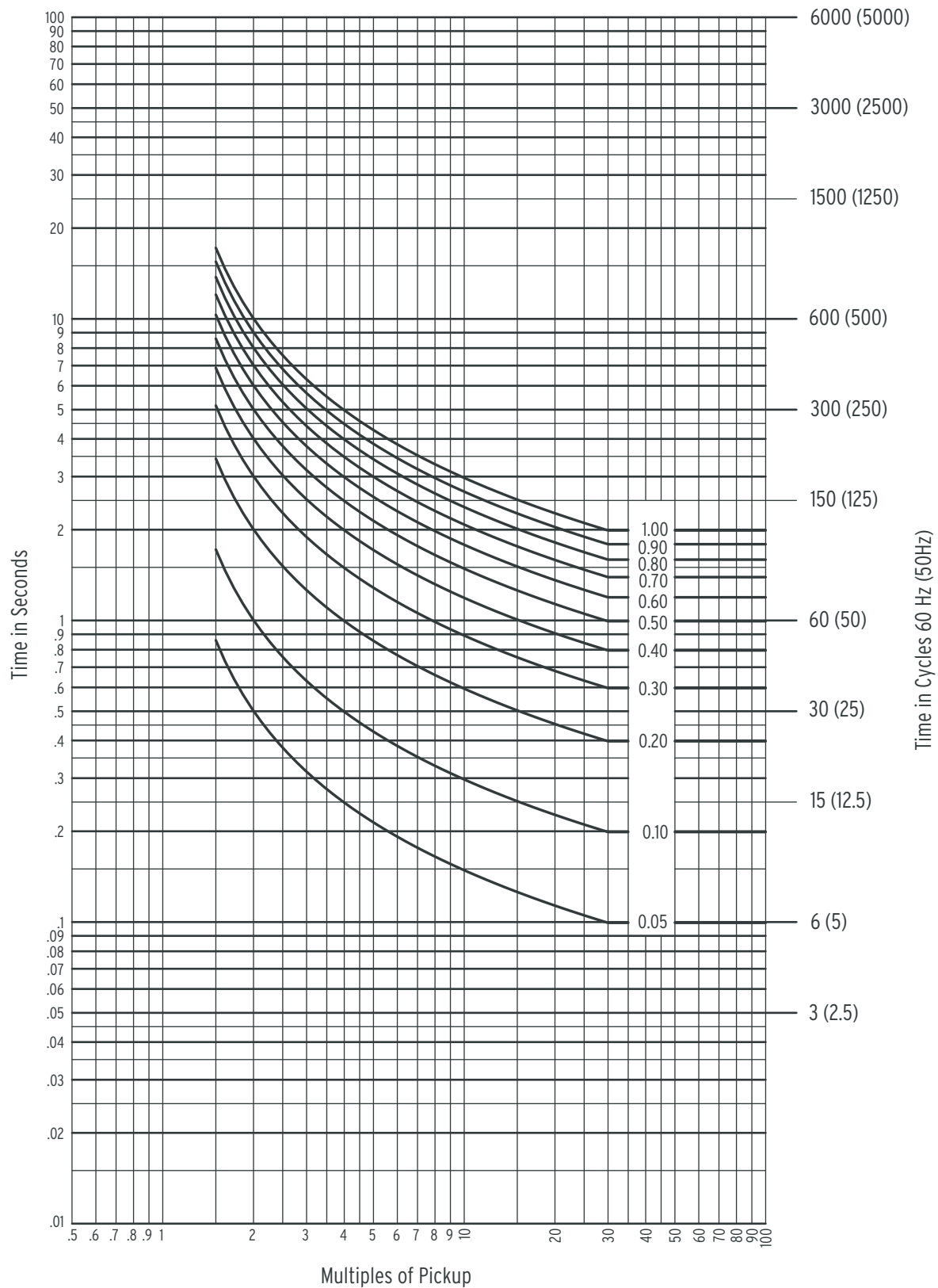


Figure 3.33 IEC Class A Curve (Standard Inverse): C1

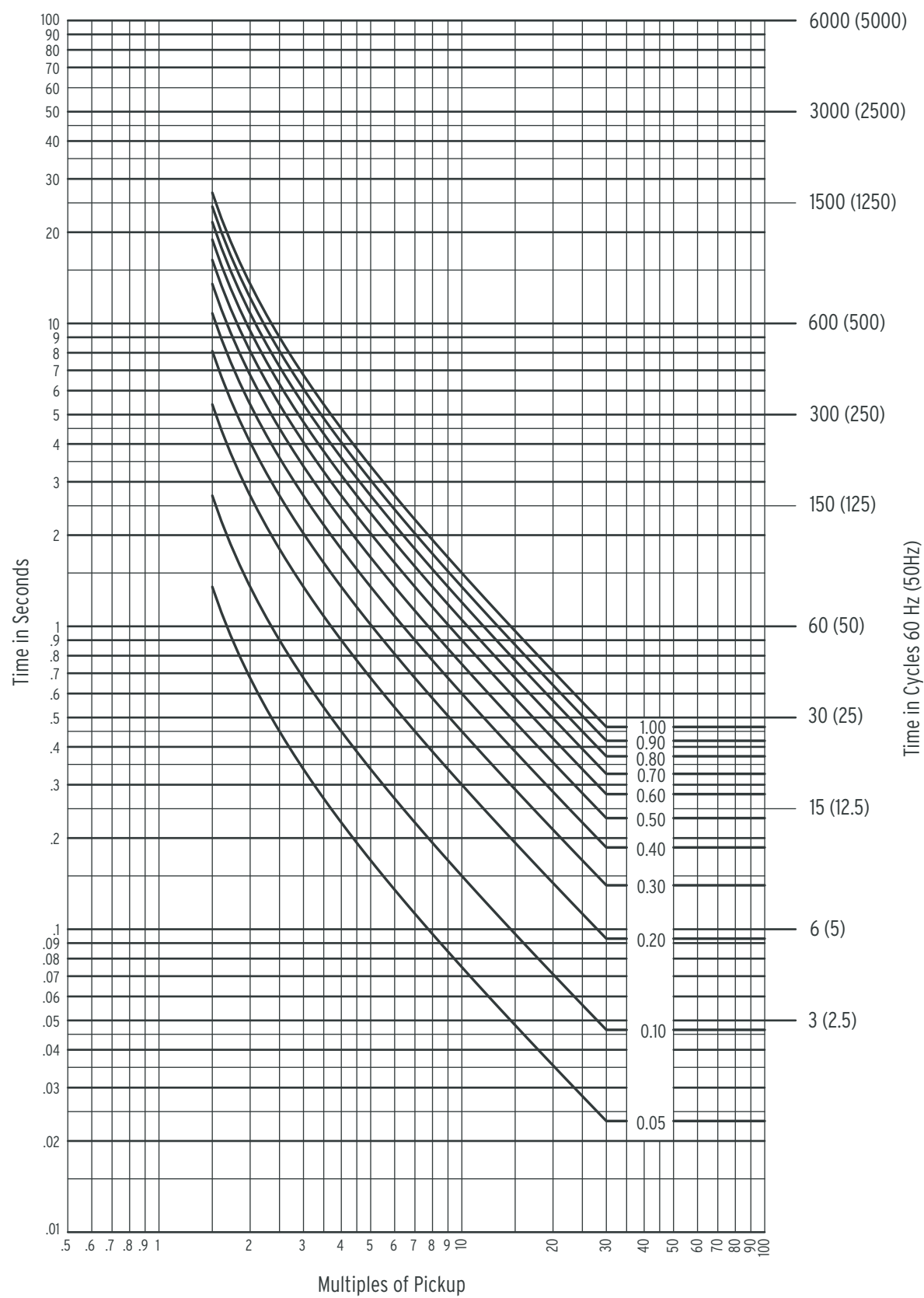


Figure 3.34 IEC Class B Curve (Very Inverse): C2

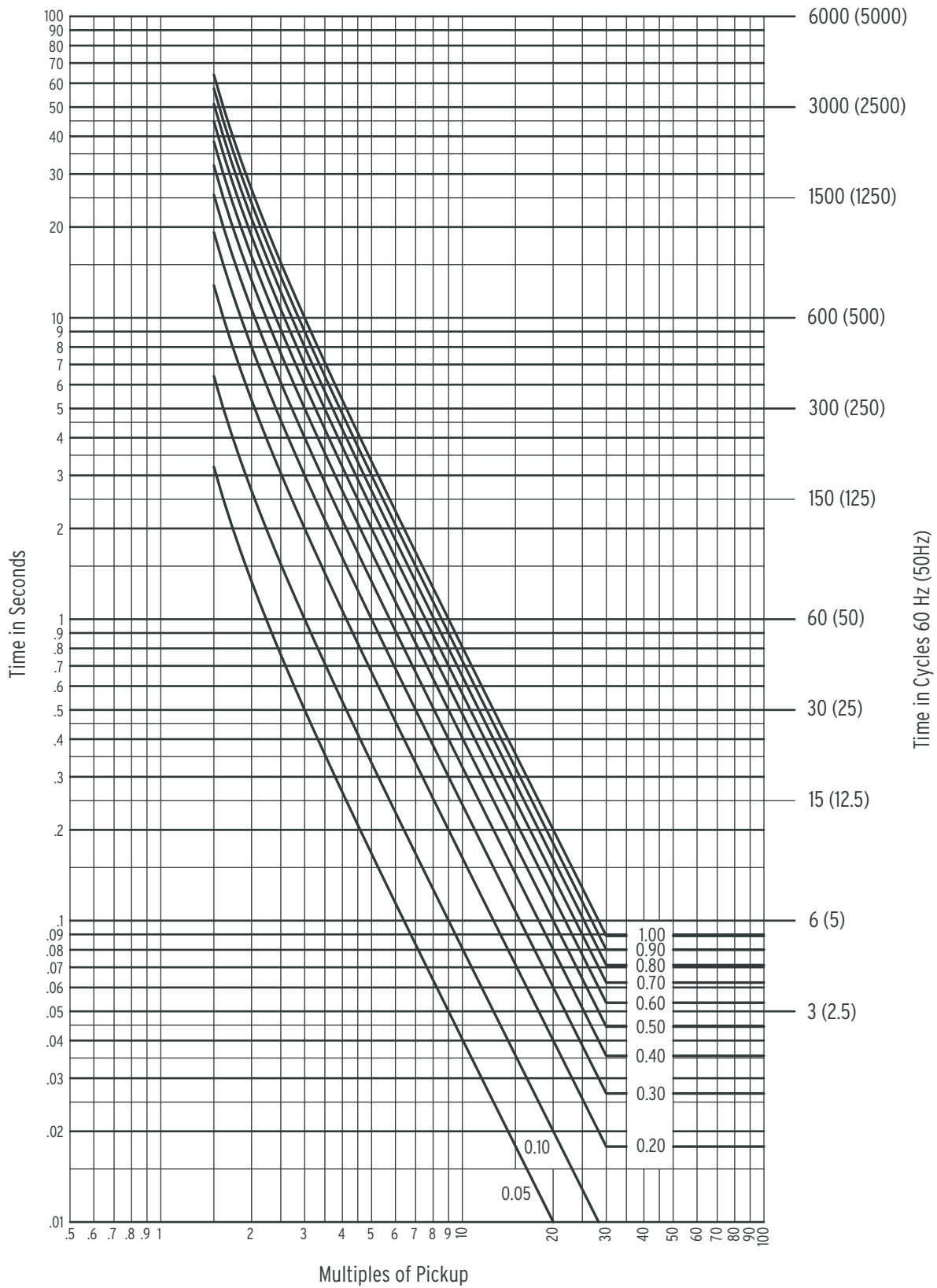


Figure 3.35 IEC Class C Curve (Extremely Inverse): C3

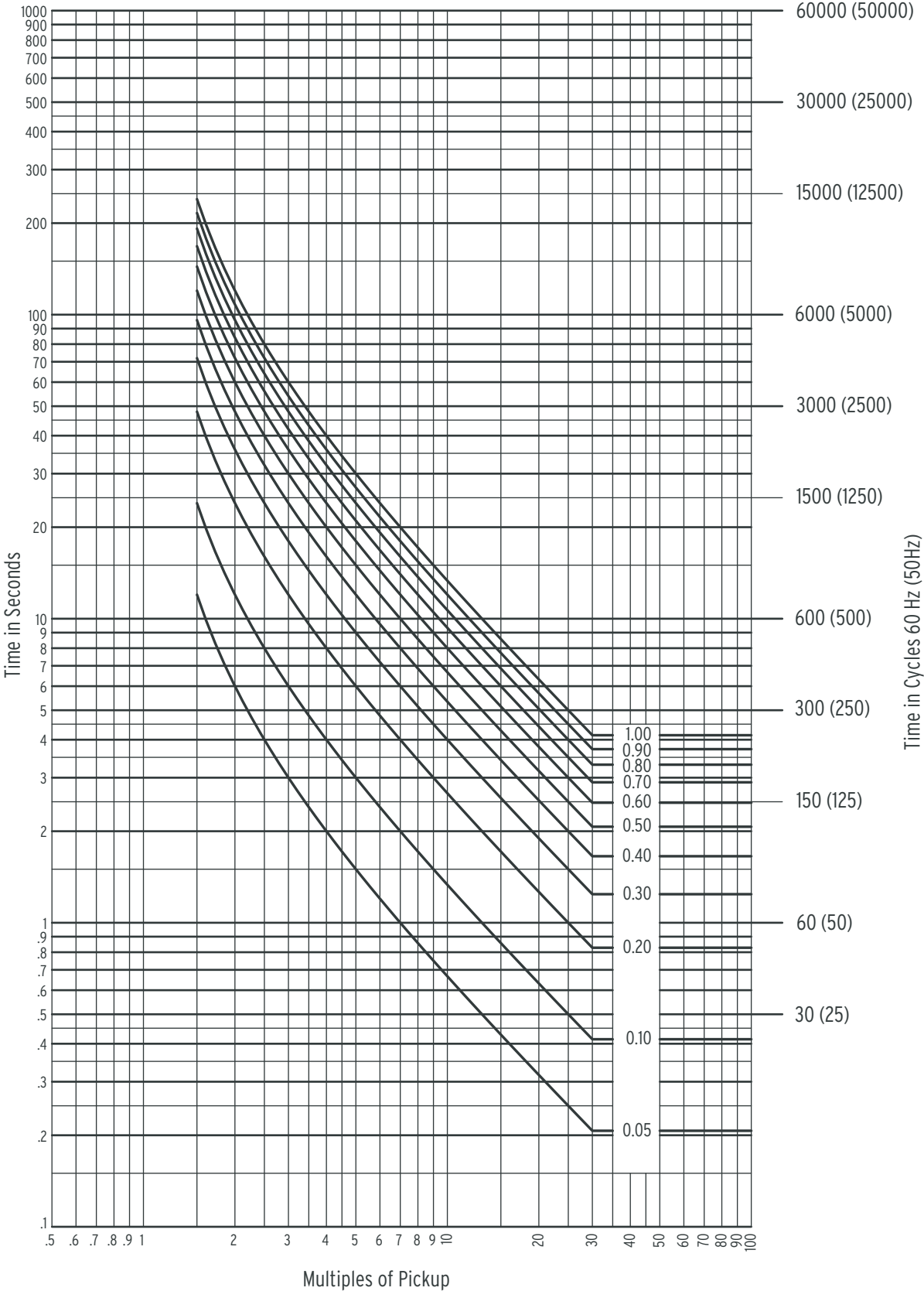


Figure 3.36 IEC Long-Time Inverse Curve: C4

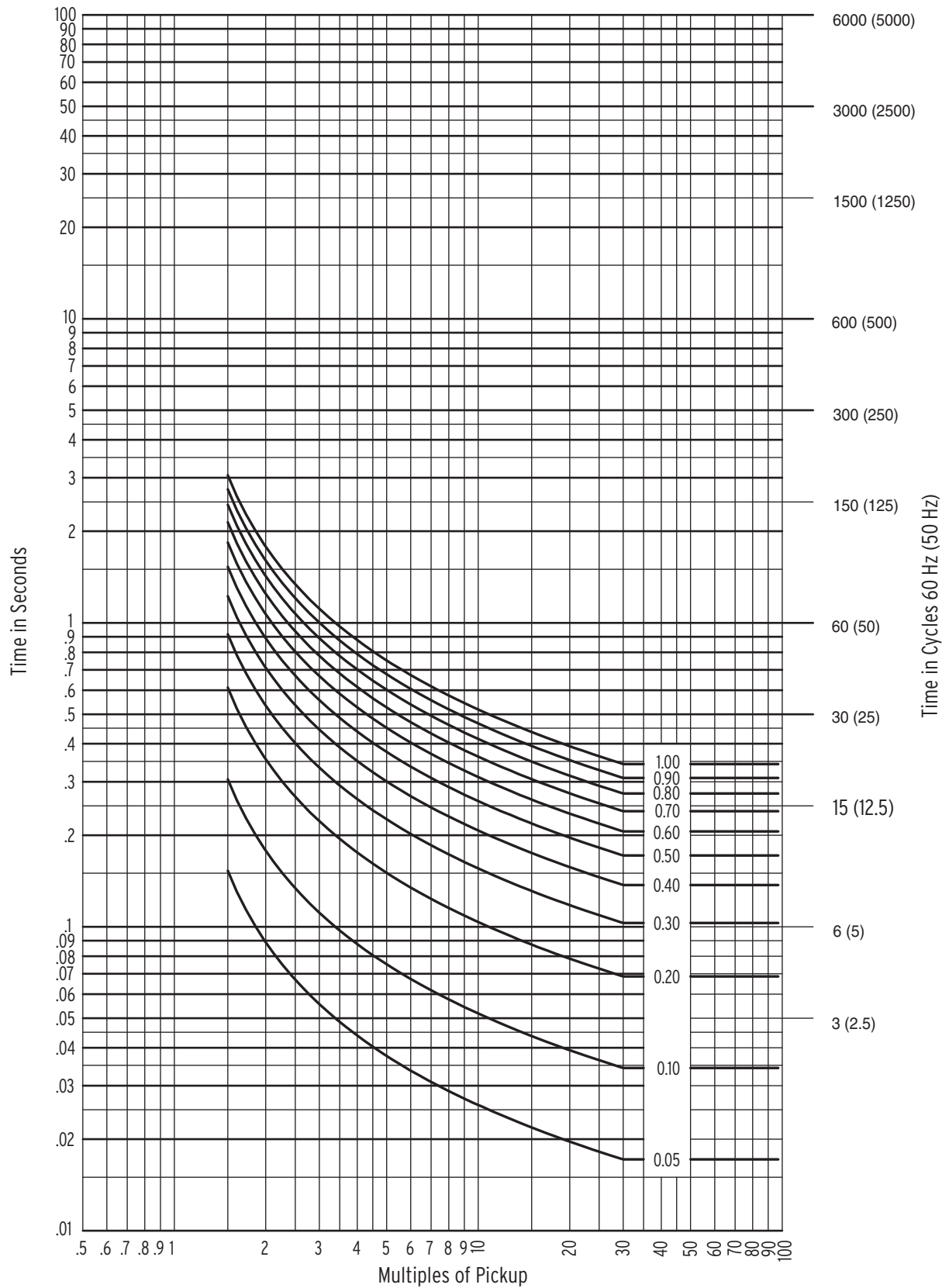


Figure 3.37 IEC Short-Time Inverse Curve: C5

Section 4

Control Logic

Overview

This section explains the settings and operation of the following:

- 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 the differential elements) have fixed internal logic, the availability of Relay Word bits and the use of SELOGIC control equations for many of the relay settings permit the user to customize how the protection functions interface with the user's control schemes and overall philosophy of operation.

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

Optoisolated Inputs

Relay Word bits IN101 through IN106, and IN201 through IN208 (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 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 that requires information on the open or closed status of Breaker 1 would use the IN101 Relay Word bit as this indication.

Local Control Switches (All But SEL-387-0 Relay)

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*).

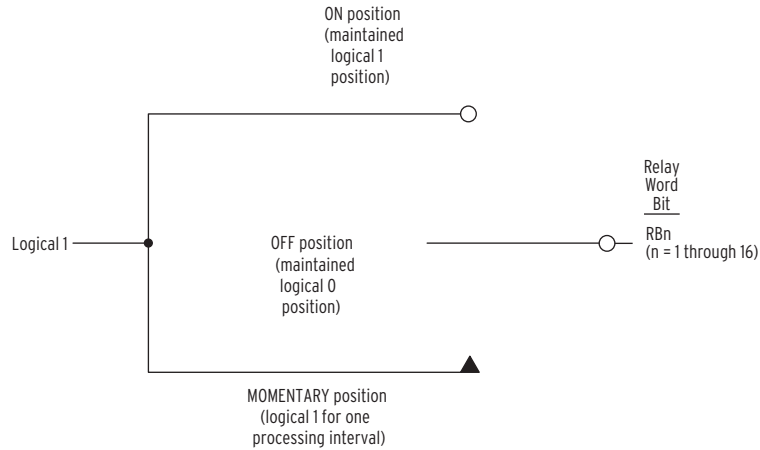


Figure 4.1 Remote Control Switches Drive Remote Bits RB1 Through RB16

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

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

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

Remote Bit Application

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

Remote Bit States Not Retained When Power Is Lost

The states of the remote bits (Relay Word bits RB1 through RB16) are not retained if power to the relay is lost and then restored. The remote control switches always come back in the OFF position (corresponding remote bit is deasserted to logical 0) when power is restored to the relay.

Remote Bit States Retained When Settings Changed or Active Setting Group Changed

The state of each remote bit (Relay Word bits RB1 through RB16) is retained if relay settings are changed (for the active setting group or one of the other setting groups) or the active setting group is changed. If a remote control switch is in the ON position (corresponding remote bit is asserted to logical 1) before a setting change or an active setting group change, it comes back in the ON position (corresponding remote bit is still asserted to logical 1) after the change.

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

Multiple Setting Groups

The relay has six (6) independent setting groups. Each group contains the following:

- Configuration Settings
- General Data
- Differential Elements
- Overcurrent Elements
- Miscellaneous Timers
- SELOGIC Control Equation Sets 1 through 3
- Trip Logic
- Close Logic
- Event Report Triggering
- Output Contact Logic

These settings can be viewed or changed via the **SHO *n*** and **SET *n*** commands. The settings for selecting which of the six groups is to be active is contained in the Global Settings area (**SHO G/SET G** commands).

Active Setting Group Indication

Only one setting group can be active at a time. Relay Word bits SG1 through SG6 indicate the active setting group.

For example, if Setting Group 4 is the active setting group, Relay Word bit SG4 asserts to logical 1 and the other Relay Word bits SG1, SG2, SG3, SG5, and SG6 are all deasserted to logical 0.

Selecting the Active Setting Group

The active setting group is selected with

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

SELOGIC control equation settings SS1 through SS6 have priority over the serial port **GROUP *n*** command and the front-panel **{GROUP}** pushbutton in selecting the active setting group. Within the SS1 through SS6 settings, the currently active group setting SS*n* has priority over the other group SS*n* 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 SS*n* (*n* = 1 to 6) is TRUE (logical state 1), the relay is instructed to go to, or remain in, Setting Group *n*.

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

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

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

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

With Setting Group 3 as the active setting group, setting SS3 has priority. If setting SS3 is asserted to logical 1, Setting Group 3 remains the active setting group, regardless of the activity of settings SS1, SS2, SS4, SS5, and SS6. With settings SS1 through SS6 all deasserted to logical 0, Setting Group 3 still remains the active setting group.

With Setting Group 3 as the active setting group, if setting SS3 is deasserted to logical 0 and one of the other settings (e.g., setting SS5) asserts to logical 1, the relay switches from Setting Group 3 as the active setting group to Setting Group 5 as the active setting group, after waiting for qualifying time setting TGR to expire:

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

In this example, TGR qualifies the assertion of setting SS5 before it can change the active setting group.

Operation of Serial Port GROUP Command and Front-Panel {GROUP} Pushbutton

SELOGIC control equation settings SS1 through SS6 have priority over the serial port **GROUP n** command and the front-panel {GROUP} pushbutton in selecting the active setting group. If any one of SS1 through SS6 asserts to logical 1, neither the serial port **GROUP n** command nor the front-panel {GROUP} pushbutton can be used to switch the active setting group. But if SS1 through SS6 all deassert to logical 0, the serial port **GROUP n** command or the front-panel {GROUP} pushbutton can be used to switch the active setting group.

See *Section 7: Serial Port Communications and Commands* for more information on the serial port **GROUP n** command. See *Section 8: Front-Panel Interface* for more information on the front-panel {GROUP} pushbutton.

Relay Disabled Momentarily During Active Setting Group Change

The relay is disabled for a **few seconds** while the relay is in the process of changing active setting groups. Relay elements, timers, and logic are reset, unless indicated otherwise in specific logic description (e.g., latch bit states are retained during an active setting group change).

Active Setting Group Switching Example

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

Table 4.2 Active Setting Group Switching Input Logic

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

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

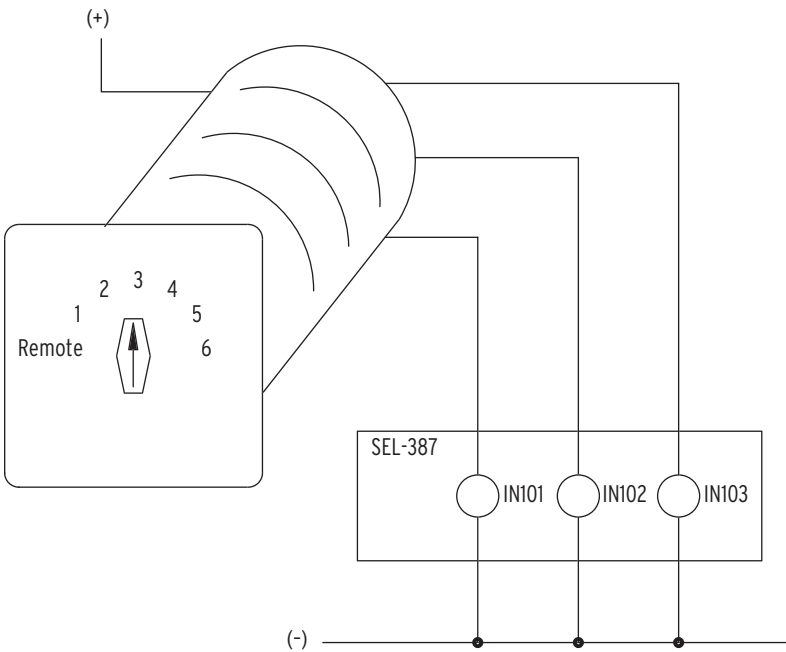


Figure 4.2 Rotating Selector Switch for Active Setting Group Selection

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 4.11* 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. Since SS1 (same group as the active group) is not asserted, the group change process is initiated, and CHSG is asserted at the same time as SS4. After the group change is made, SG1 will deassert and SG4 will assert, indicating the relay is now in group 4. When this agreement of SS4 and SG4 occurs, CHSG will deassert to indicate the relay is no longer in the process of changing groups.

When the active group bit 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, it may be desirable to immediately block some relay elements as soon as the change is needed to prevent misoperation. This could easily be done via the CHSG bit. CHSG could be used, for example, to supervise the tripping variable for differential trips. The default TR4 setting is $TR4 = 87R + 87U$; this could be changed to $TR4 = 87R * !CHSG + 87U * !CHSG$. CHSG optimizes (in this case minimizes) the amount of time to block TR4, since CHSG asserts exactly when the change of groups is needed, and deasserts exactly when the change has taken place.

Active Setting Group Retained for Power Loss, Settings Change

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.

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

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.

SELogic Control Equation Sets (1–3) Variables

Each setting group (1 through 6) has three sets of SELOGIC control equation variables for use in constructing SELOGIC control equations. In the SEL-387 these variables are of two types:

- Timed variables
- Latch bits

The variables are processed in the order in which they appear in the Setting Sheets. If variables that appear earlier are used as input to later variables, the processing of both will occur within the same processing interval. If a later variable is an input to an earlier variable, the scheme output will be delayed one processing interval.

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

There are timed variables and 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* and *Table 4.5*.

Table 4.4 SELogic Control Equation Variables (SEL-387-O Relay Only)

SELogic Control Equation Set	Timers	Latch Control Switches (Latch Bits)
1	4	4
2	4	4
3	8	0

Table 4.5 SELogic Control Equation Variables (All But SEL-387-O Relay)

SELogic Control Equation Set	Timers	Latch Control Switches (Latch Bits)
1	4	4
2	4	4
3	8	8

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

Timed Variable
Name: $SnVm$ (n = Set Number; m = Variable Number)

Timer Pickup
Delay: $SnVmPU$ (cycles)

Timer Dropout
Delay: $SnVmDO$ (cycles)

Set Latch Bit: $SnSLTm$

Reset Latch Bit: $SnRLTm$ (Reset takes precedence over Set)

Timers $SnVmPU$ and $SnVmDO$ have a setting range of about 4.63 hours:
0.00 through 999999.00 cycles in 0.125-cycle increments

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

Variables/Timers

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

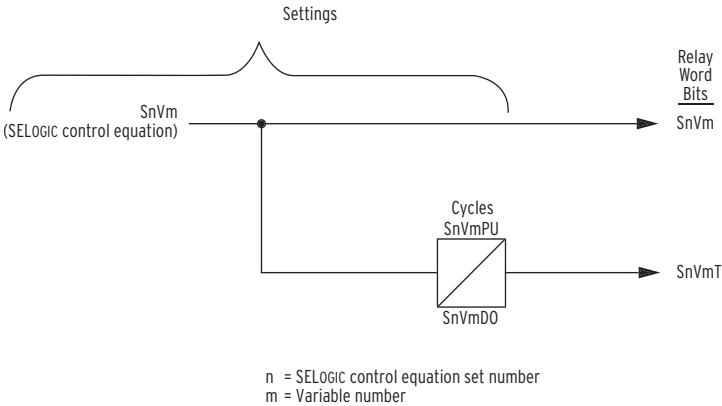


Figure 4.3 Timed Variables in SELogic Control Equation Sets

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

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

If power is lost to the relay, settings are changed (for the active setting group), or the active setting group is changed, the SELOGIC control equation variables/timers are reset. Relay Word bits $SnVm$ and $SnVmT$ are reset to logical 0 and corresponding timer settings $SnVmPU$ and $SnVmDO$ load up again after power restoration, settings change, or active setting group switch.

Latch Control Switches

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

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

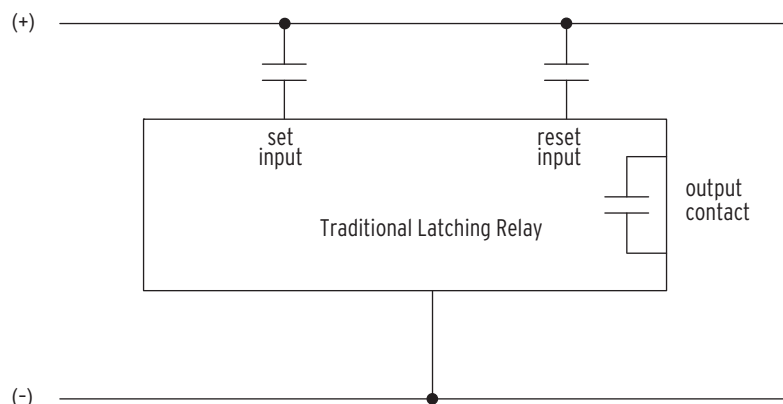


Figure 4.4 Traditional Latching Relay

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

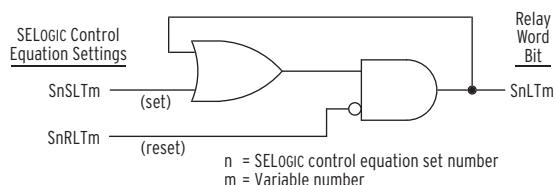


Figure 4.5 Latch Bits in SELogic Control Equation Sets

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 when the relay turns on.

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

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

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

NOTE: Make Latch Bit Settings With Care.

The latch bit states are stored in nonvolatile memory so they can be retained during power loss, settings change, or active setting group change. The nonvolatile memory is rated for a finite number of "writes" for all cumulative latch bit state changes. Exceeding the limit can result in an EEPROM self-test failure. An average of 70 latch bit changes per day can be made for a 25-year relay service life.

Output Contacts

SELOGIC control equation settings OUT101 through OUT107 and OUT201 through OUT212 control Relay Word bits having the same names. These Relay Word bits in turn control the output contacts **OUT101** through **OUT107** and **OUT201** through **OUT212** (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 and OUT201 through OUT212

The execution of the serial port command **PULSE xxx** ($xxx = \text{OUT101}–\text{OUT107}, \text{OUT201}–\text{OUT212}$), 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 OUT_m ($m = 101–107, 201–212$) to logical 1 also asserts the corresponding Relay Word bit OUT_m to logical 1.

The assertion of Relay Word bit OUT_m to logical 1 causes the energization of the corresponding output contact OUT_m coil. Depending on the contact type (a or b), the output contact closes or opens. An a type output contact is open when the output contact coil is 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 OUT_m contact to either an a or b type. **OUT101** through **OUT107** are factory-configured as type a, as are **OUT201** through **OUT212** if the additional interface board is ordered.

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

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

ALARM Output Contact

NOTE: In the SEL-387-5 and SEL-387-6 Relays with firmware revisions prior to R600, the NOTALM Relay Word bit is !ALARM.

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 NOTALM**. Execution of this command momentarily de-energizes the **ALARM** output contact coil.

The Relay Word bit NOTALM is asserted to logical 1, and the **ALARM** output contact coil is energized, when the SEL-387 is operating correctly. When the serial port command **PULSE NOTALM** (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 falls closed. The **ALARM** contact also drops closed when a loss of power occurs.

Rotating Default Display

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

LED Targeting Logic

The SEL-387 has 16 LEDs on the front panel. One (EN) is dedicated to indication of the relay 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*.

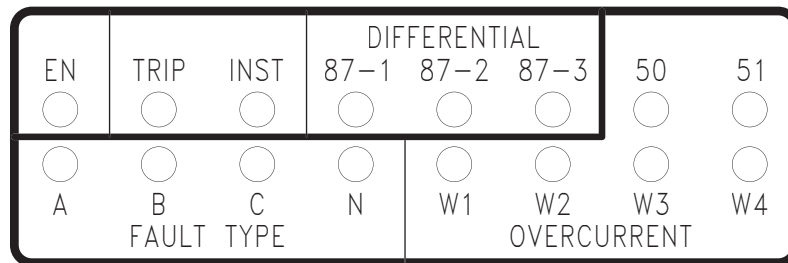


Figure 4.6 SEL-387 Front-Panel LEDs

Table 4.6 describes the basic targeting functions associated with each of the 16 LEDs.

Table 4.6 LED Assignments (Sheet 1 of 2)

LED	Legend	Description
1	EN	Relay enabled
2	TRIP ^a	Relay trip
3	INST ^a	Instantaneous trip
4	87-1 ^a	Differential element 1 asserted at, or 1 cycle after, rising edge of trip
5	87-2 ^a	Differential element 2 asserted at, or 1 cycle after, rising edge of trip
6	87-3 ^a	Differential element 3 asserted at, or 1 cycle after, rising edge of trip
7	50 ^a	Instantaneous O/C element asserted at, or 1 cycle after, rising edge of trip
8	51 ^a	Time O/C element asserted at, or 1 cycle after, rising edge of trip
9	A	A-phase involved in the fault (Programmable LEDA)
10	B	B-phase involved in the fault (Programmable LEDB)
11	C	C-phase involved in the fault (Programmable LEDC)

Table 4.6 LED Assignments (Sheet 2 of 2)

LED	Legend	Description
12	N ^a	Residual element asserted at, or 1 cycle after, rising edge of trip
13	W1 ^a	Winding 1 overcurrent asserted at, or 1 cycle after, rising edge of trip
14	W2 ^a	Winding 2 overcurrent asserted at, or 1 cycle after, rising edge of trip
15	W3 ^a	Winding 3 overcurrent asserted at, or 1 cycle after, rising edge of trip
16	W4 ^a	Winding 4 overcurrent asserted at, or 1 cycle after, rising edge of trip

^a Indicates nonvolatile targets.

The operation of each LED is discussed in the following paragraphs.

LED 1–EN– Relay Enabled

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

LED 2–TRIP– Relay Trip

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

LED 3–INST– Instantaneous Trip

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

LED 4–87-1– Differential Element 1

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

LED 5–87-2– Differential Element 2

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

LED 6–87-3– Differential Element 3

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

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

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

**LED 8–51–Inverse-
Time Overcurrent
Element Trip**

This LED will illuminate if any inverse-time overcurrent element present in the TR1 through TR5 settings has timed out and is asserted at the rising edge of the trip or one cycle later. Applicable elements include any of the overcurrent elements indicated by Relay Word bits “51**(*)T,” which include the four combined overcurrent elements, as well as the REFP bit indicating time-out of the Restricted Earth Fault inverse-time curve. LED 8 remains illuminated 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 illuminated, 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—87-1—Differential Element 1 on page 4.14*).

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

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

Relay Word bit OCB indicates B-phase overcurrent during the fault. It is derived by first checking which winding “Wn” LED is illuminated, 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—87-2—Differential Element 2 on page 4.14*).

**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 illuminated, 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—87-3—Differential Element 3 on page 4.14*).

LED 12—N—Residual Overcurrent Element Trip

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

LED 13—W1—Winding 1 Overcurrent Element Operation

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

LED 14—W2—Winding 2 Overcurrent Element Operation

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

LED 15—W3—Winding 3 Overcurrent Element Operation

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

LED 16—W4—Winding 4 Overcurrent Element Operation

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

Trip and Close Logic

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

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

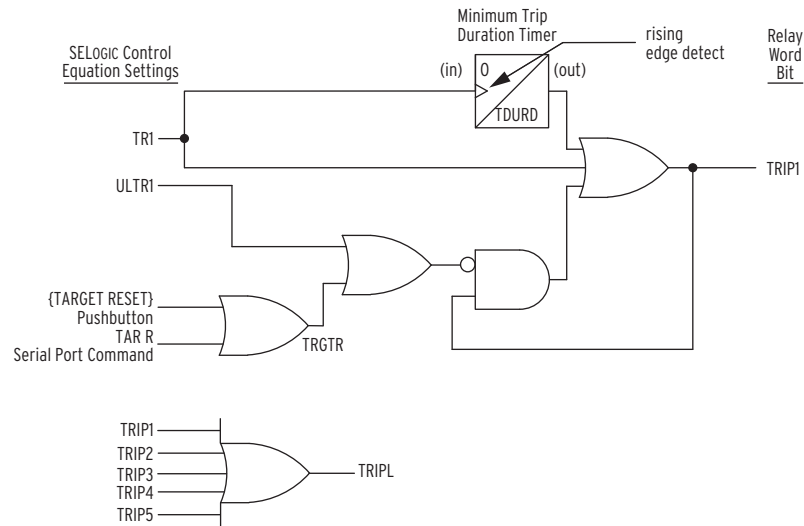


Figure 4.7 SEL-387 Trip Logic (TRIP1)

The logic begins with the assertion of SELOGIC control equation TR_1 , 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 TR_1 . TR_1 directly asserts $TRIP_1$ via the three-input OR gate at the right.

However, TR_1 may only assert briefly while a more lengthy assertion of $TRIP_1$ is needed. There are two means to ensure a longer $TRIP_1$ assertion. At the top of the diagram is an Edge Trigger Timer. It detects the rising edge of TR_1 , 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 TR_1 input to the timer is ignored. Thus, $TRIP_1$ will be asserted for a minimum of $TDURD$ cycles, even if TR_1 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.

$TRIP_1$ also seals itself in via the AND gate at the bottom. This AND gate receives the negated inputs from the unlatching functions. As long as no unlatch function is asserted, the seal of $TRIP_1$ remains intact. $TRIP_1$ is used to drive an output contact to initiate tripping of the breaker or breakers. In our example, $OUT101 = TRIP_1$.

The unlatching of the trip logic is accomplished via three means. The first is the assertion of the SELOGIC control equation setting $ULTR_1$. In our example, $ULTR_1 = !50P13 = \text{NOT } 50P13$. This current element is set to pick up at 0.5 A. Thus, $ULTR_1$ 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, de-energizing the trip circuit. Presumably, the trip circuit current has already been interrupted by a breaker 52a contact in series with the trip coil. Should a failure to trip occur, followed by backup tripping of other breakers, the TR1 setting may deassert and the ULTR1 setting may assert, while the contact continues to carry dc trip circuit current. This could damage the contact as it tries to interrupt this current. The emergency nature of the situation might warrant this minor risk, but another choice might be to program into the ULTR1 setting not only removal of current but also indication that the breaker has opened.

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

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

Close Logic

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

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

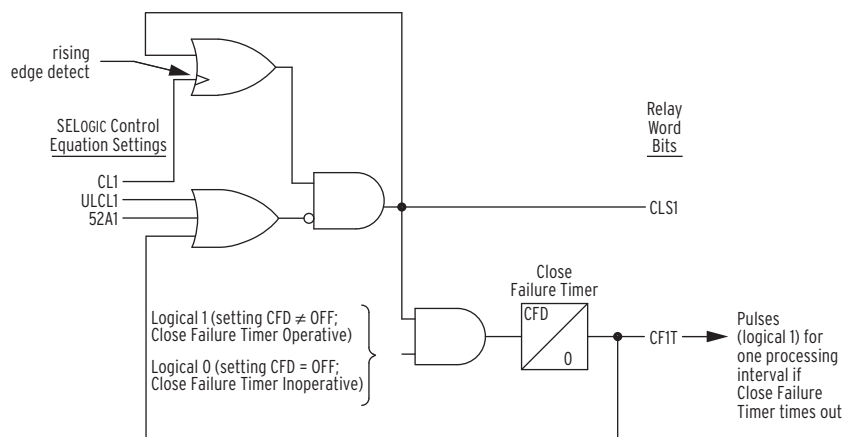


Figure 4.8 SEL-387 Close Logic (CLS1)

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 that 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, it effectively will be ignored, and **CLS1** will not assert. If **CL1** has asserted before **ULCL1** and the closing process has begun, assertion of **ULCL1** will unseal **CLS1** and interrupt the process. In our example, **ULCL1** = **TRIP1** + **TRIP4**. That is, if a Winding 1 overcurrent trip, or a high-speed differential trip has been initiated, **ULCL1** will prevent the close process from starting, or it will prevent it from going to completion if it has already begun.

Under normal circumstances, the second means of unlatching occurs. This is the closure of the Breaker 1 52a contact. The close logic setting **52A1** = **IN101**. When **CLS1** asserts, **OUT105** closes and the breaker begins to close. When the breaker closing is complete, the 52a contact closes, duplicating the operation of the breaker contacts themselves, and effectively indicating that the breaker is closed. The 52a contact is wired to **IN101**. When **IN101** asserts, the equation **52A1** asserts and unlatches the close logic, deasserting **CLS1** and opening **OUT105**. The close process is now complete. (Presumably, interruption of the current in the closing circuit has been accomplished via a breaker 52b contact, and not by **OUT105**.)

The third means of unlatching is a Close Failure Detection. This function can be set OFF if necessary. This function is useful in the event the breaker does not close in response to energization of the closing circuit. This might be the result of 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. It is sent to the OR gate for the unlatch functions and interrupts the closing process. This prevents the closing circuit from being energized too long. It also creates the possibility that the **OUT105** contact may be damaged by interrupting the closing circuit current flow. However, the emergency nature of the situation generally would be worth the risk. The **CF1T** bit might also be used to set a SELOGIC control equation Latch Bit to close a contact, informing a SCADA system of the aborted closure attempt.

SELogic Control Equations

SELogic Control Equations Fundamental Description

SELogic Control Equation Logical Operators

Throughout this manual, reference is made to settings or variables that take the form of SELOGIC control equations. It is a convenient method for providing customized control logic to the relay, to enhance the relay performance for specific customer needs and practices.

While most users of SEL relays are at least somewhat familiar with SELOGIC control equations in a general sense, the capabilities of this logic, the types of logical operators, the number of allowable variables, and the construction rules of the equations have varied from one relay product to another. This portion of the manual is intended to inform the user of how SELOGIC control equations work in general and how they are implemented in the SEL-387.

The basic building blocks of SELOGIC control equations are the Relay Word bits. A complete list of these bits is included at the end of this section of the manual. The Relay Word bits are simple digital quantities having a logical value of either 0 or 1. The terms “assert” or “asserted” refer to a Relay Word bit that has a value of 1 or is changing from 0 to 1. The terms “deassert” or “deasserted” refer to a Relay Word bit that has a value of 0 or is changing from 1 to 0. Relay Word bits are asserted or deasserted by various elements within the relay, and are used in the fixed internal logic of the relay to make decisions, to interpret inputs, or to drive outputs. These same bits are made available to the user, so that the user can exercise flexibility in defining inputs or outputs, specifying control variables for internal logic, or for creating special customized logic through the use of SELOGIC control equations.

SELOGIC control equations use logic similar to Boolean algebra logic. A SELOGIC control equation consists of some combination of Relay Word bits and logical operators that define how the Relay Word bits are to be evaluated as a group or individually. The Relay Word bits take on their values of 0 or 1, the operators perform logical operations on these values, and the result is a logical value of 0 or 1 for the SELOGIC control equation itself. Thus, expressions of assertion or deassertion apply to the SELOGIC control equation as a whole, as well as to the individual components of the equation. In the end, the SELOGIC control equation itself is a simple digital variable having a value of 0 or 1.

In the SEL-387, 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 4.7* lists these operators in order of processing.

Table 4.7 SELogic Control Equation Operators

Operator	Logic Function
()	parentheses
!	NOT (negation)
/	rising-edge detect
\	falling-edge detect
*	AND
+	OR

Parentheses Operator ()

More than one set of parentheses can be used in a SELOGIC control equation. However, parentheses cannot be “nested,” that is you cannot have parentheses within parentheses. The following is an example:

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

The expressions within the parentheses are evaluated first. First, is IN105 OR RB3 asserted; next, is 87R OR 87U asserted. Assuming that at least one bit is asserted in each parentheses, the equation can now be evaluated:

$$S1V1 = 1 * 1 = 1$$

The equation for S1V1 is thus asserted.

NOT Operator !

The ! operator performs a simple negation or inversion. On logic diagrams, it is represented by a small circle on an input or output line. Whatever the state of the logical quantity to which it is applied, it simply reverses that state. For example, if 87R is a logical 1, then !87R is a logical 0. The ! operator can be applied to a parentheses containing several elements. The expression within the parentheses is evaluated first then the result is negated.

Rising-Edge and Falling-Edge Operators / and \

These operators can be applied to individual Relay Word bits only. They cannot be used on groups in parentheses or on negated elements. They are not interested in the present value of that bit, as are most operators. Rather, they are only intended to detect a **change** of that value. The rising-edge operator “/” detects a change from a 0 state to a 1 state. The falling-edge operator “\” detects a change from a 1 state to a 0 state. Typical applications might include triggering an event report or unlatching internal logic. These two operators assert a 1 for a single processing interval, when they sense the change of state.

AND and OR Operators * and +

These operators produce an output state that combines the states of two or more inputs. The AND operator requires that every one of the inputs is a logical 1 before it issues a logical 1 output. For example, in the equation

$$S1V1 = 87R * IN103, S1V1 \text{ will only assert if } 87R = 1 \text{ and } IN103 = 1$$

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 $TRIPL = TRIP1 + TRIP2 + TRIP3 + TRIP4 + TRIP5$. All TRIPL needs to assert is a 1 from any of the five ORed inputs. Thus, it is useful for indicating that “any trip” has occurred.

Ways of Setting SELogic Control Equation Relay Settings

Many of the Group and Global settings are defined as being SELOGIC control equations. A typical example would be the torque-control variables for the various overcurrent elements. For example, let us look at the setting 51P1TC for torque controlling the Winding 1 phase inverse-time overcurrent element.

We could set 51P1TC to a single Relay Word bit. For example, $51P1TC = IN105$. This might be used for torque controlling by a contact input from some external device like a directional relay.

Limitations of SELOGIC Control Equations

We could set 51P1TC to some combination of Relay Word bits. For example, $51P1TC = IN105 * !IN106$. Here, we might want 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.

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 4.7*. 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 .

SELOGIC control equation settings in the Group Setting Class and Global Setting Class can contain no more Relay Word bits, equations, or falling- and rising-edge operators than the maximums shown in *Table 4.8*.

An attempt to set the relay with more than 17 operands will cause the relay to display the message `Maximum of 17 elements allowed in a SELOGIC equation` and prompt you to reenter the equation. Exceeding the maximum settings for each setting class will cause the relay to display the message `Overall SELOGIC setting size too large. Try simplifying equations.` The relay will then prompt you to edit the first unhidden SELOGIC control equation.

SELOGIC control equation settings that are set directly to 1 (logical 1) or 0 (logical 0) also have to be included in these limitations—each such setting counts as one element.

After SELOGIC control equation settings have been made and the settings are saved, the SEL-387 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 GR n CHK) is yyyy. The relay provides use and checksum results for the GLOBAL and GROUP n settings.

Table 4.8 Maximums for SELogic Control Equations

	Group Setting Class	Global Setting Class
Relay Word bits per Equation	17	17
Relay Word bits per Setting Class	462	81
Equations per Setting Class (with two 16-output interface boards)	154	29
Rising- or Falling-Edge Operators per Setting Class	77	14

Relay Word Bits

The available Relay Word bits that can be used in SELOGIC control equations (except Row 0 or Row 1 target elements) are listed below in *Table 4.9* through *Table 4.11*. *Table 4.9* shows the names and locations in each row. The row number or bit name can be used when using the **TAR** command. *Table 4.10* lists the Relay Word bit definitions, in their row order. *Table 4.11* lists the Relay Word bits alphabetically to provide an easier method for looking for a specific bit.

Table 4.9 SEL-387 Relay Word Bits and Locations (Sheet 1 of 2)

Row	SEL-387 Relay Word Bits							
0	EN	TRIP	INST	87-1	87-2	87-3	50	51
1	A	B	C	N	W1	W2	W3	W4
2	50P11	50P11T	50P12	51P1	51P1T	51P1R	PDEM1	OCA
3	50A13	50B13	50C13	50P13	50A14	50B14	50C14	50P14
4	50N11	50N11T	50N12	51N1	51N1T	51N1R	NDEM1	OC1
5	50Q11	50Q11T	50Q12	51Q1	51Q1T	51Q1R	QDEM1	CC1
6	50P21	50P21T	50P22	51P2	51P2T	51P2R	PDEM2	OCB
7	50A23	50B23	50C23	50P23	50A24	50B24	50C24	50P24
8	50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
9	50Q21	50Q21T	50Q22	51Q2	51Q2T	51Q2R	QDEM2	CC2
10	50P31	50P31T	50P32	51P3	51P3T	51P3R	PDEM3	OCC
11	50A33	50B33	50C33	50P33	50A34	50B34	50C34	50P34
12	50N31	50N31T	50N32	51N3	51N3T	51N3R	NDEM3	OC3
13	50Q31	50Q31T	50Q32	51Q3	51Q3T	51Q3R	QDEM3	CC3
14	50P41	50P41T	50P42	51P4	51P4T	51P4R	PDEM4	CTS ^a
15	50A43	50B43	50C43	50P43	50A44	50B44	50C44	50P44
16	50N41	50N41T	50N42	51N4	51N4T	51N4R	NDEM4	OC4
17	50Q41	50Q41T	50Q42	51Q4	51Q4T	51Q4R	QDEM4	CC4
18	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R
19	2HB1	2HB2	2HB3	5HB1	5HB2	5HB3	TH5	TH5T
20	87BL1	87BL2	87BL3	87BL	87E1	87E2	87E3	32IE
21	87O1	87O2	87O3	50GC	50G4	32IR	32IF	REFP
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2

Table 4.9 SEL-387 Relay Word Bits and Locations (Sheet 2 of 2)

Row	SEL-387 Relay Word Bits							
23	51PC2	51PC2T	51PC2R	51NC2	51NC2T	51NC2R	DC3	DC4
24	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
25	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16
26	SG1	SG2	SG3	SG4	SG5	SG6	CHSG	COMFLG ^b
27	4HBL ^c	DCBL ^c	IN106	IN105	IN104	IN103	IN102	IN101
28	IN208	IN207	IN206	IN205	IN204	IN203	IN202	IN201
29	*d	*d	*d	*d	*d	*d	*d	*d
30	*d	*d	*d	*d	*d	*d	*d	*d
31	*d	*d	*d	*d	*d	*d	*d	*d
32	S1V1	S1V2	S1V3	S1V4	S1V1T	S1V2T	S1V3T	S1V4T
33	S2V1	S2V2	S2V3	S2V4	S2V1T	S2V2T	S2V3T	S2V4T
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 ^c	S3LT2 ^c	S3LT3 ^c	S3LT4 ^c	S3LT5 ^c	S3LT6 ^c	S3LT7 ^c	S3LT8 ^c
38	TLL ^b	RLL ^b	FAA1 ^b	FAA2 ^b	TO1 ^b	TO2 ^b	HS1 ^b	HS2 ^b
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2
40	BCWA3	BCWB3	BCWC3	BCW3	BCWA4	BCWB4	BCWC4	BCW4
41	TRIP1	TRIP2	TRIP3	TRIP4	TRIP5	TRIPL	CSE ^c	TRGTR
42	CLS1	CLS2	CLS3	CLS4	CF1T	CF2T	CF3T	CF4T
43	NOTALM ^e	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	*d	*d	*d	*d	*d	*d	*d	*d
47	*d	*d	*d	*d	*d	*d	*d	*d
48	LB1 ^c	LB2 ^c	LB3 ^c	LB4 ^c	LB5 ^c	LB6 ^c	LB7 ^c	LB8 ^c
49	LB9 ^c	LB10 ^c	LB11 ^c	LB12 ^c	LB13 ^c	LB14 ^c	LB15 ^c	LB16 ^c
50	*d	*d	*d	*d	*d	*d	*d	*d
53	49A01A	49T01A	49A02A	49T02A	49A03A	49T03A	49A04A	49T04A
54	49A05A	49T05A	49A06A	49T06A	49A07A	49T07A	49A08A	49T08A
55	49A09A	49T09A	49A10A	49T10A	49A11A	49T11A	49A12A	49T12A
56	49A01B	49T01B	49A02B	49T02B	49A03B	49T03B	49A04B	49T04B
57	49A05B	49T05B	49A06B	49T06B	49A07B	49T07B	49A08B	49T08B
58	49A09B	49T09B	49A10B	49T10B	49A11B	49T11B	49A12B	49T12B
59	COMFLA	RTDINA	COMFLB	RTDINB	*d	*d	*d	ISQTAL

^a Not available in SEL-387-0 Relays prior to firmware version R602.

^b SEL-387-6 only.

^c SEL-387-5 and SEL-387-6 Relays only.

^d * Reserved for future use.

^e !ALARM in the SEL-387-5 and SEL-387-6 Relays for firmware versions prior to R600.

Table 4.10 Relay Word Bit Definitions (Sheet 1 of 12)

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
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

Table 4.10 Relay Word Bit Definitions (Sheet 2 of 12)

Row	Bit	Definition
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
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

Table 4.10 Relay Word Bit Definitions (Sheet 3 of 12)

Row	Bit	Definition
11	50A33	Winding 3 A-phase instantaneous O/C Level 3 element picked up
	50B33	Winding 3 B-phase instantaneous O/C Level 3 element picked up
	50C33	Winding 3 C-phase instantaneous O/C Level 3 element picked up
	50P33	50A33 + 50B33 + 50C33
	50A34	Winding 3 A-phase instantaneous O/C Level 4 element picked up
	50B34	Winding 3 B-phase instantaneous O/C Level 4 element picked up
	50C34	Winding 3 C-phase instantaneous O/C Level 4 element picked up
	50P34	50A34 + 50B34 + 50C34
12	50N31	Winding 3 residual definite-time O/C Level 1 element picked up
	50N31T	Winding 3 residual definite-time O/C Level 1 element timed out
	50N32	Winding 3 residual instantaneous O/C Level 2 element picked up
	51N3	Winding 3 residual inverse-time O/C element picked up
	51N3T	Winding 3 residual inverse-time O/C element timed out
	51N3R	Winding 3 residual inverse-time O/C 51N3 element is reset
	NDEM3	Winding 3 residual demand current threshold exceeded
	OC3	Breaker 3 OPEN command execution
13	50Q31	Winding 3 neg.-seq. definite-time O/C Level 1 element picked up
	50Q31T	Winding 3 neg.-seq. definite-time O/C Level 1 element timed out
	50Q32	Winding 3 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q3	Winding 3 neg.-seq. inverse-time O/C element picked up
	51Q3T	Winding 3 neg.-seq. inverse-time O/C element timed out
	51Q3R	Winding 3 neg.-seq. inverse-time O/C 51Q3 element is reset
	QDEM3	Winding 3 neg.-seq. demand current threshold exceeded
	CC3	Breaker 3 CLOSE command execution
14	50P41	Winding 4 phase definite-time O/C Level 1 element picked up
	50P41T	Winding 4 phase definite-time O/C Level 1 element timed out
	50P42	Winding 4 phase instantaneous O/C Level 2 element picked up
	51P4	Winding 4 phase inverse-time O/C element picked up
	51P4T	Winding 4 phase inverse-time O/C element timed out
	51P4R	Winding 4 phase inverse-time O/C 51P4 element is reset
	PDEM4	Winding 4 phase demand current threshold exceeded
	CTS	Current transformer saturation (not available in the SEL-387-0 Relay prior to firmware version R602)
15	50A43	Winding 4 A-phase instantaneous O/C Level 3 element picked up
	50B43	Winding 4 B-phase instantaneous O/C Level 3 element picked up
	50C43	Winding 4 C-phase instantaneous O/C Level 3 element picked up
	50P43	50A43 + 50B43 + 50C43
	50A44	Winding 4 A-phase instantaneous O/C Level 4 element picked up
	50B44	Winding 4 B-phase instantaneous O/C Level 4 element picked up
	50C44	Winding 4 C-phase instantaneous O/C Level 4 element picked up
	50P44	50A44 + 50B44 + 50C44

Table 4.10 Relay Word Bit Definitions (Sheet 4 of 12)

Row	Bit	Definition
16	50N41	Winding 4 residual definite-time O/C Level 1 element picked up
	50N41T	Winding 4 residual definite-time O/C Level 1 element timed out
	50N42	Winding 4 residual instantaneous O/C Level 2 element picked up
	51N4	Winding 4 residual inverse-time O/C element picked up
	51N4T	Winding 4 residual inverse-time O/C element timed out
	51N4R	Winding 4 residual inverse-time O/C 51N4 element is reset
	NDEM4	Winding 4 residual demand current threshold exceeded
	OC4	Breaker 4 OPEN command execution
17	50Q41	Winding 4 neg.-seq. definite-time O/C element picked up
	50Q41T	Winding 4 neg.-seq. definite-time O/C element timed out
	50Q42	Winding 4 neg.-seq. instantaneous O/C Level 2 element picked up
	51Q4	Winding 4 neg.-seq. inverse-time O/C element picked up
	51Q4T	Winding 4 neg.-seq. inverse-time O/C element timed out
	51Q4R	Winding 4 neg.-seq. inverse-time O/C 51Q4 element is reset
	QDEM4	Winding 4 neg.-seq. demand current threshold exceeded
	CC4	Breaker 4 CLOSE command execution
18	87U1	Unrestrained differential element 1 picked up
	87U2	Unrestrained differential element 2 picked up
	87U3	Unrestrained differential element 3 picked up
	87U	Unrestrained differential element picked up
	87R1	Restrained differential element 1 picked up
	87R2	Restrained differential element 2 picked up
	87R3	Restrained differential element 3 picked up
	87R	Restrained differential element picked up
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

Table 4.10 Relay Word Bit Definitions (Sheet 5 of 12)

Row	Bit	Definition
21	87O1	Restrained differential element 1 operating current above O87P
	87O2	Restrained differential element 2 operating current above O87P
	87O3	Restrained differential element 3 operating current above O87P
	50GC	Combined residual current sensitivity threshold exceeded
	50G4	W4 residual current sensitivity threshold exceeded
	32IR	32I element reverse (external) fault declaration
	32IF	32I element forward (internal) fault declaration
22	REFP	Restricted Earth Fault inverse-time O/C element timed out
	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
23	DC2	DC battery voltage level 2 exceeded
	51PC2	Windings 3 and 4 phase inverse-time O/C element picked up
	51PC2T	Windings 3 and 4 phase inverse-time O/C element timed out
	51PC2R	Windings 3 and 4 phase inverse-time O/C element is reset
	51NC2	Windings 3 and 4 residual inverse-time O/C element picked up
	51NC2T	Windings 3 and 4 residual inverse-time O/C element timed out
	51NC2R	Windings 3 and 4 residual inverse-time O/C element is reset
	DC3	DC battery voltage level 3 exceeded
24	DC4	DC battery voltage level 4 exceeded
	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
25	RB8	Remote bit RB8 asserted
	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
26	RB16	Remote bit RB16 asserted

Table 4.10 Relay Word Bit Definitions (Sheet 6 of 12)

Row	Bit	Definition
26	SG1	Setting Group 1 is the active setting group
	SG2	Setting Group 2 is the active setting group
	SG3	Setting Group 3 is the active setting group
	SG4	Setting Group 4 is the active setting group
	SG5	Setting Group 5 is the active setting group
	SG6	Setting Group 6 is the active setting group
	CHSG	Timing to change setting groups
	COMFLG	Asserted when communications fail or when out-of-range temperature data are received on the serial port used to obtain temperature data (SEL-387-6 Relay only)
27	4HBL	Fourth-harmonic block asserted (all but SEL-387-0 Relay)
	DCBL	DC block asserted (all but SEL-387-0 Relay)
	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	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved

Table 4.10 Relay Word Bit Definitions (Sheet 7 of 12)

Row	Bit	Definition
31	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
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

Table 4.10 Relay Word Bit Definitions (Sheet 8 of 12)

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 (all but SEL-387-0 Relay)
	S3LT2	Set 3 latch bit S3LT2 asserted (all but SEL-387-0 Relay)
	S3LT3	Set 3 latch bit S3LT3 asserted (all but SEL-387-0 Relay)
	S3LT4	Set 3 latch bit S3LT4 asserted (all but SEL-387-0 Relay)
	S3LT5	Set 3 latch bit S3LT5 asserted (all but SEL-387-0 Relay)
	S3LT6	Set 3 latch bit S3LT6 asserted (all but SEL-387-0 Relay)
	S3LT7	Set 3 latch bit S3LT7 asserted (all but SEL-387-0 Relay)
	S3LT8	Set 3 latch bit S3LT8 asserted (all but SEL-387-0 Relay)
38	TLL	Total accumulated loss-of-life alarm asserted (SEL-387-6 Relay only)
	RLL	Daily rate of loss-of-life alarm asserted (SEL-387-6 Relay only)
	FAA1	Insulation aging acceleration factor alarm level 1 asserted (SEL-387-6 Relay only)
	FAA2	Insulation aging acceleration factor alarm level 2 asserted (SEL-387-6 Relay only)
	TO1	Top-oil temperature alarm level 1 asserted (SEL-387-6 Relay only)
	TO2	Top-oil temperature alarm level 2 asserted (SEL-387-6 Relay only)
	HS1	Hot-spot temperature alarm level 1 asserted (SEL-387-6 Relay only)
	HS2	Hot-spot temperature alarm level 2 asserted (SEL-387-6 Relay only)

Table 4.10 Relay Word Bit Definitions (Sheet 9 of 12)

Row	Bit	Definition
39	BCWA1	A-phase Breaker 1 contact wear threshold exceeded
	BCWB1	B-phase Breaker 1 contact wear threshold exceeded
	BCWC1	C-phase Breaker 1 contact wear threshold exceeded
	BCW1	BCWA1 + BCWB1 + BCWC1
	BCWA2	A-phase Breaker 2 contact wear threshold exceeded
	BCWB2	B-phase Breaker 2 contact wear threshold exceeded
	BCWC2	C-phase Breaker 2 contact wear threshold exceeded
	BCW2	BCWA2 + BCWB2 + BCWC2
40	BCWA3	A-phase Breaker 3 contact wear threshold exceeded
	BCWB3	B-phase Breaker 3 contact wear threshold exceeded
	BCWC3	C-phase Breaker 3 contact wear threshold exceeded
	BCW3	BCWA3 + BCWB3 + BCWC3
	BCWA4	A-phase Breaker 4 contact wear threshold exceeded
	BCWB4	B-phase Breaker 4 contact wear threshold exceeded
	BCWC4	C-phase Breaker 4 contact wear threshold exceeded
	BCW4	BCWA4 + BCWB4 + BCWC4
41	TRIP1	Trip 1 logic asserted
	TRIP2	Trip 2 logic asserted
	TRIP3	Trip 3 logic asserted
	TRIP4	Trip 4 logic asserted
	TRIP5	Trip 5 logic asserted
	TRIPL	Any trip asserted
	CSE	Cooling system efficiency alarm asserted (SEL-387-6 Relay only)
42	TRGTR	{TARGET RESET} pushbutton/TAR R command
	CLS1	Breaker 1 CLOSE output asserted
	CLS2	Breaker 2 CLOSE output asserted
	CLS3	Breaker 3 CLOSE output asserted
	CLS4	Breaker 4 CLOSE output asserted
	CF1T	Breaker 1 close failure timer timed out
	CF2T	Breaker 2 close failure timer timed out
	CF3T	Breaker 3 close failure timer timed out
43	CF4T	Breaker 4 close failure timer timed out
	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

Table 4.10 Relay Word Bit Definitions (Sheet 10 of 12)

Row	Bit	Definition
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	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
47	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
	*	Reserved
48	LB1	Local Bit 1 asserted (all but SEL-387-0 Relay)
	LB2	Local Bit 2 asserted (all but SEL-387-0 Relay)
	LB3	Local Bit 3 asserted (all but SEL-387-0 Relay)
	LB4	Local Bit 4 asserted (all but SEL-387-0 Relay)
	LB5	Local Bit 5 asserted (all but SEL-387-0 Relay)
	LB6	Local Bit 6 asserted (all but SEL-387-0 Relay)
	LB7	Local Bit 7 asserted (all but SEL-387-0 Relay)
	LB8	Local Bit 8 asserted (all but SEL-387-0 Relay)

Table 4.10 Relay Word Bit Definitions (Sheet 11 of 12)

Row	Bit	Definition
49	LB9	Local Bit 9 asserted (all but SEL-387-0 Relay)
	LB10	Local Bit 10 asserted (all but SEL-387-0 Relay)
	LB11	Local Bit 11 asserted (all but SEL-387-0 Relay)
	LB12	Local Bit 12 asserted (all but SEL-387-0 Relay)
	LB13	Local Bit 13 asserted (all but SEL-387-0 Relay)
	LB14	Local Bit 14 asserted (all but SEL-387-0 Relay)
	LB15	Local Bit 15 asserted (all but SEL-387-0 Relay)
	LB16	Local Bit 16 asserted (all but SEL-387-0 Relay)
53	49A01A	RTD1A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T01A	RTD1A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A02A	RTD2A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T02A	RTD2A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A03A	RTD3A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T03A	RTD3A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A04A	RTD4A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T04A	RTD4A trip picked up (SEL-387-5 and SEL-387-6 Relays)
54	49A05A	RTD5A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T05A	RTD5A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A06A	RTD6A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T06A	RTD6A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A07A	RTD7A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T07A	RTD7A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A08A	RTD8A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T08A	RTD8A trip picked up (SEL-387-5 and SEL-387-6 Relays)
55	49A09A	RTD9A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T09A	RTD9A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A10A	RTD10A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T10A	RTD10A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A11A	RTD11A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T11A	RTD11A trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A12A	RTD12A alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T12A	RTD12A trip picked up (SEL-387-5 and SEL-387-6 Relays)
56	49A01B	RTD1B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T01B	RTD1B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A02B	RTD2B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T02B	RTD2B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A03B	RTD3B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T03B	RTD3B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A04B	RTD4B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T04B	RTD4B trip picked up (SEL-387-5 and SEL-387-6 Relays)

Table 4.10 Relay Word Bit Definitions (Sheet 12 of 12)

Row	Bit	Definition
57	49A05B	RTD5B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T05B	RTD5B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A06B	RTD6B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T06B	RTD6B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A07B	RTD7B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T07B	RTD7B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A08B	RTD8B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T08B	RTD8B trip picked up (SEL-387-5 and SEL-387-6 Relays)
58	49A09B	RTD9B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T09B	RTD9B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A10B	RTD10B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T10B	RTD10B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A11B	RTD11B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T11B	RTD11B trip picked up (SEL-387-5 and SEL-387-6 Relays)
	49A12B	RTD12B alarm picked up (SEL-387-5 and SEL-387-6 Relays)
	49T12B	RTD12B trip picked up (SEL-387-5 and SEL-387-6 Relays)
59	COMFLA	Asserts when communications fails or when out-of-range temperature data received from RTDA (SEL-387-5 and SEL-387-6 Relays)
	RTDINA	State of external RTDA module's digital input (SEL-387-5 and SEL-387-6 Relays)
	COMFLB	Asserts when communications fails or when out-of-range temperature data received from RTDB (SEL-387-5 and SEL-387-6 Relays)
	RTDINB	State of external RTDB module's digital input (SEL-387-5 and SEL-387-6 Relays)
	ISQTAL	Cumulative through-fault I ² t on a phase of a designated winding has exceeded the through-fault I ² t threshold ISQT (SEL-387-5 and SEL-387-6 Relays)

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 1 of 13)

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
32IE	Internal enable for the 32I element	20
32IF	32I element forward (internal) fault declaration	21
32IR	32I element reverse (external) fault declaration	21
49A01A	RTD1A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	53
49A01B	RTD1B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	56
49A02A	RTD2A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	53
49A02B	RTD2B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	56

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 2 of 13)

Bit	Definition	Row
49A03A	RTD3A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	53
49A03B	RTD3B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	56
49A04A	RTD4A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	53
49A04B	RTD4B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	56
49A05A	RTD5A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	54
49A05B	RTD5B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	57
49A06A	RTD6A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	54
49A06B	RTD6B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	57
49A07A	RTD7A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	54
49A07B	RTD7B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	57
49A08A	RTD8A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	54
49A08B	RTD8B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	57
49A09A	RTD9A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	55
49A09B	RTD9B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	58
49A10A	RTD10A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	55
49A10B	RTD10B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	58
49A11A	RTD11A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	55
49A11B	RTD11B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	58
49A12A	RTD12A alarm picked up (SEL-387-5 and SEL-387-6 Relays)	55
49A12B	RTD12B alarm picked up (SEL-387-5 and SEL-387-6 Relays)	58
49T01A	RTD1A trip picked up (SEL-387-5 and SEL-387-6 Relays)	53
49T01B	RTD1B trip picked up (SEL-387-5 and SEL-387-6 Relays)	56
49T02A	RTD2A trip picked up (SEL-387-5 and SEL-387-6 Relays)	53
49T02B	RTD2B trip picked up (SEL-387-5 and SEL-387-6 Relays)	56
49T03A	RTD3A trip picked up (SEL-387-5 and SEL-387-6 Relays)	53
49T03B	RTD3B trip picked up (SEL-387-5 and SEL-387-6 Relays)	56
49T04A	RTD4A trip picked up (SEL-387-5 and SEL-387-6 Relays)	53
49T04B	RTD4B trip picked up (SEL-387-5 and SEL-387-6 Relays)	56
49T05A	RTD5A trip picked up (SEL-387-5 and SEL-387-6 Relays)	54
49T05B	RTD5B trip picked up (SEL-387-5 and SEL-387-6 Relays)	57
49T06A	RTD6A trip picked up (SEL-387-5 and SEL-387-6 Relays)	54
49T06B	RTD6B trip picked up (SEL-387-5 and SEL-387-6 Relays)	57
49T07A	RTD7A trip picked up (SEL-387-5 and SEL-387-6 Relays)	54
49T07B	RTD7B trip picked up (SEL-387-5 and SEL-387-6 Relays)	57
49T08A	RTD8A trip picked up (SEL-387-5 and SEL-387-6 Relays)	54
49T08B	RTD8B trip picked up (SEL-387-5 and SEL-387-6 Relays)	57
49T09A	RTD9A trip picked up (SEL-387-5 and SEL-387-6 Relays)	55

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 3 of 13)

Bit	Definition	Row
49T09B	RTD9B trip picked up (SEL-387-5 and SEL-387-6 Relays)	58
49T10A	RTD10A trip picked up (SEL-387-5 and SEL-387-6 Relays)	55
49T10B	RTD10B trip picked up (SEL-387-5 and SEL-387-6 Relays)	58
49T11A	RTD11A trip picked up (SEL-387-5 and SEL-387-6 Relays)	55
49T11B	RTD11B trip picked up (SEL-387-5 and SEL-387-6 Relays)	58
49T12A	RTD12A trip picked up (SEL-387-5 and SEL-387-6 Relays)	55
49T12B	RTD12B trip picked up (SEL-387-5 and SEL-387-6 Relays)	58
4HBL	Fourth-harmonic element asserted (all but SEL-387-0 Relay)	27
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
50A43	Winding 4 A-phase instantaneous O/C Level 3 element picked up	15
50A44	Winding 4 A-phase instantaneous O/C Level 4 element picked up	15
50B13	Winding 1 B-phase instantaneous O/C Level 3 element picked up	3
50B14	Winding 1 B-phase instantaneous O/C Level 4 element picked up	3
50B23	Winding 2 B-phase instantaneous O/C Level 3 element picked up	7
50B24	Winding 2 B-phase instantaneous O/C Level 4 element picked up	7
50B33	Winding 3 B-phase instantaneous O/C Level 3 element picked up	11
50B34	Winding 3 B-phase instantaneous O/C Level 4 element picked up	11
50B43	Winding 4 B-phase instantaneous O/C Level 3 element picked up	15
50B44	Winding 4 B-phase instantaneous O/C Level 4 element picked up	15
50C13	Winding 1 C-phase instantaneous O/C Level 3 element picked up	3
50C14	Winding 1 C-phase instantaneous O/C Level 4 element picked up	3
50C23	Winding 2 C-phase instantaneous O/C Level 3 element picked up	7
50C24	Winding 2 C-phase instantaneous O/C Level 4 element picked up	7

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 4 of 13)

Bit	Definition	Row
50C33	Winding 3 C-phase instantaneous O/C Level 3 element picked up	11
50C34	Winding 3 C-phase instantaneous O/C Level 4 element picked up	11
50C43	Winding 4 C-phase instantaneous O/C Level 3 element picked up	15
50C44	Winding 4 C-phase instantaneous O/C Level 4 element picked up	15
50G4	W4 residual current sensitivity threshold exceeded	21
50GC	Combined residual current sensitivity threshold exceeded	21
50N11	Winding 1 residual definite-time O/C Level 1 element picked up	4
50N11T	Winding 1 residual definite-time O/C Level 1 element timed out	4
50N12	Winding 1 residual instantaneous O/C Level 2 element picked up	4
50N21	Winding 2 residual definite-time O/C Level 1 element picked up	8
50N21T	Winding 2 residual definite-time O/C Level 1 element timed out	8
50N22	Winding 2 residual instantaneous O/C Level 2 element picked up	8
50N31	Winding 3 residual definite-time O/C Level 1 element picked up	12
50N31T	Winding 3 residual definite-time O/C Level 1 element timed out	12
50N32	Winding 3 residual instantaneous O/C Level 2 element picked up	12
50N41	Winding 4 residual definite-time O/C Level 1 element picked up	16
50N41T	Winding 4 residual definite-time O/C Level 1 element timed out	16
50N42	Winding 4 residual instantaneous O/C Level 2 element picked up	16
50P11	Winding 1 phase definite-time O/C Level 1 element picked up	2
50P11T	Winding 1 phase definite-time O/C Level 1 element timed out	2
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

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 5 of 13)

Bit	Definition	Row
50P31T	Winding 3 phase definite-time O/C Level 1 element timed out	10
50P32	Winding 3 phase instantaneous O/C Level 2 element picked up	10
50P33	50A33 + 50B33 + 50C33	11
50P34	50A34 + 50B34 + 50C34	11
50P41	Winding 4 phase definite-time O/C Level 1 element picked up	14
50P41T	Winding 4 phase definite-time O/C Level 1 element timed out	14
50P42	Winding 4 phase instantaneous O/C Level 2 element picked up	14
50P43	50A43 + 50B43 + 50C43	15
50P44	50A44 + 50B44 + 50C44	15
50Q11	Winding 1 neg.-seq. definite-time O/C Level 1 element picked up	5
50Q11T	Winding 1 neg.-seq. definite-time O/C element timed out	5
50Q12	Winding 1 neg.-seq. instantaneous O/C Level 2 element picked up	5
50Q21	Winding 2 neg.-seq. definite-time O/C Level 1 element picked up	9
50Q21T	Winding 2 neg.-seq. definite-time O/C Level 1 element timed out	9
50Q22	Winding 2 neg.-seq. instantaneous O/C Level 2 element picked up	9
50Q31	Winding 3 neg.-seq. definite-time O/C Level 1 element picked up	13
50Q31T	Winding 3 neg.-seq. definite-time O/C Level 1 element timed out	13
50Q32	Winding 3 neg.-seq. instantaneous O/C Level 2 element picked up	13
50Q41	Winding 4 neg.-seq. definite-time O/C element picked up	17
50Q41T	Winding 4 neg.-seq. definite-time O/C element timed out	17
50Q42	Winding 4 neg.-seq. instantaneous O/C Level 2 element picked up	17
51N1	Winding 1 residual inverse-time O/C element picked up	4
51N1R	Winding 1 residual inverse-time O/C 51N1 element is reset	4
51N1T	Winding 1 residual inverse-time O/C element timed out	4
51N2	Winding 2 residual inverse-time O/C element picked up	8
51N2R	Winding 2 residual inverse-time O/C 51N2 element is reset	8
51N2T	Winding 2 residual inverse-time O/C element timed out	8
51N3	Winding 3 residual inverse-time O/C element picked up	12
51N3R	Winding 3 residual inverse-time O/C 51N3 element is reset	12
51N3T	Winding 3 residual inverse-time O/C element timed out	12
51N4	Winding 4 residual inverse-time O/C element picked up	16
51N4R	Winding 4 residual inverse-time O/C 51N4 element is reset	16
51N4T	Winding 4 residual inverse-time O/C element timed out	16

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 6 of 13)

Bit	Definition	Row
51NC1	Windings 1 and 2 residual inverse-time O/C element picked up	22
51NC1R	Windings 1 and 2 residual inverse-time O/C element is reset	22
51NC1T	Windings 1 and 2 residual inverse-time O/C element timed out	22
51NC2	Windings 3 and 4 residual inverse-time O/C element picked up	23
51NC2R	Windings 3 and 4 residual inverse-time O/C element is reset	23
51NC2T	Windings 3 and 4 residual inverse-time O/C element timed out	23
51P1	Winding 1 phase inverse-time O/C element picked up	2
51P1R	Winding 1 phase inverse-time O/C 51P1 element is reset	2
51P1T	Winding 1 phase inverse-time O/C element timed out	2
51P2	Winding 2 phase inverse-time O/C element picked up	6
51P2R	Winding 2 phase inverse-time O/C 51P2 element is reset	6
51P2T	Winding 2 phase inverse-time O/C element timed out	6
51P3	Winding 3 phase inverse-time O/C element picked up	10
51P3R	Winding 3 phase inverse-time O/C 51P3 element is reset	10
51P3T	Winding 3 phase inverse-time O/C element timed out	10
51P4	Winding 4 phase inverse-time O/C element picked up	14
51P4R	Winding 4 phase inverse-time O/C 51P4 element is reset	14
51P4T	Winding 4 phase inverse-time O/C element timed out	14
51PC1	Windings 1 and 2 phase inverse-time O/C element picked up	22
51PC1R	Windings 1 and 2 phase inverse-time O/C element is reset	22
51PC1T	Windings 1 and 2 phase inverse-time O/C element timed out	22
51PC2	Windings 3 and 4 phase inverse-time O/C element picked up	23
51PC2R	Windings 3 and 4 phase inverse-time O/C element is reset	23
51PC2T	Windings 3 and 4 phase inverse-time O/C element timed out	23
51Q1	Winding 1 neg.-seq. inverse-time O/C element picked up	5
51Q1R	Winding 1 neg.-seq. inverse-time O/C 51Q1 element is reset	5
51Q1T	Winding 1 neg.-seq. inverse-time O/C element timed out	5
51Q2	Winding 2 neg.-seq. inverse-time O/C element picked up	9
51Q2R	Winding 2 neg.-seq. inverse-time O/C 51Q2 element is reset	9
51Q2T	Winding 2 neg.-seq. inverse-time O/C element timed out	9
51Q3	Winding 3 neg.-seq. inverse-time O/C element picked up	13
51Q3R	Winding 3 neg.-seq. inverse-time O/C 51Q3 element is reset	13
51Q3T	Winding 3 neg.-seq. inverse-time O/C element timed out	13
51Q4	Winding 4 neg.-seq. inverse-time O/C element picked up	17
51Q4R	Winding 4 neg.-seq. inverse-time O/C 51Q4 element is reset	17
51Q4T	Winding 4 neg.-seq. inverse-time O/C element timed out	17
5HB1	Fifth-harmonic block asserted for differential element 1	19
5HB2	Fifth-harmonic block asserted for differential element 2	19

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 7 of 13)

Bit	Definition	Row
5HB3	Fifth-harmonic block asserted for differential element 3	19
87BL	Harmonic block asserted for differential element	20
87BL1	Harmonic block asserted for differential element 1	20
87BL2	Harmonic block asserted for differential element 2	20
87BL3	Harmonic block asserted for differential element 3	20
87E1	Trip by differential element 1	20
87E2	Trip by differential element 2	20
87E3	Trip by differential element 3	20
87O1	Restrained differential element 1 operating current above O87P	21
87O2	Restrained differential element 2 operating current above O87P	21
87O3	Restrained differential element 3 operating current above O87P	21
87R	Restrained differential element picked up	18
87R1	Restrained differential element 1 picked up	18
87R2	Restrained differential element 2 picked up	18
87R3	Restrained differential element 3 picked up	18
87U	Unrestrained differential element picked up	18
87U1	Unrestrained differential element 1 picked up	18
87U2	Unrestrained differential element 2 picked up	18
87U3	Unrestrained differential element 3 picked up	18
BCW1	BCWA1 + BCWB1 + BCWC1	39
BCW2	BCWA2 + BCWB2 + BCWC2	39
BCW3	BCWA3 + BCWB3 + BCWC3	40
BCW4	BCWA4 + BCWB4 + BCWC4	40
BCWA1	A-phase Breaker 1 contact wear threshold exceeded	39
BCWA2	A-phase Breaker 2 contact wear threshold exceeded	39
BCWA3	A-phase Breaker 3 contact wear threshold exceeded	40
BCWA4	A-phase Breaker 4 contact wear threshold exceeded	40
BCWB1	B-phase Breaker 1 contact wear threshold exceeded	39
BCWB2	B-phase Breaker 2 contact wear threshold exceeded	39
BCWB3	B-phase Breaker 3 contact wear threshold exceeded	40
BCWB4	B-phase Breaker 4 contact wear threshold exceeded	40
BCWC1	C-phase Breaker 1 contact wear threshold exceeded	39
BCWC2	C-phase Breaker 2 contact wear threshold exceeded	39
BCWC3	C-phase Breaker 3 contact wear threshold exceeded	40
BCWC4	C-phase Breaker 4 contact wear threshold exceeded	40
CC1	Breaker 1 CLOSE command execution	5
CC2	Breaker 2 CLOSE command execution	9
CC3	Breaker 3 CLOSE command execution	13
CC4	Breaker 4 CLOSE command execution	17

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 8 of 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
CF4T	Breaker 4 close failure timer timed out	42
CHSG	Timing to change setting groups	26
CLS1	Breaker 1 CLOSE output asserted	42
CLS2	Breaker 2 CLOSE output asserted	42
CLS3	Breaker 3 CLOSE output asserted	42
CLS4	Breaker 4 CLOSE output asserted	42
COMFLA	Asserts when communication fails or when out-of-range temperature data received from RTDA (SEL-387-5 and SEL-387-6 Relays only)	59
COMFLB	Asserts when communication fails or when out-of-range temperature data received from RTDB (SEL-387-5 and SEL-387-6 Relays only)	59
COMFLG	Asserted when communications fail or when out-of-range temperature data are received on the serial port used to obtain temperature data (SEL-387-6 Relay only)	26
CSE	Cooling system efficiency alarm asserted (SEL-387-6 Relay only)	41
CTS	Current transformer saturation (not available in the SEL-387-0 Relay prior to firmware version R602)	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 (all but SEL-387-0 Relay)	27
FAA1	Insulation aging acceleration factor alarm level 1 asserted (SEL-387-6 Relay only)	38
FAA2	Insulation aging acceleration factor alarm level 2 asserted (SEL-387-6 Relay only)	38
HS1	Hot-spot temperature alarm level 1 asserted (SEL-387-6 Relay only)	38
HS2	Hot-spot temperature alarm level 2 asserted (SEL-387-6 Relay only)	38
IN101	Input IN101 asserted	27
IN102	Input IN102 asserted	27
IN103	Input IN103 asserted	27
IN104	Input IN104 asserted	27
IN105	Input IN105 asserted	27
IN106	Input IN106 asserted	27
IN201	Input IN201 asserted	28
IN202	Input IN202 asserted	28
IN203	Input IN203 asserted	28
IN204	Input IN204 asserted	28

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 9 of 13)

Bit	Definition	Row
IN205	Input IN205 asserted	28
IN206	Input IN206 asserted	28
IN207	Input IN207 asserted	28
IN208	Input IN208 asserted	28
IN209	Input IN209 asserted	29
IN210	Input IN210 asserted	29
IN211	Input IN211 asserted	29
IN212	Input IN212 asserted	29
IN213	Input IN213 asserted	29
IN214	Input IN214 asserted	29
IN215	Input IN215 asserted	29
IN216	Input IN216 asserted	29
ISQTAL	Cumulative through-fault I^2t on a phase of a designated winding has exceeded the through-fault I^2t threshold ISQT (SEL-387-5 and SEL-387-6 Relays only)	59
LB1	Local Bit 1 asserted (all but SEL-387-0 Relay)	48
LB10	Local Bit 10 asserted (all but SEL-387-0 Relay)	49
LB11	Local Bit 11 asserted (all but SEL-387-0 Relay)	49
LB12	Local Bit 12 asserted (all but SEL-387-0 Relay)	49
LB13	Local Bit 13 asserted (all but SEL-387-0 Relay)	49
LB14	Local Bit 14 asserted (all but SEL-387-0 Relay)	49
LB15	Local Bit 15 asserted (all but SEL-387-0 Relay)	49
LB16	Local Bit 16 asserted (all but SEL-387-0 Relay)	49
LB2	Local Bit 2 asserted (all but SEL-387-0 Relay)	48
LB3	Local Bit 3 asserted (all but SEL-387-0 Relay)	48
LB4	Local Bit 4 asserted (all but SEL-387-0 Relay)	48
LB5	Local Bit 5 asserted (all but SEL-387-0 Relay)	48
LB6	Local Bit 6 asserted (all but SEL-387-0 Relay)	48
LB7	Local Bit 7 asserted (all but SEL-387-0 Relay)	48
LB8	Local Bit 8 asserted (all but SEL-387-0 Relay)	48
LB9	Local Bit 9 asserted (all but SEL-387-0 Relay)	49
NDEM1	Winding 1 residual demand current threshold exceeded	4
NDEM2	Winding 2 residual demand current threshold exceeded	8
NDEM3	Winding 3 residual demand current threshold exceeded	12
NDEM4	Winding 4 residual demand current threshold exceeded	16
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
OC4	Breaker 4 OPEN command execution	16
OCA	O/C element A-phase selection	2
OCB	O/C element B-phase selection	6

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 10 of 13)

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
PDEM1	Winding 1 phase demand current threshold exceeded	2
PDEM2	Winding 2 phase demand current threshold exceeded	6
PDEM3	Winding 3 phase demand current threshold exceeded	10
PDEM4	Winding 4 phase demand current threshold exceeded	14
QDEM1	Winding 1 neg.-seq. demand current threshold exceeded	5
QDEM2	Winding 2 neg.-seq. demand current threshold exceeded	9
QDEM3	Winding 3 neg.-seq. demand current threshold exceeded	13
QDEM4	Winding 4 neg.-seq. demand current threshold exceeded	17
RB1	Remote bit RB1 asserted	24
RB10	Remote bit RB10 asserted	25
RB11	Remote bit RB11 asserted	25
RB12	Remote bit RB12 asserted	25
RB13	Remote bit RB13 asserted	25
RB14	Remote bit RB14 asserted	25
RB15	Remote bit RB15 asserted	25
RB16	Remote bit RB16 asserted	25
RB2	Remote bit RB2 asserted	24

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 11 of 13)

Bit	Definition	Row
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
REFP	Restricted Earth Fault inverse-time O/C element timed out	21
RTDINA	State of external RTDA module's digital input (SEL-387-5 and SEL-387-6 Relays only)	59
RTDINB	State of external RTDB module's digital input (SEL-387-5 and SEL-387-6 Relays only)	59
RLL	Daily rate of loss-of-life alarm asserted (SEL-387-6 Relay only)	38
S1LT1	Set 1 latch bit S1LT1 asserted	36
S1LT2	Set 1 latch bit S1LT2 asserted	36
S1LT3	Set 1 latch bit S1LT3 asserted	36
S1LT4	Set 1 latch bit S1LT4 asserted	36
S1V1	Set 1 SELOGIC control equation variable S1V1 timer input asserted	32
S1V1T	Set 1 SELOGIC control equation variable S1V1 timer output asserted	32
S1V2	Set 1 SELOGIC control equation variable S1V2 timer input asserted	32
S1V2T	Set 1 SELOGIC control equation variable S1V2 timer output asserted	32
S1V3	Set 1 SELOGIC control equation variable S1V3 timer input asserted	32
S1V3T	Set 1 SELOGIC control equation variable S1V3 timer output asserted	32
S1V4	Set 1 SELOGIC control equation variable S1V4 timer input asserted	32
S1V4T	Set 1 SELOGIC control equation variable S1V4 timer output asserted	32
S2LT1	Set 2 latch bit S2LT1 asserted	36
S2LT2	Set 2 latch bit S2LT2 asserted	36
S2LT3	Set 2 latch bit S2LT3 asserted	36
S2LT4	Set 2 latch bit S2LT4 asserted	36
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

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 12 of 13)

Bit	Definition	Row
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 (all but SEL-387-0 Relay)	37
S3LT2	Set 3 latch bit S3LT2 asserted (all but SEL-387-0 Relay)	37
S3LT3	Set 3 latch bit S3LT3 asserted (all but SEL-387-0 Relay)	37
S3LT4	Set 3 latch bit S3LT4 asserted (all but SEL-387-0 Relay)	37
S3LT5	Set 3 latch bit S3LT5 asserted (all but SEL-387-0 Relay)	37
S3LT6	Set 3 latch bit S3LT6 asserted (all but SEL-387-0 Relay)	37
S3LT7	Set 3 latch bit S3LT7 asserted (all but SEL-387-0 Relay)	37
S3LT8	Set 3 latch bit S3LT8 asserted (all but SEL-387-0 Relay)	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

Table 4.11 Relay Word Bits Sorted Alphabetically (Sheet 13 of 13)

Bit	Definition	Row
SG1	Setting Group 1 is the active setting group	26
SG2	Setting Group 2 is the active setting group	26
SG3	Setting Group 3 is the active setting group	26
SG4	Setting Group 4 is the active setting group	26
SG5	Setting Group 5 is the active setting group	26
SG6	Setting Group 6 is the active setting group	26
TH5	Fifth-harmonic alarm threshold exceeded	19
TH5T	Fifth-harmonic alarm threshold exceeded for longer than TH5D	19
TLL	Total accumulated loss-of-life alarm asserted (SEL-387-6 Relay only)	38
TO1	Top-oil temperature alarm level 1 asserted (SEL-387-6 Relay only)	38
TO2	Top-oil temperature alarm level 2 asserted (SEL-387-6 Relay only)	38
TRGTR	{TARGET RESET} pushbutton/TAR R command	41
TRIP1	Trip 1 logic asserted	41
TRIP2	Trip 2 logic asserted	41
TRIP3	Trip 3 logic asserted	41
TRIP4	Trip 4 logic asserted	41
TRIP5	Trip 5 logic asserted	41
TRIPL	Any trip asserted	41

Section 5

Metering and Monitoring

Overview

The SEL-387 Relay provides metering information in several report formats for each of the 4 three-phase winding current inputs and for the 3 differential elements. A DC Battery Monitor reports on the supply voltage to the relay and can be programmed to alarm for voltage excursions. There is also a Breaker Monitor function that keeps track of breaker trips, the cumulative current interrupted over time, and the amount of estimated contact wear. These functions and their associated reports are discussed in this section.

Metering Functions

There are three types of fundamental frequency metering functions in the SEL-387:

- Instantaneous
- Demand (thermal)
- Peak demand

Quantities metered include the following:

- Phase currents for all four winding inputs
- Positive-, negative-, and zero-sequence (residual) currents for all four winding inputs
- Operate, restraint, second-harmonic, and fifth-harmonic currents for the three differential elements

There are several report formats, employing different groups of the above quantities, accessible by variants of the **METER** command through the relay serial port. This information is also available at the relay front panel via the LCD display.

There is also a specialized metering function, Harmonic Metering. It provides a snapshot of harmonic current magnitudes in the phase currents, fundamental through the fifteenth harmonic.

This section will discuss which quantities are used in each of the report formats and show the format for each of the **METER** command displays, as they would appear on the screen. The relay front-panel LCD displays the same quantities but requires several stages of keystrokes to select the data of interest. These displays are covered in *Section 8: Front-Panel Interface*.

All **METER** displays herein show the default Analog Input Labels (**IAW1**, **IBW1**, etc.). Relay displays show the user setting values of the Analog Input Labels.

Instantaneous Phase Current Meter Function (METER Command)

The **METER** or **MET** command, with no additional parameters, displays instantaneous magnitude values, in primary rms amperes of the three-phase currents, the positive-sequence current, negative-sequence current, and residual current, for each of the four winding inputs. It also displays the value of the station battery dc supply voltage at the relay obtained from the Battery Voltage Monitor. If the command is typed as **MET m**, where *m* is any number from 1 to 32767, the report will be repeated *m* times in succession. In this mode subsequent reports are not generated until the previous report has been completely sent. The format for the **MET** report is as follows:

⇒METER <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)	12345	12345	12345	12345	12345	12345
Wdg2	IAW2	IBW2	ICW2	3I1W2	3I2W2	IRW2
I (A,pri)	12345	12345	12345	12345	12345	12345
Wdg3	IAW3	IBW3	ICW3	3I1W3	3I2W3	IRW3
I (A,pri)	12345	12345	12345	12345	12345	12345
Wdg4	IAW4	IBW4	ICW4	3I1W4	3I2W4	IRW4
I (A,pri)	12345	12345	12345	12345	12345	12345
VDC (V)	123					

Demand Ammeter Function (METER D Command)

The SEL-387 includes a thermal demand metering function for all four windings. In response to the **MET D** command, the individual phase demand currents, as well as the negative-sequence and residual demand currents for each winding, are displayed in primary rms amperes. If the command is typed as **MET D m**, where *m* is any number from 1 to 32767, the report will be repeated *m* times in succession. In this mode, subsequent reports are not generated until the previous report has been completely sent. The format for the **MET D** report is as follows:

```
=>METER D <Enter>
```

XFMR 1			Date: MM/DD/YY	Time: HH:MM:SS.SSS		
STATION A						
Phase Currents						
Wdg1	IAW1	IBW1	ICW1	3I2W1	IRW1	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Sequence Currents						
Wdg2	IAW2	IBW2	ICW2	3I2W2	IRW2	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Wdg3	IAW3	IBW3	ICW3	3I2W3	IRW3	
Dem I (A,pri)	12345	12345	12345	12345	12345	
Wdg4	IAW4	IBW4	ICW4	3I2W4	IRW4	
Dem I (A,pri)	12345	12345	12345	12345	12345	
LAST DEMAND RESET FOR			Wdg1: mm/dd/yy	hh:mm:ss.sss		
			Wdg2: mm/dd/yy	hh:mm:ss.sss		
			Wdg3: mm/dd/yy	hh:mm:ss.sss		
			Wdg4: mm/dd/yy	hh:mm:ss.sss		

The most recent demand resets for each winding are shown in the **METER D** report.

The Demand Ammeter function simulates the long-term heating effects of current at a particular level by accumulating the demand current on an exponential basis, using a thermal time constant setting, **DATCn**, for each winding (*n* = 1, 2, 3, 4). **DATCn** can be set over a range of 5 to 255 minutes (4 hrs 15 min). The demand values in secondary amperes are compared to user-defined thresholds, **PDEMnP**, **QDEMnP**, and **NDEMnP**. **PDEMnP** is compared to the greatest of the three individual phase current demands for Winding *n*, while **QDEMnP** is compared to the negative-sequence demand,

and $NDEMnP$ is compared to the residual demand. Relay Word bits $PDEMn$, $QDEMn$, or $NDEMn$ are asserted if the appropriate demand exceeds the stated threshold. These bits can be used to initiate a display or to close an output contact, for alarming or tripping purposes.

The demand ammeter output for a step change in current of S amperes is a smoothly rising exponential that produces a demand change of 0.9 times S at time $DATCn$ after the step change occurred (see *Figure 5.1*). For example, if the demand current has stabilized at some value 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:

$$Id(t) = I_{NEW} + (Id_0 - I_{NEW}) \cdot e^{-[\ln(10)] \cdot \frac{t}{DATCn}}$$

Equation 5.1

The next function, the peak demand ammeter function, keeps track of the greatest 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 winding, i.e., the largest of the phase current demands, the negative-sequence demand, and the residual demand, against registers containing the greatest demand value of each type since the last reset of the registers. This is done every two seconds. If the particular $Id(t)$ 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** 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 **METER 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
STATION A
Date: MM/DD/YY
Time: HH:MM:SS.SSS

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

Wdg 4
IAW4 12345 MM/DD/YY HH:MM:SS.SSS
IBW4 12345 MM/DD/YY HH:MM:SS.SSS
ICW4 12345 MM/DD/YY HH:MM:SS.SSS
3I2W4 12345 MM/DD/YY HH:MM:SS.SSS
IRW4 12345 MM/DD/YY HH:MM:SS.SSS

LAST PEAK DEMAND RESET FOR
Wdg1: MM/DD/YY HH:MM:SS.SSS
Wdg2: MM/DD/YY HH:MM:SS.SSS
Wdg3: MM/DD/YY HH:MM:SS.SSS
Wdg4: MM/DD/YY HH:MM:SS.SSS

```

Differential Metering Function (METER DIF Command)

The report for **MET P** contains the last reset times for the peak demand registers for each winding.

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, then divided by the tap value for each winding, and entered into the calculations as dimensionless “multiples of tap.” These values are then summed in 87 1 on a phasor basis for determining operating current (IOP_k) and on a scalar magnitude basis for the restraint current (IRT_k) calculation ($k = 1, 2, 3$). The B-phase and C-phase values find their way to 87 2 and 87 3, respectively.

In response to the **MET DIF** command, the fundamental frequency Operate and Restraint currents for each differential element are displayed in multiples of tap. The second- and fifth-harmonic currents in each element are also shown in multiples of tap. These are calculated in the same way as the operate currents, using the harmonic current from each winding in a phasor addition. If the command is typed as **MET DIF m**, where m is any number from 1 to 32767, the report will be repeated m times in succession. In this mode, subsequent reports are not generated until the previous report has been completely sent. The format for the **MET DIF** report is as follows:

=>METER DIF <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 percent) are compared to the user-selected blocking threshold settings PCT2 and PCT5.

Phasor Current Metering Function (METER SEC Command)

The phasor current metering function is a useful tool for verifying proper phase rotation of input currents, for checking CT connections and polarities, and for checking that “in” currents are about 180° out-of-phase with “out” currents. With normal load currents on the transformer, the correctness (or lack thereof) of all the input connections becomes apparent.

In response to the **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 **MET 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		
Wdg4	IAW4	IBW4	ICW4	3I1W4	3I2W4	IRW4		
I (A,sec)	123.12	123.12	123.12	123.12	123.12	123.12		
Angle (deg)	±123.12	±123.12	±123.12	±123.12	±123.12	±123.12		

The phase angles given are all referenced to current IAW1. That is, the full set of 24 calculated current phasors is rotated in a manner that brings IAW1 to an angle of zero degrees. However, if the magnitude of IAW1 is less than 0.05x I_{NOM} (0.25A for a 5 A relay), the angles are listed according to the phasor calculation without further adjustment.

Demand Reset Functions (MET RD and MET RP Commands)

The demand ammeter function performs an integration of current over time and, as such, contains a “history” of the currents dating back minutes or hours from the present time. The peak demand ammeter function maintains registers with the highest recorded demands of each type over a period of time since the last reset of the registers. For both of these functions, it may be desirable to erase this “history.”

The **MET RD *n*** (Reset Demand) command returns the demand ammeter current values to zero. This is useful during testing, for example, so that previous test quantities do not appear as part of the metered values or in order to check the shape of the rising exponential for a fixed current over a period of time.

The **MET RP *n*** (Reset Peak demand) command stores the present values of the demands, along with their associated date/time stamps, in the registers used to store the values of the peaks. These become the new peaks of record until higher values occur. This function might typically be performed on a daily, weekly, or monthly basis to determine a peak demand profile of the equipment over time.

Both of the reset commands must be followed by a value for “*n*.” A value of 1, 2, 3, or 4 will produce a reset of all the demand or peak demand values for Winding *n*. If the letter A is entered, reset will be done on all of the windings. Failure to enter a value will produce an Invalid parameter response from the relay. For valid *n* values, the relay will ask for a Yes/No verification of your request to reset. No reports are issued for either command.

Figure 5.1 is an overall diagram representative of the five demand ammeters for each Winding *n*, and the relationship of the four related commands (**MET D**, **MET P**, **MET RD**, **MET RP**). The currents are indicated generically as IX, the demand of each as XD(t), the peak demand of each XD(t) as PXD, the three demand alarm thresholds as XDEM*n*P, and the associated Relay Word bit as XDEM*n*. The greatest of the XD(t) demands for IAW*n*, IBW*n*, and ICW*n* is compared to the phase threshold PDEM*n*P; if the threshold is exceeded, Relay Word bit PDEM*n* is set. Negative-sequence current demand is compared to QDEM*n*P, and Relay Word bit QDEM*n* is set if the threshold is exceeded. Residual current demand is compared to NDEM*n*P, and Relay Word bit NDEM*n* is set if the threshold is exceeded.

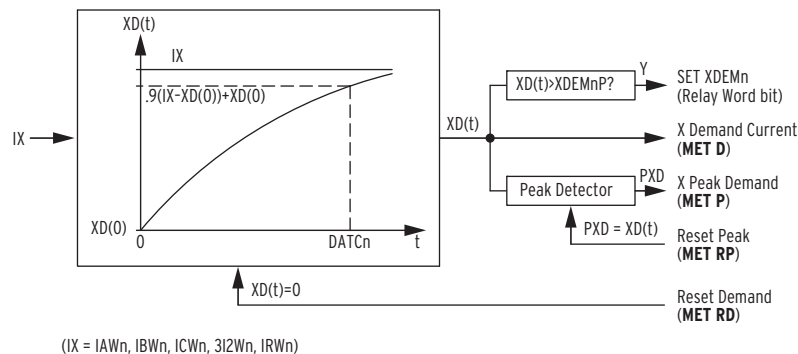


Figure 5.1 SEL-387 Demand Ammeter Functions and Commands

Harmonic Metering
Function (MET H
Command)

The Harmonic Metering function, in response to the **MET H** command, retrieves 1 full cycle of unfiltered sample data, at 64 samples per cycle, from each of the 12 analog current inputs. Harmonic magnitudes are obtained through use of a Fast Fourier transform method, which calculates a Discrete Fourier Transform, given by the following equation, for each harmonic from fundamental to fifteenth.

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

Equation 5.2

- where:
- N = samples per cycle = 64
 - n = order of the harmonic = 1, 2, . . . , 15
 - hk = sampled data for one full cycle at system frequency
 - k = summation index = 0, 1, . . . , 63
 - Hn = result of the Discrete Fourier Transform calculation for the nth harmonic

After the 15 Hn are calculated, they are adjusted to compensate for filter gain, and the resulting magnitudes are listed in secondary amperes:

=>MET H <Enter>
processing harmonic spectrum

XFMR 1
STATION A

Date: 04/30/97 Time: 15:30:40.556

Magnitudes of Harmonic Currents (Amps Sec)

H	IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4
1	5.00	5.00	5.00	5.00	5.01	5.01	5.00	5.01	5.00	5.02	5.02	5.02
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
3	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

=>

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

Temperature Measurement (SEL-387-5 and SEL-387-6 Relays)

The relay accepts up to 12 RTD inputs from the SEL-2600A RTD Module at any one of the ports. The SEL-387-5 and SEL-387-6 can use up to two SEL-2600A RTD Modules (two ports), processing the temperatures of a total of 24 RTDs.

```
=>>MET T <Enter>

XFMR 1                               Date: 01/18/02   Time: 11:00:28.404
STATION A

RTDA Input Temperature Data (deg. C)
Communication Failure

RTDB Input Temperature Data (deg. F)
RTD 1B = 123
RTD 2B = 123
RTD 3B = 123
RTD 4B = 123
RTD 5B = 123
RTD 6B = 123
RTD 7B = 123
RTD 8B = 123
RTD 9B = 123
RTD 10B = 123
RTD 11B = 123
RTD 12B = 123

=>>
```

Station DC Battery Monitor

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

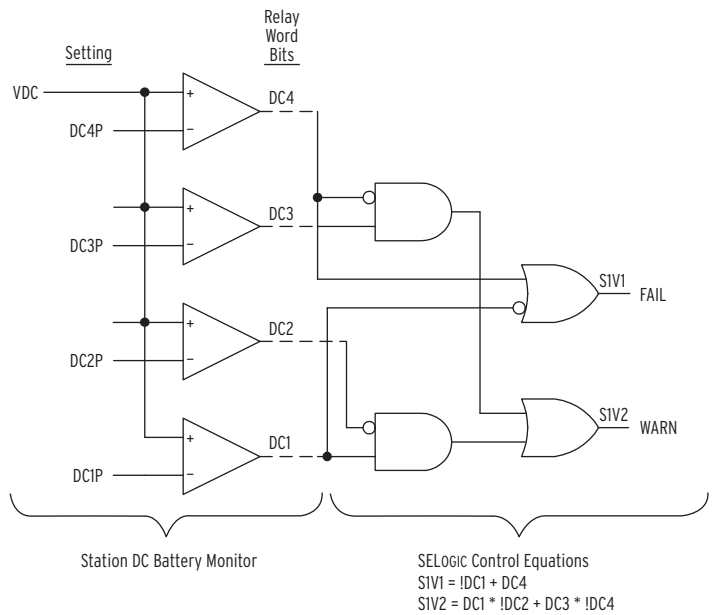


Figure 5.2 Station DC Battery Monitor Alarm Logic

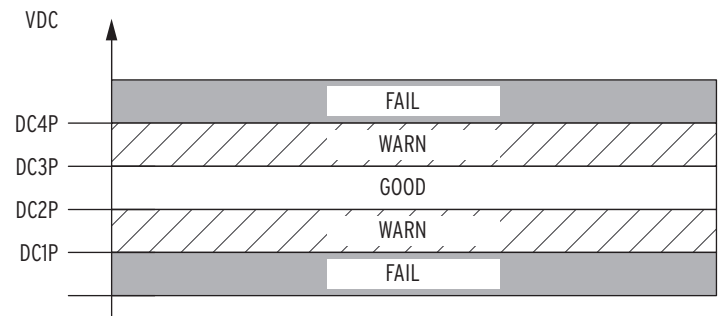


Figure 5.3 Undervoltage and Overvoltage Warning and Alarm Regions

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

Breaker Monitor Description and Initiation Setting

The SEL-387 breaker monitoring function is intended to capture information on the number of operations and total interrupted current for as many as four breakers. These data are used to estimate the amount of contact wear per pole, based on a wear curve input by the user, and derived from the breaker manufacturer maintenance curves. Separate settings for each breaker determine under what conditions the monitoring function is initiated for that breaker. The breaker monitoring function is capable of differentiating between an internal trip, generated by units associated with the winding where the breaker is applied, and an external trip, initiated by units from another winding, another relay, or control contact. This information will assist the user in determining when to schedule maintenance of the breakers.

The breaker monitor function has one initiation setting for each breaker. The BKMON1 through BKMON4 settings, in the Global/Relay settings area, are SELOGIC control equations, using Relay Word bits to initiate the monitor. The BKMON n 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 (TR n), which is associated with the particular Breaker n that BKMON n is monitoring. The monitor logic examines, for example, the status of the TRIP1 variable at the time the BKMON1 setting equation is asserted. If the TRIP1 variable is asserted when BKMON1 asserts, the trip count and the currents measured are recorded as internal. If TRIP1 is not asserted when BKMON1 asserts, the trip and currents are recorded as external. A trip initiated by any other winding elements (Windings 2, 3, or 4) or the differential element is regarded as external, even though it originates within the same relay.

In our example transformer application, we want Breaker 1 to trip for its own overcurrent elements (OUT101 = TRIP1; TR1 = 50P11T + 51P1T + 51Q1T) or for a differential trip (86T device trip via OUT104 = TRIP4; TR4 = 87R + 87U). In this case, we make the following setting:

BKMON1 = **TRIP1 + TRIP4**

Winding 1 overcurrent trips (TRIP1) will be credited to the internal trip counter and current accumulators, and differential trips (TRIP4) will appear as external trips.

In order to capture trip information for other Breaker 1 trips initiated by devices other than the SEL-387, BKMON n 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 internal comparison with TRIP1 is then made to sort out internal versus external trips.

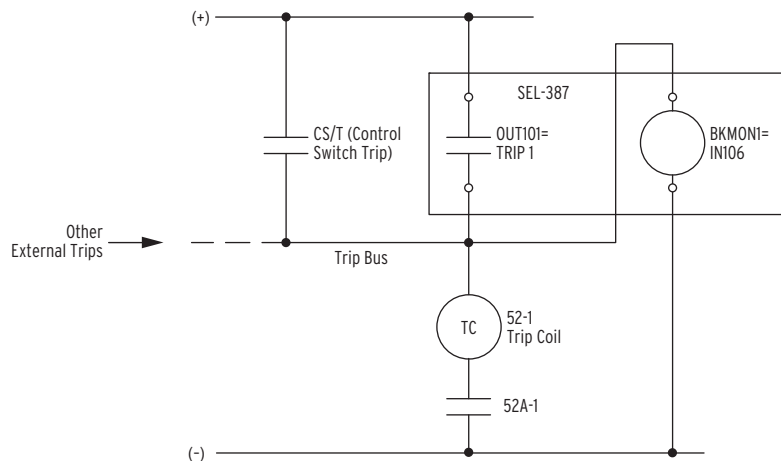


Figure 5.4 Trip Bus Sensing With Relay Input

Breaker Wear Curve Description and Settings

Based on maintenance curves supplied by manufacturers of the breakers, a contact wear curve for each breaker is constructed (*Figure 5.5*).

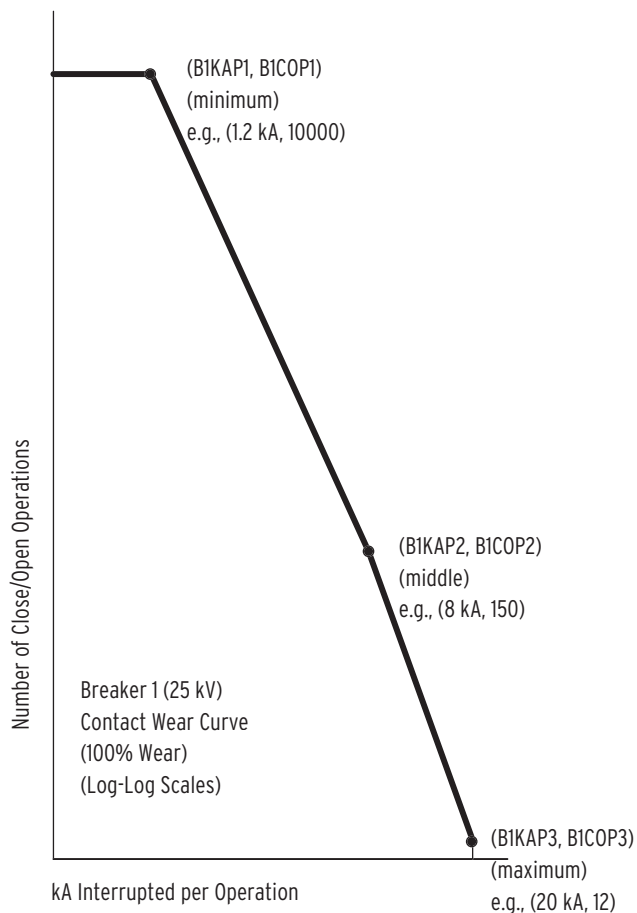


Figure 5.5 Breaker Contact Wear Curve

The curve is a plot of Close/Open operations versus interrupted current in kiloamperes (kA). The scales are logarithmic on both axes. For each Breaker n , three points are input in the Global setting area as relay settings. The points are defined by pairs of coordinates of current and operations. For Breaker n , these are the points ($BnKAP1$, $BnCOP1$), ($BnKAP2$, $BnCOP2$),

and (BnKAP3, BnCOP3). As shown in *Figure 5.5*, the point (BnKAP1, BnCOP1) must represent the lowest current value, point (BnKAP2, BnCOP2) an intermediate current value, and point (BnKAP3, BnCOP3) the maximum current value. The relay will not accept the settings unless $BnKAP1 < BnKAP2 < BnKAP3$.

For values of current in kA (I) below BnKAP1, the number of operations is assumed to be the same as for BnKAP1. In this part of the curve, the number of operations may be governed more by the cumulative mechanical wear-and-tear on the breaker operating mechanism, rather than actual contact degradation. For values of I above BnKAP3, there is assumed to be no breaker capability to interrupt, and 100 percent contact wear is assumed. BnKAP3, then, is typically set at the maximum rated interrupting current for the particular breaker. BnKAP1 is set at a value approximating the continuous load current rating of the breaker. BnKAP2 is set at some intermediate value of current, chosen to provide the closest visual “fit” to the manufacturer’s curve.

The two straight line segments of the curve between the three defined points define number of operations as a function of current in kiloamperes by an equation of the form:

$$O(I) = K \cdot I^{\alpha} \quad \text{Equation 5.3}$$

To determine the constants K and alpha for a given segment, any two current-operations pairs in that segment must be known. For any given pairs (I1, O1) and (I2, O2), the alpha constant is determined by the equation:

$$\alpha = \frac{\log_{10}\left(\frac{O1}{O2}\right)}{\log_{10}\left(\frac{I1}{I2}\right)} \quad \text{Equation 5.4}$$

The K constant can be found by back-substitution:

$$K = \frac{O1}{I1^{\alpha}}$$

or

$$K = \frac{O2}{I2^{\alpha}} \quad \text{Equation 5.5}$$

Here, we can use the endpoint pairs (BnKAP1, BnCOP1) and (BnKAP2, BnCOP2) to determine the equation that applies between these two input points and pairs (BnKAP2, BnCOP2) and (BnKAP3, BnCOP3) for the equation between the latter two points.

In *Figure 5.5*, for example, the two segments have the following equations:

$$O(I) = 14,972 \cdot I^{-2.214}$$

and

$$O(I) = 46,284 \cdot I^{-2.756} \quad \text{Equation 5.6}$$

For a particular value of I in kA, the calculated value O(I) represents 100 percent wear of the breaker contacts. Thus, the incremental percent wear for one trip operation at the defined current level is $100 / O(I)$ percent. For $I < BnKAP1$, $O(I) = BnCOP1$. For $BnKAP1 < I < BnKAP2$, $O(I)$ is

calculated by the first equation. For $BnKAP2 < I < BnKAP3$, $O(I)$ is calculated by the second equation. For $I > BnKAP3$, $O(I) = 0$ and contact wear = 100 percent.

Since the breaker monitor calculates and accumulates current by phase, the wear for each pole of the breaker is calculated separately, using the same wear curve as a basis. Thus, over time, the cumulative percent wear for each of the three poles will be different. If a breaker already has some estimated wear when the relay is first applied, the user can preload a separate amount of wear for each pole of the breaker using the serial port command **BRE W n** (or **BRE n W**). All integer values of percent wear are accepted by the relay. The incremental wear for the next interruption, and all subsequent interruptions, is added to the prestored value for a total wear value.

When the cumulative wear on any breaker pole reaches 100 percent, Relay Word bits are set to one for the particular pole, as well as for the breaker containing that pole. For example, for Breaker “n” the Relay Word bits for the three poles are designated $BCWAn$, $BCWBn$, and $BCWCn$; for the breaker itself, Relay Word bit $BCWn$ is set to one if any of the individual pole bits are set to one. These bits may be used for alarm or display purposes to alert the user that breaker inspection and maintenance may be required.

After breaker maintenance is performed or a new breaker installed, the breaker monitor operation counters, cumulative interrupted currents by pole, and percent wear by pole should be reset to zero. This can be done via the **BRE R n** (or **BRE n R**) serial port command or from the front panel via the {OTHER} pushbutton menu.

Both the **BRE W n** and **BRE R n** commands can be executed from Access Level B or 2.

Breaker Wear Example

A breaker having the wear curve of *Figure 5.5* experiences a fault current interruption of 17,000 A. Previous accumulated wear is 44 percent.

The fault current falls between $BnKAP2$ (8 kA) and $BnKAP3$ (20 kA). The second equation is used to calculate $O(I)$.

$$\begin{aligned} O(I) &= 46,284 \cdot 17^{-2.756} \\ &= 46,284 \cdot 0.00041 \\ &= 18.81 \end{aligned} \quad \text{Equation 5.7}$$

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 Report Function (BRE Command)

The accumulators for each breaker can be reviewed either by a serial port command **BRE** or via the front-panel display, using the {OTHER} pushbutton menu.

The report lists all breakers, giving the number of internal and external trips for each breaker, the total accumulated rms current by phase, and the Percent Wear by pole. The operation accumulators for each trip type have a maximum value of 65,000 trips. The current accumulators for each trip type have a maximum value of 99,999.00 kA rms. Percent Wear never exceeds 100 percent. The accumulators can be reset by the serial port command **BRE n R** or via the {OTHER} front-panel pushbutton menu. The serial port report format is shown below.

```

=>BRE <Enter>

XFMR 1                                     Date: 04/21/97      Time: 14:52:14.179
STATION A

BREAKER 1
Int Trips=      0   IAW1=      0.00  IBW1=      0.00  ICW1=      0.00  kA(pri)
Ext Trips=      0   IAW1=      0.00  IBW1=      0.00  ICW1=      0.00  kA(pri)
Percent Wear:    POLE1=      0  POLE2=      0  POLE3=      0

BREAKER 2
Int Trips=      0   IAW2=      0.00  IBW2=      0.00  ICW2=      0.00  kA(pri)
Ext Trips=      0   IAW2=      0.00  IBW2=      0.00  ICW2=      0.00  kA(pri)
Percent Wear:    POLE1=      0  POLE2=      0  POLE3=      0

BREAKER 3
Int Trips=      0   IAW3=      0.00  IBW3=      0.00  ICW3=      0.00  kA(pri)
Ext Trips=      0   IAW3=      0.00  IBW3=      0.00  ICW3=      0.00  kA(pri)
Percent Wear:    POLE1=     11  POLE2=     22  POLE3=     33

BREAKER 4
Int Trips=      0   IAW4=      0.00  IBW4=      0.00  ICW4=      0.00  kA(pri)
Ext Trips=      0   IAW4=      0.00  IBW4=      0.00  ICW4=      0.00  kA(pri)
Percent Wear:    POLE1=      0  POLE2=      0  POLE3=      0

LAST BREAKER MONITOR RESET FOR   Bkr1:   04/21/97      14:35:15.742
                                   Bkr2:   04/21/97      14:35:15.821
                                   Bkr3:   04/21/97      14:35:15.898
                                   Bkr4:   04/21/97      14:35:15.975

==>>

```

Thermal Monitor (SEL-387-6 Relay)

The thermal report functions provide information about the thermal status of the transformer(s) monitored by the SEL-387-6. There are four different types of thermal reports that display the present thermal status, event reports, hourly profile data, and daily profile data.

This section describes the quantities used in each of the reports and shows the format for each of the **THERM** command displays as they appear on the screen.

Thermal Monitor Report Function (THE Command)

The **THERM** or **THE** command, with no additional parameters, displays the present thermal status of the transformer(s) monitored by the relay. If an alarm condition is detected (one or more of the thermal Relay Word bits are set), the relay saves a snapshot of the thermal status of the transformer to EEPROM. The format for the **THE** report is as follows:

NOTE: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 displays only the values for Transformer 1; but when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 displays the values for Transformer 1, Transformer 2, and Transformer 3.

=>>THE <Enter>		
XFMR 1	Date: 05/21/00	Time: 14:17:35.045
STATION A		
FID=SEL-387-6-Xxxx-V0-Z001001-Dxxxxxxxxx		
Transformer 1		
Thermal Element Condition	:	NORMAL
Load(Per Unit)	:	0.96
In Service Cooling Stage	:	1
Ambient (deg. C)	:	15.0
Calculated Top Oil (deg. C)	:	23.4
Measured Top Oil (deg. C)	:	400.0
Winding Hot Spot (deg. C)	:	46.7
Aging Acceleration Factor, FAA	:	0.00
Rate of LOL (%/day)	:	0.00
Total Accumulated LOL (%)	:	0.00
Time-Assert TLL (hours)	:	0.00
Transformer 2		
Thermal Element Condition	:	NORMAL
Load(Per Unit)	:	0.96
In Service Cooling Stage	:	1
Ambient (deg. C)	:	15.0
Calculated Top Oil (deg. C)	:	23.4
Measured Top Oil (deg. C)	:	400.0
Winding Hot Spot (deg. C)	:	46.7
Aging Acceleration Factor, FAA	:	0.00
Rate of LOL (%/day)	:	0.00
Total Accumulated LOL (%)	:	0.00
Time-Assert TLL (hours)	:	0.00
Transformer 3		
Thermal Element Condition	:	NORMAL
Load(Per Unit)	:	0.96
In Service Cooling Stage	:	1
Ambient (deg. C)	:	15.0
Calculated Top Oil (deg. C)	:	23.4
Measured Top Oil (deg. C)	:	400.0
Winding Hot Spot (deg. C)	:	46.6
Aging Acceleration Factor, FAA	:	0.00
Rate of LOL (%/day)	:	0.00
Total Accumulated LOL (%)	:	0.00
Time-Assert TLL (hours). . . .	:	0.00

Thermal Event Report
Quantities

Thermal Element Conditions

The load condition value can be Normal, Warning 1, Warning 2, or Warning 3.

Table 5.1 Thermal Element Conditions

Value	Description
Normal	TO1, TO2, HS1, HS2, FAA1, FAA2, CSE, RLL, and TLL Relay Word bits are not asserted.
Warning 1	TO1, HS1, FAA1, RLL, or TLL Relay Word bit is asserted.
Warning 2	TO2, HS2, FAA2 Relay Word bit is asserted.
Warning 3	CSE Relay Word bit is asserted.

Load Current

The load current is reported as a per-unit value based on the transformer rating.

In-Service Cooling Stage

The active cooling system is displayed. The displayed value is 1 for Cooling Stage 1, 2 for Cooling Stage 2, and 3 for Cooling Stage 3. The SEL-387-6 selects the cooling stage with the aid of contact inputs or SELOGIC control equation expressions defined in settings. The settings are defined by SELOGIC control equations, using defined contact inputs or any Relay Word elements to switch transformer constants based on the cooling stage. Only one of the cooling stages can be active at a time.

Ambient Temperature

The value displayed (in degrees Celsius) is either the actual ambient temperature received from the serial port or the value of the default ambient temperature setting (DTMP), if actual temperatures are not received by the relay.

Calculated Top-Oil Temperature

The value displayed (in degrees Celsius) is the top-oil temperature of the transformer computed using the load current. The maximum value displayed is 3276°C.

Measured Top-Oil Temperature

The value displayed (in degrees Celsius) is the top-oil temperature of the transformer received from the serial port. If no data (or invalid data) are received from the serial port, the value displayed is -0-.

Winding Hot-Spot Temperature

The value displayed (in degrees Celsius) is the computed value of the winding hot-spot temperature using the actual ambient and top-oil temperatures or the load current. The maximum value displayed is 3276°C.

Aging Acceleration Factor

The value displayed is the active insulation aging acceleration factor (FAA). The maximum value of FAA is clamped at 9999.0.

Rate of Loss of Life

The value displayed is the computed daily rate of loss of life (percent) accumulated in a 24-hour period. This value is updated at midnight daily.

Total Loss of Life

The value displayed represents the total accumulated loss of life (percent) since last reset.

Time to Assert TLL

The value displayed represents the estimated time (in hours) to assert the total loss-of-life alarm (TLL Relay Word bit).

Thermal Event Report
Function (THE n
Command)

Whenever a thermal alarm condition is set (load conditions are Warning 1, Warning 2, or Warning 3), the SEL-387-6 saves a snapshot of the thermal status of the transformer(s) in EEPROM. The five most recent thermal events are saved. If the command for retrieving the nth saved thermal event report is **THE n**, where *n* is a number from one to five, **THE 1** will display the most recent event report while **THE 5** will display the oldest thermal event report. The format and data for the **THE n** report are the same as for the **THE** report.

Thermal Profile Data
Report Function
(THE H and THE D
Commands)

The SEL-387-6 stores two types of trend data: one set on an hourly basis for the last 24 hours; a second set on a daily basis for the last 31 days. The format of the retrieved data report is suitable for display in Microsoft® Excel.

Hourly Profile Data Report (THE H Command)

NOTE: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 displays only the values for Transformer 1; when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 displays the values for Transformer 1, Transformer 2, and Transformer 3.

The SEL-387-6 stores the following data on an hourly basis for the last 24 hours. The data are stored at the beginning of each hour.

- One-hour average ambient temperature
- One-hour average calculated top-oil temperature
- One-hour average measured top-oil temperature
- One-hour average winding hot-spot temperature
- One-hour average per-unit load current
- One-hour average insulation aging acceleration factor (FAA)

The format for the **THE H** report is as follows:

```

-->>THE H <Enter>

XFMR 1                                     Date: 04/24/00      Time: 13:20:03.956
STATION A
FID=SEL-387-6-X117-V0-Z001001-D20000419

Transformer 1

Date      Time      Ambient      Calc      Measured      Load      FAA
      Time      Temp      Top Oil      Top Oil      Hot Spot      Current
04/24/00 13:00*    15.0        32.5        -0-          32.7        0.04      0.0
04/24/00 12:00*    15.0        32.5        -0-          32.8        0.05      0.0

Transformer 2

Date      Time      Ambient      Calc      Measured      Load      FAA
      Time      Temp      Top Oil      Top Oil      Hot Spot      Current
04/24/00 13:00*    15.0        32.5        -0-          32.5        0.01      0.0
04/24/00 12:00*    15.0        32.5        -0-          32.5        0.02      0.0

Transformer 3

Date      Time      Ambient      Calc      Measured      Load      FAA
      Time      Temp      Top Oil      Top Oil      Hot Spot      Current
04/24/00 13:00*    15.0        32.5        -0-          32.7        0.05      0.0
04/24/00 12:00*    15.0        32.5        -0-          32.7        0.06      0.0
-->>

```

Daily Profile Data Report Function (THE D Command)

NOTE: When the thermal model is applied on one three-phase transformer (XTYPE = 3), the SEL-387-6 displays only the values for Transformer 1; but when the thermal model is applied on a set of three single-phase transformers (XTYPE = 1), the SEL-387-6 displays the values for Transformer 1, Transformer 2, and Transformer 3.

The relay stores the following on a daily basis (at midnight) for the last 30 days:

- Maximum ambient temperature
- Maximum calculated top-oil temperature
- Maximum measured top-oil temperature

- Maximum winding hot-spot temperature
- Maximum per-unit load
- Maximum insulation aging acceleration factor (FAA)
- Daily 24-hour accumulated loss of life (value of accumulated 24-hour loss of life at midnight)
- Total accumulated loss of life (sum of the daily 24-hour accumulated loss of life values)
- * showing a communication failure

The format for the **THE D** report is as follows:

```

=>THE D <Enter>

XFMR 1                                     Date: 04/25/00   Time: 00:00:43.248
STATION A
FID=SEL-387-6-X117-V0-Z001001-D20000419

Transformer 1
      Max      Max Calc Max Msd      Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0   32.6   -0-   34.2   0.48   0.0   0.00   0.00

Transformer 2
      Max      Max Calc Max Msd      Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0   32.6   -0-   34.2   0.48   0.0   0.00   0.00

Transformer 3
      Max      Max Calc Max Msd      Max
Date  Ambient Top Oil Top Oil Hot Spot Max Load Max FAA RL0L TL0L
04/25/00 15.0   32.6   -0-   34.2   0.48   0.0   0.00   0.00
=>>

```

Retrieving Thermal Data Reports

Thermal data reports are accessed with the **THE** command in the following different ways:

Table 5.2 Using the THE Command to Access Data Reports (Sheet 1 of 2)

Example THE Serial Port Commands	Format
THE	Enter THE command with no additional parameters to display the present status of the monitored transformer.
THE 1	Enter THE command followed by a number (1 in this example) to display the latest archived thermal event report.
THE D	Enter THE command followed by D and no additional parameters to display all available daily profile data records.
THE H	Enter THE command followed by an H but with no additional parameters to display all available hourly profile data records. The chronological progression through the report is down the page and in descending order.
THE H (or D) 3/30/00	Enter THE H (or D) followed by the date (3/30/00 in this example) to display all records (if they exist) starting with that date and ending with the present date. The records display with the latest record at the beginning (top) of the report and the oldest record at the end (bottom) of the report. Chronological progression through the report is down the page and in descending order.

Table 5.2 Using the THE Command to Access Data Reports (Sheet 2 of 2)

Example THE Serial Port Commands	Format
THE D (or H) 2/17/00 3/07/00	Enter THE D (or H) followed by two dates (2/17/00 chronologically precedes 3/07/00 in this example) to display all the records (if they exist) between (and including) those dates. The records display with the latest record (3/07/00) at the beginning (top) of the report and the oldest record (2/17/00) at the end (bottom) of the report.
THE D 3/07/00 2/17/00	Enter THE D (or H) followed by two dates (3/07/00 chronologically follows date 2/17/00 in this example) to display all records (if they exist) between (and including) those dates. The records display with the latest record (3/07/00) at the beginning (top) of the report and the oldest record (2/17/00) at the end (bottom) of the report.

The date entries in the examples for the **THE H** and **THE D** commands are dependent on the Date Format setting DATE_F. If setting DATE_F = MDY, enter the dates as in the above examples (Month/Day/Year). If setting DATE_F = YMD, enter the dates Year/Month/Day.

If the requested **THE** hourly or daily profile records do not exist, the relay responds: Invalid Record. If there are no data in the hourly or daily profile buffers, the relay responds: No Data Available.

Thermal Monitor
Reset Functions
(THE R, THE C, and
THE P Commands)

The **THE C** (Clear Thermal Archives Function) command clears the daily profile archives, hourly profile archives, and the thermal event archives.

The **THE R** (Reset Thermal Function) command clears all the thermal archives (daily profile data, hourly profile data, and thermal event data) and resets the total accumulated loss-of-life value to its preset value (if it exists) or zero.

Using the **THE P n** (Load Preset Value of Total Loss of Life) command, the user can preset the initial loss-of-life values for each phase of the monitored transformer. The command must be followed by a value between zero and 100 percent. This command initializes the total loss-of-life value to the preset value entered by the user, clears all the thermal archive data, and restarts the thermal element.

Through-Fault Event Monitor

Figure 5.6 shows a distribution feeder fault beyond the protection zone of the SEL-387-5 and SEL-387-6 Relays. Nevertheless, the fault current passes through the transformer bank, subjecting the windings to mechanical stress and the winding insulation to thermal stress. The more feeders on a distribution bus, the more the transformer bank is exposed to these through faults.

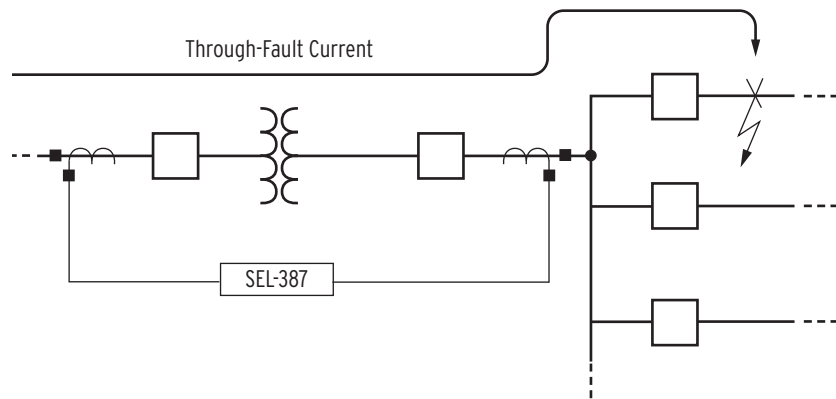


Figure 5.6 Distribution Feeder Faults Expose Transformer Bank to Through Faults

Monitor and document this through-fault activity with the through-fault event monitor in the SEL-387-5 and SEL-387-6 relays. The through-fault event monitor captures maximum current levels, duration, and date/time for each transformer through fault. The monitor also performs a simple I^2t calculation (analogous to the energy expended during the through fault) and cumulatively stores calculation results for each monitored phase.

Through-Fault Event Monitor Settings

Activate and adjust the through-fault event monitor with the settings in *Table 5.3*.

Table 5.3 Through-Fault Event Monitor Settings

Setting	Definition	Range
ETHRU	Enable Through-Fault Event Winding	N, 1, 2, 3, 4
THRU	Through-Fault Event Trigger (SELOGIC control equation)	Relay Word bits (<i>Table 4.9</i>)
ISQT	Through-Fault I^2t Alarm Threshold	OFF, 0-4294967 (kA) ² seconds

NOTE: The above examples show the designated current inputs (ETHRU = 2) and triggering element (THRU = 50P23) both from Winding 2. While this is a common setting approach, triggering elements can be from any winding or be of any element available in *Table 4.9* (e.g., THRU = IN101; set to trigger a through-fault event on the assertion of input IN101).

Setting ETHRU = N turns off the through-fault event monitor. Any other setting selection for ETHRU designates the winding to monitor for through-fault events. For example, ETHRU = 2 designates Winding 2 as the winding to monitor for through-fault events. Specifically, Winding 2 current inputs IAW2, IBW2, and ICW2 (A-phase, B-phase, and C-phase, respectively) are monitored for maximum currents for through-fault events. Changing setting ETHRU resets/clears through-fault event information (see **TFE C** and **TFE R** command discussions that follow).

Setting THRU triggers the through-fault event—the through-fault event monitor starts acquiring maximum current and duration information, along with a date/time tag. Typically, the THRU setting is set with an overcurrent element. For example, set THRU to trigger a through-fault event on the pickup of a phase instantaneous overcurrent element on Winding 2:

THRU = 50P23

To block triggering of through-fault events resulting from transformer inrush, consider settings such as

THRU = 50P23 * !87BL

Figure 5.7 shows the time progression of a through fault, such as that in Figure 5.6. Typically, SELLOGIC setting THRU would be set to some instantaneous overcurrent element (e.g., THRU = 50P23). When THRU asserts at the outset of the through fault, event duration timing begins. When THRU de-asserts (e.g., the distribution feeder breaker interrupts the fault), through-fault event duration timing ends and the duration time is recorded for that event.

If SELLOGIC setting THRU is asserted (by whatever means), then maximum currents are recorded for the monitored current inputs. Figure 5.7 shows the current jumping up to a short-term maximum before being interrupted (perhaps the feeder fault “burned through” and became more “bolted”). This short-term maximum current, which occurred within the duration timing, is what gets recorded for the particular monitored phase.

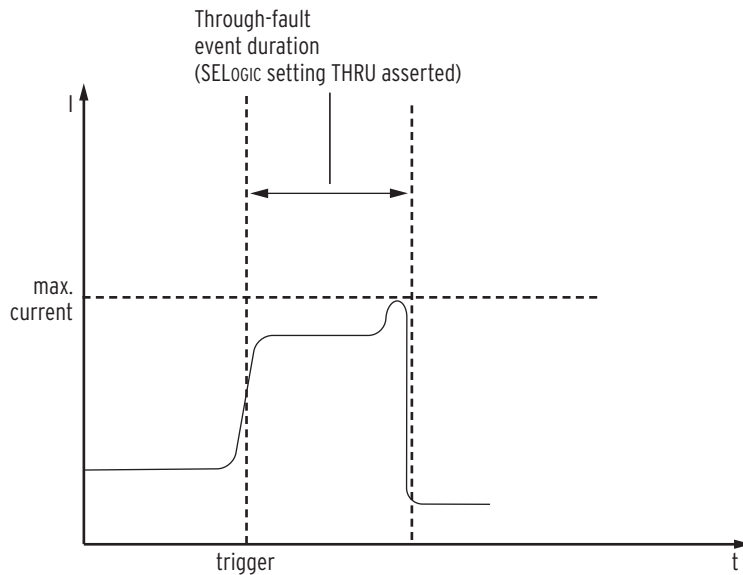


Figure 5.7 Through-Fault Triggering, Duration, and Maximum Current

Through-Fault Calculation

The through-fault event monitor uses the recorded duration time value and maximum currents to perform simple I^2t calculations and cumulatively store results of these calculations for each monitored phase. For example, if a through fault is 6000 A primary (maximum) and lasts 0.067 sec., the monitor would calculate I^2t for that event as follows:

$$(6 \text{ kA})^2 \cdot 0.067 \text{ sec.} = 2.412 (\text{kA})^2 \text{ seconds} \quad \text{Equation 5.8}$$

If the above calculation were for the example in Figure 5.7, it would be a conservative calculation (i.e., the calculation would indicate more I^2t stress/wear than actually occurred). This is because the current peaked momentarily.

Through-Fault Alarm

Figure 5.8 shows an I^2t alarm, with Through-Fault I^2t Alarm Threshold setting ISQT. When the cumulative I^2t for any monitored phase exceeds setting threshold ISQT, Relay Word bit ISQTAL (I-squared-t alarm) asserts. Setting threshold ISQT would usually be set to alarm for excessive, cumulative transformer bank stress, as such stress corresponds to a certain level of cumulative I^2t . Output Relay Word bit ISQTAL can be assigned to an output for annunciation or perhaps also be used to modify distribution feeder autoreclosing (e.g., reduce the number of reclosures from 3 to 2).

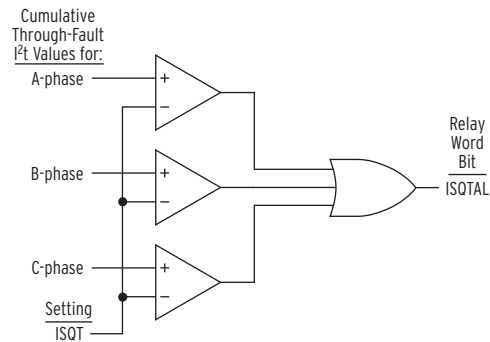


Figure 5.8 Cumulative I²t Alarm (Relay Word bit ISQTAL)

Through-Fault Event (TFE) Serial Port Command

The **TFE** command displays the following discussed data for each individually recorded through-fault event:

- Date and time of the through fault
- Duration (seconds) of the through fault
- Maximum current (A primary) for each monitored current input

The following cumulative values (updated for each new through-fault event) are also displayed:

- Through-fault count
- Simple I²t calculation for each monitored current input

Relay response to the **TFE** command is:

```

=>TFE <Enter>

XFMR 1                               Date: 02/12/04   Time: 18:59:49.130
STATION A

FID=SEL-387E-X300-V0-Z102102-D20040211
Number of Through Faults:      2   Last Reset: 02/10/04 19:56:22
Winding 1 Total I-squared-t (kA^2 seconds, primary):
    A-phase    B-phase    C-phase
      1.783      88.270      6.610

#      Date      Time      Duration      IA      IB      IC
      (seconds)  (A, primary max)
1 02/14/04 18:59:22.244    5.002    241    4158    260
2 02/11/04 11:37:55.495   30.834    220     241    451

```

In the above response, only two through-fault events have been recorded since the monitor was last reset (most recent event listed first, labeled #1). Notice also that Winding 1 is the winding whose current inputs are being monitored.

The **TFE** command just by itself (no parameters, as in the above example) can list as many as 20 through-fault events. To list all the stored through-fault events since the monitor was last reset, execute the **TFE A** command. To list a particular number of through-fault events, execute the **TFE n** command ($n = 1$ to 1200; 1200 is the maximum number of through-fault events that can be stored before overwriting begins).

To reset the cumulative through-fault count, reset cumulative I^2t , and clear out the stored through-fault events, execute the **TFE C** (clear) or **TFE R** (reset) command. The relay responds:

```
=>TFE R <Enter>
Clear Through Fault Event Buffer
Are you sure (Y/N) ? Y <Enter>
Clearing Complete
=>
```

Changing Global setting ETHRU also has the same effect as executing the **TFE C** or **TFE R** command.

Preload the following cumulative through-fault count and I^2t values:

- 10 through-fault counts
- 147.8 (kA)² seconds on A-phase
- 303.5 (kA)² seconds on B-phase
- 237.9 (kA)² seconds on C-phase

Execute the **TFE P** command to preload these values. The relay responds:

```
=>TFE P <Enter>
Number of Through Faults Preload = 2? 10 <Enter>

Winding 1 Total I-squared-t Preload (kA^2 seconds, primary):
A-phase = 1.783? 147.8 <Enter>
B-phase = 88.270? 303.5 <Enter>
C-phase = 6.610? 237.9 <Enter>
Are you sure (Y/N) ? Y <Enter>
```

If the **TFE** command is then executed, the response shows the new preloaded values (the through-fault events at bottom are not disturbed):

```
=>TFE <Enter>

XFMR 1                                Date: 02/12/04    Time: 18:59:49.130
STATION A

FID=SEL-387E-X300-V0-Z102102-D20040211
Number of Through Faults: 10    Last Reset: 02/10/04 19:56:22
Winding 1 Total I-squared-t (kA^2 seconds, primary):
  A-phase    B-phase    C-phase
  147.800    303.500    237.900

#      Date      Time      Duration      IA      IB      IC
      (seconds)  (A, primary max)
1 02/14/04 18:59:22.244    5.002    241    4158    260
2 02/11/04 11:37:55.495    30.834    220    241    451
```

Deriving Cumulative I^2t Values for Preloading

If cumulative I^2t values need to be derived for preloading, refer first to *Through-Fault Calculation on page 5.20* to see how individual I^2t calculations are made (even though this referenced subsection refers to how the relay does the calculation automatically, the same approach is still valid for “hand” calculations). In the referenced subsection, notice how the example 6000 A (6 kA) fault value is handled in the calculation, so that the resultant comes out in units of (kA)² seconds. All the individual I^2t calculations, for the corresponding faults on a specific phase, are then summed together to create a cumulative I^2t value that can then be preloaded for that phase. Use the previously discussed **TFE P** command to preload the cumulative I^2t values for each phase.

Magnitude Limits on Through-Fault Event Data

In the above **TFE** command responses, there are limits, besides the aforementioned 1200 event limit on stored through-fault events, to data accumulation. These limits are:

- “Number of Through Faults” counts: 65,535 counts
- “Total I-squared-t” (per phase): 4,294,967.295 kA² seconds
- “Duration” for through-fault event: 8191 cycles, converted to seconds
- “IA, IB, IC” for through-fault event 65,535 A, primary

If any of these values exceed their limits, a plus sign (+) is appended to the above maximum limit number in the display. If “Duration” or “IA, IB, IC” values are at their maximums or beyond, then the monitor uses the above maximum values in performing subsequent simple I²t calculations and cumulatively storing calculation results for each monitored phase.

All these through-fault event data are stored in nonvolatile memory.

Status Monitor

The status monitor of the SEL-387 is designed to provide information on the internal health of the major components of the relay. The relay continuously runs a variety of self-tests. Some tests have warning and failure states; others only have failure states.

Status Monitor Report Function (STATUS Command)

The **STATUS** command displays a report of the self-test diagnostics. The relay automatically executes the **STATUS** command whenever the self-test software enters a warning or failure state.

If a warning or failure state occurs, the next time the **STA** command is issued, the warning state is reported. If a warning or failure occurs, it will not be cleared until relay power is cycled and the problem is fixed. Saving relay settings performs a warm boot of relay logic. This may clear some warnings. If warnings persist, contact the factory.

Below is the **STATUS** report format. All warnings, represented by a **W** in the status report, generate an automatic serial port message and pulse the **ALARM** output contact for five seconds. All failures, represented by an **F** in the status report, generate an automatic serial port message, display the failure on the front-panel display, and latch the **ALARM** output contact.

```
=>STA <Enter>

XFMR 1                               Date: 04/25/00   Time: 00:23:54.259
STATION A
FID=SEL-387-6-X117-V0-Z001001-D20000419  CID=2001
SELF TESTS

W=Warn  F=Fail

OS      IAW1  IBW1  ICW1  IAW2  IBW2  ICW2
        2      -0    2      1      1      1
OS      IAW3  IBW3  ICW3  IAW4  IBW4  ICW4
        4      3      0      3      2      -0
PS      +5V_PS +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
        4.95  5.00  -5.07  11.98 -12.17  14.92 -14.91
        TEMP  RAM   ROM   A/D   CR_RAM EEPROM IO_BRD
        41.1  OK    OK    OK    OK    OK    OK

Relay Enabled
```

The quantities shown in the **STATUS** report are discussed below. The applicable limits for warning or failure of each self-test are summarized in *Table 5.4*

The **{STATUS}** pushbutton on the front-panel interface can also be used to access the information in the report. See *Section 8: Front-Panel Interface*.

Channel Offset

The relay measures the dc offset (OS) voltage of each of the 12 analog current input channels and compares the value against a fixed limit of 30 mV. If an offset measurement is outside the fixed limit, the relay declares a warning.

Power Supply

The relay measures the internal power supply (PS) voltages and regulated +5 and -5 voltages, and compares the values against fixed limits. If a voltage measurement is outside the limits, the relay declares a warning or failure.

Temperature

The relay measures its internal temperatures (TEMP). If the relay measures a temperature less than 40°C or greater than +85°C, it issues a warning. If the relay measures a temperature less than 50°C or greater than +100°C, it issues a failure. 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 state for the test.

EEPROM

EEPROM is checked by computing a checksum. If the computed value does not agree with the stored value, the relay declares a EEPROM failure. There is no warning state 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 5.4 summarizes the limits for issuing warning or failure alarms during self-testing. The power supply and temperature alarms list the lower values below which, and upper values above which, the stated alarm is issued.

Table 5.4 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/v5.40 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

Overview

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 <i>n</i>	Relay	Overcurrent elements for settings group <i>n</i> (<i>n</i> = 1, 2, 3, 4, 5, 6).
SET G	Global	Battery and breaker monitors, etc.
SET R	SER	Sequential Events Recorder trigger conditions.
SET P <i>n</i>	Port	Serial port settings for Serial Port <i>n</i> (<i>n</i> = 1, 2, 3, or 4).

View settings with the respective serial port **SHOWSET** commands (**SHO**, **SHO G**, **SHO R**, **SHO P**). See discussion of *SHO (Show Group 1—6 Settings)* on page 7.29. *Settings Sheets* are located at the end of this section.

Settings Changes Via the Front Panel

The relay front-panel {SET} pushbutton provides access to the Relay, Global, and Port settings only. Thus, the corresponding Relay, Global, and Port settings sheets that follow in this section can also be used when making these settings via the front panel. Refer to *Figure 8.8* for information on front-panel settings.

Settings Changes Via the Serial Port

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...4). The relay selects the active group or port if *m* is not specified.

s = the name of the specific setting you want 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 want 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 typically are used to identify the equipment protected by the relay or the identifier of the circuit breaker(s) controlled by the relay. The relay tags event reports with the Relay and Terminal Identifier Strings. This allows you to distinguish the event report as one generated for a specific breaker and substation. The RID setting is limited to 39 characters and the TID setting to 59 characters. For our example, we have selected RID = XFMR1 and TID = STATION A.

Demand Ammeter Settings (DATC, PDEM, QDEM, NDEM)

The relay provides demand ammeters for Windings 1 through 4, for phase, negative-sequence, and residual currents. The relay saves time- and date-stamped peak demand readings for each of the quantities. View this information using the relay front panel or serial port **METER** commands.

The demand ammeters behave much like low-pass filters, responding to gradual trends in the current magnitude. The relay uses the demand ammeter time constant setting, **DATC_n**, for all 5 demand ammeter calculations for Winding “*n*.” The time constant is settable from 5 to 255 minutes. The demand ammeters operate such that if demand current is reset and a constant input current is applied, the demand current output will be 90 percent of the constant input current value **DATC_n** minutes later.

Settable demand ammeter thresholds are available for all five demand ammeters in units of amperes secondary. The thresholds are **PDEM_{nP}**, **QDEM_{nP}**, and **NDEM_{nP}** 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 **PDEM_n**, **QDEM_n**, or **NDEM_n** asserts. You can use these Relay Word bits to alarm for phase overload and negative-sequence or residual current unbalance, for Winding “*n*.” See *Section 5: Metering and Monitoring* for more information.

For our example, the Demand Ammeter function is enabled only for Winding 1, the 230 kV primary winding, with the following settings: **DATC1** = 15 minutes, **PDEM1P** = 7 A, **QDEM1P** = 1 A, and **NDEM1P** = 1 A.

The demand ammeter settings can be different in the six settings groups.

Instantaneous metering functions have no settings. These functions show primary phase, negative-sequence, and residual current magnitudes; secondary winding current magnitudes and angles; differential quantities (operate, restraint, second- and fifth-harmonics) in multiples of tap. Access is by the front panel or one of the communications ports.

Input and Output Assignments

Optoisolated inputs (**IN101** through **IN106**) and contact outputs (**OUT101** through **OUT107**) are fully programmable, with no numbered input or output specifically dedicated to a function. The one exception is the **ALARM** contact, factory-set as a form-B contact (normally closed), and dedicated to the alarm function. **OUT107** can be made into an additional alarm contact that follows the normal **ALARM** contact via JMP23 on the main board (see *Section 2: Installation*). Standard SELOGIC® control equations can be written to drive the output contacts. The inputs appear as elements of SELOGIC control equations. Examples of this are illustrated in *Trip and Close Logic on page 6.4*. These settings can be different in the six settings groups.

Trip and Close Logic

The *Settings Sheets* contain two specific areas highlighting the assignment of variables for the **Trip Logic** and **Close Logic**. These functions, along with those in the **Output Contact Logic** area, must be programmed in order for the relay to take action. Settings in all three areas are SELOGIC control equations.

There are five trip variables to define conditions under which a trip will be issued. These are named TR1 to TR5. This will cover trip conditions for four separate breakers, plus one extra for a general trip of all breakers. The settings for the example transformer application illustrate this.

In the example, TR1 through TR3 are set to respond to overcurrent elements specific to the winding associated with Breakers 1 to 3. For example, $TR1 = 50P11T + 51P1T + 51Q1T$. Complete operation of the phase definite-time or inverse-time elements, or the negative-sequence inverse-time element, will set the appropriate Relay Word bits $5xxxT$ to one, and TR1 will respond to any of them. TR1 initiates the Trip Logic, producing output of the logic and setting of Relay Word bit TRIP1 to one. For tripping Breaker 2, $TR2 = 51P2T + 51Q2T$. For tripping Breaker 3, $TR3 = 50P31 + 51P3T$. Technically, $50P31T$ should have been used, since this would indicate that the definite-time element has timed out. However, since $50P31$ is set for zero delay, or is instantaneous, there is no reason to wait. For group tripping of all three breakers, $TR4 = 87R + 87U$. This results in a tripping output to an external 86 lockout device, which then trips the three breakers with separate contacts. This takes place only if a differential operation, either restrained or unrestrained, is detected. TR5 is not used, and is set to zero.

In general, definition of the TR1 and TR5 variables should include only Relay Word bits 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 five settings. Exceptions might be bits used for opening the breaker by command during nonfault conditions, such as the OCn bits or the remote bits, RBn .

When the trip logic is activated, and one or more Relay Word bits TRIP1 to TRIP4 are set to one, a trip can take place. However, in order for this to happen an output contact must be assigned for each trip. These assignments are made on the Output Contact Logic setting sheet area. In this case, $OUT101 = TRIP1$, $OUT102 = TRIP2$, $OUT103 = TRIP3$, and $OUT104 = TRIP4$. $OUT101$ to $OUT103$ go directly to the three breaker trip coils, and $OUT104$ goes to the 86 operate coil. These connections are shown in *Figure 2.9*.

Corresponding to the five trip variables in the Trip Logic setting area are five unlatch variables. The variables ULTR1 to ULTR5 define the conditions to unlatch the seal-in of trip logic that takes place when TRn goes to one. They sense when it is appropriate to 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. ULTR5 is not used and is set to zero.

In the Close Logic setting area, inputs are defined to represent the 52a auxiliary contacts from the individual breakers. Defined as well are the four Close and four Unlatch Close variables, if the closing function is to be used.

In our example, inputs **IN101** to **IN103** are assigned to represent the 52a contacts. That is, $52A1 = IN101$, $52A2 = IN102$, and $52A3 = IN103$. (Note again that inputs appear on the right side of an equation, outputs on the left side.) **52A4** is not used, and is set to zero. The connections for the 52a inputs are shown in *Figure 2.9*.

The four Close variables **CL1** through **CL4** are set up to define the conditions under which a closing can take place. In our example, these are set up to respond to a **CLOSE *n*** command from a communications port, or an external contact input from a SCADA RTU or other switch. Specifically, $CL1 = CC1 + /IN104$, $CL2 = CC2 + /IN105$, and $CL3 = CC3 + /IN106$, where “/” denotes detection of a “rising edge” for the input shown. **CL4** is not used, and is set to zero. Within these SELOGIC control equations, inputs **IN104** to **IN106** have been defined as being related to the close initiation function for the specific breakers. The **CL_n** variable initiates the close logic, resulting in Relay Word bit **CLS_n** being set to one, unless the logic is disabled by an unlatch condition, discussed below. Note that connections for the closing function are not shown in *Figure 2.9*.

Closing can now take place, but only if an output contact has been assigned to this function. Returning to the Output Contact Logic setting area for our example, we set $OUT105 = CLS1$, $OUT106 = CLS2$, and $OUT107 = CLS3$. These contacts must be wired to the closing circuits of the individual breakers.

In the Close Logic setting area, four variables remain. **ULCL1** to **ULCL4** define the conditions for unlatching the close logic. These are set in our example to be the presence of any trip logic output. That is, $ULCL1 = TRIP1 + TRIP4$, $ULCL2 = TRIP2 + TRIP4$, and $ULCL3 = TRIP3 + TRIP4$. **ULCL4** is not used and is set to zero. **ULCL_n** will remove the seal-in of the close logic and return Relay Word bit **CLS_n** to zero. A closed 52a contact or a Close Failure Detection will also unlatch the Close Logic. The output contact that follows the **CLS_n** bit will open in response.

The Trip Logic and Close Logic settings can be set differently in the six setting groups. See *Section 4: Control Logic* for more information on Trip and Close Logic.

There are two additional miscellaneous timer settings that apply to the Trip and Close Logic. These are **TDURD** and **CFD**. **TDURD** is the minimum trip duration time and defines the minimum length of time the trip signal will be issued, regardless of other inputs to the Trip Logic. The default setting is 9 cycles. The **CFD**, or Close Failure Detection time delay, is an overriding timer to unlatch the close logic if the breaker has not yet closed. The default setting is 60 cycles.

Event Report Triggering (ER) and Length Selection (LER, PRE)

There are three settings for Event Reports: (1) **ER**, (2) **LER**, and (3) **PRE**.

The first, **ER**, defines in a SELOGIC control equation the conditions under which a report will be generated. In our example, $ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3$. Events will be generated from the pickup of the various overcurrent elements, whether they fully time out or not. This will yield reports for some external faults that do not result in tripping of the transformer breakers, but for which information might be useful. Winding 3 element pickup is used to detect external tertiary circuit faults that may be too weak to be detected by the Winding 1 elements. Also, since tertiary circuits normally are short, probably only including the substation buses and auxiliary equipment, reports on faults of any kind would be of great interest.

The LER setting defines how long the overall report should be: 15, 30, or 60 cycles. The related setting PRE defines how much of that length should be “pre-trigger,” and can be set from one cycle to LER-1 cycles. We have selected the standard SEL report length of 15 for LER, with PRE set at 4, giving 15-4 = 11 cycles of fault data. This is probably long enough to capture the entire event, for trips by high-speed elements (87R, 87U, 50Pxx), but may not be long enough for inverse-time trips. Since any trip will generate an Event Report, inverse-time trips may be captured on two reports, one generated by element pickup and the other by the eventual trip.

Event Report settings are Global settings, accessible with a **SET G** command from a communications port.

System Frequency (NFREQ) and Phase Rotation (PHROT)

The relay settings NFREQ and PHROT establish your basic system parameters for the SEL-387.

1. Set NFREQ equal to the nominal power system operating frequency, either 50 Hz or 60 Hz.
2. Set PHROT to the power system phase rotation, either ABC or ACB.

These are Global settings, set after issuing a **SET G** command from a communications port.

Miscellaneous (DATE_F, SCROLL, FP_TO, TGR)

There are four miscellaneous settings to complete the setting process. These are the following:

- Date format
- Front-panel time-out
- Scroll data
- Group change delay

These settings are Global settings, accessible with the **SET G** command from a communications port or the front panel.

The DATE_F setting permits the user to define either a Month-Day-Year (MDY) format or a Year-Month-Day (YMD) format for all relay date reporting. Default is MDY.

Use the display update rate (SCROLL or scroll data) setting to control how long each pair of display text messages is displayed on the front panel. Setting range is 1 to 60 seconds with a default of 2 seconds.

The front-panel time-out setting, FP_TO, defines the length of time before the panel returns to normal default scrolling displays and LED targeting. This feature is useful for preventing the panel from being accidentally left in a display state that was being used during testing or to confirm Relay Word bit status. It can be set from 0 to 30 minutes; default is 16 minutes.

The Group Change Delay timer setting, TGR, defines the amount of time that must pass before a new group of settings take effect. It requires the conditions to change to a new group to persist for time TGR before the relay enacts the new settings. The setting range is 0 through 900 seconds. The factory default value is 3 seconds. This function prevents the relay from jumping around from group to group in response to spurious fulfillment of the SS1 setting conditions and ensures that a request for change is real and justified.

DC Battery Monitor (DC1P-DC4P)

The DC Battery Monitor function is described in *Section 5: Metering and Monitoring*. You can choose one of four dc voltage thresholds, DC1P through DC4P, to assert Relay Word bits DC1 to DC4 when supply voltage to the relay exceeds the specific threshold. This allows the user to readily determine if the voltage is within certain limits and to alarm if the voltage goes too high or low. The four threshold settings are found in the Global setting area.

Breaker Monitor

The Breaker Monitor function is described fully in *Section 5: Metering and Monitoring*. There is one setting for each of four breakers, BKMON1 through BKMON4. This setting accepts a SELOGIC control equation using Relay Word elements to describe the triggering conditions for that particular monitor. When triggered, the monitor measures the three-phase currents 1.5 cycles after triggering, adds them to the total accumulated current for that breaker, and adds one to the external or internal trip counter, depending on whether the associated TRIP variable was asserted at time of triggering.

In addition, for each breaker there is a contact wear curve, defined by entering three operations versus current coordinate pairs. This curve is applied by pole to track and alarm when excessive contact wear is encountered. This helps the user schedule breaker maintenance intervals.

Analog Input Labels

In the Global setting area, the user can rename the 12 analog current inputs to suit local preferences. The present names, IAW1 through ICW4, can be replaced with other designations of not more than four characters. This function recognizes the need by 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 **STa**tuS, **BR**EaKer, **EV**Ent, and **ME**Ter, including the variants of each command. The new labels will also appear in the front-panel LCD displays for the {**STATUS**} and {**METER**} pushbutton menus.

Setting Group Selection

In the Global settings there are settings to define which of the six settings groups is to be the active group. Use the **SET G** command from a communications port to access settings SS1 to SS6. The front panel cannot be used to access or change these settings. The settings are defined by SELOGIC control equations, using defined contact inputs or any Relay Word elements to switch groups. The simplest method is to set a value of one for the SS n setting corresponding to the desired settings group “ n .” The SELOGIC control equations permit greater user flexibility in defining when to switch setting groups. If any variable SS1 to SS6 is asserted, the **GRO n** serial port command and the front-panel {**GROUP**} pushbutton cannot be used to change setting groups.

Front-Panel Targeting, Displays, and Control

There are settings for elements of the front-panel display, if the user is interested in customizing an LED target or display for a specific function. Three of the 16 front-panel LEDs are fully programmable. These are the **FAULT TYPE A, B, C** LEDs in the second row. The default settings for these LEDs are based on phase selection logic for overcurrent trips or differential trips by a specific element. For example, the A-phase LED is programmed normally as follows: LEDA = OCA + 87E1. This means that the LED will come on if it is determined that A-phase was involved in an overcurrent trip or that differential element 1 issued a trip. The user can define any SELOGIC control equation to operate these targets by programming LEDA, LEDB, or LEDC.

There are 16 programmable display points, for creating customized messages on the LCD display. They appear in pairs and stay on screen for two seconds before scrolling to the next display. The variables DP1 through DP16 are defined by a SELOGIC control equation that at any time will have a logical value of 0 or 1. For each DP m there are two settings showing the display content. These are DP m _1 and DP m _0. The relay displays any nonblank DP m _1 or _0 values if the current logical value of DP m corresponds. The LED and display point settings are Global settings, accessible with the **SET G** command from a communications port.

Use local control to enable/disable schemes, trip/close breakers, and so on via the front panel. Local control asserts (sets to logical 1) or deasserts (sets to logical 0) local bits LB1 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC control equations.

For more information on the LEDs, display points, and Local Bits, see *Section 8: Front-Panel Interface*.

Sequential Events Recorder

The SER, or Sequential Events Recorder, lists up to 512 events. This can help the user in determining the correct order of operation during a complicated event with multiple device operations within a short time interval. The settings for the SER are the trigger conditions and the Relay Word bit ALIAS names. Up to 96 total Relay Word bit names can be selected and entered into settings SER1, SER2, SER3, and SER4, in any order, with a maximum of 24 bits in any SER n . Up to 20 Relay Word bits can be given ALIAS names to make the SER report more user friendly. For example, a given input can be given an ALIAS that designates a 52a input for a specific named breaker.

The SER settings are made after issuing the **SET R** command from a communications port. The SER operation and settings are described fully in *Section 9: Event Reports and SER*.

Communications Ports

There are four communications ports on the SEL-387. Port 1 is an EIA-485 port on the rear panel. Ports 2 and 3, also on the rear panel, are EIA-232. Port 4 is an EIA-232 on the front panel. These ports are set via the **SET P** command. To identify the port by which one is presently communicating with the relay, issue the **SHO P** command, which lists settings for that port.

Initial connection to the relay can be made with standard SEL protocol, at 2400 baud, 8 data bits, No parity, 1 stop bit, and VT100 emulation, using any standard communications program such as Microsoft Windows 95 HyperTerminal®.

Complete information on the communications ports and necessary settings can be found in *Section 7: Serial Port Communications and Commands*.

Default Settings

SEL-387 Default Settings (5 A)

```
=>>SHO <Enter>
Group 1

RID      =XFMR 1
TID      =STATION A
E87W1    = Y      E87W2    = Y      E87W3    = Y      E87W4    = N
EOC1     = Y      EOC2     = Y      EOC3     = Y      EOC4     = N
EOCC     = N
ETHER    = Y      E49A     = N      E49B     = N
ESLS1    = N      ESLS2    = N      ESLS3    = N

W1CT     = Y      W2CT     = Y      W3CT     = Y      W4CT     = Y
CTR1     = 120    CTR2     = 240    CTR3     = 400    CTR4     = 400
MVA      = 100.0  ICOM     = Y
W1CTC    = 11     W2CTC    = 11     W3CTC    = 0
VWDG1    = 230.00 VWDG2    = 138.00 VWDG3    = 13.80

TAP1     = 2.09   TAP2     = 1.74   TAP3     = 10.46
O87P     = 0.30   SLP1     = 25     SLP2     = 50     IRS1     = 3.0
U87P     = 10.0   PCT2     = 15     PCT5     = 35
TH5P     = OFF    IHBL     = N

E32I     =0

Press RETURN to continue

50P11P   = 20.00  50P11D   = 5.00   50P11TC  =1
50P12P   = OFF    50P12D   = 5.00   50P12TC  =1
50P13P   = 0.50   50P14P   = 4.00   51P1TD   = 3.00   51P1RS   = Y
51P1P    = 4.00   51P1C    = U2     51P1TD   = 3.00   51P1RS   = Y
51P1TC   =1

50Q11P   = OFF    50Q12P   = OFF    51Q1TD   = 3.00   51Q1RS   = Y
51Q1P    = 6.00   51Q1C    = U2     51Q1TD   = 3.00   51Q1RS   = Y
51Q1TC   =1

50N11P   = OFF    50N12P   = OFF
51N1P    = OFF    PDEM1P   = 7.00   QDEM1P   = 1.00   NDEM1P   = 1.00
DATC1    = 15

50P21P   = OFF    50P22P   = OFF    51P2TD   = 3.50   51P2RS   = Y
50P23P   = 0.50   50P24P   = 3.50   51P2C    = U2
51P2P    = 3.50   51P2C    = U2
51P2TC   =1

Press RETURN to continue

50Q21P   = OFF    50Q22P   = OFF    51Q2TD   = 3.50   51Q2RS   = Y
51Q2P    = 5.25   51Q2C    = U2     51Q2TD   = 3.50   51Q2RS   = Y
51Q2TC   =1

50N21P   = OFF    50N22P   = OFF
51N2P    = OFF    PDEM2P   = 7.00   QDEM2P   = 1.00   NDEM2P   = 1.00
DATC2    = 15

50P31P   = 7.00   50P31D   = 0.00   50P31TC  =1
50P32P   = OFF    50P32D   = 0.00   50P32TC  =1
50P33P   = 0.50   50P34P   = 4.00   51P3TD   = 1.30   51P3RS   = Y
51P3P    = 4.00   51P3C    = U2     51P3TD   = 1.30   51P3RS   = Y
51P3TC   =1

50Q31P   = OFF    50Q32P   = OFF
51Q3P    = OFF    50Q32P   = OFF
50N31P   = OFF    50N32P   = OFF
51N3P    = OFF

Press RETURN to continue
DATC3    = 15     PDEM3P   = 7.00   QDEM3P   = 1.00   NDEM3P   = 1.00
TMWDG    = 1      VWDG     = 230.00  XTYPE    = 3      TRTYPE   = Y
Thwr     = 65     NCS      = 1
MCS11    = 100.0  TRDE     =0
DTMP     = 15     AMB      = THM1   OIL1     = THM2
NTHM     = 2      TOT2     = 100   HST1     = 200
TOT1     = 100    HST2     = 200

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FAAL1	= 50.00	FAAL2	= 50.00	RLOLL	= 50.00	TLOLL	= 50.00
CSEP1	= 15						
ILIFE	= 180000	EDFTC	= Y				
TDURD	= 9.000	CFD	= 60.000				

TR1	=50P11T + 51P1T + 51Q1T + 0C1 + LB3
TR2	=51P2T + 51Q2T + 0C2
TR3	=50P31 + 51P3T + 0C3
TR4	=87R + 87U
TR5	=0
ULTR1	=!50P13
ULTR2	=!50P23

Press RETURN to continue

ULTR3	=!50P33
ULTR4	=!(50P13 + 50P23 + 50P33)
ULTR5	=0
52A1	=IN101
52A2	=IN102
52A3	=IN103
52A4	=0
CL1	=CC1 + LB4 + /IN104
CL2	=CC2 + /IN105
CL3	=CC3 + /IN106
CL4	=0
ULCL1	=TRIP1 + TRIP4
ULCL2	=TRIP2 + TRIP4
ULCL3	=TRIP3 + TRIP4
ULCL4	=0
ER	=/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101	=TRIP1
OUT102	=TRIP2
OUT103	=TRIP3
OUT104	=TRIP4

Press RETURN to continue

OUT105	=CLS1
OUT106	=CLS2
OUT107	=CLS3

SCEUSE	46.8
GR1CHK	A577

=>>

SEL-387 Default Settings (1 A)

=>>SH0 <Enter>
Group 1

RID	-XFMR 1						
TID	-STATION A						
E87W1	= Y	E87W2	= Y	E87W3	= Y	E87W4	= N
E0C1	= Y	E0C2	= Y	E0C3	= Y	E0C4	= N
E0CC	= N						
ETHER	= Y	E49A	= N	E49B	= N		
ESLS1	= N	ESLS2	= N	ESLS3	= N		
W1CT	= Y	W2CT	= Y	W3CT	= Y	W4CT	= Y
CTR1	= 600	CTR2	= 1200	CTR3	= 2000	CTR4	= 2000
MVA	= 100.0	ICOM	= Y				
W1CTC	= 11	W2CTC	= 11	W3CTC	= 0		
VWDG1	= 230.00	VWDG2	= 138.00	VWDG3	= 13.80		
TAP1	= 0.42	TAP2	= 2.35	TAP3	= 2.09		
O87P	= 0.30	SLP1	= 25	SLP2	= 50	IRS1	= 3.0
U87P	= 10.0	PCT2	= 15	PCT5	= 35		
TH5P	= OFF	IHLB	= N				

E32I = 0

Press RETURN to continue

50P11P = 4.00	50P11D = 5.00	50P11TC =1	
50P12P = OFF			
50P13P = 0.10	50P14P = 0.80		
51P1P = 0.80	51P1C = U2	51P1TD = 3.00	51P1RS = Y
51P1TC =1			
50Q11P = OFF	50Q12P = OFF		
51Q1P = 1.20	51Q1C = U2	51Q1TD = 3.00	51Q1RS = Y
51Q1TC =1			
50N11P = OFF	50N12P = OFF		
51N1P = OFF			
DATC1 = 15	PDEM1P = 1.40	QDEM1P = 0.20	NDEM1P = 0.20

50P21P = OFF 50P22P = OFF
50P23P = 0.10 50P24P = 0.70
51P2P = 0.70 51P2C = U2 51P2TD = 3.50 51P2RS = Y
51P2TC = 1

Press RETURN to continue

50Q21P	= OFF	50Q22P	= OFF				
51Q2P	= 1.05	51Q2C	= U2	51Q2TD	= 3.50	51Q2RS	= Y
51Q2TC	= 1						
50N21P	= OFF	50N22P	= OFF				
51N2P	= OFF						
DATC2	= 15	PDEM2P	= 1.40	QDEM2P	= 0.20	NDEM2P	= 0.20

50P31P = 1.40 50P31D = 0.00 50P31TC =1
50P32P = OFF
50P33P = 0.10 50P34P = 0.80
51P3P = 0.80 51P3C = U2 51P3TD = 1.30 51P3RS = Y
51P3TC =1

```
50Q31P  = OFF      50Q32P  = OFF
51Q3P   = OFF
50N31P  = OFF      50N32P  = OFF
51N3P   = OFF
```

```

Press RETURN to continue
DATC3   = 15          PDEM3P  = 1.40          QDEM3P  = 0.20          NDEM3P  = 0.20

```

TMWDG	= 1	VWDG	= 230.00	XTYPE	= 3	TRTYPE	= Y
THwr	= 65	NCS	= 1				
MCS11	= 100.0						
DTMP	= 15	TRDE	= 0				
NTMH	= 2	AMB	= THM1	OIL1	= THM2		
TOT1	= 100	TOT2	= 100	HST1	= 200	HST2	= 200
FAAL1	= 50.00	FAAL2	= 50.00	RLOLL	= 50.00	TLOLL	= 50.00
CSEP1	= 15						
ILIFE	= 180000	EDFTC	= Y				
TDURD	= 9.000	CFD	= 60.000				

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```

TR1      =50P11T + 51P1T + 51Q1T + 0C1 + LB3
TR2      =51P2T + 51Q2T + 0C2
TR3      =50P31 + 51P3T + 0C3
TR4      =87R + 87U
TR5      =0
ULTR1    =!50P13
ULTR2    =!50P23

Press RETURN to continue
ULTR3    =!50P33
ULTR4    =!(50P13 + 50P23 + 50P33)
ULTR5    =0
52A1     =IN101
52A2     =IN102
52A3     =IN103
52A4     =0
CL1      =CC1 + LB4 + /IN104
CL2      =CC2 + /IN105
CL3      =CC3 + /IN106
CL4      =0
ULCL1    =TRIP1 + TRIP4
ULCL2    =TRIP2 + TRIP4
ULCL3    =TRIP3 + TRIP4
ULCL4    =0
ER       =/50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101   =TRIP1
OUT102   =TRIP2
OUT103   =TRIP3
OUT104   =TRIP4

Press RETURN to continue
OUT105   =CLS1
OUT106   =CLS2
OUT107   =CLS3

SCEUSE    46.8
GR1CHK    A526
=>>

```

The Group settings shown above are the only settings that are different from the 5 A relay settings. The Global, Port, and SER settings remain the same.

Settings Sheets

The rest of this section consists of Settings Sheets and an example of how the sheets could be filled out.

You can photocopy the Settings Sheets and write your settings on the copy before you enter the settings in the relay. The Settings Sheets begin with the Group Settings (**SET** Command), followed by Global Settings (**SET G** Command), Sequential Events Recorder Settings (**SET R** Command), and Port Settings (**SET P** Command).

Following the Settings Sheets is an example of how the sheets could be filled out. As with the Settings Sheets, the example begins with the Group Settings (**SET** Command), followed by Global Settings (**SET G** Command), Sequential Events Recorder Settings (**SET R** Command), and Port Settings (**SET P** Command).

You can download blank editable Microsoft® Word settings sheets from the SEL website: selinc.com/literature/settings-sheets/.

SEL-387-0, -5, -6 Relay 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 4 in Differential Element (Y, N, Y1) **E87W4** = _____

 Enable Winding 1 O/C Elements and Dmd Thresholds (Y, N) **EOC1** = _____

 Enable Winding 2 O/C Elements and Dmd Thresholds (Y, N) **EOC2** = _____

 Enable Winding 3 O/C Elements and Dmd Thresholds (Y, N) **EOC3** = _____

 Enable Winding 4 O/C Elements and Dmd Thresholds (Y, N) **EOC4** = _____

 Enable Combined O/C Elements (Y, N) **EOCC** = _____

 Enable Thermal Element (Y, N) (SEL-387-6 Relay only) **ETHER** = _____

 Enable RTDA Element (Y, N)
(SEL-387-5 and SEL-387-6 Relays only) **E49A** = _____

 Enable RTDB Element (Y, N)
(SEL-387-5 and SEL-387-6 Relays only) **E49B** = _____

 Enable SELOGIC® Control Equations Set 1 (Y, N) **ESLS1** = _____

 Enable SELOGIC Control Equations Set 2 (Y, N) **ESLS2** = _____

 Enable SELOGIC Control Equations Set 3 (Y, N) **ESLS3** = _____

General Data

 Winding 1 CT Connection (D, Y) **W1CT** = _____

 Winding 2 CT Connection (D, Y) **W2CT** = _____

 Winding 3 CT Connection (D, Y) **W3CT** = _____

 Winding 4 CT Connection (D, Y) **W4CT** = _____

 Winding 1 CT Ratio (1–50000) **CTR1** = _____

 Winding 2 CT Ratio (1–50000) **CTR2** = _____

Winding 3 CT Ratio (1–50000)	CTR3	= _____
Winding 4 CT Ratio (1–50000)	CTR4	= _____
Maximum Power Transformer Capacity (OFF, 0.2–5000 MVA)	MVA	= _____
Define Internal CT Connection Compensation (Y, N)	ICOM	= _____
Winding 1 CT Conn. Compensation (0, 1, ..., 12)	W1CTC	= _____
Winding 2 CT Conn. Compensation (0, 1, ..., 12)	W2CTC	= _____
Winding 3 CT Conn. Compensation (0, 1, ..., 12)	W3CTC	= _____
Winding 4 CT Conn. Compensation (0, 1, ..., 12)	W4CTC	= _____
Winding 1 Line-to-Line Voltage (1–1000 kV)	VWDG1	= _____
Winding 2 Line-to-Line Voltage (1–1000 kV)	VWDG2	= _____
Winding 3 Line-to-Line Voltage (1–1000 kV)	VWDG3	= _____
Winding 4 Line-to-Line Voltage (1–1000 kV)	VWDG4	= _____

Differential Elements

NOTE: TAP1-TAP4 are auto-set by relay if MVA setting is not OFF.

Winding 1 Current Tap (0.50–155.00 A secondary) (5 A) (0.10–31.00 A secondary) (1 A)	TAP1	= _____
Winding 2 Current Tap (0.50–155.00 A secondary) (5 A) (0.10–31.00 A secondary) (1 A)	TAP2	= _____
Winding 3 Current Tap (0.50–155.00 A secondary) (5 A) (0.10–31.00 A secondary) (1 A)	TAP3	= _____
Winding 4 Current Tap (0.50–155.00 A secondary) (5 A) (0.10–31.00 A secondary) (1 A)	TAP4	= _____
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%) (all but SEL-387-0 Relay)	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) (all but SEL-387-0 Relay)	DCRB	= _____
Harmonic Restraint (Y, N) (all but SEL-387-0 Relay)	HRSTR	= _____
Independent Harmonic Blocking (Y, N)	IHBL	= _____

Restricted Earth Fault

Enable 32I (SELOGIC control equation)

E32I = _____

Operating Quantity from Wdg. 1, Wdg. 2, Wdg. 3
(1, 2, 3, 12, 23, 123) **32IOP** = _____

Positive-Sequence Current Restraint Factor, I0/I1 (0.02–0.50) **a0** = _____

Residual Current Sensitivity Threshold

(0.25–15.00 A secondary) (5 A)

(0.05–3.00 A secondary) (1 A) **50GP** = _____

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** = _____

Winding 4 O/C Elements

Winding 4 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) **50P41P** = _____

Phase Level 1 O/C Delay (0–16000 cycles)

50P41D = _____

50P41 Torque Control (SELOGIC control equation)

50P41TC = _____

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) **50P42P** = _____

50P42 Torque Control SELOGIC control equation)

50P42TC = _____

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) **50P43P** = _____

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A) **50P44P** = _____

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A) **51P4P** = _____

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P4C = _____

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00) **51P4TD** = _____

Phase Inv.-Time O/C EM Reset (Y, N) **51P4RS** = _____

51P4 Torque Control (SELOGIC control equation)
51P4TC = _____

Winding 4 Negative-Sequence O/C Elements

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

Neg.-Seq. Def.-Time O/C Level 1 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) **50Q41P** = _____

Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles) **50Q41D** = _____

50Q41 Torque Control SELOGIC control equation)
50Q41TC = _____

Neg.-Seq. Inst. O/C Level 2 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) **50Q42P** = _____

50Q42 Torque Control (SELOGIC control equation)
50Q42TC = _____

Neg.-Seq. Inv.-Time O/C PU
(OFF, 0.5–16.0 A secondary) (5 A)
(OFF, 0.1–3.2 A secondary) (1 A) **51Q4P** = _____

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5) **51Q4C** = _____

Neg.-Seq. Inv.-Time O/C Time-Dial
(US 0.5–15.0, IEC 0.05–1.00) **51Q4TD** = _____

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N) **51Q4RS** = _____

51Q4 Torque Control SELOGIC control equation)
51Q4TC = _____

Winding 4 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU
(OFF, 0.25–100.00 A secondary) (5 A)
(OFF, 0.05–20.00 A secondary) (1 A) **50N41P** = _____

Residual Level 1 O/C Delay (0–16000 cycles) **50N41D** = _____

50N41 Torque Control (SELOGIC control equation)
50N41TC = _____

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

(OFF, 0.05–20.00 A secondary) (1 A)

50N42P = _____

50N42 Torque Control (SELOGIC control equation)

50N42TC = _____

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

51N4P = _____

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N4C = _____

Residual Inv.-Time O/C Time-Dial

(US 0.5–15.0, IEC 0.05–1.00)

51N4TD = _____

Residual Inv.-Time O/C EM Reset (Y, N)

51N4RS = _____

51N4 Torque Control (SELOGIC control equation)

51N4TC = _____

Winding 4 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

DATC4 = _____

Phase Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

PDEM4P = _____

Neg.-Seq. Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

QDEM4P = _____

Residual Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

(OFF, 0.1–3.2 A secondary) (1 A)

NDEM4P = _____

Combined O/C Elements

NOTE: The combined overcurrent elements use a normalization factor that scales the secondary current magnitude to the larger of the two winding CT ratios. See 51PCm and 51NCm Combined Overcurrent Element (m = 1, 2) on page 3.54 for details and examples for the combined overcurrent 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 = _____

W3–W4 Phase O/C Element

W3–W4 Phase Inv.-Time O/C PU
(OFF, 0.5–16.0 A secondary) (5 A)
(OFF, 0.1–3.2 A secondary) (1 A)
** Must be OFF if Restricted Earth Fault is used.*

51PC2P* = _____

W3–W4 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC2C = _____

W3–W4 Phase Inv.-Time O/C Time-Dial
(US 0.5–15.0, IEC 0.05–1.00)

51PC2TD = _____

W3–W4 Phase Inv.-Time O/C EM Reset (Y, N)

51PC2RS = _____

W3–W4 Residual O/C Element

W3–W4 Residual Inv.-Time O/C PU
(OFF, 0.5–16.0 A secondary) (5 A)
(OFF, 0.1–3.2 A secondary) (1 A)
** Must be OFF if Restricted Earth Fault is used.*

51NC2P* = _____

W3–W4 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC2C = _____

W3–W4 Residual Inv.-Time O/C Time-Dial
(US 0.5–15.0, IEC 0.05–1.00)

51NC2TD = _____

W3–W4 Residual Inv.-Time O/C EM Reset (Y, N)

51NC2RS = _____

Thermal Element (SEL-387-6 Relay Only)

Thermal Model Winding Current (1, 2, 3, 4, 12, 34)

TMWDG = _____

Winding LL Voltage (1–1000 kV)

VWDG = _____

Transformer Construction (1, 3)

XTYPE = _____

Transformer Type (D, Y)

TRTYPE = _____

Winding Temp/Amb (65, 55)	THwr	= _____
Number of Cooling Stages (1–3)	NCS	= _____
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS11	= _____
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS21	= _____
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS31	= _____
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS12	= _____
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS22	= _____
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS32	= _____
Cooling Stage 2 (SELOGIC control equation) CS12S		= _____
Cooling Stage 2 (SELOGIC control equation) CS22S		= _____
Cooling Stage 2 (SELOGIC control equation) CS32S		= _____
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS13	= _____
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS23	= _____
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS33	= _____
Cooling Stage 3 (SELOGIC control equation) CS13S		= _____
Cooling Stage 3 (SELOGIC control equation) CS23S		= _____
Cooling Stage 3 (SELOGIC control equation) CS33S		= _____
Default Ambient Temp. –40–85°C)	DTMP	= _____
De-energized Transformer (SELOGIC control equation) TRDE		= _____
Number Thermal Inputs (0–4)	NTHM	= _____

Thermal Function Settings for SEL-387-6 Firmware Revisions R404 and Earlier

Thermal Function (AMB, OIL1, OIL2, OIL3)	THM1	= _____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM2	= _____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM3	= _____
Thermal Function (AMB, OIL1, OIL2, OIL3)	THM4	= _____

Thermal Function Settings for SEL-387-6 Firmware Revisions R606 and Later

Ambient Temperature (THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)	AMB	= _____
Top-Oil Temperature 1 (THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)	OIL1	= _____
Top-Oil Temperature 2 (THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)	OIL2	= _____
Top-Oil Temperature 3 (THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)	OIL3	= _____
Top-Oil Temp. Limit 1 (50–150°C)	TOT1	= _____
Top-Oil Temp. Limit 2 (50–150°C)	TOT2	= _____
Hot-Spot Limit 1 (80–300°C)	HST1	= _____
Hot-Spot Limit 2 (80–300°C)	HST2	= _____
Aging Acceleration Factor Limit 1 (0.00–599.99)	FAAL1	= _____
Aging Acceleration Factor Limit 2 (0.00–599.99)	FAAL2	= _____
Daily Loss-of-Life Limit (0.00–99.99%)	RLOLL	= _____
Total Loss-of-Life Limit (0.00–99.99%)	TLOLL	= _____
Cooling System Efficiency-Transformer 1 (5–100°C)	CSEP1	= _____
Cooling System Efficiency-Transformer 2 (5–100°C)	CSEP2	= _____
Cooling System Efficiency-Transformer 3 (5–100°C)	CSEP3	= _____

General Cooling System Constants

Nominal Insulation Life (1000–999999 hr)	ILIFE	= _____
Enable Default Constants (Y/N)	EDFTC	= _____

Transformer 1

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths1	= _____
Constant to Calc. FAA (0–100000)	BFFA1	= _____
Cooling Stage 1 Constants		
Top-Oil Rise/Amb (0.1–100.0°C)	THor11	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr11	= _____
Ratio Losses (0.0–100.0)	RATL11	= _____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR11	= _____
Oil Exponent (0.1–5)	EXPn11	= _____
Winding Exponent (0.1–5)	EXPm11	= _____

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor12	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr12	= _____
Ratio Losses (0.0–100.0)	RATL12	= _____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR12	= _____
Oil Exponent (0.1–5)	EXPn12	= _____
Winding Exponent (0.1–5)	EXPm12	= _____

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor13	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr13	= _____
Ratio Losses (0.0–100.0)	RATL13	= _____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR13	= _____
Oil Exponent (0.1–5)	EXPn13	= _____
Winding Exponent (0.1–5)	EXPm13	= _____

Transformer 2

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths2	= _____
Constant to Calc. FAA (0–100000)	BFFA2	= _____

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor21	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr21	= _____
Ratio Losses (0.0–100.0)	RATL21	= _____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR21	= _____
Oil Exponent (0.1–5)	EXPn21	= _____
Winding Exponent (0.1–5)	EXPm21	= _____

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor22	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr22	= _____
Ratio Losses (0.0–100.0)	RATL22	= _____
Oil Thermal Time Constant (0.1–20.0 hr)	OTR22	= _____
Oil Exponent (0.1–5)	EXPn22	= _____
Winding Exponent (0.1–5)	EXPm22	= _____

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor23	= _____
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr23	= _____
Ratio Losses (0.0–100.0)	RATL23	= _____

Oil Thermal Time Constant (0.1–20.0 hr)

OTR23 = _____

Oil Exponent (0.1–5)

EXPn23 = _____

Winding Exponent (0.1–5)

EXPm23 = _____**Transformer 3**

Hot-Spot Thermal Time Constant (0.01–2.00 hr)

Ths3 = _____

Constant to Calc. FAA (0–100000)

BFFA3 = _____

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)

THor31 = _____

Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)

THgr31 = _____

Ratio Losses (0.0–100.0)

RATL31 = _____

Oil Thermal Time Constant (0.1–20.0 hr)

OTR31 = _____

Oil Exponent (0.1–5)

EXPn31 = _____

Winding Exponent (0.1–5)

EXPm31 = _____

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)

THor32 = _____

Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)

THgr32 = _____

Ratio Losses (0.0–100.0)

RATL32 = _____

Oil Thermal Time Constant (0.1–20.0 hr)

OTR32 = _____

Oil Exponent (0.1–5)

EXPn32 = _____

Winding Exponent (0.1–5)

EXPm32 = _____

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)

THor33 = _____

Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)

THgr33 = _____

Ratio Losses (0.0–100.0)

RATL33 = _____

Oil Thermal Time Constant (0.1–20.0 hr)

OTR33 = _____

Oil Exponent (0.1–5)

EXPn33 = _____

Winding Exponent (0.1–5)

EXPm33 = _____**RTD A Elements (SEL-387-5 and SEL-387-6 Relays Only)**

RTD 1A Alarm Temperature (OFF, 32–482°F)

49A01A = _____

RTD 1A Trip Temperature (OFF, 32–482°F)

49T01A = _____

RTD 2A Alarm Temperature (OFF, 32–482°F)

49A02A = _____

RTD 2A Trip Temperature (OFF, 32–482°F)

49T02A = _____

RTD 3A Alarm Temperature (OFF, 32–482°F)

49A03A = _____

RTD 3A Trip Temperature (OFF, 32–482°F)

49T03A = _____

RTD 4A Alarm Temperature (OFF, 32–482°F)	49A04A	= _____
RTD 4A Trip Temperature (OFF, 32–482°F)	49T04A	= _____
RTD 5A Alarm Temperature (OFF, 32–482°F)	49A05A	= _____
RTD 5A Trip Temperature (OFF, 32–482°F)	49T05A	= _____
RTD 6A Alarm Temperature (OFF, 32–482°F)	49A06A	= _____
RTD 6A Trip Temperature (OFF, 32–482°F)	49T06A	= _____
RTD 7A Alarm Temperature (OFF, 32–482°F)	49A07A	= _____
RTD 7A Trip Temperature (OFF, 32–482°F)	49T07A	= _____
RTD 8A Alarm Temperature (OFF, 32–482°F)	49A08A	= _____
RTD 8A Trip Temperature (OFF, 32–482°F)	49T08A	= _____
RTD 9A Alarm Temperature (OFF, 32–482°F)	49A09A	= _____
RTD 9A Trip Temperature (OFF, 32–482°F)	49T09A	= _____
RTD 10A Alarm Temperature (OFF, 32–482°F)	49A10A	= _____
RTD 10A Trip Temperature (OFF, 32–482°F)	49T10A	= _____
RTD 11A Alarm Temperature (OFF, 32–482°F)	49A11A	= _____
RTD 11A Trip Temperature (OFF, 32–482°F)	49T11A	= _____
RTD 12A Alarm Temperature (OFF, 32–482°F)	49A12A	= _____
RTD 12A Trip Temperature (OFF, 32–482°F)	49T12A	= _____

RTD B Elements (SEL-387-5 and SEL-387-6 Relays Only)

RTD 1B Alarm Temperature (OFF, 32–482°F)	49A01B	= _____
RTD 1B Trip Temperature (OFF, 32–482°F)	49T01B	= _____
RTD 2B Alarm Temperature (OFF, 32–482°F)	49A02B	= _____
RTD 2B Trip Temperature (OFF, 32–482°F)	49T02B	= _____
RTD 3B Alarm Temperature (OFF, 32–482°F)	49A03B	= _____
RTD 3B Trip Temperature (OFF, 32–482°F)	49T03B	= _____
RTD 4B Alarm Temperature (OFF, 32–482°F)	49A04B	= _____
RTD 4B Trip Temperature (OFF, 32–482°F)	49T04B	= _____
RTD 5B Alarm Temperature (OFF, 32–482°F)	49A05B	= _____
RTD 5B Trip Temperature (OFF, 32–482°F)	49T05B	= _____
RTD 6B Alarm Temperature (OFF, 32–482°F)	49A06B	= _____
RTD 6B Trip Temperature (OFF, 32–482°F)	49T06B	= _____

RTD 7B Alarm Temperature (OFF, 32–482°F)	49A07B	= _____
RTD 7B Trip Temperature (OFF, 32–482°F)	49T07B	= _____
RTD 8B Alarm Temperature (OFF, 32–482°F)	49A08B	= _____
RTD 8B Trip Temperature (OFF, 32–482°F)	49T08B	= _____
RTD 9B Alarm Temperature (OFF, 32–482°F)	49A09B	= _____
RTD 9B Trip Temperature (OFF, 32–482°F)	49T09B	= _____
RTD 10B Alarm Temperature (OFF, 32–482°F)	49A10B	= _____
RTD 10B Trip Temperature (OFF, 32–482°F)	49T10B	= _____
RTD 11B Alarm Temperature (OFF, 32–482°F)	49A11B	= _____
RTD 11B Trip Temperature (OFF, 32–482°F)	49T11B	= _____
RTD 12B Alarm Temperature (OFF, 32–482°F)	49A12B	= _____
RTD 12B Trip Temperature (OFF, 32–482°F)	49T12B	= _____

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

(S3LT1 To S3LT8 are not included in the SEL-387-0 Relay)

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** = _____**TR5** = _____**ULTR1** = _____**ULTR2** = _____**ULTR3** = _____**ULTR4** = _____**ULTR5** = _____

Close Logic

52A1 = _____**52A2** = _____**52A3** = _____**52A4** = _____**CL1** = _____**CL2** = _____**CL3** = _____**CL4** = _____**ULCL1** = _____**ULCL2** = _____**ULCL3** = _____**ULCL4** = _____

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 = _____

Global Settings (SET G Command)

Relay Settings

Length of Event Report (15, 30, 60 cycles)	LER	= _____
Length of Pre-fault in Event Report (1 to (LER-1))	PRE	= _____
Nominal Frequency (50, 60 Hz)	NFREQ	= _____
Phase Rotation (ABC, ACB)	PHROT	= _____
Date Format (MDY, YMD)	DATE_F	= _____
Display Update Rate (1–60 seconds)	SCROLL	= _____
Front-Panel Time-out (OFF, 0–30 minutes)	FP_TO	= _____
Group Change Delay (0–900 seconds)	TGR	= _____
RTDA Temperature Preference (C, F) (SEL-387-5 and SEL-387-6 Relays only)	TMPREFA	= _____
RTDB Temperature Preference (C, F) (SEL-387-5 and SEL-387-6 Relays only)	TMPREFB	= _____

Battery Monitor

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

Breaker 1 Monitor

BKR1 Trigger Equation (SELOGIC control equation)	BKMON1	= _____
Close/Open Set Point 1 max (1–65000 operations)	B1COP1	= _____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B1KAP1	= _____
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	= _____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B1KAP2	= _____
Close/Open Set Point 3 max (1–65000 operations)	B1COP3	= _____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B1KAP3	= _____

Breaker 2 Monitor

BKR2 Trigger Equation (SELOGIC control equation)	BKMON2	= _____
Close/Open Set Point 1 max (1–65000 operations)	B2COP1	= _____

kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B2KAP1	= _____
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	= _____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B2KAP2	= _____
Close/Open Set Point 3 max (1–65000 operations)	B2COP3	= _____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B2KAP3	= _____

Breaker 3 Monitor

BKR3 Trigger Equation (SELOGIC control equation)

BKMON3 = _____

Close/Open Set Point 1 max (1–65000 operations)	B3COP1	= _____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B3KAP1	= _____
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	= _____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B3KAP2	= _____
Close/Open Set Point 3 max (1–65000 operations)	B3COP3	= _____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B3KAP3	= _____

Breaker 4 Monitor

BKR4 Trigger Equation (SELOGIC control equation)

BKMON4 = _____

Close/Open Set Point 1 max (1–65000 operations)	B4COP1	= _____
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B4KAP1	= _____
Close/Open Set Point 2 max (1–65000 operations)	B4COP2	= _____
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B4KAP2	= _____
Close/Open Set Point 3 max (1–65000 operations)	B4COP3	= _____
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B4KAP3	= _____

Through-Fault Event Monitor (SEL-387-5 and SEL-387-6 Relays)

Enable Through-Fault Event Winding (N, 1, 2, 3, 4) **ETHRU** = _____

NOTE: Changing setting ETHRU resets/clears through-fault event information.

Through-Fault Event Trigger (SELOGIC control equation)

THRU = _____

Through-Fault I²t Alarm Threshold

(OFF, 0–4294967 (kA)² seconds) **ISQT** = _____

Analog Input Labels

Rename Current Input IAW1 (1–4 characters)	IAW1	= _____
Rename Current Input IBW1 (1–4 characters)	IBW1	= _____
Rename Current Input ICW1 (1–4 characters)	ICW1	= _____
Rename Current Input IAW2 (1–4 characters)	IAW2	= _____
Rename Current Input IBW2 (1–4 characters)	IBW2	= _____
Rename Current Input ICW2 (1–4 characters)	ICW2	= _____
Rename Current Input IAW3 (1–4 characters)	IAW3	= _____
Rename Current Input IBW3 (1–4 characters)	IBW3	= _____
Rename Current Input ICW3 (1–4 characters)	ICW3	= _____
Rename Current Input IAW4 (1–4 characters)	IAW4	= _____
Rename Current Input IBW4 (1–4 characters)	IBW4	= _____
Rename Current Input ICW4 (1–4 characters)	ICW4	= _____

Setting Group Selection

Select Setting Group 1 (SELOGIC control equation)

SS1 = _____

Select Setting Group 2 (SELOGIC control equation)

SS2 = _____

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 (All But SEL-387-0 Relay)

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** = _____

Sequential Events Recorder Settings (SET R Command)

Trigger Conditions

Trigger SER (24 Relay Word bits per SER_n 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 = _____

Port Settings (SET P Command)

NOTE: RTSCTS setting does not appear if PROTO = LMD or DNP. LMD PREFIX, ADDR, and SETTLE do not appear if PROTO = SEL or DNP. See Appendix C: SEL Distributed Port Switch Protocol (LMD) for details on LMD protocol and see Appendix G: Distributed Network Protocol for details on DNP protocol.

Port 1 (SET P 1) Rear Panel, EIA-485 Plus IRIG-B

Port Protocol (SEL, LMD, DNP)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only] **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)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only] **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)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]

LMD Prefix (@, #, \$, %, &)

LMD Address (1–99)

LMD Settling Time (0–30 seconds)

Baud (300, 1200, 2400, 4800, 9600, 19200)

Data Bits (7, 8)

Parity Odd, Even, or None (O, E, N)

Stop Bits (1, 2)

Time-out (for inactivity) (0–30 minutes)

Send auto messages to port (Y, N)

Enable hardware handshaking (Y, N)

Fast Operate Enable (Y, N)

PROTO = _____
PREFIX = _____
ADDR = _____
SETTLE = _____
SPEED = _____
BITS = _____
PARITY = _____
STOP = _____
T_OUT = _____
AUTO = _____
RTSCTS = _____
FASTOP = _____

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

Port Protocol (SEL, LMD, DNP)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]

LMD Prefix (@, #, \$, %, &)

LMD Address (1–99)

LMD Settling Time (0–30 seconds)

Baud (300, 1200, 2400, 4800, 9600, 19200)

Data Bits (7, 8)

Parity Odd, Even, or None (O, E, N)

Stop Bits (1, 2)

Time-out (for inactivity) (0–30 minutes)

Send auto messages to port (Y, N)

Enable hardware handshaking (Y, N)

Fast Operate Enable (Y, N)

PROTO = _____
PREFIX = _____
ADDR = _____
SETTLE = _____
SPEED = _____
BITS = _____
PARITY = _____
STOP = _____
T_OUT = _____
AUTO = _____
RTSCTS = _____
FASTOP = _____

Port N (SET P N), EIA-232 for PROTO = RTDA

(SEL-387-5 and SEL-387-6 Relays only)

Number of RTDA (0–12)

RTD 1A Type (NA, PT100, NI100, NI120, CU10)

RTDNUMA = _____
RTD1TA = _____

RTD 2A Type (NA, PT100, NI100, NI120, CU10)

RTD2TA = _____

RTD 3A Type (NA, PT100, NI100, NI120, CU10)

RTD3TA = _____

RTD 4A Type (NA, PT100, NI100, NI120, CU10)

RTD4TA = _____

RTD 5A Type (NA, PT100, NI100, NI120, CU10)

RTD5TA = _____

RTD 6A Type (NA, PT100, NI100, NI120, CU10)

RTD6TA = _____

RTD 7A Type (NA, PT100, NI100, NI120, CU10)

RTD7TA = _____

RTD 8A Type (NA, PT100, NI100, NI120, CU10)

RTD8TA = _____

RTD 9A Type (NA, PT100, NI100, NI120, CU10)

RTD9TA = _____

RTD 10A Type (NA, PT100, NI100, NI120, CU10)

RTD10TA = _____

RTD 11A Type (NA, PT100, NI100, NI120, CU10)

RTD11TA = _____

RTD 12A Type (NA, PT100, NI100, NI120, CU10)

RTD12TA = _____**Port N (SET P N), EIA-232 for PROTO = RTDB**

(SEL-387-5 and SEL-387-6 Relays only)

Number of RTDB (0–12)

RTDNUMB = _____

RTD 1B Type (NA, PT100, NI100, NI120, CU10)

RTD1TB = _____

RTD 2B Type (NA, PT100, NI100, NI120, CU10)

RTD2TB = _____

RTD 3B Type (NA, PT100, NI100, NI120, CU10)

RTD3TB = _____

RTD 4B Type (NA, PT100, NI100, NI120, CU10)

RTD4TB = _____

RTD 5B Type (NA, PT100, NI100, NI120, CU10)

RTD5TB = _____

RTD 6B Type (NA, PT100, NI100, NI120, CU10)

RTD6TB = _____

RTD 7B Type (NA, PT100, NI100, NI120, CU10)

RTD7TB = _____

RTD 8B Type (NA, PT100, NI100, NI120, CU10)

RTD8TB = _____

RTD 9B Type (NA, PT100, NI100, NI120, CU10)

RTD9TB = _____

RTD 10B Type (NA, PT100, NI100, NI120, CU10)

RTD10TB = _____

RTD 11B Type (NA, PT100, NI100, NI120, CU10)

RTD11TB = _____

RTD 12B Type (NA, PT100, NI100, NI120, CU10)

RTD12TB = _____

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SEL-387-0, -5, -6 Relay Settings Sheets Example

Group Settings (SET Command)

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	= <u>Y</u>
Enable Winding 2 in Differential Element (Y, N, Y1)	E87W2	= <u>Y</u>
Enable Winding 3 in Differential Element (Y, N, Y1)	E87W3	= <u>Y</u>
Enable Winding 4 in Differential Element (Y, N, Y1)	E87W4	= <u>N</u>
Enable Winding 1 O/C Elements and Dmd Thresholds (Y, N)	EOC1	= <u>Y</u>
Enable Winding 2 O/C Elements and Dmd Thresholds (Y, N)	EOC2	= <u>Y</u>
Enable Winding 3 O/C Elements and Dmd Thresholds (Y, N)	EOC3	= <u>Y</u>
Enable Winding 4 O/C Elements and Dmd Thresholds (Y, N)	EOC4	= <u>N</u>
Enable Combined O/C Elements (Y, N)	EOCC	= <u>N</u>
Enable Thermal Element (Y, N) (SEL-387-6 Relay only)	ETHER	= <u>Y</u>
Enable RTDA Element (Y, N) (SEL-387-5 and SEL-387-6 Relays only)	E49A	= <u>N</u>
Enable RTDB Element (Y, N) (SEL-387-5 and SEL-387-6 Relays only)	E49B	= <u>N</u>
Enable SELOGIC® Control Equations Set 1 (Y, N)	ESLS1	= <u>N</u>
Enable SELOGIC Control Equations Set 2 (Y, N)	ESLS2	= <u>N</u>
Enable SELOGIC Control Equations Set 3 (Y, N)	ESLS3	= <u>N</u>

General Data

Winding 1 CT Connection (D, Y)	W1CT	= <u>Y</u>
Winding 2 CT Connection (D, Y)	W2CT	= <u>Y</u>
Winding 3 CT Connection (D, Y)	W3CT	= <u>Y</u>
Winding 4 CT Connection (D, Y)	W4CT	= <u>Y</u>

Winding 1 CT Ratio (1–50000) (first value applies to a 5 A relay; second value applies to a 1A relay)	CTR1	= <u>120; 600</u>
Winding 2 CT Ratio (1–50000) (first value applies to a 5 A relay; second value applies to a 1A relay)	CTR2	= <u>240; 1200</u>
Winding 3 CT Ratio (1–50000) (first value applies to a 5 A relay; second value applies to a 1A relay)	CTR3	= <u>400; 2000</u>
Winding 4 CT Ratio (1–50000) (first value applies to a 5 A relay; second value applies to a 1A relay)	CTR4	= <u>400; 2000</u>
Maximum Power Transformer Capacity (OFF, 0.2–5000 MVA)	MVA	= <u>100</u>
Define Internal CT Connection Compensation (Y, N)	ICOM	= <u>Y</u>
Winding 1 CT Conn. Compensation (0, 1, ..., 12)	W1CTC	= <u>11</u>
Winding 2 CT Conn. Compensation (0, 1, ..., 12)	W2CTC	= <u>11</u>
Winding 3 CT Conn. Compensation (0, 1, ..., 12)	W3CTC	= <u>0</u>
Winding 4 CT Conn. Compensation (0, 1, ..., 12)	W4CTC	= <u>0</u>
Winding 1 Line-to-Line Voltage (1–1000 kV)	VWDG1	= <u>230</u>
Winding 2 Line-to-Line Voltage (1–1000 kV)	VWDG2	= <u>138</u>
Winding 3 Line-to-Line Voltage (1–1000 kV)	VWDG3	= <u>13.8</u>
Winding 4 Line-to-Line Voltage (1–1000 kV)	VWDG4	= <u>13.8</u>

Differential Elements

NOTE: TAP1-TAP4 are auto-set by relay if MVA setting is not OFF.

Winding 1 Current Tap (0.50–155.00 A secondary) (5 A)	TAP1	= <u>2.09</u>
(0.10–31.00 A secondary) (1 A)		= <u>0.42</u>
Winding 2 Current Tap (0.50–155.00 A secondary) (5 A)	TAP2	= <u>1.74</u>
(0.10–31.00 A secondary) (1 A)		= <u>0.35</u>
Winding 3 Current Tap (0.50–155.00 A secondary) (5 A)	TAP3	= <u>10.46</u>
(0.10–31.00 A secondary) (1 A)		= <u>2.09</u>
Winding 4 Current Tap (0.50–155.00 A secondary) (5 A)	TAP4	= <u>10.46</u>
(0.10–31.00 A secondary) (1 A)		= <u>2.09</u>
Restrained Element Operating Current PU ((0.10–1.00) multiple of tap)	O87P	= <u>0.30</u>
Restraint Slope 1 Percentage (5–100%)	SLP1	= <u>25</u>
Restraint Slope 2 Percentage (OFF, 25–200%)	SLP2	= <u>50</u>

Restraint Current Slope 1 Limit ((1–20) multiple of tap)	IRS1	= <u>3</u>
Unrestrained Element Current PU ((1–20) multiple of tap)	U87P	= <u>10</u>
Second-Harmonic Blocking Percentage (OFF, 5–100%)	PCT2	= <u>15</u>
Fourth-Harmonic Blocking Percentage (OFF, 5–100%) (all but SEL-387-0 Relay)	PCT4	= <u>15</u>
Fifth-Harmonic Blocking Percentage (OFF, 5–100%)	PCT5	= <u>35</u>
Fifth-Harmonic Alarm Threshold (OFF, (0.02–3.20) multiple of tap)	TH5P	= <u>OFF</u>
Fifth-Harmonic Alarm TDPU (0–8000 cycles)	TH5D	= <u>30</u>
DC Ratio Blocking (Y, N) (all but SEL-387-0 Relay)	DCRB	= <u>N</u>
Harmonic Restraint (Y, N) (all but SEL-387-0 Relay)	HRSTR	= <u>Y</u>
Independent Harmonic Blocking (Y, N)	IHBL	= <u>N</u>

Restricted Earth Fault

Enable 32I (SELOGIC control equation)

E32I = 0

Operating Quantity from Wdg. 1, Wdg. 2, Wdg. 3 (1, 2, 3, 12, 23, 123)	32IOP	= <u>1</u>
Positive-Sequence Current Restraint Factor, I0/I1 (0.02–0.50)	a0	= <u>0.10</u>
Residual Current Sensitivity Threshold (0.25–15.00 A secondary) (5 A)	50GP	= <u>0.50</u>
(0.05–3.00 A secondary) (1 A)		= <u>0.10</u>

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	= <u>20.00</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>4.00</u>
Phase Level 1 O/C Delay (0–16000 cycles)	50P11D	= <u>5</u>
50P11 Torque Control (SELOGIC control equation)		
50P11TC	= <u>1</u>	
Phase Inst. O/C Level 2 PU (OFF, 0.25–100.00 A secondary) (5 A)	50P12P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50P12 Torque Control (SELOGIC control equation)		
50P12TC	= <u>1</u>	

Phase Inst. O/C Level 3 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50P13P	= <u>0.50</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>0.10</u>
Phase Inst. O/C Level 4 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50P14P	= <u>4.00</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>0.80</u>
Phase Inv.-Time O/C PU		
(OFF, 0.5–16.0 A secondary) (5 A)	51P1P	= <u>4.00</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>0.80</u>
Phase Inv.-Time O/C Curve (U1–U5, C1–C5)	51P1C	= <u>U2</u>
Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51P1TD	= <u>3.00</u>
Phase Inv.-Time O/C EM Reset (Y, N)	51P1RS	= <u>Y</u>
51P1 Torque Control (SELOGIC control equation)		
51P1TC	=	<u>1</u>

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	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
Neg.-Seq. Level 1 O/C Delay (0.5–16000 cycles)	50Q11D	= <u>5</u>
50Q11 Torque Control (SELOGIC control equation)		
50Q11TC	=	<u>1</u>
Neg.-Seq. Inst. O/C Level 2 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50Q12P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50Q12 Torque Control (SELOGIC control equation)		
50Q12TC	=	<u>1</u>
Neg.-Seq. Inv.-Time O/C PU		
(OFF, 0.5–16.0 A secondary) (5 A)	51Q1P	= <u>6.0</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>1.2</u>
Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)	51Q1C	= <u>U2</u>
Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51Q1TD	= <u>3.00</u>
Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)	51Q1RS	= <u>Y</u>

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)

$$50N11P = \underline{\text{OFF}}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \underline{\text{OFF}}$$

Residual Level 1 O/C Delay (0–16000 cycles)

$$50N11D = \underline{5}$$

50N11 Torque Control (SELOGIC control equation)

$$50N11TC = 1$$

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$50N12P = \underline{\text{OFF}}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \underline{\text{OFF}}$$

50N12 Torque Control (SELOGIC control equation)

$$50N12TC = 1$$

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

$$51N1P = \underline{\text{OFF}}$$

(OFF, 0.1–3.2 A secondary) (1 A)

$$= \underline{\text{OFF}}$$

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

$$51N1C = \underline{U2}$$

Residual Inv.-Time O/C Time-Dial
(US 0.5–15.0, IEC 0.05–1.00)

$$51N1TD = \underline{1.00}$$

Residual Inv.-Time O/C EM Reset (Y, N)

$$51N1RS = \underline{Y}$$

51N1 Torque Control (SELOGIC control equation)

$$51N1TC = 1$$

Winding 1 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)

$$DATC1 = \underline{15}$$

Phase Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

$$PDEM1P = \underline{7.0}$$

(0.1–3.2 A secondary) (1 A)

$$= \underline{1.4}$$

Neg.-Seq. Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

$$QDEM1P = \underline{1.0}$$

(0.1–3.2 A secondary) (1 A)

$$= \underline{0.2}$$

Residual Demand Ammeter Threshold

(0.5–16.0 A secondary) (5 A)

$$NDEM1P = \underline{1.0}$$

(0.1–3.2 A secondary) (1 A)

$$= \underline{0.2}$$

Winding 2 O/C Elements

Winding 2 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

Phase Level 1 O/C Delay (0–16000 cycles)

50P21D = 5

50P21 Torque Control (SELOGIC control equation)

50P21TC = 1

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50P22 Torque Control (SELOGIC control equation)

50P22TC = 1

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P23P = 0.50

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.10

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50P24P = 3.50

(OFF, 0.05–20.00 A secondary) (1 A)

= 0.70

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51P2P = 3.5

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.7

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51P2C = U2

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

51P2TD = 3.50

Phase Inv.-Time O/C EM Reset (Y, N)

51P2RS = Y

51P2 Torque Control (SELOGIC control equation)

51P2TC = 1

Winding 2 Negative-Sequence O/C Elements

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

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50Q21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

Neg.-Seq. Level 1 O/C Delay (0.5–16000 cycles)

50Q21D = 5

50Q21 Torque Control (SELOGIC control equation)

50Q21TC = 1

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50Q22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50Q22 Torque Control (SELOGIC control equation)

50Q22TC = 1

Neg.-Seq. Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51Q2P = 5.25

(OFF, 0.1–3.2 A secondary) (1 A)

= 1.05

Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)

51Q2C = U2

Neg.-Seq. Inv.-Time O/C Time-Dial

(US 0.5–15.0, IEC 0.05–1.00)

51Q2TD = 3.50

Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)

51Q2RS = Y

51Q2 Torque Control (SELOGIC control equation)

51Q2TC = 1

Winding 2 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50N21P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

Residual Level 1 O/C Delay (0–16000 cycles)

50N21D = 5

50N21 Torque Control (SELOGIC control equation)

50N21TC = 1

Residual Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

50N22P = OFF

(OFF, 0.05–20.00 A secondary) (1 A)

= OFF

50N22 Torque Control (SELOGIC control equation)

50N22TC = 1

Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51N2P = OFF

(OFF, 0.1–3.2 A secondary) (1 A)

= OFF

Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51N2C = U2

Residual Inv.-Time O/C Time-Dial

(US 0.5–15.0, IEC 0.05–1.00)

51N2TD = 1.00

Residual Inv.-Time O/C EM Reset (Y, N)

51N2RS = Y

51N2 Torque Control (SELOGIC control equation)

51N2TC = 1

Winding 2 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)	DATC2	= <u>15</u>
Phase Demand Ammeter Threshold (0.5–16.0 A secondary) (5 A)	PDEM2P	= <u>7.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>1.4</u>
Neg.-Seq. Demand Ammeter Threshold (0.5–16.0 A secondary) (5 A)	QDEM2P	= <u>1.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>0.2</u>
Residual Demand Ammeter Threshold (0.5–16.0 A secondary) (5 A)	NDEM2P	= <u>1.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>0.2</u>

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	= <u>7.00</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>1.40</u>
Phase Level 1 O/C Delay (0–16000 cycles)	50P31D	= <u>0</u>
50P31 Torque Control (SELOGIC control equation) 50P31TC		= <u>1</u>
Phase Inst. O/C Level 2 PU (OFF, 0.25–100.00 A secondary) (5 A)	50P32P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50P32 Torque Control (SELOGIC control equation) 50P32TC		= <u>1</u>
Phase Inst. O/C Level 3 PU (OFF, 0.25–100.00 A secondary) (5 A)	50P33P	= <u>0.50</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>0.10</u>
Phase Inst. O/C Level 4 PU (OFF, 0.25–100.00 A secondary) (5 A)	50P34P	= <u>4.00</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>0.80</u>

Phase Inv.-Time O/C PU		
(OFF, 0.5–16.0 A secondary) (5 A)	51P3P	= <u>4.0</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>0.8</u>
Phase Inv.-Time O/C Curve (U1–U5, C1–C5)	51P3C	= <u>U2</u>
Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51P3TD	= <u>1.30</u>
Phase Inv.-Time O/C EM Reset (Y, N)	51P3RS	= <u>Y</u>
51P3 Torque Control (SELOGIC control equation)		
51P3TC	=	<u>1</u>

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	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles)	50Q31D	= <u>5</u>
50Q31 Torque Control (SELOGIC control equation)		
50Q31TC	=	<u>1</u>
Neg.-Seq. Inst. O/C Level 2 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50Q32P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50Q32 Torque Control (SELOGIC control equation)		
50Q32TC	=	<u>1</u>
Neg.-Seq. Inv.-Time O/C PU		
(OFF, 0.5–16.0 A secondary) (5 A)	51Q3P	= <u>OFF</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>OFF</u>
Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)	51Q3C	= <u>U2</u>
Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51Q3TD	= <u>3.00</u>
Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)	51Q3RS	= <u>Y</u>
51Q3 Torque Control (SELOGIC control equation)		
51Q3TC	=	<u>1</u>

Winding 3 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50N31P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>

Residual Level 1 O/C Delay (0–16000 cycles)	50N31D	= <u>5</u>
50N31 Torque Control (SELOGIC control equation)		
50N31TC	=	<u>1</u>
Residual Inst. O/C Level 2 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50N32P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50N32 Torque Control (SELOGIC control equation)		
50N32TC	=	<u>1</u>
Residual Inv.-Time O/C PU		
(OFF, 0.5–16.0 A secondary) (5 A)	51N3P	= <u>OFF</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>OFF</u>
Residual Inv.-Time O/C Curve (U1–U5, C1–C5)	51N3C	= <u>U2</u>
Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51N3TD	= <u>1.00</u>
Residual Inv.-Time O/C EM Reset (Y, N)	51N3RS	= <u>Y</u>
51N3 Torque Control (SELOGIC control equation)		
51N3TC	=	<u>1</u>

Winding 3 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)	DATC3	= <u>15</u>
Phase Demand Ammeter Threshold		
(0.5–16.0 A secondary) (5 A)	PDEM3P	= <u>7.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>1.4</u>
Neg.-Seq. Demand Ammeter Threshold		
(0.5–16.0 A secondary) (5 A)	QDEM3P	= <u>1.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>0.2</u>
Residual Demand Ammeter Threshold		
(0.5–16.0 A secondary) (5 A)	NDEM3P	= <u>1.0</u>
(0.1–3.2 A secondary) (1 A)		= <u>0.2</u>

Winding 4 O/C Elements

Winding 4 Phase O/C Elements

Phase Def.-Time O/C Level 1 PU		
(OFF, 0.25–100.00 A secondary) (5 A)	50P41P	= <u>20.00</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>4.00</u>
Phase Level 1 O/C Delay (0–16000 cycles)	50P41D	= <u>5</u>

50P41 Torque Control (SELOGIC control equation)

$$\mathbf{50P41TC} = \mathbf{1}$$

Phase Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$\mathbf{50P42P} = \mathbf{OFF}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \mathbf{OFF}$$

50P42 Torque Control SELOGIC control equation)

$$\mathbf{50P42TC} = \mathbf{1}$$

Phase Inst. O/C Level 3 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$\mathbf{50P43P} = \mathbf{0.50}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \mathbf{0.10}$$

Phase Inst. O/C Level 4 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$\mathbf{50P44P} = \mathbf{4.00}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \mathbf{0.80}$$

Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

$$\mathbf{51P4P} = \mathbf{4.0}$$

(OFF, 0.1–3.2 A secondary) (1 A)

$$= \mathbf{0.8}$$

Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

$$\mathbf{51P4C} = \mathbf{U2}$$

Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)

$$\mathbf{51P4TD} = \mathbf{3.00}$$

Phase Inv.-Time O/C EM Reset (Y, N)

$$\mathbf{51P4RS} = \mathbf{Y}$$

51P4 Torque Control (SELOGIC control equation)

$$\mathbf{51P4TC} = \mathbf{1}$$

Winding 4 Negative-Sequence O/C Elements

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

Neg.-Seq. Def.-Time O/C Level 1 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$\mathbf{50Q41P} = \mathbf{OFF}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \mathbf{OFF}$$

Neg.-Seq. Level 1 O/C Delay (0.5–16000.0 cycles)

$$\mathbf{50Q41D} = \mathbf{5}$$

50Q41 Torque Control SELOGIC control equation)

$$\mathbf{50Q41TC} = \mathbf{1}$$

Neg.-Seq. Inst. O/C Level 2 PU

(OFF, 0.25–100.00 A secondary) (5 A)

$$\mathbf{50Q42P} = \mathbf{OFF}$$

(OFF, 0.05–20.00 A secondary) (1 A)

$$= \mathbf{OFF}$$

50Q42 Torque Control (SELOGIC control equation)

$$\mathbf{50Q42TC} = \mathbf{1}$$

Neg.-Seq. Inv.-Time O/C PU (OFF, 0.5–16.0 A secondary) (5 A)	51Q4P	= <u>6.0</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>1.2</u>
Neg.-Seq. Inv.-Time O/C Curve (U1–U5, C1–C5)	51Q4C	= <u>U2</u>
Neg.-Seq. Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51Q4TD	= <u>3.00</u>
Neg.-Seq. Inv.-Time O/C EM Reset (Y, N)	51Q4RS	= <u>Y</u>
51Q4 Torque Control SELOGIC control equation) 51Q4TC	= 1	

Winding 4 Residual O/C Elements

Residual Def.-Time O/C Level 1 PU (OFF, 0.25–100.00 A secondary) (5 A)	50N41P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
Residual Level 1 O/C Delay (0–16000 cycles)	50N41D	= <u>5</u>
50N41 Torque Control (SELOGIC control equation) 50N41TC	= 1	
Residual Inst. O/C Level 2 PU (OFF, 0.25–100.00 A secondary) (5 A)	50N42P	= <u>OFF</u>
(OFF, 0.05–20.00 A secondary) (1 A)		= <u>OFF</u>
50N42 Torque Control (SELOGIC control equation) 50N42TC	= 1	
Residual Inv.-Time O/C PU (OFF, 0.5–16.0 A secondary) (5 A)	51N4P	= <u>OFF</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>OFF</u>
Residual Inv.-Time O/C Curve (U1–U5, C1–C5)	51N4C	= <u>U2</u>
Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51N4TD	= <u>1.00</u>
Residual Inv.-Time O/C EM Reset (Y, N)	51N4RS	= <u>Y</u>
51N4 Torque Control (SELOGIC control equation) 51N4TC	= 1	

Winding 4 Demand Metering

Demand Ammeter Time Constant (OFF, 5–255 min)	DATC4	= <u>15</u>
Phase Demand Ammeter Threshold (OFF, 0.5–16.0 A secondary) (5 A)	PDEM4P	= <u>7.0</u>
(OFF, 0.1–3.2 A secondary) (1 A)		= <u>1.4</u>

Neg.-Seq. Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

QDEM4P = 1.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

Residual Demand Ammeter Threshold

(OFF, 0.5–16.0 A secondary) (5 A)

NDEM4P = 1.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2**Combined O/C Elements**

NOTE: The combined overcurrent elements use a normalization factor that scales the secondary current magnitude to the larger of the two winding CT ratios. See 51PCm and 51NCm Combined Overcurrent Element (m = 1, 2) on page 3.54 for details and examples for the combined overcurrent elements.

W1-W2 Phase O/C Element

W1–W2 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51PC1P = 4.0

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.8

W1–W2 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC1C = U2

W1–W2 Phase Inv.-Time O/C Time-Dial

(US 0.5–15.0, IEC 0.05–1.00)

51PC1TD = 3.00

W1–W2 Phase Inv.-Time O/C EM Reset (Y, N)

51PC1RS = Y**W1-W2 Residual O/C Element**

W1–W2 Residual Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51NC1P = 1.9

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.2

W1–W2 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)

51NC1C = U2

W1–W2 Residual Inv.-Time O/C Time-Dial

(US 0.5–15.0, IEC 0.05–1.00)

51NC1TD = 3.00

W1–W2 Residual Inv.-Time O/C EM Reset (Y, N)

51NC1RS = Y**W3-W4 Phase O/C Element**

W3–W4 Phase Inv.-Time O/C PU

(OFF, 0.5–16.0 A secondary) (5 A)

51PC2P* = 4.00

(OFF, 0.1–3.2 A secondary) (1 A)

= 0.8* *Must be OFF if Restricted Earth Fault is used.*

W3–W4 Phase Inv.-Time O/C Curve (U1–U5, C1–C5)

51PC2C = U2

W3–W4 Phase Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51PC2TD	= <u>3.00</u>
W3–W4 Phase Inv.-Time O/C EM Reset (Y, N)	51PC2RS	= <u>Y</u>

W3–W4 Residual O/C Element

W3–W4 Residual Inv.-Time O/C PU (OFF, 0.5–16.0 A secondary) (5 A)	51NC2P*	= <u>1.00</u>
(OFF, 0.1–3.2 A secondary) (1 A)		
<i>* Must be OFF if Restricted Earth Fault is used.</i>		= <u>0.2</u>
W3–W4 Residual Inv.-Time O/C Curve (U1–U5, C1–C5)	51NC2C	= <u>U2</u>
W3–W4 Residual Inv.-Time O/C Time-Dial (US 0.5–15.0, IEC 0.05–1.00)	51NC2TD	= <u>3.00</u>
W3–W4 Residual Inv.-Time O/C EM Reset (Y, N)	51NC2RS	= <u>Y</u>

Thermal Element (SEL-387-6 Relay Only)

Thermal Model Winding Current (1, 2, 3, 4, 12, 34)	TMWDG	= <u>1</u>
Winding LL Voltage (1–1000 kV)	VWDG	= <u>230</u>
Transformer Construction (1, 3)	XTYPE	= <u>1</u>
Transformer Type (D, Y)	TRTYPE	= <u>Y</u>
Winding Temp/Amb (65, 55)	THwr	= <u>65</u>
Number of Cooling Stages (1–3)	NCS	= <u>3</u>
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS11	= <u>100.0</u>
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS21	= <u>100.0</u>
Cooling Stage 1 Rating (0.2–5000.0 MVA)	MCS31	= <u>100.0</u>
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS12	= <u>140.0</u>
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS22	= <u>140.0</u>
Cooling Stage 2 Rating (0.2–5000.0 MVA)	MCS32	= <u>140.0</u>
Cooling Stage 2 (SELOGIC control equation)		
CS12S	= <u>0</u>	
Cooling Stage 2 (SELOGIC control equation)		
CS22S	= <u>0</u>	
Cooling Stage 2 (SELOGIC control equation)		
CS32S	= <u>0</u>	
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS13	= <u>170.0</u>
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS23	= <u>170.0</u>
Cooling Stage 3 Rating (0.2–5000.0 MVA)	MCS33	= <u>170.0</u>

Cooling Stage 3 (SELOGIC control equation)

CS13S = 0

Cooling Stage 3 (SELOGIC control equation)

CS23S = 0

Cooling Stage 3 (SELOGIC control equation)

CS33S = 0

Default Ambient Temp. -40–85°C)

DTMP = 15

De-energized Transformer (SELOGIC control equation)

TRDE = 0

Number Thermal Inputs (0–4)

NTHM = 4

Thermal Function Settings for SEL-387-6 Firmware Revisions R404 and Earlier

Thermal Function (AMB, OIL1, OIL2, OIL3)

THM1 = AMB

Thermal Function (AMB, OIL1, OIL2, OIL3)

THM2 = OIL1

Thermal Function (AMB, OIL1, OIL2, OIL3)

THM3 = OIL2

Thermal Function (AMB, OIL1, OIL2, OIL3)

THM4 = OIL3

Thermal Function Settings for SEL-387-6 Firmware Revisions R606 and Later

Ambient Temperature

(THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)

AMB = THM1

Top-Oil Temperature 1

(THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)

OIL1 = THM2

Top-Oil Temperature 2

(THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)

OIL2 = THM3

Top-Oil Temperature 3

(THM1...THM4, RTD1A...RTD12A, RTD1B...RTD12B)

OIL3 = THM4

Top-Oil Temp. Limit 1 (50–150°C)

TOT1 = 100

Top-Oil Temp. Limit 2 (50–150°C)

TOT2 = 100

Hot-Spot Limit 1 (80–300°C)

HST1 = 200

Hot-Spot Limit 2 (80–300°C)

HST2 = 200

Aging Acceleration Factor Limit 1 (0.00–599.99)

FAAL1 = 50.00

Aging Acceleration Factor Limit 2 (0.00–599.99)

FAAL2 = 50.00

Daily Loss-of-Life Limit (0.00–99.99%)

RLOLL = 50.00

Total Loss-of-Life Limit (0.00–99.99%)

TLOLL = 50.00

Cooling System Efficiency-Transformer 1 (5–100°C)

CSEP1 = 15

Cooling System Efficiency-Transformer 2 (5–100°C)	CSEP2	= <u>15</u>
Cooling System Efficiency-Transformer 3 (5–100°C)	CSEP3	= <u>15</u>

General Cooling System Constants

Nominal Insulation Life (1000–999999 hr)	ILIFE	= <u>180000</u>
Enable Default Constants (Y/N)	EDFTC	= <u>Y</u>

Transformer 1

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths1	= <u>0.08</u>
Constant to Calc. FAA (0–100000)	BFFA1	= <u>15000</u>
Cooling Stage 1 Constants		
Top-Oil Rise/Amb (0.1–100.0°C)	THor11	= <u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr11	= <u>25.0</u>
Ratio Losses (0.0–100.0)	RATL11	= <u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR11	= <u>3.0</u>
Oil Exponent (0.1–5)	EXPn11	= <u>0.8</u>
Winding Exponent (0.1–5)	EXPm11	= <u>0.8</u>

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor12	= <u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr12	= <u>30.0</u>
Ratio Losses (0.0–100.0)	RATL12	= <u>4.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR12	= <u>2.0</u>
Oil Exponent (0.1–5)	EXPn12	= <u>0.9</u>
Winding Exponent (0.1–5)	EXPm12	= <u>0.9</u>

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor13	= <u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr13	= <u>35.0</u>
Ratio Losses (0.0–100.0)	RATL13	= <u>6.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR13	= <u>1.3</u>
Oil Exponent (0.1–5)	EXPn13	= <u>1.0</u>
Winding Exponent (0.1–5)	EXPm13	= <u>1.0</u>

Transformer 2

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths2	= <u>0.08</u>
Constant to Calc. FAA (0–100000)	BFFA2	= <u>15000</u>

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor21	= <u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr21	= <u>25.0</u>
Ratio Losses (0.0–100.0)	RATL21	= <u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR21	= <u>3.0</u>
Oil Exponent (0.1–5)	EXPn21	= <u>0.8</u>
Winding Exponent (0.1–5)	EXPm21	= <u>0.8</u>

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor22	= <u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr22	= <u>30.0</u>
Ratio Losses (0.0–100.0)	RATL22	= <u>4.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR22	= <u>2.0</u>
Oil Exponent (0.1–5)	EXPn22	= <u>0.9</u>
Winding Exponent (0.1–5)	EXPm22	= <u>0.9</u>

Cooling Stage 3 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor23	= <u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr23	= <u>35.0</u>
Ratio Losses (0.0–100.0)	RATL23	= <u>6.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR23	= <u>1.3</u>
Oil Exponent (0.1–5)	EXPn23	= <u>1.0</u>
Winding Exponent (0.1–5)	EXPm23	= <u>1.0</u>

Transformer 3

Hot-Spot Thermal Time Constant (0.01–2.00 hr)	Ths3	= <u>0.8</u>
Constant to Calc. FAA (0–100000)	BFFA3	= <u>15000</u>

Cooling Stage 1 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor31	= <u>55.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr31	= <u>25.0</u>
Ratio Losses (0.0–100.0)	RATL31	= <u>3.2</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR31	= <u>3.0</u>
Oil Exponent (0.1–5)	EXPn31	= <u>0.8</u>
Winding Exponent (0.1–5)	EXPm31	= <u>0.8</u>

Cooling Stage 2 Constants

Top-Oil Rise/Amb (0.1–100.0°C)	THor32	= <u>50.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr32	= <u>30.0</u>
Ratio Losses (0.0–100.0)	RATL32	= <u>4.5</u>

Oil Thermal Time Constant (0.1–20.0 hr)	OTR32	= <u>2.0</u>
Oil Exponent (0.1–5)	EXPn32	= <u>0.9</u>
Winding Exponent (0.1–5)	EXPm32	= <u>0.9</u>
Cooling Stage 3 Constants		
Top-Oil Rise/Amb (0.1–100.0°C)	THor33	= <u>45.0</u>
Hot-Spot Cond. Rise/Top Oil (0.1–100.0°C)	THgr33	= <u>35.0</u>
Ratio Losses (0.0–100.0)	RATL33	= <u>6.5</u>
Oil Thermal Time Constant (0.1–20.0 hr)	OTR33	= <u>1.3</u>
Oil Exponent (0.1–5)	EXPn33	= <u>1.0</u>
Winding Exponent (0.1–5)	EXPm33	= <u>1.0</u>

RTD A Elements (SEL-387-5 and SEL-387-6 Relays Only)

RTD 1A Alarm Temperature (OFF, 32–482°F)	49A01A	= <u>OFF</u>
RTD 1A Trip Temperature (OFF, 32–482°F)	49T01A	= <u>OFF</u>
RTD 2A Alarm Temperature (OFF, 32–482°F)	49A02A	= <u>OFF</u>
RTD 2A Trip Temperature (OFF, 32–482°F)	49T02A	= <u>OFF</u>
RTD 3A Alarm Temperature (OFF, 32–482°F)	49A03A	= <u>OFF</u>
RTD 3A Trip Temperature (OFF, 32–482°F)	49T03A	= <u>OFF</u>
RTD 4A Alarm Temperature (OFF, 32–482°F)	49A04A	= <u>OFF</u>
RTD 4A Trip Temperature (OFF, 32–482°F)	49T04A	= <u>OFF</u>
RTD 5A Alarm Temperature (OFF, 32–482°F)	49A05A	= <u>OFF</u>
RTD 5A Trip Temperature (OFF, 32–482°F)	49T05A	= <u>OFF</u>
RTD 6A Alarm Temperature (OFF, 32–482°F)	49A06A	= <u>OFF</u>
RTD 6A Trip Temperature (OFF, 32–482°F)	49T06A	= <u>OFF</u>
RTD 7A Alarm Temperature (OFF, 32–482°F)	49A07A	= <u>OFF</u>
RTD 7A Trip Temperature (OFF, 32–482°F)	49T07A	= <u>OFF</u>
RTD 8A Alarm Temperature (OFF, 32–482°F)	49A08A	= <u>OFF</u>
RTD 8A Trip Temperature (OFF, 32–482°F)	49T08A	= <u>OFF</u>
RTD 9A Alarm Temperature (OFF, 32–482°F)	49A09A	= <u>OFF</u>
RTD 9A Trip Temperature (OFF, 32–482°F)	49T09A	= <u>OFF</u>
RTD 10A Alarm Temperature (OFF, 32–482°F)	49A10A	= <u>OFF</u>
RTD 10A Trip Temperature (OFF, 32–482°F)	49T10A	= <u>OFF</u>
RTD 11A Alarm Temperature (OFF, 32–482°F)	49A11A	= <u>OFF</u>
RTD 11A Trip Temperature (OFF, 32–482°F)	49T11A	= <u>OFF</u>

RTD 12A Alarm Temperature (OFF, 32–482°F)	49A12A	= <u>OFF</u>
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RTD 12A Trip Temperature (OFF, 32–482°F)	49T12A	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD B Elements (SEL-387-5 and SEL-387-6 Relays Only)

RTD 1B Alarm Temperature (OFF, 32–482°F)	49A01B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 1B Trip Temperature (OFF, 32–482°F)	49T01B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 2B Alarm Temperature (OFF, 32–482°F)	49A02B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 2B Trip Temperature (OFF, 32–482°F)	49T02B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 3B Alarm Temperature (OFF, 32–482°F)	49A03B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 3B Trip Temperature (OFF, 32–482°F)	49T03B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 4B Alarm Temperature (OFF, 32–482°F)	49A04B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 4B Trip Temperature (OFF, 32–482°F)	49T04B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 5B Alarm Temperature (OFF, 32–482°F)	49A05B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 5B Trip Temperature (OFF, 32–482°F)	49T05B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 6B Alarm Temperature (OFF, 32–482°F)	49A06B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 6B Trip Temperature (OFF, 32–482°F)	49T06B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 7B Alarm Temperature (OFF, 32–482°F)	49A07B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 7B Trip Temperature (OFF, 32–482°F)	49T07B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 8B Alarm Temperature (OFF, 32–482°F)	49A08B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 8B Trip Temperature (OFF, 32–482°F)	49T08B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 9B Alarm Temperature (OFF, 32–482°F)	49A09B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 9B Trip Temperature (OFF, 32–482°F)	49T09B	= <u>OFF</u>
-----------------------------------------	---------------	--------------

RTD 10B Alarm Temperature (OFF, 32–482°F)	49A10B	= <u>OFF</u>
-------------------------------------------	---------------	--------------

RTD 10B Trip Temperature (OFF, 32–482°F)	49T10B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 11B Alarm Temperature (OFF, 32–482°F)	49A11B	= <u>OFF</u>
-------------------------------------------	---------------	--------------

RTD 11B Trip Temperature (OFF, 32–482°F)	49T11B	= <u>OFF</u>
------------------------------------------	---------------	--------------

RTD 12B Alarm Temperature (OFF, 32–482°F)	49A12B	= <u>OFF</u>
-------------------------------------------	---------------	--------------

RTD 12B Trip Temperature (OFF, 32–482°F)	49T12B	= <u>OFF</u>
------------------------------------------	---------------	--------------

Miscellaneous Timers

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

SELogic Control Equations Set 1

Set 1 Variable 1 (SELOGIC control equation)

$$\mathbf{S1V1} = \mathbf{0}$$

S1V1 Timer Pickup (0–999999 cycles)

$$\mathbf{S1V1PU} = \mathbf{0.000}$$

S1V1 Timer Dropout (0–999999 cycles)

$$\mathbf{S1V1DO} = \mathbf{0.000}$$

Set 1 Variable 2 (SELOGIC control equation)

$$\mathbf{S1V2} = \mathbf{0}$$

S1V2 Timer Pickup (0–999999 cycles)

$$\mathbf{S1V2PU} = \mathbf{0.000}$$

S1V2 Timer Dropout (0–999999 cycles)

$$\mathbf{S1V2DO} = \mathbf{0.000}$$

Set 1 Variable 3 (SELOGIC control equation)

$$\mathbf{S1V3} = \mathbf{0}$$

S1V3 Timer Pickup (0–999999 cycles)

$$\mathbf{S1V3PU} = \mathbf{0.000}$$

S1V3 Timer Dropout (0–999999 cycles)

$$\mathbf{S1V3DO} = \mathbf{0.000}$$

Set 1 Variable 4 (SELOGIC control equation)

$$\mathbf{S1V4} = \mathbf{0}$$

S1V4 Timer Pickup (0–999999 cycles)

$$\mathbf{S1V4PU} = \mathbf{0.000}$$

S1V4 Timer Dropout (0–999999 cycles)

$$\mathbf{S1V4DO} = \mathbf{0.000}$$

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

$$\mathbf{S1SLT1} = \mathbf{0}$$

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

$$\mathbf{S1RLT1} = \mathbf{0}$$

Set 1 Latch Bit 2 SET Input (SELOGIC control equation)

$$\mathbf{S1SLT2} = \mathbf{0}$$

Set 1 Latch Bit 2 RESET Input (SELOGIC control equation)

$$\mathbf{S1RLT2} = \mathbf{0}$$

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

$$\mathbf{S1SLT3} = \mathbf{0}$$

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

$$\mathbf{S1RLT3} = \mathbf{0}$$

Set 1 Latch Bit 4 SET Input (SELOGIC control equation)

$$\mathbf{S1SLT4} = \mathbf{0}$$

Set 1 Latch Bit 4 RESET Input (SELOGIC control equation)

$$\mathbf{S1RLT4} = \mathbf{0}$$

SELogic Control Equations Set 2

Set 2 Variable 1 (SELOGIC control equation)

$$\mathbf{S2V1} = \mathbf{0}$$

S2V1 Timer Pickup (0–999999 cycles)

$$\mathbf{S2V1PU} = \mathbf{0.000}$$

S2V1 Timer Dropout (0–999999 cycles)

$$\mathbf{S2V1DO} = \mathbf{0.000}$$

Set 2 Variable 2 (SELOGIC control equation)

$$\mathbf{S2V2} = \mathbf{0}$$

S2V2 Timer Pickup (0–999999 cycles)

$$\mathbf{S2V2PU} = \mathbf{0.000}$$

S2V2 Timer Dropout (0–999999 cycles)

$$\mathbf{S2V2DO} = \mathbf{0.000}$$

Set 2 Variable 3 (SELOGIC control equation)

$$\mathbf{S2V3} = \mathbf{0}$$

S2V3 Timer Pickup (0–999999 cycles)

$$\mathbf{S2V3PU} = \mathbf{0.000}$$

S2V3 Timer Dropout (0–999999 cycles)

$$\mathbf{S2V3DO} = \mathbf{0.000}$$

Set 2 Variable 4 (SELOGIC control equation)

$$\mathbf{S2V4} = \mathbf{0}$$

S2V4 Timer Pickup (0–999999 cycles)

$$\mathbf{S2V4PU} = \mathbf{0.000}$$

S2V4 Timer Dropout (0–999999 cycles)

$$\mathbf{S2V4DO} = \mathbf{0.000}$$

Set 2 Latch Bit 1 SET Input (SELOGIC control equation)

$$\mathbf{S2SLT1} = \mathbf{0}$$

Set 2 Latch Bit 1 RESET Input (SELOGIC control equation)

$$\mathbf{S2RLT1} = \mathbf{0}$$

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

$$\mathbf{S2SLT2} = \mathbf{0}$$

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

$$\mathbf{S2RLT2} = \mathbf{0}$$

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

$$\mathbf{S2SLT3} = \mathbf{0}$$

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

$$\mathbf{S2RLT3} = \mathbf{0}$$

Set 2 Latch Bit 4 SET Input (SELOGIC control equation)

$$\mathbf{S2SLT4} = \mathbf{0}$$

Set 2 Latch Bit 4 RESET Input (SELOGIC control equation)

$$\mathbf{S2RLT4} = \mathbf{0}$$

SELogic Control Equations Set 3

(S3LT1 To S3LT8 are not included in the SEL-387-0 Relay)

Set 3 Variable 1 (SELOGIC control equation)

$$\mathbf{S3V1} = \mathbf{0}$$

S3V1 Timer Pickup (0–999999 cycles)	S3V1PU	=	<u>0.000</u>
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S3V1 Timer Dropout (0–999999 cycles)	S3V1DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 2 (SELOGIC control equation)

$$\mathbf{S3V2} = \mathbf{0}$$

S3V2 Timer Pickup (0–999999 cycles)	S3V2PU	=	<u>0.000</u>
-------------------------------------	---------------	---	---------------------

S3V2 Timer Dropout (0–999999 cycles)	S3V2DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 3 (SELOGIC control equation)

$$\mathbf{S3V3} = \mathbf{0}$$

S3V3 Timer Pickup (0–999999 cycles)	S3V3PU	=	<u>0.000</u>
-------------------------------------	---------------	---	---------------------

S3V3 Timer Dropout (0–999999 cycles)	S3V3DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 4 (SELOGIC control equation)

$$\mathbf{S3V4} = \mathbf{0}$$

S3V4 Timer Pickup (0–999999 cycles)	S3V4PU	=	<u>0.000</u>
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S3V4 Timer Dropout (0–999999 cycles)	S3V4DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 5 (SELOGIC control equation)

$$\mathbf{S3V5} = \mathbf{0}$$

S3V5 Timer Pickup (0–999999 cycles)	S3V5PU	=	<u>0.000</u>
-------------------------------------	---------------	---	---------------------

S3V5 Timer Dropout (0–999999 cycles)	S3V5DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 6 (SELOGIC control equation)

$$\mathbf{S3V6} = \mathbf{0}$$

S3V6 Timer Pickup (0–999999 cycles)	S3V6PU	=	<u>0.000</u>
-------------------------------------	---------------	---	---------------------

S3V6 Timer Dropout (0–999999 cycles)	S3V6DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 7 (SELOGIC control equation)

$$\mathbf{S3V7} = \mathbf{0}$$

S3V7 Timer Pickup (0–999999 cycles)	S3V7PU	=	<u>0.000</u>
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S3V7 Timer Dropout (0–999999 cycles)	S3V7DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

Set 3 Variable 8 (SELOGIC control equation)

$$\mathbf{S3V8} = \mathbf{0}$$

S3V8 Timer Pickup (0–999999 cycles)	S3V8PU	=	<u>0.000</u>
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S3V8 Timer Dropout (0–999999 cycles)	S3V8DO	=	<u>0.000</u>
--------------------------------------	---------------	---	---------------------

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

$$\mathbf{S3SLT1} = \mathbf{0}$$

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

$$\mathbf{S3RLT1} = \mathbf{0}$$

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

$$\mathbf{S3SLT2} = \mathbf{0}$$

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

$$\mathbf{S3RLT2} = \mathbf{0}$$

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

$$\mathbf{S3SLT3} = \mathbf{0}$$

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

$$\mathbf{S3RLT3} = \mathbf{0}$$

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

$$\mathbf{S3SLT4} = \mathbf{0}$$

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

$$\mathbf{S3RLT4} = \mathbf{0}$$

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

$$\mathbf{S3SLT5} = \mathbf{0}$$

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

$$\mathbf{S3RLT5} = \mathbf{0}$$

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

$$\mathbf{S3SLT6} = \mathbf{0}$$

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

$$\mathbf{S3RLT6} = \mathbf{0}$$

Set 3 Latch Bit 7 SET Input (SELOGIC control equation)

$$\mathbf{S3SLT7} = \mathbf{0}$$

Set 3 Latch Bit 7 RESET Input (SELOGIC control equation)

$$\mathbf{S3RLT7} = \mathbf{0}$$

Set 3 Latch Bit 8 SET Input (SELOGIC control equation)

$$\mathbf{S3SLT8} = \mathbf{0}$$

Set 3 Latch Bit 8 RESET Input (SELOGIC control equation)

$$\mathbf{S3RLT8} = \mathbf{0}$$

Trip Logic

$$\mathbf{TR1} = \mathbf{50P11T + 51P1T + 51Q1T + OC1 + LB3}$$

$$\mathbf{TR2} = \mathbf{51P2T + 51Q2T + OC2}$$

$$\mathbf{TR3} = \mathbf{50P31 + 51P3T + OC3}$$

TR4	= 87R + 87U
TR5	= 0
ULTR1	= !50P13
ULTR2	= !50P23
ULTR3	= !50P33
ULTR4	= !(50P13 + 50P23 + 50P33)
ULTR5	= 0

Close Logic

52A1	= IN101
52A2	= IN102
52A3	= IN103
52A4	= 0
CL1	= CC1 + LB4 + /IN104
CL2	= CC2 + /IN105
CL3	= CC3 + /IN106
CL4	= 0
ULCL1	= TRIP1 + TRIP4
ULCL2	= TRIP2 + TRIP4
ULCL3	= TRIP3 + TRIP4
ULCL4	= 0

Event Report Triggering

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

Global Settings (SET G Command)

Relay Settings

Length of Event Report (15, 30, 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	_____
Date Format (MDY, YMD)	DATE_F	= MDY	_____
Display Update Rate (1–60 seconds)	SCROLL	= 2	_____
Front Panel Time-out (OFF, 0–30 minutes)	FP_TO	= 16	_____
Group Change Delay (0–900 seconds)	TGR	= 3	_____
RTDA Temperature Preference (C, F) (SEL-387-5 and SEL-387-6 Relays only)	TMPREFA	= F	_____
RTDB Temperature Preference (C, F) (SEL-387-5 and SEL-387-6 Relays only)	TMPREFB	= F	_____

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)

$$\mathbf{BKMON1} = \mathbf{TRIP1 + TRIP4}$$

Close/Open Set Point 1 max (1–65000 operations)	B1COP1	= 10000
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B1KAP1	= 1.2
Close/Open Set Point 2 max (1–65000 operations)	B1COP2	= 160
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	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 pri)	B1KAP3	= 20.0

Breaker 2 Monitor

BKR2 Trigger Equation (SELOGIC control equation)

$$\mathbf{BKMON2} = \mathbf{TRIP2 + TRIP4}$$

Close/Open Set Point 1 max (1–65000 operations)	B2COP1	= 10000
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B2KAP1	= 1.2
Close/Open Set Point 2 max (1–65000 operations)	B2COP2	= 160
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	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 pri)	B2KAP3	= 20.0

Breaker 3 Monitor

BKR3 Trigger Equation (SELOGIC control equation)

$$\mathbf{BKMON3} = \mathbf{TRIP3 + TRIP4}$$

Close/Open Set Point 1 max (1–65000 operations)	B3COP1	= 10000
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B3KAP1	= 1.2
Close/Open Set Point 2 max (1–65000 operations)	B3COP2	= 160
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	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 pri)	B3KAP3	= 20.0

Breaker 4 Monitor

BKR4 Trigger Equation (SELOGIC control equation)

$$\mathbf{BKMON4} = \mathbf{0}$$

Close/Open Set Point 1 max (1–65000 operations)	B4COP1	= 10000
kA Interrupted Set Point 1 min (0.1–999.0 kA pri)	B4KAP1	= 1.2

Close/Open Set Point 2 max (1–65000 operations)	B4COP2	= 160
kA Interrupted Set Point 2 min (0.1–999.0 kA pri)	B4KAP2	= 8.0
Close/Open Set Point 3 max (1–65000 operations)	B4COP3	= 12
kA Interrupted Set Point 3 min (0.1–999.0 kA pri)	B4KAP3	= 20.0

Through-Fault Event Monitor (SEL-387-5 and SEL-387-6 Relays)

Enable Through-Fault Event Winding (N, 1, 2, 3, 4)	ETHRU	= N
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NOTE: Changing setting ETHRU resets/clears through-fault event information.

Through-Fault Event Trigger (SELOGIC control equation)

THRU	= 0
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Through-Fault I²t Alarm Threshold

(OFF, 0–4294967 (kA) ² seconds)	ISQT	= OFF
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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 Current Input IAW4 (1–4 characters)	IAW4	= IAW4
Rename Current Input IBW4 (1–4 characters)	IBW4	= IBW4
Rename Current Input ICW4 (1–4 characters)	ICW4	= ICW4

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 (All But SEL-387-0 Relay)

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	=	_____

Sequential Events Recorder Settings (SET R Command)

Trigger Conditions

Trigger SER (24 Relay Word bits per SER_n 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	

Port Settings (SET P Command)

NOTE: RTSCTS setting does not appear if PROTO = LMD or DNP. LMD PREFIX, ADDR, and SETTLE do not appear if PROTO = SEL or DNP. See Appendix C: SEL Distributed Port Switch Protocol (LMD) for details on LMD protocol and see Appendix G: Distributed Network Protocol for details on DNP protocol.

Port 1 (SET P 1) Rear Panel, EIA-485 Plus IRIG-B

Port Protocol (SEL, LMD, DNP)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]	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)

[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]	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)		
[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]	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)		
[RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays only]	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 N (SET P N), EIA-232 for PROTO = RTDA**

(SEL-387-5 and SEL-387-6 Relays only)

Number of RTDA (0–12)

RTDNUMA = _____

RTD 1A Type (NA, PT100, NI100, NI120, CU10)

RTD1TA = _____

RTD 2A Type (NA, PT100, NI100, NI120, CU10)

RTD2TA = _____

RTD 3A Type (NA, PT100, NI100, NI120, CU10)

RTD3TA = _____

RTD 4A Type (NA, PT100, NI100, NI120, CU10)

RTD4TA = _____

RTD 5A Type (NA, PT100, NI100, NI120, CU10)

RTD5TA = _____

RTD 6A Type (NA, PT100, NI100, NI120, CU10)

RTD6TA = _____

RTD 7A Type (NA, PT100, NI100, NI120, CU10)

RTD7TA = _____

RTD 8A Type (NA, PT100, NI100, NI120, CU10)

RTD8TA = _____

RTD 9A Type (NA, PT100, NI100, NI120, CU10)

RTD9TA = _____

RTD 10A Type (NA, PT100, NI100, NI120, CU10)

RTD10TA = _____

RTD 11A Type (NA, PT100, NI100, NI120, CU10)

RTD11TA = _____

RTD 12A Type (NA, PT100, NI100, NI120, CU10)

RTD12TA = _____**Port N (SET P N), EIA-232 for PROTO = RTDB**

(SEL-387-5 and SEL-387-6 Relays only)

Number of RTDB (0–12)

RTDNUMB = _____

RTD 1B Type (NA, PT100, NI100, NI120, CU10)

RTD1TB = _____

RTD 2B Type (NA, PT100, NI100, NI120, CU10)

RTD2TB = _____

RTD 3B Type (NA, PT100, NI100, NI120, CU10)

RTD3TB = _____

RTD 4B Type (NA, PT100, NI100, NI120, CU10)

RTD4TB = _____

RTD 5B Type (NA, PT100, NI100, NI120, CU10)

RTD5TB = _____

RTD 6B Type (NA, PT100, NI100, NI120, CU10)

RTD6TB = _____

RTD 7B Type (NA, PT100, NI100, NI120, CU10)

RTD7TB = _____

RTD 8B Type (NA, PT100, NI100, NI120, CU10)

RTD8TB = _____

RTD 9B Type (NA, PT100, NI100, NI120, CU10)

RTD9TB = _____

RTD 10B Type (NA, PT100, NI100, NI120, CU10)

RTD 11B Type (NA, PT100, NI100, NI120, CU10)

RTD 12B Type (NA, PT100, NI100, NI120, CU10)

RTD10TB = _____

RTD11TB = _____

RTD12TB = _____

Section 7

Serial Port Communications and Commands

Overview

The SEL-387 Relay is equipped with four serial ports:

- One EIA-232 port on the front
- Two EIA-232 ports on the rear
- 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-2032, an SEL-2030, or an SEL-2020 Communications Processor, an SEL-2885, a SCADA serial port, and/or RTUs for local or remote communications.

Use one of the SEL protocols for communication. The SEL ASCII commands and structure are defined in detail in this section. Other SEL protocols used for interfacing other intelligent electronic devices for automated communication are described in detail in the appendices.

Establish Communication

Establish communication with the SEL-387 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. Many terminal emulation programs will work with the SEL-387. 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 Bit = 1
- RTS/CTS = N

Change the port settings, using the front panel or the **SET P <Enter>** command.

Port Identification

If there is ever uncertainty about the number of the port to which you are connected (1–4), use the command **SHO P <Enter>**. The relay will respond with a message identifying the port number, and will list the settings for that port. The **SHO P** command is discussed later in more detail.

Cables

Connect the SEL-387 to another device, using the appropriate cable. The pin definitions for Ports 1, 2, 3, and 4 are given on the relay rear panel and detailed in *Table 7.1*.

A 9-pin port connector drawing and pin definitions appear in *Figure 7.1*.

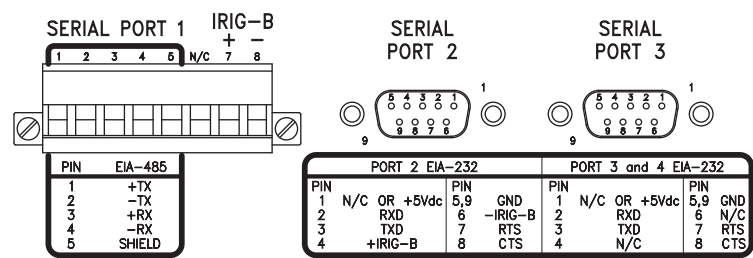


Figure 7.1 SEL-387 Serial Port Connectors

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 ^a	N/C	N/C
5	Shield	GND	GND	GND
6	N/C	N/C or –IRIG-B ^a	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

^a 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.

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.

Port 1 is an EIA-485 protocol connection on the rear of the relay. It accepts a pluggable terminal block that supports wire sizes from 24 AWG up to 12 AWG. The connector is supplied with the relay. Ports 2, 3, and 4 are EIA-232 protocol connections with Ports 2 and 3 on the rear of the relay and Port 4 on the front of the relay. These female connectors are 9-pin, D-subminiature connectors. Any combination of these ports or all of them may be used for relay communication. *Table 7.2* lists cables that can be purchased from SEL for various communication applications.

Table 7.2 SEL-387 Communication Cable Numbers

SEL-387 Port #	Connect to Device (gender refers to device)	SEL Cable #
2, 3, 4	PC, 25-Pin Male (DTE)	SEL-C227A
2, 3, 4	PC, 9-Pin Male (DTE)	SEL-C234A
2, 3	SEL-2032, SEL-2030, or SEL-2020 without IRIG-B	SEL-C272A
2	SEL-2032, SEL-2030, or SEL-2020 with IRIG-B	SEL-C273A
2	SEL IDM, Ports 2 through 11	Requires an SEL-C254 and SEL-C257 cable
2, 3	Modem, 5 Vdc Powered (pin 10)	SEL-C220 ^a
2, 3	Standard Modem, 25-Pin Female (DCE)	SEL-C222

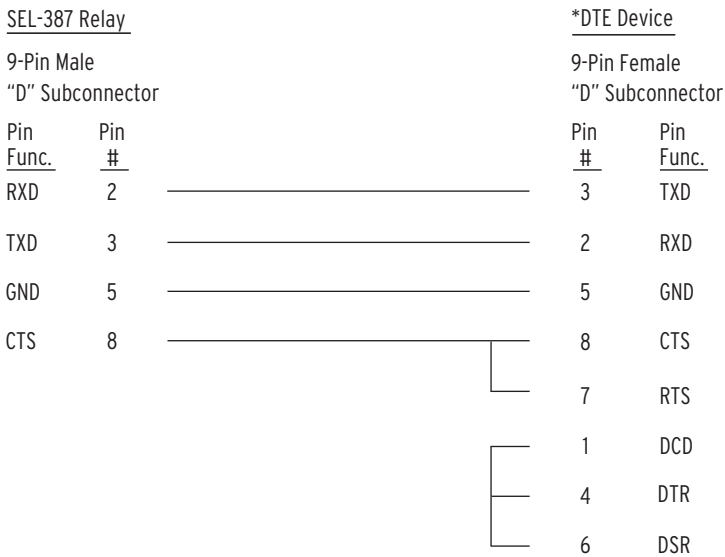
^a The 5 Vdc serial port jumper must be installed to power the Modem using SEL-C220. See Section 2: Installation.

For example, to connect the SEL-387 Ports 2, 3, or 4 to the 9-pin male connector on a laptop, order cable number SEL-C234A and specify the length needed. To connect the SEL-387 Port 2 to the SEL-2032, SEL-2030 or SEL-2020 Communications Processor that supplies the communication link and the time synchronization signal, order cable number SEL-C273A, and specify the length needed. For connecting devices at over 100 feet, fiber-optic transceivers are available. The SEL-2800 and SEL-2810 provide fiber-optic links between devices for electrical isolation and long-distance signal transmission. Call the factory for further information on these products.

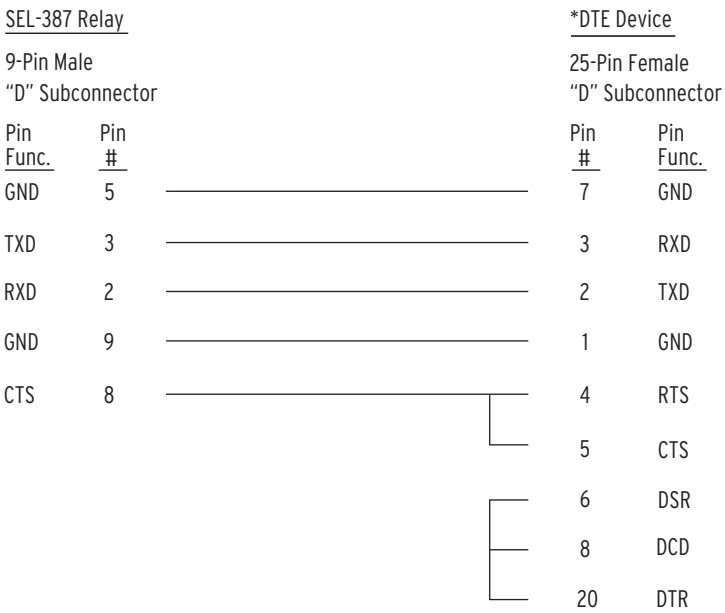
The following cable diagrams show several types of EIA-232 serial communications cables. These and other cables are available from SEL. Contact the factory for more information.

SEL-387 to Computer

Cable SEL-C234A



Cable SEL-C227A



*DTE = Data Terminal Equipment (Computer, Terminal, etc.)

SEL-387 to Modem

Cable SEL-C222

SEL-387 Relay			*DCE Device	
9-Pin Male			25-Pin Male	
"D" Subconnector			"D" Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
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 SEL-C220

SEL-387 Relay			Modem 5Vdc Powered	
9-Pin Male			25-Pin Male	
"D" Subconnector			"D" Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
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

*DCE = Data Communications Equipment (Modem, etc.)

SEL-387 to
SEL Communications
Processor

Cable SEL-C272A

SEL-2032, SEL-2030, or SEL-2020			SEL-387 Relay		
9-Pin Male "D" Subconnector			9-Pin Male "D" Subconnector		
Pin Func.	Pin #		Pin #	Pin Func.	
RXD	2	_____	3	TXD	
TXD	3	_____	2	RXD	
GND	5	_____	5	GND	
RTS	7	_____	7	RTS	
CTS	8	_____	8	CTS	

Cable SEL-C273A

SEL-2032, SEL-2030, or SEL-2020			SEL-387 Relay		
9-Pin Male "D" Subconnector			9-Pin Male "D" Subconnector		
Pin Func.	Pin #		Pin #	Pin Func.	
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	

Table 7.3 Serial Communications Port Pin Function Definitions

Pin Function	Definition
N/C	No Connection
+5 Vdc	5 Vdc Power Connection
RXD, RX	Receive Data
TXD, TX	Transmit Data
+(-)IRIG-B	IRIG-B Time-Code Input
GND	Ground
SHIELD	Shielded Ground
RTS	Request to Send
CTS	Clear to Send
DCD	Data Carrier Detect
DTR	Data Terminal Ready
DSR	Data Set Ready

Communications Protocol

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

Relay output appears boxed and in the following format:

XFMR 1

Date: 02/01/97

Time: 11:03:25.180

The communications protocol consists of hardware and software features.

Hardware Protocol

All EIA-232 serial ports support RTS/CTS hardware handshaking. RTS/CTS handshaking is not supported on the EIA-485 serial port.

To enable hardware handshaking, use the **SET P** command (or front-panel {SET} pushbutton) to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS = N.

If RTSCTS = N, the relay permanently asserts the RTS line.

If RTSCTS = Y, the relay deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the relay does not send characters until the CTS input is asserted.

Software Protocol

Software protocols consist of standard SEL ASCII, SEL Distributed Port Switch (LMD), SEL Distributed Network Protocol (DNP), SEL Fast Meter, SEL Fast Operate, and SEL Compressed ASCII. Based on the port PROTOCOL setting, the relay activates SEL ASCII, SEL LMD, or SEL DNP protocol. SEL Fast Meter and SEL Compressed ASCII commands are always active.

SEL ASCII Protocol

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

1. All commands received by the relay must be of the form:

<command><CR> or <command><CR><LF>

A command transmitted to the relay should consist of the following:

- A command followed by either a carriage return or a carriage return and line feed.
- You must separate arguments from the command by spaces, commas, semicolons, colons, or slashes.
- You may truncate commands to the first three characters. **EVENT 1 <Enter>** would become **EVE 1 <Enter>**.
- Upper- and lowercase characters may be used without distinction, except in passwords.

2. The relay transmits all messages in the following format:

<STX><CR><LF>

<MESSAGE LINE 1><CR><LF>

<MESSAGE LINE 2><CR><LF>

.

.

.

LAST MESSAGE LINE><CR><LF>

<ETX> <PROMPT>

Each message begins with the start of transmission character STX (ASCII character 02) and ends with the end of transmission character ETX (ASCII character 03).

3. The relay indicates how full its receive buffer is through an XON/XOFF protocol.

The relay transmits XON (ASCII hex 11) when the buffer drops below 40 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is over 80 percent full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the relay sends XON.

4. You can use an XON/XOFF procedure to control the relay during data transmission. When the relay receives an **XOFF** command during transmission, it pauses until it receives an **XON** command. If there is no message in progress when the relay receives an **XOFF** command, it blocks transmission of any message presented to its buffer.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

5. Control characters can be sent from most keyboards with the following keystrokes:

XON: <Ctrl+Q> (hold down the Control key and press Q)

XOFF: <Ctrl+S> (hold down the Control key and press S)

CAN: <Ctrl+X> (hold down the Control key and press X)

SEL Distributed Port Switch Protocol

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. Select the protocol by setting PROTOCOL = LMD, a SET P setting. See *Appendix C: SEL Distributed Port Switch Protocol (LMD)* for more information.

SEL Distributed Network Protocol (Not Available in the SEL-387-0)

SEL Distributed Network Protocol (DNP) meets DNP3 Level 2 requirements. Select the protocol by setting PROTOCOL = DNP, a SET P setting. See *Appendix G: Distributed Network Protocol* for more information.

SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering messages. SEL Fast Meter protocol is always available on any serial port. The protocol is described in *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*.

SEL Fast Operate Protocol

SEL Fast Operate protocol supports binary messages to control Relay Word bits. SEL Fast Operate protocol is available on any serial port. Turn it off by setting FAST_OP = N, a SET P setting. The protocol is described in *Appendix D: Configuration, Fast Meter, and Fast Operate Commands*.

SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the relay ASCII commands. SEL Compressed ASCII protocol is always available on any serial port. The protocol is described in *Appendix E: Compressed ASCII Commands*.

SEL Unsolicited Sequential Events Recorder (SER) Protocol

SEL Unsolicited Sequential Events Recorder (SER) Protocol provides SER events to an automated data collection system. SEL Unsolicited SER Protocol is available on any serial port. The protocol is described in *Appendix F: Unsolicited SER Protocol*.

SEL ASCII Protocol Details

Automatic Messages

The SEL-387 generates automatic messages and sends them out the serial port(s) with the SET P setting AUTO = Y. Four different automatic messages can be displayed:

- Relay startup message
- Setting group change message
- Relay self-test warning or failure
- Event summary message

Startup Message

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

XFMR 1	Date: 03/13/97	Time: 14:26:22.324
STATION A		
SEL-387		
=		

Group Switch Message

The SEL-387 has six different setting groups for the SET settings. The active group is selected by the SS1 through SS6 SELOGIC® control equation variable bits, or by the **GRO n** serial port command or the front-panel {GROUP} pushbutton. At the moment when the active group is changed, the following automatic message is generated.

```
XFMR 1                                     Date: 03/13/97   Time: 14:33:49.109
STATION A

Active Group = 2
=>>
```

NOTE: The SET G settings SS1 through SS6 take precedence over the **GRO n** command.

- RID and TID settings for the new active group
- Date and time of group change
- Active setting group now being used

Status Report

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

```
XFMR 1                                     Date: 04/21/00   Time: 21:29:42.829
STATION A

FID=SEL-387-6-X117-V0-Z001001-D20000419  CID=2001
SELF TESTS

W=Warn      F=Fail
IAW1      IBW1      ICW1      IAW2      IBW2      ICW2
OS         0         -0         -0         1         0         1
IAW3      IBW3      ICW3      IAW4      IBW4      ICW4
OS         0         0         -0         1         0        -1
+5V_PS     +5V_REG   -5V_REG   +12V_PS  -12V_PS   +15V_PS  -15V_PS
PS         4.93      4.99      -5.07     11.90    -12.08    14.96    -14.90
TEMP       RAM       ROM       A/D       CR_RAM    EEPROM   IO_BRD
          32.1      OK        OK        OK        OK        OK        OK

Relay Enabled
=>
```

- RID and TID settings for the active group
- Date and time the failure or warning was detected
- Firmware identification string
- Individual self-test results
- Relay protection enabled or disabled indication

Summary Event Report

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

```
XFMR 1                                     Date: 03/13/97   Time: 15:03:53.409
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 2 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 3 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 4 Currents (A Sec), ABC:   0.0   0.0   0.0

=>>
```

- RID and TID settings for the active group
- Date and time the event was triggered
- The event type
- Target information
- Phase currents for all four windings

Access Levels

Commands can be issued to the relay via the serial port to view metering values, change relay settings, etc. The available ASCII serial port commands are listed in *Figure 7.2*, and summarized by level in the *SEL-387 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) on page 7.22*. 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	=>>	0, 1, B, 2
C (highest)	==>>	0, 1, B, 2, C

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 `Invalid Command` to commands not listed or if a command is not followed by the correct number or letter.

Access Level 0

Once serial port communications are established with the relay, the Access Level 0 prompt (=) appears. If a different prompt appears, the relay was left in a different access level or the terminal emulation you are using is translating the characters differently. VT 100 emulation is recommended.

The only commands that can be executed at Access Level 0 are the **ACC** and **QUI** commands (see *Figure 7.2*. Enter the **ACC** command at the Access Level 0 prompt to go to Access Level 1.

Access Level 1

After issuing the **ACC** command and entering the password, if it is required [see *PAS (Passwords) on page 7.22* for default factory passwords], the relay is in Access Level 1. The prompt for Access Level 1 appears (=>).

Many commands can be executed from Access Level 1 for viewing relay information. The **2AC** command allows the relay to go to Access Level 2. The **BAC** command allows the relay to go to Access Level B. The **2AC** command allows the relay to go to Access Level 2.

Access Level B (Breaker Level)

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

Many commands can be executed from Access Level B for viewing relay information, and controlling the breaker. While in Access Level B, any of the commands available in the lower Access Levels 0 and 1 can be executed.

Access Level 2

After issuing the **2AC** command and entering the password, if it is required [see *PAS (Passwords)* for default factory passwords], the relay pulses the **ALARM** contact and is in Access Level 2. The Access Level 2 prompt appears (=>>).

This is the highest access level. All commands listed in this manual, for any access level, can be executed from Access Level 2 for viewing relay information, controlling the breaker, and changing settings. Firmware upgrades to Flash memory (see *Appendix B: SEL-300 Series Relays Firmware Upgrade Instructions*) are also performed from this level.

Access Level C

The **CAL** (Calibration Access Level) command is used to enter the calibration access level in the relay. Normal relay operation does not require access to this level. The only user command that may be necessary to use from this level is the **R_S** command, which resets factory default settings. Do not access this level unless instructed by the factory or using the **R_S** command. The relay is calibrated at the factory and will not need field calibration. Contact the factory if you suspect the relay is not calibrated.



Command Definitions

SEL ASCII commands require three characters and some commands require certain parameters. Each command is defined in alphabetical order. Examples are shown for some commands following their definitions. Text you type appears in bold, and keyboard keys you push appear in bold with brackets. For example, to enter Access Level 1 from Access Level 0 type **ACC <Enter>**.

2AC (Access Level 2)

Access Levels 1, B

Use the **2ACCESS** command to enter Access Level 2. The default password for Level 2 is shown in the table under *PAS (Passwords)* on page 7.22. Use the **PASSWORD** command from Access Level 2 to change passwords. Install main board jumper JMP6A to disable password protection. With JMP6A installed, the relay will not display a request for the password, but will immediately execute the command.

The following display indicates successful access to Level 2:

```
=>2AC <Enter>
Password: ? @@@@

XFMR 1                               Date: 11/09/96   Time: 14:23:41.758
STATION A

Level 2
=>>
```

You can use any command from the =>> prompt. The relay pulses the **ALARM** contact for one second after any Level 2 access attempt unless an alarm condition already exists.

ACC (Access Level 1)

Access Levels 0, B, 2

Use the **ACCESS** command to enter Access Level 1. The default password for Level 1 is shown in the table under *PAS (Passwords)*. Use the **PASSWORD** command from Access Level 2 to change passwords. Install main board jumper JMP6A to disable password protection.

The following display indicates successful access to Level 1:

```
=ACC <Enter>
Password: ? @@@@

XFMR 1                               Date: 11/09/96   Time: 14:23:41.758
STATION A

Level 1
=>
```

BAC (Access Level B)

Access Levels 1, 2

Use the **BACCESS** command to enter Access Level B. The default password for Level B is shown in the table under *PAS (Passwords)* on page 7.22. Use the **PASSWORD** command from Access Level 2 to change this password. Install main board jumper JMP6A to disable password protection.

The following display indicates successful access to Level B:

```

=>BAC <Enter>
Password: ? @@@@

XFMR 1                               Date: 11/11/96   Time: 14:04:51.251
STATION A

Breaker Level
=>

```

The relay pulses the **ALARM** contact closed for one second after any Level B access attempt unless an alarm condition already exists.

BRE (Breaker Report)

Access Levels 1, B, 2

Use the **BREAKER** command to display a report of breaker operation information. The breaker report provides trip counter and trip current information for up to four breakers. The summary of the operations provides valuable breaker diagnostic information at a glance. An example breaker report follows. Refer to *Section 5: Metering and Monitoring* for further information. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

```

=>>BRE <Enter>

XFMR 1                               Date: 06/19/97   Time: 21:04:30.973
STATION A

BREAKER 1
Int Trips=    4   IAW1=    0.01 IBW1=    0.01 ICW1=    0.02 kA(pri)
Ext Trips=   15   IAW1=    1.04 IBW1=    0.50 ICW1=    0.16 kA(pri)
Percent Wear:   POLE1=    0 POLE2=    0 POLE3=    0

BREAKER 2
Int Trips=    3   IAW2=   59.31 IBW2=    0.09 ICW2=    0.08 kA(pri)
Ext Trips=   14   IAW2=  160.91 IBW2=    1.70 ICW2=    0.33 kA(pri)
Percent Wear:   POLE1=   88 POLE2=    0 POLE3=    0

BREAKER 3
Int Trips=   11   IAW3=  316.47 IBW3=    0.33 ICW3=    0.46 kA(pri)
Ext Trips=    6   IAW3=    6.32 IBW3=    3.03 ICW3=    0.24 kA(pri)
Percent Wear:   POLE1=   100 POLE2=    0 POLE3=    0

BREAKER 4
Int Trips=    0   IAW4=    0.00 IBW4=    0.00 ICW4=    0.00 kA(pri)
Ext Trips=    0   IAW4=    0.00 IBW4=    0.00 ICW4=    0.00 kA(pri)
Percent Wear:   POLE1=    0 POLE2=    0 POLE3=    0

LAST BREAKER MONITOR RESET FOR   Bkr1: 06/12/97   16:02:07.407
                                   Bkr2: 06/12/97   16:02:07.533
                                   Bkr3: 06/12/97   16:02:07.651
                                   Bkr4: 06/12/97   16:02:07.758

=>>

```

BRE R n (Breaker Reset)

Access Levels B, 2

The **BRE R n** command resets the trip counter, trip current data and contact wear percentages for Breaker *n*. Issue **BRE R A** to reset all Breaker Monitors at one time. Use the **BRE** command to verify resetting of the data.

BRE W n (Breaker Wear Pre-Set)

Access Levels B, 2

This command is used to pre-set the amount of contact wear for Breaker *n*, on the assumption that the breaker has already experienced some fault duty before the relay is installed. The command prompts for percentage wear for each pole of the breaker. These must be entered as integer values, from 0 to 100 percent. Values over 100 will not be accepted. The data are stored in EEPROM and are nonvolatile. The procedure is shown below.

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

Breaker 1: Pole 1 % = 0 ? 15
Breaker 1: Pole 2 % = 0 ? 20
Breaker 1: Pole 3 % = 0 ? 10
Are you sure (Y/N) ? Y<Enter>
=>>
```

After entering the values, use the **BRE** command to verify that the data have been accepted properly.

CAL (Calibration Access Level) Command

Access Level 2

The **CALIBRATION** command is used to enter the calibration access level in the relay. Normal relay operation does not require access to this level. The only user command that may be necessary to use from this level is the **R_S** command, which resets factory default settings. Do not access this level unless instructed by the factory or using the **R_S** command. The relay is calibrated at the factory and will not need field calibration. Contact the factory if you suspect the relay is not calibrated.

CEV (Compressed Event)

Access Levels 1, B, 2

SEL-5601-2 SYNCHROWAVE® Event Software is available for graphical analysis of event reports. The **CEV** command is a compressed (comma-delimited formatting) version of the **EVE** command. Use the **CEV** command to download events for SYNCHROWAVE Event.

The **CEV** command can generate both winding and differential reports.

The command syntax is **CEV [DIF R][n Sx Ly[-[w]] C]**. All parameters are optional. Enter them in any order.

DIF specifies generation of the differential element report in compressed form. Otherwise, the winding report will be produced.

R specifies “raw,” or unfiltered analog data, in a format [1.5 cycles + Ly].

Letter *n* specifies the event number.

Sx specifies samples per cycle. The *x* value can be 4, 8, 16, 32, or 64 for raw reports (default is 16) or 4, 8 for filtered reports (default is 4). Digital elements will be displayed at the resolution specified by Sx, up to a maximum of eight samples per cycle.

Ly specifies the report length in cycles. The *y* value can be from 1 to the LER setting. Default is 15 cycles. **Ly-** specifies reporting from cycle *y* to the end of the report. **Ly-w** specifies reporting from cycle *y* to cycle *w*.

C specifies using the eight samples per cycle compressed format for compatibility with the SEL-2032, SEL-2030, or SEL-2020 and is equivalent to using the **EVE C** command.

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

Refer to *Appendix E: Compressed ASCII Commands* for a complete description of the command, as well as additional Compressed ASCII commands **CAS**, **CBR**, **CHI**, **CST**, and **CTA**.

CLO n (Close)

Access Levels B, 2

The **CLO n** command asserts the CCn Relay Word bit. This bit must be included in the CLn Close Logic setting for Breaker n, in order for closing to take place. This logic is described in *Section 4: Control Logic*.

To close the circuit breaker with this command, type **CLOSE n <Enter>**. The prompting message `Close Breaker n (Y/N) ?` is displayed. Then `Are you sure (Y/N)?` Typing **N <Enter>** after either of the above prompts aborts the closing operation with the message `Command Aborted`. If both questions are answered **Y <Enter>**, the breaker will be closed, an automatic message summarizing the close operation will be sent, and an Event Report will be created.

If the main board jumper JMP6B is not in place, the relay responds: `Aborted: Breaker Jumper Not in Place`.

CON n (Control RBn)

Access Level 2

This command is used to control the Relay Word bit RBn, or Remote Bit n, having a value of 1 to 16. The relay responds with **CONTROL RBn**. The user must then respond with one of the following: **SRB n <Enter>** (Set Remote Bit n), or **CRB n <Enter>** (Clear Remote Bit n), or **PRB n <Enter>** (Pulse Remote Bit n). The latter asserts RBn for one processing interval, one-eighth cycle. The Remote Bits permit design of SELOGIC control equations that can be set, cleared, or momentarily activated via a remote command.

COP m n (Copy Settings)

Access Level 2

The **COPY** command copies settings and logic from setting Group m to Group n (m and n can be any combination of 1 through 6). After entering the settings into one setting group with the **SET** command, copy it to the other groups with the **COPY** command. Use the **SET** command to modify copied setting groups. The **ALARM** output contact closes momentarily when you change settings in an active setting group but not in an inactive setting group.

```
=>>COP 13 <Enter>
COPY 1 to 3
Are you sure (Y/N) ? Y <Enter>

Please wait...
Settings copied
=>>
```

DAT (Date)

Access Levels 1, B, 2

NOTE: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

The **DATE** command displays or sets the date stored by the internal calendar/clock. Simply typing **DAT <Enter>** displays the date. Set the date by typing **DATE d1 <Enter>** where d1 is either mm/dd/yy or yy/mm/dd depending on the SET G date format setting DATE_F. The following example views the current date, verifies the DATE_F setting, and changes the date. Note that single-digit numbers may be entered without leading zeros like the 9 in 11/9/96.

```
=>>DAT <Enter>
11/11/96
=>>SHO G DATE_F <Enter>

RELAY SETTINGS
DATE_F = MDY      FP_TO = 5      TGR   = 5

=>>DAT 11/9/96 <Enter>
11/09/96
=>>
```

EVE (Event Reports)

Access Levels 1, B, 2

Use the **EVENT** command to view event reports. See *Section 9: Event Reports and SER* for further details on retrieving event reports.

GRO and GRO n (Setting Group)

Access Levels 1, B, 2

The **GROUP** command, at Access Level 1, displays the setting group variable for the currently active setting group. Changing the variable is not permitted. The **GROUP n** command, at Levels B and 2, designates what the setting group variable is to be ($n = 1$ to 6), thereby asking the relay to change to the setting group so designated. The relay will only make the change if the setting group selection SELOGIC control equations (SS1 through SS6) are not assigned or are not asserted. The following example verifies the existing group variable, changes it, and then waits for the automatic message when the setting group changes. The variable must be changed for a certain number of seconds as specified by the TGR setting (under SET G) before the new settings are enabled.

```
=>>GRO <Enter>
Active Group = 1
=>>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
=>>
```

NOTE: The relay will be disabled momentarily while the change in groups takes place.

The **GROUP** command does not clear the event report buffer. If the active group is changed, the relay pulses the **ALARM** output contacts and generates the following automatic message:

```
XFMR 1                      Date: 03/13/97   Time: 14:33:49.109
STATION A

Active Group = 2
=>>
```

HIS (History of Events)

Access Levels 1, B, 2

NOTE: SEL-387-0 firmware versions R100-R105 display 99 event summaries. SEL-387-6 firmware versions R304 and R405 display 40 event summaries. All other firmware versions display 80 event summaries.

The **HISTORY** command displays the 80 most recent event summaries in reverse chronological order (most recent event at the top, with lowest event number #). The number of full Event Reports completely saved in Flash memory depends on the SET G setting LER as follows:

LER Setting	Number of Event Reports Stored
15 cycles	18–21
30 cycles	12–14
60 cycles	7

Each summary shows the date, time, event type, active setting group at the time of the event, and relay targets.

Event types, in decreasing order of precedence, are: TRIP n ($n = 1$ to 5), CLS m ($m = 1$ to 4), ER (SELOGIC control equation event trigger), PULSE (user-initiated momentary contact operation), and TRIG (user-initiated triggering of an Event Report). If more than one event type occurs during the same event, the type with highest precedence will be displayed in the EVENT field of each line of the display.

NOTE: SEL-387-0 firmware versions R100-R105 display 99 event summaries. SEL-387-6 firmware versions R304 and R405 display 40 event summaries. All other firmware versions display 80 event summaries.

Enter **HIS n** , where n is a positive number (1 through 80), to limit the history report to the most recent n events. The history is stored in nonvolatile memory, so it is retained through power failures.

The date and time is saved to the nearest millisecond and referenced to the trigger row of data in the Event Report.

An example of the display appears below. In this example, seven events have occurred since the history was last cleared:

```
=>HIS<Enter>
```

XFMR 1		Date: 6/1/96	Time: 01:16:24
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 A B W3
4	01/01/96	00:18:10.258	TRIP1	1	
5	01/01/96	00:18:08.095	TRIP3	1	50 A B W3
6	12/09/95	22:41:33.108	ER	1	
7	12/09/95	22:27:47.870	TRIP3	1	50 A B W3

```
=>
```

If an event has not occurred since the history was last cleared, the headings are displayed with the message: History Buffer Empty.

HIS C (Clear History and Events)

Access Levels 1, B, 2

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.

HIS C command clears the history and events associated with them from nonvolatile Flash memory. The clearing process can take up to 30 seconds under normal operation. It can 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)
=>
```

ID (Identification)

Access Levels 0, 1, B, 2

The **ID** command displays a variety of identification and configuration information about the relay.

FID: reports the FID string; **CID:** reports the checksum of the ROM code; **DEVID:** reports the terminal ID as set by the TID setting; **DEVCODE:** reports the Modbus® code (32).

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 DNP3 Level 2 Slave; for *p* = X, it will be standard with no DNP.

CONFIG: reports nominal frequency, phase rotation, input current, and PT connections.

The designators “abcdef” represent the following:

“a” the nominal frequency; where 0 = N/A, 1 = 60Hz, and 2 = 50Hz.

“b” the phase rotation; where 0 = N/A, 1 = ABC, and 2 = ACB.

“c” the phase input current scaling; where 0 = N/A, 1 = 5A, and 2 = 1A.

“d” the neutral input current scaling; where 0 = N/A, 1 = 5A, 2 = 1A.

“e” the voltage input connection; where 0 = N/A, 1 = Delta and 2 = Wye.

“f” the current input connection; where 0 = N/A, 1 = Delta and 2 = Wye.

```
=>>>ID <Enter>
"FID=SEL-387-0-X131-V0-Z002002-020011105","0903"
"CID=0FA1","0265"
"DEVID=XFMR 1","0838"
"DEVCODE=32","030C"
"PARTNO=0387003X5HXX4XX","064F"
"CONFIG=111100","0387"

=>>>
```

INI (Initialize Interface Boards)

Access Levels 1, B, 2

The **INITIO** 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 the last time the relay turned on, INITIO will confirm that the interface boards present are correct from Access Level 2.


```
=>>IRI <Enter>
I/O BOARD      INPUTS      OUTPUTS
Main           6           7
1              No Board Connected
2              No Board Connected

=>>
```

IRI (IRIG-B Synchronization)

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.

Access Levels 1, B, 2

The **IRIG** command forces the relay to read the demodulated IRIG-B time-code input at the time of the command.

If the relay reads the time code successfully, it updates the internal clock/calendar time and date to the time-code reading. The relay then transmits a message with relay settings RID and TID, and the date and time.

```
=>>IRI <Enter>

XFMR 1                      Date: 02/01/96    Time: 01:45:40.762
STATION A
=>
```

If no IRIG-B signal is present or the code cannot be read successfully, the relay sends the error message **IRIG-B DATA ERROR**.

MET (Metering Report)

Access Levels 1, B, 2

The **METER** command displays currents, demand currents, peak demand currents, or differential data, depending on the command statement. There are several choices for the **MET** command, listed briefly below. Refer to *Section 5: Metering and Monitoring* for a complete description of the metering reports.

Table 7.4 MET Command Choices

MET	Displays winding current metering data, in primary amperes
MET D	Displays winding demand ammeter data, in primary amperes
MET DIF	Displays differential metering data, in multiples of tap
MET H	Displays harmonic spectrum of currents (see MET H below)
MET P	Displays peak demand ammeter data, in primary amperes
MET RD <i>n</i>	Resets demand ammeter for Winding <i>n</i> (<i>n</i> = 1, 2, 3, 4, A)
MET RP <i>n</i>	Resets peak demand ammeter values for Winding <i>n</i> (<i>n</i> = 1, 2, 3, 4, A)
MET SEC	Displays winding current metering data, with magnitude and phase angle, in secondary amperes
MET T	Displays the temperature values of up to 12 RTDs per port (maximum of 24 RTDs) (SEL-387-5 and SEL-387-6 relays only)

Use the **MET XXX *n*** command, where *n* is a positive integer, to repeat the MET XXX report *n* times. For example, to display a series of eight meter readings, type **MET 8 <Enter>**.

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

MET H (Harmonic Metering)

Access Levels 1, B, 2

The **METER H** command is different from the normal metering functions, in that it uses 1 full cycle of unfiltered data, at 64 samples per cycle, to provide a snapshot of total harmonic content of all 12 analog current inputs. It uses a Fast Fourier transform technique to provide secondary current values for all harmonics from 1 (fundamental) to 15.

This function is explained more fully in *Section 5: Metering and Monitoring* where a sample report also is shown. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set.

MET T (Temperature Metering) (SEL-387-5 and SEL-387-6)

Access Levels 1, B, 2

METER T reports the temperature values of up to 24 RTD inputs: RTDA Input Temperature Data (deg. X); RTD 1A through RTD 12A; RTDB Input Temperature Data (deg. Y); RTD 1B through RTD 12B.

where:

deg X: C or F depending on the TMPREFA setting

deg Y: C or F depending on the TMPREFB setting

OPE n (Open)

Access Levels B, 2

The **OPE n** command asserts the OC n Relay Word bit. This bit must be included in the TR n trip logic setting for Breaker n , in order for opening to take place. This logic is described in *Section 4: Control Logic*.

To open circuit Breaker n by this command, type **OPE n <Enter>**. The prompt `Open Breaker n (Y/N) ?` is displayed. Then `Are you sure (Y/N) ?` is displayed. Typing **N <Enter>** after either of the above prompts aborts the opening operation with the message `Command Aborted`. If both questions are answered **Y <Enter>**, the breaker will be opened, an automatic message summarizing the trip will be sent, an Event Report will be created, and the **TRIP LED** on the front panel will light. This must be turned off by a **TAR R** command or by the {TARGET RESET} pushbutton on the front panel.

If the main board jumper JMP6B is not in place, the relay responds: `Aborted : Breaker Jumper Not in Place`.

PAS (Passwords)

Access Level 2, C

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

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	Factory Default Password
1	OTTER
B	EDITH
2	TAIL
C	CLARKE

The **PAS**word command allows you to change existing Level 1, B, and 2 passwords at Access Level 2 and allows you to change the Level C password from Level C. To change passwords, enter **PAS x**, where *x* is the access level whose password is being changed. The relay will prompt for the old password, new password, and a confirmation of the new password.

To change the password for Access Level 1, enter the following:

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: *****
Confirm New Password: *****

Password Changed
=>>
```

The new password will not echo on the screen, and passwords cannot be viewed from the device. Record the new password in a safe place for future reference.

If the passwords are lost or you wish to operate the relay without password protection, put the main board Password jumper in place (Password jumper = ON). Refer to *Password and Breaker Jumpers on page 2.15* for Password jumper information. With the Password jumper in place, issue the **PAS x** command at Access Level 2. The relay will prompt for a new password and a confirmation of the new password.

Passwords may include up to 12 characters. See *Table 7.5* for valid characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 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:

- Ot3579A24.68
- Ih2d&s4u-Iwg
- .387e.Nt9g-t

Table 7.5 Valid Password Characters

Alpha	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
Numeric	0123456789
Special	!"#\$%&'()*+,-./:;<=>?@[\\\]^_`{|}~

The relay shall issue a weak password warning if the new password does not include at least one special character, number, lowercase letter, and uppercase letter.

```
=>>PAS 1 <Enter>

Old Password: *****

New Password: *****
Confirm New Password: *****

Password Changed
=>>

CAUTION: This password can be strengthened. Strong passwords do not include a name,
         date, acronym, or word. They consist of the maximum allowable characters, with
```

at least one special character, number, lower-case letter, and upper-case letter. A change in password is recommended.

==>>

PUL n (Pulse)

NOTE: The **PUL** command is useful during testing to verify operation of output contacts, but it should not be used while the relay is in service. During the entire time the specified output contact is being pulsed, all other output contacts are frozen in their existing state and are not permitted to change. This could prevent a trip or other critical output from being issued during the specified PUL time interval.

Access Levels B, 2

The **PULSE n k** command asserts the selected output contact *n* for *k* seconds. The *k* parameter is optional. If *k* is not specified, the output contact is pulsed for 1 second. Main board breaker jumper JMP6B must be in place. After issuing the **PULSE** command, the relay asks for confirmation of the operation, and then asks if you are sure. An invalid output contact name or incorrect *k* value produces an error message.

Parameter *n* can be any existing output contact element name such as **OUT107**. Parameter *k* must be a number ranging from 1 to 30 seconds.

```
=>>>PUL OUT107 3 <Enter>
Pulse contact OUT107 for 3 second(s) (Y/N) ? Y <Enter>
Are you sure (Y/N) ? Y <Enter>
=>>
```

QUI (Quit)

Access Levels 0, 1, B, 2

The **QUIT** command returns the relay to Access Level 0 from Level 1, B, or 2. The command displays the relay settings RID, TID, date, and time of **QUIT** command execution.

Use the **QUI** command when you finish communicating with the relay to prevent unauthorized access. The relay automatically returns to Access Level 0 after a certain inactivity time dependent on the SET P setting T_OUT.

```
=>>QUI <Enter>

XFMR 1                      Date: 02/01/93    Time: 15:15:32.161
STATION A
-
```

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

Access Level 2

The **RESET51** command clears the inverse-time overcurrent element accumulators (phase, negative-sequence, and residual) for all four windings. It also clears the four combined overcurrent phase and residual inverse-time elements. This command is useful in testing of the inverse-time elements, because it mimics the action of immediately returning an electromechanical disk to the starting position. This command can save time in waiting for some units to reset according to their electromechanical reset equations in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements*.

The relay will ask Reset 51 Elements (Y/N) ? when given the **RES** command. If No, it will abort the command. If Yes, it will respond All Time-Overcurrent Element Accumulators Cleared. This command is not likely to have much use in normal in-service relay operation.

SER (Sequential Events Recorder)

Access Levels 1, B, 2

The **SER** command displays the last 512 SER records. To limit the number of records displayed, use number or date parameters with the **SER** command.

SER d1 shows only events triggered on the date specified by d1. **SER d1 d2** shows only events triggered on or between the specified dates. **SER m** shows the most recent m events. **SER m n** shows event records m through n. The following is an example of the SER report. See *Section 9: Event Reports and SER* for a complete description of the report.

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

XFMR 1	Date: 03/13/97	Time: 18:27:42.091
STATION A		


```
FID=SEL-387-X104-V-D970311
```

#	DATE	TIME	ELEMENT	STATE
4	2/26/97	10:33:54.873	TRIP3	Asserted
3	2/26/97	10:33:55.373	TRIP3	Deasserted
2	2/27/97	10:34:06.872	CLS3	Asserted
1	2/27/97	10:34:07.372	CLS3	Deasserted

```
=>
```

SER C (Clear Sequential Events Recorder)

Access Levels 1, B, 2

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.

Clear the sequential event records from relay memory with the **SER C** command. The process can 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 <Enter>
Clearing Complete

=>>
```

SET (Edit Group 1-6 Settings)

Access Level 2

Configure the relay using the **SET** command. The entire syntax of the **SET** command follows:

SET n Setting TERSE <Enter>

All parameters are optional and perform the following functions:

- **n** specifies the setting group (1 through 6). The default is the active setting group.
- **Setting** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the group settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

If a setting is hidden because that section of the settings is turned OFF, you cannot jump to that setting. **TERSE** is very useful when making small changes to the settings. For example, the following procedure is recommended when making a change to one setting:

Change the CTR1 Setting

=>>SET CTR1 TE <Enter>

Group 1

GENERAL DATA

Wdg 1 CT Ratio (1-50000)

CTR1 = 120 ? 160 <Enter>

Wdg 2 CT Ratio (1-50000)

CTR2 = 240 ? END <Enter>

Save Changes? Y <Enter>

Settings saved

Verify the CTR1 Setting

=>>SHO CTR1 <Enter>

Group 1

GENERAL DATA

CTR1 = 160

CTR2 = 240

CTR3 = 400

CTR4 = 400

MVA = 100.0

ICOM = Y

W1CTC = 11

W2CTC = 11

W3CTC = 0

VWDG1 = 230.00

VWDG2 = 138.00

VWDG3 = 13.80

Issue <Ctrl+X> to Stop Scrolling

=>>

Table 7.6 lists the editing keys that you can use with the **SET** command.

Table 7.6 Editing Keys for SET Commands

Press Key(s)	Results
^ <Enter>	Moves to previous entry in a setting category until you get to the first entry in the category, and then it moves to previous category.
< <Enter>	Moves to previous settings category when making group settings.
> <Enter>	Moves to next settings category when making group settings.
<Enter>	Moves to next entry.
END <Enter>	Exits editing session and displays all settings (if TERSE not used). Prompts: SAVE CHANGES (Y/N)? Type Y <Enter> to save changes and exit, N <Enter> to exit without saving.
<CONTROL> X	Aborts editing session without saving changes.
OFF <Enter>	Flags a setting as not applicable. Only applies to certain settings.

After you enter a setting, you are prompted for the next setting. Press **<Enter>** to move from setting to setting. The settings are arranged into families of related settings to simplify setting changes. You can start at a specific setting by entering the setting name as a parameter.

The relay checks each entry to ensure that it is within the allowable input range. If it is not, an *Out of Range* message is generated, and the relay prompts for the setting again.

When you have made all the necessary setting changes, it is not necessary to scroll through the remaining settings. Type **END <Enter>** at the next setting prompt to display the new settings and request confirmation.

Answer **Y <Enter>** to the confirmation request to approve the new settings. If you violate a rule for setting relationships, a fail message is displayed, and the settings prompt moves to the first setting that affects the failure. While the active settings are updated, the relay is disabled, the **ALARM** output contacts

close, and all timers and relay elements reset. The relay logic is fully functional while editing settings. The relay is only disabled for approximately one second when settings are saved.

Refer to *Section 6: Setting the Relay* for all default settings and setting worksheets.

SET G (Edit Global Settings)

Access Level 2

Configure the relay Global settings using the **SET G** command. The Global settings include Event Report parameters, frequency, phase rotation, date format, front-panel time-out, rotating display update rate, the group switching time delay, DC battery monitor thresholds, breaker monitor settings, analog input labels, *SSn* setting group variables, and definition of front-panel programmable LED and display point variables. The entire syntax of the **SET G** command follows:

SET G Setting TERSE <Enter>

The two parameters are optional and perform the following functions:

- **Setting** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the Global settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

The **SET G** procedure works just like the **SET** procedure. *Table 7.6* lists the editing keys that you can use with the **SET** command.

Refer to *Section 6: Setting the Relay* for all default settings and setting worksheets.

SET P (Edit Port Settings)

Access Level 2

Configure the relay port settings using the **SET P** command. The port settings include the communication and protocol settings. The entire syntax of the **SET P** command follows:

SET P *n* Setting TERSE <Enter>

The two parameters are optional and perform the following functions:

- *n* specifies the serial port number (1, 2, 3, or 4). Default is the port issuing the command.
- **Setting** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the port settings at the end of the setting procedure.

The command will function properly if just **TE** is entered, instead of the full word.

The **SET P** procedure works just like the **SET** procedure. *Table 7.6* lists the editing keys that you can use with the **SET** command.

The settings for each communications port are:

Table 7.7 Settings for Each Communications Port

PROTO	protocol can be SEL, LMD, DNP, RTDA, or RTDB.
PREFIX	If PROTO is LMD, prefix can be @, #, \$, %, or &.
ADDR	If PROTO is LMD, ADDR can be any integer 1 through 99.
SETTLE	If PROTO is LMD, the settling time can be 0 to 30 seconds.
SPEED	baud can be set to 300, 1200, 2400, 4800, 9600, or 19200.
BITS	data can be 7 or 8 bits.
PARITY	can be O, E, or N (Odd, Even, None).
STOP	bits can be 1 or 2.
T_OUT	port inactivity time-out can be 0 through 30 minutes. T_OUT = 0 setting means port will never time out. Time-out returns port to Access Level 0.
AUTO	send auto messages to the port; Yes or No.
RTSCTS	enable hardware handshaking; Yes or No (only if PROTO = SEL).
FASTOP	enable Fast Operate function; Yes or No.

Refer to *Section 6: Setting the Relay* for all default settings and setting worksheets.

SET R (Edit SER Settings)

Access Level 2

Configure the Sequential Events Recorder settings using the **SET R** command. The settings are the four sequential events recorder trigger conditions (SER1 to SER4) and the ALIAS1 to ALIAS20 settings for re-naming Relay Word bits for the SER report. The entire syntax of the **SET R** command follows:

SET R Setting TERSE <Enter>

The two parameters are optional and perform the following functions:

- **Setting** specifies the setting name with which to begin. The default is the first setting.
- **TERSE** eliminates the display of the new settings at the end of the setting procedure. The command will function properly if just **TE** is entered, instead of the full word.

The **SET R** procedure works just like the **SET** procedure. *Table 7.6* lists the editing keys that you can use with the **SET** command.

Refer to *Section 6: Setting the Relay* for setting worksheets. Refer to *Section 9: Event Reports and SER* for more details on default settings and data retrieval.

NOTE: Make Sequential Events Recorder (SER) Settings With Care. The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, SER3, or SER4 trigger settings. Nonvolatile memory is used to store the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory is rated for a finite number of "writes." Exceeding the limit can result in an EEPROM self-test failure. An average of 1 state change every 3 minutes can be made for a 25-year relay service life.

SHO (Show Group 1-6 Settings)

Access Levels 1, B, 2

SHOWSET displays the relay settings of the currently selected group. The entire syntax of the **SHO** command follows:

SHO n Setting A <Enter>

- **n** specifies the setting group (1 through 6). The default is the active setting group.
- **Setting** specifies the setting name with which to begin. The default is the first setting.
- If **Setting = A**, then hidden settings are shown in addition to the regular settings.

Control characters provide control over the scrolling of the data:

Temporarily Stop Scrolling: **<Ctrl+Q>** (hold down the Control key and press Q)Restart Scrolling: **<Ctrl+S>** (hold down the Control key and press S)Cancel Scrolling Completely: **<Ctrl+X>** (hold down the Control key and press X)

Settings cannot be entered or modified with this command. Change settings with the **SET** command from Access Level 2. Refer to *Section 6: Setting the Relay* for information on all settings. The following example demonstrates the report for the **SHO** command.

```
=>>SHO <Enter>
Group 1
```

```

RID      =XFMR 1
TID      =STATION A
E87W1    = Y      E87W2    = Y      E87W3    = Y      E87W4    = N
EOC1     = Y      EOC2     = Y      EOC3     = Y      EOC4     = N
EOCC     = N
ETHER    = Y      E49A     = N      E49B     = N
ESLS1    = N      ESLS2    = N      ESLS3    = N

W1CT     = Y      W2CT     = Y      W3CT     = Y      W4CT     = Y
CTR1     = 600    CTR2     = 1200   CTR3     = 2000   CTR4     = 2000
MVA      = 100.0  ICOM     = Y
W1CTC    = 11     W2CTC    = 11     W3CTC    = 0
VWDG1    = 230.00 VWDG2    = 138.00 VWDG3    = 13.80

TAP1     = 0.42   TAP2     = 2.35   TAP3     = 2.09
O87P     = 0.30   SLP1     = 25     SLP2     = 50     IRS1     = 3.0
U87P     = 10.0   PCT2     = 15     PCT5     = 35
TH5P     = OFF    IHBL     = N

E32I     =0
```

Press RETURN to continue

```

50P11P   = 4.00   50P11D   = 5.00   50P11TC  =1
50P12P   = OFF    50P12D   = 5.00   50P12TC  =1
50P13P   = 0.10   50P13D   = 0.80   50P13TC  =1
51P1P    = 0.80   51P1D    = 0.80   51P1TC   =1
51P1C    = U2     51P1TD   = 3.00   51P1RS   = Y

50Q11P   = OFF    50Q12P   = OFF    50Q12D   = 3.00   50Q12TC  =1
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
```

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```

50P21P = OFF      50P22P = OFF
50P23P = 0.10     50P24P = 0.70
51P2P  = 0.70     51P2C  = U2      51P2TD = 3.50      51P2RS = Y
51P2TC = -1

Press RETURN to continue

50Q21P = OFF      50Q22P = OFF
51Q2P  = 1.05     51Q2C  = U2      51Q2TD = 3.50      51Q2RS = Y
51Q2TC = -1

50N21P = OFF      50N22P = OFF
51N2P  = OFF
DATC2  = 15        PDEM2P = 1.40     QDEM2P = 0.20     NDEM2P = 0.20

50P31P = 1.40     50P31D = 0.00     50P31TC = -1
50P32P = OFF
50P33P = 0.10     50P34P = 0.80
51P3P  = 0.80     51P3C  = U2      51P3TD = 1.30     51P3RS = Y
51P3TC = -1

50Q31P = OFF      50Q32P = OFF
51Q3P  = OFF
50N31P = OFF      50N32P = OFF
51N3P  = OFF

Press RETURN to continue
DATC3  = 15        PDEM3P = 1.40     QDEM3P = 0.20     NDEM3P = 0.20

TMWDG  = 1         VWDG  = 230.00   XTYPE  = 3         TRTYPE = Y
THwr   = 65        NCS   = 1
MCS11  = 100.0     TRDE  = 0
DTMP   = 15        AMB   = THM1     OIL1    = THM2
NTHM   = 2         TOT2  = 100        HST1    = 200
TOT1   = 100       FAAL2  = 50.00   RLLOLL  = 50.00   HST2    = 200
FAAL1  = 50.00     FAAL1  = 50.00     TLLOLL  = 50.00
CSEP1  = 15
ILIFE  = 180000    EDFTC  = Y
TDURD  = 9.000     CFD    = 60.000
TR1    = 50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2    = 51P2T + 51Q2T + OC2
TR3    = 50P31 + 51P3T + OC3
TR4    = 87R + 87U
TR5    = 0
ULTR1  = !50P13
ULTR2  = !50P23

Press RETURN to continue
ULTR3  = !50P33
ULTR4  = !(50P13 + 50P23 + 50P33)
ULTR5  = 0
52A1   = !IN101
52A2   = !IN102
52A3   = !IN103
52A4   = 0
CL1    = !CC1 + LB4 + /IN104
CL2    = !CC2 + /IN105
CL3    = !CC3 + /IN106
CL4    = 0
ULCL1  = !TRIP1 + TRIP4
ULCL2  = !TRIP2 + TRIP4
ULCL3  = !TRIP3 + TRIP4
ULCL4  = 0
ER     = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101 = !TRIP1
OUT102 = !TRIP2
OUT103 = !TRIP3
OUT104 = !TRIP4

Press RETURN to continue
OUT105 = !CLS1
OUT106 = !CLS2
OUT107 = !CLS3

SCEUSE  46.8
GR1CHK  A526
=>>

```

SHO G (Show Global Settings)

Access Levels 1, B, 2

SHOWSET G displays the relay Global settings of the currently selected group. The Global settings include Event Report parameters, frequency, phase rotation, date format, front-panel time-out, the group switching time delay, DC battery monitor thresholds, breaker monitor settings, analog input labels, SSn setting group variables, and definition of front-panel programmable LED and display point variables. The syntax of the **SHO G** command follows:

SHO G Setting <Enter>

- **Setting** specifies the setting name with which to begin. The default is the first setting.

Settings cannot be entered or modified with this command. Change settings with the **SET G** command from Access Level 2. Refer to *Section 6: Setting the Relay* for information on all settings. The following example demonstrates the report for the **SHO G** command.

```

->>>SHO G <Enter>
LER      = 15      PRE      = 4      NFREQ     = 60      PHROT     = ABC
DATE_F   = MDY     SCROLLD  = 2      FP_TO     = 16      TGR       = 3
TMPREFA  = F       TMPREFB  = F      DC3P      = OFF     DC4P      = OFF
DC1P     = OFF     DC2P     = 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

BKMON4   =0

Press RETURN to continue

ETHRU    = N

IAW1     =IAW1
IBW1     =IBW1
ICW1     =ICW1
IAW2     =IAW2
IBW2     =IBW2
ICW2     =ICW2
IAW3     =IAW3
IBW3     =IBW3
ICW3     =ICW3
IAW4     =IAW4
IBW4     =IBW4
ICW4     =ICW4

SS1      =0
SS2      =0
SS3      =0
SS4      =0

Press RETURN to continue
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

```

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```

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

Press RETURN to continue
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    =

Press RETURN to continue
NLB3    =MANUAL TRIP 1 CLB3    =RETURN  SLB3    =          PLB3    =TRIP
NLB4    =MANUAL CLOSE 1 CLB4    =RETURN  SLB4    =          PLB4    =CLOSE
NLB5    =          CLB5    =          SLB5    =          PLB5    =
NLB6    =          CLB6    =          SLB6    =          PLB6    =
NLB7    =          CLB7    =          SLB7    =          PLB7    =
NLB8    =          CLB8    =          SLB8    =          PLB8    =
NLB9    =          CLB9    =          SLB9    =          PLB9    =
NLB10   =          CLB10   =          SLB10   =          PLB10   =
NLB11   =          CLB11   =          SLB11   =          PLB11   =
NLB12   =          CLB12   =          SLB12   =          PLB12   =
NLB13   =          CLB13   =          SLB13   =          PLB13   =
NLB14   =          CLB14   =          SLB14   =          PLB14   =
NLB15   =          CLB15   =          SLB15   =          PLB15   =
NLB16   =          CLB16   =          SLB16   =          PLB16   =

SCEUSE   48.2
GBLCHK   D03C
=>>

```

SHO P (Show Port Settings)

Access Levels 1, B, 2

SHOWSET P displays the relay serial port settings. The port settings include the communications and protocol settings. The syntax of the **SHO P** command follows:

SHO P *n* Setting <Enter>

The two parameters are optional and perform the following functions:

- ***n*** specifies the serial port number (1, 2, 3, or 4). Default is the port issuing the command.
- **Setting** specifies the setting name with which to begin. The default is the first setting.

Entering **SHO P** <Enter> is an easy way to identify the port to which you are presently connected.

Settings cannot be entered or modified with this command. Change settings with the **SET P** command from Access Level 2. The following example shows the factory default settings. Refer to *Section 6: Setting the Relay for Settings Sheets*.

```
=>>SHO P <Enter>
Port 2

PROTO = SEL
SPEED = 19200   BITS = 8      PARITY = N      STOP = 1
T_OUT  = 0      AUTO  = Y      RTSCTS = N      FASTOP = N
=>>
```

SHO R (Show SER Settings)

Access Levels 1, B, 2

SHOWSET R displays the Sequential Events Recorder settings. The syntax of the **SHO R** command follows:

SHO R Setting <Enter>

- **Setting** specifies the setting name with which to begin. The default is the first setting.

Settings cannot be entered or modified with this command. Change settings with the **SET R** command from Access Level 2. Refer to *Section 6: Setting the Relay* for information on all settings. Following is an example of the display for the **SHO R** command.

```
=>>SHO R <Enter>

SER1  =IN101, IN102, IN103, IN104, IN105, IN106
SER2  =OUT101, OUT102, OUT103, OUT104, OUT105, OUT106, OUT107
SER3  =0
SER4  =0
ALIAS1 =OUT101 B1TRIP
ALIAS2 =OUT105 B1CLOSE
ALIAS3 =OUT102 B2TRIP
ALIAS4 =OUT106 B2CLOSE
ALIAS5 =OUT103 B3TRIP
ALIAS6 =OUT107 B3CLOSE
ALIAS7 =NA
ALIAS8 =NA
ALIAS9 =NA
ALIAS10 =NA
ALIAS11 =NA
ALIAS12 =NA
ALIAS13 =NA
ALIAS14 =NA
ALIAS15 =NA
ALIAS16 =NA
ALIAS17 =NA
ALIAS18 =NA
ALIAS19 =NA
ALIAS20 =NA

=>>
```

STA (Status Report)

Access Levels 1, B, 2

The **STATUS** command displays a report of the self-test diagnostics. The relay automatically executes the **STATUS** command whenever the self-test software enters a warning or failure state. You can repeat the **STA** command by appending a number as a repeat count parameter. Type **STA 4 <Enter>** to view the status information four times.

If a warning or failure state occurs, the next time the **STA** command is issued, the warning state is reported. If a warning or failure occurs, it will not be cleared until relay power is cycled and the problem is fixed. Saving relay settings performs a warm boot of relay logic. This can clear some warnings, but do not ignore warnings; contact the factory.

The **STA C <Enter>** command clears any out-of-tolerance condition from the status report and restarts the relay. Do not ignore warnings; contact the factory.

If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the report as set. The STATUS report format appears below:

XFMR 1			Date: 04/21/00		Time: 21:29:42.829		
STATION A							
FID=SEL-387-6-X117-V0-Z001001-D20000419			CID=2001				
SELF TESTS							
W=Warn		F=Fail					
	IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	
OS	0	-0	-0	1	0	1	
	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4	
OS	0	0	-0	1	0	-1	
	+5V_PS	+5V_REG	-5V_REG	+12V_PS	-12V_PS	+15V_PS	-15V_PS
PS	4.93	4.99	-5.07	11.90	-12.08	14.96	-14.90
	TEMP	RAM	ROM	A/D	CR_RAM	EEPROM	IO_BRD
	32.1	OK	OK	OK	OK	OK	OK
Relay Enabled							
=>							

TAR (Show Relay Word Targets On Screen)

Access Levels 1, B, 2

The **TARGET** command displays the default row of the Relay Word showing the Relay Word bit names and their value, which is either a logical 1 (asserted) or logical 0 (deasserted). The syntax of the **TAR** command follows:

TAR n k X <Enter>

- **n** specifies a new default Relay Word row by entering the row number or the specific Relay Word bit name (except names of target elements in rows 0 and 1). If **n** is not specified, the last default row is displayed.
- **k** specifies a repeat count for the command. The default is 1.
- **X** allows viewing a Relay Word row without changing the default row.

The default row number can also be changed by the **TAR F** command, but each serial port has independent defaults. The default row number returns to 0 when the port times out, the **QUIT** command is executed, **TAR 0** command is executed, or the **TAR R** command is executed.

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

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

=>>TAR <Enter>							
Default Row is 0							
EN	TRIP	INST	87-1	87-2	87-3	50	51
1	0	0	0	0	1	0	0
=>>TAR 8 <Enter>							
Display and Change Default to Row 8							
50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
0	0	0	0	0	1	0	0
=>>TAR <Enter>							
Default Row is 8							
50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
0	0	0	0	0	1	0	0
=>>TAR 8 5 <Enter>							
Display Row 8 Five Times							
50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0
=>>TAR RB4 X <Enter>							
Display Row 24 (RB4) But Do Not Change Default							
RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
0	0	0	0	1	0	0	0
=>>TAR <Enter>							
50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2
0	0	0	0	0	1	0	0
=>>TAR R <Enter>							
Reset Default to Row 0							
EN	TRIP	INST	87-1	87-2	87-3	50	51
1	0	0	0	0	0	0	0
=>>							

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

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

Access Levels 1, B, 2

The **TARGET F** command works like the **TARGET** command, but it also remaps the second row of target LEDs on the front panel to follow the default row. This may be useful, for example, in testing situations where a display on the relay front-panel LEDs of element pickup or operation may be desired. The syntax of the **TAR F** command follows:

TAR F n k X <Enter>

- **n** specifies a new default Relay Word row by entering the number or the specific Relay Word bit name. If **n** is not specified, the last default row is displayed.
- **k** specifies a repeat count for the command for the serial port display. The default is 1.
- **X** allows remapping the LEDs to a Relay Word row without changing the default row.

The default row number returns to 0 when the serial port times out, the **QUIT** command is executed, **TAR 0** command is executed, or the **TAR R** command is executed.

The front-panel LEDs remain remapped until the front panel times out, the **TAR R** command is executed, or the {TARGET RESET} pushbutton is pushed.

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

TAR R (Reset Targets)

Access Levels 1, B, 2

The **TARGET R** command resets the default row for the **TAR** and **TAR F** commands to 0, and remaps the second row of front-panel LEDs to display Row 1, which is the standard target display. It also resets any tripping front-panel targets.

Use the **TAR R** command to return the front-panel LEDs to the standard targets when you are done using the **TAR** or **TAR F** command for testing.

TFE (Through-Fault Event Report) (SEL-387-5 and SEL-387-6 Relays Only)

The **TFE** command displays the following data for each individually recorded through-fault event:

- Date and time of the through fault
- Duration (seconds) of the through fault
- Maximum current (A primary) for each monitored current input

The following cumulative values (updated for each new through-fault event) are also displayed:

- Through-fault count
- Simple I^2t calculation for each monitored current input

There are various choices for the **TFE** command, listed briefly below. Refer to *Section 5: Metering and Monitoring* for a complete description of the through-fault event reports:

Table 7.8 TFE Command Choices

TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE n	Displays cumulative and individual through-fault event data. The n most recent individual events are displayed, where $n = 1$ to 1200.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.

THE (Thermal Report) (SEL-387-6 Relay only)

Access Levels 1, B, 2

The **THERM** command displays temperature inputs, thermal event reports, hourly profile data or daily profile data, depending on the command statement. There are several choices for the **THE** command, listed briefly below. Refer to *Section 5: Metering and Monitoring* for a complete description of the thermal monitoring reports.

Table 7.9 THE Command Choices

THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D <i>x y</i>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE H <i>x y</i>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE <i>n</i>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
THE P <i>n</i>	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020.

TIM (Time)

Access Levels 1, B, 2

The **TIME** command displays or sets the time stored by the internal clock. The time is set or displayed on a 24-hour clock basis, not a.m./p.m. View the current time with **TIM <Enter>**. To set the clock, type **TIM t1 <Enter>** where t1 is the new time in h:m:s; the seconds are optional. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. The following example sets the clock to 23:30:00:

NOTE: After setting the time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

```
=>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.

TRI (Trigger an Event)

Access Levels 1, B, 2

The **TRIGGER** command generates an event record. The command is a convenient way to record all inputs and outputs from the relay at any time you 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: 03/13/97   Time: 18:49:21.586
STATION A

Event: TRIG
Targets:
Winding 1 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 2 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 3 Currents (A Sec), ABC:   0.0   0.0   0.0
Winding 4 Currents (A Sec), ABC:   0.0   0.0   0.0

=>>

```

Alarm Conditions

The SEL-387 asserts the **ALARM** output while the relay is turning on 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 7.10*.

Table 7.10 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 <i>m n</i>	Copying a setting group to the active setting group
GRO <i>n</i>	Changing the active setting group
PAS <i>n</i>	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 7.11* lists all jumpers you should be concerned with and their effects.

Table 7.11 Main Board Jumpers

Jumper	Comment
JMP6A	Disables password protection when installed
JMP6B	Enables CLO , OPE , and PUL commands when installed

SEL-387 Relay Command Summary

Access Level 0 Commands	The only thing that can be done at Access Level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper (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	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper (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 four breakers.
CEV <i>n</i>	Show compressed winding event report number <i>n</i> , 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/ <i>m</i> -cycle resolution (<i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
DAT	Show date presently in the relay.
DAT <i>m/d/y</i>	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT <i>y/m/d</i>	Enter date in this manner if Date Format setting DATE_F = YMD.
EVE <i>n</i>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE D <i>n</i>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF1 <i>n</i>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF2 <i>n</i>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF3 <i>n</i>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE R <i>n</i>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach Sm for 1/ <i>m</i> -cycle resolution (<i>m</i> = 4, 8, 32, 64).
EVE T	Show event summary.
GRO	Display active setting group number.
HIS <i>n</i>	Show brief summary of the <i>n</i> latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
ID	Display variety of identification and configuration information about the relay.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET <i>k</i>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET D <i>k</i>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET DIF <i>k</i>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET P <i>k</i>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET RD <i>n</i>	Reset demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET RP <i>n</i>	Reset peak demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET SEC <i>k</i>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET T	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
QUI	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
SER <i>d1</i>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
SER <i>d1 d2</i>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER <i>m n</i>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
SER <i>n</i>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO <i>n</i>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> 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 <i>n</i>	Show port settings for port <i>n</i> (<i>n</i> = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
STA C	Clear relay status report from memory and restart the relay.
TAR <i>n k</i>	Show Relay Word row <i>n</i> status (<i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append F to display targets on the front panel, second row of LEDs.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays	
TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE <i>n</i>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: ==>
All commands that begin THE apply to the SEL-387-6 Relay	
THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE n	Displays saved thermal monitor report n where $n = 1$ is the most recently saved report.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D x y	Retrieves daily profile data from day x to day y . If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE H x y	Retrieves hourly profile data from day x to day y . If x and y are omitted, retrieves entire profile data. If x or y is omitted, retrieves profile from day x (y) to present.
THE P n	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
TIM	Show or set time (24 hour time). Show time presently in the relay by entering just TIM . Example time 22:47:36 is entered with command TIM 22:47:36 .
TRI	Trigger an event report.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
ACC	Enter Access Level 1. If the main board password jumper (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 ($n = 1, 2, 3, 4, A$).
BRE W n	Pre-set the percent contact wear for each pole of breaker n ($n = 1, 2, 3, \text{ or } 4$).
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; $m = 4, 8, 16, 32, \text{ or } 64$ for raw data).
CLO n	Assert the CC n Relay Word bit. Used to close breaker n if CC n 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.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
EVE R <i>n</i>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <i>Sm</i> for 1/ <i>m</i> -cycle resolution (<i>m</i> = 4, 8, 32, 64).
EVE T	Show event summary.
GRO	Display active setting group number.
GRO <i>n</i>	Switch to Setting Group <i>n</i> . (Will not function if any <i>SSn</i> Relay Word bit is asserted.)
HIS <i>n</i>	Show brief summary of the <i>n</i> latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
ID	Display variety of identification and configuration information about the relay.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET <i>k</i>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET D <i>k</i>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET DIF <i>k</i>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET P <i>k</i>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET RD <i>n</i>	Reset demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET RP <i>n</i>	Reset peak demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET SEC <i>k</i>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET T	Report temperature values of the 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
OPE <i>n</i>	Assert the <i>OCn</i> Relay Word bit. Used to open breaker <i>n</i> if <i>OCn</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
PUL <i>y k</i>	Pulse output contact <i>y</i> (<i>y</i> = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number <i>k</i> to pulse for <i>k</i> seconds [<i>k</i> = 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 <i>d1</i>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
SER <i>d1 d2</i>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER <i>m n</i>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
SER <i>n</i>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER) event reports from memory.
SHO <i>n</i>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> 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 <i>n</i>	Show port settings for port <i>n</i> (<i>n</i> = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR <i>n k</i>	Show Relay Word row <i>n</i> status (<i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen. Append F to display targets on the front panel, second row of LEDs.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays	
TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE <i>n</i>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.
All commands that begin THE apply to the SEL-387-6 Relay	
THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE <i>n</i>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D <i>x y</i>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE H <i>x y</i>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE P <i>n</i>	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
TIM	Show or set time (24 hour time). Show time presently in the relay by entering just TIM . Example time 22:47:36 is entered with command TIM 22:47:36 .
TRI	Trigger an event report.
Access Level 2 Commands	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 four breakers.
BRE R <i>n</i>	Reset trip counters, trip currents, and wear data for breaker <i>n</i> (<i>n</i> = 1, 2, 3, 4, A).
BRE W <i>n</i>	Preset the percent contact wear for each pole of breaker <i>n</i> (<i>n</i> = 1, 2, 3, or 4).
CAL	Moves from Access Level 2 to Access Level C.
CEV <i>n</i>	Show compressed winding event report number <i>n</i> , 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/ <i>m</i> -cycle resolution (<i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
CLO <i>n</i>	Assert the CC <i>n</i> Relay Word bit. Used to close breaker <i>n</i> if CC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.

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: ==>>
CON <i>n</i>	Control Relay Word bit RB <i>n</i> (Remote Bit <i>n</i> ; <i>n</i> = 1 through 16). Execute CON <i>n</i> and the relay responds: CONTROL RB <i>n</i> . Reply with one of the following: SRB <i>n</i> set Remote Bit <i>n</i> (assert RB <i>n</i>) CRB <i>n</i> clear Remote Bit <i>n</i> (deassert RB <i>n</i>) PRB <i>n</i> pulse Remote Bit <i>n</i> [assert RB <i>n</i> for one processing interval (1/8-cycle)].
COPY <i>m n</i>	Copy settings and logic from setting Group <i>m</i> to Group <i>n</i> .
DAT	Show date presently in the relay.
DAT <i>m/d/y</i>	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT <i>y/m/d</i>	Enter date in this manner if Date Format setting DATE_F = YMD.
EVE <i>n</i>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE D <i>n</i>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF1 <i>n</i>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF2 <i>n</i>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE DIF3 <i>n</i>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach S8 for 1/8-cycle resolution.
EVE R <i>n</i>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach S<i>m</i> for 1/ <i>m</i> -cycle resolution (<i>m</i> = 4, 8, 32, 64).
EVE T	Show event summary.
GRO	Display active setting group number.
GRO <i>n</i>	Switch to Setting Group <i>n</i> . (Will not function if any SS <i>n</i> Relay Word bit is asserted.)
HIS <i>n</i>	Show brief summary of the <i>n</i> latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
ID	Display variety of identification and configuration information about the relay.
INI	INITIO command reports the number and type of I/O boards in the relay. In Access Level 2, confirms that I/O boards are correct.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET <i>k</i>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET D <i>k</i>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET H	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
MET DIF <i>k</i>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET P <i>k</i>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET RD <i>n</i>	Reset demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET RP <i>n</i>	Reset peak demand metering values (<i>n</i> = 1, 2, 3, 4, A).
MET SEC <i>k</i>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET T	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
OPE <i>n</i>	Assert the OC <i>n</i> Relay Word bit. Used to open breaker <i>n</i> if OC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
PAS 1 xxxxxx	Change Access Level 1 password to xxxxxx.

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: =>>
PAS B <i>xxxxxx</i>	Change Access Level B password to <i>xxxxxx</i> .
PAS 2 <i>xxxxxx</i>	Change Access Level 2 password to <i>xxxxxx</i> . If <i>xxxxxx</i> is DISABLE (uppercase), password for selected level is disabled.
PAS C <i>xxxxxx</i>	Change Access Level C password to <i>xxxxxx</i> . If <i>xxxxxx</i> is DISABLE (uppercase), password for selected level is disabled.
PUL <i>y k</i>	Pulse output contact <i>y</i> (<i>y</i> = OUT101,...,OUT107, OUT2XX, OUT3XX, and ALARM). Enter number <i>k</i> to pulse for <i>k</i> seconds [<i>k</i> = 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 <i>d1</i>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
SER <i>d1 d2</i>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
SER <i>m n</i>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
SER <i>n</i>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER) event reports from memory.
SET <i>n</i>	Change relay group settings (overcurrent, differential, etc.). For the SET commands, parameter <i>n</i> is the setting name at which to begin editing settings. If parameter <i>n</i> is not entered, setting editing starts at the first setting.
SET G	Change Global settings.
SET P <i>n</i>	Change port settings.
SET R	Change Sequential Events Recorder (SER) settings.
SHO <i>n</i>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> 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 <i>n</i>	Show port settings for port <i>n</i> (<i>n</i> = 1, 2, 3, 4).
SHO R	Show Sequential Events Recorder (SER) settings.
STA	Show relay self-test status.
TAR <i>n k</i>	Show Relay Word row <i>n</i> status (<i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append F to display targets on the front panel, second row of LEDs.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays	
TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE <i>n</i>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.

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: =>>
All commands that begin THE apply to the SEL-387-6 Relay	
THE	Displays a thermal monitor report that indicates the present thermal status of the transformer.
THE <i>n</i>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
THE C	Clears the hourly profile, daily profile, and thermal event data archives.
THE D <i>x y</i>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE H <i>x y</i>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> (<i>y</i>) to present.
THE P <i>n</i>	Loads preset value of accumulated insulation loss of life.
THE R	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
THE T	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
TIM	Show or set time (24 hour time). Show time presently in the relay by entering just TIM . Example time 22:47:36 is entered with command TIM 22:47:36 .
TRI	Trigger an event report.

Section 8

Front-Panel Interface

Front-Panel Operation

A close-up view of the user interface portion of the SEL-387 Relay front panel is shown in *Figure 8.1*. It includes a two-line, 16-character LCD display; 16 LED target indicators; and eight pushbuttons for local communication.

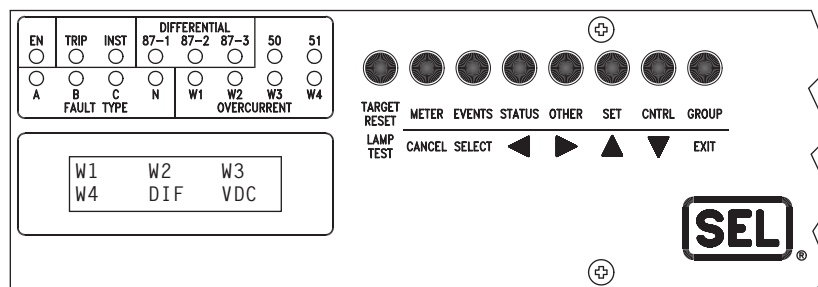


Figure 8.1 SEL-387 Front-Panel User Interface

The LCD display shows event, metering, setting, and relay self-test status information. The display is controlled with the eight multifunction pushbuttons. The target LEDs display relay target information as described by the legend. The bottom row can be remapped to display a Relay Word row of bits, in response to the **TAR F** serial port command.

Time-Out

If no buttons are pressed on the front panel, the relay waits a time period specified in the SET G setting FP_TO (Front-Panel Time-Out) and then takes the following actions:

- The front-panel LCD display resets to the default display.
- The front-panel access level reverts to Access Level 1.
- The LCD backlighting is turned off.
- Any routine being executed via a front-panel command is interrupted.
- The target LEDs (lower row) revert to the default targets.

FP_TO is factory-set to 15 minutes and can be set from 0 to 30 minutes. If zero is selected, the front panel will never time out. A zero setting is useful when testing, but do not leave the time out set at zero. The backlight will fail if illuminated for prolonged periods of time, and the target LEDs that may have been changed using the **TAR F** command will not be reset to the default targets. Reset FP_TO to some nonzero value, then **push any button**—the relay will not revert to the new value of FP_TO until a button has been pushed.

Displays

The LCD display is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed display points. display points and LCD scrolling controls are discussed at the end of this section in more detail. The default display is a scroll through any active, nonblank display points. If none are active, the relay scrolls through up to four two-line displays of the A-, B-, and C-phase currents in the four windings in primary amperes. If the Analog Input Label settings (IAW1, etc.) have been renamed, these will appear in the display as set. The two-line current display for a Winding “*n*” is turned off if both of the settings E87W*n* and EOC*n* are set to “N.” Each display (except for the SEL-387-0) remains for Global setting SCROLLD (seconds) before scrolling continues. Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The {EXIT} button returns the display to the default display, if some other front-panel function is being performed.

Error messages such as self-test failures are displayed on the LCD in place of the default display when they occur. Do not turn off the relay if this occurs; refer to *Section 10: Testing and Troubleshooting* for further instructions.

While the relay is turning on and when executing the R_S command to reset factory default settings, the LCD displays *Initializing*. It will then scroll through the winding current displays until the relay is again enabled. When the EN LED indicates the relay is enabled, the active display points will be scrolled.

Menu choices on the LCD display are listed horizontally on the second line. The first character of the menu choice is underlined. The left and right arrow buttons move the underline to the adjacent menu selection. Once the underline indicates your selection, use the {SELECT} pushbutton to proceed.

Target LEDs

The target LEDs are an indication of what the relay has detected on the power system and how the relay has reacted. The front-panel legend gives a brief description of each target, but *Section 4: Control Logic* describes each target LED in detail.

The only times the target LEDs do not illuminate according to their labels is when one of the following occurs:

1. LEDA, LEDB, or LEDC has been reprogrammed by the user to respond to a ²⁸® control equation
2. The **TAR F** command is issued through one of the serial ports

The **TAR F** command remaps the second row of LEDs to follow a particular row in the Relay Word bits, such that a Relay Word bit that is asserted will light the corresponding LED position. Refer to *Section 7: Serial Port Communications 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 power to the relay is lost, these 12 targets will return to their last state when power is restored. **EN** responds only to internal self-test routines, while **A**, **B**, and **C** respond to the present state of their Global settings, which are SELOGIC control equations.

Password Access

Commands that are at Access Level 2 (2AC) or the Breaker Access Level (BAC) are password protected from the front panel. Access Level 1 commands are not password protected. The front panel is normally active at Access Level 1. If you issue a command from the front panel that requires a Level B or Level 2 password, the relay prompts you for a password. After you

enter the password for the higher access level, you remain at that access level only until the front panel times out from inactivity or you **EXIT** from the specific command. When you **EXIT** the command, the front panel returns to Access Level 1.

If the password jumper, JMP6A, is installed, there is no password protection, and you will not be prompted for a password. If a particular level password has been disabled with serial port command **PAS n DISABLE <Enter>**, you will not be prompted for a password.

When prompted for a password, enter the BAC or 2AC password, depending on the requirements of the command. All commands are available using the 2AC password. The front-panel request for password shows a display of six characters, shown initially as ABCDEF, with the A underscored. Use the up/down arrow keys to scroll and set the first character of the password. Passwords are case sensitive; be sure you use upper -or lowercase 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 that level’s commands. If it is incorrect, the relay will declare an *Invalid Password*, and allow another attempt. After three incorrect attempts, the relay will pulse the **ALARM** contact for one second and the front panel will exit the command you are trying to access.

Pushbuttons

Eight multifunction pushbuttons control the front-panel display. The button legend defines the primary function in the top row and the secondary function in the bottom row. The primary functions are for command selection, and the secondary functions are for cursor movements and specific commands within dialogs. The eight pushbutton primary functions will be discussed in the order in which they appear from left to right on the front panel.

Primary Function Review

TARGET RESET / LAMP TEST

The left-most button is dedicated to the {**TARGET RESET**} function. Except while viewing or editing settings, pressing {**TARGET RESET**} causes the front-panel LEDs to illuminate for a two-second lamp test and then clears all target LEDs except for the **EN** LED, which is illuminated if the relay is enabled. While viewing or editing settings, the {**TARGET RESET**} button acts as a Help function, showing specific information about the displayed setting.

METER

The {**METER**} pushbutton 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**} pushbutton will take the user back to the previous menu. The {**EXIT**} pushbutton 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 can 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 W1, W2, W3, W4, DIF, or VDC metering display. W1 to W4 are winding displays, DIF is the differential element display, and VDC is the Battery Monitor display. Use any arrow button to highlight the choice. Then push {SELECT}.

Windings (W1, W2, W3, W4)

NOTE: The harmonic spectrum metering function, the **MET H** serial port command, is not available from the front panel.

If a winding has been selected, a second menu appears prompting the user to select the type of metering to display. The choices are INSTantaneous, DEMand, PKD peak demand, or SECondary. Use the right/left arrows to choose, then push {SELECT}.

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 to either DISPLAY the demand information or to RESET the demand accumulators.

Use the right/left arrows and {SELECT} to choose. If RESET is chosen, the relay will prompt for a Yes/No verification of the choice. Use the right/left arrows and {SELECT} to choose. If DISPLAY is chosen, the relay will scroll through the demand values.

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

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 (VDC)

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

EVENTS

Push the {EVENTS} pushbutton to display short event summaries, comparable to the **HIS** serial port command.

If no EVENT records exist, the display states No Fault Data and terminates the command.

If there are records to view, use the right/left arrows to review data within an event record and the up/down arrows to move between event records. Information displayed for a given event is the event number, date/time, active setting group, fault targets, and the winding secondary current magnitudes (IA, IB, IC). The currents only appear if the entire event report still resides in relay memory. The Analog Input Label names are not used in this display. Current information is simply listed, for example, as W1 followed by A B C and the magnitudes. There may be more than 75 event summaries in the

history buffer, but a much smaller number of full event reports. The **EVENTS** command will display everything but the currents for the older, incomplete history summaries. Use **{CANCEL}** or **{EXIT}** to return to the default display.

Figure 8.6, at the end of this section, shows the **EVENTS** display structure.

STATUS

The **{STATUS}** pushbutton displays the relay status information in similar fashion to the serial port **STA** command. When **{STATUS}** is pushed, the initial display shows:

```
STATUS: [OK/WARN/FAIL]
```

```
FID=SEL-387-R103 (e.g., the first 12 characters of the FID string)
```

The **STATUS** line shows the worst state of the several parameters examined. The right/left arrow keys can be used to view the rest of the **FID** string.

The up/down arrow keys are then used to manually scroll through the diagnostic fields, showing the analog channel offsets, power supply voltages, internal temperature, **RAM (OK/FAIL)**, etc. The display remains in this scroll sequence until either **{CANCEL}** or **{EXIT}** is pushed.

OTHER

The **{OTHER}** pushbutton is used to access several miscellaneous functions, and mimics the corresponding serial port commands for these functions. Pushing **{OTHER}** provides a menu that prompts the user to select **DATE**, **TIME**, **TARGET**, **BKR** (breaker), **RESET51**, or **LCD**. These perform the same functions as the serial port commands **DAT**, **TIM**, **TAR**, **BRE**, and **RES**. Use any arrow key and **{SELECT}** to choose the function. These **{OTHER}** subfunctions are discussed below in alphabetical order.

BKR

This function displays the breaker monitor accumulator values for internal and external trips, the accumulated interrupted currents by pole, the percent contact wear, and the time/date of last reset, for the selected breaker.

When **BKR** is selected, a second menu appears to prompt the user to select **Bk1**, **Bk2**, **Bk3**, or **Bk4**. Use the right/left arrow keys and **{SELECT}** to choose. Another menu appears, asking whether **DISPLAY** or **RESET** is desired. Use the right/left arrow keys and **{SELECT}** to choose.

If **DISPLAY** is selected, the display scrolls automatically, showing the Internal and External trip counters for the breaker chosen, the phase currents accumulated for each type of trip, and the percent contact wear by breaker pole. The first two-line display shows **P1**, the second **P2**, and the third **P3**. The fourth display shows % wear for each of the three poles, in integer values of 100 or less. The fifth display shows Last Reset From and the date/time of last reset. Pushing **{SELECT}** will toggle between stop-scroll and resume-scroll, to facilitate hand-recording of data values.

Push **{CANCEL}** to return to the **OTHER** main menu. Push **{EXIT}** to return to the default display.

Figure 8.7, at the end of this section, shows the full **OTHER/BKR** menu and display structure.

DATE

The **DATE** function is used to change the date stored in the relay. It is identical to the serial port **DATE** command.

When selected, a two-line display appears with the current date on the first line and a prompt to **Set** or **Cancel** on the second. Use the right/left arrows and **{SELECT}** to choose. The date display will follow whichever format was selected by the **DATE_F** setting, either **MDY** or **YMD**. If **Set** is selected, a second display appears prompting the user to change the date. Since this is a Level 1 command, it is not password protected from the front panel. Use the right/left arrows to move between the **MM/DD/YY** fields, and the up/down arrows to scroll to the number selected for the field. When the date is shown correctly, push **{SELECT}** to enter it. Push **{CANCEL}** to return to the **OTHER** main menu. Push **{EXIT}** to return to the default display.

NOTE: After setting the date, allow at least 60 seconds before powering down the relay or the new setting may be lost.

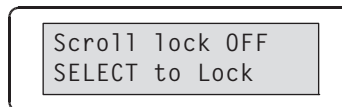
LCD

The rotating default display can be locked on a single screen. Access the scroll lock control with the **{OTHER}** pushbutton.



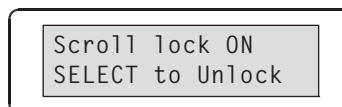
DATE TIME TAR
BKR RESET51 LCD

Select **LCD** for Scroll Lock Control mode. The rotating display will then appear, and the scroll mode reminder screen will appear every eight seconds for one second as a reminder that the display is in Scroll Lock Control mode.



Scroll lock OFF
SELECT to Lock

Stop Scrolling (Lock). When in the Scroll Lock Control mode, press the **{SELECT}** key to stop display rotation. Scrolling can be stopped on any of the display point screens. While rotation is stopped, the active display is updated continuously so that the display point changes can be seen. If no button is pressed for eight seconds, the reminder message will appear for one second followed by the active screen.



Scroll lock ON
SELECT to Unlock

Restart Scrolling (Unlock). The **{SELECT}** key unlocks the modified rotating display.

Single Step. From the Scroll Locked state, single-step through the display screens by pressing the **{SELECT}** key twice. Wait for the first press to display the next screen as the active display, then press the **{SELECT}** key a second time to freeze scrolling.

Exit. Press the **{EXIT}** key to leave Scroll Lock Control and return the rotating display to normal operation.

Cancel. Press the **{CANCEL}** key to return to the **OTHER** menu.



RESET51

This command exactly equates to the **RES** serial port command. **RESET51** clears all time accumulators of all the inverse-time overcurrent elements, both for separate windings and for the combined overcurrent elements. **RESET51** may be useful for saving time in testing the relay overcurrent elements but is not likely to be used while the relay actually is in-service.

If **RESET51** is selected, a password screen will appear if password protection is in force. Next, a `Reset 51? Yes No` screen appears. Use the right/left arrows to underscore `Yes` or `No`, then push **{SELECT}**. `Yes` will reset the accumulators and exit the command. `No` will abort the command and return to the **OTHER** main menu; or, simply push **{CANCEL}** to return to the **OTHER** main menu. Push **{EXIT}** to return to the default display.

TAR

This command is roughly equivalent to the **TAR F** serial port command. When **TAR** is selected in the **OTHER** main menu, the display shows `TAR 0`, the first row of the Relay Word bits, with `EN` shown in the second row (relay enabled). The up/down arrow keys can 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 illuminated in the target area above the display. If more bits are asserted than will fit in the display, the right/left arrow keys can be used to see the off-screen names.

Push **{CANCEL}** to return to the **OTHER** main menu. Push **{EXIT}** to return to the default display.

TIME

This command works like the **DATE** command above and is equivalent to the **TIME** serial port command.

When selected, a two-line display appears, with the current time on the first line and a prompt to `Set or Cancel` on the second. Use the right/left arrows and **{SELECT}** to choose. Since this is a Level 1 command, it is not password protected from the front panel. If `Set` is selected, a second display appears prompting the user to change the time. Use the right/left arrows to move between the `HH:MM:SS` fields and the up/down arrows to scroll to the number selected for the field. When the time is shown correctly, push **{SELECT}** to enter it. Push **{CANCEL}** to return to the **OTHER** main menu. Push **{EXIT}** to return to the default display.

NOTE: After setting the time, allow at least 60 seconds before powering down the relay or the new setting may be lost.

SET

The **SET** function has the most elaborate menu and display structure of all the pushbutton functions. Only numeric value settings or settings having fixed Character string values can be displayed or changed on the display. Settings 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 8.8, at the end of this section, shows the essential menu and display structure for the {SET} button. It does not show anything below the setting section (subgroup) level, since this would be too cumbersome.

GLOBAL

This command is roughly equivalent to the **SHO G** and **SET G** serial port commands. When **GLOBAL** is selected, a menu appears for selecting whether to Set or Show the settings. If Set, a password entry screen appears if password protection is in force.

The next screen is either the Set GLOBAL or Show GLOBAL display, in which a message scrolls across the second line, reminding the user to Press **TARGET RESET** for help during set/show routine. This special use for the {**TARGET RESET**} pushbutton provides the user with a short description of the setting and the range of values, should the user not recognize the setting by its Character string name.

The next menus to appear allow the user to enter a specific section of the GLOBAL settings, rather than having to scroll through all GLOBAL settings. The sections are RELAY SETTINGS, BATTERY MONITOR, BKRn MONITOR, ANALOG INPUT LABELS, SETTING GROUP Selection, and FRONT PANEL. Use any arrow key to move to the desired section, then push {**SELECT**} to enter that section.

For example, selecting RELAY SETTINGS, causes the first setting LER=15 to appear in the second line of the display. If you do not recognize this setting, push the {**TARGET RESET**} pushbutton, and the following description will scroll across the first line: Length of Event Report (15, 30, 60 Cycles).

In the Show mode, we can only observe the value. The {**SELECT**} pushbutton 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.

In the Set mode, we can choose to change the value by pushing {**SELECT**}. An underscore will appear under the first character of the value. If it has discrete values, like LER, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at the new value, push {**SELECT**} to enter the change.

When the complete list of settings has been shown or set, the display returns to the level of selection of which section to Set or Show. {**CANCEL**} can also be used to move to this level from within the section of settings. {**EXIT**}, in the Set mode, brings the display to a Save Changes? Y/N selection point. In the Show mode, it returns to the default display.

GROUP

This command is roughly equivalent to the **SHO** and **SET** serial port commands. When **GROUP** is selected, a menu appears for selecting which of the six setting groups to Show or Set. Use the right/left arrow keys and {**SELECT**} to choose. The next screen asks you if you intend to Set or Show the settings. If Set, a password entry screen appears, if password protection is in force.

The next screen is either the Set GROUP n or Show GROUP n display (n = the group number), in which a message scrolls across the second line, reminding the user to Press **TARGET RESET** for help during set/show routine. This special use for the {**TARGET RESET**} pushbutton provides the user with a short description of the setting and the range of values, should the user not recognize the setting by its Character string name.

The next menus to appear are to allow the user to enter a specific section of the GROUP settings, rather than having to scroll through all GROUP settings. The sections are CONFIG. SETTINGS, GENERAL DATA, DIFF ELEMS, RESTRICTED EARTH, WINDING n ELEMS, COMBINED ELEMS, and MISC. TIMERS. Four additional section titles appear after MISC. TIMERS. These are TRIP LOGIC, CLOSE LOGIC, EVENT TRIGGER, and OUTPUT CONTACT Logic. These sections are entirely SELOGIC control equations, and cannot be viewed or changed from the front panel. Use an arrow key to scroll past these latter sections. Use any arrow key to move to the desired section, then push {SELECT} to enter that section.

For example, selecting CONFIG. SETTINGS, causes the first setting E87W1=Y to appear in the second line of the display. If you do not recognize this setting, push the {TARGET RESET} pushbutton and the following description will scroll across the first line: Enable Wdg1 in Differential Element (Y, N).

In the Show mode, we can only observe the value. The {SELECT} pushbutton 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.

In the Set mode, we can choose to change the value by pushing {SELECT}. An underscore will appear under the first character of the value. If it has discrete values, like E87W1, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at its new value, push {SELECT} to enter the change.

When the complete list of settings has been shown or set, the display returns to the menu level of selection of which section to Set or Show. {CANCEL} can also be used to move to this level from within the section of settings. {EXIT}, in the Set mode, brings the display to a Save Changes? Y/N selection point. In the Show mode it returns to the default display.

PASSWORD

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 it, Push {SELECT} when the new password is displayed fully.

{CANCEL} can 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 you if you intend to Set or Show the settings. If Set, a password entry screen appears, if password protection is in force.

The next screen is either the Set PORT *n* or Show PORT *n* display (*n* = the port number), in which a message scrolls across the second line reminding the user to Press TARGET RESET for help during set/show routine. This special use for the {TARGET RESET} pushbutton 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 you do not recognize this setting, you can push the {TARGET RESET} pushbutton, and a single scroll across the first line will indicate that this is the Protocol (SEL, LMD, DNP) (RTDA, RTDB for SEL-387-5 and SEL-387-6 Relays) setting.

In the Show mode, we can only observe the value. The {SELECT} pushbutton 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.

In the Set mode, we can choose to change the value by pushing {SELECT}. An underscore will appear under the first character of the value. If it has discrete values, like `PROTO`, the up/down arrows can be used to scroll through the available choices. If it is a numerical variable, the digits are changed one at a time, using the right/left arrows to move to the digit and the up/down arrows to select the number to insert. When the setting is displayed at the new value, push {SELECT} to enter the change.

When the complete list of settings has been shown or set, the display prompts for a Save Changes? Y/N choice. After the choice, it exits the PORT command and returns to the default display. {CANCEL} can be used to return to an earlier menu. {EXIT} will abort the PORT command and return to the default display.

CNTRL (Not Included in SEL-387-0)

Use local control to enable/disable schemes, trip/close breakers, and so on, via the front panel.

Local Control

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

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

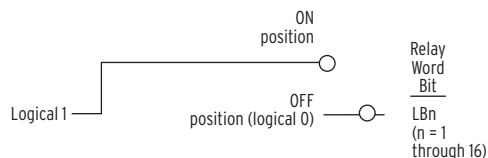


Figure 8.2 Local Control Switch Configured as an ON/OFF Switch

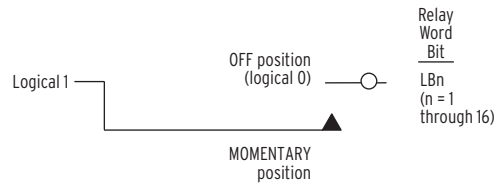


Figure 8.3 Local Control Switch Configured as an OFF/MOMENTARY Switch

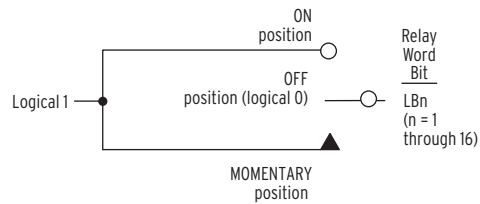


Figure 8.4 Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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 (Show Group 1—6 Settings)* on page 7.29.

Table 8.1 Correspondence Between Local Control Switch Positions and Label Settings

Switch Position	Label Setting	Setting Definition	Logic State
not applicable	NLBn	Name of Local Control Switch	not applicable
ON	SLBn	“Set” Local bit LBn	logical 1
OFF	CLBn	“Clear” Local bit LBn	logical 0
MOMENTARY	PLBn	“Pulse” Local bit LBn	logical 1 for one processing interval

Note the first setting in *Table 8.1* (NLBn) is the overall switch name setting.

Table 8.2 Correspondence Between Local Control Switch Types and Required Label Settings

Local Switch Type	Label NLBn	Label CLBn	Label SLBn	Label PLBn
ON/OFF	X	X	X	
OFF/MOMENTARY	X	X		X
ON/OFF/MOMENTARY	X	X	X	X

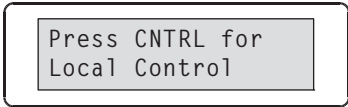
Disable local control switches by “nulling out” all the label settings for that switch. The local bit associated with this disabled local control switch is then fixed at logical 0.

Factory Settings Examples: Local bits LB3 and LB4 are used in a few of the factory SELOGIC control equation settings for manual trip and close functions. Their corresponding local control switch position labels are set to configure the switches as OFF/MOMENTARY switches:

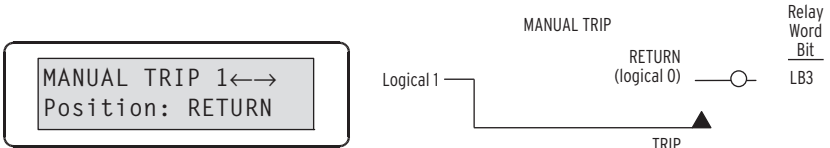
Local Bit	Label Settings	Function
LB3	NLB3 = MANUAL TRIP 1	trips breaker and drives reclosing relay to lock out
	CLB3 = RETURN	OFF position (“return” from MOMENTARY position)
	SLB3 =	ON position—not used (left “blank”)
	PLB3 = TRIP	MOMENTARY position
LB4	NLB4 = MANUAL CLOSE 1	closes breaker, separate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

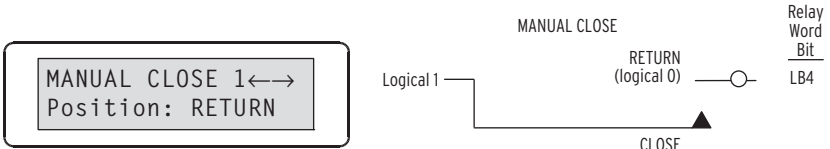
Access local control via the {CNTRL} pushbutton. If local control switches exist (i.e., corresponding switch position label settings were made), the following message displays with the rotating default display messages.



Press 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*).

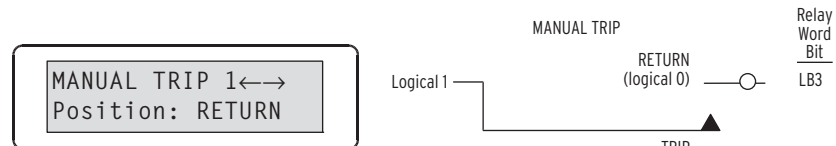
There are no more local control switches in the factory default settings. Press the right arrow pushbutton and scroll to the Output Contact Testing function.



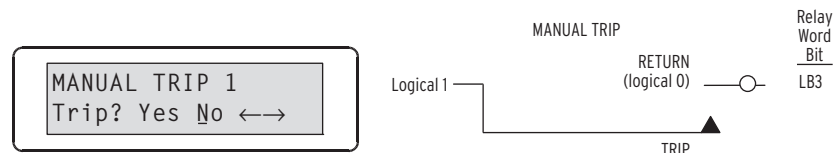
This front-panel function provides the same function as the serial port **PUL** command.

Operate Local Control (With Factory Settings)

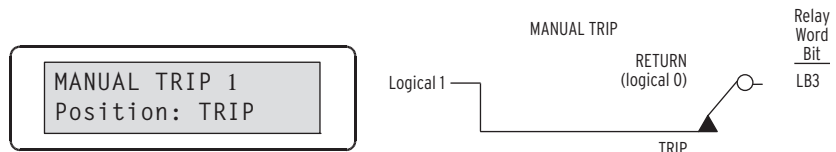
Press the right arrow pushbutton and scroll back to the first set local control switch in the factory default settings.



Press the **{SELECT}** pushbutton to display the operate option for the displayed local control switch.

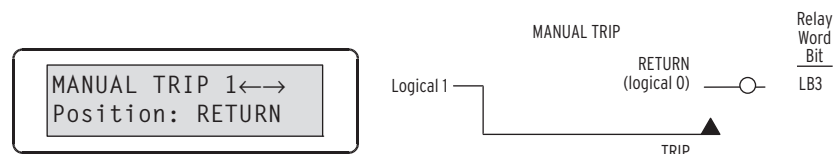


Scroll left with the left arrow button and then select **Yes** to show the new local control switch position.



Because this is an OFF/MOMENTARY type switch, the **MANUAL TRIP 1** switch returns to the **RETURN** position after momentarily being in the **TRIP** position. Technically, the **MANUAL TRIP 1** switch (being an OFF/MOMENTARY type switch) is in the **TRIP** position for one processing interval (1/4 cycle; long enough to assert the corresponding local bit **LB3** to logical 1) and then returns to the **RETURN** position (local bit **LB3** deasserts to logical 0 again).

On the display, the **MANUAL TRIP 1** switch shows in the **TRIP** position for two seconds (long enough to be seen), and then it returns to the **RETURN** position.

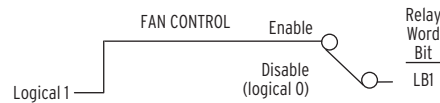


The **MANUAL CLOSE 1** switch is an OFF/MOMENTARY type switch, like the **MANUAL TRIP 1** switch, and operates similarly.

Local Control State Retained When Relay 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 8.2*).



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

Pulse Output Contacts

Use the control pushbutton **{CNTRL}** to mimic the **PULse**, **OPEn**, and **CLOse** serial port commands. This is useful during relay checkout to verify that output contacts actually function in response to a command.

Pulse Output Contacts are available in the **{CNTRL}** menu after the Local Bit pushbutton functions. The screen will prompt for Pulse Close Open. Use the right/left arrow keys and **{SELECT}** to choose.

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 **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.

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 assert 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}** pushbutton or by the **TAR R** serial port command.

Since all three **{CNTRL}** functions are legitimate event types, an Event Report will be triggered whenever any is activated. An automatic message will be sent to any port set to receive messages. If the contact outputs are listed as **SER** triggers, the contact assertion and deassertion will appear in the **SER** report, with time tags. Contact operate timing can thus be easily analyzed.

GROUP

The **{GROUP}** function is identical to the **GRO** and **GRO n** ($n = 1$ to 6) serial port commands.

When you select the **{GROUP}** button, the relay display shows `Active Group 1` (for example), and asks whether you wish to `Change` or `Exit`. Use the right/left arrow keys and **{SELECT}** to choose.

If `Change` is selected, the display shows `Change to Group` in the first line, and the present group number in the second line. Use the up/down arrows and **{SELECT}** to choose another group. The relay will ask for a `Yes/No` verification of the change. Use the right/left arrow keys and **{SELECT}** to choose. The change will be made and the **ALARM** contact pulsed for one second if `Yes` is chosen, **and if SS1 through SS6 are not asserted or not assigned**. These group selection settings always take precedence over the **GROUP** command function.

{CANCEL} may be used to return to an earlier menu. **{EXIT}** will abort the command and return to the default display.

Secondary Function Review

The secondary button functions come into effect as soon as one of the buttons for the above primary functions has been pushed. These secondary functions remain in effect until a primary function has been completed, aborted, or exited and the display has returned to the default display. They will be discussed in the left-to-right order in which they appear on the front panel, below the horizontal line. The first button, **{TARGET RESET / LAMP TEST}**, has no secondary function except as a **HELP** key, explained earlier under the **SET** primary function.

CANCEL

The **{CANCEL}** pushbutton returns the display to the previous menu within a primary function. Use the **{CANCEL}** pushbutton to go back after issuing a **{SELECT}**. If there is no previous menu, the default display is shown. If the **{CANCEL}** pushbutton is pushed while the relay is in the default display mode, the relay interprets the button as the **{METER}** pushbutton.

SELECT

The **{SELECT}** pushbutton is used within primary function dialogs to select a menu choice. Once the choice has been identified with the arrow buttons, use the **{SELECT}** pushbutton to select that choice. If the **{SELECT}** pushbutton is pushed while the relay is in the default display mode, the relay interprets the button as the **{EVENTS}** pushbutton.

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 the relay is 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}** pushbutton at any time within one of the dialogs, the procedure is aborted and the display reverts to the default display. If the **{EXIT}** pushbutton is pushed while the relay is in the default display mode, the relay interprets the button as the **{GROUP}** pushbutton.

Pushbutton/Serial Port Equivalents

Table 8.3 summarizes the pushbutton functions and their approximate equivalents in serial port commands.

Table 8.3 Front-Panel Pushbutton Serial Port Equivalents

Pushbutton	Similar SEL-387 Serial Port Commands
{TARGET RESET/LAMP TEST}	TAR R
{METER}	MET, MET (D, DIF, P, SEC, RD, RP, T)
{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 <i>n</i>

Programmable LEDA, LEDB, LEDC

Three of the LEDs in the second row can 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 A-, B-, or C-phase by the overcurrent elements for those respective phases. The Relay Word bits 87E1, 87E2, and 87E3 indicate Trips initiated by Differential Elements 1, 2, or 3, respectively. These correspond, essentially, to Phases A, B, and C. Thus, LEDA, LEDB, and LEDC are factory-set to indicate either an overcurrent or differential selection of their respective phases as the ones involved in a fault. They are therefore labeled as **FAULT TYPE** LEDs.

It is probably best to leave these settings in place when the relay is in-service so that observers of the front-panel labels will not be confused by seeing the LEDs illuminated for apparently no reason and being unable to verify why they are illuminated without having a serial port connection to the relay. For testing or other purposes, however, these programmable LEDs can be very helpful for identifying conditions, defined by SELOGIC control equations, that are of interest to the user.

Rotating Default Display

Traditional Indicating Panel Lights Replaced With Rotating Default Display

Rotating default displays on the relay front panel replace indicating panel lights. Traditional indicating panel lights are turned on and off by circuit breaker auxiliary contacts, front-panel switches, SCADA contacts, etc. They indicate such conditions as circuit breaker open/closed.

The indicating panel lights are not needed if the rotating default display feature in the SEL-387 is used.

There are 16 of these default displays available in the SEL-387. Referred to as display points, each default display has available two complementary screens (e.g., `BREAKER CLOSED` and `BREAKER OPEN`). The settings for these display points are located in the `FRONT PANEL` area of the Global settings. They are viewable and settable from the serial ports, via the **SHO G** or **SET G** commands. Since they include SELOGIC control equations and variable text, they cannot be accessed from the front panel.

General Operation of Rotating Default Display Settings

SELOGIC control equations display point setting DPn ($n = 1$ through 16) controls the display of corresponding, complementary text settings:

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

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

Make each text setting through the serial port using the command **SET G**. View these text settings using the serial port command **SHO G**. These text settings are displayed in pairs on the SEL-387 front-panel display in rotation. Global setting `SCROLL` determines how long each pair is displayed. The text settings must not be longer than 16 characters maximum. Any active display points take precedence as the default display over the standard scroll through the winding current values. Relay-generated messages, however, take precedence over the display points.

Below are some examples of how the display points can be used.

Circuit Breaker Status Indication Example

Make SELOGIC control equations display point setting $DP2$:

$DP2 = \text{IN102}$ (IN102 is assigned to the 52A2 function for Breaker 2)

Make corresponding, complementary text settings:

$DP2_1 = \text{BREAKER 2 CLOSED}$

$DP2_0 = \text{BREAKER 2 OPEN}$

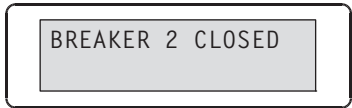
Display point setting $DP2$ controls the display of the text settings.

Circuit Breaker Closed

The optoisolated input **IN102** is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

$DP2 = \text{IN102} = \text{logical } 1$

This results in the display of corresponding text setting $DP2_1$ on the front-panel display.



Circuit Breaker Open

The optoisolated input IN1 is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

$$DP2 = \text{IN102} = \text{logical } 0$$

This results in the display of corresponding text setting DP2_0 on the front-panel display.



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:

$$DP2 = \text{IN102} \text{ (52a circuit breaker auxiliary contact connected to input IN102)}$$

$$DP2_1 = \text{BREAKER 2 CLOSED} \text{ (displays when DP2 = logical 1)}$$

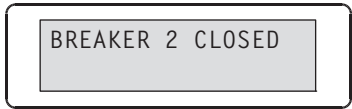
$$DP2_0 = \text{(blank)}$$

Circuit Breaker Closed

The optoisolated input IN102 is energized when the 52a circuit breaker auxiliary contact is closed, resulting in:

$$DP2 = \text{IN102} = \text{logical } 1$$

This results in the display of corresponding text setting DP2_1 on the front-panel display.



Circuit Breaker Open

The optoisolated input IN102 is de-energized when the 52a circuit breaker auxiliary contact is open, resulting in:

$$DP2 = \text{IN102} = \text{logical } 0$$

Corresponding text setting DP2_0 is not set (it is “blank”), so no message is displayed on the front-panel display.

Dynamic Display

You can display relay time-overcurrent pickup settings, metering values, breaker wear monitor values, and RTD readings on the SEL-387 front-panel LCD (subject to the number of available display points); these dynamic display points reflect actual settings and values in the relay and are in addition to the programmable text discussed previously. The relay displays these settings and metering quantities on the rotating default display.

Display Formats and Settings

The SEL-387 presents dynamic display points in a dual-line or a same-line format. Dual-line dynamic displays require two display points; the same-line format uses only one display point.

Dual-Line Format

Apply special control characters in display-point settings DPn_0 and DPn_1 to display relay values. Use the display point settings with a leading two-character sequence “:.” (double-colon) followed by the element name or mnemonic text setting. For a dual-line complementary-screen presentation format for the deasserted state (logical 0) use:

$DPn_0 = ::XXXXXXXXXXXXXXXXXX$

$DP(n+1)_0 = ::NAME$

where:

Xs indicate as many as 16 label characters,

n is display point 1, 3, 5, 7, 9, 11, 13, or 15,

$(n+1)$ is the next display point, and

$NAME$ is a relay element or mnemonic representing a time-overcurrent element pick up, a metering value, a breaker wear monitor value, or RTD readings.

For the asserted state (logical 1), replace DPn_0 with DPn_1 .

For a setting example, see *Dual-Line Setting Example on page 8.20*.

Same-Line Format (Time-Overcurrent Elements Only)

You can display time-overcurrent pickup settings on a single display point. For a same-line presentation format, use the display point settings with a prelabel (if needed), an embedded two-character sequence or an embedded three-character sequence, the mnemonic text, and a postlabel (if needed). The format for a same-line display point setting for the deasserted state (logical 0) is:

$DPn_0 = XXX;;51nnP;YYY$

or

$DPn_0 = XXX;;;kk;YYY$

where:

XXX is the prelabel,

YYY is the postlabel,

$51nnP$ is the time-overcurrent element pickup, and

kk is a shorthand number indicating a particular time-overcurrent element pickup.

For the asserted state (logical 1) replace DPn_0 with DPn_1 .

Table 8.4 shows the time-overcurrent element settings, resolution, and the maximum label characters. The maximum number of label characters in a same-line display is either six or nine characters. The relay shows six label characters when you use the embedded double semicolon (;;) and the actual name of the overcurrent element pick up; the relay displays nine label characters when you use the embedded triple semicolon (;;;) and overcurrent element number shown in *Table 8.4*. You can vary the number of label characters in the prelabel and the postlabel as long as the sum does not exceed the maximum.

You can omit either the prelabel or the postlabel. When excluding the postlabel, be sure to include the last semicolon.

For setting examples, see *Same-Line Setting Examples on page 8.21*.

Table 8.4 Dynamic Display Same-Line Overcurrent Elements

Setting	Setting Displayed	Display Resolution	Label Characters (maximum)
::51P1P	51P1P	#####.##	6
::51Q1P	51Q1P	#####.##	6
::51N1P	51N1P	#####.##	6
::51P2P	51P2P	#####.##	6
::51Q2P	51Q2P	#####.##	6
::51N2P	51N2P	#####.##	6
::51NN1P	51NN1P	#####.##	6
::51NN2P	51NN2P	#####.##	6
::51NN3P	51NN3P	#####.##	6
:::0	51P1P	#####	9
:::1	51Q1P	#####	9
:::2	51N1P	#####	9
:::3	51P2P	#####	9
:::4	51Q2P	#####	9
:::5	51N2P	#####	9
:::12	51NN1P	#####	9
:::13	51NN2P	#####	9
:::14	51NN3P	#####	9

Display Time-Overcurrent Element Pickup Settings

Use display point text settings and logic settings to display the following relay elements in primary units:

51P1P, 51Q1P, 51N1P, 51P2P, 51Q2P, 51N2P, 51NN1P, 51NN2P, 51NN3P

The relay shows a dynamic display for these overcurrent element pickup settings in either a dual-line presentation or a same-line presentation.

Dual-Line Setting Example

Enter the following settings for a dual-line display:

DP1_0 = **Brkr 1 Trips at**

DP2_0 = **::51P1P**

DP1 = **0**

DP2 = **0**

The following appears on the front-panel display:



```
BRKR 1 TRIPS AT
#####.## A pri
```

where # designates the primary value of the 51P1P setting (51P1P multiplied by CTR1).

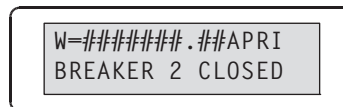
The relay recognizes the double-colon control string, locates the element name, validates the name, obtains the secondary value, multiplies the secondary value by setting CTR n , and displays the value with “A pri” appended.

Same-Line Setting Examples

Enter the following settings for a same-line display with six label characters:

```
DP1_0 = W = ;;51P1P;Apri
DP1 = 0
```

The following appears on the front-panel display:



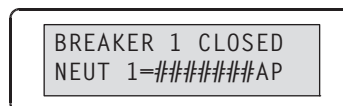
```
W=#####.##APRI
BREAKER 2 CLOSED
```

where # designates the primary value of the 51P1P setting (51P1P multiplied by setting CTR1). The second display point on this display was previously programmed to show circuit breaker status.

Enter the following settings for a same-line display with nine label characters:

```
DP2_0 = Neut 1 = ;;12;Ap
DP2 = 0
```

The following appears on the front-panel display:



```
BREAKER 1 CLOSED
NEUT 1=#####AP
```

where # designates the primary value of the 51NN1P setting (51NN1P multiplied by CTRN1). The first display point on this display was previously programmed to show circuit breaker status.

Display Metering and Breaker Wear Monitor

The LCD displays the following secondary metering quantities as primary metering quantities (primary values) when you set the appropriate display point text settings and logic settings. Use the double-colon control string (::) for a dynamic display of the metering or breaker quantities listed in the following paragraphs.

Some of these display elements match internal Relay Word bits, and other display elements have mnemonics that represent the dynamic display quantity.

Matching Relay Word Bits

These dynamic display names have the same names as the Relay Word bits: IAW1, IBW1, ICW1, 3I1W1, 3I2W1, IRW1, IAW2, IBW2, ICW2, 3I1W2, 3I2W2, IRW2, IOP1, IOP2, IOP3, IRT1, IRT2, IRT3, I1F2, I2F2, I3F2, I1F5, I2F5, I3F5, VDC, RTD1A, RTD2A, RTD3A, RTD4A, RTD5A, RTD6A, RTD7A, RTD8A, RTD9A, RTD10A, RTD11A, RTD12A, RTD1B, RTD2B, RTD3B, RTD4B, RTD5B, RTD6B, RTD7B, RTD8B, RTD9B, RTD10B, RTD11B, RTD12B. For a description of these Relay Word bits, see *Section 4: Control Logic*.

Mnemonics

Table 8.5 lists the secondary metering quantities that differ from the Relay Word bits that the relay uses for demand metering, peak demand metering, and the breaker wear monitor.

Table 8.5 Dynamic Display Mnemonics (Sheet 1 of 2)

Mnemonic	Data
IAW1DEM	IAW1 demand current
IBW1DEM	IBW1 demand current
ICW1DEM	ICW1 demand current
3I2W1DEM	3I2W1 demand current
IRW1DEM	IRW1 demand current
IAW1PK	IAW1 peak demand current
IBW1PK	IBW1 peak demand current
ICW1PK	ICW1 peak demand current
3I2W1PK	3I2W1 peak demand current
IRW1PK	IRW1 peak demand current
IAW2DEM	IAW2 demand current
IBW2DEM	IBW2 demand current
ICW2DEM	ICW2 demand current
3I2W2DEM	3I2W2 demand current
IRW2DEM	IRW2 demand current
IAW2PK	IAW2 peak demand current
IBW2PK	IBW2 peak demand current
ICW2PK	ICW2 peak demand current
3I2W2PK	3I2W2 peak demand current
IRW2PK	IRW2 peak demand current
INTTRB1	Bkr1 internal trip count
INTIAW1	Bkr1 internal trip IA
INTIBW1	Bkr1 internal trip IB
INTICW1	Bkr1 internal trip IC
EXTTRB1	Bkr1 external trip count
EXTIAW1	Bkr1 external trip IA
EXTIBW1	Bkr1 external trip IB
EXTICW1	Bkr1 external trip IC
WEARAB1	Bkr1 A-phase wear monitor

Table 8.5 Dynamic Display Mnemonics (Sheet 2 of 2)

Mnemonic	Data
WEARBB1	Bkr1 B-phase wear monitor
WEARCB1	Bkr1 C-phase wear monitor
INTTRB2	Bkr2 internal trip count
INTIAW2	Bkr2 internal trip IA
INTIBW2	Bkr2 internal trip IB
INTICW2	Bkr2 internal trip IC
EXTTRB2	Bkr2 external trip count
EXTIAW2	Bkr2 external trip IA
EXTIBW2	Bkr2 external trip IB
EXTICW2	Bkr2 external trip IC
WEARAB2	Bkr2 A-phase wear monitor
WEARBB2	Bkr2 B-phase wear monitor
WEARCB2	Bkr2 C-phase wear monitor

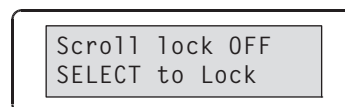
Scroll Lock Control of Front-Panel LCD

Select Scroll Lock

The rotating default display can be locked on a single screen. Access the scroll lock control with the {OTHER} pushbutton.

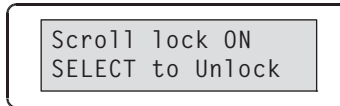


Select **LCD** for **Scroll Lock Control** mode. The rotating display will then appear, and the scroll mode reminder screen will appear every eight seconds for one second as a reminder that the display is in **Scroll Lock Control** mode.



Stop Scrolling (Lock)

When in the **Scroll Lock Control** mode, press the {SELECT} pushbutton to stop display rotation. Scrolling can be stopped on any of the display point screens or on the current-meter display screen. While rotation is stopped, the active display is updated continuously so that current or display point changes can be seen. If no button is pressed for eight seconds, the reminder message will appear for one second, followed by the active screen.



Restart Scrolling (Unlock)

The **{SELECT}** pushbutton unlocks the LCD and resumes the rotating display.

Single Step

From the `Scroll Locked` state, single-step through the display screens by pressing the **{SELECT}** pushbutton twice. Wait for the first press to display the next screen as the active display, then press the **{SELECT}** pushbutton a second time to freeze scrolling.

Exit

Press the **{EXIT}** pushbutton to leave `Scroll Lock Control` and return the rotating display to normal operation.

Figures of Selected Front-Panel Menu Structures

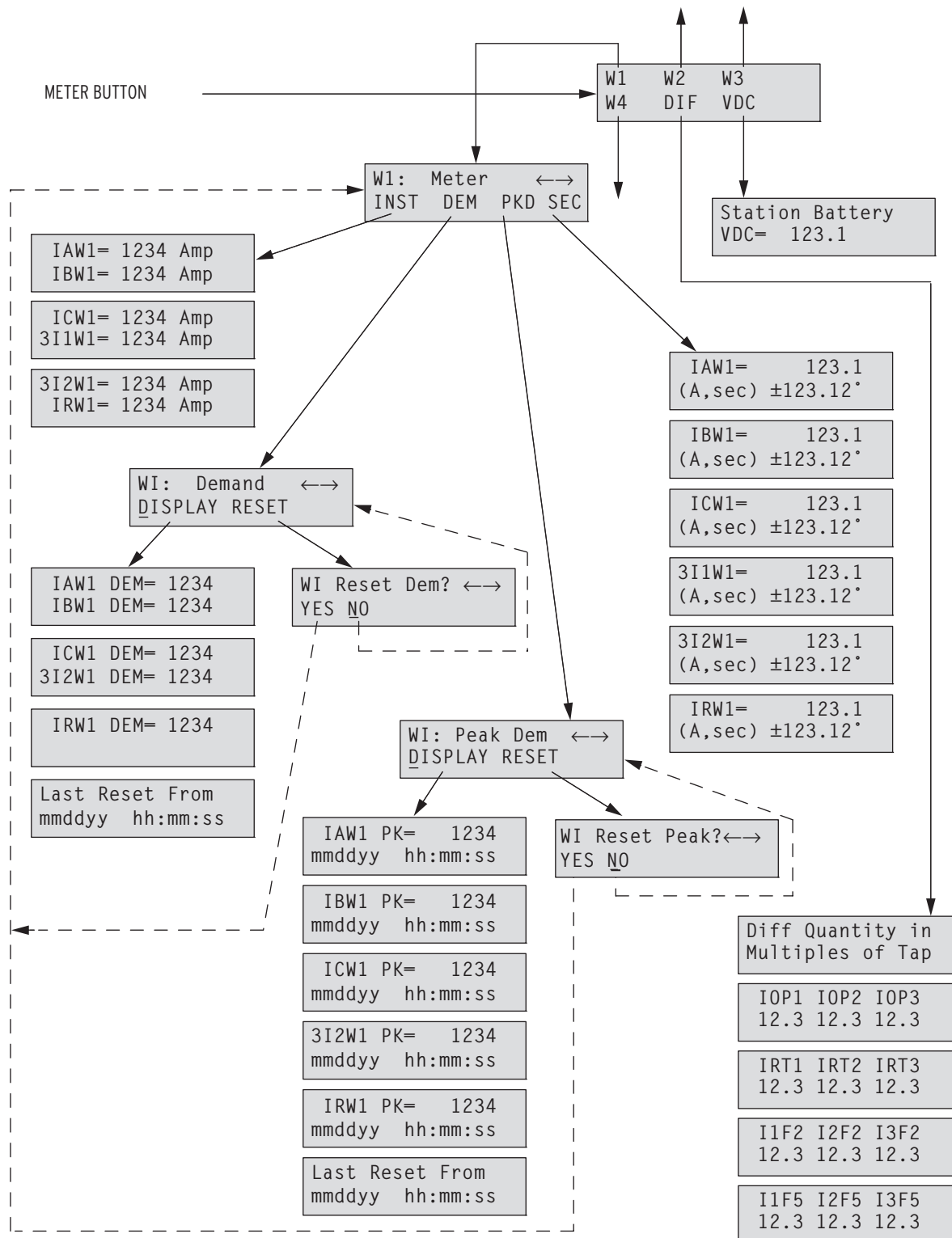


Figure 8.5 METER Menu and Display Structure

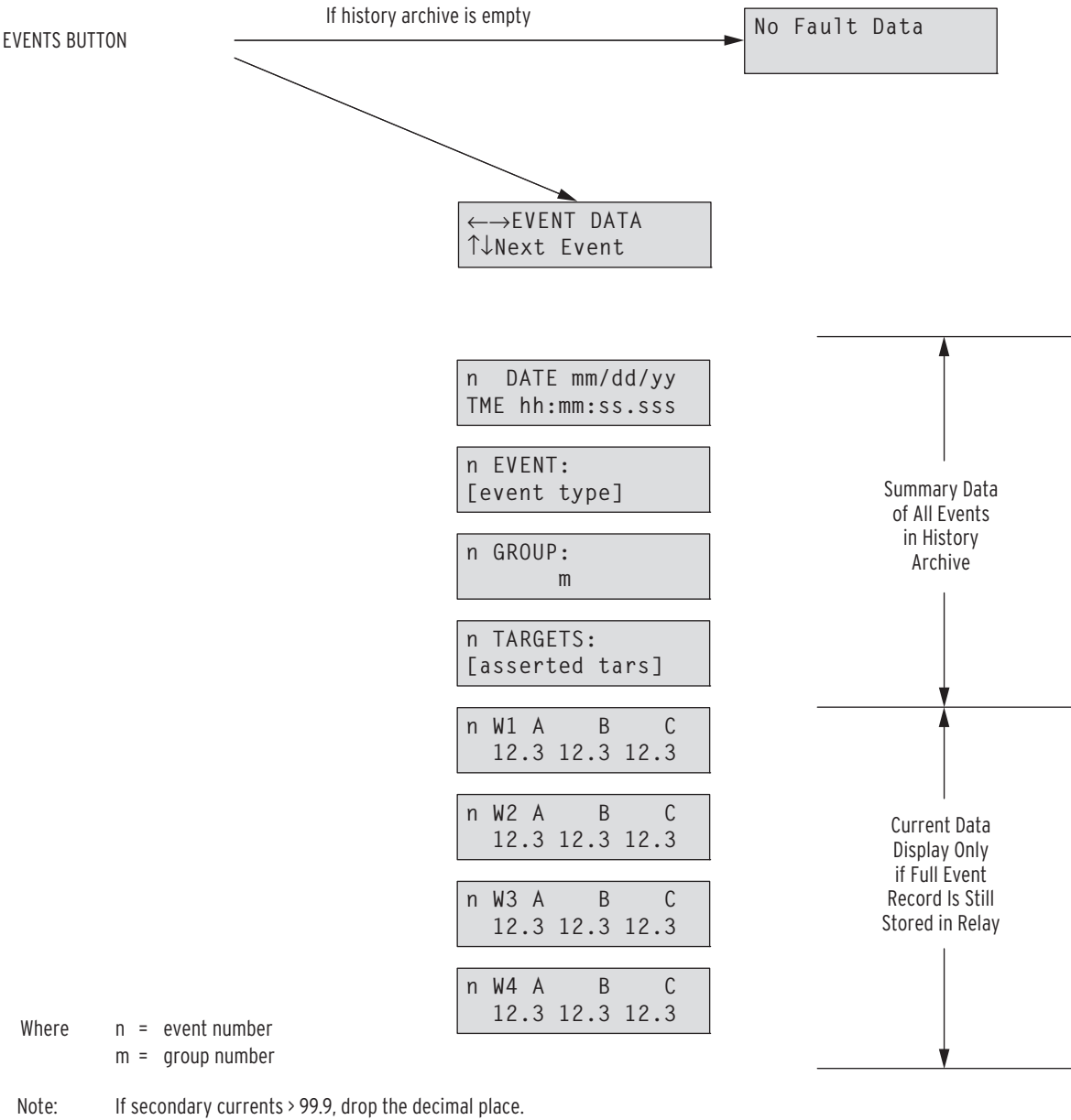


Figure 8.6 EVENTS Display Structure

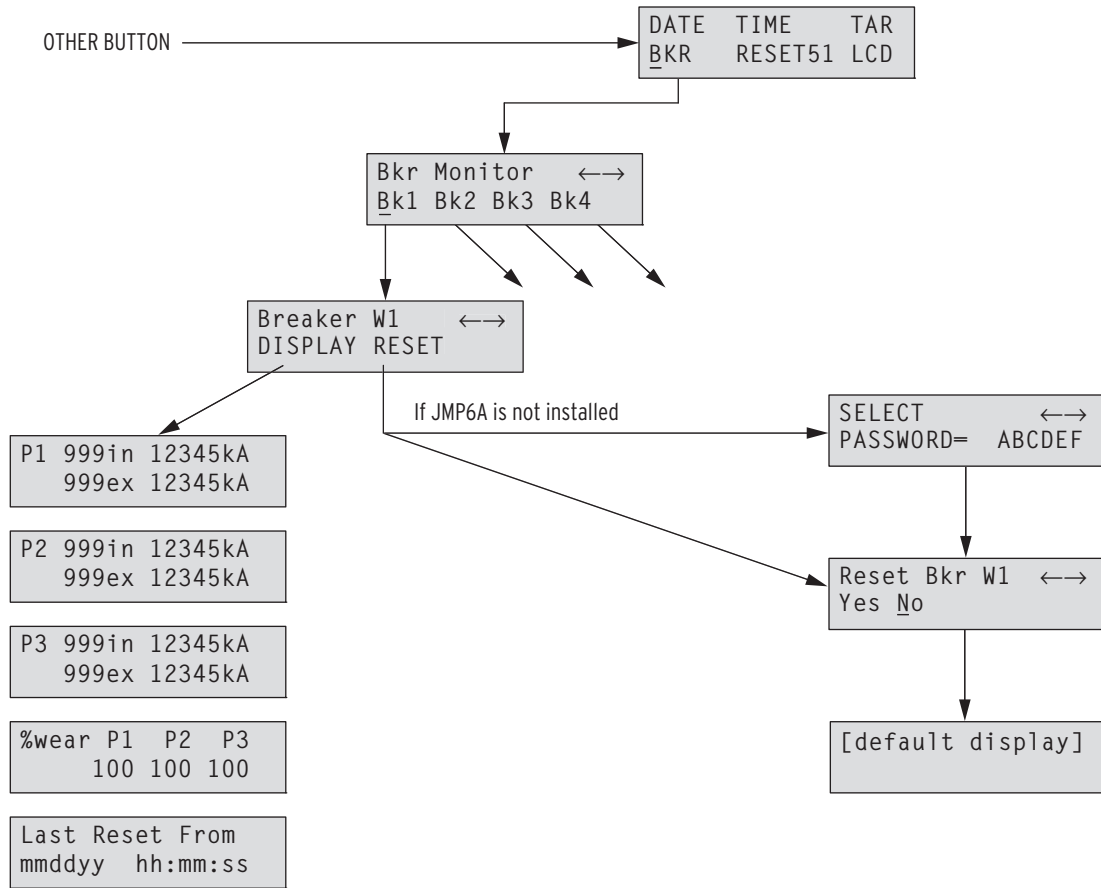


Figure 8.7 OTHER / BKR Menu and Display Structure

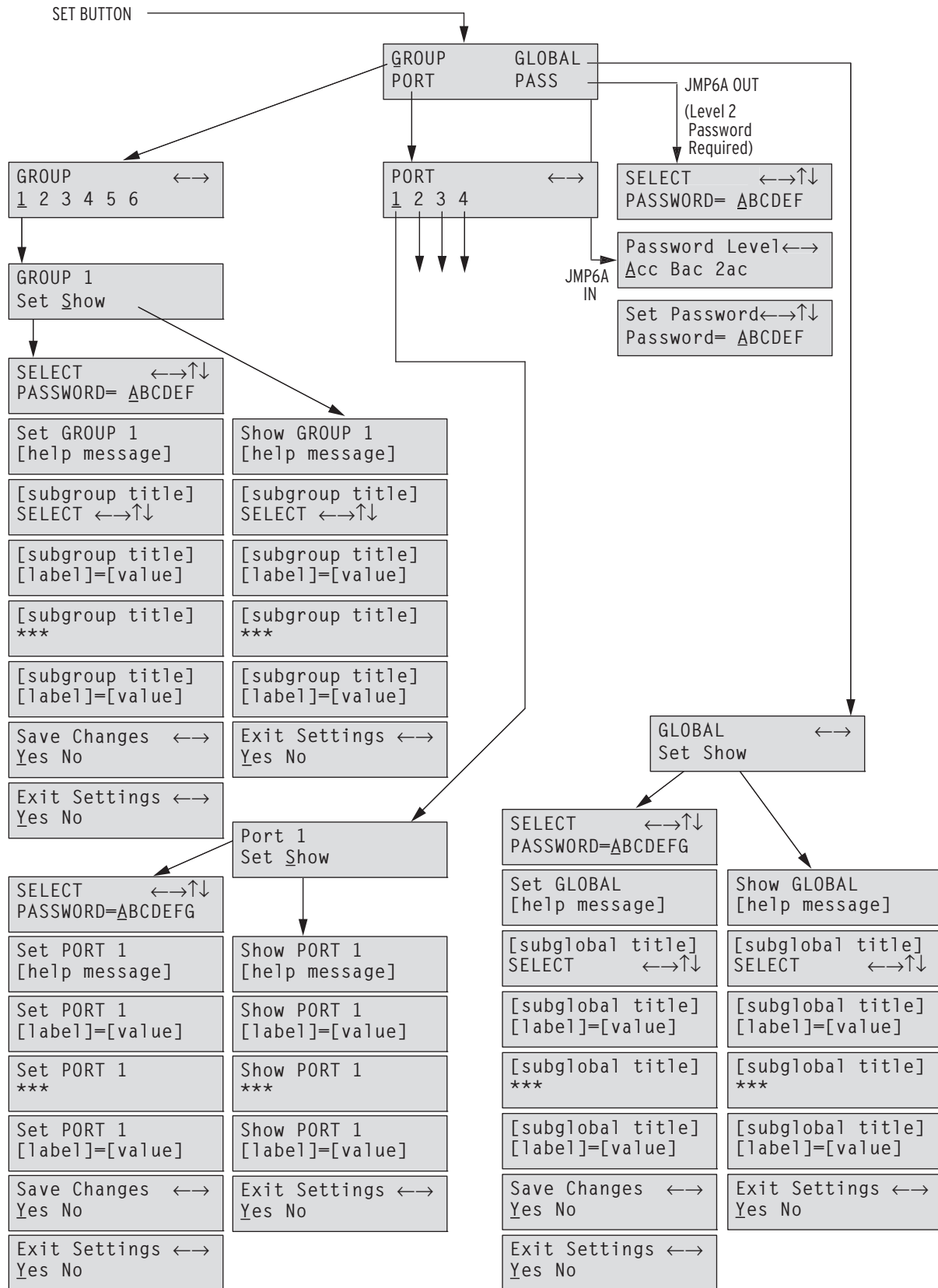


Figure 8.8 SET Menu and Display Structure

Section 9

Event Reports and SER

Overview

The SEL-387 Relay offers two styles of event reports:

- Standard 15-, 30-, or 60-cycle event reports
- Sequential Events Recorder (SER) report

These event reports contain date, time, current, relay element, optoisolated input, and output contact information.

The relay generates (triggers) standard 15-, 30-, or 60-cycle event reports by fixed and programmable conditions. These reports show information for 15, 30, or 60 continuous cycles depending on the Global setting LER. The length of the pre-fault data contained in the event report is determined by the Global setting PRE. This setting allows for 1 to (LER-1) cycles of pre-fault data in each event report. The number of event reports stored in nonvolatile memory depends on the LER setting as follows:

LER	Number of Event Reports Saved
15	8–21
30	12–14
60	7

The number of events saved will be fewer if mixed lengths (e.g., LER = 60 for 3 event reports and then changed to LER = 30) are stored together or if the relay is subjected to frequent power-down/power-up cycles.

If the relay nonvolatile memory is full and another event is triggered, the latest event report will overwrite the oldest event report, and the oldest event report will be lost. See *Figure 9.2* for an example standard 15-cycle event report.

The relay adds lines in the Sequential Events Recorder (SER) report by programmable conditions only. The SER lists date- and time-stamped lines of information each time a programmed condition changes state. The relay stores the latest 512 lines of the SER report in nonvolatile memory. If the report fills up, newer rows overwrite the oldest rows in the report. See *Figure 9.8* for an example SER report.

Standard 15-, 30-, or 60-Cycle Event Reports

Event Report Length (Settings LER and PRE)

The SEL-387 provides user-programmable event report length and pre-fault length. Event report length is set at 15, 30, or 60 cycles, using the Global setting LER. Pre-fault length ranges from 1 to (LER-1) cycles. Set the pre-fault length with the Global setting PRE. The LER and PRE settings are accessible either via the **SET G** serial port command or via the **{SET}/GLOBAL** front-panel pushbuttons.

Changing the LER and/or PRE settings has no effect on previously stored nonvolatile reports.

Standard Event Report Triggering

The relay triggers (generates) a standard 15-, 30-, or 60-cycle event report when any of the following occur:

- Relay Word bits TRIP1 through TRIP5 assert
- Relay Word bits CLS1 through CLS4 assert
- Programmable SELOGIC® control equation setting ER asserts to logical 1
- **PULSE** serial port/front-panel command executed for output contact **OUT101** through **OUT107** or other **OUTnnn** contacts if available
- **TRIGGER** serial port command executed

Relay Word Bits TRIP1-TRIP5, CLS1-CLS4

Relay Word bits $TRIPn$ ($n = 1, 2, 3, 4, \text{ or } 5$) usually would be assigned to an output contact for tripping a circuit breaker (e.g., setting $OUT101 = TRIP1$). SELOGIC control equation settings TRn initiate the Trip Logic and control the assertion of Relay Word bits $TRIPn$ (see *Figure 4.7*). The Relay Word bit OCm ($m = 1, 2, 3, 4$), initiated by the “Open breaker m ” serial port command **OPE m** or the front-panel **{CNTRL}/Open** command, normally would be assigned to TRm .

Similarly, Relay Word bits $CLSm$ ($m = 1, 2, 3, 4$) 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 4.8*). The Relay Word bit CCm , initiated by the “Close breaker m ” serial port command **CLO m** or the front-panel **{CNTRL}/Close** command, normally would 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 equations setting ER. The assertion of Relay Word bit $TRIPn$ or $CLSm$ automatically triggers a standard 15-, 30-, or 60-cycle event report.

Programmable SELOGIC Control Equation Setting ER

The SELOGIC control equation setting ER is set to trigger standard 15-, 30-, or 60-cycle event reports for conditions other than tripping or closing conditions already listed in settings 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-, 30-, or 60-cycle event report.

Note the rising-edge operator symbol (/) in front of each of these elements. See *Section 4: Control Logic* for more information on rising-edge operators and SELOGIC control equations in general.

Rising-edge operators are especially useful in generating an event report at fault inception, then generating another event report later if a breaker trips on some time-delayed element.

PULSE and TRIGGER Commands

The **PULSE** serial port/front-panel command is used to assert the output contacts for testing purposes or for remote control. If an output contact **OUT101–OUT107** or an available interface board contact **OUT nnn** is asserted with the **PULSE** command, a standard 15-, 30-, or 60-cycle event report is also generated. Since the **PUL** command generates an event report, precautions should be taken to retrieve and store any existing event reports of interest that presently may be in the relay before testing the output contacts with the **PUL** command. Failure to do so may result in some or all of the existing reports being overwritten when **PUL** commands are issued.

The sole function of the **TRIGGER** serial port command is to generate standard 15-, 30-, or 60-cycle event reports primarily for testing purposes. Simply type **TRI <Enter>** to execute the command.

See *Section 7: Serial Port Communications and Commands* for more information on serial port commands **TRIGGER** and **PULSE**.

Standard Event Report Summary

Each time the relay generates a standard 15-, 30-, or 60-cycle event report, it also generates a corresponding event summary (see *Figure 9.1*). Use the **EVE T** command to generate this summary. Event summaries contain the following information:

- Relay and terminal identifiers (settings RID and TID)
- Date and time when the event was triggered
- Event type
- Front-panel targets at the time of trip
- Phase (IA, IB, IC) currents for the four (4) winding inputs

NOTE: The relay sends event summaries to all serial ports with setting **AUTO = Y** each time an event triggers.

This event summary information is also contained in the corresponding standard 15-, 30-, or 60-cycle event report. The identifiers, date, and time information is at the top of the standard 15-, 30-, or 60-cycle event report, and the other information follows at the end. See *Figure 9.2*.

The example event summary in *Figure 9.1* corresponds to the full-length standard 15-cycle event report in *Figure 9.2*.

XFMR 1		Date: 02/28/97	Time: 06:28:38.888
STATION A			
Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5			
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4			
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4			
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4			
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4			
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4			

Figure 9.1 Example Event Summary

NOTE: SEL-387-0 firmware versions R100-R105 display 99 event summaries. SEL-387-6 firmware versions R304 and R405 display 40 event summaries. All other firmware versions display 80 event summaries.

The latest 80 event summaries are stored in nonvolatile memory and are accessed by the **HISTORY** command. The **HIS C** command clears the event summaries and corresponding full-length standard event reports from nonvolatile memory. See *HIS (History of Events)* on page 7.19 and *HIS C (Clear History and Events)* on page 7.19 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* on page 9.2).

Table 9.1 Event Types

Event	Event Triggered by:
TRIP1	Assertion of Relay Word bit TRIP1
TRIP2	Assertion of Relay Word bit TRIP2
TRIP3	Assertion of Relay Word bit TRIP3
TRIP4	Assertion of Relay Word bit TRIP4
TRIP5	Assertion of Relay Word bit TRIP5
CLS1	Assertion of Relay Word bit CLS1
CLS2	Assertion of Relay Word bit CLS2
CLS3	Assertion of Relay Word bit CLS3
CLS4	Assertion of Relay Word bit CLS4
ER	SELOGIC control equations setting ER
PULSE	Execution of PULSE serial port command
TRIG	Execution of TRIGGER serial port command

The order of precedence for listing the event type in the summary is: TRIP, CLOSE, ER, PULSE, TRIG (as implied by Table 9.1). If more than one type of report trigger occurs within the same report period, the type of highest precedence will be shown in the **Event:** field of the report summary.

Targets

The target field shows all front-panel targets that were illuminated at the end of the triggered event report. The targets include: TRIP, INST, 87-1, 87-2, 87-3, 50, 51, A, B, C, N, W1, W2, W3, and W4.

Winding Currents

The Winding n Currents (A Sec), ABC: ($n = 1, 2, 3$, or 4) field shows each winding input current present in the event report row containing the maximum secondary phase current. The standard 15-, 30-, or 60-cycle event report will mark the reference row used in the summary report with an asterisk. The listed currents for each of the four (4) winding inputs are:

Phase (A = channel IA, B = channel IB, C = channel IC)

Retrieving Full-Length Standard Event Reports

Any given event report has four different ways it can be displayed, depending on the particular serial port command issued to the relay. The command choices are shown below.

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 T	Event summary (see <i>Figure 9.1</i>)

Event (Winding Event Report)

The winding event report contains secondary phase currents for each of the four winding inputs as well as the status of the eight digital outputs and six optoisolated inputs.

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

EVE [n , Sx , Ly [- w]] (parameters in [] are optional)

where:

n = Event number; defaults to 1 if not listed, where 1 is the most recent event

Sx = Displays x samples per cycle (4 or 8); defaults to 4 if not listed

Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed

$Ly-$ = Displays from cycle y to end of report

$Ly-w$ = Displays from cycle y to cycle w

Refer to *Figure 9.2* for an example winding event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE <Enter>** command.

XFMR 1										Date: 02/28/97				Time: 06:28:38.888			
STATION A																	
FID=SEL-387-R102-V#####-D970226																	
Winding 1			Winding 2			Winding 3			Winding 4			OUT		IN			
Amps Sec			Amps Sec			Amps Sec			Amps Sec			1357		135			
IAW1	IBW1	ICW1	IAW2	IBW2	ICW2	IAW3	IBW3	ICW3	IAW4	IBW4	ICW4	246A	246				
[1]																	
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....	...		
[2]																	
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234>	....			
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....			
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	....			
+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+1234	+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	+1234	+1234	+1234	+1234	....			
Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5																	
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4																	
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4																	
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4																	
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4																	
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4																	

Figure 9.2 Example Winding Event Report

The trigger row includes a > character following immediately after the last analog column to indicate the trigger point. A * character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The * character takes precedence over the > character when both conditions occur for the same row.

Table 9.2 summarizes the event report current columns. The column headings shown are the default headings, corresponding to the designations on terminals Z01 to Z24. If the Analog Input Labels settings have been changed within the Global setting area, these will appear in the report as set.

Table 9.2 Winding Event Report Current Columns

Column Heading	Definition
IAW1	Current measured by Winding 1 input channel IA (amperes, secondary)
IBW1	Current measured by Winding 1 input channel IB (amperes, secondary)
ICW1	Current measured by Winding 1 input channel IC (amperes, secondary)
IAW2	Current measured by Winding 2 input channel IA (amperes, secondary)
IBW2	Current measured by Winding 2 input channel IB (amperes, secondary)
ICW2	Current measured by Winding 2 input channel IC (amperes, secondary)
IAW3	Current measured by Winding 3 input channel IA (amperes, secondary)
IBW3	Current measured by Winding 3 input channel IB (amperes, secondary)
ICW3	Current measured by Winding 3 input channel IC (amperes, secondary)
IAW4	Current measured by Winding 4 input channel IA (amperes, secondary)
IBW4	Current measured by Winding 4 input channel IB (amperes, secondary)
ICW4	Current measured by Winding 4 input channel IC (amperes, secondary)

Table 9.3 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	Output contact OUT101 asserted
	2	Output contact OUT102 asserted
	b	Both OUT101 and OUT102 asserted
OUT 34	3	Output contact OUT103 asserted
	4	Output contact OUT104 asserted
	b	Both OUT103 and OUT104 asserted
OUT 56	5	Output contact OUT105 asserted
	6	Output contact OUT106 asserted
	b	Both OUT105 and OUT106 asserted
OUT 7A	7	Output contact OUT107 asserted
	A	Output contact ALARM asserted
	b	Both OUT107 and ALARM asserted
IN 12	1	Optoisolated input IN101 asserted
	2	Optoisolated input IN102 asserted
	b	Both IN101 and IN102 asserted
IN 34	3	Optoisolated input IN103 asserted
	4	Optoisolated input IN104 asserted
	b	Both IN103 and IN104 asserted
IN 56	5	Optoisolated input IN105 asserted
	6	Optoisolated input IN106 asserted
	b	Both IN105 and IN106 asserted

Event D (Digital Event Report)

The digital event report contains the status of the instantaneous, definite-time, and inverse-time overcurrent phase, single-phase, calculated residual, and negative-sequence overcurrent elements and the demand current thresholds for phase, calculated residual, and negative-sequence for each of the four winding inputs. The status of the Relay Word bits $TRIP_n$ ($n = 1, 2, 3, 4$, and 5) as well as the status of the eight digital outputs and six optoisolated inputs are also included.

Use the **EVENT D** command to retrieve digital event reports. There are several options to customize the report format. The general command format is:

EVE D [*n*, *Sx*, *Ly*[-*w*]] (parameters in [] are optional)

where:

- n* = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx* = Displays *x* samples per cycle (4 or 8); defaults to 4 if not listed
- Ly* = Displays *y* cycles of data (1 to LER); defaults to LER if not listed
- Ly-* Displays from cycle *y* to end of report
- Ly-w* Displays from cycle *y* to cycle *w*

Refer to *Figure 9.3* for an example digital event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE D <Enter>** command.

[illegible]

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.

Table 9.4 summarizes the digital event report columns.

Table 9.4 Digital Event Report Column Description (Sheet 1 of 3)

Column Heading	Symbol	Definition
All	.	All indication deasserted
Winding 1 50P1	1 T	50P11 asserted 50P11T asserted
Winding 1 50P2	2	50P12 asserted
Winding 1 50A34	3 4 b	50A13 asserted 50A14 asserted 50A13 and 50A14 asserted
Winding 1 50B34	3 4 b	50B13 asserted 50B14 asserted 50B13 and 50B14 asserted
Winding 1 50C34	3 4 b	50C13 asserted 50C14 asserted 50C13 and 50C14 asserted
Winding 1 50N1	1 T	50N11 asserted 50N11T asserted
Winding 1 50N2	2	50N12 asserted

Table 9.4 Digital Event Report Column Description (Sheet 2 of 3)

Column Heading	Symbol	Definition
Winding 1 50Q1	1 T	50Q11 asserted 50Q11T asserted
Winding 1 50Q2	2	50Q12 asserted
Winding 1 51P	p T r l .	51P1 asserted 51P1T asserted Timing to reset (51P1RS=Y) Timing to reset after 51P1T assertion (51P1RS=N) 51P1R asserted
Winding 1 51N	p T r l .	51N1 asserted 51N1T asserted Timing to reset (51N1RS=Y) Timing to reset after 51N1T assertion (51N1RS=N) 51N1R asserted
Winding 1 51Q	p T r l .	51Q1 asserted 51Q1T asserted Timing to reset (51Q1RS=Y) Timing to reset after 51Q1T assertion (51Q1RS=N) 51Q1R asserted
Use same logic for overcurrent elements in Winding 2, Winding 3, and Winding 4		
51PC1	p T r l .	51PC1 asserted 51PC1T asserted Timing to reset (51PC1RS=Y) Timing to reset after 51PC1T assertion (51PC1RS=N) 51PC1R asserted
51NC1	p T r l .	51NC1 asserted 51NC1T asserted Timing to reset (51NC1RS=Y) Timing to reset after 51NC1T assertion (51NC1RS=N) 51NC1R asserted
51PC2	p T r l .	51PC2 asserted 51PC2T asserted Timing to reset (51PC2RS=Y) Timing to reset after 51PC2T assertion (51PC2RS=N) 51PC2R asserted
51NC2	p T r l .	51NC2 asserted 51NC2T asserted Timing to reset (51NC2RS=Y) Timing to reset after 51NC2T assertion (51NC2RS=N) 51NC2R asserted
DC 12	1 2 b	DC1 asserted DC2 asserted DC1 and DC2 asserted
DC 34	3 4 b	DC3 asserted DC4 asserted DC3 and DC4 asserted
TRP 12	1 2 b	TRIP1 asserted TRIP2 asserted TRIP1 and TRIP2 asserted
TRP 34	3 4 b	TRIP3 asserted TRIP4 asserted TRIP3 and TRIP4 asserted
TRP 5	5	TRIP5 asserted

Table 9.4 Digital Event Report Column Description (Sheet 3 of 3)

Column Heading	Symbol	Definition
DEM P12	1 2 b	PDEM1 asserted PDEM2 asserted PDEM1 and PDEM2 asserted
DEM P34	3 4 b	PDEM3 asserted PDEM4 asserted PDEM3 and PDEM4 asserted
DEM N12	1 2 b	NDEM1 asserted NDEM2 asserted NDEM1 and NDEM2 asserted
DEM N34	3 4 b	NDEM3 asserted NDEM4 asserted NDEM3 and NDEM4 asserted
DEM Q12	1 2 b	QDEM1 asserted QDEM2 asserted QDEM1 and QDEM2 asserted
DEM Q34	3 4 b	QDEM3 asserted QDEM4 asserted QDEM3 and QDEM4 asserted
OUT 12	1 2 b	Output contact OUT101 asserted Output contact OUT102 asserted Both OUT101 and OUT102 asserted
OUT 34	3 4 b	Output contact OUT103 asserted Output contact OUT104 asserted Both OUT103 and OUT104 asserted
OUT 56	5 6 b	Output contact OUT105 asserted Output contact OUT106 asserted Both OUT105 and OUT106 asserted
OUT 7A	7 A b	Output contact OUT107 asserted Output contact ALARM asserted Both OUT107 and ALARM asserted
IN 12	1 2 b	Optoisolated input IN101 asserted Optoisolated input IN102 asserted Both IN101 and IN102 asserted
IN 34	3 4 b	Optoisolated input IN103 asserted Optoisolated input IN104 asserted Both IN103 and IN104 asserted
IN 56	5 6 b	Optoisolated input IN105 asserted Optoisolated input IN106 asserted Both IN105 and IN106 asserted

Event DIF (Differential Event Report)

The differential event report contains the operate and restraint currents in a given differential element along with the second- and fifth-harmonic content of the current. The status of the restrained and unrestrained differential elements, the fifth-harmonic alarm, the REF function, the Relay Word bits TRIP n ($n = 1, 2, 3, 4$, and 5), the SELOGIC control equation Timed Variables and Latch Bits, eight of the 16 Remote Bits, the eight digital outputs, and the six optoisolated inputs are shown.

Use the **EVENT DIF** command to retrieve differential event reports. There are several options to customize the report format. The general command format is:

EVE DIF_z [*n*, **Sx**, **Ly**[−*w*]] (parameters in [] are optional)

where:

z = Displays results for differential element z ($z = 1, 2$, or 3)

n = Event number; defaults to 1 if not listed, where 1 is the most recent event

Sx = Displays *x* samples per cycle (4 or 8); defaults to 4 if not listed

Ly = Displays y cycles of data (1 to LER); defaults to LER if not listed

Ly- = Displays from cycle y to end of report

Ly-w = Displays from cycle y to cycle w

Refer to *Figure 9.4* for an example differential event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE DIF1** **<Enter>** command.

```

XFMR 1                                     Date: 02/28/97   Time: 06:28:38.888
STATION A

FID=SEL-387-R102-V#####-D970226

      Differential
      Differential Quantities      Set 1  Set 2  Set 3
      Multiples of TAP            R      LT      LT      OUT  IN
      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 TRIP5
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4
Winding 1 Currents (A Sec), ABCPN: 123.4 123.4 123.4 123.4 123.4 123.4
Winding 2 Currents (A Sec), ABCPN: 123.4 123.4 123.4 123.4 123.4 123.4
Winding 3 Currents (A Sec), ABCPN: 123.4 123.4 123.4 123.4 123.4 123.4
Winding 4 Currents (A Sec), ABCPN: 123.4 123.4 123.4 123.4 123.4 123.4

```

Figure 9.4 Example Differential Event Report

The trigger row includes a > character following immediately after the last analog column to indicate the trigger point. A * character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The * character takes precedence over the > character when both conditions occur for the same row.

Table 9.5 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)

Table 9.6 summarizes the digital event report columns.

Table 9.6 Differential Event Report Element Columns (Sheet 1 of 3)

Column Heading	Symbol	Definition
All	.	All indication deasserted
Differential 87RU	R U b	87R asserted 87U asserted 87R and 87U asserted
Differential 87 1	R U b	87R1 asserted 87U1 asserted 87R1 and 87U1 asserted
Differential 87 2	R U b	87R2 asserted 87U2 asserted 87R2 and 87U2 asserted
Differential 87 3	R U b	87R3 asserted 87U3 asserted 87R3 and 87U3 asserted
Differential 87B 1	1 .	87BL1 asserted 87BL1 not asserted
Differential 87B 2	1 .	87BL2 asserted 87BL2 not asserted
Differential 87B 3	1 .	87BL3 asserted 87BL3 not asserted
Differential HB 1	2 5 b	2HB1 asserted 5HB1 asserted 2HB1 and 5HB1 asserted
Differential HB 2	2 5 b	2HB2 asserted 5HB2 asserted 2HB2 and 5HB2 asserted
Differential HB 3	2 5 b	2HB3 asserted 5HB3 asserted 2HB3 and 5HB3 asserted
TH5	p T	TH5 asserted TH5 asserted longer than TH5D
REF	p T 1 .	32IF * 50G4 * !REFP asserted (timing to trip) 32IF * 50G4 * REFP asserted (timed out) Timing 1 cycle to reset after REFP assertion Reset
TRP 12	1 2 b	TRIP1 asserted TRIP2 asserted TRIP1 and TRIP2 asserted
TRP 34	3 4 b	TRIP3 asserted TRIP4 asserted TRIP3 and TRIP4 asserted
TRP 5	5	TRIP5 asserted

Table 9.6 Differential Event Report Element Columns (Sheet 2 of 3)

Column Heading	Symbol	Definition
Set 1 V1 V2 V3 V4	p T d	S1Vn asserted (timing to output) S1VnT asserted (timed out); S1Vn asserted S1VnT asserted, S1Vn deasserted (timing to reset)
Set 1 LT 12	1 2 b	Latch Bit 1 Latched Latch Bit 2 Latched Latch Bit 1 and Latch Bit 2 Latched
Set 1 LT 34	3 4 b	Latch Bit 3 Latched Latch Bit 4 Latched Latch Bit 3 and Latch Bit 4 Latched
Set 2 V1 V2 V3 V4	p T d	S2Vn asserted (timing to output) S2VnT asserted (timed out); S2Vn asserted S2VnT asserted, S2Vn deasserted (timing to reset)
Set 2 LT 12	1 2 b	Latch Bit 1 Latched Latch Bit 2 Latched Latch Bit 1 and Latch Bit 2 Latched
Set 2 LT 34	3 4 b	Latch Bit 3 Latched Latch Bit 4 Latched Latch Bit 3 and Latch Bit 4 Latched
Set 3 V1 V2 V3 V4 V5 V6 V7 V8	p T d	S3Vn asserted (timing to output) S3VnT asserted (timed out); S3Vn asserted S3VnT asserted, S3Vn deasserted (timing to reset)
RB 12	1 2 b	RB1 asserted RB2 asserted RB1 and RB2 asserted
RB 34	3 4 b	RB3 asserted RB4 asserted RB3 and RB4 asserted
RB 56	5 6 b	RB5 asserted RB6 asserted RB5 and RB6 asserted
RB 78	7 8 b	RB7 asserted RB8 asserted RB7 and RB8 asserted
OUT 12	1 2 b	OUT101 asserted OUT102 asserted OUT101 and OUT102 asserted
OUT 34	3 4 b	OUT103 asserted OUT104 asserted OUT103 and OUT104 asserted
OUT 56	5 6 b	OUT105 asserted OUT106 asserted OUT105 and OUT106 asserted
OUT 7A	7 A b	OUT107 asserted ALARM asserted OUT107 and ALARM asserted

Table 9.6 Differential Event Report Element Columns (Sheet 3 of 3)

Column Heading	Symbol	Definition
IN 12	1	IN101 asserted
	2	IN102 asserted
	b	IN101 and IN102 asserted
IN 34	3	IN103 asserted
	4	IN104 asserted
	b	IN103 and IN104 asserted
IN 56	5	IN105 asserted
	6	IN106 asserted
	b	IN105 and IN106 asserted

Event R (Raw Winding Event Report)

The raw winding event report contains secondary phase currents for each of the four winding inputs as well as the status of the eight digital outputs and six optoisolated inputs. The SEL-387 samples the analog ac input currents 64 times per power system cycle. The relay filters the samples to remove transient signals. The relay operates on the filtered values and reports them in most event reports. The raw or unfiltered event report allows for viewing the samples before digital filtering occurs.

Use the **EVENT R** command to retrieve raw winding event reports. There are several options to customize the report format. The general command format is:

EVE R [*n*, *Sx*, *Ly*[-*w*]] (parameters in [] are optional)

where:

- n* = Event number; defaults to 1 if not listed, where 1 is the most recent event
- Sx* = Displays *x* samples per cycle (4, 8, 16, 32, or 64); defaults to 16 if not listed
- Ly* = Displays *y* cycles of data (1 to LER); defaults to LER if not listed
- Ly*- = Displays from cycle *y* to end of report
- Ly*-*w* = Displays from cycle *y* to cycle *w*

Refer to *Figure 9.5* for an example raw winding event report. This example event report displays rows of information each quarter-cycle and was retrieved with the **EVE R S4 <Enter>** command. The raw event report always shows 1.5 cycles of pretrigger data, in this case six samples instead of four.

```

XFMR 1                                     Date: 02/28/97   Time: 06:28:38.888
STATION A

FID=SEL-387-R100-V#####-D970226

      Winding 1      Winding 2      Winding 3      Winding 4      OUT  IN
      Amps Sec      Amps Sec      Amps Sec      Amps Sec      1357 135
      IAW1 IBW1 ICW1 IAW2 IBW2 ICW2 IAW3 IBW3 ICW3 IAW4 IBW4 ICW4 246A 246
[0]
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
[1]
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234>....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234*....
[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 ....
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.
[15]
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....
+1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 +1234 ....

Event: TRIP1 TRIP2 TRIP3 TRIP4 TRIP5
Targets: TRIP INST 87-1 87-2 87-3 50 51 A B C N W1 W2 W3 W4
Winding 1 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 2 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 3 Currents (A Sec), ABC: 123.4 123.4 123.4
Winding 4 Currents (A Sec), ABC: 123.4 123.4 123.4

```

Figure 9.5 Example Raw Winding Event Report

The trigger row includes a > character following immediately after the last analog column to indicate the trigger point. A * character following immediately after the last analog column denotes that the designated row was used for the Event Summary currents. The * character takes precedence over the > character when both conditions occur for the same row.

Table 9.7 summarizes the raw event report current columns. The column headings shown are the default headings, corresponding to the designations on terminals Z01 to Z24. If the Analog Input Labels settings have been changed within the Global setting area, these will appear in the report as set.

Table 9.7 Raw Winding Event Report Current Columns (Sheet 1 of 2)

Column Heading	Definition
IAW1	Current measured by Winding 1 input channel IA (amperes, secondary)
IBW1	Current measured by Winding 1 input channel IB (amperes, secondary)
ICW1	Current measured by Winding 1 input channel IC (amperes, secondary)
IAW2	Current measured by Winding 2 input channel IA (amperes, secondary)
IBW2	Current measured by Winding 2 input channel IB (amperes, secondary)
ICW2	Current measured by Winding 2 input channel IC (amperes, secondary)
IAW3	Current measured by Winding 3 input channel IA (amperes, secondary)
IBW3	Current measured by Winding 3 input channel IB (amperes, secondary)
ICW3	Current measured by Winding 3 input channel IC (amperes, secondary)
IAW4	Current measured by Winding 4 input channel IA (amperes, secondary)

Table 9.7 Raw Winding Event Report Current Columns (Sheet 2 of 2)

Column Heading	Definition
IBW4	Current measured by Winding 4 input channel IB (amperes, secondary)
ICW4	Current measured by Winding 4 input channel IC (amperes, secondary)

Table 9.8 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	Output contact OUT101 asserted
	2	Output contact OUT102 asserted
	b	Both OUT101 and OUT102 asserted
OUT 34	3	Output contact OUT103 asserted
	4	Output contact OUT104 asserted
	b	Both OUT103 and OUT104 asserted
OUT 56	5	Output contact OUT105 asserted
	6	Output contact OUT106 asserted
	b	Both OUT105 and OUT106 asserted
OUT 7A	7	Output contact OUT107 asserted
	A	Output contact ALARM asserted
	b	Both OUT107 and ALARM asserted
IN 12	1	Optoisolated input IN101 asserted
	2	Optoisolated input IN102 asserted
	b	Both IN101 and IN102 asserted
IN 34	3	Optoisolated input IN103 asserted
	4	Optoisolated input IN104 asserted
	b	Both IN103 and IN104 asserted
IN 56	5	Optoisolated input IN105 asserted
	6	Optoisolated input IN106 asserted
	b	Both IN105 and IN106 asserted

Compressed ASCII Event Reports

The SEL-387 provides Compressed ASCII event reports to facilitate event report storage and display. The SEL-2032, the SEL-2030, or the SEL-2020 Communications Processor and the SEL-5601-2 SYNCHROWAVE® Event Software take advantage of the Compressed ASCII format. Use the **EVE C** command or the **CEVENT** command to display Compressed ASCII event reports. See the **CEVENT** command discussion in *Appendix E: Compressed ASCII Commands* for further information.

Extracting RMS Phasor Data from Filtered Event Reports

Figure 9.6 and Figure 9.7 look in detail at one cycle of A-phase current (channel IA) from a typical filtered Event Report. Figure 9.6 shows how the event report ac current column data relates to the actual sampled waveform and rms magnitude values. Figure 9.7 shows how the event report current column data can be converted to phasor rms values.

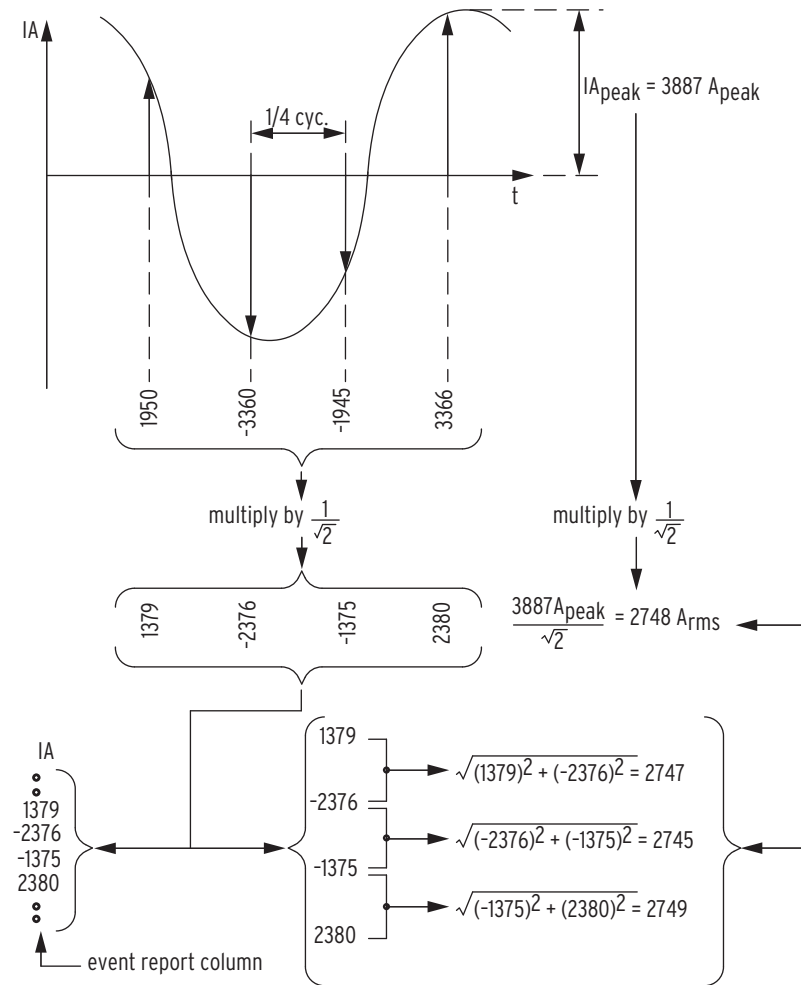


Figure 9.6 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 9.6*, note that any two rows of current data from the event report that are one-quarter cycle apart, can be used to calculate rms current values. One-quarter cycle represents 90 electrical degrees, so the two samples are effectively perpendicular to each other and can be treated as rectangular components of the phasor quantity. By using the normal method of taking the square root of the sum of the squares of the samples, the magnitude of the phasor can be extracted. Since the actual sample values have been divided by $\sqrt{2}$ (multiplied by $1/\sqrt{2}$ in the drawing) before being entered into the report column, no further adjustment is needed after doing the magnitude calculation. In the example in *Figure 9.6*, successive pairs of samples result in magnitude calculations very close to the true value of 2748 A, rms. The true rms value is shown as $I_{A_{peak}} \text{ times } 1/\text{sqrt}(2) = 3887 \cdot 0.707 = 2748 \text{ A}$.

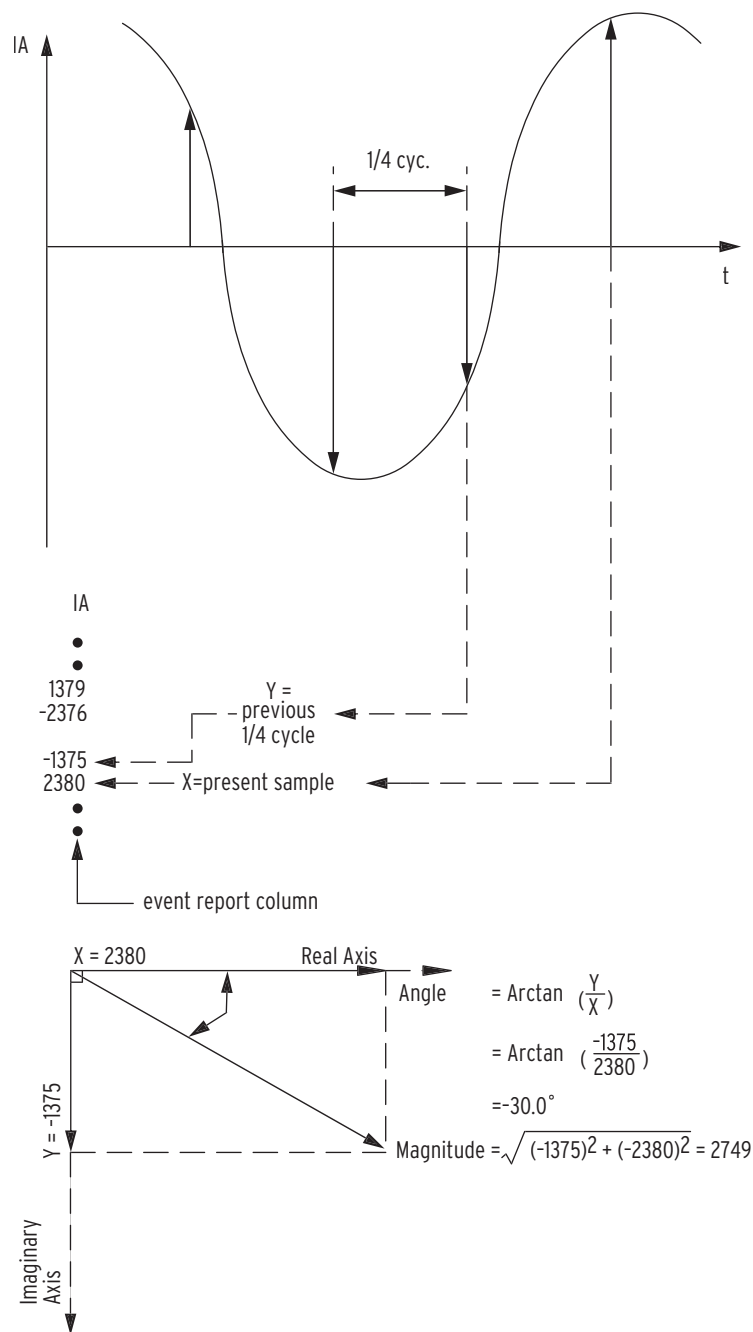


Figure 9.7 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 9.7*, note that two rows of current data one-quarter cycle apart can be used to calculate phasor rms current values. At the time of interest, the present sample is used as the Real Axis, or “X” component, while the value from one-quarter cycle before is used as the Imaginary Axis, or “Y” component. Plotting the components as shown, and noting that the angle of the phasor is $\text{Arctan}(Y/X)$, the complete phasor quantity can be derived and compared with other current phasors calculated from other current pairs selected from the same two rows of the Event Report. In *Figure 9.7* at the present sample the phasor rms current value is:

$$IA = 2749 \text{ A} \angle -30.0^\circ \quad \text{Equation 9.1}$$

The present sample ($I_A = 2380 \text{ A}$) is a real rms current value that relates to the phasor rms current value:

$$2749 \text{ A} \cdot \cos(-30.0^\circ) = 2380 \text{ A} \quad \text{Equation 9.2}$$

A calculation of the phasor using the previous pair, $X = -1375$ and $Y = -2376$, yields a calculation of:

$$I_A = 2745 \text{ A} \angle -120.0^\circ \quad \text{Equation 9.3}$$

Thus, the phasor rotates in a counterclockwise direction in 90-degree increments, as expected, when successive pairs of samples are used for making the calculation.

Sequential Events Recorder (SER) Event Report

Figure 9.8 demonstrates an example SER event report.

```

->SER 2/26/97 2/27/97 <Enter>

```

XFMR 1	Date: 03/13/97	Time: 18:27:42.091
STATION A		

```

FID=SEL-387-R102-V-D970226
#    DATE        TIME        ELEMENT        STATE
4    2/26/97     10:33:54.873  TRIP3      Asserted
3    2/26/97     10:33:55.373  TRIP3      Deasserted
2    2/27/97     10:34:06.872  CLS3       Asserted
1    2/27/97     10:34:07.372  CLS3       Deasserted

```

```

->

```

Figure 9.8 Example SER Event Report

SER Event Report Row Triggering and ALIAS Settings

The relay triggers (generates) a row in the SER event report for any change of state in any one of the elements listed in the SER1, SER2, SER3, or SER4 trigger settings. Use port command **SHO R** to view the settings, or **SET R** to set them. The factory default settings are:

```

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

```

The elements are Relay Word bits from *Table 4.7* to *Table 4.9*. Each element is looked at individually to see if it asserts or deasserts. Any assertion or deassertion of a listed element triggers a row in the SER event report. For example, setting SER1 contains all six of the optoisolated inputs. Any time dc voltage is applied to, or removed from, one of these inputs, a row is triggered in the SER event report.

In the SER settings are 20 settings by which the user can redefine the names of Relay Word bits in the SER report, to make the entries more readily identifiable to the user. The settings are ALIAS1 to ALIAS20. If they are not set, they are listed as, for example, ALIAS1 = NA.

NOTE: Alias names can consist of all printable characters (including spaces).

To rename a Relay Word bit with an **ALIAS_n** setting, use **SET R** to access the settings. For each “**ALIAS_n**=” setting, list the bit name; a separator, which can be one of the following characters: = ; : ' , / \ ? " ; and then the desired name, which can include as many as 15 characters. For example, one setting might be **ALIAS2 = CLS1 BKR1CLOSE**. Instead of **CLS1** being listed in the report, the name **BKR1CLOSE** will appear, indicating that a Breaker 1 close operation was performed.

In addition to the **SER_n** trigger settings, if the relay is newly powered up or a settings change is made, a row is triggered in the SER event report with the message: **Relay newly powered up or settings changed.**

Each entry in the SER includes SER row number, date, time, element name, and element state. Generally, the rows are listed from top to bottom in chronological order, oldest first, to facilitate analyzing the sequence. The newest records have the lowest row numbers, the oldest records the highest row numbers.

Making SER Event Report Trigger Settings

Each SER trigger setting (**SER1**, **SER2**, **SER3**, or **SER4**) can be set with up to 24 elements (Relay Word bits from *Table 4.7* to *Table 4.9*). Thus, up to 96 total elements can be monitored for SER event report row triggering.

The SER settings can be made using spaces or commas as delimiters between elements. For example, if setting **SER1** is made as follows:

SER1 = IN101,IN102 IN103,,IN104 , IN105, , IN106

The relay displays the settings as:

SER1 = IN101,IN102,IN103,IN104,IN105,IN106

Retrieving SER Event Report Rows

The latest 512 rows of the SER event report are stored in nonvolatile memory. Row 1 is the most recently triggered row, and row 512 is the oldest. These lines are accessed with the **SER** command in the following ways shown in *Table 9.9*:

Table 9.9 Different SER Event Report Responses (Sheet 1 of 2)

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.

Table 9.9 Different SER Event Report Responses (Sheet 2 of 2)

Example SER Serial Port Commands	Format
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

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.

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.

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Section 10

Testing and Troubleshooting

Overview

The Testing section should be used for determining and establishing test routines for the SEL-387 Relay. Included are discussions on testing philosophies, methods, and tools. Example test procedures are shown for the overcurrent elements, differential elements, harmonic blocking functions, Restricted Earth Fault protection, and metering. Relay troubleshooting procedures are shown at the end of the section.

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

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

Testing Methods and Tools

Test Features Provided by the Relay

The following features will assist you during relay testing.

Table 10.1 Features to Use to Test the Relay

METER Command	The METER command shows the currents presented to the relay in primary values. Compare these quantities against other devices of known accuracy.
EVENT Command	The relay generates an event report in response to faults or disturbances. Each report contains current information, relay element states, and input/output contact information. If you question the relay response or your test method, use the EVENT command to display detailed information.
TARGET, TARGET F Command	Use the TARGET <i>n</i> command to view the state of relay control inputs, relay outputs, and relay elements individually during a test.
SER Command	Use the Sequential Events Recorder for timing tests by setting the SER trigger settings (SER1, SER2, SER3, or SER4) to trigger for specific elements asserting or deasserting. View the SER with the SER command.
Programmable Outputs	Programmable outputs allow you to isolate individual relay elements. Refer to the SET command.

For more information on these features and commands, see *Section 7: Serial Port Communications and Commands*.

Low-Level Test Interface

The SEL-387 has a low-level test interface between the calibrated input module and the separately calibrated processing module. You can test the relay in either of two ways:

- Conventionally, by applying ac current signals to the relay inputs
- or
- By applying low magnitude ac voltage signals to the low-level test interface.

Access the test interface by removing the relay front panel.

Figure 10.1 shows the low-level interface connections. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

You can test the relay processing module using signals from the SEL RTS Low-Level Relay Test System. Never apply voltage signals greater than 9 V peak-to-peak to the low-level test interface. Figure 10.1 shows the signal scaling factors.

CAUTION

The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel 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} pushbutton, and compare the relay readings to other accurate instruments in the relay input circuits.

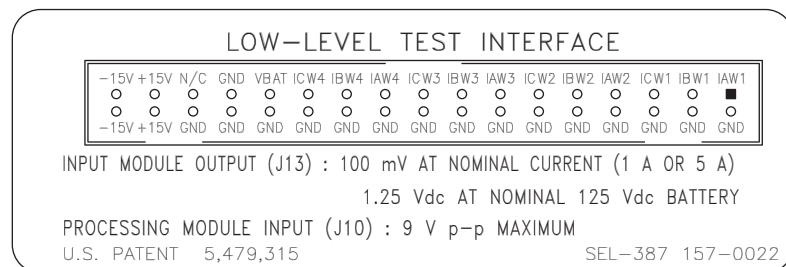


Figure 10.1 Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements using one of three methods:

- Front-panel target LCD/LED indication
- Output contact operation
- Sequential Events Recorder (SER)

Target LED Illumination

During testing, use target LED illumination to determine relay element status. Using the **TAR F** command, set the front-panel targets to display the element under test. Monitor element pickup and dropout by observing the target LEDs.

For example, the Winding 1 phase definite-time overcurrent element 50P11 appears in Relay Word Row 2. When you type the command **TAR F 50P11 <Enter>**, the terminal displays the labels and status for each bit in the Relay

Word row (2) and the LEDs display their status. Thus, with these new targets displayed, if the Winding 1 phase definite-time overcurrent element (50P11) asserts, the far left LED illuminates. See *Section 4: Control Logic* for a list of all Relay Word elements.

Be sure to reset the front-panel targets to the default targets after testing before returning the relay to service. This can be done by pressing the front-panel {TARGET RESET} pushbutton 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.

Goals:

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

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

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

Equipment Required

The following equipment is necessary to perform all of the acceptance tests:

1. A terminal or computer with terminal emulation with EIA-232 serial interface
2. Interconnecting data cable between terminal and relay
3. Source of relay control power
4. Source of two currents at nominal frequency
5. Source of one current at two times and/or five times nominal frequency
6. Ohmmeter or contact opening/closing sensing device

Initial Checkout

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

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

- Step 2. Purpose: Verify requirements for relay logic inputs, control power voltage level, and voltage and current inputs.

Method: Refer to the information sticker on the rear panel of the relay. *Figure 10.2* provides an example. Check the information on this sticker before applying power to the relay or starting tests. Be sure your dc supply is correctly adjusted for the control and logic input requirements.

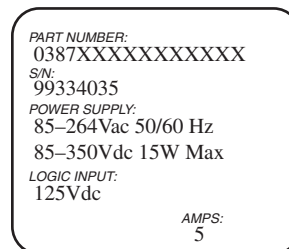


Figure 10.2 Relay Part Number and Hardware Identification Sticker

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 can 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 **SERIAL PORTS 2** and **3**. This voltage is sometimes required by external devices that include a dc-powered modem.

Method:

- a. Execute the **STATUS** command from the serial port or front panel, and inspect the voltage readings for the power supply.
- b. 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.
- c. 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.
- d. 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

NOTE: If you are using a battery simulator, be sure the simulator voltage level is stabilized before turning the relay on.

Step 1. Purpose: Verify the communications interface setup.

Method: Connect a computer terminal to **Ports 2, 3, or 4** of the relay.

Communication Parameters: 2400 Baud, 8 Data Bits, 1 Stop Bit, N Parity

Cables: SEL-C234A for 9-pin male computer connections
SEL-C227A for 25-pin male computer connections

Step 2. Purpose: Apply control voltage to the relay, and start Access Level 0 communications.

Method: Apply control voltage to the relay. The enable target (EN) LED should illuminate. If not, be sure that power is present. Type **<Enter>** from your terminal to get the Access Level 0 response from the relay. The = prompt should appear, indicating that you have established communications at Access Level 0.

The **ALARM** relay should pull in, holding its b contacts open.

If the relays pull in but your terminal does not respond with the equals sign, check the terminal configuration. If neither occurs, turn off the power, and refer to *Relay Troubleshooting on page 10.34*.

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.

Step 3. Purpose: Establish Access Level 1 communications.

Method:

- a. Type **ACC <Enter>**.
- b. At the prompt, enter the Access Level 1 password and press **<Enter>**. (See *PAS (Passwords) on page 7.22* 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>**. The following display should appear on the terminal: (Note: The current input names shown are the default values; any inputs renamed in the Analog Input Labels settings will appear as set.)

Step 5. Purpose: View factory settings entered before shipment.

Method: The relay is shipped with factory settings; type **SHO <Enter>** to view the settings. *Section 6: Setting the Relay* includes a complete description of the settings. The terminal display should look similar to the following:

```
=>SHO <Enter>
Group 1

RID      =XFMR 1
TID      =STATION A
E87W1    = Y      E87W2    = Y      E87W3    = Y      E87W4    = N
EOC1     = Y      EOC2     = Y      EOC3     = Y      EOC4     = N
EOCC     = N      ETHER    = Y      ESLS1    = N      ESLS2    = N
ESLS3    = N

W1CT     = Y      W2CT     = Y      W3CT     = Y      W4CT     = Y
CTR1     = 120    CTR2     = 240    CTR3     = 400    CTR4     = 400
MVA      = 100.0  ICOM     = Y
W1CTC    = 11     W2CTC    = 11     W3CTC    = 0
VWDG1    = 230.00 VWDG2    = 138.00 VWDG3    = 13.80

TAP1     = 2.09   TAP2     = 1.74   TAP3     = 10.46
O87P     = 0.3    SLP1     = 25     SLP2     = 50     IRS1     = 3.0
U87P     = 10.0   PCT2     = 15     PCT5     = 35
TH5P     = OFF    IHBL     = N

E32I     =0

Press RETURN to continue

50P11P    = 20.00  50P11D    = 5.00   50P11TC  =1
50P12P    = OFF    50P14P    = 4.00
50P13P    = 0.50   51P1C     = U2     51P1TD   = 3.00   51P1RS   = Y
51P1P     = 4.00   51P1TC    =1
51P1TD    =1

50Q11P    = OFF    50Q12P    = OFF    51Q1TD   = 3.00   51Q1RS   = Y
51Q1P     = 6.00   51Q1C     = U2
51Q1TC    =1

50N11P    = OFF    50N12P    = OFF
51N1P     = OFF
DATC1     = 15     PDEM1P    = 7.00   QDEM1P   = 1.00   NDEM1P   = 1.00

50P21P    = OFF    50P22P    = OFF
50P23P    = 0.50   50P24P    = 3.50
51P2P     = 3.50   51P2C     = U2     51P2TD   = 3.50   51P2RS   = Y
51P2TC    =1

Press RETURN to continue

50Q21P    = OFF    50Q22P    = OFF    51Q2TD   = 3.50   51Q2RS   = Y
51Q2P     = 5.25   51Q2C     = U2
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    50P34P    = 4.00
50P33P    = 0.50   51P3C     = U2     51P3TD   = 1.30   51P3RS   = Y
51P3P     = 4.00   51P3TC    =1
51P3TD    =1

50Q31P    = OFF    50Q32P    = OFF
51Q3P     = OFF    50N32P    = OFF
50N31P    = OFF
51N3P     = OFF
```

```

Press RETURN to continue
DATC3 = 15      PDEM3P = 7.00      QDEM3P = 1.00      NDEM3P = 1.00

TMWDG = 1      VWDG = 230      XTYPE = 3      TRTYPE = Y
THwr = 65      NCS = 1
MCS11 = 100.0
DTMP = 15      TRDE = 0
NTHM = 2      AMB = THM1      OIL1 = THM2
TOT1 = 100      TOT2 = 100      HST1 = 200      HST2 = 200
FAAL1 = 50.00  FAAL2 = 50.00      RL0LL = 50.00      TL0LL = 50.00
CSEP1 = 15
ILIFE = 180000  EDFTC = Y
TDURD = 9.000  CFD = 60.000

TR1 = 50P11T + 51P1T + 51Q1T + OC1 + LB3
TR2 = 51P2T + 51Q2T + OC2
TR3 = 50P31 + 51P3T + OC3
TR4 = 87R + 87U
TR5 = 0
ULTR1 = 50P13
ULTR2 = 50P23

Press RETURN to continue
ULTR3 = 50P33
ULTR4 = (50P13 + 50P23 + 50P33)
ULTR5 = 0
52A1 = IN101
52A2 = IN102
52A3 = IN103
52A4 = 0
CL1 = CC1 + LB4 + /IN104
CL2 = CC2 + /IN105
CL3 = CC3 + /IN106
CL4 = 0
ULCL1 = TRIP1 + TRIP4
ULCL2 = TRIP2 + TRIP4
ULCL3 = TRIP3 + TRIP4
ULCL4 = 0
ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3
OUT101 = TRIP1
OUT102 = TRIP2
OUT103 = TRIP3
OUT104 = TRIP4

Press RETURN to continue
OUT105 = CLS1
OUT106 = CLS2
OUT107 = CLS3

OUT201 = 0
OUT202 = 0
OUT203 = 0
OUT204 = 0
OUT205 = 0
OUT206 = 0
OUT207 = 0
OUT208 = 0
OUT209 = 0
OUT210 = 0
OUT211 = 0
OUT212 = 0

SCEUSE 47.1
GR1CHK 9FAE

```

Outputs

Step 1. Purpose: Verify that contact outputs operate when you execute the **PULSE** command.

Method:

- Isolate all circuitry connected to the output contacts.
- Set the target LEDs to display the contact outputs by typing **TAR F OUT101 <Enter>**. The front-panel LEDs should now follow Row 41 of the Relay Word where OUT101 is listed.

- c. Execute the **PULSE *n*** command for each output contact.
Verify that the corresponding target LED illuminates and output contact closes for approximately one second. For example, type **PUL OUT101 <Enter>** to test output contact **OUT101**.
- d. Repeat this step for each output. Use the **TARGET F** command to display the appropriate output elements.

Step 2. Purpose: Verify externally connected circuitry is operational.

Method:

- a. Isolate all circuitry connected to the output contacts except the circuit under test.
- b. Set the target LEDs to display the contact outputs by typing **TAR F OUT101 <Enter>**. The bottom row of the front-panel LEDs will follow Row 41 of the Relay Word where OUT101 is listed.
- c. Execute the **PULSE *n*** command for each output contact.
Verify that the corresponding target LED illuminates and output contact closes for approximately one second. For example, type **PUL OUT101 <Enter>** to test output contact **OUT101**.
- d. Repeat this step for each output. Use the **TARGET F** command to display the appropriate output elements.
Verify that the connected circuitry operates as expected.

Inputs

Step 1. Purpose: Verify that logic inputs assert when control voltage is applied across the respective terminal pair.

Method:

- a. 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.
- b. Apply the appropriate control voltage to each input and make sure the corresponding target LED turns on.
- c. Repeat this step for each input. Use the **TARGET F** command to display the appropriate output elements.

Metering

Step 1. Purpose: Connect simulated power system secondary current sources to the relay.

Method:

- a. Turn power off to the relay and connect current sources.
If three current sources are available, connect them to the relay in a full three-phase connection, as shown in *Figure 10.3*. If only two current sources are available, connect the sources as shown in *Figure 10.4* to generate balanced positive-sequence currents:
- b. Connect the A-phase and B-phase current sources to the dotted A and B current input terminals.
- c. Connect both undotted A and B current input terminals to the undotted C current input terminal.

- d. 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:

- a. Turn relay power on, and use the **METER** command to measure the currents applied in *Step 1*.

With applied currents of one ampere per phase and a current transformer ratio of 120:1 (**SHO CTR1** **<Enter>** displays the CT ratios for each winding, **<Ctrl + X>** cancels scrolling), the displayed line currents should be the applied current, 120 amperes $\pm 3\%$, ± 12 amperes.

Step 3. Purpose: Verify phase rotation.

Method:

- a. Verify that residual (IR) and negative-sequence (3I2) quantities are approximately zero.

If IR equals three times the applied current, all three phases have the same angle. If 3I2 equals three times the applied current, the phase rotation is reversed.

- b. Turn the current sources off.

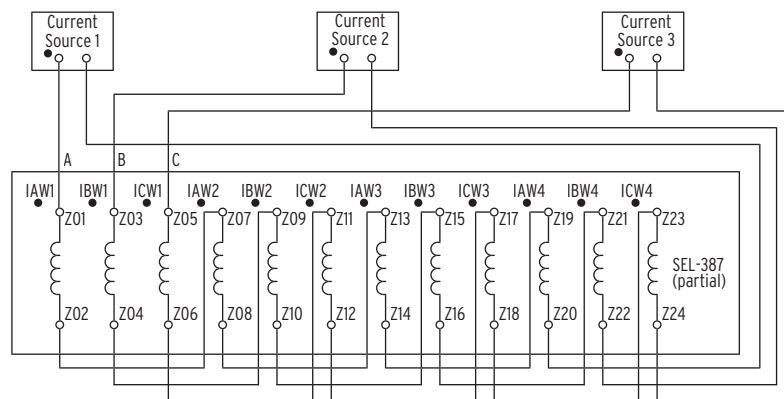


Figure 10.3 Test Connections for Balanced Load With Three Phase-Current Sources

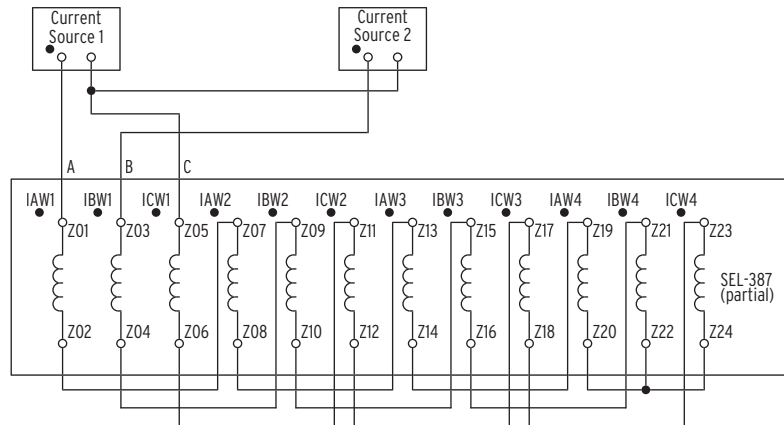


Figure 10.4 Test Connections for Balanced Load With Two Phase-Current Sources

Winding Overcurrent

Each winding overcurrent element that is to be tested must be enabled. Enable the overcurrent elements for a particular winding with the EOC1, EOC2, EOC3, and EOC4 settings for Windings 1, 2, 3, and 4 respectively. By setting these to “Y” the overcurrent elements are enabled for the corresponding winding. The pickup settings for each overcurrent element must also be set to a pickup value. If they are not set to a value but are set to “OFF,” that particular overcurrent element is disabled.

Instantaneous Overcurrent Elements

NOTE: This example tests the Winding 1 50P11 phase overcurrent element. Use the same procedure to test all instantaneous overcurrent elements for each winding.

- Step 1. Purpose: Determine the expected instantaneous overcurrent element pickup value.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO 50P11P <Enter>**).

- Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 50P11 <Enter>**). The SEL-387 now displays the state of several Winding 1 overcurrent elements on the bottom row of front-panel LEDs.

- Step 3. Purpose: Connect and apply a single current test source until the appropriate LED illuminates.

Method:

- Connect a single current test source (i.e., source 1) as shown in *Figure 10.5*.
- Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the appropriate element asserts (i.e., 50P11), causing the LED to illuminate (i.e., left-most). Note the magnitude of the current applied. It should equal the 50P1P setting $\pm 5\%$ of the setting $\pm 0.02 I_{NOM}$ (negative-sequence elements are $\pm 6\%$ of the setting $\pm 0.02 I_{NOM}$).

Step 4. Purpose: Repeat test for each instantaneous overcurrent element for each winding.

Method:

- Repeat *Step 1* through *Step 3* for each instantaneous overcurrent element listed in *Table 10.1* for each winding.
- Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the **TAR F** command is issued.

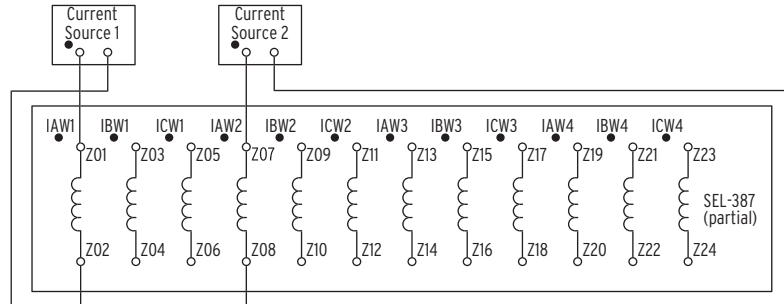


Figure 10.5 Test Connections for Two Single Current Test Sources

Table 10.2 Instantaneous Overcurrent Elements and Corresponding Settings

	Winding 1		Winding 2		Winding 3		Winding 4	
	Bit	Setting	Bit	Setting	Bit	Setting	Bit	Setting
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P	50P41	50P41P
Phase Level 2	50P12	50P12P	50P22	50P22P	50P32	50P32P	50P42	50P42P
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P	51P4	51P4P
A-Phase Level 3	50A13	50P13P	50A23	50P23P	50A33	50P33P	50A43	50P43P
B-Phase Level 3	50B13		50B23		50B33		50B43	
C-Phase Level 3	50C13		50C23		50C33		50C43	
Phase Level 3	50P13		50P23		50P33		50P43	
A-Phase Level 4	50A14	50P14P	50A24	50P24P	50A34	50P34P	50A44	50P44P
B-Phase Level 4	50B14		50B24		50B34		50B44	
C-Phase Level 4	50C14		50C24		50C34		50C44	
Phase Level 4	50P14		50P24		50P34		50P44	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P	50N41	50N41P
Residual Level 2	50N12	50N12P	50N22	50N22P	50N32	50N32P	50N42	50N42P
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P	51N4	51N4P
Neg-Seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P	50Q41	50Q41P
Neg-Seq Level 2	50Q12	50Q12P	50Q22	50Q22P	50Q32	50Q32P	50Q42	50Q42P
Neg-Seq Inverse-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P	51Q4	51Q4P

Definite-Time and Inverse-Time Overcurrent Elements

NOTE: This example tests the Winding 1 51P1 phase inverse-time overcurrent element. Use the same procedure to test all definite-time and inverse-time overcurrent elements for each winding.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

Method:

- Execute the **SHO** command via the relay front panel or serial port and verify the time delay settings (i.e., **SHO 51P1 <Enter>**). The delay settings will follow the pickup settings when they are displayed.
- Calculate the time delay to pick up (tp).

Definite-time elements will be equal to the delay setting (i.e., 50P11D setting for the 50P11 element). Inverse-time elements are calculated using three element settings and the operating time equations shown in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements*. TD is the time-dial setting (i.e., 51P1TD), and M is the applied multiple of pickup current.

For example, if 51P1P = 2.2 A, 51P1C = U3, and 51P1TD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M • 51P1P = 6.6 A):

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

$$tp = 2.33 \text{ seconds}$$

Equation 10.1

Step 2. Purpose: Set the Sequential Events Recorder to record the element timing.

Method:

- Use **SET R SER1 <Enter>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 51P1, 51P1T).
- When prompted, set SER2, SER3, and SER4 to NA. Save the settings.

Step 3. Purpose: Connect and apply a single current test source at a level that is M times greater than the pickup (i.e., $2.2 \cdot M = 6.6$ A for this example).

Method:

- Connect a single current test source as shown in *Figure 10.5*.
- Turn on the single current test source for the winding under test at the desired level.

Step 4. Purpose: Verify the operation times.

Method:

- Type **SER <Enter>** to view the SER. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings are recorded.
- Subtract the time from the assertion of the pickup (i.e., 51P1) to the assertion of the time-delayed element (i.e., 51P1T). **SER C** clears the SER records.

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.

Step 5. Purpose: Repeat the test for each definite-time and inverse-time overcurrent element, for each winding.

Method:

- Repeat *Step 1* through *Step 4* for each time element listed in *Table 10.3* for each winding.
- Remember to set the SER for the appropriate elements and apply current to the appropriate winding.

Table 10.3 Time-Delayed Overcurrent Elements and Corresponding Settings

	Winding 1		Winding 2		Winding 3		Winding 4	
	Bit	Setting	Bit	Setting	Bit	Setting	Bit	Setting
Phase Level 1	50P11	50P11P	50P21	50P21P	50P31	50P31P	50P41	50P41P
Definite-Time	50P11T	50P11D	50P21T	50P21D	50P31T	50P31D	50P41T	50P41D
Phase Inverse-Time	51P1	51P1P	51P2	51P2P	51P3	51P3P	51P4	51P4P
Curve		51P1C		51P2C		51P3C		51P4C
Time-Dial		51P1TD		51P2TD		51P3TD		51P4TD
Time-Out	51P1T		51P2T		51P3T		51P4T	
Residual Level 1	50N11	50N11P	50N21	50N21P	50N31	50N31P	50N41	50N41P
Definite-Time	50N11T	50N11D	50N21T	50N21D	50N31T	50N31D	50N41T	50N41D
Residual Inverse-Time	51N1	51N1P	51N2	51N2P	51N3	51N3P	51N4	51N4P
Curve		51N1C		51N2C		51N3C		51N4C
Time-Dial		51N1TD		51N2TD		51N3TD		51N4TD
Time-Out	51N1T		51N2T		51N3T		51N4T	
Neg-Seq Level 1	50Q11	50Q11P	50Q21	50Q21P	50Q31	50Q31P	50Q41	50Q41P
Definite-Time	50Q11T	50Q11D	50Q21T	50Q21D	50Q31T	50Q31D	50Q41T	50Q41D
Neg-Seq Inv-Time	51Q1	51Q1P	51Q2	51Q2P	51Q3	51Q3P	51Q4	51Q4P
Curve		51Q1C		51Q2C		51Q3C		51Q4C
Time-Dial		51Q1TD		51Q2TD		51Q3TD		51Q4TD
Time-Out	51Q1T		51Q2T		51Q3T		51Q4T	

Phase Overcurrent Elements

The SEL-387 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 previously outlined in this section.

Negative-Sequence Overcurrent Elements

The SEL-387 has 12 negative-sequence overcurrent elements. They all operate based on a comparison between a negative-sequence calculation of the three-phase inputs and the negative-sequence overcurrent setting. The negative-sequence calculation that is performed on the three-phase inputs is as follows:

$$3I_2 = \text{A-phase} + \text{B-phase (shifted by } -120^\circ) + \text{C-phase (shifted by } 120^\circ)$$

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $3I_2 = 0$ (load conditions).

For testing purposes, apply a single-phase current to the relay and the negative-sequence overcurrent elements will operate. For example, assume one ampere on A-phase and zero on B- and C-phases:

$$3I_2 = 1 + 0 \text{ (shifted } -120^\circ) + 0 \text{ (shifted } 120^\circ) = 1 \text{ (simulated ground fault condition)}$$

Test the instantaneous and time-delayed negative-sequence overcurrent elements by applying current to the inputs and comparing relay operation to the negative-sequence overcurrent settings. These tests were previously outlined in this section.

Residual Overcurrent Elements

The SEL-387 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:

$$IR = \text{A-phase} + \text{B-phase} + \text{C-phase (all angles are considered as well)}$$

This means that if balanced positive-sequence currents are applied to the relay, the relay reads $IR = 0$ (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:

$$IR = 1 + 0 \text{ (shifted } 120^\circ) + 0 \text{ (shifted } -120^\circ) = 1 \text{ (simulated ground fault condition)}$$

Test the instantaneous and time-delayed residual overcurrent elements by applying current to the inputs and comparing relay operation to the residual overcurrent settings. These tests were previously outlined in this section.

Torque Control

SELOGIC® control equations are provided for various overcurrent elements (i.e., 51P1TC) that provide a torque control (required to be true for element operation). Follow the following procedure to test the torque-control equations.

- Step 1. Purpose: Set the torque-control equation for the desired condition.

Method:

- a. 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.
- b. Enter **SET 51P1TC <Enter>**.
- c. When prompted, set 51P1TC to IN101. Note that the 51P1TC can be set to 1 (always asserted) or 0 (always deasserted) for testing instead of asserting an input.

- Step 2. Purpose: Assert the torque-control equation.

Method: Apply the appropriate conditions to assert the torque-control equation. For this test example, apply control voltage to IN101.

- Step 3. Purpose: Display the appropriate Relay Word bit to verify the torque-control equation.

Method: Execute the **TARGET** command (i.e., **TAR F IN101 <Enter>**). The SEL-387 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.

- Step 5. Method: Execute the **TARGET** command (i.e., **TAR F 51P1 <Enter>**). The SEL-387 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 6. 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 7. Purpose: Verify that the torque-control equation disables the overcurrent element when deasserted.

Method:

- a. Remove the torque-control conditions to deassert the torque-control equation.
- b. For this test example, remove control voltage from IN101. Re-execute the same overcurrent test and verify that it does not operate.

Combined Overcurrent Elements

The SEL-387 has two sets of combined overcurrent elements. Set EOCC = Y to enable them. One set uses the sum of currents from Windings 1 and 2, the other the sum of currents from Windings 3 and 4. Each set has a phase overcurrent and a residual overcurrent element, both of which are inverse-time elements using the same curves as the similar Winding 51 elements. The first set, for Windings 1 and 2, consists of units 51PC1 and 51NC1; the other set, for Windings 3 and 4, has units 51PC2 and 51NC2.

The test for the combined overcurrent elements is intended to simulate the application for these elements, namely a ring-bus or breaker-and-a-half scheme where two sets of CT inputs from two breakers are brought to the relay. These two inputs are for the same physical winding, whose current is the phasor sum of the two inputs.

The test configuration is that shown in *Figure 10.5*, with two sources delivering current to the same phase of Windings 1 and 2, or Windings 3 and 4.

The following test 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 **SHO** command via the relay front panel or serial port and verify the element settings (i.e., **SHO 51PC1P <Enter>**). The pickup is 51PC1P, the curve type is 51PC1C, and the time dial is 51PC1TD.
- Calculate the time delay to pick up (tp). Inverse-time elements are calculated using three element settings and the operating time equations shown in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements*. TD is the time-dial setting (i.e., 51PC1TD), and M is the applied multiple of pickup current.

For example, if 51PC1P = 2.2 A, 51PC1C = U3, and 51PC1TD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M • 51PC1P = 6.6 A):

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

$$tp = 2.33 \text{ seconds}$$

Equation 10.2

- Step 2. Purpose: Set the Sequential Events Recorder to record the element timing.

Method:

- Use **SET R SER1 <Enter>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 51PC1, 51PC1T).
- When prompted, set SER2, SER3, and SER4 to NA.
- Save the settings.

Step 3. (For $CTR1 < CTR2$).

Purpose: Connect and apply two single current test sources to create sufficient current to operate the 51PC1 element.

Method:

- a. Connect two single current test sources as shown in *Figure 10.5*.
- b. Set the **IAW2** current at some fixed value, such as 10 A at angle zero degrees.
- c. Set the **IAW1** current to a value equal to $IAW2 \cdot CTR2 / CTR1$ at 180 degrees. Since the phasor sum is zero, nothing will happen.
- d. 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 illuminated, representing bit 51PC1R (reset).
- e. Slowly reduce **IAW1** until the unit picks up, indicated by **LED A**. This should happen when **IAW1** equals $CTR2 / CTR1 \cdot (IAW2 - 51PC1P)$.
- f. After verifying pickup, increase **IAW1** back to $IAW2 \cdot CTR2 / CTR1$. **LED A** will extinguish.
- g. Wait for **LED C** to reappear, indicating reset. Or, issue command **RES** to force a reset.
- h. Suddenly reduce the current **IAW1** to a value equal to $CTR2 / CTR1 \cdot (IAW2 - M \cdot 51PC1P)$, where M is the desired multiple of pickup.
- i. Allow the unit to proceed to time-out, indicated by the lighting of **LED B**.
(**LED A** will also be illuminated.)

Step 4. (For $CTR2 < CTR1$).

Purpose: Connect and apply two single current test sources to create sufficient current to operate the 51PC1 element.

Method:

- a. Connect two single current test sources as shown in *Figure 10.5*.
- b. Set the **IAW1** current at some fixed value, such as 10 A at angle zero degrees.
- c. Set the **IAW2** current to a value equal to $IAW1 \cdot CTR1 / CTR2$ at 180 degrees. Since the phasor sum is zero, nothing will happen.
- d. 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 illuminated, representing bit 51PC1R (reset).
- e. Slowly reduce **IAW2** until the unit picks up, indicated by **LED A**. This should happen when **IAW2** equals $CTR1 / CTR2 \cdot (IAW1 - 51PC1P)$.
- f. After verifying pickup, increase **IAW2** back to $IAW1 \cdot CTR1 / CTR2$. **LED A** will extinguish.

- g. Wait for **LED C** to reappear, indicating reset. Or, issue command **RES** to force a reset.
- h. Suddenly reduce the current **IAW2** to a value equal to $CTR1/CTR2 \cdot (IAW1 - M \cdot 51PC1P)$, where M is the desired multiple of pickup.
- i. Allow the unit to proceed to time-out, indicated by the lighting of **LED B**.
(**LED A** will also be illuminated.)

Step 5. Purpose: Verify the operation time.

Method:

- a. Type **SER <Enter>** to view the SER records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings are recorded.
- b. Subtract the time of the assertion of the pickup (i.e., 51PC1) from the assertion time of the time-out bit (i.e., 51PC1T). This is the operate time. **SER C** clears the SER records.

Step 6. Purpose: Repeat the test for 51NC1, 51PC2, and 51NC2.

Method:

- a. Repeat *Step 1* through *Step 4* for the other elements.
- b. Remember to set the SER for the appropriate elements and apply current to the appropriate windings.
- c. 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 the following:

Set:

E32I = **1** E32I = Enabling SELOGIC control equations
32IOP = **1** 32IOP = Winding(s) for obtaining the Operate quantity

Use default setting:

a0 = **0.1** a0 = Positive-sequence restraint factor
50GP = **0.5 A** 50GP = Residual current sensitivity level

Recall that the default CT ratio settings are: CTR1 = 120, and CTR4 = 400.

NOTE: To use the setting 50GP = 0.5, be sure that the ratio CTRmax/CTR4 is not more than 2.0, where CTRmax is the greater of CTR1 or CTR4. Using the default CT ratio settings, CTRmax = CTR4, so the ratio CTRmax/CTR4 = 1. Therefore, the 50GP setting can remain at 0.5 A.

If the ratio CTRmax/CTR4 is greater than 2.0, set 50GP equal to 0.25 A times the actual ratio of CTRmax/CTR4.

Step 1. Purpose: Determine the expected time delay for the overcurrent element.

Method:

- a. Execute the **SHO** command via the relay front panel or serial port and verify the element settings (i.e., **SHO E32I <Enter>**).
- b. Calculate the time delay to pick up (tp). Inverse-time elements are calculated using three element settings and the operating time equations shown in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements*. TD is the time-dial setting, and M is the applied multiple of pickup current.

For example, 50GP = 0.5 A. The REF curve is type U4, extremely inverse. The time dial is fixed at 0.5. Only the IRW4 current is used for the time curve calculation. Setting IRW4 at 1 A represents a multiple of pickup of M = 2.0. We can use the equation below to calculate the expected operating time for curve U4 at M = 2, TD = 0.5:

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

$$tp = 0.963 \text{ seconds} \quad \text{Equation 10.3}$$

Step 2. Purpose: Set the Sequential Events Recorder to record the element timing.

Method:

- a. Use **SET R SER1 <Enter>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 50G4, 32IF, and REFP).
- b. When prompted, set SER2, SER3, and SER4 to NA.
- c. Save the settings.

Step 3. Purpose: Connect and apply two single current test sources to test the REF element.

Method:

- a. Connect two single current test sources as shown in *Figure 10.5*, but with source current 2 connected to one of the Winding 4 inputs (e.g., **IAW4**).
- b. Set the **IAW1** current magnitude to:
$$IAW1 \geq 2 \cdot 50GP \cdot CTR4/CTR1$$
- c. Using the default CT ratios, **IAW1** should be set to at least $2 \cdot 0.5 \text{ A} \cdot 400/120$, or 3.33 A.
- d. Set the magnitude of **IAW1** to 4 A; set the angle of **IAW1** to 180 degrees.
- e. Set the **IAW4** current at 1 A at zero degrees. Since the currents are opposite in phase, nothing should happen.

Verify this as follows:

- f. Execute the **TAR 21** command. Relay Word bits 50G4, 32IR, 32IF, and REFP are all in this row. With the currents applied as above, 50G4 should be 1, and REFP should remain at 0. Bit 32IR should be 1, indicating an external (reverse) fault. Bit 32IF should be 0.
- g. Change the angle of **IAW1** to zero degrees, or any value within about ± 80 degrees of **IAW4**. The REF element should function.
Verify this as follows:
- h. Execute the **TAR 21** command again. 50G4 should still be 1, REFP should be 1 (indicating time-out), 32IR should be 0, and 32IF should be 1 (indicating an internal, or forward, fault).

Step 4. Purpose: Verify the operation time.

Method:

- a. Type **SER <Enter>** to view the SER records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings are recorded.
- b. Subtract the time of assertion of the directional element (32IF) from the assertion time of the time-out bit (REFP). This is the operate time, which should be about one second, as calculated above. (50G4 will have remained asserted from earlier in the test, since no change was made to the **IAW4** current.) **SER C** clears the SER records.

Step 5. Purpose: Verify relay operation for faults with high neutral current but a small difference in phase current.

Method:

- a. Clear the SER by typing **SER C <Enter>**.
- b. Connect a single current source to phase **IAW4**.
- c. Set both current magnitude and phase angle to zero.
- d. Change the 32IOP setting to 12.
- e. Type **TAR 32IE 9999** and confirm that the status of the 32IE Relay Word bit is logical 0.
- f. Inject 0.7 A in phase **IAW4** and confirm that Relay Word bit 32IE asserts to logical 1.
- g. Type **TAR 50GC 10** and verify that Relay Word bit 50GC is logical 0.
- h. Stop the injection and use the **SER** command to confirm the assertion of Relay Word bit 32IF in approximately 1.5 cycles after the assertion of Relay Word bit 32IE.
- i. Repeat the test injecting first in phase **IBW4** and then in phase **ICW4**.

Differential

The SEL-387 has several components to its differential element. *Figure 10.6* gives a representation of the differential characteristic and the plot of each test. Each test only uses Winding 1 and Winding 2 inputs. Any combination of two winding inputs may be used for the test. The differential elements for each

winding must be enabled for each winding under test with the E87W1, E87W2, E87W3, and E87W4 settings. Set each setting equal to “Y” to enable the corresponding differential element.

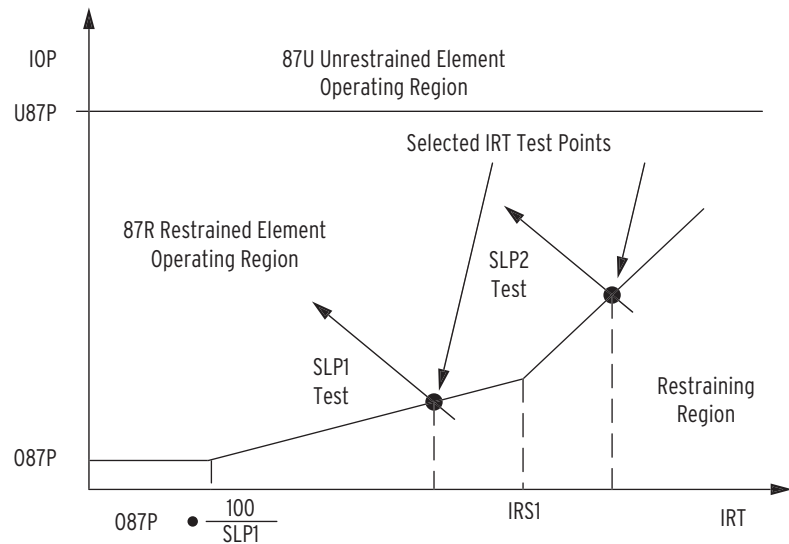


Figure 10.6 Percentage Restraint Differential Characteristic

U87P Unrestrained Differential Element

Step 1. Purpose: Verify the expected unrestrained differential element pickup setting.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO U87P <Enter>**). This value is in per unit of tap.

Step 2. Purpose: Calculate the required current to pick up the unrestrained differential element.

Method:

- a. Calculate the expected pickup for the 87U element by multiplying the U87P setting by the TAP1, TAP2, TAP3, or TAP4 setting and the compensation constant A shown in *Table 10.4*. The CT connection compensation settings W1CTC, W2CTC, W3CTC, and W4CTC determine the A constant for the calculations.
- b. 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 87U <Enter>**). The SEL-387 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.

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 to limit the required test current to a safe value.

Step 4. Purpose: Connect and ramp a single current test source until the appropriate LED illuminates.

Method:

- a. Connect a single current test source as shown in *Figure 10.5*.
- b. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87U element asserts. Note the magnitude of the current applied. It should equal the value calculated in *Step 2*, $\pm 5\% \pm 0.02 I_{\text{NOM}}$.

Step 5. Purpose: Repeat the test for each phase for each winding if desired.

Method:

- a. Repeat *Step 1* through *Step 4* for each phase.
- b. 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 10.4 Connection Compensation Factor

WnCTC Setting	A and B Constants
0	1
Odd: 1, 3, 5, 7, 9, 11	$\sqrt{3}$
Even: 6, 12	1.5
Even: 2, 4, 8, 10	3.0

087P Differential Element Pickup

Step 1. Purpose: Verify the expected restrained differential element minimum pickup setting.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO 087P <Enter>**). This value is in per unit of tap.

Step 2. Purpose: Calculate the required current to pick up the restrained differential element.

Method:

- a. Calculate the expected pickup for the 87R element by multiplying the 087P setting by the TAP1, TAP2, TAP3, or TAP4 setting and the compensation constant A shown in *Table 10.4*. The CT connection compensation settings W1CTC, W2CTC, W3CTC, and W4CTC determine the A constant for the calculations.
- b. Use the corresponding TAP n and W n CTC settings for the winding under test.

Step 3. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 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:

- a. Connect a single current test source as shown in *Figure 10.5*.
- b. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in *Step 2*, $\pm 5\% \pm 0.02 I_{\text{NOM}}$.

Step 5. Purpose: Repeat the test for each phase for each winding if desired.

Method:

- a. Repeat *Step 1* through *Step 4* for each phase.
- b. 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:

- a. Execute the **SHO TAP1 <Enter>** command via the relay front panel or serial port and verify the (TAP n) 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.
- b. Execute the **SET W1CTC <Enter>** command and set the W n CTC settings for the two windings to be used to the same value (0, 1, ..., 12).
- c. Save the settings.

Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

Step 3. Purpose: Select a test point on the percentage differential curve in *Figure 10.6*.

Method:

- a. Decide where you want to cross the differential characteristic by picking a restraint value IRT that is a vertical line on the graph.
- b. Since this test is for the SLP1 threshold, select a point above the O87P intersection point and below IRS1. If SLP2 = OFF, IRS1 and SLP2 are not functional.
$$O87P \cdot 100 / SLP1 < IRT < IRS1$$

The value of IOP corresponding to the selected IRT equals the following:

$$IOP = \frac{SLP1}{100} \cdot IRT \quad \text{Equation 10.4}$$

Both IRT and IOP are in multiples of tap.

- Step 4. Purpose: Calculate the expected current for Winding 1 and Winding 2 at the restrained differential element SLP1 threshold for the test point selected above.

Method:

- a. Calculate the Winding 1 current for the test using the following formula:

$$IAW1 = IRT \cdot \left(1 + \frac{SLP1}{200}\right) \cdot TAP1 \cdot A \quad \text{Equation 10.5}$$

- b. Calculate the Winding 2 current for the test using the following formula:

$$IAW2 = IRT \cdot \left(1 - \frac{SLP1}{200}\right) \cdot TAP2 \cdot B \quad \text{Equation 10.6}$$

The A and B connection compensation constants are based on *Table 10.4*. Since the windings have the same *WnCTC* setting, the A and B constants will be the same for both windings. The constants 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.

- Step 5. Purpose: Calculate the initial current for Winding 2 for this test.

Method: Calculate the Winding 2 initial current for the test using the following formula:

$$IAW2 = IAW1 \cdot \frac{TAP2}{TAP1} \cdot \left(\frac{B}{A}\right) \quad \text{Equation 10.7}$$

This formula determines the current necessary for IOP = 0 given the *IAW1* calculated above.

- Step 6. Purpose: Connect a single current test source to A-phase of Winding 1 and a single current test source to A-phase of Winding 2. Ramp down Winding 2 current until the appropriate LED illuminates.

Method:

- Connect the two current test sources as shown in *Figure 10.5*.
- Turn on the current test source for A-phase of Winding 1 (*IAW1*) at the value calculated above, **and set the phase angle at zero degrees.**
- Turn on the current test source for A-phase of Winding 2 (*IAW2*) at the calculated initial current **and set the phase angle at 180 degrees.**

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.

- d. Slowly decrease the magnitude of IAW2 until the 87R1 element asserts.
- e. Use 87R2 when injecting current into B-phase and 87R3 when testing C-phase. Note the magnitude of the current applied. It should equal the value calculated in step 4 $\pm 5\% \pm 0.02 I_{\text{NOM}}$.

Step 7. Purpose: Repeat the test for each phase for each winding if desired.

Method:

- a. Repeat *Step 1* through *Step 6* for each phase.
- b. 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.

IRS1 must be greater than:

$$\frac{100}{\text{SLP1}} \cdot 087\text{P} \quad \text{Equation 10.8}$$

if SLP2 is not set to OFF.

SLP2 Restrained Differential Threshold

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 1. Purpose: Verify the differential characteristic settings and set winding compensation.

Method:

- a. Execute the **SHO TAP1 <Enter>** command via the relay front panel or serial port and verify the (TAP n) settings, the Restraint Slope 1 Percentage (SLP1) setting, the Restraint Slope 2 Percentage (SLP2) setting, and the restraint current slope 1 limit (IRS1) setting.
- b. Execute the **SET W1CTC <Enter>** command and set the WnCTC settings for the two windings to be used to the same value.
- c. Save the settings.

Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

Step 3. Purpose: Select a test point on the percentage differential curve in *Figure 10.6*.

Method: Decide where you want to cross the differential characteristic by picking a restraint value IRT that 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:

$$IOP = \frac{SLP2}{100} \cdot IRT + IRS1 \cdot \left(\frac{SLP1 - SLP2}{100} \right) \quad \text{Equation 10.9}$$

Both IRT and IOP are in multiples of tap.

- Step 4. Purpose: Calculate the expected current for Winding 1 and Winding 2 at the restrained differential element SLP2 threshold for the test point selected above.

Method: Calculate the Winding 1 current for the test using the following formula:

$$IAW1 = \left(IRT \cdot \left(1 + \frac{SLP2}{200} \right) + RS1 \cdot \left(\frac{SLP1 - SLP2}{200} \right) \right) \cdot TAP1 \cdot A \quad \text{Equation 10.10}$$

⚠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.

Calculate the Winding 2 current for the test using the following formula:

$$IAW2 = \left(IRT \cdot \left(1 - \frac{SLP2}{200} \right) - IRS1 \cdot \left(\frac{SLP1 - SLP2}{200} \right) \right) \cdot TAP2 \cdot A \quad \text{Equation 10.11}$$

The A connection compensation constant is based on *Table 10.4*. Since the windings have the same WnCTC setting, the A constant will be the same for both windings. The A constant must be used to achieve the exact curve point on which we have based the calculations. The TAPn settings can be different for the two windings.

- Step 5. Purpose: Calculate the initial current for Winding 2 for this test.

Method: Calculate the Winding 2 initial current by multiplying the Winding 2 expected current calculated above by 110 percent.

$$IAW2 \text{ (initial)} = 1.1 \cdot IAW2 \text{ (from step 4)}$$

- Step 6. Purpose: Connect a single current test source to A-phase of Winding 1 and a single current test source to A-phase of Winding 2. Ramp down Winding 2 current until the appropriate LED illuminates.

Method:

- Connect the two current test sources as shown in *Figure 10.5*.
- Turn on the current test source for A-phase of Winding 1 (IAW1) at the value calculated above **and set the phase angle to zero degrees**.
- Turn on the current test source for A-phase of Winding 2 (IAW2) at the calculated starting current **and set the phase angle at 180 degrees**.
- Slowly decrease the magnitude of current IAW2 until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in *Step 4* $\pm 5\% \pm 0.02 I_{NOM}$.

Step 7. Purpose: Repeat the test for each phase for each winding combination if desired.

Method:

- a. Repeat *Step 1* through *Step 6* for each phase.
- b. 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:

- a. 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 and that $HRSTR = N$.
- b. Enter **SHO PCT2 <Enter>**.

Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 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:

- a. Connect a current source to the **IAW1** input.
- b. Connect a second current source in parallel with the first source to the **IAW1** input as shown in *Figure 10.7*.

Step 4. Purpose: Apply fundamental current to pick up the 87R element.

Method: Turn on the first current test source connected to the Winding 1 input (**IAW1**) equal to the TAP1 setting multiplied by the connection constant A shown in *Table 10.4*. The **87R** LED will illuminate once current is applied to the relay.

Step 5. Purpose: Apply and ramp second-harmonic current to drop out the 87R element.

Method:

- a. Turn on the second current source for second-harmonic current (120 Hz for NFREQ = 60 and 100 Hz for NFREQ = 50).
- b. Starting at zero current, slowly increase the magnitude of this second current source until the 87R element deasserts, causing the 87R LED to completely extinguish. Note the value of the applied current from the second test source. The current from the second-

harmonic source should equal the PCT2 setting divided by 100, multiplied by the magnitude of the fundamental current source, $\pm 5\%$ and $\pm 0.02 I_{NOM}$.

$IAW1$ (second harmonic) = $PCT2/100 \cdot IAW1$
(fundamental), $\pm 5\% \pm 0.02 I_{NOM}$

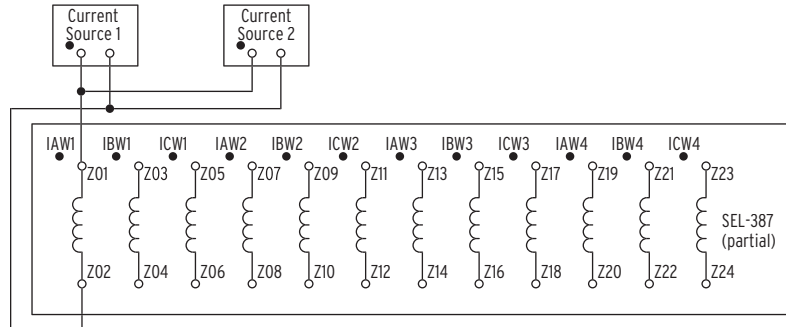


Figure 10.7 Test Connections for Parallel Current Sources

Fifth-Harmonic Blocking

Step 1. Purpose: Verify the fifth-harmonic restraint percentage.

Method:

- Execute the **SHOW** command via the relay front panel or serial port and verify the percentage of fundamental current that the magnitude of fifth-harmonic current must exceed for differential restraint.
- Enter **SHO PCT5 <Enter>**.

Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 now displays the state of several differential elements in the second row of the front-panel LEDs. The 87R bit is the right-most LED.

Step 3. Purpose: Connect two current test sources to one phase of one winding input.

Method:

- Connect a current source to the **IAW1** input.
- Connect a second current source in parallel with the first source to the **IAW1** input as shown in *Figure 10.7*.

Step 4. Purpose: Apply fundamental current to pick up the 87R element.

Method: Turn on the first current test source connected to the Winding 1 input (**IAW1**) equal to the TAP1 setting multiplied by the connection constant A shown in *Table 10.4*. The **87R** LED will illuminate once current is applied to the relay.

NOTE: This test requires a current source capable of generating fifth-harmonic current. This example tests the fifth-harmonic blocking function.

- Step 5. Purpose: Apply and ramp fifth-harmonic current to drop out the 87R element.

Method:

- a. Turn on the second current source for fifth-harmonic current (300 Hz for NFREQ = 60 and 250 Hz for NFREQ = 50).
- b. Starting at zero current, slowly increase the magnitude of this second current source until the 87R element deasserts, causing the 87R LED to completely extinguish. Note the value of the applied current from the second test source. The current from the fifth-harmonic source should equal the PCT5 setting divided by 100, multiplied by the magnitude of the fundamental current source, $\pm 5\%$ and $\pm 0.02 I_{\text{NOM}}$.

$$\text{IAW1 (fifth harmonic)} = \text{PCT5}/100 \cdot \text{IAW1 (fundamental)}, \pm 5\% \pm 0.02 I_{\text{NOM}}$$

Harmonic Restraint (All But SEL-387-0 Relay)

- Step 1. Purpose: Verify the second-harmonic restraint percentage.

Method:

- a. 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.
- b. Enter **SHO PCT2 <Enter>**.

- Step 2. Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R <Enter>**). The SEL-387 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:

- a. Connect a current source to the **IAW1** input.
- b. Connect a second current source in parallel with the first source to the **IAW1** input as shown in *Figure 10.7*.

- Step 4. Purpose: Apply fundamental current to pick up the 87R element.

Method: Turn on the first current test source connected to the Winding 1 input (**IAW1**) equal to the TAP1 setting multiplied by the connection constant A shown in *Table 10.2*. The **87R** LED will illuminate once current is applied to the relay.

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 in a similar way.

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: ($\pm 5\% \pm 0.10$ A (5 A relay) or $\pm 5\% \pm 0.02$ A (1 A relay)):

$$I1F2 = [IOP1 - IRT1 \cdot f(SLP)] \cdot \frac{PCT}{100} \quad \text{Equation 10.12}$$

where f(SLP) is the value of the slope for the chosen value of IRT1

and

$$\% \text{ harmonic} = \frac{I1F2}{IOP1} \cdot 100 \text{ percent} \quad \text{Equation 10.13}$$

For inrush conditions, current normally is applied to one side of the transformer, and the equation simplifies to the following:

$$\% \text{ harmonic} = PCT2 \cdot \left(1 - \frac{SLP1}{200}\right) \quad \text{Equation 10.14}$$

where

PCT2 = second-harmonic setting in percent

SLP1 = slope 1 setting

For example

SLP1 = 50 percent

PCT2 = 20 percent

$$\% \text{ harmonic} = 20 \cdot \left(1 - \frac{50}{200}\right) = 15 \text{ percent} \quad \text{Equation 10.15}$$

For values on the second slope, use the following equation:

$$\% \text{ harmonic} = \left(\frac{PCT2}{200}\right) \cdot \left(200 - \left(SLP2 - \frac{IRS1}{IRT}\right)(SLP1 - SLP2)\right) \quad \text{Equation 10.16}$$

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

NOTE: The second and fourth harmonics are combined to form the restraint quantity.

For example:

Slope 1 = 25 percent

Slope 2 = 60 percent

PCT2 = 20 percent

IRS1 = 3, and choose IRT = 6

$$\% \text{ harmonic} = \left(\frac{20}{200} \right) \cdot \left(200 - 60 - \frac{3}{6}(25 - 60) \right) = 15.75 \text{ percent}$$

Equation 10.17

Time-Code Input (IRIG-B)

Step 1. Purpose: Verify operation of the IRIG-B clock input for **SERIAL PORT 2** and the connector of **SERIAL PORT 1**.

Method:

- a. 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.
- b. Adjust the source to obtain an “ON” current of about 10 mA.
- c. Execute the **IRIG** command.
- d. Make sure the relay clock displays the correct date and time.
- e. Optional. Connect the demodulated IRIG-B time code to the relay as in *Step a*, but through the **SERIAL PORT 1** connector (pins 7 and 8).

Thermal Element

The SEL-387 thermal element provides information on power transformer insulation aging at present loading and temperatures. Ambient temperature is either measured or fixed via a setting. Top-oil temperatures are either calculated from the applied current or measured. All measured temperatures are obtained via a serial port using a specific data format. Measured temperatures are not used in the following test.

Certain thermal element outputs are calculated once per minute. Other outputs are calculated once per hour (on the hour) or once per day (at midnight). To limit the elapsed test time to one hour, only the outputs that are calculated once per minute are tested.

Step 1. Start with all settings at the default values, verify or change to the values listed below:

Setting	Value	Setting	Value
CTR1 =	1000/IN	VWDG1 =	100
W1CT =	Y		
ETHER =	Y		
TMWDG =	1	VWDG =	100
XTYPE =	3	TRTYPE =	Y
THwr =	65	NCS =	1
MCS11 =	100	DTMP =	40
TRDE =	IN101	NTHM =	0
TOT1 =	50	TOT2 =	51
HST1 =	130	HST2 =	135
FAAL1 =	15	FAAL2 =	20
EDFTC =	Y		

- a. Configure an external contact wired to **IN101** such that **IN101** is asserted (contact closed) to simulate a “de-energized” power transformer prior to the start of the test. This contact must be configured to open (power transformer “energized”) at the instant when the test is started (current is applied), and to stay open while the test is in progress.
- b. Use the **SET R** command to configure the sequential events recorder SER1 trigger conditions to:
SER1 = IN101,TO1,TO2,HS1,HS2,FAA1,FAA2
The sequential events recorder in the relay will be used to establish the time for the TO1, TO2, HS1, HS2, FAA1, and FAA2 bits to assert.

Step 2. Initialize the thermal element.

- a. With the relay turned on and the contact wired to **IN101** closed, issue the **THE R** command to initialize the thermal element.

Step 3. Start the test.

- a. Simultaneously open the contact wired to **IN101** and apply $(1.2 * I_N)$ amperes to **I_{AW1}** (Z01–Z02). The test starts, $t = 0$, when input **IN101** is deasserted (external contact opens). The expected operating times (in minutes) from $t = 0$ are:

TO1 = 10

TO2 = 12

HS1 = 14

HS2 = 17

FAA1 = 19

FAA2 = 22

Acceptable values are ± 1 minute of the above times.
The following is a typical SER report for this test.

06/09/00	07:27:39.752	IN101	Deasserted
06/09/00	07:37:16.315	T01	Asserted
06/09/00	07:39:16.689	T02	Asserted
06/09/00	07:41:16.436	HS1	Asserted
06/09/00	07:44:16.448	HS2	Asserted
06/09/00	07:46:17.062	FAA1	Asserted
06/09/00	07:49:16.316	FAA2	Asserted

Commissioning Testing

WARNING

Before working on a CT circuit, first apply a short to the secondary winding of the CT.

When: When installing a new protection system.

Goal:

- Ensure that all system ac and dc connections are correct.
- Ensure that the relay functions as intended using your settings.
- Ensure that all auxiliary equipment operates as intended.

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

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

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

At commissioning time, use the relay **METER DIF** command to record the measured operate and restraint values for through-load currents. Use the **PULSE** command to verify relay output contact operation.

Use the *SEL-387-0, -5, -6 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:

- Ensure that the relay is measuring ac quantities accurately.
- Ensure that scheme logic and protection elements are functioning correctly.
- Ensure that auxiliary equipment is functioning correctly.

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

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

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

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

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

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

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

Relay Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to the *Troubleshooting Procedure*.

- Step 1. Do not turn the relay off.
- Step 2. Check to see that the power is on.
- Step 3. Measure and record the power supply voltage at the power input terminals.
- Step 4. Measure and record the voltage at all control inputs.
- Step 5. Measure and record the state of all output relays.

Troubleshooting Procedure

NOTE: For 1, 2, 3, and 4 the **ALARM** relay contacts should be closed.

Table 10.5 Troubleshooting (Sheet 1 of 4)

Symptom	Diagnosis/Solution
All Front-Panel LEDs Dark	<ol style="list-style-type: none"> 1. Power is off. 2. Blown power supply fuse. 3. Input power not present. 4. Self-test failure. 5. TAR F command improperly set.
Cannot See Characters on Relay LCD Screen	<ol style="list-style-type: none"> 1. Relay is de-energized. Check to see if the ALARM contact is closed. 2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast. <ol style="list-style-type: none"> a. Press any front-panel button. The relay should turn on the LCD backlighting. 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	<ol style="list-style-type: none"> 1. Communications device not connected to relay. 2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error. 3. System is processing event record. Wait several seconds. 4. System is attempting to transmit information, but cannot due to handshake line conflict. Check communications cabling. 5. System is in the XOFF state, halting communications. Type <Ctrl+Q> to put system in XON state. 6. If the serial port or front-panel interface that does not respond was working before, <i>Step 1</i> through <i>Step 5</i> above have been tried, and the MET command was the last issued command, the Digital Signal Processor may have failed, and you should call the factory.

Table 10.5 Troubleshooting (Sheet 2 of 4)

Symptom	Diagnosis/Solution
Relay Does Not Respond to Faults	
	<ol style="list-style-type: none"> 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	
	<ol style="list-style-type: none"> 1. The digital signal processor has failed; contact the factory.
Tripping Output Relay Remains Closed Following Fault	
	<ol style="list-style-type: none"> 1. Auxiliary contact inputs improperly wired. 2. Output relay contacts burned closed. 3. Interface board failure.
"SELBOOT" on Front Display at Power-Up; Serial Port Warning to Remove Link	
	<ol style="list-style-type: none"> 1. A jumper has been installed at position JMP6D. <ol style="list-style-type: none"> a. Turn off. b. Remove the jumper. c. Turn on the relay again.
No Prompting Message Issued to Terminal Upon Turning the Relay On	
	<ol style="list-style-type: none"> 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	
	<ol style="list-style-type: none"> 1. Baud rate set incorrectly. 2. Check terminal configuration. See <i>Section 7: Serial Port Communications and Commands</i>.

Table 10.5 Troubleshooting (Sheet 3 of 4)

Symptom	Diagnosis/Solution
Self-Test Failure: +5 V PS	
	<ol style="list-style-type: none"> 1. Power supply +5 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: +5 V REG	
	<ol style="list-style-type: none"> 1. Regulated +5 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: -5 V REG	
	<ol style="list-style-type: none"> 1. Regulated -5 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: +12 V PS	
	<ol style="list-style-type: none"> 1. Power supply +12 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: -12 V PS	
	<ol style="list-style-type: none"> 1. Power supply -12 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: +15 V PS	
	<ol style="list-style-type: none"> 1. Power supply +15 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: -15 V PS	
	<ol style="list-style-type: none"> 1. Power supply -15 V output out-of-tolerance. See STATUS command. 2. A/D converter failure.
Self-Test Failure: Offset	
	<ol style="list-style-type: none"> 1. Offset drift. 2. A/D converter drift. 3. Loose ribbon cable between transformers and main board.
Self-Test Failure: ROM	
	<ol style="list-style-type: none"> 1. Memory failure. Contact the factory.
Self-Test Failure: RAM	
	<ol style="list-style-type: none"> 1. Failure of static RAM IC. Contact the factory.

Table 10.5 Troubleshooting (Sheet 4 of 4)

Symptom	Diagnosis/Solution
Self-Test Failure: A/D Converter	
	<ol style="list-style-type: none"> 1. A/D converter failure. 2. RAM error not detected by RAM test.
Self-Test Failure: IO_BRD	
	<ol style="list-style-type: none"> 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. <i>Step 2</i> only applies to the upper interface board in a relay that has two interface boards. 3. Interface board failure.
Self-Test Failure: CR_RAM, EEPROM, and IO_BRD	
	<ol style="list-style-type: none"> 1. Self-test detected setting location movement as a result of Flash firmware upgrade. Execute R_S command. 2. Main board failure, contact the factory.
Alarm Contacts Closed	
	<ol style="list-style-type: none"> 1. Power is off. 2. Blown fuse. 3. Power supply failure. 4. Main board or interface board failure. 5. Other self-test failure.
Self-Test Failure: Temp After R_S Command	
	<ol style="list-style-type: none"> 1. Record STA command and state of all outputs. 2. Call the factory. 3. Powering down the relay will reset the logic.

Relay Calibration

The SEL-387 is factory calibrated. If you suspect that the relay is out of calibration, please contact the factory.

Technical Support

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 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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SEL-387-0, -5, -6 Relay Commissioning Test Worksheet

System Information

System Settings

RID (Relay identification) =								
TID (Terminal identification) =								
MVA (Maximum transformer Rating) =								
	Winding 1		Winding 2		Winding 3		Winding 4	
Current transformer connection:	W1CT =		W2CT =		W3CT =		W4CT =	
Current transformer ratio:	CTR1 =		CTR2 =		CTR3 =		CTR4 =	
Connection compensation:	W1CTC =		W2CTC =		W3CTC =		W4CTC =	
Nominal line-to-line voltage (kV):	VWDG1=		VWDG2=		VWDG3=		VWDG4=	
TAP calculation:	TAP1 =		TAP2 =		TAP3 =		TAP4 =	

Differential Settings

087P =		SLP1 =		SLP2 =		IRS1 =		U87P =	
--------	--	--------	--	--------	--	--------	--	--------	--

Metered Load (Data taken from substation panel meters, not the SEL-387)

± Readings from meters	Winding 1		Winding 2		Winding 3		Winding 4	
Megawatts:	MW1 =		MW2 =		MW3 =		MW4 =	
Megavars:	MVAR1 =		MVAR2 =		MVAR3 =		MVAR4 =	
MVA calculation:	MVA1 =		MVA2 =		MVA3 =		MVA4 =	

MVA calculation:

$$MVA_n = \sqrt{MW_n^2 + MVAR_n^2}$$

Calculated Relay Load

	Winding 1		Winding 2		Winding 3		Winding 4	
Primary Amperes calculation:	I1pri =		I2pri =		I3pri =		I4pri =	
Secondary Amperes calculation:	I1sec =		I2sec =		I3sec =		I4sec =	

Primary Amperes calculation:

$$I_{npri} = \frac{MVAn \cdot 1000}{\sqrt{3} \cdot VWDGn}$$

Secondary Amperes calculation:

$$W_{nCT} = Y, I_{nsec} = \frac{I_{npri}}{CTRn}$$

$$W_{nCT} = D, I_{nsec} = \frac{I_{npri} \cdot \sqrt{3}}{CTRn}$$

Settings Check

The following check assures zero-sequence current filtering is applied to all necessary transformer windings.

It is essential to use a non-zero Winding CT Connection Compensation (W_{nCTC}) setting for all grounded-wye connected transformer windings with wye-connected CTs.

Verify that no grounded-wye transformer windings with wye-connected CTs has setting $W_{nCTC} = 0$. Use a setting of 12 instead of 0 for proper zero-sequence current filtering.

Note the following commissioning checks will not detect the failure to properly filter zero-sequence current. Failure to adhere to this check will result in a differential operation for external faults involving ground.

Proper zero-sequence filtering verified?

Connection Check

System load conditions should be higher than 0.1 A secondary. 0.5 A secondary is recommended for the best results.

Differential Connection (issue MET DIF <Enter> to serial port or front panel)

Operate Current:	IOP1 =		IOP2 =		IOP3 =	
Restraint Current:	IRT1 =		IRT2 =		IRT3 =	
Mismatch Calculation:	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.

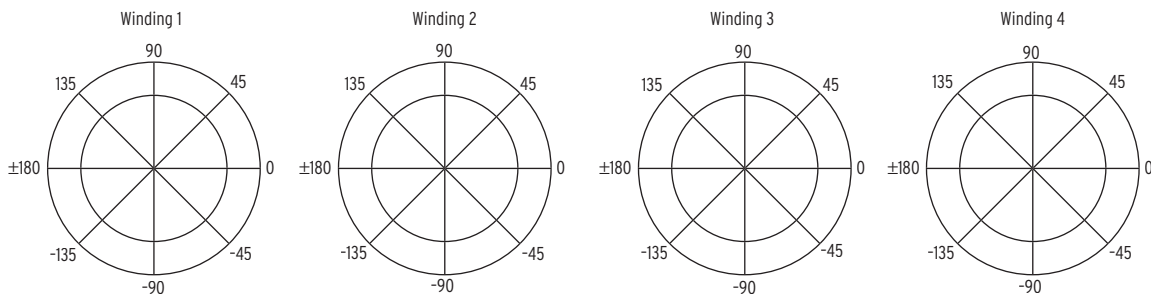
Mismatch Calculation:

$$MM_n = \frac{IOP_n}{IRT_n}$$

Magnitude, Angle, and Phase Rotation Check

Issue MET SEC <Enter> to the serial port or front panel.

	Winding 1		Winding 2		Winding 3		Winding 4	
A-Phase Secondary Amperes:	IAW1 =		IAW2 =		IAW3 =		IAW4 =	
A-Phase Angle:								
B-Phase Secondary Amperes:	IBW1 =		IBW2 =		IBW3 =		IBW4 =	
B-Phase Angle:								
C-Phase Secondary Amperes:	ICW1 =		ICW2 =		ICW3 =		ICW4 =	
C-Phase Angle:								



1. Calculated relay amperes match MET SEC amperes?
2. Phase rotation is as expected for each winding?
3. Do angular relationships among windings correspond to expected results? (Remember that secondary current values for load current flowing out of a winding will be 180° out of phase with the reference phase position for that winding. The reason is that CT polarity marks normally face away from the transformer on all windings.)

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Appendix A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

NOTE: The hardware in SEL-387 Relays with R500, R600 and subsequent firmware is different than the hardware in SEL-387 Relays with R1xx, R2xx, R3xx, and R4xx series firmware. The hardware associated with R5xx and R6xx firmware is incompatible with R1xx, R2xx, R3xx, and R4xx series firmware. You can upgrade R1xx, R2xx, R3xx, or R4xx firmware to any other firmware numbered R1xx, R2xx, R3xx, or R4xx. However, you cannot upgrade R1xx, R2xx, R3xx, or R4xx firmware to R5xx or R6xx firmware. Similarly, you cannot downgrade R5xx or R6xx firmware to R1xx, R2xx, R3xx, or R4xx firmware.

To find the firmware revision number in your relay, view the status report using the serial port **STATUS** command or the front-panel {**STATUS**} pushbutton. For firmware versions prior to October 4, 1999, for the SEL-387-5 Relay or June 29, 2000, for the SEL-387-0 Relay, the status report displays the Firmware Identification (FID) label:

FID=SEL-387-x-Rxxx-Vx-Dxxxxxx

For firmware versions with the date code of October 4, 1999 (SEL-387-5), or June 29, 2000 (SEL-387-0), or later, the FID label will appear as follows with the Part/Revision number in bold:

FID=SEL-387-x-Rxxx-Vx-Z001001-Dxxxxxxxx

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 firmware revision number follows the “R” and the release date follows the “D.” The single “x” after “SEL-387-” is the relay number and will be a 0, 5, or 6, depending on the relay features ordered:

x = 0	Standard features
x = 5	Standard features, harmonic restraint
x = 6	Standard features, harmonic restraint, thermal element

For example:

FID=SEL-387-5-R602-V0-Z003003-D20020118

is SEL-387-5 Relay firmware revision number 602, which was released on January 18, 2002.

Table A.1 lists firmware versions, a description of firmware modifications, and the instruction manual date codes that correspond to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History--SEL-387-0, -5, -6 Relay (Sheet 1 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-387-0-R611-V0-Z004004-D20140124 SEL-387-5-R611-V0-Z004004-D20140124 SEL-387-6-R611-V0-Z004004-D20140124	➤ Manual update only (see <i>Table A.2</i>).	20170601
SEL-387-0-R611-V0-Z004004-D20140124 SEL-387-5-R611-V0-Z004004-D20140124 SEL-387-6-R611-V0-Z004004-D20140124	➤ Manual update only (see <i>Table A.2</i>).	20160122
SEL-387-0-R611-V0-Z004004-D20140124 SEL-387-5-R611-V0-Z004004-D20140124 SEL-387-6-R611-V0-Z004004-D20140124	➤ Manual update only (see <i>Table A.2</i>).	20150126
SEL-387-0-R611-V0-Z004004-D20140124 SEL-387-5-R611-V0-Z004004-D20140124 SEL-387-6-R611-V0-Z004004-D20140124	SEL-387-0 ➤ Revised relay so that password characters are not echoed as they are entered. ➤ Increased the maximum number of allowed password characters from six to twelve. SEL-387-5 and SEL-387-6 ➤ Improved the accuracy of DNP Delay Measurement response. In previous firmware, the Delay Measurement response could be incorrect by as much as 150 ms, which, in applications where the DNP master uses this function code to measure the communication channel delay, could cause the master to set the wrong relay time. ➤ Revised relay so that password characters are not echoed as they are entered. ➤ Increased the maximum number of allowed password characters from six to twelve.	20140124
SEL-387-0-R610-V0-Z004004-D20100324 SEL-387-5-R610-V0-Z004004-D20100324 SEL-387-6-R610-V0-Z004004-D20100324	➤ Manual update only (see <i>Table A.2</i>).	20120127
SEL-387-0-R610-V0-Z004004-D20100324 SEL-387-5-R610-V0-Z004004-D20100324 SEL-387-6-R610-V0-Z004004-D20100324	➤ Corrected problem with incorrect assertion of Relay Word bit COMFLG when receiving RTD temperature data from an SEL-2600 RTD module.	20100324
SEL-387-0-R609-V0-Z004004-D20071025 SEL-387-5-R609-V0-Z004004-D20071025 SEL-387-6-R609-V0-Z004004-D20071025 Supports PROTO=DNP SEL-387-5-R409-V0-Z102102-D20050614 SEL-387-6-R406-V0-Z103103-D20050614 Does Not Support PROTO=DNP SEL-387-6-R304-V0-Z003003-D20041018	➤ Manual update only (see <i>Table A.2</i>).	20090730
SEL-387-0-R609-V0-Z004004-D20071025 SEL-387-5-R609-V0-Z004004-D20071025 SEL-387-6-R609-V0-Z004004-D20071025 Supports PROTO=DNP SEL-387-5-R409-V0-Z102102-D20050614 SEL-387-6-R406-V0-Z103103-D20050614 Does Not Support PROTO=DNP SEL-387-6-R304-V0-Z003003-D20041018	➤ Manual update only (see <i>Table A.2</i>).	20071220
SEL-387-0-R609-V0-Z004004-D20071025 SEL-387-5-R609-V0-Z004004-D20071025 SEL-387-6-R609-V0-Z004004-D20071025	➤ Modified A5C1 Fast Message header to properly indicate Delta CT connections when Group Setting $WnCT = D$ (Delta). ➤ Corrected CHSG Relay Word bit so that it will maintain the correct state through a relay setting group transition. ➤ Set the default event record length equal to relay LER setting.	20071025

Table A.1 Firmware Revision History—SEL-387-0, -5, -6 Relay (Sheet 2 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-387-0-R608-V0-Z004003-D20050919 SEL-387-5-R608-V0-Z004003-D20050919 SEL-387-6-R608-V0-Z004003-D20050919	➤ Fixed ability to properly process SEL Fast Message data with corrupted length field.	20050919
SEL-387-0-R607-V0-Z004003-D20050614 SEL-387-5-R607-V0-Z004003-D20050614 SEL-387-6-R607-V0-Z004003-D20050614 Supports PROTO=DNP SEL-387-5-R409-V0-Z102102-D20050614 SEL-387-6-R406-V0-Z103103-D20050614 Does Not Support PROTO=DNP SEL-387-6-R304-V0-Z003003-D20041018	➤ Manual update only (see <i>Table A.2</i>).	20050719
SEL-387-0-R607-V0-Z004003-D20050614 SEL-387-5-R607-V0-Z004003-D20050614 SEL-387-6-R607-V0-Z004003-D20050614 Supports PROTO=DNP SEL-387-5-R409-V0-Z102102-D20050614 SEL-387-6-R406-V0-Z103103-D20050614	SEL-387-0 ➤ Supports firmware modifications to SEL-387-5 and SEL-387-6. SEL-387-5 and SEL-387-6 ➤ Fixed DNP3 Index 216, 217, 218 Fault Time data types to provide DNP3 Type 30, default variation 2 data (16 bit signed analog input).	20050614
Supports PROTO=DNP SEL-387-6-R405-V0-Z103103-D20041018 Does Not Support PROTO=DNP SEL-387-6-R304-V0-Z003003-D20041018	➤ Changed number of event summaries from 80 to 40.	20041018
SEL-387-5-R606-V0-Z004003-D20040628 SEL-387-6-R606-V0-Z004003-D20040628	SEL-387-0 ➤ Supports firmware modifications to SEL-387-5 and SEL-387-6. SEL-387-5 and SEL-387-6 ➤ Added Direct SEL-2600A communications. ➤ Added Temperature Monitoring and Alarms. ➤ Added Dynamic Display capability. ➤ Added Through-Fault Monitor (SEL-387-5 only). ➤ Updated SEL-387-6 DSP. Note that this DSP change makes the hardware functionally incompatible with all previous firmware revisions (SEL-387-6 only).	20040628
Supports PROTO=DNP SEL-387-6-R404-V0-Z103103-D20040312 Does Not Support PROTO=DNP SEL-387-6-R303-V0-Z003003-D20040312	➤ Added through-fault event monitor, including the TFE serial port commands.	20040312
SEL-387-0-R602-V0-Z003003-D20020118 SEL-387-5-R602-V0-Z003003-D20020118 Supports PROTO=DNP SEL-387-6-R403-V0-Z102102-D20010518 Does Not Support PROTO=DNP SEL-387-6-R302-V0-Z002002-D20010518	➤ Manual update only (see <i>Table A.2</i>).	20021004
SEL-387-0-R602-V0-Z003003-D20020118 SEL-387-5-R602-V0-Z003003-D20020118 Supports PROTO=DNP SEL-387-6-R403-V0-Z102102-D20010518 Does Not Support PROTO=DNP SEL-387-6-R302-V0-Z002002-D20010518	➤ Manual update only (see <i>Table A.2</i>).	20020118

Table A.1 Firmware Revision History—SEL-387-0, -5, -6 Relay (Sheet 3 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-387-0-R602-V0-Z003003-D20020118 SEL-387-5-R602-V0-Z003003-D20020118	SEL-387-0 <ul style="list-style-type: none"> ➤ Added support for new DSP. ➤ Added support for faster CPU. ➤ Added Relay Word bit CTS for SELOGIC Control Equation use. ➤ Changed front-panel breaker monitor display scroll time from 0.5 seconds to 2 seconds. ➤ Changed prompt reset to read “Port 4” instead of “Port F.” ➤ Increased the O87P setting range. ➤ Added “n” command option to the CHI command. “CHI n” will now return the last <i>n</i> items contained in the history. ➤ Added CID to STA command. ➤ Updated FID string to include four-digit year. ➤ Added capability of using mismatched CRTs in the combined current elements. ➤ Added “23” combination for REF Directional Element (See <i>Figure 3.14: REF Directional Element</i>). ➤ Added the STA C (Status Clear) command option. ➤ Changed the CASCII command to level 0. ➤ Added EVE T that displays short event summary. ➤ Added VDC to Fast Meter response. SEL-387-0 and SEL-387-5 <ul style="list-style-type: none"> ➤ Corrected ADC power up. SEL-387-5 <ul style="list-style-type: none"> ➤ Modified CEV report to improve compatibility with the SEL-5601. 	20011219
Supports PROTO=DNP SEL-387-5-R600-V0-Z102102-D20010910 Does Not Support PROTO=DNP SEL-387-5-R500-V0-Z002002-D20010910	<ul style="list-style-type: none"> ➤ Added support for new DSP. ➤ Added support for faster CPU. ➤ Changed front-panel breaker monitor display scroll time for 0.5 seconds to 2 seconds. 	20010910
Supports PROTO=DNP SEL-387-5-R408-V0-Z102102-D20010518 SEL-387-6-R403-V0-Z102102-D20010518 Does Not Support PROTO=DNP SEL-387-5-R307-V0-Z002002-D20010518 SEL-387-6-R302-V0-Z002002-D20010518	<ul style="list-style-type: none"> ➤ Added harmonic restraint function. ➤ Added dc ratio blocking feature. ➤ Added dc battery voltage to the binary Fast Meter. ➤ Changed prompt reset to read “Port 4” instead of “Port F.” ➤ Added feature to check the number of rising and falling edges. ➤ Increased the O87P setting range. 	20010518
SEL-387-R105-V0-D20000629 Supports PROTO=DNP SEL-387-5-R407-V0-Z101101-D20001220 SEL-387-6-R402-V0-Z101101-D20001220 Does Not Support PROTO=DNP SEL-387-5-R306-V0-Z001001-D20001121 SEL-387-6-R301-V0-Z001001-D20001121	<ul style="list-style-type: none"> ➤ Manual update only (see <i>Table A.2</i>). 	20010330
SEL-387-R105-V0-D20000629 SEL-387-5-R407-V0-Z101101-D20001220 SEL-387-6-R402-V0-Z101101-D20001220 SEL-387-5-R306-V0-Z001001-D20001121 SEL-387-6-R301-V0-Z001001-D20001121	<ul style="list-style-type: none"> ➤ Manual update only (see <i>Table A.2</i>). 	20010209
Supports PROTO=DNP SEL-387-5-R407-V0-Z101101-D20001220 SEL-387-6-R402-V0-Z101101-D20001220	<ul style="list-style-type: none"> ➤ Corrected Object 32 in DNP versions. 	20001220

Table A.1 Firmware Revision History—SEL-387-0, -5, -6 Relay (Sheet 4 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
Supports PROTO=DNP SEL-387-5-R406-V0-Z101101-D20001121 SEL-387-6-R401-V0-Z101101-D20001121 Does Not Support PROTO=DNP SEL-387-5-R306-V0-Z001001-D20001121 SEL-387-6-R301-V0-Z001001-D20001121	SEL-387-5 ➤ Corrected A5C0 message to include DNP on DNP versions (applies to R406 only). ➤ Corrected Event Report formatting error. ➤ Removed 32IOP supervision from REF logic to improve performance for fault close to the neutral point. SEL-387-6 ➤ Corrected A5C0 message to include DNP on DNP versions (applies to R401 only). ➤ Improved THE command output. ➤ Improved thermal element response to measured top-oil values. ➤ Removed 32IOP supervision from REF logic to improve performance for fault close to the neutral point.	20001115
Supports PROTO=DNP SEL-387-6-R400-V0-Z101101-D20000831 Does Not Support PROTO=DNP SEL-387-6-R300-V0-Z001001-D20000831	➤ Initial version.	20000831
SEL-387-R105-V0-D20000629	➤ Made internal changes to support battery-backed clock hardware change.	20000630
Supports PROTO=DNP SEL-387-5-R405-V0-Z101101-D20000621 Does Not Support PROTO=DNP SEL-387-5-R305-V0-Z001001-D20000621	➤ Created version that supports DNP 3.00 Level 2 Slave protocol. ➤ Added “ <i>n</i> ” command option to the CHI command. “ CHI <i>n</i> ” will now return the last <i>n</i> items contained in the history. ➤ Added DS1302 battery-backed clock support. ➤ Fixed the 50GP setting so it does not accept a violation of: $50Gp_{min} \geq 0.05 \cdot Inom \cdot CTR_{max}/CTR4$.	20000621
SEL-387-R104 SEL-387-5-R304-V0-Z001001-D19991029	➤ Manual update only (see <i>Table A.2</i>).	20000203
SEL-387-R104 SEL-387-5-R304-V0-Z001001-D19991029	➤ Manual update only (see <i>Table A.2</i>).	20000128
SEL-387-R104 SEL-387-5-R304-V0-Z001001-D19991029	➤ Manual update only (see <i>Table A.2</i>).	991130
SEL-387-5-R304-V0-Z001001-D19991029	➤ Fixed TID problem. ➤ Fixed OPEN/CLOSE command display error. ➤ Added CID to STA command.	991029

Table A.1 Firmware Revision History—SEL-387-0, -5, -6 Relay (Sheet 5 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-387-5-R303-V0-Z001001-D19991004	<ul style="list-style-type: none"> ➤ Updated FID string to include four-digit year. ➤ Added capability of using mismatched CTRs in the combined current elements. ➤ Added CT Saturation (CTS) Relay Word bit in the REF Decision Logic (See <i>Figure 3.13: REF Enable/Block Logic</i>). ➤ Added “23” combination for REF Directional Element (See <i>Figure 3.14: REF Directional Element</i>). ➤ Added characters that can be separators in the alias setting. ➤ Fixed the CEV report to show the correct input and outputs and to show the correct number of rows being displayed in the report header. ➤ Fixed front-panel LCD timeout to time out regardless of whether a front-panel pushbutton is being pressed or not. ➤ Fixed SER to record RB (Remote Bits) and TRGTR (Target Reset) transitions. ➤ Added the STA C (Status Clear) command option. ➤ Increased character usage in ALIAS settings. ➤ Changed the TAP setting response from error to warning. ➤ Improved the harmonic supervision logic. ➤ Closed a timing window where events triggered after midnight January 1 show the incorrect time. ➤ Fixed the rising-edge timers so they are always initialized correctly. ➤ Changed the CASCII command to level 0. ➤ Fixed the SG (Set Group) bits so they assert correctly when changing groups quickly using the serial port or front panel. ➤ Removed “*” from accepted Relay Word bits. ➤ Enabled serial port time-outs to reset front-panel target index. 	991008
SEL-387-5-R302-V-D990914	➤ Fixed SOE lockup problem.	990915
SEL-387-5-R301-V-D990721	➤ Fixed Alias problem in the unsolicited SER protocol.	990721
SEL-387-5-R300-V-D990621	➤ Initial version.	990518
SEL-387-R104	➤ Manual update only (see <i>Table A.2</i>).	990513
SEL-387-R104	➤ Manual update only (see <i>Table A.2</i>).	990506
SEL-387-R104	➤ Manual update only (see <i>Table A.2</i>).	990111
SEL-387-R104	➤ Improved CHISTORY command.	981218
SEL-387-R103	➤ Manual update only (see <i>Table A.2</i>).	981012
SEL-387-R103	➤ Manual update only (see <i>Table A.2</i>).	980807
SEL-387-R103	<ul style="list-style-type: none"> ➤ Modified the breaker monitor logic so that the BRE command does not disable the relay when executed after cycling power with BKMON1 setting set to zero. ➤ Hide RTSCTS port setting if PROTO=LMD. ➤ Hide RTSCTS port setting if PROTO=LMD. ➤ Assert CHSG Relay Word bit at instant setting group change decision is made, when using SS<i>n</i> bits. 	980227
SEL-387-R102	➤ Initial version.	970630

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.2 lists the instruction manual release dates and descriptions of modifications for the SEL-387-0, -5, -6. The most recent instruction manual revisions are listed at the top.

For revision histories of the SEL-387-0 and SEL-387-5, -6 manuals (before they were combined into one manual), see *Table A.3* and *Table A.4*.

Table A.2 Manual Revision History—SEL-387-0, -5, -6 (Sheet 1 of 7)

Revision Date	Summary of Revisions
20191107	Section 1 ➤ Updated <i>Specifications</i> .
20190809	Section 7 ➤ Updated <i>SEL ASCII Protocol Details</i> to include the SEL-5601-2 instead of SEL-5601. Section 9 ➤ Updated <i>Compressed ASCII Event Reports in Standard 15-, 30-, or 60-Cycle Event Reports</i> . Appendix I ➤ Added <i>Appendix K: PC Software</i> .
20170601	General ➤ Renamed and updated <i>Appendix H: Protection Application Examples</i> . Section 1 ➤ Updated <i>Compliance in Specifications</i> . Section 3 ➤ Updated <i>Setting Calculation in Differential Element</i> . ➤ Updated <i>Example of Setting the SEL-387 for a Three-Winding Transformer in Differential Element</i> . ➤ Added <i>Figure 3.10: Primary Currents and Secondary Currents as Measured by the Relay</i> .
20160122	Section 1 ➤ Updated <i>Specifications</i> .
20150126	Preface ➤ Added <i>Safety Information</i> . Section 1 ➤ Updated <i>Specifications</i> .
20140124	Section 4 ➤ Removed Relay Word bits that are not available in <i>Table 4.7: SELOGIC Control Equation Operators</i> , <i>Table 4.8: Maximums for SELOGIC Control Equations</i> , and <i>Table 4.9: SEL-387 Relay Word Bits and Locations</i> . Section 7 ➤ Modified PASSword command description to reflect relay behavior. Appendix A ➤ Updated for firmware version R611. Appendix G ➤ Expanded fault current description in <i>Table G.6: SEL-387-5 and SEL-387-6 Relays Continuation of Wye/Delta DNP Data Map</i> (index values 203–215). ➤ Removed Relay Word bits that are not available in <i>Table G.7: SEL-387-5, -6 Relay Binary Input Lookup Table</i> .

Table A.2 Manual Revision History--SEL-387-0, -5, -6 (Sheet 2 of 7)

Revision Date	Summary of Revisions
20120127	<p>Section 3</p> <ul style="list-style-type: none"> ➤ Updated <i>Figure 3.34: U.S. Short-Time Inverse Curve: U5</i>. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added <i>CAL (Calibration Access Level)</i> section. ➤ Added Access Level C password. <p>Command Summary</p> <ul style="list-style-type: none"> ➤ Added CAL (Calibration Access Level) command to Access Level 2. ➤ Added PAS C password command to Access Level 2. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated Firmware Revision History and Manual Revision History.
20100324	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated for firmware version R610.
20090730	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Updated <i>Optoisolated Inputs</i> specification. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Updated <i>Figure 3.3: Differential Element (87-1) Quantities (SEL-387-0)</i> and <i>Figure 3.4: Differential Element (87-1) Quantities (all But SEL-387-0)</i>. ➤ Updated <i>Harmonic Restraint (All But SEL-387-0)</i>. ➤ Updated <i>Figure 3.9: DC Blocking (DCBL1) Logic (All But SEL-387-0)</i>. ➤ Updated <i>Harmonic Restraint (HRSTR) (all But SEL-387-0)</i>. ➤ Updated <i>Independent Harmonic Blocking (IHBL)</i>. ➤ Added criterion in <i>CT Arrangements</i>. ➤ Updated <i>Operating Characteristic</i>. ➤ Updated range in <i>Operating Quantity from W1, W2, W3 (32IOP)</i>. ➤ Added note relating to <i>Ambient Temperature Input (AMB)</i>, <i>Top Oil 1 Temperature Input (OIL1)</i>, & <i>Top Oil 2 Temperature Input (OIL2)</i>. ➤ Updated <i>51Qn and 51Nn--Sequence Inverse-Time Elements</i>. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Updated <i>Table 4.9: SEL-387 Relay Word Bits and Locations</i>. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Updated information in Winding 2 Bit column in <i>Table 10.2: Instantaneous Overcurrent Elements and Corresponding Settings</i>. ➤ Updated <i>Table 10.4: Connection Compensation Factor</i>. ➤ Updated Equation 10.12. <p>Appendix H</p> <ul style="list-style-type: none"> ➤ Added <i>Appendix H: Transformer/CT Winding Connection Diagrams</i>.
20071220	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Combined firmware revision history tables.
20071025	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated for firmware version R609.
20050919	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated Firmware Revision History and Manual Revision History.
20050719	<p>Entire Manual</p> <ul style="list-style-type: none"> ➤ Updated format of instruction manual. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Corrected <i>Figure 1.5</i> to add connecting line between a 51 P/G/Q circle and the 87 differential circuit.

Table A.2 Manual Revision History--SEL-387-0, -5, -6 (Sheet 3 of 7)

Revision Date	Summary of Revisions
	<p>Section 3</p> <ul style="list-style-type: none"> ➤ Corrected <i>Figure 3.13: REF Enable/Block Logic</i>. ➤ Clarified text explaining harmonic blocking and harmonic restraint. ➤ Added a final row to <i>Table 3.4: Overcurrent Element Summary</i>. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Corrected number of latch bits in <i>Table 4.4: SELOGIC Control Equation Variables (SEL-387-0 Relay Only)</i>. ➤ Corrected <i>Figure 4.4: Traditional Latching Relay</i>. ➤ Adjusted text under ALARM Output Contact to indicate NOTALM is the Relay Word bit associated with the ALARM output contact. ➤ Changed !ALARM to NOTALM in Relay Word bit Row 43 (see <i>Table 4.9</i>, <i>Table 4.10</i>, and <i>Table 4.11</i>). <p>Section 5</p> <ul style="list-style-type: none"> ➤ Corrected <i>Figure 5.4: Trip Bus Sensing With Relay Input</i>. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Added text at the end of the section stating that the Word files of the <i>Settings Sheets</i> are available to download from the SEL website. <p>Settings Sheets</p> <ul style="list-style-type: none"> ➤ Added an explanatory note to <i>Combined O/C Elements</i>. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated Firmware Revision History and Manual Revision History. <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Updated firmware upgrade instructions. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Changed !ALARM to NOTALM in Relay Word bit Row 43 (see <i>Table G.7</i>).
20050614	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated Firmware Revision History and Manual Revision History. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Corrected DNP Index references.
20041018	<p>Section 7</p> <ul style="list-style-type: none"> ➤ Changed number of event summaries in HIS command. <p>Section 9</p> <ul style="list-style-type: none"> ➤ Changed number of event summaries in HIS command. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated Firmware Revision History and Manual Revision History.
20040628	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Revised <i>Figure 1.1</i>. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Added temperature measurement description. ➤ Added to description of CT Connection (W1CT through W4CT). ➤ Revised definitions for oil thermal time constant description. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Revised <i>Table 4.9</i>, <i>Table 4.10</i>, and <i>Table 4.11</i> to add through-fault information. <p>Section 5</p> <ul style="list-style-type: none"> ➤ Resolved grammatical and stylistic issues. ➤ Added temperature measurement description. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Modified screen captures depicting default settings for 5 A and 1 A relays. ➤ Added RTD A and RTD B element settings to the Settings Sheets.

Table A.2 Manual Revision History–SEL-387-0, -5, -6 (Sheet 4 of 7)

Revision Date	Summary of Revisions
	<p>Settings Sheets</p> <ul style="list-style-type: none"> ➤ Resolved stylistic and formatting issues. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added description of the MET T command. ➤ Modified listing of protocol settings available under the SET P command. ➤ Revised <i>Figure 7.2</i>. <p>Command Summary</p> <ul style="list-style-type: none"> ➤ Added description of the MET T command to the <i>Command Summary</i>. <p>Section 8</p> <ul style="list-style-type: none"> ➤ Modified the description of the PROTO command to include RTDA and RTDB settings. ➤ Added description of dynamic display. ➤ Revised <i>Table 8.3</i>. ➤ Revised <i>Figure 8.5</i>. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Added Zero-Sequence Filter Check to the <i>Commissioning Test Worksheet</i>. <p>Appendix D</p> <ul style="list-style-type: none"> ➤ Modified A5C1 and A5D1 descriptions. ➤ Modified description of A546 temperature data block. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Modified <i>Table G.3</i>. ➤ Added information about Analogs 219–242. ➤ Updated <i>Table G.4</i>.
20040312	<p>Title Page and Reverse of Title Page</p> <ul style="list-style-type: none"> ➤ Added CONSELTANT to SEL copyright list. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Added general description of new through-fault event monitor (SEL-387-6 Relay only). <p>Section 2</p> <ul style="list-style-type: none"> ➤ Added SEL-2032 where SEL communications processors are mentioned. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Added information about CT connection settings $WnCT = D$ (delta) causing current modification before the current is displayed or used in breaker monitoring, metering, or through-fault event monitoring. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Added new Relay Word bit ISQTAL for through-fault event monitor. ➤ Added information to note in Relay Word bit table. <p>Section 5</p> <ul style="list-style-type: none"> ➤ Added detailed explanation of new through-fault event monitor. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Added Global settings ETHRU, THRU, and ISQT for through-fault event monitoring. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added TFE serial port commands for through-fault event monitoring. ➤ Added SEL-2032 where SEL communications processors are mentioned. <p>Command Summary</p> <ul style="list-style-type: none"> ➤ Added SEL-2032 where SEL communications processors are mentioned. <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Updated firmware upgrade instructions.

Table A.2 Manual Revision History--SEL-387-0, -5, -6 (Sheet 5 of 7)

Revision Date	Summary of Revisions
	<p>Appendix D</p> <ul style="list-style-type: none"> ➤ Changed digital banks for A5C1 Fast Meter Configuration Block because of the addition of a new row for new Relay Word bit ISQTAL for through-fault event monitor. ➤ Changed message length and digital banks for A5D1 Fast Meter Data Block because of the addition of a new row for new Relay Word bit ISQTAL for through-fault event monitor. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Added SEL-2032 where SEL communications processors are mentioned. ➤ Added new Relay Word bit ISQTAL to <i>Table G.4</i>.
20021004	<p>Title Page and Reverse of Title Page</p> <ul style="list-style-type: none"> ➤ Added the date code. ➤ Added patent number 6,356,421. <p>Manual Change Information</p> <ul style="list-style-type: none"> ➤ Deleted this page from the instruction manual. <p>Section 2</p> <ul style="list-style-type: none"> ➤ Updated information about relay mounting. ➤ Updated relay dimensions and panel-mount cutout drawing. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Corrected row ordering in <i>Table 4.10: Relay Word Bits Sorted Alphabetically</i>. <p>Command Summary</p> <ul style="list-style-type: none"> ➤ Corrected JMP24A and JMP24B to JMP6A and JMP6B. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Added Step 5 in <i>Restricted Earth Fault (REF) Function</i> test. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Changed the name of the appendix to Firmware and Manual Versions. ➤ Revised the firmware versions tables to include the corresponding manual date code for firmware versions. ➤ Added <i>Table A.6</i>, <i>Table A.7</i>, and <i>Table A.8</i> to replace the Manual Change Information page previously included in the manual. <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Updated to latest version of SEL-300 Series Relays Firmware Upgrade Instructions.
20020118	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated SEL-387-0-R602 and SEL-387-5-R602 (firmware change corresponds with instruction manual edits with date code of 20011219).
20011219	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Changed text related to new firmware changes. ➤ Corrected tightening torque specification for terminal block models. <p>Section 2</p> <ul style="list-style-type: none"> ➤ Added a clarifying sentence regarding Frame Ground. ➤ Added voltage 220 in description of optoisolated inputs. ➤ Replaced dimension drawing and front- and rear-panel drawings with updated versions. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Deleted figures. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Deleted the Relay Word bit table that applied to the SEL-387-0 Relay. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Deleted repetitious text. ➤ Corrected some defaults in <i>Settings Sheets Example</i>. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added information about the ID command.

Table A.2 Manual Revision History--SEL-387-0, -5, -6 (Sheet 6 of 7)

Revision Date	Summary of Revisions
	<p>Section 8</p> <ul style="list-style-type: none"> ➤ Updated figures. <p>Section 9</p> <ul style="list-style-type: none"> ➤ Added a description of EVENT T to the <i>Command Summary</i> and in <i>Section 9: Event Reports and SER</i>. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware version for the SEL-387-0 Relay (R602). <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Replaced Appendix B: Firmware Upgrade Instructions with a revised, more comprehensive <i>Appendix B: SEL-300 Series Relays Firmware Upgrade Instructions</i>.
20010910	<p>Title Page</p> <ul style="list-style-type: none"> ➤ Deleted the term “Integration Standard” from the title page. ➤ Added SEL-PROFILE to list of SEL copyrighted terms on the reverse of the title page. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Added power supply rated 48/125 Vdc or 125 Vac. ➤ Added 220 Vac optoisolated input. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Revised the <i>Factory Assistance</i> paragraph. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Added SEL-387-5 Relay firmware versions R600 and R500.
20010518	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Made changes to specifications related to new firmware. ➤ Changed minimum temperature rating from 90°C to 105°C under <i>Terminal Connections</i> in <i>General Specifications</i>. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Made changes to text and figures related to new firmware. ➤ Included <i>Restrained Element Operating Current Pickup</i> and <i>Unrestrained Element Current Pickup</i> information in the <i>Differential Element</i> subsection. ➤ Included <i>Application Guidelines</i> information for the <i>Overcurrent Element</i> subsection. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Made changes to Relay Word bit tables related to new firmware. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Made changes to <i>Setting Sheets</i> and <i>Settings Sheets Example</i> related to new firmware. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Included notation about the number of events in an SEL-387-0 Relay event report. <p>Section 8</p> <ul style="list-style-type: none"> ➤ Included notation about the number of events in an SEL-387-0 Relay event report. <p>Section 9</p> <ul style="list-style-type: none"> ➤ Included notation about the number of events in an SEL-387-0 Relay event report. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Added a test of harmonic restraint related to new firmware. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect addition of harmonic restraint function to the SEL-387-5 (R408 and R307) and the SEL-387-6 (R403 and R302). <p>Appendix D</p> <ul style="list-style-type: none"> ➤ Changed to document the addition of Vdc to the Fast Meter message.

Table A.2 Manual Revision History--SEL-387-0, -5, -6 (Sheet 7 of 7)

Revision Date	Summary of Revisions
	<p>Appendix E</p> <ul style="list-style-type: none"> ➤ Changed Compressed ASCII report for the SEL-387-5 Relay to reflect 40 rather than 35 characters in the FID string. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Made changes to the <i>Binary Input Lookup Table</i> related to new firmware. ➤ Reordered settings in <i>DNP Settings Sheets</i> so they are in the same order as in the relay.
20010330	<p>Reissued Entire Manual as SEL-387-0, -5, -6 Instruction Manual</p> <ul style="list-style-type: none"> ➤ Merged SEL-387-0 Instruction Manual into the SEL-387-5, -6 Instruction Manual to create the SEL-387-0, -5, -6 Instruction Manual. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Added introductory paragraph about CTs. ➤ Referenced SEL Application Guide 99-07. ➤ Added information about <i>Tightening Torque</i> and <i>Terminal Connections</i>. ➤ Corrected data in <i>AC Current Inputs</i> in <i>General Specifications</i>. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Added REF Enable/Block Logic, REF Directional Element, and 51PC1 and 51NC1 Combined Inverse-Time O/C Elements drawings specific to the SEL-387-0 Relay. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Added a table presenting SELOGIC® control equation variables for the SEL-387-0 Relay. ➤ Added Relay Word bit information for the SEL-387-0 Relay. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Made text changes throughout the section to advise the user to change default passwords to private, strong passwords at installation. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Added SEL-387-0 Relay firmware versions to <i>Appendix A</i>.

Table A.3 Manual Revision History--SEL-387-0 Relay (Sheet 1 of 3)

Revision Date	Summary of Revisions
20010330	<p>Reissued Entire Manual as SEL-387-0, -5, -6 Instruction Manual</p> <ul style="list-style-type: none"> ➤ Merged SEL-387-0 Instruction Manual into the SEL-387-5, -6 Instruction Manual to create the SEL-387-0, -5, -6 Instruction Manual. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Added introductory paragraph about CTs. ➤ Referenced SEL Application Guide 99-07. ➤ Corrected data in <i>AC Current Inputs</i> in <i>General Specifications</i>. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Added REF Enable/Block Logic, REF Directional Element, and 51PC1 and 51NC1 Combined Inverse-Time O/C Elements drawings specific to the SEL-387-0. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Added a table presenting SELOGIC control equation variables for the SEL-387-0. ➤ Added Relay Word bit information for the SEL-387-0. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Made text changes throughout the section to advise the user to change default passwords to private, strong passwords at installation. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Added SEL-387-0 firmware versions to <i>Appendix A</i>.

Table A.3 Manual Revision History--SEL-387-0 Relay (Sheet 2 of 3)

Revision Date	Summary of Revisions
20010209	<p>Title Page</p> <ul style="list-style-type: none"> ➤ Added cautions, warnings, and dangers in English and French to the reverse of the title page. <p>Section 1</p> <ul style="list-style-type: none"> ➤ Updated specifications. <p>Section 2</p> <ul style="list-style-type: none"> ➤ Updated relay dimension/panel-mount cutout drawing. ➤ Added a caution about replacing the battery. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added warning to change default passwords to private passwords at relay installation. ➤ Added <i>SEL-387 Relay Command Summary</i> to end of the section. <p>Section 9</p> <ul style="list-style-type: none"> ➤ Added information about Compressed ASCII reports. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Adjusted text of a caution. <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Corrected an instruction.
20000630	<p>Section 5</p> <ul style="list-style-type: none"> ➤ Corrected <i>Note: Make Active Setting Group Switching Settings With Care.</i> ➤ Corrected <i>Note: Make Latch Bit Settings With Care.</i> <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added notes to descriptions of DATE and TIME commands. ➤ Added <i>Note: Make Sequential Events Recorder (SER) Settings With Care.</i> <p>Section 9</p> <ul style="list-style-type: none"> ➤ Added notes to descriptions of DATE and TIME commands. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Listed firmware version SEL-387-R105, which supports battery-backed clock hardware change.
20000128	<p>Section 2</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors.
991130	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Added 24 Vdc and 110 Vdc control input voltage options. ➤ Clarified <i>Type Tests and Standards.</i> <p>Section 2</p> <ul style="list-style-type: none"> ➤ Added 24 Vdc and 110 Vdc control input voltage options. ➤ Added relay dimensions and drill plan drawing for panel-mount models. ➤ Added rear-panel drawing of model 038701, terminal blocks. ➤ Moved rear-panel drawing of model 038707 Connectorized®. ➤ Changed numbering of figures following <i>Figure 2.2</i> because of the addition of two figures. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Corrected an equation.

Table A.3 Manual Revision History--SEL-387-0 Relay (Sheet 3 of 3)

Revision Date	Summary of Revisions
	Section 5 <ul style="list-style-type: none"> ➤ Added paragraph <i>Make Latch Bit Settings with Care</i>. ➤ Changed a reference to a figure in <i>Section 2: Installation</i>. Section 6 <ul style="list-style-type: none"> ➤ Changed references to figures in <i>Section 2: Installation</i>.
990513	Section 6 <ul style="list-style-type: none"> ➤ Reissued all <i>Settings Sheets</i> and <i>Settings Sheets Examples</i>.
990506	Section 5 <ul style="list-style-type: none"> ➤ Changed Relay Word bit 50Q1T to 51Q1T, and corrected description in <i>Table 5.9</i> and <i>Table 5.10</i>.
990111	Appendix A <ul style="list-style-type: none"> ➤ Corrected documentation error. U87P and TH5P contained incorrect information in <i>Description of Firmware</i>. Setting U87P and TH5P out-of-range was not changed from an error to a warning. Appendix B <ul style="list-style-type: none"> ➤ Updated.
981218	Appendix A <ul style="list-style-type: none"> ➤ Revised manual in conjunction with firmware release R104. ➤ Improved CHISTORY command. ➤ Changed setting U87P and TH5P out-of-range from an error to a warning.
981012	<ul style="list-style-type: none"> ➤ Revised manual to change model references from 0387J to 0387Y. Models 0387J and 0387Y are identical, the model number change was made to be compatible with other relay models.
980807	Revised manual to: <ul style="list-style-type: none"> ➤ Include new Connectorized model SEL03870J. ➤ Reflect jumper name changes associated with use of new Main Boards. ➤ Correct miscellaneous errata from 970630 release. ➤ No firmware changes were made for these product hardware modifications.
980227	Revised manual in conjunction with firmware release R103 <ul style="list-style-type: none"> ➤ Notes in setting sheets to set negative-sequence units in 3I2. ➤ RTSCTS setting to be hidden if PROTO = SEL (SET P command). ➤ Include discussion of CHSG Relay Word bit in <i>Section 5: Protection and Control Logic Functions</i>.
970630	<ul style="list-style-type: none"> ➤ Initial version (R102).

Table A.4 Manual Revision History--SEL-387-5, -6 Relay (Sheet 1 of 4)

Revision Date	Summary of Revisions
20010330	Reissued Entire Manual as SEL-387-0, -5, -6 Instruction Manual <ul style="list-style-type: none"> ➤ Merged SEL-387-0 Instruction Manual into the SEL-387-5, -6 Instruction Manual to create the SEL-387-0, -5, -6 Instruction Manual. Section 1 <ul style="list-style-type: none"> ➤ Added introductory paragraph about CTs. ➤ Referenced SEL Application Guide 99-07. ➤ Added information about <i>Tightening Torque</i> and <i>Terminal Connections</i>. ➤ Corrected data in <i>AC Current Inputs</i> in <i>General Specifications</i>. Section 3 <ul style="list-style-type: none"> ➤ Added REF Enable/Block Logic, REF Directional Element, and 51PC1 and 51NC1 Combined Inverse-Time O/C Elements drawings specific to the SEL-387-0 Relay. Section 4 <ul style="list-style-type: none"> ➤ Added a table presenting SELOGIC control equation variables for the SEL-387-0. ➤ Added Relay Word bit information for the SEL-387-0.

Table A.4 Manual Revision History–SEL-387-5, -6 Relay (Sheet 2 of 4)

Revision Date	Summary of Revisions
	<p>Section 7</p> <ul style="list-style-type: none"> ➤ Made text changes throughout the section to advise the user to change default passwords to private, strong passwords at installation. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Added SEL-387-0 firmware versions to <i>Appendix A</i>.
20001220	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware (387-5, R407).
20001115	<p>Title Page</p> <ul style="list-style-type: none"> ➤ Added cautions, warnings, and dangers in English and French to reverse of title page. ➤ Added a warning to change default passwords to private passwords at relay installation. <p>Section 2</p> <ul style="list-style-type: none"> ➤ Added a caution about replacing the battery affecting subsequent pagination. <p>Section 3</p> <ul style="list-style-type: none"> ➤ Corrected <i>Figure 3.8: REF Enable/Block Logic</i> and <i>Figure 3.9: REF Directional Element</i>. ➤ Added clarifying text under <i>Top-Oil Temperature Limit</i> (TOT1, TOT2). <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added warning to change default passwords to private passwords at relay installation. <p>Section 8</p> <ul style="list-style-type: none"> ➤ Added warning to change default passwords to private passwords at relay installation, affecting subsequent pagination. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Listed firmware that makes corrections and improvements to the SEL-387-5 (R406 and R306) and the SEL-387-6 (R401 and R301), with and without DNP. <p>Appendix D</p> <ul style="list-style-type: none"> ➤ Corrected data in the <i>A5C0 Relay Definition Block</i>, affecting subsequent pagination. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Corrected DNP instruction list.
20000831	<ul style="list-style-type: none"> ➤ Reorganized and reissued entire manual. ➤ Added information about the SEL-387-6 (R400 and R300).
20000621	<p>Section 5</p> <ul style="list-style-type: none"> ➤ Corrected <i>Figure 5.23: REF Enable/Block Logic</i>. ➤ Corrected Rows 48 and 49 in <i>Table 5.8: SEL-387 Relay Word Bits and Locations</i>. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Made changes to <i>Settings Sheets</i> to reflect changes to firmware. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Made changes to reflect changes to firmware. <p>Section 8</p> <ul style="list-style-type: none"> ➤ Made changes to reflect changes to firmware. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect the addition of Distributed Network Protocol (DNP) 3.00. (SEL-387-5, R405 and R305) ➤ Changed formatting. <p>Appendix B</p> <ul style="list-style-type: none"> ➤ Reordered steps. <p>Appendix E</p> <ul style="list-style-type: none"> ➤ Corrected CHISTORY command explanation.

Table A.4 Manual Revision History—SEL-387-5, -6 Relay (Sheet 3 of 4)

Revision Date	Summary of Revisions
	<p>Appendix F</p> <ul style="list-style-type: none"> ➤ Corrected name of <i>Appendix F: Unsolicited SER Protocol</i>. <p>Appendix G</p> <ul style="list-style-type: none"> ➤ Created <i>Appendix G: Distributed Network Protocol (DNP) 3.00</i>.
20000203	<p>Section 2</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors. <p>Section 10</p> <ul style="list-style-type: none"> ➤ Corrected typographical errors.
991130	<p>Section 1</p> <ul style="list-style-type: none"> ➤ Added 24 Vdc and 110 Vdc control input voltage options. ➤ Clarified <i>Type Tests and Standards</i>. <p>Section 2</p> <ul style="list-style-type: none"> ➤ Added 24 Vdc and 110 Vdc control input voltage options. ➤ Added relay dimensions and drill plan drawing for panel-mount models (<i>Figure 2.2</i>). ➤ Added rear-panel drawing of model 0387x1, terminal blocks (<i>Figure 2.3</i>). ➤ Moved rear-panel drawing of model 0387xY Connectorized (<i>Figure 2.4</i>). ➤ Changed numbering of figures following <i>Figure 2.2</i> because of the addition of two figures. <p>Section 4</p> <ul style="list-style-type: none"> ➤ Corrected an equation. <p>Section 5</p> <ul style="list-style-type: none"> ➤ Changed a reference to a figure in <i>Section 2: Installation</i>. <p>Section 6</p> <ul style="list-style-type: none"> ➤ Changed references to figures in <i>Section 2: Installation</i>. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Corrected firmware date number.
991029	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware (SEL-387-5, R304).
991008	<p>Section 3</p> <ul style="list-style-type: none"> ➤ Replaced IRT = 1 with IRT = 4 in discussion of <i>Differential Element Operation</i>. <p>Section 5</p> <ul style="list-style-type: none"> ➤ Inserted note about making latch bit settings with care. ➤ Replaced and added text. ➤ Added a figure (<i>Figure 5.19</i>). ➤ Updated <i>Figure 5.20</i>, <i>Figure 5.21</i>, <i>Figure 5.23</i>, and <i>Figure 5.24</i>. ➤ Added CTS to Row 14 of <i>Table 5.8</i> and <i>Table 5.9</i>. <p>Section 7</p> <ul style="list-style-type: none"> ➤ Added discussion of STA C command. <p>Section 9</p> <ul style="list-style-type: none"> ➤ Specified acceptable alias setting format and characters for alias names.

Table A.4 Manual Revision History–SEL-387-5, -6 Relay (Sheet 4 of 4)

Revision Date	Summary of Revisions
	<p>Section 10</p> <ul style="list-style-type: none"> ➤ Replaced label with updated version. ➤ Replaced step 3 under <i>Combined Overcurrent Elements</i> (this affected pagination for the rest of the section). ➤ Added STA C command to <i>Command Summary</i>. <p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware (SEL-387-5, R303).
990915	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware (SEL-387-5, R302). <p>Appendix D</p> <ul style="list-style-type: none"> ➤ Added A5ED to <i>Binary Message List</i>. <p>Appendix F</p> <ul style="list-style-type: none"> ➤ Updated text throughout.
990721	<p>Appendix A</p> <ul style="list-style-type: none"> ➤ Updated to reflect new firmware (SEL-387-5, R301).
990518	<ul style="list-style-type: none"> ➤ Initial version (SEL-387-5, R300).

Appendix B

SEL-300 Series Relays

Firmware Upgrade Instructions

Overview

From time to time, SEL issues firmware upgrades. The instructions that follow explain how you can install new firmware in your SEL-300 series relay.

This firmware upgrade kit contains firmware files for the relay and the Ethernet card of the relay, if the relay is equipped for Ethernet communications. If the relay is equipped with Ethernet communications, upgrade the Ethernet card firmware to the latest available version, or ensure the Ethernet card firmware is the latest available version, *before* upgrading the relay firmware. The latest available version is supplied on the upgrade CD. Issue the **STATUS** command to the Ethernet card to compare the Ethernet firmware version number to the revision on the upgrade CD. Follow the *Ethernet Card Firmware Upgrade Instructions on page B.17*, then return here and continue to upgrade the relay firmware.

Relay Firmware Upgrade Instructions

Introduction

These firmware upgrade instructions apply to SEL-300 series relays except those listed in *Table B.1*.

Table B.1 Relays Not Covered by These Instructions

SEL-311C-1, -2
SEL-321 (uses EPROM)
SEL-351 Relays equipped with Ethernet

SEL occasionally offers firmware upgrades to improve the performance of your relay. Changing physical components is unnecessary because the relay stores firmware in Flash memory.

A firmware loader program called SELBOOT resides in the relay. To upgrade firmware, use the SELBOOT program to download an SEL-supplied file from a personal computer to the relay via any communications port. This procedure is described in the following steps.

NOTE: SEL strongly recommends that you upgrade firmware at the location of the relay and with a *direct connection* from the personal computer to one of the relay serial ports. Do not load firmware from a remote location; 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 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 Settings, Calibration, Status, Breaker Wear, and Metering*
- I. Return the Relay to Service*

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- Terminal emulation software that supports 1K Xmodem or Xmodem (these instructions use HyperTerminal from a Microsoft Windows operating system)
- Serial communications cable (SEL Cable SEL-C234A or equivalent)
- Disc containing the firmware upgrade file
- Firmware Upgrade Instructions (these instructions)

Optional Equipment

These items help you manage relay settings and understand firmware upgrade procedures:

- SEL-5010 Relay Assistant software or ACSELERATOR QuickSet® SEL-5030 software

The SEL-5010 has a feature that guides you through the conversion process. This upgrade guide will assist you with steps C, D, E, F, and G of these upgrade instructions. If you do not have the latest SEL-5010 software, please contact your customer service representative or the factory for details on getting the SEL-5010.

- Your relay instruction manual

Upgrade Procedure

A. Prepare the Relay

- Step 1. If the relay is in use, follow your company practices for removing a relay from service.

Typically, these include changing settings, or disconnecting external voltage sources or output contact wiring, to disable relay control functions.

- Step 2. Apply power to the 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 (usually the front port).
- 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; write down the value for each setting.
- Step 10. At the **EXIT SETTINGS?** prompt, select **Yes** and press the **SELECT** pushbutton.
- Step 11. Connect an SEL Cable SEL-C234A (or equivalent) serial communications cable to the relay serial port selected in *Step 6* above.

B. Establish a Terminal Connection

To establish communication between the relay and a PC, you must be able to modify the computer serial communications parameters (i.e., data transmission rate, data bits, parity) and set the file transfer protocol to 1K Xmodem or Xmodem protocol.

- Step 1. Connect a serial communications cable to the computer serial port.
 - a. Check the computer for a label identifying the serial communications ports.
 - b. Choose a port and connect an SEL Cable SEL-C234A (or equivalent) serial communications cable to the PC serial port.

If there is no identification label, connect the cable to any computer serial port. Note that you might later change this computer serial port to a different port in order to establish communication between the relay and the computer.

- Step 2. Disconnect any other serial port connection(s).
- Step 3. From the computer, open **HyperTerminal**.
 On a PC running Windows, you would typically click **Start > Programs > Accessories**.
- Step 4. Enter a name, select any icon, and click **OK** (*Figure B.1*).

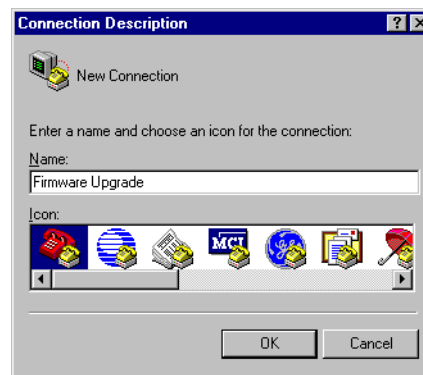


Figure B.1 Establishing a Connection

- Step 5. Select the computer serial port you are using to communicate with the relay (*Figure B.2*) and click **OK**. This port matches the port connection that you made in *Step 1 on page B.3*.

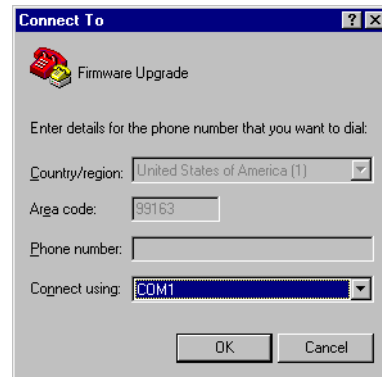


Figure B.2 Determining the Computer Serial Port

- Step 6. Establish serial port communications parameters.

The settings for the computer (*Figure B.3*) must match the relay settings you recorded earlier.

- a. Enter the serial port communications parameters (*Figure B.3*) that correspond to the relay settings you recorded in *Step 9 on page B.3*.

If the computer settings do not match the relay settings, change the computer settings to match the relay settings.

- b. Click **OK**.

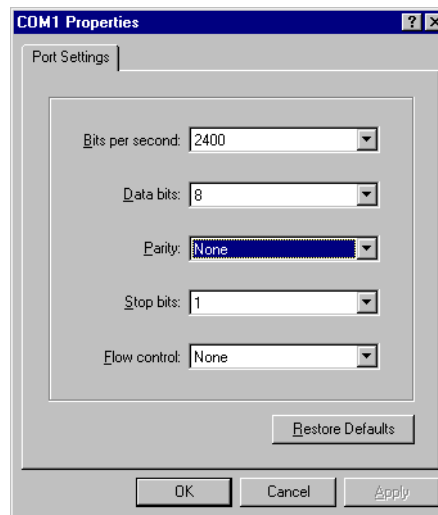


Figure B.3 Determining Communications Parameters for the Computer

- Step 7. Set the terminal emulation to VT100.

- a. From the **File** menu, choose **Properties**.
- b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).
- c. Select **VT100** from the **Emulation** list box and click **OK**.

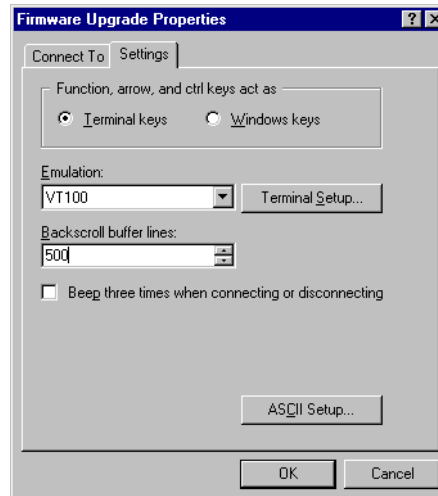


Figure B.4 Setting Terminal Emulation

Step 8. Confirm serial communication.

Press **<Enter>**. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

If this is successful, proceed to *C. Save Settings and Other Data* on page B.6.

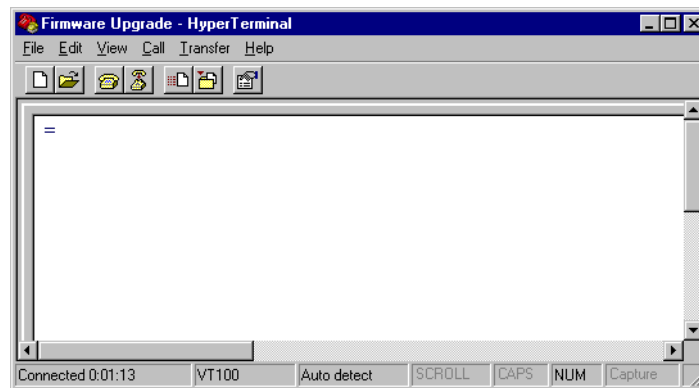


Figure B.5 Terminal Emulation Startup Prompt

Failure to Connect

If you do not see the Access Level 0 = prompt, press **<Enter>** again. If you still do not see the Access Level 0 = prompt, you have either selected the incorrect serial communications port on the computer, or the computer speed setting does not match the data transmission rate of the relay. Perform the following steps to reattempt a connection.

Step 9. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 10. Correct the port setting.

- a. From the **File** menu, choose **Properties**.
 You should see a dialog box similar to *Figure B.6*.
- b. Select a different port in the **Connect using** list box.

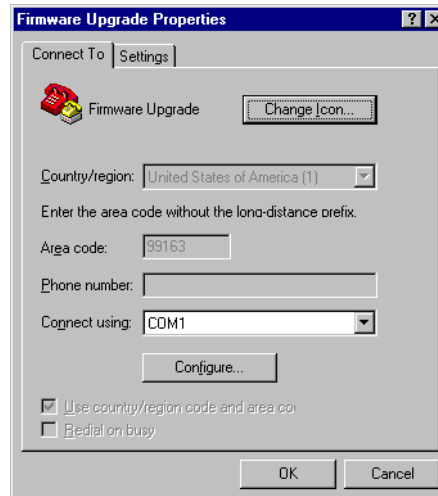


Figure B.6 Correcting the Port Setting

Step 11. Correct the communications parameters.

- From the filename **Properties** dialog box shown in *Figure B.6*, click **Configure**.
 You will see a dialog box similar to *Figure B.7*.
- Change the settings in the appropriate list boxes to match the settings you recorded in *Step 9 on page B.3* and click **OK** twice to return to the terminal emulation window.

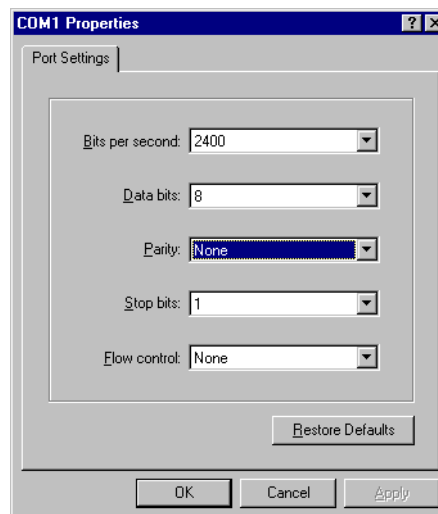


Figure B.7 Correcting the Communications Parameters

Step 12. Press **<Enter>**. In the terminal emulation window, you should see the Access Level 0 = prompt, similar to that in *Figure B.5*.

C. Save Settings and Other Data

Before upgrading firmware, retrieve and record any History (**HIS**), Event (**EVE**), Metering (**MET**), Breaker Wear Monitor (**BRE**), Communications Log Summary (**COM X** or **COM Y**), or Sequential Events Recorder (**SER**) data that you want to retain (see the relay instruction manual for these procedures).

Enter Access Level 2

NOTE: If the relay does not prompt you for Access Level 1 and Access Level 2 passwords, check whether the relay has a password jumper in place. With this jumper in place, the relay is unprotected from unauthorized access (see the relay instruction manual).

- Step 1. Type **ACC <Enter>** at the Access Level 0 = prompt.
- Step 2. Type the Access Level 1 password and press **<Enter>**.
You will see the Access Level 1 => prompt.
- Step 3. Type **2AC <Enter>**.
- Step 4. Type the Access Level 2 password and press **<Enter>**.
You will see the Access Level 2 ==>> prompt.

Backup Relay Settings

The relay preserves settings and passwords during the firmware upgrade process. However, interruption of relay power during the upgrade process can cause the relay to lose settings. Make a copy of the original relay settings in case you need to reenter the settings. Use either the SEL-5010 or QuickSet to record the existing relay settings and proceed to *D. Start SELBOOT* on page B.7. Otherwise, perform the following steps.

- Step 1. From the **Transfer** menu in **HyperTerminal**, select **Capture Text**.
- Step 2. Enter a directory and filename for a text file where you will record the existing relay settings.
- Step 3. Click **Start**.

The **Capture Text** command copies all the information you retrieve and all the keystrokes you type until you send the command to stop capturing text. The terminal emulation program stores these data in the text file.

- Step 4. Execute the Show Calibration (**SHO C**) command to retrieve the relay calibration settings.

Use the following Show commands to retrieve the relay settings: **SHO G**, **SHO 1**, **SHO L 1**, **SHO 2**, **SHO L 2**, **SHO 3**, **SHO L 3**, **SHO 4**, **SHO L 4**, **SHO 5**, **SHO L 5**, **SHO 6**, **SHO L 6**, **SHO P 1**, **SHO P 2**, **SHO P 3**, **SHO P F**, **SHO R**, and **SHO T**.

- Step 5. From the **Transfer** menu in **HyperTerminal**, select **Capture Text** and click **Stop**.

The computer saves the text file you created to the directory you specified in *Step 2* under *Backup Relay Settings* on page B.7.

- Step 6. Write down the present relay data transmission setting (SPEED).

This setting is SPEED in the **SHO P** relay settings output. The SPEED value should be the same as the value you recorded in *A. Prepare the Relay* on page B.2.

NOTE: Settings classes can vary among SEL relays. See the relay instruction manual for a listing.

D. Start SELBOOT

- Step 1. Find and record the firmware identification string (FID).
 - a. From the **File** menu, choose **Properties**.
 - b. Select the **Settings** tab in the **Properties** dialog box (*Figure B.4*).

- c. Click **ASCII Setup**.
 You should see a dialog box similar to *Figure B.8*.
- d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

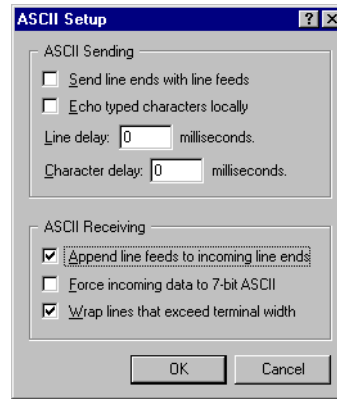


Figure B.8 Preparing HyperTerminal for ID Command Display

- e. Click **OK** twice to go back to the terminal emulation window.
- f. Type **ID <Enter>** and record the FID number the relay displays.
- g. Repeat *Step a* through *Step c*, then uncheck the **Append line feeds to incoming line ends** check box. (This feature can cause problems when uploading firmware to the relay.)

Step 2. From the computer, start the SELBOOT program.

- a. From the Access Level 2 ==> prompt, type **L_D <Enter>**.

The relay responds with the following:

Disable relay to send or receive firmware (Y/N)?

- b. Type **Y <Enter>**.

The relay responds with the following:

Are you sure (Y/N)?

- c. Type **Y <Enter>**.

The relay responds with the following:

Relay Disabled

Step 3. Wait for the SELBOOT program to load.

The front-panel LCD screen displays the SELBOOT firmware number (e.g., SLBT-3xx-R100). The number following the R is the SELBOOT revision number. This number is different from the relay firmware revision number.

After SELBOOT loads, the computer will display the SELBOOT !> prompt.

Step 4. Press **<Enter>** to confirm that the relay is in SELBOOT.

You will see another SELBOOT !> prompt.

Commands Available in SELBOOT

For a listing of commands available in SELBOOT, type **HELP** <Enter>. You should see a screen similar to *Figure B.9*.

```
>HELP <Enter>
SELboot-3xx-Rxxx
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
```

Figure B.9 List of Commands Available in SELBOOT

Establish a High-Speed Connection

Step 5. Type **BAU 38400** <Enter> at the SELBOOT !> prompt.

Match Computer Communications Speed to the Relay

Step 6. From the **Call** menu, choose **Disconnect** to terminate communication.

Step 7. Correct the communications parameters.

- From the **File** menu, choose **Properties**.
- Choose **Configure**.
- Change the computer communications speed to match the new data transmission rate in the relay (*Figure B.10*).
- Click **OK** twice.

Step 8. Press <Enter> to check for the SELBOOT !> prompt indicating that serial communication is successful.

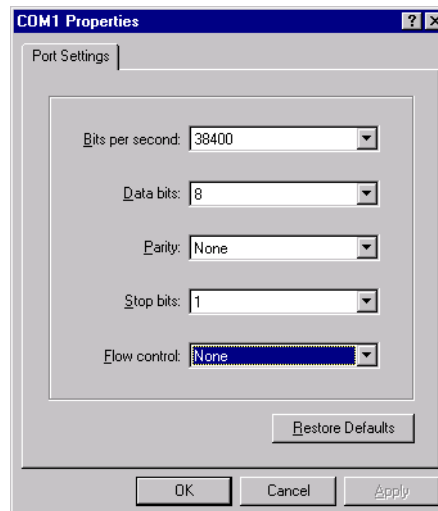


Figure B.10 Matching Computer to Relay Parameters

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 existing firmware, the computer will need as much as 3 MB of free disk space. This backup procedure takes 5–10 minutes at 38400 bps.

Step 1. Type **SEN** <Enter> at the SELBOOT !> prompt to initiate the firmware transfer from the relay to the computer.

Step 2. From the **Transfer** menu in **HyperTerminal**, select **Receive File**.

You should see a dialog box similar to *Figure B.11*.

Step 3. Enter the path of a folder on the computer hard drive where you want to record the existing relay firmware.

Step 4. Select **1K Xmodem** if this protocol is available on the PC.

If the computer does not have **1K Xmodem**, choose **Xmodem**.

Step 5. Click **Receive**.

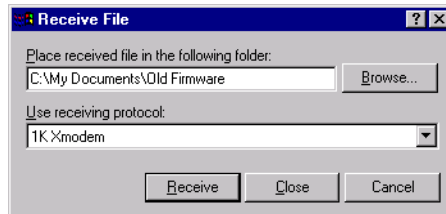


Figure B.11 Example Receive File Dialog Box

Step 6. Enter a filename that clearly identifies the existing firmware version (*Figure B.12*), using the version number from the FID you recorded earlier in *Step 1 on page B.7* and click **OK**.

SEL lists the firmware revision number first, then the product number.

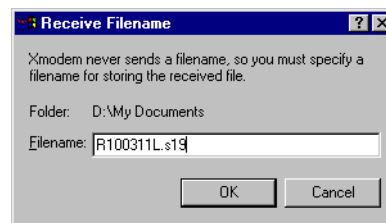


Figure B.12 Example Filename Identifying Old Firmware Version

If Xmodem times out before the download completes, repeat the process from *Step 1 on page B.10*.

For a successful download, you should see a dialog box similar to *Figure B.13*. After the transfer, the relay responds with the following:

Download completed successfully!

NOTE: HyperTerminal stored any path you entered in Step 3 and any filename you entered in Step 6 during the earlier download attempt; this saves you from reentering these on a subsequent attempt.

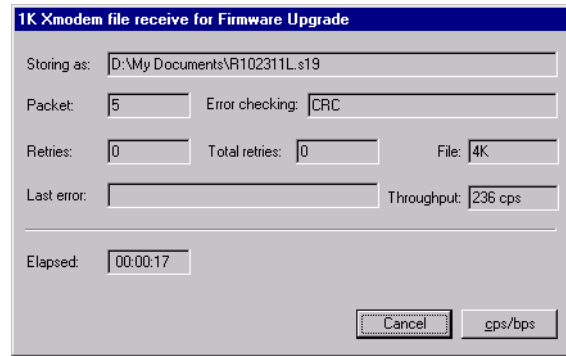


Figure B.13 Downloading Old Firmware

F. Upload New Firmware

Step 1. Prepare to load the firmware.

- a. Insert the disk containing the new firmware into the appropriate disk drive on the computer.
- b. Some firmware is in self-extracting compressed files (files with .exe extensions). For firmware in such files, from Windows Explorer double-click on the file and select the directory on the hard drive where you want to access the uncompressed files. Verify that these uncompressed files have an .s19 extension.

NOTE: This example shows uploading new firmware directly from a disk. For a faster upload (and less potential for file corruption), copy the new firmware to the local hard drive and upload the new firmware from the hard drive.

Step 2. Type **REC** <Enter> at the SELBOOT !> prompt to command the relay to receive new 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.

The relay asks whether you want to erase the existing firmware.

Are you sure you wish to erase the existing firmware? (Y/N) Y <Enter>

Step 3. Type **Y** to erase the existing firmware and load new firmware. (To abort, type **N** or press <Enter>).

The relay responds with the following:

Erasing

Erase successful

Press any key to begin transfer, then start transfer at the PC <Enter>

Step 4. Press <Enter> to start the file transfer routine.

Step 5. Send new firmware to the relay.

- a. From the **Transfer** menu in **HyperTerminal**, choose **Send File** (Figure B.14).
- b. In the **Filename** text box, type the location and filename of the new firmware or use the **Browse** button to select the firmware file.

- c. In the **Protocol** text box, select **1K Xmodem** if this protocol is available.

If the computer does not have **1K Xmodem**, select **Xmodem**.

- d. Click **Send** to send the file containing the new firmware.

You should see a dialog box similar to *Figure B.14*. Incrementing numbers in the **Packet** box and a bar advancing from left to right in the **File** box indicate that a transfer is in progress.

Receiving software takes 10–15 minutes at 38400 bps, depending on the relay. 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.

After the transfer completes, the relay displays the following:

Upload completed successfully. Attempting a restart.

A successful restart sequence can take as long as two minutes, after which time the relay leaves SELBOOT. You will see no display on your PC to indicate a successful restart.

NOTE: Unsuccessful uploads can result from Xmodem time-out, a power failure, loss of communication between the relay and the computer, or voluntary cancellation. Check connections, reestablish communication, and start again at Step 2 on page B.11.

If you want to reload the previous firmware, begin at Step 2 on page B.11 and use the firmware you saved in E. Download Existing Firmware on page B.10. Contact the factory for assistance in achieving a successful firmware upgrade.

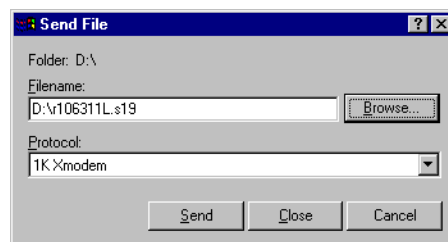


Figure B.14 Selecting New Firmware to Send to the Relay

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware. Upon power-up, the relay serial port will be at the default 2400 baud. Perform the steps beginning in B. Establish a Terminal Connection on page B.3 to increase the serial connection data speed. Then resume the firmware upgrade process at F. Upload New Firmware on page B.11.

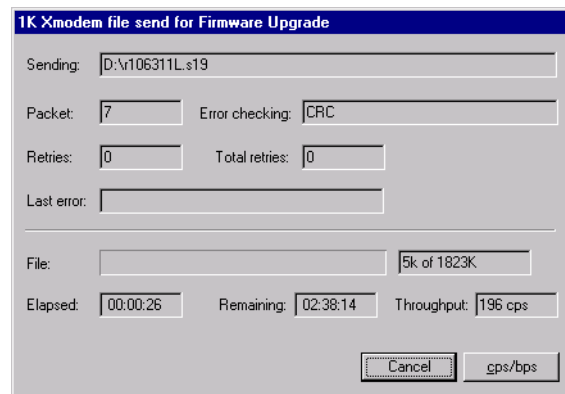


Figure B.15 Transferring New Firmware to the Relay

- Step 6. Press **<Enter>** and confirm that the Access Level 0 = prompt appears on the computer screen.
- Step 7. If you see the Access Level 0 = prompt, proceed to G. Check Relay Self-Tests on page B.13.

No Access Level 0 = Prompt

If no Access Level 0 = prompt appears in the terminal emulation window, one of three things could have occurred. Refer to *Table B.2* to determine the best solution.

Table B.2 Troubleshooting New Firmware Upload

Problem	Solution
The restart was successful, but the relay data transmission rate reverted to the rate at which the relay was operating prior to entering SELBOOT (the rate you recorded in <i>A. Prepare the Relay on page B.2</i>).	Change the computer terminal speed to match the relay data transmission rate you recorded in <i>A. Prepare the Relay on page B.2</i> (see <i>Match Computer Communications Speed to the Relay on page B.9</i>). Step 1. From the Call menu, choose Disconnect to terminate relay communication. Step 2. Change the communications software settings to the values you recorded in <i>A. Prepare the Relay on page B.2</i> . Step 3. From the Call menu, choose Connect to reestablish communication. Step 4. Press <Enter> to check for the Access Level 0 = prompt indicating that serial communication is successful. Step 5. If you get no response, proceed to <i>Match Computer Communications Speed to the Relay on page B.9</i> .
The restart was successful, but the relay data transmission rate reverted to 2400 bps (the settings have been reset to default).	Match the computer terminal speed to a relay data transmission rate of 2400 bps: Step 1. From the Call menu, choose Disconnect to terminate relay communication. Step 2. Change the communications software settings to 2400 bps, 8 data bits, no parity, and 1 stop bit (see <i>Match Computer Communications Speed to the Relay on page B.9</i>). Step 3. From the Call menu, choose Connect to reestablish communication. Step 4. Press <Enter> to check for the Access Level 0 = prompt indicating successful serial communication.
	If you see a SELBOOT !> prompt, type EXI <Enter> to exit SELBOOT. Check for the Access Level 0 = prompt. If you see the Access Level 0 = prompt, proceed to <i>G. Check Relay Self-Tests</i> .
The restart was unsuccessful, in which case the relay is in SELBOOT.	Reattempt to upload the new firmware (beginning at <i>Step 5</i> under <i>Establish a High-Speed Connection on page B.9</i>) or contact the factory for assistance.

G. Check Relay Self-Tests

The relay can display various self-test fail status messages. The troubleshooting procedures that follow depend upon the status message the relay displays.

Step 1. Type **ACC <Enter>**.

Step 2. Type the Access Level 1 password and press **<Enter>**.

You will see the Access Level 1 => prompt.

Step 3. Enter the **STATUS** command (**STA <Enter>**) to view relay status messages.

If the relay displays no fail status message, proceed to *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering on page B.15.*

IO_BRD Fail Status Message

Perform this procedure only if you have only an IO_BRD Fail Status message; for additional fail messages, proceed to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.15.*

Step 1. From Access Level 2, type **INI <Enter>** to reinitialize the I/O board(s). If this command is unavailable, go to *CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.15.*

The relay asks the following:

Are the new I/O board(s) correct (Y/N)?

- a. Type **Y <Enter>**.
- b. After a brief interval (as long as a minute), the **EN** LED will illuminate.
 If the **EN** LED does not illuminate and you see a SELBOOT !> prompt, type **EXI <Enter>** to exit SELBOOT. After a brief interval, the **EN** LED will illuminate. Check for Access Level 0 = prompt.
- c. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.
- d. Enter the **SHO n** command to view relay settings and verify that these match the settings you saved (see *Backup Relay Settings on page B.7*).

Step 2. If the settings do not match, reenter the settings you saved earlier.

- a. If you have the SEL-5010 or QuickSet, restore the original settings by following the instructions for the respective software.
- b. If you do not have the SEL-5010 or QuickSet, restore the original settings by issuing the necessary **SET n** commands, where **n** can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes in the relay).

Step 3. Use the **PAS** command to set the relay passwords.

For example, type **PAS 1<Enter>** to set the Access Level 1 password.

Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.

Step 4. Go to *H. Verify Settings, Calibration, Status, Breaker Wear, and Metering on page B.15.*

NOTE: Depending upon the relay, n can be 1–6, G, P, L, T, R, X, or Y.

CR_RAM, EEPROM, and IO_BRD Fail Status Messages

- Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.
- The factory-default passwords are in effect; use the default relay passwords listed in the **PAS** command description in the relay instruction manual.
- Step 2. Type **R_S <Enter>** to restore factory-default settings in the relay (type **R_S 1 <Enter>** for a 1 A SEL-387 or 1 A SEL-352 relay).
- The relay asks whether to restore default settings. If the relay does not accept the **R_S** (or **R_S 1**) command, contact your customer service representative or the factory for assistance.
- Step 3. 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.
- Step 4. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.
- Step 5. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.
- Step 6. Restore the original settings.
- If you have the SEL-5010 or QuickSet, restore the original settings by following the instructions for the respective software.
 - If you do not have the SEL-5010 or QuickSet, restore the original settings by issuing the necessary **SET n** commands, where *n* can be 1–6, G, P, L, T, R, X, or Y (depending upon the settings classes available in the relay).
- Step 7. Use the **PAS** command to set the relay passwords.
- For example, type **PAS 1 <Enter>** to set the Access Level 1 password.
- Use a similar format for other password levels. SEL relay passwords are case sensitive, so the relay treats lowercase and uppercase letters as different letters.
- Step 8. If any failure status messages still appear on the relay display, see *Section 10: Testing and Troubleshooting* or contact your customer service representative or the factory for assistance.

NOTE: If the relay prompts you to enter a part number, use either the number from the firmware envelope label or the number from the new part number sticker (if supplied).

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

- Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.
- Step 2. Use the **SHO** command to view the relay settings and verify that these match the settings you saved earlier (see *Backup Relay Settings on page B.7*).
- If the settings do not match, reenter the settings you saved earlier (see *Step 6 under CR_RAM, EEPROM, and IO_BRD Fail Status Messages on page B.15*).

Step 3. Type **SHO C** <Enter> to verify the relay calibration settings.

If the settings do not match the settings contained in the text file you recorded in *C. Save Settings and Other Data* on page B.6, contact your customer service representative or the factory for assistance.

Step 4. Use the firmware identification string (FID) to verify download of the correct firmware.

- a. From the **File** menu, choose **Properties**.
- b. Select the **Settings** tab in the **Firmware Upgrade Properties** dialog box (*Figure B.4*).
- c. Click **ASCII Setup**.

You should see a dialog box similar to *Figure B.16*.

- d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

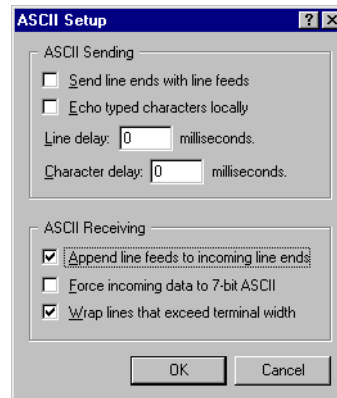


Figure B.16 Preparing HyperTerminal for ID Command Display

- e. Click **OK** twice to return to the terminal emulation window.
- f. Type **ID** <Enter> and compare the number the relay displays against the number from the firmware envelope label.
- g. If the label FID and part number match the relay display, proceed to *Step 5*.
- h. For a mismatch between a displayed FID or part number, and the firmware envelope label, reattempt the upgrade or contact the factory for assistance.

Step 5. Type **STA** <Enter> and verify that all relay self-test parameters are within tolerance.

Step 6. If you use the Breaker Wear Monitor, type **BRE** <Enter> 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 *C. Save Settings and Other Data* on page B.6.

Step 7. Apply current and voltage signals to the relay.

Step 8. Type **MET** <Enter> and verify that the current and voltage signals are correct.

- Step 9. Use the **TRIGGER** and **EVENT** 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 the Relay to Service

- Step 1. Follow your company procedures for returning a relay to service.
- Step 2. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay.

This step reestablishes automatic data collection between the SEL communications processor and the relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

The relay is now ready for your commissioning procedure.

Ethernet Card Firmware Upgrade Instructions

Introduction

NOTE: This section only applies to products equipped with an optional Ethernet port.

Perform the firmware upgrade process in the following sequence:

- A. Prepare the Relay*
- B. Establish an FTP Connection and Transfer New Firmware*
- C. Establish a Telnet Connection*
- D. Verify Firmware Transfer*
- E. Verify or Restart IEC 61850 Operation (Optional)*

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- FTP client software (may be included with the PC operating system)
- Disk containing the communications card firmware upgrade (.s19) file
- Firmware upgrade instructions (these instructions)

Upgrade Procedure

A. Prepare the Relay

- Step 1. If the relay is in use, follow your company practices for removing a relay from service. Typically, these include changing settings, or disconnecting external voltage sources or output contact wiring, to disable relay control functions.
- Step 2. Apply power to the relay.

- Step 3. Apply the following **PORT 1** setting and leave all others at default.

PROTO = TELNET

- Step 4. These instructions assume that the Ethernet port (**PORT 5**) settings are set as follows:

NOTE: Use IP settings (IPADDR, SUBNETM, DEFRTTR) that are compatible with your PC's network settings.

IPADDR = 10.201.0.213

SUBNETM = 255.255.0.0

DEFRTTR = 10.201.0.1

ETELNET = Y

TPORTC = 1024

EFTPSERV = Y

FTPUSER = 2AC

B. Establish an FTP Connection and Transfer New Firmware

The following instructions use the Microsoft Windows command line and FTP client to establish an FTP connection between a PC and the relay. Consult your operating system or FTP client manuals if your equipment or software differs. These instructions assume that both devices are on the same side of any firewalls.

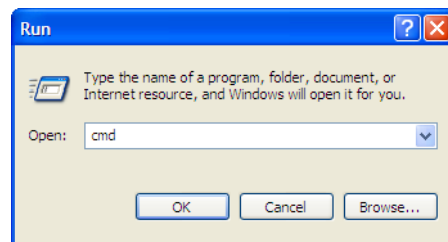
- Step 1. Connect an Ethernet cable from the relay Ethernet port to an Ethernet switch and another cable from the PC Ethernet port to the same Ethernet switch.

Alternatively, connect a crossover Ethernet cable between the relay Ethernet port (**PORT 5**) and the PC Ethernet port.

- Step 2. Copy the firmware upgrade file to the root directory of the PC's primary drive (usually C:\).

- Step 3. Open a Command Prompt window.

- Click **Start > Run**.
- Type **cmd** in the dialog box.
- Click **OK**.



- Step 4. In the Command Prompt window, set the current directory to the root of the primary drive (usually C:\).

- Type **C: <Enter>**.
- Type **cd \ <Enter>**.

- Step 5. In the Command Prompt window, type **FTP <IP Address> <Enter>** (substitute the IP address of the Ethernet port for **<IP Address>**, e.g., **FTP 10.201.0.213**).

- Step 6. When prompted, type the relay FTPUSER user name (the default user name is 2AC) and press **<Enter>**. After that, type the FTP user password (the default password is TAIL) and press **<Enter>**.
- Step 7. Set the FTP file transfer mode to Binary by typing **BIN <Enter>** at the FTP prompt.
- Step 8. Transfer the new firmware to the relay by typing **PUT C:\filename.s19 <Enter>** at the FTP prompt (substitute the firmware file name for *filename.s19*).
- Step 9. The FTP file transfer will begin immediately. As the transfer progresses, and upon completion, messages similar to the following will be displayed.
- ```
200 PORT Command okay.
150 File status okay; about to open data connection.
226 Closing data connection.
ftp: 2926780 bytes sent in 46.80 Seconds
62.54 Kbytes/sec.
```
- Step 10. Type **QUIT <Enter>** to exit the FTP session when the transfer is complete.
- Step 11. (Optional) Delete the firmware upgrade file from the root directory of the computer's primary drive by typing **DELETE C:\filename.s19 <Enter>** at the command prompt.

## C. Establish a Telnet Connection

To establish a Telnet-to-card connection, perform the following steps.

- Step 1. Click **Start > Run**.
- Step 2. Type **cmd <Enter>** to launch a Command Prompt window.
- Step 3. Type **Telnet <IP Address> port** at the prompt (e.g., **Telnet 10.201.0.213 1024**).
- Step 4. Press **<Enter>** several times until you see the **=** prompt.

## D. Verify Firmware Transfer

To verify the firmware transfer completed properly, perform the following steps after establishing a Telnet connection.

- Step 1. Issue a Status (**STA**) command.
- Step 2. Verify that the Status report does not include any warnings or failures.
- Step 3. Verify that the Status report includes `Device Enabled` at the end of the report.
- Step 4. Verify that the Status report FID matches the FID of the firmware you transferred.

## E. Verify or Restart IEC 61850 Operation (Optional)

SEL-300 series relays with optional IEC 61850 protocol require the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new Ethernet card firmware does not support the current

CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after an Ethernet card firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the Ethernet card firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet card (see *B. Establish an FTP Connection and Transfer New Firmware on page B.18*).

Step 2. Open the ERR.TXT file for reading.

If the ERR.TXT file contains error messages relating to CID file parsing, this indicates that the relay has disabled the IEC 61850 protocol. If this file is empty, the relay found no errors during CID file processing and IEC 61850 should remain enabled. Skip to *Step 3* if ERR.TXT is empty.

If the IEC 61850 protocol has been disabled because of an upgrade-induced CID file incompatibility, you can use ACSELERATOR Architect® SEL-5032 Software to convert the existing CID file and make it compatible again.

- a. Install the Architect software upgrade that supports your required CID file version.
- b. Run Architect and open the project that contains the existing CID file for the relay.
- c. Download the CID file to the relay.

Upon connecting to the relay, Architect will detect the upgraded Ethernet card firmware and prompt you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 3. In the Telnet session, type **GOO <Enter>**.

Step 4. View the GOOSE status and verify that the transmitted and received messages are as expected.

If you are upgrading both relay firmware and Ethernet card firmware, return to *Upgrade Procedure on page B.2*.

## Technical Support

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We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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# Appendix C

## SEL Distributed Port Switch Protocol (LMD)

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### Overview

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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

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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

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**NOTE:** You can use the front-panel **{SET}** pushbutton to change the port settings to return to SEL protocol.

- Step 1. The relay ignores all input from this port until it detects the prefix character and the two-byte address.
- Step 2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
- Step 3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.
- Step 4. Until the relay connection terminates, you can use the standard commands that are available when PROTO is set to SEL.
- Step 5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port timeout period, it automatically terminates the connection.
- Step 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.



# Appendix D

## Configuration, Fast Meter, and Fast Operate Commands

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### Overview

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SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

*SEL Application Guide AG95-10, Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-387 Relay.

### Message Lists

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**Table D.1 Binary Message List (Sheet 1 of 2)**

| 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            |

**Table D.1 Binary Message List (Sheet 2 of 2)**

| Request to Relay (hex) | Response From Relay          |
|------------------------|------------------------------|
| A5E3                   | Fast Operate Breaker Control |
| A5ED                   | Fast Operate Reset Command   |
| A546                   | Temperature Data Block       |

**Table D.2 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 Request

In response to the A5C0 request, the relay sends the following block.

**Table D.3 A5C0 Relay Definition Block (Sheet 1 of 2)**

| Data                     | Description                                                          |
|--------------------------|----------------------------------------------------------------------|
| A5C0                     | Command                                                              |
| 40                       | Message length (64 bytes)                                            |
| 42                       | Message length (66 bytes (DNP versions only))                        |
| xx                       | Non-DNP versions = 02                                                |
| xx                       | DNP versions = 03                                                    |
| 03                       | Support Fast Meter, fast demand, and fast peak                       |
| 05                       | Status flag commands supported: Warn, Fail, Group or Settings change |
| A5C1                     | Fast meter configuration                                             |
| A5D1                     | Fast meter message                                                   |
| A5C2                     | Fast demand configuration                                            |
| A5D2                     | Fast demand message                                                  |
| A5C3                     | Fast peak configuration                                              |
| A5D3                     | Fast peak message                                                    |
| 0002                     | Self-test warning bit                                                |
| 5354410D0000 (STA<CR>)   | Check status                                                         |
| 0003                     | Self-test failure bit                                                |
| 5354410D0000 (STA<CR>)   | Check status                                                         |
| 0004                     | Settings change bit                                                  |
| A5C100000000             | Reconfigure Fast Meter on settings change                            |
| 0004                     | Settings change bit                                                  |
| 53484F0D0000 (SHO<CR>)   | Check the settings                                                   |
| 0004                     |                                                                      |
| 53484F20470D (SHO G<CR>) | Check the Global settings                                            |

**Table D.3 A5CO Relay Definition Block (Sheet 2 of 2)**

| Data | Description                                                                                  |
|------|----------------------------------------------------------------------------------------------|
| xxxx | SEL protocol, (SEL-387-0 = 0100 Fast Meter, SEL-5, SEL-6 = 0300 Fast Meter and Fast Message) |
| xxxx | LMD protocol, (SEL-387-0 = 0101 Fast Meter, SEL-5, SEL-6 = 0301 Fast Meter and Fast Message) |
| 0005 | DNP protocol (DNP versions only)                                                             |
| 00   | Reserved                                                                                     |
| xx   | Checksum                                                                                     |

## A5C1 Request

In response to the A5C1 request, the relay sends the following block.

**Table D.4 A5C1 Fast Meter Configuration Block (Sheet 1 of 4)**

| 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                  |
| 3F                  | # digital banks (63 bytes)             |
| 04                  | # calculation blocks                   |
| 0004                | Analog channel data offset             |
| 0038                | Time stamp offset (52) bytes           |
| 0040                | Digital data offset (60) 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) |                                        |

**Table D.4 A5C1 Fast Meter Configuration Block (Sheet 2 of 4)**

| Data                | Description                                                             |
|---------------------|-------------------------------------------------------------------------|
| 00                  | (Winding 3)                                                             |
| 01                  |                                                                         |
| 00CE                |                                                                         |
| 494357320000 (ICW2) |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00CE                |                                                                         |
| 494157330000 (IAW3) |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00D2                |                                                                         |
| 494257330000 (IBW3) |                                                                         |
| 00                  | (Winding 4)                                                             |
| 01                  |                                                                         |
| 00D2                |                                                                         |
| 494357330000 (ICW3) |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00D2                |                                                                         |
| 494157340000 (IAW4) |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00D6                |                                                                         |
| 494257340000 (IBW4) |                                                                         |
| 00                  | (Winding 5)                                                             |
| 01                  |                                                                         |
| 00D6                |                                                                         |
| 494357340000 (ICW4) |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00D6                |                                                                         |
| 564443000000 (VDC)  |                                                                         |
| 00                  |                                                                         |
| 01                  |                                                                         |
| 00DA                |                                                                         |
| xx                  |                                                                         |
| 03                  | Connection byte—Based on PHROT and W1CT settings (Calculation block #1) |
| FFFF                | Current calculation only                                                |
| FFFF                | No skew adjustment                                                      |
| FFFF                | No RS offset                                                            |
| FFFF                | No XS offset                                                            |

**Table D.4 A5C1 Fast Meter Configuration Block (Sheet 3 of 4)**

| <b>Data</b> | <b>Description</b>                                                         |
|-------------|----------------------------------------------------------------------------|
| 00          | IAW1                                                                       |
| 01          | IBW1                                                                       |
| 02          | ICW1                                                                       |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| xx          | Connection byte–Based on PHROT and W2CT settings<br>(Calculation block #2) |
| 03          | Current calculation only                                                   |
| FFFF        | No skew adjustment                                                         |
| FFFF        | No RS offset                                                               |
| FFFF        | No XS offset                                                               |
| 03          | IAW2                                                                       |
| 04          | IBW2                                                                       |
| 05          | ICW2                                                                       |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| xx          | Connection byte–Based on PHROT and W3CT settings<br>(Calculation block #3) |
| 03          | Current calculation only                                                   |
| FFFF        | No skew adjustment                                                         |
| FFFF        | No RS offset                                                               |
| FFFF        | No XS offset                                                               |
| 06          | IAW3                                                                       |
| 07          | IBW3                                                                       |
| 08          | ICW3                                                                       |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| xx          | Connection byte–Based on PHROT and W4CT settings<br>(Calculation block #4) |
| 03          | Current calculation only                                                   |
| FFFF        | No skew adjustment                                                         |
| FFFF        | No RS offset                                                               |
| FFFF        | No XS offset                                                               |
| 09          | IAW4                                                                       |
| 0A          | IBW4                                                                       |
| 0B          | ICW4                                                                       |
| FF          | NA                                                                         |
| FF          | NA                                                                         |
| FF          | NA                                                                         |

**Table D.4 A5C1 Fast Meter Configuration Block (Sheet 4 of 4)**

| Data     | Description                                |
|----------|--------------------------------------------|
| xxxxxxx  | Scale factor (200 * Inom) * CTR1 Winding 1 |
| xxxxxxx  | Scale factor (200 * Inom) * CTR2 Winding 2 |
| xxxxxxx  | Scale factor (200 * Inom) * CTR3 Winding 3 |
| xxxxxxx  | Scale factor (200 * Inom) * CTR4 Winding 4 |
| 3C23D70A | Scale factor (1/100)                       |
| 00       | Reserved                                   |
| xx       | Checksum                                   |

## A5D1 Request

In response to the A5D1 request, the relay sends the following block.

**Table D.5 A5D1 Fast Meter Data Block**

| Data     | Description                                                                                                                                               |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| A5D1     | Command                                                                                                                                                   |
| 80       | Message length (128 bytes)                                                                                                                                |
| xx       | Status byte<br>Bit: 2; Usage: Self-test warning<br>Bit: 3; Usage: Self-test warning<br>Bit: 4; Usage: Settings change                                     |
| 52 bytes | Integers for the following: IAW1, IBW1, ICW1, IAW2, IBW2, ICW2, IAW3, IBW3, ICW3, IAW4, IBW4, ICW4, VDC (Imaginary values first, followed by Real values. |
| 8 bytes  | Time stamp                                                                                                                                                |
| 63 bytes | Digital banks—targets 0-62                                                                                                                                |
| xx       | Checksum                                                                                                                                                  |

**NOTE:** The Imaginary value for VDC is always zero.

## A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the SEL-387 clears the Settings change (STSET) bit in the Status Byte of the Fast Meter messages (A5D1, A5D2, and A5D3). The bit is set when the relay turns on 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/A5CE Demand/Peak Demand

In response to the A5C2 or A5C3 request, the relay sends the following block.

**Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 1 of 4)**

| Data         | Description                                  |
|--------------|----------------------------------------------|
| A5C2 or A5C3 | Command; Demand (A5C2) or Peak Demand (A5C3) |
| DA           | Message length (218 bytes)                   |
| 00           | No status byte                               |
| 01           | Scale factors in Fast Meter configuration    |
| 00           | No scale factors used                        |
| 14           | 20 analog input channels                     |
| 01           | One sample per channel                       |

**Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 2 of 4)**

| <b>Data</b>          | <b>Description</b>                            |
|----------------------|-----------------------------------------------|
| 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                   |                                               |

**Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 3 of 4)**

| Data                 | Description |
|----------------------|-------------|
| 0000                 |             |
| 495257320000 (IRW2)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494157330000 (IAW3)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494257330000 (IBW3)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494357330000 (ICW3)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 334932573300 (3I2W3) |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 495257330000 (IRW3)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494157340000 (IAW4)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494257340000 (IBW4)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 494357340000 (ICW4)  |             |
| 02                   |             |
| FF                   |             |
| 0000                 |             |
| 334932573400 (3I2W4) |             |
| 02                   |             |
| FF                   |             |



**Table D.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages (Sheet 4 of 4)**

| Data                | Description |
|---------------------|-------------|
| 0000                |             |
| 495257340000 (IRW4) |             |
| 02                  |             |
| FF                  |             |
| 0000                |             |
| 00                  | Reserved    |
| xx                  | Checksum    |

## A5D2/A5D3 Demand/ Peak Demand

In response to the A5D2 or A5D3 request, the relay sends the following block.

**Table D.7 A5D2/A5D3 Demand/Peak Demand Fast Meter Message**

| Data         | Description                                                                         |
|--------------|-------------------------------------------------------------------------------------|
| A5D2 or A5D3 | Command                                                                             |
| A6           | Message length (166 bytes)                                                          |
| 00           | Reserved                                                                            |
| 160 bytes    | Demand meter values in double floats in the same order as channel listings in A5C2. |
| 00           | Reserved                                                                            |
| xx           | Checksum                                                                            |

## A5CE Fast Operate

In response to the A5CE request, the relay sends the following block.

**Table D.8 A5CE Fast Operate Configuration Block (Sheet 1 of 3)**

| Data | Description                  |
|------|------------------------------|
| A5CE | Command                      |
| 42   | Message length, #bytes (66)  |
| 04   | # circuit breakers supported |
| 0010 | 16 remote bits               |
| 01   | Remote bit pulse supported   |
| 00   | Reserved                     |
| 31   | Open breaker 1               |
| 11   | Close breaker 1              |
| 32   | Open breaker 2               |
| 12   | Close breaker 2              |
| 33   | Open breaker 3               |
| 13   | Close breaker 3              |
| 34   | Open breaker 4               |
| 14   | Close breaker 4              |
| 00   | Clear remote bit RB1         |
| 20   | Set remote bit RB1           |
| 40   | Pulse remote bit RB1         |

**Table D.8 A5CE Fast Operate Configuration Block (Sheet 2 of 3)**

| Data | Description           |
|------|-----------------------|
| 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   |

**Table D.8 A5CE Fast Operate Configuration Block (Sheet 3 of 3)**

| Data | Description           |
|------|-----------------------|
| 4E   | Pulse remote bit RB15 |
| 0F   | Clear remote bit RB16 |
| 2F   | Set remote bit RB16   |
| 4F   | Pulse remote bit RB16 |
| 00   | Reserved pad          |
| xx   | Checksum              |

## A5E0 Fast Operate

The external device sends the following message to perform a remote bit operation (set, clear, pulse).

**Table D.9 A5E0 Fast Operate Remote Bit Control**

| Data | Description                                                         |
|------|---------------------------------------------------------------------|
| A5E0 | Command                                                             |
| 06   | Message length                                                      |
| xx   | Operate code (0-F, 20-2F, 40-4F for remote bit clear, set or pulse) |
| xx   | Operate validation: $4 * \text{operate code} + 1$                   |
| xx   | Checksum                                                            |

Remote bit set and clear operations are latched by the relay. Remote bit pulse operations assert the remote bit for one processing interval.

## A5E3 Fast Operate

The external device sends the following message to perform a fast breaker open/close of breakers 1 through 4.

**Table D.10 A5E3 Fast Operate Breaker Control**

| Data | Description                                                         |
|------|---------------------------------------------------------------------|
| A5E3 | Command                                                             |
| 06   | Message length                                                      |
| xx   | Operate code (hex 31-34 open, hex 11-14 close breakers 1 through 4) |
| xx   | Operate validation: $4 * \text{operate code} + 1$                   |
| xx   | Checksum                                                            |

## A5CD Fast Operate

In response to an A5CD request, the relay sends the configuration block for the Fast Operate Reset message.

**Table D.11 A5CD Fast Operate Reset Definition Block**

| Data | Description                                           |
|------|-------------------------------------------------------|
| A5CD | Command                                               |
| 0E   | Message length                                        |
| 01   | The number of Fast Operate reset codes supported      |
| 00   | Reserved for future use                               |
|      | Per Fast Operate reset code, repeat:                  |
| 00   | Fast Operate reset code (e.g., "00" for target reset) |

**Table D.11 A5CD Fast Operate Reset Definition Block**

| Data           | Description                                           |
|----------------|-------------------------------------------------------|
| 54415220520000 | Fast Operate reset description string (e.g., "TAR R") |
| xx             | Checksum                                              |

## A5ED Fast Operate

The Fast Operate Reset commands take the following form.

**Table D.12 A5ED Fast Operate Reset Command**

| Data | Description                                         |
|------|-----------------------------------------------------|
| A5ED | Command                                             |
| 06   | Message Length—always 6                             |
| 00   | Operate Code (e.g., "00" for target reset, "TAR R") |
| 01   | Operate Validation—(4 + Operate Code) + 1           |
| xx   | Checksum                                            |

## A546 Temperature

The SEL-387 understands the contents of the following binary data packet from an external SEL-2600A RTD module.

**Table D.13 A546 Temperature Data Block (SEL-387-5 and SEL-387-6)**

| Data          | Description                                                                                                                                                                                                                                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0xA546        | Header code to flag the beginning of message                                                                                                                                                                                                                                                                                                                      |
| 74h           | Message length (116 bytes)                                                                                                                                                                                                                                                                                                                                        |
| 0000000000h   | Routing value: 0 for point-to-point communication                                                                                                                                                                                                                                                                                                                 |
| 00h           | Status byte                                                                                                                                                                                                                                                                                                                                                       |
| 12h           | Function code: unsolicited read response                                                                                                                                                                                                                                                                                                                          |
| 00h           | Sequence byte                                                                                                                                                                                                                                                                                                                                                     |
| 00h           | Pad byte                                                                                                                                                                                                                                                                                                                                                          |
| xxxxxxx       | Internal time since the relay turned on or rollover at 86400000 milli-seconds                                                                                                                                                                                                                                                                                     |
| xxxx          | External RTD Unit Status: Bit 0 indicates the state of the external RTD power supply (0 = good, 1 = fail). Bit 1 indicates the state of the external RTD RAM (0 = good, 1 = fail). Bits 2–14 are 0. Bit 15 indicates the state of the external RTD's digital input (0 = deasserted, 1 = asserted).                                                                |
| xxxx * 4 * 12 | Temperature Data (°C) in 12 data sets of 4 words.<br>Word One-16 bit representation of a PT100 RTD.<br>Word Two-16 bit representation of a NI100 RTD.<br>Word Three-16 bit representation of a NI120 RTD.<br>Word Three-16 bit representation of a CU10 RTD.<br>This set is repeated 12 times.<br>Open / Shorted RTDs are processed by the RTD diagnostic module. |
| yyyy          | CRC-16 Block Check Code.                                                                                                                                                                                                                                                                                                                                          |

## ID Command

In response to the **ID** command, the relay sends the firmware ID, the relay TID setting, and the Modbus® device code, as described below.

---

```

<STX> (STX character, 02)
"FID STRING ENCLOSED IN QUOTES","yyyy"<CR>
"ID SETTING ENCLOSED IN QUOTES","yyyy"<CR>
32,"yyyy"<CR>
<ETX> (ETX character, 03)

```

---

where:

yyyy = the 4-byte ASCII representation of the hex checksum for the line

32 = the device code used by the SEL-2030 to identify the relay to Modbus users.

## DNA Command

In response to the **DNA** command, the relay sends names of the Relay Word bits, as described below:

---

```

<STX> (STX character, 02)
"xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","xxxxxx","yyyy"<CR>
... (49 more [50 more for SEL-387-6 Relay], where xxxxxx is a relay word element
 name)
<ETX> (ETX character, 03)

```

---

where:

xxxxxx = 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 = 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 = the 4-byte ASCII representation of the hex checksum for the line.

The bits named are defined as follows:

- **STSET** Set when a power-up or settings change has occurred. It is cleared by the A5B9 request (see earlier in this Appendix).
- **STFAIL** One or more of the monitored status quantities is in a FAIL state.
- **STWARN** One or more of the monitored status quantities is in a WARN state.

## SNS Message

In response to the **SNS** command, the relay sends the name string of the SER (SER1, SER2, SER3, and SER4) settings. **SNS** command is available at Access Level 1.

The relay responds to the **SNS** command with the name string in the SER settings. The name string starts with SER1, followed by SER2, SER3, and SER4.

For example: If SER1 = 50P11 OUT101; SER2 = 87U1 32IF; SER3 = OUT102 52A, SER4 = 0; the name string will be "50P11","OUT101","87U1"," 32IF","OUT102","52A".

If there are more than eight settings in SER, the SNS message will have several rows. Each row will have eight strings, followed by the checksum and carriage return. The last row may have less than eight strings.

The ALIAS settings are ignored for the **SNS** command (i.e., if ALIAS1 = OUT101 CL\_BKR\_1, SNS includes “OUT101”, not the custom label). Refer to *Settings in Section 6: Setting the Relay*.

SNS message for the SEL-387-5 is:

---

```
<STX>"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","yyyy"<CR>
"xxxx","xxxx","xxxx",<CR><ETX>
```

---

where:

xxxx = a string from the settings in SER (SER1, SER2, SER3, and SER4).

yyyy = the 4-byte ASCII representation of the checksum.

# Appendix E

## Compressed ASCII Commands

### Overview

The SEL-387 Relay provides Compressed ASCII versions of some of the relay ASCII commands. The Compressed ASCII commands allow an external device to obtain data from the relay, in a format that directly imports into spreadsheets or database programs and that can be validated with a checksum.

Refer to *Table E.1* for the Compressed ASCII Commands of the SEL-387.

**NOTE:** The bold portion of each command appearing in Table E.1 is the abbreviated command. You only need to key the abbreviated command.

**Table E.1 SEL-387 Compressed ASCII Commands**

| Command             | Description                         |
|---------------------|-------------------------------------|
| CASCII              | Configuration message               |
| CBREAKER            | Breaker report                      |
| CEVENT              | Event report (Winding)              |
| CEVENT <b>DIF</b>   | Event report (Differential)         |
| CHISTORY            | History report                      |
| CSTATUS             | Status report                       |
| CTARGET             | Target display                      |
| CTHERMAL            | Thermal report                      |
| CTHERMAL <b>D 1</b> | Transformer 1 daily thermal report  |
| CTHERMAL <b>D 2</b> | Transformer 2 daily thermal report  |
| CTHERMAL <b>D 3</b> | Transformer 3 daily thermal report  |
| CTHERMAL <b>H 1</b> | Transformer 1 hourly thermal report |
| CTHERMAL <b>H 2</b> | Transformer 2 hourly thermal report |
| CTHERMAL <b>H 3</b> | Transformer 3 hourly thermal report |
| CTHERMAL <b>T</b>   | RTD input report                    |

# CASCI 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",11,"yyyy" <CR>
"#H","xxxxx","xxxxx",.....,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
"COMMAND 2",11,"yyyy" <CR>
"#h","ddd","ddd",.....,"ddd","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR>
.
.
.
"COMMAND n",11,"yyyy" <CR>
"#H","xxxxx","xxxxx",.....,"xxxxx","yyyy" <CR>
"#D","ddd","ddd","ddd","ddd",.....,"ddd","yyyy" <CR><ETX>
```

where:

- n = the number of Compressed ASCII command descriptions to follow.
- COMMAND = 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.
- 11 = 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 = 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 = 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>
```

## SEL-387-0, -5 Relay

## CASCI Command

Display the SEL-387 Compressed ASCII configuration message by sending:

**CAS <Enter>**

The SEL-387-5 sends (the SEL-387-0 sends a similar response):

[illegible]

(Continued on next page)

**NOTE:** If the analog current input names (**I<sub>AW1</sub>**, etc.) have been changed via the Analog Input Labels Global settings, they will appear in the above report as set.

(Continued from previous page)

where:

yyyy = 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-character 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>
```

## CBREAKER Command

Display the SEL-387 Compressed ASCII breaker report by sending:

**CBR <Enter>**

The relay sends:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXXXX-DXXXXXXXXX","yyyy"<CR>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
"BREAKER", "INT_TRIPS", "IAW", "IBW", "ICW", "EXT_TRIPS", "IAW", "IBW", "ICW",
"POLE1", "POLE2", "POLE3", "MONTH", "DAY", "YEAR", "HOUR", "MIN", "SEC", "MSEC",
"yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx,
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx,
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx,
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx,
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
<ETX>
```

where: The data are a summation of breaker information collected since the last summary clear.  
 xxxx = are the data values corresponding to the first line labels.  
 yyyy = 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:

**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.

Report Types:	Description
<b>DIF</b>	Display differential information for all the elements.
<b>R</b>	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:	Description
<b>n</b>	Event number Default to 1
<b>Sx</b>	Samples per cycle x = 4 or 8 (See "R" option) Default to 4 if Sx not specified
<b>Ly</b>	Display first y cycles of event report y = 1 – LER Default to L15 if Ly not specified
<b>Ly-</b>	Displays event report from cycle y to end of report
<b>Ly-w</b>	Displays event report from cycle y to cycle w
<b>C</b>	Default to 8 samples/cycle (same as EVE C)

## CEVENT Winding Report (Default)

**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 two front-panel rows.

If **DIF** is not specified in the command line, the default report is the winding currents report. To obtain a report, send the following:

**CEV <Enter>**

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxx","yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS"<CR>
... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>
```

**NOTE:** 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.

where:

xxxx = are the data values corresponding to the first line labels.  
yyyy = the 4-byte ASCII representation of the hex checksum for the line.

z = ">" 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.

## CEVENT Differential Report

**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 two front-panel rows.

If **DIF** is specified in the command line, the report on differential element quantities is provided. To obtain the report, send the following:

**CEV DIF <Enter>**

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IOP1","IRT1","I1F2","I1F5"
"IOP2","IRT2","I2F2","I2F5","IOP3","IRT3","I3F2","I3F5",
"TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS","yyyy"
<CR> ... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","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.

z = ">" to mark where the event was triggered, "\*" to mark the maximum current for the event, with the "\*" overriding the ">".

RLY\_BITS = relay element data, in hex ASCII, corresponding to the DIGITAL\_ELEMENT\_NAMES

SETTINGS = text refers to the current settings of the relay as described in the event report section.

## CHISTORY Command

Display the SEL-387 Compressed ASCII history report by sending:

**CHI <Enter>**

or display the last *n* items in the SEL-387 Compressed ASCII history report by sending:

**CHI *n* <Enter>**

The relay responds to the **CHI <Enter>** command by sending the following:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"GROUP", "TARGETS", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,"xxxx", "yyyy"<CR>
... (continue previous line until all events are listed -- max 80)
<ETX>
```

where: The data are a list of all events since the last history clear.

xxxx = the data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CSTATUS Command

Display the SEL-387 Compressed ASCII status report by sending:

**CST <Enter>**

The relay sends:

**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.

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS",
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xx
xx", "xxxx", "xxxx", "yyyy"<CR>
<ETX>
```

where:

xxxx = the data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CTARGET Command

Display the SEL-387 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.

```
<STX>
"LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","LLLL","yyyy"<CR>
x,x,x,x,x,x,x,x,x,"yyyy"<CR>
<FTX>
```

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CASCI Command

**CAS <Enter>**

[illegible]

(Continued on next page)

<ETX>





The command parameters, all optional, can be entered in any order. They are:

Report Types:	Description
<b>DIF</b>	Display differential information for the all elements.
<b>R</b>	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

**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.

Report Options:	Description
<b>n</b>	Event number Default to 1
<b>Sx</b>	Samples per cycle x = 4 or 8 (See “R” option) Default to 4 if Sx not specified
<b>Ly</b>	Display first y cycles of event report y = 1 – LER Default to L15 if Ly not specified
<b>Ly–</b>	Displays event report from cycle y to end of report
<b>Ly–w</b>	Displays event report from cycle y to cycle w
<b>C</b>	Default to 8 samples/cycle (same as <b>EVE C</b> )

## CEVENT Winding Report (Default)

**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 two front-panel rows.

**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.

If **DIF** is not specified in the command line, the default report is the winding currents report. To obtain a report, send the following:

**CEV <Enter>**

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","VDC","TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"z","RLY_BITS"<CR>
... (previous line repeated for SAM/CYC_A*NUM_OF_CYC)
"SETTINGS","yyyy"<CR>
"SETTINGS text","yyyy"<CR>
<ETX>
```

where:

xxxx = are the data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

z = “>” 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.

## CEVENT Differential Report

**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 two front-panel rows.

If **DIF** is specified in the command line, the report on differential element quantities is provided. To obtain the report, send the following:

**CEV DIF <Enter>**

The relay responds:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-D","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"FREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","EVENT","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,"xxxx","yyyy"<CR>
"IOP1","IRT1","IIF2","IIF5",
 "IOP2","IRT2","I2F2","I2F5","IOP3","IRT3","I3F2","I3F5",
 "TRIG","DIGITAL_ELEMENT_NAMES","yyyy"<CR>
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>
```

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 = ">" to mark where the event was triggered, "\*" to mark the maximum current for the event, with the "\*" overriding the ">"

RLY\_BITS = relay element data, in hex ASCII, corresponding to the DIGITAL\_ELEMENT\_NAMES

SETTINGS = text refers to the current settings of the relay as described in the event report section.

## CHISTORY Command

Display the SEL-387 Compressed ASCII history report by sending:

**CHI <Enter>**

or display the last *n* items in the SEL-387 Compressed ASCII history report by sending:

**CHI *n* <Enter>**

The relay responds to the **CHI <Enter>** command by sending the following:

```
<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"GROUP","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxx",xxxx,"xxxx","yyyy"<CR>
... (continue previous line until all events are listed -- max 80)
<ETX>
```

where: the data consists of a list of all events since the last history clear.

xxxx = the data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CSTATUS Command

Display the SEL-387 Compressed ASCII status report by sending:

**CST <Enter>**

The relay sends:

**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.

```

<STX>
"FID","yyyy"<CR>
"FID=SEL-387-XXXX-V0-ZXXXXXX-DXXXXXXXXX","yyyy"<CR>
"MONTH_","DAY_","YEAR_","HOUR_","MIN_","SEC_","MSEC_","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"yyyy"<CR>
"IAW1","IBW1","ICW1","IAW2","IBW2","ICW2","IAW3","IBW3","ICW3","IAW4",
"IBW4","ICW4","+5V_PS","+5V_REG","-5V_REG","+12V_PS","-12V_PS","+15V_PS",
"-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM","IO_BRD","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx",
"xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xxxx","xx
xx", "xxxx","xxxx","yyyy"<CR>
<ETX>

```

where:

xxxx = the data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CTARGET Command

Display the SEL-387 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 = the labels for the given target.

x = 0 or 1 corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the hex checksum for the line.

## CTH Thermal Report Command

Display the following thermal reports in Compressed ASCII format by sending:

**CTH [H D T] [phase] <Enter>**

Report Types:	Description
(Default)	Display all archived thermal event reports.
H	Display all archived hourly profile data for specified phase ([phase] option)
D	Display all archived daily profile data for specified phase ([phase] option)
T	Display Temperature input data

Report Options:	(only for H and D report types)
Phase:	Phase A, B or C.

## CTH Event Report

If no parameters are specified on the command line, all archived thermal event reports are displayed. To obtain thermal event reports, send the following:

---

```
CTH <Enter>
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
"Event#", "Phase", "MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "Load Cond", "Cool
Sys", "Load", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot",
"FAA", "RLOL", "TLOL", "TLL", "yyyy" <CR>
x, x, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "xxxxxx", "xxxxxxxxxx", xxxx, xxxx, xxxx, xxxx, xxx
x, xxxx, xxxx, xxxx, "yyyy" <CR>
...(previous line repeated until all archived events are listed)
<ETX>
```

---

If no data are available, the relay replies:

---

```
"No Data Available", "0668" <CR>
```

---

where:

xxxx = data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the checksum for the line.

## CTH Daily Profile Data Report

If **D** is specified in the command line, the report on daily profile data is provided. To obtain the report for Phase A, send the following:

**CTH D 1 <Enter>**

---

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

---

To obtain the report for Phase B, send the following:

**CTH D 2 <Enter>**

---

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

---

To obtain the report for Phase C, send the following:

**CTH D 3 <Enter>**

---

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
"MONTH_", "DAY_", "YEAR_", "Ambient", "Calc TopOil", "Msrd TopOil", "Hot Spot", "Load",
"Max FAA", "RLOL", "TLOL", "yyyy" <CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy" <CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

---

If no data are available, the relay replies:

"No Data Available", "0668"<CR>

where:

xxxx = data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the checksum for the line.

## CTH Hourly Profile Data Report

If **H** is specified in the command line, the report on hourly profile data is provided. To obtain the report for Phase A, send the following:

**CTH H 1 <Enter>**

```
<STXT>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "CommError", "Ambient", "Calc TopOil", "Msrdr
TopOil", "Hot Spot", "Load", "FAA", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, "x", xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETXT>
```

To obtain the report for Phase B, send the following:

**CTH H 2 <Enter>**

```
<CTX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "CommError", "Ambient", "Calc TopOil", "Msrdr
TopOil", "Hot Spot", "Load", "FAA",
, "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, "x", xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<CTX>
```

To obtain the report for Phase C, send the following:

CTH H 3 <Enter>

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "ComError", "Ambient", "Calc TopOil", "Msrd
TopOil", "Hot Spot", "Load", "FAA", "yyyy"<CR>
xxxx, xxxx, xxxx, xxxx, xxxx, "x", xxxx, xxxx, xxxx, xxxx, xxxx, xxxx, "yyyy"<CR>
...(previous line repeated until all archive data is listed)
<ETX>
```

If no data are available, the relay replies:

```
"No Data Available", "0668"<CR>
```

where:

xxxx = data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the checksum for the line.

## CTH Temperature Input Data Report

```
<STX>
"MONTH_", "DAY_", "YEAR_", "HOUR_", "MIN_", "SEC_", "MSEC_", "yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxx,xxxx,"yyyy"<CR>
"Input#", "Temp", "yyyy"<CR>
xxxx,xxxx,"yyyy"<CR>
...(previous line repeated for each input available)
<ETX>
```

If no data are available the relay replies:

---

```
"No Data Available","0668"<CR>
```

---

where:

xxxx = data values corresponding to the first line labels.

yyyy = the 4-byte ASCII representation of the checksum for the line

# Appendix F

## Unsolicited SER Protocol

---

### Overview

---

**NOTE:** The SEL-387-0 Relay does not include this feature.

This appendix describes special binary Sequential Events Recorder (SER) messages that are not included in *Section 9: Event Reports and SER* of the instruction manual. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from the SEL-387.

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.

**NOTE:** Make Sequential Events Recorder (SER) Settings With Care

The relay triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, SER3, or SER4 trigger settings. Nonvolatile memory stores the latest 512 rows of the SER event report so they can be retained during power loss. The nonvolatile memory stores a finite number of "writes." Exceeding the limit can result in an EEPROM self-test failure. **An average of 1 state change every 3 minutes can be made for a 25-year relay service life.**

This mechanism allows use of a single communications channel for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data. To exploit this feature, the device at the other end of the link requires software that uses the separate data streams. A device that does not interleave the data streams can also access the binary commands and ASCII commands.

### Recommended Message Usage

---

Use the following sequence of commands to enable unsolicited binary SER messaging in the SEL-387:

- Step 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.
  - a. Send the "Enable Unsolicited Data Transfer" message to enable the SEL-387 to transmit unsolicited binary SER messages.
- Step 2. When SER records are triggered in the SEL-387, the relay responds with an unsolicited binary SER message. If this message has a valid checksum, it must be acknowledged by sending an acknowledge message with the same response number as that contained in the original message. The relay

will wait about 100 ms to 500 ms to receive an acknowledge message, at which time the relay will resend the same unsolicited SER message with the same response number.

- Step 3. Upon receiving an acknowledge message with a matching response number, the relay increments the response number and continues to send and seek acknowledgment for unsolicited SER messages, if additional SER records are available. When the response number reaches three, it wraps around to zero on the next increment.

## Functions and Function Codes

In the messages shown below, all numbers are in hexadecimal unless otherwise noted.

### 0x01—Function Code: Enable Unsolicited Data Transfer

Upon power-up, the SEL-387 disables its own unsolicited transmissions. This function enables the SEL-387 to begin sending unsolicited data to the device that sent the enable message, if the SEL-387 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-387 verifies the message by checking the header, length, function code, and enabled function code against the expected values. It also checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to enable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

The “nn” field is used to set the maximum number of SER records per message. The relay checks for SER records approximately every 500 ms. If there are new records available, the relay immediately creates a new unsolicited SER message and transmits it. If there are more than “nn” new records available, or if the first and last records are separated by more than 16 seconds, the relay will break the transmission into multiple messages so that no message contains more than “nn” records, and the first and last records of each message are separated by no more than 16 seconds.



If the function to enable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing a response code 01 (function code unrecognized), and no functions are enabled. If the SER triggers are disabled, (SER1, SER2, SER3, and SER4 are all set to NA), the unsolicited SER messages are still enabled, but the only SER records generated result from settings changes and power being applied to the relay. If the SER1, SER2, SER3, or SER4 settings subsequently change to any non-NA value and SER entries trigger, unsolicited SER messages will generate with the new SER records.

## 0x02—Function Code: Disable Unsolicited Data Transfer

This function disables the SEL-387 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-387 verifies the message by checking the header, length, function code, and disabled function code against the expected values, and checks the entire message against the CRC-16 field. If any of the checks fail, except the function code or the function to disable, the message is ignored.

If an acknowledge is requested as indicated by the least significant bit of the status byte, the relay transmits an acknowledge message with the same response number received in the enable message.

If the function to disable is not 18 or the function code is not recognized, the relay responds with an acknowledge message containing the response code 01 (function code unrecognized) and no functions are disabled.

## 0x18—Function: Unsolicited Sequence-of-Events Response

The function 0x18 is used for the transmission of unsolicited Sequential Events Recorder (SER) data from the SEL-387. 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 (As many as $34 + 4 \cdot nn$ decimal, where nn is the maximum number of SER records allowed per message as indicated in the “Enable Unsolicited Data Transfer” message.)
0000000000	Five bytes reserved for future use as a routing address

Data	Description
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.

Data	Description
mmmmmmmm	Four-byte time of day in milliseconds since midnight
FFFFFFFFE	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 that contains a status byte with the LSB set (except another acknowledge message) and that 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-387 supports the following response codes:

RR	Response
00	Success
01	Function code not recognized
02	Function disabled

## Examples

### EXAMPLE F.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.)

### EXAMPLE F.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.)

### EXAMPLE F.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)

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**EXAMPLE F.4 Successful acknowledge from the relay for the "Disable Unsolicited Data Transfer" message:**

A5 46 0E 00 00 00 00 00 82 00 XX cc cc

(XX is the same as the response number in the "Disable Unsolicited Data Transfer" message to which it responds.)

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**EXAMPLE F.5 Successful acknowledge message from the master for an unsolicited SER message:**

A5 46 0E 00 00 00 00 00 98 00 XX cccc

(XX is the same as the response number in the unsolicited SER message to which it responds.)

## Notes

Once the relay receives an acknowledge with response code 00 from the master, it will clear the settings changed bit (bit 1) in its status byte, if that bit is asserted, and it will clear the settings changed bit in Fast Meter, if that bit is asserted.

An element index of 0xFE indicates that the SER record is due to the relay turning on. 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 can 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 can 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

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### Overview

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Some versions of the SEL-387 family of relays support Distributed Network Protocol (DNP3) Level 2 Slave protocol. This includes access to metering data, protection elements (Relay Word), contact I/O, targets, Sequential Events Recorder, breaker monitor, relay summary event reports, settings groups, and time synchronization. The SEL-387 Relay supports DNP point remapping and virtual terminal object.

### Configuration

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To configure a port for DNP, set the port PROTO setting to DNP. Although DNP can be selected on any of the available ports, DNP cannot be enabled on more than one port at a time. The following information is required to configure a port for DNP operation:

**Table G.1 Data Needed to Configure a Port for DNP (Sheet 1 of 2)**

Label	Description	Default
SPEED	Baud rate (300–19200)	2400
T_OUT	Port time-out (0–30 minutes)	5
DNPADR	DNP Address (0–65534)	0
MODEM	Modem connected to port (Y, N)	N
MSTR	Modem startup string (up to 30 characters)	E0X0&D0S0=2
PH_NUM	Phone number to dial-out to (up to 30 characters)	
MDTIME	Time to attempt dial (5–300 seconds)	60
MDRETI	Time between dial-out attempts (5–3600 seconds)	120
MDRETN	Number of dial-out attempts (0–5)	3
ECLASSA	Class for Analog event data (0 for no event, 1–3)	2
ECLASSB	Class for Binary event data (0 for no event, 1–3)	1
ECLASSC	Class for Counter event data (0 for no event, 1–3)	0
DECPLA	Currents scaling (0–3 decimal places)	1
TIMERQ	Time-set request interval (0–32767 min)	0
STIMEO	Select/operate time-out (0.0–30.0 sec.)	1.0
DTIMEO	Data-link time-out (0–5 sec.)	1
MINDLY	Minimum time from DCD to TX (0.00–1.00 sec.)	0.05
MAXDLY	Maximum time from DCD to TX (0.00–1.00 sec.)	0.10

**Table G.1 Data Needed to Configure a Port for DNP (Sheet 2 of 2)**

Label	Description	Default
PREDLY	Settle time from RTS on to TX (OFF, 0.00–30.00 sec.)	0
PSTDLY	Settle time after TX to RTS off (0.00–30.00 sec.)	0
ANADBA	Analog reporting deadband (0–32767 counts)	100
ETIMEO	Event data confirmation time-out (0.1–50.0 sec)	2.0
DRETRY	Data-link retries (0–15)	3
UNSOL	Enable unsolicited reporting (Y, N)	N
PUNSOL	Enable unsolicited reporting at power-up (Y, N)	N
REPADR	DNP Address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Age of oldest event to transmit on (0–60 sec.)	2.0

The RTS signal can 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 can be sent once an idle time is satisfied. This idle time is randomly selected between the minimum and maximum allowed idle times (i.e., MAXDLY and MINDLY). In addition, the SEL-387 monitors received data and treats receipt of data as a DCD indication. This allows RTS to be looped back to CTS in cases where the external transceiver does not support DCD. When the SEL-387 transmits a DNP message, it delays transmitting after asserting RTS by at least the time in the PREDLY setting. After transmitting the last byte of the message, the SEL-387 delays for at least PSTDLY milliseconds before deasserting RTS. If the PSTDLY time delay is in progress (RTS still high) following a transmission and another transmission is initiated, the SEL-387 transmits the message without completing the PSTDLY delay and without any preceding PREDLY delay. The RTS/CTS handshaking can be completely disabled by setting PREDLY to OFF. In this case RTS is forced high and CTS is ignored, with only received characters acting as a DCD indication. The timing is the same as above, but PREDLY functions as if it were set to 0, and RTS is not actually deasserted after the PSTDLY time delay expires.

## Data-Link Operation

It is necessary to make two important decisions about the data-link layer operation. One is how to handle data-link confirmation, the other is how to handle data-link access. If a highly reliable communications link exists, the data-link access can be disabled altogether, which significantly reduces communications overhead. Otherwise, it is necessary to enable confirmation and determine how many retries to allow and what the data-link time-out should be. The noisier the communications channel, the more likely a message will be corrupted. Thus, the number of retries should be set higher on noisy channels. Set the data-link time-out long enough to allow for the worst-case response of the master plus transmission time. When the SEL-387 decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-387 monitors physical connections by using CTS input (treated as a Data Carrier Detect) and monitoring character receipt. Once the physical link goes idle, as indicated by CTS being deasserted and no characters being received, the SEL-387 will wait a configurable amount of time before beginning a transmission. This hold-off time will be a random value between the MINDLY and MAXDLY setting values. The hold-off time is random, which prevents multiple devices waiting to communicate on the network from continually colliding.

## Data Access Method

Based on the capabilities of the system, it is necessary to choose a method for retrieving data on the DNP connection. The following table summarizes the main options, listed from least to most efficient, and indicates corresponding key related settings.

**Table G.2 Data Access Methods**

Data Retrieval Method	Description	Relevant SEL-387 Relay 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.

# DNP3 Documentation

## Device Profile

Table G.3 contains the standard DNP3 device profile information. Rather than check boxes in the example Device Profile in the DNP3 Subset Definitions, only the relevant selections are shown.

**Table G.3 SEL-387 DNP3 Device Profile (Sheet 1 of 2)**

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-387 Relay
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	Enabling and disabling of unsolicited reports on a class basis Virtual terminal
Maximum data-link frame size transmitted/received (octets)	292
Maximum data-link retries	Configurable, range 0 to 15
Requires data-link layer confirmation	Configurable by setting
Maximum application fragment size transmitted/received (octets)	2048
Maximum application layer retries	None
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable
Complete application fragment time-out	None
Application confirm time-out	Configurable
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE-NO ACK	Always
Executes control count greater than 1	Never
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch On	Always
Executes control Latch Off	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only non-time-tagged
Reports time-tagged binary input change events when no specific variation requested	Never
Sends unsolicited responses	Configurable with unsolicited message enable settings



**Table G.3 SEL-387 DNP3 Device Profile (Sheet 2 of 2)**

Parameter	Value
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 6
Counter roll-over	16 bits
Sends multifragment responses	Yes

In all cases of a configurable item within the device profile, the item is controlled by SEL-387 settings.

## Object Table

The following object table lists supported objects, functions, and qualifier code combinations.

**Table G.4 SEL-387 Relay DNP Object Table (Sheet 1 of 4)**

Object			Request (supported)		Response (may generate)	
Obj.	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	Binary Output Status	1	0,1,6,7,8	129	0,1
12	0	Control Block-All Variations				
12	1	Control Relay Output Block	3,4,5,6	17,28	129	echo of request
12	2	Pattern Control Block				
12	3	Pattern Mask				
20	0	Binary Counter-All Variations	1	0,1,6,7,8		
20	1	32-Bit Binary Counter				
20	2	16-Bit Binary Counter				
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1	0,1,6,7,8	129	0,1,7,8
20	6 <sup>a</sup>	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				

**Table G.4 SEL-387 Relay DNP Object Table (Sheet 2 of 4)**

Object			Request (supported)		Response (may generate)	
Obj.	Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
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 <sup>a</sup>	16-Bit Counter Change Event Without Time	1	6,7,8	129,130	17,28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6,7,8	129	17,28
22	6	16-Bit Counter Change Event With Time	1	6,7,8	129	17,28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event-All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Frozen Delta Counter Event With Time				
23	8	16-Bit Frozen Delta Counter Event With Time				
30	0	Analog Input-All Variations	1	0,1,6,7,8		
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	0,1,7,8

**Table G.4 SEL-387 Relay DNP Object Table (Sheet 3 of 4)**

Object			Request (supported)		Response (may generate)	
Obj.	Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	16-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8
41	0	Analog Output Block-All Variations				
41	1	32-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129	echo of request
50	0	Time and Date-All Variations				
50	1	Time and Date	1,2	7,8 index = 0	129	07, quantity = 1
50	2	Time and Date With Interval				
51	0	Time and Date CTO-All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO				07, quantity = 1
52	0	Time Delay-All Variations				
52	1	Time Delay Coarse				
52	2	Time Delay Fine			129	07, quantity = 1
60	0	All Classes of Data	1,20,21	6		
60	1	Class 0 Data	1	6		

**Table G.4 SEL-387 Relay DNP Object Table (Sheet 4 of 4)**

Object			Request (supported)		Response (may generate)	
Obj.	Var.	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
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			

<sup>a</sup> Default.

## Data Map

The following is the default object map supported by the SEL-387 (see *Appendix A: Firmware and Manual Versions*).

**Table G.5 SEL-387 Relay-Wye/Delta DNP Data Map (Sheet 1 of 4)**

DNP Object Type	Index	Description
01,02	000–799	Relay Word, where OCA is 0 and TRIP1 is 319.
01,02	800–1599	Relay Word from the SER, encoded same as inputs 000–799 with 800 added.
01,02	1600–1615	Relay front-panel targets, where 1615 is A, 1608 is W4, 1607 is EN, and 1600 is 51.
01,02	1616	Relay Disabled.
01,02	1617	Relay diagnostic failure.
01,02	1618	Relay diagnostic warning.
01,02	1619	New relay event available.
01,02	1620	Settings change or relay restart.
10,12	00–15	Remote bits RB1–RB16.
10,12	16	Pulse Open breaker 1 command OC.

**Table G.5 SEL-387 Relay-Wye/Delta DNP Data Map (Sheet 2 of 4)**

<b>DNP Object Type</b>	<b>Index</b>	<b>Description</b>
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	Pulse Open breaker 4 command OC.
10,12	23	Pulse Close breaker 4 command CC.
10,12	24-31	Remote bit pairs RB1-RB16.
10,12	32	Open/Close pair for breaker 1.
10,12	33	Open/Close pair for breaker 2.
10,12	34	Open/Close pair for breaker 3.
10,12	35	Open/Close pair for breaker 4.
10,12	36	Reset demands.
10,12	37	Reset demand peaks.
10,12	39	Reset breaker monitor.
10,12	40	Reset front-panel targets.
10,12	41	Read next relay event.
20,22	00	Active settings group.
20,22	01	Internal breaker trips 1.
20,22	02	Internal breaker trips 2.
20,22	03	Internal breaker trips 3.
20,22	04	Internal breaker trips 4.
20,22	05	External breaker trips 1.
20,22	06	External breaker trips 2.
20,22	07	External breaker trips 3.
20,22	08	External breaker trips 4.
30,32	00,01	IA magnitude and angle for Wdg. 1.
30,32	02,03	IB magnitude and angle for Wdg. 1.
30,32	04,05	IC magnitude and angle for Wdg. 1.
30,32	06,07	3I1 magnitude and angle for Wdg. 1.
30,32	08,09	3I2 magnitude and angle for Wdg. 1.
30,32	10,11	IRW magnitude and angle for Wdg. 1.
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.

**Table G.5 SEL-387 Relay-Wye/Delta DNP Data Map (Sheet 3 of 4)**

DNP Object Type	Index	Description
30,32	22,23	IRW magnitude and angle for Wdg. 2.
30,32	24,25	IA magnitude and angle for Wdg. 3.
30,32	26,27	IB magnitude and angle for Wdg. 3.
30,32	28,29	IC magnitude and angle for Wdg. 3.
30,32	30,31	3I1 magnitude and angle for Wdg. 3.
30,32	32,33	3I2 magnitude and angle for Wdg. 3.
30,32	34,35	IRW magnitude and angle for Wdg. 3.
30,32	36,37	IA magnitude and angle for Wdg. 4.
30,32	38,39	IB magnitude and angle for Wdg. 4.
30,32	40,41	IC magnitude and angle for Wdg. 4.
30,32	42,43	3I1 magnitude and angle for Wdg. 4.
30,32	44,45	3I2 magnitude and angle for Wdg. 4.
30,32	46,47	IRW magnitude and angle for Wdg. 4.
30,32	48	IOP1 Operate Current.
30,32	49	IOP2 Operate Current.
30,32	50	IOP3 Operate Current.
30,32	51	IRT1 Restraint Current.
30,32	52	IRT2 Restraint Current.
30,32	53	IRT3 Restraint Current.
30,32	54	I1F2 Second-Harmonic Current.
30,32	55	I2F2 Second-Harmonic Current.
30,32	56	I3F2 Second-Harmonic Current.
30,32	57	I1F5 Fifth-Harmonic Current.
30,32	58	I2F5 Fifth-Harmonic Current.
30,32	59	I3F5 Fifth-Harmonic Current.
30,32	60	VDC.
30,32	61–65	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 1.
30,32	66–70	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 2.
30,32	71–75	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 3.
30,32	76–80	Demand A, B, C, 3I2, and IR magnitudes for Wdg. 4.
30,32	81	Peak demand IA mag. for Wdg.1.
30	82–84	Peak demand IA time in DNP format for Wdg.1.
30,32	85	Peak demand IB mag. for Wdg.1.
30	86–88	Peak demand IB time in DNP format for Wdg.1.
30,32	89	Peak demand IC mag. for Wdg.1.
30	90–92	Peak demand IC time in DNP format for Wdg.1.
30,32	93	Peak demand 3I2 mag. for Wdg.1.
30	94–96	Peak demand 3I2 time in DNP format for Wdg.1.
30,32	97	Peak demand IR mag. for Wdg.1.
30	98–100	Peak demand IR time in DNP format for Wdg.1.

**Table G.5 SEL-387 Relay-Wye/Delta DNP Data Map (Sheet 4 of 4)**

<b>DNP Object Type</b>	<b>Index</b>	<b>Description</b>
30,32	101	Peak demand IA mag. for Wdg.2.
30	102–104	Peak demand IA time in DNP format for Wdg.2.
30,32	105	Peak demand IB mag. for Wdg.2.
30	106–108	Peak demand IB time in DNP format for Wdg.2.
30,32	109	Peak demand IC mag. for Wdg.2.
30	110–112	Peak demand IC time in DNP format for Wdg.2.
30,32	113	Peak demand 312 mag. for Wdg.2.
30	114–116	Peak demand 312 time in DNP format for Wdg.2.
30,32	117	Peak demand IR mag. for Wdg.2.
30	118–120	Peak demand IR time in DNP format for Wdg.2.
30,32	121	Peak demand IA mag. for Wdg.3.
30	122–124	Peak demand IA time in DNP format for Wdg.3.
30,32	125	Peak demand IB mag. for Wdg.3.
30	126–128	Peak demand IB time in DNP format for Wdg.3.
30,32	129	Peak demand IC mag. for Wdg.3.
30	130–132	Peak demand IC time in DNP format for Wdg.3.
30,32	133	Peak demand 312 mag. for Wdg.3.
30	134–136	Peak demand 312 time in DNP format for Wdg.3.
30,32	137	Peak demand IR mag. for Wdg.3.
30	138–140	Peak demand IR time in DNP format for Wdg.3.
30,32	141	Peak demand IA mag. for Wdg.4.
30	142–144	Peak demand IA time in DNP format for Wdg.4.
30,32	145	Peak demand IB mag. for Wdg.4.
30	146–148	Peak demand IB time in DNP format for Wdg.4.
30,32	149	Peak demand IC mag. for Wdg.4.
30	150–152	Peak demand IC time in DNP format for Wdg.4.
30,32	153	Peak demand 312 mag. for Wdg.4.
30	154–156	Peak demand 312 time in DNP format for Wdg.4.
30,32	157	Peak demand IR mag. for Wdg.4.
30	158–160	Peak demand IR time in DNP format for Wdg.4.
30,32	161–163	Breaker contact wear percentage (A, B, C) for Wdg. 1.
30,32	164–166	Breaker contact wear percentage (A, B, C) for Wdg. 2.
30,32	167–169	Breaker contact wear percentage (A, B, C) for Wdg. 3.
30,32	170–172	Breaker contact wear percentage (A, B, C) for Wdg. 4.

**Table G.6 SEL-387-5 and SEL-387-6 Relays Continuation of Wye/Delta DNP Data Map**

SEL-387-5 Relay			SEL-387-6 Relay		
Type	Index	Description	Type	Index	Description
30,32	173–200	Reserved	30,32	173	Ambient temperature
30,32	201	Event type (See Event Cause table, following)	30,32	174–176	Thermal Load (A, B, C)
30,32	202	Fault Targets (bit 15:EN, bit 8:51, and bit 7:A–bit 0:W4)	30,32	177–179	In-Service Cooling System (A, B, C)
30,32	203–205	Fault Currents Winding 1 (A, B, C)	30,32	180–182	Calculated Top-Oil Temperature (A, B, C)
30,32	206–208	Fault Currents Winding 2 (A, B, C)	30,32	183–185	Measured Top-Oil Temperature (A, B, C) <sup>a</sup>
30,32	209–211	Fault Currents Winding 3 (A, B, C)	30,32	186–188	Hot-Spot Temperature (A, B, C)
30,32	212–214	Fault Currents Winding 4 (A, B, C)	30,32	189–191	Aging Acceleration Factor, FAA (A, B, C)
30,32	215	Fault settings group	30,32	192–194	Rate of Loss-of-Life (A, B, C)
30,32	216–218	Fault time in DNP format (high, middle, and low 16 bits)	30,32	195–197	Total Loss-of-Life (A, B, C)
			30,32	198–200	Time to assert TLL (A, B, C) <sup>b</sup>
			30,32	201	Event Type (See Event Cause table, following)
			30,32	202	Fault Targets (bit 15:EN, bit 8:51, and bit 7:A–bit 0:W4)
			30,32	203–205	Fault Currents Winding 1 (A, B, C)
			30,32	206–208	Fault Currents Winding 2 (A, B, C)
			30,32	209–211	Fault Currents Winding 3 (A, B, C)
			30,32	212–214	Fault Currents Winding 4 (A, B, C)
			30,32	215	Fault settings group
			30	216–218	Fault time in DNP format (high, middle, and low 16 bits)
30,32	219–230	Measured RTD temperatures (RTD 1A–RTD 12A)	30,32	219–230	Measured RTD temperatures (RTD 1A–RTD 12A)
30,32	231–242	Measured RTD temperatures (RTD 1B–RTD 12B)	30,32	231–242	Measured RTD temperatures (RTD 1B–RTD 12B)
40,41	00	Active settings group	40,41	00	Active settings group

<sup>a</sup> Error code = 400 (when measured top-oil temperature is not available).

<sup>b</sup> Infinite marker = -1 (when RLOL = 0).

Binary inputs (objects 1 and 2) are supported as defined by the previous table. Binary inputs 0–799 and 1600–1619 are scanned approximately once every 128 ms to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This can be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. To determine the point index for an element, 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. If DECPLA is 3, then its value is multiplied by 1000. VDC is not scaled. Event-class messages are generated whenever an input changes beyond the value given by the ANADBA setting. The deadband check is done after any scaling is applied. The angles will only generate an event if, in addition to their deadband check, the corresponding magnitude (the preceding point) contains a value greater than the value given by the ANADBA setting. Analog inputs are scanned at approximately a 1/2-second rate, except for analogs 201–218. During a scan, all events generated will use the time the scan was initiated. Analogs 201–218 are derived from the history queue data for the most recently read fault and do not generate event messages. Analog 201 is defined as follows:

Value	Event Cause
1	Trigger command
2	Pulse command
4	ER element
8	Trip 5
16	Trip 4
32	Trip 3
64	Trip 2
128	Trip 1

If Analog 201 is 0, fault information has not been read and the related analogs (202–218) do not contain valid data.

The SEL-387 has the DNP event buffer capacities as follows:

Value	Maximum Number of Events
Binary	512
Counters	128
Analog	128

Analogs 219–242 are temperature values in F or C in the SEL-387-5 and SEL-387-6 Relays, depending on TMPREFA and TMPREFB settings. The valid values can be in the range of 0–250° C (32–482° F). The invalid values will be set as:

RTD Failure Mode	Error Code
Open (Temp < –50°C)	7FFFh
Short (Temp > 250°C)	8000h
Fiber-Optic Communications Failure	7FFCh
External RTD Unit Status Failure	7FF8h
RTD Channel Not Used	7FF0h

Control Relay Output Blocks (object 12, variation 1) are supported. The control relays correspond to the remote bits and other functions, as shown above. The Trip/Close bits take precedence over the control field. If either the Trip or Close bit is set, one of the other control field bits must be set as well. The control field is interpreted as follows:

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–15	Set	Clear	Set	Clear	Pulse	Clear
16–23	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
24	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
25	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
26	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
27	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
28	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9	Pulse RB10	Pulse RB9
29	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
30	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
31	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15
32	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1	Pulse CC1	Pulse OC1
33	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2	Pulse CC2	Pulse OC2
34	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3	Pulse CC3	Pulse OC3
35	Pulse CC4	Pulse OC4	Pulse CC4	Pulse OC4	Pulse CC4	Pulse OC4
36–41	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing

If the Trip bit is set, a Latch Off operation is performed, and if the Close bit is set, a Latch On operation is performed on the specified index. The Status field is used exactly as defined. All other fields are ignored. A pulse operation asserts a point for a single processing interval. Caution should be exercised with multiple remote bit pulses in a single message (i.e., point count > 1), as this can 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.7 SEL-387-5, -6 Relay Binary Input Lookup Table (Sheet 1 of 3)**

Row	SEL-387 Relay Word Bits								Binary Input Point
<b>2</b>	50P11	50P11T	50P12	51P1	51P1T	51P1R	PDEM1	OCA	7–0
<b>3</b>	50A13	50B13	50C13	50P13	50A14	50B14	50C14	50P14	15–8
<b>4</b>	50N11	50N11T	50N12	51N1	51N1T	51N1R	NDEM1	OC1	23–16
<b>5</b>	50Q11	50Q11T	50Q12	51Q1	51Q1T	51Q1R	QDEM1	CC1	31–24
<b>6</b>	50P21	50P21T	50P22	51P2	51P2T	51P2R	PDEM2	OCB	39–32
<b>7</b>	50A23	50B23	50C23	50P23	50A24	50B24	50C24	50P24	47–40
<b>8</b>	50N21	50N21T	50N22	51N2	51N2T	51N2R	NDEM2	OC2	55–48
<b>9</b>	50Q21	50Q21T	50Q22	51Q2	51Q2T	51Q2R	QDEM2	CC2	63–56

**Table G.7 SEL-387-5, -6 Relay Binary Input Lookup Table (Sheet 2 of 3)**

Row	SEL-387 Relay Word Bits								Binary Input Point
10	50P31	50P31T	50P32	51P3	51P3T	51P3R	PDEM3	OCC	71–64
11	50A33	50B33	50C33	50P33	50A34	50B34	50C34	50P34	79–72
12	50N31	50N31T	50N32	51N3	51N3T	51N3R	NDEM3	OC3	87–80
13	50Q31	50Q31T	50Q32	51Q3	51Q3T	51Q3R	QDEM3	CC3	95–88
14	50P41	50P41T	50P42	51P4	51P4T	51P4R	PDEM4	CTS	103–96
15	50A43	50B43	50C43	50P43	50A44	50B44	50C44	50P44	111–104
16	50N41	50N41T	50N42	51N4	51N4T	51N4R	NDEM4	OC4	119–112
17	50Q41	50Q41T	50Q42	51Q4	51Q4T	51Q4R	QDEM4	CC4	127–120
18	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R	135–128
19	2HB1	2HB2	2HB3	5HB1	5HB2	5HB3	TH5	TH5T	143–136
20	87BL1	87BL2	87BL3	87BL	87E1	87E2	87E3	32IE	151–144
21	87O1	87O2	87O3	50GC	50G4	32IR	32IF	REFP	159–152
22	51PC1	51PC1T	51PC1R	51NC1	51NC1T	51NC1R	DC1	DC2	167–160
23	51PC2	51PC2T	51PC2R	51NC2	51NC2T	51NC2R	DC3	DC4	175–168
24	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8	183–176
25	RB9	RB10	RB11	RB12	RB13	RB14	RB15	RB16	191–184
26	SG1	SG2	SG3	SG4	SG5	SG6	CHSG	COMFLG <sup>a</sup>	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	*b	*b	*b	*b	*b	*b	*b	*b	231–224
31	*b	*b	*b	*b	*b	*b	*b	*b	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	TLL <sup>a</sup>	RLL <sup>a</sup>	FAA1 <sup>a</sup>	FAA2 <sup>a</sup>	TO1 <sup>a</sup>	TO2 <sup>a</sup>	HS1 <sup>a</sup>	HS2 <sup>a</sup>	295–288
39	BCWA1	BCWB1	BCWC1	BCW1	BCWA2	BCWB2	BCWC2	BCW2	303–296
40	BCWA3	BCWB3	BCWC3	BCW3	BCWA4	BCWB4	BCWC4	BCW4	311–304
41	TRIP1	TRIP2	TRIP3	TRIP4	TRIP5	TRIPL	CSE <sup>a</sup>	TRGTR	319–312
42	CLS1	CLS2	CLS3	CLS4	CF1T	CF2T	CF3T	CF4T	327–320
43	NOTALM <sup>c</sup>	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	*b	*b	*b	*b	*b	*b	*b	*b	359–352
47	*b	*b	*b	*b	*b	*b	*b	*b	367–360
48	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	375–368
49	LB9	LB10	LB11	LB12	LB13	LB14	LB15	LB16	383–376

Table G.7 SEL-387-5, -6 Relay Binary Input Lookup Table (Sheet 3 of 3)

Row	SEL-387 Relay Word Bits								Binary Input Point
50	*b	*b	*b	*b	*b	*b	*b	*b	391–384
53	49A01A	49T01A	49A02A	49T02A	49A03A	49T03A	49A04A	49T04A	415–408
54	49A05A	49T05A	49A06A	49T06A	49A07A	49T07A	49A08A	49T08A	423–416
55	49A09A	49T09A	49A10A	49T10A	49A11A	49T11A	49A12A	49T12A	431–424
56	49A01B	49T01B	49A02B	49T02B	49A03B	49T03B	49A04B	49T04B	439–432
57	49A05B	49T05B	49A06B	49T06B	49A07B	49T07B	49A08B	49T08B	447–440
58	49A09B	49T09B	49A10B	49T10B	49A11B	49T11B	49A12B	49T12B	455–448
59	COMFLA	RTDINA	COMFLB	RTDINB	*b	*b	*b	ISQTAL	463–456

<sup>a</sup> SEL-387-6 Relay only.

<sup>b</sup> Reserved for future use.

<sup>c</sup> !ALARM for firmware versions prior to R600 in the SEL-387-5 and SEL-387-6 Relays.

## Relay Summary Event Data

Whenever there are unread relay event summary data (fault data), binary input point 1619 will be set. To load the next available relay event summary, the master should pulse binary output point 41. This will cause the event summary analogs (points 201–218) to be loaded with information from the next oldest relay event summary. Since the summary data are 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 201) 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 [A|I|A|O|B|I|B|O|C] [VIEW]**

The DNP analog input, analog output, counter, binary output, and binary input points can 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 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 can 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 are entered:

---

```
xx is referenced more than once, changes not saved

xx is not a valid index, changes not saved

Invalid format, changes not saved
```

---

## Custom Scaling

In addition to remapping, these commands can be used on analog inputs to create custom scaling and deadbands 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. deadbands are added using a colon and deadband count. This deadband will override the ANADBA setting. For example:

---

```
==>DNP AI <Enter>

Enter the new DNP Analog Input map
112;5 28;0.2 17;10 1;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 deadband. The value at index 17 (now at index 2) is left for default scaling, but uses a deadband of +/- 10 counts. Similarly, the value that was at index 1 (now at index 3) is now scaled by 1 and uses a deadband of +/- 15 counts.

## Modem Support

The modem handling will only be applied when the port settings include the following:

PROTOCOL = DNP

MODEM = Y

---

**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 can only be transmitted while DCD is asserted. (Normally, a modem will be connected with an SEL-C220 or SEL-C222 cable that ties the DCD of the modem to the CTS.)

On power-up and settings change, the relay shall initialize the modem by issuing the string “+++AT” followed by the MSTR string and <CR>. This will initialize the modem. The MSTR (modem string) is a port setting visible only when the protocol setting is DNP. The MSTR setting is a series of ASCII characters that initialize the modem by sending the modem a series of commands.

If someone calls in, the modem will send “RING” and “CONNECT” messages to the relay. These messages, as well as all messages received while DCD is low, shall be ignored. All DNP messages received while connected shall be treated normally.

If the relay needs to send an unsolicited message and it is not currently connected, it must attempt to make a connection by sending the string “+++ATDT” followed by the phone number and <CR>. It shall then wait for a “CONNECT” message. Once “CONNECT” is received and CTS is asserted, the relay can consider itself connected and continue its transaction. If connection is not achieved within MDTIME seconds of initiating the phone call, the relay shall issue the command “+++ATH<CR>” and wait at least

MDRETI seconds before trying again and try MDRETN times before giving up. If it fails to connect in the first try, it will try again at a later time every six hours.

If the relay initiates a connection, it shall disconnect once there have been no transactions for TIMEOUT time, using the disconnect command “+++ATH<CR>”. Also, if an outside caller connects to the modem in the SEL-387, the SEL-387 will disconnect the modem if there have been no transactions for the TIMEOUT time.

## Virtual Terminal

The purpose of this Virtual Terminal (VT) Protocol is to allow ASCII data transfers between a master and an SEL relay over a DNP port. DNP3 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 can 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 *SEL-387 Relay Command Summary*. 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.

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# SEL-387-5, -6 Relay DNP Port-SET P Settings Sheets

Port Protocol (SEL, LMD, DNP)	<b>PROTO</b>	= _____
Baud (300, 1200, 2400, 4800, 9600, 19200)	<b>SPEED</b>	= _____
Port Time-out (0–30 minutes)	<b>T_OUT</b>	= _____
DNP Address (0–65534)	<b>DNPADR</b>	= _____
Modem connected to port (Y, N)	<b>MODEM</b>	= _____
Modem startup string (up to 30 characters)	<b>MSTR</b>	= _____
Phone number to dial-out to (up to 30 characters)	<b>PH_NUM</b>	= _____
Time to attempt dial (5–300 seconds)	<b>MDTIME</b>	= _____
Time between dial-out attempts (5–3600 seconds)	<b>MDRETI</b>	= _____
Number of dial-out attempts (0–5)	<b>MDRETN</b>	= _____
Class for Analog event data (0 for no event, 1–3)	<b>ECLASSA</b>	= _____
Class for Binary event data (0 for no event, 1–3)	<b>ECLASSB</b>	= _____
Class for Counter event data (0 for no event, 1–3)	<b>ECLASSC</b>	= _____
Currents scaling (0–3 decimal places)	<b>DECPLA</b>	= _____
Time-set request interval, minutes (0 for never, 1–32767)	<b>TIMERQ</b>	= _____
Select/Operate time-out interval, seconds (0.0–30.0)	<b>STIMEO</b>	= _____
Data link time-out interval, seconds (0–5)	<b>DTIMEO</b>	= _____
Minimum Delay from DCD to transmission, seconds (0.00–1.00)	<b>MINDLY</b>	= _____
Maximum Delay from DCD to transmission, seconds (0.00–1.00)	<b>MAXDLY</b>	= _____
Transmission delay from RTS assertion, seconds (OFF, 0.00–30.00)	<b>PREDLY</b>	= _____
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	<b>PSTDLY</b>	= _____
Analog reporting deadband (0–32767 counts)	<b>ANADBA</b>	= _____
Event Data Confirmation time-out (0.1–50.0 sec)	<b>ETIMEO</b>	= _____
Number of data-link retries (0 for no confirm, 1–15)	<b>DRETRY</b>	= _____
Allow Unsolicited reporting (Y, N)	<b>UNSOL</b>	= _____

Enable unsolicited messages on power-up (Y, N)	<b>PUNSOL</b>	= _____
Address of master to report to (0–65534)	<b>REPADR</b>	= _____
Number of events to transmit on (1–200)	<b>NUMEVE</b>	= _____
Age of oldest event to force transmit on, seconds (0.0–60.0)	<b>AGEEVE</b>	= _____

# Appendix H

## Protection Application Examples

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### Overview

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This section provides instructions for setting the SEL-387 Relay protection functions. Use these application examples to help familiarize yourself with the relay and assist you with your own protection settings calculations. This section is not intended to provide a complete settings guide for the relay.

### Transformer Winding and CT Connection Compensation Settings Examples

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In electromechanical and solid-state transformer differential relays, the standard current transformer (CT) configuration was wye-connected on the delta winding of the transformer and delta-connected on the wye winding of the transformer. The CT delta connection was constructed based on the power transformer delta to compensate for the phase shift that occurred on the system primary currents because of the power transformer connection. The CT configuration allowed the currents entering the relay for through-load or external faults to be 180 degrees out-of-phase so that the phasor sum of the currents added to zero (no differential current) in an electromechanical differential relay. Taps on the relay current inputs compensated for magnitude differences. Modern digital relays perform both the connection (or phase) and magnitude compensation mathematically so all CTs can be connected in wye.

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NOTE: In this settings guideline, the term "phase rotation" is synonymous with "phase sequence." This settings guideline uses "phase rotation" to be consistent with the relay Global setting, PHROT.

This section provides a procedure for SEL-387 Relays to determine and set the Terminal  $n$  CT connection compensation settings,  $W_nCTC$  (where  $n = 1, 2, 3$ , or  $4$ ), to compensate for the phase shift across the transformer. Each of the connection compensation settings offer thirteen 3x3 matrices,  $CTC(0)$ – $CTC(12)$ , permitting CT connection compensation from 0 degrees to 360 degrees, in increments of 30 degrees, respectively. Refer to *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements (Table 3.1)* for each of the compensation matrices. When applied on a system with an ABC phase rotation, these matrices perform phase angle correction in a counterclockwise (CCW) direction in multiples of 30 degrees, as shown in *Table H.1*. For a system with an ACB phase rotation, the direction of correction is clockwise (CW). See *Special Cases* for a compensation settings example on a system with an ACB phase rotation.

**Table H.1 WnCTC Setting: Corresponding Phase and Direction of Correction**

WnCTC Setting <sup>a</sup>	Matrix	Amount and Direction of Correction	
		ABC Phase Rotation	ACB Phase Rotation
0	CTC(0)	0°	0°
1	CTC(1)	30° CCW	30° CW
2	CTC(2)	60° CCW	60° CW
3	CTC(3)	90° CCW	90° CW
4	CTC(4)	120° CCW	120° CW
5	CTC(5)	150° CCW	150° CW
6	CTC(6)	180° CCW	180° CW
7	CTC(7)	210° CCW	210° CW
8	CTC(8)	240° CCW	240° CW
9	CTC(9)	270° CCW	270° CW
10	CTC(10)	300° CCW	300° CW
11	CTC(11)	330° CCW	330° CW
12	CTC(12)	0° (360°) CCW	0° (360°) CW

<sup>a</sup> n = 1, 2, 3, 4.

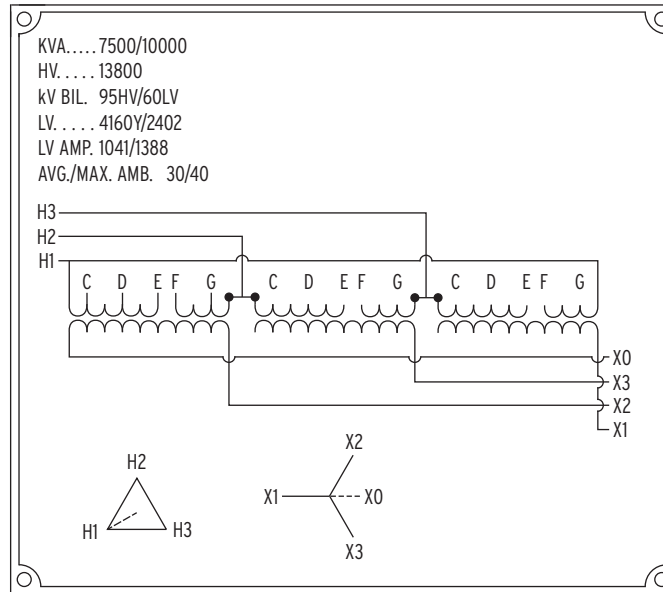
As shown in *Section 3: Differential, Restricted Earth Fault, Thermal, and Overcurrent Elements (Table 3.1)*, compensation matrix CTC(0) multiplies the currents by the identity matrix and creates no change in the currents. Compensation matrix CTC(12) is similar to CTC(0) in that it produces no phase shift (or, more correctly, 360 degrees of shift) in a balanced set of phasors separated by 120 degrees. However, CTC(12) removes zero-sequence components from the measured current, as do all of the matrices with non-zero values.

## Transformer Nameplates and System Connections

To determine the phase shift seen by the relay, the following information is required:

- Transformer phasor (vector) diagram (transformer nameplate)
- Three-line connection diagram showing:
  - System phase-to-transformer bushing connections
  - CT connections
  - CT-to-relay connections

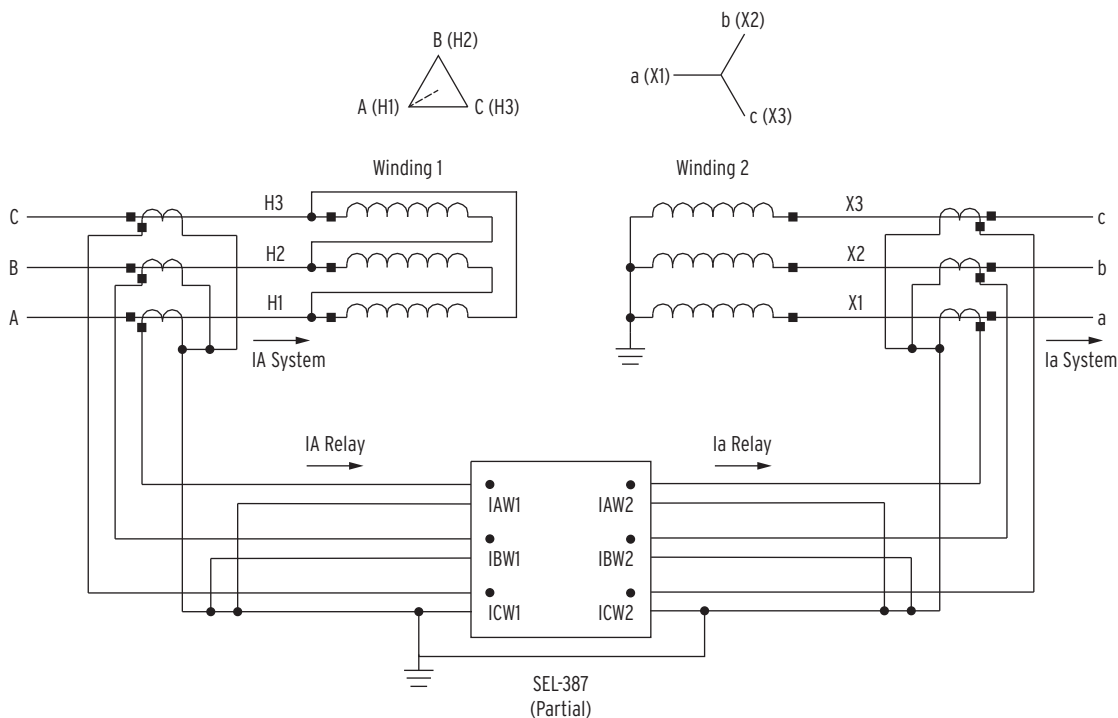
*Figure H.1* shows the key information from a typical nameplate for a two-winding transformer. The winding connection diagram and the phasor (vector) diagram are needed to determine the winding compensation settings in the relay.



**Figure H.1 Transformer Nameplate**

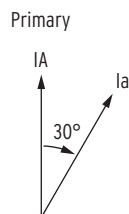
Note that there is no phase designation nor any phase rotation designation on the nameplate. However, the phasor diagram is representative of an H1-H2-H3 sequence. The phase shift on the power system depends on the transformer winding connections, the system phase-to-transformer bushing connections, and the system phase rotation.

*Figure H.2* shows a three-line connection diagram with the transformer shown in *Figure H.1* with what this guideline refers to as standard connections. Standard phase-to-bushing connections are A-phase to H1, B-phase to H2, C-phase to H3, a-phase to X1, b-phase to X2, and c-phase to X3. Standard CT connections include wye-connected CTs with polarity marks of both CTs away from or toward the transformer. *Figure H.2* shows both H-side and X-side CTs connected in wye and the polarity marks away from the transformer. A CT-to-relay connection is considered to be standard when the polarity of the CT is connected to the polarity of the relay analog current input and the primary system phase current is connected to the same phase input on the relay (e.g., IA system to IAW1). Unless otherwise noted, an ABC phase rotation is assumed for the following discussion.

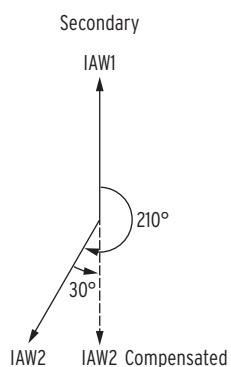


**Figure H.2 Three-Line Diagram Showing System Phase-to-Transformer Bushing, CT, and CT-to-Relay Connections**

If all the connections are standard as shown in *Figure H.2*, under a through-load condition the phase relationship between the system primary currents ( $I_a$  system and  $I_A$  system) and corresponding secondary currents as seen by the relay ( $I_{AW2}$  and  $I_{AW1}$ ) will look like as shown in *Figure H.3* ( $I_a$  lags  $I_A$  by 30 degrees) and *Figure H.4* ( $I_{AW2}$  lags  $I_{AW1}$  by 210 degrees), respectively. The goal of the compensation settings is to compensate  $I_{AW2}$  so as to bring  $I_{AW2\_compensated}$  180 degrees out-of-phase with  $I_{AW1}$  for proper application of the differential function.



**Figure H.3 Primary Current Phasors**



**Figure H.4 Current at the Relay Terminals**

Many applications do not conform to the standard connections, but compensation settings are adaptable to fit any application. The subsequent sections outline the procedure to determine the phase shift and current transformer compensation settings, and also discuss what to do with non-standard phase-to-bushing, CT, and CT-to-relay connections.

## Steps to Determine the Compensation Settings (WnCTC)

Use the following guidelines to determine compensation settings for your application(s).

- Step 1. Determine the phase shift as seen by the relay.
  - a. Determine the phase shift in the primary load current.
  - b. Determine if there are non-standard CT connections.
- Step 2. Select the reference winding and associated relay terminal.
  - a. If a delta winding exists and is wired into the relay, choose it as the reference winding. Select matrix CTC(0) for the compensation of the delta winding. If a zigzag grounding transformer exists on the delta side of the transformer and is within the zone of protection, then select matrix CTC(12).
  - b. If a delta winding does not exist, select one of the wye windings as the reference and choose matrix CTC(11) for the compensation.
- Step 3. Determine the required compensation setting for all other windings. Select matrix CTC(0) for delta windings. Use odd matrices for compensating wye windings. Avoid the use of even matrices when possible.

There may be applications that require the guidelines to be violated, but they should be followed when possible.

The rest of this section discusses each of the guidelines in detail. Examples and special cases are provided to illustrate the application of the guidelines in determining the compensation settings.

### Step 1. Determine the Phase Shift as Seen by the Relay

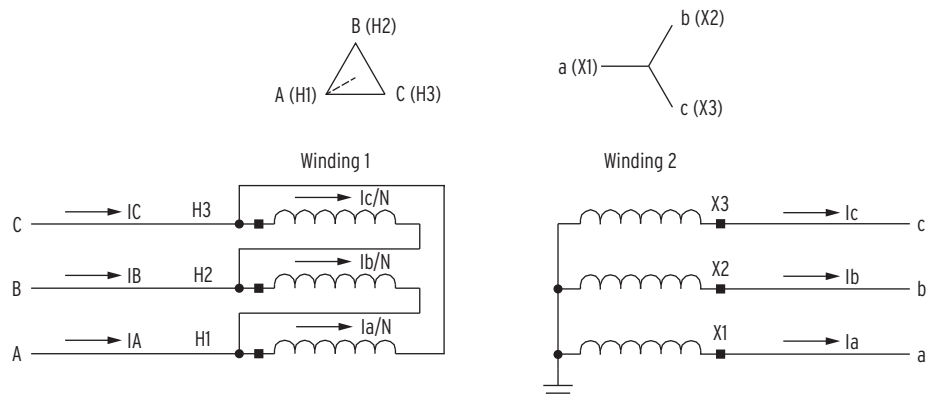
#### Determine the Phase Shift in the Primary Load Current

The first step in selecting the compensation setting in the relay is to determine the phase shift in the primary load current.

#### Standard System Phase-to-Transformer Bushing Connections.

Consider the transformer in *Figure H.1* and the phase-to-bushing connections in *Figure H.2*. Assume balanced X-side (wye-winding) three-phase currents  $I_a$ ,  $I_b$ , and  $I_c$ , as shown in *Figure H.5*. The currents on the H-side (delta-winding) of the transformer are  $I_a/N$ ,  $I_b/N$ , and  $I_c/N$  where  $N$  is the turns ratio of the transformer. Because the discussion focuses on the phase shift and not the magnitude, you can assume  $N = 1$  for this discussion.

**NOTE:** Unless otherwise stated, this discussion assumes an ABC system phase rotation.



**Figure H.5 Standard System Phase-to-Transformer Bushing Connections**

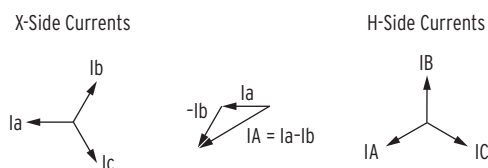
Kirchhoff's Current Law is used at each H-node to determine the primary phase currents on the H-side of the system:

$$I_A = I_a - I_b$$

$$I_B = I_b - I_c$$

$$I_C = I_c - I_a$$

The following examples start with the currents on the wye-side of the transformer to graphically derive the currents on the delta side of the transformer. *Figure H.6* shows that system primary current  $I_a$  (X-side) lags the system primary current  $I_A$  (H-side) by 30 degrees.



**Figure H.6 X- and H-Side Current Phasors for Figure H.5**

The primary load phase shift determined in *Figure H.6* applies for the phase-to-bushing connections shown in *Table H.2*. In each of these phase-to-bushing connections, the order of the phases (A, B, C) matches the order of the bushings (H1, H2, H3).

**Table H.2 (A, B, C) to (H1, H2, H3) Phase-to-Bushing Connections**

	Bushing					
	H1	H2	H3	X1	X2	X3
System Phase	A	B	C	a	b	c
	B	C	A	b	c	a
	C	A	B	c	a	b

**Non-Standard Phase-to-Bushing Connections.** Consider the transformer connections in *Figure H.7*. This is the same transformer discussed in *Figure H.5*, but with different phase-to-bushing connections: A-phase to H3, B-phase to H2, C-phase to H1, a-phase to X3, b-phase to X2, and c-phase to X1.



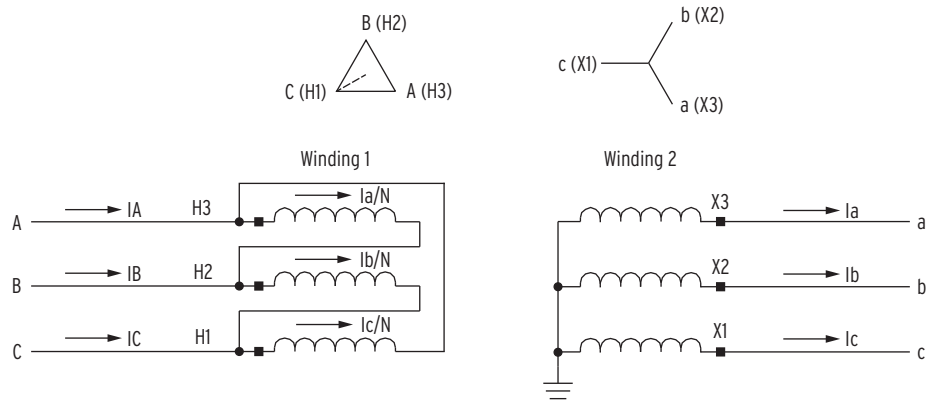


Figure H.7 Non-Standard System Phase-to-Transformer Bushing Connections

Assume balanced X-side (wye-winding) three-phase currents Ia, Ib, and Ic. Kirchhoff's Current Law is used at each H-node to determine the primary phase currents on the H-side of the system:

$$I_A = I_a - I_c$$

$$I_B = I_b - I_a$$

$$I_C = I_c - I_b$$

Figure H.8 shows that system primary current Ia (X-side) leads the system primary current IA (H-side) by 30 degrees.

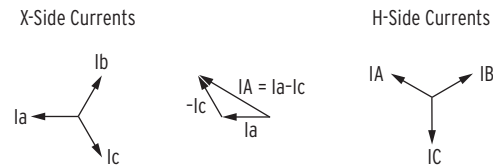


Figure H.8 X- and H-Side Current Phasors for Figure H.7

The primary load phase shift determined in Figure H.8 applies for the phase-to-bushing connections shown in Table H.3. In each of these phase-to-bushing connections, the order of the phase connections (A, C, B) is opposite the order of the bushings (H1, H2, H3).

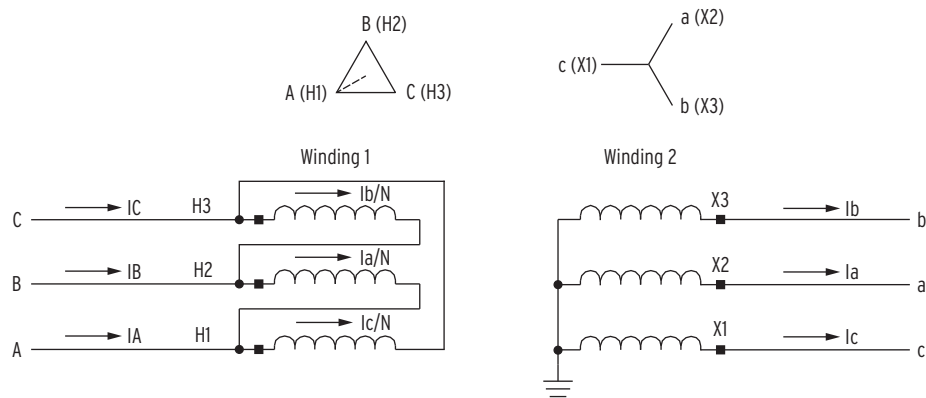
Table H.3 (A, C, B) to (H1, H2, H3) Phase-to-Bushing Connections

	Bushing					
	H1	H2	H3	X1	X2	X3
System Phase	C	B	A	c	b	a
	B	A	C	b	a	c
	A	C	B	a	c	b

The system phase-to-transformer bushing connection diagrams in Figure H.5 and Figure H.7 are on the same transformer, but with a different order of the phases connected to the transformer bushings. As a result, the X-side primary current shifts 30 degrees in opposite directions in the two systems.

### Combination of Standard and Non-Standard Phase-to-Bushing Connections.

Consider the transformer connections shown in *Figure H.9*. The transformer is the same as in previous examples. However, in this example, the H-side phase-to-bushing connections are standard: A-phase to H1, B-phase to H2, and C-phase to H3. The X-side connections are non-standard: a-phase to X2, b-phase to X3, and c-phase to X1.



**Figure H.9** Combination of Standard and Non-Standard Phase-to-Bushing Connection Diagram

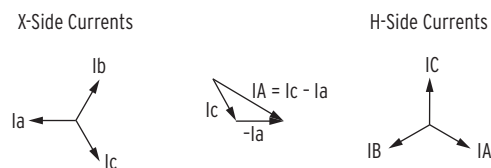
Assume balanced X-side (wye-winding) three-phase currents  $I_a$ ,  $I_b$ , and  $I_c$ . Kirchhoff's Current Law is used at each H-node to determine the primary phase currents on the H-side of the system:

$$I_A = I_c - I_a$$

$$I_B = I_a - I_b$$

$$I_C = I_b - I_c$$

*Figure H.10* shows that system primary current  $I_a$  (X-side) lags the system primary current  $I_A$  (H-side) by 150 degrees.

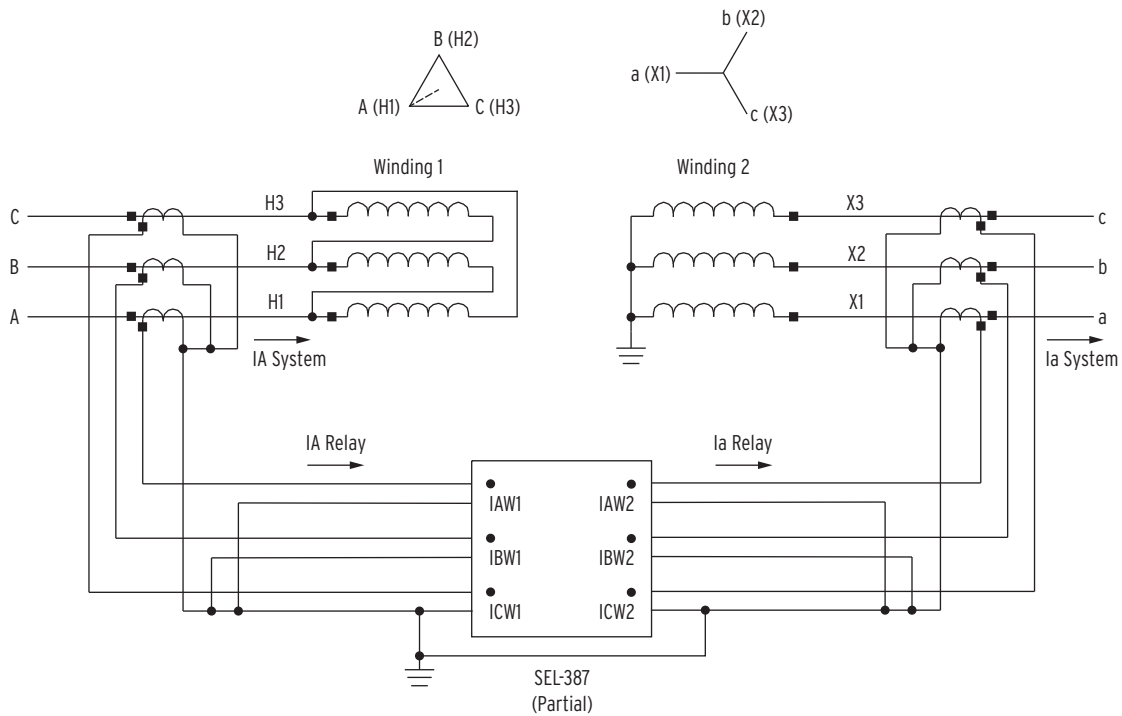


**Figure H.10** X- and H-Side Current Phasors for Figure H.9

These three examples show that the same transformer winding connections can produce different phase shifts in the system primary load current based on the phase-to-bushing connections.

### Determine if There Are Non-Standard CT Connections

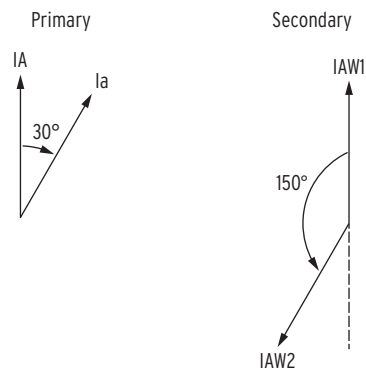
*Figure H.11* shows the transformer of *Figure H.2* with a standard current transformer configuration; that is, both the H-side and X-side CTs are connected in wye and the polarity marks are away from the power transformer.



**Figure H.11** Standard CT Connections

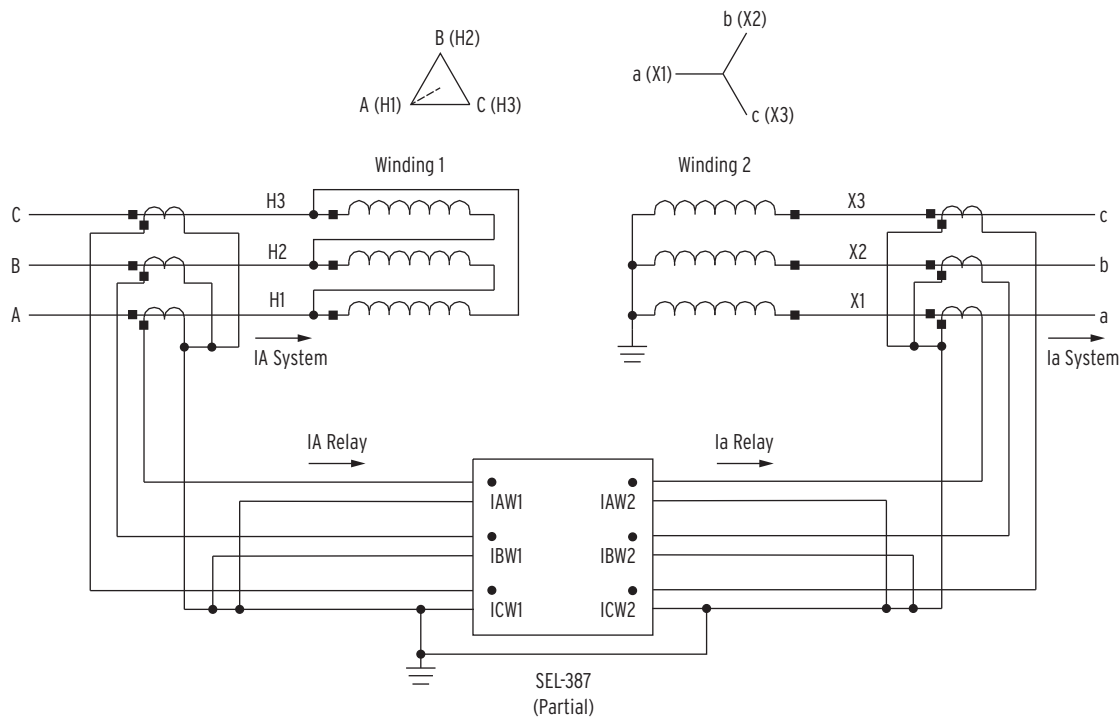
**Standard CT Connections.** In *Figure H.11*, the polarity of the CT connects to the polarity of the relay current input, and the primary system phase current connects to the same phase input on the relay (e.g., IA system to IAW1 relay input). While the H-side currents connect to the W1-terminal and the X-side currents connect to W2-terminal, they could be connected to any two sets of current inputs on the relay. *Figure H.11* represents the standard connections for the transformer, CTs, and relay.

*Figure H.11* also shows the primary system currents (IA system, Ia system) and the CT secondary currents seen by the relay (IA relay, Ia relay) based on the currents of *Figure H.6*. For these connections, with power flow from the H-side to the X-side of the transformer, currents enter the relay at the polarity mark on the H-side, and leave the relay at the polarity mark on the X-side. Thus, on the primary system, Ia lags IA by 30 degrees, but at the relay, IAW2 leads IAW1 by 150 degrees, as shown in *Figure H.12*. B- and C-phases follow this relationship. Only A-phase is discussed for simplicity, but the concept is the same.



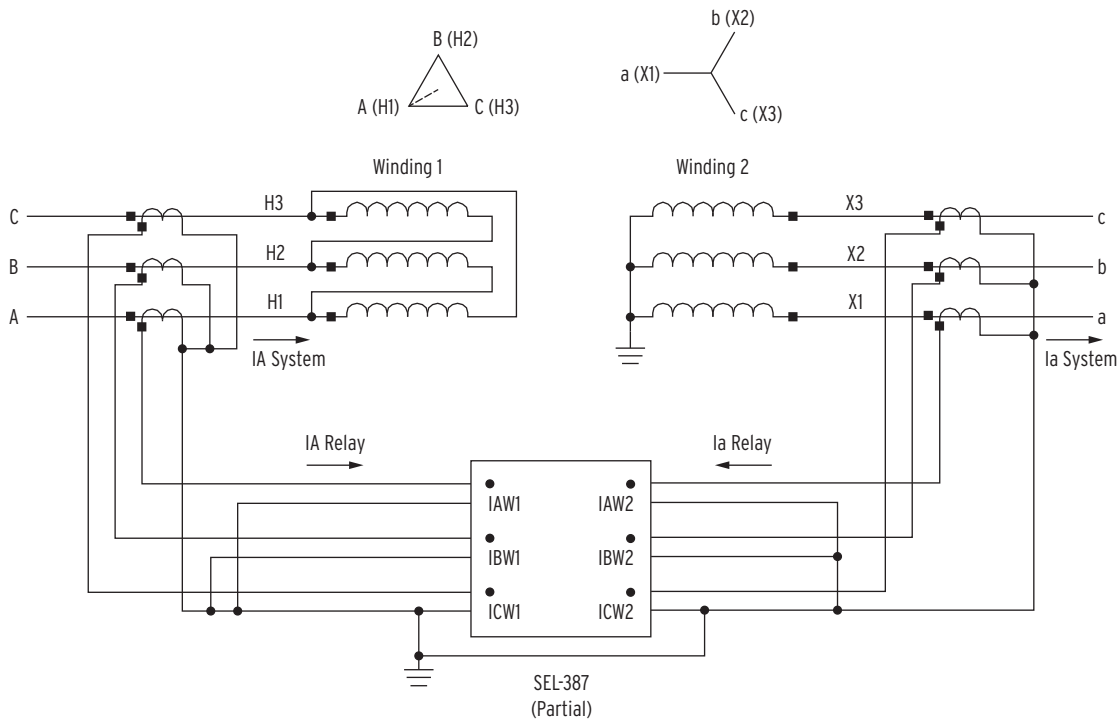
**Figure H.12** Primary System Currents and Currents as Seen by the Relay

**Non-Standard CT Connections: Reversed CT Polarity.** *Figure H.13* shows the X-side CT polarity marks toward the transformer. However, because the connections to the relay remain the same, the relay currents flow the same, as in *Figure H.12*. No additional adjustments need to be made because of this type of non-standard CT connection.



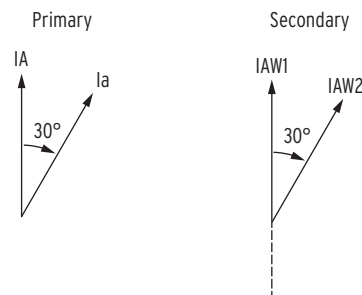
**Figure H.13** Current Flow With Reversed X-Side CT Polarity

**Non-Standard CT Connections: Reversed CT Polarity and Reversed Connections.** In *Figure H.14*, the polarity marks of the X-side CTs are toward the transformer, as in *Figure H.13*, but the neutral sides of the CTs are away from the transformer. With these connections, the H-side and X-side currents are both entering the relay at the relay polarity mark.



**Figure H.14** Current Flow With Reversed X-Side CT Polarity and Reversed Connections

As shown in *Figure H.15*, the resulting IAW2 current measured by the relay is now shifted 180 degrees, as compared to *Figure H.12*.



**Figure H.15** Results of Reversed X-Side CT Polarity and Reversed Connections

One method to correct this is to reverse the current connections at the relay. Connect the non-polarity terminal of the CT to the polarity terminal of the relay current input and the polarity terminal of the CT to the non-polarity terminal of the relay current input. These changes result in the connections shown in *Figure H.13*.

An alternate method to correct the phase shift is to use the CT compensation setting,  $WnCTC$ . As shown in *Table H.1*, each CTC setting results in a counter-clockwise phase shift that is a multiple of 30 degrees for an ABC system phase rotation. Selecting a compensation setting of 6 effectively shifts the current by 180 degrees ( $6 \cdot 30^\circ = 180^\circ$ ). Further explanation for selecting the final settings for non-standard CT connections is provided in *Example H.3*.

## Step 2. Select the Reference Winding and Associated Relay Terminal

If there is a delta winding on the power transformer, the delta winding should be selected as the reference winding regardless of whether it is the high- or low-voltage winding. The reference winding can be associated with any analog current measurement terminal on the relay. For example, if the delta winding current is measured by the W1-terminal inputs on the relay, W1CTC is the setting that corresponds to the reference winding.

The compensation for the delta winding should be set to matrix CTC(0) ( $WnCTC = 0$ ) unless there is a grounding bank on the delta winding within the differential zone. Grounding banks are a source of zero-sequence current and this current needs to be filtered to avoid operation of the differential element for external ground faults. If there is a grounding bank within the differential zone, use  $WnCTC = 12$ . Both  $WnCTC = 0$  and  $WnCTC = 12$  result in no phase shift, but  $WnCTC = 12$  additionally removes zero-sequence current from the differential calculation.

If there is no delta winding, select one of the wye windings as the reference and set the compensation setting to 11 ( $WnCTC = 11$ ) for the reference winding.

## Step 3. Determine the Required Compensation Settings for All Other Windings

Use the following guidelines for choosing the remaining CT compensation settings.

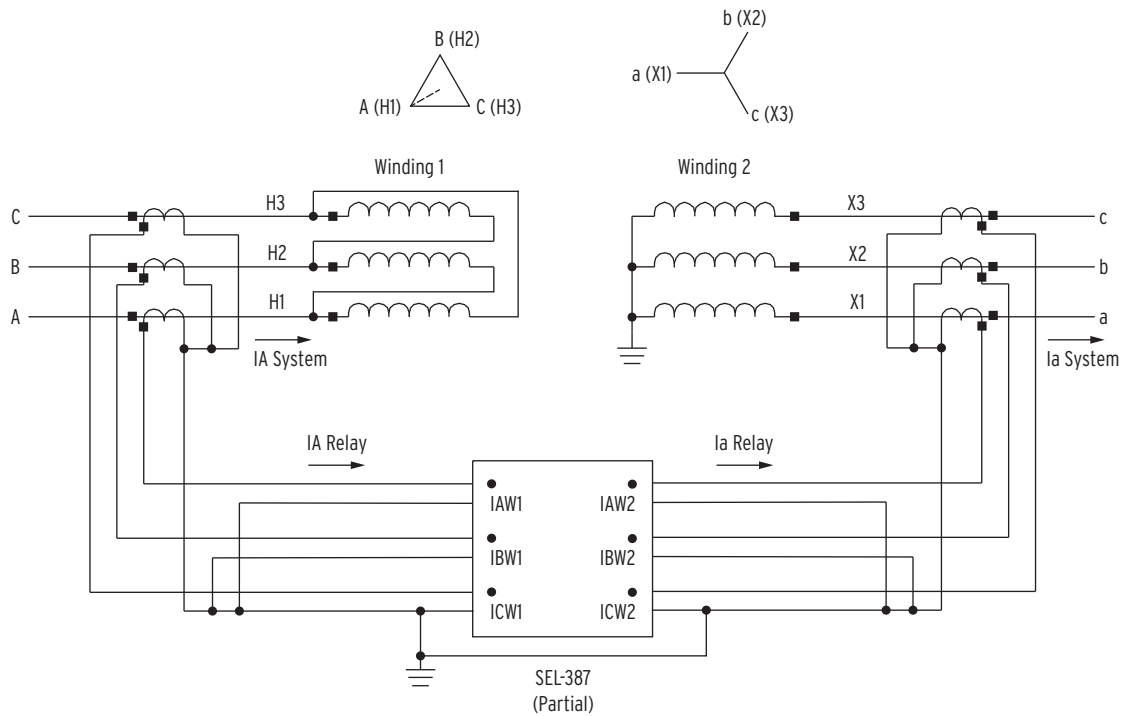
1. Compensate delta windings with matrix CTC(0)
2. Compensate wye windings with odd matrices
3. Avoid the use of even matrices

There may be applications that require one or more of the guidelines to be violated, but they should be followed when possible. The following examples illustrate the steps required to determine the compensation setting(s) for the remaining winding(s).

## Application Examples

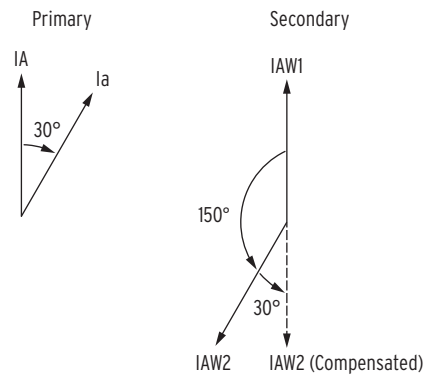
### **EXAMPLE H.1 Delta-Wye Transformer With Standard Phase-to-Bushing Connections, Standard CT Connections, and an ABC System Phase Rotation**

Consider the system shown in Figure H.16. The primary current phase shift for these connections was determined in Figure H.6. Figure H.17 shows the phase relationship of both the primary system phase currents and the secondary phase currents as seen by the relay. The system primary current  $I_a$  (X-side) lags the system primary current  $I_A$  (H-side) by 30 degrees. The CT connections are standard, which results in  $I_{AW2}$  leading  $I_{AW1}$  by 150 degrees.



**Figure H.16 Delta-Wye Transformer With Standard Phase-to-Bushing Connections**

Select the delta winding as the reference winding. The H-side delta current is connected to Terminal W1 of the SEL-387 Relay. Therefore, set W1CTC = 0. The X-side currents are connected to Terminal W2 of the SEL-387 Relay, so W2CTC must be determined.



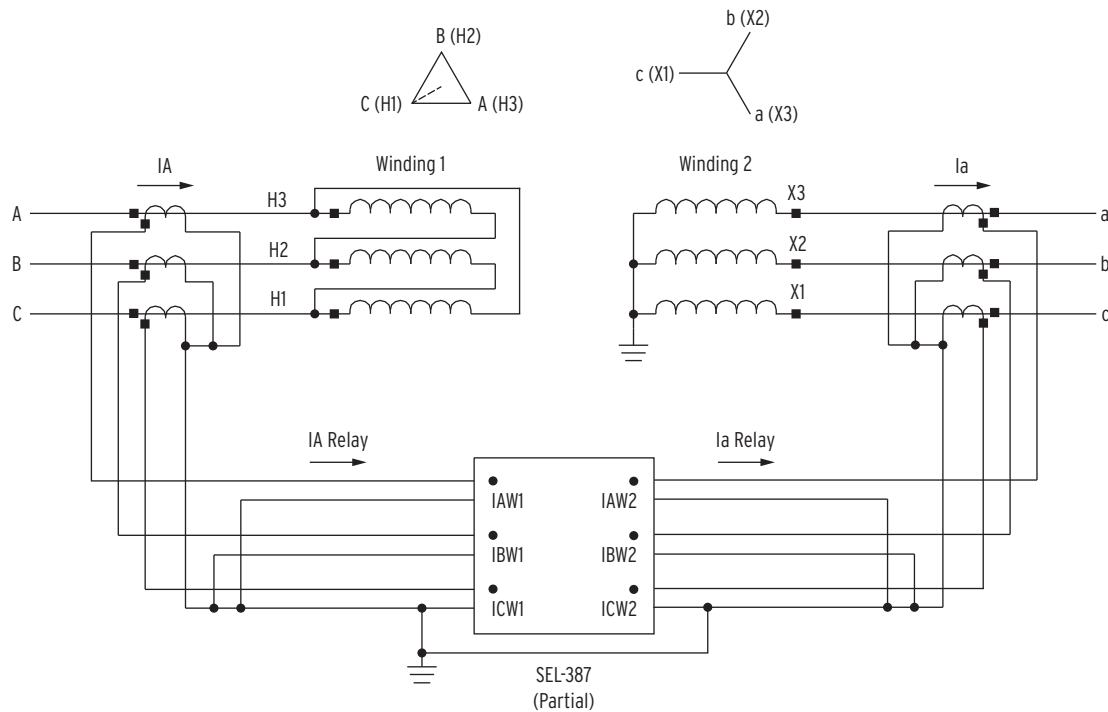
**Figure H.17 Primary Currents and Secondary Currents as Measured by the Relay**

IAW2 must be rotated 30 degrees (1 multiple of 30 degrees) in the counterclockwise direction for a system with an ABC phase rotation to be 180 degrees out-of-phase with IAW1. Therefore, set W2CTC = 1. The resulting compensation settings for this system are W1CTC = 0 and W2CTC = 1.

#### EXAMPLE H.2 Delta-Wye Transformer With Non-Standard Phase-to-Bushing Connections, Standard CT Connections, and an ABC System Phase Rotation

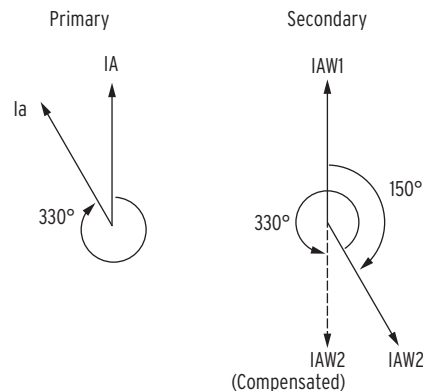
This example uses the transformer and relay connections of Figure H.18. This is the same transformer as in Example H.1, but with non-standard phase-to-bushing connections. Figure H.19 shows that for this connection, the system current Ia (X-side) leads the system current IA (H-side) by 30 degrees, or lags by 330 degrees. The CT connections are standard, which results in IAW2 lagging IAW1 by

150 degrees. Figure H.19 shows the phase relationship of both the primary system phase currents and the secondary phase currents as seen by the relay.



**Figure H.18 Delta-Wye Transformer With Non-Standard Phase-to-Bushing Connections**

Select the delta winding as the reference winding. The H-side delta current is connected to Terminal W1 of the SEL-387 Relay. Therefore, set W1CTC = 0. The X-side currents are connected to Terminal W2, so W2CTC must be determined.



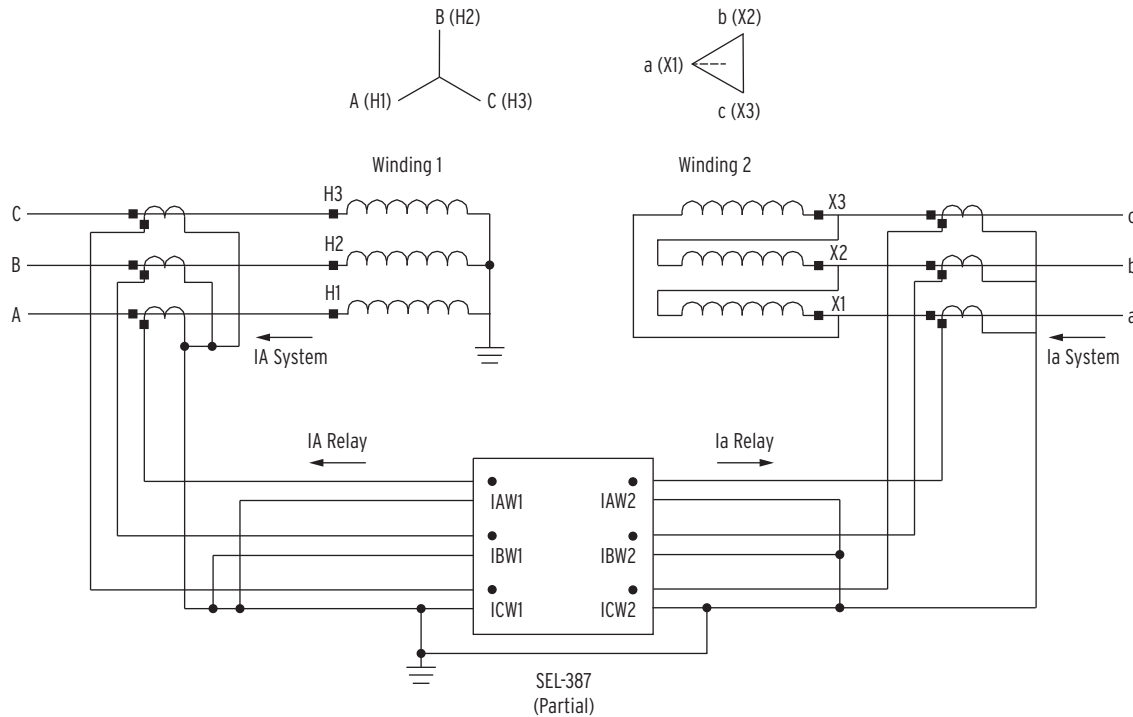
**Figure H.19 Primary Currents and Secondary Currents as Measured by the Relay**

IAW2 must be rotated 330 degrees (11 multiples of 30 degrees) in the counter-clockwise direction for a system with an ABC phase rotation to be 180 degrees out-of-phase with IAW1. Therefore, set W2CTC = 11. The resulting compensation settings are W1CTC = 0 and W2CTC = 11. Although the same transformer is used in Example H.1 and Example H.2, notice that the non-standard phase-to-bushing connections affect the compensation settings in both examples.



### EXAMPLE H.3 Delta-Wye Transformer With Standard Phase-to-Bushing Connections, X-Side Non-Standard CT Connections, and an ABC System Phase Rotation

This example uses standard phase-to-bushing connections as shown in Figure H.20. Notice the X-side CT connections are non-standard. This example differs from the previous examples because the wye winding is now on the high side. The method to solve for the compensation settings is the same.



**Figure H.20 Wye-Delta Transformer With Non-Standard CT Connections on the X-Side**

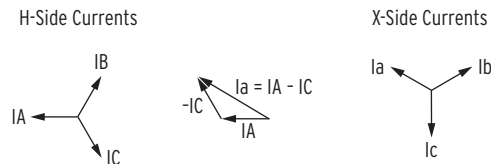
Assume balanced three-phase currents on the wye side of the transformer. In this example, the wye side is associated with the H-side of the transformer. The phase currents on the X-side are:

$$I_a = I_A - I_C$$

$$I_b = I_B - I_A$$

$$I_c = I_C - I_B$$

In Figure H.21,  $I_A$  on the wye side of the transformer is chosen as the reference to derive the phasor diagram of the delta-side currents. The system primary current  $I_a$  (X-side) lags  $I_A$  (H-side) by 30 degrees or leads  $I_A$  by 330 degrees.

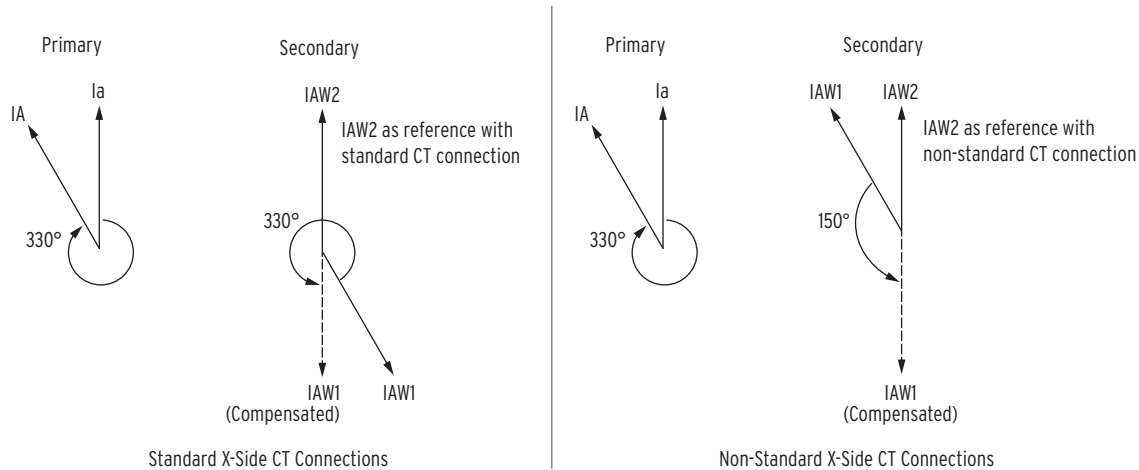


**Figure H.21 X- and H-Side Current Phasors for Figure H.20**

With the reversed CT polarity on the X-side, the current is leaving Terminal W2 at the polarity mark instead of entering the polarity mark, which makes the current seen by the relay 180 degrees out-of-phase compared to a standard CT connection. In Non-Standard CT Connections: Reversed CT Polarity and Reversed Connections, two methods are proposed to correct the phase shift for reverse polarity CTs. The first method is to rewire the current inputs on the relay so

that they match the standard connections. The second method is to use the compensation settings; by adding or subtracting 6 from the setting. This example explores the latter method.

Following the settings guidelines, select the delta side as the reference. The delta side of the transformer is connected to relay Terminal W2, therefore, W2CTC = 0 and is used as the reference. Figure H.22 compares the current phasors if the X-side CT connections use standard connections rather than non-standard connections. On the left side of Figure H.22, standard CT connections and an ABC phase rotation require IAW1 to be rotated by 330 degrees (11 multiples of 30 degrees) counterclockwise to be 180 degrees out-of-phase with IAW2. Therefore, if the X-side CTs have standard connections, set W1CTC = 11. The resulting compensation settings with standard CT connections are W2CTC = 0 and W1CTC = 11.



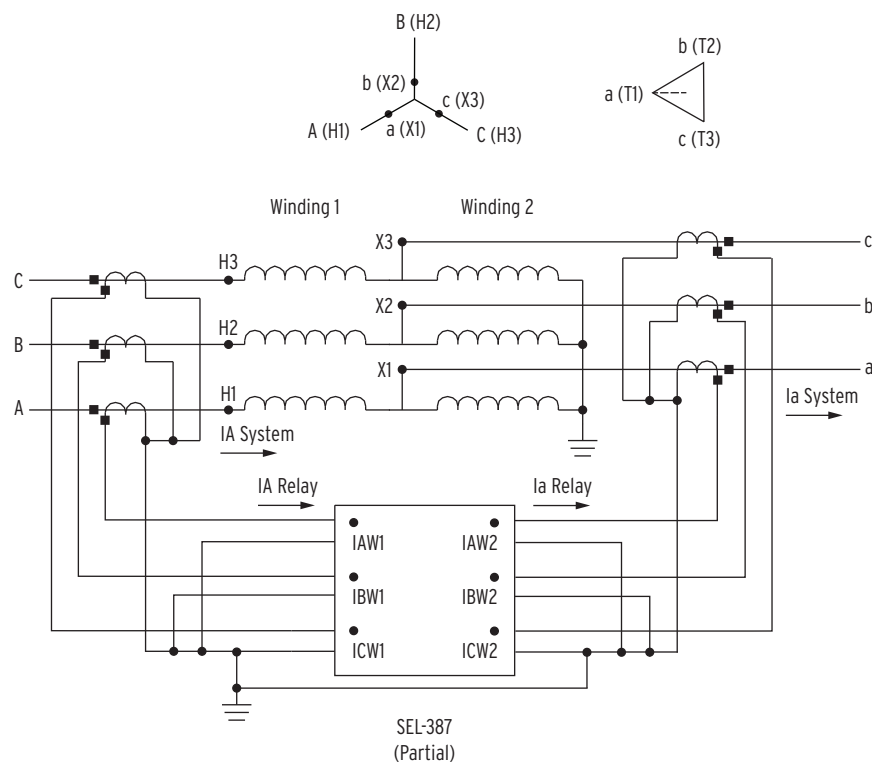
**Figure H.22 Comparison of Standard and Non-Standard CT Connections on the X-Side of the Transformer**

However, in this example, non-standard CT connections are used on the delta winding, which results in IAW1 leading IAW2 by 30 degrees. IAW1 needs to rotate 150 degrees (5 multiples of 30 degrees) counterclockwise for a system with an ABC phase rotation to be 180 degrees out-of-phase with IAW2. Therefore, set W1CTC = 5. The resulting compensation settings with non-standard CT connections on the X-side are W2CTC = 0 and W1CTC = 5.

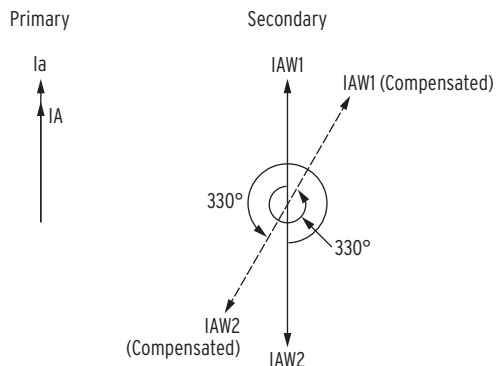
#### EXAMPLE H.4 Autotransformer, Standard Phase-to-Bushing Connections, Standard CT Connections, and an ABC System Phase Rotation

Consider the autotransformer shown in Figure H.23. The delta tertiary exists, but is buried and not brought out to the relay. The primary current phase shift for these connections is shown in Figure H.24. The system primary current  $I_a$  (X-side) is in phase with the system primary current  $I_A$  (H-side). The CT connections are standard, which results in IAW2 180 degrees out-of-phase with IAW1.

Per the guidelines, since there is no delta winding connected to the relay, choose any one of the wye windings, say H-side, as the reference winding and choose matrix CTC(11) for the compensation. The H-side currents are connected to Terminal W1 of the SEL-387 Relay. Therefore, set W1CTC = 11. The X-side currents are connected to Terminal W2, so W2CTC must be determined. Figure H.24 shows the phase relationship of both the primary system phase currents and the secondary phase currents as seen by the relay. Since Matrix 11 is applied to Winding 1, this will shift IAW1 11 multiples of 30 degrees in the counterclockwise direction. To keep Winding 2 current, IAW2 180 degrees out-of-phase with IAW1, you must also shift IAW2 by 11 multiples of 30 degrees in the counterclockwise direction. The resulting compensation settings are W1CTC = 11 and W2CTC = 11.



**Figure H.23 Autotransformer With Standard Phase-to-Bushing Connections**

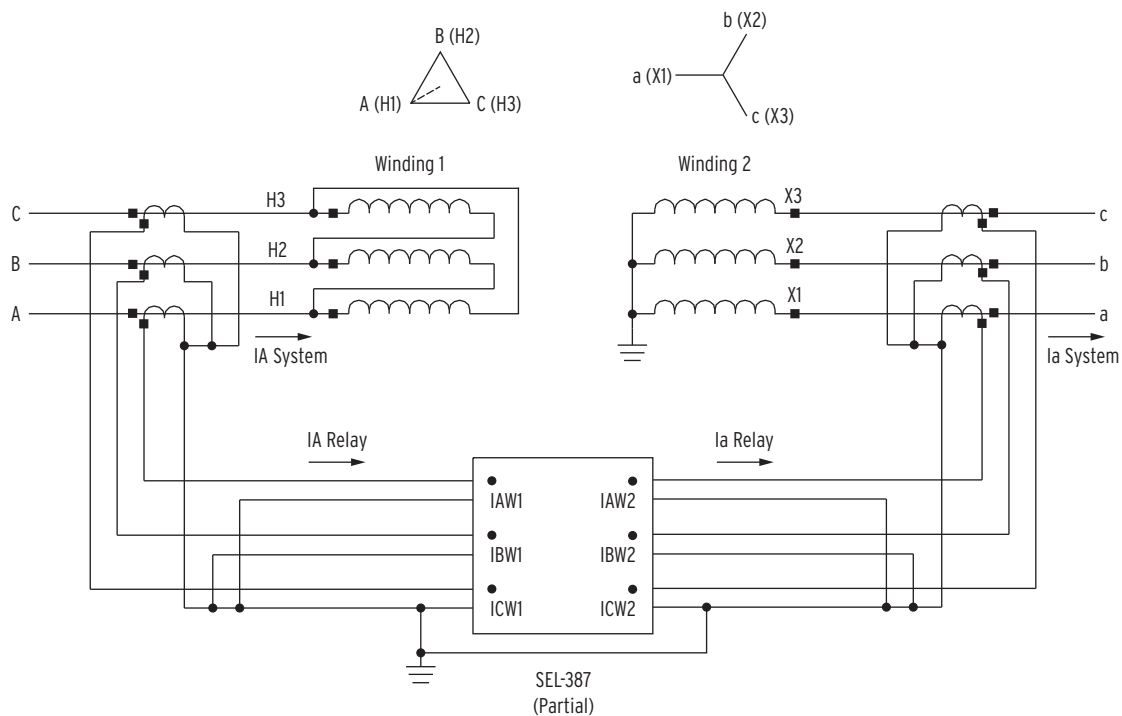


**Figure H.24 Primary Currents and Secondary Currents as Measured by the Relay**

## Special Cases

### **EXAMPLE H.5 Delta-Wye Transformer With Standard Phase-to-Bushing Connections, Standard CT Connections, and an ACB System Phase Rotation**

Consider the application in Figure H.25 with standard phase-to-bushing connections, standard CT connections, and an ACB system phase rotation.



**Figure H.25 Delta-Wye Transformer With Standard Phase-to-Bushing Connections With an ACB Phase Rotation**

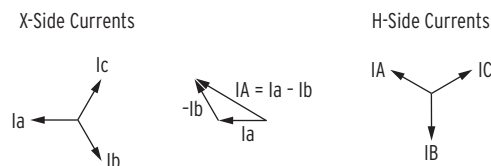
The H-side currents are:

$$I_A = I_a - I_b$$

$$I_B = I_b - I_c$$

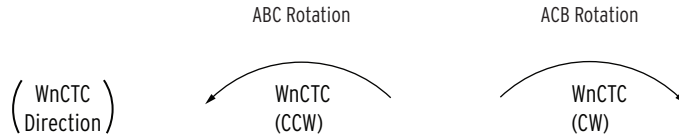
$$I_C = I_c - I_a$$

Figure H.26 uses a balanced set of three-phase currents with an ACB phase sequence on the wye winding as a reference to derive the delta winding (H-side) currents. When compared to Example H.1, even with the same transformer and the same connections, Figure H.26 shows that  $I_a$  (X-side) now leads  $I_A$  (H-side) by 30 degrees because of the system phase rotation. Note that in Example H.1,  $I_a$  (X-side) lags  $I_A$  (H-side) by 30 degrees. The CT connections are standard, which results in  $I_{AW2}$  lagging  $I_{AW1}$  by 150 degrees. Figure H.28 shows the phase relationship of both the primary system phase currents and the secondary phase currents as seen by the relay.



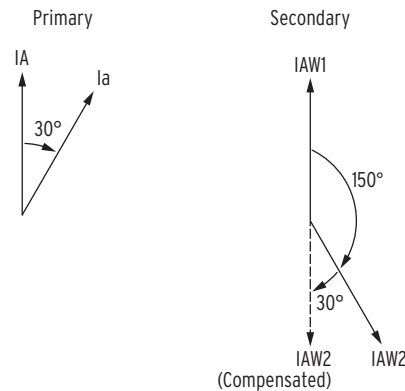
**Figure H.26 X- and H-Side Current Phasors for Figure H.25**

A common misconception is that a different compensation setting pair is required depending on the system phase rotation. However, closer inspection of the compensation matrices and the direction of correction in Table H.1 (also shown in Figure H.27) indicate that the matrix causes the compensated currents to rotate in the opposite direction depending on the system phase rotation.



**Figure H.27 Direction of Compensation Based on System Phase Rotation**

Thus, the compensation settings required for Example H.1 and Example H.5 are the same. Following the settings guideline, the delta side of the transformer is selected as the reference, so  $W1CTC = 0$ . Figure H.28 shows IAW2 needs to be rotated 30 degrees (1 multiple of 30 degrees) clockwise for a system with an ACB phase rotation to be 180 degrees out-of-phase with IAW1. Therefore, set  $W2CTC = 1$ . The resulting compensation settings are  $W1CTC = 0$  and  $W2CTC = 1$ .



**Figure H.28 Primary Currents and Secondary Currents as Measured by the Relay**

If the relay is set assuming an ABC phase rotation, but the actual system phase sequence is ACB, the relay compensation settings do not need to be changed. However, the calculated positive- and negative-sequence currents will be incorrect unless the Global setting for phase rotation, PHROT, matches the system phase sequence. PHROT does not affect the compensation settings or the differential protection.

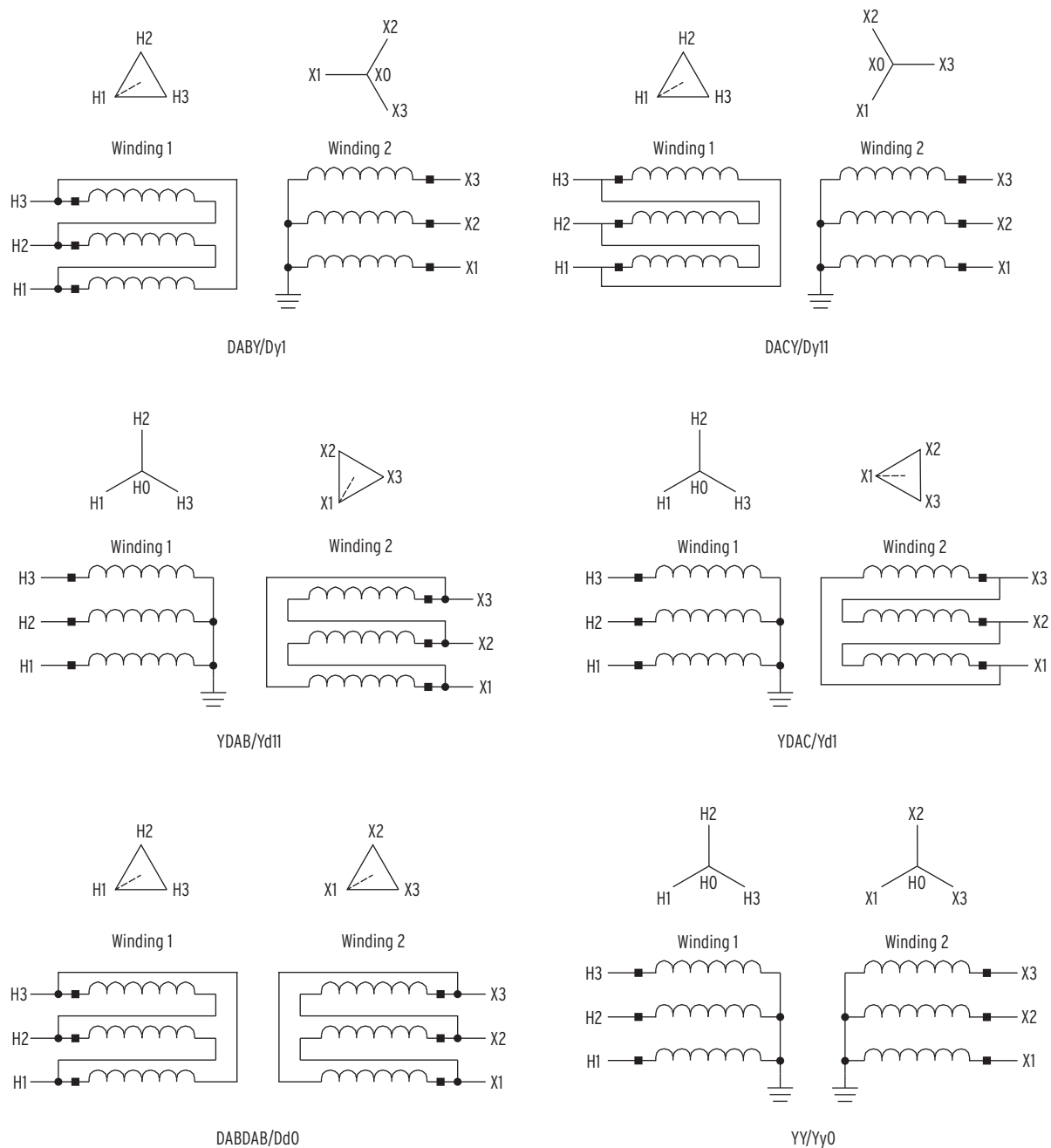
#### **EXAMPLE H.6 Delta-Wye Transformer With Standard Phase-to-Bushing Connections, Standard CT Connections, and an ABC System Phase Rotation With a Zig-Zag Grounding Transformer Within the Differential Zone on the Delta Side**

This example uses the same transformer and CT connections as in Example H.1, except that it includes a zig-zag grounding transformer within the differential zone on the delta side of the transformer. Zig-zag transformers are typically used for grounding purposes and act as a source of zero-sequence current. If the zig-zag transformer is located outside of the differential zone on the delta side, it can be ignored, and the compensation settings will remain the same as in Example H.1. The same is true if the zig-zag transformer is present on the wye side, be it inside or outside the differential zone. If the zig-zag grounding transformer is within the differential zone on the delta side, then it has to be accounted for when determining the compensation settings.

The compensation settings in Example H.1 are  $W1CTC = 0$  for the delta winding (reference winding) and  $W2CTC = 1$  for the wye winding. When a ground current source is within the differential zone on the delta side, the recommended compensation setting of  $W1CTC = 0$  cannot be used. The zero-sequence current needs to be filtered to avoid an operation of the differential element for external ground faults. Therefore, set  $W1CTC = 12$ . Matrix  $CTC(12)$  has no phase shift, but  $CTC(12)$  removes zero-sequence current from the differential calculation.

## Quick Settings Guide for Standard Connections

Figure H.29 shows examples of common transformer connections. Table H.4 is a quick reference guide to be used when all standard phase-to-bushing, CT, and relay connections are present. Table H.4 is applicable to both ABC and ACB system phase rotations.



**Figure H.29 Common Transformer Connections**

**Table H.4 Quick Settings Guide for Common Transformer Configurations and Standard Connections (Sheet 1 of 2)**

XFMR Connection	W1CTC (Winding 1)	W2CTC (Winding 2)
DABY/Dy1	0	1
DACY/Dy11	0	11

**Table H.4 Quick Settings Guide for Common Transformer Configurations and Standard Connections** (Sheet 2 of 2)

XFMR Connection	W1CTC (Winding 1)	W2CTC (Winding 2)
YDAC/Yd1	11	0
YDAB/Yd11	1	0
DABDAB/Dd0 DACDAC/Dd0	0	0
YY/Yy0	11	11

The compensation settings of *Table H.4* assume that the Winding 1 side of the transformer is connected to relay Terminal W1 and the Winding 2 side of the transformer is connected to relay Terminal W2. These settings apply for all standard phase-to-bushing connections shown in *Table H.2*. In each of these phase-to-bushing connections, the order of the phase connections (A, B, C) matches the order of the bushings (H1, H2, H3).

## References

Further discussion on selecting transformer compensations settings can be found in the technical paper, *Beyond the Nameplate – Selecting Transformer Compensation Settings for Secure Differential Protection* by Barker Edwards, David G. Williams, Ariana Hargrave, Matthew Watkins, and Vinod K. Yedidi.

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# Appendix I

## PC Software

### Overview

**NOTE:** PC software is updated more frequently than relay firmware. As a result, the descriptions in this section may differ slightly from the software. Select **Help** in the PC software for information.

SEL provides many PC software solutions (applications) that support SEL devices. These software solutions are listed in *Table I.1*.

Visit [selinc.com](http://selinc.com) to obtain the latest versions of the software listed in *Table I.1*.

**Table I.1 SEL Software Solutions**

Product Name	Description
SEL Compass®	This application provides an interface for web-based notification of product updates and automatic software updating.
ACSELERATOR QuickSet® SEL-5030 Software	QuickSet is a powerful setting, event analysis, and measurement tool that aids in applying and using the relay. See the <i>ACSELERATOR QuickSet SEL-5030 Software Instruction Manual</i> for information about the various QuickSet applications. <sup>a</sup>
ACSELERATOR Architect® SEL-5032 Software	Use this application to design and commission SEL IEDs in IEC 61850 substations, create and map GOOSE messages, use predefined reports, create and edit data sets, and read in SCD, ICD, and CID files.
ACSELERATOR TEAM® SEL-5045 Software	The TEAM system provides custom data collection and movement of a wide variety of device information. The system provides tools for device communication, automatic collection of data, and creation of reports, warnings, and alarms. See <i>ACSELERATOR Team SEL-5045 Software Instruction Manual</i> for information about the various TEAM applications.
SEL-5601-2 SYNCHROWAVE® Event Software	Converts SEL Compressed ASCII and COMTRADE event report files to oscillography.
Cable Selector SEL-5801 Software	Selects the proper SEL cables for your application.

<sup>a</sup> The SEL-387 does not support the freeform logic described in the QuickSet instruction manual.

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# SEL-387 Relay Command Summary

Access Level 0 Commands	The only thing that can be done at Access Level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper (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	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper (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 four breakers.
CEV <i>n</i>	Show compressed winding event report number <i>n</i> , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
DAT	Show date presently in the relay.
DAT <i>m/d/y</i>	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT <i>y/m/d</i>	Enter date in this manner if Date Format setting DATE_F = YMD.
EVE <i>n</i>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE D <i>n</i>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF1 <i>n</i>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF2 <i>n</i>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF3 <i>n</i>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE R <i>n</i>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
EVE T	Show event summary.
GRO	Display active setting group number.
HIS <i>n</i>	Show brief summary of the <i>n</i> latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
ID	Display variety of identification and configuration information about the relay.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET <i>k</i>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET D <i>k</i>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET DIF <i>k</i>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>QUI</b>	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
<b>SER <i>d1</i></b>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
<b>SER <i>d1 d2</i></b>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
<b>SER <i>m n</i></b>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
<b>SER <i>n</i></b>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
<b>SER C</b>	Clear the Sequential Events Recorder (SER) event reports from memory.
<b>SHO <i>n</i></b>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> is not specified.
<b>SHO G</b>	Show relay Global settings.
<b>SHO P</b>	Show port settings and identification of port to which user is connected.
<b>SHO P <i>n</i></b>	Show port settings for port <i>n</i> ( <i>n</i> = 1, 2, 3, 4).
<b>SHO R</b>	Show Sequential Events Recorder (SER) settings.
<b>STA</b>	Show relay self-test status.
<b>STA C</b>	Clear relay status report from memory and restart the relay.
<b>TAR <i>n k</i></b>	Show Relay Word row <i>n</i> status ( <i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append F to display targets on the front panel, second row of LEDs.
<b>TAR R</b>	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
<b>TFE</b>	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
<b>TFE <i>n</i></b>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
<b>TFE A</b>	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
<b>TFE C</b>	Clears/resets cumulative and individual through-fault event data.
<b>TFE P</b>	Preloads cumulative through-fault event data.
<b>TFE R</b>	Clears/resets cumulative and individual through-fault event data.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: ==>
<b>All commands that begin THE apply to the SEL-387-6 Relay</b>	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE n</b>	Displays saved thermal monitor report $n$ where $n = 1$ is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D x y</b>	Retrieves daily profile data from day $x$ to day $y$ . If $x$ and $y$ are omitted, retrieves entire profile data. If $x$ or $y$ is omitted, retrieves profile from day $x$ ( $y$ ) to present.
<b>THE H x y</b>	Retrieves hourly profile data from day $x$ to day $y$ . If $x$ and $y$ are omitted, retrieves entire profile data. If $x$ or $y$ is omitted, retrieves profile from day $x$ ( $y$ ) to present.
<b>THE P n</b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>ACC</b>	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.
<b>2AC</b>	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.
<b>BRE</b>	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
<b>BRE R n</b>	Reset trip counters, trip currents, and wear data for breaker $n$ ( $n = 1, 2, 3, 4, A$ ).
<b>BRE W n</b>	Pre-set the percent contact wear for each pole of breaker $n$ ( $n = 1, 2, 3, \text{ or } 4$ ).
<b>CEV n</b>	Show compressed winding event report number $n$ , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ $m$ -cycle resolution ( $m = 4$ or $8$ for filtered data; $m = 4, 8, 16, 32, \text{ or } 64$ for raw data).
<b>CLO n</b>	Assert the CC $n$ Relay Word bit. Used to close breaker $n$ if CC $n$ is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>DAT</b>	Show date presently in the relay.
<b>DAT m/d/y</b>	Enter date in this manner if Date Format setting DATE_F = MDY.
<b>DAT y/m/d</b>	Enter date in this manner if Date Format setting DATE_F = YMD.
<b>EVE n</b>	Show standard event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE D n</b>	Show digital data event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF1 n</b>	Show differential element 1 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF2 n</b>	Show differential element 2 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF3 n</b>	Show differential element 3 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>EVE R <i>n</i></b>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <i>Sm</i> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
<b>EVE T</b>	Show event summary.
<b>GRO</b>	Display active setting group number.
<b>GRO <i>n</i></b>	Switch to Setting Group <i>n</i> . (Will not function if any <i>SSn</i> Relay Word bit is asserted.)
<b>HIS <i>n</i></b>	Show brief summary of the <i>n</i> latest event reports.
<b>HIS C</b>	Clear the brief summary and corresponding standard event reports.
<b>ID</b>	Display variety of identification and configuration information about the relay.
<b>INI</b>	<b>INITIO</b> command reports the number and type of I/O boards in the relay.
<b>IRI</b>	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
<b>MET <i>k</i></b>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET D <i>k</i></b>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET DIF <i>k</i></b>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of the 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>OPE <i>n</i></b>	Assert the <i>OCn</i> Relay Word bit. Used to open breaker <i>n</i> if <i>OCn</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>PUL <i>y k</i></b>	Pulse output contact <i>y</i> ( <i>y</i> = OUT101,...,OUT107, OUT2XX, and OUT3XX). Enter number <i>k</i> to pulse for <i>k</i> seconds [ <i>k</i> = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP6B has to be in place to enable this command.
<b>QUI</b>	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
<b>SER <i>d1</i></b>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
<b>SER <i>d1 d2</i></b>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
<b>SER <i>m n</i></b>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
<b>SER <i>n</i></b>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
<b>SER C</b>	Clear the Sequential Events Recorder (SER) event reports from memory.
<b>SHO <i>n</i></b>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> is not specified.
<b>SHO G</b>	Show relay Global settings.
<b>SHO P</b>	Show port settings and identification of port to which user is connected.
<b>SHO P <i>n</i></b>	Show port settings for port <i>n</i> ( <i>n</i> = 1, 2, 3, 4).
<b>SHO R</b>	Show Sequential Events Recorder (SER) settings.
<b>STA</b>	Show relay self-test status.
<b>TAR <i>n k</i></b>	Show Relay Word row <i>n</i> status ( <i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append <b>F</b> to display targets on the front panel, second row of LEDs.
<b>TAR R</b>	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
<b>TFE</b>	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
<b>TFE <i>n</i></b>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
<b>TFE A</b>	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
<b>TFE C</b>	Clears/resets cumulative and individual through-fault event data.
<b>TFE P</b>	Preloads cumulative through-fault event data.
<b>TFE R</b>	Clears/resets cumulative and individual through-fault event data.
<b>All commands that begin THE apply to the SEL-387-6 Relay</b>	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE <i>n</i></b>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D <i>x y</i></b>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE H <i>x y</i></b>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE P <i>n</i></b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.
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: ==>
<b>ACC</b>	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.
<b>BAC</b>	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.
<b>BRE</b>	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
<b>BRE R <i>n</i></b>	Reset trip counters, trip currents, and wear data for breaker <i>n</i> ( <i>n</i> = 1, 2, 3, 4, A).
<b>BRE W <i>n</i></b>	Pre-set the percent contact wear for each pole of breaker <i>n</i> ( <i>n</i> = 1, 2, 3, or 4).
<b>CAL</b>	Moves from Access Level 2 to Access Level C.
<b>CEV <i>n</i></b>	Show compressed winding event report number <i>n</i> , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
<b>CLO <i>n</i></b>	Assert the CC <i>n</i> Relay Word bit. Used to close breaker <i>n</i> if CC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.

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: ==>>
<b>CON <i>n</i></b>	Control Relay Word bit RB <i>n</i> (Remote Bit <i>n</i> ; <i>n</i> = 1 through 16). Execute <b>CON <i>n</i></b> and the relay responds: CONTROL RB <i>n</i> . Reply with one of the following: <b>SRB <i>n</i></b> set Remote Bit <i>n</i> (assert RB <i>n</i> ) <b>CRB <i>n</i></b> clear Remote Bit <i>n</i> (deassert RB <i>n</i> ) <b>PRB <i>n</i></b> pulse Remote Bit <i>n</i> [assert RB <i>n</i> for one processing interval (1/8-cycle)].
<b>COPY <i>m n</i></b>	Copy settings and logic from setting Group <i>m</i> to Group <i>n</i> .
<b>DAT</b>	Show date presently in the relay.
<b>DAT <i>m/d/y</i></b>	Enter date in this manner if Date Format setting DATE_F = MDY.
<b>DAT <i>y/m/d</i></b>	Enter date in this manner if Date Format setting DATE_F = YMD.
<b>EVE <i>n</i></b>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE D <i>n</i></b>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF1 <i>n</i></b>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF2 <i>n</i></b>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF3 <i>n</i></b>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE R <i>n</i></b>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <b>S<i>m</i></b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
<b>EVE T</b>	Show event summary.
<b>GRO</b>	Display active setting group number.
<b>GRO <i>n</i></b>	Switch to Setting Group <i>n</i> . (Will not function if any SS <i>n</i> Relay Word bit is asserted.)
<b>HIS <i>n</i></b>	Show brief summary of the <i>n</i> latest event reports.
<b>HIS C</b>	Clear the brief summary and corresponding standard event reports.
<b>ID</b>	Display variety of identification and configuration information about the relay.
<b>INI</b>	<b>INITIO</b> command reports the number and type of I/O boards in the relay. In Access Level 2, confirms that I/O boards are correct.
<b>IRI</b>	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
<b>MET <i>k</i></b>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET D <i>k</i></b>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET DIF <i>k</i></b>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>OPE <i>n</i></b>	Assert the OC <i>n</i> Relay Word bit. Used to open breaker <i>n</i> if OC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>PAS</b>	Show existing Access Level 1, B, and 2 passwords.



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: =>
PAS 1 xxxxx	Change Access Level 1 password to xxxxx.
PAS B xxxxx	Change Access Level B password to xxxxx.
PAS 2 xxxxx	Change Access Level 2 password to xxxxx. If xxxxx is <b>DISABLE</b> (uppercase), password for selected level is disabled.
PAS C xxxxx	Change Access Level C password to xxxxx. If xxxxx is <b>DISABLE</b> (uppercase), password for selected level is disabled.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, and OUT3XX). 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	<b>RESET51</b> command resets all inverse-time O/C elements for the four windings, including the Combined Overcurrent elements.
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 m n	Show rows m through n in the Sequential Events Recorder (SER) event report.
SER n	Show the latest n rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER) event reports from memory.
SET n	Change relay group settings (overcurrent, differential, etc.). For the <b>SET</b> 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 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.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE n	Displays cumulative and individual through-fault event data. The n most recent individual events are displayed, where n = 1 to 1200.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.

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: ==>>
All commands that begin THE apply to the SEL-387-6 Relay	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE n</b>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D x y</b>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE H x y</b>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE P n</b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.

# SEL-387 Relay Command Summary

Access Level 0 Commands	The only thing that can be done at Access Level 0 is to go to Access Level 1. The screen prompt is: =
ACC	Enter Access Level 1. If the main board password jumper (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	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
2AC	Enter Access Level 2. If the main board password jumper (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 four breakers.
CEV <i>n</i>	Show compressed winding event report number <i>n</i> , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
DAT	Show date presently in the relay.
DAT <i>m/d/y</i>	Enter date in this manner if Date Format setting DATE_F = MDY.
DAT <i>y/m/d</i>	Enter date in this manner if Date Format setting DATE_F = YMD.
EVE <i>n</i>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE D <i>n</i>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF1 <i>n</i>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF2 <i>n</i>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE DIF3 <i>n</i>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
EVE R <i>n</i>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
EVE T	Show event summary.
GRO	Display active setting group number.
HIS <i>n</i>	Show brief summary of the <i>n</i> latest event reports.
HIS C	Clear the brief summary and corresponding standard event reports.
ID	Display variety of identification and configuration information about the relay.
INI	INITIO command reports the number and type of I/O boards in the relay.
IRI	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
MET <i>k</i>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET D <i>k</i>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
MET DIF <i>k</i>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: =>
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>QUI</b>	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
<b>SER <i>d1</i></b>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
<b>SER <i>d1 d2</i></b>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
<b>SER <i>m n</i></b>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
<b>SER <i>n</i></b>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
<b>SER C</b>	Clear the Sequential Events Recorder (SER) event reports from memory.
<b>SHO <i>n</i></b>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> is not specified.
<b>SHO G</b>	Show relay Global settings.
<b>SHO P</b>	Show port settings and identification of port to which user is connected.
<b>SHO P <i>n</i></b>	Show port settings for port <i>n</i> ( <i>n</i> = 1, 2, 3, 4).
<b>SHO R</b>	Show Sequential Events Recorder (SER) settings.
<b>STA</b>	Show relay self-test status.
<b>STA C</b>	Clear relay status report from memory and restart the relay.
<b>TAR <i>n k</i></b>	Show Relay Word row <i>n</i> status ( <i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append F to display targets on the front panel, second row of LEDs.
<b>TAR R</b>	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
<b>TFE</b>	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
<b>TFE <i>n</i></b>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
<b>TFE A</b>	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
<b>TFE C</b>	Clears/resets cumulative and individual through-fault event data.
<b>TFE P</b>	Preloads cumulative through-fault event data.
<b>TFE R</b>	Clears/resets cumulative and individual through-fault event data.

Access Level 1 Commands	The Access Level 1 commands primarily allow the user to look at information (e.g., settings, metering, etc.), but not to change it. The screen prompt is: ==>
<b>All commands that begin THE apply to the SEL-387-6 Relay</b>	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE n</b>	Displays saved thermal monitor report $n$ where $n = 1$ is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D x y</b>	Retrieves daily profile data from day $x$ to day $y$ . If $x$ and $y$ are omitted, retrieves entire profile data. If $x$ or $y$ is omitted, retrieves profile from day $x$ ( $y$ ) to present.
<b>THE H x y</b>	Retrieves hourly profile data from day $x$ to day $y$ . If $x$ and $y$ are omitted, retrieves entire profile data. If $x$ or $y$ is omitted, retrieves profile from day $x$ ( $y$ ) to present.
<b>THE P n</b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>ACC</b>	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.
<b>2AC</b>	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.
<b>BRE</b>	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
<b>BRE R n</b>	Reset trip counters, trip currents, and wear data for breaker $n$ ( $n = 1, 2, 3, 4, A$ ).
<b>BRE W n</b>	Pre-set the percent contact wear for each pole of breaker $n$ ( $n = 1, 2, 3, \text{ or } 4$ ).
<b>CEV n</b>	Show compressed winding event report number $n$ , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ $m$ -cycle resolution ( $m = 4$ or $8$ for filtered data; $m = 4, 8, 16, 32, \text{ or } 64$ for raw data).
<b>CLO n</b>	Assert the CC $n$ Relay Word bit. Used to close breaker $n$ if CC $n$ is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>DAT</b>	Show date presently in the relay.
<b>DAT m/d/y</b>	Enter date in this manner if Date Format setting DATE_F = MDY.
<b>DAT y/m/d</b>	Enter date in this manner if Date Format setting DATE_F = YMD.
<b>EVE n</b>	Show standard event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE D n</b>	Show digital data event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF1 n</b>	Show differential element 1 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF2 n</b>	Show differential element 2 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF3 n</b>	Show differential element 3 event report number $n$ , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>EVE R <i>n</i></b>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <i>Sm</i> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
<b>EVE T</b>	Show event summary.
<b>GRO</b>	Display active setting group number.
<b>GRO <i>n</i></b>	Switch to Setting Group <i>n</i> . (Will not function if any <i>SSn</i> Relay Word bit is asserted.)
<b>HIS <i>n</i></b>	Show brief summary of the <i>n</i> latest event reports.
<b>HIS C</b>	Clear the brief summary and corresponding standard event reports.
<b>ID</b>	Display variety of identification and configuration information about the relay.
<b>INI</b>	<b>INITIO</b> command reports the number and type of I/O boards in the relay.
<b>IRI</b>	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
<b>MET <i>k</i></b>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET D <i>k</i></b>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET DIF <i>k</i></b>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of the 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>OPE <i>n</i></b>	Assert the <i>OCn</i> Relay Word bit. Used to open breaker <i>n</i> if <i>OCn</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>PUL <i>y k</i></b>	Pulse output contact <i>y</i> ( <i>y</i> = OUT101,...,OUT107, OUT2XX, and OUT3XX). Enter number <i>k</i> to pulse for <i>k</i> seconds [ <i>k</i> = 1 to 30 (seconds)], otherwise pulse time is 1 second. JMP6B has to be in place to enable this command.
<b>QUI</b>	Quit. Returns to Access Level 0. Returns front-panel LEDs to the default targets.
<b>SER <i>d1</i></b>	Show rows in the Sequential Events Recorder (SER) event report for date <i>d1</i> .
<b>SER <i>d1 d2</i></b>	Show rows in the Sequential Events Recorder (SER) event report from date <i>d1</i> to <i>d2</i> . Entry of dates is dependent on the Date Format setting DATE_F (= MDY or YMD).
<b>SER <i>m n</i></b>	Show rows <i>m</i> through <i>n</i> in the Sequential Events Recorder (SER) event report.
<b>SER <i>n</i></b>	Show the latest <i>n</i> rows in the Sequential Events Recorder (SER) event report.
<b>SER C</b>	Clear the Sequential Events Recorder (SER) event reports from memory.
<b>SHO <i>n</i></b>	Show relay group <i>n</i> settings. Shows active group if <i>n</i> is not specified.
<b>SHO G</b>	Show relay Global settings.
<b>SHO P</b>	Show port settings and identification of port to which user is connected.
<b>SHO P <i>n</i></b>	Show port settings for port <i>n</i> ( <i>n</i> = 1, 2, 3, 4).
<b>SHO R</b>	Show Sequential Events Recorder (SER) settings.
<b>STA</b>	Show relay self-test status.
<b>TAR <i>n k</i></b>	Show Relay Word row <i>n</i> status ( <i>n</i> = 0 through 41). Enter number <i>k</i> to scroll Relay Word row <i>n</i> status <i>k</i> times on screen.
	Append <b>F</b> to display targets on the front panel, second row of LEDs.
<b>TAR R</b>	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.

Access Level B Commands	The Access Level B commands allow the user to control breakers and contact outputs. All Access Level 1 commands can also be executed from Access Level B. The screen prompt is: ==>
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
<b>TFE</b>	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
<b>TFE <i>n</i></b>	Displays cumulative and individual through-fault event data. The <i>n</i> most recent individual events are displayed, where <i>n</i> = 1 to 1200.
<b>TFE A</b>	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
<b>TFE C</b>	Clears/resets cumulative and individual through-fault event data.
<b>TFE P</b>	Preloads cumulative through-fault event data.
<b>TFE R</b>	Clears/resets cumulative and individual through-fault event data.
<b>All commands that begin THE apply to the SEL-387-6 Relay</b>	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE <i>n</i></b>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D <i>x y</i></b>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE H <i>x y</i></b>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE P <i>n</i></b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.
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: ==>
<b>ACC</b>	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.
<b>BAC</b>	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.
<b>BRE</b>	Breaker report shows trip counters, trip currents, and wear data for up to four breakers.
<b>BRE R <i>n</i></b>	Reset trip counters, trip currents, and wear data for breaker <i>n</i> ( <i>n</i> = 1, 2, 3, 4, A).
<b>BRE W <i>n</i></b>	Pre-set the percent contact wear for each pole of breaker <i>n</i> ( <i>n</i> = 1, 2, 3, or 4).
<b>CAL</b>	Moves from Access Level 2 to Access Level C.
<b>CEV <i>n</i></b>	Show compressed winding event report number <i>n</i> , at 1/4-cycle resolution. Attach <b>DIF</b> for compressed differential element report, at 1/4-cycle resolution. Attach <b>R</b> for compressed raw winding data report, at 1/16-cycle resolution. Attach <b>Sm</b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4 or 8 for filtered data; <i>m</i> = 4, 8, 16, 32, or 64 for raw data).
<b>CLO <i>n</i></b>	Assert the CC <i>n</i> Relay Word bit. Used to close breaker <i>n</i> if CC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.

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: ==>>
<b>CON <i>n</i></b>	Control Relay Word bit RB <i>n</i> (Remote Bit <i>n</i> ; <i>n</i> = 1 through 16). Execute <b>CON <i>n</i></b> and the relay responds: CONTROL RB <i>n</i> . Reply with one of the following: <b>SRB <i>n</i></b> set Remote Bit <i>n</i> (assert RB <i>n</i> ) <b>CRB <i>n</i></b> clear Remote Bit <i>n</i> (deassert RB <i>n</i> ) <b>PRB <i>n</i></b> pulse Remote Bit <i>n</i> [assert RB <i>n</i> for one processing interval (1/8-cycle)].
<b>COPY <i>m n</i></b>	Copy settings and logic from setting Group <i>m</i> to Group <i>n</i> .
<b>DAT</b>	Show date presently in the relay.
<b>DAT <i>m/d/y</i></b>	Enter date in this manner if Date Format setting DATE_F = MDY.
<b>DAT <i>y/m/d</i></b>	Enter date in this manner if Date Format setting DATE_F = YMD.
<b>EVE <i>n</i></b>	Show standard event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE D <i>n</i></b>	Show digital data event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF1 <i>n</i></b>	Show differential element 1 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF2 <i>n</i></b>	Show differential element 2 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE DIF3 <i>n</i></b>	Show differential element 3 event report number <i>n</i> , with 1/4-cycle resolution. Attach <b>S8</b> for 1/8-cycle resolution.
<b>EVE R <i>n</i></b>	Show raw analog data event report number <i>n</i> , with 1/16-cycle resolution. Attach <b>S<i>m</i></b> for 1/ <i>m</i> -cycle resolution ( <i>m</i> = 4, 8, 32, 64).
<b>EVE T</b>	Show event summary.
<b>GRO</b>	Display active setting group number.
<b>GRO <i>n</i></b>	Switch to Setting Group <i>n</i> . (Will not function if any SS <i>n</i> Relay Word bit is asserted.)
<b>HIS <i>n</i></b>	Show brief summary of the <i>n</i> latest event reports.
<b>HIS C</b>	Clear the brief summary and corresponding standard event reports.
<b>ID</b>	Display variety of identification and configuration information about the relay.
<b>INI</b>	<b>INITIO</b> command reports the number and type of I/O boards in the relay. In Access Level 2, confirms that I/O boards are correct.
<b>IRI</b>	Force synchronization attempt of internal relay clock to IRIG-B time-code input.
<b>MET <i>k</i></b>	Display metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET D <i>k</i></b>	Display demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET H</b>	Generate harmonic spectrum report for all input currents, showing first to fifteenth harmonic levels in secondary amperes.
<b>MET DIF <i>k</i></b>	Display differential metering data, in multiples of TAP. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET P <i>k</i></b>	Display peak demand metering data, in primary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET RD <i>n</i></b>	Reset demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET RP <i>n</i></b>	Reset peak demand metering values ( <i>n</i> = 1, 2, 3, 4, A).
<b>MET SEC <i>k</i></b>	Display metering data (magnitude and phase angle), in secondary amperes. Enter number <i>k</i> to scroll metering <i>k</i> times on screen.
<b>MET T</b>	Report temperature values of up to 24 RTD inputs (SEL-387-5 and SEL-387-6 Relays only).
<b>OPE <i>n</i></b>	Assert the OC <i>n</i> Relay Word bit. Used to open breaker <i>n</i> if OC <i>n</i> is assigned to an output contact. JMP6B has to be in place to enable this command.
<b>PAS</b>	Show existing Access Level 1, B, and 2 passwords.



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: =>
PAS 1 xxxxx	Change Access Level 1 password to xxxxx.
PAS B xxxxx	Change Access Level B password to xxxxx.
PAS 2 xxxxx	Change Access Level 2 password to xxxxx. If xxxxx is <b>DISABLE</b> (uppercase), password for selected level is disabled.
PAS C xxxxx	Change Access Level C password to xxxxx. If xxxxx is <b>DISABLE</b> (uppercase), password for selected level is disabled.
PUL y k	Pulse output contact y (y = OUT101,...,OUT107, OUT2XX, and OUT3XX). 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	<b>RESET51</b> command resets all inverse-time O/C elements for the four windings, including the Combined Overcurrent elements.
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 m n	Show rows m through n in the Sequential Events Recorder (SER) event report.
SER n	Show the latest n rows in the Sequential Events Recorder (SER) event report.
SER C	Clear the Sequential Events Recorder (SER) event reports from memory.
SET n	Change relay group settings (overcurrent, differential, etc.). For the <b>SET</b> 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 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.
TAR R	Return front-panel LED targets to regular operation and reset the tripping front-panel targets.
<b>All commands that begin TFE apply to the SEL-387-5 and SEL-387-6 Relays</b>	
TFE	Displays cumulative and individual through-fault event data. The twenty (20) most recent individual events are displayed.
TFE n	Displays cumulative and individual through-fault event data. The n most recent individual events are displayed, where n = 1 to 1200.
TFE A	Displays cumulative and individual through-fault event data. All the most recent individual events are displayed, up to 1200.
TFE C	Clears/resets cumulative and individual through-fault event data.
TFE P	Preloads cumulative through-fault event data.
TFE R	Clears/resets cumulative and individual through-fault event data.

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: =>>
All commands that begin THE apply to the SEL-387-6 Relay	
<b>THE</b>	Displays a thermal monitor report that indicates the present thermal status of the transformer.
<b>THE n</b>	Displays saved thermal monitor report <i>n</i> where <i>n</i> = 1 is the most recently saved report.
<b>THE C</b>	Clears the hourly profile, daily profile, and thermal event data archives.
<b>THE D x y</b>	Retrieves daily profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE H x y</b>	Retrieves hourly profile data from day <i>x</i> to day <i>y</i> . If <i>x</i> and <i>y</i> are omitted, retrieves entire profile data. If <i>x</i> or <i>y</i> is omitted, retrieves profile from day <i>x</i> ( <i>y</i> ) to present.
<b>THE P n</b>	Loads preset value of accumulated insulation loss of life.
<b>THE R</b>	Clears the hourly profile, daily profile, and thermal event data archives and resets the total loss-of-life values.
<b>THE T</b>	Displays the four temperature inputs received from an SEL-2032, an SEL-2030, or an SEL-2020 Communications Processor.
<b>TIM</b>	Show or set time (24 hour time). Show time presently in the relay by entering just <b>TIM</b> . Example time 22:47:36 is entered with command <b>TIM 22:47:36</b> .
<b>TRI</b>	Trigger an event report.