SEL-421 Relay
SEL-421-1 Relay

Protection
Automation
Control

User's Guide

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⚠ **CAUTION:** Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

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

⚠ **DANGER:** Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠ **DANGER:** Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠ **WARNING:** Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

⚠ **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.

⚠ **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.

⚠ **ATTENTION:** Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

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

⚠ **DANGER:** Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

⚠ **DANGER:** Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessuers ou la mort.

⚠ **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.

⚠ **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.

⚠ **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 accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.

The information in this manual is furnished for informational use only and is subject to change without notice.

The English language manual is the only approved SEL manual.

This product is covered by U.S. Patent Numbers: 4,996,624; 5,041,737; 5,317,472; 5,325,061; 5,349,490; 5,365,396; 5,367,426; 5,479,315; 5,515,227; 5,652,688; 5,694,281; 5,703,745; 5,731,943; 5,790,418; 5,793,750; 5,883,578; 5,914,663; 6,028,754; 6,084,755; U.S. and Foreign Patent(s) Pending.

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

 PM421-01

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Manual Change Information

The date code at the bottom of each page of this manual reflects the creation or revision date.

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

Release Date	Summary of Changes in this Release (Sheet 1 of 2)
This *Manual Change Information* section is provided as a record of all changes made to this manual since the initial release.	
20020501	**Reference Manual Section 6: DNP 3.0 Communications** Updated *Table 6.17 on page R6.29*. **Reference Manual Appendix C: GOMSFE Tables** All UCA2 control points were made readable. Default data was set for the UCA2 FAULT model.
20020417	**User's Guide Appendix A: Firmware Versions** Firmware updated. Spurious Quart interrupts caused by varying character spacing will cause the relay to disable. This condition occurs when a communications processor is automatically retrieving data from the relay simultaneously with a serial port terminal session.
20020403	Initial Release with Synchrophasor Measurement capability to SEL-421. Added VAZ, VBZ, VCZ settings options to SYNCP. Added VAY, VBY, VCY settings options to SYNCS1, SYNCS2 and ASYNCS2. Added ACOS, ASIN, CEIL, FLOOR and LOG math functions to SELOGIC control equations. Added new analog quantities for use in SELOGIC control equations: Terminal W and X current magnitudes Terminal Y and Z voltage magnitudes Instantaneous sequence quantities Contact inputs Modified CHI output for SEL-2030 compatibility.
20020108	SEL-421-1 Relay introduction. Configurable front-panel labels. I and V Source Selection settings clarifications. **Preface** Added Notes explanation. **User's Guide Section 1: Introduction and Specifications** Added description of SEL-421-1 Relay. Added Notes to flag the differences in the SEL-421-1 Relay. Added Humidity to *Specifications*. Added SEL-421-1 Relay Maximum Operating Time to *Specifications*. Revised Power and Energy in *Specifications*. **User's Guide Section 2: Installation** Added subsection *Front-Panel Labels on page U2.26* to describe configurable front-panel labels. **User's Guide Section 3: PC Software** Added description of SEL-5030 ACSELERATOR® Software Analysis function keys F2, F3, and F4. Revised Relay Editor settings tree view operation. **User's Guide Section 4: Basic Relay Operations** Included front-panel label kit in shipped items list. Added Notes to flag the differences in the SEL-421-1 Relay. Fixed *Figure 4.45 on page U4.50* and setting SER example procedure. Fixed *Figure 4.55 on page U4.61* and setting control input/52A example procedure. **User's Guide Section 5: Front-Panel Operations** Added descriptions of configurable front-panel labels. **User's Guide Section 6: Testing and Troubleshooting** Updated ACSELERATOR software screen captures.

Release Date	**Summary of Changes in this Release** (Sheet 2 of 2)
	Applications Handbook Section 1: Protection Application Examples Added Notes to flag the differences in the SEL-421-1 Relay. Corrected control inputs in Auto-Reclose Examples. Added explanation for missing setting 3PMRCD (Manual Close Reclaim Time Delay) in *Recloser Closing on page A1.137*. **Applications Handbook Section 2: Monitoring and Metering** Corrected communications equipment battery voltage to 48 Vdc in *Figure 2.12 on page A2.22*. Revised text and *Table 2.16 on page A2.32* for power and energy specifications. **Applications Handbook Section 3: Analyzing Data** Corrected compressed ASCII command example in Event File Download procedure. **Reference Manual Section 1: Protection Functions** Added Notes to flag the differences in the SEL-421-1 Relay. Included more explanation for settings ALTI and ALTV in *Current and Voltage Source Selection on page R1.2*. Corrected setting ORDER text in *ORDER on page R1.24*. Supplemented *Series-Compensation Line Logic on page R1.38* material. **Reference Manual Section 3: SELOGIC® Control Equation Programming** Added Notes to flag the differences in the SEL-421-1 Relay. **Reference Manual Section 6: DNP 3.0 Communications** Updated setting TIMERQ to reflect correct prompt and default (no change in the relay). **Reference Manual Section 9: Settings** Added Notes to flag the differences in the SEL-421-1 Relay. **Reference Manual Appendix A: Relay Word Bits** Added Notes to flag the differences in the SEL-421-1 Relay. **Index** Added index entries for configurable front-panel labels, SEL-421-1 Relay, and series-compensated line.
20010703	Initial Release.

Preface

This manual provides information and instructions for installing and operating the SEL-421 Relay. The three volumes that comprise this manual are for use by power engineers and others experienced in protective relaying applications. Included are detailed technical descriptions of the relay and application examples. While this manual gives reasonable examples and illustrations of relay uses, you must exercise sound judgment at all times when applying the SEL-421 Relay in a power system.

Use this manual for both the SEL-421 Relay and the SEL-421-1 Relay. Margin notes next to the text specify differences between the two relay models when these differences affect relay functions or operations.

Manual Overview

The SEL-421 Relay Manual consists of three volumes:

➤ User's Guide

➤ Applications Handbook

➤ Reference Manual

In addition, the SEL-421 Relay Manual contains a comprehensive Index that encompasses the entire manual. The Index appears at the end of each printed volume. In the electronic version of the manual, the Index appears once; hyperlinks take you to material referenced in the Index. Also included is a Glossary that lists and defines technical terms used throughout the manual.

The SEL-421 Relay Manual is a comprehensive work covering all aspects of relay application and use. Read the sections that pertain to your application to gain valuable information about using the SEL-421 Relay. For example, to learn about relay protection functions, read the protection sections of this manual and skim the automation sections. You can concentrate on the operation sections or on the automation sections of this manual as your job needs and responsibilities dictate. An overview of each manual section and section topics follows.

User's Guide

Preface. describes manual organization and conventions used to present information (appears once in the electronic form of the manual; repeated in each printed volume).

Section 1: Introduction and Specifications. introduces SEL-421 Relay features; summarizes relay functions and applications; lists relay specifications, type tests, and ratings.

Section 2: Installation. discusses the ordering configurations and interface features (control inputs, control outputs, and analog inputs, for example); provides information about how to design a new physical installation and secure the relay in a panel or rack; details how to set relay board jumpers and make proper rear-panel connections (including wiring to CTs, PTs, and a GPS receiver); explains basic connections for the relay communications ports and how to install optional communications cards (such as the SEL-2701 Ethernet Processor).

Section 3: PC Software. explains how to use the SEL-5030 ACSELERATOR® Software Program.

Section 4: Basic Relay Operations. describes how to perform fundamental operations such as applying power and communicating with the relay, setting and viewing passwords, checking relay status, viewing metering data, reading event reports and SER (Sequential Events Recorder) records, operating relay control outputs and control inputs, and using relay features to make relay commissioning easier.

Section 5: Front-Panel Operations. describes the LCD display messages and menu screens; shows you how to use front-panel pushbuttons and read targets; provides information about local substation control and how to make relay settings via the front panel.

Section 6: Testing and Troubleshooting. describes techniques for testing, troubleshooting, and maintaining the SEL-421 Relay; includes the list of status notification messages and a troubleshooting chart.

Appendix A: Firmware Versions. lists the current firmware versions and details differences between the current and previous versions.

Applications Handbook

Section 1: Protection Application Examples. provides the following protection schemes with explanations and settings:

- Overhead single 230 kV transmission line
- Overhead parallel 500 kV transmission lines with zero-sequence mutual coupling
- Overhead tapped 345 kV transmission line
- Parallel submarine 230 kV underground cables

This section also provides separate application examples for out-of-step blocking and tripping, circuit breaker failure protection, and automatic reclose and synchronism checking.

Section 2: Monitoring and Metering. describes how to use the circuit breaker monitors and the substation dc battery monitors; provides information on viewing fundamental and rms metering quantities for voltages and currents, as well as power and energy metering data.

Section 3: Analyzing Data. explains how to obtain and interpret high-resolution raw data oscillograms, filtered event reports, event summaries, history reports, and SER reports; discusses how to enter SER trigger and alias settings.

Section 4: Time-Synchronized Measurements. explains synchronized phasor measurements and estimation of power system states using the SEL-421 Relay high-accuracy time-stamping capability; presents real-time load flow/power flow application ideas.

Section 5: Substation Automatic Restoration. describes an example of automatic substation restoration; gives a real-world example of the programming ease and flexibility of free-form expanded SELOGIC® control equations.

Section 6: SEL-2030 Applications. provides examples of how to use the SEL-421 Relay with the SEL-2020 and SEL-2030 Communications Processors for total substation automation solutions.

Section 7: Direct Network Communication. explains how to use DNP 3.0 and the Ethernet protocols such as Telnet, FTP, and UCA2.

Reference Manual

Section 1: Protection Functions. describes the function of various relay protection elements; describes how the relay processes these elements; gives detailed specifics on protection scheme logic for POTT, DCB, DCUB, and DTT; provides trip logic diagrams, and current and voltage source selection details.

Section 2: Auto-Reclose and Synchronism Check. explains how to operate the SEL-421 Relay two-circuit breaker multi-shot recloser; describes how to set the SEL-421 Relay for single-pole reclosing, three-pole reclosing, or both; shows selection of the lead and follow circuit breakers; explains how to set and apply synchronism-check elements for automatic and manual closing.

Section 3: SELOGIC® Control Equation Programming. describes SELOGIC control equations and how to apply these equations; discusses expanded SELOGIC control equation features such as PLC-style commands, math functions, counters, and conditioning timers; provides a tutorial for converting older format SELOGIC control equations to new free-form equations.

Section 4: Communications Interfaces. explains the physical connection of the SEL-421 Relay to various communications network topologies.

Section 5: SEL Communications Protocols. describes the various SEL software protocols and how to apply these protocols to substation integration and automation; includes details about SEL ASCII, SEL Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, and enhanced MIRRORED BITS™ communications.

Section 6: DNP 3.0 Communications. describes the DNP 3.0 communications protocol and how to apply this protocol to substation integration and automation; provides a Job Done® example for implementing DNP 3.0 in a substation.

Section 7: UCA2 Communications. describes the UCA2 communications protocol and how to apply this protocol to substation integration and automation; presents a Job Done example for using UCA2 to operate and control a substation.

Section 8: ASCII Command Reference. provides an alphabetical listing of all ASCII commands with examples for each ASCII command option.

Section 9: Settings . provides a list of all SEL-421 Relay settings and defaults. The organization of the settings is the same as for the settings organization in the relay and in the ACSELERATOR software.

Appendix A: Relay Word Bits. contains a summary of Relay Word bits.

Appendix B: Analog Quantities. contains a summary of analog quantities.

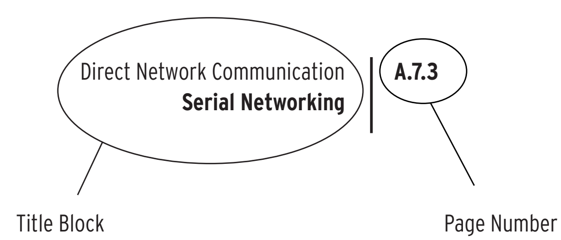
Appendix C: GOMSFE Tables. contains a UCA2 GOMSFE model.

CD-ROM

The CD-ROM contains the SEL-421 Relay Manual in an electronic form that you can search easily.

Page Numbering

This manual shows page identifiers at the top of each page; see the figure below.



Page Number Format.

The page number appears at the outside edge of each page; a vertical bar separates the page number from the page title block. The three volumes of the SEL-421 Relay Manual are represented by the first letter in the page number character string: U is for User's Guide, A is for Applications Handbook, and R is for the Reference Manual. The next character in the page number is the section number; the last digit is the actual page number in the particular section.

The section title is at the top of the page title block, with the main subsection reference in bold type underneath the section title. This number and title arrangement makes navigating the printed manual and the CD-ROM manual easy and efficient.

Conventions

The SEL-421 Relay Manual uses certain conventions that identify particular terms and help you find information. To benefit fully from reading this manual, take a moment to familiarize yourself with these conventions.

Typographic Conventions

The SEL-421 Relay Manual shows certain information with specific font and formatting attributes. The following table lists the typographic conventions used in this documentation.

Typographic Conventions

Example	Description
STATUS	ASCII and Compressed ASCII commands.
TAR 23 <Enter>	Commands/input that you type.
{CLOSE}	Relay front-panel pushbuttons.
<Enter>	Single keystroke command.
<Ctrl+D>	Multiple keystroke command to bring up a control window or activate a control function.
RELAY ELEMENTS	Front-panel LCD menu items.
Analysis > Read History	Choosing the Read History submenu in the Analysis menu of the ACSELERATOR software. Depiction of the navigation to other submenus is similar.
Are you sure (Y,N)?	Communications terminal screen response style.
www.selinc.com	Web site reference. The prefix http:// is understood.
SELOGIC control equations	SEL Trademarks and registered trademarks contain the appropriate symbol on first reference in a section. In the SEL-421 Relay Manual, certain SEL trademarks appear in small caps. These include SELOGIC control equations, MIRRORED BITS communications, and SEL-5030 ACSELERATOR Software Program.
Best Choice Ground Directional Element™	Other SEL trademarks and registered trademarks contain the appropriate symbol on first reference in a section, but these trademarks do not appear in small caps.
Modbus®	Registered trademarks of other companies include the registered trademark symbol with the first occurrence of the term in a section.
U.3.1 A.3.1 R.3.1	Page numbers include a reference to the volume, section and page number. U stands for User's Guide, A stands for Applications Handbook, and R stands for Reference Manual.

Cross-References

Cross-references are formatted as described below in both the hard copy and electronic documentation for the SEL-421 Relay. In the electronic documentation, clicking with the mouse on cross-references takes you to the referenced location.

- Reference to information on the same page includes only the reference item
  - *Table 3.1*
  - *Oscillography*

- Reference to information on another page in the same section includes the reference item and the page number
  - *Table 3.1 on page 3.2*
  - *Oscillography on page 3.8*
- Reference to information in another section in the same volume includes the reference item, page number (if appropriate), and the volume name
  - *Table 3.1 on page A.3.2 in the Applications Handbook*
  - *Oscillography on page A.1.5 in the Applications Handbook*
- Reference to information in another volume includes the reference item, page number (if appropriate), and volume name
  - *Access Levels on page U.4.8 in the User's Guide*
  - *Section 4: Basic Relay Operations in the User's Guide*

Alerts

DANGER

⚠ **DANGER:** Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

DANGER statements indicate an imminently hazardous situation that, if not avoided, will result in death or serious injury. The text to the left is an example of a DANGER statement.

WARNING

⚠ **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.

WARNING statements indicate a potentially hazardous situation that, if not avoided, can result in death or serious injury. WARNING and DANGER tags do not apply to property damage hazards unless these hazards also involve personal injury risk appropriate to these levels. The text to the left is an example of a WARNING statement.

CAUTION

CAUTION statements are in two different forms:

⚠ **CAUTION:** Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

- A CAUTION statement indicates a potentially hazardous situation that, if not avoided, can possibly result in minor or moderate injury. The text to the left is an example of this kind of CAUTION statement.

CAUTION: Equipment damage can result from connecting ac circuits to Hybrid (high-current-interrupting) control outputs. Do not connect a circuit to Hybrid control outputs. Use only dc circuit with Hybrid control outputs.

- A CAUTION statement alerts you about unsafe practices that can possibly cause property damage. The text to the left is an example of this kind of CAUTION statement.

Notes

Margin notes serve two purposes in the SEL-421 Relay Manual. Notes present valuable or important points about relay features or functions. Use these notes as tips to easier and more efficient operation of the relay. Also in this manual, Notes specify differences between the SEL-421 Relay and the SEL-421-1 Relay models when these differences affect relay functions or operations.

Step-by-Step Procedures

The SEL-421 Relay Manual contains many step-by-step procedures. These procedures lead you easily and efficiently through complex tasks. Each procedure lists required equipment, as well as the basic knowledge you need to perform the steps in the procedure. Throughout the procedure, the documentation references other SEL-421 Relay Manual sections where you can find more information.

Read the entire procedure before performing the listed steps. Read each step again before you perform it. The format of a single step is the following:

- ➤ Synopsis of the step
- ➤ Tasks to perform the step

The following text shows sample steps. Steps include explanations, text references, table references, and figure references to further illustrate the step.

Synopsis

Step 1. Establish communication. Press **<Ctrl+T>** to use the serial communications terminal in the ACSELERATOR software. Press **<Enter>** to see if the communications link is active between the software and the relay. You should see the = action prompt in the terminal window.

Tasks

Step 2. Confirm that you have loaded the correct passwords in the ACSELERATOR software. Open the Communication menu and click Port Parameters. Confirm that you have entered the correct passwords in the Level One Password dialog box and the Level Two Password dialog box.

Step 3. Read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. Select settings. Click the + mark next to the Group you want to program on the Settings tree view. This example uses Group 1, as shown in *Figure 1.2*.

Figure Reference

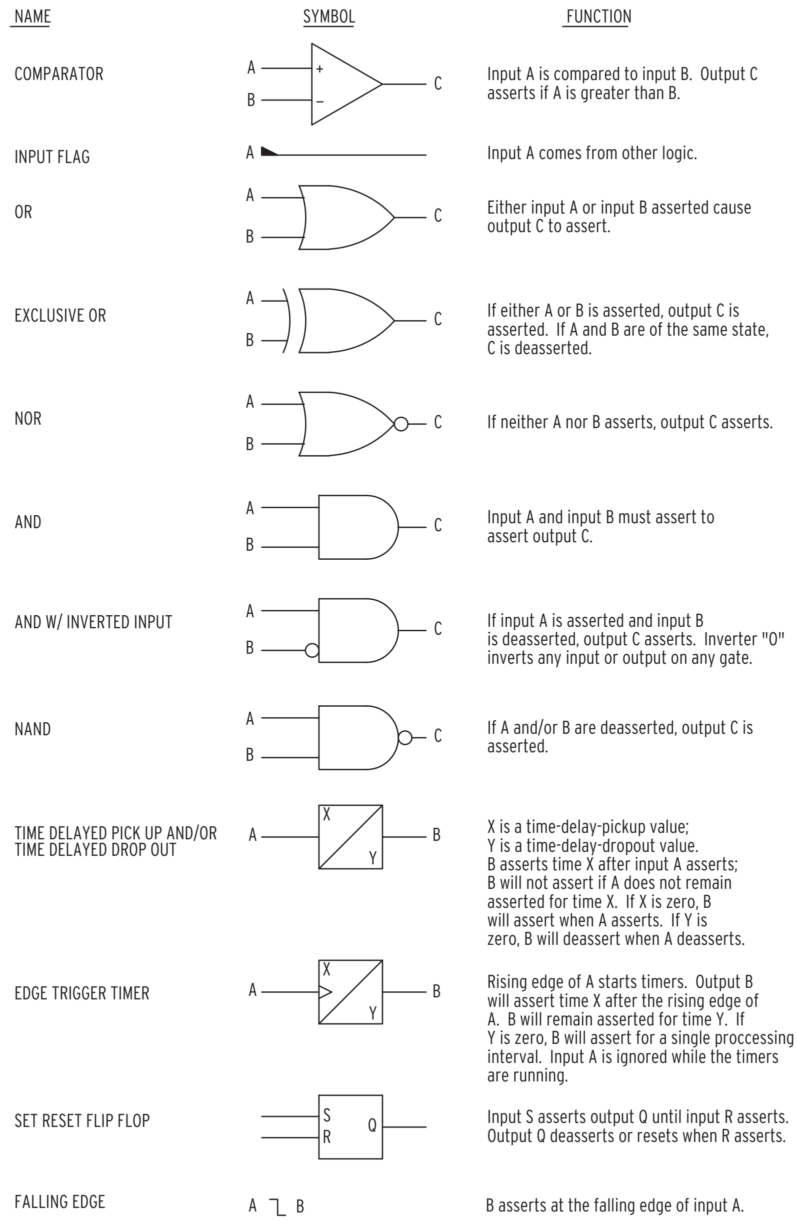
Sample Step-By-Step Instructions.

Numbers

This manual displays numbers as decimal values. Hexadecimal numbers include the letter “h” appended to the number. Alternatively, the prefix 0X can also indicate a hexadecimal number. For instance, 11 is the decimal number eleven, but 11h and 0X11 are hexadecimal representations of the decimal value seventeen.

Logic Diagrams

Logic diagrams in this manual follow the conventions and definitions shown below.



Logic Diagram Symbols.

Section 1

Introduction and Specifications

The SEL-421 Relay is a high-speed transmission line protection relay featuring single-pole and three-pole tripping and reclosing with synchronism check, circuit breaker monitoring, circuit breaker failure protection, and series-compensated line protection logic. The SEL-421-1 Relay contains all of the protection functions of the SEL-421 Relay except high-speed distance elements and series-compensated line protection logic. Both relays feature extensive metering and data recording including high-resolution data capture and reporting.

The relays feature expanded SELOGIC® control equation programming for easy and flexible implementation of custom protection and control schemes. The SEL-421 Relay has separate protection and automation SELOGIC control equation programming areas with extensive protection programming capability and 1000 lines of automation programming capability. You can organize automation SELOGIC control equation programming into 10 blocks of 100 program lines each. The SEL-421-1 Relay has the same protection programming capability but has only 1 block of 100 lines of automation programming capability.

Both the SEL-421 Relay and the SEL-421-1 Relay provide extensive communications interfaces from standard SEL ASCII and enhanced MIRRORED BITS™ communications protocols to Ethernet connectivity with the optional SEL-2701 Ethernet Processor. Using the SEL-421 Relay, you can employ the latest industry communications tools including UCA2, FTP, and DNP 3.0 protocols.

Included with the SEL-421 Relay and the SEL-421-1 Relay is the SEL-5030 ACSELERATOR® Software Program. The ACSELERATOR software assists you in setting, controlling, and acquiring data from the relays both locally and remotely.

A simple and robust hardware design features efficient digital signal processing. Combined with extensive self-testing, these features provide relay reliability and enhance relay availability.

This section introduces the SEL-421 Relay and the SEL-421-1 Relay and provides information on the following topics:

- Features
- Models and options
- Applications
- Specifications

Features

The SEL-421 Relay contains many protection, automation, and control features. *Figure 1.1* presents a simplified functional overview of the relay.

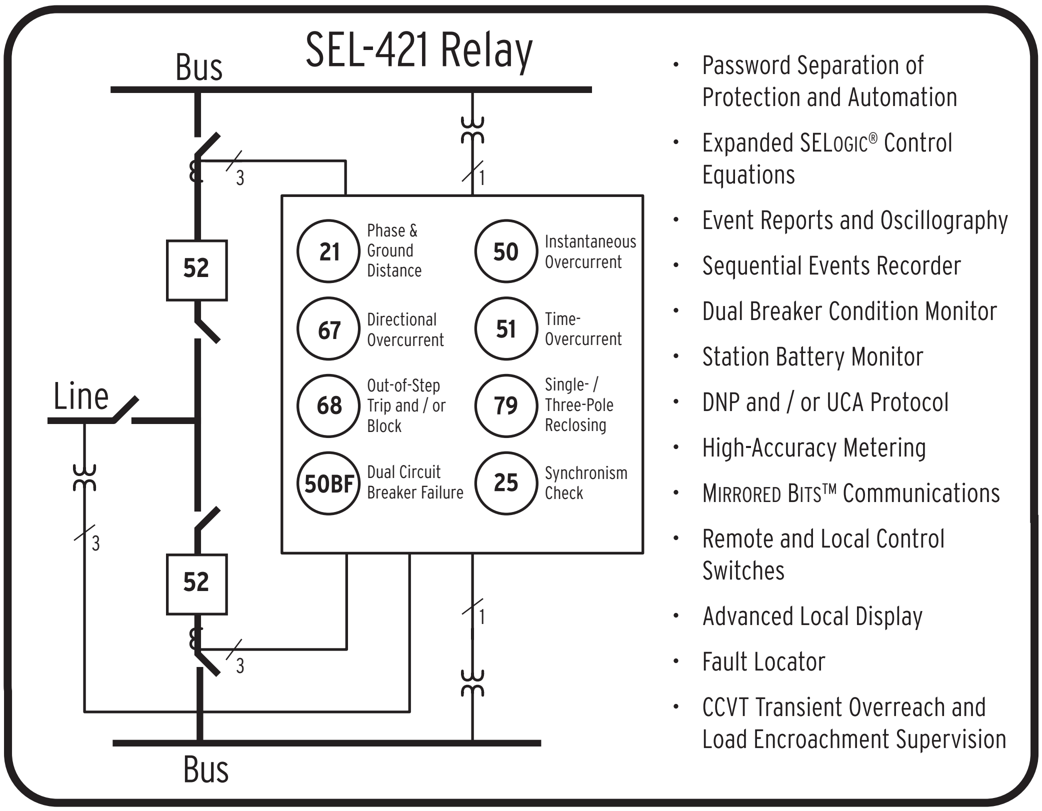


Figure 1.1 SEL-421 Relay Functional Overview.

SEL-421 Relay features include the following:

NOTE: The SEL-421-1 Relay does not provide series-compensated line protection logic.

Superior Protection. Combine five zones of phase distance and ground distance elements with directional overcurrent elements. Patented Coupling Capacitor Voltage Transformer (CCVT) transient overreach logic enhances Zone 1 distance element security. The Best Choice Ground Directional Element™ optimizes directional element performance and eliminates many settings. Additional logic prevents Zone 1 overreach on series-compensated lines.

NOTE: The SEL-421-1 Relay does not provide high-speed directional elements and high-speed distance elements.

High-Speed Tripping. The SEL-421 Relay uses the HSDPS (High-Speed Directional and Phase Selection) element and high-speed distance elements for subcycle detection of power system faults.

Reclosing Control. Incorporate programmable single-pole and three-pole tripping and reclosing of one and two circuit breakers into an integrated substation control system. Synchronism and voltage checks from multiple sources provide complete bay control.

Breaker Failure. The SEL-421 Relay incorporates CT subsidence detection to produce element dropout in 5/8 cycle. Included is the necessary logic for single-pole and three-pole breaker failure retrip and initiation of transfer tripping.

Out-of-Step Blocking and Tripping. Select out-of-step blocking of distance elements or out-of-step tripping during power swings. The SEL-421 Relay includes multizone elements and logic for detection of an out-of-step condition.

Switch-Onto-Fault. Relay switch-onto-fault (SOTF) logic permits specific protection elements to quickly trip after the circuit breaker closes, protecting maintenance personnel and substation equipment.

Fault Locator. Efficiently dispatch line crews to quickly repair line problems.

Primary Potential Redundancy. Multiple voltage inputs to the SEL-421 Relay provide primary input redundancy. At loss-of-potential (LOP) detection, configure the relay to use inputs from an electrically equivalent source. Protection remains in service without compromising security.

Dual CT Input. Connect separate CTs to the relay inputs and combine these currents inside the relay for protection functions, but keep these CT currents separately available for protection, monitoring, and station integration applications.

NOTE: The SEL-421-1 Relay has only one 100-line automation programming block.

Expanded SELOGIC Control Equations. Modify and set custom relay applications with PLC–style (programmable logic controller, IEC 61131-3 ST compatible) SELOGIC control equation programming that includes math and comparison functions. Use counters and multifunction timers for greater application flexibility. Perform advanced PLC functions within the relay. The SEL-421 Relay has separate protection and automation SELOGIC control equation programming areas. These programming areas provide you with ample protection programming capability and 10 blocks of 100-line automation programming capability (1000 lines).

Monitoring. Schedule breaker maintenance when accumulated breaker duty (independently monitored for each pole of two circuit breakers) indicates excessive contact wear. The SEL-421 Relay records electrical and mechanical operation times for the last operation and for the average of operations since the monitor function reset. In addition, the relay alarms for out-of-tolerance conditions that you specify. Use the two independent battery monitors to detect substation battery voltage problems even if battery voltage is low only during a trip or close operation.

Metering. View metering information for Line, Circuit Breaker 1, and Circuit Breaker 2. SEL-421 Relay metering includes fundamental and rms metering, as well as energy import/export, demand, and peak demand metering data.

Oscillography and Event Reporting. Record raw voltages and currents at a sampling rate as great as 8 kHz (8000 samples/second). Investigate relay internal logic points and power system performance with event report phasor and harmonic analysis.

Sequential Events Recorder (SER). Record 1000 system entries, including settings changes, power-ups, and Relay Word bit elements that you select. Set element names to easily understood aliases.

High-Accuracy Time Stamping. Time-tag event reports with real-time accuracy of 10 µs. You can coordinate time-stamped data to determine system states at an accuracy of 0.25 electrical degree.

Digital Relay-to-Relay Communication. Use MIRRORED BITS communications to monitor internal element conditions between relays within a substation and between substations using communication channels (SEL fiber-optic transceivers, for example).

Ethernet Communications Capability. Add the optional plug-in SEL-2701 Ethernet Processor to implement control and data gathering capabilities via substation local-area-networks (LANs) and company wide-area-networks (WANs). Employ UCA and FTP protocols for system data acquisition and control.

Increased Security. The SEL-421 Relay divides control and settings into seven relay access levels; the relay has separate breaker, protection, automation, and output access levels, among others. Set unique passwords for each access level.

Computer Software. Use the rules-based settings editor, the ACSELERATOR software, to develop settings off-line. View a graphical human machine interface (HMI) for metering and control.

Settings Reduction. Internal relay programming shows only the settings for the functions and elements you have enabled.

Models and Options

The SEL-421 Relay and the SEL-421-1 Relay have many common features. Consider the following options when ordering and configuring these relays.

- Chassis size
  - 3U, 4U, and 5U
    (U is one rack unit–1.75 inches or 44.45 mm)
- Additional I/O boards (for 4U and 5U chassis)
  - INT1: 8 independent inputs; 13 Standard form A outputs; 2 Standard form C outputs
  - INT5: 8 independent inputs; 8 Fast High-Current-Interrupting form A outputs
  - INT6: 8 independent inputs; 13 High-Current Interrupting form A outputs, 2 Standard form C outputs
- Chassis orientation and type
  - Horizontal rack mount
  - Horizontal panel mount
  - Vertical rack mount
  - Vertical panel mount
- Power supply
  - 24/48 Vdc
  - 48/125 Vdc or 120 Vac
  - 125/250 Vdc or 120/230 Vac
- Secondary inputs
  - 1 A nominal or 5 A nominal CT inputs.
    300 V phase-to-neutral wye configuration PT inputs
- Communications card options
  - SEL-2701 Ethernet Processor with combinations of 10 MHz and 100 MHz copper and fiber jacks on each of two ports
- Communications protocols
  - Complete group of SEL protocols
    (SEL ASCII, SEL Compressed ASCII, SEL Settings File Transfer, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, Enhanced MIRRORED BITS Communications)
  - Complete group of SEL protocols plus DNP 3.0
- Connector type
  - Fixed PT and CT terminal block inputs
  - Plug-in/plug-out PT and shorting CT Connectorized® versions

Contact the SEL factory or your local Technical Service Center for particular part number and ordering information (see *Factory Assistance on page U.6.43 in the User's Guide*). You can also view the latest part number and ordering information on the SEL website at www.selinc.com.

Applications

Use the SEL-421 Relay in a variety of transmission line protection applications. For information on connecting the relay, see *Section 2: Installation in the User's Guide*. See *Applications Handbook* for thorough discussions of protection and automation applications using the SEL-421 Relay.

The figures in this subsection illustrate common relay application configurations. *Figure 1.3*, *Figure 1.4 on page 1.7*, *Figure 1.5 on page 1.7*, *Figure 1.6 on page 1.8*, and *Figure 1.7 on page 1.8* demonstrate relay versatility with Global setting ESS (Current and Voltage Source Selection). These figures show the power and simplicity of the four preprogrammed ESS options. For more information on setting ESS, see *Current and Voltage Source Selection on page R.1.2 in the Reference Manual*.

The SEL-421 Relay has two sets of three phase analog current inputs, IW and IX, and two sets of three-phase analog voltage inputs, VY and VZ. The drawings that follow use a two-letter acronym to represent all three phases of a relay analog input. For example, IW represents IAW, IBW, and ICW for A-, B-, and C-phase current inputs on terminal W, respectively. The drawings list a separate phase designator if you need only one or two phases of the analog input set (VAZ for the A-phase voltage of the VZ input set, for example).

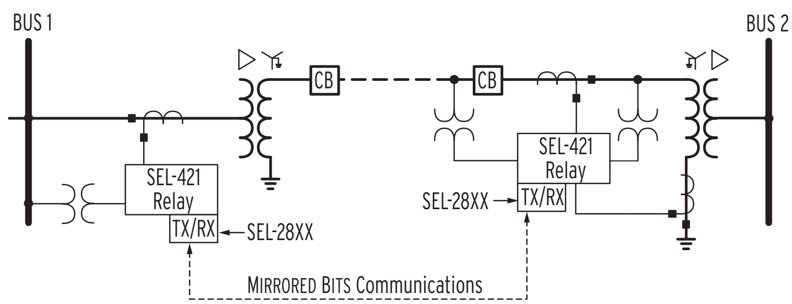


Figure 1.2 Protecting a Line Segment With MIRRORED BITS Communications on a Fiber Channel.

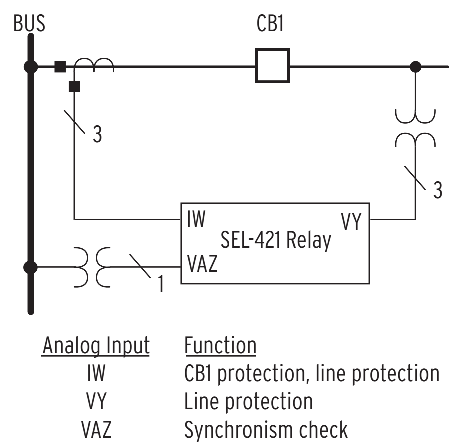
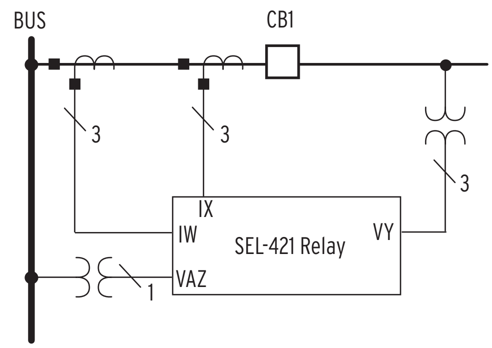
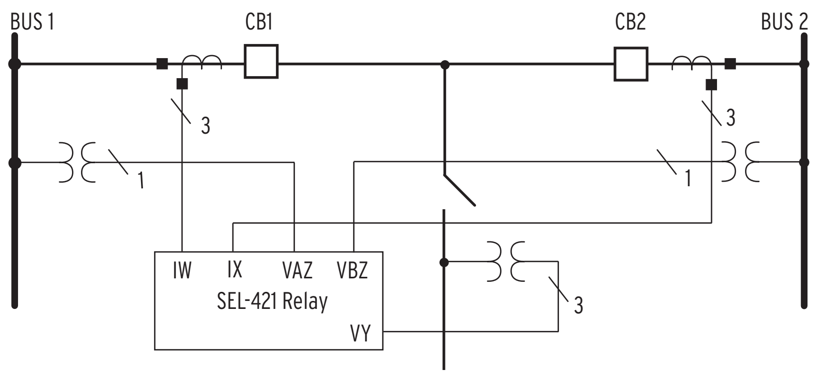


Figure 1.3 Single Circuit Breaker Configuration (ESS := 1).



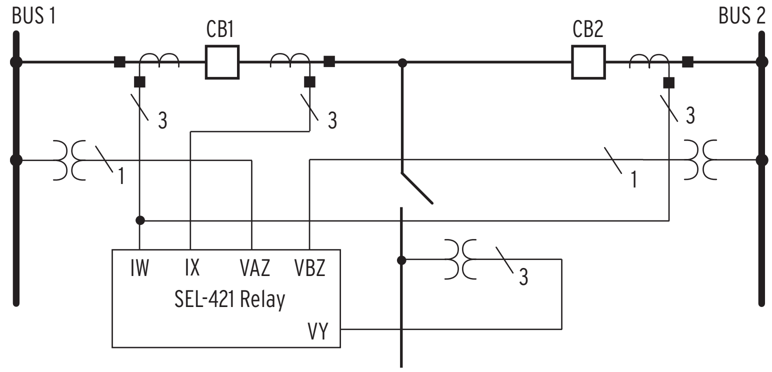
Analog Input	Function
IW	CB1 protection, line protection
IX	CB1 breaker failure
VY	Line protection
VAZ	Synchronism check

Figure 1.4 Single Circuit Breaker Configuration With Line and Breaker CTs (ESS := 2).



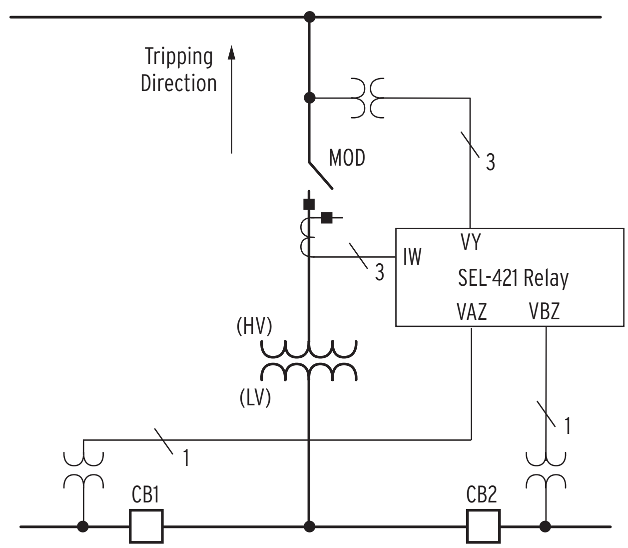
Analog Input	Function
IW+IX	Line Protection
IW	CB1 protection
IX	CB2 protection
VY	Line protection
VAZ	Synchronism check Circuit Breaker 1
VBZ	Synchronism check Circuit Breaker 2

Figure 1.5 Double Circuit Breaker Configuration (ESS := 3).



Analog Input	Function
IW+IX	CB2 protection
IW	Line protection
IX	CB1 protection
VY	Line protection
VAZ	Synchronism check Circuit Breaker 1
VBZ	Synchronism check Circuit Breaker 2

Figure 1.6 Double Circuit Breaker Configuration With Bus Protection (ESS := 4).



Analog Input	Function
IW	Line protection
VY	Line protection
VAZ	Synchronism check Circuit Breaker 1
VBZ	Synchronism check Circuit Breaker 2

Figure 1.7 Tapped Line (ESS := Y).

Application Highlights

NOTE: The SEL-421-1 Relay does not provide high-speed directional elements and high-speed distance elements.

Apply the SEL-421 Relay in power system protection and control situations. *Table 1.1* lists applications and key features of the relay.

Table 1.1 Application Highlights (Sheet 1 of 2)

Application	Key Features
Single-pole and three-pole tripping	High-speed distance elements Best Choice Ground Directional element Secure protection during open-pole interval Pole-discordance logic trips three-pole for excessive single-pole-open conditions
Multiple-breaker tripping	SPT one; 3PT other SPT both; 3PT both Breaker failure protection
Reclosing and synchronism check	2 shots SPT; 4 shots 3PT Leader/follower breaker arrangements Two-circuit-breaker universal synchronism check
Coupling-Capacitor Voltage Transformer (CCVT) transient detection logic	Detect CCVT transients to provide correct operation of the direct tripping (Zone 1) distance elements
Long lines	Load-encroachment elements prevent unwanted trips on load Voltage elements detect local bus overvoltages Sensitive negative-sequence and residual overcurrent elements provide sensitive backup protection
Tapped and three-terminal lines	Five zones Three zero-sequence compensation factors for more accurate ground-distance reach on either side of tap Independent reach settings for phase, ground mho, and ground quadrilateral elements Multiple settings groups cover any switching configurations
Bus-tie or transfer circuit breakers	Multiple setting groups Match relay settings group to each line substitution Eliminate current reversing switches Local or remote operator switches the setting groups
Subtransmission lines	Time-step distance protection Ground directional overcurrent protection Torque-controlled time-overcurrent elements
Lines with capacitors	Series-compensated line logic
Lines with transformers	Negative-sequence overcurrent protection
Short transmission lines	Directional overcurrent elements and communications-assisted tripping schemes
Permissive Overreaching Transfer Tripping (POTT) schemes	Current reversal guard logic Open breaker echo keying logic Weak-infeed and zero-infeed logic Time-step distance backup protection
Directional Comparison Unblocking Tripping (DCUB) schemes	Includes all POTT logic All loss-of-channel logic is inside the relay Time-step distance backup protection
Permissive Underreaching Transfer Tripping (PUTT) schemes	Supported by POTT logic Time-step distance backup protection

NOTE: The SEL-421-1 Relay does not provide series-compensated line protection logic.

Table 1.1 Application Highlights (Sheet 2 of 2)

Application	Key Features
Directional Comparison Blocking Trip (DCB) schemes	Current reversal guard logic Carrier coordinating timers Carrier send and receive extend logic Zone 3 latch eliminates the need for offset three-phase distance elements Time-step distance backup protection
Direct Transfer Tripping (DTT) schemes	SELOGIC control equations program the elements that key direct tripping
SCADA applications	Analog and digital data acquisition for station wide functions
Communications capability	SEL ASCII MIRRORED BITS communications SEL Fast Meter, SEL Fast Operate, SEL Fast SER SEL Compressed ASCII Optional protocols: Ethernet, UCA2, FTP, Telnet Optional DNP 3.0
Customized protection and automation schemes	Separate protection and automation SELOGIC control equation programming areas Use timers and counters in expanded SELOGIC control equations for complete flexibility
Synchronized phasor measurement	Phase and positive-sequence voltage measurements synchronized within 0.25 degrees, sampled at 20 times per second

NOTE: Synchrophasor capability is not available in the SEL-421-1 Relay.

Specifications

General Specifications

AC Current Inputs (Secondary Circuits)

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

AC Voltage Inputs

300 V_{L-N} continuous (connect any voltage up to 300 Vac)
600 Vac for 10 seconds

Burden:	0.03 VA @ 67 V
	0.06 VA @ 120 V
	0.8 VA @ 300 V

Power Supply

125/250 Vdc or 120/230 Vac

Range:	85–300 Vdc <35 W or 85–264 Vac (30 Hz–120 Hz)
Burden:	<120 VA

48/125 Vdc or 120 Vac

Range:	38–140 Vdc <35W or 85–140 Vac (30 Hz–120 Hz)
Burden:	<120 VA

24/48 Vdc

Range:	18–60 Vdc
Burden:	<35 W

Control Outputs

Standard:

Make:	30 A
Carry:	6 A continuous carry at 70°C
	4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	250 Vac/330 Vdc
Pickup/Dropout Time:	6 ms, resistive load
Update Rate:	1/8 cycle

Break Capacity (10000 operations):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycle/second):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Hybrid (high current interrupting):

Make:	30 A
Carry:	6 A continuous carry at 70°C
	4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc
Pickup/Dropout Time:	6 ms, resistive load
Update Rate:	1/8 cycle

Break Capacity (10000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation)

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Do not use hybrid control outputs to switch ac control signals. These outputs are polarity dependent.

Fast Hybrid (high-speed high current interrupting):

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 (maximum voltage):	250 Vac/330 Vdc
Pickup Time:	10 µs, resistive load
Dropout Time:	8 ms, resistive load
Update Rate:	1/8 cycle

Break Capacity (10000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation)

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Per IEC 60255-23 (1994), using the simplified method of assessment.
Note: Make rating per IEEE C37.90-1989.

Control Inputs

Range:	15–265 Vdc
Accuracy:	±5% plus ±3 Vdc
Maximum Voltage:	300 Vdc
Sampling Rate:	1/16 cycle
Typical Burden:	0.24 W @ 125 Vdc

Frequency and Rotation

System Frequency:	50/60 Hz
Phase Rotation:	ABC or ACB
Frequency tracking range:	40–65 Hz

Communications Ports

EIA-232:	1 Front & 3 Rear
Serial Data Speed:	300–57600 bps

Communications Card Slot for optional SEL-2701 Ethernet Processor

Time Inputs

IRIG Input

Input:	Demodulated IRIG-B time code
Nominal Voltage:	5 Vdc +10%
Maximum Voltage:	8 Vdc
Input Impedance:	333 Ohms
Isolation:	500 Vdc

1k PPS Input

Input:	Demodulated IRIG-B and 1k PPS
Nominal Voltage:	5 Vdc +10%
Maximum Voltage:	8 Vdc
Input Impedance:	500 Ohms

Operating Temperature

–40° to +85°C (–40° to +185°F)
Note: LCD contrast impaired for temperatures below –20° and above +70°C

Humidity

5% to 95% without condensation

Weight (Maximum)

3U Rack Unit:	17.5 lbs (8.0 kg)
4U Rack Unit:	21.5 lbs (9.8 kg)
5U Rack Unit:	25.5 lbs (11.6 kg)

Type Tests

Electromagnetic Compatibility (EMC)

Electromagnetic Emissions:	EN 50263: 1999
Emissions:	IEC 60255-25 (2000)

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	ENV 50141: 1993, 10 V rms
Digital Radio Telephone RF:	ENV 50204: 1995, 10 V/m at 900 MHz and 1.89 GHz
Electrostatic Discharge:	IEC 60255-22-2 (1996), Levels 1, 2, 3, 4

IEC 61000-4-2 (1995), Levels 1, 2, 3, 4

Fast Transient Disturbance: IEC 61000-4-4 (1995), IEC 60255-22-4 (1992), 4 kV at 2.5 and 5 kHz

Magnetic Field Immunity: IEC 61000-4-8 (1993) 850 A/m for 3 seconds; IEC 61000-4-9 (1993) 850 A/m

Power Supply Immunity: IEC 61000-4-11 (1994), 5 cycles; IEC 60255-11 (1979)

Radiated Radio Frequency: ENV 50140: 1993, IEC 60255-22-3 (1989) IEC 61000-4-3 (1998) 10 V/m; IEEE C37.90.2-1995, 35 V/m; Exceptions: DC Battery System Monitor, 10 V/m (±10%); SEL-2701 Installed, 10 V/m

Surge Withstand: IEC 60255-22-1(1988), 2.5 kV peak common mode, 2.5 kV peak differential mode; IEEE C37.90.1-1989, 3.0 kV oscillatory, 5.0 kV fast transient

Environmental

Cold: IEC 60068-2-1 (1990) [EN 60068-2-1: 1993], Test Ad: 16 hours at –40°C

Dry Heat: IEC 60068-2-2 (1974) [EN 60068-2-2: 1993], Test Bd: Dry heat, 16 hours at +85°C

Damp Heat, Cyclic: IEC 60068-2-30 (1980), Test Db: 55°C, 6 cycles, 95% humidity

Object Penetration: IEC 60529 (1989), IP30

Vibration: IEC 60255-21-1 (1988), Class 1; IEC 60255-21-2 (1988), Class 1; IEC 60255-21-3 (1993), Class 2

Safety

Dielectric Strength: IEC 60255-5 (1977), IEEE C37.90-1989, 2500 Vac on control inputs, control outputs, and analog inputs; 3100 Vdc on power supply

Impulse: IEC 60255-5 (1977), 0.5 J, 5 kV

Insulation Resistance: IEC 60255-5 (1977), Resistance @ 500 V >1 minute. Resistance 10 MΩ–100 MΩ

Laser Safety (optional SEL-2701 Ethernet Processor): 21 CFR 1040.10, FDA, IEC 60825-1 (1993), ANSI Z136.1-1993, Class 1; ANSI Z136.2-1988, Service Group 1

Certifications

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

Product Safety: IEC 60255-6 (1988) [EN 60255-6: 1994]

Reporting Functions

High-Resolution Data

Rate: 8000 samples/second; 4000 samples/second; 2000 samples/second; 1000 samples/second

Output Format: Binary COMTRADE

Note: Per *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999*

Event Reports

Storage: 35 quarter-second events or 24 half-second events

Maximum Duration: Record events as long as 5 seconds

Resolution: 8- or 4-samples/cycle

Event Summary

Storage: 100 summaries

Breaker History

Storage: 128 histories

Sequential Events Recorder

Storage: 1000 entries

Trigger elements: 250 relay elements

Processing Specifications

AC Voltage and Current Inputs

8000 samples per second, 3 dB low-pass analog filter cut-off frequency of 3000 Hz.

Digital Filtering

Full-cycle cosine and half-cycle Fourier filters after low-pass analog and digital filtering.

Protection and Control Processing

8 times per power system cycle

Control Points

32 remote bits
32 local control bits
32 latch bits in protection logic
32 latch bits in automation logic

Relay Element Pickup Ranges and Accuracies

Mho Phase Distance Elements

Zones 1–5 Impedance Reach

Setting Range:
- 5 A Model: OFF, 0.05 to 64 Ω secondary, 0.01 Ω steps
- 1 A Model: OFF, 0.25 to 320 Ω secondary, 0.01 Ω steps

Sensitivity:
- 5 A Model: 0.5 A_{P-P} secondary
- 1 A Model: 0.1 A_{P-P} secondary (Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.)

Accuracy (Steady State): ± 3% of setting at line angle for SIR (source-to-line impedance ratio) < 30; ± 5% of setting at line angle for 30 ≤ SIR ≤ 60

Zone 1 Transient Overreach: < 5% of setting plus steady state accuracy

SEL-421 Maximum Operating Time: 0.8 cycle at 70% of reach and SIR = 1

SEL-421-1 Maximum Operating Time: 1.5 cycle at 70% of reach and SIR = 1

Mho Ground Distance Elements

Zones 1–5 Impedance Reach

Mho Element Reach:
- 5 A Model: OFF, 0.05 to 64 Ω secondary, 0.01 Ωsteps
- 1 A Model: OFF, 0.25 to 320 Ω secondary, 0.01 Ω steps

Sensitivity:
- 5 A Model: 0.5 A secondary
- 1 A Model: 0.1 A secondary

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

Accuracy (Steady State): ±3% of setting at line angle for SIR < 30
±5% of setting at line angle for 30 ≤ SIR ≤ 60

Zone 1 Transient Overreach: < 5% of setting *plus* steady state accuracy

SEL-421 Maximum Operating Time: 0.8 cycle at 70% of reach and SIR = 1

SEL-421-1 Maximum Operating Time: 1.5 cycle at 70% of reach and SIR = 1

Quadrilateral Ground Distance Elements

Zones 1–5 Impedance Reach

Quadrilateral Reactance Reach:
- 5 A Model: OFF, 0.05 to 64 Ω secondary, 0.01 Ω steps
- 1 A Model: OFF, 0.25 to 320 Ω secondary, 0.01 Ω steps

Quadrilateral Resistance Reach:
- 5 A Model: OFF, 0.05 to 50 Ω secondary, 0.01 Ω steps
- 1 A Model: OFF, 0.25 to 250 Ω secondary, 0.01 Ω steps

Sensitivity:
- 5 A Model: 0.5 A secondary
- 1 A Model: 0.1 A secondary
(Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone.)

Accuracy (Steady State): ±3% of setting at line angle for SIR < 30
±5% of setting at line angle for 30 ≤ SIR ≤ 60

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

Instantaneous/Definite-Time Overcurrent Elements

Phase, Residual Ground, and Negative-Sequence

Pickup Range:
- 5 A Model: OFF, 0.25–100.00 A secondary, 0.01 A steps
- 1 A Model: OFF, 0.05–20.00 A secondary, 0.01 A steps

Accuracy (Steady State):
- 5 A Model: ±0.05 A plus ±3% of setting
- 1 A Model: ±0.01 A plus ±3% of setting

Transient Overreach: < 5% of pickup

Time Delay: 0.00–16000.00 cycles, 0.125 cycle steps

Timer Accuracy: ±0.125 cycle plus ±0.1% of setting

Maximum Operating Time: 1.5 cycles

Note: See pickup and reset time curves in the *Inverse Time-Overcurrent Elements on page R.1.69 in the Reference Manual*.

Time-Overcurrent Elements

Pickup Range:
- 5 A Model: 0.50–16.00 A secondary, 0.01 A steps
- 1 A Model: 0.10–3.20 A secondary, 0.01 A steps

Accuracy (Steady State):
- 5 A Model: ±0.05 A plus ±3% of setting
- 1 A Model: ±0.01 A plus ±3% of setting

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

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

Reset: 1 power cycle or Electromechanical Reset Emulation time

Ground Directional Elements

Neg.-Seq. directional impedance threshold (Z2F, Z2R):
- 5 A Model: –64 to 64 Ω
- 1 A Model: –320 to 320 Ω

Zero-Seq. directional impedance threshold (Z0F, Z0R)
- 5 A Model: –64 to 64 Ω
- 1 A Model: –320 to 320 Ω

Supervisory overcurrent pickup 50FP, 50RP:
- 5 A Model: 0.25 to 5.00 A 3I0 secondary
0.25 to 5.00 A 3I2 secondary
- 1 A Model: 0.05 to 1.00 A 3I0 secondary
0.05 to 1.00 A 3I2 secondary

Undervoltage and Overvoltage Elements

Pickup Ranges: Phase elements: 1–200 V secondary, 1 V steps

Phase-to-phase elements: 1.0–300.0 V secondary, 0.1 V steps

Accuracy (Steady State): ±1 V plus ±5% of setting

Transient Overreach: < 5% of pickup

Breaker Failure Instantaneous Overcurrent

Setting Range:
- 5 A Model: 0.50–50.0 A, 0.01 A steps
- 1 A Model: 0.10–10.0 A, 0.01 A steps

Accuracy:
- 5 A Model: ±0.05 A plus ±3% of setting
- 1 A Model: ±0.01 A plus ±3% of setting

Transient Overreach: < 5% of setting

Maximum Pickup Time: 1.5 cycles

Maximum Reset Time: 1 cycle

Timers Setting Range: 0–6000 cycles, 0.125 cycle steps (All but BFIDOn, BFISPn)
0–1000 cycles, 0.125 cycle steps (BFIDOn, BFISPn)

Time Delay Accuracy: 0.125 cycle plus ±0.1% of setting

Synchronism-Check Elements

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

Slip Frequency Pickup Accuracy: ±0.0025 Hz plus ±2% of setting

Close Angle Range: 3–80°, 1° steps

Close Angle Accuracy: ± 3°

Load-Encroachment Detection

Setting Range:
- 5 A Model: 0.05–64 Ω secondary, 0.01 Ωsteps
- 1 A Model: 0.25–320 Ω secondary, 0.01 Ωsteps
- Forward Load Angle: –90° to +90°
- Reverse Load Angle: +90° to +270°

Accuracy:
- Impedance measurement: ±3%
- Angle measurement: ±2°

Out-of-Step Elements

Blinders (R1) parallel to the line angle:
- 5 A Model: 0.05 to 70 Ω secondary
–0.05 to –70 Ω secondary
- 1 A Model: 0.25 to 350 Ω secondary
–0.25 to –350 Ω secondary

Blinders (X1) perpendicular to the line angle:
- 5 A Model: 0.05 to 96 Ω secondary
–0.05 to –96 Ω secondary
- 1 A Model: 0.25 to 480 Ω secondary
–0.25 to –480 Ω secondary

Accuracy (Steady State):
- 5 A Model: ± 5% of setting plus ±0.01 A for SIR (source to line impedance ratio) < 30
± 10% of setting plus ±0.01 A for 30 ≤ SIR ≤ 60
- 1 A Model: ±5% of setting plus ±0.05 A for SIR (source to line impedance ratio) < 30
±10% of setting plus ±0.05 A for 30 ≤ SIR ≤ 60

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

Positive-Sequence Overcurrent Supervision:

Setting Range:
- 5 A Model: 1.0–100.0 A, 0.01 A steps
- 1 A Model: 0.2–20.0 A, 0.01 A steps

Accuracy:
- 5 A Model: ±3% of setting plus ±0.05 A
- 1 A Model: ±3% of setting plus ±0.01 A

Transient Overreach: < 5% of setting

Timer Specifications

Setting Ranges

Breaker Failure:	0–6000 cycles, 0.125 cycle steps (All but BFIDOn, BFISPn)
	0–1000 cycles, 0.125 cycle steps (BFIDOn, BFISPn)
Communications-Assisted Tripping Schemes:	0.000–16000 cycles, 0.125 cycle steps
Out-of-Step Timers:	
OSBD, OSTD:	0.500–8000 cycles, 0.125 cycle steps
UBD:	0.500–120 cycles, 0.125 cycle steps
Pole Open Timer:	0.000–60 cycles, 0.125 cycle steps
Recloser:	1–99999 cycles, 1 cycle steps
Switch-Onto-Fault:	
CLOEND, 52AEND:	OFF, 0.000–16000 cycles, 0.125 cycle steps
SOTFD:	0.50–16000 cycles, 0.125 cycle steps
Synchronism Check Timers:	
TCLSBK1, TCLSBK2:	1.00–30.00 cycles, 0.25 cycle steps
Zone Time Delay:	0.000–16000 cycles, 0.125 cycle steps

Station DC Battery System Monitor Specifications

Operating Range:	0–350 Vdc
Input Sampling Rate:	2 kHz
Processing Rate:	1/8 cycle
Maximum Operating Time:	≤ 1.5 cycles
Setting Range:	
DC settings:	15–300 Vdc, 1 Vdc steps
AC ripple setting:	1–300 Vac, 1 Vac steps
Accuracy:	
Pickup Accuracy:	±3% plus ±2 Vdc (all elements but DC1RP and DC2RP)
	±10% plus ±2 Vac (DC1RP and DC2RP)

Metering Accuracy

All metering accuracy is at 0.1 • I_{nom}, 20°C, and nominal frequency unless otherwise noted.

Currents

Phase Current Magnitude	
5 A Model Input ≥ 0.5 A:	±0.2% plus ±4 mA
1 A Model Input ≥ 0.1 A:	±0.2% plus ±0.8 mA
Phase Current Angle:	±0.2°
Sequence Currents Magnitude	
5 A Model Input > 0.5 A:	±0.3% plus ±4 mA
1 A Model Input ≥ 0.1 A:	±0.3% plus ±0.8 mA
Sequence Current Angle:	±0.3 degree

Voltages

Phase and Phase-to-Phase Voltage Magnitude:	
Input > 33.5 volts:	±0.1%
Phase and Phase-to-Phase Angle:	±0.05 degree
Sequence Voltage Magnitude:	
Input > 33.5 volts:	±0.15%
Sequence Voltage Angle:	±0.1 degree

Frequency (Input 40–65 Hz)

Accuracy:	±0.01 Hz

Power and Energy

Real Power, P (MW), Three Phase	
At 0.1 • I_{nom}	
Power factor unity	±0.4%
Power factor 0.5 lag, 0.5 lead	±0.7%
At 1.0 • I_{nom}	
Power factor unity	±0.4%
Power factor 0.5 lag, 0.5 lead	±0.4%
Reactive Power, Q (MVAR), Three Phase	
At 0.1 • I_{nom}	
Power factor 0.5 lag, 0.5 lead	±0.5%
At 1.0 • I_{nom}	
Power factor 0.5 lag, 0.5 lead	±0.4%
Energy (MWh), Three Phase	
At 0.1 • I_{nom}	
Power factor unity	±0.5%
Power factor 0.5 lag, 0.5 lead	±0.7%
At 1.0 • I_{nom}	
Power factor unity	±0.4%
Power factor 0.5 lag, 0.5 lead	±0.4%

Synchronized Phasor Measurements*

Sampling Rate:	20 sps
Voltage Magnitude Accuracy:	±0.1%
Voltage Angle Accuracy:	±0.125°
Voltage Range:	30–150 V

* Synchrophasor capability is not available in the SEL-421-1 Relay.

Section 2
Installation

The first steps in applying the SEL-421 Relay are installing and connecting the relay. This section describes common installation features and particular installation requirements for the many physical configurations of the SEL-421 Relay. You can order the relay in horizontal and vertical orientations, and in panel-mount and rack-mount versions. SEL also provides various expansion I/O (input/output) interface boards to tailor the relay to your specific needs.

To install and connect the relay safely and effectively, you must be familiar with relay configuration features and options and relay jumper configuration. You should carefully plan relay placement, cable connection, and relay communication. Consider the following when installing the SEL-421 Relay:

- Shared relay configuration attributes
- Plug-in boards
  - I/O interface board(s) (if applicable)
  - Communications card (if applicable)
- Jumpers
- Placement
  - Physical location
  - Cutting and drilling the mounting panel (if the relay is a panel-mount configuration)
  - Mounting the relay to a panel or into a rack
- Connection
  - Grounding
  - Power
  - DC battery monitor
  - Secondary circuits
  - Control circuits
  - IRIG-B
  - 1k PPS [from a GPS (Global Positioning System) receiver]
  - Communications circuits

This section contains drawings of typical ac and dc connections to the SEL-421 Relay (*AC/DC Connection Diagrams on page 2.47*). Use these drawings as a starting point for planning your particular relay application.

It is also very important to limit access to the SEL-421 Relay settings and control functions by using passwords. For information on relay access levels and passwords, see *Changing the Default Passwords: Terminal on page U.4.10 in the User's Guide*.

Shared Configuration Attributes

There are common or shared attributes among the many possible configurations of SEL-421 Relays. This section discusses the main shared features of the relay.

Relay Sizes

SEL produces the SEL-421 Relay in horizontal and vertical rack-mount versions and horizontal and vertical panel-mount versions. Relay sizes correspond to height in rack units, U, where U is approximately 1.75 inches or 44.45 mm. The SEL-421 Relay is available in 3U, 4U, and 5U sizes.

Front-Panel Templates

The horizontal front-panel template shown in *Figure 2.1 on page 2.4* is the same for all 3U, 4U, and 5U horizontal versions of the relay. The vertical front-panel template (shown in *Figure 2.2 on page 2.4*) is the same for all 3U, 4U, and 5U vertical versions of the relay.

The SEL-421 Relay front panel has three pockets for slide-in labels: one pocket for the Target LED label, and two pockets for the Operator Control labels. *Figure 2.1 on page 2.4* shows the front-panel pocket areas and openings for typical horizontal and vertical relay orientations; dashed lines denote the pocket areas. See *Changing Configurable Front-Panel Labels on page 2.27* for information on reconfiguring front-panel LED and pushbutton labels.

Rear Panels

Rear panels are identical for the horizontal and the vertical configurations of the relay. *Figure 2.3 on page 2.5* is an example of a rear panel for a 3U relay with fixed terminal block analog inputs. *Figure 2.4 on page 2.5* shows a rear panel for a 3U relay with Connectorized® analog inputs. See *Rear-Panel Layout on page 2.33* for representative 3U, 4U, and 5U relay rear panels (large drawings are in *Figure 2.21 on page 2.34*, *Figure 2.22 on page 2.34*, *Figure 2.23 on page 2.34*, and *Figure 2.24 on page 2.35*).

Connector Types

Screw Terminal Connectors-I/O and Monitor/Power

Connect to the relay I/O and Monitor/Power terminals on the rear panel through screw terminal connectors. You can remove the entire screw terminal connector from the back of the relay to disconnect relay I/O, DC Battery Monitor, and Power without removing each wire connection. The screw terminal connectors are keyed (see *Figure 2.26 on page 2.36*), so you can replace the screw terminal connector on the rear panel only at the location from which you removed the screw terminal connector. In addition, the receptacle key prevents you from inverting the screw terminal connector. This feature makes relay removal and replacement easier.

Secondary Circuit Connectors

Fixed Terminal Blocks

Connect PT and CT inputs to the fixed terminal blocks in the bottom row of the relay rear panel. You cannot remove these terminal blocks from the relay rear panel. These terminals offer a secure high-reliability connection for PT and CT secondaries.

Connectorized

The Connectorized SEL-421 Relay features receptacles that accept plug-in/plug-out connectors for terminating PT and CT inputs; you must order a wiring harness (SEL-WA0421) with mating plugs and wire leads. *Figure 2.4 on page 2.5* shows the relay 3U chassis with Connectorized CT and PT analog inputs. See *Connectorized on page 2.40* for more information.

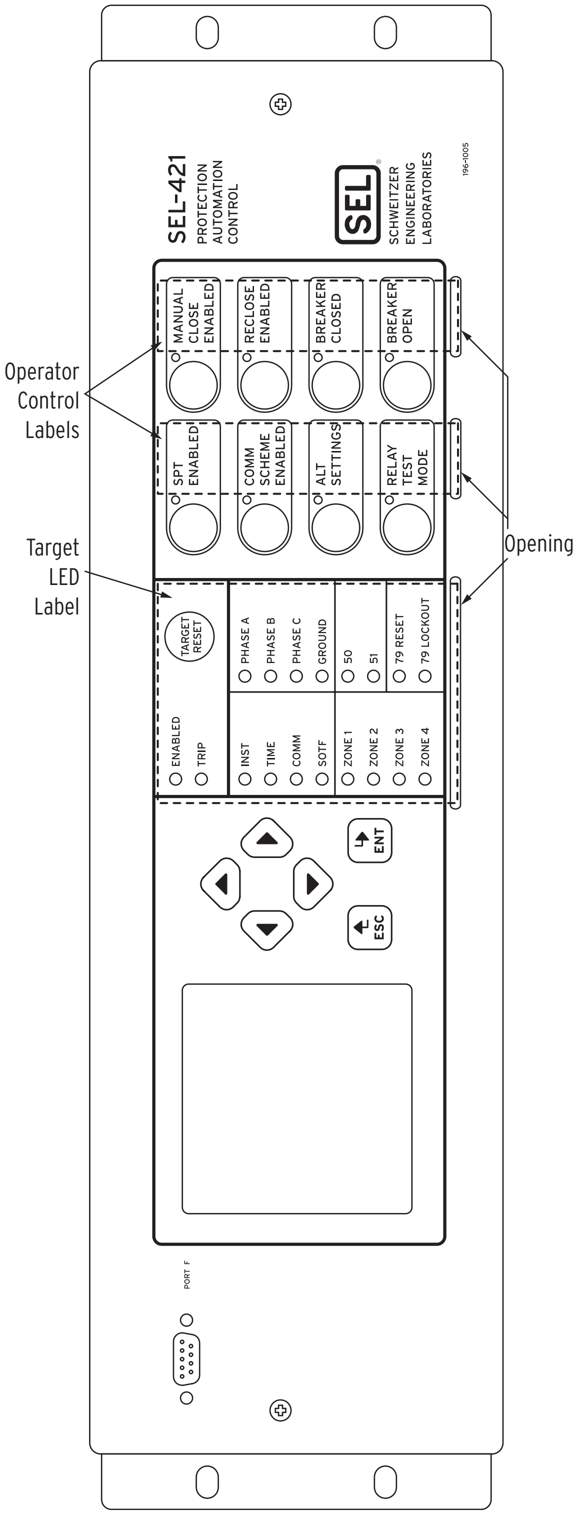


Figure 2.1 Horizontal Front-Panel Template.

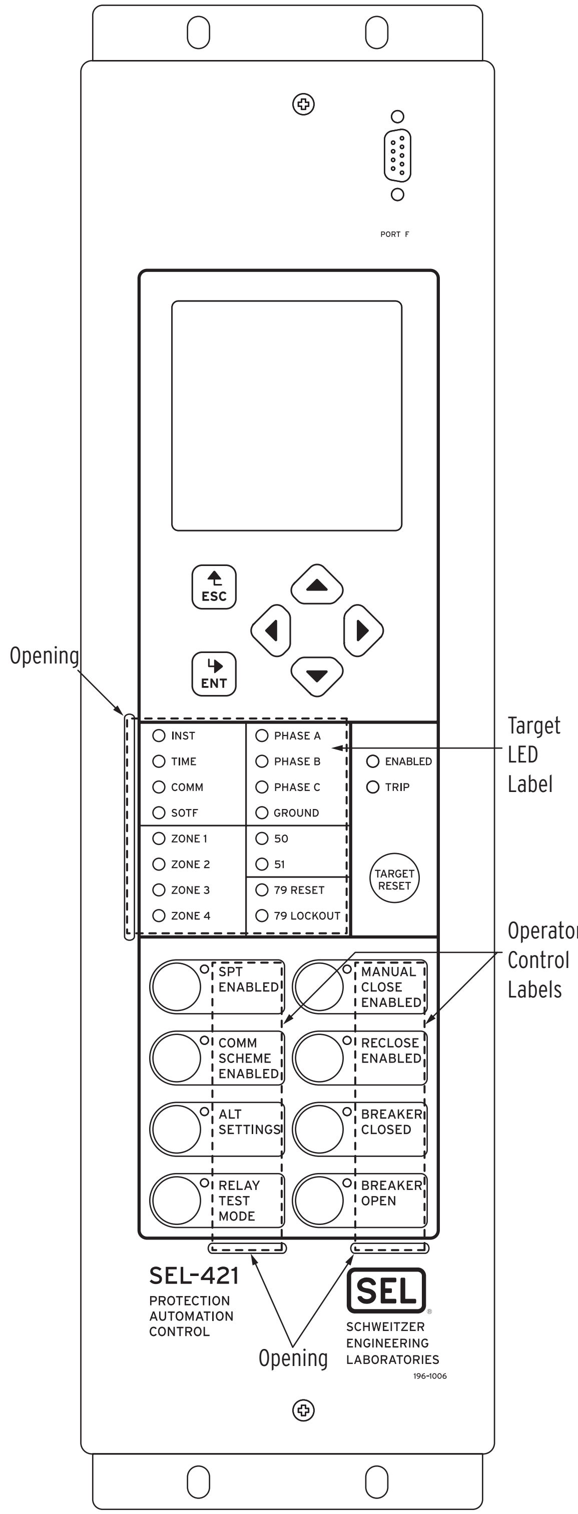


Figure 2.2 Vertical Front-Panel Template.

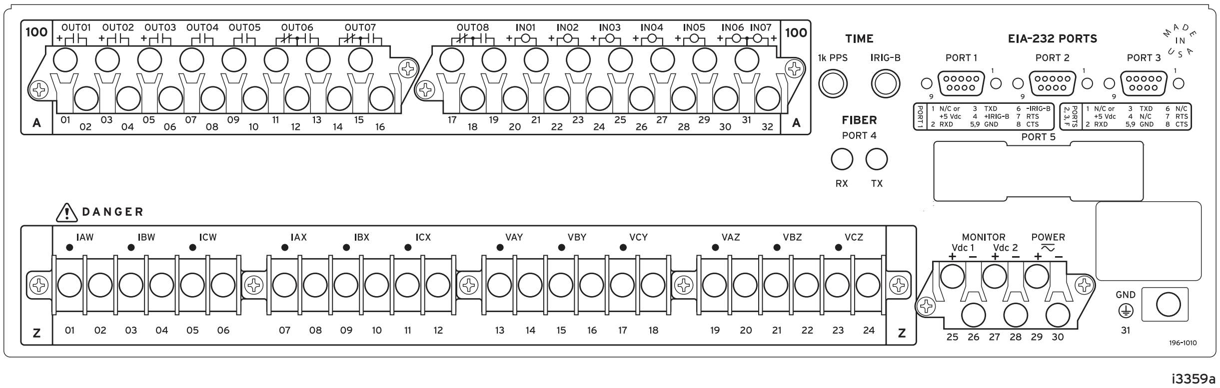


Figure 2.3 Rear 3U Template, Fixed Terminal Block Analog Inputs.
(When using a vertical-mount relay, the right rear side is at the top.)

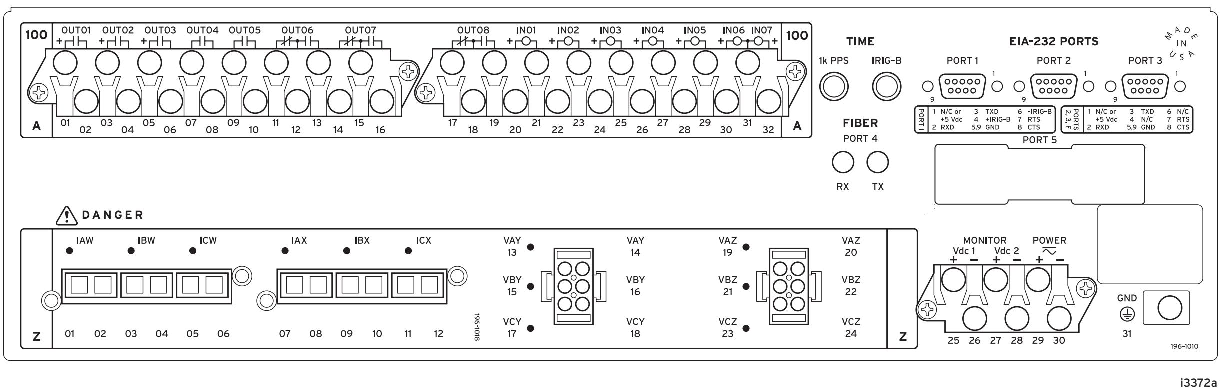


Figure 2.4 Rear 3U Template, Connectorized Analog Inputs.
(When using a vertical-mount relay, the right rear side is at the top.)

Secondary Circuits

The SEL-421 Relay is a very low burden load on the CT secondaries and PT secondaries. For both the CT and PT inputs, the frequency range is 40–65 Hz.

The relay accepts two sets of three-phase currents from power system CT inputs:

- IAW, IBW, and ICW
- IAX, IBX, and ICX

For 5 A relays, the rated nominal input current, I_{nom}, is 5 A. For 1 A relays, the rated nominal input current, I_{nom}, is 1 A. Input current for both relay types can range to 20 • I_{nom}. The CT burden is 0.27 VA @ 5A and 2.51 VA @ 15 A for the 5 A relay. The CT burden for the 1 A relay is 0.13 VA @ 1 A and 1.31 VA @ 3A. See the *AC Current Inputs (Secondary Circuits) on page U.1.11 in the User's Guide* for complete CT input specifications.

The relay also accepts two sets of three-phase, four-wire (wye) potentials from power system PT or CCVT (coupling-capacitor voltage transformer) secondaries:

- VAY, VBY, and VCY
- VAZ, VBZ, and VCZ

The nominal line-to-neutral input voltage for the PT inputs is 67 volts with a range of 0–300 volts. The PT burden is less than 0.5 VA at 67 volts, L-N. See *AC Voltage Inputs on page U.1.11 in the User's Guide* for complete PT input specifications.

Some applications do not use all three phases of a source; for example, voltage synchronization sources can be single phase. See *Section 1: Protection Application Examples in the Applications Handbook* for examples of connections to the potential inputs.

See *Secondary Circuit Connections on page 2.40* for information on connecting power system secondary circuits to these inputs.

Control Inputs

NOTE: The SEL-421 Relay has polarity-sensitive inputs. Observe the polarity marks when connecting external wiring.

I/O inputs into the relay are direct-coupled, high-impedance control inputs. Use these inputs for monitoring on/off and logical change-of-state conditions of power system equipment. These high-isolation control inputs are polarity-sensitive, ground-isolated circuits. You cannot damage these inputs with a reverse polarity connection, although the relay will not detect input changes with a reverse-polarity input. For more information on control input specifications, see *Control Inputs on page U.1.11 in the User's Guide*.

Inputs can be independent or common. Independent inputs have two separate ground-isolated connections to a high-isolation ADC (analog to digital converter). There are no internal connections among independent inputs. Common inputs share one input leg in common; all input legs of common inputs are ground-isolated. Each pair of common inputs is isolated from all other pairs.

Nominal current draw for these inputs is very low (4 mA or less) with an input voltage range of 15 Vdc to 265 Vdc. You can adjust the level at which these inputs assert; use the **SET G** (Global) command for control input pickup settings, GINP, and advanced settings, IN*nnn*P, where *n* represents the input number. You can also debounce the control inputs by using the **SET G** command for control input debounce settings, GIND, and advanced settings, IN*nnn*D. You can also set a global dropout factor, GINDF. See *Global Settings on page R.9.3 in the Reference Manual* for the default settings and more information. The control input accuracy is ±5 percent of the applied signal plus ±3 Vdc. The maximum voltage input is 300 Vdc, and the relay samples the control inputs 16 times per cycle.

Control Outputs

I/O control outputs from the relay include Standard outputs, Hybrid (high-current-interrupting) outputs, and Fast Hybrid (fast high-current-interrupting) outputs. Fast Hybrid outputs are available only on the optional I/O interface board INT5. An MOV (metal-oxide varistor) protects against excess voltage transients for each contact. Each output is individually isolated except Form C outputs, which share a common connection between the NC (normally closed) and NO (normally open) contacts.

The relay updates control outputs eight times per cycle. Updating of relay control outputs does not occur when the relay is disabled. When the relay is reenabled, the control outputs assume the state that reflects the present protection processing.

Standard Control Outputs

NOTE: You can use ac or dc circuits with Standard control outputs.

The Standard control outputs are "dry" Form A contacts rated for tripping duty. Ratings for Standard outputs are 30 A make, 6 A continuous, and 0.5 A or less break (depending on circuit voltage). Standard contact outputs have a maximum voltage rating of 250 Vac/330 Vdc. Maximum break time is 6 ms (milliseconds) with a resistive load. The maximum pickup time for the Standard control outputs is 6 ms. *Figure 2.5 on page 2.7* shows a representative connection for a Form A Standard control output on the main board I/O terminals.

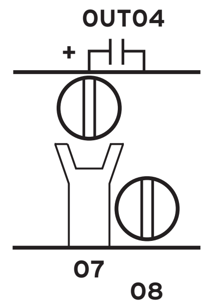


Figure 2.5 Standard Control Output Connection.

See *Control Outputs on page U.1.11 in the User's Guide* for complete standard control output specifications.

Hybrid (High-Current-Interrupting) Control Outputs

CAUTION: Equipment damage can result from connecting ac circuits to Hybrid (high-current-interrupting) control outputs. Do not connect ac circuits to Hybrid control outputs. Use only dc circuits with Hybrid control outputs.

The Hybrid (high-current-interrupting) control outputs are polarity dependent and are capable of interrupting high-current, inductive loads. Hybrid control outputs use an IGBT (Insulated Gate Bipolar Junction Transistor) in parallel with a mechanical contact to interrupt (break) highly inductive dc currents. The contacts can carry continuous current, while eliminating the need for heat sinking and providing security against voltage transients.

With any hybrid output, break time varies according to the L/R (circuit inductive/resistive) ratio. As the L/R ratio increases, the time needed to interrupt the circuit fully increases also. The reason for this increased interruption delay is that circuit current continues to flow through the output MOV after the output deasserts, until all of the inductive energy dissipates. Maximum dropout (break) time is 6 ms with a resistive load, the same as for the Standard control outputs. The other ratings of these control outputs are similar to the Standard control outputs, except that the Hybrid outputs can break current as great as 10 A. Hybrid contact outputs have a maximum voltage rating of 330 Vdc.

The maximum pickup time for the Hybrid control outputs is 6 ms. *Figure 2.6* shows a representative connection for a Form A Hybrid control output on the main board I/O terminals.

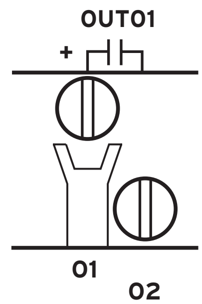


Figure 2.6 Hybrid Control Output Connection.

See *Section 1: Introduction and Specifications in the User's Guide*, for complete Hybrid control output specifications.

Fast Hybrid (Fast High-Current-Interrupting) Control Outputs

NOTE: You can use ac or dc circuits with Fast Hybrid (fast high-current-interrupting) outputs.

In addition to the Standard control outputs and the Hybrid control outputs, I/O interface board INT5 offers Fast Hybrid (fast high-current-interrupting) control outputs. These control outputs have a resistive load pickup time of 10 µs (microseconds), which is much faster than the 6 ms pickup time of the Standard and Hybrid control outputs. The Fast Hybrid control outputs drop out at a maximum time of 8 ms. The maximum voltage rating is 250 Vac/330 Vdc. See *Control Outputs on page U.1.11 in the User's Guide*, for complete Fast Hybrid control output specifications. *Figure 2.7* shows a representative connection for a Form A Fast Hybrid control output on the INT5 I/O interface terminals.

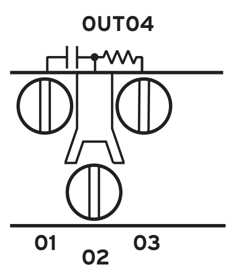


Figure 2.7 Fast Hybrid Control Output Connection.

Short transient inrush current can flow at the closing of an external switch in series with open Fast Hybrid contacts. This transient will not energize the circuits in typical relay-coil control applications (trip coils and close coils), and standard auxiliary relays will not pick up. However, an extremely sensitive digital input or light-duty, high-speed auxiliary relay can pick up for this condition. This false pick-up transient occurs when the capacitance of the Fast Hybrid output circuitry charges (creating a momentary short circuit that a fast, sensitive device sees as a contact closure). A third terminal (03 in *Figure 2.8*) provides an internal path for precharging the Fast Hybrid output circuit capacitance when the circuit is open.

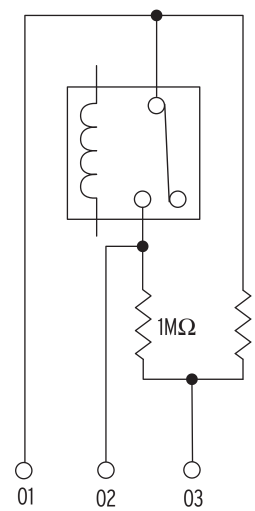


Figure 2.8 Fast Hybrid Control Output Typical Terminals.

Figure 2.9 on page 2.9 shows some possible connections for this third terminal that will eliminate the false pick-up transients when closing an external switch. In general, you must connect the third terminal to the dc rail (positive or negative) that is on the same side as the open external switch condition. If an open switch exists on either side of the output contact, then you can accommodate only one condition because two open switches (one on each side of the contact) defeat the precharge circuit.

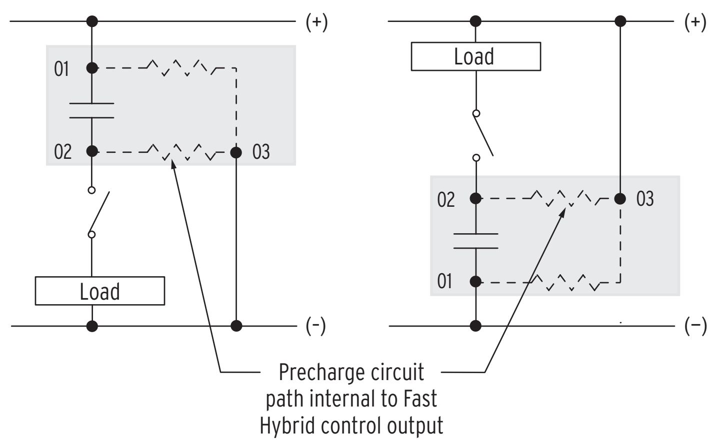


Figure 2.9 Precharging Internal Capacitance of Fast Hybrid Output Contacts.

Main Board I/O

The SEL-421 Relay base model is a 3U chassis with I/O interface on the main board (the top board). See *Figure 2.20 on page 2.33* and *Figure 2.21 on page 2.34* for representative rear-panel views of the 3U chassis rear panel. Every SEL-421 Relay configuration includes the main board I/O and features these connections:

- Three Hybrid (high-current-interrupting) Form A outputs
- Two Standard Form A outputs
- Three Standard Form C outputs
- Seven high-isolation control inputs (five independent and two with a common leg)

TIME Inputs

The SEL-421 Relay has high-accuracy time-keeping modes IRIG and PPS. You can provide IRIG-B time code format signals to the relay from many sources (SEL-2030 Communications Processor, GPS receiver, etc.). For even greater accuracy, use GPS satellite-locked 1000 PPS (pulse-per-second) time code signals for extremely accurate time stamping of power system events. This is very valuable for analyzing event data and developing a look at instantaneous power system states (state estimation). See *Section 3: Analyzing Data in the Applications Handbook* and *Section 4: Time-Synchronized Measurements in the Applications Handbook* for more information on the use and benefits of high-accuracy time keeping.

IRIG-B

The IRIG-B serial data format consists of a 1-second frame containing 100 pulses divided into fields. The relay decodes the second, minute, hour, and day fields and sets the internal time clock upon detecting valid time data in the IRIG time mode. Timing accuracy for IRIG-only time mode is as close as 150 µs for a highly stable and accurate IRIG-B source. See *IRIG-B on page U.4.66 in the User's Guide* for information on enabling IRIG-B time keeping.

1k PPS

The 1000 PPS (1k PPS) pulse train output of a GPS receiver provides a high-accuracy time source. The GPS receiver generates this pulse train from the 1k PPS satellite-transmitted time signal. High-accuracy GPS-based time and frequency receivers from various manufacturers provide the 1k PPS signal as an ordering option. In PPS time mode, use both an IRIG-B and a 1000 PPS time code signal for extremely accurate time stamping of power system events. Timing accuracy for PPS mode is ± 10 µs. See *1k PPS on page U.4.66 in the User's Guide*, for information on enabling PPS time keeping.

Battery-Backed Clock

If relay input power is lost or removed, a lithium battery powers the relay clock providing date and time backup. The battery is a 3 V lithium coin cell, Ray-O-Vac® No. BR2335 or equivalent. If power is lost or disconnected, the battery discharges to power the clock. At room temperature (25° C), the battery will operate for approximately 10 years at rated load.

When the SEL-421 Relay is operating with power from an external source, the self-discharge rate of the battery only is very small. Thus, battery life can extend well beyond the nominal 10-year period because the battery rarely discharges after the relay is installed. The battery cannot be recharged. *Figure 2.13 on page 2.18* shows the clock battery location (at the front of the main board).

If the relay does not maintain the date and time after power loss, replace the battery. See *Replacing the Lithium Battery on page 2.44*.

Communications Interfaces

The SEL-421 Relay has several communications interfaces you can use to communicate with other IEDs (intelligent electronic devices) via EIA-232 ports: PORT 1, PORT 2, PORT 3, and PORT F. See *Section 4: Communications Interfaces in the Reference Manual* for more information and options for connecting your relay to the communications interfaces.

You can install an optional communications card to obtain Ethernet capability for the SEL-421 Relay. A communications card, such as the SEL-2701 Ethernet Processor, gives the relay access to popular Ethernet networking standards including TCP/IP, FTP, Telnet, and UCA2 over local area networks and wide area networks. For more information on UCA2 applications, see *Section 7: UCA2 Communications in the Reference Manual*.

Other Shared Configuration Attributes

All versions of the SEL-421 Relay also feature ground, power, and battery monitor connections, communications ports, and fiber ports. See *Connection on page 2.33* for information on these relay interface features.

Plug-In Boards

The SEL-421 Relay is available in many input/output configuration options. The relay base model is a 3U chassis with Standard I/O and screw terminal connector connections (see *Figure 2.3 on page 2.5*). Other ordering options include versions of the relay in larger enclosures (4U or 5U) with all, partial, or no extra I/O boards installed.

NOTE: Ordering the 4U and 5U relay with partial or no extra I/O allows for future system expansion and future use of additional relay features.

Also available for the SEL-421 Relay is a plug-in communications card. The optional SEL-2701 Ethernet Processor communications card allows you to use TCP/IP, FTP, Telnet, and UCA2 applications on an Ethernet network.

I/O Interface Boards

You can choose among three input/output interface boards for the I/O slots of the 4U and 5U chassis. These I/O interface boards are in addition to the main board I/O described in *Shared Configuration Attributes on page 2.2*. The I/O interface boards are INT1, INT5, and INT6. *Figure 2.10* and *Figure 2.11* show the rear screw terminal connectors associated with these interface boards.

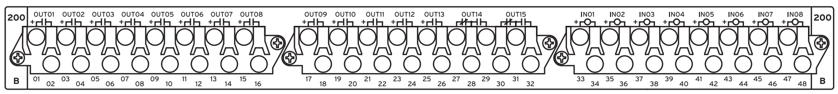


Figure 2.10 INT1 or INT6 I/O Interface Board.

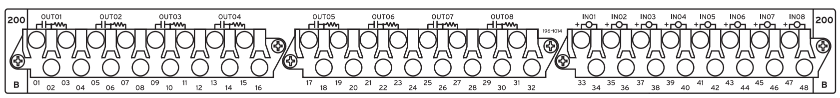


Figure 2.11 INT5 I/O Interface Board.

The I/O interface boards carry jumpers that identify the board location. See *Jumpers on page 2.17* for more information on I/O board jumpers.

I/O Interface Board Inputs

All optional I/O interface boards have eight independent control inputs. All independent inputs are isolated from other inputs. These high-isolation control inputs are polarity-sensitive, ground-isolated circuits. You cannot damage these inputs with a reverse polarity connection; though, the relay will not detect input changes with a reverse-polarity input.

Table 2.1 is a comparison of the I/O board input capacities; the table also shows the I/O inputs on the main board. See *Control Inputs on page U.1.11 in the User's Guide* for complete control input specifications.

.

Table 2.1 I/O Interface Boards Control Inputs

Board Number	Independent Contact Pairs	Common Contact Pairs
INT1	8	
INT5	8	
INT6	8	
Main Board	5	2

I/O Interface Board Outputs

The I/O interface boards vary by the type and amount of output capabilities. *Table 2.2* lists the outputs of the additional I/O interface boards; the table also shows the I/O outputs on the main board. Information about the Standard and Hybrid (high-current interrupting) control outputs is in *Control Outputs on page 2.6*.

Table 2.2 I/O Interface Boards Control Outputs

Board Number	Standard		Fast Hybrid[a]	Hybrid[b]	
	Form A	Form C	Form A	Form A	Form C
INT1	13	2			
INT5			8		
INT6				13	2
Main Board	2	3		3	

[a] High-Speed/High-Current Interrupting
[b] High-Current Interrupting

Installing Optional I/O Interface Boards

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.

DANGER: Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

When expanding the capability of the SEL-421 Relay with additional I/O interface boards, perform the following steps:

Step 1. Remove the relay from service. Follow your company standard for removing a relay from service. Disconnect power from the SEL-421 Relay. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect all cables from the main board (the top board).

Step 4. Confirm proper installation of address jumpers on the interface board. See *Jumpers on page 2.17*.

Step 5. Confirm drawout tray keying. The relay chassis and the drawout trays for the 200-addresses slot and the 300-addresses slot are keyed (see *Figure 2.12*). The keys are two round plug-in/plug-out discs on the bottom of the drawout tray. The 200-addresses slot keys go to the left, and the 300-addresses slot keys go to the right (when viewed from the top and front of the drawout tray). Move a key on the bottom of the drawout tray to the correct position by prying the key from the tray and reinserting the key in the proper position. Do this for both keys.

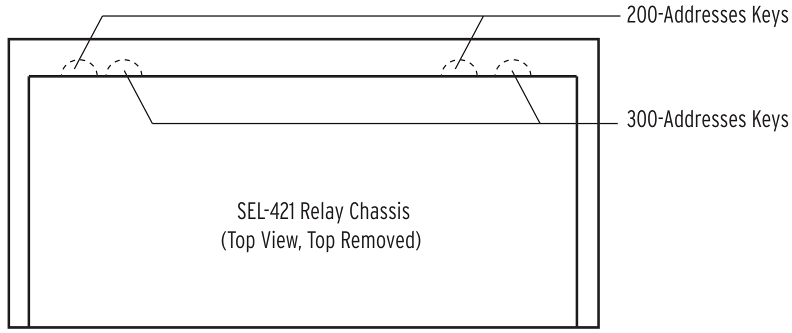


Figure 2.12 Chassis Key Positions for I/O Interface Boards.

Step 6. Install the drawout tray with I/O interface board. Use the following precautions when installing the I/O interface board:

➤ Position the drawout tray edges into the left-side and right-side internally mounted slots.

➤ Slide the I/O interface board into the SEL-421 Relay by pushing the front edge of the board drawout tray.

➤ Apply firm pressure to fully seat the I/O interface board.

➤ If you encounter resistance, stop, and withdraw the board. Inspect the drawout tray edge guide slots for damage. If you see no damage, take all of the precautions outlined above and try again to insert the board.

Step 7. If this is a new I/O interface board installation, remove the INTERFACE BOARD EXPANSION SLOT self-sticking label from the rear panel. Do this by lifting a corner of the label with a sharp tool and peeling away the label from the rear panel.

Step 8. Confirm screw terminal connector keying. SEL supplies three new screw terminal connectors with new I/O interface boards. Inspect the screw terminal connector receptacles on the rear of the I/O interface board. Refer to *Figure 2.27 on page 2.37* for the corresponding key positions inside the receptacle. If the keys inside the I/O Interface board receptacles are not in these positions, grasp the key edge with long-nosed pliers to remove the key and reinsert the key in the correct position. Break the webs of the screw terminal connectors in the position that matches the receptacle key (see *Figure 2.26 on page 2.36*).

Step 9. Attach the screw terminal connector. Mount the screw terminal connectors to the rear panel of the SEL-421 Relay. Refer to *Figure 2.10 on page 2.12* and *Figure 2.11 on page 2.12* for screw terminal connector placement. Tighten the screw terminal connector mounting screws to between 7 in-lb. and 12 in-lb. (0.8 Nm to 1.4 Nm).

Step 10. Connect the interface cable(s) from the I/O board(s) to the main board.

Step 11. Reconnect the internal power and analog cables.

Step 12. Reattach the front panel.

Step 13. Apply power. Enter Access Level 2 (*Making Simple Settings Changes on page U.4.15 in the User's Guide*). Issue the **STA** command and answer **Y<Enter>** to accept the new hardware configuration (see *STATUS on page R.8.45 in the Reference Manual*).

Step 14. Inspect the relay targets to confirm that the relay reads the added I/O interface board(s). You can see the new control inputs in the target listings by using a terminal, the SEL-5030 ACSELERATOR® Software Program, and the front panel. Use a communications terminal to issue the commands **TAR OUT201<Enter>** (for the 200-addresses slot) or **TAR OUT301<Enter>** (for the 300-addresses slot). Alternatively, from the front panel MAIN MENU, select RELAY ELEMENTS, press the down pushbutton to go to ROW 94 (for the 200-addresses slot) or ROW 97 (for the 300-addresses slot).

Step 15. Follow your company standard procedure to return the relay to service.

Communications Card

You can add other communications protocols to the SEL-421 Relay by inserting a communications card in the rear-panel PORT 5 slot. Ethernet communication is possible by adding the SEL-2701 Ethernet Communications Processor card. The SEL-2701 is an Ethernet device for industrial installations that handles data traffic between the SEL-421 Relay and a LAN (local area network).

Installing the Communications Card

To install a communications card in an SEL-421 Relay, perform the following steps. If your communications card is already installed, skip the following steps and perform the Initial Checkout procedures for your communications card.

DANGER: Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

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.

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

Step 1. Remove the relay from service. Follow your company standard for removing a relay from service. Disconnect power from the SEL-421 Relay. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect the power, interface board cable(s), and input board analog cable from the main board (the top board).

Step 4. Remove the cover from the PORT 5 slot.

Step 5. Remove the screw terminal connectors. Loosen the attachment screws at each end of the 100-addresses screw terminal connectors. Pull straight back to remove.

Step 6. Remove rear-panel EIA-232 Ports mating connectors. Unscrew the keeper screws and disconnect any serial cables connected to the Port 1, Port 2, and Port 3 rear-panel receptacles.

Step 7. Pull out the drawout tray containing the main board.

Step 8. Insert the communications card 80-pin connector into the 80-pin receptacle on the underside of the host main board, taking the following precautions:

- ➢ Ensure the connector pins line up with the guide holes on the host main board.

- ➢ Apply firm pressure while inserting the connector pins into the host receptacle, but do not force the connection. Forcing the connection can cause damage to the pins or guide holes. Rocking the communications card slightly from side to side can help align the connector pins.
- ➢ If you encounter resistance or all the pins do not protrude evenly on the upper side of the main board, stop, and withdraw the card. Inspect the pins and guide holes for damage. If pins and receptacle are undamaged, take all the precautions outlined above, and try again to insert the card.

Step 9. Use the four screws included with the communications card to attach the cart to standoffs on the host main board. Tighten the screws to 8.0 in-lbs (0.9 Nm) to prevent stripping the threads in the nylon standoffs.

Step 10. Reinstall the SEL-421 Relay main board, and reconnect power, interface board cables, and the input board analog cable.

Step 11. Reattach rear-panel connections. Affix the screw terminal connectors to the appropriate 100-addresses locations on the rear panel. Reconnect any serial cables that you removed in the disassembly process to the EIA-232 Ports.

Step 12. Reattach the front panel.

Step 13. Follow your company standard procedure to return the relay to service.

Step 14. Proceed with the Initial Checkout procedures for your communications card.

Jumpers

The SEL-421 Relay contains jumpers that configure the relay for certain operating modes. The jumpers are located on the main board (the top board) and the I/O interface boards (one or two boards located immediately below the main board).

Main Board Jumpers

The jumpers on the main board of the SEL-421 Relay perform these functions:

- ➤ Temporary/emergency password disable
- ➤ Circuit breaker control enable
- ➤ Rear serial port +5 Vdc source enable

Figure 2.13 on page 2.18 shows the positions of the main board jumpers. The main board jumpers are in two locations. The password disable jumper and circuit breaker control jumper are at the front of the main board. The serial port jumpers are near the rear-panel serial ports; each serial port jumper is directly in front of the serial port that it controls.

Password and Circuit Breaker Jumpers

You can access the password disable jumper and circuit breaker control jumper without removing the main board from the relay cabinet. Remove the SEL-421 Relay front cover to view these jumpers (use appropriate ESD precautions). The password and circuit breaker jumpers are on jumper header J18 on the front of the main board, located immediately left of Power connector J17 (see *Figure 2.13*).

CAUTION: Do not install a jumper on positions A or D of the main board J18 header. Relay misoperation can result if you install jumpers on positions J18A and J18D.

The J18 header is denoted A, B, C, and D from right to left (position A is on the right). Position B is the password disable jumper; position C is the circuit breaker control enable jumper. Positions A and D are not used. *Figure 2.14 on page 2.19* shows the jumper header with the circuit breaker/control jumper in the ON position and the password jumper in the OFF position; these are the normal jumper positions for an in-service relay. *Table 2.3 on page 2.19* lists the J18 jumper positions and functions.

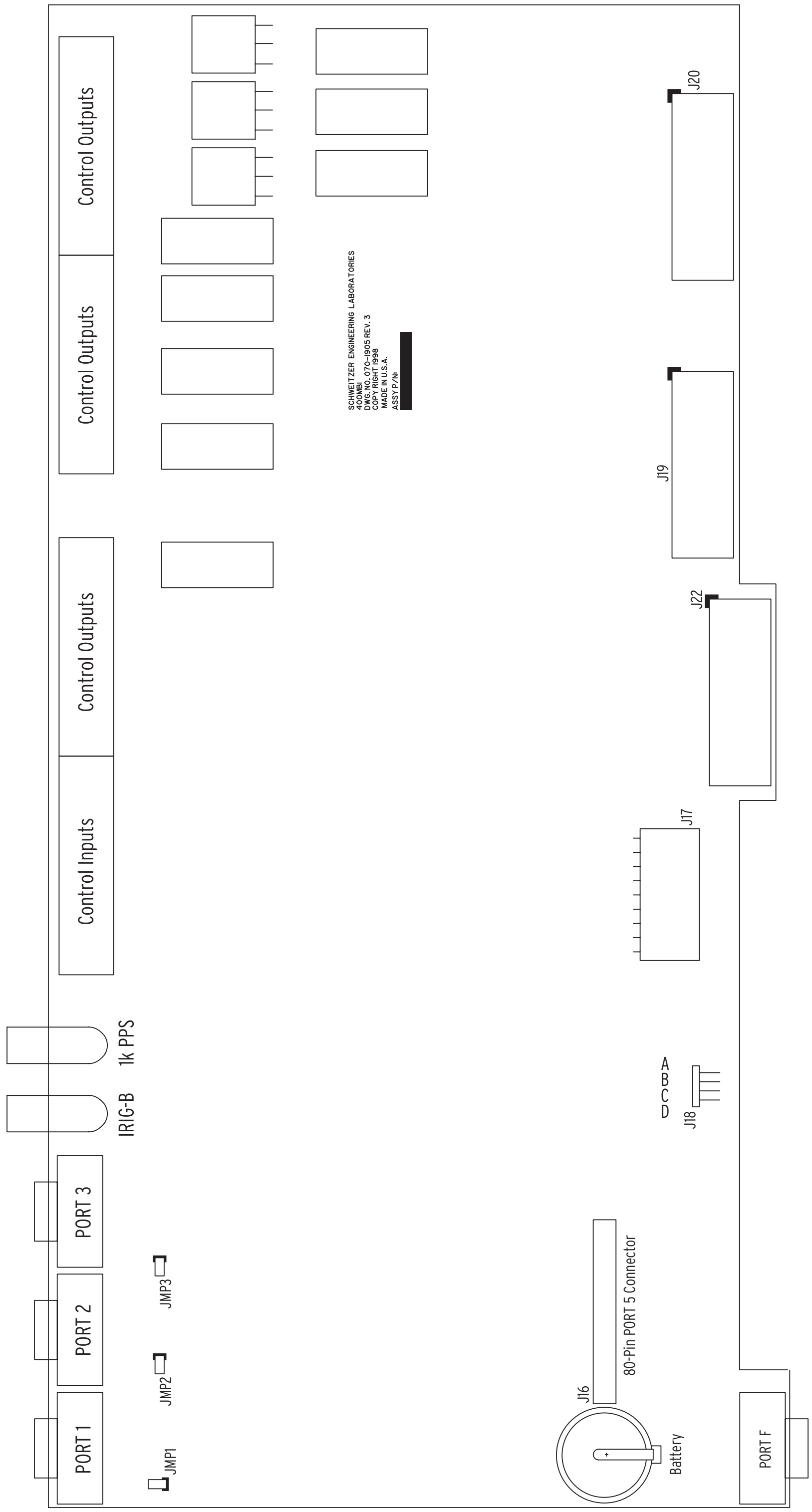


Figure 2.13 Major Component Locations on the SEL-421 Relay Main Board.

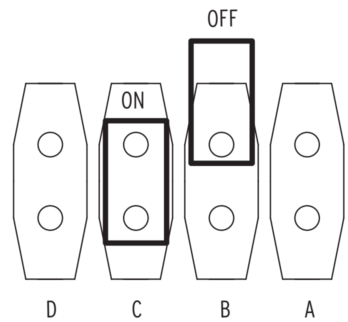


Figure 2.14 J18 Header—Password and Breaker Jumpers.

Table 2.3 Main Board Jumpers[a]

Jumper	Jumper Location	Jumper Position	Function
J18A	Front	OFF	For SEL use only
J18B	Front	OFF	Enable password protection (normal and shipped position)
		ON	Disable password protection (temporary or emergency only)
J18C	Front	OFF	Disable control outputs (shipped position)
		ON	Enable control outputs, including circuit breaker CLOSE and OPEN (normal position)
J18D	Front	OFF	For SEL use only

[a] ON is the jumper shorting both pins of the jumper. Place the jumper over one pin only for OFF.

The password disable jumper, J18B, is for temporary or emergency suspension of the relay password protection mechanisms. Under no circumstance should you install J18B on a long-term basis. The SEL-421 Relay ships with password disable jumper J18B OFF (passwords enabled). For temporary unprotected access to a particular access level, use the **PAS *n* DISABLE** command (*n* is the access level: *n* = 1, B, P, A, O, 2). For more information on this command and setting passwords, see *Passwords on page U.4.10 in the User's Guide*.

The circuit breaker control enable jumper, Jumper J18C, supervises the ***CLOSE n*** command, the ***OPEN n*** command, the **PULSE OUT*nnn*** command, and front-panel local bit control. To use these functions you must install jumper J18C. The relay checks the status of the circuit breaker control jumper when you issue **CLOSE *n***, **OPEN *n***, **PULSE OUT*nnn***, and when you use the front panel to close or open circuit breakers, control a local bit, or pulse an output. Jumper J18C is usually installed on a long-term basis after you have completed relay commissioning and installation tests. The SEL-421 Relay ships with circuit breaker jumper J18C OFF (control outputs disabled). After commissioning tests, move jumper J18C to ON for proper control output operation.

Serial Port Jumpers

Place jumpers on the main board to connect +5 Vdc to Pin 1 of each of the three rear-panel EIA-232 serial ports. The maximum current available from this Pin 1 source is 0.5 A. The Pin 1 source is useful for powering an external modem. *Table 2.4 on page 2.20* describes the JMP1, JMP2, and JMP3 positions. Refer to *Figure 2.13 on page 2.18* for the locations of these jumpers. The SEL-421 Relay ships with JMP1, JMP2, and JMP3 OFF (no +5 Vdc on Pin 1).

Table 2.4 Main Board Jumpers—JMP1, JMP2, and JMP3[a]

Jumper	Jumper Location	Jumper Position	Function
JMP1	Rear	OFF	Serial Port 1, Pin 1 = not connected
		ON	Serial Port 1, Pin 1 = +5 Vdc
JMP2	Rear	OFF	Serial Port 2, Pin 1 = not connected
		ON	Serial Port 2, Pin 1 = +5 Vdc
JMP3	Rear	OFF	Serial Port 3, Pin 1 = not connected
		ON	Serial Port 3, Pin 1 = +5 Vdc

[a] ON is the jumper shorting both pins of the jumper. Place the jumper over one pin only for OFF.

Changing Serial Port Jumpers

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

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.

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

You must remove the main board to access the serial port jumpers. To change the JMP1, JMP2, and JMP3 jumpers in an SEL-421 Relay, perform the following steps:

Step 1. Remove the relay from service. Follow your company standard for removing a relay from service. Disconnect power from the SEL-421 Relay. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect the power cable, interface board cable(s), and input board analog cable from the main board (the top board).

Step 4. Remove the screw terminal connectors. Loosen the attachment screws at each end of the 100-addresses screw terminal connectors. Pull straight back to remove.

Step 5. Remove rear-panel EIA-232 Ports mating connectors. Unscrew the keeper screws and disconnect any serial cables connected to the Port 1, Port 2, and Port 3 rear-panel receptacles.

Step 6. Carefully pull out the drawout assembly containing the main board.

Step 7. Locate the jumper you want to change. Jumpers JMP1, JMP2, and JMP3 are located at the rear of the main board, directly in front of Port 1, Port 2, and Port 3, respectively (see *Figure 2.13 on page 2.18*).

Step 8. Install or remove the jumper as needed. See *Table 2.4* for jumper position descriptions.

Step 9. Reinstall the SEL-421 Relay main board, and reconnect power, interface board cable(s) and the input board analog cable.

Step 10. Reattach rear-panel connections. Affix the screw terminal connectors to the appropriate 100-addresses locations on the rear panel. Reconnect any serial cables that you removed in the disassembly process to the EIA-232 Ports.

Step 11. Reattach the front panel.

Step 12. Follow your company standard procedure to return the relay to service.

I/O Interface Board Jumpers

Jumpers on the I/O interface boards identify the particular I/O board configuration and I/O board control address. Three I/O interface boards are available: INT1, INT5, and INT6 (see *I/O Interface Boards on page 2.12* for more information on these boards). The jumpers on these I/O interface boards are at the front of each board, as shown in *Figure 2.15 on page 2.22*, *Figure 2.16 on page 2.23*, and *Figure 2.17 on page 2.24*.

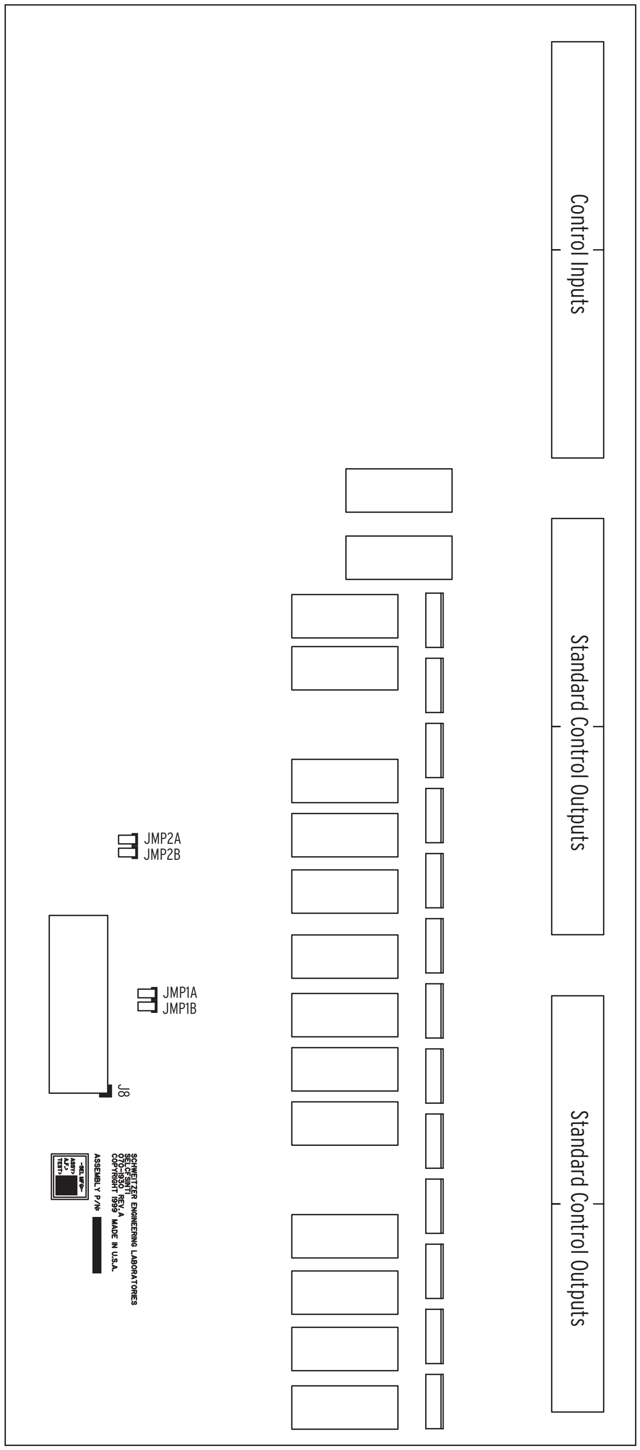


Figure 2.15 Major Component Locations on the SEL-421 Relay INT1 I/O Board.

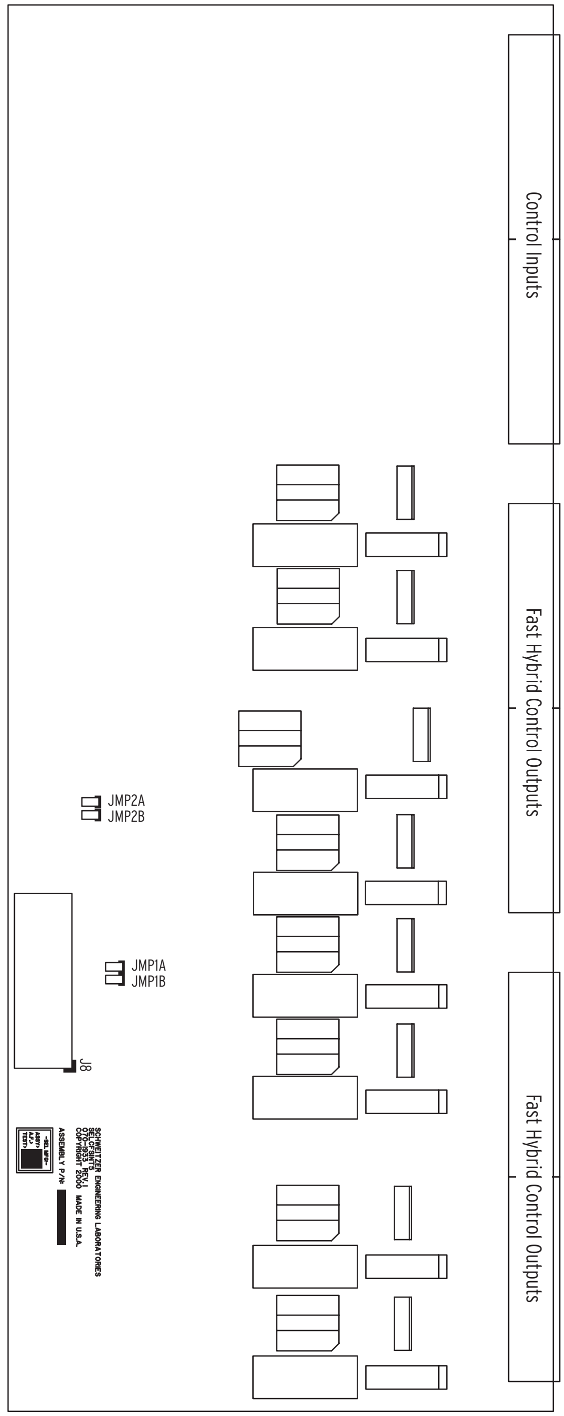


Figure 2.16 Major Component Locations on the SEL-421 Relay INT5 I/O Board.

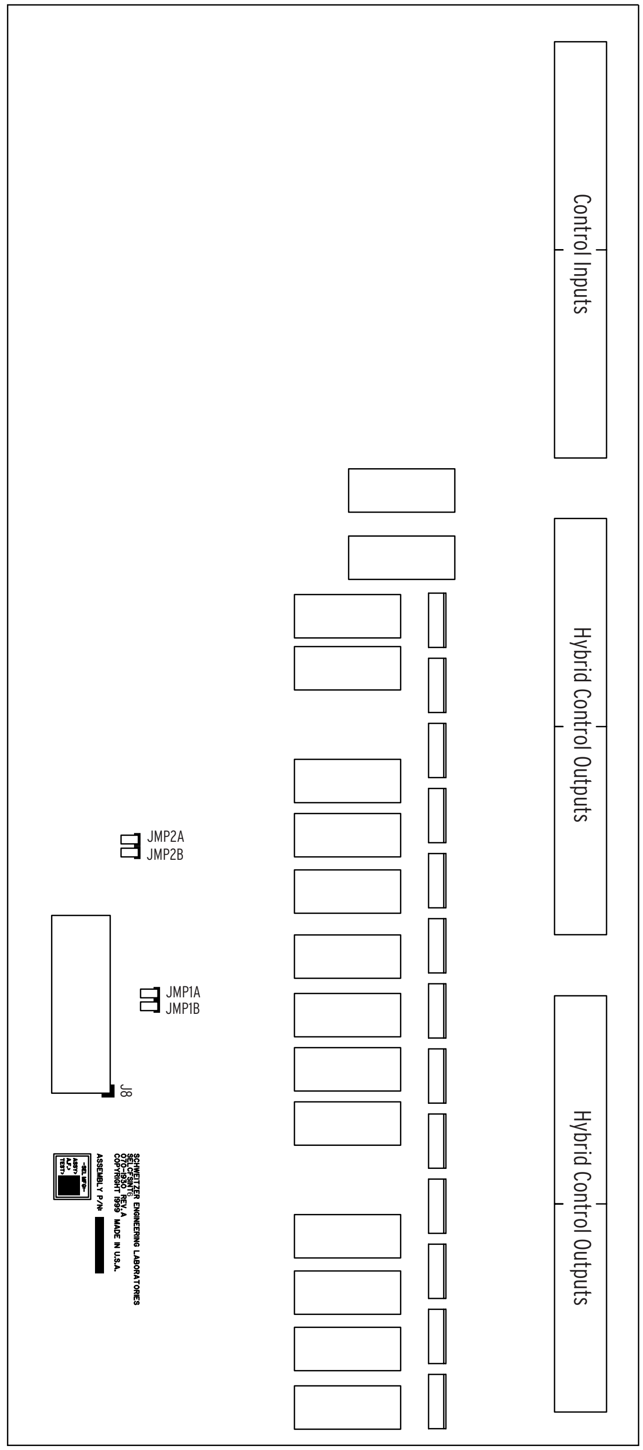


Figure 2.17 Major Component Locations on the SEL-421 Relay INT6 I/O Board.

To confirm the positions of your I/O board jumpers, you can remove the front panel and inspect the jumper placements visually. *Table 2.5 on page 2.25* lists the four jumper positions for I/O interface boards. Refer to *Figure 2.15 on page 2.22*, *Figure 2.16 on page 2.23*, and *Figure 2.17 on page 2.24* for the locations of these jumpers.

The I/O board control address has a hundreds-series prefix attached to the control inputs and control outputs for that particular I/O board chassis slot. A 4U chassis has a 200-addresses slot for inputs IN201, IN202, etc., and outputs OUT201, OUT202, etc. A 5U chassis has a 200-addresses slot and a 300-addresses slot. The drawout tray on which each I/O board is mounted is keyed. See *Installing Optional I/O Interface Boards on page 2.13* for information on the key positions for the 200-addresses slot trays and the 300-addresses slot trays.

Table 2.5 I/O Board Jumpers

I/O Board Control Address	JMP1A	JMP1B	JMP2A	JMP2B
2XX	OFF	OFF	OFF	OFF
3XX	ON	OFF	ON	OFF

Changing I/O Interface Board Jumpers

Change the I/O interface board jumpers only when you move the slot position of an I/O board. You must remove the I/O interface boards to access the jumpers. To change JMP1A, JMP1B, JMP2A, and JMP2B on an SEL-421 Relay I/O interface board, perform the following steps:

DANGER: Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

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.

CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

Step 1. Remove the relay from service. Follow your company standard for SEL-421 for removing a relay from service. Disconnect power from the SEL-421 Relay. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect the interface board cable from the main board (the top board).

Step 4. Pull out the drawout assembly containing the I/O interface board.

Step 5. Locate the jumper you want to change. Jumpers JMP1A, JMP1B, JMP2A, and JMP2B are located at the front of the I/O board to the left and right of the interface board connector (see *Figure 2.15 on page 2.22*, *Figure 2.16 on page 2.23*, and *Figure 2.17 on page 2.24*).

Step 6. Install or remove the jumper as needed. See *Table 2.5* for jumper position descriptions.

Step 7. Reinstall the SEL-421 Relay I/O interface board, and reconnect the interface board cable.

Step 8. Reattach the front panel.

Step 9. Follow your company standard procedure to return the relay to service.

Step 10. At relay power-up, confirm that the relay does not display a Status Warning about I/O board addresses. For information on this Status Warning, see *Relay Self-Tests on page U.6.37 in the User's Guide*.

Front-Panel Labels

The SEL-421 Relay features a versatile front panel that you can customize for your needs. Use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs and operator control pushbuttons and LEDs. Horizontal and vertical relay configurations have slide-in labels as shown in *Figure 2.1 on page 2.4* and *Figure 2.2 on page 2.4*.

The blank slide-in label set, shown in *Figure 2.18*, is included with the SEL-421 Relay. The Operator Control Labels and front-panel pockets are keyed for left and right placement corresponding to the left and right operator control pushbuttons and LEDs.

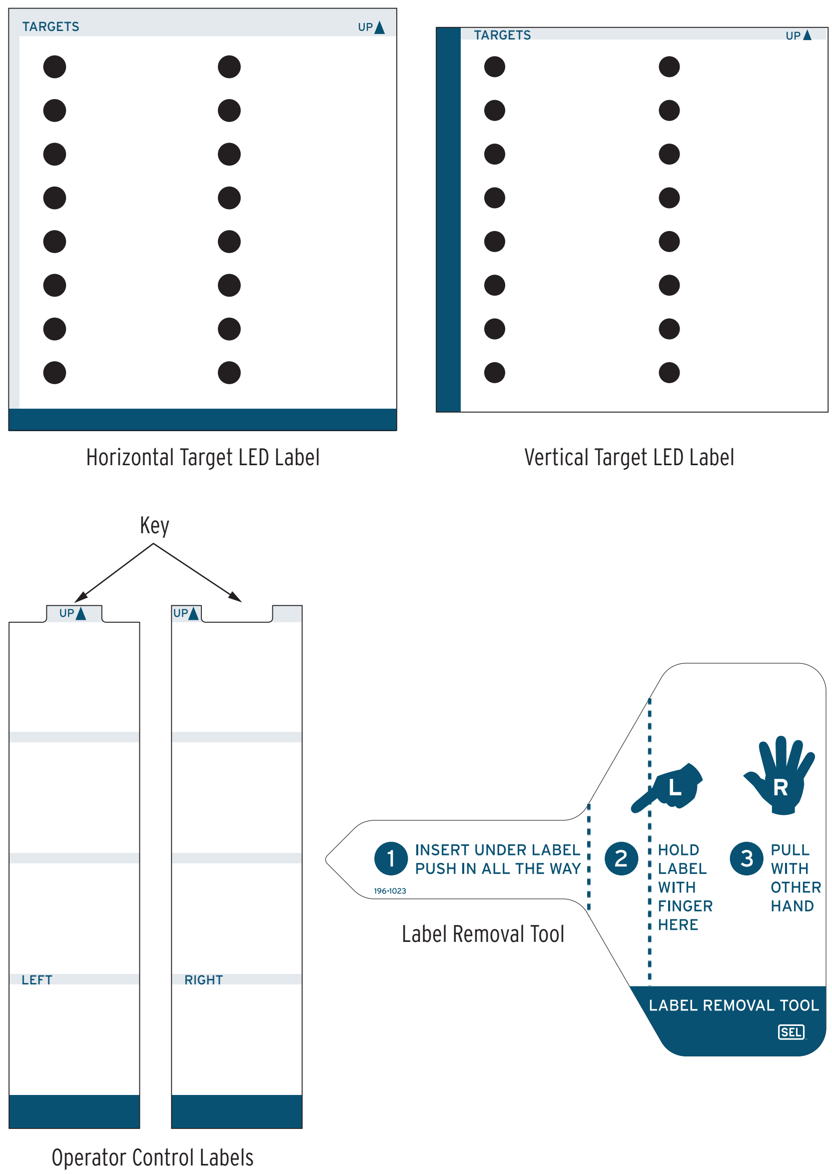


Figure 2.18 Blank Slide-In Label Set and Label Removal Tool.

If you need additional configurable front-panel label supplies, order the horizontal labels kit or the vertical labels kit in *Table 2.6*. The table lists the part numbers of each kit component as an aid for determining which Part

Number 926000x kit to order. Contact your Technical Service Center or the SEL factory to obtain these kits (see *Factory Assistance on page 6.43 in Section 6: Testing and Troubleshooting*).

Table 2.6 Configurable Front-Panel Label Kits

Content Descriptions	Quantity	Part Number
SEL-421 Relay Labels Kit—Horizontal	One	9260004
Blank Customer Label Templates on perforated paper for laser printing; horizontal	Five	196-1009
Blank slide-in label sets for labeling by hand (use only a fine point permanent marker); horizontal	Two sets—three labels for each set	196-1008
Label Removal Tool	One	196-1023
SEL-421 Relay Labels Kit—Vertical	One	9260005
Blank Customer Label Templates on perforated paper for laser printing; vertical	Five	196-1022
Blank slide-in label sets for labeling by hand (use only a fine point permanent marker); vertical	Two sets—three labels for each set	196-1021
Label Removal Tool	One	196-1023

Removing Configurable Front-Panel Labels

Included with the relay is the Label Removal Tool, also shown in *Figure 2.18 on page 2.26*. Use this tool to remove labels from the front-panel pockets. Use the procedure in the following steps to remove a slide-in front-panel label:

Step 1. Push the existing label all the way inside the label pocket.

Step 2. Slide the tip of the tool under the label at the label pocket opening (see *Figure 2.1 on page 2.4* for opening locations).

Step 3. Push the exposed, bottom edge of the label against the Label Removal Tool while pulling out the combined label and Label Removal Tool to extract the label. For the Target LED Label, slide the Label Removal Tool from side to side to extract the label.

Changing Configurable Front-Panel Labels

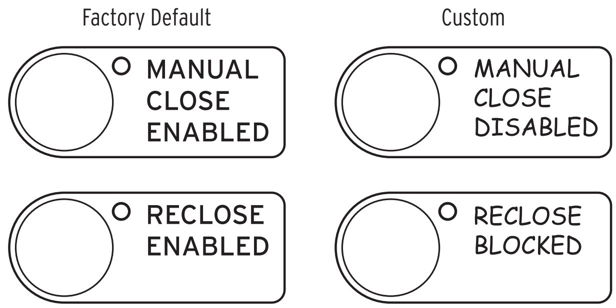
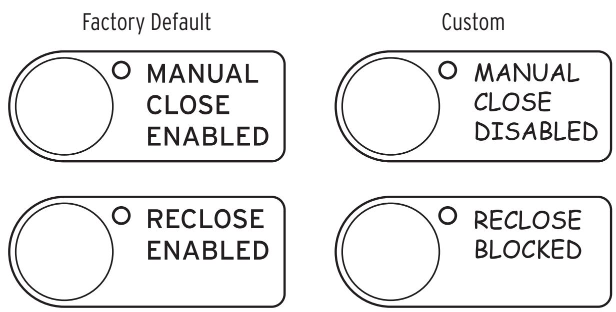
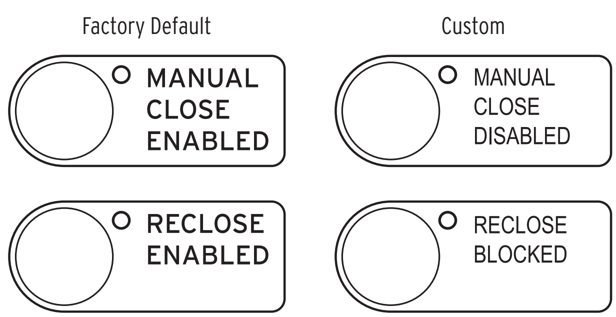
NOTE: The SEL-421 Relay ships with factory default labels and settings. To change the front-panel factory default labels, you must examine and perhaps modify relay settings. Verify that any customized Target LED and Operator Control Label matches relay programming.

There are four options for producing custom labels for the SEL-421 Relay front panel:

- ➤ Use factory default labels
- ➤ Use handwritten labels on factory default labels
- ➤ Use handwritten labels on blank labels
- ➤ Use laser-printed labels on perforated paper labels

Table 2.7 on page 2.28 illustrates each option. The Operator Control Label examples in *Table 2.7 on page 2.28* show a common application for configurable front-panel labels: changing from factory default "enabled" functions to custom "disabled/blocked" functions. *Table 2.7 on page 2.28* shows just one possibility; you can program front-panel pushbutton/LED functions to any relay-supported control or monitoring function. Check any label change against relay programming to confirm that the new label and relay functioning match.

Table 2.7 Options for Configurable Front-Panel Labels

Default Labels	
Use the default labels supplied with the relay.	See *Figure 2.1 on page 2.4*.
Handwritten Labels: Reusing Factory Default Labels	
➤ Use the Label Removal Tool to remove the factory default labels from the front panel (see *Removing Configurable Front-Panel Labels*). ➤ Write on the backside of the labels with a fine point permanent marker. ➤ Reinsert the modified labels in the appropriate pockets; be sure to fully seat the label in each pocket.	
Handwritten Labels: Using Blank Labels	
➤ Write on the blank labels with a fine point permanent marker to create handwritten labels. ➤ Use the Label Removal Tool to remove the factory default labels from the front panel (see *Removing Configurable Front-Panel Labels*). ➤ Insert the handwritten labels in the appropriate pockets; be sure to fully seat the label in each pocket.	
Laser-Printed Labels: Using Perforated Paper Labels	
➤ Create labels on a computer with the word-processing templates contained on the SEL-421/SEL-421-1 Relay Product Literature CD. See *Creating Laser-Printed Labels*. ➤ Print to a laser printer on the Customer Label Templates perforated paper. ➤ Use the Label Removal Tool to remove the factory default labels from the front panel (see *Removing Configurable Front-Panel Labels*). ➤ Insert the laser-printed labels in the appropriate pockets; be sure to fully seat the label in each pocket.	

Creating Laser-Printed Labels

NOTE: The template is a Word 2000 file. The default template font is Arial Narrow. You can use this font or choose a different font that is available on your computer system.

The purpose of this procedure is to create laser-printed configurable front-panel labels on blank Customer Label Templates (supplied). These steps are for both the horizontal and the vertical versions of the relay.

The source for label template files and test sheet files is the SEL-421/SEL-421-1 Relay Product Literature CD. In addition, you can find these files on the SEL website; visit www.selinc.com.

Step 1. Open Microsoft® Windows® Explorer and find the Microsoft Word label template files (421_Horizontal.dot and 421_Vertical.dot) in the Customer Label Template folder on the SEL-421/SEL-421-1 Relay Product Literature CD. In the Word program, use the Tools > Options > File Locations menu to locate the “User templates” folder on your computer; note the directory path to this folder. Open another Windows Explorer window and navigate to the Templates folder noted earlier.

Copy the template files from the SEL-421/SEL-421-1 Relay Product Literature CD (in the first Explorer window) to the Templates folder on your computer (in the second Explorer window).

Step 2. In Microsoft Word use the File > New menu to access the 421_Horizontal.dot or 421_Vertical.dot files from your storage drive. Choose the template file that matches the layout you want to use (see *Figure 2.18 on page 2.26*). Double-click on the template file you have chosen to open a copy of that file. Make sure you can see table gridlines. Toggle the Table > Hide Gridlines menu item to see the template gridlines.

Step 3. Save the document with a new file name.

Step 4. Edit the template document placing LED and pushbutton labels in appropriate positions on the blank Customer Label Template. Fill in the fields (use the tab and arrow keys, or the mouse to move from field to field). Field space is limited; only text displayed on the screen prints on the label. Save the file often to preserve your work in progress.

Use the identification fields at the top of the Target LED Label and in four positions between pushbutton labels to mark the relay that corresponds with the label set.

NOTE: If you want to adjust the font size, use the procedure in Step 8 to Unprotect the document.

Step 5. Complete all necessary entries and save the file.

Step 6. Create test sheets for a test print. Print test sheets from Adobe® Acrobat® or Acrobat Reader® (the Reader is included on the SEL-421/SEL-421-1 Relay Product Literature CD).

Use the Acrobat File > Open menu to access the Customer Label Template folder on the SEL-421/SEL-421-1 Relay Product Literature CD. Open the test sheet file that corresponds to your relay (either 421_Horizontal_TestSheet.pdf or 421_Vertical_TestSheet.pdf). When printing, be sure that “Fit to Page” is not checked.

NOTE: If your printer has duplex capability, be sure to set the printer to print single sided.

Step 7. Print on the test sheet. Position the test sheet properly in the printer. Print the labels from Microsoft Word to the printer.

Step 8. Examine the printed test sheet (the identification fields are good indicators of printed text alignment on the test sheet). Printer drivers differ greatly resulting in label position discrepancies from the positioning shown on your screen. Make minor adjustments as necessary to print in the proper location on the test sheet. To make these adjustments, change margin settings as follows:

NOTE: DO NOT “Protect” the document afterwards, because the Protect function automatically deletes your labels contained in field data.

- Use the Tools > Unprotect Document to unlock/unprotect the document
- Use the File > Page Setup menu to adjust the top or left margins as needed to correct the alignment
- Do a test print on the test sheets
- Examine the label position

When the printed label alignment is correct, save the document.

Step 9. When the labels print correctly on the test sheets, print the labels on the perforated stock sheets.

If the labels are incorrect, repeat this procedure beginning with *Step 4 on page 2.29*.

Step 10. Fold and tear the perforated edges of the stock paper to remove the labels from the sheet.

Step 11. Use the Label Removal Tool to remove existing labels from front-panel label pockets and insert the created labels in the appropriate pockets on the relay front panel. (*Figure 2.18 on page 2.26* shows the Label Removal Tool.)

Step 12. To change the labeling again, remove existing labels and repeat the above procedure.

Relay Placement

Proper placement of the SEL-421 Relay helps make certain that you receive years of trouble-free power system protection. Use the following guidelines for proper physical installation of the SEL-421 Relay.

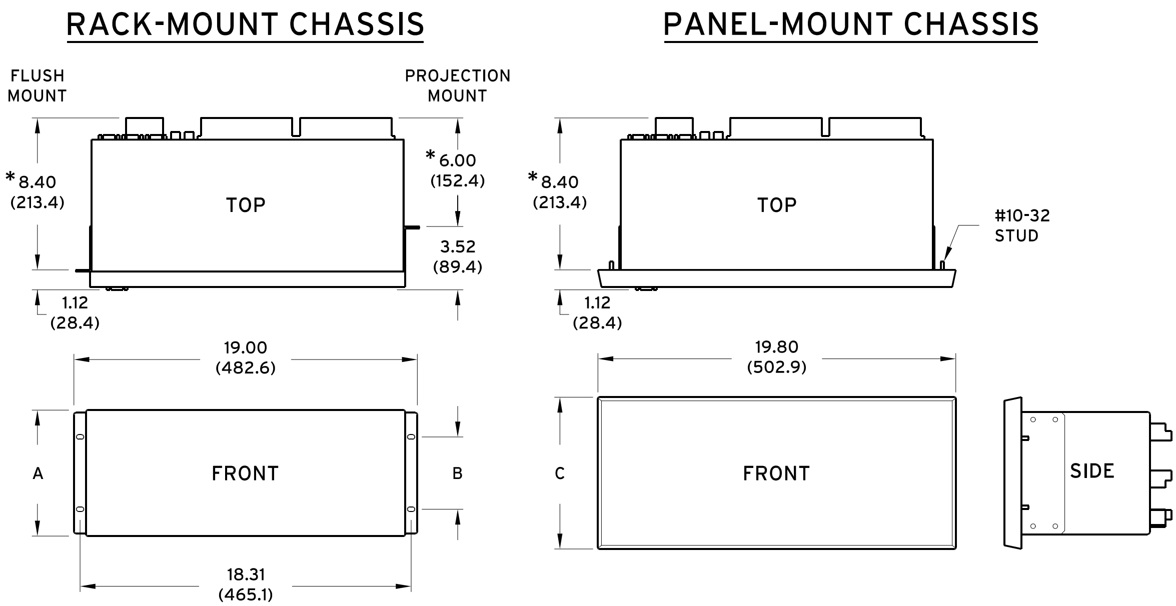
Physical Location

You can mount the SEL-421 Relay in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the relay. The relay is IEC EN61010-1 rated at Installation/Overvoltage Category II and Pollution Degree 2. This rating allows mounting the relay indoors or in an outdoor (extended) enclosure where the relay is protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity are controlled.

You can place the relay in extreme temperature and humidity locations. The temperature range over which the relay operates is –40° to +185°F (–40° to +85°C, see *Operating Temperature on page U.1.11 in the User's Guide*). The relay operates in a humidity range from 5 percent to 95 percent, no condensation. For EN61010 certification, the SEL-421 Relay rating is 2000 m (6560 feet) above mean sea level.

Rack Mounting

When mounting in a rack, use the reversible front flanges to either semiflush-mount or projection mount the relay. The semiflush mount gives a small panel protrusion from the relay rack rails of approximately 1.1 in. or 27.9 mm. The projection mount places the front panel approximately 3.5 in. or 88.9 mm in front of the relay rack rails. See *Figure 2.19 on page 2.32* for exact mounting dimensions for both the horizontal and vertical rack-mount relays. Use four screws of the appropriate size for your rack.



DIMENSION	MAIN BOARD ONLY (3U)	ONE I/O BOARD (4U)	TWO I/O BOARD (5U)
A	5.22 (132.6)	6.97 (177.0)	8.72 (221.5)
B	2.25 (57.2)	4.00 (101.6)	5.75 (146.0)
C	6.65 (168.9)	8.40 (213.4)	10.15 (257.8)
D	5.10 (129.5)	6.85 (174.0)	8.60 (218.4)

*ADD 0.30 (7.6) FOR CONNECTORIZED RELAYS

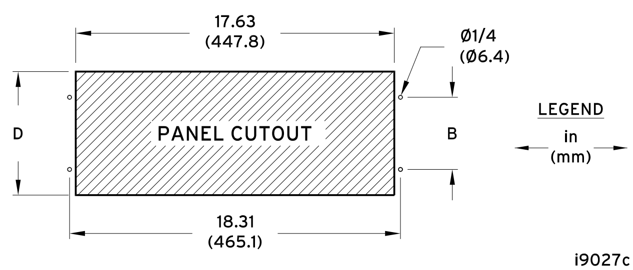


Figure 2.19 SEL-421 Relay Chassis Dimensions.

Panel Mounting

Place the panel-mount versions of the SEL-421 Relay in a switchboard panel. See the drawings in *Figure 2.19* for panel cut and drill dimensions (these dimensions apply to both the horizontal and vertical panel-mount relay versions). Use the supplied mounting hardware to attach the relay.

Connection

CAUTION: Insufficiently rated insulation can deteriorate under abnormal operating conditions and cause equipment damage. For external circuits, use wiring of sufficiently rated insulation that will not break down under abnormal operating conditions.

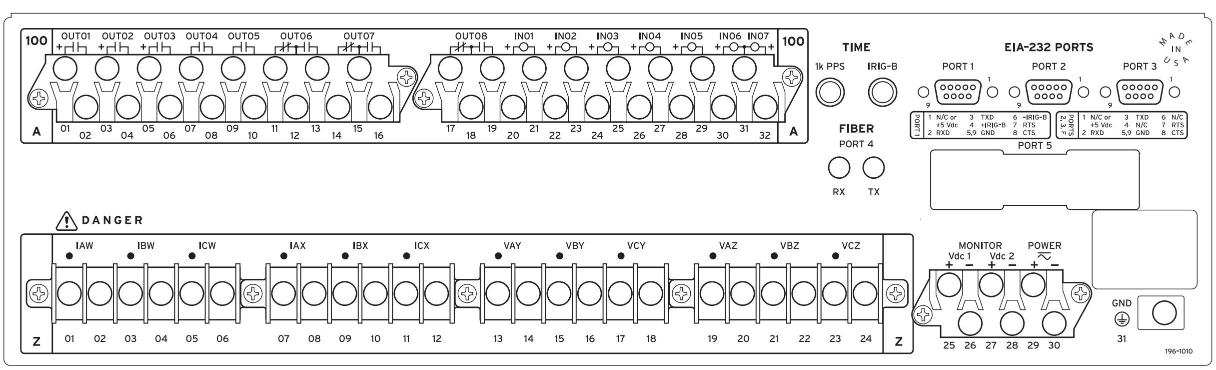
The SEL-421 Relay is available in many different configurations depending on the number and type of control inputs, control outputs, and analog input termination you specified at ordering. This subsection presents a representative sample of relay rear-panel configurations and the connections to these rear panels. Only horizontal chassis are shown; rear panels of vertical chassis are identical to horizontal chassis rear panels for each of the 3U, 4U, and 5U sizes.

When connecting the SEL-421 Relay, refer to your company plan for wire routing and wire management. Be sure to use wire that is appropriate for your installation with an insulation rating of at least 90°C.

Rear-Panel Layout

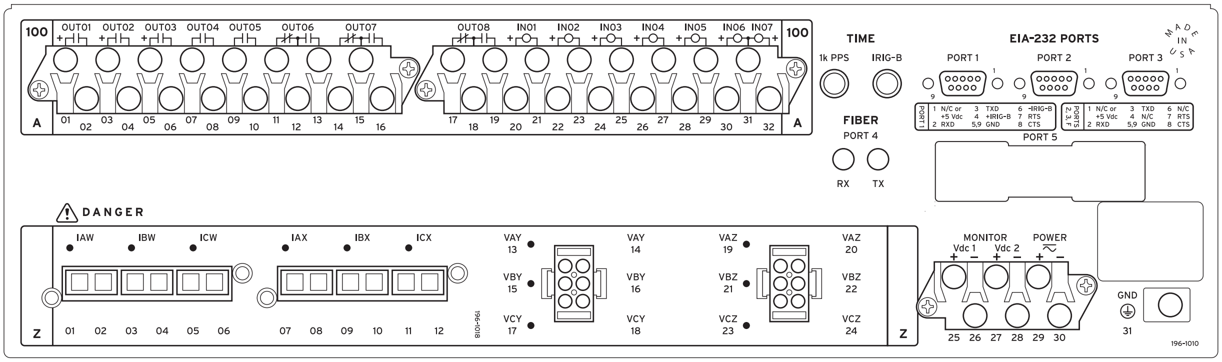
Figure 2.20 on page 2.33, *Figure 2.21*, *Figure 2.22*, and *Figure 2.23 on page 2.34*, and *Figure 2.24 on page 2.35* show some of the available SEL-421 Relay rear panels. All relay versions have screw terminal connectors for I/O, power, and battery monitor. You can order the relay with fixed terminal blocks for the CT and PT connections, or you can order SEL Connectorized rear-panel configurations that feature plug-in/plug-out PT connectors and shorting CT connectors for relay analog inputs. *Figure 2.21 on page 2.34* shows the Connectorized 3U horizontal configuration of the SEL-421 Relay. For clarity, the figures do not show a communications card installed in PORT 5.

The screw terminal connections for the INT1 and the INT6 I/O interface boards are the same. The INT5 I/O interface board has control output terminals grouped in threes, with the fourth terminal as a blank additional separator (terminals 4, 8, 12, 16, 20, 24, 28, and 32). For more information on the main board control inputs and control outputs, see *Main Board I/O on page 2.9*. For more information on the I/O interface board control inputs and control outputs, see *I/O Interface Board Jumpers on page 2.21*.



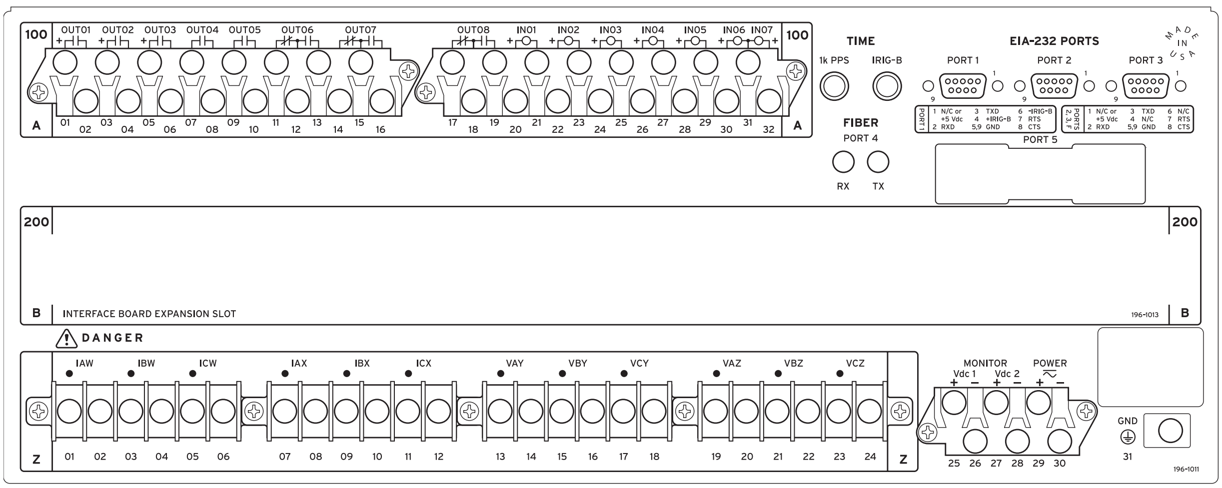
i3359a

Figure 2.20 3U Rear Panel, SEL-421 Relay.



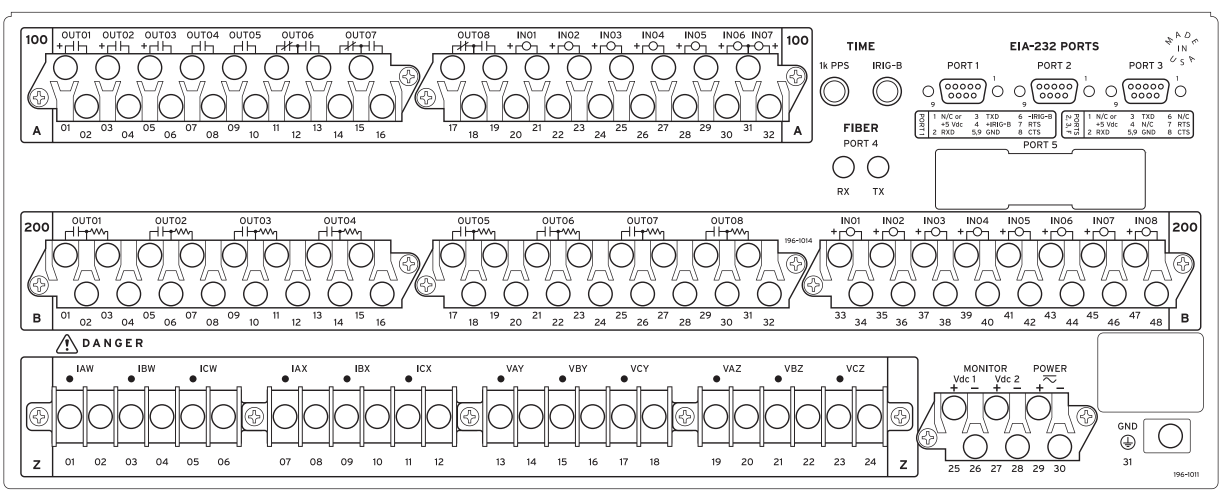
i3372a

Figure 2.21 3U Rear Panel, Connectorized SEL-421 Relay.



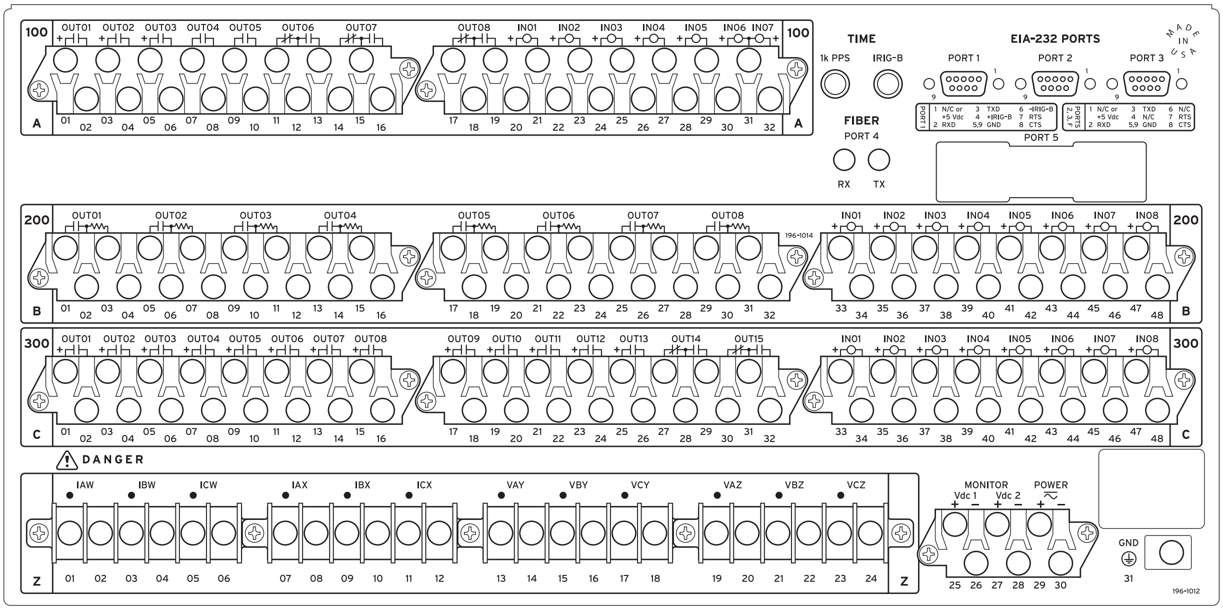
i3360a

Figure 2.22 4U Rear Panel, Without Optional I/O, SEL-421 Relay.



i3362a

Figure 2.23 4U Rear Panel, INT5 I/O Interface Board, SEL-421 Relay.



i3369a

Figure 2.24 5U Rear Panel, INT5 and INT1/INT6 I/O Interface Board, SEL-421 Relay.
(The INT5 board is the 200-addresses slot; the INT1/INT6 board is the 300-addresses slot.)

Rear-Panel Symbols

There are important safety symbols on the rear of the SEL-421 Relay (see *Figure 2.25*). Observe proper safety precautions when you connect the relay at terminals marked by these symbols. In particular, the danger symbol located on the rear panel corresponds to the following: *Contact with instrument terminals can cause electrical shock that can result in injury or death*. Be careful to limit access to these terminals.

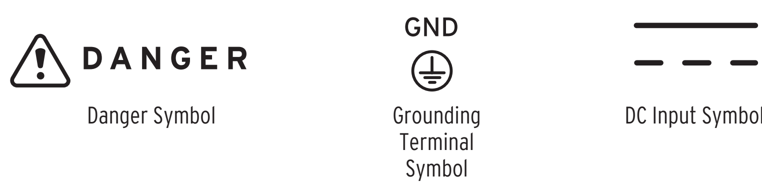


Figure 2.25 Rear-Panel Symbols.

Screw Terminal Connectors

Terminate connections to the SEL-421 Relay screw terminal connectors with ring-type crimp lugs. Use a #8 ring lug with a maximum width of 0.360 in. (9.1 mm). The screws in the rear-panel screw terminal connectors are #8-32 binding head, slotted, nickel-plated brass screws. Tightening torque for the terminal connector screws is 9 in-lb. to 18 in-lb. (1.0 Nm to 2.0 Nm).

You can remove the screw terminal connectors from the rear of the SEL-421 Relay by unscrewing the screws at each end of the connector block. Remove the connector by pulling the connector block straight out. Note that the receptacle on the relay circuit board is keyed; you can insert each screw terminal connector in only one location on the rear panel. To replace the screw terminal connector, confirm that you have the correct connector, push the connector firmly onto the circuit board receptacle, and reattach the two screws at each end of the block.

Changing Screw Terminal Connector Keying

You can rotate a screw terminal connector so that the connector wire dress position is the reverse of the factory-installed position (for example, wires entering the relay panel from below instead of from above). In addition, you can move similar function screw terminal connectors to other locations on the rear panel. To move these connectors to other locations, you must change the screw terminal connector keying.

Inserts in the circuit board receptacles key the receptacles for only one screw terminal connector in one orientation. Each screw terminal connector has a missing web into which the key fits (see *Figure 2.26*). If you want to move a screw terminal connector to another circuit board receptacle or reverse the connector orientation, you must rearrange the receptacle keys to match the screw terminal connector block. Use long-nosed pliers to move the keys. *Figure 2.27 on page 2.37* shows the factory default key positions.

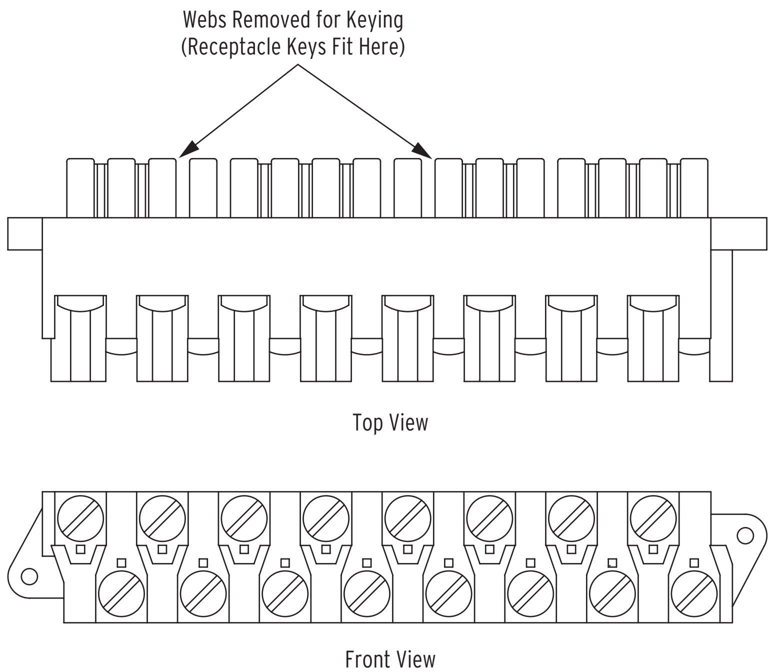


Figure 2.26 Screw Terminal Connector Keying.

Grounding

You must connect the grounding terminal (#Z31) labeled "GND" on the rear panel to a rack frame ground or main station ground for proper safety and performance. This protective earthing terminal is in the lower right side of the relay panel (see *Figure 2.20*, *Figure 2.21*, *Figure 2.22*, and *Figure 2.23 on page 2.34*, and *Figure 2.24 on page 2.35*). The symbol that indicates the grounding terminal is shown in *Figure 2.25 on page 2.35*. Use 12 AWG (4 mm^2) or heavier wire less than 6.6 feet (2 m) in length for this connection. This terminal connects directly to the internal chassis ground of the SEL-421 Relay.

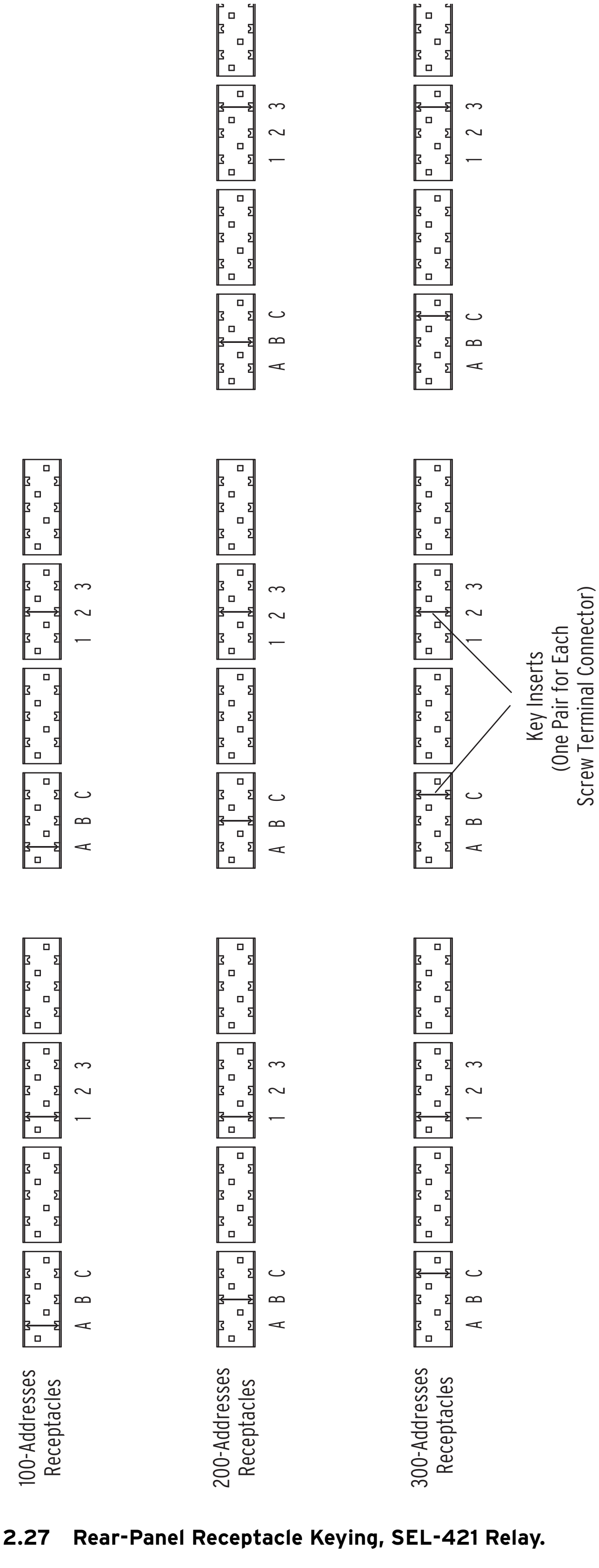


Figure 2.27 Rear-Panel Receptacle Keying, SEL-421 Relay.

Power Connections

The terminals labeled POWER on the rear panel (#Z29 and #Z30) must connect to a power source that matches the power supply characteristics that your SEL-421 Relay specifies on the rear-panel serial number label. (See *Power Supply on page U.1.11 in the User's Guide*, for complete power input specifications.) For the relay models that accept dc input, the serial number label specifies dc with the symbol shown in *Figure 2.25 on page 2.35*.

NOTE: The combined voltages applied to the POWER and MONITOR terminals must not exceed 600 V (rms or dc).

The POWER terminals are isolated from chassis ground. Use 16 AWG (1.5 mm^2) size or heavier wire to connect to the POWER terminals. Connection to external power must comply with IEC 947-1 and IEC 947-3.

Place an external switch, circuit breaker, or overcurrent device in the POWER leads for the SEL-421 Relay; this device must interrupt both the hot (H) and neutral (N) power leads. The maximum current rating for the power disconnect circuit breaker or overcurrent device (fuse) must be 20 A. Be sure to locate this device within 9.8 feet (3.0 m) of the relay.

Operational power is internally fused by power supply fuse F1. *Table 2.8* lists the SEL-421 Relay power supply fuse requirements. Be sure to use fuses that comply with IEC 127-2.

You can order the SEL-421 Relay with one of three operational power input ranges listed in *Table 2.8*. Each of the three supply voltage ranges represents a power supply ordering option. As noted in *Table 2.8*, model numbers for the relay with these power supplies begin 04210*n*, where *n* is 2, 4, or 6, to indicate low, middle, and high voltage input power supplies, respectively. Note that each power supply range covers two widely used nominal input voltages. The SEL-421 Relay power supply operates from 30 Hz to 120 Hz when ac power is used for the POWER input.

Table 2.8 Fuse Requirements for the SEL-421 Relay Power Supply

Nominal Power Supply Voltage Rating	Power Supply Voltage Range	Fuse F1	Fuse Description	Model Number
24/48 V	18–60 Vdc	T6.3A H250V	5x20 mm, time-lag, 6.3 A, high break capacity, 250 V	042102
48/125 V	38–140 Vdc or 85–140 Vac (30–120 Hz)	T3.15A H250V	5x20 mm, time-lag, 3.15 A, high break capacity, 250 V	042104
125/250 V	85–300 Vdc or 85–264 Vac (30–120 Hz)	T3.15A H250V	5x20 mm, time-lag, 3.15 A, high break capacity, 250 V	042106

The SEL-421 Relay accepts dc power input for all three power supply models. The 48/125 Vdc supply also accepts 120 Vac; the 125/250 Vdc supply also accepts 120/240 Vac. When connecting a dc power source, you must connect the source with the proper polarity, as indicated by the + (terminal #Z29) and – (terminal #Z30) symbols on the power terminals. When connecting an ac power source, the + terminal #Z29 is hot (H), and the – terminal #Z30 is neutral (N).

Each model of the SEL-421 Relay internal power supply exhibits low power consumption and a wide input voltage tolerance. For more information on the power supplies, see *Power Supply on page U.1.11 in the User's Guide*.

Power Supply Fuse Replacement

⚠ **DANGER:** Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠ **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.

⚠ **CAUTION:** Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

You can replace a bad fuse in an SEL-421 Relay power supply, or you can return the SEL-421 Relay to SEL for fuse replacement. If you decide to replace the fuse, perform the following steps to replace the power supply fuse:

Step 1. Remove the relay from service. Follow your company standard for removing a relay from service. Disconnect power from the SEL-421 Relay. Remove the relay from the rack or panel. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect the interface board cable(s) from the main board (the top board) and the I/O interface board(s).

Step 4. Disconnect the power, input board analog cable, and interface board cable(s) from the main board.

Step 5. Remove the screw terminal connectors. Loosen the attachment screws at each end of the 100-addresses, 200-addresses, and 300-addresses screw terminal connectors. Pull straight back to remove.

Step 6. Remove rear-panel EIA-232 Ports mating connectors. Unscrew the keeper screws and disconnect any serial cables connected to the Port 1, Port 2, and Port 3 rear-panel receptacles.

Step 7. Pull out the drawout tray containing the I/O interface board(s).

Step 8. Pull out the drawout tray containing the main board.

Step 9. Remove the top chassis plate by unscrewing seven screws from the chassis.

Step 10. Locate the power supply. Fuse F1 is at the rear of the power supply circuit board. See *Figure 2.28 on page 2.40*. Examine the power supply for blackened parts or other damage. If you can see obvious damage, reinstall all boards and contact SEL to arrange return of the relay for repair.

Step 11. Remove the spent fuse from the fuse clips. Replace the fuse with an exact replacement. See *Table 2.8 on page 2.38* for the proper fuse for your power supply.

Step 12. Replace the chassis top on the relay and secure it with seven screws.

Step 13. Reinstall the SEL-421 Relay main board, and the I/O interface board(s).

Step 14. Reattach the power cable, the interface board cable(s), and the input board analog cable.

Step 15. Reattach rear-panel connections. Affix the screw terminal connectors to the appropriate 100-addresses, 200-addresses, and 300-addresses locations on the rear panel. Reconnect any serial cables that you removed in the disassembly process to the EIA-232 Ports.

Step 16. Reattach the front panel.

Step 17. Follow your company standard procedure to return the relay to service.

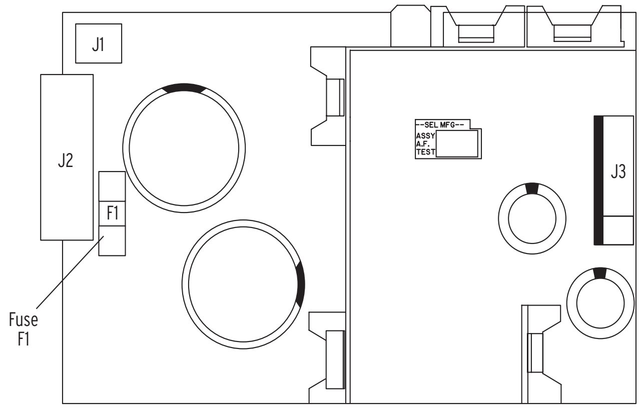


Figure 2.28 PS30 Power Supply Fuse Location.

Monitor Connections (DC Battery)

NOTE: The combined voltages applied to the POWER and MONITOR terminals must not exceed 600 V (rms or dc).

The SEL-421 Relay monitors two dc battery systems. For information on the battery monitoring function, see *Station DC Battery System Monitor on page A.2.22 in the Applications Handbook*. Connect the positive lead of Battery System 1 to Terminal #Z25 and the negative lead of Battery System 1 to Terminal #Z26. (Usually Battery System 1 is also connected to the rear-panel POWER input terminals.) For Battery System 2, connect the positive lead to Terminal #Z27, and the negative lead to Terminal #Z28.

Secondary Circuit Connections

The SEL-421 Relay has two sets of three-phase current inputs and two sets of three-phase voltage inputs. *Shared Configuration Attributes on page 2.2* describes these inputs in detail. The alert symbol and the word DANGER on the rear panel indicate that you should use all safety precautions when connecting secondary circuits to these terminals.

.

⚠ **DANGER:** Contact with instrument terminals can cause electrical shock that can result in injury or death.

To verify these connections, use SEL-421 Relay metering (See *Examining Metering Quantities on page U.4.31 in the User's Guide*). You can also review metering data in an event report that results when you issue the **TRIGGER** command (see *Triggering Data Captures and Event Reports on page A.3.4 in the Applications Handbook*).

Fixed Terminal Blocks

CAUTION: Relay misoperation can result from applying other than specified secondary voltages and currents. Before making any secondary circuit connections, check the nominal voltage and nominal current specified on the rear-panel nameplate.

Connect the secondary circuits to the Z terminal blocks on the relay rear panel. Note the polarity dots above the odd-numbered terminals #Z01, #Z03, #Z05, #Z07, #Z09, and #Z11 for CT inputs. Similar polarity dots are above the odd-numbered terminals #Z13, #Z15, #Z17, #Z19, #Z21, and #Z23 for PT inputs.

Connectorized

For the Connectorized SEL-421 Relay, you must order the wiring harness kit, SEL-WA0421. The wiring harness contains four prewired connectors for the relay current and voltage inputs. You can order the wiring harness with various wire sizes and lengths. Contact your local Technical Service Center or the SEL factory for ordering information.

Plug the CT shorting connectors into terminals #Z01 through #Z06 for the IW inputs, and #Z07 through #Z12 for the IX inputs, as appropriate. Odd-numbered terminals are the polarity terminals. Secure the connector to the relay chassis with the two screws located on each end of the connector. When you remove the CT shorting connector, pull straight away from the relay rear panel. As you remove the connector, internal mechanisms within the connector separately short each power system current transformer. You can install these connectors in only one orientation.

Plug the PT voltage connectors into terminals #Z13 to #Z18 for the VY inputs, and #Z19 to #Z24 for the VZ inputs, as appropriate. Odd numbered terminals are the polarity terminals. You can install these connectors in only one orientation.

Control Circuit Connections

You can configure the SEL-421 Relay with many combinations of control inputs and control outputs. See *Main Board I/O on page 2.9* and *I/O Interface Boards on page 2.12* for information about I/O configurations. This subsection provides details about connecting these control inputs and outputs. Refer to *Figure 2.3 on page 2.5*, *Figure 2.10 on page 2.12*, and *Figure 2.11 on page 2.12* for representative rear-panel screw terminal connector locations.

Control Inputs

NOTE: The combined voltages applied to the INnnn and OUTnnn terminals must not exceed 600 V (rms or dc).

The control input connections on the rear-panel I/O screw terminal connectors are polarity sensitive. A + indication appears over each pair of control inputs. Connect the positive sense of the control input to the + terminal. Although you cannot damage these inputs with a reverse polarity connection, a reverse polarity connection will cause the relay internal A/D converter to measure the input voltage incorrectly and the relay will no longer detect input changes. See *Control Inputs on page 2.6* for more information.

Note that the main board I/O control inputs have one set of two inputs that share a common input leg. These inputs are IN106 and IN107 found on terminals #A30, #A31, and #A32.

To assign the functions of the control inputs, see *Operating the Relay Inputs and Outputs on page U.4.52 in the User's Guide*, or the **SET G** command in *SET on page R.8.38 in the Reference Manual* for more details. You can also use the ACSELERATOR Software to set and verify operation of the inputs.

Control Outputs

The SEL-421 Relay has three types of outputs:

- Standard outputs (example: main board OUT104)
- Hybrid (high-current-interrupting) outputs (example: main board OUT101)
- Fast Hybrid (fast high-current-interrupting) outputs (example: INT5 board OUT201, or OUT301)

See *Control Outputs on page 2.6* for more information.

You can connect the Standard outputs and the Fast Hybrid (fast high-current-interrupting) outputs in either ac or dc circuits. Connect the Hybrid (high-current-interrupting) outputs to dc circuits only. The screw terminal connector legends alert you about this requirement by showing polarity marks on the Hybrid (high-current-interrupting) contacts.

Form A (SPST NO) contacts comprise the majority of the control outputs. Two pairs of Form C (DPST CO) contacts are on the main board, the INT1 I/O interface board, and the INT6 I/O interface board.

The INT5 I/O interface board features high-speed operation capability using Fast Hybrid control outputs. To limit the false pickup indications with digital inputs and light duty high-speed auxiliary relays, precharging resistors are available on the screw terminal connector for each pair of control output contacts. See *Fast Hybrid (Fast High-Current-Interrupting) Control Outputs on page 2.8* for further information, and *Figure 2.8 on page 2.9* and *Figure 2.9 on page 2.9* for resistor connection details.

Alarm Output

The SEL-421 Relay monitors internal processes and hardware in continual self-tests. If the relay senses an out-of-tolerance condition, the relay declares a Status Warning or a Status Failure. The relay signals a Status Warning by pulsing the HALARM Relay Word bit (hardware alarm) to a logical 1 for five seconds. For a Status Failure, the relay latches the HALARM Relay Word bit at logical 1.

To provide remote alarm status indication, connect the ‘b’ contact of OUT108 to your control system remote alarm input. *Figure 2.29* shows the configuration of the ‘a’ and ‘b’ contacts of control output OUT108.

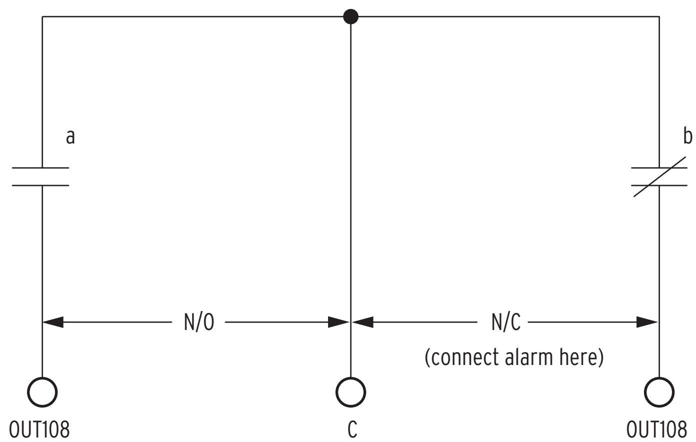


Figure 2.29 Control Output OUT108.

Program OUT108 to respond to NOT HALARM by entering the following SELOGIC® control equation with a communications terminal, with the ACSELERATOR software, or by using the front-panel LCD and navigation pushbuttons:

OUT108 := **NOT HALARM**

When the relay is operating normally, the NOT HALARM signal is at logical 1 and the ‘b’ contacts of control output OUT108 are open. When a Status Warning condition occurs, the relay pulses the NOT HALARM signal to logical 0 and the ‘b’ contacts of OUT108 close momentarily to indicate an alarm condition. For a Status Failure, the relay disables all control outputs and the OUT108 ‘b’ contacts close to trigger an alarm. Also, when relay power is off, the OUT108 ‘b’ contacts close to generate a power-off alarm. See *Relay Self-Tests on page U.6.37 in the User’s Guide* for information on relay self-tests.

The relay pulses the SALARM Relay Word bit for software programmed conditions; these include settings changes, access level changes, and alarming after three unsuccessful password entry attempts. You can add the software alarm SALARM to the alarm output by entering the following SELOGIC control equation:

OUT108 := **NOT (HALARM OR SALARM)**

Tripping and Closing Outputs

To assign the control outputs for tripping and closing, see *Setting Outputs for Tripping and Closing on page U.4.57 in the User's Guide*. In addition, you can use the **SET O** command; see *SET on page R.8.38 in the Reference Manual*, for more details. You can also use the front panel to set and verify operation of the outputs. See *SET/SHOW on page U.5.21 in the User's Guide*.

TIME Input Connections

IRIG-B Input Connection

The SEL-421 Relay accepts a demodulated IRIG-B signal through two types of rear-panel connectors. These IRIG-B inputs are through the BNC connector labeled TIME IRIG-B or through Pin 4 (+) and Pin 6 (–) of the rear-panel 9-pin D-subminiature connector PORT 1. See *Communications Ports Connections on page 2.44* for other DE-9 connector pinouts and additional details. These inputs accept the dc shift time code generator output (demodulated) IRIG-B signal with positive edge on the time mark. For more information on IRIG-B and the SEL-421 Relay, see *TIME Inputs on page 2.10*.

The BNC IRIG-B input and the PORT 1 IRIG-B input circuit connect to a 330 Ω resistor in series with an optocoupler input diode. The optocoupler input diode forward voltage drop is about 1.5 V. Driver circuits should source approximately 10 mA through the circuit for the ON state. When using the PORT 1 input, ensure that you connect Pins 4 and 6 with the proper polarity.

For ease of connection or for long runs from the IRIG-B generator to the SEL-421 Relay, use the BNC IRIG-B input. Connect a 50 Ω coaxial cable assembly with a male BNC connector to the IRIG-B input of the SEL-421 Relay and the other end of the coaxial cable to the GPS receiver or other IRIG-B generation equipment.

Where distance between the SEL-421 Relay and the IRIG-B sending device exceeds the cable length recommended for conventional EIA-232 metallic conductor cables, you can use transceivers to provide isolation and to establish communication to remote locations. Conventional fiber-optic and telephone modems do not support IRIG-B signal transmission. Use the SEL-2810 transceiver to provide long distance delivery of the IRIG-B signal to the SEL-421 Relay. The SEL-2810 includes a channel for the IRIG-B time code. These transceivers enable you to synchronize time precisely from IRIG-B time code generators (such as the SEL-2020 Communications Processor) over a fiber-optic communications link.

1k PPS Input Connection

The SEL-421 Relay accepts a 1k PPS (or 1000 PPS) input from a GPS receiver/time source through the rear-panel BNC jack labeled 1k PPS. (For PPS mode, you must also supply a locked IRIG-B input.) For more information on 1k PPS and the SEL-421 Relay, see *TIME Inputs on page 2.10*.

The 1k PPS port input impedance is 50 Ω. Use a BNC cable assembly to connect the 1k PPS signal from the GPS receiver/time source to the rear-panel BNC jack labeled 1k PPS. Typical input levels are approximately 2.5 Vdc into 50 Ω (open circuit 0–5 Vdc). See *Time Inputs on page U.1.11 in the User's Guide* for complete 1k PPS input specifications. For high-accuracy timing applications, be sure to match the lengths and propagation delays of the coaxial cables carrying the IRIG-B and 1k PPS signals to the SEL-421 Relay inputs.

Replacing the Lithium Battery

⚠ DANGER: Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠ 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.

⚠ CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

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

You can replace a bad lithium battery in the SEL-421 Relay. Perform the following steps to replace the lithium battery.

Step 1. Remove the relay from service. Follow your company standard procedure for removing a relay from service. Disconnect power from the SEL-421 Relay. Remove the relay from the rack or panel. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-421 Relay.

Step 3. Disconnect power, interface board cable(s), and input board analog cable from the main board.

Step 4. Pull out the drawout tray containing the main board.

Step 5. Locate the lithium battery. The lithium battery is at the front of the main board. See *Figure 2.13 on page 2.18*.

Step 6. Remove the spent battery from beneath the clip of the battery holder. Replace the battery with an exact replacement. Use a 3 V lithium coin cell, Ray-O-Vac® No. BR2335 or equivalent. The positive side (+) of the battery faces up.

Step 7. Reinstall the SEL-421 Relay main board drawout tray.

Step 8. Reattach the power cable, interface board cable(s), and input board analog cable.

Step 9. Reattach the front panel

Step 10. Set the relay date and time via the communications ports or front panel (See *Making Simple Settings Changes on page U.4.15 in the User's Guide*).

Step 11. Follow your company standard procedure to return the relay to service.

Communications Ports Connections

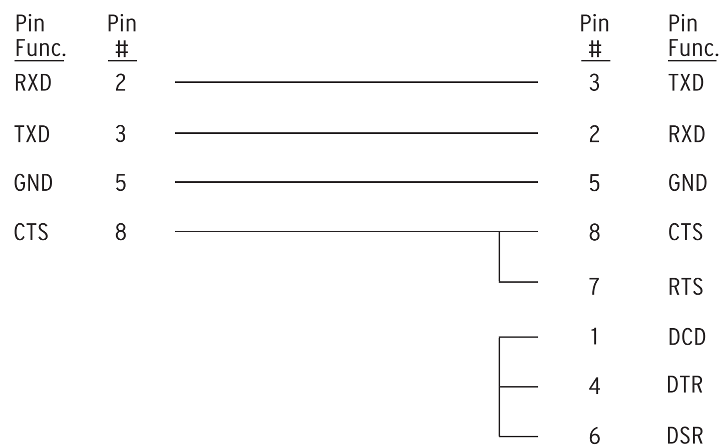
The SEL-421 Relay has three rear-panel EIA-232 serial communications ports labeled PORT 1, PORT 2, and PORT 3 and one front-panel port, PORT F. For information on serial communications, see *Establishing Communication on page U.4.5 in the User's Guide*, *Serial Communication on page R.4.3 in the Reference Manual*, and *Serial Port Hardware Protocol on page R.5.2 in the Reference Manual*.

In addition, the rear panel features a PORT 5 for an optional communications card. For additional information about communications topologies and standard protocols that are available in the SEL-421 Relay, see *Section 6: SEL-2030 Applications in the Applications Handbook*, *Section 7: Direct Network Communication in the Application Handbook*, the *Section 6: DNP 3.0 Communications in the Reference Manual*, and the *Section 7: UCA2 Communications in the Reference Manual*.

Serial Ports

The SEL-421 Relay serial communications ports use EIA-232 standard signal levels in a D-subminiature 9-pin connector. To establish communication between the relay and a DTE device (a computer terminal, for example) with a D-subminiature 9-pin connector, use an SEL Cable C234A. See *Section 4: Basic Relay Operations in the User's Guide*.

Figure 2.30 shows the configuration of SEL Cable C234A that you can use for basic ASCII and binary communication with the relay. A properly configured ASCII terminal, terminal emulation program, or the ACSELERATOR software along with the C234A cable provide communication with the relay in most cases. See *Section 4: Communications Interfaces in the Reference Manual* for a list of hardware interfaces to the SEL-421 Relay.



*DTE = Data Terminal Equipment (Computer, Terminal, etc.)

Figure 2.30 SEL-421 Relay to Computer—D-Subminiature 9-Pin Connector.

Serial Cables

CAUTION: Severe power and ground problems can occur on the communications ports of this equipment as a result of using non-SEL cables. Never use Standard null-modem cables with this equipment.

Using an improper cable can cause numerous problems or failure to operate, so you must be sure to specify the proper cable for application of your SEL-421 Relay. Several standard SEL communications cables are available for use with the relay. See *EIA-232 Communications Cables on page R.4.4 in the Reference Manual* for information on recommended serial cables.

The following list provides additional rules and practices you should follow for successful communication using EIA-232 serial communications devices and cables:

➤ Route communications cables well away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in the communications circuits if power and control circuits are not adequately separated from communications cables.

- You should keep the length of the communications cables as short as possible to minimize communications circuit interference and also to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions.
- EIA-232 communications cable lengths should never exceed 50 feet, and you should always use shielded cables for communications circuit lengths greater than 10 feet.
- Modems provide communication over long distances and give isolation from ground potential differences that are present between device locations. (Examples are the SEL-28XX-series transceivers.)
- Lower data speed communication is less susceptible to interference and will transmit greater distances over the same medium than higher data speeds. You should use the lowest data speed that provides an adequate data transfer rate.

AC/DC Connection Diagrams

You can apply the SEL-421 Relay in many power system protection schemes. *Figure 2.31 on page 2.48* shows one particular application scheme with connections that represent typical interfaces to the relay for a single circuit breaker connection. *Figure 2.32 on page 2.49* depicts typical connections for a dual circuit breaker protection scheme.

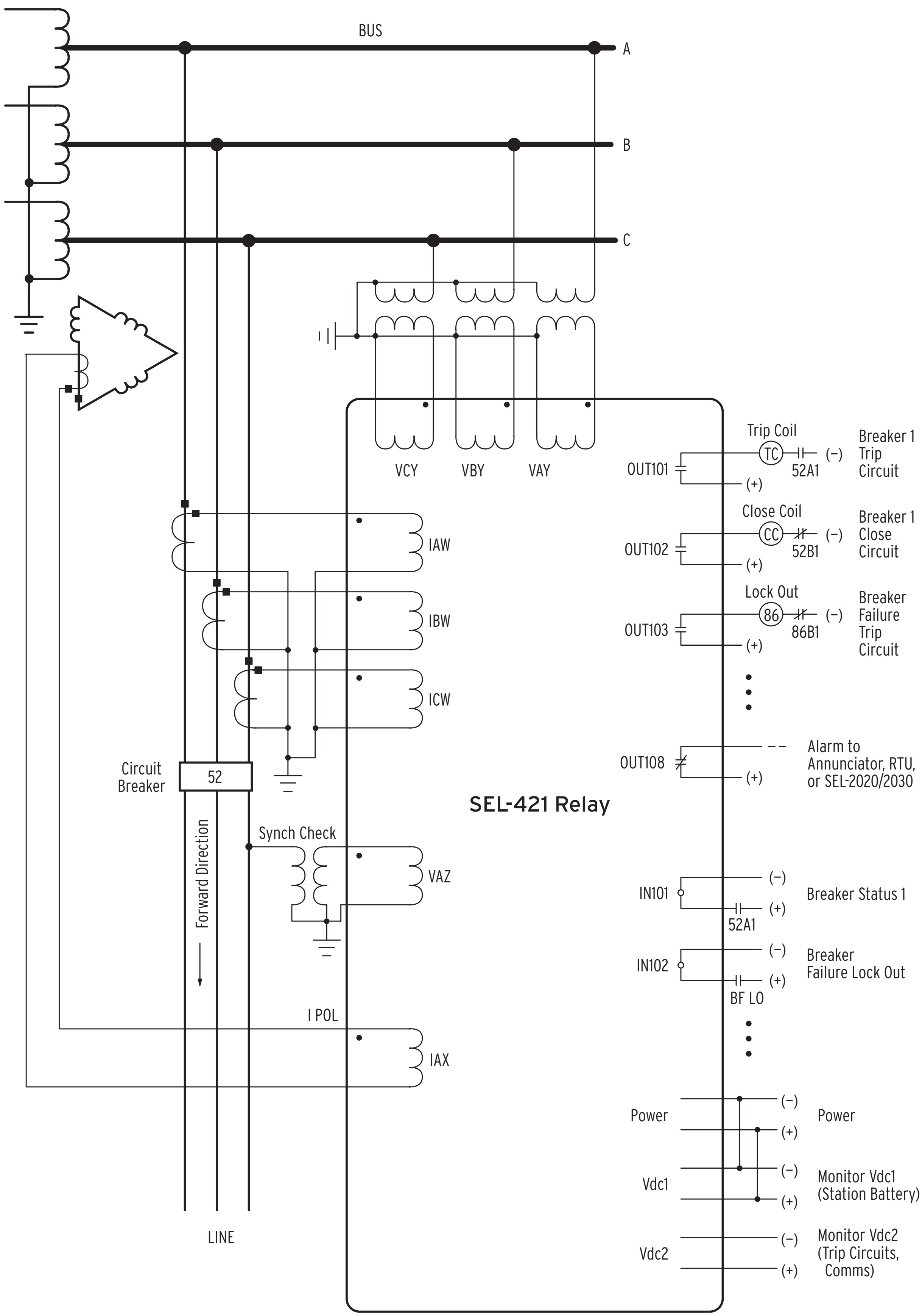


Figure 2.31 Typical External AC/DC Connections—Single Circuit Breaker.

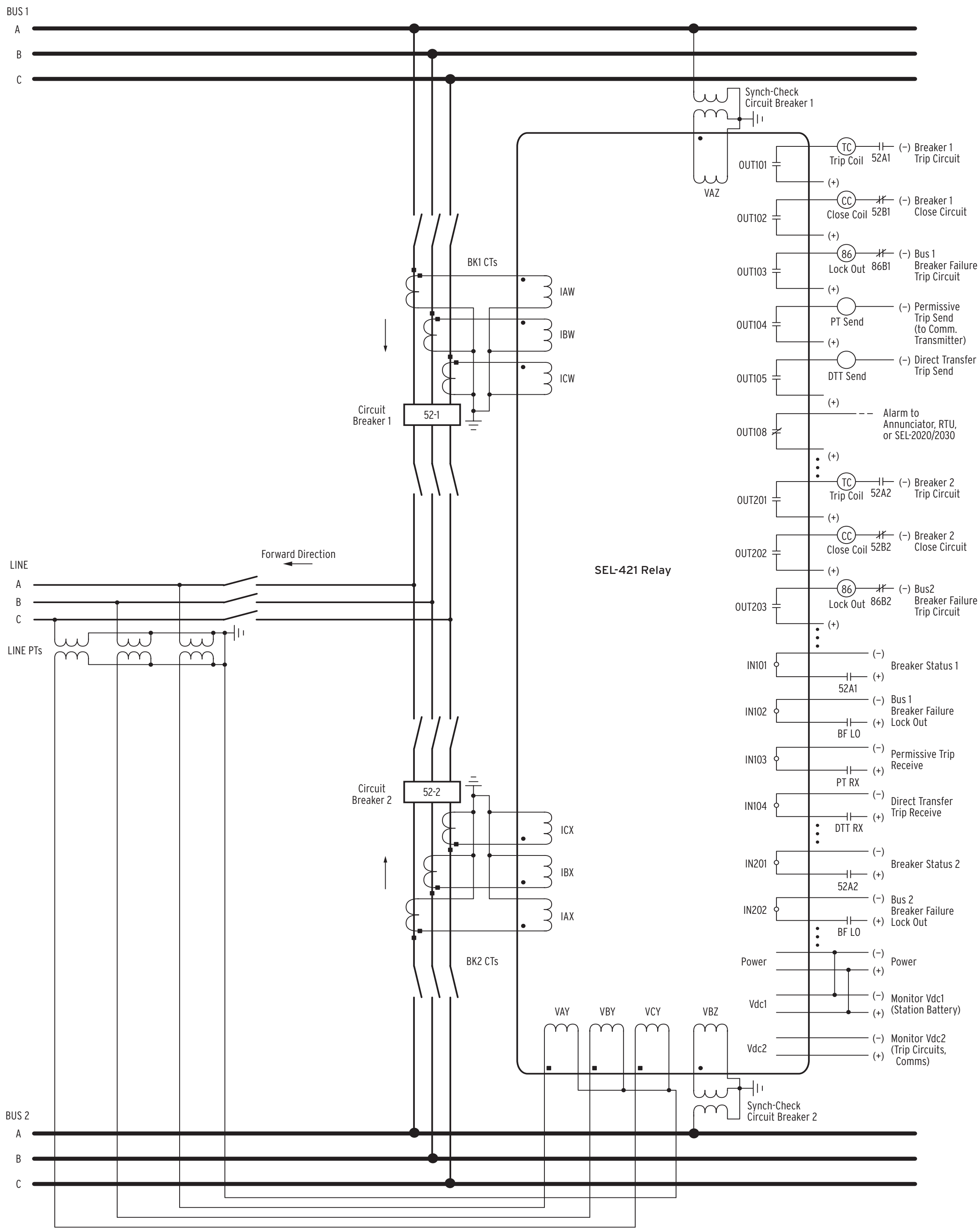


Figure 2.32 Typical External AC/DC Connections—Dual Circuit Breaker.

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Section 3
PC Software

The SEL-421 Relay includes a powerful relay settings, analysis, and measurement tool to aid you in applying and using the relay; this tool is the SEL-5030 ACSELERATOR® Software Program. The ACSELERATOR software reduces engineering costs for relay settings, logic programming, and system analysis. The ACSELERATOR software makes it easier for you to do the following:

- Create and manage relay settings
  - Create settings for one or more SEL-421 Relays
  - Store and retrieve settings with an IBM-compatible PC (personal computer)
  - Upload and download relay settings files to and from SEL-421 Relays
- Analyze events
  - Use the integrated waveform and harmonic analysis tools
- Monitor real-time and relay-stored power system data
  - Use the HMI (human machine interface) to view metering, Relay Word bits, and circuit breaker monitor data
- Control the relay
  - Command relay operation through use of a GUI (graphical user interface) environment
  - Execute relay serial port commands in terminal mode
- Configure the serial port and passwords

SEL provides the ACSELERATOR software for easier, more efficient configuration of relay settings, metering, and control. However, you do not have to use the ACSELERATOR software to configure the SEL-421 Relay; you can continue to use an ASCII terminal or a computer running terminal emulation software to access all relay settings and metering. The ACSELERATOR software gives you the advantages of rules-based settings checks, SELOGIC® control equation Expression Builder, operator control and metering HMI, and event analysis.

Installing the Computer Software

Load the ACSELERATOR software on an IBM-compatible PC. If you encounter any difficulties installing the ACSELERATOR software, contact your Technical Service Center or the SEL factory for assistance. See *Factory Assistance on page U.6.43 in the User's Guide* for contact information.

System Requirements

To successfully install and use the ACSELERATOR software, your computer must have the minimum resources listed in *Table 3.1*.

Table 3.1 System Requirements for ACSELERATOR Software

Item	Description
Processor	Pentium® class, ≥ 90 MHz
Operating System / RAM	Microsoft® Windows® 95/98/ME–64 MB RAM Microsoft Windows 2000–64 MB RAM Microsoft Windows NT®–32 MB RAM (64 MB recommended)
Hard drive	At least 25 MB available storage space
Communications Port	One EIA-232 serial port or one Ethernet port (SEL-2701 Ethernet Processor installed in the relay)
Drives	CD-ROM for software installation
Monitor	SVGA 800 x 600 pixel resolution or greater (1024 x 768 pixel resolution recommended)
Pointing Device	Mouse or other pointing device

Installation

You can load the ACSELERATOR software automatically if your computer autorun feature is enabled; this is Method A. If autorun is not enabled on your computer, use the Windows Run command to load the ACSELERATOR software; this is Method B.

Perform the following steps to install the ACSELERATOR software:

Step 1. Load the ACSELERATOR software using one of the following methods:

- ➢ Method A. Load the ACSELERATOR software automatically. To load the software automatically, turn on your PC and run the Windows operating environment. Close all other applications on your PC. Place the ACSELERATOR CD-ROM in the PC CD-ROM drive. The setup software should run automatically and the SEL Software License Agreement will appear as in *Figure 3.1*.

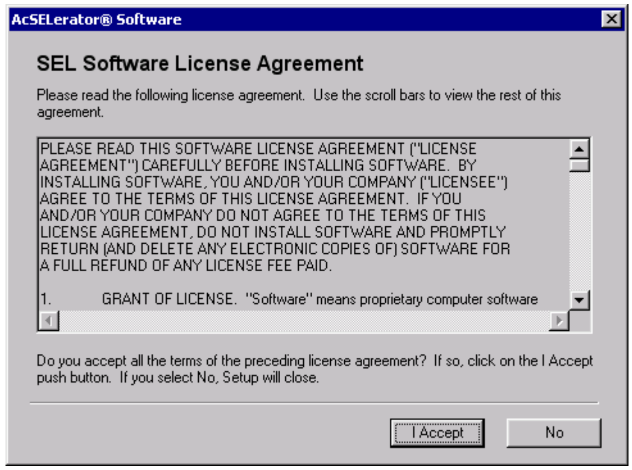

Figure 3.1 SEL Software License Agreement.

➢ Method B. Use the Windows Run command to load the ACSELERATOR software. If the Setup program does not start automatically, use the Microsoft Windows Run function (in the Start menu) to load the ACSELERATOR software. Type the command shown in *Figure 3.2*, being certain to use the correct drive letter for the CD-ROM drive in your PC (the CD-ROM drive in the *Figure 3.2* example is drive D). You should see the SEL Software License Agreement (*Figure 3.1*).

Figure 3.2 Windows Run Command Line to Load the ACSELERATOR Software.

Step 2. Complete the software loading process. Read the Software License Agreement and follow the loading instructions as these instructions appear on the PC screen.

Starting the ACSELERATOR Software

You can use the Windows Start menu to open the ACSELERATOR software. If you installed the ACSELERATOR software to the Program Manager group, click the Start button and point to Programs. Point to SEL Applications and click ACSELERATOR. If you used a custom program group, click the Start button and click ACSELERATOR in the custom group.

You can also create a shortcut on the Windows Desktop. See your Windows documentation for instructions on creating a shortcut. Double-click the shortcut icon to start the ACSELERATOR software from the shortcut.

Communications Setup

The ACSELERATOR software uses the relay communications ports to communicate with the SEL-421 Relay. Configure the ACSELERATOR Communication menu Parameters settings to communicate effectively with the relay. You can also use a basic terminal emulation any time you run the ACSELERATOR software. Use the Communication menu to view and clear a Connection Log. For a step-by-step procedure using the ACSELERATOR software to communicate with the relay, see *Checking Relay Status: ACSELERATOR Software on page U.4.12 in the User's Guide*.

Communication Parameters

Use the Communication Parameters dialog box to configure relay communications settings. Select the Communication menu on the top ACSELERATOR toolbar and click Parameters to open this dialog box. *Figure 3.3* shows the ACSELERATOR Communication Parameters dialog box.

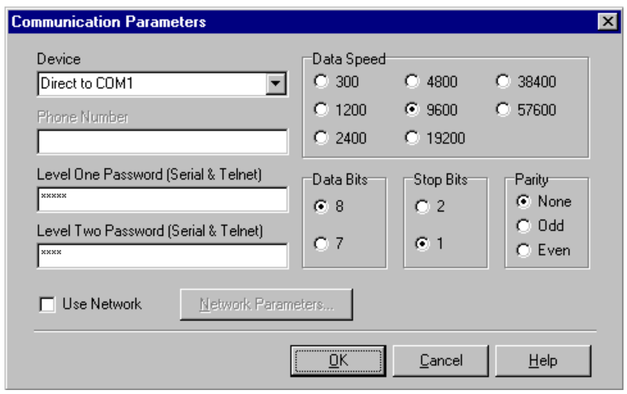

Figure 3.3 ACSELERATOR Communication Parameters Dialog Box.

Serial Setup

You can use serial communication via relay Ports 1, 2, 3, and F (front panel). *Figure 3.3* shows the default serial port parameters (9600, 8, N, 1). Enter your relay Access Level One and Access Level Two passwords in the respective text boxes. (For complete information on passwords, see *Changing the Default Passwords: Terminal on page U.4.10 in the User's Guide*.) If you choose a device from the Device text box that is a telephone modem, enter the dial-up telephone number in the Phone Number text box.

FTP Setup

Click the Use Network check box to access the Network Parameters. *Figure 3.4* shows the Network Parameters dialog box. For FTP (File Transfer Protocol) use Telnet Port number 23.

When you connect to a relay to use FTP, you must specify the access level and password. Provide the access level command (ACC, 2AC, for example) in the User ID text box and the corresponding access level password in the Password text box to control the relay at a specific access level. See *Changing the Default Passwords: Terminal on page U.4.10 in the User's Guide*.

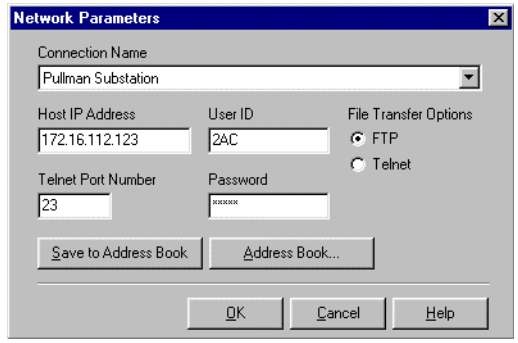

Figure 3.4 ACSELERATOR Network Parameters Dialog Box: FTP.

Telnet Setup

Click the Telnet option button in the Network Parameters dialog box (see *Figure 3.5*) to connect to a relay for a Telnet session. The Telnet session uses the relay passwords on the Communication Parameters dialog box (*Figure 3.3*). The default Telnet Port Number for accessing the relay is T1PNUM := 23. The default Telnet Port Number for communicating directly with the SEL-2701 Ethernet Processor is T2PNUM := 1024. See *Section 7: Direct Network Communication in the Application Handbook* for information on changing the Telnet Port Number.

Figure 3.5 ACSELERATOR Network Parameters Dialog Box: Telnet.

Terminal Mode

The terminal window is an ASCII interface between you and the relay. This is a basic terminal emulation with no file transfer capabilities. Many third-party terminal emulation programs are available with file transfer encoding schemes.

Click the Communication menu and then click Terminal to start the terminal window. Another convenient method to start the terminal is to type **<Ctrl+T>**.

Terminal Logging

When you check the Terminal Logging item in the Communication menu, the ACSELERATOR software records communications events and errors in a log. Click Communication > Connection Log to view the log. Clear the log by selecting Communication > Clear Connection Log.

Settings Database Management and Drivers

Database Manager

The ACSELERATOR software uses a relay database to save relay settings. The ACSELERATOR software contains sets of all settings files for each relay that you specify in the Database Manager. See *Virtual File Interface on page R.5.14 in the Reference Manual* for a list of the settings file in the SEL-421 Relay. Choose appropriate storage backup methods and a secure location for storing your relay database files. Use the File > Active Database menu to retrieve a relay database from computer memory.

Relay Database

The default relay database file already configured in the ACSELERATOR software is Relay.rdb. This database contains example settings files for the SEL products with which you can use the ACSELERATOR software. Open the Database Manager to access the database. Click on File in the ACSELERATOR top toolbar, then select and click the Database Manager menu item. You will see the dialog box similar to *Figure 3.6*. You can enter descriptions for the database and for each relay in the database in the Database Description and Relay Description dialog boxes. Type in the Relay Description dialog box special operating characteristics that describe the relay settings. These can include the protection scheme settings and communications settings.

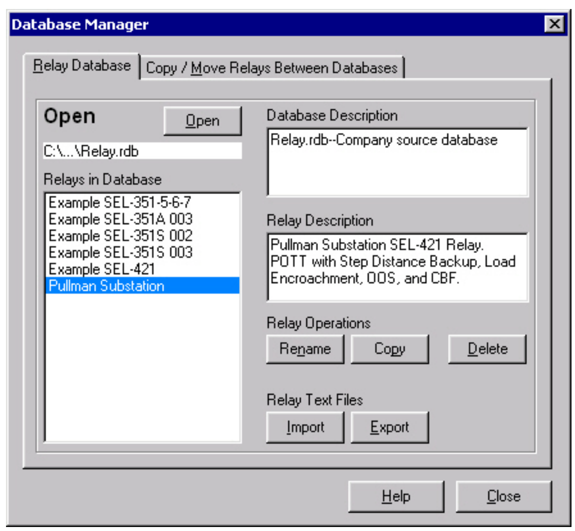

Figure 3.6 Database Manager Relay Database in the ACSELERATOR Software.

Highlight one of the relays listed in Relays in Database and select the Copy option button to create a new collection of relay settings. The ACSELERATOR software prompts you to provide a new name. Be sure to enter a new description in Relay Description.

Copy/Move Relays Between Databases

You can create multiple relay databases with the Database Manager; these databases are useful for grouping similar protection schemes or geographic areas. Select the Copy/Move Relays Between Databases tab to access the dialog box shown in *Figure 3.7*. Click the Open B option button to open a relay database. Type a filename and click open; for example, Relay2.rdb is the B relay database in *Figure 3.7*.

Highlight a relay in the A database, select Copy or Move, and click the > button to create a new relay in the B database. Reverse this process to take relays from the B database to the A database. Copy creates an identical relay that appears in both databases. Move removes the relay from one database and places the relay in another database.

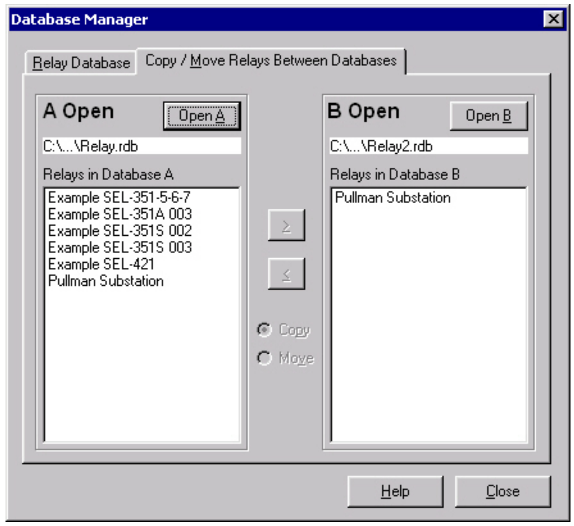

Figure 3.7 Database Manager Copy/Move in the ACSELERATOR Software.

Create a New Database

To create and copy an existing database of relays to a new database, select the File > Database Manager menu and select the Copy / Move Relays Between Databases Tab on the Database Manager dialog box. The ACSELERATOR software opens the last active database and assigns it as Database A (see *Figure 3.7*).

Click on the Open B button; the ACSELERATOR software prompts you for a file location. Type a new database name, click on the Open button, and answer Yes; the program creates a new empty database. Load relays into the new database as in Copy/Move Relays Between Databases.

Drivers

Relay settings folders in the ACSELERATOR software are closely associated with the ACSELERATOR software relay driver that you used to create the settings. The relay settings and the ACSELERATOR software drivers must match.

Use the **STATUS** command to query the relay for the FID (firmware identification number) to determine the active ACSELERATOR drivers. Click the Status button in the HMI tree view to see the relay FID information. See *Checking Relay Status on page U.4.12 in the User's Guide* for information on viewing relay status. At a terminal (**<Ctrl+T>** from the ACSELERATOR software), you can type **ID<Enter>** to view the FID.

Use the "Z-number" to determine the proper ACSELERATOR software relay settings driver version when creating or editing relay settings files. View the ACSELERATOR software settings driver information at the bottom of the Relay Editor window (see *Figure 3.14 on page 3.11*). The first portion of the Z-number is the ACSELERATOR software settings driver version number (see *Figure 3.8*). Compare the ACSELERATOR driver number and the relay FID number. This ACSELERATOR software driver Z-number and the corresponding part of the relay FID must match.

Relay Settings Version Number

FID = SEL-421-R101-V0-Z001001-D20010315

HMI Version Number

Figure 3.8 ACSELERATOR Software Driver Information in the FID String.

The ACSELERATOR software reads the latter portion of the Z-number (ZXXX001, for example) to determine the correct HMI to display when you select the HMI > Meter and Control menu. View the bottom of the HMI window to check the HMI driver number (see *Figure 3.9*).

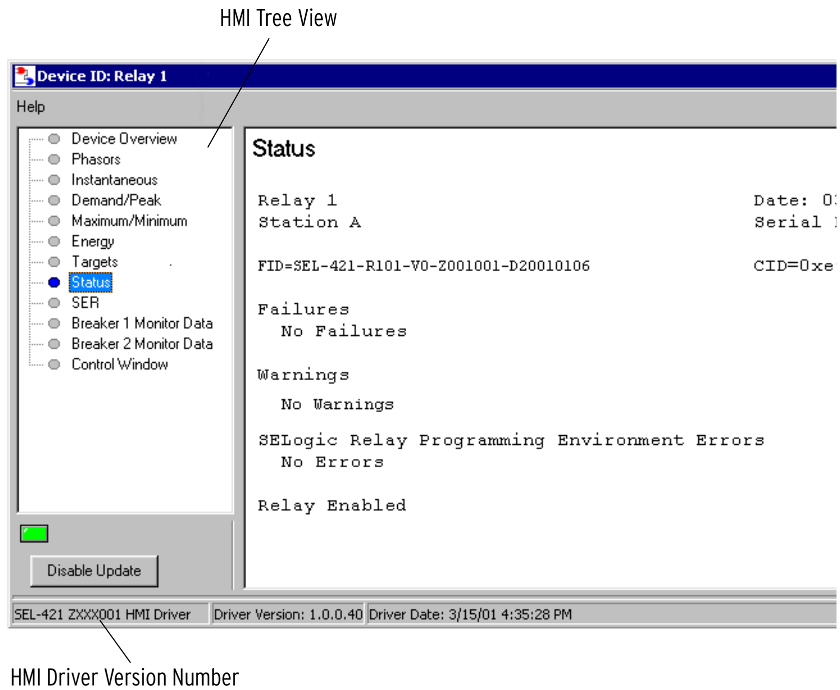

Figure 3.9 HMI Driver Version Number in the HMI Window.

As SEL develops new drivers, you can update your existing ACSELERATOR software with specific relay drivers for each SEL product that uses the ACSELERATOR software. Contact your local Technical Service Center or the SEL factory for the latest ACSELERATOR software drivers.

Create and Manage Relay Settings

The ACSELERATOR software gives you the ability to create settings for one or more SEL-421 Relays. You can store existing relay settings downloaded from SEL-421 Relays with the ACSELERATOR software, creating a library of relay settings (see *Database Manager on page 3.6*). You can then modify and upload these settings from your settings library to an SEL-421 Relay.

The ACSELERATOR software makes setting the relay easy and efficient. For an example of setting the SEL-421 Relay with the ACSELERATOR software, see *Making Initial Global Settings: ACSELERATOR Software on page U.4.25 in the User's Guide*.

Collected Settings

The ACSELERATOR software arranges relay settings in easy-to-understand categories (for an explanation of settings organization, see *Making Simple Settings Changes on page U.4.15 in the User's Guide*). These categories of collected settings help you quickly set the relay. *Figure 3.10* is an example of relay settings categories in the Relay Editor Settings tree view. (Use the procedures described in Settings Menu to view the tree views in *Figure 3.10*.)

The ACSELERATOR software shows all of the settings categories in the settings tree view. When you enable and disable settings categories, the tree view remains constant, but when you click on the tree view to access the settings in a disabled category, the disabled settings are dimmed. For example, select the Group 1 > Set 1 > Relay Configuration branch of the Settings tree view and choose N for E50Q. Click on the Negative-Sequence O/C branch and observe that the Negative-Sequence Overcurrent Elements settings are dim. If you select 1 for E50Q, then only the level 1 overcurrent element settings are active and the remainder of the Negative-Sequence Overcurrent Element settings are dim. *Figure 3.10* illustrates this feature of the ACSELERATOR software.

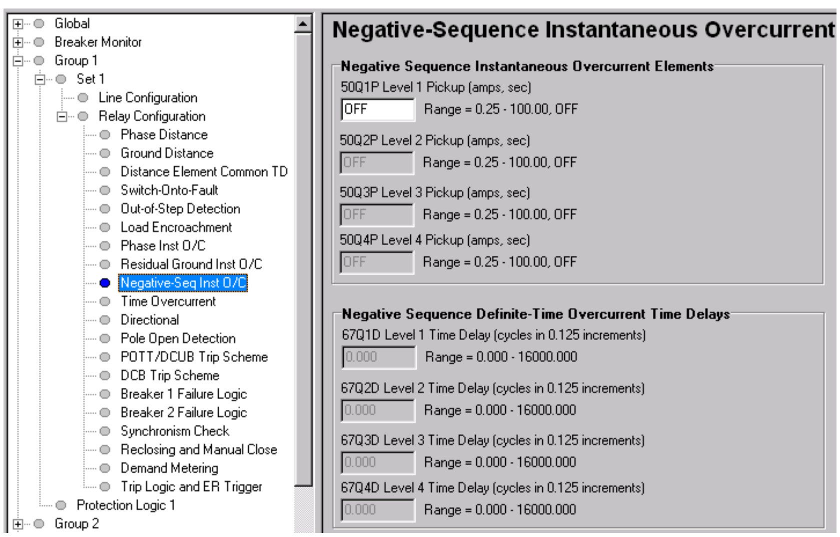

Figure 3.10 Sample Settings in the ACSELERATOR Software.

Settings Menu

The Settings menu on the top ACSELERATOR toolbar is the starting point for all settings entries. The menu items in the Settings menu are New, Open, and Read. All of these menu items open the Relay Editor (see *Relay Editor on page 3.11*).

New

Selecting the New menu item creates new relay settings files. The ACSELERATOR software makes the new settings files from the relay drivers that you specify in the Relay Editor Selection dialog box (see *Figure 3.11*). The ACSELERATOR software uses the Z-number in the relay FID string to create a particular version of relay settings (see *Drivers on page 3.7*).

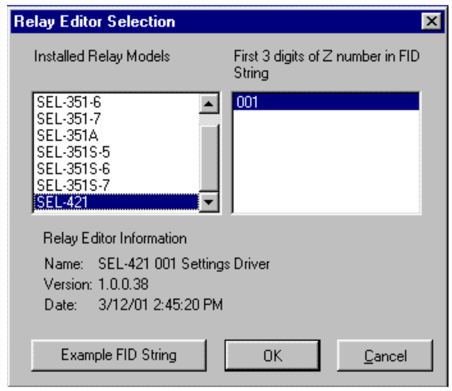

Figure 3.11 Selecting a Settings Driver in the ACSELERATOR Software.

After selecting the relay model and settings driver, the ACSELERATOR software presents the Relay Part Number dialog box. Use this dialog box to configure the Relay Editor to produce settings for a relay with options determined by the part number. See *Relay Part Number on page 3.11*.

Open

The Open menu item opens an existing relay from the active database folder (see *Figure 3.12*). The ACSELERATOR software prompts you for a folder containing relay settings to load into the Relay Editor.

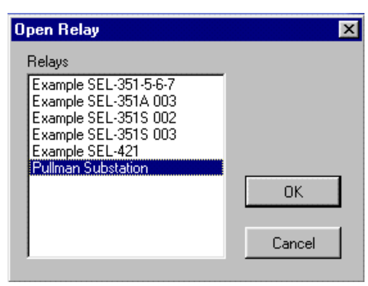

Figure 3.12 Opening Relay Settings in the ACSELERATOR Software.

Read

When you select the Read menu item, the ACSELERATOR software reads the relay settings from a connected relay. As the ACSELERATOR software reads the relay, you will see a dialog box similar to *Figure 3.13*. The ACSELERATOR software uses serial protocols at a serial port or FTP from an Ethernet port to read settings from SEL devices.

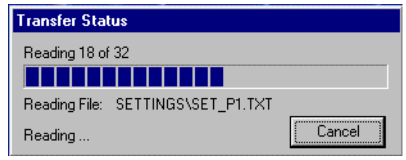

Figure 3.13 Reading Relay Settings in the ACSELERATOR Software.

Relay Editor

Use the Relay Editor to enter relay settings. *Figure 3.14* illustrates the important features of the editor. These features include the ACSELERATOR software settings driver version number (the first three digits of the Z-number) in the lower left corner of the Relay Editor.

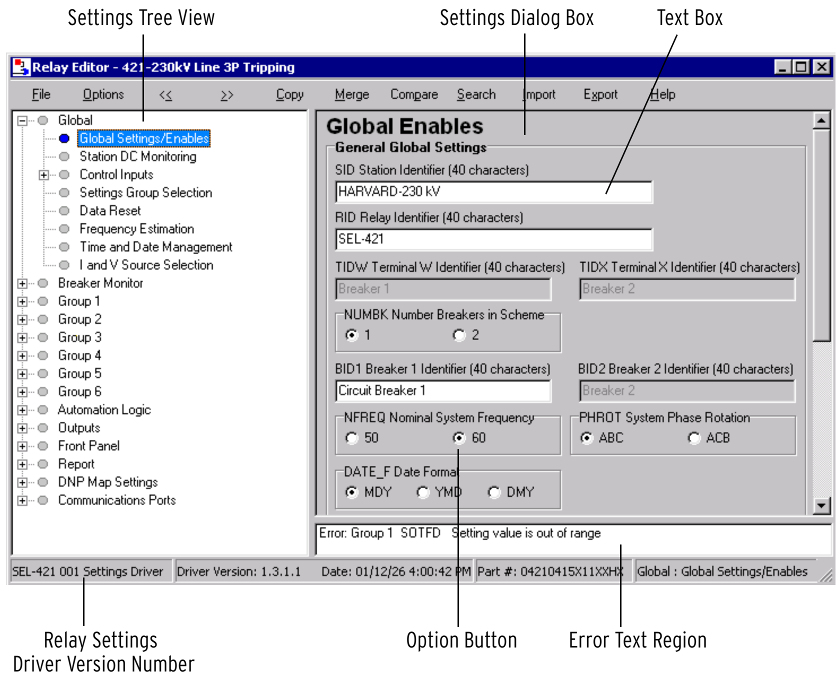

Figure 3.14 ACSELERATOR Software Relay Editor.

Entering Settings

Click the + marks and the buttons in the Settings Tree View to expand and select the settings class, instance, and category that you want to change. Use Tab or click in a dialog box to edit a setting. The right-click mouse button performs two special functions when you are editing settings: Previous Value and Default Value. To restore the previous value for a setting, right click the mouse over the setting and select Previous Value. Right click in the setting dialog box and select Default Value if you want to restore the factory default setting value.

If you enter a setting that is out of range or has an error, the ACSELERATOR software shows the error at the bottom of the Relay Editor. Double-click on the error listing to go to the setting to enter a valid input.

Relay Part Number

The relay part number determines the settings that the ACSELERATOR software displays and the functions that the software controls. When configuring the ACSELERATOR software to control a particular relay, you should confirm that the ACSELERATOR software part number matches the relay part number so that you can access all of the settings you need for your relay.

Configuring the Part Number

Select the Settings Menu on the ACSELERATOR top toolbar and click New, Open, or Read to start the Relay Editor; see *Settings Menu on page 3.9*. Once in the Relay Editor, click the Options menu on the Relay Editor toolbar (see *Figure 3.15*). Point to Part Number and click this option.

Figure 3.15 Retrieving the Relay Part Number.

You will see the Relay Part Number dialog box, as shown in *Figure 3.16*. Use the arrows inside the text boxes to match corresponding portions of the Relay Part Number dialog box to your relay.

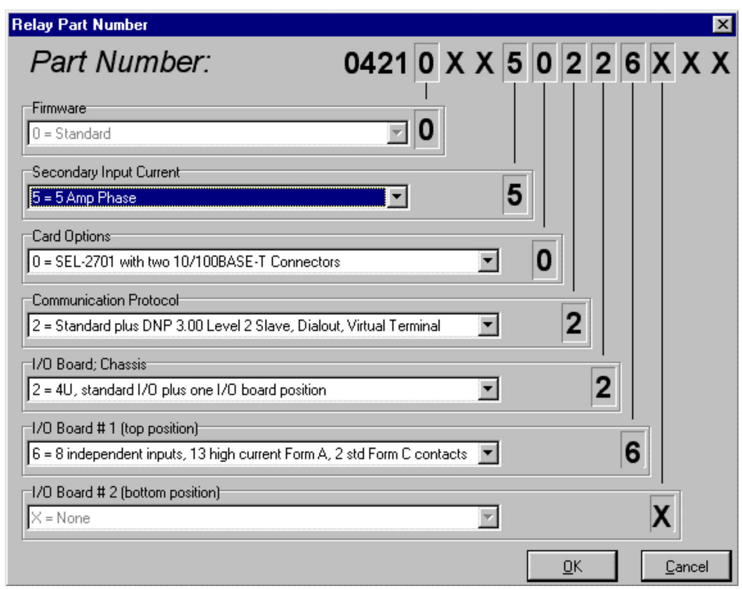

Figure 3.16 Setting the Relay Part Number in the ACSELERATOR Software.

Expression Builder

SELOGIC control equations are a powerful means for customizing relay performance. Creating these equations can be difficult, because of the large number of relay elements (Relay Word bits) and analog quantities in the relay. The ACSELERATOR software simplifies this process with the Expression Builder, a rules-based editor for programming SELOGIC control equations. The Expression Builder organizes relay elements, analog quantities, and SELOGIC control equation variables and focuses your equation decision-making. The Expression Builder checks basic rules and flags mistakes in SELOGIC control equation settings.

Access the Expression Builder

Settings dialog boxes in the Relay Editor window show an "EB" option button (see *Figure 3.17*). Click the EB option button to use the Expression Builder.

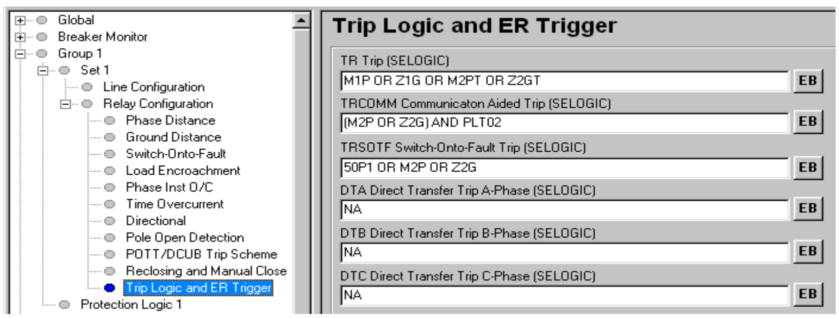

Figure 3.17 Location of EB Option Button.

Expression Builder Organization

The Expression Builder dialog box is organized into two main parts representing the left side (LVALUE) and right side (RVALUE) of the SELOGIC control equation. (The LVALUE is fixed for all settings except Protection Free-Form SELOGIC and Automation Free Form SELOGIC settings; see *Fixed SELOGIC Control Equations on page R.3.5 in the Reference Manual*.) *Figure 3.18* shows the two sides of the Expression Builder, with the SELOGIC control equation that you are constructing at the top of the dialog box. Note the dark vertical line and the equals sign (:=) separating the equation left and right sides.

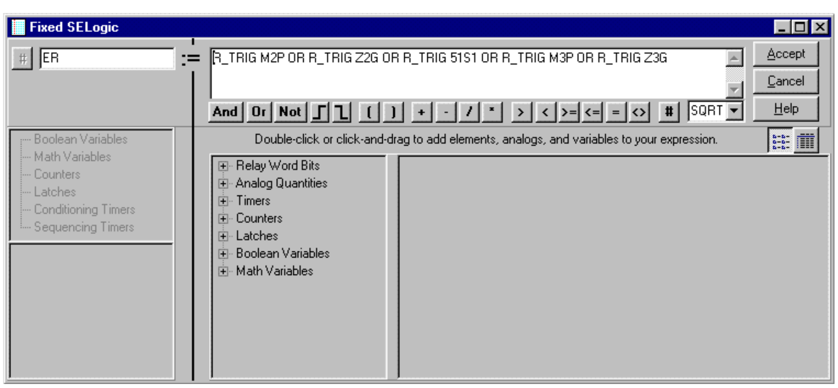

Figure 3.18 The ACSELERATOR Expression Builder.

Using the Expression Builder

For Protection Free-Form SELOGIC and Automation Free Form SELOGIC, select the type of result (LVALUE) for the SELOGIC control equation to use the Expression Builder. The ACSELERATOR software shows these possibilities in the file box directly underneath the left side of the equation. The program shows the relay elements for each type of SELOGIC control equation (Boolean Variables, Math Variables, etc.).

On the right side of the equation (RVALUE), you can select broad categories of relay elements, analog quantities, counters, timers, latches, Boolean variables, and math variables. Select a category in the RVALUE tree view, and the Expression Builder displays all elements for that category in the list box at the bottom right side.

Directly underneath the right side of the equation, you can choose operations to include in the RVALUE. These operations include basic logic functions, rising and falling edge triggers, expression compares, and math functions.

For more information on programming SELOGIC control equations, see *Section 3: SELOGIC® Control Equation Programming in the Reference Manual*.

Analyze Events

The ACSELERATOR software has integrated analysis tools that help you retrieve information about protection system operations quickly and easily. Use the protection system event information that the SEL-421 Relay stores to evaluate the performance of a protection system.

Event Waveforms

The SEL-421 Relay records power system events for all trip situations and for other operating conditions that you program with SELOGIC control equations (see *SELOGIC Control Equation ER on page A.3.4 in the Applications Handbook*). The relay provides two types of event data captures: high-resolution oscillography that uses raw sample per second data and event report oscillography that uses filtered sample per cycle data. See *Triggering Data Captures and Event Reports on page A.3.4 in the Applications Handbook* and *Generating an Event on page U.4.39 in the User's Guide* for information on recording events. Use the ACSELERATOR software to view high resolution and event report oscillograms, phasor diagrams, harmonic analyses, and settings.

Read History

You can retrieve event files stored in the relay and transfer these files to your computer. For information on the types of event files and data capture, see *Triggering Data Captures and Event Reports on page A.3.4 in the Applications Handbook*.

To download event files from the relay, open the ACSELERATOR software Analysis menu at the top ACSELERATOR toolbar and click Read History. The Relay Event History dialog box will appear (*Figure 3.19* is similar).

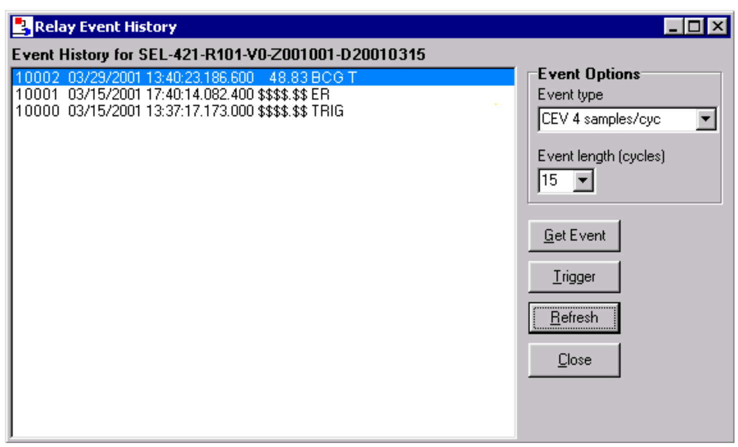

Figure 3.19 Retrieving Relay Event History.

Get Event

Highlight the event you want to view and click the Get Event button. The Event Type dialog box lists high resolution data files as Binary COMTRADE, and event report files (from Compressed ASCII format) as CEV 4 samples/cyc or CEV 8 samples/cyc. When downloading is complete, the ACSELERATOR software prompts whether you want to save the file on your computer. (You can save the file for later analysis.) The ACSELERATOR software displays the Event Waveform dialog box and the event oscillogram (see *Figure 3.20* and *Figure 3.21*).

When viewing the event oscillogram, use keyboard function keys to measure the time of oscillogram occurrences. These function keys and related functions help in event analysis

<F2>: go to trigger

<F3>: Cursor 1

<F4>: Cursor 2

The display shows the time difference between the **<F3>** and **<F4>** cursors.

You can see high-accuracy time-stamp information on the event oscillogram. Click the Pref button at the bottom of the oscillogram and select Time (under Time Units, Starting/Ending Row); click OK. Click on any point in a graph to observe the Event Time in microseconds of that data point at the bottom of the oscillogram.

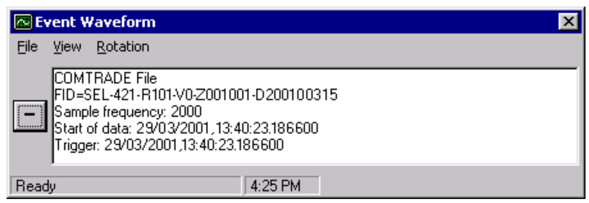

Figure 3.20 ACSELERATOR Event Waveform Window.

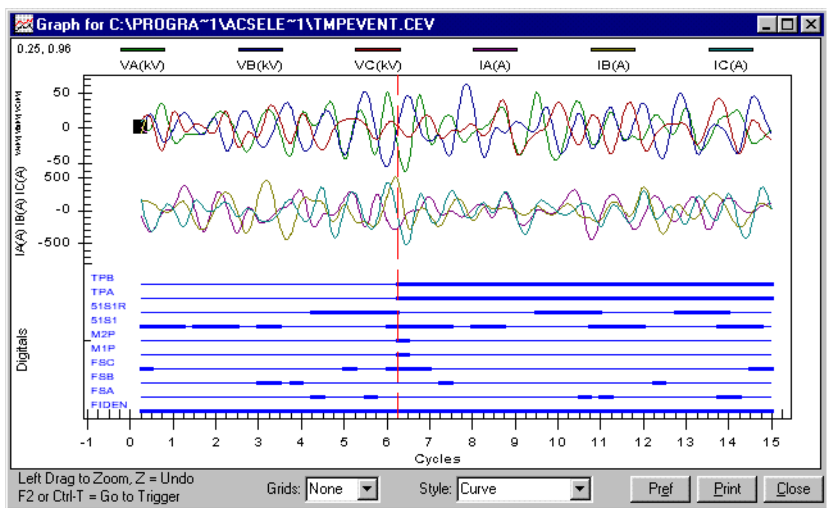

Figure 3.21 Sample Event Oscillogram.

You can also view other event displays. From the Event Waveform dialog box, select the View menu and click Phasors, as shown in *Figure 3.22*, to view a sample-by-sample phasor display. You should see a phasor display similar to *Figure 3.23*.

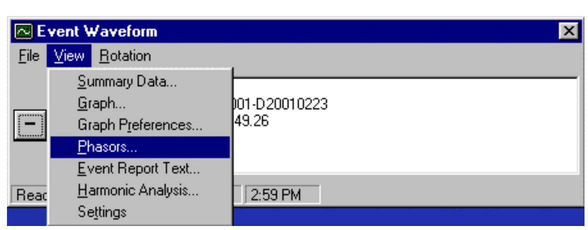

Figure 3.22 Retrieving Event Report Waveforms.

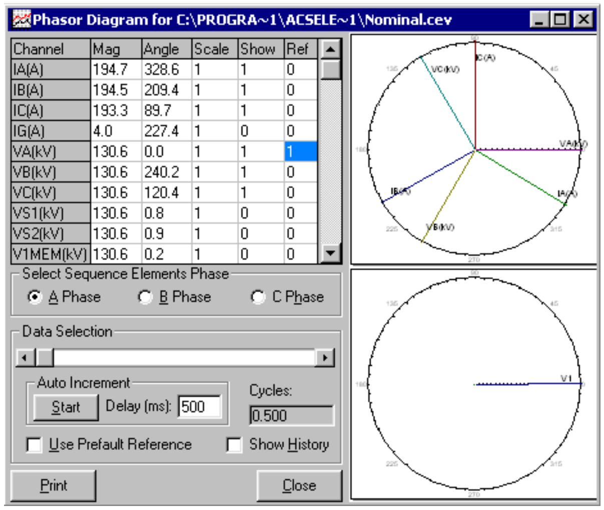

Figure 3.23 Sample Phasors Event Waveform Screen.

The ACSELERATOR software also presents a harmonic analysis of power system data for raw data binary COMTRADE event captures. From the Event Waveform View menu, click Harmonic Analysis. You will see a window similar to *Figure 3.24*. On the left side of the Harmonic Analysis screen, choose the relay voltage and current channels to monitor for harmonic content. You can view both a spectral analysis plot and a harmonic analysis bar chart. Click the arrows of the Data Scroll box or the # Cycles box to change the data analysis range.

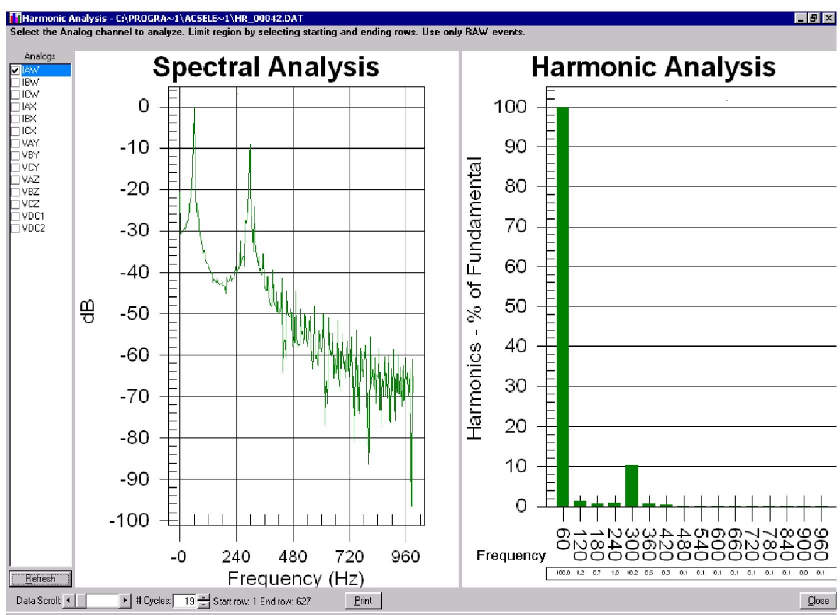

Figure 3.24 Sample Harmonic Analysis Event Waveform Screen.

Click Summary Data on the Event Waveform View menu to see event summary information and to confirm that you are viewing the correct event. *Figure 3.25* shows a sample ACSELERATOR software Event Report Summary screen.

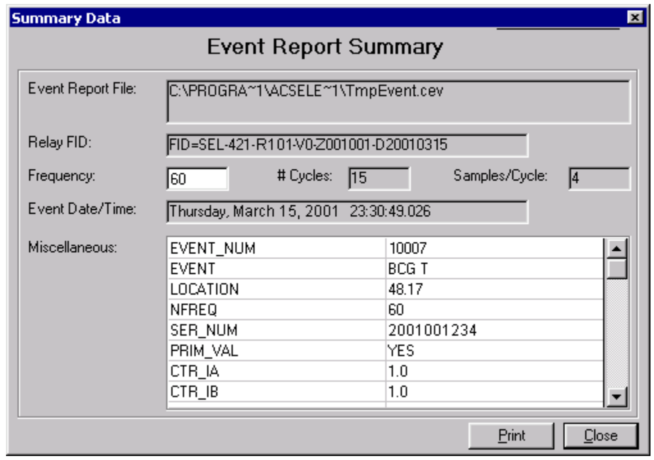

Figure 3.25 Sample Event Report Summary Screen.

Click Settings on the Event Waveform View menu to view the relay settings that were active at the time of the event. *Figure 3.26* shows a sample CEV-type event Settings screen.

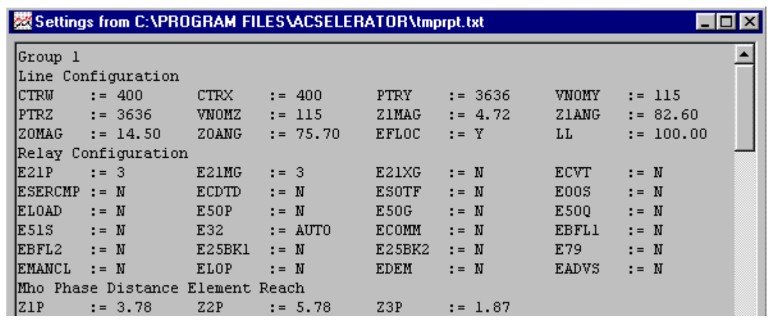

Figure 3.26 Sample Event Waveform Settings Screen.

Open File

Computer-stored data captures are available as COMTRADE files (*.DAT) or compressed event report files (*.CEV). Open the ACSELERATOR software Analysis menu and click Open File to view the waveforms in an event file stored on your computer. You should see the Event Waveform dialog box similar to *Figure 3.20 on page 3.16* and an oscillographic event screen similar to *Figure 3.21 on page 3.16*.

At the Event Waveform dialog box, you can select the Phasors display, the Harmonic Analysis display, the Summary Data display, and the Settings display from the Event Waveform window (see *Read History on page 3.15*).

HMI Meter and Control

Use the ACSELERATOR HMI feature to view real-time relay information in a graphical format. Use the virtual relay front panel to read metering and targets and to operate the relay.

Open the ACSELERATOR HMI

On the HMI menu, click Meter and Control. The ACSELERATOR software opens the HMI window and downloads the interface data. See the detailed examples in *View Metering: ACSELERATOR Software on page U.4.34 in the User's Guide* for step-by-step instructions.

ACSELERATOR HMI Features

You can use the ACSELERATOR software to access many types of relay information and relay controls. Click the HMI menu at the top ACSELERATOR toolbar and then click Meter and Control to access the ACSELERATOR HMI. *Figure 3.27* shows the HMI tree view; *Table 3.2* lists the functions in the HMI tree view and a brief explanation of each function.

In the ACSELERATOR HMI, an LED representation shows that a color is asserted or "on." The flashing LED representation in the lower left of each HMI screen indicates an active data update via the communications channel. Click the button marked "Disable Update" to suspend HMI use of the communications channel.

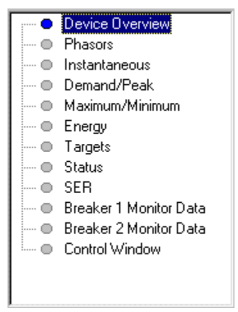

Figure 3.27 ACSELERATOR HMI Features.

Table 3.2 ACSELERATOR HMI Tree View Functions

Function	Description
Device Overview	View general metering, selected targets, control input, control outputs, and the virtual front panel.
Phasors	A graphical and textual representation of phase and sequence voltage and current phasors.
Instantaneous	A table of instantaneous voltages, currents, powers, frequency, and dc monitor voltages.
Demand/Peak	A table showing demand and peak demand values. Reset buttons are in this display.
Max/Min	A table showing maximum/minimum metering quantities. A reset button is in this display.
Energy	A table showing energy import/export. A reset button is in this display.
Targets	View selected Relay Word bits in a row/column format.
Status	A list of relay status conditions.
SER	Sequential Events Recorder data listed oldest to newest, top to bottom. Set the range of SER records with the dialog boxes at the bottom of the display.
Breaker Monitor Data	A table showing the latest circuit breaker monitor data.
Control Window	Metering and records reset buttons, trip and close control, output pulsing, target reset, time and date set, group switch, and remote bit control.

Section 4
Basic Relay Operations

The SEL-421 Relay is a powerful tool for power system protection and control. Understanding basic relay operation principles and methods will help you use the relay effectively. This section presents the fundamental knowledge you need to operate the SEL-421 Relay organized by task. These tasks help you become familiar with the relay and include the following:

- Inspecting a new relay
- Connecting and applying power
- Establishing communication
- Changing the default passwords
- Checking relay status
- Making simple settings changes
- Examining metering quantities
- Reading oscillograms, event reports, and the SER (Sequential Events Recorder)
- Operating the relay inputs and outputs
- Configuring high-accuracy timekeeping
- Readying the relay for field application

Perform these tasks to gain a good understanding of relay operation, be able to confirm that the relay is properly connected, and be more effective when using the relay.

Inspecting a New Relay

CAUTION: Do not connect power to the relay until you have completed these procedures and receive instruction to apply power. Otherwise, equipment damage can result.

The following items are included in your shipment from SEL:

- SEL-421 Relay
- Printed volume of the entire SEL-421 Relay *User's Guide*
- CD-ROM containing the electronic version of the entire SEL-421 Relay Manual and the Customer Label Templates
- CD-ROM containing the SEL-5030 ACSELERATOR® Software Program
- SEL Contact Card
- Configurable Front-Panel Label Kit

If any item is missing or damaged, please contact your distributor or SEL immediately.

Initial Inspection

Remove the protective wrapping from the SEL-421 Relay. Observe the outside of the front cover and the rear panel. Check that no significant scratches or dents are evident on any outer surface. Confirm that all terminal strips on the rear panel are secure.

Cleaning

Use care when cleaning the SEL-421 Relay. Use a mild soap or detergent solution and a damp cloth to clean the relay chassis. Allow the relay to air dry, or wipe dry with a soft dry cloth. Do not use abrasive materials or polishing compounds on any relay surface. Be careful cleaning the front and rear panels because a permanent plastic sheet covers each panel; do not use harsh chemical solvents such as xylene or acetone on these surfaces.

Verify Relay Configuration

When you first inspect the relay, confirm that the relay power supply voltage and nominal ac signal magnitudes are appropriate for your application. Examine the serial number label on the relay rear panel; *Figure 4.1* shows a sample rear-panel serial number label.

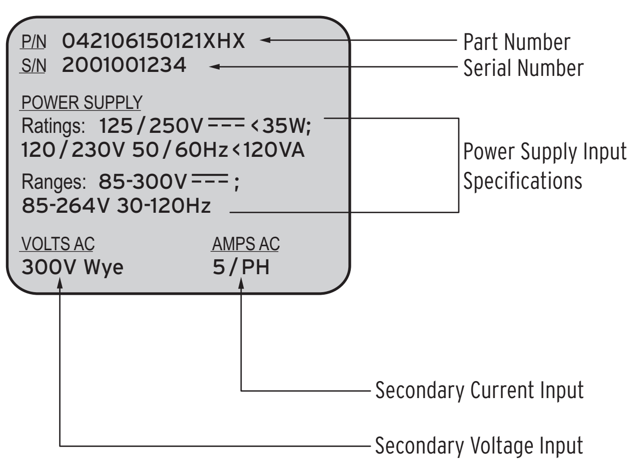

Figure 4.1 SEL-421 Relay Serial Number Label.

Figure 4.1 shows a serial number label for an SEL-421 Relay with standard I/O in a 3U horizontal chassis. This example serial number label is for a 5 A-per-phase secondary current transformer input relay. For information on CT and PT inputs, see *Secondary Circuits on page U.2.5 in the User's Guide*.

The power supply specification in *Figure 4.1* indicates that this relay is equipped with a power supply that accepts a nominal 125/250 Vdc input. This power supply also accepts a 120/230 Vac input. Other power supply options include nominal 24/48 Vdc, and 48/125 Vdc power supplies. The 48/125 Vdc power supply also accepts a 120 Vac input. Refer to the serial number label affixed to the back of your relay to determine the power supply voltage you should apply to the relay power supply input terminals. As this label indicates, the voltage source should be capable of providing at least 35 W for dc inputs and 120 VA for ac inputs. See *Power Supply on page U.1.11 in the User's Guide* for more information on power supply specifications.

The serial number label does not call out power system phase rotation and frequency ratings, because you can use relay settings to configure these parameters. The factory defaults are ABC phase rotation and 60 Hz nominal frequency. See *Making Settings Changes: Initial Global Settings on page 4.19* for details on setting these parameters.

The serial number label does not list a control input (logic input) level because the SEL-421 Relay uses an advanced A/D input converter circuit that accepts inputs over a wide range. For more information on control inputs, see *Control Inputs on page U.2.6 in the User's Guide*.

Connecting and Applying Power

Connect external power to the SEL-421 Relay to perform the initial checkout and familiarization procedures in this section. For complete information on power connections, see *Power Connections on page U.2.38 in the User's Guide*. *Figure 4.2* shows the portion of the relay rear panel where you connect the power input.

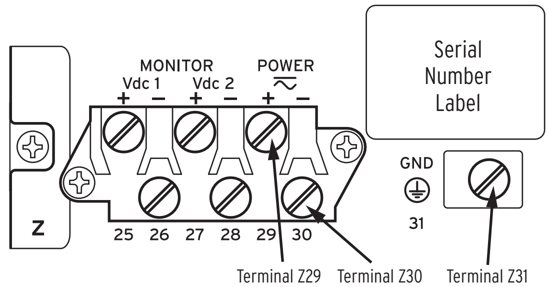

Figure 4.2 Power Connection Area of the Rear Panel.

⚠ **DANGER:** Contact with instrument terminals can cause electrical shock that can result in injury or death.

Always attach a safety ground as the first connection you make to the SEL-421 Relay. You must connect the grounding terminal (#Z31) labeled "GND" on the rear panel to a rack frame ground or main station ground for proper safety and performance.

You can order the SEL-421 Relay with one of three power supplies with nominal operating voltages: 24/48 Vdc, 48/125 Vdc, and 125/250 Vdc. The two higher voltage supplies, 48/125 Vdc and 125/250 Vdc use ac input and dc input. The relay serial number label on the back of the relay lists voltage ranges that encompass the nominal voltages. *Table 4.1* shows the nominal voltage inputs and power supply voltage ranges for dc input, and ac inputs if applicable.

Table 4.1 Power Supply Voltage Inputs

Nominal DC Voltage Input	DC Input Range	AC Input Range (30–120 Hz)
24/48 Vdc	18–60 Vdc <35 W	N/A
48/125 Vdc	38–140 Vdc <35 W	120 Vac <120 VA
125/250 Vdc	85–300 Vdc <35 W	120/230 Vac <120 VA

Use 16 AWG (1.5 mm^2) wire (or heavier) to connect to the POWER terminals. When you use a dc power source, you must connect the source with the proper polarity, as indicated by the + (Terminal #Z29) and – (Terminal #Z30) symbols on the power terminals. You can use ac input for the 48/125 Vdc power supply and the 125/250 Vdc power supply. The relay operates from 30 to 120 Hz (nominal 50/60 Hz) when alternating current supplies the POWER input.

Upon connecting power, you will see information on the front-panel LCD (liquid crystal display) and the ENABLED LED (light-emitting diode) will light. For complete information on the SEL-421 Relay front panel, see *Section 5: Front-Panel Operations in the User's Guide*.

Establishing Communication

Once you have applied the correct power input successfully, you are ready to operate the relay. Use the relay front panel and the communications ports to communicate with the relay.

Front-panel control of relay functions involves use of a menu system that you access through the LCD and the six navigational pushbuttons shown in *Figure 4.3*. For complete instructions on using the front-panel menu system, see *Navigating the Menus on page U.5.3 in the User's Guide*.

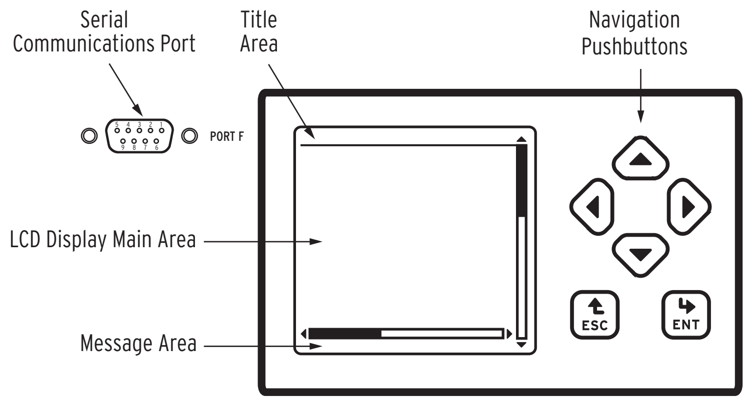

Figure 4.3 PORT F, LCD Display, and Navigation Pushbuttons.

Fast and efficient communication with the relay is available through communications ports such as PORT F, also shown in *Figure 4.3*. A design philosophy for all SEL relays is that an ASCII or open terminal is all that you need to communicate with the relay. Many "off-the-shelf" computer programs provide terminal emulation. These programs are inexpensive and widely available. Use the cable connections appropriate for your terminal configuration. See *Section 4: Communications Interfaces in the Reference Manual* for more information on communications ports.

All ASCII commands you send to the relay must terminate with a carriage return or carriage return/line feed; the terminal emulation program appends the necessary carriage return when you press Enter ↵ on the computer keyboard. You can truncate commands to the first three characters: **EVENT 1 <Enter>** becomes **EVE 1 <Enter>**. Use upper- and lower-case characters without distinction, except in passwords, which are case sensitive. For a list of ASCII commands see *Section 8: ASCII Command Reference in the Reference Manual*.

Help

When you are using a terminal, you can access built-in relay help for each ASCII command. Relay help is access-level sensitive; you see only the ASCII commands for the present access level when you type **HELP<Enter>**. For in-depth information on a particular ASCII command, enter the command name after typing HELP. For example, for help on the **EVENT** ASCII command, type **HELP EVE<Enter>**.

When you are using the ACSELERATOR software, press the <F1> key to get help, or select the Help menu from the ACSELERATOR toolbars. The help information in the ACSELERATOR software gives detailed information and sample screens in a GUI format.

Making an EIA-232 Serial Port Connection

The following steps use any popular computer terminal emulation software and SEL serial cables to connect to the SEL-421 Relay. Use an SEL Cable C234A cable to connect a 9-pin computer serial port to the SEL-421 Relay. Use an SEL Cable C227A cable to connect a 25-pin computer serial port to the relay. See *Section 4: Communications Interfaces in the Reference Manual* for further information on serial communications connections. These and other cables are available from SEL. Contact the factory or your local distributor for more information.

Step 1. Connect the computer and the SEL-421 Relay using the serial communications cable. Use the 9-pin serial port labeled PORT F on the relay front panel.

Step 2. Apply power to both the computer and to the relay.

Step 3. Start the computer terminal emulation program.

Step 4. Set your computer terminal emulation program serial communications parameters. The default SEL-421 Relay communications port settings are listed in *Table 4.2*. Set your computer terminal emulation program to the parameters in the Default column. Also set the terminal program to emulate either VT100 or VT52 terminals. These terminal emulations work best with SEL relays.

Table 4.2 General Serial Port Settings

Name	Description	Default
PROTO	Protocol (SEL, DNP[a], MBA, MBB)	SEL
SPEED	Data speed (300 to 57600, SYNC)	9600
DATABIT	Data bits (7, 8 bits)	8
PARITY	Parity (Odd, Even, None)	N
STOPBIT	Stop bits (1, 2, bits)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N

[a] DNP protocol is an ordering option.

Step 5. Check the communications link. Press the **<Enter>** key on the computer keyboard to confirm that you can communicate with the relay. You will see the "=" action prompt at the left side of your computer screen (column 1). If you do not see the prompt, check the cable connections and confirm the settings for the default communications parameters of *Table 4.2* in your terminal emulation program.

Step 6. View the relay report header. Type **QUIT<Enter>**. You will see a computer screen display similar to *Figure 4.4*. (Text that you type is emphasized in bold letters.) If you see jumbled characters, change the terminal emulation type in the computer terminal program.

```
=QUIT<Enter>

Relay 1                                       Date: 03/15/2001  Time: 00:01:05.209
Station A                                     Serial Number: 2001001234
=
```

Figure 4.4 Report Header.

When you communicate with the relay at the “=” prompt, you are in security Access Level 0. You cannot control relay functions at this level. Higher access levels are password protected and allow increased control over relay operation. For more information on access levels and password protection, see *Changing the Default Passwords: Terminal on page 4.10*.

Changing the Default Passwords

NOTE: Perform the password-change steps described in Changing the Default Passwords-Terminal at the end of this subsection.

It is extremely important that you change the factory default passwords programmed in the SEL-421 Relay. Setting unique passwords for the relay access levels increases the security of your substation and the power system. This subsection begins with information on the access level/password system in the SEL-421 Relay and includes an example of changing the default passwords.

Access Levels

Access levels control whether you can perform different operations within the SEL-421 relay. These security levels are labeled 0, 1, B, P, A, O, and 2. *Figure 4.5* presents an overview of the general access level structure in the relay.

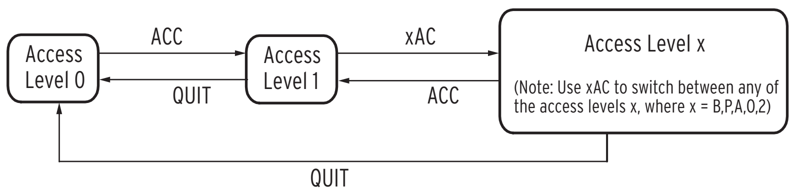

Figure 4.5 Access Level Structure.

Access Level 0 is the least secure and most limited access level, and Access Level 2 is the most secure level at which you have total relay functionality. For example, from Access Level 1, you can view settings; you cannot change settings unless you are at a higher access level. *Table 4.3* lists access levels and operator functions for the SEL-421 Relay.

Table 4.3 SEL-421 Relay Access Levels

Access Level	Prompt	Allowed Operations
0	=	Log in to Access Level 1; some test diagnostics.
1	=>	View data and status information.
B	==>	Access Level 1 functions plus breaker control and data.
P	P=>	Access Level B functions plus protection settings.
A	A=>	Access Level B functions plus automation settings.
O	O=>	Access Level B functions plus output settings.
2	=>>	Perform all relay access level functions.

The SEL-421 Relay performs command interpretation and execution according to your validated access level. Each access level has a password that the relay must verify before you can control the relay at that level. *Table 4.4 on page 4.9* lists the access level commands with corresponding passwords.

Table 4.4 Access Level Commands and Passwords

Access Level	Command	Factory Default Password
0	QUIT	(None)
1	ACCESS	OTTER
B	BACCESS	EDITH
P	PACCESS	AMPERE
A	AACCESS	VOLTA
O	OACCESS	WATT
2	2ACCESS	TAIL

Communications Ports Access Levels

Entrance to the higher security levels is sequential. You must first enter a correct password to move from Access Level 0 to Access Level 1. To enter Access Levels B, P, A, O, and 2, you must enter a correct password from Access Level 1. For example, to go to the O (Output) Access Level from Access Level 1, type **OAC<Enter>**; at the "Password: ?" prompt, type your Access Level O password.

Use the relay **QUIT** command from any access level to return the relay to Access Level 0. To reestablish control at a previous access level from Access Level 1, you must use the access level commands and passwords to log in to that previous access level.

When a connection with the SEL-421 Relay times out, the relay reduces the access level to Access Level 0 for that communications port connection.

Front-Panel Access Levels

The lowest access level for the front panel is Access Level 1. To enter Access Levels B, P, A, O, and 2, you must enter a correct password from Access Level 1. The front-panel LCD displays a password prompt when you attempt to control the relay at any access level higher than Access Level 1. (For more information on entering passwords from the front panel, see *Password on page U.5.10 in the User's Guide*.) The front-panel MAIN MENU item RESET ACCESS LEVEL returns the relay to Access Level 1. In addition, when the front-panel inactivity timer times out (indicated by the ROTATING DISPLAY on the front-panel LCD), the relay returns the front-panel access level to Access Level 1.

ACCESS Command

NOTE: You can shorten relay commands to the first three letters of the full command. See Section 8: ASCII Command Reference in the Reference Manual for more information.

Use the **ACCESS (ACC)** command to change to Access Level 1. Passwords are case sensitive; you must enter a password exactly as set. If you enter the password correctly, the SEL-421 Relay moves you to Access Level 1 from Access Level 0. The Access Level 1 action prompt (=>) appears. If you are at a higher access level (B, P, A, O, and 2), you can reduce the access level to Access Level 1 by entering the **ACC** command; the relay performs no password validation to reduce the present access level.

Higher Access Level Commands

Use the commands in *Table 4.4 on page 4.9* to enter access levels above Access Level 1. For example, use the **2ACCESS (2AC)** command to change to Access Level 2. If you are presently at Access Level 1, B, P, A, or O, typing **2AC <Enter>** causes the SEL-421 Relay to prompt you to type the Access Level 2 password. If the present level is Access Level 0, the SEL-421 Relay responds with "Invalid Access Level." The relay asserts alarm Relay Word bit SALARM when entering Access Level B, P, A, O, and 2 from a lower access level.

If you are unable to enter the correct password after the third failed attempt, the SEL-421 Relay asserts the SALARM Relay Word bit and displays on a communications terminal screen the error message "WARNING: ACCESS BY UNAUTHORIZED PERSONS STRICTLY PROHIBITED." In addition, you cannot make further access level entry attempts for 30 seconds. The relay terminates the communications connection after the third failed attempt when you use Ethernet via an SEL-2701 Ethernet Processor, DNP (Distributed Network Protocol), and MIRRORED BITS™ communications virtual terminal mode. For more information on these protocols, see *Section 6: DNP 3.0 Communications in the Reference Manual* and *Section 5: SEL Communications Protocols in the Reference Manual*.

If your connection to the SEL-421 Relay has an inactivity time-out (in the **SET P** port settings), the SEL-421 Relay automatically closes the communications connection and changes to Access Level 0 when the time-out occurs.

Passwords

Valid passwords are character sequences of as many as six characters. Valid password characters are numbers, upper- and lower-case alphabetic characters, "." (period), and "-" (hyphen). Passwords are case-sensitive. Use strong passwords. These contain a mix of the valid password characters in a combination that does not spell common words in any portion of the password.

Changing the Default Passwords: Terminal

⚠ **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.

NOTE: Passwords are case sensitive; you must enter passwords exactly as set.

Step 1. Confirm that the relay is operating. See *Connecting and Applying Power on page 4.4*.

Step 2. Establish communication with the SEL-421 Relay. See *Making an EIA-232 Serial Port Connection on page 4.6* to learn how to use a terminal to communicate with the relay.

Step 3. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>.** Type the Access Level 1 password OTTER and press **<Enter>**. You will see the => action prompt. Type **2AC<Enter>**. At the password prompt, type **TAIL<Enter>**. You will see the =>> action prompt.

Step 4. View the list of access levels and passwords. Type **PAS<Enter>**. For a new relay, you will see a terminal screen similar to *Figure 4.6*. (Text that you type is emphasized in bold letters.)

```
=>>PAS<Enter>
1:OTTER
B:EDITH
P:AMPERE
A:VOLTA
O:WATT
2:TAIL
=>>
```

Figure 4.6 Default Passwords.

Step 5. Set a new password for Access Level 2. Type **PAS 2 nE2Pw-<Enter>**. (nE2Pw- becomes the new strong password). The relay will return the word "Set" and the Access Level 2 prompt =>>.

Step 6. Set new passwords for each access level. In a similar manner as the previous step, create new strong passwords for each access level. Work through the passwords list presented in *Figure 4.6*.

Step 7. Confirm that you have changed all the default passwords. Type **PAS<Enter>**. You will see the list of *Figure 4.6* with your new passwords at each access level. Commit these passwords to memory, permanently record your new passwords, and store this permanent record in a secure location.

Eliminate password verification for an access level by entering DISABLE in place of the new password. This action will disable the password of that level; therefore, the relay does not check for a password upon entering that access level. Using DISABLE is not recommended. Always set a unique, strong password in the relay for each access level. Failure to do this can severely jeopardize the security of your substation and the power system.

After you enter a new password, the relay pulses the Relay Word bit SALARM for one second and responds "Set." The relay responds with the message "Password Disabled," if you used the DISABLE parameter.

If you forget a password, or encounter difficulty changing the default passwords in *Changing the Default Passwords: Terminal on page 4.10*, you can temporarily disable password verification. See *Jumpers on page U.2.17 in the User's Guide* for information on the password disable jumper J18B.

Checking Relay Status

With continual self-testing, the SEL-421 Relay monitors the internal operation of all circuits to verify optimal performance of relay functions. If an internal circuit, protection algorithm, or automation algorithm enters an out-of-tolerance operating range, the relay reports a status warning. In the unlikely event that an internal failure occurs, the relay reports a status failure. For more information on relay status, see *Relay Self-Tests on page U.6.37 in the User's Guide*.

You can check relay status through a communications port by using a terminal, terminal emulation computer program, or the ACSELERATOR software. In addition, you can use the relay front panel to view status information.

Checking Relay Status: Terminal

The procedure in the following steps assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.

Step 2. Type **STA<Enter>**. The relay returns a status terminal screen similar to that in *Figure 4.7*.

```
=>STA<Enter>

Relay 1                                      Date: 03/15/2001  Time:07:02:50.776
Station A                                    Serial Number: 000101234

FID=SEL-421-R101-V0-Z001001-D20010315        CID=0x9aed

Failures
  No Failures

Warnings
  No Warnings

SELogic Relay Programming Environment Errors
  No Errors

Relay Enabled
=>
```

Figure 4.7 Relay Status.

To view all relay status entries, use the **STA A** command. For more information on relay status report items, see *STATUS on page R.8.45 in the Reference Manual*.

Checking Relay Status: ACSELERATOR Software

You can use the SEL-5030 ACSELERATOR Software Program to check relay status. Use the HMI > Meter Control menu to view status conditions.

The procedure in the following steps assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default*

Passwords: Terminal on page 4.10 to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Communication Parameters. You will see the Communication Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters and connect to the relay. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm that you have loaded the correct passwords in the ACSELERATOR software. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

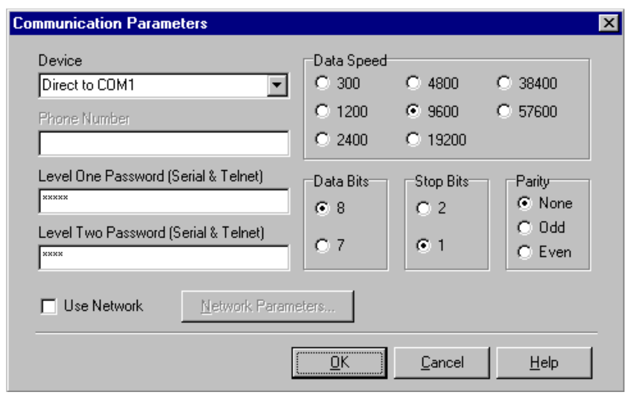

Figure 4.8 ACSELERATOR Software Port Parameters and Password Entry.

Step 3. Start the ACSELERATOR software operator interface. In the top toolbar HMI menu, click Meter and Control.

Step 4. Select ACSELERATOR status information. Click the Status button of the HMI tree view. See *Figure 4.9*.

Step 5. View relay status. The ACSELERATOR software displays relay status with a display similar to that in *Figure 4.7*.

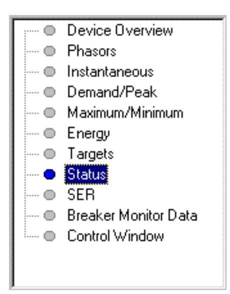

Figure 4.9 Retrieving Relay Status: ACSELERATOR Software.

Checking Relay Status: Front Panel

Use the front-panel display and navigation pushbuttons to check SEL-421 Relay status. See *Section 5: Front-Panel Operations in the User's Guide* for information on using the relay front panel.

Step 1. Prepare to use the front panel. Apply power to the relay, and note that the LCD shows a sequence of screens called the ROTATING DISPLAY. (Also, if you do not operate the front panel for a certain period, the relay will enter front-panel time-out mode and you will see the sequential screens of the ROTATING DISPLAY.)

Step 2. View the MAIN MENU. Press the **{ENT}** pushbutton to display the MAIN MENU of *Figure 4.10*.

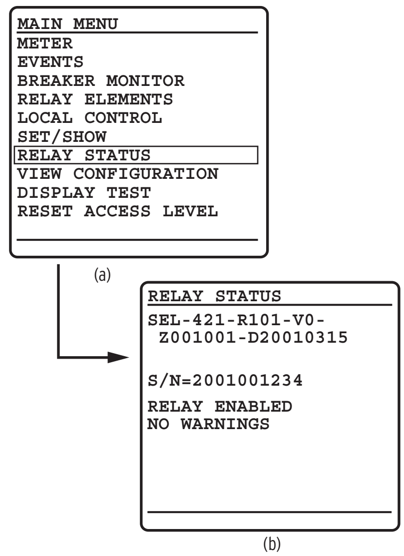

Figure 4.10 Checking Relay Status: Front-Panel LCD.

Step 3. View relay status. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the RELAY STATUS action item (See *Figure 4.10*). Press the **{ENT}** pushbutton. You will see the RELAY STATUS screen (the second screen of *Figure 4.10*).

Step 4. Normalize the front-panel display. To return to the MAIN MENU, press the **{ESC}** key. To return to the ROTATING DISPLAY, press **{ESC}** again.

For more information on the front-panel screen presentations and the items in the STATUS screens, see *RELAY STATUS on page U.5.24 in the User's Guide*.

Making Simple Settings Changes

The SEL-421 Relay settings structure makes setting the relay easy and efficient. Settings are grouped logically, and you do not see relay elements that are not used in your selected protection scheme. For example, if you select only three levels of a particular type of overcurrent protection, the corresponding Level 4 overcurrent element settings do not appear on the communications terminal screen. Hiding unused elements and settings that you have not enabled greatly simplifies the task of setting the SEL-421 Relay.

The ACSELERATOR software uses a similar method to focus your attention on the active settings. Unused relay elements and inactive settings are dimmed (grayed) in the ACSELERATOR software menus. See *Section 3: PC Software in the User's Guide* for more information on the ACSELERATOR software.

Settings Structure

The SEL-421 Relay settings structure assigns each relay setting to a specific location based on the setting type. A top-down organization allocates relay settings into these layers:

- Class
- Instance
- Category
- Setting

Examine *Figure 4.11* to understand the settings structure in the SEL-421 Relay. The top layer of the settings structure contains classes and instances. Class is the primary sort level; all classes have at least one instance, and some classes have multiple instances. Settings classes and related instances for the SEL-421 Relay are listed in *Table 4.5 on page 4.17*.

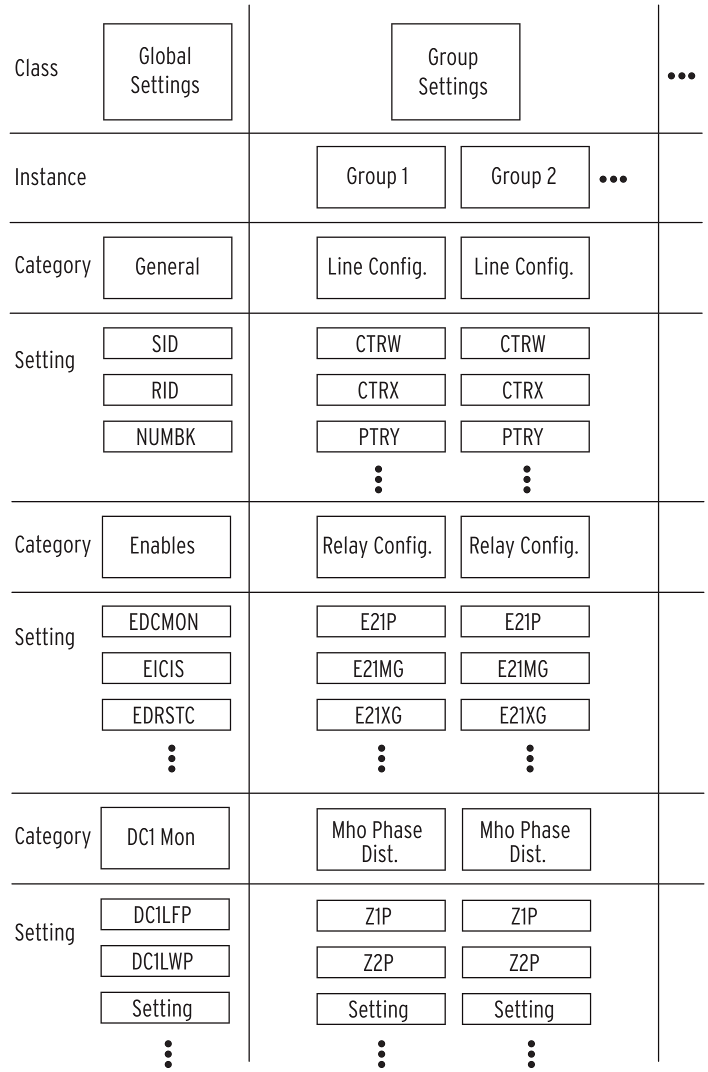

Figure 4.11 Relay Settings Structure Overview.

Table 4.5 Settings Classes and Instances

Class	Description	Instance	Description	ASCII Command
Global	Relay-wide applications settings	Global		SET G
Group	Individual scheme settings	Group 1 • • • Group 6	Group 1 settings • • • Group 6 settings	SET 1, SET S 1 • • • SET 6, SET S 6
Breaker Monitor	Circuit breaker monitoring settings	Breaker Monitor		SET M
Port	Communications port settings	Port F Port 1 • • • Port 3 Port 5	Front-panel port Port 1 settings • • • Port 3 settings Communications card settings	SET P F SET P 1 • • • SET P 3 SET P 5
Report	Event report and SER[a] settings	Report		SET R
Front Panel	Front-panel HMI settings	Front Panel		SET F
Protection SELOGIC® control equations	Protection-related SELOGIC control equations	Group 1 • • • Group 6	Group 1 protection SELOGIC control equations • • • Group 6 protection SELOGIC control equations	SET L 1 • • • SET L 6
Automation SELOGIC control equations	Automation-related SELOGIC control equations	Block 1 • • • Block 10	Block 1 automation SELOGIC control equations • • • Block 10 automation SELOGIC control equations	SET A 1 • • • SET A 10
DNP	Direct Network Protocol data remapping	DNP		SET D
Output SELOGIC control equations	Relay control output settings and Mirrored Bits communication transmit equations	Output		SET O

[a] SER is the Sequential Events Recorder; see SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook.

Note that some settings classes have only one instance and you do not specify the instance designator when accessing these classes. An example is the Global settings class. You can view or modify Global settings with a communications terminal by entering **SET G** as shown in the ASCII Command column of *Table 4.5 on page 4.17*. The relay presents the Global settings categories at the **SET G** command; no instance numbers follow **SET G**. Conversely, the Port settings command has five instances (Port F, Port 1, Port 2, Port 3, and Port 5). To access the Port 1 settings, you must type **SET P 1<Enter>**. If you do not specify which port to set, the relay defaults to the active port (the port you are presently using).

The Group settings can have the optional one-letter acronym 'S' attached to the command; you can enter **SET 1** or **SET S 1** for Group 1 settings, **SET 2** or **SET S 2** for Group 2 settings, etc. If you do not specify which group to set, the relay defaults to the present active group. If Group 6 is the active group, and you type **SET<Enter>**, for example, you will see the settings prompts for the Group 6 settings.

Settings: Terminal

When you change settings (with any **SET** command) from a terminal, the relay shows the setting category, prompt, present value, and action prompt. *Figure 4.12* shows two settings examples: multiple-line settings (SID and RID) and an in-line setting (NUMBK) for relay Global settings from Access Level P (protection). The relay prompts you for input by presenting an action prompt. You have many options for navigating the settings at the "?" action prompt. *Table 4.6 on page 4.19* lists the operations possible from a settings action prompt. This table denotes the enter key <Enter> with the ↵ symbol.

```
P=>SET G<Enter>
Global

General Global Settings ------------------ Category

Station Identifier (40 characters) ---------------- Prompt
SID := "Station A"-------------------------------- Present Value
?<Enter> ------------------------------------------ Action Prompt
Relay Identifier (40 characters)                                      Present        Action
RID := "Relay 1"                           Prompt                      Value         Prompt
?<Enter>
Number of Breakers in Scheme (1,2)                      NUMBK    := 1        ?<Enter>
```

Figure 4.12 Components of SET Commands.

Table 4.6 Actions at Settings Prompts[a]

Action[a]	Relay Response
↵	Accept setting and move to the next setting; if at the last setting, exit settings.
[*value*]↵	Enter the given *value* and move to the next setting if valid; if at the last setting, exit settings.
^↵	Move to the previous setting; if at the top of settings, stay at the present setting.
<↵	Move to the top of the previous settings category; if at the top of settings, stay at the present setting.
>↵	Move to the top of the next settings category; if in the last category, exit settings.
END↵	Go to the end of the present settings session. Prepare to exit settings via the "Save settings (Y,N) ?" prompt.
<Ctrl+X>	Abort editing session without saving changes.

[a] In this table, the ↵ symbol represents the Enter key <Enter>.

When you exit settings entry from the SET commands, the relay responds, "Save settings (Y,N) ?". If you answer **Y<Enter>** (Yes), the relay writes the new settings to nonvolatile storage. If you answer **N <Enter>** (No), the relay discards any settings changes you have made.

Making Settings Changes: Initial Global Settings

You must configure the SEL-421 Relay for specific conditions found in the power system where you are connecting the relay. In particular, you must set the nominal frequency and phase rotation.

The procedure in the following steps assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

This example jumps to a Global setting that is not at the beginning of the Global settings list. Thus, you enter **SET G**, the setting name, and **<Enter>**. To start at the beginning of the Global settings, simply type **SET G<Enter>** without a settings name.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Set the nominal system frequency. Use the **NFREQ** setting, which has options of 50 Hz and 60 Hz. Type **SET G NFREQ<Enter>.** The relay responds with a terminal screen display similar to the beginning of *Figure 4.13*.

```
=>>SET G NFREQ<Enter>
Global

General Global Settings

Nominal System Frequency (50,60 Hz)                  NFREQ   := 60     ?<Enter>
System Phase Rotation (ABC,ACB)                      PHROT   := ABC    ?<Enter>
Date Format (MDY,YMD,DMY)                            DATE_F  := MDY    ?YMD<Enter>
Fault Condition Equation (SELogic Equation)
FAULT := 50P1 OR 51S1 OR M2P OR Z2G OR M3P OR Z3G
?  END<Enter>
.
.
.

Save settings (Y,N)  ?Y<Enter>
Saving Settings, Please Wait..........
Settings Saved
=>>
```

Figure 4.13 Initial Global Settings.

Step 3. Accept default settings. For a 60 Hz system, simply press **<Enter>** to accept the NFREQ existing value of 60 (Hz). The relay presents the next setting, which is the PHROT (phase rotation) setting. Type **<Enter>** to accept the ABC phase rotation default.

Step 4. Set the date format. The SEL-421 Relay reports dates in three formats: MDY, YMD, and DMY (where M = month, D = date, and Y = year). For this procedure type **YMD<Enter>.** At each setting in turn, the relay presents the settings prompt, name, present value, and action prompt. Note that SELOGIC control equation settings, such as FAULT in *Figure 4.13*, appear on multiple lines.

If you make a mistake or want to go backward through the settings, type the ^ character (on most computer keyboards, this is a shifted numeral 6) and **<Enter>**. Refer to *Table 4.6 on page 4.19* for this and other navigational aids.

Step 5. End the settings session. Type **END<Enter>** at the FAULT action prompt. (The FAULT SELOGIC control equation remains unchanged.) The relay next scrolls a readback of all the Global settings, eventually displaying the “Save settings (Y, N) ?” prompt. (In *Figure 4.13*, a vertical ellipsis represents the relay information during readback.) Examine the settings readback to verify your new settings. Answer **Y<Enter>** to save your new settings.

The TERSE Option

You can avoid viewing the entire class settings summary the relay displays when you type **END<Enter>** midway through a settings class or instance. On slow data speed links, waiting for the complete settings readback can clog your automation control system or take too much of your time for a few settings changes. Eliminate the settings readback by appending **TERSE** to the **SET** command.

Text-Edit Mode Line Editing

Some SEL-421 Relay settings present multiple input lines to your terminal; you use basic line text editing commands to construct the setting. For display, the relay references each line of the setting by line number, not by the setting name. See *Making Text-Edit Mode Settings Changes on page 4.21* for an example of a text-edit mode setting.

While in the text-edit mode, you see a prompt consisting of the line number and the present setting for that line. You can keep the setting, enter a new setting, or delete the setting. *Table 4.7* lists the commands for text-edit mode.

Table 4.7 Actions at Text-Edit Mode Prompts

Action[a]	Relay Response
↵	Accept the setting and move to the next line; if at the last line or at a blank line, exit settings.
>*n*↵	Move to line *n*. If this is beyond the end of the list, move to a blank line following the last line.
^↵	Move to the previous line; if at the first line, stay at the present line.
<↵	Move to the first line.
>↵	Move to a blank line following the last line.
LIST↵	List all settings and return to the present action prompt.
DELETE [*n*]↵	Delete the present line and subsequent lines for a total of *n* lines; *n*=1 if not provided. Lines after deletion shift upward by the number of lines deleted.
INSERT↵	Insert a blank line at the present location; the present line and subsequent lines shift downward.
END↵	Go to the end of the present settings session. Prepare to exit settings via the "Save settings (Y,N) ?" prompt.
<Ctrl+X>	Abort editing session without saving changes.

[a] In this table, the ↵ symbol represents the Enter key <Enter>.

Use commas to separate the items in a text-edit mode setting when you are entering multiple items per line. After you enter each line, the relay checks the validity of the setting. If the entered setting is invalid, the relay responds with an error message and prompts you again for the setting.

Making Text-Edit Mode Settings Changes

The procedure in the following steps familiarizes you with basic text-edit mode line editing. You set Display Point 1 through Display Point 3 to show the status of Circuit Breaker 1, Circuit Breaker 2, and the operational state (on or off) of the transformer cooling fans near the circuit breaker bay where you have installed the SEL-421 Relay. See *Display Points on page U.5.6 in the User's Guide* for information on programming display points.

For this example, use inputs IN101 through IN103. You can use other inputs for your particular application. See *Control Inputs on page U.2.6 in the User's Guide* for more information on control inputs.

This procedure assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Access the display point settings. Type **SET F<Enter>** to modify the front-panel settings. Advance through the front-panel settings (repeatedly type **>** and then **<Enter>**) until you reach the Display Points and Aliases category. *Figure 4.14* shows a representative terminal screen. The relay displays the first line that you can edit. For the case of display points, the line number is the display point number.

Step 3. Set Display Point 1. At the Line 1 "?" settings action prompt, type **IN101,"CB1",CLOSED,OPEN<Enter>** to create Display Point 1. The relay verifies that this is a valid entry, then responds with the next line prompt "2:" followed by the "?" settings action prompt (see *Figure 4.15 on page 4.24*).

Step 4. Set Display Point 2. At the Line 2 "?" settings action prompt, type **IN102,"CB2",CLOSED,OPEN<Enter>** to create Display Point 2. The relay verifies that this is a valid entry, then responds with the next line prompt "3:" followed by the "?" settings action prompt (see *Figure 4.15 on page 4.24*).

Step 5. List active display points. At the Display Points and Aliases prompt, use the text-edit mode line editing commands to list the active display points. Type **LIST<Enter>**. After showing the active display points, the relay returns you to line "3:" followed by the "?" settings action prompt.

Step 6. Set Display Point 3. Type **IN105,"5 MVA XFMR Fans",ON,OFF<Enter>** to create Display Point 3. The relay verifies that this is a valid entry, then responds with the next line prompt "4:" followed by the "?" settings action prompt (See *Figure 4.14*).

Step 7. End the settings session. Type **END<Enter>**. The relay scrolls a readback of all the Front-Panel settings, eventually displaying the "Save settings (Y,N) ?" prompt. (A vertical ellipsis in *Figure 4.14* represents the readback.) At the end of the readback information, just before the "Save settings (Y,N) ?" prompt, you can verify the new display point information. Answer **Y<Enter>** to save the new settings.

```
Display Points and Aliases
Syntax: Relay word bit, alias name, alias for set state, alias for clear state

1:
? IN101,"CB1","CLOSED","OPEN"<Enter>
2:
? IN102,"CB2","CLOSED","OPEN"<Enter>
3:
? LIST<Enter>

1: IN101,"CB1","CLOSED","OPEN"
2: IN102,"CB2","CLOSED","OPEN"

3:
? IN105,"5 MVA XFMR Fans",ON,OFF<Enter>
4:
?  END<Enter>
              .
              .
              .
Display Points and Aliases
Syntax: Relay word bit, alias name, alias for set state, alias for clear state

1: IN101,"CB1","CLOSED","OPEN"
2: IN102,"CB2","CLOSED","OPEN"
3: IN105,"5 MVA XFMR Fans","ON","OFF"
              .
              .
              .
Save settings (Y,N)  ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 4.14 Using Text-Edit Mode Line Editing to Set Display Points.

This procedure proposes connecting the transformer bank fan sensor to relay input IN105. In the **SET G** (GLOBAL) command, verify that the assertion level (setting IN105P) and the debounce time (setting IN105D) are correct for your fan-running sensor. To access separate input parameters, you must first enable independent control input settings with setting EICIS. To change the input conditioning, enter these settings:

EICIS := Y Independent Control Input Settings (Y, N)

IN105P := 80 Input IN105 Pickup Level (15–265 Vdc)

IN105D := 0.375 Input IN105 Debounce Time (0.00–5.00 cycles)

Use the appropriate interface hardware to connect the fan-running sensor to IN105. Choose any relay input that conforms to your requirements. See *Control Inputs on page U.2.6 in the User's Guide* for more information on SEL-421 Relay control inputs.

Deleting a Display Point

This example shows how you can delete a previously used display point. In the **SET F** command, at the Display Points and Aliases prompt, use the text-edit mode line editing commands to set and delete the display points. This procedure shows two previously programmed display points that indicate on the front-panel LCD the status of Circuit Breaker 1 and Circuit Breaker 2. Relay control inputs IN101 and IN102 are the Relay Word bits for the Circuit Breaker 1 and Circuit Breaker 2 display points, respectively (see *Making Text-Edit Mode Settings Changes on page 4.21*). You can use other inputs for your particular application. See *Control Inputs on page U.2.6 in the User's Guide* for more information on control inputs.

The procedure in the following steps assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Access the Display Points and Aliases prompt. Enter the **SET F** command. Advance through the front-panel settings (repeatedly type **><Enter>**) until you reach the Display Points and Aliases category. *Figure 4.15* shows a representative terminal screen. The relay displays the first line that you can edit. For display points, the line number is the display point number.

```
Display Points and Aliases
Syntax: Relay word bit, alias name, alias for set state, alias for clear state

1: IN101,"CB1","CLOSED","OPEN"
?  LIST<Enter>

1: IN101,"CB1","CLOSED","OPEN"
2: IN102,"CB2","CLOSED","OPEN"
3: IN105,"5 MVA XFMR Fans","ON","OFF"

1: IN101,"CB1","CLOSED","OPEN"
?  <Enter>
2: IN102,"CB2","CLOSED","OPEN"
?  DELETE<Enter>
2: IN105,"5 MVA XFMR Fans","ON","OFF"
?  LIST<Enter>

1: IN101,"CB1","CLOSED","OPEN"
2: IN105,"5 MVA XFMR Fans","ON","OFF"

2: IN105,"5 MVA XFMR Fans","ON","OFF"
?  END<Enter>
               .
               .
               .
Display Points and Aliases
Syntax: Relay word bit, alias name, alias for set state, alias for clear state

1: IN101,"CB1","CLOSED","OPEN"
2: IN105,"5 MVA XFMR Fans","ON","OFF"
               .
               .
               .
Save settings (Y,N)  ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 4.15 Using Text-Edit Mode Line Editing to Delete a Display Point.

Step 3. List the present display points. At the Control Points and Aliases prompt, use the text-edit mode line editing commands to list the active display points. Type **LIST<Enter>**. After showing the active display points, the relay returns you to line "1:" followed by the "?" settings action prompt.

Step 4. Ready the relay to edit line 2. Type **<Enter>** once to proceed to the line 2 present value and "?" settings action prompt.

Step 5. Delete Display Point 2. Type **DELETE<Enter>**.

Step 6. Examine the remaining display points. Type **LIST<Enter>**. Former Display Point 2 is eliminated, and Display Point 3 moves up to position 2. The relay returns you to line "2:" followed by the "?" settings action prompt.

Step 7. End the settings process. Type **END<Enter>**. The relay next scrolls a readback of all the Front-Panel settings, eventually displaying the "Save settings (Y,N) ?" prompt. (In *Figure 4.15*, a vertical ellipsis represents this scrolling readback.) At the end of the readback information, just before the "Save settings (Y,N) ?" prompt, you can verify the new display point information. Answer **Y<Enter>** to save your new settings.

Settings: the ACSELERATOR Software

You can use the ACSELERATOR software to develop settings for the SEL-421 Relay offline. The ACSELERATOR software automatically checks interrelated settings and alerts you to out-of-range settings. Upload the off-line ACSELERATOR software settings to the relay via the communications ports. See *Checking Relay Status: ACSELERATOR Software on page 4.12* for an introductory tutorial on using the ACSELERATOR software.

You can also use the ACSELERATOR software as a terminal program to interact in real time with the relay. For an introduction to the ACSELERATOR software and all of features of this software, see *Section 3: PC Software in the User's Guide*.

Making Initial Global Settings: ACSELERATOR Software

The ACSELERATOR software makes setting the relay an easy task. The purpose of the procedure in the following steps is to familiarize you with reading, modifying, and sending settings with the ACSELERATOR software.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software; see *Section 3: PC Software in the User's Guide*, and *Checking Relay Status: ACSELERATOR Software on page 4.12*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Communication Parameters. You will see the Communication Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Type **<Ctrl+T>** to open the ACSELERATOR software terminal window. Type **<Enter>** to see whether the communications link is active between the ACSELERATOR software and the relay. You will see the = action prompt in the terminal window. Exit the terminal window.

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. Select Global settings. Click on the plus mark (+) next to the Global branch of the left-hand ACSELERATOR software tree structure shown in *Figure 4.16*. Click on Global Settings/Enables. You will see the Global Settings/Enables window with General Global Settings and Global Enables (See *Figure 4.17*).

Step 5. Change settings. Click on the button for the correct option for NFREQ and PHTROT to specify your system frequency and phase rotation. When you tab or click to the next field, the relay validates the new setting.

The right-click mouse button performs two special functions when you are editing settings: Previous Value and Default Value. Right click in the setting dialog box and select Previous Value if you want to revert to the setting value before you made a change. Right click in the setting dialog box and select Default Value if you want to restore the factory default setting value.

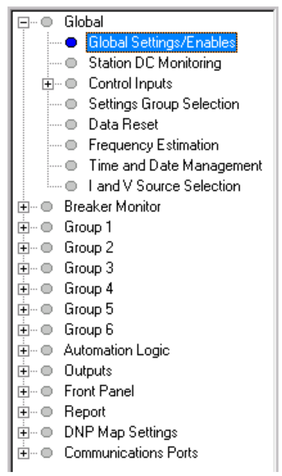

Figure 4.16 Selecting Global Settings in the ACSELERATOR Software.

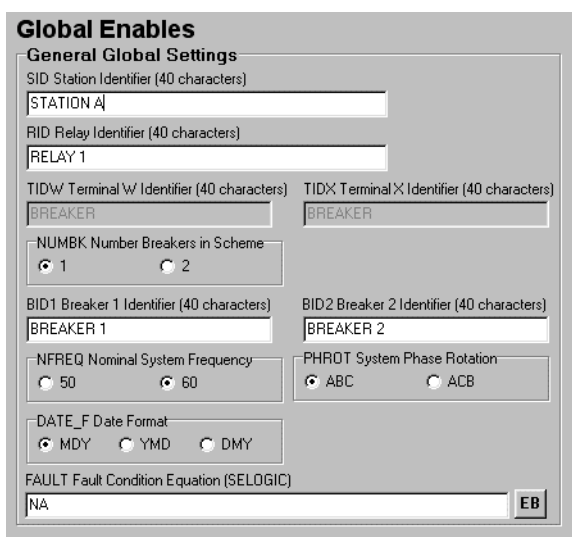

Figure 4.17 The ACSELERATOR Software Global Settings Window.

Step 6. Save the new settings in the ACSELERATOR software. On the Relay Editor File menu, click Save, specify a Relay Name, and click OK.

Step 7. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class or instance you want to send to the relay, as shown in the first dialog box of *Figure 4.18*. Click the check box for Global. Click OK. The ACSELERATOR software responds with the second dialog box of *Figure 4.18*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 4.18 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

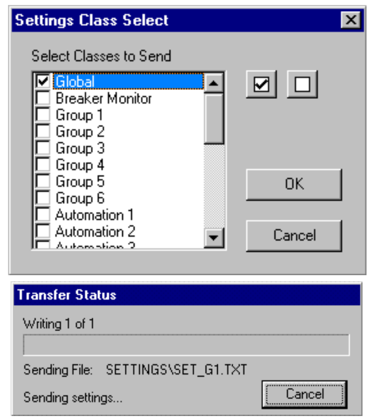

Figure 4.18 Uploading Global Settings to the SEL-421 Relay.

Settings: Front Panel

You can use the relay front panel to enter some of the relay settings. The SEL-421 Relay presents the settings in order from class to instance (if applicable) to category to the particular setting, in a manner similar to setting the relay using a terminal. Use the LCD and the adjacent navigation pushbuttons to enter each character of the setting in sequence. This can be a laborious process for some settings (e.g., long SELOGIC control equations). However, if you need to make a quick correction or have no faster means to make settings, settings functions are available at the front panel. For more information on making settings changes from the front panel, see *SET/SHOW on page U.5.21 in the User's Guide*.

Entering DATE and TIME from the Front Panel

The purpose of the procedure in the following steps is to familiarize you with entering data from the SEL-421 Relay front panel. Refer to *Connecting and Applying Power on page 4.4* before performing this example.

Step 1. Prepare to use the front panel. Apply power to the relay; note that the relay front-panel display shows a sequence of LCD screens called the ROTATING DISPLAY. (If you do not operate the front panel for a certain period, the relay will enter front-panel time-out mode and you will see the sequential screens of the ROTATING DISPLAY.)

Step 2. View the MAIN MENU. Press the **{ENT}** pushbutton to display the MAIN MENU of *Figure 4.19*.

Step 3. View settings screens. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the SET/SHOW action item (See *Figure 4.19*). Press the **{ENT}** pushbutton. You will see the SET/SHOW submenu (the second screen in *Figure 4.19*).

Step 4. View the date/time screen. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the DATE/TIME action item (*Figure 4.19*, second screen). Press the **{ENT}** pushbutton. The relay next displays the DATE/TIME submenu (the third screen of *Figure 4.19*).

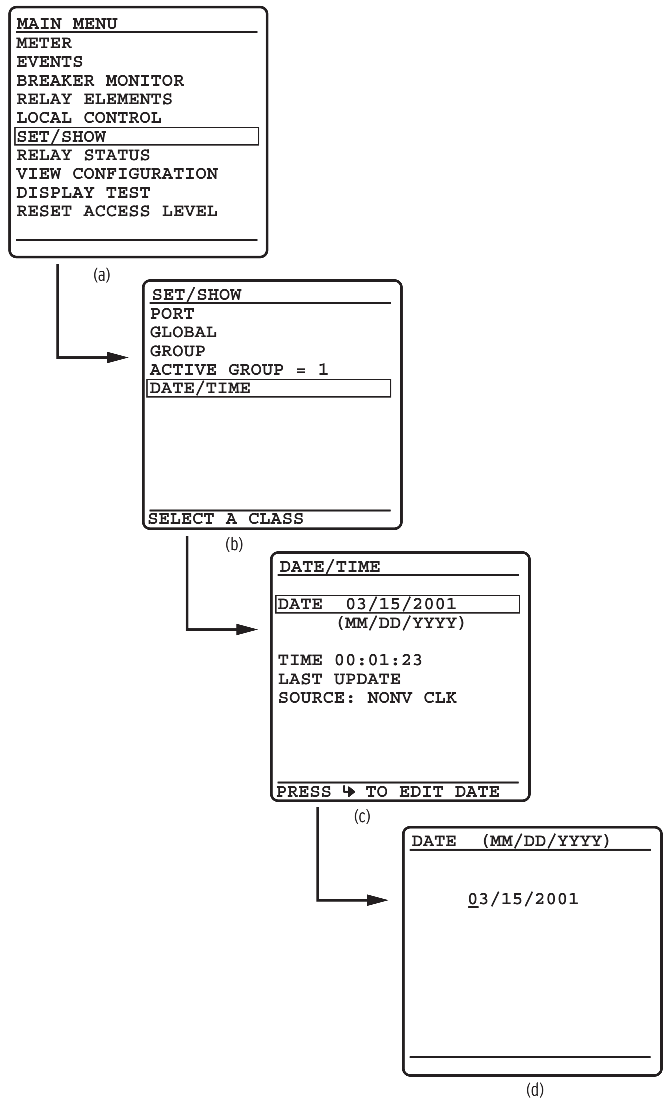

Figure 4.19 DATE and TIME Settings: Front-Panel LCD.

Step 5. Set the date. Press the **{ENT}** pushbutton. The relay shows the last screen of *Figure 4.19*, the DATE edit screen. Use the **{Up}** arrow and **{Down}** arrow navigation pushbuttons to increase and decrease the date position numbers. Step to the next or previous position by using the **{Left}** and **{Right}** arrow pushbuttons. When finished adjusting the new date, press **{ENT}**.

The relay returns the display to the DATE/TIME submenu. Note that the relay reports the TIME SOURCE as FP DATE (front-panel date).

Step 6. Normalize the front-panel display. Press **{ESC}** repeatedly.

Changing a Relay Setting From the Front Panel

The purpose of the procedure in the following steps is to provide additional practice at entering relay settings from the front panel. In this example, you change the PORT F front-panel communications port settings.

Step 1. View the MAIN MENU. If you have been using the front panel (as in the previous example), press the **{ESC}** key repeatedly until you see the MAIN MENU. If the relay is displaying the ROTATING DISPLAY, press the **{ENT}** pushbutton to display the MAIN MENU. The first screen of *Figure 4.20* shows the MAIN MENU at the beginning of the front-panel settings process.

Step 2. View the settings screens. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the SET/SHOW action item (See *Figure 4.20*). Press the **{ENT}** pushbutton. You will see the SET/SHOW submenu (the second screen in *Figure 4.20*).

Step 3. Select PORT F. Highlight PORT and press the **{ENT}** pushbutton. Next, the relay displays the PORT instances (the third screen of *Figure 4.20*). Choose the port you want to configure by using the **{Up}** and **{Down}** arrow navigation pushbuttons to move the screen arrow. For this example, select PORT F and press **{ENT}**.

Step 4. View the Communications Settings category screen. The relay shows the fourth screen of *Figure 4.20*, the PORT F category screen. Use the **{Up}** and **{Down}** arrow navigation pushbuttons to select the settings category. For this example, highlight Communications Settings and press **{ENT}**. The relay displays the fifth screen of *Figure 4.20*, the Communications Settings screen.

Step 5. Change settings. Highlight the SPEED setting. Press **{ENT}**. (The relay possibly requires a password here; see *Passwords on page 4.10* and *Section 5: Front-Panel Operations in the User's Guide*.) The LCD displays the SPEED selection submenu that has all the possible choices for serial data speeds. The highlight in the sixth screen of *Figure 4.20* indicates the default setting of 9600 (bps). Use the **{Up}** and **{Down}** arrow navigation pushbuttons to select a different speed. Once you have selected a data speed, press the **{ENT}** pushbutton.

NOTE: Once you have changed communications parameters, you must change the corresponding parameters in your terminal emulation program to communicate with the relay via a communications port.

Step 6. End the settings session. The relay returns to the previous category settings list screen. Press **{ESC}** to return to the categories screen where you see the Save Settings item at the bottom of the screen. Use the **{Up}** and **{Down}** arrow pushbuttons to highlight Save Settings and press **{ENT}**. Highlight YES, and then press **{ENT}**. The relay validates the setting and returns you to the PORT screen (the third screen of *Figure 4.20*).

Step 7. Normalize the front-panel display. Press **{ESC}** repeatedly to return to the MAIN MENU.

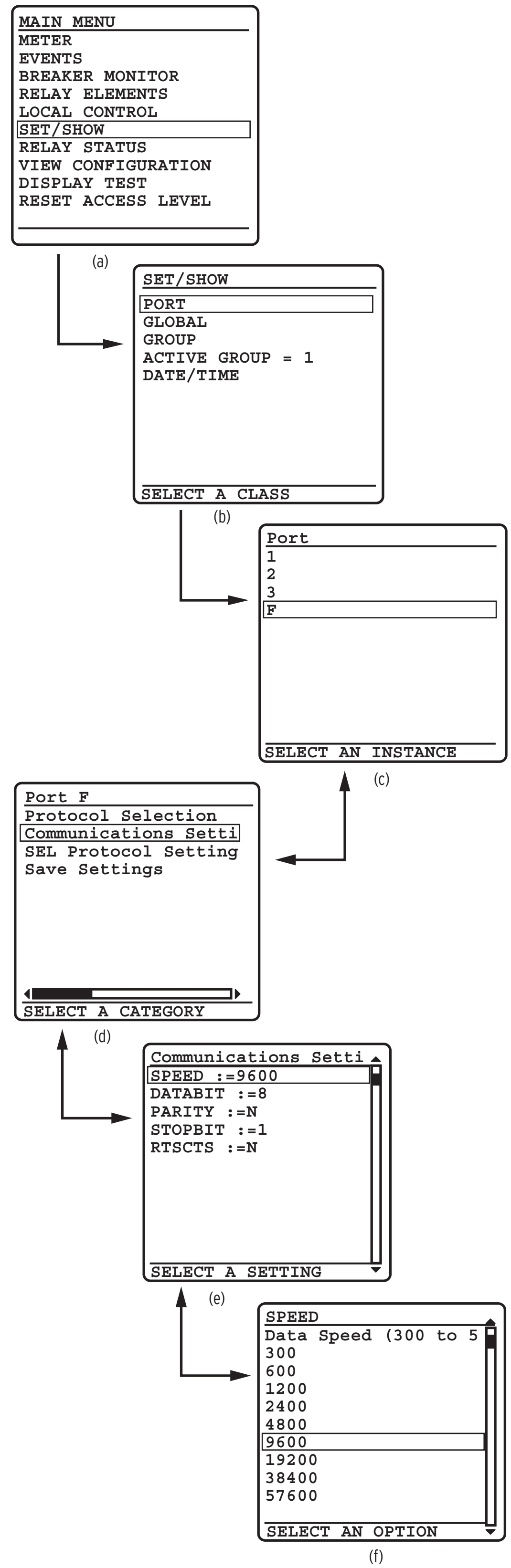

Figure 4.20 SETTINGS Menus.

Examining Metering Quantities

The SEL-421 Relay features high-accuracy power system metering. You can view fundamental and rms quantities by using a communications terminal, the ACSELERATOR software, or the front panel. For more information on SEL-421 Relay metering, see *Metering on page A.2.28 in the Applications Handbook*.

View Metering: Terminal

The procedure in the following steps shows how to use a terminal or terminal emulation computer program to view power system metering. In this example, you connect specific voltages and currents for a 5 A, 60 Hz relay. Scale these quantities appropriately for your particular relay. For more information on testing the relay and making test connections, see *Section 6: Testing and Troubleshooting in the User's Guide*.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Set the relay to a nominal operation mode. Use a terminal to perform the initial global settings relay setup in *Making Settings Changes: Initial Global Settings on page 4.19*. Set the relay for 60-Hz operation, ABC phase rotation.

Step 3. Set the relay for a basic voltage and current configuration. See *Figure 4.21*. Use the terminal to set global settings ESS := 1. Type **SET G ESS TERSE<Enter>**. Type **1<Enter>** if the ESS setting is not 1. Type **END<Enter>** to finish this settings session. Answer **Y <Enter>** to the save settings prompt.

```
=>>SET G ESS TERSE<Enter>
Global

Current and Voltage Source Selection

Current and Voltage Source Selection (Y,N,1,2,3,4)      ESS    := N    ?1<Enter>
Line Current Source (IW,COMB)                           LINEI  := IW   ?END<Enter>

Save settings (Y,N) ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 4.21 Setting ESS: Terminal.

Step 4. Set CT and PT ratios. Use the terminal to confirm that Group 1 setting CTRW := 200 (the current transformer W-input ratio), and PTRY := 2000 (the potential transformer Y-input ratio). Type **SET CTRW TERSE<Enter>**. If the CTRW setting is not 200, type **200<Enter>**. Proceed as shown in *Figure 4.22* to PTRY and change PTRY to 2000, if needed. Type **END<Enter>** to finish this settings session. Answer **Y <Enter>** to the save settings prompt.

```
=>>SET CTRW TERSE<Enter>

Group 1

Line Configuration

Current Transformer Ratio - Input W (1-50000)    CTRW  := 1000  ?200<Enter>
Current Transformer Ratio - Input X (1-50000)    CTRX  := 1000  ?<Enter>
Potential Transformer Ratio - Input Y (1-10000)  PTRY  := 2000  ?END<Enter>

Save settings (Y,N) ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 4.22 Setting CTRW and PTRY: Terminal.

Step 5. Turn relay power off.

Step 6. Connect analog inputs. If three voltage sources and three current sources are available, connect the sources to the relay as shown in *Figure 4.23*. If three voltage sources and two current sources are available, use the connection diagram of *Figure 4.24*. Apply 67 V per phase (line-to-neutral) in ABC phase rotation. Apply 2.0 A per phase, in phase with the applied phase voltages.

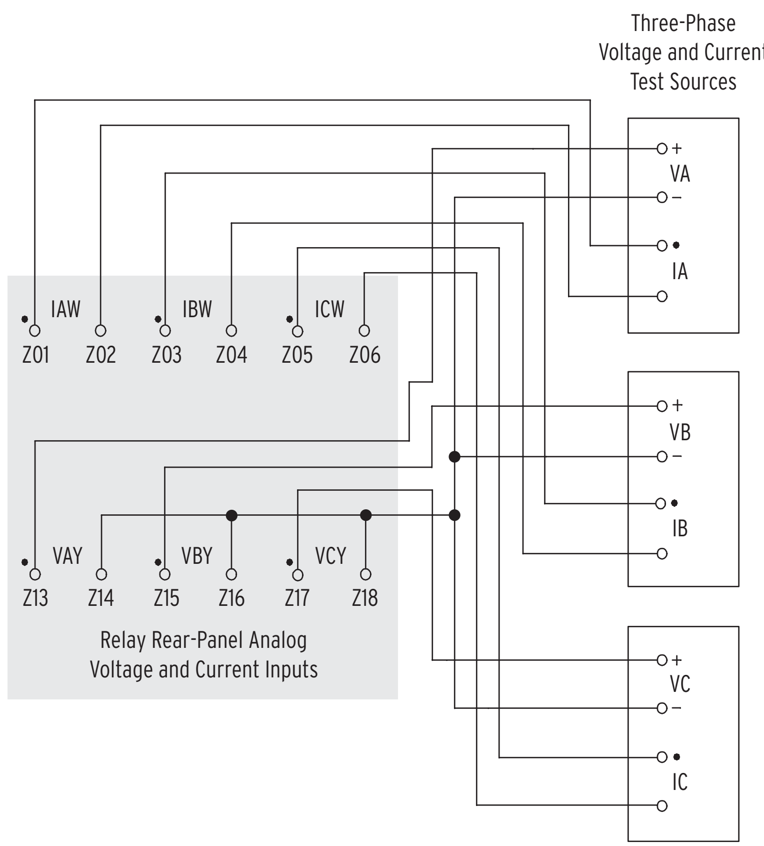

Figure 4.23 Test Connections Using Three Voltage Sources/Three Current Sources.

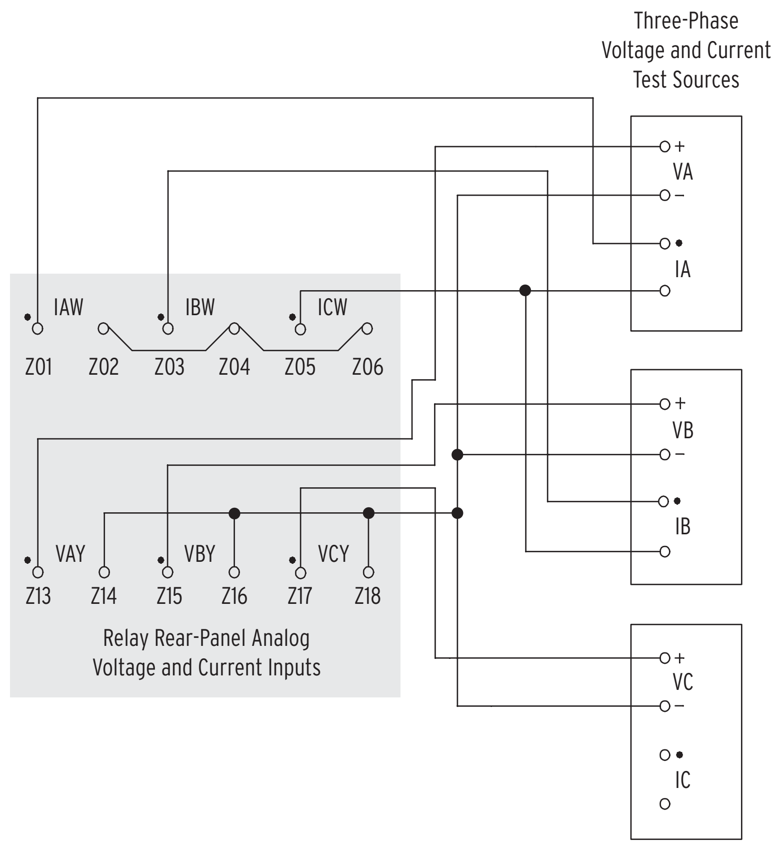

Figure 4.24 Test Connections Using Two Current Sources for Three-Phase Faults and METER Test.

Step 7. Turn relay power on.

Step 8. View metering. Type **ACC<Enter>** to log-in to relay Access Level 1, then type your password and press **<Enter>**. Type **MET<Enter>**. The relay displays the fundamental frequency (50 Hz or 60 Hz) metering information in a manner similar to that in *Figure 4.25*.

```
=>>MET<Enter>

Relay 1                                     Date: 03/15/2001  Time: 00:00:14.938
Station A                                   Serial Number: 2001001234

                      Phase Currents

                 IA        IB        IC
I MAG (A)      400.000   400.345   400.431
I ANG (DEG)     00.00   -120.10    119.90

                      Phase Voltages              Phase-Phase Voltages
                 VA        VB        VC          VAB       VBC       VCA
V MAG (kV)     134.001   133.999   134.001     232.095   232.093   232.097
V ANG (DEG)     00.00   -120.10    119.90       00.00    -00.10     00.10

                     Sequence Currents (A)       Sequence Voltages (kV)
                  I1        3I2       3I0         V1        3V2       3V0
MAG            400.252     0.739     0.861      133.954     0.003     0.001
ANG (DEG)        0.01    -50.86    -63.65         0.00    -49.97   -120.70


                    A           B           C             3P
P (MW)            53.60       53.60       53.60         160.08
Q (MVAR)           0.00       -0.00       -0.00          -0.00
S (MVA)            0.00        0.00        0.00           0.00
POWER FACTOR       1.00        0.99        1.00           1.00
                                LAG

FREQ (Hz)      60.00       VDC1(V)   125.00   VDC2(V)    48.00
=>>
```

Figure 4.25 Terminal Screen MET Metering Quantities.

The metering quantities of *View Metering: Terminal on page 4.31* are the fundamental line quantities. Other variants of the **MET** command give different relay metering quantities. For example, you can see the line RMS (harmonics-included) quantities by issuing the **MET RMS** command. See *Metering on page A.2.28 in the Applications Handbook* and *METER on page R.8.28 in the Reference Manual* for more information on the **MET** command.

View Metering: ACSELERATOR Software

Use the procedures in the following steps to examine the SEL-421 Relay metering with the ACSELERATOR software HMI.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Checking Relay Status: ACSELERATOR Software on page 4.12* and *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Set the relay to a nominal operation mode. Perform the initial global settings relay setup of *Making Initial Global Settings: ACSELERATOR Software on page 4.25* to set the relay for 60-Hz operation, ABC phase rotation.

Step 4. Set a basic voltage and current configuration. In the ACSELERATOR software Settings tree view, double-click the Global entry of the Settings tree view to expand the Global branch (See *Figure 4.26*). Click the I and V Source Selection branch. You will see the Current and Voltage Source Selection dialog box of *Figure 4.26*. Click on the down button to select 1 for ESS (Current and Voltage Source Selection).

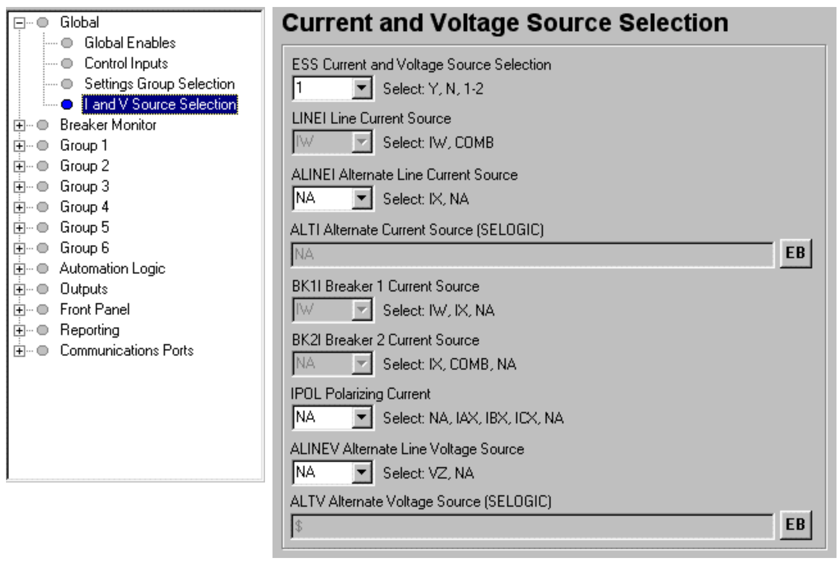

Figure 4.26 Global Alternate Source Selection Settings in the ACSELERATOR Software.

Step 5. Set PT and CT ratios. In the ACSELERATOR Settings tree view, click the "+" mark next to Group 1 to expand this branch (See *Figure 4.27*). Click the plus (+) mark next to Set 1. Click Line Configuration. You will see the Line Configuration window similar to *Figure 4.27*. Confirm that setting CTRW is 200 (the current transformer W-input ratio), and PTRY is 2000 (the potential transformer Y-input ratio). Save the settings and send the Group 1 settings if you change the settings. See *Step 6* and *Step 7 on page 4.27*.

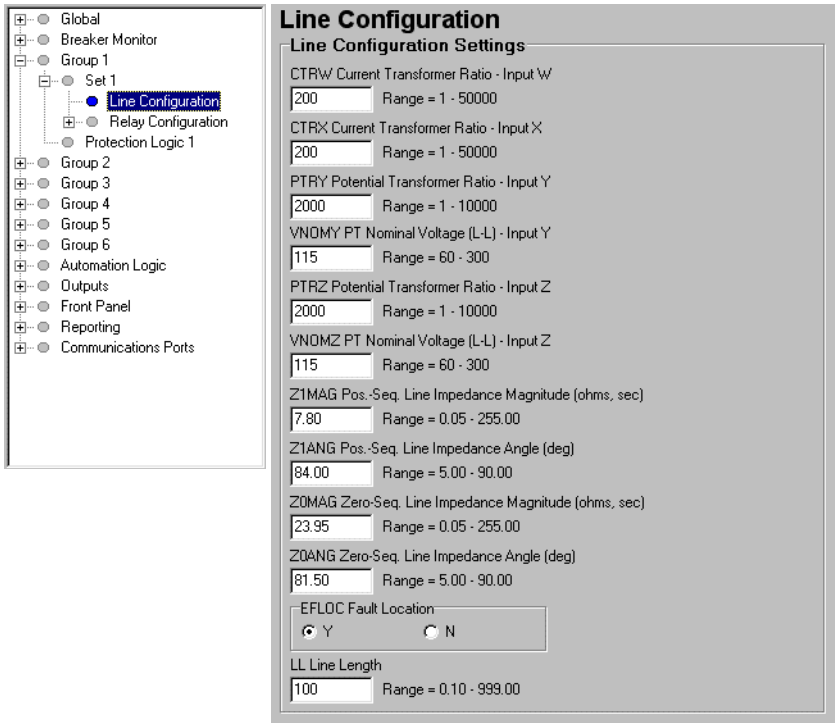

Figure 4.27 Group 1 Terminal Configuration Settings: ACSELERATOR Software.

Step 6. Start the ACSELERATOR software operator interface. In the top toolbar HMI menu, click Meter and Control.

Step 7. View phasors. Click the Phasors button of the HMI tree view. See *Figure 4.28*. The ACSELERATOR software displays fundamental line metering quantities with a display similar to *Figure 4.29*. (The test setup is adjusted for an approximately 30-degree lagging current.)

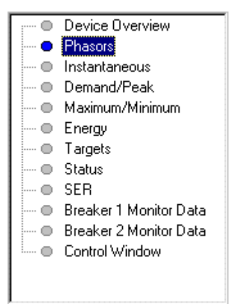

Figure 4.28 HMI Tree View: ACSELERATOR Software.

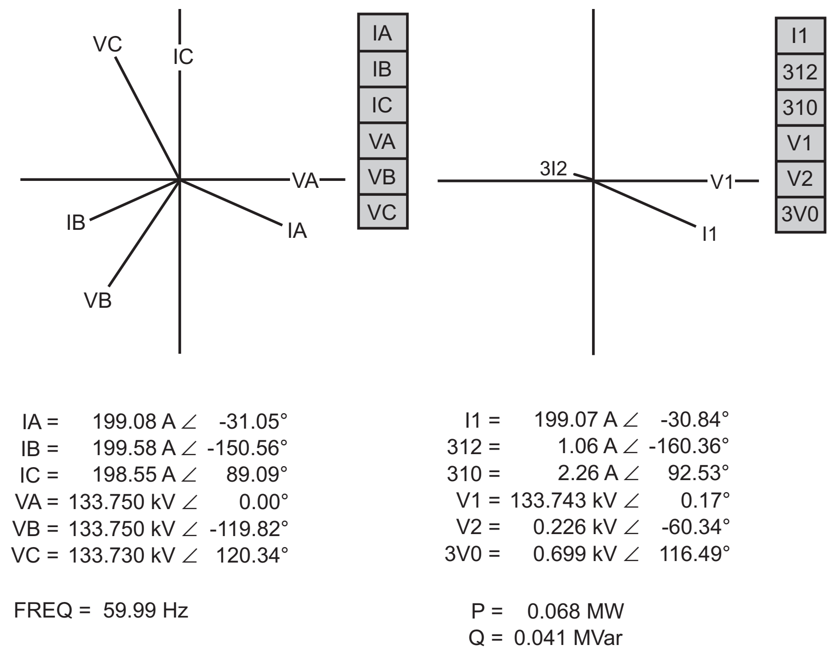

Figure 4.29 Phasor Metering Quantities: ACSELERATOR HMI.

Step 8. View metering data. Click the Instantaneous button of the HMI tree view to see metering information similar to the terminal display of *Figure 4.25*.

View Metering: Front Panel

You can use the front-panel display and navigation pushbuttons to view the metering quantities of the SEL-421 Relay. See *METER on page U.5.11 in the User's Guide* for more information on viewing metering on the relay front panel. The screens in this procedure are for one circuit breaker, and this example assumes that you have not enabled the demand metering and synchronism check features.

Step 1. Prepare to use the front panel. After applying power to the relay, note that the LCD shows a sequence of screens called the ROTATING DISPLAY. (If you do not operate the front panel for a certain period, the relay will enter front-panel time-out mode and you will see the sequential screens of the ROTATING DISPLAY.)

Step 2. View the MAIN MENU. Press the **{ENT}** pushbutton to display the MAIN MENU at the top of *Figure 4.30*.

Step 3. View the metering selection screen. Highlight the METER action item (see the first screen of *Figure 4.30*). Press the **{ENT}** pushbutton. The relay displays the METER submenu (the second screen in *Figure 4.30*).

Step 4. View the metering screens. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the FUNDAMENTAL METER action item (See *Figure 4.30*, middle screen). Press the **{ENT}** pushbutton. The relay displays the first FUNDAMENTAL METER screen (the third screen of *Figure 4.30*). Use the **{Up}** and **{Down}** arrow navigation pushbuttons to move among the fundamental line quantities metering screens.

Step 5. Normalize the front-panel display. To exit metering, press the **{ESC}** pushbutton repeatedly to return to the MAIN MENU.

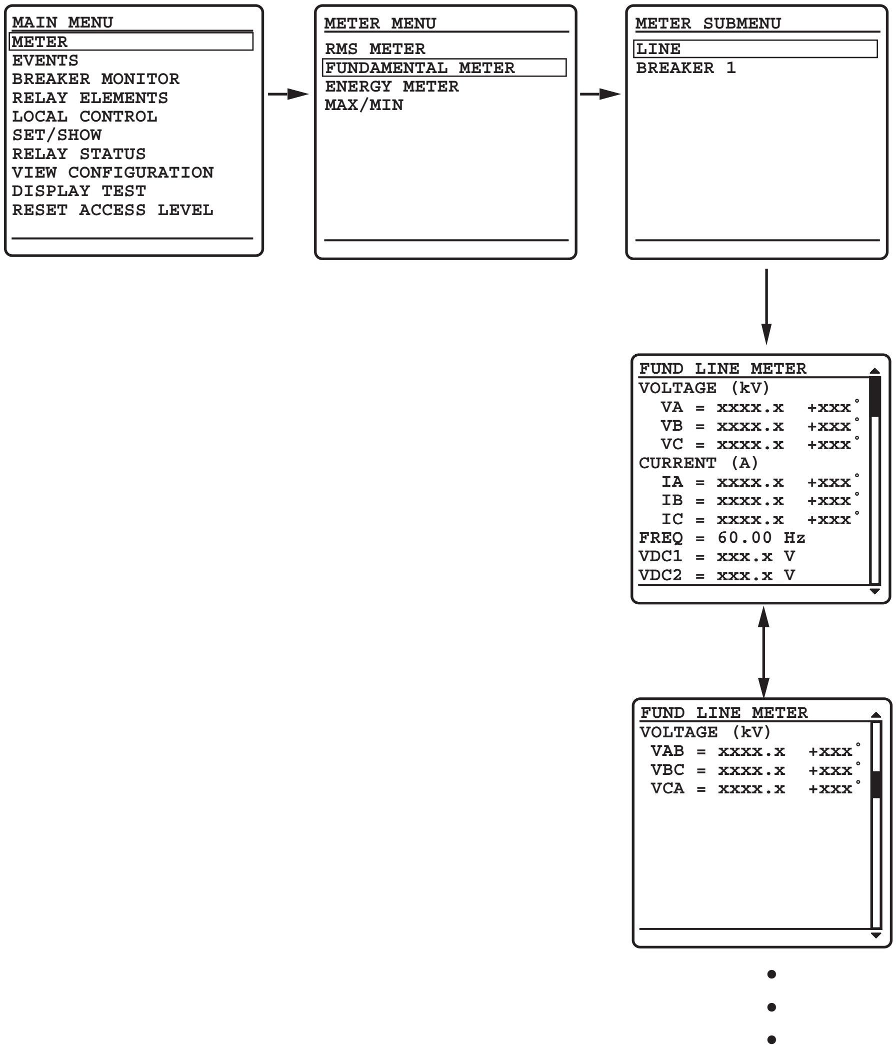

Figure 4.30 Front-Panel Screens for METER.

Reading Oscillograms, Event Reports, and SER

The SEL-421 Relay has great capabilities for storing and reporting power system events. These include high-resolution oscillography with sampling as high as 8 kHz, event reports that encompass important variables in the power system, and the SER that reports changing power system conditions and relay operating states.

You can view oscillograms taken from high-resolution raw data or from filtered event report data. Each type of presentation gives you a unique view of the power system. High-resolution oscillograms are useful for viewing system transients and dc artifacts outside the relay filter system; event report oscillograms give you a picture of the quantities that the relay used in the protection algorithms.

The examples listed in this subsection give step-by-step procedures to acquaint you with these features. *Section 3: Analyzing Data in the Applications Handbook* gives a complete discussion of these relay features.

Generating an Event

To view high-resolution raw data oscillograms and event reports, you must generate a relay event. High-resolution oscillography and event reports use the same event triggering methods. The relay uses three sources to initiate a data capture: Relay Word bit TRIP asserts, SELOGIC control equation ER (event report trigger), and the **TRI** command. (Factory default setup no longer includes the **PUL** command as an event report trigger. You can add the **PUL** command by entering the Relay Word bit TESTPUL in the ER SELOGIC control equation.) See *Test Commands on page U.6.6 in the User's Guide*.

Triggering an Event

You can use an event trigger to initiate capturing power system data. The procedure in the following steps shows how to use the ACSELERATOR HMI to generate the **TRI** command, which triggers an event capture. In this example, the relay uses default parameters to record the event. These parameters are at a sampling rate (SRATE) of 2000 samples per second (2 kHz), a pretrigger or prefault recording length (PRE) of 0.1 seconds, and an event report length (LER) of 0.5 seconds. See *Duration of Data Captures and Event Reports on page A.3.6 in the Applications Handbook* for complete information on changing these default settings to match your application.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Checking Relay Status: ACSELERATOR Software on page 4.12* and *Section 3: PC Software in the User's Guide*. In addition, you should perform *View Metering: Terminal on page 4.31* to connect secondary test voltages and currents, and to set the relay to meter these quantities correctly.

Step 1. Connect voltage and current sources to the relay secondary voltage and secondary current inputs. Use the connections of *View Metering: Terminal on page 4.31* and *Figure 4.23* or *Figure 4.24*.

Step 2. Apply power to the relay and establish communication. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 3. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 4. Start the ACSELERATOR software operator interface. In the top toolbar HMI menu, click Meter and Control.

Step 5. View the Control Window. Click the Control Window button of the HMI tree view. See *Figure 4.31*. The ACSELERATOR software displays the Control Window similar to that in *Figure 4.32*.

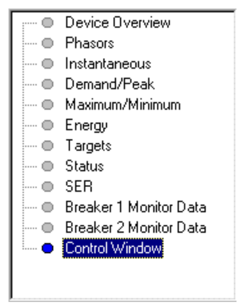

Figure 4.31 ACSELERATOR HMI Tree View.

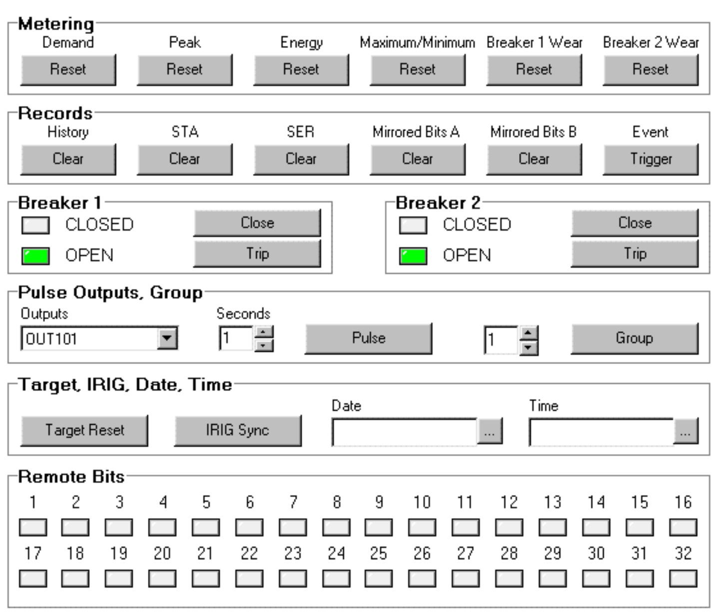

Figure 4.32 ACSELERATOR HMI Control Window.

Step 6. Trigger an event. Click the Event Trigger box. The ACSELERATOR software displays a prompt in a dialog box similar to that in *Figure 4.33*. Click Yes to trigger an event.

Figure 4.33 Event Trigger Prompt: ACSELERATOR Software.

Reading the Event History

The SEL-421 Relay has two convenient methods for checking whether you successfully captured power system data. You can view the event history data with the ACSELERATOR software, or you can examine internal relay file folders for the recorded data.

Reading the Event History: ACSELERATOR Software

The procedure in the following steps shows how to use the ACSELERATOR HMI to gather relay event history information. See *Event History on page A.3.31 in the Applications Handbook* for more information on event history.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Checking Relay Status: ACSELERATOR Software on page 4.12* and *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm that you have loaded the correct passwords in the ACSELERATOR software. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. View the event history report. Open the ACSELERATOR Analysis menu and click Read History. You will see the Relay Event History dialog box similar to that in *Figure 4.34*.

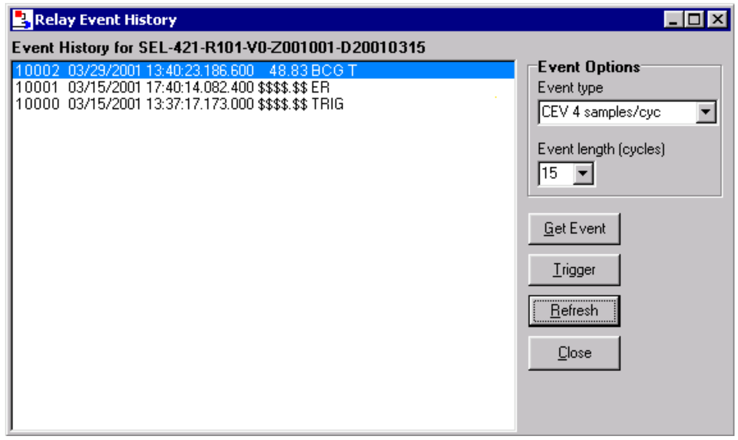

Figure 4.34 Relay Event History Dialog Box.

Reading the Event History: Terminal

The procedure in the following steps shows how to use the SEL-421 Relay file structure to confirm that you captured power system data with an event trigger. This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.

Step 2. Examine the event history. Type **HIS<Enter>**. You will see a screen display similar to *Figure 4.35 on page 4.42*.

```
=>>HIS<Enter>

RELAY 1                          Date: 05/25/2001 Time: 21:12:16.974
Station A                        Serial Number: 2001001234
#      DATE       TIME           EVENT    LOCAT   CURR GRP   TARGETS
10134 05/25/2001 21:10:56.948 ABC T   20.56   1998   1    INST ZONE_1A_PHASE
10133 05/25/2001 21:10:41.715 ABC T   20.55   1998   1    INST ZONE_1A_PHASE
10132 05/25/2001 21:10:35.482 ABC T   20.56   1997   1    INST ZONE_1A_PHASE
=>>
```

Figure 4.35 Sample HIS Command Output: Terminal.

For more information on the event history, see *Event History on page A.3.31 in the Applications Handbook*.

Viewing High-Resolution Oscillograms

Once you have successfully generated an event, you can view high-resolution oscillograms and event report oscillograms about this event. When gathered from a field-installed relay, this information helps you assess power system operating conditions. In addition, when you first install the relay, this reporting information helps you confirm that you have connected the relay correctly.

The SEL-421 Relay outputs high-resolution oscillography data in the binary COMTRADE file format (*IEEE/ANSI standard C37.111-1999*). File transfer is the only mechanism for retrieving high-resolution COMTRADE data from the relay. The SEL-5601 Analytic Assistant is a program you can use to view COMTRADE data. Many third-party software suppliers can provide you with programs to display and manipulate COMTRADE files.

Retrieving High-Resolution COMTRADE Data: Terminal

The relay recorded the event triggered in *Triggering an Event on page 4.39*. The procedure in the following steps shows you how to retrieve the high-resolution raw oscillography data for this event. Perform the steps listed in *Triggering an Event on page 4.39* before executing the instructions in this example. For this procedure, you must use a communications terminal emulation computer program capable of file transfers (this function is not available in the ACSELERATOR software). If you need help finding a terminal emulation program, please contact the SEL factory or your local Technical Service Center.

Step 1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.

Step 2. View the events file directory. Type **FILE DIR EVENTS <Enter>** to view the contents of the SEL-421 Relay events file directory. The relay lists file names for recently recorded events in a manner similar to that shown in *Figure 4.36 on page 4.43*. The relay shows three high-resolution oscillography files with the file extensions .HDR, .CFG, and .DAT for each event. This procedure uses HR_10001 as the number of the event that you recently triggered; use the event number corresponding to your triggered event.

```
=>>FILE DIR EVENTS<Enter>

CHISTORY.TXT                 RW
HISTORY.TXT                  RW
C4_10001.TXT                 RW          03/15/2001      00:25:45.384
C8_10001.TXT                 RW          03/15/2001      00:25:45.384
E4_10001.TXT                 RW          03/15/2001      00:25:45.384
E8_10001.TXT                 RW          03/15/2001      00:25:45.384
HR_10001.HDR                 RW          03/15/2001      00:25:45.384
HR_10001.CFG                 RW          03/15/2001      00:25:45.384
HR_10001.DAT                 RW          03/15/2001      00:25:45.384
=>>
```

Figure 4.36 EVENTS Folder Files.

Step 3. Prepare the relay to download the high-resolution oscillography files. Type **FILE READ EVENTS HR_10001.*<Enter>** to ready the relay to transfer the HR_10001.HDR, HR_10001.CFG, and HR_10001.DAT files to your computer.

Step 4. Download the files. Perform the steps necessary for your terminal emulation program to receive a file. Typically, these are the file transfer steps:

- Specify the destination file location in your computer file storage system and file name.
- Select the transfer type as Y-Modem (if this transfer type is not already enabled).
- Click on Receive.

You will usually see a confirmation message when the file transfer is complete. When these files have transferred successfully, you have the entire COMTRADE file for the high-resolution raw data capture.

Step 5. Analyze the data. Use the SEL-5601 Analytic Assistant, SEL-5030 ACSELERATOR Software Program, or other COMTRADE-capable programs to play back high-resolution raw data oscillograms of the high-resolution raw data capture files you just transferred.

Retrieving High Resolution COMTRADE Data: ACSELERATOR Software

The procedure in the following steps shows how to use the ACSELERATOR software to view the event that you triggered in *Triggering an Event on page 4.39*. You can use this procedure to view other events stored in the SEL-421 Relay.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Checking Relay Status: ACSELERATOR Software on page 4.12* and *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. View the Event History. Open the ACSELERATOR software Analysis menu and click Read History. You will see the Relay Event History dialog box similar to that shown in *Figure 4.37*.

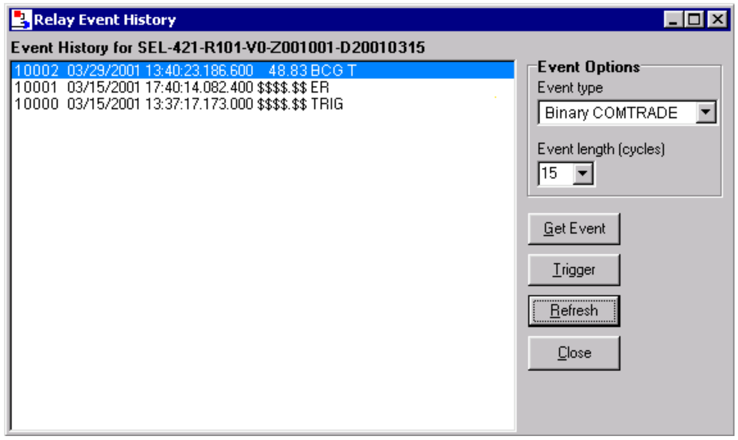

Figure 4.37 Relay Event History Dialog Box in the ACSELERATOR Software.

Step 4. Get the event. Select Binary COMTRADE in the Event Type dialog box. Highlight the event you want to view and click the Get Event button. The relay saves the .HDR, .CFG, and .DAT files in the ACSELERATOR 421\EVENTS\ directory with the HR_nnnnn file prefix (nnnnn represents the event number). The ACSELERATOR software then presents the Event Waveform window similar to that in *Figure 4.38* and the sample event oscillogram of *Figure 4.39*.

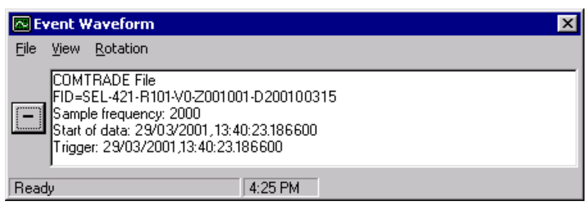

Figure 4.38 ACSELERATOR Event Waveform Window.

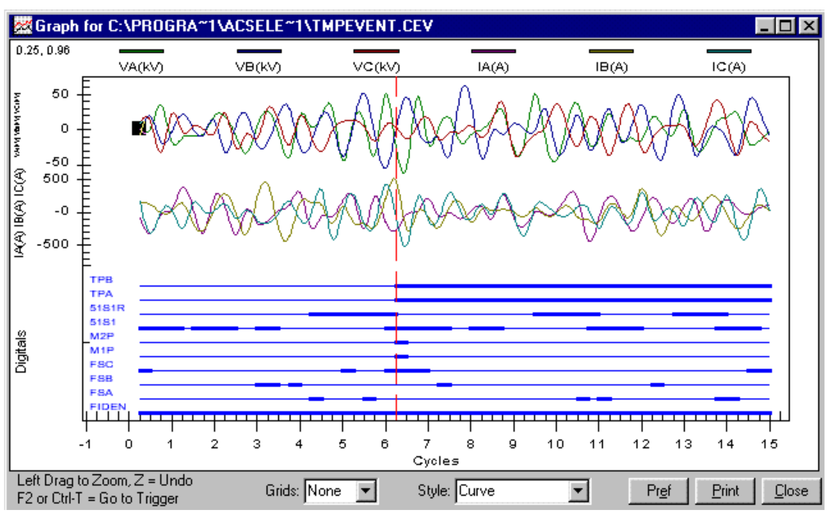

Figure 4.39 Sample Event Oscillogram.

You can also examine a phasors display, an event harmonic analysis display, and the event summary from the Event Waveform View menu. See *Analyze Events on page U.3.15 in the User's Guide* and *Section 3: Analyzing Data in the Applications Handbook* for more information.

Viewing Event Report Data

Examine relay event reports to inspect the operating quantities the SEL-421 Relay used at each triggered event. Unlike the raw data samples/second high-resolution oscillography files, these reports contain the filtered samples/cycle data the relay uses to make protection decisions. Event reports are useful for determining why the relay operated for a particular set of power system conditions. For more information on event reports, see *Event Report on page A.3.12 in the Applications Handbook*.

Retrieving Event Report Data Files: Terminal

The relay recorded the event triggered in *Triggering an Event on page 4.39*. The procedure in the following steps shows you how to retrieve the event report data files for this event. Perform the steps listed in *Triggering an Event on page 4.39* before executing the instructions in this example. For this procedure, you must use a terminal program capable of Ymodem protocol file transfer.

Step 1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.

Step 2. View the events file directory. Type **FILE DIR EVENTS <Enter>.** The relay lists file names for recently recorded events in a manner similar to that shown in *Figure 4.36 on page 4.43*. In the figure, the relay shows two event report files: E4_10001.TXT and E8_10001.TXT, and two Compressed ASCII event report files: C4_10001.TXT and C8_10001.TXT.

Step 3. Prepare the relay to download the 8-samples/cycle event report. Type **FILE READ EVENTS C8_10001.TXT<Enter>** to transfer the Compressed ASCII event report file to your computer.

Step 4. Download the file. Perform the steps necessary for your terminal emulation program to receive a file. Typically, these are the file transfer steps:

- ➢ Specify the destination file location in your computer file storage system and file name.
- ➢ Select the transfer type as Y-Modem (if not already enabled).
- ➢ Click on Receive.
- ➢ You will usually see a confirmation message when the file transfer is complete.

Step 5. When this file has transferred successfully, use the SEL-5601 Analytic Assistant to play back the event report oscillograms of the 8-samples/cycle event report file you just transferred.

Use the ASCII command **CEVENT** to retrieve event report files in Compressed ASCII format. See *SEL Compressed ASCII Commands on page R.5.6 in the Reference Manual* and *CEVENT on page R.8.5 in the Reference Manual* for more information.

Viewing SER Records

The relay SER records relay operating changes and relay element states. In response to an element change of state, the SER logs the element, the element state, and a time stamp. Program the relay elements that the relay stores in the SER records, thus capturing significant system events such as an input/output change of state, element pickup/dropout, recloser state changes, etc. The

SEL-421 Relay stores the latest 1000 entries to a nonvolatile record. Use the relay communications ports or the ACSELERATOR software to view the SER records. For more information on the SER, see *Section 3: Analyzing Data in the Applications Handbook*.

Setting the SER and Examining an SER Record: ACSELERATOR Software

The procedure in the following steps shows you how to use the ACSELERATOR software to program relay elements into the SER. Also, use these procedures to review SER records with the ACSELERATOR software.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Read the present configuration of the SEL-421 Relay. Download the present configuration in the SEL-421 Relay by opening the Settings menu, then click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. View the SER settings entry screen. Click on the Report branch of the ACSELERATOR Settings tree view structure (See *Figure 4.40*). You will see the SER Points and Aliases window similar to *Figure 4.41*.

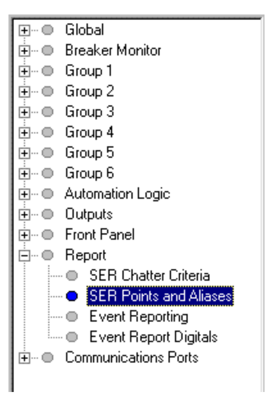

Figure 4.40 Selecting SER Points and Aliases Settings: ACSELERATOR Software.

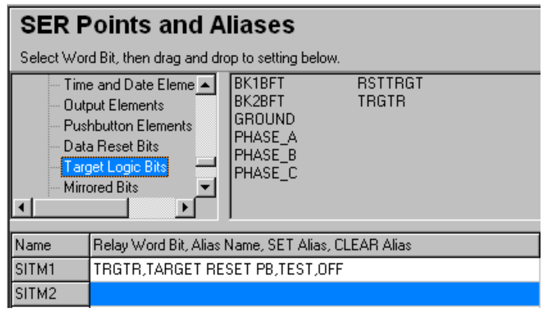

Figure 4.41 SER Points and Aliases Settings: ACSELERATOR Software.

Step 5. Enter SER trigger settings. For this example, select Target Logic Bits in the Relay Word bits list (See *Figure 4.41*). Click and drag the TRGTR Relay Word bit to the SER Points and Aliases text box for Element Name 1 (labeled SITM1). If you want the relay to display an alias for the element, enter an alias name of 20 or fewer characters following the comma after TRGTR. For this example, type **TARGET RESET PB**. Similarly, type **,TEST,OFF** to enter a Set Alias and a Clear Alias. Click in any other row or push Tab; the ACSELERATOR software validates your entry. You can enter as many as 250 relay elements in the SER Points and Aliases list.

Step 6. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 7. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the first dialog box of *Figure 4.42*. Click the check box for Report. Click OK. The ACSELERATOR software responds with the second dialog box of *Figure 4.42*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 4.42 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

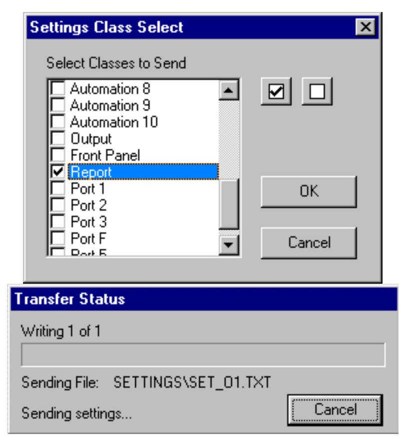

Figure 4.42 Uploading Report Settings to the SEL-421 Relay.

Step 8. Generate an SER record. Press and release the front-panel **{TARGET RESET}** pushbutton.

Step 9. View the SER report. Start the ACSELERATOR software operator interface. In the top toolbar HMI menu, click Meter and Control. Click the SER button of the HMI tree view. See *Figure 4.43*. The ACSELERATOR software displays the SER records with a display similar to *Figure 4.44*.

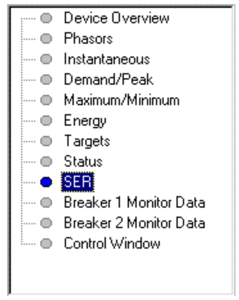

Figure 4.43 Retrieving SER Records With the ACSELERATOR Software.

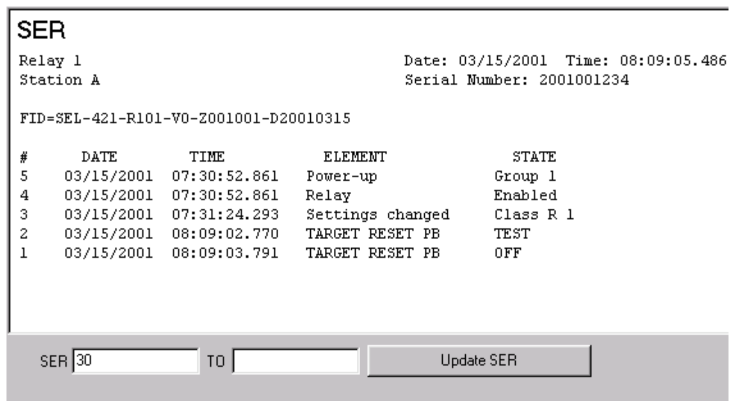

Figure 4.44 SER Records in the ACSELERATOR HMI.

The relay lists the SER records in chronological order from top to bottom as shown in *Figure 4.44*. In addition, the relay numbers each record with the most recent record as number 1; new events are usually more important for determining the effects of recently occurring power system events. For each application of power to the relay, the SER reports a “Power-up” indication and the active settings group (Group 1 in *Figure 4.44*). A properly operating relay immediately goes to the enabled state, an event that causes the SER to report another SER record. The SER reports the TARGET RESET button when you first press the pushbutton. When you release the pushbutton, the SER records the pushbutton release. For more information on the Sequential Events Recorder, see *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook*.

Setting the SER and Examining the SER Record: Terminal

The procedure in the following steps shows how to use a terminal connected to an SEL-421 Relay communications port to set an element in the SER. Use text edit mode line editing to enter the SER settings; see *Text-Edit Mode Line Editing on page 4.21*. Also included is a procedure for viewing the SER report with a terminal. For more information on the SER, see *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook*.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the =>

action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Enter SER trigger data. Type **SET R TERSE<Enter>** to access the Report settings (See *Figure 4.45*). Type **<Enter>** to move past the SER Chatter Criteria setting. At the SER Points and Aliases action prompt line, type **TRGTR,“TARGET RESET PB”,TEST,OFF<Enter>**. At the next line, type **END<Enter>**. The relay prompts you to save the new setting; type **Y<Enter>**.

```
=>>SET R TERSE<Enter>

Report
SER Chatter Criteria
Automatic Removal of Chattering SER Points (Y,N)   ESERDEL := N   ?<Enter>


SER Points and Aliases
(Relay Word Bit, Alias Name, Alias for Set State, Alias for Clear State)

1:
? TRGTR,"TARGET RESET PB",TEST,OFF
2:
? END<Enter>

Save settings (Y,N) ?Y<Enter>
Saving Settings, Please Wait..........
Settings Saved
=>>
```

Figure 4.45 Setting an SER Element: Terminal.

Step 3. Generate an SER record. Press and release the front-panel **{TARGET RESET}** pushbutton.

Step 4. View the SER report. Type **SER<Enter>** (at the Access Level 1 prompt or higher). The relay presents a screen similar to the SER display of *Figure 4.44*.

Downloading an SER Report File

The procedure in the following steps shows you how to retrieve the SER report stored in the relay as a file. For this procedure you must use a terminal emulation program with file transfer capability. For more information on the SER, see *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook*.

Step 1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.

Step 2. View the events file directory. Type **FILE DIR REPORTS <Enter>.** The terminal lists the file names for standard reports as shown in *Figure 4.46*.

Step 3. Prepare the relay to download SER report. Type **FILE READ REPORTS SER.TXT<Enter>**. If you want the Compressed ASCII file, type **FILE READ REPORTS CSER.TXT<Enter>**.

```
=>FILE DIR REPORTS <ENTER>

BRE_1.TXT                         R
BRE_2.TXT                         R
BRE_S1.TXT                        R
BRE_S2.TXT                        R
CBRE.TXT                          R
CHISTORY.TXT                      R
CSER.TXT                          R
HISTORY.TXT                       R
SER.TXT                           R
=>
```

Figure 4.46 Reports File Structure.

Step 4. Download the SER report. Perform the steps necessary for your terminal emulation program to receive a file. Typically, these are the file transfer steps:

- ➢ Specify the destination file location in your computer file storage system and file name.
- ➢ Select the transfer type as Y-Modem (if not already enabled).
- ➢ Click on Receive.

You will usually see a confirmation message when the file transfer is complete.

Step 5. Confirm a successful download. When the SER.TXT file has transferred successfully, use a word-processing program to view the contents of the file. You will see the SER records in a format similar to *Figure 4.44*. The CSER.TXT file viewed with a word-processing program is similar to the example in CSER, SER (Sequential Events Recorder), in *CSER on page A.3.35 in the Applications Handbook*.

Operating the Relay Inputs and Outputs

The SEL-421 Relay gives you great ability to perform control actions at bay and substation locations via the relay control outputs. The control outputs close and open circuit breakers, switch disconnects, and operate auxiliary station equipment such as fans and lights. The relay reads data from the power system and interfaces with external signals (contact closures and data) through the control inputs. This subsection is an introduction to operating the SEL-421 Relay control outputs and control inputs. For more information on connecting and applying the control outputs and control inputs, see *Section 2: Installation in the User's Guide*.

Control Output

The SEL-421 Relay features Standard, Hybrid (High-Current Interrupting), and Fast Hybrid (Fast High-Current Interrupting) control outputs that you can use to control circuit breakers and other devices in an equipment bay or substation control house. See *Control Outputs on page U.2.6 in the User's Guide* for more information on control outputs.

Pulsing a Control Output: Terminal

When first connecting the relay, or at any time that you want to test relay control outputs, perform the following procedure. The procedure in the following steps shows how to use a communications terminal to pulse the control output contacts. Perform the steps in this example to become familiar with relay control and serial communication. For more information on the **PULSE** command, see *PULSE on page R.8.36 in the Reference Manual*.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

NOTE: To PULSE an output, the circuit breaker control enable jumper, J18C, must be installed on the main board.

Step 1. Prepare to control the relay at Access Level B. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **BAC<Enter>** command, and then type the correct password to go to Access Level B. You will see the ==> action prompt.

Step 2. Connect an output monitor. Attach an indicating device (ohmmeter with a beep sounder or a test set) to the terminals for control output OUT104. This output is a Standard control output and is not polarity sensitive. For more information on connecting control outputs, see *Control Outputs on page U.2.6 in the User's Guide*.

Step 3. Perform the pulse operation. Type **PULSE OUT104<Enter>**. The relay confirms your request to pulse an output with a prompt such as that shown in *Figure 4.47*. Type **Y<Enter>** at the prompt. You will see or hear the indicating device turn on for a second and then turn off.

```
==>PULSE OUT104 <Enter>

Pulse contact OUT104 for 1 seconds(Y/N)    ?Y<Enter>
==>
```

Figure 4.47 Terminal Display for PULSE Command.

You can also pulse an output for longer than the default 1-second period. If you enter a number after the PULSE command, that number specifies the duration in seconds for the pulse. For example, if you enter **PULSE OUT104 3<Enter>**, the relay pulses OUT104 for 3 seconds.

Pulsing a Control Output: Front Panel

The procedure in the following steps shows you how to use the front-panel display and navigation pushbuttons to check for proper operation of the SEL-421 Relay control outputs. See *Section 5: Front-Panel Operations in the User's Guide* for information on using the relay front panel.

Step 1. Connect an output monitor. Attach an indicating device (an ohmmeter with a beep sounder or a test set) to the terminals for control output OUT104. This output is a Standard control output and is not polarity sensitive. For more information on connecting control outputs, see *Control Outputs on page U.2.6 in the User's Guide*.

Step 2. View the front-panel display. After applying power to the relay, note that the LCD shows a sequence of screens called the ROTATING DISPLAY. (Also, if you do not operate the front panel for a certain period, the relay will enter front-panel time-out mode and you will see the sequential screens of the ROTATING DISPLAY.)

Step 3. View the MAIN MENU. Press the **{ENT}** pushbutton to cause the relay to display a MAIN MENU similar to that at the top of *Figure 4.48*.

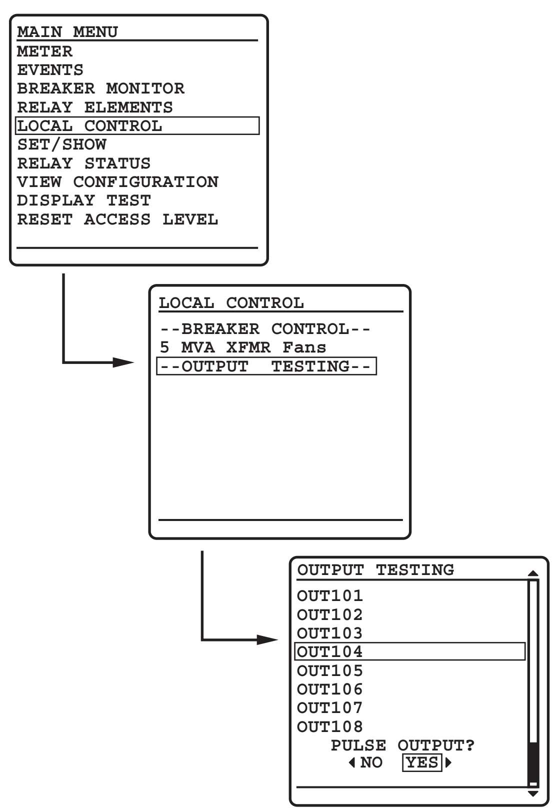

Figure 4.48 Front-Panel Menus for Pulsing OUT104.

Step 4. View the local control screen. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the LOCAL CONTROL action item (See *Figure 4.48*). Press the **{ENT}** pushbutton. You will see the LOCAL CONTROL submenu (the middle screen in *Figure 4.48*).

Step 5. View the output testing screen. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight the --OUTPUT TESTING-- action item (See *Figure 4.48*, middle screen). Press the **{ENT}** pushbutton. The relay next displays the OUTPUT TESTING submenu (the last screen of *Figure 4.48*).

Step 6. Command the relay to pulse the control output. Press the **{Up}** and **{Down}** arrow navigation pushbuttons to highlight OUT104 (See *Figure 4.48*, last screen). Press the **{RIGHT}** arrow navigation pushbutton to highlight YES under “PULSE OUTPUT?” Press the **{ENT}** pushbutton. The relay detects your request for a function at an access level for which you do not yet have authorization. Whenever this condition occurs, the relay displays the password access screen of *Figure 4.49*.

```
PASSWORD REQUIRED
█
A B C D E F G H
I J K L M N O P
Q R S T U V W X
Y Z a b c d e f
g h i j k l m n
o p q r s t u v
w x y z 0 1 2 3
4 5 6 7 8 9 _ .
ACCEPT  BACKSPACE
```

Figure 4.49 Password Entry Screen.

Step 7. Input a password and pulse the output. Enter a valid Access Level B, P, A, O, or 2 password. (The front panel is always at Access Level 1, so you do not enter the Access Level 1 password.) Enter a valid password by using the navigation pushbuttons to select, in sequence, the alphanumeric characters that correspond to your password. Press the **{ENT}** pushbutton at each password character. (If you make a mistake, highlight the BACKSPACE option and press **{ENT}** to reenter a character or characters.) After entering all password characters, press the **{Up}** arrow or **{Down}** arrow pushbuttons to highlight ACCEPT, and press **{ENT}**. The relay pulses the output, and you will see the indicating device turn on for a second and then turn off.

Controlling a Relay Control Output With a Local Bit: Terminal

In this example, you set Local Bit 3 to start the transformer cooling fans near the breaker bay where you have installed the SEL-421 Relay. Thus, you can use the LCD screen and navigation pushbuttons to toggle relay Local Bit 3 to control the state of the cooling fans. For more information on local bits, see *Local Control Bits on page U.5.18 in the User’s Guide*.

The procedure in the following steps proposes connecting the transformer bank fan control to relay output OUT105. You can choose any relay output that conforms to your requirements. See *Control Outputs on page U.2.6 in the User’s Guide* for more information on SEL-421 Relay control outputs.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Access the local control settings. Type **SET F <Enter>** command. Repeatedly type **>** and then **<Enter>** to advance through the front-panel settings until you reach the Display Points and Aliases category. Press **<Enter>** to access the Control Points and Aliases Category. *Figure 4.50* shows a representative terminal screen.

```
Control Points and Aliases
(Local Bit, Alias Name, Alias for Set State, Alias for Clear State,
Pulse Enable)
 1:
? LIST<Enter>

1:
? LB03,"5 MVA XFMR Fans","ON","OFF",N<Enter>
2:
? END<Enter>
              .
              .
              .

Control Points and Aliases
(Local Bit, Alias Name, Alias for Set State, Alias for Clear State,
Pulse Enable)

1: LB03,"5 MVA XMFR Fans","ON","OFF",N

Save settings (Y,N) ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
 =>>
```

Figure 4.50 Using Text-Edit Mode Line Editing to Set Local Bit 3.

Step 3. List the active control points. Type **LIST<Enter>** at the Local Control and Aliases prompt, This example assumes that you are using no local bits, so the relay returns you to line “1:” followed by the “?” settings action prompt.

Step 4. Create Local Bit 3. Type **LB03,“5 MVA XFMR Fans”,“ON”,“OFF”,N<Enter>** at the line 1 prompt:

1: **LB03,“5 MVA XFMR Fans”,“ON”,“OFF”,N<Enter>**

The relay checks that this is a valid entry and responds with the next line prompt “2:” followed by the “?” settings action prompt.

Step 5. End the settings session. Type **END<Enter>**. The relay scrolls a readback of all the front-panel settings, eventually displaying the “Save settings (Y,N) ?” prompt. (In *Figure 4.50* a vertical ellipsis represents the readback.) At the end of the readback information, just before the “Save settings (Y,N) ?” prompt, you can see the new local bit information. Answer **Y<Enter>** to save your new settings.

Step 6. Set OUT105 to respond to Local Bit 3. Type **SET O OUT105<Enter>** (See *Figure 4.51*). At the ? action prompt, type **LB03<Enter>**. At the next ? action prompt, type **END<Enter>**. When prompted to save settings, answer **Y<Enter>**.

```
=>>SET O OUT105<Enter>
Output

Main Board

OUT105 :== NA
? LB03<Enter>

OUT106 := NA

? END<Enter>
Output

Main Board

OUT101 := 3PT AND NOT PLT04
OUT102 := 3PT AND NOT PLT04
OUT103 := BK1 CL AND NOT PLT04
OUT104 := KEY AND PLT02 AND NOT PLT04
OUT105 := LB03
OUT106 := NA
OUT107 := PLT04
OUT108 := NOT (HALARM OR SALARM)

Save settings (Y,N) ?Y<Enter>
Saving Settings, Please Wait..........
Settings Saved
=>>
```

Figure 4.51 Setting Control Output OUT105: Terminal.

Step 7. Test the connection and programming. Use the appropriate interface hardware to connect the fan control start circuit to OUT105. At the relay front-panel MAIN MENU, select LOCAL CONTROL and press the **{ENT}** pushbutton (See *Figure 4.52*). Select 5 MVA XFMR Fans on the LOCAL CONTROL screen as shown in *Figure 4.52*. Press **{ENT}** to see the last screen of *Figure 4.52*. Highlight “1 ON” and press **{ENT}**. The graphical local control handle moves to the 1 position. At this time, the transformer fans will begin running.

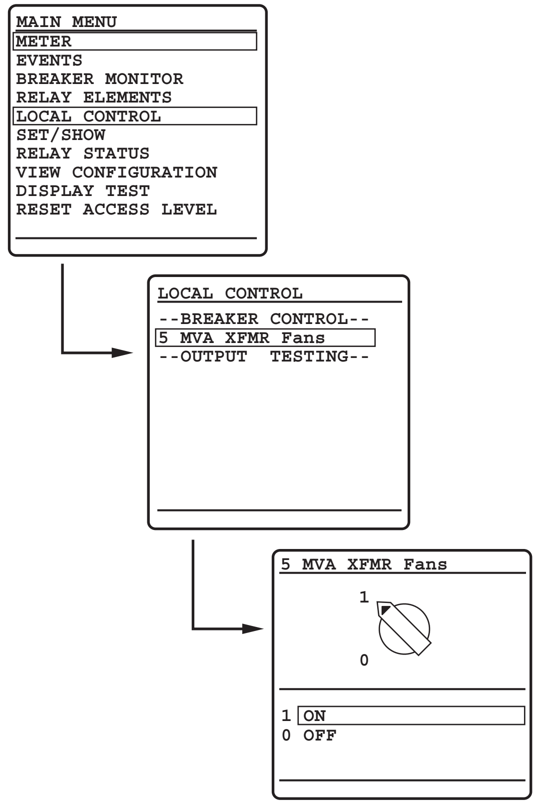

Figure 4.52 Front-Panel LOCAL CONTROL Screens.

Setting Outputs for Tripping and Closing

To actuate power system circuit breakers, you must configure the SEL-421 Relay control outputs to operate the trip bus and close bus. The relay uses internal logic and SELOGIC control equations to activate the control outputs.

Trip Output Signals

The SEL-421 Relay is capable of single-pole tripping and three-pole tripping. There are many Relay Word bits (e.g., TPA1, TPA2, RTA1, and 3PT) that you can program to drive control outputs to trip circuit breakers. See *Section 1: Protection Functions in the Reference Manual* for complete information on tripping equations and settings. For target illumination at tripping, see *Section 5: Front-Panel Operations in the User's Guide*.

Close Output Signals

The SEL-421 Relay features an automatic recloser for single circuit breaker and two circuit breaker applications. The relay provides as many as two single-pole and four three-pole reclose shots. See *Section 2: Auto-Reclose and Synchronism Check in the Reference Manual* for more information. Close the circuit breakers using Relay Word bits BK1CLS and BK2CLS for Circuit Breaker 1 and Circuit Breaker 2, respectively.

Assigning Control Outputs for Tripping and Closing

The procedure in the following steps shows a method for setting the relay to operate the trip bus and the close bus at a typical substation. Relay factory defaults assign control outputs OUT101 and OUT102 to the trip bus and OUT103 to the close bus for a three-pole tripping circuit breaker. This procedure assigns an additional close output at OUT106.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. Access the Main Board output settings. Expand the Outputs branch of the Settings tree view. Click on Main Board (See *Figure 4.53*).

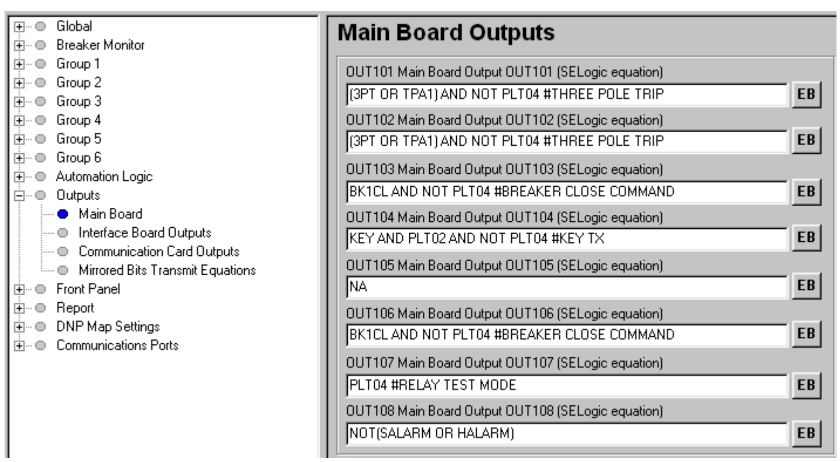

Figure 4.53 Assigning an Additional Close Output: ACSELERATOR Software.

Step 5. Assign a control output for the close bus. In the Main Board Outputs dialog box click in the OUT106 text box and type **BK1CL AND NOT PLT04#BREAKER CLOSE COMMAND**. (The # indicates that a comment follows.) Click or tab to another text box. The ACSELERATOR software checks that your entry is valid.

Step 6. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 7. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class or instance you want to send to the relay. Click the check box for Outputs as shown in the first dialog box of *Figure 4.54*. Click OK. The ACSELERATOR software responds with the second dialog box of *Figure 4.54*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 4.54 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

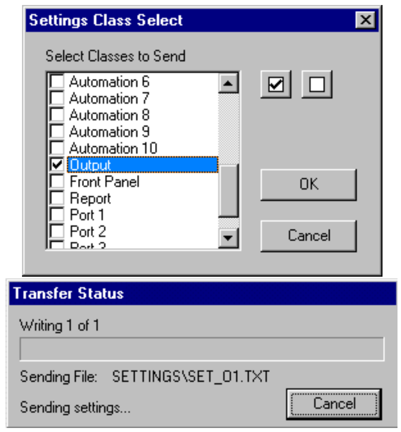

Figure 4.54 Uploading Output Settings to the SEL-421 Relay.

Control Input Assignment

The SEL-421 Relay features high-isolation direct connection control inputs that the relay uses to detect contact closures and signal level changes in an equipment bay or substation control house. See *Control Inputs on page U.2.6 in the User's Guide* for more information on control inputs.

If all of the control inputs share common signal properties of assertion level, debounce time, and dropout or deassertion level, you can enter these settings for all inputs. These settings are **GINP**, **GIND**, and **GINDF** for global input pickup level, global input debounce, and global input dropout (hysteresis) factor, respectively. See *Global Settings on page R.9.3 in the Reference Manual* for more information. When you enable setting EICIS (Enable Independent Control Input Settings), you can set separate specific assert/deassert levels and debounce times for control inputs that are exceptions to these global control input settings.

Setting a Control Input: Circuit Breaker Auxiliary Contacts (52A): Terminal

This is a step-by-step procedure to configure a control input that reflects the state of the circuit breaker auxiliary (52A) NO (normally open) contact. A common relay input is from circuit breaker auxiliary contacts; the relay monitors the 52A contacts to detect the closed/open status of the circuit breaker. Perform the following steps to connect three-pole circuit breaker auxiliary contacts to the SEL-421 Relay. This example is for a 125 Vdc system; the open state of the auxiliary contacts is 0 Vdc (circuit breaker open), and the closed state of the auxiliary contacts is approximately 125 Vdc (circuit breaker closed). The voltage drop in the connecting wires from the auxiliary contacts through the station battery to the relay gives a slightly lower voltage than the station battery at the relay control input terminals. The default value for GINP (Global Control Input Pickup Level) at 85 Vdc is sufficient.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 2. Configure the relay to read the circuit breaker auxiliary contact. Type **SET M<Enter>** (See *Figure 4.55*). These settings are the breaker monitor settings. Type **<Enter>** to bypass the Breaker 1 Monitoring enable, and **<Enter>** again to bypass the Breaker 2 Monitoring enable (NUMBK := 2 in this example). At the BK1TYP setting, type **3<Enter>** for a three-pole circuit breaker for this particular example. (Use the setting BK1TYP appropriate for your circuit breaker(s).) At the BK2TYP setting, type **3<Enter>** for a three-pole circuit breaker for this example. The relay next displays the 52AA1 SELOGIC control equation action prompt. Type **IN101<Enter>** at the ? prompt to specify input IN101 as the control input that represents the close/open state of Circuit Breaker 1. The relay next displays the 52AA2 SELOGIC control equation action prompt. Type **IN102<Enter>** at the ? prompt to specify input IN102 as the control input that represents the close/open state of Circuit Breaker 2.

Step 3. End the settings process. The relay next scrolls a readback of all the Global settings, eventually displaying the “Save settings (Y,N) ?” prompt. In the readback information, just before the “Save settings (Y,N) ?” prompt, you can confirm the new control input information. Answer **Y<Enter>** to save your new settings.

```
=>>SET M<Enter>
Breaker Monitor

Breaker Configuration

Breaker 1 Monitoring (Y,N)                          EB1MON  := N        ? <Enter>
Breaker 2 Monitoring (Y,N)                          EB2MON  := N        ? <Enter>
Breaker 1 Trip Type (Single Pole=1,Three Pole=3)    BK1TYP  := 1        ?3<Enter>
Breaker 2 Trip Type (Single Pole=1,Three Pole=3)    BK2TYP  := 1        ? 3<Enter>

Breaker 1 Inputs

N/O Contact Input -BK1 (SELogic Equation)
52AA1 := NA
?  IN101<Enter>

Breaker 2 Inputs

A-Phase N/O Contact Input -BK2 (SELogic Equation)
52AA2 := NA
?  IN102<Enter>
Breaker Monitor

Breaker Configuration

EB1MON  := N        EB2MON  := N        BK1TYP  := 3        BK2TYP  := 3

Breaker 1 Inputs

52AA1   := IN101

Breaker 2 Inputs

52AA2   := IN102

Save settings (Y,N)  ?Y<Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 4.55 Setting 52AA1: Terminal.

Setting a Control Input for Circuit Breaker Auxiliary Contacts (52A): ACSELERATOR Software

The procedure in the following steps shows how to program the SEL-421 Relay control input IN101 to read the state of circuit breaker auxiliary contacts. This example uses a single three-pole tripping breaker. Modify the procedure listed here for your application.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords. You should also be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. Access the Global Enable settings. Click on the + mark next to the Global branch of the Settings tree view. Click on the Global Settings/Enables branch of the Settings tree view. See *Figure 4.56*.

Step 5. Change settings. Set EICIS (Independent Control Input Settings) to Y by clicking the Y button.

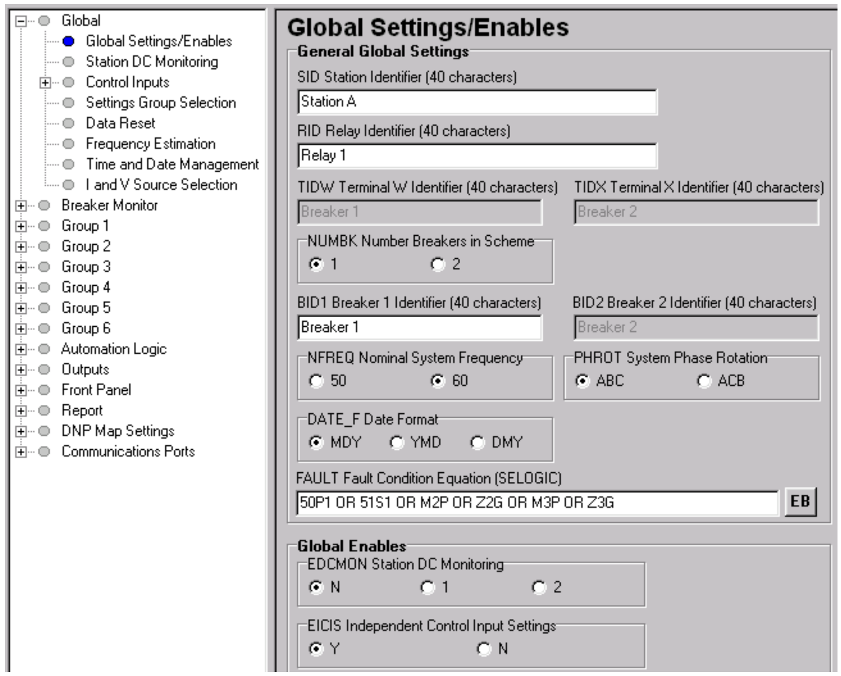

Figure 4.56 Accessing Global Enable Settings in the ACSELERATOR Software.

Step 6. Access the Control Inputs settings. In the expanded Global Settings tree view, click on the plus (+) mark next to Control Inputs. Click on Main Board. You will see the input window similar to that in *Figure 4.57*.

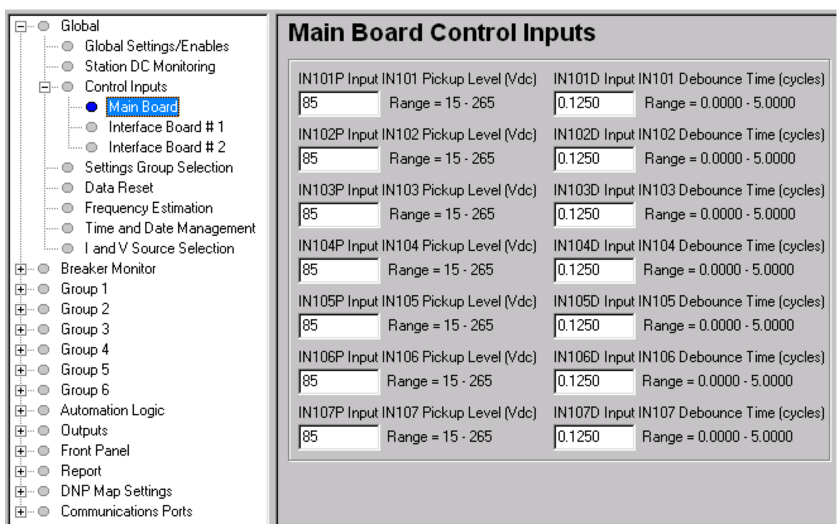

Figure 4.57 Control Input Settings in the ACSELERATOR Software.

Step 7. Set the control input IN101 debounce time. For this example, assume that the auxiliary contacts are slow and noisy; you must provide a slightly longer debounce time for these contacts. Double-click the mouse cursor (or use the Tab key) to highlight IN101D Input101 Debounce Time. Delete the present setting by using the Delete key. Type **0.25<Enter>**. The relay checks the new value and enters the value in the ACSELERATOR database.

Step 8. Set the control input IN101 pickup threshold. For this example, obtain added security by setting the threshold voltage higher than the default. Click the mouse cursor (or use the Tab key) to highlight IN101P Main Board Input 101 Assertion Level. Delete the present setting by using the Delete key. Type **100**, and then click or Tab to another value. The relay checks the new value and enters the value in the ACSELERATOR database.

Step 9. Configure the relay to read the circuit breaker auxiliary contact. Expand the Breaker Monitor branch of the Settings tree view by clicking the "+" button (See *Figure 4.58*). In the tree view, click on Breaker Monitor to select circuit breaker monitor settings for Circuit Breaker 1. At the BK1TYP setting, click 3 for the three-pole circuit breaker of this particular example. (Use the setting BK1TYP appropriate for your circuit breaker(s).) Click the Breaker 1 branch as shown in *Figure 4.59*. Set the 52AA1 SELOGIC control equation by clicking in the text box labeled N/O Contact Input –BK1. Type **IN101**, and then click or tab to another field to specify input IN101 as the control input that represents the close/open state of Circuit Breaker 1.

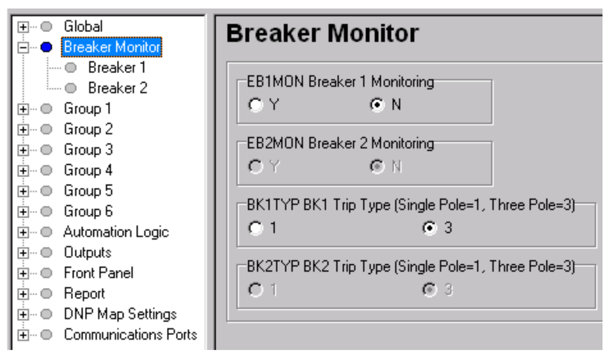

Figure 4.58 Setting BK1TYP in the ACSELERATOR Software.

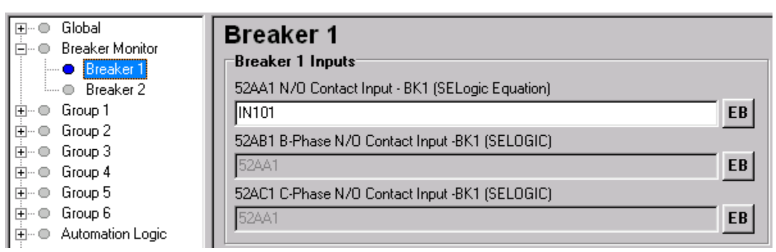

Figure 4.59 Setting 52AA1 in the ACSELERATOR Software.

Step 10. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 11. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class or instance you want to send to the relay. Click the check box for Global and the check box for Breaker Monitor, as shown in the first dialog box of *Figure 4.60*. Click OK. The ACSELERATOR software responds with the second dialog box of *Figure 4.60*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 4.60 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

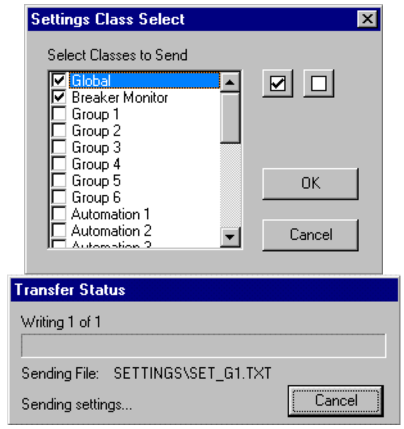

Figure 4.60 Uploading Global and Breaker Monitor Settings to the SEL-421 Relay.

Configuring High-Accuracy Timekeeping

You can use the SEL-421 Relay in two high-accuracy timekeeping modes; these modes are IRIG mode and PPS mode. The relay can time-stamp event reports and SER data to 10 µs accuracy with a proper time reference. For more information on high-accuracy timekeeping and state estimation, see *Oscillography on page A.3.8 in the Applications Handbook*, and *Section 4: Time-Synchronized Measurements in the Applications Handbook*.

IRIG-B

You can connect time signals from many sources that produce the IRIG-B (Inter-Range Instrumentation Group-B) time code format (SEL-2030, GPS receiver, etc.). The IRIG-B signal includes code for time-of-day and day-of-year time stamping. The signal does not include a code to identify the year. To verify that the SEL-421 Relay calendar is set to the proper year, use the **DATE** command to view or change the date (see *DATE on page R.8.17 in the Reference Manual*). The relay stores the year in nonvolatile memory and will maintain the proper year even if relay power cycles off and on. The relay also maintains the time, month, and day in nonvolatile memory while relay power is off.

The IRIG-B serial data format consists of a 1-second frame containing 100 pulses divided into fields. The relay decodes the second, minute, hour, and day fields and sets the internal time clock upon detecting valid time data.

Maximum jitter of the input IRIG-B signal must be less than ± 3 ms. If the IRIG-B input signal meets this requirement, the relay switches automatically to IRIG mode when relay setting ETIRIG := Y (default). See *Automatic Time Source Selection on page 4.66* for more information.

1k PPS

A very high-accuracy time source is the 1000 PPS (1k PPS) pulse train output of a GPS receiver. For PPS mode, use both GPS satellite-locked IRIG-B and 1000 PPS (1k PPS) time code signals for extremely accurate time stamping of power system events. The GPS receiver generates this pulse train from the 1k PPS satellite time signal. High accuracy GPS-based time and frequency receivers from various manufacturers provide the 1k PPS signal as an ordering option. Be sure that the 1k PPS signal output is locked to the IRIG-B time code output (this is the case in the majority of GPS receivers).

The relay switches automatically to PPS mode timekeeping if you connect an IRIG-B input that is stable to within ±200 µs of the 1k PPS signal, and a 1k PPS signal with absolute stability of ± 500 ns (0.5 µs). If the two signals meet this requirement, the relay automatically switches to PPS mode when relay setting ETPPS := Y (default). See *Automatic Time Source Selection on page 4.66* for more information.

Automatic Time Source Selection

The SEL-421 Relay automatically switches time source inputs. *Table 4.8* lists the timekeeping automatic switching enable settings.

Table 4.8 Time Source Automatic Switching Enable Settings

Setting	Description	Default
ETIRIG	IRIG Time Source (Y, N)	Y
ETPPS	PPS/IRIG Time Source (Y, N)	Y

With ETIRIG and ETPPS set to Y, the relay at power up first attempts to achieve PPS mode. If the relay cannot find a 1k PPS source coupled to an IRIG-B source, or if the relay determines the sources are unreliable, then the relay switches to IRIG mode. When ETPPS := Y and ETIRIG := N, the relay uses PPS timing mode for a valid 1k PPS signal locked to an IRIG-B input signal. If the PPS source becomes unavailable, the relay does not switch to IRIG mode.

If the IRIG-B time source is unavailable or is unreliable, then the relay switches to a lower-priority source (DNP, MIRRORED BITS, and ASCII, for example). The relay automatically switches up to a higher priority time source (PPS/IRIG-B, or IRIG-B only) when the relay measures an acceptable time source stability and reliability.

Connecting High-Accuracy Timekeeping

The procedure in the following steps assumes that you have a modern high-accuracy GPS receiver with BNC jack outputs for both an IRIG-B signal and a 1000 PPS signal. Use a communications terminal to send commands and receive data from the relay (see *Making an EIA-232 Serial Port Connection on page 4.6*).

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page 4.10* to change the default access level passwords.

Step 1. Confirm that the relay is operating. See *Connecting and Applying Power on page 4.4*.

Step 2. Prepare to control the relay at Access Level 2. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt. Type the **2AC<Enter>** command, and then type the correct password to go to Access Level 2. You will see the =>> action prompt.

Step 3. Connect cables. Attach the IRIG-B signal with a BNC-to-BNC coaxial jumper cable from the GPS receiver IRIG-B output to the SEL-421 Relay TIME IRIG-B BNC jack. Connect the 1k PPS signal with a BNC-to-BNC coaxial jumper cable from the GPS receiver 1000 PPS output to the SEL-421 Relay TIME 1k PPS BNC jack. See *Figure 4.61*.

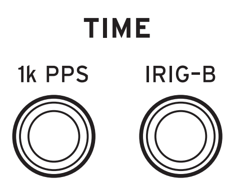

Figure 4.61 TIME BNC Jacks.

Step 4. Confirm/Enable automatic detection and changeover to high-accuracy PPS timing mode. Verify that the relay default settings are "Y" for settings ETIRIG and ETPPS. At the communications terminal, type **SET G EGADVS TERSE<Enter>**. (See *Making Simple Settings Changes on page 4.15*.) The relay will return the settings in *Figure 4.62*. Type **Y<Enter>** to enable advanced global settings. Type **><ENTER>** to skip settings categories to advance to the Time and Date Management category. Confirm that ETPPS := Y. Because you are viewing this data from the **SET** command, you can change setting ETPPS to Y if this setting is N. Press the **<Enter>** key on the terminal. The relay responds with setting ETIRIG. Confirm that ETIRIG := Y and then type

END<Enter> to end the settings session. Type **N<Enter>** (for no) to return to the Access Level 2 prompt. (If you changed either setting ETPPS or ETIRIG from N to Y, save the new settings by answering **Y<Enter>** to the Save settings (Y,N) ? prompt).

```
=>>SET G EGADVS TERSE<Enter>
Global

Global Enables

Advanced Global Setting (Y,N)                      EGADVS  := N      ?Y<Enter>

Control Inputs (Global)

Input Pickup Level (15-265 Vdc)                    GINP    := 85     ?><Enter>

Settings Group Selection

Select Setting Group 1 (SELogic Equation)
SS1 := PB3 AND NOT SG1
?  ><Enter>

Frequency Estimation

Alternate Freq. Source (SELogic Equation)
EAFSRC := NA
?  ><Enter>

Time and Date Management

PPS/IRIG Time Source (Y,N)                         ETPPS   := Y      ?<Enter>
IRIG Time Source (Y,N)                             ETIRIG  := Y      ?<Enter>

Current and Voltage Source Selection

Current and Voltage Source Selection (Y,N,1,2)     ESS     := N      ?END<Enter>

Save settings (Y,N)  ?N<Enter>
Settings aborted
```

Figure 4.62 Confirming the High-Accuracy Timekeeping Enable Settings.

Step 5. Confirm that the relay is operating in the high-accuracy PPS mode. Type **TIME Q<Enter>**. The relay displays information similar to *Figure 4.63*. The Time Source will be PPS, indicating that the relay internal clock is locked to the 1k PPS input signal.

```
=>TIME Q<Enter>

Relay 1                                         Date: 03/15/2001 Time: 14:09:14.803
Station A                                       Serial Number: 2001001234

Time Source: PPS
Last Update Source: PPS

Sync Status: SYNC

FF   Time Mark Period:    0.000 µs
PPS  Time Mark Period: 1000.018 µs
IRIG Time Mark Period: 1000.000 ms

Internal Clock Period:  24.999816 ns
=>
```

Figure 4.63 Results of the TIME Q Command.

TIME Q Descriptions

The TIME Q command provides details about relay timekeeping *Figure 4.63 on page 4.68*. The header line internal clock setting is initially calibrated at the SEL factory; you do not need to connect a PPS mode satellite receiver to get good time results from the SEL-421 Relay. The Time Source provides the present high-accuracy timing input source; entries for this line are PPS, IRIG, and OTHER. The Last Update Source reports the source from which the relay referenced the last time value measurement. Entries for this line can be high-accuracy or low-accuracy sources. *Table 4.9* lists the possible Last Update Source values for the SEL-421 Relay.

Table 4.9 Date/Time Last Update Sources

Time Input Source Mode (QQQQQ)	Accuracy	Time Source	Front Panel Editing?
PPS	High	Time/date from the IRIG-B input coupled to the 1000 PPS (pulse per second) pulse signal	No
IRIG	High	Time/date from the IRIG-B format time base signal	No
COMM CRD	Low	Time/date signal from the communications card	Date and Time
DNP	Low	Time/date from the DNP communications port	Date and Time
MIRROR B	Low	Time/date from the MIRRORED BIT port	Date and Time
ASC TIME	Low	Time from the relay serial ports	Date only
ASC DATE	Low	Date from the relay serial ports	Time only
NONV CLK	Low	Time/date from the nonvolatile random access memory clock	Date and Time
FP TIME	Low	Time from the front-panel TIME entry screen	Date and Time
FP DATE	Low	Time from the front-panel DATE entry screen	Date and Time

Sync Status shows whether the relay internal clock is locked. The PPS Time Mark Period value and the IRIG Time Mark Period value indicate the instantaneous period in which the relay measures the time source inputs. The relay displays the time mark periods showing the present time precision derived from the applied time source signals. (The FF Time Mark Period is for a future fiber port time input).

Adaptive Internal Clock Period Adjustment

The Internal Clock Period is the internal relay timekeeping period. The relay adjusts this master internal clock when you apply PPS mode timekeeping, adapting the internal relay clock for your installation temperature conditions. If you lose the PPS timing lock, the relay internal clock operates at this precisely adapted clock period until PPS mode is restored. Time tags for event reports during a loss of PPS mode timekeeping remain very accurate. Lower accuracy time sources do not adaptively adjust the internal relay clock period.

Monitoring High-Accuracy Time Source Status

The purpose of the procedure in the following steps is to show one method for deriving the TIME Q Time Source information from Relay Word bits TPPS and TIRIG. The TPPS Relay Word bit is at logical 1 when the relay is in PPS time mode. The relay sets Relay Word bit TUPDH to logical 1, if the updating source is a high-accuracy time source. For this application example, use a PSV (Protection SELOGIC Variable) to monitor time keeping status.

PSV01 asserts when the relay uses a high-priority source to update the time value, the synchronizing time source is PPS, and the relay is not synchronizing to the PPS source. This condition triggers the relay alarm output (OUT108 for this application example).

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page 4.6* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on* *page 4.10* to change the default access level passwords. Also, you should be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the communications port. Start the ACSELERATOR software. On the top toolbar, open the Communication menu, and then click Port Parameters. You will see the Port Parameters dialog box similar to *Figure 4.8*. Select the Data Speed, Data Bits, Parity, and Stop Bits that match the relay settings. Defaults are 9600, 8, N, 1, respectively. Click OK to update the ACSELERATOR software communications parameters. Confirm that the Communications Status bar at the bottom of the ACSELERATOR window says "Connected."

Step 2. Confirm the correct ACSELERATOR software passwords. Reopen the Communication menu and click Port Parameters. Enter your Access Level 1 password in the Level One Password text box, and your Access Level 2 password in the Level Two Password text box. Click the OK button to accept changes and close the dialog box.

Step 3. Read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all configuration and settings data to the ACSELERATOR software.

Step 4. Access the protection free-form SELOGIC settings. Click on the + mark next to Group 1 in the Settings tree view. Click the Protection Logic 1 settings (See *Figure 4.64*).

Step 5. Set a PSV. Enter the three lines of SELOGIC control equation programming in the Protection Free-Form Logic Settings shown in *Figure 4.64*. Comments begin with the # character; see *Fixed SELOGIC Control Equations on page R.3.5 in the Reference Manual*.

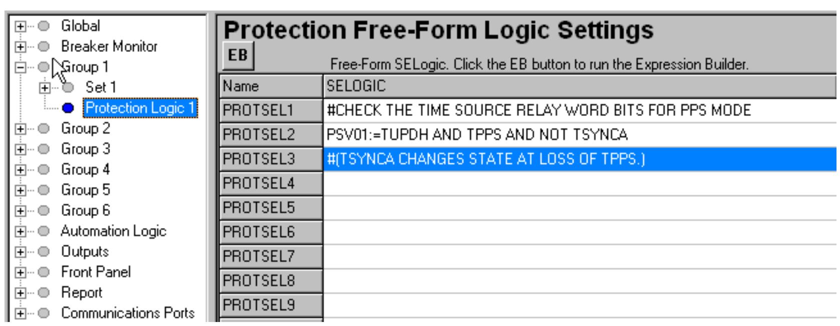

Figure 4.64 Programming a PSV in the ACSELERATOR Software.

Step 6. Configure a control output to alarm a loss of PPS mode. In the Settings tree view, double-click Outputs and then click Main Board (See *Figure 4.65*). In the Main Board Outputs OUT108 text box, enter the PSV01 condition to the preexisting OUT108 := NOT (SALARM OR HALARM) equation, as shown in *Figure 4.65*.

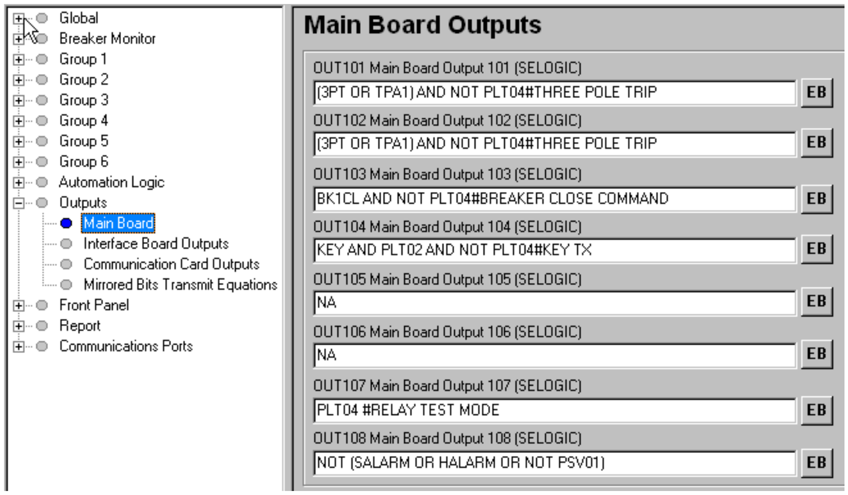

Figure 4.65 Setting OUT108 in the ACSELERATOR Software.

Step 7. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 8. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class or instance you want to send to the relay. Click the check box for Group 1 and the check box for Breaker Monitor, as shown in the first dialog box of *Figure 4.66*. Click OK. The ACSELERATOR software responds with a display similar to the second dialog box of *Figure 4.66*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 4.66 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

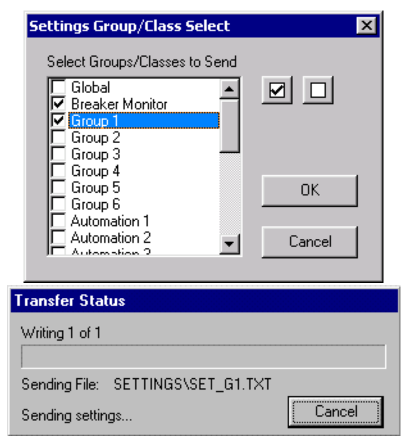

Figure 4.66 Uploading Group 1 and Breaker Monitor Settings to the SEL-421 Relay.

To confirm that you have prepared an out-of synchronization/loss of PPS mode alarm, disconnect the PPS input. The relay alarm will activate.

Readying the Relay for Field Application

Before applying the SEL-421 Relay in your power system, set the relay for your particular field application. Be sure to modify the relay factory default settings for your power system conditions to enable relay features to help you protect and control your system.

This procedure is a guide to help you ready the relay for field application. If you are unfamiliar with the steps in this procedure, see the many relay usage examples presented in this section. This is a suggested procedure; modify the procedure as necessary to conform to your standard company practices.

Step 1. Open the appropriate low-voltage breaker(s) and remove fuses to verify removal of control power and ac signals from the SEL-421 Relay. Isolate the relay TRIP control output.

Step 2. Perform point-to-point continuity checks on the circuits associated with the SEL-421 Relay to verify the accuracy and correctness of the ac and dc connections.

Step 3. Apply power to the relay. See *Connecting and Applying Power on page 4.4*. The green enable LED on the front panel will illuminate.

Step 4. Use an SEL Cable C234A to connect a serial terminal to the relay. Start the terminal (usually a PC with terminal emulation software). Establish communication with the relay at Access Level 0. Proceed to Access Level 2 (see *Changing the Default Passwords on page 4.8*).

Step 5. Change the default passwords. See *Changing the Default Passwords on page 4.8*.

Step 6. Set the DATE and TIME. See *Making Simple Settings Changes on page 4.15*.

Step 7. Use test sources to verify relay ac connections. See *Examining Metering Quantities on page 4.31*.

Step 8. Verify control input connections. See *Operating the Relay Inputs and Outputs on page 4.52* and *Control Inputs on page U.2.6 in the User's Guide*.

Step 9. Verify control output connections. See *Operating the Relay Inputs and Outputs on page 4.52* and *Control Outputs on page U.2.6 in the User's Guide*.

Step 10. Perform protection element tests. See *Checking Relay Operation on page U.6.24 in the User's Guide*.

Step 11. Set the relay. See *Making Simple Settings Changes on page 4.15*, *Section 1: Protection Application Examples in the Applications Handbook*, and *Section 1: Protection Functions in the Reference Manual*.

Step 12. Connect the relay for tripping/closing duty. See *AC/DC Connection Diagrams on page U.2.47 in the User's Guide*.

Step 13. Clear the relay data buffers. From Access Level 2, use a communications terminal to issue the commands listed in *Table 4.10 on page 4.73*.

Table 4.10 Communications Port Commands That Clear Relay Buffers

Communications Port Command	Task Performed
MET RD	Reset demand meter data
MET RP	Reset peak demand meter data
MET RE	Reset energy meter data
MET RM	Reset maximum/minimum meter data
HIS CA	Reset event report and history buffers
SER CA	Reset Sequential Events Recorder data

Step 14. Connect the secondary voltage and current inputs. See *User's Guide Section 2: Installation*.

Step 15. Confirm secondary connections. Use the MET command or the ACSELERATOR HMI to view relay metering. See *Examining Metering Quantities on page 4.31*.

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Section 5

Front-Panel Operations

The SEL-421 Relay front panel makes power system data collection and system control quick and efficient. Using the front panel, you can analyze power system operating information, view and change relay settings, and perform relay control functions. The relay features a straightforward menu-driven control structure presented on the front-panel liquid crystal display (LCD). Front-panel targets and other LED indicators give a quick look at SEL-421 Relay operation status. You can perform often-used control actions rapidly by using the large direct-action pushbuttons. All of these features help you operate the relay from the front panel and include:

- ➤ Reading metering
- ➤ Inspecting targets
- ➤ Accessing settings
- ➤ Controlling relay operations

Front-Panel Layout

The front panel for the horizontal 3U (3 rack unit) SEL-421 Relay configuration is shown in *Figure 5.1* (other configurations are similar).

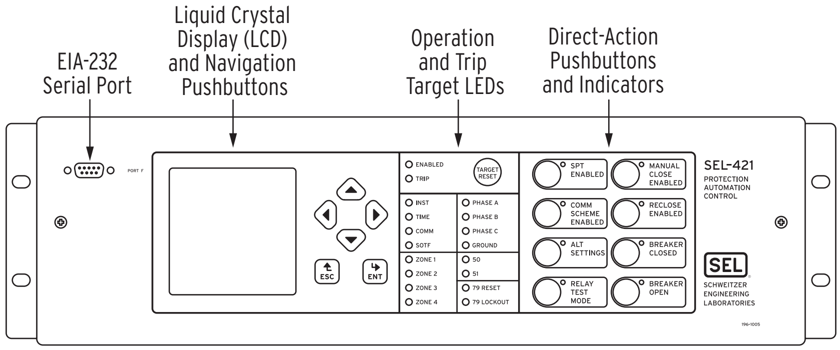


Figure 5.1 SEL-421 Relay Front Panel.

A 128 x 128 pixel LCD (liquid crystal display) shows relay operating data including event summaries, metering, settings, and relay self-test information. Six navigation pushbuttons adjacent to the LCD window control the relay menus and information screens. Sequentially rotating display screens relate important power system metering parameters; you can easily change this ROTATING DISPLAY to suit your particular on-site monitoring needs. Use a simple and efficient menu structure to operate the relay from the front panel. With these menus you can quickly access SEL-421 Relay metering, control, and settings.

Front-panel LEDs (light emitting diodes) indicate the relay operating status. You can confirm that the SEL-421 Relay is operational by viewing the ENABLED LED. The relay illuminates the TRIP LED target to indicate a tripping incident. The relay is factory programmed for particular relay elements to illuminate the other target LEDs. You can program these target LEDs to show the results of the most recent relay trip event. Change the pushbutton and pushbutton LED labels with the slide-in label carriers adjacent to the pushbuttons.

The SEL-421 Relay front panel features large operator control pushbutton switches with annunciator LEDs that facilitate local control. Factory default settings associate specific relay functions with these eight direct-action pushbuttons and LEDs. Using SELOGIC® control equations, you can readily change the default direct-action pushbutton functions and LED indications to fit your specific control and operational needs. Change the pushbutton and pushbutton LED labels with the slide-in labels adjacent to the pushbuttons.Change the pushbutton and pushbutton LED labels with the slide-in label carriers adjacent to the pushbuttons.

The SEL-421 Relay front panel includes an EIA-232 serial port (labeled PORT F) for connecting a communications terminal or using the SEL-5030 ACSELERATOR® Software Program. Use the common EIA-232 open ASCII communications protocol to communicate with the relay via front-panel Port F. Other communications protocols available with the front-panel port are MIRRORED BITS™ communications, and DNP 3.0. For more information on communications protocols and Port F, see *Communications Ports Connections on page U.2.44 in the User's Guide* and *Serial Communication on page R.4.3 in the Reference Manual*.

Front-Panel LCD

The LCD is the prominent feature of the SEL-421 Relay front panel. *Figure 5.2 on page 5.3* shows the areas contained in the LCD:

- ➤ Title area
- ➤ Main area
- ➤ Message area
- ➤ Scroll bars

The scroll bars are present only when a display has multiple screens.

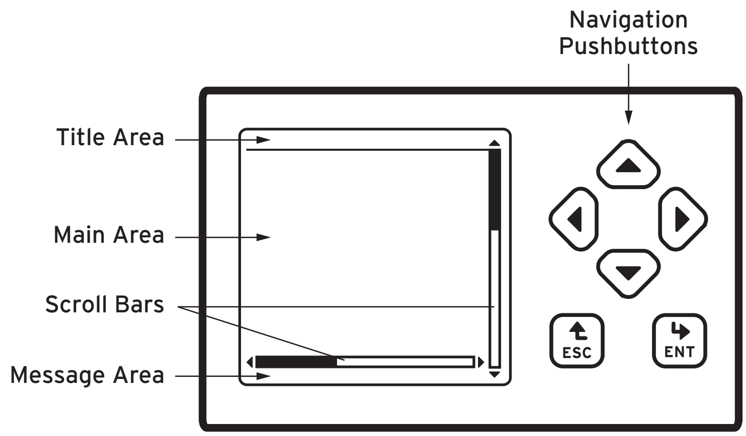


Figure 5.2 LCD Display and Navigation Pushbuttons.

Front-Panel Inactivity Time Out

The LCD has a backlight that illuminates the screen when you press any front-panel pushbutton. This backlight extinguishes after a front-panel inactivity time out. You can control the duration of the time out with relay setting FP_TO, listed in *Table 5.1*. To set FP_TO, use the **SET F** (set front panel) settings from any communications port or use the Front Panel branch of the ACSELERATOR software settings tree view. The maximum backlight time is one hour. Obtain this 60-minute maximum backlight time by setting FP_TO to 60 or to OFF. When the front-panel times out, the relay displays an automatic ROTATING DISPLAY, described later in this section under *Screen Scrolling on page 5.4*.

Table 5.1 Front-Panel Inactivity Time-Out Setting

Name	Description	Range	Default
FP_TO	Front-panel display time-out	OFF, 1–60 minutes	15 minutes

Navigating the Menus

The SEL-421 Relay front panel presents a menu system for accessing metering, settings, and control functions. Use the LCD and the six pushbuttons adjacent to the display (see *Figure 5.2*) to navigate these front-panel menus.

The navigation pushbutton names and functions are the following:

- ➤ **{ESC}**–Escape pushbutton
- ➤ **{ENT}**–Enter pushbutton
- ➤ **{Left}**, **{Right}**, **{Up}**, and **{Down}**–Navigation pushbuttons

Relay menus show lists of items that display information or control the relay. A rectangular box around an action or choice indicates the menu item you have selected. This rectangular box is the menu item highlight. *Figure 5.3 on page 5.4* shows an example of the highlighted item RELAY ELEMENTS in the MAIN MENU. When you highlight a menu item, pressing the **{ENT}** pushbutton selects the highlighted item.

```
MAIN MENU
METER
EVENTS
BREAKER MONITOR
RELAY ELEMENTS
LOCAL CONTROL
SET/SHOW
RELAY STATUS
VIEW CONFIGURATION
DISPLAY TEST
RESET ACCESS LEVEL
```

Figure 5.3 RELAY ELEMENTS Highlighted in MAIN MENU.

The **{Up}** pushbutton and **{Down}** pushbutton scroll the highlight box to the previous or next menu selection, respectively. When there is more than one screen of menu items, pressing **{Up}** while at the first menu item causes the display to show the previous set of full-screen menu items, with the last menu item highlighted. Pressing **{Down}** while at the bottom menu item causes the display to show the next set of full-screen menu items, with the first menu item highlighted.

Pressing the **{ESC}** pushbutton reverts the LCD display to the previous screen. Pressing **{ESC}** repeatedly returns you to the MAIN MENU. If a status warning or event condition is active (not acknowledged or reset), the relay displays the full-screen status warning or trip event screen in place of the MAIN MENU.

Screen Scrolling

The SEL-421 Relay has two screen scrolling modes: autoscrolling mode and manual-scrolling mode. After front-panel time out, the LCD presents each of the display screens in this sequence:

- ➤ Any active (filled) display points screens
- ➤ Enabled metering screens

The relay displays enabled metering screens in the order listed in *Table 5.2*. (see *Figure 5.13 on page 5.13* for samples of the metering screens.) This sequence comprises the ROTATING DISPLAY.

Table 5.2 Metering Screens Enable Settings (Sheet 1 of 2)

Name	Description	Range	Default
RMS_V	RMS Line Voltage Screen	Y, N	N
RMS_I	RMS Line Current Screen[a]	Y, N	Y
RMS_VPP	RMS Line Voltage Phase-to-Phase Screen	Y, N	N
RMS_W	RMS Active Power Screen	Y, N	N
FUNDVAR	Fundamental Reactive Power Screen	Y, N	N
RMS_VA	RMS Apparent Power Screen	Y, N	N
RMS_PF	RMS Power Factor Screen	Y, N	N
RMS_BK1	RMS Breaker 1 Currents Screen	Y, N	N
RMS_BK2	RMS Breaker 2 Currents Screen	Y, N	N
STA_BAT	Station Battery Screen	Y, N	N

NOTE: The initial display can present only the RMS_I line current screen. This can occur when you have not enabled any of the metering screens and display points.

Table 5.2 Metering Screens Enable Settings (Sheet 2 of 2)

Name	Description	Range	Default
FUND_VI	Fundamental Voltage and Current Screen[a]	Y, N	Y
FUNDSEQ	Fundamental seqUence Quantities Screen	Y, N	N
FUND_BK	Fundamental Breaker Currents Screen	Y, N	N

[a] The default displays are RMS_I and FUND_VI.

Use the front-panel settings (the **SET F** command from a communications port or the Front Panel settings in the ACSELERATOR software) to access the metering screen enables. Entering a Y (Yes) for a metering screen enable setting causes the corresponding metering screen to appear in the ROTATING DISPLAY. Entering an N (No) hides the metering screen from presentation in the ROTATING DISPLAY. *Figure 5.4 on page 5.5* shows a sample ROTATING DISPLAY consisting of an example display points screen, and the two factory-default metering screens, RMS_I and FUND_VI (the screen values in *Figure 5.4* are representative values).

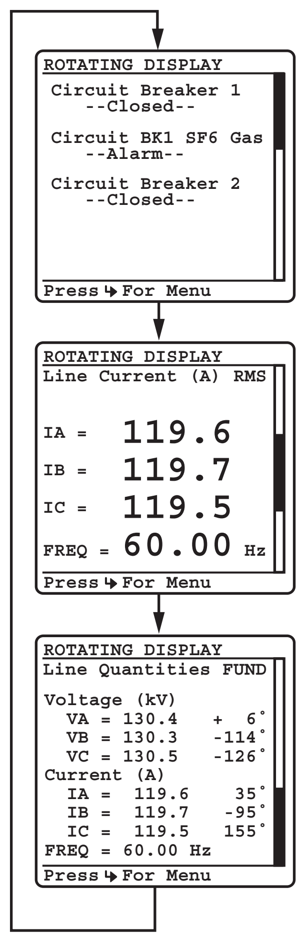


Figure 5.4 Sample ROTATING DISPLAY.

The active display points are the first screens in the ROTATING DISPLAY (see *Display Points*). Each display points screen shows as many as four enabled display points. (With 32 display points, the SEL-421 Relay can present a maximum of eight display points screens.) If a display point does not have text to display, the screen space for that display point is maintained.

Autoscrolling Mode

Autoscrolling mode shows each screen for five seconds. When you first apply power to the relay, the LCD shows the autoscrolling ROTATING DISPLAY.

The autoscrolling ROTATING DISPLAY also appears after a front-panel inactivity time out (see *Front-Panel Inactivity Time Out on page 5.3*). The relay retrieves data prior to displaying each new screen. The relay does not update screen information during the five-second display interval. At any time during autoscrolling mode, pressing **{ENT}** takes you to the MAIN MENU. Pressing any of the four navigation pushbuttons switches the display to manual-scrolling mode.

Manual-Scrolling Mode

In the manual-scrolling mode you can use the directional navigation arrow pushbuttons to select the next or previous screen. Pressing the **{Down}** or **{Right}** pushbuttons switches the display to the next screen; pressing the **{Up}** or **{Left}** pushbuttons switches the display to the previous screen. In manual-scrolling mode, the display shows arrows at the top and bottom of the vertical scroll bar. The screen arrows indicate that you can navigate between the different screens at will. The relay retrieves data prior to displaying each new screen. Unlike the autoscrolling mode, the relay continues to update screen information while you view it in the manual-scrolling mode. To return to autoscrolling mode, press **{ESC}** or wait for a front-panel time out.

Display Points

You can display messages on the SEL-421 Relay front-panel LCD that indicate conditions in the power system. The relay uses display points to place these messages on the LCD. *Figure 5.5* shows a sample display points screen. The relay has 32 possible display points; *Table 5.3 on page 5.7* lists the display points settings. The relay updates the display points data once per second if you are viewing the display points in manual-scrolling mode; in autoscrolling mode, the relay updates the display points information each time the screen appears in the ROTATING DISPLAY sequence.

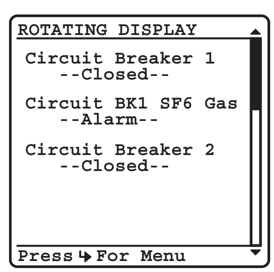


Figure 5.5 Sample Display Points Screen.

To enable a display point, enter the display point settings listed in *Table 5.3*. The format for entering the display point data is the following comma-delimited string:

Relay Word bit,display point name,alias for set state,alias for clear state

Names or aliases can contain any valid ASCII character. Enclose the name or alias within double quotation marks. See *Example 5.1* for particular information on the format for entering display point data.

Table 5.3 Display Point Settings

Description	Range
Relay Word Bit	Any valid relay element
Display Point Name	20-character maximum ASCII string
Display Point SET Alias (logical 1)	20-character maximum ASCII string
Display Point CLR Alias (logical 0)	20-character maximum ASCII string

If you enter a Relay Word bit that does not match a valid relay element, the relay displays "Invalid element." If you enter an alias or name that is too long, the relay displays "Too many characters, limit 20 characters per alias."

If a display point was used previously and you want to remove the display point, you can delete the display point. In the Front Panel settings (SET F), at the Display Points and Aliases prompt, use the text-edit mode line editing commands to set the display points. (See *Text-Edit Mode Line Editing on page U.4.21 in the User's Guide* for information on text-edit mode line editing.) To delete Display Point 1, type **DELETE<Enter>** at the Front Panel settings Line 1 prompt.

EXAMPLE 5.1 Creating a Display Point

Display points screens provide operator feedback about the readiness of equipment connected to the SEL-421 Relay. A display points screen contains four display points; this example demonstrates a method to set the top (first) display point message that is shown in Figure 5.5 on page 5.6. The SEL-421 Relay in this example has an additional I/O interface board.

Use appropriate interface hardware to connect the circuit breaker auxiliary contacts to IN201 to read the circuit breaker status. Assume a 125 Vdc system and use the factory defaults for settings EICIS, GINP, GIND, and GINDF (see Control Input Assignment on page U.4.59 in the User's Guide.

In the Front Panel settings (**SET F**), enter the following after the Display Points and Aliases line 1 prompt:

1: **IN201,"Circuit Breaker 1"," --Closed--"," --Open--"**

This example sets input IN201, represented by Relay Word bit IN201, as Circuit Breaker 1. The circuit breaker closed condition is indicated by the set state, " --Closed--" where leading spaces are added to center the set state message. Add a clear state named " --Open--" to show that the circuit breaker is open.

EXAMPLE 5.2 Monitoring Test Modes With Display Points

This example uses the Relay Word bit TESTFM (Fast Meter test running) to activate a front-panel display point that alerts an on-site operator that the relay is in Fast Meter test mode.

In the Front Panel settings (**SET F**), enter the following after the line 4 prompt:

4: **TESTFM,,"FAST METER TEST!!!!"**

The LCD displays the screen shown in Figure 5.6 on page 5.8 as a part of the ROTATING DISPLAY if the Fast Meter test is running. (Instruct the operator to view the relay front panel for messages or warnings as the last item on a "Leaving the Substation" checklist.)

Again, this display point application example does not require a clear state, so the clear state is blank. If the Fast Meter test is not running and no other display points are active, the relay shows a blank screen in the ROTATING DISPLAY.

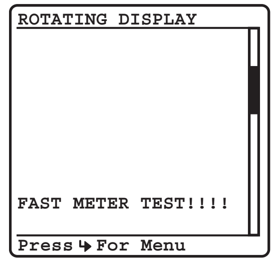


Figure 5.6 Fast Meter Display Points Sample Screen.

Front-Panel Menus and Screens

Operate the SEL-421 Relay front panel through a sequence of menus that you view on the front-panel display. The MAIN MENU is the introductory menu for other front-panel menus (see *Figure 5.3 on page 5.4*). These additional menus allow you on-site access to metering, control, and settings for configuring the SEL-421 Relay to your specific application needs. Use the following menus and screens to set the relay, perform local control actions, and read metering:

- Support Screens
  - Contrast
  - Password
- MAIN MENU
  - METER
  - EVENTS
  - BREAKER MONITOR
  - RELAY ELEMENTS
  - LOCAL CONTROL
  - SET/SHOW
  - RELAY STATUS
  - VIEW CONFIGURATION
  - DISPLAY TEST
  - RESET ACCESS LEVEL

Support Screens

The relay displays special screens over the top of the menu or screen that you are using to control the relay or view data. These screens are the contrast adjustment screen and the PASSWORD REQUIRED screen.

Contrast

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **{ESC}** pushbutton for one second. The relay displays a contrast adjustment box superimposed over the display. *Figure 5.7* shows the contrast adjustment box with the MAIN MENU screen in the background. Pressing the **{Right}** pushbutton increases the contrast. Pressing the **{Left}** pushbutton decreases the screen contrast. When finished adjusting the screen contrast, press the **{ENT}** pushbutton.

Figure 5.7 Contrast Adjustment.

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.

The SEL-421 Relay uses passwords to control access to settings and control menus. The relay has six access-level passwords. See *Changing the Default Passwords on page U.4.8 in the User's Guide* for more information on access levels and setting passwords. The SEL-421 Relay front panel is at Access Level 1 upon initial power-up and after front-panel time out.

Password validation occurs only when you request a menu function that is at a higher access level than the presently authorized level. At this point, the relay displays a password entry screen, shown in *Figure 5.8*. This screen has a blank password field and an area containing alphabetic, numeric, and special password characters with a movable highlight box.

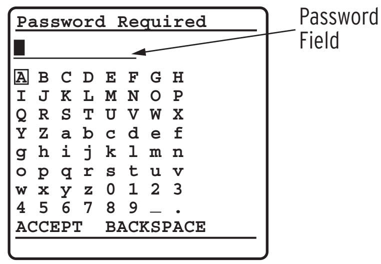


Figure 5.8 Enter Password Screen.

Enter the password by pressing the navigation pushbuttons to move the highlight box through the alphanumeric field. When at the desired character, press **{ENT}**. The relay enters the selected character in the password field and moves the dark box cursor one space to the right. You can backspace at any time by highlighting the BACKSPACE character and then pressing **{ENT}**. When finished, enter the password by highlighting the ACCEPT option and then pressing **{ENT}**.

If you entered a valid password for an access level greater than or equal to the required access level, the relay authorizes front-panel access to the combination of access levels (new level and all lower levels) for which the password is valid. The relay replaces the password screen with the menu screen that was active before the password validation routine. When you enter Access Levels B, P, A, O, and 2, the Relay Word bit SALARM pulses for one second.

If you did not enter a valid password, the relay displays the error screen shown in *Figure 5.9 on page 5.10*. Entering a valid password for an access level below the required access level also causes the relay to generate the error screen. In both password failure cases, the relay does not change the front-panel access level (it does not reset to Access Level 1 if at a higher access level). The relay displays the PASSWORD INVALID screen for five seconds. If you do not want to wait for the relay to remove the message, press any of the six navigational pushbuttons during the five-second error message to return to the previous screen in which you were working.

Figure 5.9 Invalid Password Screen.

MAIN MENU

The MAIN MENU is the starting point for all other front-panel menus. The relay MAIN MENU is shown in *Figure 5.10*. When the front-panel LCD is in the ROTATING DISPLAY, press the **{ENT}** pushbutton to show the MAIN MENU.

```
MAIN MENU
METER
EVENTS
BREAKER MONITOR
RELAY ELEMENTS
LOCAL CONTROL
SET/SHOW
RELAY STATUS
VIEW CONFIGURATION
DISPLAY TEST
RESET ACCESS LEVEL
```

Figure 5.10 MAIN MENU.

METER

The SEL-421 Relay displays metering screens on the LCD. Highlight METER on the MAIN MENU screen to select these screens. The METER MENU, shown in *Figure 5.11*, allows you to choose the following metering screens corresponding to the relay metering modes:

- RMS METER
- FUNDAMENTAL METER
- DEMAND METER (if enabled)
- ENERGY METER
- MAX/MIN
- SYNCHRONISM CHECK (if enabled)

```
METER MENU
RMS METER
FUNDAMENTAL METER
DEMAND METER
ENERGY METER
MAX/MIN
SYNCHRONISM CHECK
```

Demand Meter Enabled
(EDEM := ROL or
EDEM := THM)
Synchronism Check Enabled
(E25BK1 := Y or
E25BK2 := Y)

```
METER MENU
RMS METER
FUNDAMENTAL METER
ENERGY METER
MAX/MIN
```

No Synchronism Check
No Demand Metering
(E25BK1 := N)
(E25BK2 := N)
(EDEM := OFF)

Figure 5.11 METER MENU Screens.

Combinations of relay Global settings ESS and NUMBK give you metering data for Line, Circuit Breaker 1, and Circuit Breaker 2 when you view RMS METER, FUNDAMENTAL METER, and MAX/MIN metering screens. The relay shows the METER SUBMENU of *Figure 5.12* so you can choose the line or circuit breaker data that you want to display.

For example, if you have two sources feeding a transmission line through two circuit breakers and you set ESS := 3, NUMBK := 2, then the SEL-421 Relay measures BREAKER 1 currents, BREAKER 2 currents, and combined (Circuit Breakers 1 and 2) currents for LINE. The relay displays the METER SUBMENU screen when you make this settings configuration.

Other combinations of settings ESS and NUMBK do not require separate circuit breaker metering screens; for these configurations, the relay does not present the METER SUBMENU screen. See *Current and Voltage Source Selection on page R.1.2 in the Reference Manual* and *Global Settings on page R.9.3 in the Reference Manual* for information on configuring global settings ESS, NUMBK, LINEI, BK1I, and BK2I.

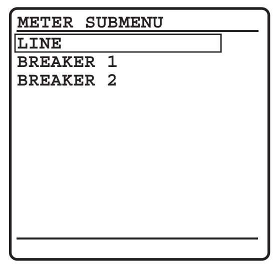


Figure 5.12 METER SUBMENU.

The relay presents the meter screens in the order shown in each column of *Figure 5.13 on page 5.13* and *Figure 5.14 on page 5.14*. Once you have selected the type of metering data to display (RMS METER, FUNDAMENTAL METER, DEMAND METER, ENERGY METER, MAX/MIN, or SYNCHRONISM CHECK), you can scroll through the particular display column by pressing the **{Down}** pushbutton. Return to a previously viewed screen in each column by pressing the **{Up}** pushbutton. Press **{ESC}** to revert the LCD screen to the METER SUBMENU and METER MENU screens.

The metering screens show reset options for the MAX/MIN, ENERGY METER, PEAK DEMAND METER, and DEMAND METER metering quantities at the end of each screen column. Use the **{Left}** and **{Right}** pushbuttons to select a NO or YES response to the reset prompt, and then press **{ENT}** to reset the metering quantity.

LINE METERING

```
RMS LINE METER
VOLTAGE (kV)
  VA = x xxx.x
  VB = x xxx.x
  VC = x xxx.x
CURRENT (A)
  IA = x xxx.x
  IB = x xxx.x
  IC = x xxx.x
FREQ = 60.00 Hz
VDC1 = xxx.x V
VDC2 = xxx.x V
```

```
FUND LINE METER
VOLTAGE (kV)
  VA = x xxx.x +xxx°
  VB = x xxx.x +xxx°
  VC = x xxx.x +xxx°
CURRENT (A)
  IA = x xxx.x +xxx°
  IB = x xxx.x +xxx°
  IC = x xxx.x +xxx°
FREQ = 60.00 Hz
VDC1 = xxx.x V
VDC2 = xxx.x V
```

```
DEMAND METER
CURRENTS (A)
 IA PEAK = xxx xxx.x
     DEM = xxx xxx.x
 IB PEAK = xxx xxx.x
     DEM = xxx xxx.x
 IC PEAK = xxx xxx.x
     DEM = xxx xxx.x
3I2 PEAK = xxx xxx.x
     DEM = xxx xxx.x
3I0 PEAK = xxx xxx.x
     DEM = xxx xxx.x
```

```
RMS LINE METER
VOLTAGE (kV)
 VAB = x xxx.x
 VBC = x xxx.x
 VCA = x xxx.x
```

```
FUND LINE METER
VOLTAGE (kV)
 VAB = x xxx.x +xxx°
 VBC = x xxx.x +xxx°
 VCA = x xxx.x +xxx°
```

```
DEMAND METER
POWER (MW)
 A PEAK = xxx xxx.x
    DEM = xxx xxx.x
 B PEAK = xxx xxx.x
    DEM = xxx xxx.x
 C PEAK = xxx xxx.x
    DEM = xxx xxx.x
3P PEAK = xxx xxx.x
    DEM = xxx xxx.x
```

```
RMS LINE METER
ACTIVE POWER (MW)
   A = -xx xxx.x
   B = -xx xxx.x
   C = -xx xxx.x
  3P = -xx xxx.x
REACTIVE (MVAR)
   A = -xx xxx.x
   B = -xx xxx.x
   C = -xx xxx.x
  3P = -xx xxx.x
```

```
FUND LINE METER
SEQUENCE I (A)
  I1 = x xxx.x +xxx°
 3I2 = x xxx.x +xxx°
 3I0 = x xxx.x +xxx°

SEQUENCE V (kV)
  V1 = x xxx.x +xxx°
 3V2 = x xxx.x +xxx°
 3V0 = x xxx.x +xxx°
```

```
DEMAND METER
POWER(MVA)
  A PEAK = xxx xxx.x
     DEM = xxx xxx.x
  B PEAK = xxx xxx.x
     DEM = xxx xxx.x
  C PEAK = xxx xxx.x
     DEM = xxx xxx.x
 3P PEAK = xxx xxx.x
     DEM = xxx xxx.x
```

```
RMS LINE METER
APPARENT POWER (MVA)
   A =  xx xxx.x
   B =  xx xxx.x
   C =  xx xxx.x
  3P =  xx xxx.x
POWER FACTOR
   A =  x.xx LAG
   B =  x.xx LAG
   C =  x.xx LAG
  3P =  x.xx LAG
```

```
FUND LINE METER
ACTIVE POWER (MW)
   A = -xx xxx.x
   B = -xx xxx.x
   C = -xx xxx.x
  3P = -xx xxx.x
REACTIVE (MVAR)
   A = -xx xxx.x
   B = -xx xxx.x
   C = -xx xxx.x
  3P = -xx xxx.x
```

```
DEMAND METER




LAST PEAK DEMAND
RESET:
MM/DD/YYYY HH:MM:SS

 RESET PEAK NOW?

     ◂NO   YES▸
```

```
FUND LINE METER
APPARENT POWER (MVA)
  A =  xx xxx.xx
  B =  xx xxx.xx
  C =  xx xxx.xx
 3P =  xx xxx.xx
POWER FACTOR
  A =  x.xx LEAD
  B =  x.xx LEAD
  C =  x.xx LEAD
 3P =  x.xx LEAD
```

```
DEMAND METER




LAST DEMAND RESET:
MM/DD/YYYY HH:MM:SS

 RESET DEMAND NOW?

     ◂NO   YES▸
```

BREAKER METERING

```
RMS BREAKER n METER
CURRENTS (A)
  IA = x xxx.x
  IB = x xxx.x
  IC = x xxx.x
```

```
FUND BREAKER n METER
CURRENTS (A)
  IA = x xxx.xx +xxx°
  IB = x xxx.xx +xxx°
  IC = x xxx.xx +xxx°
```

n = 1 or 2, representing Circuit Breaker 1 or Circuit Breaker 2, respectively.

Figure 5.13 RMS, FUND, and DEMAND Metering Screens.

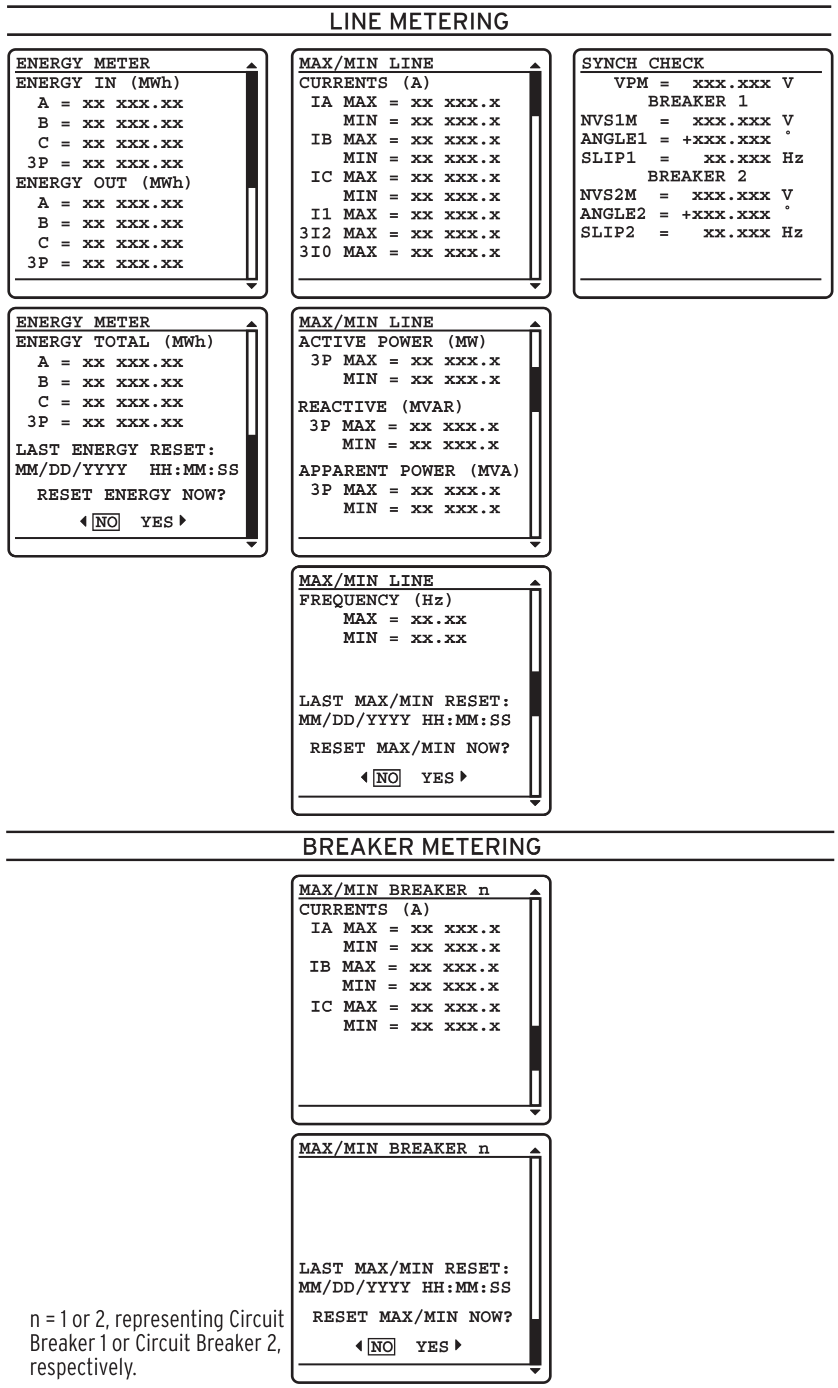


Figure 5.14 ENERGY, MAX/MIN, and SYNCH CHECK Metering Screens.

EVENTS

The SEL-421 Relay front panel features summary event reporting, which simplifies post-fault analysis. These summary event reports include all trip events, event and data capture triggering (via the ER SELOGIC control equation), and manual triggers. The relay displays event reports based on the Relay Word bit elements in the ER (event report trigger) SELOGIC control equation. See *Event Report on page A.3.12 in the Applications Handbook* for more information on event reports.

The front-panel event buffer size is 100 summaries. The relay numbers summary events in order from 10000 through 42767 and displays the most recent summaries on the LCD. You can view summary event reports from the relay front-panel display by selecting EVENTS from the MAIN MENU. *Figure 5.15* shows sample EVENT SUMMARY screens for a phase-to-phase-to-ground fault. Use the **{Right}** and **{Left}** pushbuttons to show each of the summary screens for the event. The horizontal scroll bar indicates that you can view other event 10002 screens. Use the **{Up}** and **{Down}** pushbuttons to move among the events in the summary buffer. Press **{ESC}** to return to the MAIN MENU.

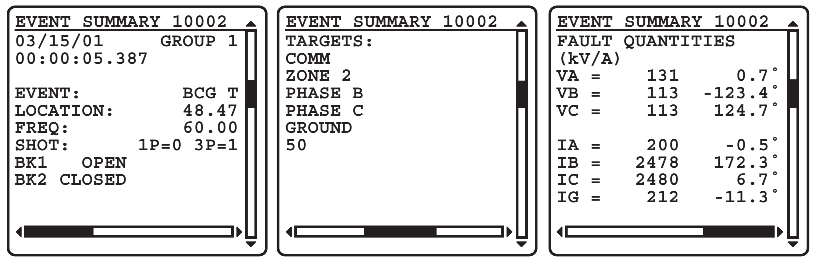


Figure 5.15 EVENT SUMMARY Screens.

BREAKER MONITOR

The SEL-421 Relay features an advanced circuit breaker monitor. Select BREAKER MONITOR screens from the MAIN MENU to view circuit breaker monitor alarm data on the front-panel display. *Figure 5.16* shows sample breaker monitor display screens. The BKR n ALARM COUNTER screen displays the number of times the circuit breaker exceeded certain alarm thresholds (see *Circuit Breaker Monitor on page A.2.2 in the Applications Handbook*). If you have two circuit breakers and have set NUMBK := 2, the alarm submenu in *Figure 5.16* appears first. Use the navigation pushbuttons to choose either Circuit Breaker 1 or Circuit Breaker 2. Press **{ENT}** to view the selected circuit breaker monitor information. An example of the Circuit Breaker 1 ALARM COUNTER screen for a single-pole tripping circuit breaker is shown on the right side of *Figure 5.16*.

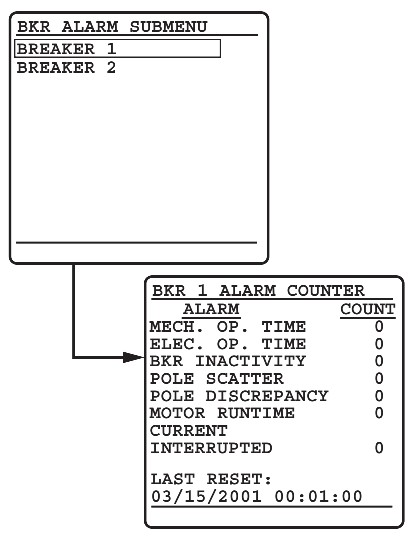


Figure 5.16 BREAKER MONITOR Report Screens.

RELAY ELEMENTS (Relay Word Bits)

You can view the RELAY ELEMENTS screen to check the state of the Relay Word bits in the SEL-421 Relay. The relay has two unique manual-scrolling features for viewing these elements:

- ➤ Accelerated navigation
- ➤ Search

These Relay Word bit scrolling features make selecting elements from among the many relay targets easy and efficient. *Figure 5.17* shows an example of the RELAY ELEMENTS screen. The asterisk (*) in *Figure 5.17* indicates that this Relay Word bit position is reserved for future use.

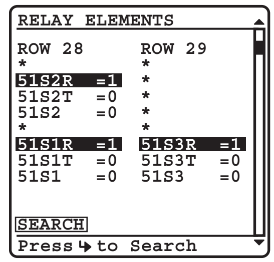


Figure 5.17 RELAY ELEMENTS Screen.

When you move item by item through the Relay Word bit table, pressing the **{Up}** or **{Down}** pushbuttons shows each previous or next screen in turn. Accelerated navigation occurs when you press and hold the **{Up}** or **{Down}** pushbuttons. Holding the **{Up}** or **{Down}** pushbuttons repeats the regular pushbutton action at 2 rows every second for the first 10 rows. Continue pressing the **{Up}** or **{Down}** pushbutton to cause the relay screen scrolling to accelerate to 20 rows per second. When scrolling up in accelerated scrolling, scrolling will stop at the first relay elements screen. When scrolling down, scrolling will stop at the last screen.

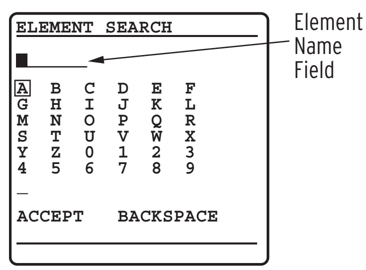


Figure 5.18 ELEMENT SEARCH Screen.

Search mode allows you to find a specific relay target element quickly. *Figure 5.18* shows the menu screen that the relay displays when you select the SEARCH option of the RELAY ELEMENTS initial menu. When you first enter this search menu, the block cursor is at the beginning of the element name field and the highlight box in the alphanumeric field is around the letter "A." Use the navigation pushbuttons to move through the alphanumeric characters. If the highlight is on one of the characters, pressing **{ENT}** enters the character at the block cursor location in the element name field. Next, the block cursor moves automatically to the character placeholder to the right. If the block cursor was already at the first character position on the left, the block cursor remains at the end of the name field. To backspace the cursor in the element name field, move the highlight to BACKSPACE and press **{ENT}**. When you have finished entering an element name, move the highlight to ACCEPT and press **{ENT}**. At any time, pressing **{ESC}** returns the display to the RELAY ELEMENTS screen.

If the highlight is on "ACCEPT," the relay finds the matching relay element when you press **{ENT}**. The relay seeks an exact match. If the relay does not find an exact match, it initiates a partial string search. If the relay finds no match, the screen displays an error message and stays in the ELEMENT SEARCH screen. If the relay finds a match, the screen displays the element row containing the matching element.

LOCAL CONTROL

The SEL-421 Relay provides great flexibility in power system control through the LOCAL CONTROL menus. You can use the front-panel LOCAL CONTROL menus to perform these relay functions:

- ➤ Trip and close circuit breakers (password required)
- ➤ Assert, deassert, and pulse relay control outputs to command station control actions
- ➤ Test relay outputs (password required)

In the first LOCAL CONTROL submenu of *Figure 5.19*, you can choose BREAKER CONTROL, local bits control, or OUTPUT TESTING. You must install the circuit breaker control enable jumper to enable circuit breaker control and output testing capability. See *Operating the Relay Inputs and Outputs on page U.4.52 in the User's Guide* and *Password and Circuit Breaker Jumpers on page U.2.17 in the User's Guide*. The submenu will not display the --BREAKER CONTROL-- option and the --OUTPUT TESTING-- option if the breaker jumper is not installed. (The relay checks the status of the breaker jumper whenever you activate the front-panel settings and at power-up.) If the breaker jumper is not installed, and there are no local bits enabled, the relay displays an information message when you attempt to enter LOCAL CONTROL and the screen returns to the MAIN MENU after a short delay.

Local bit names that you have programmed (see *Example 5.3 on page 5.20*) appear in the local control bit names field between --BREAKER CONTROL-- and --OUTPUT TESTING--, as shown in *Figure 5.19*. Use the **{Up}** and **{Down}** pushbuttons to highlight the local control action you want to perform. Pressing **{ENT}** takes you to the specific LOCAL CONTROL screen.

```
LOCAL CONTROL
--BREAKER CONTROL--
Enable Bus Switching
North Bus MOD
South Bus MOD
Bus Tie Interlock
Alternate Settings 3
--OUTPUT TESTING--
```

Figure 5.19 LOCAL CONTROL Initial Menu.

BREAKER CONTROL

The BREAKER CONTROL option presents a circuit breaker selection submenu if NUMBK := 2. Use the navigation pushbuttons and **{ENT}** to select the circuit breaker you want to control. *Figure 5.20 on page 5.18* shows the BREAKER CONTROL submenu and sample circuit breaker control screens for BREAKER 1. Use the **{Up}** and **{Down}** pushbuttons to highlight the TRIP BREAKER 1 or CLOSE BREAKER 1 control actions. When you highlight the trip option and press **{ENT}**, the relay displays the confirmation message “OPEN COMMAND ISSUED” and trips Circuit Breaker 1. The BREAKER 1 STATUS changes to OPEN. When you highlight the close option and press **{ENT}**, the relay displays the confirmation message “CLOSE COMMAND ISSUED” and closes Circuit Breaker 1. The BREAKER 1 STATUS changes to CLOSED.

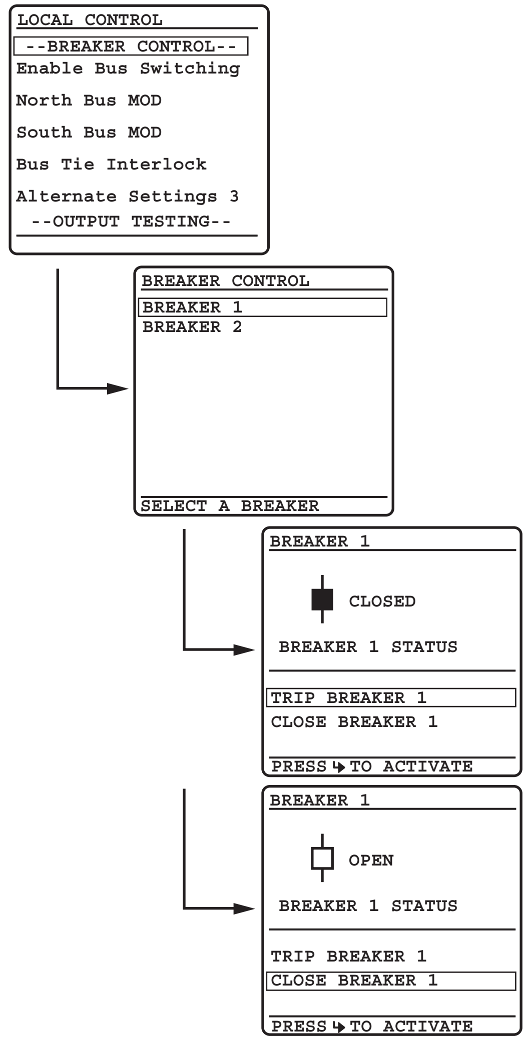


Figure 5.20 BREAKER CONTROL Screens.

Local Control Bits

The relay provides 32 local control bits. These local bits replace substation control handles to perform switching functions such as bus transfer switching. The SEL-421 Relay saves the states of the local bits in nonvolatile memory and restores the local bit states at relay power-up.

Any unused local control bits default to the clear (logical 0) state. Also, any reconfigured local bit retains the existing bit state after you change the bit setting. Deleting a local bit sets that bit to the clear (logical 0) state.

Figure 5.21 on page 5.19 shows a control example using the LOCAL CONTROL menus. The LCD shows a graphic representation of a substation control handle. If the local bit is in the clear state, the graphic control handle points to 0; if the local bit is in the set state, the switch points to 1. You can program names or aliases for the local bit clear and set states; these appear next to logical 0 and logical 1, respectively, in the lower portion of the sample Bus Tie Interlock screens of *Figure 5.21*. Use the **{Up}** and **{Down}** pushbuttons to highlight the set (1) or clear (0) control actions. Highlighting the set option (shown in *Figure 5.21* as "Closed (OK to TIE)") and pressing **{ENT}** changes the local control bit and performs the required control action. The graphical switch moves to 1 to indicate the new local bit status.

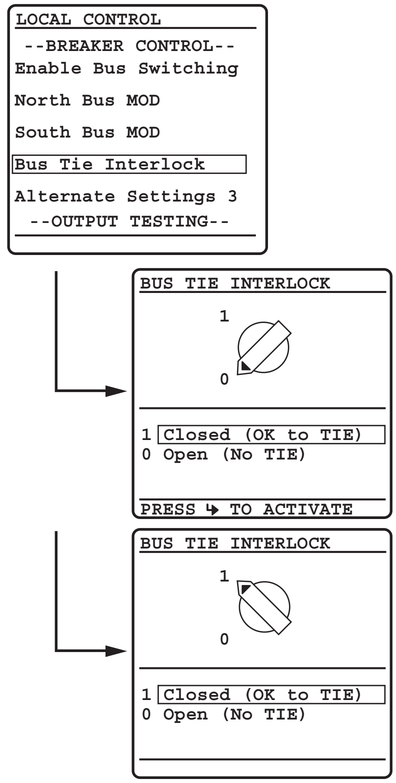


Figure 5.21 LOCAL CONTROL Example Menus.

To enable a local bit, enter the local bit settings in *Table 5.4* (*n* = 1–32). The format for entering the local bit data is the comma-delimited string:

> local bit,control function name,alias for the set state,alias for the clear state,pulse enable

Names or aliases can contain any printable ASCII character except double quotation marks. Use double quotation marks to enclose the name or alias. See *Example 5.3 on page 5.20* for particular information on enabling a local control bit.

Table 5.4 Local Bit Control Settings[a]

Description	Range	Default
Local Bit *n*	1–32	1
Local Bit *n* Name	20-character maximum ASCII string	(blank)
Local Bit *n* Set Alias (1 state)	20-character maximum ASCII string	(blank)
Local Bit *n* Clear Alias (0 state)	20-character maximum ASCII string	(blank)
Pulse Local Bit *n*	Y, N	N

[a] n = 1–32

The pulse state enable setting at the end of the setting string is optional. If your application requires a pulsed or momentary output, you can activate an output pulse by setting the option at the end of the local bit command string to “Y” (for Yes). The default for the pulse state is “N” (for No); if you do not specify “Y,” the local bit defaults at “N” and gives a continuous set or clear switch level.

If you enter an invalid setting, the relay displays an error message prompting you to correct your input. If you do not enter a valid local bit number, the relay displays "A local bit number must be entered." If you enter a local bit number and that local bit is already in use, the relay displays "The local bit number is already in use." Likewise, if you do not enter valid local bit name, set alias, and clear alias, the relay returns an error message. If an alias is too long, the relay displays "Too many characters, limit 20 characters per alias."

EXAMPLE 5.3 Enabling Local Bit Control

This application example demonstrates a method to create one of the control points in the LOCAL CONTROL screens of Figure 5.21 on page 5.19 to control the interlock on a power bus tie circuit breaker. Perform the following actions to create a local control bit:

- Eliminate previous usage of the local bit and condition the state of the local bit
- Set the local bit
- Assign the local bit to a relay output

If you are using a previously used local bit, delete all references to the local bit from the SELogic control equations already programmed in the relay. A good safety practice would be to disconnect any relay output that was programmed to that local bit.

To change the local bit state, select the bit and set it to the state you want. In addition, you can delete the local bit, which changes the state of this local bit to logical 0 when you save the settings. To delete, use the front-panel settings. When using a communications port and terminal, use the text-edit mode line setting editing commands at the Local Bits and Aliases prompt to go to the line that lists Local Bit 9. (See Text-Edit Mode Line Editing on page U.4.21 in the User's Guide for information on text-edit mode line editing.) To delete Local Bit 9, type **DELETE<Enter>** after the line that displays Local Bit 9 information. For example, if a previously programmed Local Bit 9 appears in the **SET F** line numbered listings on Line 1, then typing **DELETE<Enter>** at Line 1 deletes Local Bit 9.

Next, set the local bit. In the Front Panel settings (**SET F**), enter the following:

1: **LB09,"Bus Tie Interlock","Closed (OK to TIE)","Open (No TIE)",N**

This sets Local Bit 9 to "Bus Tie Interlock" with the set state as "Closed (OK to TIE)" and the clear state as "Open (No TIE)."

Assign the local bit to a relay output. In the Output settings (**SET O**), set the SELogic control equation, OUT201, to respond to Local Bit 9.

OUT201 := **LB09**

Use the appropriate interface hardware to connect the circuit breaker interlock to OUT201.

OUTPUT TESTING

NOTE: The circuit breaker control enable jumper J18C must be installed to perform output testing. See Main Board Jumpers on page U.2.17 in the User's Guide.

You can check for proper operation of the SEL-421 Relay control outputs by using the OUTPUT TESTING submenu of the LOCAL CONTROL menu. A menu screen similar to *Figure 5.22 on page 5.21* displays a list of the control outputs available in your relay configuration. For more information on output testing, see *Control Output on page U.4.52 in the User's Guide*.

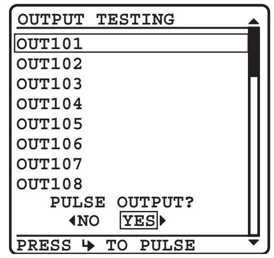


Figure 5.22 OUTPUT TESTING Screen.

SET/SHOW

NOTE: You cannot use the front-panel SET/SHOW menus to change front-panel settings. To change front-panel settings, use a communications port interface and the **SET F** command or use the ACSELERATOR software Front Panel settings.

You can use the SET/SHOW menus to examine or modify SEL-421 Relay port settings, global settings, active group settings, and date/time. From the front panel you can change only the settings classes and settings listed in *Table 5.5*.

Table 5.5 Settings Available From the Front Panel

Class/Setting	Description
PORT	Relay communications port settings
GLOBAL	Global relay settings
GROUP	Relay group settings
ACTIVE GROUP	Active settings group number 1–6
DATE/TIME	Date and time settings

Figure 5.23 on page 5.22 shows how to enter the setting CTRW (Terminal W CT ratio) from the front panel. At the MAIN MENU, select the SET/SHOW item and press **{ENT}**. The LCD screen displays the SET/SHOW screen of *Figure 5.23*. Use the navigation pushbuttons to select the relay settings class (PORT, GROUP, and GLOBAL) or to change the ACTIVE GROUP or the DATE/TIME. Select the GROUP class.

Next, select the particular instance of the settings class. For the PORT settings class, the instances are Port 1, Port 2, Port 3, Port F, and Port 5. For the GROUP class, the instances are the numbered groups from 1 through 6 and M, the breaker monitor (see the GROUP screen in *Figure 5.23*). The class GLOBAL, the setting ACTIVE GROUP = n (where n is a number from 1 to 6), and the settings for DATE/TIME have no settings instance screens. In the GROUP screen, move the highlight box to "3" and press **{ENT}**.

Proceed to selecting the settings category. The GROUP submenu in *Figure 5.23* is an example of settings Group 3 categories. Once you have highlighted the settings category, pressing **{ENT}** causes the relay to display the particular settings in that category. The LINE CONFIGURATION screen in *Figure 5.23* shows the settings that you can set in the line configuration settings category.

To edit or examine a setting, use the **{Up}** and **{Down}** pushbuttons to highlight that setting, then press **{ENT}**. The relay displays a settings entry screen with the existing setting value (see the SET CTRW screen in *Figure 5.23*). If the prompt for the selected setting does not fit on the line, the relay scrolls the setting prompt across the screen.

Enter the setting name using a method similar to the method described in *RELAY ELEMENTS (Relay Word Bits) on page 5.15*. Place characters in the element name field (with the block cursor) using the navigation pushbuttons. If the data you entered is valid (within settings range checks), the front-panel display returns to the settings category screen that shows each setting and corresponding present value (see the LINE CONFIGURATION screen of *Figure 5.23*). If the data you entered are invalid, the relay displays an error message screen, then returns to the particular settings entry screen so you can attempt a valid settings entry (see the CTRW screen of *Figure 5.23*).

When finished entering the new settings data, press **{ESC}**. The relay prompts you with a Save Settings screen. Using the navigation pushbuttons, answer YES to make the settings change(s), or NO to abort the settings change(s).

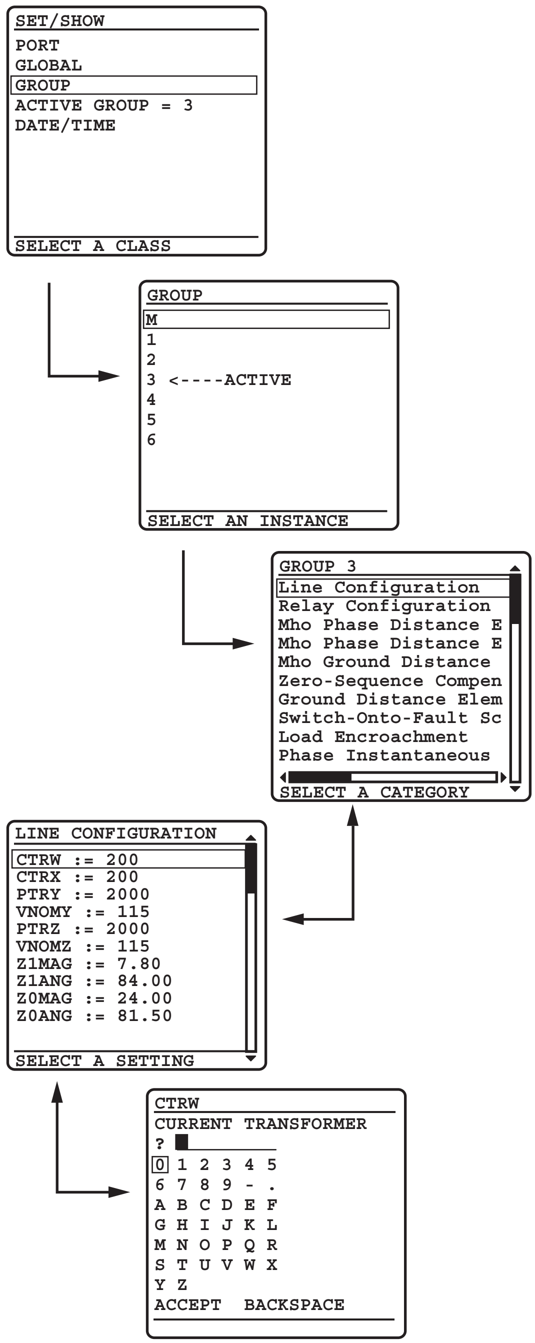
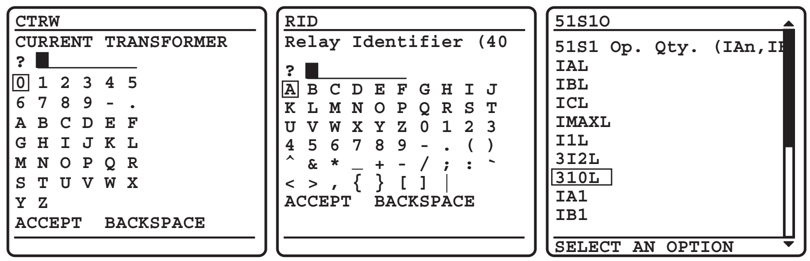


Figure 5.23 SET/SHOW Screens.

The SEL-421 Relay displays different settings entry screens depending on the settings type. For the CTRW setting in *Figure 5.23 on page 5.22*, the relay requires basic alphanumeric input. Other settings can have other data input requirements. The front-panel settings input data types are the following:

- Basic alphanumeric
- Character or string or SELOGIC control equations
- Setting options

For alphanumeric settings, the relay presents the character or string input screen. Some settings have specific options; use the setting options screens to select these options. *Figure 5.24* shows examples of the settings input screens.



Basic Alphanumeric | Character or String or SELOGIC control equations | Setting Options

Figure 5.24 Sample Settings Input Screens.

ACTIVE GROUP

Select the ACTIVE GROUP option of the SET/SHOW submenu screen (shown in *Figure 5.23 on page 5.22*) to change the settings group. The relay performs a password validation test at this point to confirm that you have Breaker Access Level authorization or above. If access is allowed, and all the results of SELOGIC control equations SS1–SS6 are not logical 1 (asserted), then the relay displays the EDIT ACTIVE GROUP screen in *Figure 5.25*. The relay shows the active group and underlines the group number after “NEW GROUP =.” Use the **{Up}** and **{Down}** pushbuttons to increase or decrease the NEW GROUP number. Once you have selected the new active group, press **{ENT}** to change the relay settings to this new settings group.

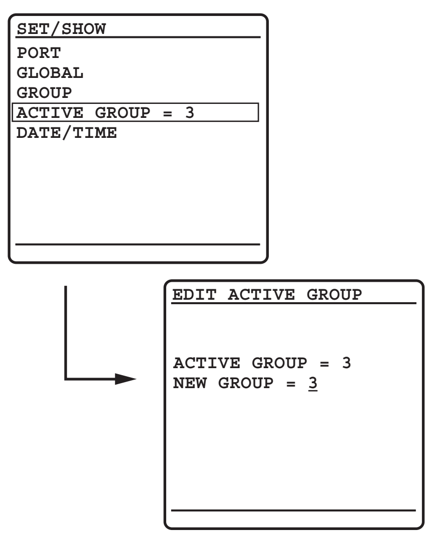


Figure 5.25 Changing the ACTIVE GROUP.

DATE/TIME

Another submenu item of the SET/SHOW first screen (*Figure 5.23 on page 5.22*) is the DATE/TIME screen shown in *Figure 5.26*. The SEL-421 Relay generates date and time information internally, or you can use external high-accuracy time modes with time sources such as a GPS receiver.

Figure 5.26 is the relay date/time screen when a high accuracy source is in use. Possible time sources, qqqqq, are listed in *Table 4.9 on page U.4.69 in the User's Guide*. If you use a high-accuracy time source, edits are disabled, the DATE/TIME display does not show the highlight, and the screen does not show the help message on the bottom line.

```
DATE/TIME
DATE   03/15/2001
     (MM/DD/YYYY)

TIME   00:00:00
LAST UPDATE
SOURCE: qqqqq
  CANNOT EDIT DATE OR
  TIME DUE TO A HIGH
  PRIORITY TIME SOURCE
PRESS ↵ TO EDIT DATE
```

Figure 5.26 DATE/TIME Screen.

When operating from a non-high-accuracy time source, you can use the front-panel DATE and TIME entry screens to set the date and time. *Figure 5.27* shows an example of these edit screens. Use the **{Left}** and **{Right}** navigation pushbuttons to move the underscore cursor; use the **{Up}** and **{Down}** navigation pushbuttons to increment or decrement each date and time digit as appropriate to set the date and time. For a description of the LAST UPDATE SOURCE field, see *Configuring High-Accuracy Timekeeping on page U.4.66 in the User's Guide*.

```
DATE   (MM/DD/YYYY)          TIME

  03/15/2001                   00:00:00
```

Figure 5.27 Edit DATE and Edit TIME Screens.

To enable a high-accuracy external time source, connect a GPS receiver to the relay. For a discussion of the IRIG and PPS timing modes in the SEL-421 Relay see *Configuring High-Accuracy Timekeeping on page U.4.66 in the User's Guide*. See *TIME Input Connections on page U.2.43 in the User's Guide* for more information on connecting time source inputs.

RELAY STATUS

The SEL-421 Relay performs continuous hardware and software self-checking. If any vital system in the relay approaches a failure condition, the relay issues a status warning. If the relay detects a failure, the relay displays the status failure RELAY STATUS screen immediately on the LCD. For both warning and failure conditions, the relay shows the error message for the system or function that caused the warning or failure condition. You can access the RELAY STATUS screen via the MAIN MENU. The RELAY STATUS screen shows the firmware identification number (FID), serial number, whether the relay is enabled, and any status warnings. *Figure 5.28* shows examples of a normal RELAY STATUS screen, a status warning RELAY STATUS screen, and a status failure RELAY STATUS screen. For more information on status warning and status failure messages, see *Relay Self-Tests on page U.6.37 in the User's Guide*.

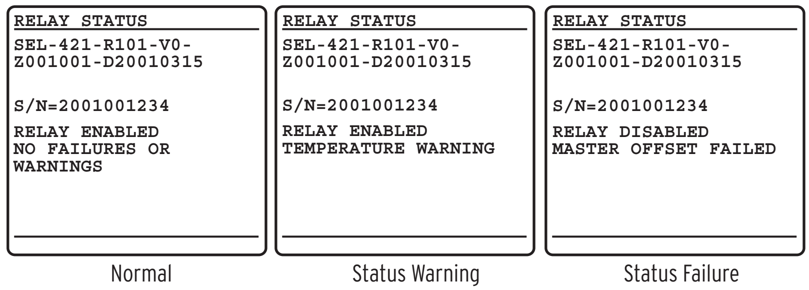


Figure 5.28 Relay STATUS Screens.

VIEW CONFIGURATION

You can use the front panel to view detailed information about the configuration of the firmware and hardware components in the SEL-421 Relay. In the MAIN MENU, highlight the VIEW CONFIGURATION option by using the navigation pushbuttons. The relay presents five screens in the order shown in *Figure 5.29*. Use the navigation pushbuttons to scroll through these screens. When finished viewing these screens, press **{ESC}** to return to the MAIN MENU.

```
CONFIGURATION INFO
FID=SEL-421-R101-V0-
  Z001001-D20010315

PART NUMBER:
  04210615X22XXHX
S/N=200101234
SELBOOT:
  BFID=SLBT-421-
  R101-V0-Z001001-
  D20010315
  CHECKSUM: D97F
```

```
CONFIGURATION INFO
MAINBOARD:
  CODE FLASH:  4 MB
  DATA FLASH:  8 MB
  RAM:         3 MB
  EEPROM:     32 KB

ANALOG INPUTS:
  W: CURRENTS:   5 A
  X: CURRENTS:   5 A
  Y: VOLTAGE:   67 V
  Z: VOLTAGE:   67 V
```

```
CONFIGURATION INFO
FIBER PORT:
  NOT INSTALLED

INTERFACE BOARDS:
  BOARD 1: 8 INPUTS
          15 OUTPUTS
  BOARD 2:NOT
          INSTALLED

EXTENDED FEATURES:
  DNP ACTIVE
```

```
CONFIGURATION INFO
COMMUNICATIONS CARD:
  MODEL: SEL-2701
  DESCR: Ethernet
  FID=SEL-2701-R101
  V0-Z000000-
  D20010307
  BFID=SLBT-2701-
  R100-V0-Z000000-
  D20010307
```

```
CONFIGURATION INFO
IF THE CONFIGURATION
IS NOT WHAT YOU
EXPECTED, CONTACT
SEL FOR ASSISTANCE.
```

Figure 5.29 VIEW CONFIGURATION Sample Screens.

DISPLAY TEST

You can use the DISPLAY TEST option of the MAIN MENU to confirm operation of all of the LCD pixels. The LCD screen alternates the on/off state of the display pixels once every time you press **{ENT}**. *Figure 5.30* shows the resulting two screens. The DISPLAY TEST option also illuminates all of the front-panel LEDs. To exit the test mode, press **{ESC}**.

NOTE: The LCD DISPLAY TEST does NOT reset the front-panel LED targets.

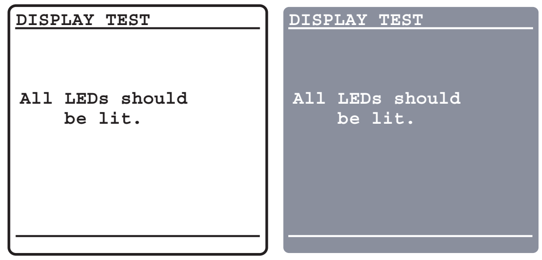


Figure 5.30 DISPLAY TEST Screens.

RESET ACCESS LEVEL

The SEL-421 Relay uses various passwords to control access to front-panel functions. As you progress through these menus, the relay detects the existing password level and prompts you for valid passwords before allowing you access to levels greater than Access Level 1 (see *Password on page 5.10* in this section). When you want to return the front-panel to the lowest access level (Access Level 1), highlight RESET ACCESS LEVEL item on the MAIN MENU. Pressing **{ENT}** momentarily displays the screen of *Figure 5.31* and places the front panel at Access Level 1.

The relay automatically resets the access level to Access Level 1 upon front-panel timeout (setting FP_TO is not set to OFF). Use this feature to reduce the front-panel access level before the timeout occurs.

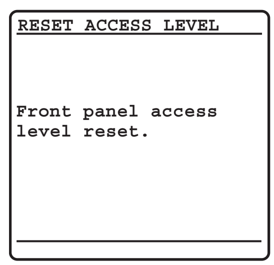


Figure 5.31 RESET ACCESS LEVEL Screen.

Front-Panel Automatic Messages

The SEL-421 Relay automatically displays alert messages. Any message generated due to an alert condition takes precedence over the normal ROTATING DISPLAY and the MAIN MENU. Alert conditions include these significant events:

- Event reports and trips
- Status warnings
- Status failures

For event reports (including trip events) and status warnings, the relay displays the full-screen automatic message that corresponds to this event, only if the front-panel display is in the time-out or standby condition (the relay is scrolling through the default display points/enabled metering screens of the ROTATING DISPLAY or is displaying the MAIN MENU). When a status warning or event is triggered, the relay full-screen presentation is similar to the screens of *Figure 5.32*.

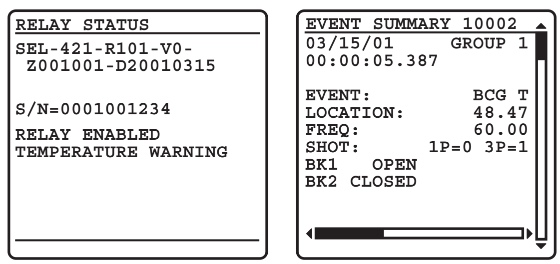


Figure 5.32 Sample Status Warning and Trip EVENT SUMMARY Screens.

If you are on site using the SEL-421 Relay front panel in menus and screens other than the MAIN MENU and a status warning occurs or an event report triggers, the relay shows automatic messages at the bottom of the active screen in the message area. For example, the message area shows RELAY STATUS WARNING for a status warning. *Figure 5.33* is an example of a status warning notification that appears in the message area of a LOCAL CONTROL (local bit) screen. If a trip event occurs while you are using a front-panel screen, the message area notification reads RELAY EVENT. When you repeatedly press **{ESC}** (as if returning to the MAIN MENU) during this warning or trip alert situation, the relay displays the full-screen automatic message concerning the warning or trip in place of the MAIN MENU. If the front-panel display is at the MAIN MENU and a status warning occurs, the full-screen warning replaces the MAIN MENU. After you view the warning or trip screen, pressing **{ESC}** returns the LCD to the MAIN MENU.

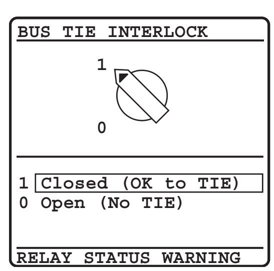


Figure 5.33 Sample Status Warning in the LCD Message Area.

For a status failure, the relay immediately displays the full-screen status alert regardless of the present front-panel operating state. The relay displays no further LCD screens until the status failure clears. Should an unlikely status failure event occur, contact your local Technical Service Center or an SEL factory representative (see *Factory Assistance on page U.6.43 in the User's Guide*).

Operation and Target LEDs

The SEL-421 Relay gives you at-a-glance confirmation of relay conditions via operation and target LEDs. These LEDs are located in the middle of the relay front panel.

You can reprogram all of these indicators except the ENABLED and TRIP LEDs to reflect other operating conditions than the factory default programming described in this subsection. Settings T*n*_LED are SELOGIC control equations that, when asserted during a relay trip event, light the corresponding LED. Parameter *n* is a number from 1 through 16 that indicates each LED. LED positions are described in parenthesis next to each LED in *Figure 5.34*. Program settings T*n*LEDL := Y to latch the LEDs during trip events; when you set T*n*LEDL := N, the trip latch supervision has no effect and the LED follows the state of the T*n*_LED SELOGIC control equation. The relay reports these targets in event reports; set the alias name listed in the report (up to eight characters) with settings T*n*LEDA. After setting the target LEDs, issue the **TAR R** command to reset the target LEDs. For a concise listing of the default programming on the front-panel LEDs, see *Front-Panel Settings on page R.9.33 in the Reference Manual*.

Use the slide-in labels to mark the LEDs with custom names. Included on the SEL-421/SEL-421-1 Relay Product Literature CD are Customer Label Templates to print labels for the slide-in label carrier.

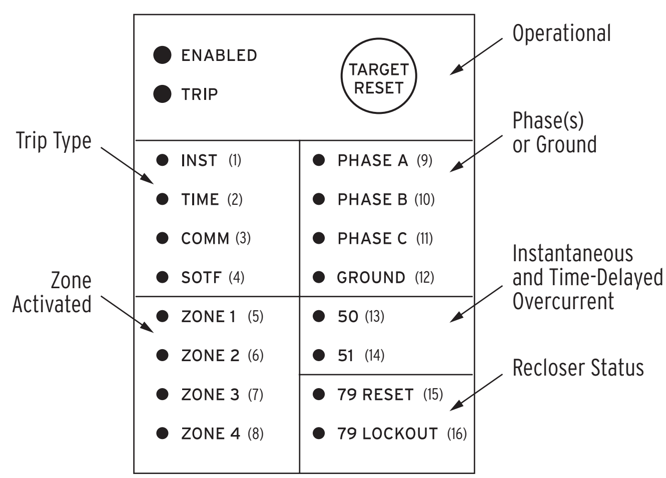


Figure 5.34 Factory Default Front-Panel Target Areas.

Figure 5.34 shows the arrangement of the operation and target LEDs region into six areas.

The six front-panel target LED areas are the following:

- Operational–ENABLED, TRIP
- Trip Type–INST, TIME, COMM, SOTF
- Zone Activated–ZONE 1, ZONE 2, ZONE 3, ZONE 4
- Phase(s) or Ground–PHASE A, PHASE B, PHASE C, GROUND
- Instantaneous and Time-Delayed Overcurrent–50, 51
- Recloser Status–79 RESET, 79 LOCKOUT

Operational

The green ENABLED LED indicates that the relay is active. Trip events illuminate the TRIP LED. The prominent location of the red TRIP LED in the top target area helps you recognize a trip event quickly.

TARGET RESET and Lamp Test

For a trip event, the relay latches the trip-involved target LEDs (except for the ENABLED LED and the Recloser Status area LEDs). Press the TARGET RESET pushbutton to reset the latched target LEDs. When a new trip event occurs and you have not reset the previously latched trip targets, the relay clears the latched targets and displays the new trip targets.

Pressing the TARGET RESET pushbutton illuminates all the LEDs. Upon releasing the TARGET RESET pushbutton, two possible trip situations can exist: the conditions that caused the relay to trip have cleared or the trip conditions remain present at the relay inputs. If the trip conditions have cleared, the latched target LEDs turn off. If the trip event conditions remain, the relay re-illuminates the corresponding target LEDs. The TARGET RESET pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

Lamp Test Function With TARGET RESET

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as you press TARGET RESET. The target LEDs return to a normal operational state after you release the TARGET RESET pushbutton.

Lamp Test Function With LCD DISPLAY TEST Menu

The LCD menus provide a front-panel DISPLAY TEST mode. This menu-activated lamp test, from the DISPLAY TEST menu, does not reset the target LEDs (see *DISPLAY TEST on page 5.27*).

Other Target Reset Options

You can reset the target LEDs with the ASCII command **TAR R**; see *TARGET on page R.8.48 in the Reference Manual* for more information. You can reset the targets from the ACSELERATOR software Control branch of the HMI tree view. Programming specific conditions in the SELOGIC control equation RSTTRGT is another method to reset the relay targets. Access RSTTRGT in the relay Global settings (Data Reset Control); to use RSTTRGT, you must enable data reset control with global setting EDRSTC := Y.

Trip Type

The SEL-421 Relay indicates essential information about the most recent relay trip event with the LEDs of the Trip Type area. These trip types are INST, TIME, COMM, and SOTF. For information on setting the corresponding trip logic, see *Trip Logic on page R.1.103 in the Reference Manual*.

The INST target LED illuminates, indicating operation of the SEL-421 Relay instantaneous elements. This LED lights if elements M1P (the Zone 1 mho phase distance element) or Z1G (the Zone 1 mho ground distance element) pick up and the relay has not illuminated the COMM or SOTF targets.

The TIME target LED indicates that a timed relay element caused a relay trip. *Table 5.6* lists the elements that activate the TIME LED in the factory default settings.

Table 5.6 TIME Target LED Trigger Elements–Factory Defaults

Mho	Quadrilateral
M2PT	Z2GT
M3PT	Z3GT
M4PT	Z4GT
M5PT	Z5GT

The COMM LED illuminates, indicating that tripping resulted from a communications-assisted trip. The relay lights the COMM target when there is a relay tripping condition and the Relay Word bit COMPRM (communications-assisted trip permission) asserts.

The SOTF target LED indicates that the switch-onto-fault protection logic operated. The relay illuminates the SOTF target when there is a relay tripping condition and the Relay Word bit SOTFT (switch-onto-fault trip) asserts.

Zone Activated

The zone activated area target indicators are the ZONE 1, ZONE 2, ZONE 3, and ZONE 4 LEDs. These targets illuminate when the corresponding zone distance elements pick up and there is a relay tripping condition. In factory default programming, the lowest zone LED has priority; only the LED corresponding to the closest protection zone latches for distance element pickups.

> The ZONE 1 target illuminates if either the M1P or Z1G distance elements operated or if the high-speed Zone 1 elements operated.
>
> The ZONE 2 target illuminates if either the M2P or Z2G distance elements operated or if the high-speed Zone 2 elements operated and the similar elements in Zone 1 did not operate.
>
> The ZONE 3 target illuminates if either the M3P or Z3G distance elements operated or if the high-speed Zone 3 elements operated and the similar elements in Zone 1 and Zone 2 did not operate.
>
> The ZONE 4 target illuminates if either the M4P or Z4G distance elements operated and the similar elements in Zone 1, Zone 2, and Zone 3 did not operate.

Phase(s) or Ground

The phase(s) or ground targets illuminate according to the SEL-421 Relay special targeting logic. This logic accurately classifies which phase, phases, and/or ground were involved in a trip event.

The PHASE A target LED lights for faults on the power system A-phase. Single-phase-to-ground faults from A-phase to ground illuminate both the PHASE A and GROUND targets. A phase-to-phase fault between A-phase and B-phase illuminates the PHASE A target and the PHASE B target. The relay displays faults involving other phase combinations similarly. If the phase-to-phase fault includes ground, the relay also lights the GROUND target. The relay lights the PHASE A, PHASE B, and PHASE C target LEDS for a three-phase fault.

Instantaneous and Time-Delayed Overcurrent

The 50 target LED indicates that an instantaneous overcurrent element picked up. These elements are the nondirectional 50Pn phase overcurrent elements, 50Qn negative-sequence overcurrent elements, and the 50Gn ground overcurrent elements, where n is the overcurrent level; n = 1, 2, 3, and 4.

The 51 target LED illuminates if a time-overcurrent element has timed out. The relay lights this LED if any of the selectable operating quantity inverse-time overcurrent elements 51S1T, 51S2T, and 51S3T assert.

Recloser Status

The 79 RESET and the 79 LOCKOUT target LEDs show the operating status of the SEL-421 Relay reclosing function. The 79 RESET LED indicates that the relay recloser is in the reset or ready-to-reclose state for Circuit Breaker 1 (Relay Word bit BK1RS is asserted). The 79 LOCKOUT target illuminates when the relay has completed the reclose attempts unsuccessfully (a drive-to-lockout condition), or when other programmed lockout conditions exist. If the 79 RESET and the 79 LOCKOUT LEDs are not lit, the relay is in the cycle state for Circuit Breaker 1. See *Section 2: Auto-Reclose and Synchronism Check in the Reference Manual* for complete information on the SEL-421 Relay recloser function.

Front-Panel Operator Control Pushbuttons

The SEL-421 Relay front panel features large operator control pushbuttons coupled with amber annunciator LEDs for local control. *Figure 5.35* shows this region of the relay front panel with factory default configurable front-panel label text.

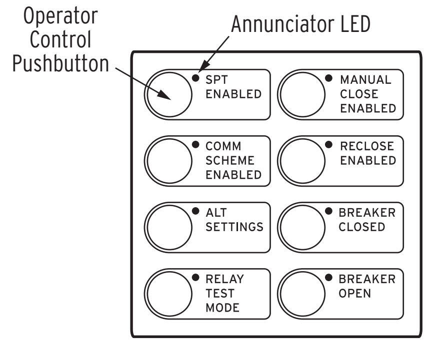


Figure 5.35 Operator Control Pushbuttons and LEDs.

Factory default programming associates specific relay functions with the eight pushbuttons and LEDs, as listed in *Table 5.7*. For a concise listing of the default programming for the front-panel pushbuttons and LEDs, see *Front-Panel Settings on page R.9.33 in the Reference Manual*.

Table 5.7 Operator Control Pushbuttons and LEDs—Factory Defaults

LED	Pushbutton	Function
SPT ENABLED		Enable single-pole tripping
COMM SCHEME ENABLED		Enable communications scheme
ALT SETTINGS		Change to alternate settings
RELAY TEST MODE		Enter test mode
MANUAL CLOSE ENABLED		Enable manual closing
RECLOSE ENABLED		Enable automatic reclosing
BREAKER CLOSED	CLOSE	Close Circuit Breaker 1
BREAKER OPEN	TRIP	Open Circuit Breaker 1

Press the operator control pushbuttons momentarily to toggle on and off the functions listed adjacent to each LED/pushbutton combination. The CLOSE and TRIP pushbuttons momentarily assert the close and trip relay outputs after a short delay.

The operator control pushbuttons and LEDs are programmable. *Figure 5.36 on page 5.35* describes the factory defaults for the four operator controls on the left side of the display, and *Figure 5.37 on page 5.36* describes the factory defaults for the operator controls on the right side of the display.

Using SELOGIC control equations, you can readily change the default pushbutton and LED functions. Use the slide-in labels to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. The labels are keyed; you can insert each Operator Control Label in only one position on the front of the relay. Included on the SEL-421/SEL-421-1 Relay Product Literature CD are word processor templates for printing slide-in labels. See *Front-Panel Labels on page 2.26 in Section 2: Installation* for more information on changing the slide-in labels.

The SEL-421 Relay has two types of outputs for each of the front-panel pushbuttons. Relay Word bits represent the pushbutton presses. One set of Relay Word bits follows the pushbutton and another set pulses for one processing interval when the button is pressed. Relay Word bits PB1 through PB8 are the "follow" outputs of operator control pushbuttons. Relay Word bits PB1_PUL through PB8_PUL are the pulsed outputs.

Annunciator LEDs for each operator control pushbutton are PB1_LED through PB8_LED. The factory defaults programmed for these LEDs are protection latches (PLT01, for example), settings groups, Relay Word bits (NOT SG1), and the status of the circuit breaker auxiliary contacts (52AA1). You can change the LED indications to fit your specific control and operational requirements. This programmability allows great flexibility and provides operator confidence and safety, especially in indicating the status of functions that are controlled both locally and remotely.

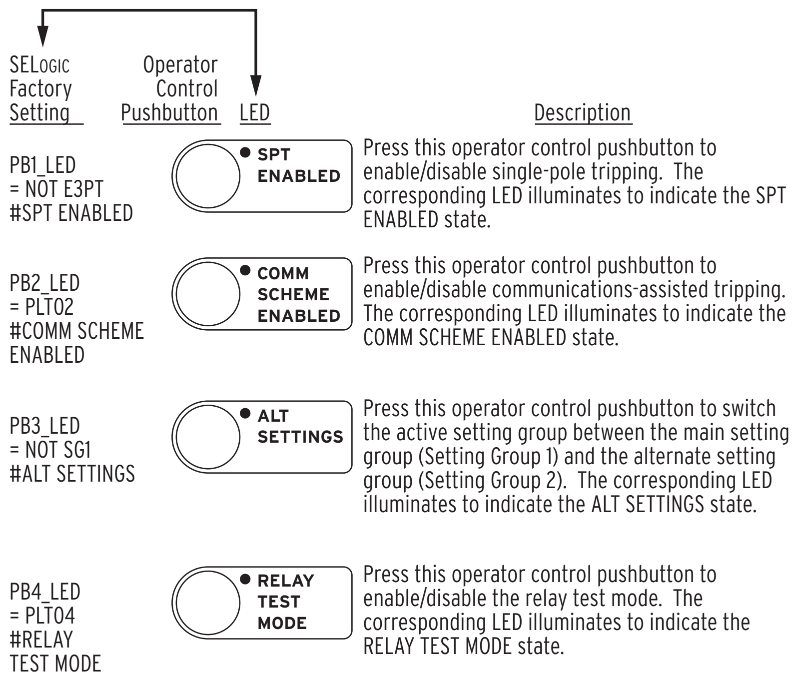


Figure 5.36 Factory Default Operator Control Pushbuttons—Left Side.

SELOGIC Factory Setting	Operator Control Pushbutton	LED	Description
PB5_LED = PLT05 #MANUAL CLOSE ENABLED		MANUAL CLOSE ENABLED	Press this operator control pushbutton to enable/disable local front-panel circuit breaker closing using the CLOSE pushbutton. The corresponding LED illuminates to indicate the MANUAL CLOSE ENABLED state.
PB6_LED = PLT06 #RECLOSE ENABLED		RECLOSE ENABLED	Press this operator control pushbutton to enable/disable the automatic recloser. The corresponding LED illuminates to indicate the RECLOSE ENABLED state.
PB7_LED = 52ACL1 and 52BCL1 and 52CCL1 #BREAKER CLOSED		BREAKER CLOSED	Press this operator control pushbutton to close Circuit Breaker 1. The corresponding BREAKER CLOSED LED illuminates indicating that Circuit Breaker 1 is closed. The MANUAL CLOSE ENABLED function above enables and disables the CLOSE pushbutton.
PB8_LED = NOT 52ACL1 and 52BCL1 and 52CCL1 #BREAKER OPEN		BREAKER OPEN	Press this operator control pushbutton to trip Circuit Breaker 1. The corresponding BREAKER OPEN LED illuminates, indicating that Circuit Breaker 1 is open.

Figure 5.37 Factory Default Operator Control Pushbuttons—Right Side.

Section 6

Testing and Troubleshooting

This section contains guidelines for determining and establishing test routines for the SEL-421 Relay. Follow the standard practices of your company in choosing testing philosophies, methods, and tools. The relay incorporates self-tests to help you diagnose potential difficulties should these occur. The subsection *Relay Troubleshooting on page 6.40* contains a quick-reference table for common relay operation problems.

Topics, tests, and troubleshooting procedures presented in this section include the following:

- Testing philosophy
- Testing features and tools
- Relay test connections
- Test methods
- Relay element tests (selected elements)
- Relay self-tests
- Relay troubleshooting
- Factory assistance

The SEL-421 Relay is factory calibrated; this section contains no calibration information. If you suspect that the relay is out of calibration, contact your Technical Service Center or the SEL factory.

Testing Philosophy

Protective relay testing generally consists of three categories: acceptance testing, commissioning testing, and maintenance testing. The categories differ in testing complexity and according to when these activities take place in the life of the relay.

Each testing category includes particular details as to when to perform the test, the testing goals at that time, and the relay functions that you need to test. This information is a guide to testing the SEL-421 Relay; be sure to follow the practices of your company for relay testing.

Acceptance Testing

SEL performs detailed acceptance testing on all new relay models and versions. We are certain that your SEL-421 Relay meets published specifications. Even so, you can perform acceptance testing on a new relay model to become familiar with the relay operating theory and settings; this familiarity helps you apply the relay accurately and correctly. A summary of acceptance testing guidelines is presented in *Table 6.1*.

Table 6.1 Acceptance Testing

Details	Description
Time	Test when qualifying a relay model for use on the utility system.
Goals	a) Confirm that the relay meets published critical performance specifications such as operating speed and element accuracy.
	b) Confirm that the relay meets the requirements of the intended application.
	c) Gain familiarity with relay settings and capabilities.
Test	Test all protection elements and logic functions critical to your intended application.

Commissioning Testing

SEL performs a complete functional check and calibration of each SEL-421 Relay before shipment so that your relay operates correctly and accurately. You should perform commissioning tests to verify proper connection of the relay to the power system and all auxiliary equipment. Check control signal inputs and outputs. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs. Use an ac connection test to verify that the relay current and voltage inputs are the proper magnitude and phase rotation.

Brief fault tests confirm that the relay settings and protection scheme logic are correct. You do not need to test every relay element, timer, and function in these tests.

At commissioning, use the relay **METER** command to verify the ac current and voltage magnitude and phase rotation (see *Examining Metering Quantities on page U.4.31 in the User's Guide*). Use the **PUL** command to pulse relay control output operation. Use the **TAR** command to view relay targets and verify that control inputs are operational. Use **TEST FM**, **TEST DNP**, and **TEST DB** to check SCADA interfaces. (See *TEST DB on page R.8.49 in the Reference Manual* for information on these relay commands.) *Table 6.2 on page 6.3* lists guidelines for commissioning testing. For further discussion of these tests, see *Checking Relay Operation on page 6.24*.

Table 6.2 Commissioning Testing

Details	Description
Time	Test when installing a new protection system.
Goals	a) Validate all system ac and dc connections.
	b) Confirm that the relay functions as intended using your settings.
	c) Check that all auxiliary equipment operates as intended.
	d) Check SCADA interface.
Tests	Test all connected/monitored inputs and outputs, and the polarity and phase rotation of ac connections. Make simple checks of protection elements. Test communications interfaces.

Maintenance Testing

The SEL-421 Relay uses extensive self-testing routines and features detailed metering and event reporting functions. These features reduce your dependence on routine maintenance testing. When you want to perform maintenance testing, follow the recommendations in *Table 6.3*.

Table 6.3 Maintenance Testing

Details	Description
Time	Test at scheduled intervals or when there is an indication of a problem with the relay or power system.
Goals	a) Confirm that the relay is measuring ac quantities accurately.
	b) Check that scheme logic and protection elements function correctly.
	c) Verify that auxiliary equipment functions correctly.
Tests	Test all relay features/power system components that did not operate during an actual fault within the past maintenance interval.

You can use the SEL-421 Relay reporting features as maintenance tools. Periodically compare the relay **METER** command output to other meter readings on a line to verify that the relay measures currents and voltages correctly and accurately. Use the circuit breaker monitor, for example, to detect slow breaker auxiliary contact operations and increasing or varying breaker pole operating times. For details on these features, see *Circuit Breaker Monitor on page A.2.2 in the Applications Handbook*.

Each occurrence of a fault tests the protection system and relay application. Review relay event reports in detail after each fault to determine the areas needing your attention. Use the event report current, voltage, and relay element data to determine that the relay protection elements and communications channels operate properly. Inspect event report input and output data to determine whether the relay asserts outputs at the correct times and whether auxiliary equipment operates properly.

At each maintenance interval, the only items to be tested are those that have not operated (via fault conditions and otherwise) during the maintenance interval. The basis for this testing philosophy is simple: you do not need to perform further maintenance testing for a correctly set and connected relay that measures the power system properly and for which no relay self-test has failed.

The SEL-421 Relay is based on microprocessor technology; the relay internal processing characteristics do not change over time. For example, if time-overcurrent element operating times change, these changes occur because of alterations to relay settings and/or differences in the signals applied to the relay. You do not need to verify relay element operating characteristics as a part of maintenance checks.

SEL recommends that you limit maintenance tests on SEL relays according to the guidelines listed in *Table 6.3 on page 6.3*. You will spend less time checking relay operations that function correctly. You can use the time you save to analyze event data and thoroughly test systems needing more attention.

Testing Features and Tools

The SEL-421 Relay provides the following features to assist you during relay testing:

- Metering
- High-resolution oscillography
- Event reports
- Event summary reports
- SER (Sequential Events Recorder) reports

Certain relay commands are useful in confirming relay operation. The following commands, for example, aid you in testing the relay:

- **TAR**
- **PUL**
- **TEST DB**
- **TEST FM**
- **TEST DNP**

In addition, the SEL-421 Relay incorporates a low-level test interface where you can interrupt the connection between the relay input transformers and the input processing module. Use the low-level test interface to apply reduced-scale test quantities from the SEL-4000 Relay Test System; you do not need to use large power amplifiers to perform relay testing.

Test Features

Metering

The metering data show the ac currents and voltages (magnitude and phase angle) connected to the relay in primary values. In addition, metering shows many other quantities including the power system frequency (FREQ) and the voltage input to the station dc battery monitors (Vdc1 and Vdc2). Compare these quantities against quantities from other devices of known accuracy. The metering data are available at the serial ports, from the SEL-5030 ACSELERATOR® Software Program HMI, and at the front-panel LCD METER menu. See *MET on page R.8.28 in the Reference Manual*, *METER on page U.5.11 in the User's Guide*, *HMI Meter and Control on page U.3.19 in the User's Guide*, and *Examining Metering Quantities on page U.4.31 in the User's Guide* for more information.

High-Resolution Oscillography

The SEL-421 Relay takes an unfiltered data snapshot of the power system at each event trigger or trip. The relay samples power system data at high sample rates from 1 kHz to 8 kHz. You can use the SEL-5601 Analytic Assistant or other COMTRADE viewing program to export and view these raw data in a binary COMTRADE file format. Use high-resolution oscillography to capture fast power system transients or to examine low frequency anomalies in the power system. See *Raw Data Oscillography on page A.3.8 in the Applications Handbook* for more information.

Event Reports

The relay also generates a filtered-quantities event report in response to faults or disturbances. Each event report contains information on current and voltage, relay element states, control inputs, and control outputs. If you are unsure of the relay response or your test method, the event report provides you with information on the operating quantities that the relay used at the event trigger. The relay provides oscillographic displays of the filtered event report data, which give you a visual tool for testing relay operating quantities. You can use the serial ports and the ACSELERATOR software to view event reports. See *Event Reports, Event Summaries, and Event Histories on page A.3.12 in the Applications Handbook* for a complete discussion of event reports.

Event Summary Reports

The relay generates an event summary for each event report; use these event summaries to quickly verify proper relay operation. With event summaries, you can quickly compare the reported fault current and voltage magnitudes and angles against the reported fault location and fault type. If you question the relay response or your test method, you can obtain the full event report and the high-resolution oscillographic report for a more detailed analysis. See *Event Summary on page A.3.28 in the Applications Handbook*for more information on the event summary.

SER Reports

The relay provides an SER report that time tags changes in relay elements, control inputs, and control outputs. Use the SER for convenient verification of the pickup and dropout of any relay element. For a complete discussion of the SER, see *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook*.

Test Commands

TAR Command

Use the **TAR** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. You can see relay targets at the serial ports, and from the front-panel LCD. See *TARGET on page R.8.48 in the Reference Manual* and *Operation and Target LEDs on page U.5.30 in the User's Guide*.

PUL Command

Use the **PUL** command to test the control output circuits. The specified output closes if open, or opens if closed. You can use the **PUL** command at the serial ports, in the ACSELERATOR HMI, and from the front-panel LCD. See *PULSE on page R.8.36 in the Reference Manual*, *HMI Meter and Control on page U.3.19 in the User's Guide*, and *Operation and Target LEDs on page U.5.30 in the User's Guide*.

TEST DB Command

Use the **TEST DB** command for testing the communications card relay database. You can use the **TEST DB** command to override any value in the relay database. Use the **MAP 1** command and the **VIEW1** command to inspect the relay database (see *MAP on page R.8.27 in the Reference Manual*). You must be familiar with the relay database structure to use the **TEST DB** command effectively; see *Communications Card Database on page R.4.6 in the Reference Manual* for more information.

TEST DNP Command

Use the **TEST DNP** command to test the DNP 3.0 interface. Values you enter in the DNP map are “override values.” Use the **TEST DNP** command to write override values in the DNP map. For more information on DNP 3.0 and the SEL-421 Relay, see *Section 6: DNP 3.0 Communications in the Reference Manual*.

TEST FM Command

Use the **TEST FM** command to override normal Fast Meter quantities for testing purposes. You can only override “reported” Fast Meter values (per-phase voltages and currents). You cannot directly test Fast Meter values that the relay derives from the reported values (power, sequence components, and so on). For more information on Fast Meter and the SEL-421 Relay, see *Section 5: SEL Communications Protocols in the Reference Manual*.

Low-Level Test Interface

The SEL-421 Relay has a low-level test interface between the calibrated input module and the processing module. You can check the relay in two ways: by using secondary injection testing, or by applying low-magnitude ac voltage signals to the low-level test interface.

Connection

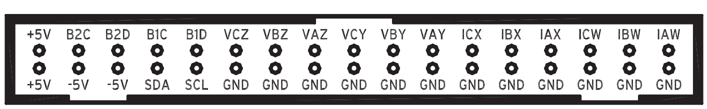
CAUTION: Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

Access the test interface by removing the relay front panel. The top circuit board is the relay main board and the bottom circuit board is the input module board. At the right side of the relay main board (the top board) is the processing module. The input to the processing module is multipin connector J20, the analog or low-level test interface connection. Receptacle J20 is on the right side of the main board; for a locating diagram, see *Figure 2.13 on page U.2.18 in the User’s Guide*.

Figure 6.1 shows the low-level interface connections. Note the nominal voltage levels, current levels, and scaling factors listed in *Figure 6.1* that you can apply to the relay. Never apply voltage signals greater than 6.6 Vp-p sinusoidal signal (2.33 Vrms) to the low-level test interface.

To use the low-level test interface, remove the ribbon cable from the main board J20 receptacle, and substitute a test cable with the signals specified in *Figure 6.1*.

SEL-421 Relay
Low-Level Test Interface



Input Module Output (J3): 66.6 mV At Nominal Current (1 A or 5 A).
446 mV at Nominal Voltage (67 V_{LN}).

Processing Module Input (J20): 6.6 Vp-p Maximum.

U.S. Patent 5,479,315.

Figure 6.1 Low-Level Test Interface.

Main Board Processing Module Tests

Use signals from the SEL-4000 Low-Level Relay Test System to test the relay processing module. Apply appropriate signals to the low-level test interface J20 from the SEL-4000 Relay Test System (see *Figure 6.1 on page 6.7*). These signals simulate power system conditions, taking into account PT ratio and CT ratio scaling. Use relay metering to determine whether the applied test voltages and currents produce correct relay operating quantities.

The UUT Database entries for the SEL-421 Relay in the SEL-5401 Relay Test System Software are shown in *Table 6.4* and *Table 6.5*.

Table 6.4 UUT Database Entries for SEL-5401 Relay Test System Software—5 A Relay

	Label	Scale Factor	Unit
1	IAW	75	A
2	IBW	75	A
3	ICW	75	A
4	IAX	75	A
5	IBX	75	A
6	ICX	75	A
7	VAY	150	V
8	VBY	150	V
9	VCY	150	V
10	VAZ	150	V
11	VBZ	150	V
12	VCZ	150	V

Table 6.5 UUT Database Entries for SEL-5401 Relay Test System Software—1 A Relay

	Label	Scale Factor	Unit
1	IAW	15	A
2	IBW	15	A
3	ICW	15	A
4	IAX	15	A
5	IBX	15	A
6	ICX	15	A
7	VAY	150	V
8	VBY	150	V
9	VCY	150	V
10	VAZ	150	V
11	VBZ	150	V
12	VCZ	150	V

Relay Test Connections

NOTE: The procedures specified in this subsection are for initial relay testing only. Follow your company policy for connecting the relay to the power system.

The SEL-421 Relay is a flexible tool that you can use to implement many protection and control schemes. Although you can connect the relay to the power system in many ways, connecting basic bench test sources helps you model and understand more complex relay field connection schemes.

Test Setup

Test Source Connections

For each relay element test, you must apply ac voltage and current signals to the relay. The text and figures in this subsection describe the test source connections you need for relay protection element checks. You can use these connections to test protective elements and simulate all fault types.

Connections for Three Voltage Sources and Three Current Sources

Figure 6.2 shows the connections to use when you have three voltage sources and three current sources available.

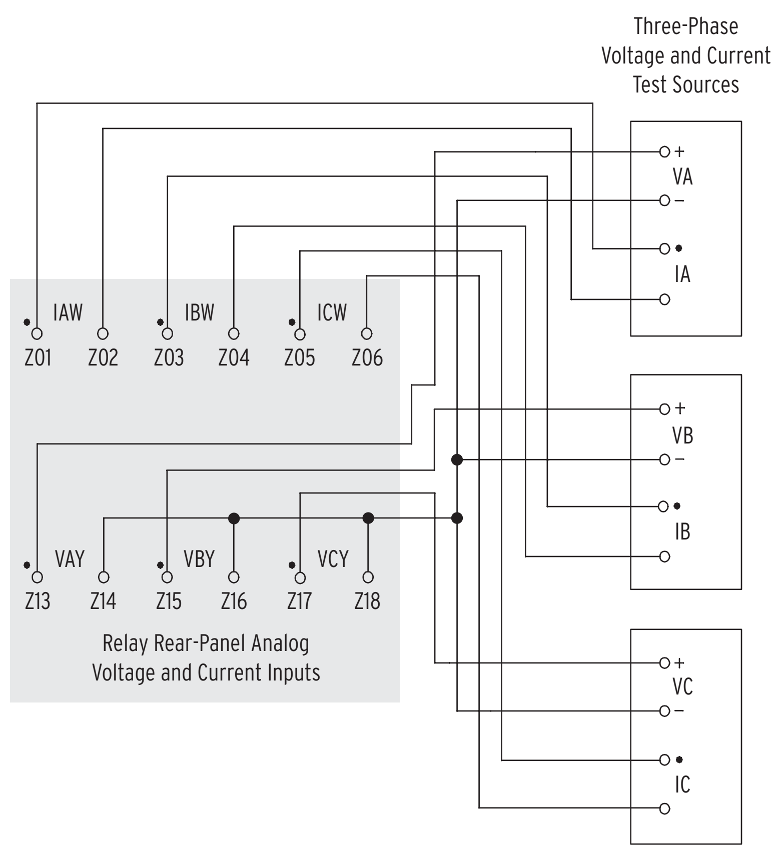


Figure 6.2 Test Connections Using Three Voltage and Three Current Sources.

Connections for Three Voltage Sources and Two Current Sources

Figure 6.3 on page 6.10 and *Figure 6.4 on page 6.11* show connections to use when you have three voltage sources and two current sources. You can use the connections shown in *Figure 6.3* to simulate phase-to-phase, phase-to-ground, and two-phase-to-ground faults. Use the connections shown in *Figure 6.4 on page 6.11* to simulate three-phase faults.

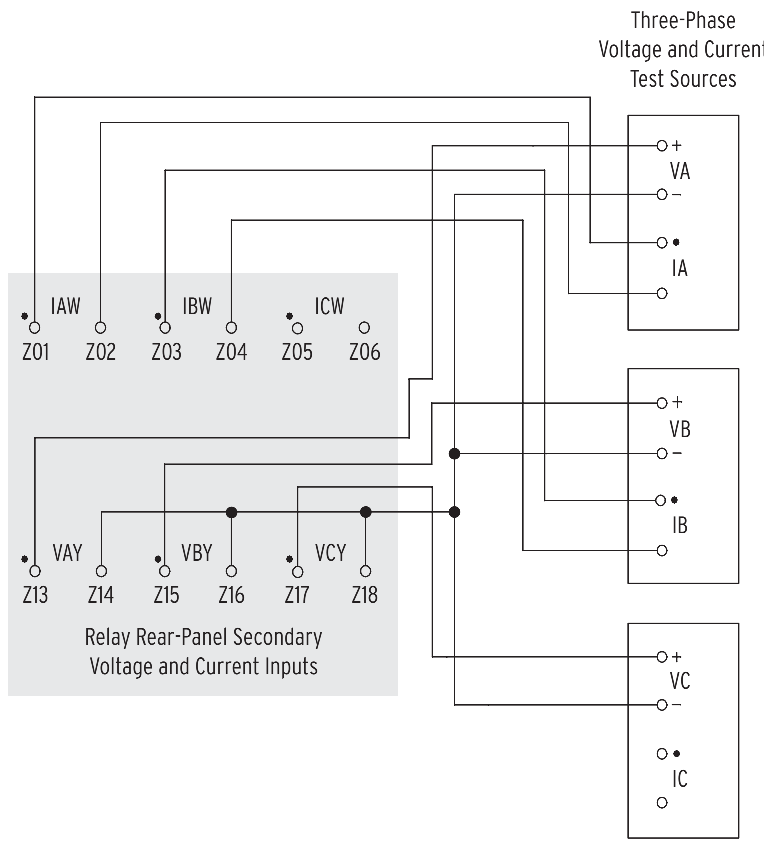


Figure 6.3 Test Connections Using Two Current Sources for Phase-to-Phase, Phase-to-Ground, and Two-Phase-to-Ground Faults.

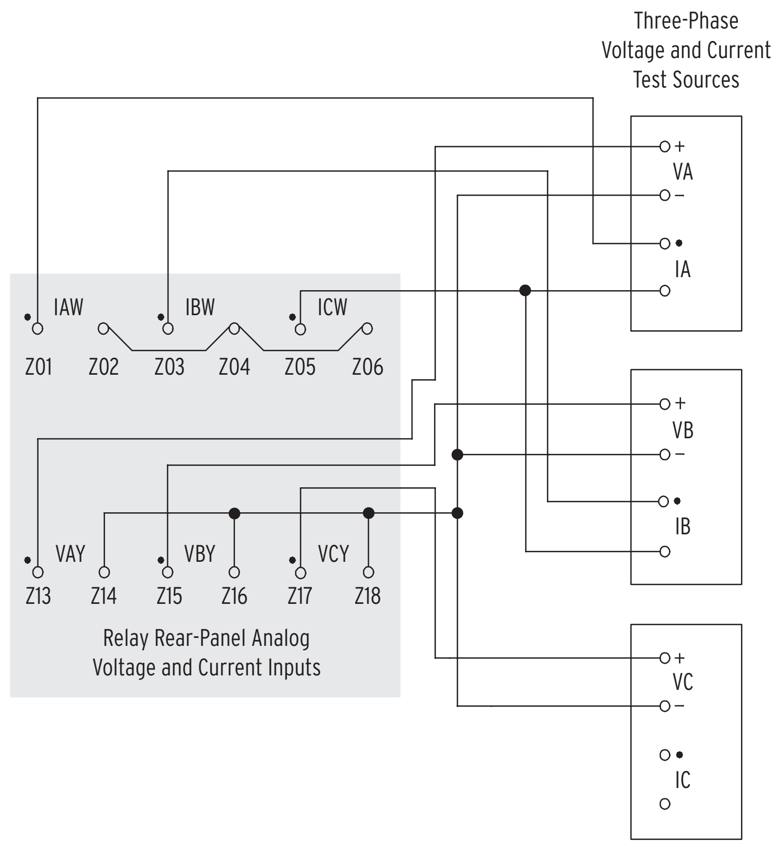


Figure 6.4 Test Connections Using Two Current Sources for Three-Phase Faults.

Connections for Three Voltage Sources and One Current Source

Figure 6.5 on page 6.12 and *Figure 6.6 on page 6.13* show connections to use when you have three voltage sources and a single current source. You can use the connections shown in *Figure 6.5* to simulate phase-to-ground faults. Use the connections shown in *Figure 6.6* to simulate phase-to-phase faults.

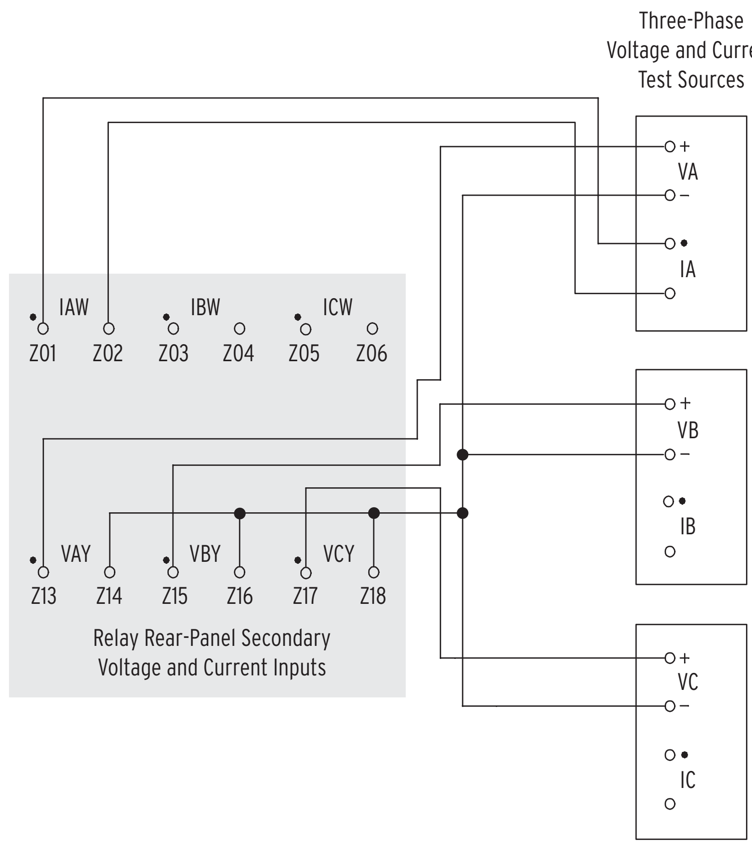


Figure 6.5 Test Connections Using a Single Current Source for a Phase-to-Ground Fault.

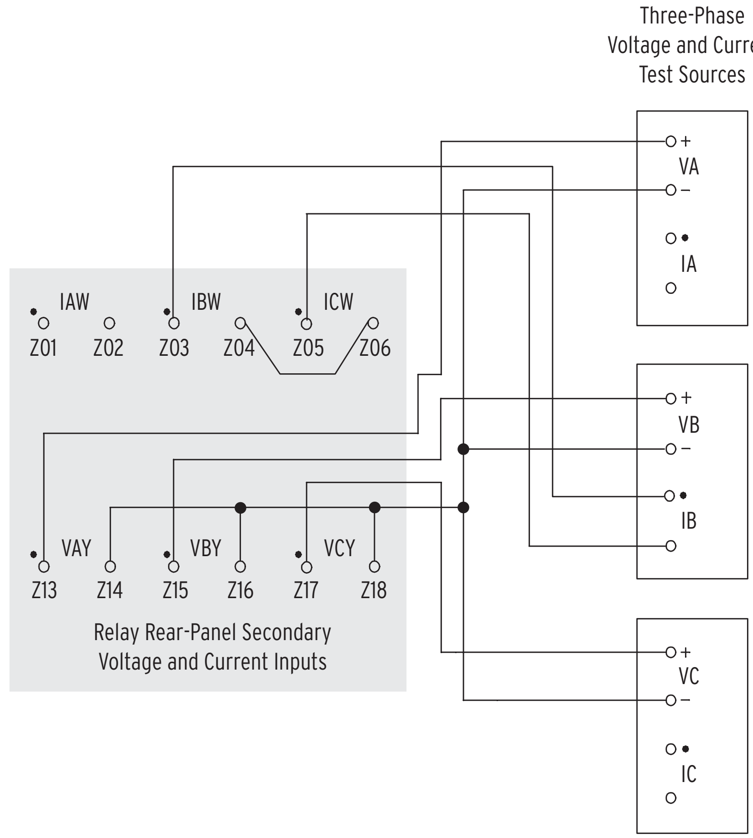


Figure 6.6 Test Connections Using a Single Current Source for a Phase-to-Phase Fault.

Test Methods

Use the following methods to conveniently test the pickup and dropout of relay elements and other relay functions:

- Target indications (element pickup/dropout)
- Control output closures
- SER reports

The tests and procedures in the following subsections are for 5A relays. Scale values appropriately for 1A relays.

Once you have completed a test, return the relay settings that you modified for the test to default or operational values.

Testing With Targets

Use the communications port **TAR** command or the front panel to display the state of relay elements, control inputs, and control outputs. Viewing a change in relay element (Relay Word bit) status is a good way to verify the pickup settings you have entered for protection elements.

View Relay Elements With a Serial Terminal

The procedure in the following steps shows you how to view a change in state for the 50P1 Phase Instantaneous Overcurrent element from a communications port. Use the factory defaults for the pickup level (see *Table 6.6*). For more information on the 50P elements, see *Instantaneous Line Overcurrent Elements on page R.1.62 in the Reference Manual*.

Table 6.6 Phase Instantaneous Overcurrent Pickup

Setting	Description	Default (5A)
50P1P	Level 1 Pickup (OFF, 0.25–100 amps secondary)	10.0

For this procedure, you must have a serial terminal or computer with terminal emulation software and a variable current source for relay testing.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page U.4.6 in the User's Guide* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords on page U.4.8 in the User's Guide* to change the default access level passwords and enter higher relay access levels.

1. Prepare to monitor the relay at Access Level 1. Using a communications terminal, type **ACC<Enter>**. Type the Access Level 1 password and press **<Enter>**. You will see the => action prompt.
2. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Section 2: Installation in the User's Guide*).
3. View the initial element status. Type **TAR 50P1<Enter>**. The relay returns a target terminal screen similar to *Figure 6.7 on page 6.15*.

```
=>TAR 50P1<Enter>

50P1 50P2 50P3 50P4 67P1 67P2 67P3 67P4

0    0    0    0    0    0    0    0
=>
```

Figure 6.7 Sample Targets Display on a Serial Terminal.

Step 4. View the element status change. Type **TAR 50P1 1000<Enter>** (this command causes the relay to repeat the TAR 50P1 command 1000 times). Increase the current source to produce a current magnitude greater than 10.00 A secondary in the relay. You will see the 50P1 element status change to 1 when the input current exceeds the 50P1P setting threshold. Type **<Ctrl+X>** to stop the relay from presenting the target display before completion of the 1000 target repeats.

View Relay Elements With the Front-Panel LCD

You can use the front-panel display and navigation pushbuttons to check Relay Word bit elements. See *Section 5: Front-Panel Operations in the User's Guide* for more information on using the relay front panel.

This procedure uses the 50P1 Phase Instantaneous Overcurrent element. Use the factory defaults for the pickup level (*Table 6.6 on page 6.14*). For more information on the 50P elements, see *Instantaneous Line Overcurrent Elements on page R.1.62 in the Reference Manual*.

Step 1. Display the MAIN MENU. If the relay LCD is in the Rotating Display, press the **{ENT}** pushbutton to display the MAIN MENU similar to that in *Figure 6.8 on page 6.16*.

Step 2. Prepare to view the elements on the front-panel LCD. Press the **{Down}** arrow navigation pushbutton to highlight the RELAY ELEMENTS action item (see the first screen of *Figure 6.8*). Press the **{ENT}** pushbutton. You will see a RELAY ELEMENTS screen (the second screen of *Figure 6.8*).

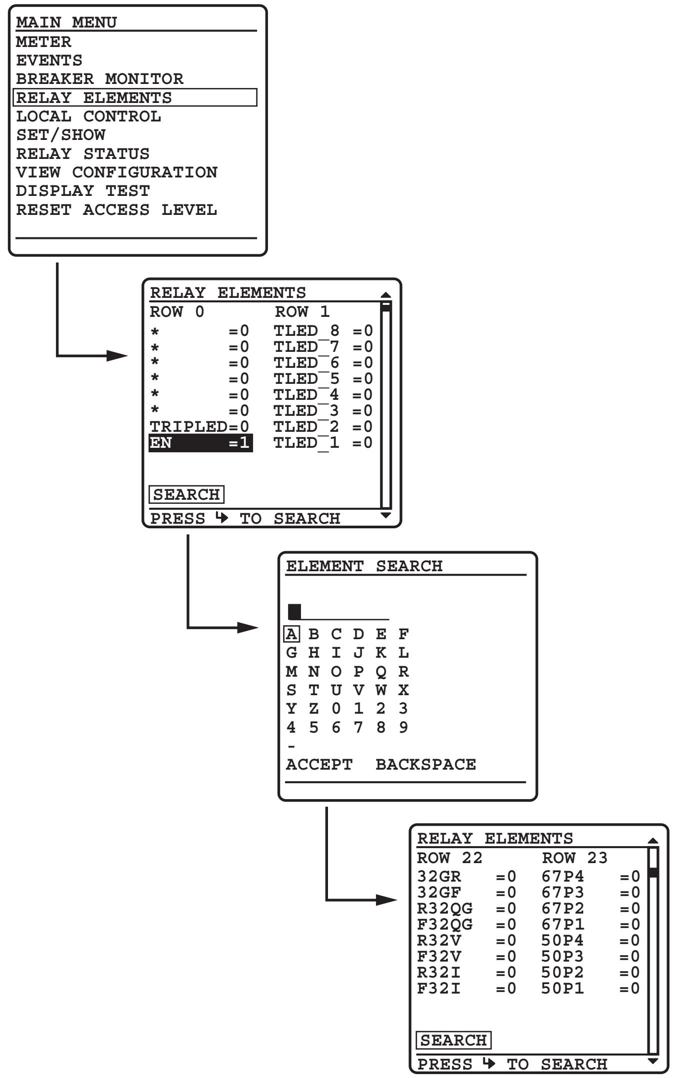


Figure 6.8 Viewing Relay Word Bits From the Front-Panel LCD.

Step 3. Display the 50P1 Relay Word bit on the front-panel LCD screen. Press **{ENT}** to go to the ELEMENT SEARCH submenu of *Figure 6.8*. Use the navigation keys to highlight 5 and then press **{ENT}** to enter the character 5 in the text input field. Enter the “0, P, and 1 characters in the same manner. Highlight ACCEPT and press **{ENT}**. The relay displays the LCD screen containing the 50P1 element, as shown in the last screen of *Figure 6.8*.

Step 4. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Secondary Circuits on page U.2.5 in the User’s Guide*).

Step 5. View the target status change. Increase the current source to produce a current magnitude greater than 10.00 A secondary in the relay. Observe the 50P1 target on the front-panel display. You will see the 50P1 element status change to 1 when the input current exceeds the 50P1P setting threshold.

Step 6. Normalize the display. To return to the MAIN MENU, press **{ESC}**.

View Relay Elements With a Front-Panel LED

The procedure in the following steps shows you how to use a front-panel LED to view a change-in-state for the 50P1 Phase Instantaneous Overcurrent element. Use the factory defaults for the pickup level (see *Table 6.6 on page 6.14*). For more information on the 50P elements, see *Instantaneous Line Overcurrent Elements on page R.1.62 in the Reference Manual*.

In this example, use the ACSELERATOR software to configure the relay. You must have a computer that is communicating with the SEL-421 Relay and running the ACSELERATOR software. See *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*. In addition, you need a variable current source suitable for relay testing.

Step 1. Prepare to control the relay with the ACSELERATOR software. Establish communication, check passwords, and read relay settings; see *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*.

Step 2. Set a pushbutton LED SELOGIC control equation. Expand the Front Panel branch of the Settings tree view and click Pushbuttons (see *Figure 6.9*). The ACSELERATOR software displays the Pushbuttons dialog box similar to *Figure 6.9*. Click in the PB4_LED text box and type 50P1. Tab or click to any other text box. The ACSELERATOR software checks to confirm that this is a valid setting.

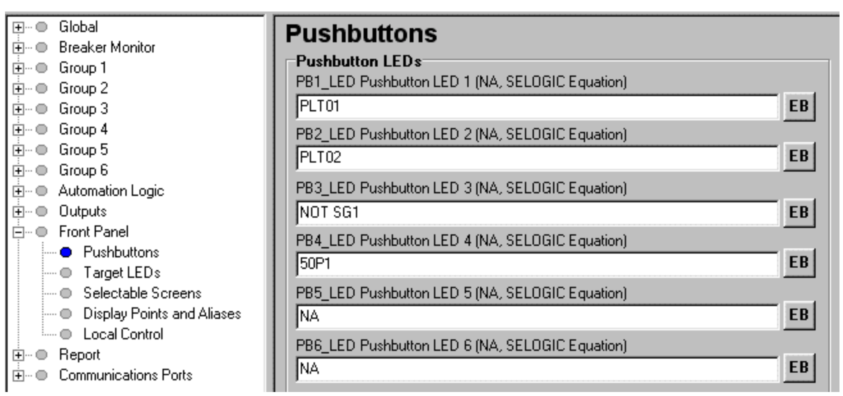


Figure 6.9 Setting Pushbutton LED Response: ACSELERATOR Software.

Step 3. Save the new settings in ACSELERATOR software. On the File menu, click Save.

Step 4. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box of *Figure 6.10 on page 6.18*. Click the check box for Front Panel. Click OK. The relay responds with the Transfer Status dialog box of *Figure 6.10*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 6.10 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

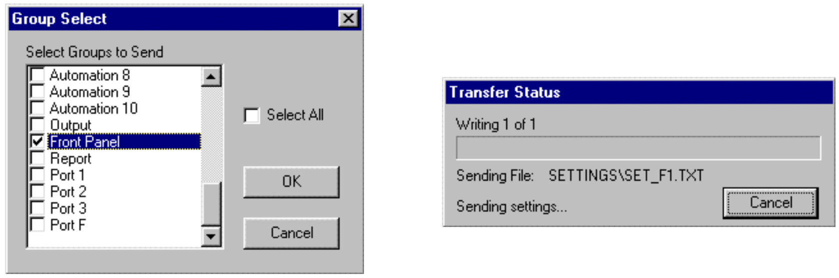


Figure 6.10 Uploading Front-Panel Settings to the SEL-421 Relay.

Step 5. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Secondary Circuits on page U.2.5 in the User's Guide*).

Step 6. View the target status change. Increase the current source to produce a current magnitude greater than 10.00 A secondary in the relay. Observe the LED next to the RELAY TEST MODE pushbutton (PB4) on the SEL-421 Relay front panel. You will see the LED light when the input current exceeds the 50P1P setting threshold.

Testing With Control Outputs

You can set the relay to operate a control output to test a single element. Set the SELOGIC control equation for a particular output (OUT101 through OUT108, for example) to respond to the Relay Word bit for the element under test. See *Operating the Relay Inputs and Outputs on page U.4.52 in the User's Guide* for configuring control inputs and control outputs. The *Appendix A: Relay Word Bits in the Reference Manual* lists the names of the relay element logic outputs.

Testing the 50P1 Element With a Control Output

This procedure shows how to set control output OUT105 to test the 50P1 Phase Instantaneous Overcurrent element. Use the factory defaults for the pickup level (see *Table 6.6 on page 6.14*). For more information on the 50P elements, see *Instantaneous Line Overcurrent Elements on page R.1.62 in the Reference Manual*.

For this test, you must have a computer with the ACSELERATOR software for the SEL-421 Relay, a variable current source for relay testing, and a control output closure indicating device such as a test set or a VOM (volt ohmmeter).

In this example, use the ACSELERATOR software to configure the relay. You must have a computer that is communicating with the SEL-421 Relay and running the ACSELERATOR software; see *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*.

Step 1. Prepare to control the relay with the ACSELERATOR software. Establish communication, check passwords, and read relay settings; see *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*.

Step 2. View Output settings. Click on the Outputs > Main Board branch of the ACSELERATOR software Settings tree structure shown in *Figure 6.11 on page 6.19*. You will see the Main Board Outputs dialog box.

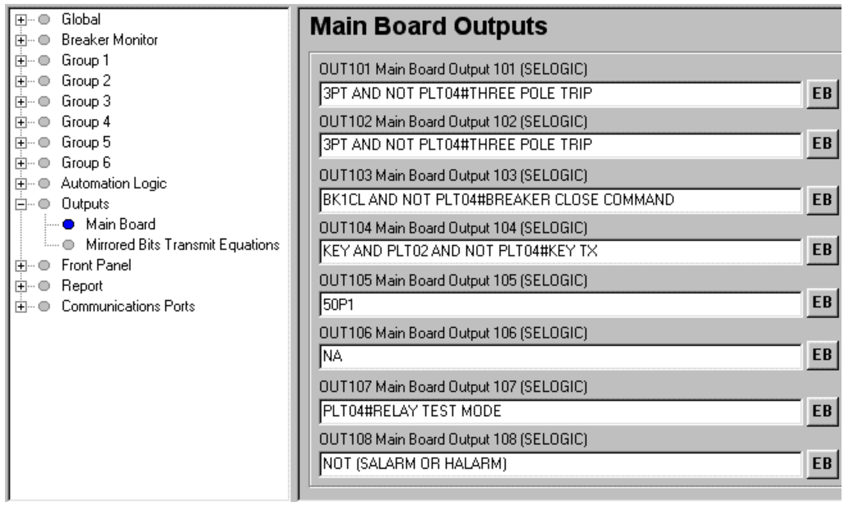


Figure 6.11 Setting Main Board Outputs: ACSELERATOR Software.

Step 3. Set OUT105 to respond to the 50P1 element pickup. Move the cursor to the OUT105 Main Board Output105 (SELOGIC) text box and double-click the left (regular) mouse button. Delete the NA default setting. Type 50P1. Push <**Tab**> or click in any other text box. The relay checks the validity of the setting you entered. An invalid setting (you could have mistyped the element name) causes the OUT105 text box to turn red. If the setting is valid, the text box displays the new setting on a white background.

Step 4. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 5. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box in *Figure 6.12*. Click the check box for Output. Click OK. The relay responds with the Transfer Status dialog box in *Figure 6.12*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 6.12 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

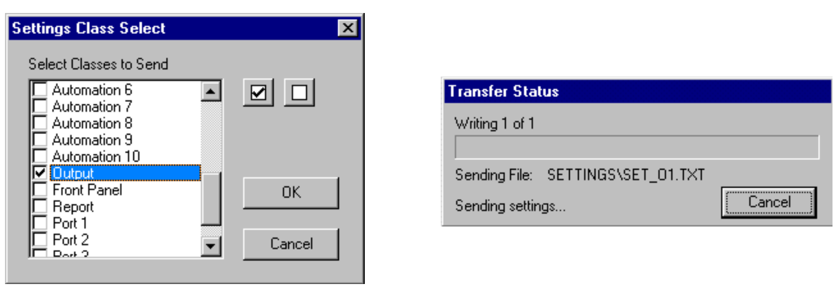


Figure 6.12 Uploading Output Settings to the SEL-421 Relay.

Step 6. Connect an indicating device to OUT105 on the relay rear panel. A VOM multi-tester on a low resistance scale can indicate an OUT105 control output closure.

Step 7. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Secondary Circuits on page U.2.5 in the User's Guide*).

Step 8. Test the element. Increase the current source to produce a current magnitude greater than 10.00 A secondary in the relay. When the 50P1 element picks up, the relay changes the 50P1 Relay Word bit to logical 1 and closes the output contacts of control output OUT105. The indicating device operates.

Testing With SER

You can set the relay to generate a report from the SER to test relay elements; include the element that you want to test in the SER Points and Aliases list. Set aliases for the element name, set state, and clear state in the SEL-421 Relay SER to simplify reading the SER report. See *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook* for complete information on the SER.

Testing the 51S1 Element Using the SER

The SER gives exact time data for testing time-overcurrent element timeouts. Subtract the 51S1T assertion time from the 51S1 assertion time to check the operation time for this element. Use the factory defaults for the operating quantity, pickup level, curve, time dial, and electromechanical reset (*Table 6.7*).

The procedure in the following steps shows how to set the SER trigger lists to capture the selectable operating quantity time-overcurrent element 51S1 operating times. The procedure also shows how to set the torque control supervision for the 51S1 element.

Table 6.7 Selectable Operating Quantity Time-Overcurrent Element (51S1) Default Settings

Setting	Description	Default 5A
51S1O	51S1 Operating Quantity (IA*n*, IB*n*, IC*n*, IMAX*n*, I1L, 3I2L, 3I0L)[a]	3I0L
51S1P	51S1 Overcurrent Pickup (0.50–16 amps, secondary)	0.75
51S1C	51S1 Inv-Time Overcurrent Curve (U1–U5, C1–C5)	U3
51S1TD	51S1 Inv-Time Overcurrent Time Dial (0.50–15.0)	1.0
51S1RS	51S1 Inv-Time Overcurrent EM Reset (Y, N)	N
51S1TC	51S1 Torque Control (SELOGIC control equation)	32GF

[a] n is L, 1, and 2 for Line, Circuit Breaker 1, and Circuit Breaker 2, respectively.

The relay uses *Equation 6.1* and *Equation 6.2* to determine the operating time for the 51S1 element. For a current input 50 percent greater than the default pickup, the test value, $I_{TEST,}$ is:

$$I_{TEST} = M \bullet (51S1P) = 1.5 \bullet (0.75\ A) = 1.125\ A \quad \textbf{Equation 6.1}$$

where M is the pickup multiple and 51S1P is the element pickup value (see *Table 6.7*).

The operating time (t_p) for a time dial (TD) equal to 1 for the U3 (Very Inverse) Curve is:

$$
\begin{aligned}
t_p &= TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right) \\
&= 1 \bullet 0.0963 + \frac{3.88}{1.5^2 - 1} \\
&= 3.2 \text{ seconds}
\end{aligned}
$$

Equation 6.2

For more information on the 51S elements, see *Inverse Time-Overcurrent Elements on page R.1.69 in the Reference Manual*.

In this example, use the ACSELERATOR software to configure the relay. You must have a computer that is communicating with the SEL-421 Relay and running the ACSELERATOR software; see *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*. You also need a variable current source for relay testing.

Step 1. Prepare to control the relay with the ACSELERATOR software. Establish communication, check passwords, and read relay settings; see *Making Settings Changes: Initial Global Settings on page U.4.19 in the User's Guide*.

Step 2. Set the selectable operating quantity time-overcurrent element for test operation. Open the Group 1 > Relay Configuration > Time Overcurrent branch of the Settings tree view (see *Figure 6.13*). In the Time Overcurrent dialog box, check that setting 51S1O Operating Quantity is at 3I0L. Check the remaining element configurations against *Table 6.7 on page 6.20*. In addition, set torque control 51S1TC to **1** to constantly operate the 51S1 element; type **1** in the text box for 51S1TC. (For more information on using the ACSELERATOR software to change settings, see *Making Initial Global Settings: ACSELERATOR Software on page U.4.25 in the User's Guide*.)

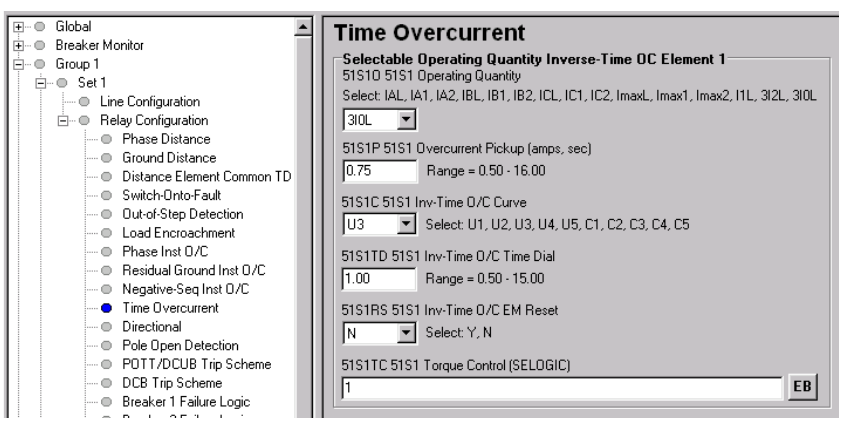


Figure 6.13 Checking the 51S1 Overcurrent Element: ACSELERATOR Software.

Step 3. View SER settings. Click on the + mark next to the Report branch of the ACSELERATOR software Settings tree view structure shown in *Figure 6.14 on page 6.22*. Click on the SER Points and Aliases branch. You will see the SER Points and Aliases dialog box (see *Figure 6.14*).

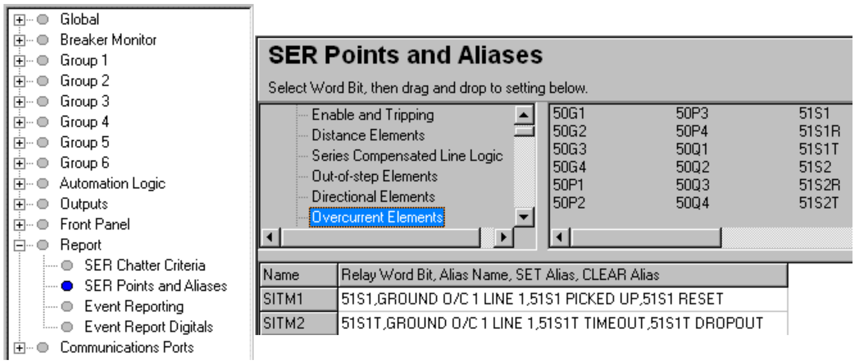


Figure 6.14 Setting SER Points and Aliases: ACSELERATOR Software.

Step 4. Enter SER element names and aliases. Type the SER points and aliases in the open text boxes beginning at SITM1. Click Overcurrent Elements in the Relay Word Bits column on the left of the SER Points and Aliases dialog box to see a list of available overcurrent elements. Select, click, and drag the 51S1 element from the right side of the SER Points and Aliases dialog box to text box SITM1. For this example enter **51S1,GROUND O/C 1 LINE 1,51S1 PICKED UP,51S1 RESET** for SITM1, and enter **51S1T,GROUND O/C 1 LINE 1,51S1T TIMEOUT,51S1T DROPOUT** for SITM2 as shown in *Figure 6.14*.

You can enter as many as 250 relay elements in the SER Points and Aliases list. See *SER (Sequential Events Recorder) on page A.3.34 in the Applications Handbook*.

Step 5. Save the new settings in the ACSELERATOR software. On the File menu, click Save.

Step 6. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box of *Figure 6.15*. Click the check box for Group 1 and for Report. Click OK. The ACSELERATOR software responds with a Transfer Status dialog box as in *Figure 6.15*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 6.15 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

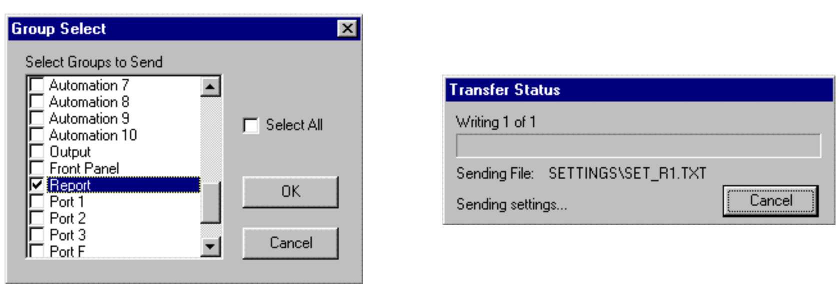


Figure 6.15 Uploading Group 1 and Report Settings to SEL-421 Relay.

Step 7. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Secondary Circuits on page U.2.5 in the User's Guide*).

Step 8. Test the element. Increase the current source to produce a current magnitude of 1.125 A secondary in the relay. Keep the current source at this level past the expected element timeout (longer than 3.2 seconds). Return the current source to zero after the element time out.

Step 9. Examine the SER report. Start the ACSELERATOR HMI interface by selecting the HMI menu (top toolbar) and then clicking Meter and Control.

Step 10. View the SER report. Click the SER button of the HMI tree view (see *Figure 6.16*). The ACSELERATOR software displays the SER report similar to *Figure 6.17*. The time difference between SER entries “51S1 PICKED UP” and “51S1 TIMOUT” is approximately 3.2 seconds.

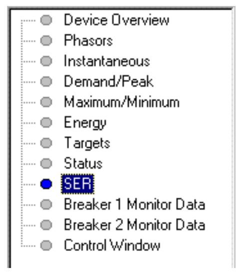


Figure 6.16 HMI Tree View: ACSELERATOR Software.

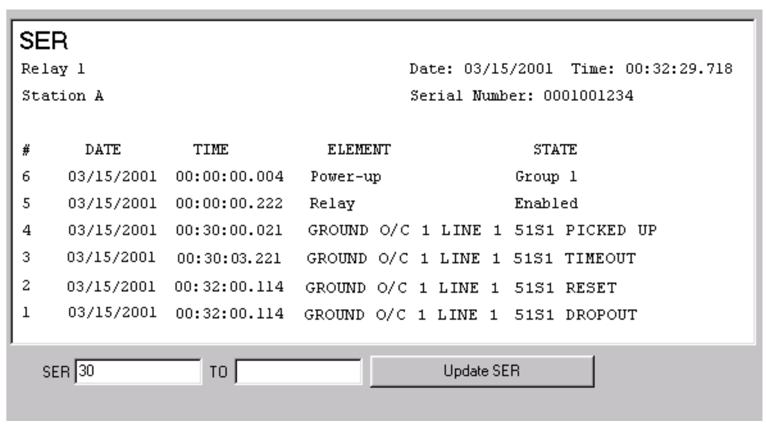


Figure 6.17 SER Report: ACSELERATOR HMI.

Checking Relay Operation

The SEL-421 Relay comes to you with all functions fully checked and calibrated so that the relay operates correctly and accurately. You can perform tests on the relay to verify proper relay operation, but you do not need to test every relay element, timer, and function in this evaluation. The following checks are valuable for confirming proper SEL-421 Relay connections and operation:

- AC connection check (metering)
- Commissioning tests
- Functional tests
- Element verification

An ac connection check uses relay metering to verify that the relay current and voltage inputs are the proper magnitude and phase rotation; see *Examining Metering Quantities on page U.4.31 in the User's Guide*. Commissioning tests help you verify that you have properly connected the relay to the power system and all auxiliary equipment. These tests confirm proper connection of control inputs and control outputs as well; see *Operating the Relay Inputs and Outputs on page U.4.52 in the User's Guide*. Brief functional tests and element verification confirm correct internal relay processing.

Selected Element Tests

This subsection discusses tests of the following relay elements:

- Overcurrent element
  - Negative-sequence instantaneous, 50Q1
- Directional element
  - Negative-sequence portion, F32Q/R32Q, of the phase directional element, F32P/R32P
- Distance element
  - Phase-to-phase mho element, MBC2, of Zone 2 mho distance element M2P

Testing Overcurrent Elements

Overcurrent elements operate by detecting power system sequence quantities and asserting when these quantities exceed a preset threshold.

Apply current to the analog current inputs and compare relay operation to the element pickup settings to test the instantaneous and definite-time overcurrent elements. Be sure to apply the test current to the proper input set (IW or IX), according to the Global Current and Voltage Source Selection settings (ESS and ALINEI, for example) to accept the input. See *Current and Voltage Source Selection on page R.1.2 in the Reference Manual*.

Phase Overcurrent Elements

The SEL-421 Relay phase overcurrent elements compare the phase current applied to the secondary current inputs with the phase overcurrent element pickup setting. The relay asserts the phase overcurrent elements when any of the three phase currents exceeds the corresponding element pickup setting.

Negative-Sequence Overcurrent Elements

The SEL-421 Relay negative-sequence overcurrent elements compare a negative-sequence calculation of the three-phase secondary inputs with the corresponding negative-sequence overcurrent element pickup setting. The relay makes this negative-sequence calculation (assuming ABC rotation):

$3I_2$ = A-phase + B-phase (shifted by –120°) + C-phase (shifted by 120°)

The relay asserts negative-sequence overcurrent elements when the $3I_2$ calculation exceeds the corresponding negative-sequence current pickup setting. If balanced currents are applied to the relay, the relay reads $3I_2 \approx 0$ (load conditions) and does not pick up the negative-sequence overcurrent elements.

For testing, apply current to a single phase of the relay, causing the negative-sequence overcurrent elements to operate. For example, assume 1 A of current on A-phase and zero current input on the B-phase and C-phase:

$3I_2$ = 1 A + 0 (shifted –120°) + 0 (shifted 120°) = 1 A (a simulated ground fault condition)

Ground Overcurrent Elements

The SEL-421 Relay ground overcurrent elements compare a residual ground calculation of the three-phase inputs with the residual overcurrent setting. The relay makes this residual current calculation:

$3I_0$ = A-phase + B-phase + C-phase

The relay asserts ground overcurrent elements when the $3I_0$ calculation exceeds the ground current element pickup setting. If balanced currents are applied to the relay, the relay reads $3I_0 = 0$ (load conditions) because the currents cancel in the calculation; the relay does not pick up the ground overcurrent elements.

For testing, apply current to a single phase of the relay, causing the residual overcurrent elements to operate. For example, assume 1 A of current on A-phase and zero current input on B-phase and C-phase:

$3I_0$ = 1 A + 0 + 0 = 1 A (a simulated ground fault condition)

Checking the Negative-Sequence Instantaneous Overcurrent Element, 50Q1

NOTE: As you perform this test, other protection elements can assert. This causes the relay to assert other targets and possibly close control outputs. Be sure to isolate the relay from the power system to avoid unexpected system effects.

The procedure in the following steps tests the 50Q1 negative-sequence overcurrent element. Use a similar procedure to test other overcurrent elements.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page U.4.6 in the User's Guide* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords on page U.4.8 in the User's Guide* to change the default access level passwords and enter higher relay access levels. You should be familiar with the ACSELERATOR software; see *Section 3: PC Software in the User's Guide*.

Step 1. Configure the relay. Start the ACSELERATOR software and read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all settings and configuration data to the ACSELERATOR software. Expand the Group 1 settings and click the Relay Configuration branch of the Settings tree view as shown in *Figure 6.18*. Click the arrow in the Instantaneous and Definite Time Overcurrent Element Levels E50Q dialog box and select 1.

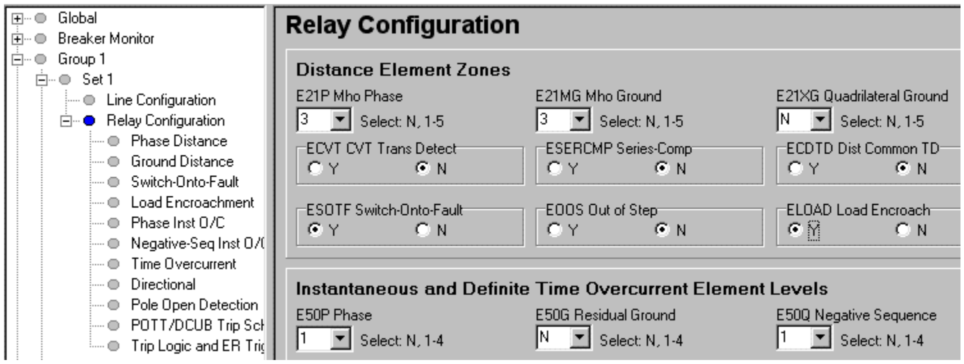


Figure 6.18 Group 1 Relay Configuration Settings: ACSELERATOR Software.

Step 2. Set the instantaneous overcurrent element pickup value. Click the Negative-Seq Inst O/C button of the Settings tree view as shown in *Figure 6.19*. You will see the Negative Sequence Instantaneous Overcurrent dialog box similar to *Figure 6.19*. For this test, set the 50Q1P level to **1.00**.

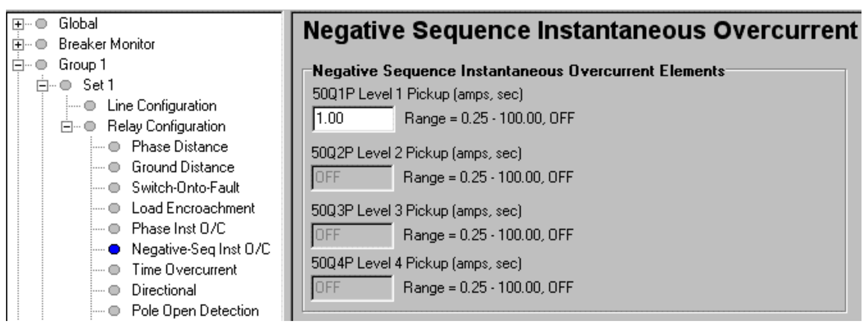


Figure 6.19 Negative-Sequence Instantaneous Overcurrent Element Settings: ACSELERATOR Software.

Step 3. Upload the new setting to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box in *Figure 6.20*. Click the check box for Group 1. Click OK. The relay responds with the Transfer Status dialog box similar to *Figure 6.20*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 6.20 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

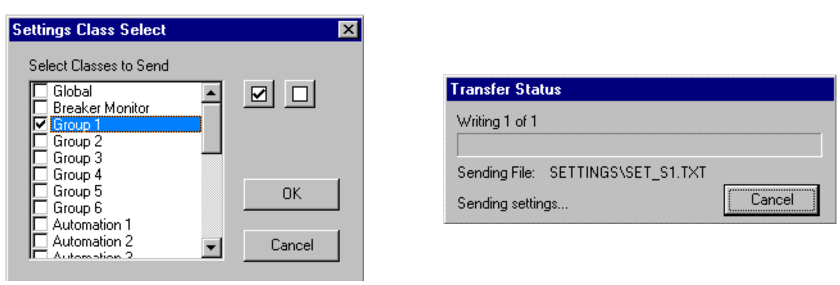


Figure 6.20 Uploading Group 1 Settings to the SEL-421 Relay.

Step 4. Display the 50Q1 Relay Word bit on the front-panel LCD screen. Access the front-panel LCD MAIN MENU. Highlight RELAY ELEMENTS and press **{ENT}**. Press **{ENT}** to go to the ELEMENT SEARCH submenu of *Figure 6.21*. Use the navigation keys to highlight 5 and then press **{ENT}** to enter characters in the text input field. Enter the 0, Q, and 1 characters in turn. Highlight ACCEPT and press **{ENT}**. The relay displays the screen containing the 50Q1 element, as shown in *Figure 6.22*.

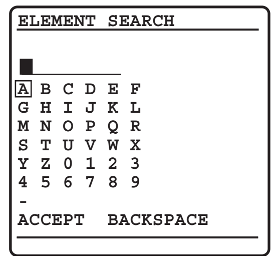


Figure 6.21 ELEMENT SEARCH Screen.

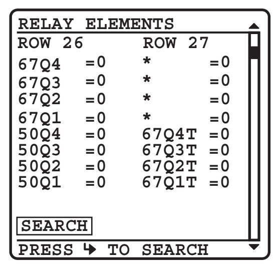


Figure 6.22 RELAY ELEMENTS Screen Containing Element 50Q1.

Step 5. Connect a test source to the relay. Set the current output of a test source to zero output level. Connect a single-phase current output of the test source to the IAW analog input (see *Figure 6.5 on page 6.12* and *Secondary Circuits on page U.2.5 in the User's Guide*).

Step 6. Test the element. Increase the current source to produce a current magnitude greater than 1.00 A secondary in the relay. You will see that the 50Q1 element state changes on the LCD screen from 50Q1 = 0 to 50Q1 = 1.

Negative-Sequence Directional Element for Phase Faults

The SEL-421 Relay features a phase directional element (represented by Relay Word bits F32P/R32P) to supervise the phase distance elements and to control phase directional elements. The negative-sequence directional element, F32Q/R32Q, is a part of the phase directional element, F32P/R32P. Whenever the negative-sequence directional element asserts, the phase directional element asserts.

The relay also contains a ground directional element, F32G/R32G, for directional control of the ground distance elements and ground overcurrent elements. For more information on directional elements, see *Ground Directional Element on page R.1.21 in the Reference Manual*, and *Section 1: Protection Application Examples in the Applications Handbook*.

The SEL-421 Relay calculates the negative-sequence impedance Z2 from the magnitudes and angles of the negative-sequence voltage and current. *Equation 6.3 on page 6.28* defines this function (the 'c' in Z2c indicates "calculated").

$$Z2c = \frac{Re[V_2 \bullet (1\angle Z1ANG \bullet I_2)^*]}{|I_2|^2} = \frac{|V_2|}{|I_2|} \bullet \cos(\angle V_2 - \angle Z1ANG - \angle I_2) \quad \textbf{Equation 6.3}$$

Where:

V_2 is the negative-sequence voltage

I_2 is the negative-sequence current

Z1ANG is the positive-sequence line impedance angle

Re indicates the real part of the term in brackets, for example, $(Re[A + jB] = A)$

* indicates the complex conjugate of the expression in parentheses, $(A + jB)^* = (A – jB)$

The result of *Equation 6.3* is an impedance magnitude that varies with the magnitude and angle of the applied current. Normally, a forward fault results in a negative Z2c relay calculation.

Test Current

Solve *Equation 6.3* to find the test current values that you need to apply to the relay to test the element. For the negative sequence current I_2, the result is

$$|I_2| = \frac{|V_2|}{Z2c} \quad \textbf{Equation 6.4}$$

when:

$$\angle I_2 = \angle V_2 - \angle Z1ANG \quad \textbf{Equation 6.5}$$

Multiply the quantities in *Equation 6.4* by three to obtain $3I_2$, the negative-sequence current that the relay processes. With a fixed applied negative-sequence voltage V_A, the relay negative sequence voltage is $3V_2$. Set Z2c = Z2F to find the test current magnitude at the point where the impedance calculation equals the forward fault impedance threshold. *Equation 6.4* becomes:

$$|I_{TEST}| = |3I_2| = \frac{|3V_2|}{Z2c} = \frac{|3V_2|}{Z2F} \quad \textbf{Equation 6.6}$$

when:

$$\angle I_{TEST} = \angle 3I_2 = \angle 3V_2 - \angle Z1ANG \quad \textbf{Equation 6.7}$$

For a reverse fault impedance threshold, where Z2c = Z2R, *Equation 6.4* becomes:

$$|I_{TEST}| = |3I_2| = \frac{|3V_2|}{Z2c} = \frac{|3V_2|}{Z2R} \quad \textbf{Equation 6.8}$$

when the angle calculation is the same as *Equation 6.7*.

For more information on the directional elements, see *Ground Directional Element on page R.1.21 in the Reference Manual* and *Quadrilateral Ground Distance Elements on page R.1.51 in the Reference Manual*. For settings and application information, see *Section 1: Protection Application Examples in the Applications Handbook*.

Checking the Negative-Sequence Directional Element (Phase Faults)

NOTE: As you perform this test, other protection elements can assert. This causes the relay to assert other targets and possibly close control outputs. Be sure to isolate the relay from the power system to avoid unexpected system effects.

This test confirms operation of the F32Q and the R32Q negative-sequence directional elements. This test procedure is for a 5A relay; scale values appropriately for a 1A relay.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page U.4.6 in the User's Guide* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords on page U.4.8 in the User's Guide* to change the default access level passwords and enter higher relay access levels. You should be familiar with the ACSELERATOR software, see *Section 3: PC Software in the User's Guide*.

Step 1. Configure the relay. Begin the ACSELERATOR software and read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all settings and configuration data to the ACSELERATOR software. Expand the Group 1 settings and click the Relay Configuration branch of the Settings tree view as shown in *Figure 6.23*. Confirm Directional Element Control E32 is AUTO.

Disable element supervisory conditions. Select the Relay Configuration button in the ACSELERATOR software Settings tree view. Confirm that ELOAD and ELOP are set to N.

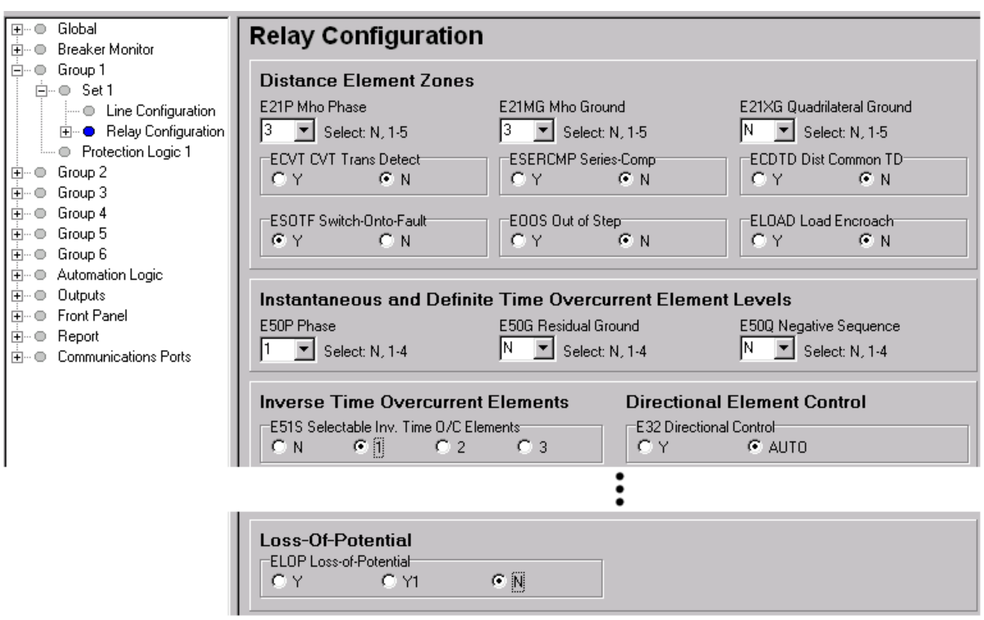


Figure 6.23 Group 1 Relay Configuration Settings: ACSELERATOR Software.

Defeat the pole-open logic. Click the + button next to Breaker Monitor to expand the Breaker Monitor branch of the Settings tree view (see *Figure 6.24*). Click Breaker 1. You will see the Breaker 1 dialog box similar to *Figure 6.24*. Enter **1** in the text boxes for 52AA1 A-Phase N/O Contact Input–BK1, 52AB1 B-Phase N/O Contact Input–BK1, and 52AC1 C-Phase N/O Contact Input–BK1. The text boxes in *Figure 6.24* appear if Breaker Monitor setting BK1TYP := 1. If BK1TYP := 3, enter 1 in the 52AA1 N/O Contact Input–BK1 text box (the other circuit breaker input boxes are dimmed.)

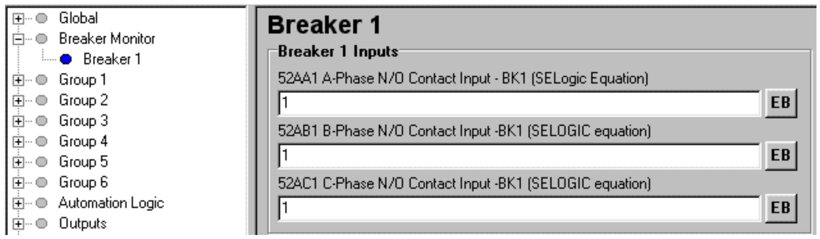


Figure 6.24 Breaker 1 Breaker Monitor Settings: ACSELERATOR Software.

Step 2. Set test values in the relay. Expand the Group 1 settings as shown in *Figure 6.25* and select the Line Configuration button. You will see the Line Configuration dialog box of *Figure 6.25*. Confirm the default settings of Z1MAG at 7.80 and Z1ANG at 84.00. Click the + mark next to the Relay Configuration branch to expand that Settings branch. Select the Directional button. You will see the Directional dialog box similar to *Figure 6.26 on page 6.31*. Confirm the following settings: 50FP is 0.60, 50RP is 0.40, Z2F is 3.90, Z2R is 4.00, a2 is 0.10, and k2 is 0.2.

The dialog box is dim since there are no settings to change. The relay calculates these settings automatically because E32 is set to AUTO. If you need to change these settings, set E32 to Y. *Table 6.8 on page 6.31* shows the calculations. See *Ground Directional Element on page R.1.21 in the Reference Manual* for details on these relay calculations.

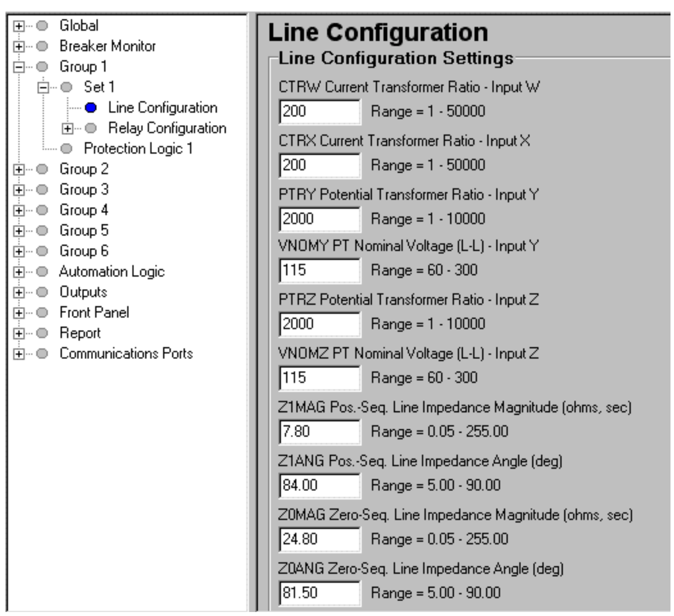


Figure 6.25 Group 1 Line Configuration Settings: ACSELERATOR Software.

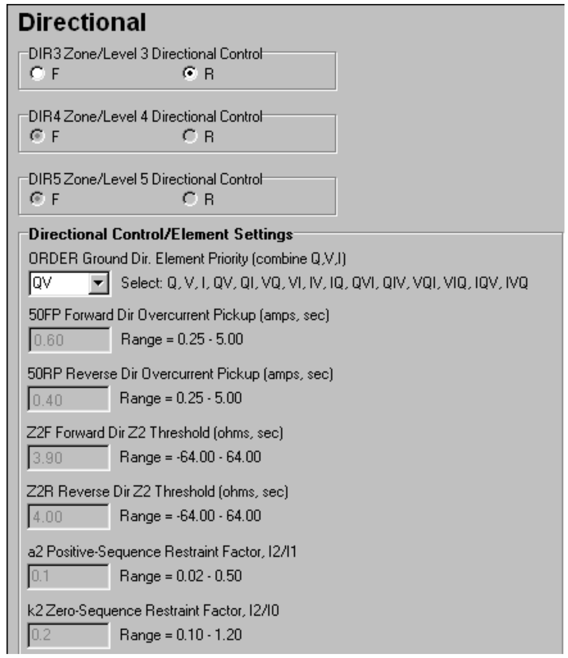


Figure 6.26 Directional Settings: ACSELERATOR Software.

Table 6.8 Negative-Sequence Directional Element Settings AUTO Calculations

Setting	Calculation
50FP	$0.12 \cdot I_{nom}$
50RP	$0.08 \cdot I_{nom}$
Z2F	$0.5 \cdot Z1MAG$
Z2R	$Z2F + 1 / (2 \cdot I_{nom})$
a2	0.1
k2	0.2

Step 3. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box in *Figure 6.27*. Click the check box for Group 1 and for Breaker Monitor. Click OK. The ACSELERATOR software responds with a Transfer Status dialog box as in *Figure 6.27*. If you see no error message, the new settings are loaded in the relay.

NOTE: The Relay Editor dialog boxes shown in Figure 6.27 are for the SEL-421 Relay. The SEL-421-1 Relay dialog boxes are similar.

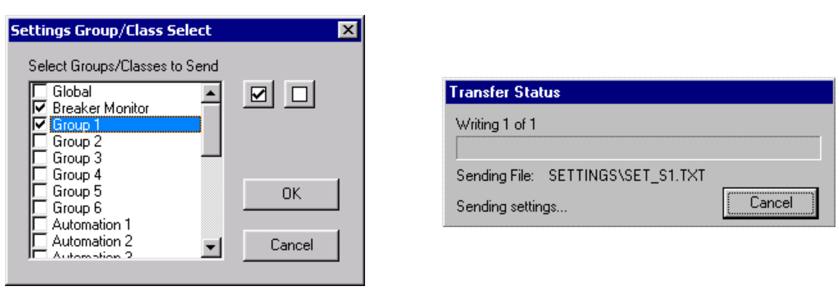


Figure 6.27 Uploading Group 1 and Breaker Monitor Settings to the SEL-421 Relay.

Step 4. Display the F32Q and R32Q Relay Word bits on the front-panel LCD screen. Access the front-panel LCD MAIN MENU. Highlight RELAY ELEMENTS and press **{ENT}**. You will see a RELAY ELEMENTS screen with SEARCH highlighted at the bottom of the screen. Press **{ENT}** to go to the ELEMENT SEARCH submenu of *Figure 6.21 on page 6.27*. Enter characters in the text input field using the navigation keys. Highlight F and press **{ENT}** to enter the F character. Enter the 3, 2, and Q characters in like manner. Highlight ACCEPT and press **{ENT}**. The relay displays the screen containing the F32Q and R32Q elements, as shown in *Figure 6.28*.

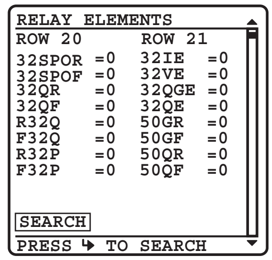


Figure 6.28 RELAY ELEMENTS LCD Screen Containing Elements F32Q and R32Q.

Step 5. Calculate impedance thresholds. For this test, apply an A-phase voltage of $V_A = 3V_2 = 18.0 \angle 180°$ V secondary. Use *Equation 6.8 on page 6.28* to find the current that is equal to the reverse impedance threshold Z2R:

$$|I_{TEST}| = |3I_2| = \frac{|3V_2|}{Z2R} = \frac{|18.0\angle 180° V|}{4.00} = 4.50 \text{ A}$$

Step 6. Use *Equation 6.6 on page 6.28* to find the current that is equal to the forward impedance threshold Z2F:

$$|I_{TEST}| = |3I_2| = \frac{|3V_2|}{Z2RF} = \frac{|18.0\angle 180° V|}{3.90} = 4.62 \text{ A}$$

Step 7. Use *Equation 6.7 on page 6.28* to determine the applied current angle ($\angle I_{TEST}$):

$$\angle I_{TEST} = \angle 3I_2 = \angle 3V_2 - \angle Z1ANG = 180° - 84° = 96°$$

Step 8. Apply a test current to confirm operation of R32Q and F32Q. Connect a single current test source as shown in *Figure 6.5 on page 6.12*. Apply an A-phase voltage of $V_A = 18.0 \angle 180°$ V secondary. Set the current source for $I_A = 0.0 \angle 96°$ A. Slowly increase the magnitude of I_A to apply the source test current. Observe the RELAY ELEMENT LCD screen. Relay Word bit R32Q asserts when $|I_A| = 0.4$ A, indicating that the relay negative-sequence current is greater than the 50RP pickup threshold. R32Q deasserts when $|I_A| = 4.5$ A, indicating that the relay negative-sequence calculation Z2c is now less than the Z2 reverse threshold Z2R. (See *Reverse Threshold on page R.1.30 in the Reference Manual* and *Forward Threshold on page R.1.30 in the Reference Manual*.) Continue to increase the current source while you observe the RELAY ELEMENT LCD screen. Relay Word bit F32Q asserts when $|I_A| = 4.62$ A, indicating that the relay negative-sequence calculation Z2c is less than the Z2 forward threshold Z2F.

Distance Elements

Apply voltages and currents to the relay analog inputs that simulate fault and load conditions to test distance elements. The relay supervises distance elements so that these elements operate under the appropriate conditions. Be sure to satisfy all the element supervisory conditions before testing a relay element. For supervisory conditions for a particular element, see *Mho Ground Distance Elements on page R.1.46 in the Reference Manual*.

Phase-to-Phase Distance Element MBC2

The SEL-421 Relay contains mho phase distance elements among the many protection elements in the relay. The relay has phase distance elements to detect phase-to-phase faults, phase-to-phase-to-ground faults, and three-phase faults. The SEL-421 Relay has five independent zones of mho phase distance protection; each zone consists of phase-to-phase elements that the relay combines to produce a particular zone output. For example, the OR combination of MAB2, MBC2, and MCA2 produces the M2P Zone 2 mho phase element. For more information on the mho phase elements and other distance elements, see *Section 1: Protection Functions in the Reference Manual* and *Section 1: Protection Application Examples in the Applications Handbook*.

Test Current and Voltage for a Phase-to-Phase Fault

To find the test current for a phase-to-phase fault, consider *Equation 6.9* for a B-phase to C-phase fault:

$$I_{TEST} = I_B = -I_C$$ **Equation 6.9**

The B-phase to C-phase current vector, I_{BC}, is:

$$I_{BC} = I_B - I_C = I_B + (I_B) = 2 \cdot I_B = 2 \cdot I_{TEST}$$ **Equation 6.10**

Choose a convenient test source current magnitude, $|I_{TEST}| = 2.5$ A; then $|I_{BC}| = 2 \cdot |I_{TEST}| = 5$ A.

Find the magnitude of the test source voltage $|V_{TEST}|$:

$$\begin{aligned} |V_{TEST}| &= |V_{BC}| = |I_{BC}| \cdot |Z_{BC}| = |I_{BC}| \cdot Z2P \\ &= 2 \cdot |I_{TEST}| \cdot Z2P \end{aligned}$$ **Equation 6.11**

where relay setting Z2P (Zone 2 Reach) substitutes for the B-phase to C-phase impedance Z_{BC}. For setting Z2P of 9.36 Ω, the test voltage magnitude $|V_{BC}|$ is:

$$\begin{aligned} |V_{TEST}| &= 2 \cdot |I_{TEST}| \cdot Z2P \\ &= 2 \cdot 2.5 \cdot 9.36 = 46.8 \text{ V} \end{aligned}$$ **Equation 6.12**

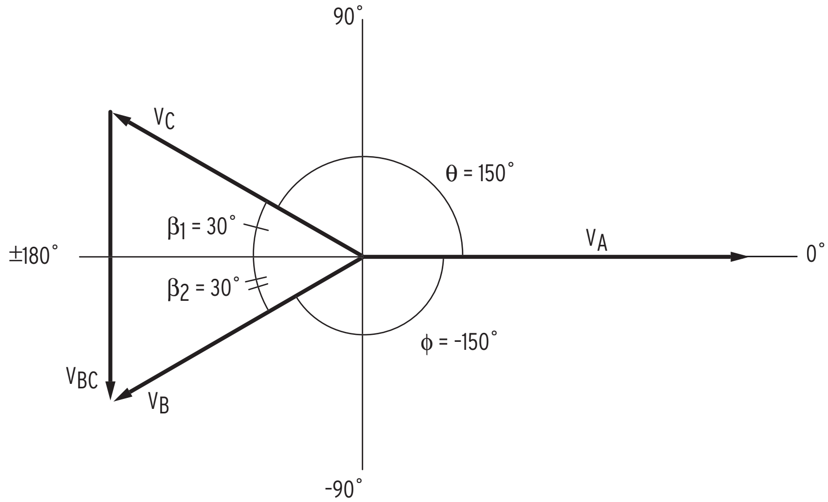


Figure 6.29 Finding Phase-to-Phase Test Quantities.

One way to create a V_{BC} phasor is to equate $|V_B|$ and $|V_C|$ and determine the appropriate angles to make an equilateral triangle as shown in *Figure 6.29*. Subtract 30 degrees (angle β_1) from 180 degrees to obtain the angle for test source V_C phasor; $V_C = 46.8 \angle 150°$ V. Similarly, add 30 degrees (angle β_2) to –180 degrees to obtain test source V_B phasor; $V_B = 46.8 \angle{-150°}$ V. Test voltage V_A can be the nominal value, $V_A = 67 \angle 0°$ V. Thus, the resulting phase-to-phase voltage is $V_{BC} = 46.8 \angle{-90°}$ V, referenced to the V_A phasor at 0 degrees.

The relay measures phase distance element maximum reach when the faulted phase-to-phase current lags the faulted phase-to-phase voltage by the distance element maximum torque angle. In the SEL-421 Relay, the phase distance element maximum torque angle is setting Z1ANG. Current I_{BC} should lag voltage V_{BC} by Z1ANG.

In this example, Z1ANG is 84.0 degrees. From *Equation 6.9 on page 6.33*, the angle of I_B is the angle of I_{TEST}, and the angle of I_C is 180 degrees from the angle of I_{TEST}. The test source current for I_B is:

$$\begin{aligned} I_B &= 2.5\angle(-90° - \text{Z1ANG})\text{A} \\ &= 2.5\angle(-90° - 84°)\text{A} \\ &= 2.5\angle{-174°}\text{A} \end{aligned}$$

Equation 6.13

And the test source current for I_C is:

$$I_C = -I_B = -(2.5\angle{-174°}\text{A}) = 2.5\angle 6°\text{A}$$

Equation 6.14

Checking the MBC2 Portion of the M2P Phase Distance Element

NOTE: As you perform this test, other protection elements can assert. This causes the relay to assert other targets and possibly close control outputs. Be sure to isolate the relay from the power system to avoid unexpected system effects.

The following procedure describes how to test the B-phase to C-phase distance element MBC2. Although this test refers directly to the Zone 2 phase distance element, you can apply this procedure to any other forward-reaching phase-to-phase distance element zone.

This example assumes that you have successfully established communication with the relay; see *Making an EIA-232 Serial Port Connection on page U.4.6 in the User's Guide* for a step-by-step procedure. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords on page U.4.8 in the User's Guide* to change the default access level passwords and enter higher relay access levels. You should be familiar with the ACSELERATOR software. See *Section 3: PC Software in the User's Guide*.

Step 1. Configure the relay. Begin the ACSELERATOR software and read the present configuration in the SEL-421 Relay. On the Settings menu, click Read. The relay sends all settings and configuration data to the ACSELERATOR software. Expand the Group 1 settings and click the Relay Configuration branch of the Settings tree view as shown in *Figure 6.23 on page 6.29*. Confirm that E21P is 2 or greater (the factory default is 3).

Disable element supervisory conditions. On the Relay Configuration dialog box, confirm that ELOAD and ELOP are set to N. See *Mho Phase Distance Elements on page R.1.55 in the Reference Manual* to determine the supervisory conditions for the MBC2 element. Confirm that Directional Element Control E32 is AUTO.

Defeat the pole-open logic. Click the + button next to Breaker Monitor to expand the Breaker Monitor branch of the Settings tree view (see *Figure 6.24 on page 6.30*). Click Breaker 1. You will see the Breaker 1 dialog box similar to *Figure 6.24*. Enter **1** in the text boxes for 52AA1 A-Phase N/O Contact Input–BK1, 52AB1 B-Phase N/O Contact Input–BK1, and 52AC1 C-Phase N/O Contact Input–BK1. The text boxes in *Figure 6.24 on page 6.30* appear if Breaker Monitor setting BK1TYP := 1. If BK1TYP := 3, enter 1 in the 52AA1 N/O Contact Input–BK1 text box (the other circuit breaker input boxes are dimmed.)

Step 2. Set test values in the relay. Expand the Group 1 settings as shown in *Figure 6.25 on page 6.30* and select the Line Configuration button. You will see the Line Configuration dialog box of *Figure 6.25*. Confirm the default settings of Z1MAG at 7.80 and Z1ANG at 84.00. Click the + mark next to the Relay Configuration branch to expand that Settings branch. Select the Directional button. You will see the Directional dialog box similar to *Figure 6.26 on page 6.31*. Confirm the settings 50FP to 0.60, 50RP to 0.40, Z2F to 3.90, Z2R to 4.00, a2 to 0.10, and k2 to 0.2. The relay calculates these settings automatically because E32 is AUTO. There are no settings to change; the dialog box is dim. *Table 6.8 on page 6.31* shows the calculations. See *Ground Directional Element on page R.1.21 in the Reference Manual* for details on these relay calculations.

Step 3. Set the phase distance element reach. Select the Phase Distance button of the ACSELERATOR software Settings tree view. You will see the Phase Distance Elements dialog box similar to *Figure 6.30 on page 6.36*. Confirm the default settings of Z1P at 6.24 and Z2P at 9.36.

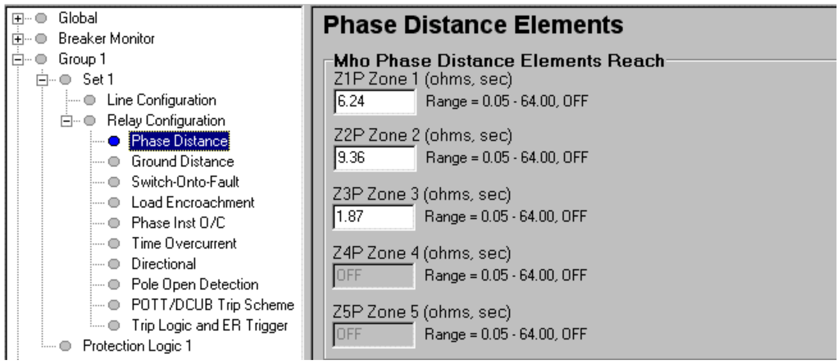


Figure 6.30 Phase Distance Elements Settings: ACSELERATOR Software.

Step 4. Upload the new settings to the SEL-421 Relay. On the File menu, click Send. The ACSELERATOR software prompts you for the settings class you want to send to the relay, as shown in the Group Select dialog box of *Figure 6.27 on page 6.31*. Click the check box for Group 1. Click OK. The ACSELERATOR software responds with a dialog box similar to the second dialog box of *Figure 6.27*. If you see no error message, the new settings are loaded in the relay.

Step 5. Display the MBC2 Relay Word bit on the front-panel LCD screen. Access the front-panel LCD MAIN MENU. Highlight RELAY ELEMENTS and press **{ENT}**. You will see a RELAY ELEMENTS screen with SEARCH highlighted at the bottom of the screen. Press **{ENT}** to go to the ELEMENT SEARCH submenu of *Figure 6.21 on page 6.27*. Use the navigation keys to highlight M and press **{ENT}** to enter character in the text input field. Enter the B, C, and 2 characters in like manner. Highlight ACCEPT and press **{ENT}**. The relay displays the LCD screen containing the MBC2 element, as shown in *Figure 6.31*.

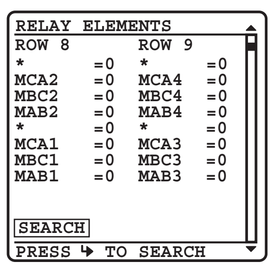


Figure 6.31 RELAY ELEMENTS LCD Screen Containing Element MBC2.

Step 6. Set the magnitudes and angles of the test signals for a B-phase-to-C-phase fault. Connect the test sources (with power off) to the relay, as in *Figure 6.6 on page 6.13*. This connection is a B-phase-to-C-phase fault where $I_A \approx 0$ and $I_B = –I_C$. Adjust the voltage sources to provide the following test voltages: $V_A = 67$ V $\angle 0°$, $V_B = 46.8$ V $\angle –150°$, and $V_C = 46.8$ V $\angle 150°$. Set the current source for $I_B = 0.0$ A $\angle –174°$.

Step 7. Apply the sources to confirm operation of MBC2. Apply the source test current by slowly increasing the magnitude of I_B. Observe the RELAY ELEMENT LCD screen. Relay Word bit MBC2 asserts when $|I_B| \geq 2.5$ A, indicating that the relay impedance calculation is less than the Z2P reach setting.

Relay Self-Tests

The SEL-421 Relay continuously runs many self-tests to detect out-of-tolerance conditions. These tests run at the same time as relay protection and automation logic, but do not degrade SEL-421 Relay performance.

Status Warning and Status Failure

The relay reports out-of-tolerance conditions as a status warning or a status failure. For conditions that do not compromise relay protection, yet are beyond expected limits, the relay issues a status warning and continues to operate. A severe out-of-tolerance condition causes the relay to declare a status failure and enter a protection-disabled state. During a protection-disabled state, the relay suspends protection element processing and trip/close logic processing and deenergizes all control outputs. When disabled, the ENABLED front-panel LED is not illuminated.

The relay signals a status warning by pulsing the HALARM Relay Word bit (hardware alarm) to logical 1 for five seconds. For a Status Failure, the relay latches the HALARM Relay Word bit at logical 1. To provide remote status indication, connect the 'b' contact of OUT108 to your control system remote alarm input and program the output SELOGIC control equation to respond to NOT (SALARM OR HALARM). See *Alarm Output on page U.2.42 in the User's Guide* on connecting this alarm output for the SEL-421 Relay.

If you repeatedly receive status warnings, check the relay operating conditions as soon as possible. Take preventive action early during the development of potential problems to avoid system failures. For any status failure, contact your Technical Service Center or the SEL factory immediately (see *Factory Assistance on page 6.43*).

The relay generates an automatic status report at the serial ports for a self-test status failure if you set Port setting AUTO := Y. The relay issues a status message with a format identical to the STATUS command output (see *Status*), except that the power supply information from the STA A response is included after the SELOGIC control equation error messages.

The relay also displays status warning and status failure automatic messages on the front-panel LCD. Use the serial port **STATUS** and **CSTATUS** commands, the ACSELERATOR HMI Status button, and the front-panel RELAY STATUS menu to display status warnings and status failures. See *STATUS on page R.8.45 in the Reference Manual*, *Checking Relay Status on page U.4.12 in the User's Guide*, and *RELAY STATUS on page U.5.24 in the User's Guide* for more information on automatic status notifications and on viewing relay status.

Status

Figure 6.32 on page 6.38 is a sample **STATUS** screen from the Status option of the ACSELERATOR HMI > Meter and Control tree view (the terminal **STATUS** report is similar). *Figure 6.33 on page 6.38* is the **STATUS A** report showing all status information on a terminal.

Firmware Version Number

At the top of each status report the relay displays the present firmware version number that identifies the software program that controls relay functions. The firmware version is the four-place designator immediately following the relay model number (the first characters in the firmware identification string). The first character in the four-place firmware version number is "R" (representing

"Release"). For example, in *Figure 6.32* and *Figure 6.33*, the firmware version number is R101. SEL numbers subsequent firmware releases sequentially; the next revision following R101 is R102. See *Appendix A: Firmware Versions in the User's Guide* for firmware version information.

```
Status

Relay 1                                    Date: 03/15/2001   Time: 09:11:54.451
Station A                                  Serial Number: 2001001234

FID=SEL-421-R101-V0-Z001001-D20010315      CID=0x6d72

Failures
  No Failures

Warnings
  No Warnings
SELogic Relay Programming Environment Errors
  No Errors

Relay Enabled
```

Figure 6.32 Relay Status: ACSELERATOR HMI.

```
=>>STA A<Enter>

Relay 1                                     Date: 03/15/2001  Time: 04:48:49.938
Station A                                   Serial Number: 2001001234

FID=SEL-421-R101-V0-Z001001-D20010315       CID=0x4572

Failures
  No Failures

Warnings
  No Warnings

Channel Offsets (mV)   W=Warn    F=Fail
  CH1  CH2  CH3  CH4  CH5  CH6  CH7  CH8  CH9 CH10 CH11 CH12  MOF
    0    0    0    0    0    0    0    0    0    0    0    0    0

Power Supply Voltages (V)   W=Warn    F=Fail
  3.3V_PS  5V_PS  N5V_PS  15V_PS   N15V_PS
     3.28   4.91   -4.93   14.70    -14.79

Temperature
   23.7 degrees Celsius

Communication Interfaces

Active High Accuracy Time Synchronization Source: PPS/IRIG-B
  PPS/IRIG-B Source PRESENT
  IRIG-B Source PRESENT
  Fast Fiber Source ABSENT

SELogic Relay Programming Environment Errors
  No Errors

Relay Enabled

=>>
```

Figure 6.33 Relay Status From a STATUS A Command on a Terminal.

CSTATUS

The relay also reports status information in the Compressed ASCII format when you issue the **CST** command. The Compressed ASCII status message is the following:

```
"RID","SID","FID","yyyy",

"relay_name","station_name","FID=SEL-xxx-x-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx","yyyy"

"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"

(Month),(Day),(Year),(Hour),(Min),(Sec),(MSec),"yyyy"

"CPU_RAM","CPU_Prog","SELBOOT","CPU_Settings","DSP_RAM","DSP","DSP_Chksum","DSP_TIME
    OUT","CPU_CARD_RAM","CPU_DSP_RAM","FRONT_PANEL","CAL_BOARD","Comm_Card","Comm_Ca
    rd_Code","QUART","Analog_Conv","IO_1","IO_2","IO_3","IO_4","yyyy"

(Ok or F),(Ok or F),(Ok or F),(Ok or F),(Ok or F),(Ok or F),(Ok or F),(Ok or F),(Ok
    or F),(Ok or F),(Ok or W), (Ok or W or F),(Ok or W),(ccrdh),(Ok or F),(Ok or
    F),(Ok or F),(Ok or F),(Ok or F),(Ok or F),"yyyy"

"AtoD_Offset","Master_Offset","3.3V_PS","5V_PS","N5V_PS","15V_PS","N15V_PS","Temp_St
    atus","Temp","FPGA","ADC_FPGA","yyyy"

(Ok or W),(Ok or W or F),(Ok or W or F),(Ok or W or F),(Ok or W or F),(Ok or W or
    F),(Ok or W or F),(Ok or W or F),(Temp value),(Ok or Fail),(Ok or Fail),"yyyy"

"Fast_Fiber_Port","MBA","MBB","Active_Time_Source","Prot_SELOGIC","Auto_SELOGIC","FM_
    Test","CCrd_Test","DNP_Test","Event_Playback_Mode","Relay_Status","Port_F_Transp
    ","Port_1_Transp","Port_2_Transp","Port_3_Transp","Port_4_Transp","Port_5_Transp
    ","yyyy"
(Ok_or_F),(Inac or Ok or F),(Inac or Ok or F),(PPS/IRIG or
    IRIG),(errbh),(errbh),(Enabled or Disabled),(Enabled or Disabled),(Enabled or
    Disabled),(Enabled or Disabled),(Enabled or Disabled),(F, 0 - 5),(F, 0 - 5),(F, 0
    - 5),(F, 0 - 5),(F, 0 - 5),(F, 0 - 5),"yyyy"
```

Definitions for the items and fields in the Compressed ASCII configuration are listed below:

- yyyy is the checksum
- x is text in the FID (Firmware ID) string
- ccrd is the communications card hex code
- errb is a hex value representing the SELOGIC control equation error bits
- (description) is text that the relay supplies
- (Ok or W or F) is normal, warning, or failure, respectively

Figure 6.34 is a sample Compressed ASCII status message.

```
=>CST<Enter>

"RID","SID","FID","03e2"
"Relay 1","Station A","SEL-421-R101-V0-Z001001-D20010315","0e06"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
3,15,2001,13,2,26,938,"0437"
"CPU_RAM","CPU_Prog","SELBOOT","CPU_Settings","DSP_RAM","DSP","DSP_Chksum","DSP_
TIMEOUT","CPU_CARD_RAM","CPU_DSP_RAM","FRONT_PANEL","CAL_BOARD","Comm_Card","Com
m_Card_Code","QUART","Analog_Conv","IO_1","IO_2","3B86"
"Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok",,,"Ok","Ok","Ok","Ok
","12F8"
"AtoD_Offset","Master_Offset","3.3V_PS","5V_PS","N5V_PS","15V_PS","N15V_PS","Tem
p_Status","Temp","FPGA","ADC_FPGA","20C0"
"Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok",24.8,"Ok","Ok","0C9C"
"Fast_Fiber_Port","MBA","MBB","Active_Time_Source","Prot_SELogic","Auto_SELogic"
,"FM_Test","CCrd_Test","DNP_Test","Relay_Status","Port_F_Transp","Port_1_Transp"
,"Port_2_Transp","Port_3_Transp","Port_5_Transp","4532"
"Not_Installed","Inac","Inac",,"0000h","0000h","Disabled","Disabled","Disabled",
"Enabled","0","0","0","0","0","1DA5"
=>
```

Figure 6.34 Compressed ASCII CST Command on a Terminal.

Relay Troubleshooting

Inspection Procedure

Complete the following inspection procedure before disturbing the system. After you finish the inspection, proceed to *Troubleshooting Procedures*.

Step 1. Confirm that the power is on. Do not turn the relay off.

Step 2. Measure and record the control power voltage at the relay POWER terminals marked "+" and "–" on the rear-panel terminal strip.

Step 3. Measure and record the voltages at all control inputs.

Step 4. Measure and record the state of all control outputs.

Step 5. Inspect the serial communications ports cabling to be sure that a communications device is connected to at least one communications port.

Troubleshooting Procedures

Troubleshooting procedures for common problems are listed in *Table 6.9*. The table lists each symptom, possible causes, and corresponding diagnoses/solutions. Related SEL-421 Relay commands are listed in bold capitals. See *Section 8: ASCII Command Reference in the Reference Manual* for details on SEL-421 Relay commands and *Section 9: Settings in the Reference Manual* for details on relay settings.

Table 6.9 Troubleshooting Procedures (Sheet 1 of 3)

Possible Cause	Diagnosis/Solution
Dark Front Panel	
Power is off.	Verify that substation battery power is operational.
Input power is not present.	Verify that power is present at the rear-panel terminal strip.
Blown power supply fuse.	Replace the fuse. See *Power Supply Fuse Replacement on page U.2.39 in the User's Guide*.
Poor contrast adjustment.	Press and hold **{ESC}** for two seconds. Press **{Up}** and **{Down}** pushbuttons to adjust contrast.
Status Failure Notice on Front Panel	
Self-test failure.	Contact the SEL factory or your Technical Service Center. The OUT108 relay control output b contacts will be closed if you programmed NOT HALARM to OUT108, see *Alarm Output on page U.2.42 in the User's Guide*
Alarm Output Asserts	
Power is off.	Restore power.
Blown power supply fuse.	Replace the fuse. See *Power Supply Fuse Replacement on page U.2.39 in the User's Guide*.
Power supply failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
Main board or interface board failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.

Table 6.9 Troubleshooting Procedures (Sheet 2 of 3)

Possible Cause	Diagnosis/Solution
Other self-test failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
System Does Not Respond to Commands	
No communication.	Confirm cable connections and types. If OK, type **<Ctrl+X>**, then **<Enter>**. This resets the terminal program.
Communications device is not connected to the system.	Connect a communications device.
Incorrect data speed (baud rate) or other communications parameters.	Configure your terminal port parameters to the particular relay port settings. Use the front panel to check port settings. See *SET/SHOW on page U.5.21 in the User's Guide*.
Incorrect communications cables.	Use SEL communications cables, or cables you build according to SEL specifications. See *Communications Ports Connections on page U.2.44 in the User's Guide*.
Communications cabling error.	Check cable connections.
Handshake line conflict; system is attempting to transmit information, but cannot do so.	Check communications cabling. Use SEL communications cables, or cables you build according to SEL specifications. See *Communications Ports Connections on page U.2.44 in the User's Guide*.
System is in the XOFF state, halting communications.	Type **<Ctrl+Q>** to put the system in the XON state.
Terminal Displays Meaningless Characters	
Data speed (baud rate) is set incorrectly.	Check the terminal parameters configuration. See *Communications Ports Connections on page U.2.44 in the User's Guide*.
Terminal emulation is not optimal.	Try other terminal types, including VT-100 and VT-52 terminal emulations.
System Does Not Respond to Faults	
Relay is set improperly.	Review the relay settings. See *Section 1: Protection Application Examples in the Applications Handbook*.
Improper test settings.	Restore operating settings.
PT or CT connection wiring error.	Confirm PT and CT wiring.
Input voltages and currents phasing, and rotation errors.	Use relay metering. Use the **TRI** event trigger command and examine the generated event report. See *Examining Metering Quantities on page U.4.31 in the User's Guide*.
The analog input (flat multipin ribbon) cable between the input module board and the main board is loose or defective.	Reseat both ends of the analog input cable, observing proper ESD precautions. See *Installing Optional I/O Interface Boards on page U.2.13 in the User's Guide*.
Check the relay self-test status.	Take preventive action as directed by relay Status Warning and Status Failure information. See *Relay Self-Tests on page 6.37* and *Checking Relay Status on page U.4.12 in the User's Guide*.

Table 6.9 Troubleshooting Procedures (Sheet 3 of 3)

Possible Cause	Diagnosis/Solution
Tripping Output Relay Remains Closed Following a Fault	
Auxiliary contact control inputs are improperly wired.	Check circuit breaker auxiliary contacts wiring.
Control output relay contacts have burned closed.	Remove relay power. Remove the control output connection. Check continuity; 'a' contacts will be open and 'b' contacts will be closed. Contact the SEL factory or your Technical Service Center if continuity checks fail.
I/O interface board failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
Power Supply Voltage Status Warning	
Power supply voltage(s) are out-of-tolerance.	Log the Status Warning. If repeated warnings occur, take preventive action.
A/D converter failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
Power Supply Voltage Status Failure	
Power supply voltage(s) are out-of-tolerance.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
A/D converter failure.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.
A/D OFFSET WARN Status Warning	
Loose ribbon cable between the input module board and the main board.	Reseat both ends of the analog input cable.
A/D converter drift.	Log the Status Warning. If repeated warnings occur, contact the SEL factory or your Technical Service Center.
Master offset drift.	LCD displays STATUS FAILURE screen. Contact the SEL factory or your Technical Service Center.

Factory Assistance

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Appendix A
Firmware Versions

Firmware Versions

This manual covers SEL-421/SEL-421-1 Relays containing firmware bearing the following firmware version numbers (most recent firmware listed at top):

Table A.1 Firmware Versions

Firmware Identification (FID) Number	Description of Changes
This firmware differs from the previous version as follows:	
SEL-421-R103-V0-Z002002-D20020417 SEL-421-1-R103-V0-Z002002-D20020417	Spurious Quart interrupts caused by varying character spacing will cause the relay to disable. This condition occurs when a communications processor is automatically retrieving data from the relay simultaneously with a serial port terminal session.
This firmware differs from the previous version as follows:	
SEL-421-R102-V0-Z002001-D20020403 SEL-421-1-R102-V0-Z002001-D20020403	Initial Release with Synchrophasor Measurement capability to the SEL-421 (not in the SEL-421-1) Added VAZ, VBZ, VCZ settings options to SYNCP Added VAY, VBY, VCY settings options to SYNCS1, SYNCS2 and ASYNCS2 Added ACOS, ASIN, CEIL, FLOOR and LOG math functions to SELOGIC control equations Added new analog quantities for use in SELOGIC control equations: Terminal W and X current magnitudes Terminal Y and Z voltage magnitudes Instantaneous sequence quantities Contact inputs Modified CHI output for SEL-2030 compatibility
This firmware differs from the previous version as follows:	
SEL-421-R101-V0-Z001001-D20010104	Added 8-cycle lockout for subsequent ALTI or ALTV switches
SEL-421-1-R101-V0-Z001001-D20010104	Initial SEL-421-1 Relay Release
SEL-421-R100-V0-Z001001-D20010703	Initial SEL-421 Relay Release.

Instructions for determining the firmware version of your SEL-421/SEL-421-1 Relay are in *Firmware Version Number on page U.6.37 in the User's Guide*.

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Glossary

"a" Contact A breaker auxiliary contact (ANSI Standard Device Number 52A) that closes when the breaker is closed and opens when the breaker is open.

"a" Output A relay control output that closes when the output relay asserts.

"b" Contact A breaker auxiliary contact (ANSI Standard Device Number 52B) that opens when the breaker is closed and closes when the breaker is open.

"b" Output A relay control output that opens when the output relay asserts.

"c" Contact A breaker auxiliary contact that can be set to serve either as an "a" contact or as a "b" contact.

"c" Output An output with both an "a" output and "b" output sharing a common post.

3U, 4U, 5U The designation of the vertical height of a device in rack units. One rack unit, U, is approximately 1.75 inches or 44.45 mm.

A Abbreviation for amps or amperes; unit of electrical current flow.

ABS Operator An operator in math SELOGIC® control equations that provides absolute value.

AC Ripple The peak-to-peak ac component of a signal or waveform. In the station dc battery system, monitoring ac ripple provides an indication of whether the substation battery charger has failed.

Acceptance Testing Testing that confirms that the relay meets published critical performance specifications and requirements of the intended application. Such testing involves testing protection elements and logic functions when qualifying a relay model for use on the utility system.

Access Level A relay command level with a specified set of relay information and commands. Except for Access Level 0, you must have the correct password to enter an access level.

Access Level 0 The least secure and most limited access level. No password protects this level. From this level, you must enter a password to go to a higher level.

Access Level 1 A relay command level you use to monitor (view) relay information. The default access level for the relay front panel.

Access Level 2 The most secure access level where you have total relay functionality and control of all settings types.

Access Level A A relay command level you use to access all Access Level 1 and Access Level B (Breaker) functions plus Automation, Global, Front Panel, Report, Port, and DNP settings.

Access Level B A relay command level you use for Access Level 1 functions plus circuit breaker control and data.

Access Level O A relay command level you use to access all Access Level 1 and Access Level B (Breaker) functions plus Output, Global, Front Panel, Report, Port, and DNP settings.

Access Level P A relay command level you use to access all Access Level 1 and Access Level B (Breaker) functions plus Protection, SELOGIC, Global, Group, Breaker Monitor, Front Panel, Report, Port, and DNP settings.

ACSELERATOR® A Windows®-based program that simplifies settings and provides analysis support.

Active Settings Group The settings group that the SEL-421 Relay is presently using from among six settings groups available in the relay.

Admittance The reciprocal of impedance; I/V.

Advanced Settings Settings for customizing protection functions; these settings are hidden unless you set EADVS := Y and EGADVS := Y.

Alias An alternate name for a Relay Word bit used in the SEL-421 Relay Sequential Events Recorder (SER) function. The assigned alias appears in the SER report in place of the Relay Word bit, making the SER report easier to review.

Analog Quantities Variables represented by such fluctuating measurable quantities as temperature, frequency, current, and voltage.

AND Operator Logical AND. An operator in Boolean SELOGIC control equations that requires fulfillment of conditions on both sides of the operator before the equation is true.

ANSI Standard Device Numbers A list of standard numbers used to represent electrical protection and control relays. The standard device numbers used in this instruction manual include the following:

25	Synchronism-check element
27	Undervoltage Element
32	Directional Elements
50	Overcurrent Element
51	Inverse Time-Overcurrent Element
52	AC Circuit Breaker
59	Overvoltage Element
67	Definite Time Overcurrent
79	Recloser
86	Breaker Failure Lockout
89	Disconnect

These numbers are frequently used within a suffix letter to further designate their application. The suffix letters used in this instruction manual include the following:

P	Phase Element
G	Residual/Ground Element
N	Neutral/Ground Element
Q	Negative-Sequence (3I2) Element

Anti-Aliasing Filter A low pass filter that blocks frequencies too high for the given sampling rate to accurately reproduce.

Apparent Power, S Complex power expressed in units of volt-amps (VA), kilovolt-amps (kVA), or megavolt-amps (MVA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: S = P + jQ. This is power at the fundamental frequency only; no harmonics are included in this quantity.

Arcing Resistance The resistance in the arc resulting from a power line fault.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters. The SEL-421 Relay uses ASCII text characters to communicate using front-panel and rear-panel EIA-232 serial ports on the relay and through virtual serial ports.

ASCII Terminal A terminal without built-in logic or local processing capability that can only send and receive information.

Assert To activate. To fulfill the logic or electrical requirements needed to operate a device. To set a logic condition to the true state (logical 1) of that condition. To apply a closed contact to an SEL-421 Relay input. To close a normally open output contact. To open a normally closed output contact.

AT Modem Command Set Dialing String Standard The command language standard that Hayes Microcomputer Products, Inc. developed to control auto-dial modems from an ASCII terminal (usually EIA-232 connected) or a PC (personal computer) containing software allowing emulation of such a terminal.

Autoconfiguration The ability to determine relay type, model number, metering capability, port ID, baud rate, passwords, relay elements, and other information that an IED (an SEL-2020/2030 communications processor) needs to automatically communicate with relays.

Automatic Messages Messages including status failure and status warning messages that the relay generates at the serial ports and displays automatically on the front-panel LCD.

Automatic Reclose Automatic closing of a circuit breaker after a breaker trip by a protective relay.

Automation Variables Variables that you include in automation SELOGIC control equations.

Auto-Reclose-Drive-to-Lockout A logical condition that drives the auto-reclose function out of service with respect to a specific circuit breaker.

Autotransformer A transformer with at least two common windings.

Bandpass Filter A filter that passes frequencies within a certain range and blocks all frequencies outside this range.

Best Choice Ground Directional Supervision™ logic An SEL logic that determines the directional element that the relay uses for ground faults.

Bit Label The identifier for a particular bit.

Bit Value Logical 0 or logical 1.

Block Trip Extension Continuing the blocking signal at the receiving relay by delaying the dropout of Relay Word bit BT.

Blocking Signal Extension The blocking signal for the DCB (directional comparison blocking) trip scheme is extended by a time delay on dropout timer to prevent unwanted tripping following current reversals.

Bolted Fault A fault with essentially zero impedance or resistance between the shorted conductors.

Boolean Logic Statements Statements consisting of variables that behave according to Boolean logic operators such as AND, NOT, and OR.

Breaker Auxiliary Contact An electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A form-a breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed and opens when the breaker is open. A form-b breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.

Breaker-and-a-half Configuration A switching station arrangement of three circuit breakers per two circuits; the two circuits share one of the circuit breakers.

Category A collection of similar relay settings.

CCVT Coupling-capacitor voltage transformer that uses a capacitive voltage divider to reduce transmission voltage to a level safe for metering and relaying devices. See CVT.

Checksum A method for checking the accuracy of data transmission involving summation of a group of digits and comparison of this sum to a previously calculated value.

CID Checksum identification of the firmware.

Circuit Breaker Failure Logic This logic within the SEL-421 Relay detects and warns of failure or incomplete operation of a circuit breaker in clearing a fault or in performing a trip or close sequence.

Circuit Breaker History Report A concise circuit breaker event history that contains as many as 128 events. This breaker history report includes circuit breaker mechanical operation times, electrical operation times, interrupted currents, and dc battery monitor voltages.

Circuit Breaker Report A full report of breaker parameters for the most recent operation. These parameters include interrupted currents, number of operations, and mechanical and electrical operating times among many parameters.

Class The first level of the relay settings structure including Global, Group, Breaker Monitor, Port, Report, Front Panel, DNP settings, Protection SELOGIC control equations, Automation SELOGIC control equations, and Output SELOGIC control equations.

Cold Start Beginning a system from power up without carryover of previous system activities.

Commissioning Testing Testing that serves to validate all system ac and dc connections and confirm that the relay, auxiliary equipment, and SCADA interface all function as intended with your settings. Perform such testing when installing a new protection system.

Common Class Components — Composite data objects that contain instances of UCA standard data types.

Common Inputs — Relay control inputs that share a common terminal.

Common Time Delay — Both ground and phase distance protection follow a common time delay on pickup.

Common Zone Timing — Both ground and phase distance protection follow a common time delay on pickup.

Communications Protocol — A language for communication between devices.

Communications-Assisted Tripping — Circuit breaker tripping resulting from the transmission of a control signal over a communications medium.

Comparison — Boolean SELOGIC control equation operation that compares two numerical values. Compares floating-point values such as currents, total counts, and other measured and calculated quantities.

COMTRADE — Abbreviation for Common Format for Transient Data Exchange. The SEL-421 Relay supports the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999.

Conditioning Timers — Timers for conditioning Boolean values. Conditioning timers either stretch incoming pulses or allow you to require that an input take a state for a certain period before reacting to the new state.

Contact Input — See Control input.

Contact Output — See Control output.

Coordination Timer — A timer that delays an overreaching element so that a downstream device has time to operate.

Control Input — Relay inputs for monitoring the state of external circuits. Connect auxiliary relay and circuit breaker contacts to the control inputs.

Control Output — Relay outputs that affect the state of other equipment. Connect control outputs to circuit breaker trip and close coils, breaker failure auxiliary relays, communications-assisted tripping circuits, and SCADA systems.

COS Operator — Operator in math SELOGIC control equations that provides the cosine function.

Counter — Variable or device such as a register or storage location that either records or represents the number of times an event occurs.

Cross-country fault — A cross-country fault consists of simultaneous separate single phase-to-ground faults on parallel lines.

CT — Current transformer.

CT Subsidence Current — Subsidence current appears as a small exponentially decaying dc current with a long time constant. This current results from the energy trapped in the CT magnetizing branch after the circuit breaker opens to clear a fault or interrupt load.

CTR — Current transformer ratio.

Current Reversal Guard Logic Under this logic, the relay does not key the transmitter and ignores reception of a permissive signal from the remote terminal when a reverse-looking element detects an external fault.

Current Transformer Saturation The point of maximum current input to a current transformer; any change of input beyond the saturation point fails to produce any appreciable change in output.

CVT Capacitive voltage transformer that uses a capacitive voltage divider to reduce transmission voltage to a level safe for metering and relaying devices. See CCVT.

CVT Transient Blocking Logic that prevents transient errors on capacitive voltage transformers from causing false operation of Zone 1 mho elements.

CVT Transient Detection Logic Logic that detects transient errors on capacitive voltage transformers.

Data Bit A single unit of information that can assume a value of either logical 0 or logical 1 and can convey control, address, information, or frame check sequence data.

Data Label The identifier for a particular data item.

Data Objects Individual pieces of UCA data created from instances of common class components or data items that are instances of standard data types.

DC Offset A dc component of fault current that results from the physical phenomenon preventing an instantaneous change of current in an inductive circuit.

DCB (Directional Comparison Blocking) A communications-assisted protection scheme. A fault occurring behind a sending relay causes the sending relay to transmit a blocking signal to a remote relay; the blocking signal interrupts the tripping circuit of the remote relay and prevents tripping of the protected line.

DCE Devices Data communication equipment devices (modems).

DCUB (Directional Comparison Unblocking) A communications-assisted tripping scheme with logic added to a POTT scheme that allows high-speed tripping of overreaching elements for a brief time during a loss of channel. The logic then blocks trip permission until the communications channel guard returns for a set time.

Deadband The range of variation an analog quantity can traverse before causing a response.

Deassert To deactivate. To remove the logic or electrical requirements needed to operate a device. To clear a logic condition to its false state (logical 0). To open the circuit or open the contacts across an SEL-421 Relay input. To open a normally open output contact. To close a normally closed output contact.

Debounce Time The time that masks the period when relay contacts continue to move after closing; debounce time covers this indeterminate state.

Default Data Map The default map of objects and indices that the SEL-421 Relay uses in DNP protocol.

Delta A phase-to-phase series connection of circuit elements, particularly voltage transformers or loads.

Demand Meter A measuring function that calculates a rolling average or thermal average of instantaneous measurements over time.

Direct Tripping Local or remote protection elements provide tripping without any additional supervision.

Directional Start A blocking signal provided by reverse reaching elements to a remote terminal used in DCB communications-assisted tripping schemes. If the fault is internal (on the protected line), the directional start elements do not see the fault and do not send a blocking signal. If the fault is external (not on the protected line), the directional start elements start sending the block signal.

Directional Supervision The relay uses directional elements to determine whether protective elements operate based on the direction of a fault relative to the relay.

Disabling Time Delay A DCUB scheme timer (UBDURD) that prevents high-speed tripping following a loss-of-channel condition.

Distance Calculation Smoothness A relay algorithm that determines whether the distance-to-fault calculation varies significantly or is constant.

Distance Protection Zone The area of a power system where a fault or other application-specific abnormal condition should cause operation of a protective relay.

DMTC Period The time of the demand meter time constant in demand metering.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware-independent communications protocol.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. You can set the time, in the case of a logic variable timer, or the dropout time can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

DTE Devices Data terminal equipment (computers, terminals, printers, relays, etc.).

DTT (Direct Transfer Trip) A communications-assisted tripping scheme. A relay at one end of a line sends a tripping signal to the relay at the opposite end of the line.

Dumb Terminal See ASCII terminal.

DUTT (Direct Underreaching Transfer Trip) A communications-assisted tripping scheme. Detection of a Zone 1 fault at either end of a line causes tripping of the local circuit breaker as well as simultaneous transmission of a tripping signal to the relay at the opposite end of the line. The scheme is said to be underreaching because the Zone 1 relays at both ends of the line reach only 80 percent (typically) of the entire line length.

Echo The action of a local relay returning (echoing) the remote terminal permissive signal to the remote terminal when the local breaker is open or a weak infeed condition exists.

Echo Block Time Delay A time delay that blocks the echo logic after dropout of local permissive elements.

Echo Duration Time Delay A time delay that limits the duration of the echoed permissive signal.

ECTT (Echo Conversion to Trip)
An element that allows a weak terminal, after satisfaction of specific conditions, to trip by converting an echoed permissive signal to a trip signal.

EEPROM
Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

EHV
Extra high voltage. Voltages greater than 230 kV.

EIA-232
Electrical definition for point-to-point serial data communications interfaces, based on the standard EIA/TIA-232. Formerly known as RS-232.

EIA-485
Electrical standard for multidrop serial data communications interfaces, based on the standard EIA/TIA-485. Formerly known as RS-485.

Electrical Operating Time
Time between trip or close initiation and an open phase status change.

Electromechanical Reset
Setting of the relay to match the reset characteristics of an electromechanical overcurrent relay.

End-Zone Fault
A fault at the farthest end of a zone that a relay is required to protect.

Energy Metering
Energy metering provides a look at imported power, exported power, and net usage over time; measured in MWh (megawatt hours).

Equalize Mode
A procedure where substation batteries are overcharged intentionally for a preselected time in order to bring all cells to a uniform output.

ESD (Electrostatic Discharge)
The sudden transfer of charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

Ethernet
A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

Event History
A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; fault location; maximum fault phase current; active group at the trigger instant; and targets.

Event Report
A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or ASCII **TRI** command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary
A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault location, time source, recloser shot counter, prefault and fault voltages, currents, and sequence current, and MIRRORED BITS communications channel status (if enabled).

The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

EXP Operator
Math SELOGIC control equation operator that provides exponentiation.

F_TRIG
Falling-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a falling edge.

Fail-Safe Refers to an output that is open during normal relay operation and closed when relay power is removed or if the relay fails. Configure alarm outputs for fail-safe operation.

Falling Edge Transition from logical 1 to logical 0.

Fast Hybrid Control Output A control output similar to, but faster than, the hybrid control output. The fast hybrid output uses an insulated gate bipolar junction transistor (IGBT) to interrupt (break) high inductive dc currents and to very rapidly make and hold the current until a metallic contact operates, at which time the IGBT turns off and the metallic contact holds the current. Unlike the hybrid control output, this output is not polarity sensitive; reversed polarity causes no misoperations.

Fast Meter SEL binary serial port command used to collect metering data with SEL relays.

Fast Operate SEL binary serial port command used to perform control with SEL relays.

Fault Type Identification Selection Logic the relay uses to identify balanced and unbalanced faults (FIDS).

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

Firmware The nonvolatile program stored in the relay that defines relay operation.

Flash Memory A type of nonvolatile relay memory used for storing large blocks of nonvolatile data.

Flashover A disruptive discharge over the surface of a solid dielectric in a gas or liquid.

Float High The highest charging voltage supplied by a battery charger.

Float Low The lowest charging voltage supplied by a battery charger.

Free-Form Logic Custom logic creation and execution order.

Free-Form SELOGIC Control Equations Free-form relay programming that includes mathematical operations, custom logic execution order, extended relay customization, and automated operation.

FTP File transfer protocol.

Function Code A code that defines how you manipulate an object in DNP 3.0 protocol.

Functional Component Portion of a UCA GOMSFE brick dedicated to a particular function including status, control, and descriptive tags.

Fundamental Frequency The component of the measured electrical signal with a frequency equal to the normal electrical system frequency, usually 50 Hz or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Global Settings General settings including those for relay and station identifiers, number of breakers, date format, phase rotation, nominal system frequency, enables, station dc monitoring, control inputs, settings group selection, data reset controls, frequency tracking, time and date management, and current and voltage source selection.

GOMSFE Generic Object Model for Substation and Feeder Equipment; a system for presenting and exchanging IED data.

GOOSE Generic Object Oriented Substation Event; a GOMSFE object for control messaging.

GPS Global Positioning System. Source of position and high-accuracy time information.

Ground Directional Element Priority The order the relay uses to select directional elements to provide ground directional decisions; relay setting ORDER.

Ground Distance Element A mho or quadrilateral distance element the relay uses to detect faults involving ground along a transmission line.

Ground Fault Loop Impedance The impedance in a fault-caused electric circuit connecting two or more points through ground conduction paths.

Ground Overcurrent Elements Elements that operate by comparing a residual ground calculation of the three-phase inputs with the residual overcurrent threshold setting. The relay asserts ground overcurrent elements when a relay residual current calculation exceeds ground current setting thresholds.

Ground Quadrilateral Distance Protection Ground distance protection consisting of a four-sided characteristic on an R-X diagram.

Ground Return Resistance Fault resistance that can consist of ground path resistance typically in tower footing resistance and tree resistance.

Guard-Present Delay A timer that determines the minimum time before the relay reinstates permissive tripping following a loss-of-channel condition in the DCUB communications-assisted tripping scheme; relay setting GARD1D.

GUI Graphical user interface.

Hexadecimal Address A register address consisting of a numeral with an “h” suffix or a “0x” prefix.

High-Resolution Data Capture Reporting of 3 kHz low-pass analog filtered data from the power system at each event trigger or trip at high sample rates of 8000 samples/second, 4000 samples/second, 2000 samples/second, and 1000 samples/second.

HMI Human machine interface.

Homogeneous System A power system with nearly the same angle (<5 ° difference) for the impedance angles of the local source, the protected line, and the remote source.

HV High voltage. System voltage greater than or equal to 100 kV and less than 230 kV.

Hybrid Control Output Contacts that use an insulated gate bipolar junction transistor (IGBT) in parallel with a mechanical contact to interrupt (break) high inductive dc currents. The contacts can carry continuous current, while eliminating the need for heat sinking and providing security against voltage transients. These contacts are polarity dependent and cannot be used to switch ac control signals.

IA, IB, IC Measured A-phase, B-phase, and C-phase currents.

IED Intelligent electronic device.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero.

IGBT Insulated gate bipolar junction transistor.

Independent Zone Timing The provision of separate zone timers for phase and ground distance elements.

Infinite Bus A constant-voltage bus.

Input Conditioning The establishment of debounce time and assertion level.

Instance A subdivision of a relay settings class. Group settings have several subdivisions (Group 1–Group 6), while the Global settings class has one instance.

Instantaneous Meter Type of meter data presented by the SEL-421 Relay that includes the present values measured at the relay ac inputs. The word “Instantaneous” is used to differentiate these values from the measurements presented by the demand, thermal, energy, and other meter types.

IRIG-B A time code input that the relay can use to set the internal relay clock.

Jitter Time, amplitude, frequency, or phase-related abrupt, spurious variations in duration, magnitude, or frequency.

L/R Circuit inductive/resistive ratio.

Latch Bits Nonvolatile storage locations for binary information.

LED Light-emitting diode. Used as indicators on the relay front panel.

Left-Side Value LVALUE. Result storage location of a SELOGIC control equation.

Line Impedance The phasor sum of resistance and reactance in the form of positive-sequence, negative-sequence, and zero-sequence impedances of the protected line.

LMD SEL distributed port switch protocol.

LN Operator Math SELOGIC control equation operator that provides natural logarithm.

Load Encroachment The load-encroachment feature allows setting of phase overcurrent elements and phase distance elements independent of load levels.

Local Bits The Relay Word bit outputs of local control switches that you access through the SEL-421 Relay front panel. Local control switches replace traditional panel-mounted control switches.

Lockout Relay An auxiliary relay that prevents operation of associated devices until it is reset either electrically or by hand.

Logical 0 A false logic condition, dropped out element, or deasserted control input or control output.

Logical 1 A true logic condition, picked up element, or asserted control input or control output.

Loss of Channel — Loss of guard and no permissive signal from communications gear in a DCUB (directional comparison unblocking scheme) for either two or three terminal lines.

Loss of Guard — No guard signal from communications gear.

Loss of Potential — Loss of one or more phase voltage inputs to the relay secondary inputs.

Low-Level Test Interface — An interface that provides a means for interrupting the connection between the relay input transformers and the input processing module and allows inserting reduced-scale test quantities for relay testing.

Maintenance Testing — Testing that confirms that the relay is measuring ac quantities accurately and verifies correct functioning of auxiliary equipment, scheme logic, and protection elements.

Math Operations — Calculations for automation or extended protection functions.

Math Operators — Operators that you use in the construction of math SELOGIC control equations to manipulate numerical values and provide a numerical base-10 result.

Maximum Dropout Time — The maximum time interval following a change of input conditions between the deassertion of the input and the deassertion of the output.

Maximum/Minimum Meter — Type of meter data presented by the SEL-421 Relay that includes a record of the maximum and minimum of each value, along with the date and time that each maximum and minimum occurred.

Mechanical Operating Time — Time between trip initiation or close initiation and the change in status of an associated circuit breaker auxiliary 52A normally open contacts.

Mho Characteristic — A directional distance relay characteristic that plots a circle for the basic relay operation characteristic on an R-X diagram.

MIRRORED BITS™ Communications — Patented relay-to-relay communications technique that sends internal logic status, encoded in a digital message, from one relay to the other. Eliminates the need for some communications hardware.

MMS — Manufacturing Messaging Specification, a data exchange protocol used by UCA.

MOD — Motor-operated disconnect.

Model — Model of device (or component of a device) including the data, control access, and other features in UCA protocol.

Motor Running Time — The circuit breaker motor running time. Depending on your particular circuit breaker, you can use the motor running time to monitor the charge time of the circuit breaker springs or the running time of the compressor motor.

MOV — Metal-oxide varistor.

Negation Operator — A SELOGIC control equation math operator that changes the sign of the argument. The argument of the negation operation is multiplied by –1.

Negative-Sequence — A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude and a phase displacement of 120°, and have clockwise phase rotation with current and voltage maxima that occur differently from that for positive-sequence configuration. If positive-sequence maxima occur as ABC, negative-sequence maxima occur as ACB.

Negative-Sequence Current Supervision Pickup An element allowed to operate only when a negative-sequence current exceeds a threshold.

Negative-Sequence Directional Element An element that provides directivity by the sign, plus or minus, of the measured negative-sequence impedance.

Negative-Sequence Impedance Impedance of a device or circuit that results in current flow with a balanced negative-sequence set of voltage sources.

Negative-Sequence Overcurrent Elements Elements that operate by comparing a negative-sequence calculation of the three-phase secondary inputs with negative-sequence overcurrent setting thresholds. The relay asserts these elements when a relay negative-sequence calculation exceeds negative-sequence current setting thresholds.

Negative-Sequence Voltage-Polarized Directional Element These directional elements are 32QG and 32Q. 32QG supervises the ground distance elements and residual directional overcurrent elements; 32Q supervises the phase distance elements.

NEMA National Electrical Manufacturers' Association.

Neutral Impedance An impedance from neutral to ground on a device such as a generator or transformer.

No Current/Residual Current Circuit Breaker Failure Protection Logic Logic for detecting and initiating circuit breaker failure protection with a logic transition, or when a weak source drives the fault or a high-resistance ground fault occurs.

Nondirectional Start A blocking signal provided by nondirectional overcurrent elements to a remote terminal used in DCB communications-assisted tripping schemes. The nondirectional start elements start sending the block signal.

Nonhomogeneous System A power system with a large angle difference (>5° difference) for the impedance angles of the local source, the protected line, and the remote source.

Nonvolatile Memory Relay memory that persists over time to maintain the contained data even when the relay is deenergized.

NOT Operator A logical operator that produces the inverse value.

OR Operator Logical OR. A Boolean SELOGIC control equation operator that compares two Boolean values and yields either a logical 1 if either compared Boolean value is logical 1 or a logical 0 if both compared Boolean values are logical 0.

OSI Open Systems Interconnect. A model for describing communications protocols. Also an ISO suite of protocols designed to this model.

Out-of-Step Blocking Blocks the operation of phase distance elements during power swings.

Out-of-Step Tripping Trips the circuit breaker(s) during power swings.

Override Values Test values you enter in Fast Meter, DNP, and communications card database storage.

Parentheses Operator Math operator. Use paired parentheses to control the execution of operations in a SELOGIC control equation.

PC Personal computer.

Peak Demand Metering Maximum demand and a time stamp for phase currents, negative-sequence and zero-sequence currents, and powers. The SEL-421 Relay stores peak demand values and the date and time these occurred to nonvolatile storage once per day, overwriting the previously stored value if the new value is larger. Should the relay lose control power, the relay restores the peak demand information saved at 23:50 hours on the previous day.

Phase Distance Element A mho distance element the relay uses to detect phase-to-phase and three-phase faults at a set reach along a transmission line.

Phase Overcurrent Element Elements that operate by comparing the phase current applied to the secondary current inputs with the phase overcurrent setting. The relay asserts these elements when any combination of the phase currents exceeds phase current setting thresholds.

Phase Rotation The sequence of voltage or current phasors in a multiphase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120°, and the C-phase voltage lags B-phase voltage by 120°. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120°.

Phase Selection Ability of the relay to determine the faulted phase or phases.

Pickup Time The time measured from the application of an input signal until the output signal asserts. You can set the time, as in the case of a logic variable timer, or the pickup time can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Polarizing Memory A circuit that provides a polarizing source for a period after the polarizing quantity has changed or gone to zero.

Pole Discrepancy A difference in the open/closed status of circuit breaker poles. The relay continuously monitors the status of each circuit breaker pole to detect open or close conditions among the three poles.

Pole-Open Logic Logic that determines the conditions that the relay uses to indicate an open circuit breaker pole.

Pole Scatter Deviation in operating time between pairs of circuit breaker poles.

Port Settings Communications port settings such as Data Bits, Speed, and Stop Bits.

Positive-Sequence A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude and a phase displacement of 120°. With conventional rotation in the counter-clockwise direction, the positive-sequence current and voltage maxima occur in ABC order.

Positive-Sequence Current Restraint Factor, a2 This factor compensates for highly unbalanced systems with many untransposed lines and helps prevent misoperation during current transformer saturation. The a2 factor is the ratio of the magnitude of negative-sequence current to the magnitude of positive-sequence current (I2/I1).

Positive-sequence Current Supervision Pickup An element that operates only when a positive-sequence current exceeds a threshold.

Positive-Sequence Impedance Impedance of a device or circuit that results in current flow with a balanced positive-sequence set of voltage sources.

POTT (Permissive Overreaching Transfer Trip) A communications-assisted line protection scheme. At least two overreaching protective relays must receive a permissive signal from the other terminal(s) before all relays trip and isolate the protected line.

Power Factor The cosine of the angle by which phase current lags or leads phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a pure resistive load.

PPS Pulse per second from a GPS receiver. PPS time mode is present when both 1k PPS and IRIG-B signals are applied to the relay Time inputs.

Protection and Automation Separation Segregation of protection and automation processing and settings.

Protection Settings Group Individual scheme settings for as many as six different schemes (or instances).

Protection-Disabled State Suspension of relay protection element and trip/close logic processing and deenergization of all control outputs.

PT Potential transformer. Also referred to as a voltage transformer or VT.

PTR Potential transformer ratio.

Quadrilateral Characteristic A distance relay characteristic on an R-X diagram consisting of a directional measurement, reactance measurement, and two resistive measurements.

Qualifier Code Specifies type of range for DNP 3.0 objects. With the help of qualifier codes, DNP master devices can compose the shortest, most concise messages.

R_TRIG Rising-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a rising edge.

RAM Random Access Memory. Volatile memory where the relay stores intermediate calculation results, Relay Word bits, and other data.

Reactance Reach The reach of a distance element in the reactive (X) direction in the R-X plane.

Real Power Power that produces actual work. The portion of apparent power that is real, not imaginary.

Reclose The act of automatically closing breaker contacts after a protective relay trip has opened the circuit breaker contacts and interrupted current through the breaker.

Relay Word Bit A single relay element or logic result. A Relay Word bit can equal either logical 1 or logical 0. Logical 1 represents a true logic condition, picked up element, or asserted control input or control output. Logical 0 represents a false logic condition, dropped out element, or deasserted control input or control output. Use Relay Word bits in SELOGIC control equations.

Remapping The process of selecting data from the default map and configuring new indices to form a smaller data set optimized to your application.

Remote Bit A Relay Word bit with a state that is controlled by serial port commands, including the **CONTROL** command, a binary Fast Operate command, DNP binary output operation, or a UCA control operation.

Report Settings Event report and Sequential Events Recorder settings.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero.

Residual Directional Overcurrent Element A residual overcurrent element allowed to operate in only the forward or reverse direction.

Residual Overcurrent Protection Overcurrent protection that operates at conditions exceeding a threshold of system unbalance ($3I_0 = I_A + I_B + I_C$).

Resistance Blinder An operate boundary in the resistive direction of a ground quadrilateral distance element.

Resistive Reach The reach of a distance element in the resistive (R) direction in the R-X plane.

Retrip A subsequent act of attempting to open the contacts of a circuit breaker after the failure of an initial attempt to open these contacts.

Reverse Fault A fault operation behind a relay terminal.

Rising Edge Transition from logical 0 to logical 1, or the beginning of an operation.

RMS Root-mean-square. This is the effective value of the current and voltage measured by the relay, accounting for the fundamental frequency and higher-order harmonics in the signal.

Rolling Demand A sliding time-window arithmetic average in demand metering.

RTU Remote Terminal Unit.

RXD Received data.

SCADA Supervisory control and data acquisition.

Self-Description A feature of GOMSFE in the UCA2 protocol. A master device can request a description of all of the GOMSFE models and data within the IED.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates detection of an out-of-tolerance condition. The SEL-421 Relay has self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.

SELOGIC Expression Builder A rules-based editor within the SEL-5030 ACSELERATOR Software Program for programming SELOGIC control equations.

SELOGIC Math Variables Math calculation result storage locations.

SELOGIC Control Equation A relay setting that allows you to control a relay function (such as a control output) using a logical combination of relay element outputs and fixed logic outputs.

Sequencing Timers Timers designed for sequencing automated operations.

Sequential Events Recorder A relay function that stores a record of the date and time of each assertion and deassertion of every Relay Word bit in a list that you set in the relay. SER provides a useful way to determine the order and timing of events of a relay operation.

SER Sequential Events Recorder or the relay serial port command to request a report of the latest 1000 sequential events.

Series-Compensated Line A power line on which the addition of series capacitance compensates for excessive inductive line impedance.

Settle/Settling Time Time required for an input signal to result in an unvarying output signal within a specified range.

Shot Counter A counter that records the number of times a recloser attempts to close a circuit breaker.

Shunt Admittance The admittance resulting from the presence of a device in parallel across other devices or apparatus that diverts some current away from these devices or apparatus.

Shunt Capacitance The capacitance between a network connection and any existing ground.

Shunt Current The current that a parallel-connected high-resistance or high-impedance device diverts away from devices or apparatus.

SIN Operator Operator in math SELOGIC control equations that provides the sine function.

Single-Pole Trip A circuit breaker trip operation that occurs when one pole of the three poles of a circuit breaker opens independently of the other poles.

SIR Source-to-line impedance ratio.

SOTF (Switch-Onto-Fault Protection Logic) Logic that provides tripping if a circuit breaker closes into a zero voltage bolted fault, such as would happen if protective grounds remained on the line following maintenance.

Source Impedance The impedance of an energy source at the input terminals of a device or network.

SQRT Operator Math SELOGIC control equation operator that provides square root.

Stable Power Swing A change in the electrical angle between power systems. A control action can return the angular separation between systems to less than the critical angle.

Status Failure A severe out-of-tolerance internal operating condition. The relay issues a status failure message and enters a protection-disabled state.

Status Warning Out-of-tolerance internal operating conditions that do not compromise relay protection, yet are beyond expected limits. The relay issues a status warning message and continues to operate.

Strong Password A mix of valid password characters in a six-character combination that does not spell common words in any portion of the password. Valid password characters are numbers, upper- and lower-case alphabetic characters, "." (period), and "-" (hyphen).

Subsidence Current See CT subsidence current.

Synch Reference A phasor the relay uses as a polarizing quantity for synchronism check calculations.

Synchronism Check Verification by the relay that system components operate within a preset frequency difference and within a preset phase angle displacement between voltages.

Synchronized Phasor A phasor calculated from data samples using an absolute time signal as the reference for the sampling process. The phasors from remote sites have a defined common phase relationship. Also known as Synchrophasor.

Telnet An Internet protocol for exchanging terminal data that connects a computer to a network server and allows control of that server and communication with other servers on the network.

Terminal Emulation Software Software such as Microsoft® HyperTerminal or ProComm® Plus that can be used to send and receive ASCII text messages and files via a computer serial port.

Thermal Demand Thermal demand is a continuous exponentially increasing or decreasing accumulation of metered quantities; used in demand metering.

Thermal Withstand Capability The capability of equipment to withstand a predetermined temperature value for a specified time.

Three-Phase Fault A fault involving all three phases of a three-phase power system.

Three-Pole Trip A circuit breaker operation that occurs when the circuit breaker opens all three poles at the same time.

Time Delay on Pickup The time interval between initiation of a signal at one point and detection of the same signal at another point.

Time Dial A control that governs the time scale of the time-overcurrent characteristic of a relay. Use the time-dial setting to vary relay operating time.

Time-Delayed Tripping Tripping that occurs after expiration of a pre-determined time.

Time-Overcurrent Element An element that operates according to an inverse relationship between input current and time, with higher current causing faster relay operation.

Torque Control A method of using one relay element to supervise the operation of another.

Total Clearing Time The time interval from the beginning of a fault condition to final interruption of the circuit.

Tower Footing Resistance The resistance between true ground and the grounding system of a tower.

Transformer Impedance The resistive and reactive parameters of a transformer looking in to the transformer primary or secondary windings. Use industry accepted open-circuit and short-circuit tests to determine these transformer equivalent circuit parameters.

Tree Resistance Resistance resulting from a tree in contact with a power line.

TXD Transmitted data.

UCA2 Utility Communications Architecture. A network-independent protocol suite that serves as an interface for individual intelligent electronic devices.

Unbalanced Fault All faults that do not include all three phases of a system.

Unconditional Tripping Protection element tripping that occurs apart from conditions such as those involving communication, switch-onto-fault logic, etc.

Unstable Power Swing A change in the electrical angle between power systems for which a control action cannot return the angular separation between systems to an angle less than the critical angle.

Untransposed Line A transmission line with phase conductors that are not regularly transposed. The result is an imbalance in the mutual impedances between phases.

User ST Region in GOOSE for user-specified applications.

VA, VB, VC Measured A-phase-to-neutral, B-phase-to-neutral, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

Virtual Terminal Connection A mechanism that uses a virtual serial port to provide the equivalent functions of a dedicated serial port and a terminal.

Volatile Storage A storage device that cannot retain data following removal of relay power.

VT Voltage transformer. Also referred to as a potential transformer or PT.

Warm Start The reset of a running system without removing and restoring power.

Weak Infeed Logic Logic that permits rapid tripping for internal faults when a line terminal has insufficient fault current to operate protective elements.

Wye A phase-to-neutral connection of circuit elements, particularly voltage transformers or loads. To form a wye connection using transformers, connect the nonpolarity side of each of three voltage transformer secondaries in common (the neutral), and take phase to neutral voltages from each of the remaining three leads. When properly phased, these leads represent the A-phase-, B-phase-, and C-phase-to-neutral voltages. This connection is frequently called ‘four-wire wye,’ alluding to the three phase leads plus the neutral lead.

Zero-Sequence A configuration of three-phase currents and voltages with currents and voltages that occur simultaneously, are always in phase, and have equal magnitude ($3I_0 = I_A + I_B + I_C$).

Zero-Sequence Compensation Factor A factor based on the zero-sequence and positive-sequence impedance of a line that modifies a ground distance element to have the same reach as a phase distance element.

Zero-Sequence Impedance Impedance of a device or circuit resulting in current flow when a single voltage source is applied to all phases.

Zero-Sequence Mutual Coupling
Zero-sequence current in an unbalanced circuit in close proximity to a second circuit induces voltage into the second circuit. When not controlled by protection system design and relay settings, this situation can cause improper operation of relays in both systems.

Zero-Sequence Overcurrent Element
Overcurrent protection that operates at conditions exceeding a threshold of system unbalance.

Zero-Sequence Voltage-Polarized Directional Element
An element that provides directionality by the sign, plus or minus, of the measured zero-sequence impedance.

Z-Number
That portion of the relay FID string that identifies the proper ACSELERATOR software relay driver version and HMI driver version when creating or editing relay settings files.

Zone Time Delay
Time delay associated with the forward or reverse step distance and zone protection.

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Page numbers appearing in bold mark the location of the topic's primary discussion.

U=User's Guide; A=Application Handbook; R=Reference Manual

D

SEL-421 Relay Command Summary

SEL-421 Relay Commands[a, b] (Sheet 1 of 2)

Command	Description
2ACCESS	Go to Access Level 2 (complete relay monitoring and control)
AACCESS	Go to Access Level A (automation control)
ACCESS	Go to Access Level 1 (monitor relay)
BACCESS	Go to Access Level B (monitor relay and control circuit breakers)
BNAME	ASCII names of all relay status bits (Fast Meter)
BREAKER *n*	Display the circuit breaker report and breaker history; preload and reset breaker monitor data (*n* = 1 is BK1; *n* = 2 is BK2)
CASCII	Generate the Compressed ASCII response configuration message
CBREAKER	BREAKER command for the Compressed ASCII response
CEVENT	EVENT command for the Compressed ASCII response
CHISTORY	HISTORY command for the Compressed ASCII response
CLOSE *n*	Close the circuit breaker (*n* = 1 is BK1; *n* = 2 is BK2)
COMM *c*	Display relay-to-relay MIRRORED BITS communications data (*c* = A is channel A; *c* = B is channel B; *c* = M is either enabled single channel)
CONTROL *nn*	Set, clear, or pulse an internal remote bit (*nn* is the remote bit number from 01–32)
COPY *m n*	Copy settings between instances in the same class (m and n are instance numbers; for example: *m* = 1 is Group 1; *n* = 2 is Group 2)
CSER	SER command for the Compressed ASCII response
CSTATUS	STATUS command for the Compressed ASCII response
CSUMMARY	SUMMARY command for the Compressed ASCII response
DATE	Display and set the date
DNAME X	ASCII names of all relay digital I/O (Fast Meter)
DNP	Access or modify DNP settings (similar to SHOW D and SET D)
EVENT	Display and acknowledge event reports
FILE	Transfer data between the relay and external software
GROUP	Display the active group number or select the active group
HELP	Display available commands or command help at each access level
HISTORY	View event summaries/histories; clear event data
ID	Display the firmware id, user id, device code, part number, and configuration information
IRIG	Update the internal clock/calendar from the IRIG-B input
LOOPBACK	Connect MIRRORED BITS data from transmit to receive on the same port
MAP 1	Analyze the communications card database
METER	Display metering data and internal relay operating variables
OACCESS	Go to Access Level O (output control)
OPEN *n*	Open the circuit breaker (*n* = 1 is BK1; *n* = 2 is BK2)
PACCESS	Go to Access Level P (protection control)

SEL-421 Relay Commands[a, b] (Sheet 2 of 2)

Command	Description
PASSWORD	Display or change relay passwords
PORT *p*	Connect to a remote relay via MIRRORED BITS virtual terminal (*p* is port number 1–3, and F)
PULSE OUT*nnn*	Pulse a relay control output (OUT*nnn* is a control output number)
QUIT	Reduce access level to Access Level 0 (exit relay control)
SER	View Sequential Events Recorder reports
SET[c]	Enter relay settings
SHOW[c]	Display relay settings
SNS	Display Sequential Events Recorder settings name strings (Fast SER)
STATUS	Report or clear relay status and SELOGIC control equation errors
SUMMARY	View summary event reports
TARGET	Display relay elements for a row in the Relay Word table
TEST DB	Display or place values in the communications card database
TEST DNP	Display or place values in the DNP object map
TEST FM	Display or place values in metering database (Fast Meter)
TIME	Display and set the internal clock
TRIGGER	Initiate a data capture and record an event report
VERSION	Display the relay hardware and software configurations
VIEW 1	View data from the communications card database

[a] See *Section 8: ASCII Command Reference on page R8.1 in Reference Manual*
[b] For help on a specific command, type **HELP [command]<Enter>** at an ASCII terminal communicating with the relay.
[c] See the table below for SET/SHOW options.

SET/SHOW Command Options

Option	Setting Type	Description
[S] ***n***	Group Settings 1–6	Particular application settings
A *n*	Automation Logic Block 1–10	Automation SELOGIC control equations
D	DNP	Direct Network Protocol remapping
F	Front Panel	Front-panel HMI settings
G	Global 1–6	Relay-wide settings
L *n*	Protection Logic Group 1–6	Protection SELOGIC control equations
M	Breaker Monitor	Circuit breaker monitor settings
O	Outputs	Output SELOGIC control equations
P *n*	Port 1–3, F, 5	Communications port settings
R	Report	Event report and SER settings