SEL-487B Relay

Protection
Automation
Control

Instruction Manual

20210514

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM487B-01

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Preface

Overview

This manual provides information and instructions for installing, setting, configuring, and operating the SEL-487B Relay. The manual is for use by power engineers and others experienced in protective relaying applications. Included are detailed technical descriptions of the relay and application examples.

Manual Overview

The SEL-487B Instruction Manual consists of three volumes:

- User's Guide
- Applications Handbook
- Reference Manual

In addition, the SEL-487B Instruction Manual contains a comprehensive *Index* that encompasses the entire manual and a *Glossary* that lists and defines technical terms used throughout the manual.

Read the sections that pertain to your application to gain valuable information about using the SEL-487B. 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.

Section 1: Introduction and Specifications. Introduces SEL-487B 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 and PTs); explains basic connections for the relay communications ports and how to install optional communications cards (such as the Ethernet card).

Section 3: PC Software. Introduces how to use the ACSELERATOR QuickSet® SEL-5030 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, and operating relay control outputs and control inputs.

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-487B; includes the list of status notification messages and a troubleshooting chart.

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

Appendix B: Firmware Upgrade Instructions. Provides information about upgrading firmware in your SEL-487B.

Applications Handbook

Section 1: System Configuration Guideline and Application Examples. Provides general guidelines for implementing the relay in single-relay and three-relay applications; provides CT and disconnect auxiliary contact requirements for proper differential protection application. The section also provides application examples for the following busbar layouts:

- ➤ Single bus and tie breaker, three-relay application
- ➤ Single bus and tie breaker, single-relay application
- ➤ Breaker-and-a half
- ➤ Single bus and transfer bus with buscoupler
- ➤ Double bus with buscoupler
- ➤ Double bus and transfer bus with two busbars
- ➤ Double and transfer bus (outboard CTs)
- ➤ Double and transfer bus (inboard CTs)

Use the worksheets provided on the SEL-487B *Product Literature CD* to collect and organize data before configuring and setting the relay.

Section 2: Monitoring and Metering. Describes how to use the substation dc battery monitors; provides information on viewing metering quantities for voltages and currents.

Section 3: Analyzing Data. Explains how to obtain raw data and filtered data event reports, event summaries, history reports, and SER reports; discusses how to enter SER trigger and alias settings.

Section 4: SEL Communications Processor Applications. Provides examples of how to use the SEL-487B with the SEL-2020, SEL-2030, and SEL-2032 Communications Processors for total substation automation solutions.

Section 5: Direct Network Communications. Explains how to use DNP3 (serial and LAN/WAN) and other Ethernet protocols such as Telnet, FTP, and IEC 61850.

Reference Manual

Section 1: Protection Functions. Describes the protection, monitoring, and control elements in the SEL-487B and how the relay processes these elements.

Section 2: 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 3: Communications Interfaces. Explains the physical connection of the SEL-487B to various communications network topologies.

Section 4: 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 5: DNP3 Communications. Explains how to use DNP3 (serial and LAN/WAN) and other Ethernet protocols such as Telnet, FTP, and IEC 61850.

Section 6: IEC 61850 Communications. Describes the IEC 61850 protocol and how to apply this protocol to substation automation and integration. Includes IEC 61850 protocol compliance statements.

Section 7: ASCII Command Reference. Provides an alphabetical listing of all ASCII commands with examples for each ASCII command option.

Section 8: Settings. Provides a list of all SEL-487B settings and defaults. The organization of the settings is the same as for the settings organization in the relay and in the ACSELERATOR QuickSet software.

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

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

SEL-487B Relay Command Summary. Contains a listing of SEL-487B commands.

CD-ROM

The CD-ROM contains the SEL-487B Instruction Manual in an electronic form that you can search easily.

Conventions

The SEL-487B Instruction 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

There are three ways to communicate with the SEL-487B:

- ➤ Using a command line interface on a PC terminal emulation window, such as Microsoft® HyperTerminal®.
- ➤ Using the front-panel menus and pushbuttons.
- ➤ Using ACSELERATOR QuickSet SEL-5030 Software.

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

Example	Description
STATUS	Commands, command options, and command variables typed at a command line interface on a PC.
n **SUM *n***	Variables determined based on an application (in bold if part of a command).
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
{CLOSE}	Relay front-panel pushbuttons.
ENABLE	Relay front- or rear-panel labels.
RELAY RESPONSE MAIN > METER	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.
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 R stands for Reference Manual
SELOGIC control equations	SEL trademarks and registered trademarks contain the appropriate symbol on first reference in a section. In the SEL-487B Instruction Manual, certain SEL trademarks appear in small caps. These include SELOGIC control equations, MIRRORED BITS communications, and ACSELERATOR QuickSet software program.
Modbus®	Registered trademarks of other companies include the registered trademark symbol with the first occurrence of the term in a section.

Commands

You can simplify the task of entering commands by shortening any ASCII command to the first three characters (upper- or lowercase); for example, **ACCESS** becomes **ACC**.

Always send a carriage return **<CR>** character, or a carriage return character followed by a line feed character **<CR><LF>**, to command the relay to process the ASCII command. Usually, most terminals and terminal programs interpret the **<Enter>** key as a **<CR>**. For example, to send the **ACCESS** command, type the following:

ACC <Enter>

Safety Information

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

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

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

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

Notes

Margin 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.

Step-by-Step Procedures

The SEL-487B Instruction 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-487B Instruction 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 following text shows sample steps. Steps include explanations, text references, table references, and figure references to further illustrate the step.

Step 1. Press **<Ctrl+T>** to use the serial communications terminal in the ACSELERATOR software.

Step 2. Press **<Enter>** to see if the communications link is active between the software and the relay.

You should see the Access Level 0 = prompt in the terminal window.

Step 3. Open the **Communication** menu and click **Port Parameters**.

Step 4. Confirm that you have entered the correct passwords in the **Level One Password** dialog box and the **Level Two Password** dialog box.

Step 5. On the **Settings** menu, click **Read**.

The relay sends all configuration and settings data to ACSELERATOR.

Step 6. 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

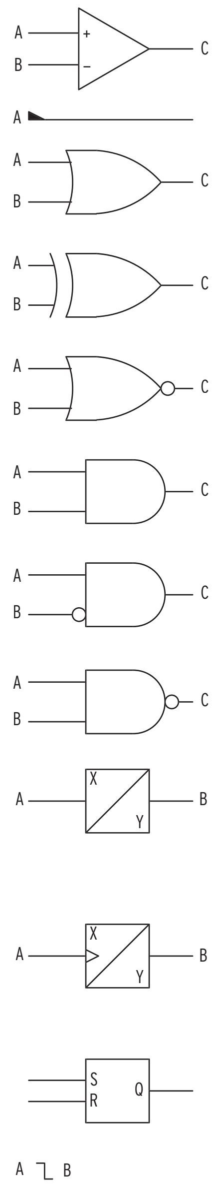
Numbers

This manual displays numbers as decimal values. Hexadecimal numbers include the letter h appended to the number. Alternatively, the prefix 0X or 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.

NAME	SYMBOL	FUNCTION
COMPARATOR		Input A is compared to input B. Output C asserts if A is greater than B.
INPUT FLAG		Input A comes from other logic.
OR		Either input A or input B asserted cause output C to assert.
EXCLUSIVE OR		If either A or B is asserted, output C is asserted. If A and B are of the same state, C is deasserted.
NOR		If neither A nor B asserts, output C asserts.
AND		Input A and input B must assert to assert output C.
AND W/ INVERTED INPUT		If input A is asserted and input B is deasserted, output C asserts. Inverter "O" inverts any input or output on any gate.
NAND		If A and/or B are deasserted, output C is asserted.
TIME DELAYED PICK UP AND/OR TIME DELAYED DROP OUT		X is a time-delay-pickup value; Y is a time-delay-dropout value. B asserts time X after input A asserts; B will not assert if A does not remain asserted for time X. If X is zero, B will assert when A asserts. If Y is zero, B will deassert when A deasserts.
EDGE TRIGGER TIMER		Rising edge of A starts timers. Output B will assert time X after the rising edge of A. B will remain asserted for time Y. If Y is zero, B will assert for a single processing interval. Input A is ignored while the timers are running.
SET RESET FLIP FLOP		Input S asserts output Q until input R asserts. Output Q deasserts or resets when R asserts.
FALLING EDGE		B asserts at the falling edge of input A.



SEL-487B Cautions, Warnings, and Dangers

The following hazard statements appear in the body of this manual in English. See the following table for the English and French translation of these statements.

English	French
⚠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.	⚠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.
⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer's instructions.	⚠ATTENTION Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ATTENTION L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.
⚠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.	⚠ATTENTION Ne pas mettre le relais sous tension avant d'avoir complété ces procédures et d'avoir reçu l'instruction de mettre en marche.
⚠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.	⚠ATTENTION Ne pas installer de cavalier sur les positions A ou D sur le connecteur J18 de la carte principale. Une défaillance du relais pourrait survenir si un cavalier était installé sur les positions J18A et J18D.
⚠CAUTION Setting E87ZSUP := Y enables the zone supervision in all six zones. If you do not enter any supervision conditions for a particular zone, be sure to enter a 1 at the SELOGIC control equation prompt.	⚠ATTENTION Le réglage E87ZSUP := Y autorise la supervision de zone des six zones. Si vous n'entrez aucune condition de supervision pour une zone particulière, assurez-vous d'entrer un 1 au message de l'équation de commande SELOGIC.
⚠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.	⚠ATTENTION Des problèmes sévères d'alimentation et de masse pourraient survenir sur les ports de communication suite à l'usage de câbles autres que ceux fournis par SEL. Ne jamais utiliser des câbles standards de type modem nul avec cet équipement.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠AVERTISSEMENT L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

English	French
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	⚠AVERTISSEMENT Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.
⚠WARNING Do not look into the fiber (laser) ports/connectors.	⚠AVERTISSEMENT Ne pas regarder vers l'extremité des ports ou connecteurs de fibres pour laser.
⚠WARNING Do not look into the end of an optical cable connected to an optical output.	⚠AVERTISSEMENT Ne pas regarder vers l'extrémité d'un câble optique raccordé à une sortie optique.
⚠WARNING Do not perform any procedures or adjustments that this instruction manual does not describe.	⚠AVERTISSEMENT Ne pas appliquer une procédure ou un ajustement qui n'est pas décrit explicitement dans ce manuel d'instruction.
⚠WARNING During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.	⚠AVERTISSEMENT Durant l'installation, la maintenance ou le test des ports optiques, utilisez exclusivement des équipements de test homologués comme produits de type laser de Classe 1.
⚠WARNING Incorporated components, such as LEDs, transceivers, and laser emitters, are not user serviceable. Return units to SEL for repair or replacement.	⚠AVERTISSEMENT Les composants internes tels que les leds (diodes électroluminescentes), émetteurs-récepteurs ou émetteurs pour rayon laser ne peuvent pas être entretenus par l'usager. Retourner ces unités à SEL pour toute réparation ou remplacement.
⚠WARNING Do not use Relay Word bit 51PnnT in any trip equation if inverse-time overcurrent protection is not required.	⚠AVERTISSEMENT Ne pas utiliser le bit de "Relay Word" 51PnnT dans une équation de déclenchement si la protection de type temps-courant à temps inverse n'est pas requise.
⚠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 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 Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessuers ou la mort.

Section 1
Introduction and Specifications

Overview

The SEL-487B Relay provides bus current differential protection, circuit breaker failure protection, and backup overcurrent protection. Equipped with four interface boards, the relay has a total of 103 inputs (74 common inputs and 29 independent inputs) and 40 outputs. It is configurable in either a three-relay or a single-relay application. The relay has 18 analog current inputs and 3 analog voltage inputs. For buses with no more than six terminals, use one SEL-487B in a single-relay application. For buses with as many as 18 terminals, use three SEL-487B relays in a three-relay application; each relay provides up to six dedicated zones of protection.

The SEL-487B has separate protection and automation SELOGIC® control equation programming areas with extensive protection and automation programming capabilities. You can organize automation SELOGIC control equation programming into 10 blocks of 100 program lines each. With the flexibility of the expanded SELOGIC control equations, the relay is suitable for custom protection and control schemes.

Communications interfaces include standard SEL ASCII and enhanced MIRRORED BITS® communications protocols. Establish Ethernet connectivity with the optional Ethernet card. With the Ethernet card, you can employ the latest industry communications tools, including Telnet, FTP, IEC 61850, and DNP3 (Serial and LAN/WAN) protocols.

Included with the SEL-487B is the ACSELERATOR QuickSet® SEL-5030 Software program. Use the ACSELERATOR QuickSet software to assist you in setting, controlling, and acquiring data from the relays both locally and remotely. ACSELERATOR Architect is included with purchase of the optional Ethernet card with IEC 61850 protocol support. ACSELERATOR Architect enables you to view and configure IEC 61850 settings via a GUI interface, tightly integrated with ACSELERATOR QuickSet.

Combining the simple and robust hardware design with extensive self-testing provides relay reliability and enhances relay availability.

This section introduces the SEL-487B and provides information on the following topics:

- Functional Overview
- Models and Options
- Applications
- Specifications

Functional Overview

The SEL-487B contains many protection, automation, and control features. *Figure 1.1* presents a simplified functional overview of the relay.

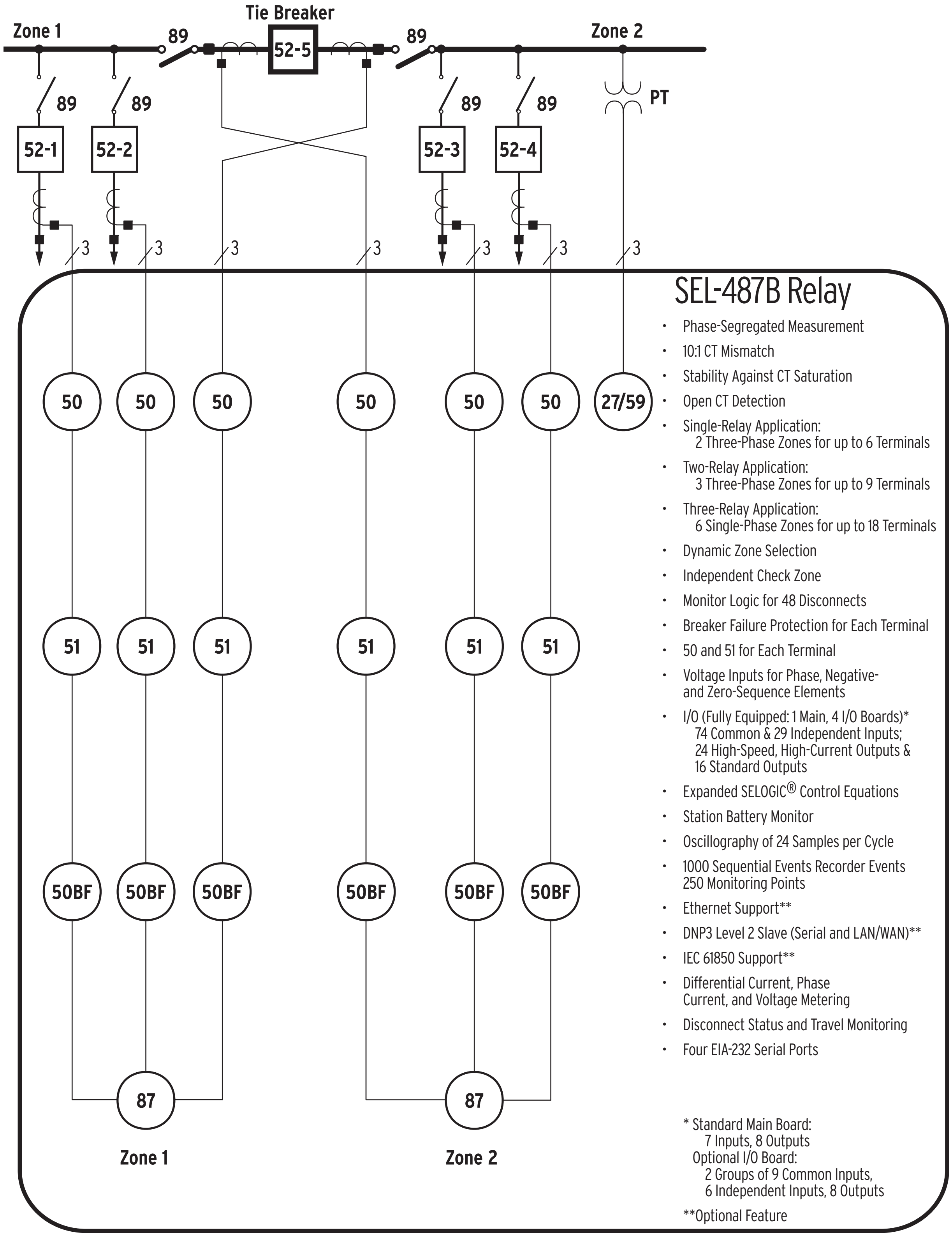


Figure 1.1 SEL-487B Relay Basic Functions in a Double-Bus Application

The SEL-487B features include the following:

Bus Protection. The SEL-487B provides differential protection for the following: single bus, double bus, double bus with transfer, breaker-and-a-half, triple bus arrangements, generators and motors, shunt capacitor banks, autotransformers and reactors.

Second Trip Criterion. Each of the six elements includes a second trip criterion. This criterion consists of the OR combination of a directional element in parallel with a fault detection element.

Check Zone Capability. If your protection philosophy calls for an overall check zone, configure any one of the six zones as a check zone or use the available independent check zone.

Voltage Elements. Phase, negative-, and/or zero-sequence elements are available as additional trip criteria for trip supervision.

Breaker Failure. Select the type of breaker failure protection (internal or external) on a terminal-by-terminal basis. Internal breaker failure protection provides breaker failure trip and breaker retrip for 18 terminals. Open-phase detection ensures current-element reset in less than one cycle. For the external breaker failure protection, select the external breaker failure option. With this option, the relay accepts inputs from breaker failure relays installed in the feeder protection panels.

Differential Protection. Innovative algorithms switch the relay to a high-security mode during through-fault conditions. While in the high-security mode, the algorithm does not block the differential elements, thus avoiding unnecessary time delays for clearing faults evolving from external to internal faults.

Overcurrent Elements. Each of the 18 terminals provides one level of phase instantaneous (50) and one level of time-overcurrent (51) protection.

CT Open-Circuit Detection. Use the independent sensitive differential element in each zone to detect CT open circuit, short circuit, or incorrect CT polarity.

Minimum CT Requirement. The relay requires primary CTs that shall reproduce the primary current without saturation for at least 2 ms after external fault inception.

Dynamic Station Configuration. Wire the disconnect (89) auxiliary contacts to the relay to assign the current inputs dynamically to the correct differential measuring element. Instead of disabling bus protection during disconnect switching, use this feature to provide bus protection during switching operations, when the safety of personnel is at high risk.

CT Ratio Mismatch. Mismatched CTs of ratios as high as 10:1 can be installed. For example, this means you can install the new feeder with a CT ratio of 2000/5 to existing bus systems that all have CT ratios of 200/5.

Expanded SELogic Control Equations. Modify and set custom relay applications with PLC-style (programmable logic controller, IEC 61131-3) SELogic control equation programming that includes math and comparison functions. Use counters and multifunction timers for greater application flexibility, i.e., perform advanced PLC functions within the relay. The SEL-487B has separate protection and automation SELogic control equation programming areas. These programming areas provide ample protection programming capability and 10 blocks of 100-line automation programming capability (1000 lines).

Alias Settings. Use as many as 200 aliases to rename any digital or analog quantity in the relay. The aliases are now available for use in customized programming, making the initial programming and maintenance much easier.

Metering. View metering primary or secondary information for phase currents and angles of all 18 terminals, phase voltages and angles, CT polarities, as well as the operating and restraint values from all protection zones.

Oscillography and Event Reporting. Record raw currents of all 18 current terminals and 3 voltages in a single report. Investigate relay internal logic points and power system performance with event report phasor analysis.

Sequential Events Recorder (SER). Record 1000 system entries from 250 monitoring points, including settings changes, power ups, and Relay Word bit elements that you select. Set element names to easily understood aliases.

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 to send a direct transfer trip, for example).

Ethernet Communications Capability. Implement control and data gathering capabilities via substation LANs (local area networks) and company WANs (wide area networks) with the optional Ethernet card. Employ the FTP protocol for system data acquisition.

Increased Security. The SEL-487B 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 offline.

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

Options and Standard Features

For ease of ordering and future expansion, the SEL-487B is available in a 9U chassis size (U is one rack unit in height—44.45 mm or 1.75 inches) that supports up to four additional expansion I/O boards, or, for applications not requiring as many contact I/O points, in a 7U chassis size that supports up to two additional expansion I/O boards. For the three-relay application, three units are required. Features not labeled as ordering options are standard.

- Up to four optional I/O boards (9U chassis size supports a maximum of four optional I/O boards; 7U chassis size supports a maximum of two optional I/O boards)
  - INT4 with high-speed outputs: 18 common inputs (2 groups of 9), 6 independent inputs, 6 high-speed Form A outputs, 2 standard Form A outputs
  - INT4 with standard outputs: 18 common inputs (2 groups of 9) 6 independent inputs, 8 standard Form A outputs
- Power supply (ordering option)
  - 24/48 Vdc
  - 48/125 Vdc or 120 Vac
  - 125/250 Vdc or 120/230 Vac
- Secondary current inputs (ordering option)
  - 1 A nominal or 5 A nominal CT inputs
- Communications card (ordering option)
  - Ethernet card with combinations of 10 Mbps and 100 Mbps copper and fiber jacks on each of two ports providing FTP, Telnet, DNP3 LAN/WAN, and IEC 61850 protocols
  - Secondary voltage inputs (standard feature)
  - 300 V maximum per voltage input
- Secondary voltage inputs (standard feature)
  - 300 V maximum per voltage input
- Communications protocols (standard features)
  - SEL Compressed ASCII
  - SEL Fast Messaging (SEL Fast Meter, SEL Fast Operate, SEL Fast SER)
  - ASCII
  - Ymodem File Transfer
  - Enhanced MIRRORED BITS
  - DNP3 Level 2 Slave, Serial (ordering option)
  - DNP LAN/WAN (ordering option)
  - IEC 61850 (ordering option)
- Fixed terminal block for PT and CT inputs (standard feature)

Contact the SEL factory or your local Technical Service Center for ordering information (see *Technical Support on page U.6.38*). You can also view the latest ordering information on the SEL website at www.selinc.com.

Applications

Use the SEL-487B for most bus protection applications. For information on connecting the relay, see *Section 2: Installation*. See the *Applications Handbook* for thorough discussions of protection and automation applications using the SEL-487B. The figures in this subsection illustrate common relay applications. Each SEL-487B has 18 analog current inputs (I01 through I18) and three analog voltage inputs (V01, V02, and V03).

Single Busbar–Up to 6 Terminals

Use one SEL-487B for the application in *Figure 1.2*. In this application, the relay has two 3-phase bus-zones available. Wire the disconnect status to the relay to dynamically assign the terminal currents to the differential elements for each zone.

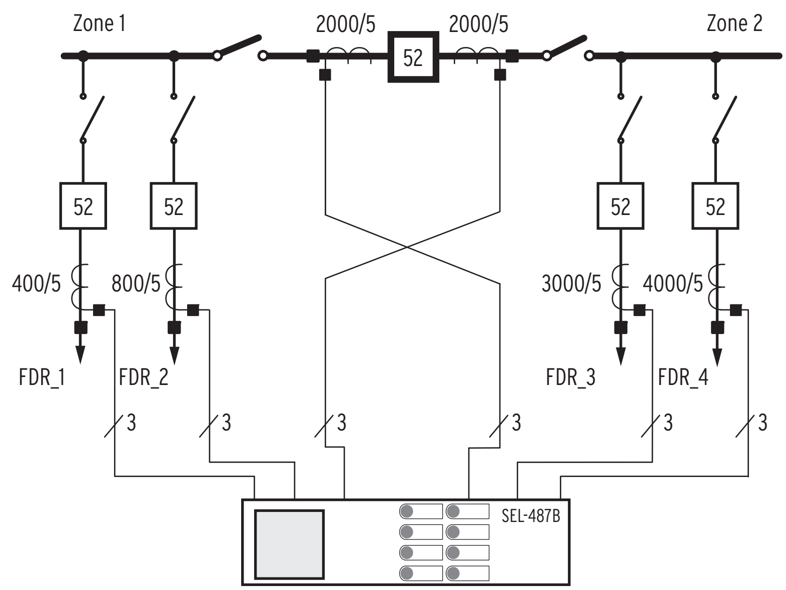


Figure 1.2 Single SEL-487B Protecting Double Bus Sections With Bus Tie Breaker

Breaker-and-a-Half Busbar Configuration

Figure 1.3 shows a station with a breaker-and-a-half busbar configuration. For this configuration, and with six or fewer terminals on either busbar, use one SEL-487B per busbar.

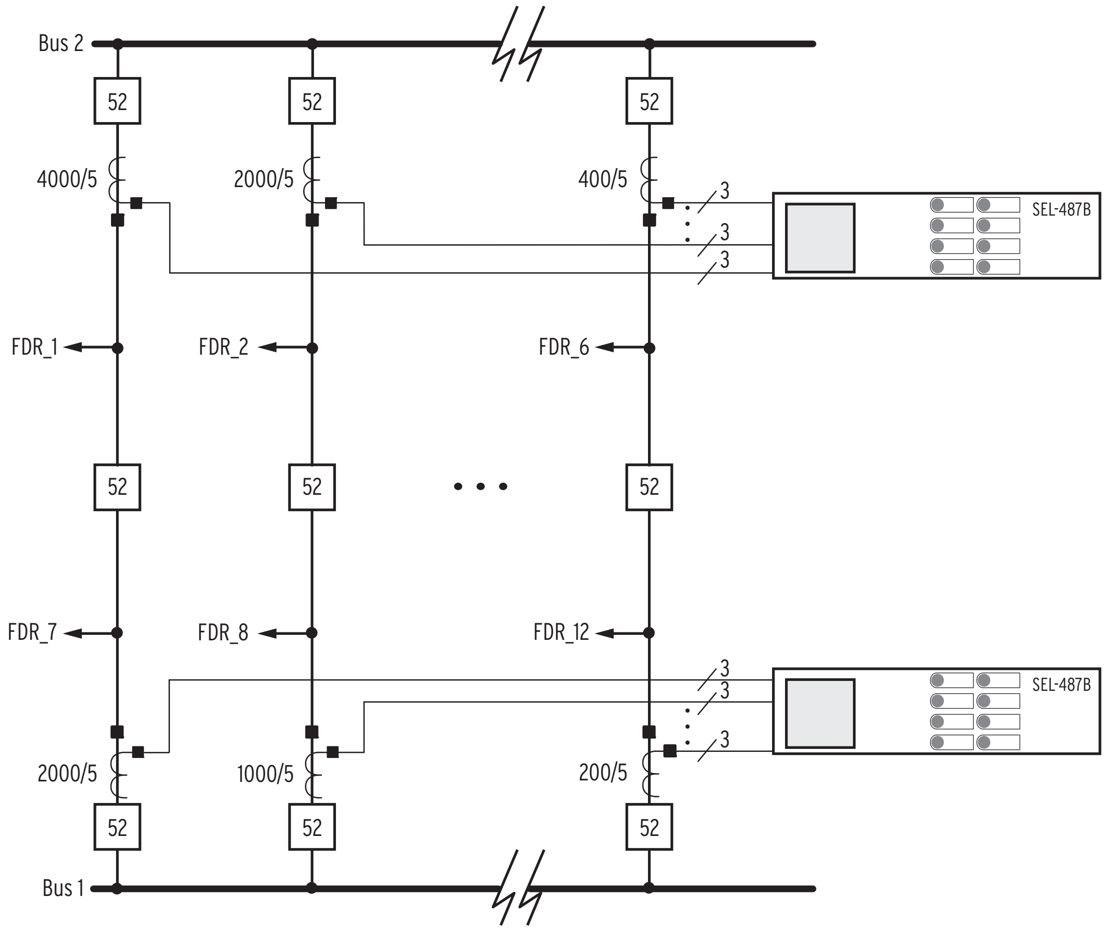


Figure 1.3 Two Single SEL-487B Relays Protecting the Two Busbars in a Breaker-and-a-Half Busbar Configuration

Triple Busbar–Up to 18 Terminals

Figure 1.4 shows a triple busbar layout (i.e., two main busbars and a transfer bus).

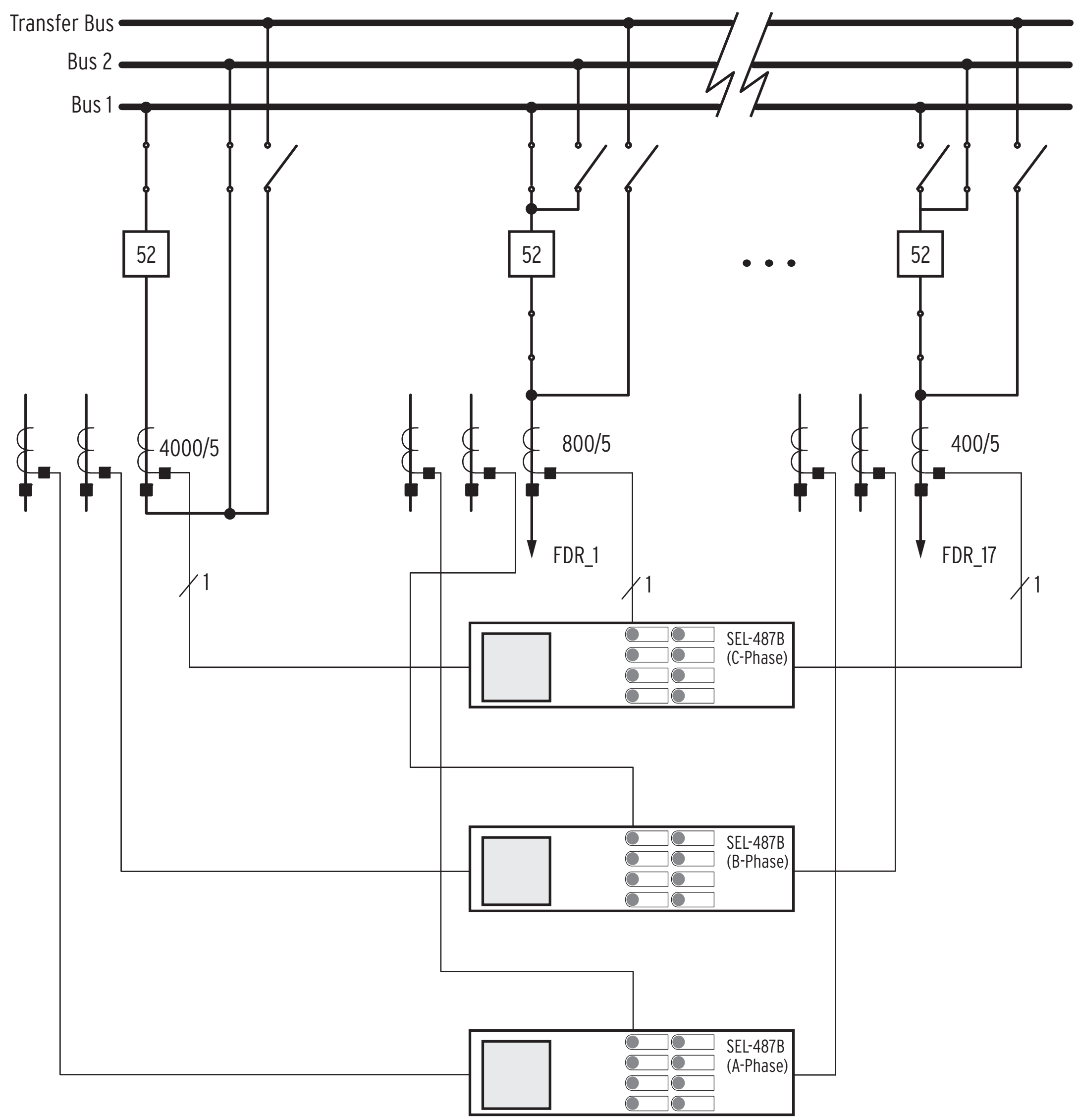


Figure 1.4 Three SEL-487B Relays Protect 2 Main Busbars and a Transfer Busbar, 1 Bus Coupler, and 17 Terminals

Optimize your SEL-487B by protecting both HV and LV busbars with three relays. *Figure 1.5* shows two HV busbars and two LV busbars. Using four zones for the four busbars (two HV and two LV) still leaves two zones available that can be configured as overall check zones, one for the HV and one for the LV busbars.

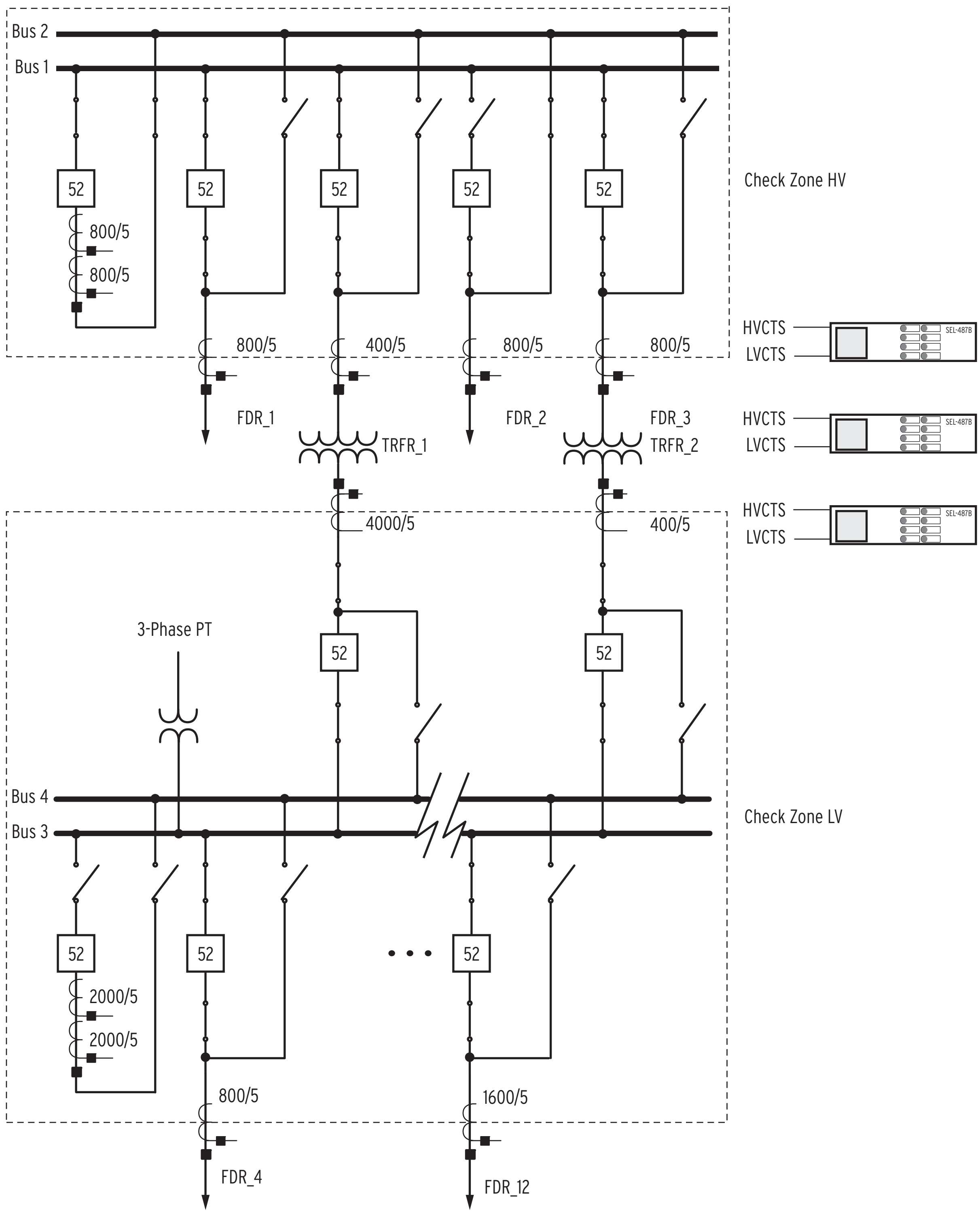


Figure 1.5 Three SEL-487B Relays Protect Both HV and LV Busbars

Table 1.1 Application Highlights

Application	Key Feature
High number of terminals and zones	Three-relay applications provide six zones of protection for as many as 18 terminals.
Complex busbar arrangements	Flexible zone selection logic uses the disconnect auxiliary contacts to dynamically assign the currents to the correct zones.
Wide range of bus applications	A variety of bus applications are available: single bus, double bus, double bus with transfer, breaker-and-a-half, triple bus arrangements.
High-speed tripping	The SEL-487B features fast differential elements and fast closing trip outputs with total clearing times of less than one cycle.
Minimum CT requirements	The differential elements are secure when the CTs reproduce the primary current without saturating for at least 2 ms after external fault inception.
Open CT detection	The open CT detection elements use delta IOP/IRT to reliably detect failed CTs within each differential zone.
Terminals with different CT ratios	The SEL-487B accepts a CT mismatch of 10:1 in any one zone or combination of zones; for example, 250/5 to 2500/5.
Fast resetting internal breaker failure protection	The SEL-487B includes breaker failure protection with retrip for each terminal. Open-phase detection ensures current-element reset in less than one cycle.
External breaker failure relays	Set any terminal to "external breaker failure" to still use the trip logic in the relay, but the breaker failure initiation is from an external breaker failure relay.
Backup overcurrent protection	Each terminal has instantaneous and inverse time-overcurrent elements.
Check zone as trip criterion	Configure any of the six zones as an overall check zone or use the available independent check zone.
Voltage as trip supervision	Choose from phase, negative-, or zero-sequence voltage to supervise the differential elements.
End-zone protection	Use SELOGIC control equations to configure end-zone protection for faults between the feeder circuit breaker and the CT.
Fault between tie breaker and CT	The SEL-487B includes logic to accelerate tripping for a fault between the tie breaker and CT. Further logic ensures the security of the healthy zone when the tie breaker is closed onto a fault.
Direct transfer trip	Use MIRRORED BITS communications to send a trip to the remote end of the line.
Auxiliary relays	The SEL-487B requires no auxiliary relays for zone selection.
SCADA applications analog and digital data acquisition for station-wide functions	The SEL-487B can acquire analog and digital data for station-wide functions.
Communications capability	These protocols are included in the relay: SEL Compressed ASCII, SEL Fast Messaging (SEL Fast Meter, SEL Fast Operate, SEL Fast SER), SEL ASCII, Enhanced MIRRORED BITS® communications, YMODEM File Transfer. Additionally, you can choose these optional protocols: Ethernet, IEC 61850, FTP, Telnet, DNP3 (Serial and/or LAN/WAN).
Customized protection and automation schemes	The SEL-487B includes separate protection and automation SELOGIC control equation programming areas. Use timers and counters in expanded SELOGIC control equations for complete flexibility.

Specifications

Important: Do not use the following specification information to order an SEL-487B. Refer to the actual ordering information sheets.

General

AC Current Inputs (Secondary Circuits)

Note: Current transformers are Measurement Category II.

Continuous Thermal Rating

5 A nominal:	15 A
1 A nominal:	3 A

Saturation Current (Linear) Rating

5 A nominal:	100 A
1 A nominal:	20 A

One-Second Thermal Rating

5 A nominal:	500 A
1 A nominal:	100 A

One-Cycle Thermal Rating

5 A nominal:	1250 A-peak
1 A nominal:	250 A-peak

Burden Rating

5 A nominal:	≤0.5 VA at 5 A 2.51 VA at 15 A
1 A nominal:	≤0.1 VA at 1 A 1.31 VA at 3 A

Minimum A/D Current Limit (peak)

5 A nominal:	247.5 A
1 A nominal:	49.5 A
Sampling Rate:	Analog input signals shall be sampled at a rate of 24 samples per cycle.
Rated Voltage (U_e):	240 Vac
Rated Insulation Voltage (U_i):	300 Vac
Sampling Rate Analog inputs:	24 samples per cycle
Rotation:	ABC, ACB

AC Voltage Inputs

Rated Voltage Range:	0–300 V_{LN}
Ten-Second Thermal Rating:	600 Vac
Burden:	<0.1 VA @ 125 V

Power Supply

125/250 Vdc or 120/240 Vac

Rated Supply Voltage:	120/240 Vac 125/250 Vdc
Absolute Voltage Range:	85–300 Vdc 85–264 Vac
Rated Frequency:	50/60 Hz ± 5 Hz
Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-11:2008
Interruption:	250 ms @ 250 Vdc per IEC 60255-11:2008
Burden:	<35 W

48/125 Vdc or 120 Vac

Rated Supply Voltage:	120 Vac 48/125 Vdc
Absolute Voltage Range:	38–140 Vdc 85–140 Vac
Rated Frequency:	50/60 Hz ± 5 Hz
Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-11:2008
Interruption:	160 ms @ 125 Vdc per IEC 60255-11:2008
Burden:	<35 W

24/48 Vdc

Rated Supply Voltage:	24/48 Vdc
Absolute Voltage Range:	18–60 Vdc
Vdc Input Ripple:	15% per IEC 60255-11:2008
Interruption:	100 ms @ 48 Vdc per IEC 60255-11:2008
Burden:	<25 W

Operating Temperature

SEL-487B Without Ethernet Card:

–40° to +85°C (–40° to +185°F)

SEL-487B With Ethernet Card:

–40° to +75°C (–40° to +167°F)

Note: LCD contrast impaired for temperatures below –20° and above +70°C. Stated temperature ranges not applicable to UL applications.

Humidity

5% to 95% without condensation

Weight (Maximum)

9U Rack Unit:	19.1 kg (42 lbs)
7U Rack Unit:	16.1 kg (35 lbs)

Control Outputs

Main Board:	5 Form A and 3 Form C
Interface Boards:	High-speed contact option: 2 standard Form A 6 high-speed, high-current interrupting Form A Standard Contact Option: 8 standard Form A contacts

Standard

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

Update Rate: 1/12 cycle

Break Capacity (10000 operations):

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

Cyclic Capacity (2.5 cycle/second):

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

High-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: 1/12 cycle

Break Capacity (10000 operations):

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

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

48 V	10.0 A	L/R = 40 ms
125 V	10.0 A	L/R = 40 ms
250 V	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.

Optoisolated Inputs

Main Board: 5 inputs with no shared terminals
2 inputs with shared terminals

INT4 Interface Board: 6 inputs with no shared terminals
18 inputs with shared terminals (2 groups of 9 inputs, with each group sharing one terminal)

Voltage Options: 24 V standard
48, 110, 125, 220, 250 V standard

DC Thresholds

24 Vdc:	Pickup 15.0–30.0 Vdc
48 Vdc:	Pickup 38.4–60.0 Vdc; Dropout below 28.8 Vdc
110 Vdc:	Pickup 88.0–132.0 Vdc; Dropout below 66.0 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout below 75 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout below 132 Vdc
250 Vdc:	Pickup 200–300 Vdc; Dropout below 150 Vdc

AC Thresholds (Ratings met only when recommended control input settings are used—see *Table 2.1 on page 2.9*)

24 Vac:	Pickup 12.3–30.0 Vac
48 Vac:	Pickup 31.4–60.0 Vac; Dropout below 20.3 Vac
110 Vac:	Pickup 71.9–132.0 Vac; Dropout below 46.6 Vac
125 Vac:	Pickup 85.8–150.0 Vac; Dropout below 53.0 Vac
220 Vac:	Pickup 143.8–264 Vac; Dropout below 93.2 Vac
250 Vac:	Pickup 163.3–300 Vac; Dropout below 106 Vac

Current Drawn: 5 mA at nominal voltage
8 mA for 110 V option

Sampling Rate: 24 samples per cycle

Frequency and Rotation

System Frequency: 50/60 Hz

Phase Rotation: ABC or ACB

Communications Ports

EIA-232: 1 Front and 3 Rear

Serial Data Speed: 300–57600 bps

Communications Card Slot for Optional Ethernet Card

Fiber Optic (Optional)

Ordering Options: 100BASE-FX

Mode:	Multi
Wavelength (nm):	1300
Source:	LED
Connector Type:	ST
Min. TX Pwr. (dBm):	–19
Max. TX Pwr. (dBm):	–14
RX Sens. (dBm):	–32
Sys. Gain (dB):	13

IRIG Time Input

Demodulated IRIG-B time code

Nominal Voltage:	5 Vdc + 10%
Maximum Voltage:	8 Vdc
Input Impedance:	333 ohms
Distance Between Relays for Cable With Capacitance of 28 pF/ft:	90 m (300 ft)

IRIG Time Output

Capable of driving 300 ohm termination with <200 ns propagation delay

Terminal Connections

Rear Screw-Terminal Tightening Torque, #8 Ring Lug

Minimum: 1.0 Nm (9 in-lb)

Maximum: 2.0 Nm (18 in-lb)

User terminals and stranded copper wire should have a minimum temperature rating of 105°C. Ring terminals are recommended.

Wire Sizes and Insulation

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes:

Connection Type	Minimum Wire Size	Maximum Wire Size
Grounding (Earthing) Connection	18 AWG ($0.8\ mm^2$)	14 AWG ($2.5\ mm^2$)
Current Connection	16 AWG ($1.5\ mm^2$)	12 AWG ($4\ mm^2$)
Potential (Voltage) Connection	18 AWG ($0.8\ mm^2$)	14 AWG ($2.5\ mm^2$)
Contact I/O	18 AWG ($0.8\ mm^2$)	14 AWG ($2.5\ mm^2$)
Other Connection	18 AWG ($0.8\ mm^2$)	14 AWG ($2.5\ mm^2$)

Type Tests

Electromagnetic Compatibility Emissions

Emissions: IEC 60255-25:2000

Electromagnetic Compatibility Immunity

Conducted RF Immunity: IEC 60255-22-6:2001
Severity Level: 10 Vrms
IEC 61000-4-6:2008
Severity Level: 10 Vrms

Electrostatic Discharge Immunity: IEC 60255-22-2:2008
Severity Level: 2, 4, 6, 8 kV contact: 2, 4, 8, 15 kV air
IEC 61000-4-2:2008
Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air
IEEE C37.90.3-2001
Severity Level: 2, 4, 8 kV contact; 4, 8, 15 kV air

Fast Transient/Burst Immunity: IEC 60255-22-4:2008
Severity Level: Class A: 4 kV, 5 kHz; 2 kV, 5 kHz on communication ports
IEC 61000-4-4:2011
Severity Level: 4 kV, 5 kHz

Magnetic Field Immunity: IEC 61000-4-8:2009
Severity Level: 900 A/m for 3 seconds, 100 A/m for 1 minute
IEC 61000-4-9:2001
Severity Level: 1000 A/m

Power Supply Immunity: IEC 60255-11:2008
IEC 61000-4-11:2004
IEC 61000-4-29:2000

Radiated Digital Radio Telephone RF Immunity: ENV 50204:1995
Severity Level: 10 V/m at 900 MHz and 1.89 GHz

Radiated Radio Frequency Immunity: IEC 60255-22-3:2007
Severity Level: 10 V/m
IEC 61000-4-3:2010
Severity Level: 10 V/m
IEEE C37.90.2-2004
Severity Level: 35 V/m

Surge Immunity: IEC 60255-22-5:2008
Severity Level: 1 kV Line to Line, 2 kV Line to Earth
IEC 61000-4-5:2005
Severity Level: 1 kV Line to Line, 2 kV Line to Earth

Surge Withstand Capability Immunity: IEC 60255-22-1:2007
Severity Level: 2.5 kV peak common mode, 1.0 kV peak differential mode
IEEE C37.90.1-2002
Severity Level: 2.5 kV oscillatory, 4 kV fast transient waveform

Environmental

Cold: IEC 60068-2-1:2007,
Severity Level: 16 hours at –40°C

Damp Heat, Cyclic: IEC 60068-2-30:2005
Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity 95%

Dry Heat: IEC 60068-2-2:2007
Severity Level: 16 hours at +85°C

Vibration: IEC 60255-21-1:1988
Severity Level: Class 1 Endurance, Class 2 Resonse
IEC 60255-21-2:1988
Severity Level: Class 1 – Shock Withstand, Bump, and Class 2 – Shock Response
IEC 60255-21-3:1983
Severity Level: Class 2 (Quake Response)

Safety

Dielectric Strength: IEC 60255-5:2000
Severity Level: 2500 Vac on control inputs, control outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute.
IEEE C37.90-2005
Severity Level: 2500 Vac on control inputs, control outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute.

Impulse: IEC 60255-5:2000
Severity Level: 0.5 Joule, 5 kV
IEEE C37.90-2005
Severity Level: 0.5 Joule, 5 kV

IP Code: IEC 60529:2001 + CRGD:2003
Severity Level: IP30

Safety Agency Certifications

Product Safety: C22.2 No 14
cUL Listed Protective Relay, Product Category NRGU7
UL 508
UL Listed Protective Relay, Product Category NRGU

Certifications

ISO 9001: This product was designed and manufactured under an ISO 9001 certified quality management system.

Event Reports

Maximum Duration: 16 events at 30 cycles,
32 events at 15 cycles,
8 events at 60 cycles,
or 4 events at 120 cycles

Resolution: 4-, 12-, and 24-samples/cycle

Event Summary

Storage: 100 summaries

Sequential Events Recorder

Sequential Events Recorder Storage:	1000 entries
Trigger Elements:	250 monitoring points
Processing Rate:	24 samples per cycle

Processing Specifications

AC Voltage and Current Inputs

24 samples per cycle, 3 dB low-pass analog filter cut-off frequency of 646 Hz, ±5%

Digital Filtering

Full-cycle cosine after low-pass analog filtering

Protection and Control Processing

12 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

Differential Elements

Number of Zones:	6
Number of Terminals:	
Three-relay Application:	18
Single-Relay Application:	6
Slope 1	
Setting Range:	15–90%
Accuracy:	±5% ±0.02 • I_{NOM}
Slope 2	
Setting Range:	50–90%
Accuracy:	±5% ±0.02 • I_{NOM}

Supervising Differential Element

Quantity:	6
Setting range:	0.10–4.00 pu
Accuracy:	±5% ±0.02 • I_{NOM}

Incremental Restraint and Operating Threshold Current Supervision

Setting range:	0.1–10.0 pu
Accuracy:	±5% ±0.02 • I_{NOM}

Sensitive Differential Current Alarm

Quantity:	6
Setting range:	0.05–1.00 pu
Accuracy:	±5% ±0.02 • I_{NOM}
Timer Setting Range:	50–6000 cycles

Instantaneous/Definite-Time Overcurrent Elements

Phase Current Setting 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, ±3% of setting
1 A Model:	±0.01 A, ±3% of setting
Transient Overreach:	<5% of setting
Timer Setting Range:	0.00–99999.00 cycles, 1/6-cycle steps
Timer Accuracy:	±0.1% of settings ±1/6 cycle
Max. Operating Time:	1.5 cycles

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, ±3% of setting
1 A Model:	±0.01 A, ±3% of setting
Time Dial Range:	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Curve Timing Accuracy:	±1.50 cycles, ±4% of curve time (for current between 2 and 30 multiples of pickup)
Reset:	1 power cycle or Electromechanical Reset Emulation time

Under/Overvoltage Elements (27, 59)

Processing Rate:	1/12 cycle
Phase Under/Overvoltage (2 Level/Phase)	
Setting Range:	1.0–200 V_{LN} in 0.1 steps
Accuracy:	±5% of setting, ±0.5 V
Transient Overreach:	<5% of pickup
Maximum Delay:	1.5 cycles
Zero- and Negative-Sequence Overvoltage Elements	
Setting Range:	1.0–200 V in 0.1 steps
Accuracy:	±5% of setting, ±1 V
Transient Overreach:	<5% of setting
Maximum Delay:	1.5 cycles

Breaker Failure Instantaneous Overcurrent

Setting Range:	
5 A Model:	0.50–50 A, 0.01 A steps
1 A Model:	0.10–10.0 A, 0.01 A steps
Accuracy:	
5 A Model:	±0.05 A, ±3% of setting
1 A Model:	±0.01 A, ±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, 1/12-cycle steps (BFPU*nn*, RTPU*nn*) 0–1000 cycles, 1/12-cycle steps (BFISP*nn*, BFIDO*nn*)
Time Delay Accuracy:	1/12 cycle, ±0.1% of setting

Disconnect Monitor

Number:	48
Timer Setting Range:	0–99999 cycles, 1 cycle step

Breaker Status Monitor

Number:	18

Coupler Security Logic

Number:	4
Timer Setting Range:	0–1000 cycles, 1/12 cycle step

Control Input Timers

Setting Range:	
Pickup:	0.00–1 cycle
Dropout:	0.00–1 cycle

Station DC Battery System Monitor Specifications

Operating Range:	0–350 Vdc
Input Sampling Rate:	24 samples per cycle
Processing Rate:	1/6 cycle
Maximum Operating Time:	≤ 1.5 seconds (element DC1R) ≤1.5 cycles (all elements but DC1R)
Setting Range:	
DC Settings:	OFF, 15–300 Vdc, 1 Vdc steps
AC Ripple Setting:	1–300 Vac, 1 Vac steps
Pickup Accuracy:	±10%, ±2 Vdc (DC1RP), ±3%, ±2 Vdc (all elements but DC1RP)

Metering Accuracy

All metering accuracies are based on an ambient temperature of 20°C and nominal frequency.

Instantaneous Differential Metering per Zone (Steady State)

IOP, IRT:	±3.0%, ±0.02 • I_{NOM}

Per-Phase Instantaneous Metering (Steady State)

V01, V02, and V03:	> 30 V ±1%
I01, I02, . . ., I18:	±1.5% ±0.004 • I_{NOM}, ±2.0°

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Section 2
Installation

Overview

The first steps in applying the SEL-487B Relay are installing and connecting the relay. This section describes common installation features and particular installation requirements for the physical configurations of the SEL-487B. You can order the relay in panel-mount or rack-mount versions, in a 9U horizontal orientation, with up to four interface boards, or in a 7U version, with up to two interface boards. To install and connect the relay safely and effectively, you must be familiar with relay configuration features, options, and relay jumper configuration. You should plan relay placement, cable connection, and relay communication carefully.

Consider the following when installing the SEL-487B:

- Shared configuration attributes
  - Relay size
  - Front-panel templates
  - Rear panels
  - Connector types
  - Secondary circuits
  - Control inputs
  - Control outputs
  - Main board I/O
  - Time inputs
  - Battery-backed clock
  - Communications interfaces
- Plug-in boards
  - I/O interface board(s) (if applicable)
  - Communications card (if applicable)
- Jumpers
  - Main board jumpers
  - Password and circuit breaker jumpers
  - I/O interface board jumpers
- Front-panel labels
  - Removing and changing configurable front-panel labels
  - Creating laser-printed labels

- Relay placement
  - Physical location
  - Rack mounting
  - Panel mounting
- Connection
  - Rear-panel layout
  - Rear-panel symbols
  - Screw terminal connectors
  - Grounding
  - Power connections
  - Monitor connections (dc battery)
  - Secondary circuit connections
  - Control circuit connections
  - Time input connections
  - Replacing the lithium battery
  - Communications ports connections
- AC/DC connection diagrams

This section contains drawings of typical ac and dc connections to the SEL-487B (*AC/DC Connection Diagrams on page U.2.38*). Use these drawings as a starting point for planning your particular relay application. It is also very important to limit access to the SEL-487B settings and control functions by using passwords. For information on relay access levels and passwords, see *Section 7: ASCII Command Reference in the Reference Manual*.

Shared Configuration Attributes

There are common or shared attributes among the many possible configurations of the SEL-487B. This section discusses the main shared features of the relay.

Relay Size

SEL produces the SEL-487B in a 9U panel-mount or rack-mount version, horizontal orientation, or in a 7U panel-mount or rack-mount version. The 9U version is capable of supporting up to a maximum of four optional I/O boards, and the 7U version is capable of supporting up to a maximum of two optional I/O boards.

Front-Panel Templates

The front-panel template is shown in *Figure 2.1*. The SEL-487B 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* and *Figure 2.2* show the front-panel pocket areas and openings; dashed lines denote the pocket areas.

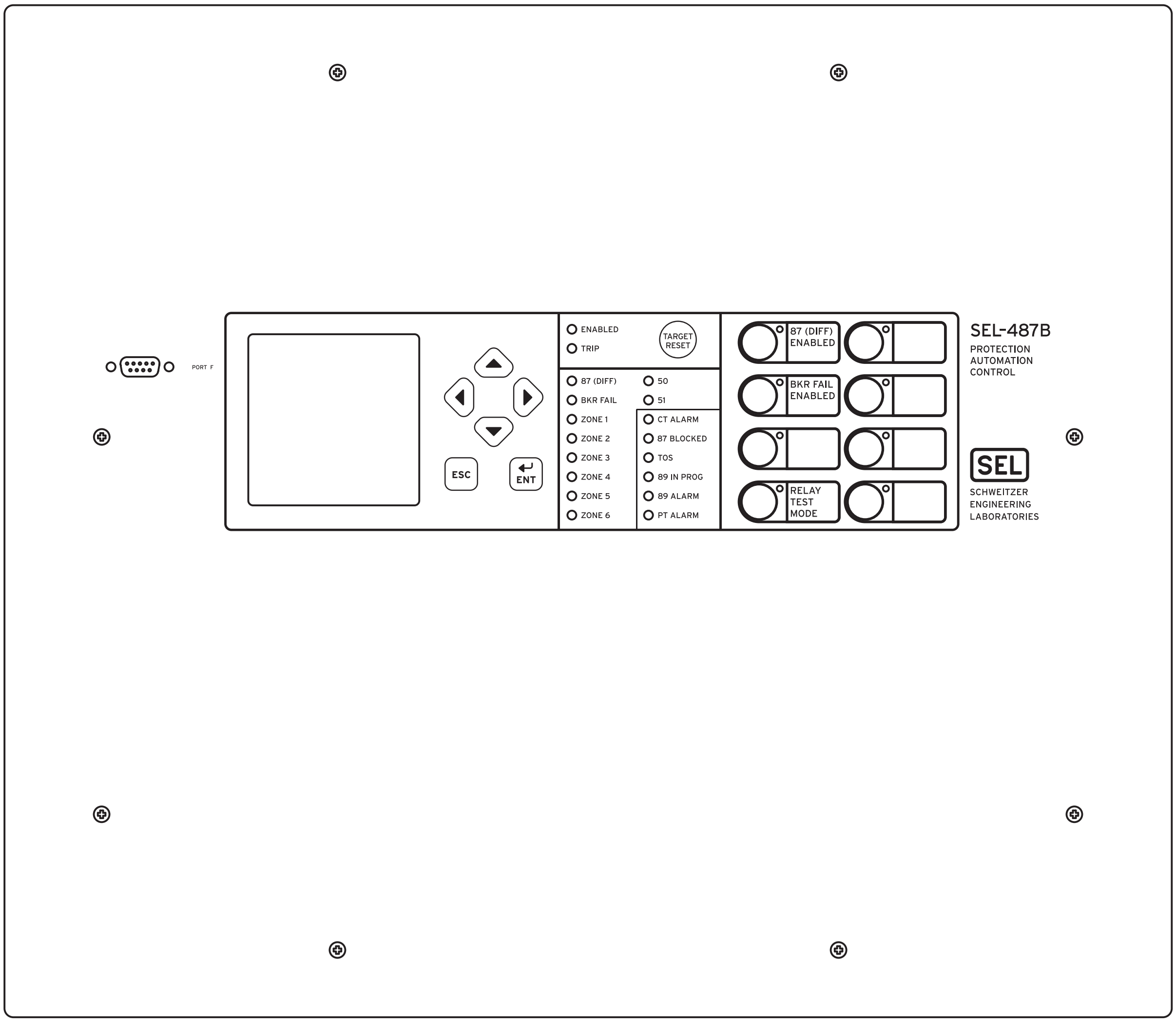


Figure 2.1 Front-Panel Diagram, Panel-Mount Option, 9U Version, Showing the Front Panel With LCD, Navigation Pushbuttons, Programmable LEDs, Reset, and Programmable Pushbuttons

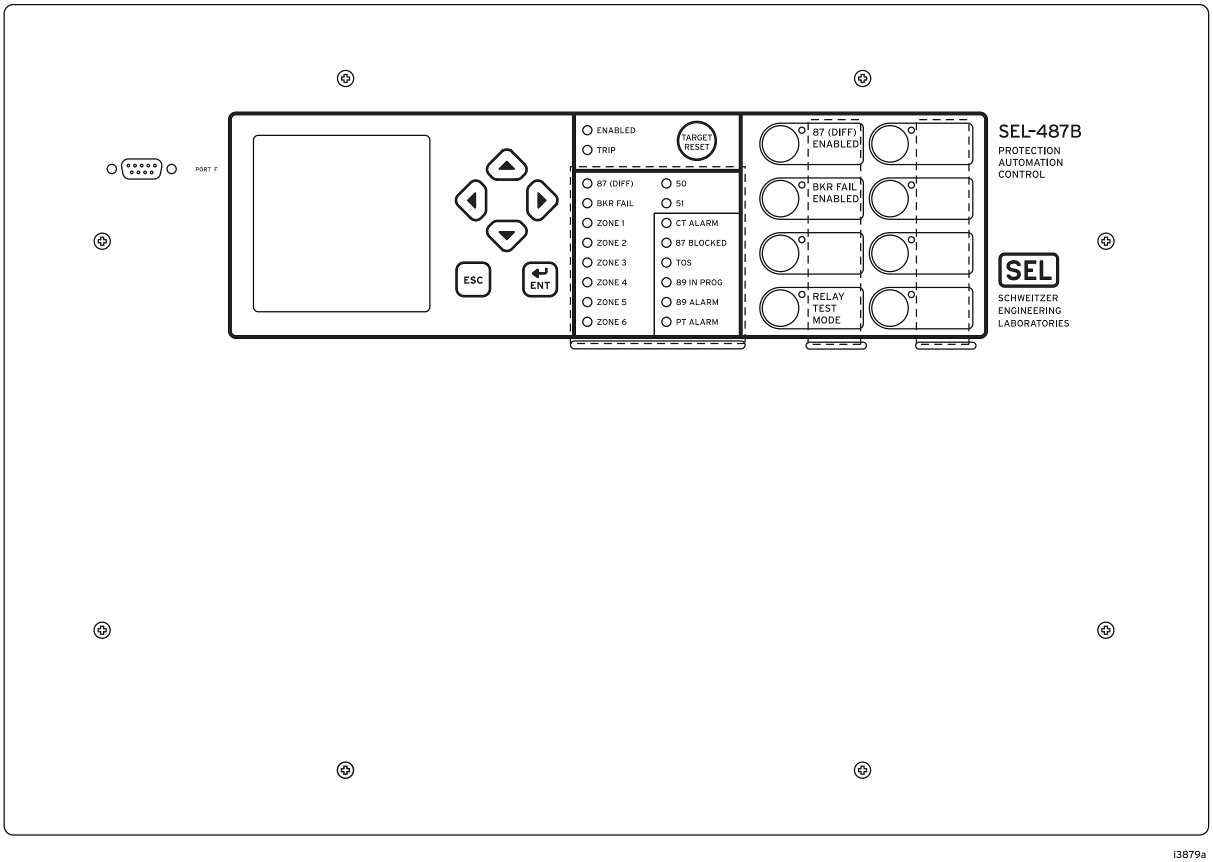


Figure 2.2 Front-Panel Diagram, Panel-Mount Option, 7U Version, Showing the Front Panel With LCD, Navigation Pushbuttons, Programmable LEDs, Reset, and Programmable Pushbuttons

Rear Panels

Figure 2.3 and *Figure 2.4* show examples of a rear panel with fixed terminal block analog inputs. Note that Connectorized® analog inputs are not available.

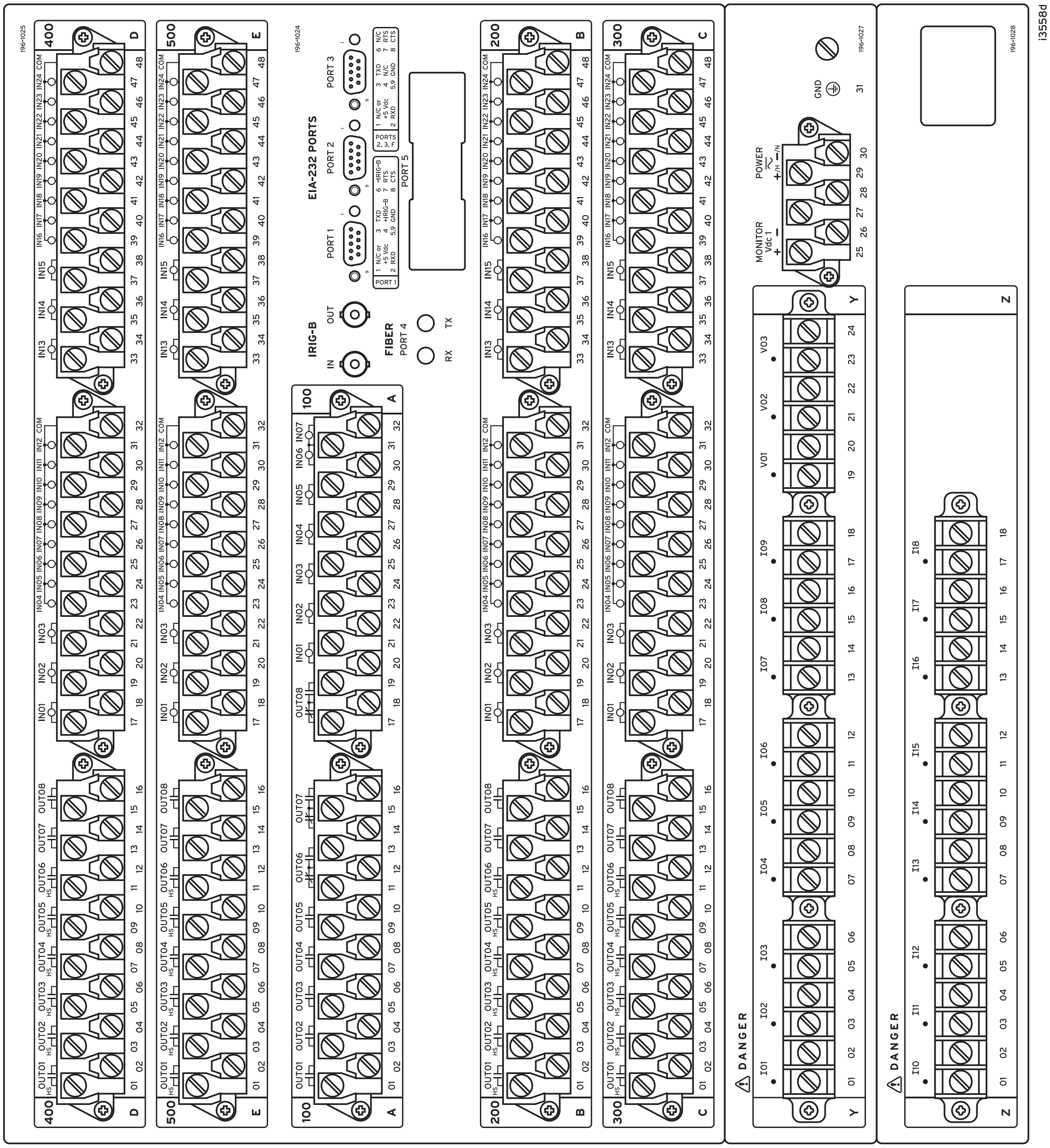


Figure 2.3 Rear-Panel Diagram of SEL-487B With Four Interface Boards (9U Version)

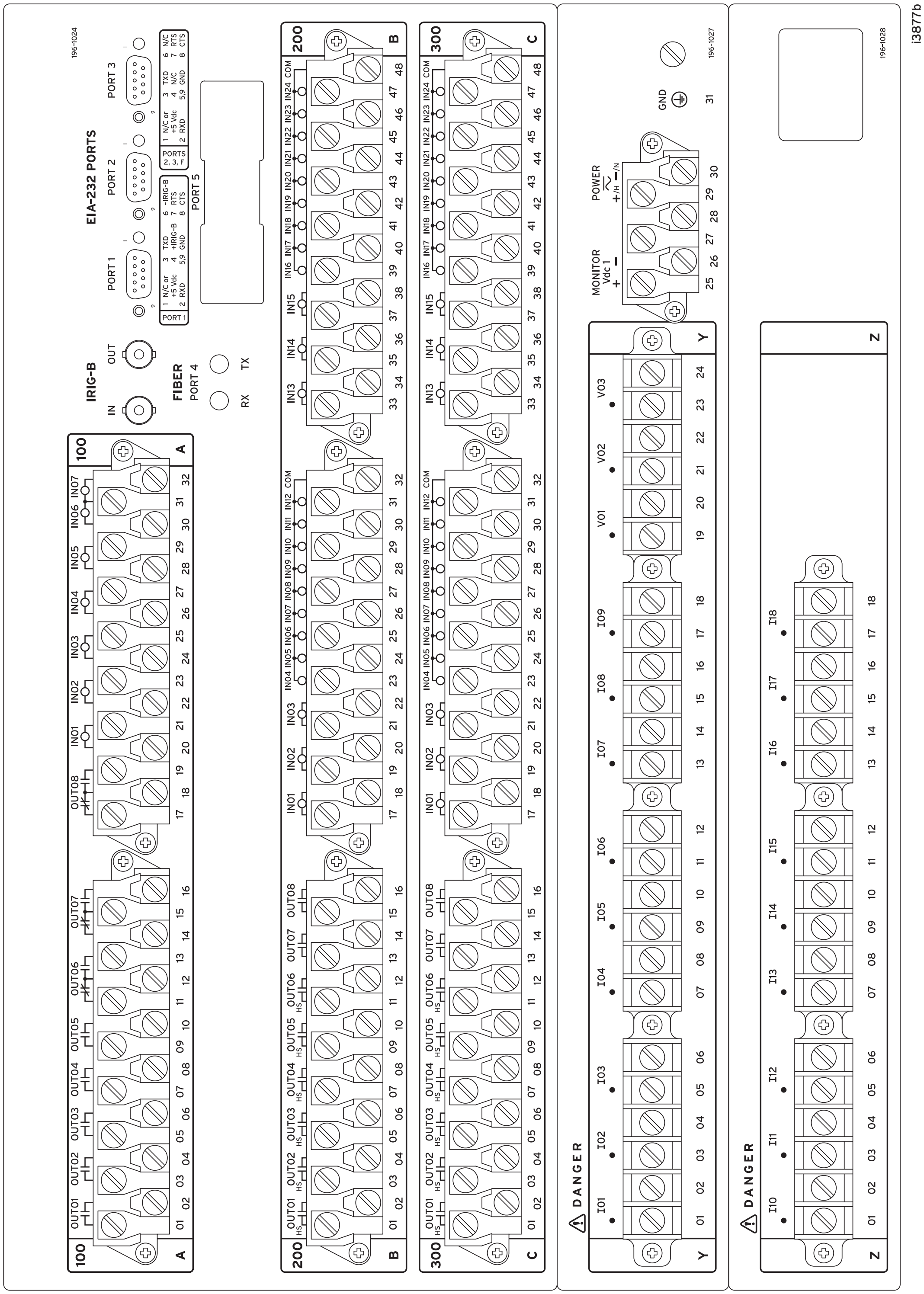


Figure 2.4 Rear-Panel Diagram of SEL-487B With Two Interface Boards (7U Version)

Connector Types

Screw Terminal Connectors–I/O and Battery Monitor/Power

Connection to the relay I/O and Battery Monitor/Power terminals on the rear panel is 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 2.18*), so you can replace the screw terminal connector on the rear panel only where 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 two rows 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.

Secondary Circuits

The SEL-487B presents a low burden to the CT and PT secondaries (see *Specifications on page U.1.11*). The relay accepts 18 analog current inputs from the power system. CT inputs are labeled as follows: I01, I02, through I18. Because the relay impedance is low, the current elements can be wired in series with current elements from other relays. *Figure 2.5* shows the CT connections of the A-phase unit in a three-relay application. Current Input IA01 enters the relay at Terminal Y01 and leaves the relay at Terminal Y02 for input to other relays.

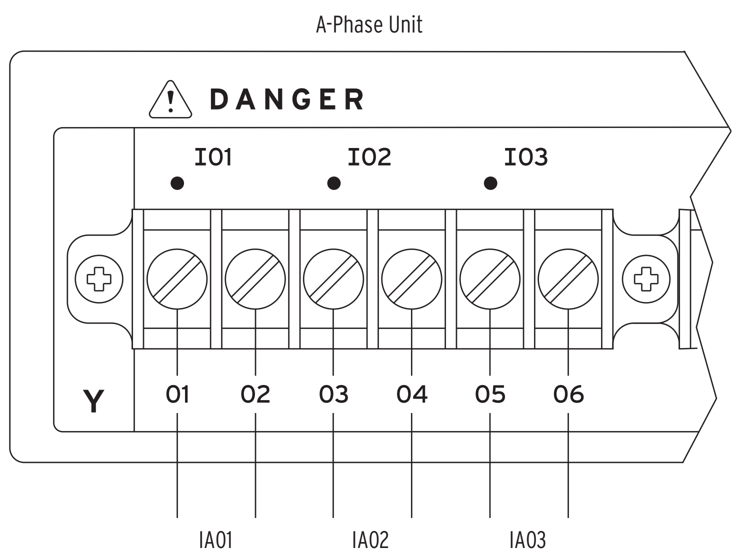


Figure 2.5 CT Connections for a Three-Relay Application

Figure 2.6 shows the CT connections if the SEL-487B is the last relay in the CT circuit. For a single-relay application, Current Input IA enters the relay at Terminal Y01, Input IB at Terminal Y03, and Input IC at Terminal Y05. Form the wye or star point by connecting Terminals Y02, Y04, and Y06 together and include the return wire to the CT on any one of these three terminals.

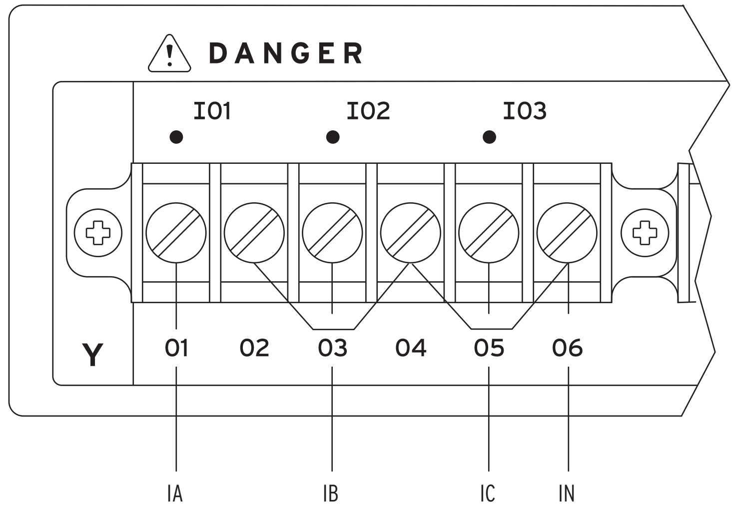


Figure 2.6 CT Connections for a Single-Relay Application When the SEL-487B Is the Last in the CT Circuit

Figure 2.7 shows the CT connections for a single-relay application when other devices are connected downstream of the SEL-487B. Current Input IA enters the relay at Terminal Y01 and leaves the relay at Terminal Y02 for input to other devices. B-phase and C-phase are wired similarly.

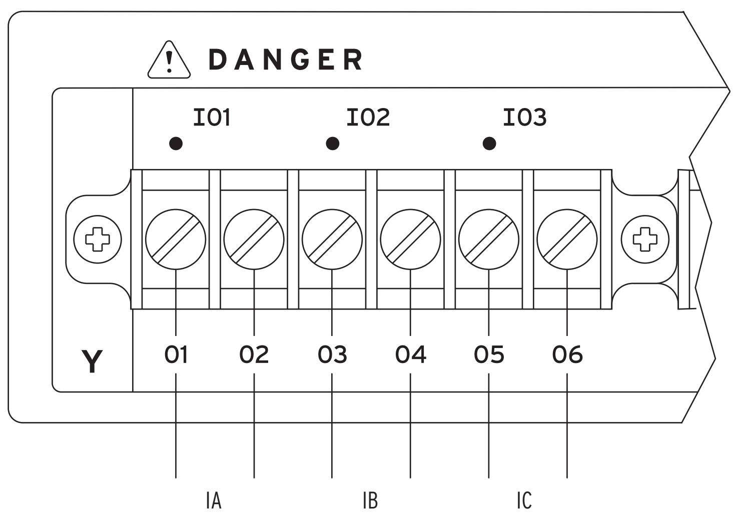


Figure 2.7 CT Connections for a Single-Relay Application When the SEL-487B Is in Series With Other Relays

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. Continuous input current for both relay types is 3 • I_{NOM}.

The relay also accepts one set of three-phase, six-wire potentials from power system PT secondaries at inputs V01, V02, and V03. The nominal line-to-neutral input voltage for the PT inputs is 67 volts with a maximum voltage rating of 300 volts. The PT inputs and elements are independent of each other for both the single-relay or three-relay applications.

Control Inputs

Inputs into the relay are high-impedance control inputs. Use these inputs for monitoring change-of-state conditions of power system equipment. These high-isolation control inputs are ground-isolated circuits and are not polarity sensitive, i.e., you cannot damage these inputs with a reverse polarity connection. For more information on control input specifications, see *Specifications on page U.1.11*. Inputs can be independent or common. Independent inputs have two separate ground-isolated connections, with no internal connections among inputs. Common inputs share one input leg in common; all input legs of common inputs are ground isolated. Each group of common inputs is isolated from all other groups. Nominal current drawn by these inputs is 8 mA or less with 6 voltage options covering a wide range of voltages, as published in the *Specifications*. You can debounce the control input pickup delay and dropout delay separately for each input as a global setting that applies to all the inputs.

AC Control Signals

Optoisolated control inputs can be used with ac control signals, within the ratings shown in *Optoisolated Inputs on page U.1.12*. Specific pickup and dropout time-delay settings are required to achieve the specified ac thresholds, as shown in *Table 2.1*.

NOTE: Only the Optoisolated Control Inputs on the INT4 I/O interface board can be used to detect ac control signals. Direct-coupled control inputs can only be used with dc control signals.

It is possible to mix ac and dc control signal detection on the same INT4 I/O interface board, provided that the two signal types are not present on the same set of combined inputs. Use standard debounce time settings (usually the same value in both the pickup and dropout settings) for the inputs being used with dc control voltages.

Table 2.1 Required Settings for Use With AC Control Signals[a]

Global Settings	Description	Entry[b]	Relay Recognition Time for AC Control Signal State Change
IN201PU–IN224PU, IN301PU–IN324PU, IN401PU–IN424PU, IN501PU–IN524PU	Pickup Delay	0.1250 cycles	0.625 cycles maximum (assertion)
IN201DO–IN224DO, IN301DO–IN324DO, IN401DO–IN424DO, IN501DO–IN524DO	Dropout Delay	1.0000 cycle	1.1875 cycles maximum (deassertion)

[a] First set Global setting EICIS := Y to gain access to the individual input pickup and dropout timer settings (only available for installed INT4 I/O interface boards).
[b] These are the only setting values that SEL recommends for detecting ac control signals. Other values may result in inconsistent operation.

The recognition times listed in *Table 2.1* are only valid when:

- ➤ The ac signal applied is at the same frequency as the power system.
- ➤ The signal is within the ac threshold pickup ranges defined in *Optoisolated Inputs on page U.1.12*.
- ➤ The signal contains no dc offset.

The SEL-487B samples the optoisolated inputs 24 times per cycle.

Control Outputs

Control outputs from the relay include standard outputs and high-speed (high-current interrupting) outputs. 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 12 times per cycle. Updating of relay control outputs does not occur when the relay is disabled. When the relay is re-enabled, 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. 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 2.8* shows a representative connection for a Form A Standard control output on the main board I/O terminals.

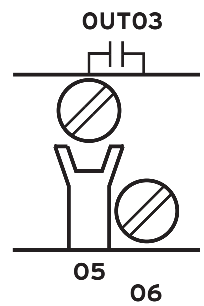


Figure 2.8 Standard Control Output Connection

See *Control Outputs on page U.1.11* for complete standard control output specifications.

High-Speed, High-Current Interrupting Control Outputs

Available only on the interface boards, high-speed, high-current interrupting control outputs are not polarity dependent and are capable of interrupting high-current, inductive loads. High-speed 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 high-speed 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 also fully increases. 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 8 ms with a resistive load. The other ratings of these control outputs are similar to the standard control outputs, except that the high-speed outputs can break current as great as 10 A. High-speed contact outputs have a maximum voltage rating of 250 Vac/330 Vdc. The maximum pickup time for the high-speed control outputs is 10 µs with resistive load. *Figure 2.9* shows a representative connection for a Form A high-speed control output on the interface board I/O terminals. High-speed contacts are marked HS (High Speed) to distinguish them from the standard contacts.

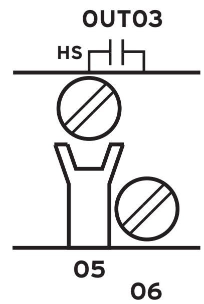


Figure 2.9 High-Speed Control Output Connection

See *Specifications on page U.1.11* for complete high-speed control output specifications.

Main Board I/O

The SEL-487B has 9U and 7U chassis options with I/O interface on the main board. See *Figure 2.3* and *Figure 2.15* for representative views of the 9U chassis rear panel and *Figure 2.4* and *Figure 2.16* for representative views of the 7U chassis rear panel.

Every SEL-487B configuration includes the main board I/O and features these connections:

- Five Standard Form A outputs
- Three Standard Form C outputs
- Seven high-isolation control inputs
(five independent and two common)

Time Inputs

The SEL-487B has two high-accuracy time-keeping IRIG-B connections, one for receiving the signal and one for providing the signal to other relays. With this capability, the user can synchronize event reports from the three relays to within 10 µs of each other. Any one of the three units can be the reference relay; by connecting the IRIG-B signal to the IRIG-B terminal labeled IN, the relay becomes the reference relay. Connect the IRIG-B terminal labeled OUT from the reference relay to the IRIG-B terminal labeled IN of the next relay, and so on. If there is no IRIG-B available, the relays generate the synchronizing signal internally to synchronize the three relays relative to each other, although not to an absolute time reference. You can provide IRIG-B time code format signals to the relay from many sources (SEL-2030 Communications Processor, for instance). See *Section 3: Analyzing Data in the Applications Handbook* and *Configuring Timekeeping on page U.4.49* 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. See *TIME Input Connections on page U.2.34* for information on enabling IRIG-B 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, 77°F), the battery will operate for approximately 10 years at rated load. When the SEL-487B 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. The battery cannot be recharged. *Figure 2.11* 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 U.2.35*.

Communications Interfaces

The SEL-487B 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 3: Communications Interfaces in the Reference Manual* for more information and options for connecting your relay to the communications interfaces.

An optional communications card provides Ethernet capability for the SEL-487B. A communications card gives the relay access to popular Ethernet networking standards including TCP/IP, FTP, Telnet, DNP3, and IEC 61850 over local area and wide area networks. The Ethernet card with IEC 61850 support is only available at purchase as a factory-installed option. For information on DNP3 applications, see *Section 5: DNP3 Communications in the Reference Manual*. For more information on IEC 61850 applications, see *Section 6: IEC 61850 Communications in the Reference Manual*.

Other Shared Configuration Attributes

Each SEL-487B also features a battery monitor connection and ground detection. See *Connection on page U.2.24* for information on these relay interface features.

Plug-In Boards

The SEL-487B supports up to four interface boards. There are ordering options for the number of I/O boards, as well as the overall chassis size. A 9U chassis ordering option provides support for up to four additional interface boards. A 7U chassis option provides support for up to two additional interface boards. Both chassis sizes are available in rack- or panel-mount versions.

Plug-in communications cards are also available for the SEL-487B. The optional Ethernet card allows you to use TCP/IP, FTP, Telnet, DNP LAN/WAN, and IEC 61850 applications on an Ethernet network. This card is only available at the time of purchase of a new SEL-487B as a factory-installed option or as a factory-installed conversion to an existing relay.

I/O Interface Boards

When the 9U chassis size is ordered, you can choose up to four INT4 interface boards for a total of 96 inputs and 32 outputs (all four boards installed). When the 7U chassis size is ordered, you can choose up to two INT4 interface boards for a total of 48 inputs and 16 outputs (both boards installed). In addition to the inputs and outputs provided by the INT4 interface boards, there are also 7 inputs and 8 outputs on the main board (described in *Shared Configuration Attributes on page U.2.2*). Refer to *Figure 2.3* for a view of the interface boards and the rear screw terminal connectors associated with the interface boards.

The I/O interface boards carry jumpers that identify the board location. See *Jumpers on page U.2.16* for more information on I/O board jumpers.

I/O Interface Board Inputs

The INT4 I/O interface board has two groups of nine (9) common contacts (18 total) and six (6) independent control inputs. All independent inputs are isolated from other inputs. These high-isolation control inputs are not polarity sensitive, i.e., you cannot damage these inputs with a reverse polarity connection.

Table 2.2 shows the I/O board input capacities and the I/O inputs on the main board. See *Optoisolated Inputs on page U.1.12* for complete control input specifications.

Table 2.2 I/O Interface Board Control Inputs

Board	Independent Contact Pairs	Common Contact Pairs
INT4	6	Two sets of 9
Main	5	2

I/O Interface Board Outputs

The INT4 I/O interface board is available with either six (6) high-speed and two (2) standard output contacts, or 8 standard contact outputs. *Table 2.3* shows the I/O board outputs; the table also shows the I/O outputs on the main board. See *Control Outputs on page U.1.11* for complete control output specifications.

Table 2.3 I/O Interface Boards Control Outputs

Board	Standard		High-Speed
	Form A	Form C	Form A
INT4 with high-speed outputs	2	0	6
INT4 with standard outputs	8	0	0
Main	5	3	0

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.

When expanding the capability of the SEL-487B with additional I/O interface boards, perform the following steps:

Step 1. Remove the relay from service.

a. Follow your company's standard for removing a relay from service.

b. Disconnect power from the SEL-487B.

c. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-487B.

Step 3. Disconnect the front-panel cable from the front panel.

Step 4. Disconnect all cables from the main board and I/O interface boards.

Step 5. Confirm proper installation of address jumpers on the interface board; see *Jumpers on page U.2.16*.

⚠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 6. Confirm the correct drawout tray keying before installing the additional interface board.

The relay chassis and the drawout trays for the 200, 300, 400, and 500-addresses slots are keyed (see *Figure 2.10*). The keys are two round plug-in/plug-out discs on the bottom of the drawout tray. The 200-address slot keys go to the left, the 300-address slot keys second to the left, 400-address next, 500-address to the right (when viewed from the top and front of the drawout tray).

Step 7. If the drawout tray keying does not match the tray keying of the target position, move a key on the bottom of the drawout tray to the correct position. (Refer to *Figure 2.10*.)

a. Pry the key from the tray.

b. Reinsert the key in the proper position.

Repeat this step for the second key.

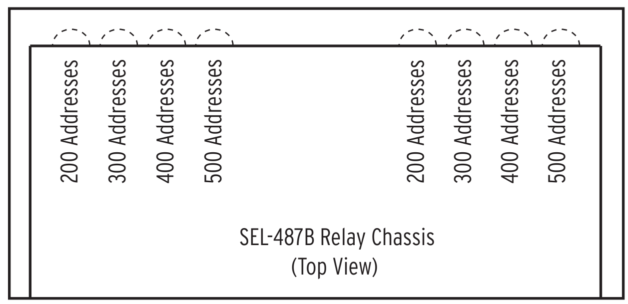


Figure 2.10 Chassis Key Positions for I/O Interface Boards

Step 8. Install the I/O interface board:

a. Position the I/O board edges into the left-side and right-side internally mounted slots.

b. Slide the I/O interface board into the SEL-487B by pushing the front edge of the board drawout tray.

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

Step 9. If this is a new I/O interface board installation, remove the INTERFACE BOARD EXPANSION SLOT self-sticking label from the rear panel by lifting a corner of the label and peeling away the label from the rear panel.

Step 10. Inspect the screw terminal connector receptacles on the rear of the I/O interface board.

Refer to *Figure 2.19* for the corresponding key positions inside the receptacle.

SEL supplies three new screw terminal connectors with new I/O interface boards.

If the keys inside the I/O interface board receptacles are not in the positions shown in *Figure 2.19*:

a. Grasp the key edge with long-nosed pliers to remove the key.

b. Reinsert the key in the correct position.

c. With long-nose pliers, remove the webs of the screw terminal connectors in the positions that match the receptacle key (see *Figure 2.18*).

Step 11. Attach the screw terminal connector.

a. Mount the screw terminal connectors to the rear panel of the SEL-487B.

Refer to *Figure 2.3* for screw terminal connector placement.

b. Tighten the screw terminal connector mounting screws to between 0.9 Nm and 1.4 Nm (8 in-lb and 12 in-lb).

Step 12. Connect the internal interface cable(s) from the I/O board(s) and front-panel cable to the main board.

Step 13. Reconnect the internal power and analog cables.

Step 14. Reconnect front-panel cable to the front panel.

Step 15. Reattach the front panel.

Step 16. Apply power.

Step 17. Enter Access Level 2 (*Making Simple Settings Changes on page U.4.12*).

Step 18. Issue the **STA** command and answer **Y <Enter>** to accept the new hardware configuration (see *STATUS on page R.7.40*).

Step 19. 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 ACSELERATOR QuickSet® SEL-5030 software program, or the front panel.

Step 20. Use a communications terminal to issue one of the following commands.

- ➢ **TAR OUT201 <Enter>** (for the 200-addresses slot)
- ➢ **TAR OUT301 <Enter>** (for the 300-addresses slot)
- ➢ **TAR OUT401 <Enter>** (for the 400-addresses slot)
- ➢ **TAR OUT501 <Enter>** (for the 500-addresses slot)

Step 21. Alternatively, from the front-panel MAIN MENU, select RELAY ELEMENTS, SEARCH.

a. Type **OUT <Enter>**.

b. Use the **{Down Arrow}** pushbutton to confirm that the Relay Word bits from the new interface board are present and available for you to use.

Step 22. Follow your company's standard procedure to return the relay to service.

Communications Card

You can add other communications protocols to the SEL-487B by purchasing the Ethernet card option. Factory-installed in the rear relay **Port 5**, the Ethernet card provides Ethernet ports for industrial applications that processes data traffic between the SEL-487B and a LAN (local area network).

Jumpers

The SEL-487B contains jumpers that configure the relay for certain operating modes. The jumpers are located on the main board and on each of the I/O interface boards.

Main Board Jumpers

The jumpers on the main board of the SEL-487B perform the following functions:

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

Figure 2.11 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-487B 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.

⚠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 2.12* 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 2.4* lists the J18 jumper positions and functions.

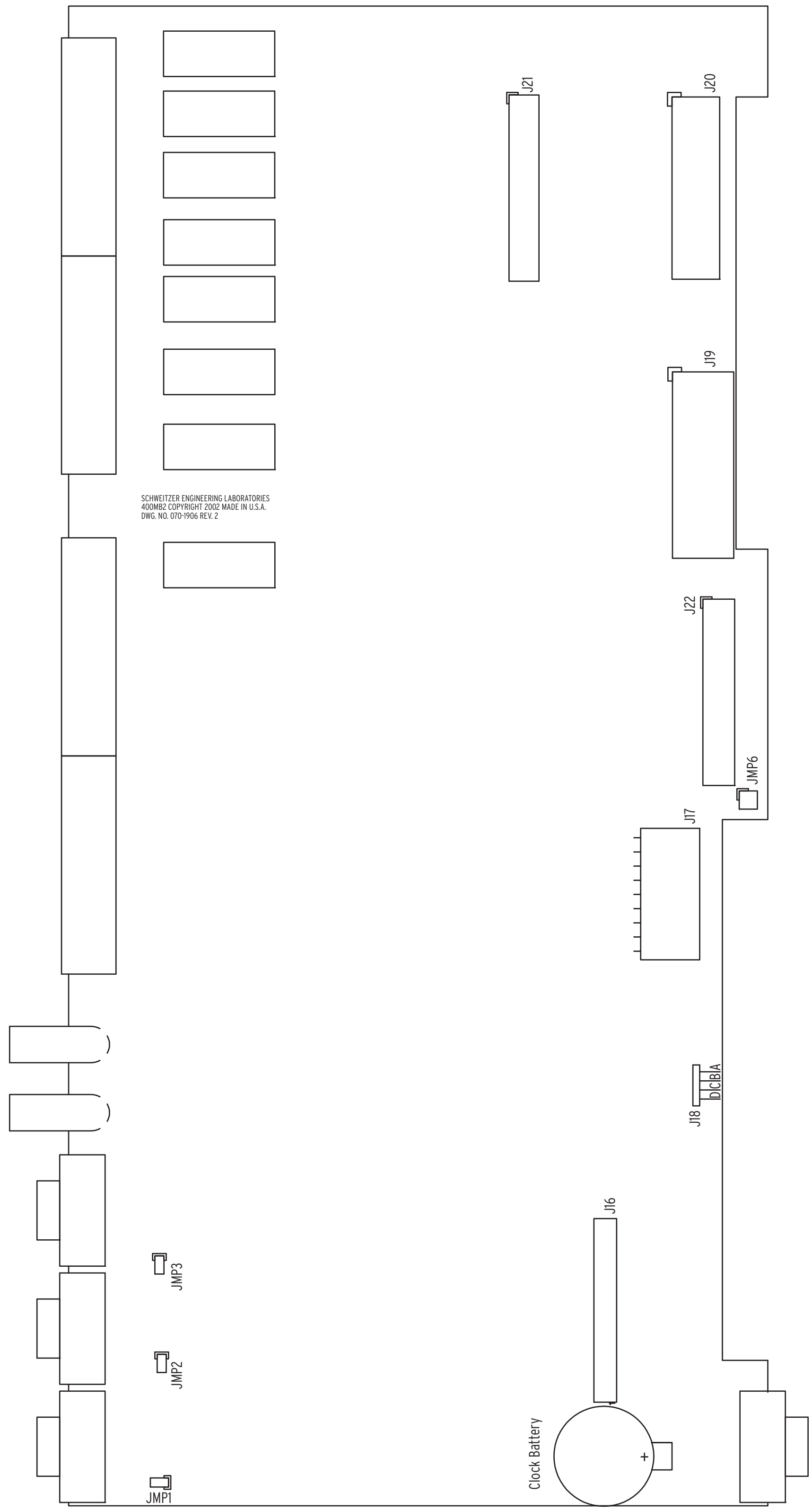


Figure 2.11 Major Component Locations on the SEL-487B Main Board

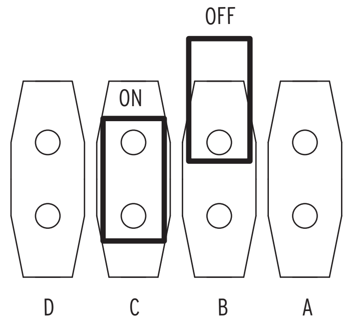


Figure 2.12 J18 Header-Password and Breaker Jumpers

Table 2.4 Main Board Jumpers[a]

Jumper	Jumper Location	Jumper Position	
J18A	Front	OFF	For SEL use only
J18B	Front	OFF ON	Enable password protection (normal and shipped position) Disable password protection (temporary or emergency only)
J18C	Front	OFF ON	Disable control outputs (shipped position) Enable control outputs, including circuit breaker 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. The SEL-487B 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 *PASSWORD on page R.7.27*. The circuit breaker control enable jumper, Jumper J18C, supervises the **OPEN *nn*** 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 **OPEN *nn***, **PULSE OUT*nnn***, and when you use the front panel to 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-487B 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 2.5* describes the JMP1, JMP2, and JMP3 positions. Refer to *Figure 2.11* for the locations of these jumpers. The SEL-487B ships with JMP1, JMP2, and JMP3 OFF (no +5 Vdc on Pin 1).

Table 2.5 Main Board Jumpers—JMP1, JMP2, and JMP3[a]

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

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

Changing Serial Port Jumpers

⚠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
Contact with instrument terminals can cause electrical shock that can result 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.

You must remove the main board to access the serial port jumpers. To change the JMP1, JMP2, and JMP3 jumpers in an SEL-487B, perform the following steps:

Step 1. Remove the relay from service.

   a. Follow your company's standard for removing a relay from service.

   b. Disconnect power from the SEL-487B.

   c. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-487B.

Step 3. Disconnect the front-panel cable at the front panel.

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

Step 5. Remove rear-panel EIA-232 ports mating connectors.

   a. Unscrew the keeper screws.

   b. 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 3**, **PORT 2**, and **PORT 1**, respectively (see *Figure 2.11*).

Step 8. Install or remove the jumper as needed.

   See *Table 2.5* for jumper position descriptions.

Step 9. Reinstall the SEL-487B main board.

Step 10. Reconnect the power cable, the interface board cable(s), and the input board analog cable.

Step 11. Reconnect any serial cables that you removed in the disassembly process to the EIA-232 ports.

Step 12. Reconnect the front-panel cable to the front panel.

Step 13. Reattach the front panel.

Step 14. Follow your company's standard procedure to return the relay to service.

I/O Interface Board Jumpers

Jumpers on the INT4 I/O interface board identify the I/O board control address (see *I/O Interface Boards on page U.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 2.13*.

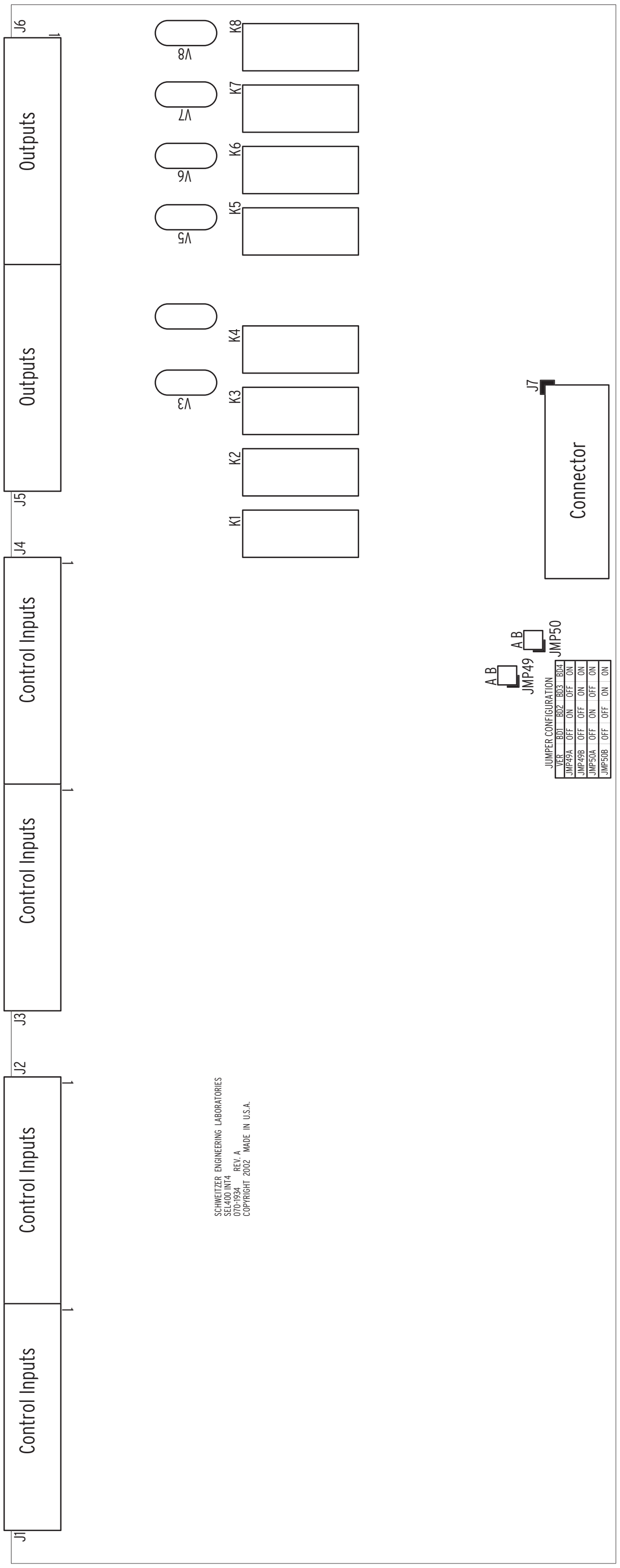


Figure 2.13 Major Component Locations on the SEL-487B INT4 I/O Board

To confirm the positions of your I/O board jumpers, you can remove the front panel and inspect the jumper placements visually. *Table 2.6* lists the four jumper positions for I/O interface boards. Refer to *Figure 2.13* 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.

Table 2.6 I/O Board Jumpers

Description	JMP49A	JMP49B	JMP50A	JMP50B
Position A (Main Board) 1xx I/O	N/A	N/A	N/A	N/A
Position B (Expansion I/O) 2xx I/O	OFF	OFF	OFF	OFF
Position C (Expansion I/O) 3xx I/O	ON	OFF	ON	OFF
Position D (Expansion I/O) 4xx I/O	OFF	ON	OFF	ON
Position E (Expansion I/O) 5xx I/O	ON	ON	ON	ON

See *Figure 2.3* for board location details.

Changing I/O Interface Board Jumpers

⚠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.

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 JMP49A, JMP49B, JMP50A, and JMP50B on an interface board, perform the following steps:

Step 1. Remove the relay from service.
  a. Follow your company's standard for removing a relay from service.
  b. Disconnect power from the SEL-487B.
  c. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Disconnect the front-panel cable from the front panel.

Step 3. Remove the front panel from the SEL-487B.

Step 4. Disconnect the interface board cable from the main board.

Step 5. Pull out the drawout assembly containing the I/O interface board.

Step 6. Locate the jumper you want to change.

Jumpers JMP49A, JMP49B, JMP50A, and JMP50B are located at the front of the I/O board to the left of the interface board connector (see *Figure 2.13*).

Step 7. Install or remove the jumper as needed.

See *Table 2.6* for jumper position descriptions.

Step 8. Reinstall the SEL-487B I/O interface board.

Step 9. Reconnect the interface board cable.

Step 10. Reconnect the front-panel cable to the front panel.

Step 11. Reattach the front panel.

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

Step 13. 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.6.34*.

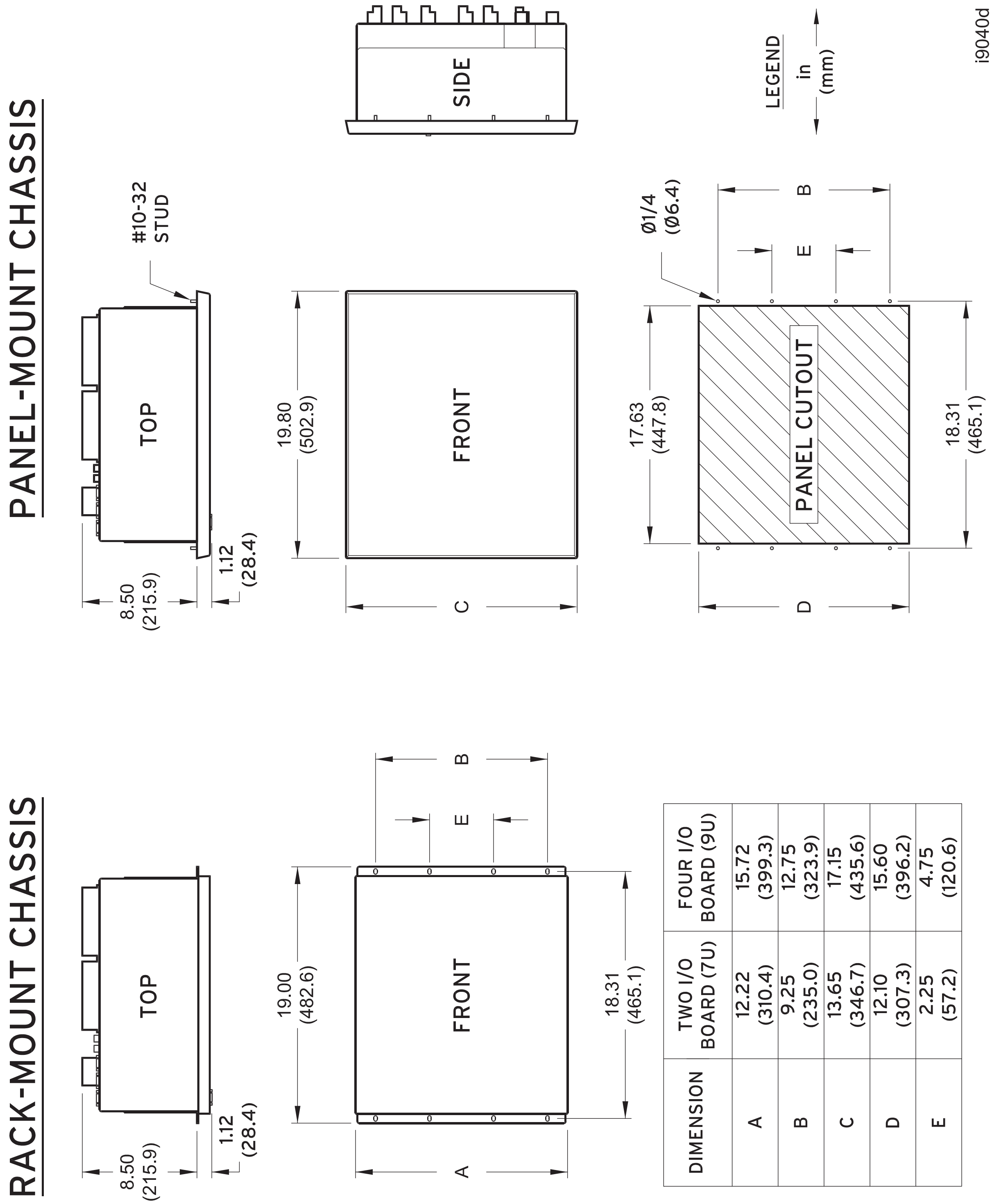
Relay Placement

Use the following guidelines for proper physical installation of the SEL-487B.

Physical Location

You can mount the SEL-487B in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the relay.

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 relay operates in –40° to +85°C (–40° to +185°F) temperatures (see *Operating Temperature on page U.1.11*). With no condensation present, the relay operates in humidity ranging from 5 percent to 95 percent.



DIMENSION	TWO I/O BOARD (7U)	FOUR I/O BOARD (9U)
A	12.22 (310.4)	15.72 (399.3)
B	9.25 (235.0)	12.75 (323.9)
C	13.65 (346.7)	17.15 (435.6)
D	12.10 (307.3)	15.60 (396.2)
E	2.25 (57.2)	4.75 (120.6)

Figure 2.14 Relay Chassis Dimensions

Panel Mounting

Place the panel-mount versions of the SEL-487B in a switchboard panel. See the drawings in *Figure 2.14* for panel cut and drill dimensions. Use the supplied mounting hardware to attach the relay.

Connection

The SEL-487B is available with a main board and 1, 2, 3 or 4 INT4 interface boards. The INT4 interface board is available to expand the control inputs and control outputs only; no analog expansion is available. There are two relay size options: a 9U chassis capable of supporting up to the maximum of four interface boards, or a 7U chassis capable of supporting up to two interface boards. This subsection presents a representative sample of relay rear-panel configurations and the connections to these rear panels. When connecting the SEL-487B, 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 2.15 and *Figure 2.16* show the rear panel of the relay with only the main board installed, and *Figure 2.3* and *Figure 2.4* show the rear panel of the relay fully equipped. For clarity, the figures do not show a communications card installed in PORT 5.

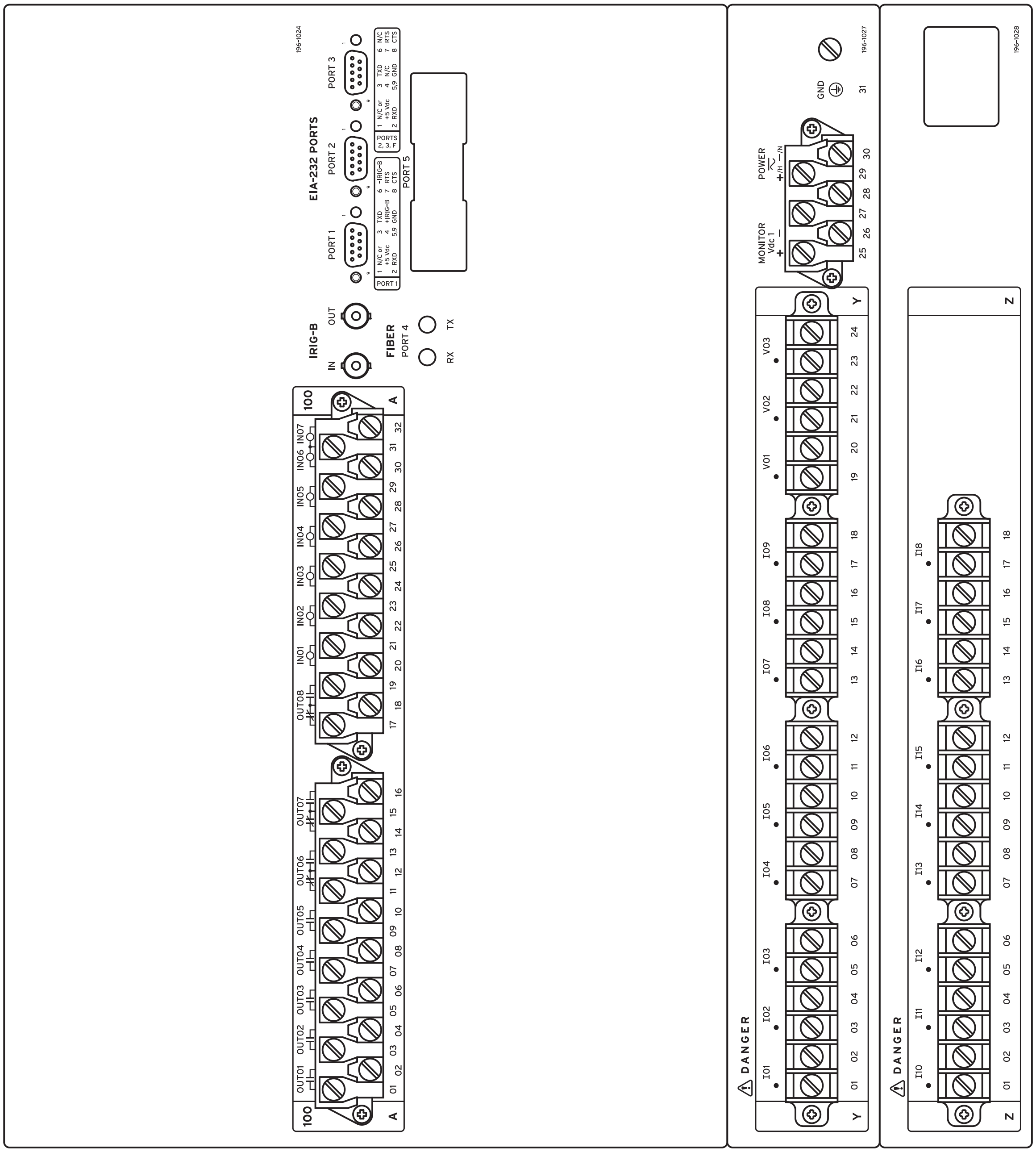


Figure 2.15 Rear Panel With Only Main Board (9U Version)

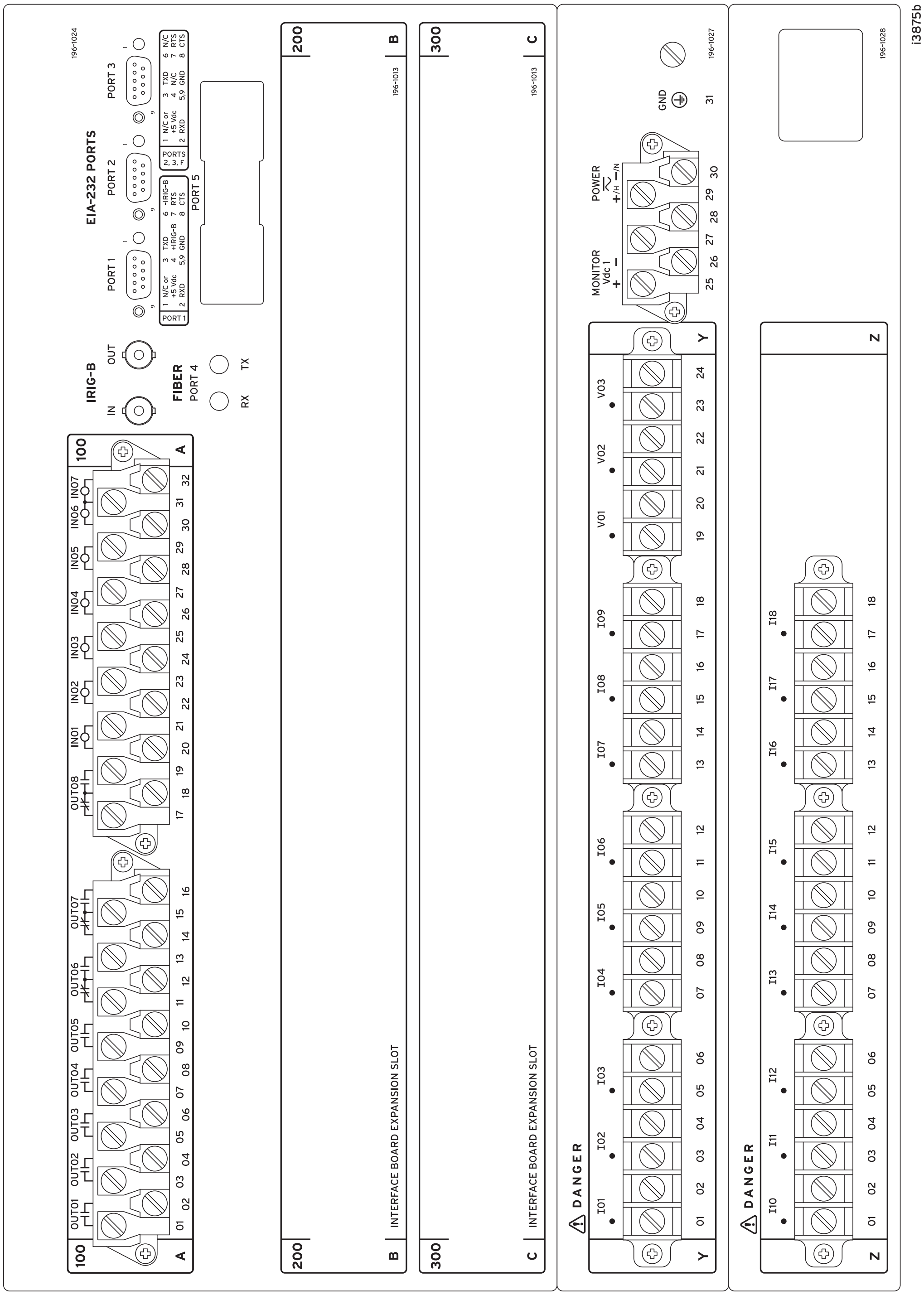


Figure 2.16 Rear Panel With Only Main Board (7U Version)

Rear-Panel Symbols

Figure 2.17 shows important safety symbols and their descriptions. These safety symbols appear on the rear of the relay. 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.

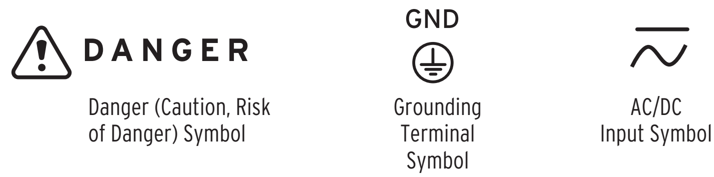


Figure 2.17 Rear-Panel Symbols

Screw Terminal Connectors

Terminate connections to the SEL-487B screw terminal connectors with ring-type crimp lugs. Use a #8 ring lug with a maximum width of 9.1 mm (360 in). 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 1.0 Nm to 2.0 Nm (9 in-lb. to 18 in-lb). You can remove the screw terminal connectors from the rear of the SEL-487B 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 2.18*). If you want to move a screw terminal connector to another circuit board receptacle or reverse the connector orientation, rearrange the receptacle keys to match the screw terminal connector block. Use long-nosed pliers to move the keys. *Figure 2.19* shows the factory default key positions.

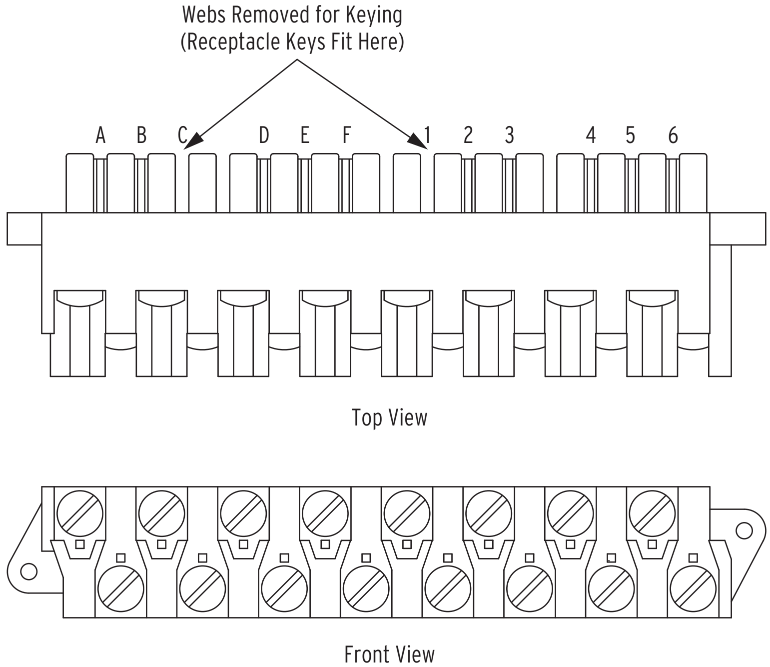


Figure 2.18 Screw Terminal Connector Keying

Grounding

Connect the grounding terminal (#Y31) 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 2.15*). The symbol that indicates the grounding terminal is shown in *Figure 2.17*. Use 10 AWG (6 mm^2) to 12 AWG (4 mm^2) 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-487B.

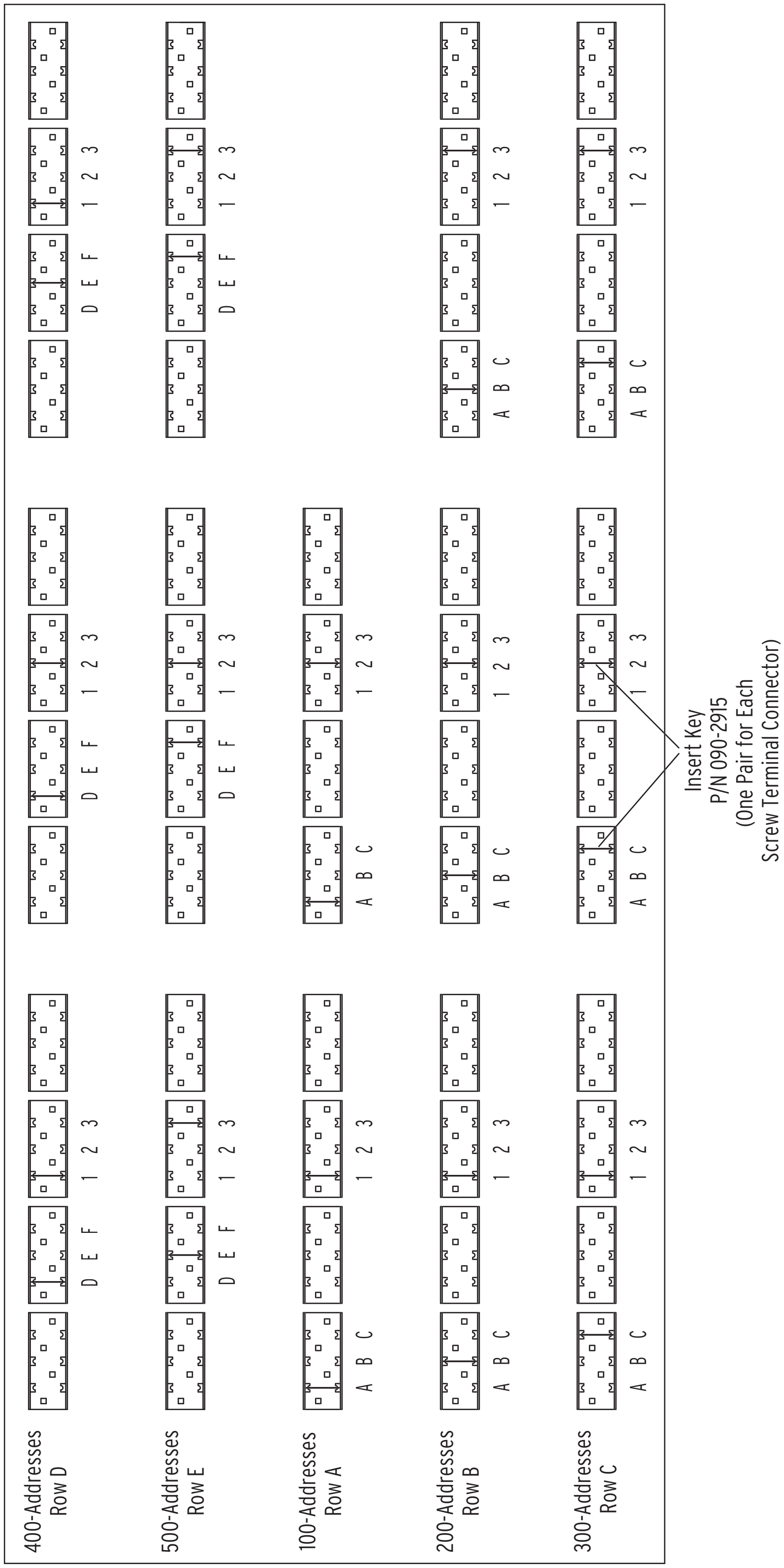


Figure 2.19 Rear-Panel Receptacle Keying

Power Connections

The terminals labeled POWER on the rear panel (Y29 and Y30) must connect to a power source that matches the power supply characteristics that your SEL-487B specifies on the rear-panel serial number label. (See *Power Supply on page U.1.11*, for complete power input specifications.)

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 to 14 AWG (1.5 mm^2 to 2 mm^2) size wire to connect to the POWER terminals. Connection to external power must comply with IEC 60947-1 and IEC 60947-3 and must be identified as the disconnect device for the equipment. Place an external disconnect device, either a switch/fuse combination or circuit breaker in the POWER leads for the SEL-487B; this device must interrupt both the hot (H/+) and neutral (N/-) power leads. The current rating for the power disconnect circuit breaker or fuse must be 20 A maximum. 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 2.7* lists the SEL-487B power supply fuse requirements. Be sure to use fuses that comply with IEC 127-2. You can order the SEL-487B with one of three operational power input ranges listed in *Table 2.7*. Each of the three supply voltage ranges represents a power supply ordering option. As noted in *Table 2.7*, model numbers for the relay with these power supplies begin with 0487B0*n*, where *n* is 2, 4, or 6, to indicate low, medium, and high voltage input power supplies, respectively. Note that each power supply range covers two widely used nominal input voltages. The SEL-487B power supply operates from 30 Hz to 120 Hz when ac power is used for the POWER input.

Table 2.7 Fuse Requirements for the SEL-487B Power Supply

Nominal Power Supply Voltage Rating	Power Supply Voltage Range	Fuse F1	Fuse Description
24/48 V	18–60 Vdc	T6.3AH250V	5x20 mm, time-lag, 6.3 A, high-break capacity, 250 V
48/125 V	38–140 Vdc or 85–140 Vac (30–120 Hz)	T3.15AH250V	5x20 mm, time-lag, 3.15 A, high-break capacity, 250 V
125/250 V	85–300 Vdc or 85–264 Vac (30–120 Hz	T3.15AH250V	5x20 mm, time-lag, 3.15 A, high-break capacity, 250 V

The SEL-487B 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, connect the source with the proper polarity, as indicated by the + (Terminal Y29) and – (Terminal Y30) symbols on the power terminals. When connecting an ac power source, the + Terminal Y29 is hot (H), and the – Terminal Y30 is neutral (N). Each model of the SEL-487B 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*.

Power Supply Fuse Replacement

⚠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.

You can replace a blown fuse in an SEL-487B power supply, or you can return the SEL-487B 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.

a. Follow your company standard for removing a relay from service.
b. Turn off power to the SEL-487B.
c. Remove the relay from the rack or panel.
d. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-487B.

Step 3. Disconnect the front-panel cable from the front panel.

Step 4. Disconnect the interface board cable(s) from the main board and the I/O interface board(s).

Step 5. Disconnect the power cables, input board analog cable, and interface board cable(s) from the main board.

Step 6. Remove the rear-panel EIA-232 ports mating connectors.

a. Unscrew the keeper screws.
b. 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. Locate the power supply.

Fuse F1 is at the rear of the power supply circuit board. See *Figure 2.20*.

Step 10. 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.

Step 12. Replace the fuse with an exact replacement.

See *Table 2.7* for the proper fuse for your power supply.

Step 13. Reinstall the SEL-487B 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. Reconnect any serial cables that you removed in the disassembly process to the EIA-232 ports.

Step 16. Reconnect the front-panel cable to the front panel.

Step 17. Reattach the front panel.

Step 18. Follow your company's standard procedure to return the relay to service.

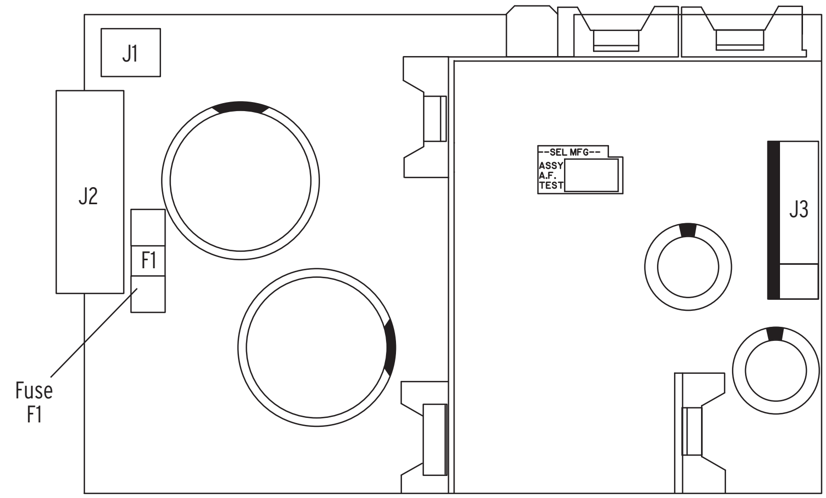


Figure 2.20 PS30 Power Supply Fuse Location

Monitor Connections (DC Battery)

Each SEL-487B monitors one dc battery system. For information on the battery monitoring function, see *Station DC Battery System Monitor on page A.2.1*. Connect the positive lead of the Battery System to Terminal Y25 and the negative lead of the Battery System to Terminal Y26. (Usually the Battery System is also connected to the rear panel POWER input terminals.) For the three-unit application and when there are two battery systems at a station, connect the second battery system to any one of the other two relays (also Terminals Y25 and Y26).

Secondary Circuit Connections

Each SEL-487B has 18 current inputs and 3 voltage inputs. *Shared Configuration Attributes on page U.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. To verify these connections, use SEL-487B metering (see *Examining Metering Quantities on page U.4.31*). You can also review metering data in an event report that results when you issue the **TRIGGER** command.

Fixed Terminal Blocks

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

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

Connect the secondary current circuits to the first 18 terminals on the Y terminal block (Terminals Y01–Y18) and on the Z terminal block (Terminals Z01–Z18).

Connect the voltage inputs to Terminals Y19–Y24 on the Y terminal block. Note the polarity dots above the odd-numbered terminals (Y01 and Y03–Y23, Z01 and Z03–Z17) for the analog inputs.

Control Circuit Connections

You can configure the SEL-487B with many combinations of control inputs and control outputs. See *Main Board I/O on page U.2.11* and *I/O Interface Boards on page U.2.12* for information about I/O configurations. This subsection provides details about connecting these control inputs and outputs. Refer to *Figure 2.3* for representative rear-panel screw terminal connector locations.

Control Inputs

No control input on the relay is polarity sensitive, which means you cannot damage these inputs with a reverse polarity connection. 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.4.40*, or the **SET G** command in *SET on page R.7.32* for more details. You can also use the ACSELERATOR software to set and verify operation of the inputs.

Control Outputs

The SEL-487B has two types of outputs:

- Standard outputs (for example: main board OUT104)
- High-speed (high-current-interrupting) outputs, optionally on the INT4 interface board (for example: INT4 board OUT01). See *Control Outputs on page U.2.9* for more information.

You can connect the standard outputs in either ac or dc circuits. Connect the high-speed (high-current interrupting) outputs to dc circuits only. The screw terminal connector legends alert you about this requirement by showing HS marks on the high-speed (high-current interrupting) contacts. Form A contacts comprise the majority of the control outputs. Two pairs of Form C contacts are on the main board. The INT4 I/O interface board is available with six high-speed and two standard output contacts, or optionally, with eight standard output contacts.

Alarm Output

The SEL-487B 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 2.21* shows the configuration of the a and b contacts of control output OUT108.

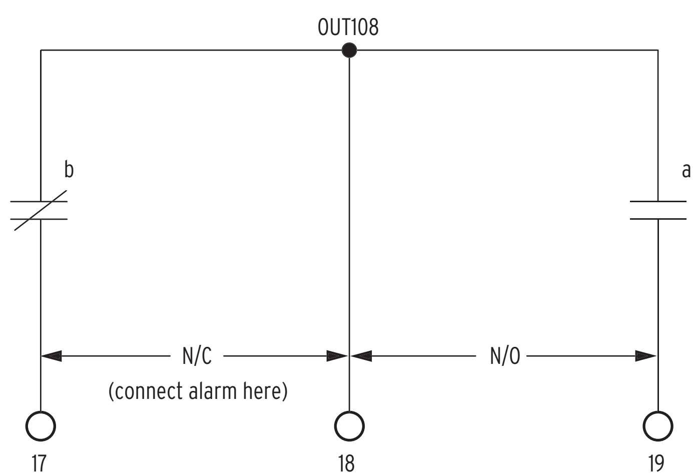


Figure 2.21 Control Output OUT108

Default settings for Output OUT 107 and Output OUT108 are as follows:

OUT107 := **TNS_SW #RELAY TEST MODE**

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

TNS_SW is a test function programmed to Pushbutton PB4, labeled **{RELAY TEST MODE}**. Output OUT107 asserts when the relay is in the test mode. When the relay is operating normally, the NOT HALARM signal is at logical 1 and the b contact of control output OUT108 is open. When a Status Warning condition occurs, the relay pulses the NOT HALARM signal to logical 0 and the b contact of OUT108 closes momentarily to indicate an alarm condition. For a Status Failure, the relay disables all control outputs and the OUT108 b contact closes to trigger an alarm. Also, when relay power is off, the OUT108 b contact closes to generate a power-off alarm. See *Relay Self-Tests on page U.6.34* 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.

Tripping and Closing Outputs

To assign the control outputs for tripping, see *Setting Outputs for Tripping on page U.4.46*. In addition, you can use the **SET O** command; see *SET on page R.7.32*, for more details.

TIME Input Connections

IRIG-B Input Connection

⚠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.

The SEL-487B accepts a demodulated IRIG-B signal through two types of rear-panel connectors. These IRIG-B inputs are the BNC connector labeled IRIG-B and Pin 4 (+) and Pin 6 (–) of the DB-9 rear panel serial port labeled PORT 1. When you use the PORT 1 input, ensure that you connect Pins 4 and 6 with the proper polarity. See *Communications Ports Connections on page 2.35* for other DB-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-487B, see *Time Inputs on page 2.11*.

The BNC IRIG-B input and the PORT 1 IRIG-B input circuit are internally connected to provide a single demodulated IRIG-B source for time signal processing. For this reason, you must only use one IRIG-B input (BNC or serial port) as the time signal source to the SEL-487B.

Where distance between the SEL-487B 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. The SEL-2810 Fiber-Optic Transceiver/Modem 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-2032 Communications Processor) over a fiber-optic communications link.

For ease of connection or for runs up to 300 feet from the IRIG-B generator to the SEL-487B, use the BNC IRIG-B input to connect the IRIG-B input of the SEL-487B to the IRIG-B generation equipment. Make this connection with a 50 Ω coaxial cable assembly.

Replacing the Lithium Battery

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

You can replace a bad lithium battery in the SEL-487B. Perform the following steps to replace the lithium battery.

Step 1. Remove the relay from service.

a. Follow your company standard procedure for removing a relay from service.

b. Disconnect power from the SEL-487B.

c. Remove the relay from the rack or panel.

d. Retain the GND connection, if possible, and ground the equipment to an ESD mat.

Step 2. Remove the front panel from the SEL-487B.

Step 3. Disconnect the front-panel cable from the front panel.

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

Step 5. Pull out the drawout tray containing the main board.

Step 6. Locate the lithium battery.

The lithium battery is at the front of the main board. See *Figure 2.11*.

Step 7. Remove the spent battery from beneath the clip of the battery holder.

Step 8. 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 9. Reinstall the SEL-487B main board drawout tray.

Step 10. Reattach the power cable, interface board cable(s), and input board analog cable.

Step 11. Reconnect the front-panel cable to the front panel.

Step 12. Reattach the front panel.

Step 13. Set the relay date and time via the communications ports or front panel (See *Making Simple Settings Changes on page U.4.12*).

Step 14. Follow your company's standard procedure to return the relay to service.

Communications Ports Connections

The SEL-487B 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.4.4*.

In addition, the rear panel features a **PORT 5** for an optional factory-installed Ethernet communications card. For additional information about communications topologies and standard protocols that are available in the SEL-487B, see *Section 4: SEL Communications Processor Applications in the*

Applications Handbook, *Section 5: Direct Network Communication in the Applications Handbook*, *Section 5: DNP3 Communications in the Reference Manual*, and *Section 8: IEC 61850 Communications in the Reference Manual*.

Serial Ports

The SEL-487B 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.

Figure 2.22 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 3: Communications Interfaces in the Reference Manual* for a list of hardware interfaces to the SEL-487B.

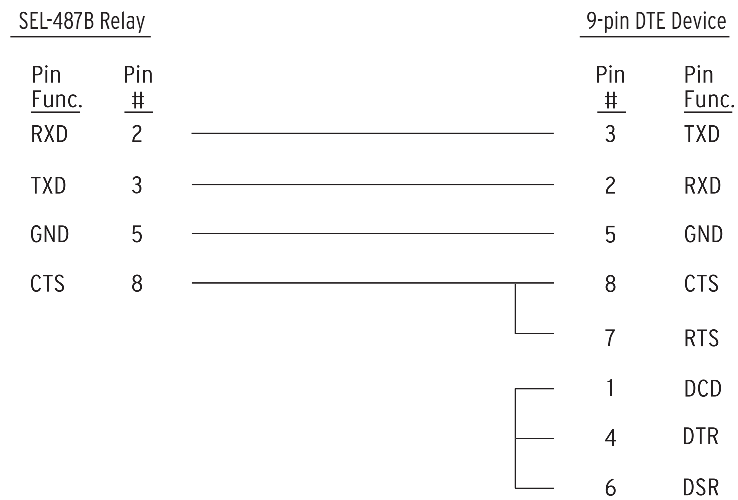


Figure 2.22 SEL-487B to Computer-D-Subminiature 9-Pin Connector

Serial Cables

Using an improper cable can cause numerous problems or failure to operate, so be sure to specify the proper cable for application of your SEL-487B. Several standard SEL communications cables are available for use with the relay. The following list provides 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 15.24 m (50 feet), and you should always use shielded cables for communications circuit lengths greater than 3.048 m (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.

Network Connections

The optional Ethernet card for the SEL-487B can use either the connection on Port A or Port B to operate on a network. These ports work together to provide a primary and backup interface, as described in *Network Port Fail-Over Operation on page R.3.9*. The following list describes the Ethernet card port options.

- 10/100BASE-T. 10 Mbps or 100 Mbps communications using CAT 5 cable (category 5 twisted-pair) and an RJ-45 connector
- 100BASE-FX. 100 Mbps communications over multimode fiber-optic cable using an ST connector

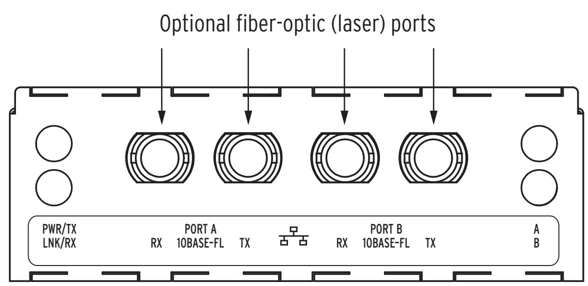


Figure 2.23 Example Ethernet Panel With Fiber-Optic Ports

Ethernet Card Rear-Panel Layout

Rear-panel layouts for the three Ethernet card port configurations are shown in *Figure 2.24–Figure 2.26*.

⚠CAUTION
Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

⚠WARNING
Do not look into the fiber (laser) ports/connectors.

⚠WARNING
Do not look into the end of an optical cable connected to an optical output.

⚠WARNING
Do not perform any procedures or adjustments that this instruction manual does not describe.

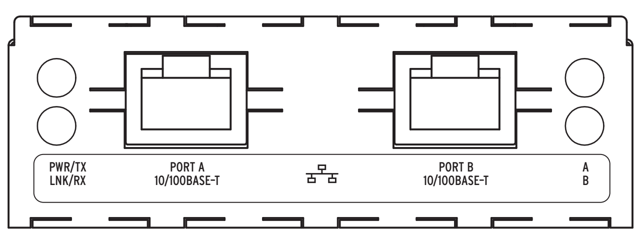


Figure 2.24 Two 10/100BASE-T Port Configuration

⚠WARNING
During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.

⚠WARNING
Incorporated components, such as LEDs, transceivers, and laser emitters, are not user serviceable. Return units to SEL for repair or replacement.

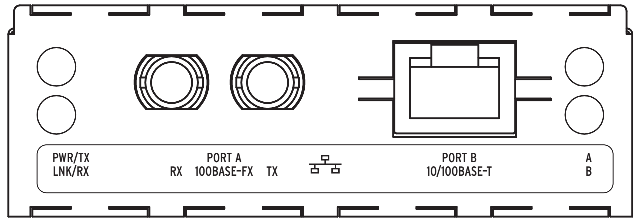


Figure 2.25 100BASE-FX and 10/100BASE-T Port Configuration

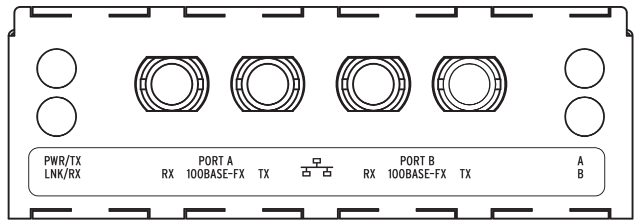


Figure 2.26 Two 100BASE-FX Port Configuration

Twisted-Pair Networks

NOTE: Use caution with UTP cables as these cables do not provide adequate immunity to interference in electrically noisy environments unless additional shielding measures are employed.

While Unshielded Twisted Pair (UTP) cables dominate office Ethernet networks, Shielded Twisted Pair (STP) cables are often used in industrial applications. The SEL-487B Ethernet card is compatible with standard UTP cables for Ethernet networks as well as STP cables for Ethernet networks.

Typically UTP cables are installed in relatively low-noise environments including offices, homes, and schools. Where noise levels are high, you must either use STP cable or shield UTP using grounded ferrous raceways such as steel conduit.

Several types of STP bulk cable and patch cables are available for use in Ethernet networks. If noise in your environment is severe, you should consider using fiber-optic cables. We strongly advise against using twisted-pair cables for segments that leave or enter the control house.

If you use twisted-pair cables, you should use care to isolate these cables from sources of noise to the maximum extent possible. Do not install twisted-pair cables in trenches, raceways, or wireways with unshielded power, instrumentation, or control cables. Do not install twisted-pair cables in parallel with power, instrumentation, or control wiring within panels, rather make them perpendicular to the other wiring.

You must use a cable and connector rated as Category 5 (CAT 5) to operate the twisted-pair interface (10/100BASE-T) at 100 Mbps. Because lower categories are becoming rare and because you may upgrade a 10 Mbps network to 100 Mbps, we recommend using all CAT 5 components.

Some industrial Ethernet network devices use 9-pin connectors for STP cables. The Ethernet card RJ-45 connectors are grounded so you can ground the shielded cable using a standard, externally shielded jack with cables terminating at the Ethernet card.

AC/DC Connection Diagrams

You can apply the SEL-487B to different power system busbar layouts. *Figure 2.27* shows one particular application scheme with connections that represent typical interfaces to the relay for a single zone layout. *Figure 2.28* depicts typical connections for a three-relay application.

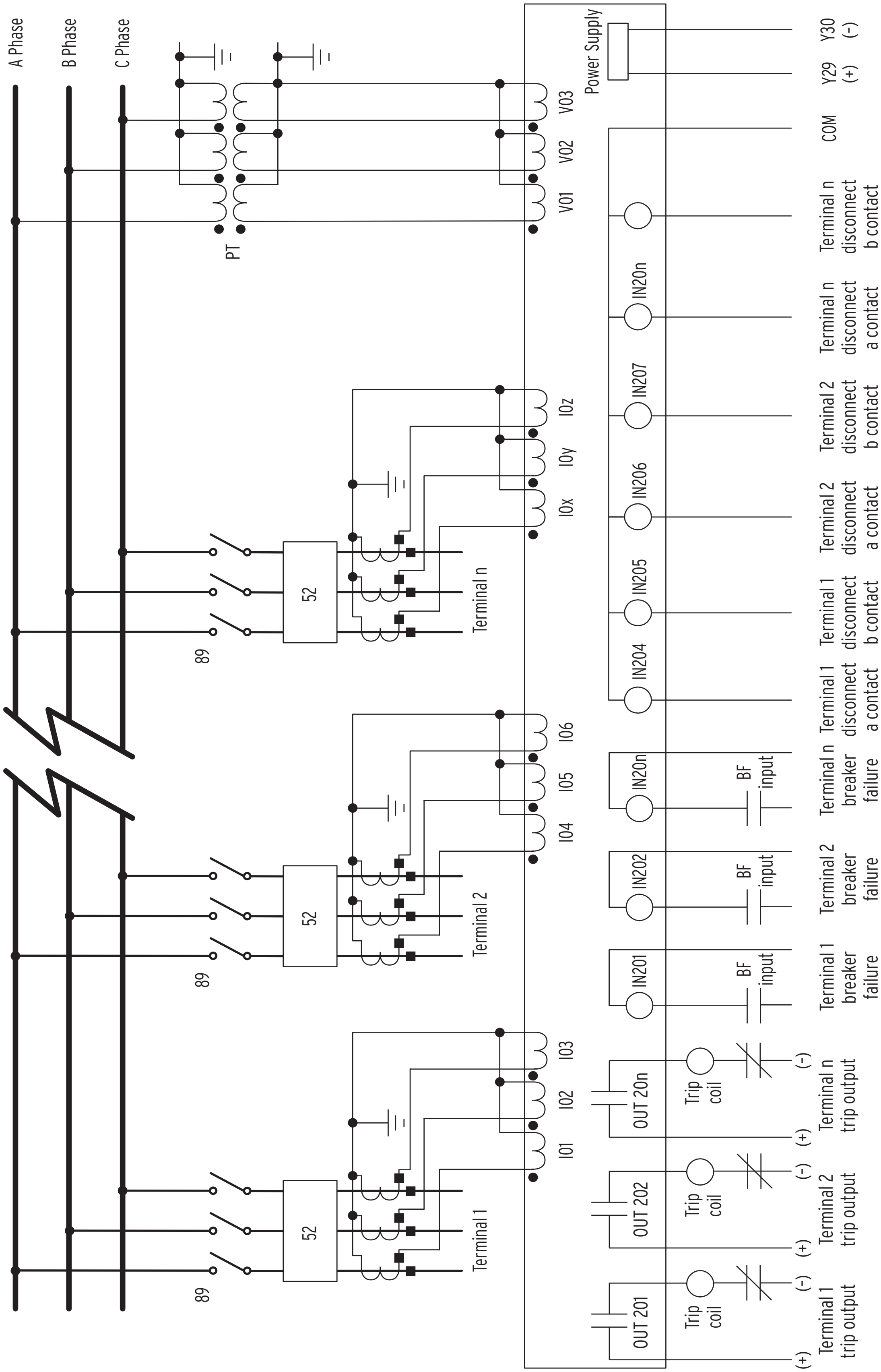


Figure 2.27 Typical External AC/DC Connections for a Single-Relay Application

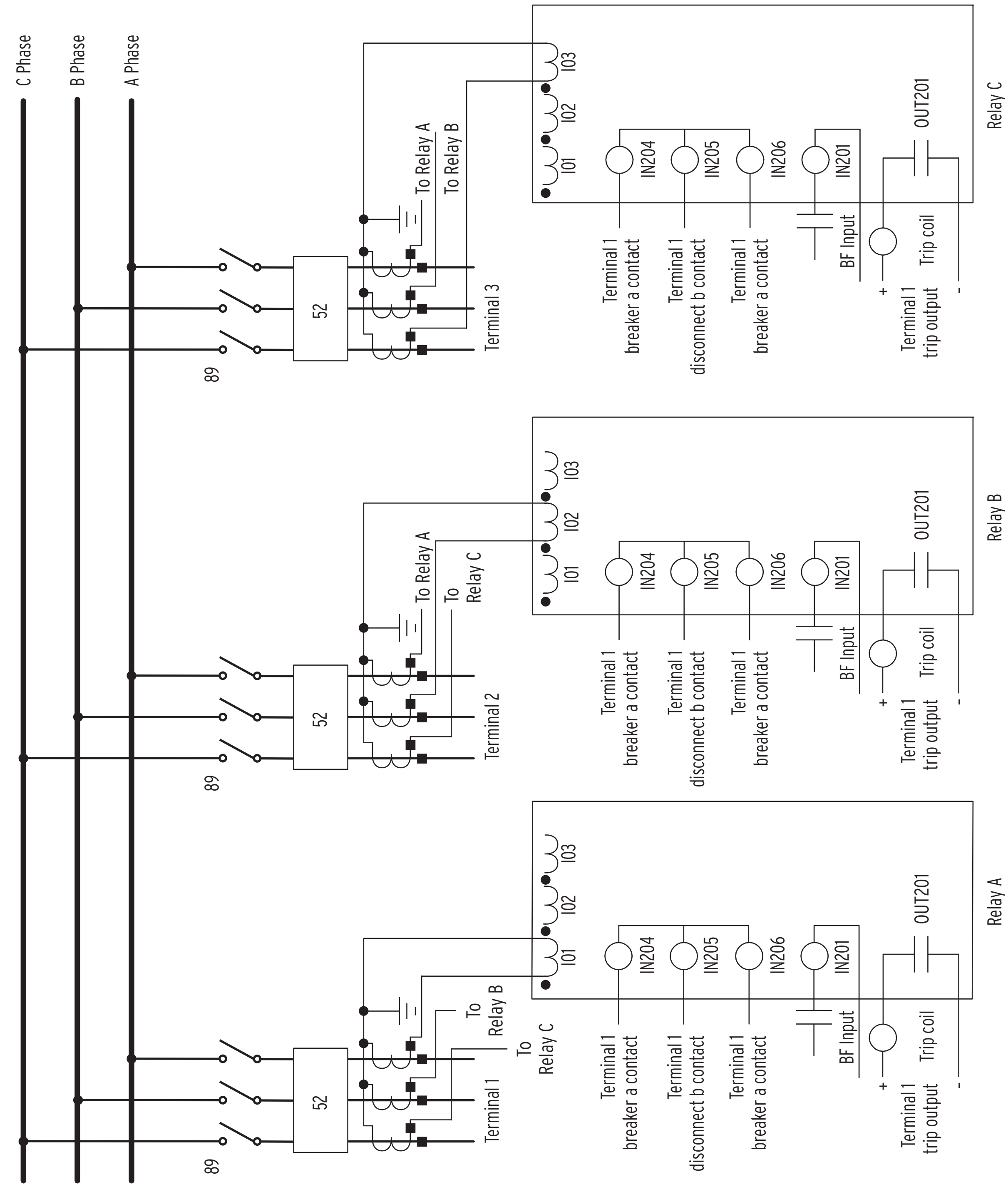


Figure 2.28 Typical External AC/DC Connections for a Three-Relay Application

Section 3
PC Software

Overview

The SEL-487B Relay includes a powerful relay settings, analysis, and measurement tool to aid you in applying and using the relay; this tool is the ACSELERATOR QuickSet® SEL-5030 software program. ACSELERATOR reduces engineering costs for relay settings, logic programming, and system analysis. ACSELERATOR makes it easier for you to do the following:

- Create and manage relay settings
  - Create settings for one or more SEL-487B relays
  - Store and retrieve settings with an IBM-compatible PC (personal computer)
  - Upload and download relay settings files to and from SEL-487B relays
- Analyze events
  - Use the integrated waveform and harmonic (single event reports) analysis tools
- 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 ACSELERATOR for easier, more efficient configuration of the relay settings. However, you do not have to use ACSELERATOR to configure the SEL-487B; you can use an ASCII terminal or a computer running terminal emulation software to access all relay settings and metering. ACSELERATOR gives you the advantages of rules-based settings checks, SELOGIC® control equation Expression Builder, and event analysis.

Communications Setup

ACSELERATOR uses the relay communications ports to communicate with the SEL-487B. Configure the ACSELERATOR **Communication Parameters** settings to communicate effectively with the relay. You can also use a basic terminal emulation any time you run ACSELERATOR. Use the **Communication** menu to view and clear a **Connection Log**.

Serial Communication Parameters

Use the **Communication Parameters** dialog box to configure relay communications settings.

Step 1. Select the **Communication** menu on the top ACSELERATOR toolbar.

Step 2. Click **Parameters** to open this dialog box.

Figure 3.1 shows the ACSELERATOR **Communication Parameters** dialog box.

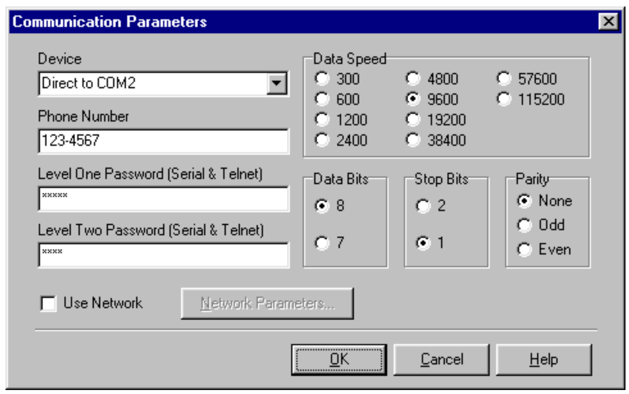


Figure 3.1 ACSELERATOR Communication Parameters Dialog Box

Serial Setup

You can use serial communication via relay Ports 1, 2, 3, and F (front panel). *Figure 3.1* shows the default serial port parameters (9600, 8, N, 1).

Step 1. Enter your relay Access Level One and Access Level Two passwords in the respective text boxes.

Step 2. If you choose a device from the **Device** drop-down list that is a telephone modem, enter the dial-up telephone number in the **Phone Number** text box.

Ethernet Card

Use the optional Ethernet card for FTP and Telnet network communications.

FTP Setup

Step 1. Access the **Network Parameters** dialog box.

a. Click the **Use Network** check box, as shown in *Figure 3.2*.

b. Click the **Network Parameters** command button.

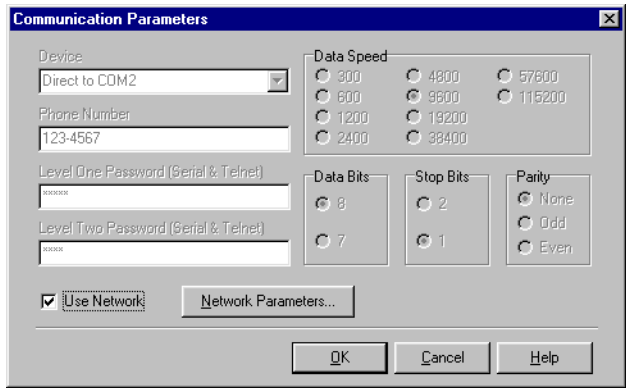


Figure 3.2 ACSELERATOR Communication Parameters Dialog Box With Network Parameters Active

Step 2. Click the **FTP File Transfer Options** option button to select FTP as the network communication protocol.

Step 3. Provide the access level command (**ACC**, **2AC**, for example) in the **User ID** text box.

Step 4. Provide 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.4.9*.

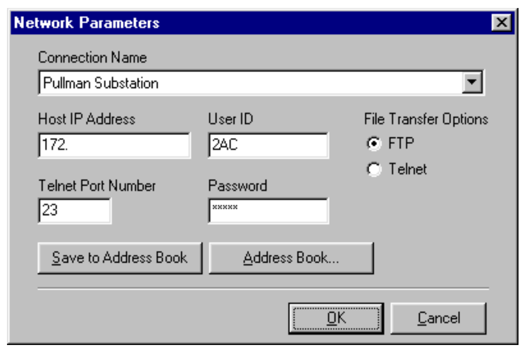


Figure 3.3 ACSELERATOR Network Parameters Dialog Box: FTP

Telnet Setup

Step 1. Access the **Network Parameters** dialog box.

a. Click the **Use Network** check box, as shown in *Figure 3.2*.

b. Click the **Network Parameters** command button.

2. Click the **Telnet File Transfer Options** button to select Telnet as the network communication protocol.

The Telnet session uses the relay passwords on the **Communication Parameters** dialog box (*Figure 3.1*). The default **Telnet Port Number** for accessing the relay is T1PNUM := 23. The default **Telnet Port Number** for communicating directly with the SEL-487B Ethernet card is T2PNUM := 1024. See *Section 5: Direct Network Communications in the Applications Handbook* for more information on Telnet.

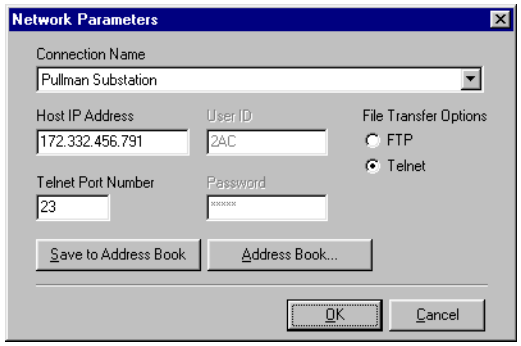


Figure 3.4 ACSELERATOR Network Parameters Dialog Box: Telnet

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.

Step 1. Click the ACSELERATOR **Communication** menu.

Step 2. 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, ACSELERATOR records communications events and errors in a log.

Step 1. Click **Communication > Connection Log** to view the log.

Step 2. Clear the log by selecting **Communication > Clear Connection Log**.

Settings Database Management and Drivers

Database Manager

ACSELERATOR uses a relay database to save relay settings. ACSELERATOR contains sets of all settings files for each relay that you specify in the **Database Manager**. 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 ACSELERATOR is **Relay.rdb**. This database contains example settings files for the SEL products with which you can use ACSELERATOR.

Step 1. Open the **Database Manager** to access the database.

a. Click on **File** in the ACSELERATOR top toolbar.

b. Select and click the **Database Manager** menu item.

You will see the dialog box similar to *Figure 3.5*.

Step 2. If you wish, you can enter descriptions of the database and/or relay in the **Database Description** and/or **Relay Description** text boxes.

A relay description would consist of special operating characteristics that describe the relay settings including the protection scheme settings and communications settings.

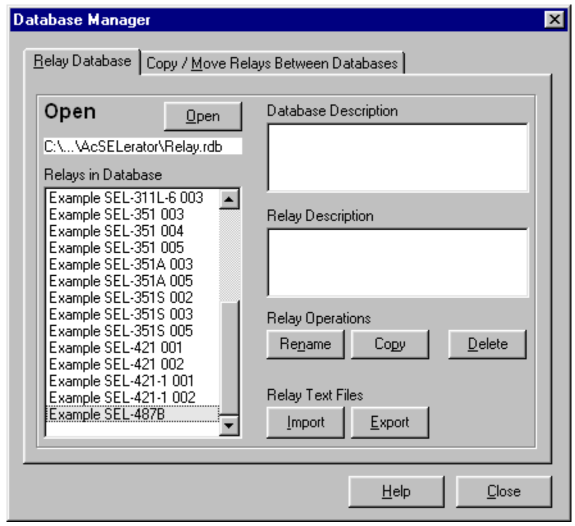


Figure 3.5 ACSELERATOR Database Manager Relay Database

Step 3. Highlight one of the relays listed in **Relays in Database.**

Step 4. Select the **Copy** option button to create a new collection of relay settings.

ACSELERATOR prompts you to provide a new name.

Step 5. 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.

Step 1. Select the **Copy/Move Relays Between Databases** tab to access the dialog box shown in *Figure 3.6*.

Step 2. Click the **Open B** option button to open a relay database.

Step 3. Type a filename.

Step 4. Click **Open**.

For example, **Relay2.rdb** is the B relay database in *Figure 3.6*.

Step 5. Highlight a relay in the A database.

Step 6. Select **Copy** or **Move.**

Step 7. 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.

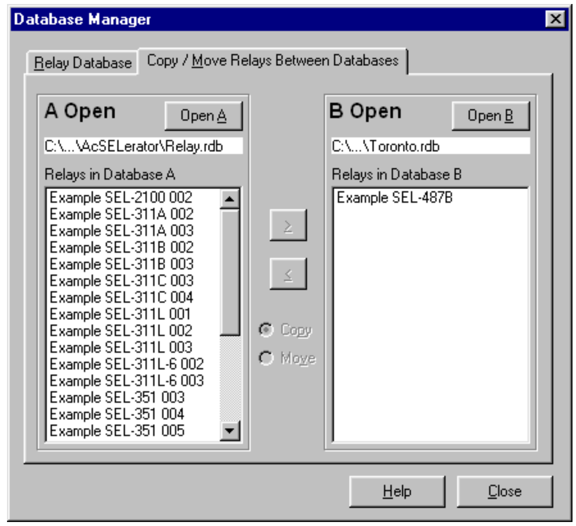


Figure 3.6 ACSELERATOR Database Manager Copy/Move

Create a New Database

Step 1. To create and copy an existing database of relays to a new database, select the **File > Database Manager** menu.

Step 2. Select **Copy/Move Relays Between Databases** on the **Database Manager** dialog box.

ACSELERATOR opens the last active database and assigns it as Database A (see *Figure 3.6*).

Step 3. Click on the **Open B** button.

ACSELERATOR prompts you for a file location.

Step 4. Type a new database name.

Step 5. Click on the **Open** button.

Step 6. Answer **Yes**.

The program creates a new empty database.

Step 7. Load relays into the new database as in *Copy/Move Relays Between Databases*.

Drivers

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

Step 1. Use one of the following methods to view the relay FID (firmware identification) number to determine the active ACSELERATOR drivers.

➤ Use the **STATUS** command from the serial port terminal emulation window.

➤ Type **ID <Enter>** in the computer emulation software window (**Ctrl+T** from ACSELERATOR).

Step 2. Locate and record the Z-number in the FID string.

The Z-number helps determine the proper ACSELERATOR relay settings driver version when creating or editing relay settings files.

Step 3. View the ACSELERATOR settings driver information at the bottom of the **Relay Editor** window (see *Figure 3.13*).

The first portion of the Z-number is the ACSELERATOR settings driver version number (see *Figure 3.7*).

Step 4. Compare the ACSELERATOR driver number and the relay FID number.

This ACSELERATOR driver Z-number and the corresponding part of the relay FID must match.

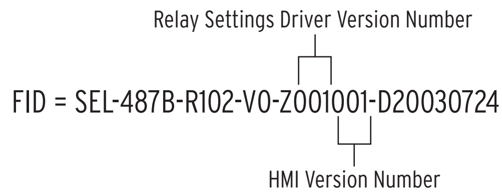


Figure 3.7 ACSELERATOR Software Driver Information in the FID String

ACSELERATOR reads the first portion of the Z-number (Z001XXX, for example) to determine the correct **Relay Editor** to display when you select **New**, **Open** or **Read**.

Step 5. View the bottom of the **Relay Editor** window to check the **Relay Editor** driver number (see *Figure 3.8*).

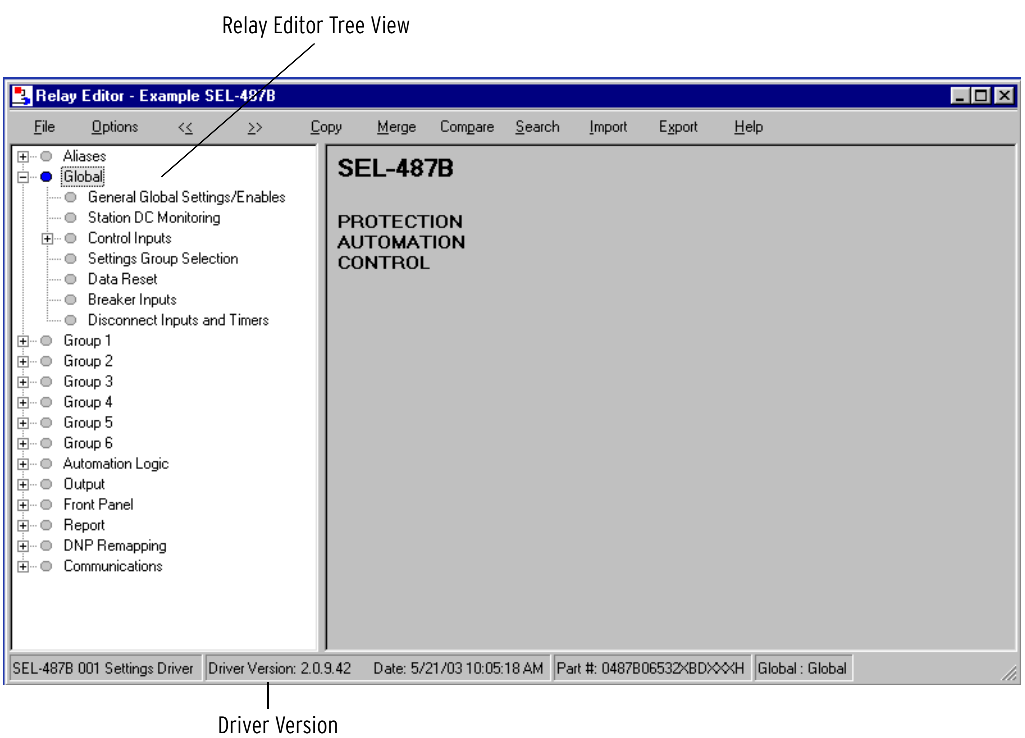


Figure 3.8 Relay Settings Driver Version Number

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

Create and Manage Relay Settings

ACSELERATOR enables you to create settings for one or more SEL-487B relays. You can store existing relay settings downloaded from SEL-487B relays with ACSELERATOR, creating a library of relay settings (see *Database Manager on page U.3.4*). You can then modify and upload these settings from your settings library to an SEL-487B. ACSELERATOR makes setting the relay easy and efficient.

Collected Settings

ACSELERATOR arranges relay settings in easy-to-understand categories (for an explanation of settings organization, see *Making Simple Settings Changes on page U.4.12*). These categories of collected settings help you quickly set the relay. *Figure 3.9* is an example of relay settings categories in the **Relay Editor Settings** tree view.

ACSELERATOR 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 try the following steps:

Step 1. Select the **Global > General Global Settings/Enables** branch of the settings tree view.

Step 2. Observe that the **EGADVS Advanced Global Settings** are dim.

Step 3. If you select **Y** for **EDCMON**, then the **EGADVS Advanced Global Settings** become active.

Step 4. *Figure 3.9* illustrates this feature of ACSELERATOR.

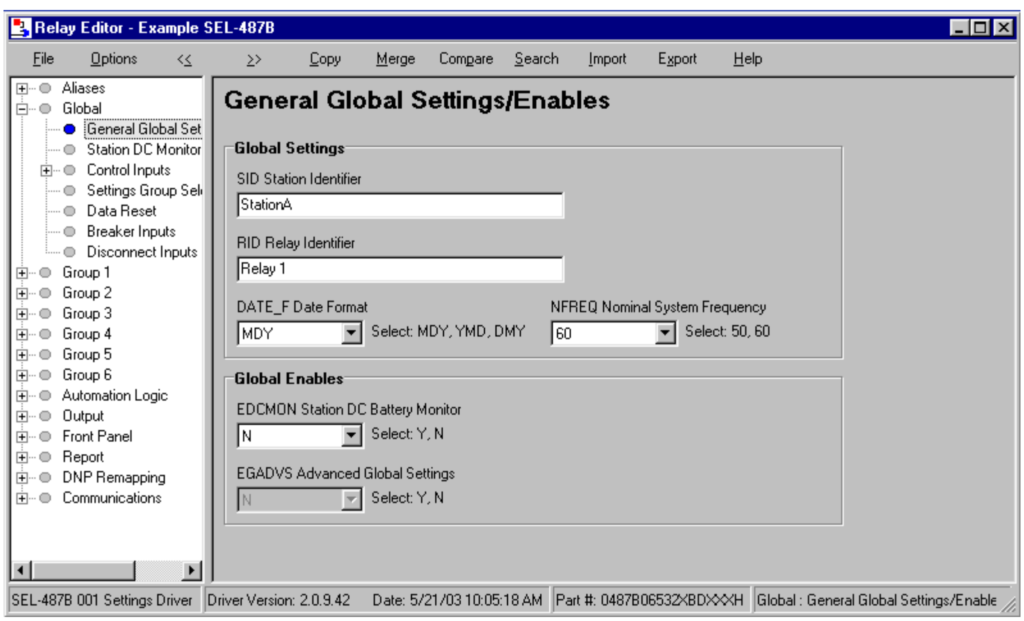


Figure 3.9 ACSELERATOR Sample Settings

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 the following:

- **New**
- **Open**
- **Read**

All of these menu items open the **Relay Editor** (see *Relay Editor on page U.3.10*).

New

Selecting the **New** menu item creates new relay settings files. ACSELERATOR makes the new settings files from the relay drivers that you specify in the **Relay Editor Selection** dialog box (see *Figure 3.10*). ACSELERATOR uses the Z-number in the relay FID string to create a particular version of relay settings.

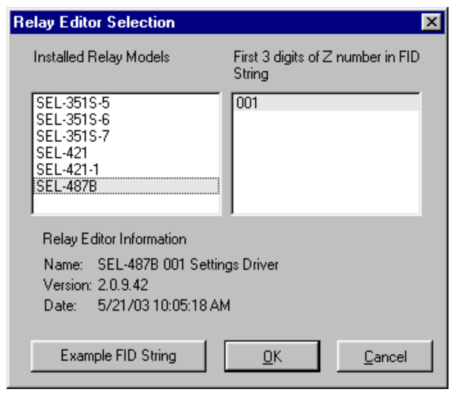


Figure 3.10 Selecting a Settings Driver in ACSELERATOR

After selecting the relay model and settings driver, ACSELERATOR 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.

Open

The **Open** menu item opens an existing relay from the active database folder (see *Figure 3.11*). ACSELERATOR prompts you for a folder containing relay settings to load into the **Relay Editor**.

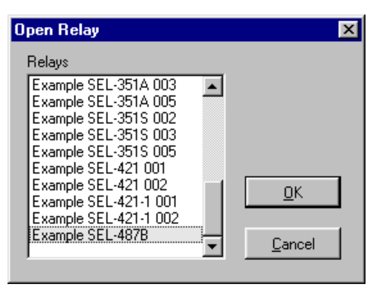


Figure 3.11 Opening Relay Settings in ACSELERATOR

Read

When you select the **Read** menu item, ACSELERATOR reads the relay settings from a connected relay. As ACSELERATOR reads data from the relay, you will see a dialog box similar to *Figure 3.12*. ACSELERATOR uses serial protocols at a serial port or FTP from an Ethernet port to read settings from SEL devices.

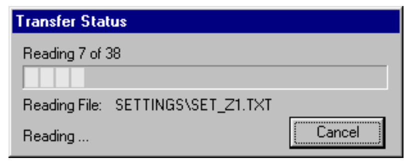


Figure 3.12 Reading Relay Settings in ACSELERATOR

Relay Editor

Use the **Relay Editor** to enter relay settings. *Figure 3.13* illustrates the important features of the editor. These features include the ACSELERATOR settings driver version number (the first three digits of the Z-number) in the lower left corner of the **Relay Editor**.

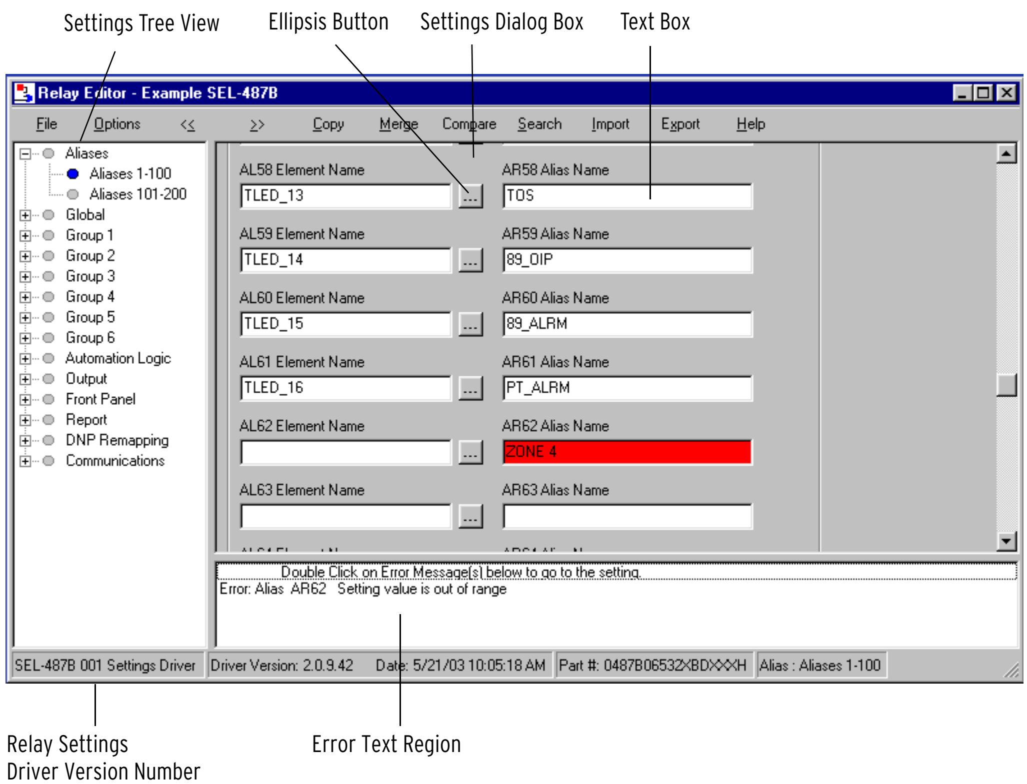


Figure 3.13 ACSELERATOR Relay Editor

Entering Settings

Step 1. Click the **+** marks to expand the **Settings Tree View** (see *Figure 3.13*).

Step 2. Click the circle buttons to select the settings class, instance, and category that you want to change.

Step 3. Use the **Tab** key to move to the setting text book and from setting to setting when entering and editing.

Step 4. The right-click mouse button performs two special functions when you are editing settings: **Previous Value** and **Default Value**.

Step 5. Use the following methods to edit the settings from ACSELERATOR.

➤ Restore previous values. Right click the mouse over the setting and select **Previous Value**.

➤ Restore default values. Right click in the setting dialog box and select **Default Value**.

If you enter a setting that is out of range or has an error, an error message appears at the bottom of the **Relay Editor** window. To correct the error, proceed to *Step 6*.

Step 6. Correct settings errors.

a. Double-click on the error listing in the **Relay Editor** window.

b. Enter a valid input for the setting where the error appears.

Relay Part Number

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

Configuring the Relay Part Number

Step 1. Select the ACSELERATOR **Settings** menu.

Step 2. Click **New**, **Open**, or **Read** to start the **Relay Editor**; see *Settings Menu on page U.3.9*.

Step 3. Once in the **Relay Editor**, click the **Options** menu on the **Relay Editor** toolbar (see *Figure 3.14*).

Step 4. Point to **Part Number.**

Step 5. Click this option.

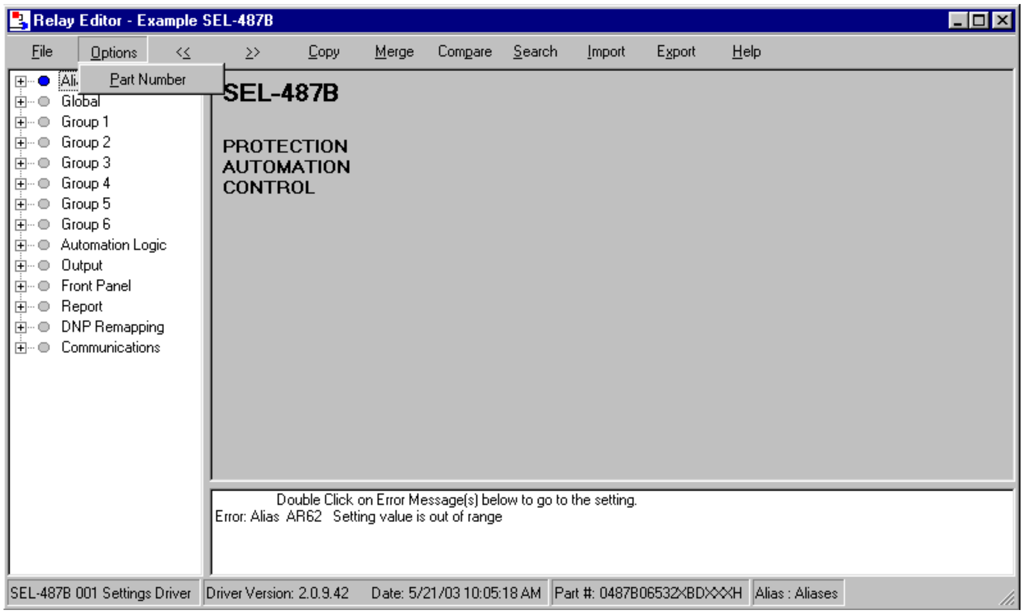


Figure 3.14 Retrieving the Relay Part Number

You will see the **Relay Part Number** dialog box, as shown in *Figure 3.15*.

Step 6. Use the arrows inside the text boxes to match corresponding portions of the **Relay Part Number** dialog box to your relay.

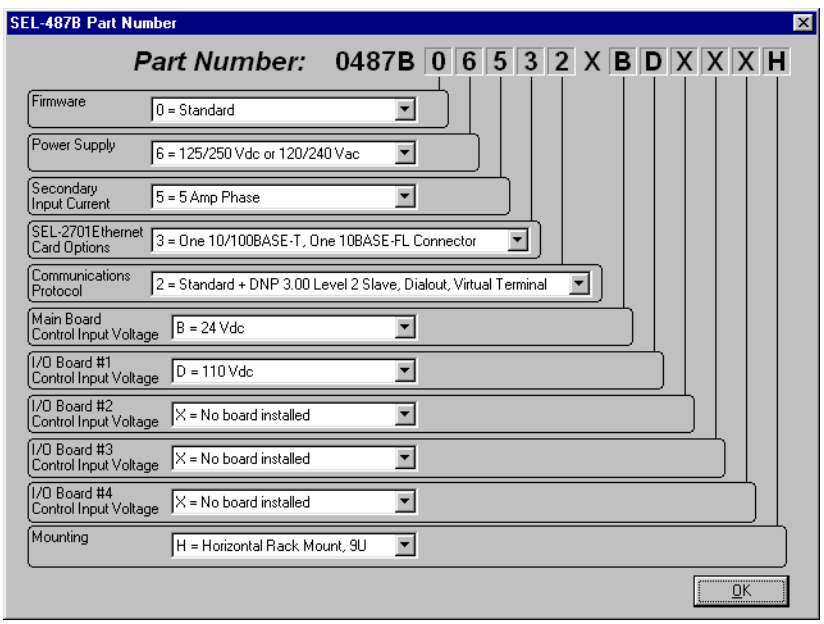


Figure 3.15 Setting the Relay Part Number in ACSELERATOR

Ellipsis Button

ACSELERATOR includes a feature called an **Ellipsis Button** (see *Figure 3.16*).

Figure 3.16 Ellipsis Button

The **Ellipsis Button** is a square button with three dots, as shown in *Figure 3.17*. Use the **Ellipsis Button** to build expressions or assist with entering settings in the relay. Whether the **Ellipsis Button** is an expression builder or a setting assistant depends on the selected relay function and is preprogrammed in the relay. For example, *Figure 3.17* shows the **Ellipsis Button** as a setting assistant, entering settings for the SER.

Step 1. Enter the SER settings by clicking on the **Report > SER Settings** in the **Tree View**.

Step 2. Click on the **SITM1 SER Points and Alias, Point 1** ellipsis button, which makes the **R1-SITM1** window available.

Step 3. Click on the Relay Word bit ellipsis button in the **R1-SITM1** window.

The software displays a list of Relay Word bits available in the relay that you can select to enter in the SER report.

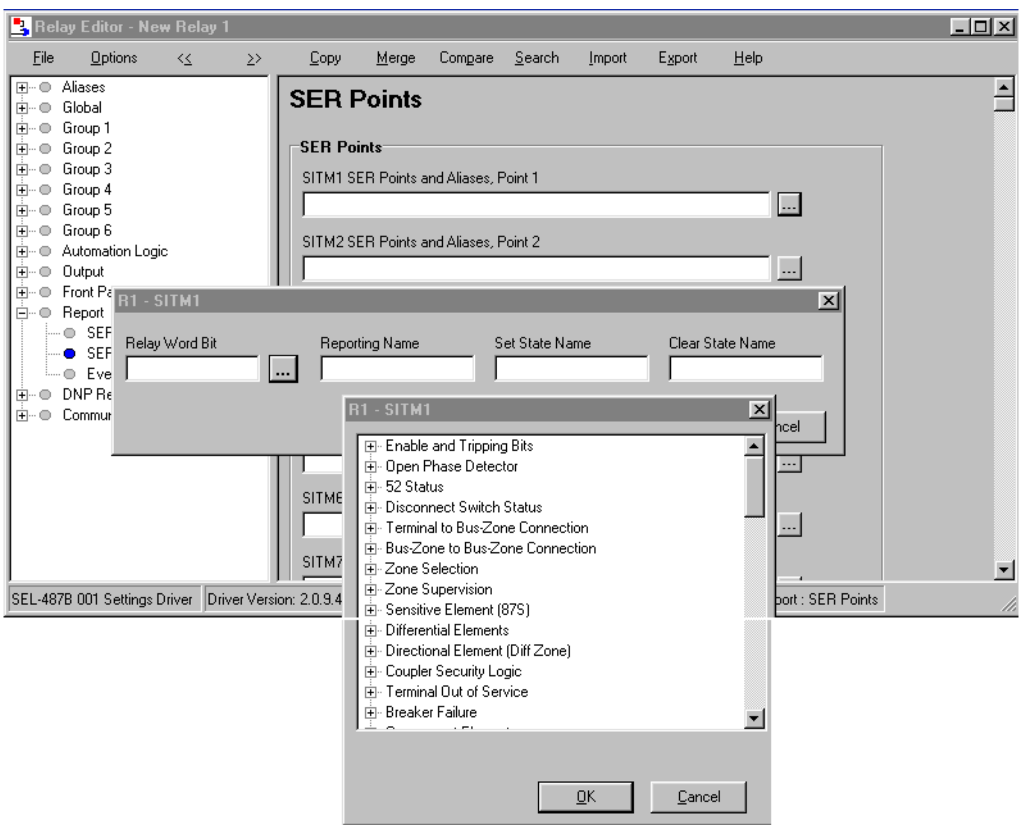


Figure 3.17 Location of Ellipsis Button

Expression Builder

The **Ellipsis Button** also includes an 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. ACSELERATOR 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.

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 control equation settings; see *Fixed SELOGIC Control Equations on page R.2.4*.) *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's left and right sides.

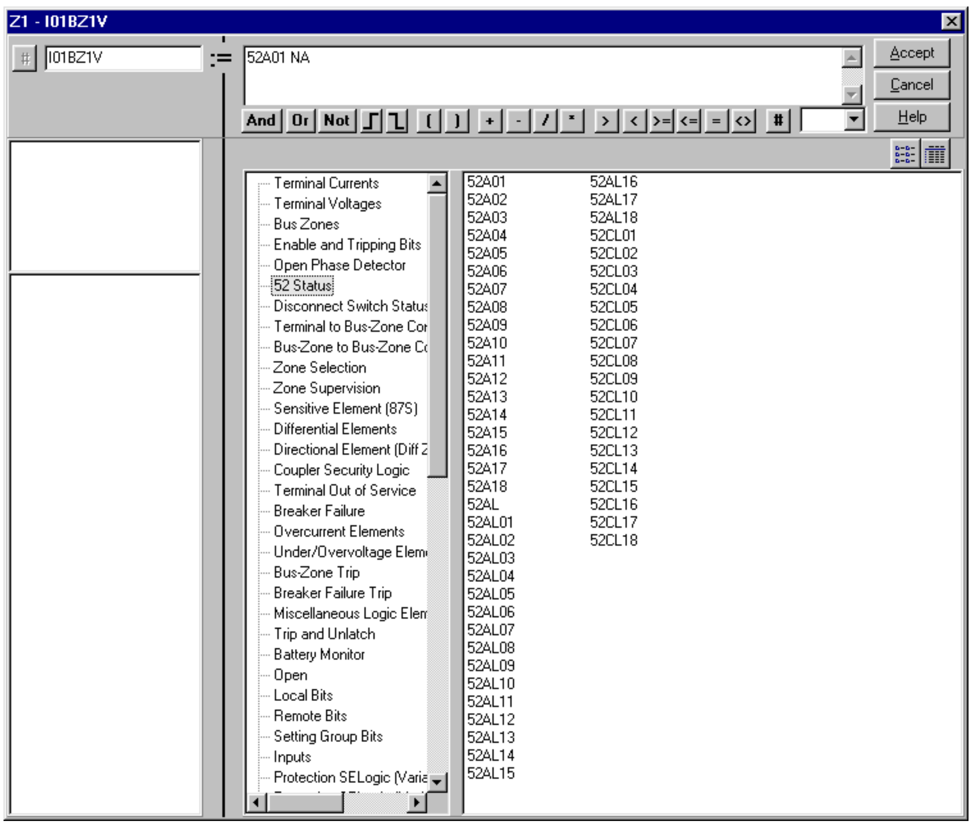


Figure 3.18 ACSELERATOR Expression Builder

Using the Expression Builder

Step 1. For Protection Free-Form SELOGIC and Automation Free-Form SELOGIC control equations, select the type of result (LVALUE) for the SELOGIC control equation to use the **Expression Builder**.

ACSELERATOR shows Relay Word bits available for use in compiling expressions. The program shows the relay elements for each type of SELOGIC control equation (e.g., Boolean Variables, Math Variables).

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.

Step 2. Select a category in the RVALUE tree view.

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 2: SELOGIC Control Equation Programming in the Reference Manual*.

Analyze Events

Each SEL-487B provides event reports for analysis with oscillography software such as the SEL-5601 Analytic Assistant product. For stations with more that six terminals, the busbar protection requires three SEL-487B relays. Except for single-phase faults, all other faults involve at least two SEL-487B relays. For example, an A-phase to B-phase fault operates the differential element in the A-phase relay, as well as the differential element in the B-phase relay. For post-fault analysis, we need to consider two different event reports from two different relays. With the SEL-5601 Analytic Assistant, you can display events from three different relays in one window to make the fault analysis easier and more meaningful. Because the three different relays time-stamp the events with values from their individual clocks, we need to time-synchronize the three SEL-487B relays.

Time Synchronization

Each SEL-487B provides two IRIG-B connectors, labeled IN and OUT. Referring to the external source connections in *Figure 3.19*, connect the IRIG-B signals to the IN connection of Relay A to update the clock of Relay A. Connect the OUT connection of Relay A to the IN connector of Relay B to update the clock in Relay B. A similar connection between Relay B and Relay C updates the time in Relay C.

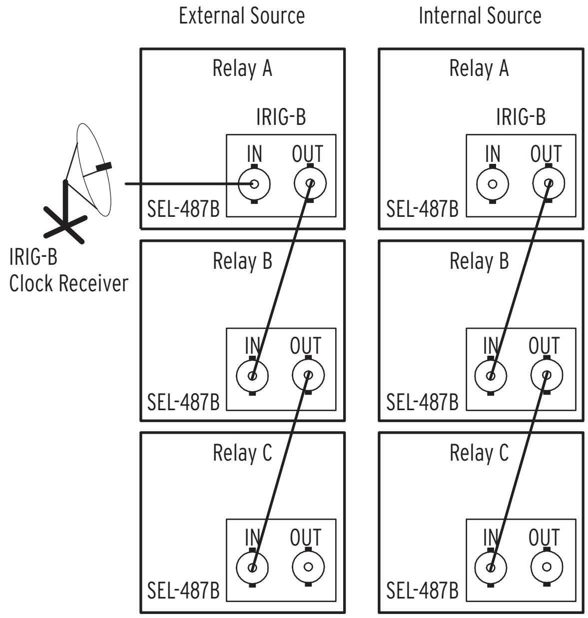


Figure 3.19 Time Synchronization Connections Between Three Relays

In the absence of an external IRIG-B signal, connect the relays as shown by the internal source connections in *Figure 3.19*. When connected this way, Relay B uses the clock of Relay A as time reference, and Relay C uses the clock of Relay B as time reference.

Because the event reports from the three relays could have the same number, be sure to enter a unique name for the RID setting of each relay. For example, at Eiger substation, label the three relays (Global settings) as follows:

Relay 1: SID = EIGER 275 KV BUSZONE, RID = A-PHASE

Relay 2: SID = EIGER 275 KV BUSZONE, RID = B-PHASE

Relay 3: SID = EIGER 275 KV BUSZONE, RID = C-PHASE

Assume a three-phase busbar fault occurs at the station. The following example shows how to download the event reports from the three relays and how to combine the three event reports into a single event report.

In this example we will do the following:

1. Use ACSELERATOR to identify the event reports of interest in each of the three relays.
2. Download the event reports from the relay.
3. Launch the SEL-5601 Analytic Assistant from ACSELERATOR.
4. Select as many as three events for analysis.
5. Select the analog channels and digital Relay Word bits from each of the three events.
6. Combine these selections into a single event report.

The following are the specific steps to download the event reports from three relays and to combine those reports into a single event report.

Step 1. Connect the communications cable to the A-phase relay.

Step 2. Launch ACSELERATOR.

Step 3. Establish communications with the A-phase relay.

Step 4. Select **Analysis > View Event History**.

The software reads the available event reports as shown in *Figure 3.20*.

> **NOTE:** 24 and 12 samples/cycle events cannot be combined.

Step 5. Select the event report of interest from the available event reports in the relay.

Step 6. Select the type of event (12 samples/cycle or 24 samples/cycle) you want to download from the relay from the **Event Options**.

Step 7. After selecting the event type, press the **Get** button to retrieve the event.

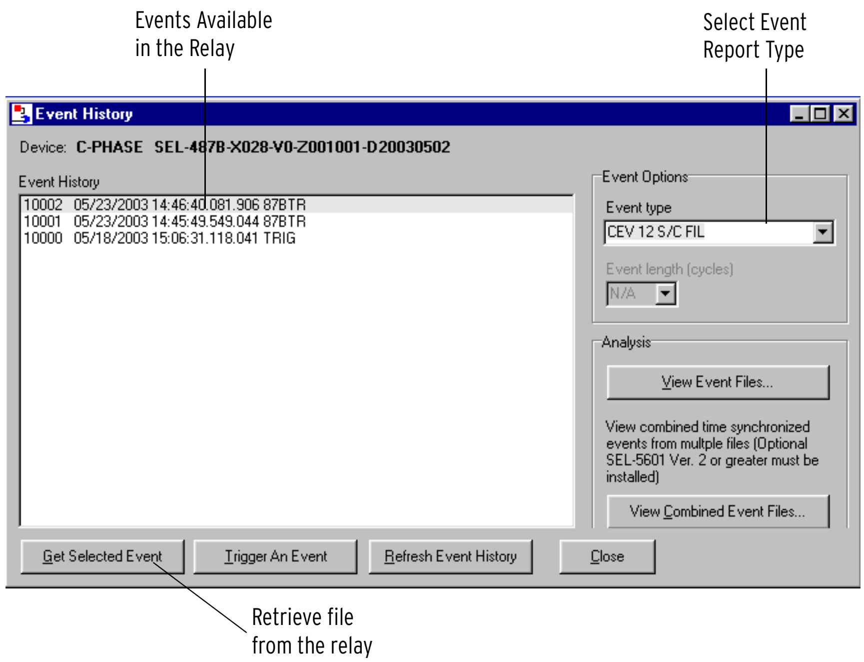


Figure 3.20 Screen for Retrieving Event Reports From the Relay

In this example, we select **Event Report 10003** and **12 samples/cycle event** type.

After pressing the **Get** button, the software downloads the event report to temporary memory and displays the screen as shown in *Figure 3.21*.

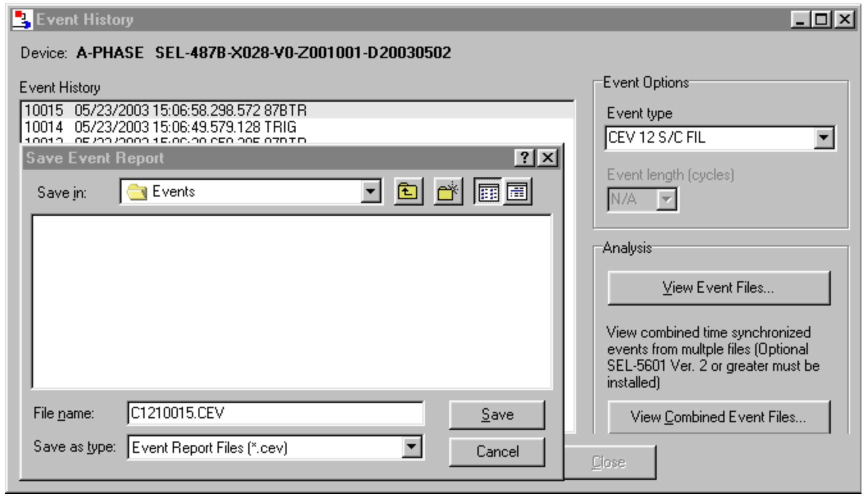


Figure 3.21 Event Report 10003 at 12 Samples/Cycle Selected for Download

The software selects the default events directory in which to save the event report.

Step 8. To avoid confusion between the three event reports from the three relays, change the file name from **C1210015.CEV** to a more descriptive name.

Figure 3.21 shows an example with the file name changed from **C1210015.CEV** to **A-PHASE_12-10015.CEV**.

Step 9. Press the **Save** button to save the file.

Step 10. Connect the communications cable to the B-phase relay.

Step 11. Ensure that the communication parameters are set properly.

Step 12. Press the **Refresh** button.

The software lists the available event reports in the B-phase relay from which you can select the event of interest.

Step 13. Change the file name to **B-PHASE_12-10001.CEV**.

Step 14. Press the **Save** button.

The software saves the file in the same directory as the **A-PHASE_12-10015.CEV** file.

Step 15. Connect the communications cable to the C-phase relay.

Step 16. Ensure that the communication parameters are set properly.

Step 17. Press the **Refresh** button.

The software lists the available event reports in the C-phase relay from which you can select the event of interest.

Step 18. Change the file name to **C-PHASE_12-10002.CEV.**

Step 19. Press the **Save** button.

The software saves the file in the same directory as the **A-PHASE_12-10015.CEV** file and the **B-PHASE_12-10001.CEV** file.

The three event reports from the three different relays are now retrieved and are available for analysis.

Step 20. Select the **View Combined Events** files to combine the three event reports into one event, as shown in *Figure 3.22*.

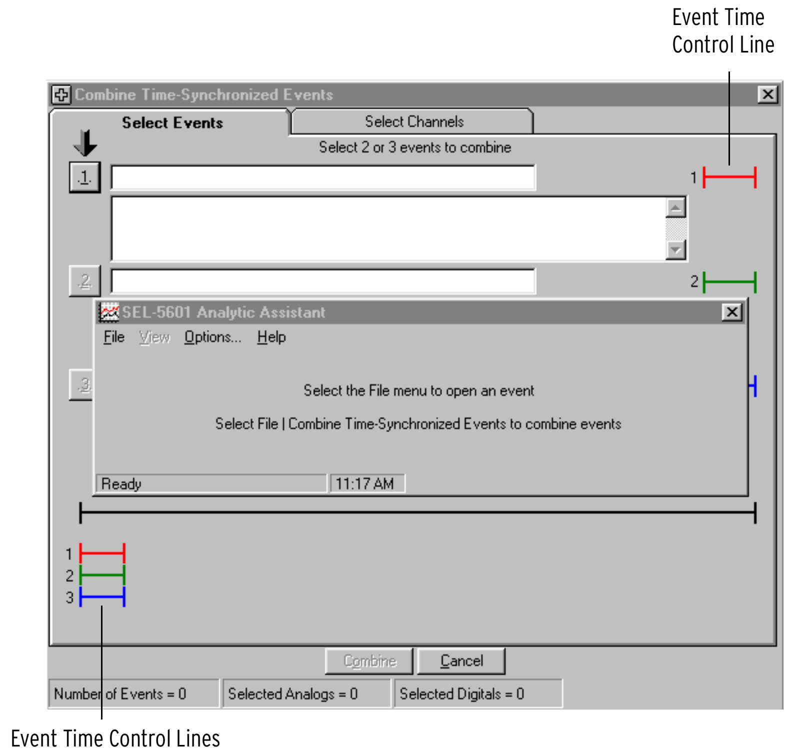


Figure 3.22 Combine Time-Synchronized Events Submenu Screen

Three placeholders are available for as many as three events. Next to each placeholder is a color-coded horizontal line called an event time control line. These event time control lines also appear at the bottom of the screen where they show the relative overall time relationship between the events, the trigger time of each event, and the number of cycles of each event. The event time control lines are color-coded with red (Event 1) on top, green (Event 2) in the center, and blue (Event 3) at the bottom. A flashing arrow points to a button for Event 1.

Step 21. Click on the button for Event 1.

The software selects the directory where you last stored an event report.

Step 22. Click on the event you want to analyze.

Step 23. Click on the **Open** button, as shown in *Figure 3.23*.

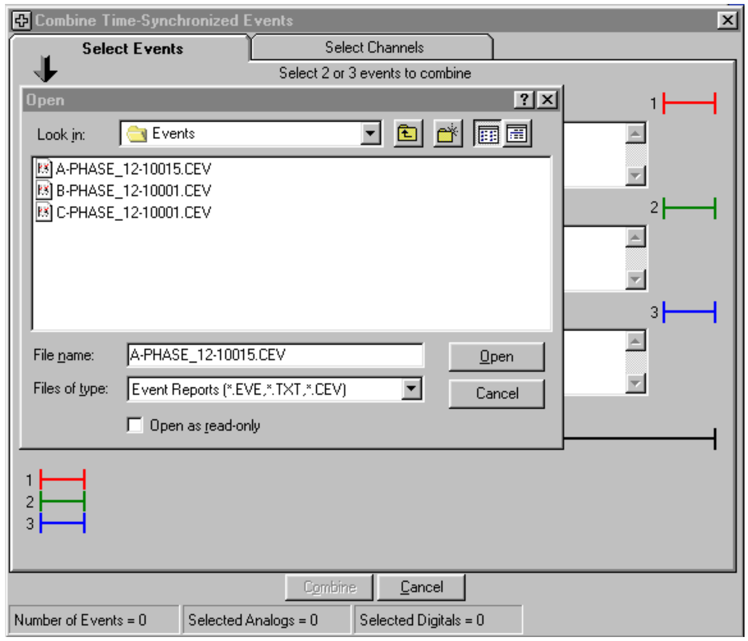


Figure 3.23 Selection of the First Event Report

The software reads the selected event report and places the event report in the first placeholder, as shown in *Figure 3.24*.

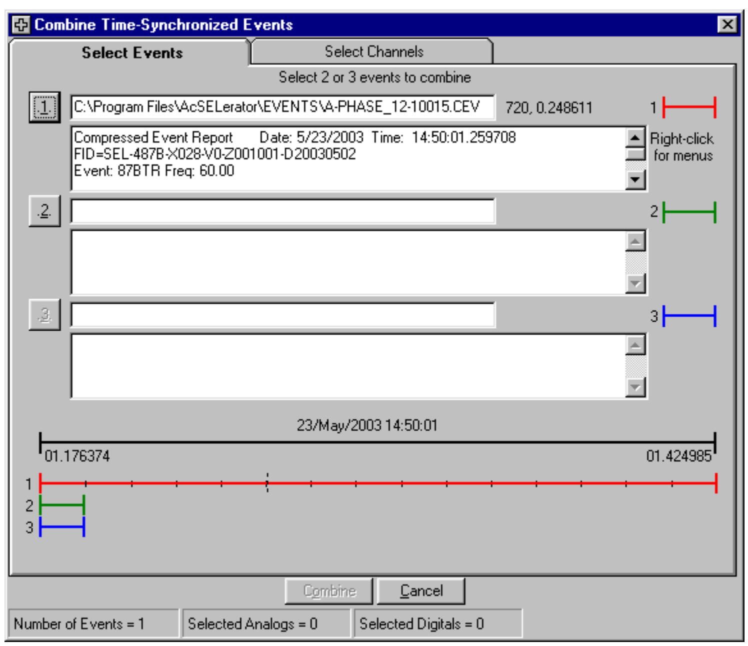


Figure 3.24 First Event of the Analysis

Notice that the actual event control line of the first events now appears at the bottom of the screen and becomes the reference time position. All other events must overlap the reference time position by at least one data point. The software positions the subsequent events relative to the position of the first event.

If the subsequent event does not overlap the first event by at least one data point, the software does not allow the events to be combined.

Step 24. Click on the button for Event 2 and repeat the steps described for selecting Event 1.

Step 25. Repeat the steps for Event 3. *Figure 3.25* shows the screen after reading all three events.

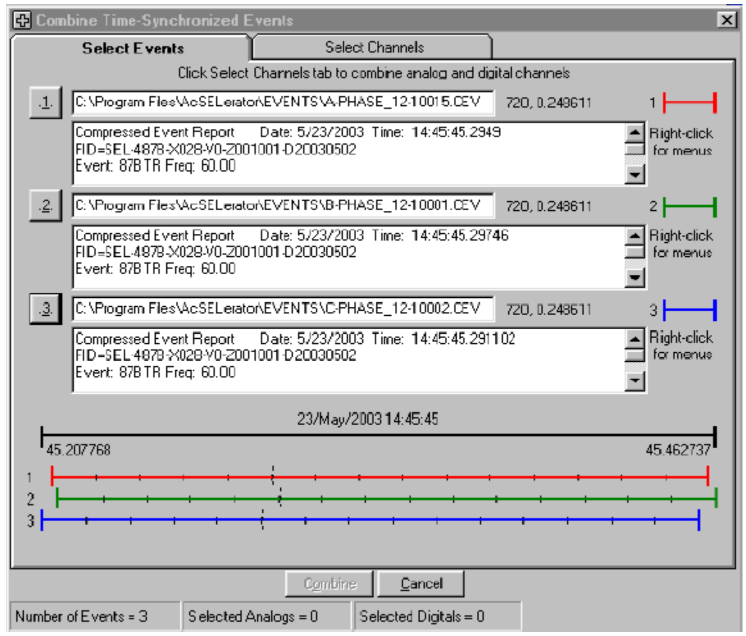


Figure 3.25 Screen After Reading All Three Events

The information displayed at the bottom of the screen shows that we have opened three events but have not as yet selected any analog channels or digital Relay Word bits from these events.

Step 26. Click on the **Select Channels** tab to select analog channels and digital Relay Word bits. *Figure 3.26* shows the screen for selecting the channels.

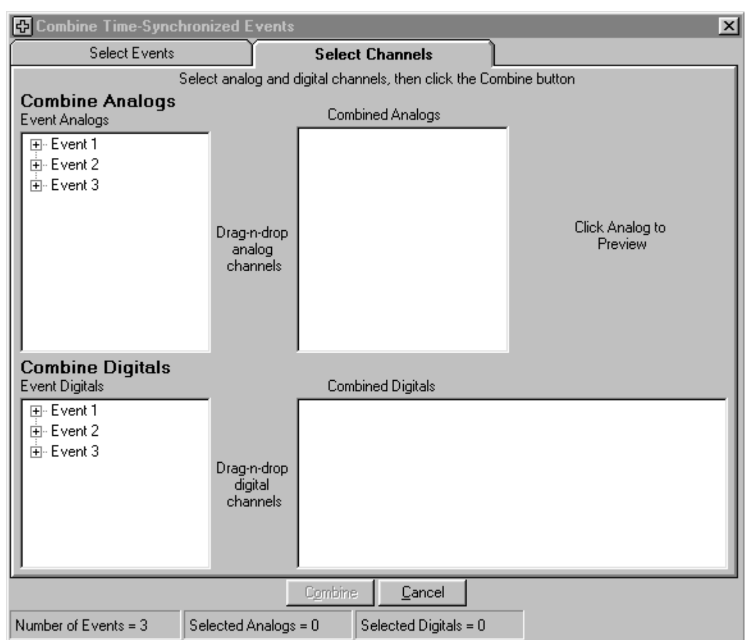


Figure 3.26 Screen for Selecting Analog Channels and Digital Relay Word Bits

The three events appear in the window labeled Event Analogs.

Step 27. Click on the **+** of Event 1 to see a list of the analog channels in the event report.

Step 28. Click on **1_FDR_1(A)**, the first analog channel in the list.

Step 29. A trace of channel **1_ FDR _1** appears on the right hand window next to the **Combined Analogs** list.

Step 30. Right click on channel **1_ FDR _1**.

Step 31. Hold the mouse button down.

Step 32. Drag the cursor to the **Combined Analogs** window.

Alternatively, press the **A** key to add the selected channel to the list.

Step 33. Release the mouse button to complete the transfer of channel 1_ FDR _1 from the **Event Analogs** window to the **Combine Analogs** window.

Alternatively, select the channels to be removed and press the **<Delete>** key.

Drag and drop is similarly supported for digital channels.

Step 34. Select a channel.

Step 35. Drop the selection into the **Event Analogs** or **Event Digitals** window to remove channels from the **Combined Analogs** or **Combined Digitals** windows.

Figure 3.27 shows the screen with Analog Channel **1_ FDR _1** from Event Report 1, **2_ FDR _1** from Event Report 2, and **3_ FDR _1** from Event Report 3 selected for analysis and appearing in the **Combined Analogs** window.

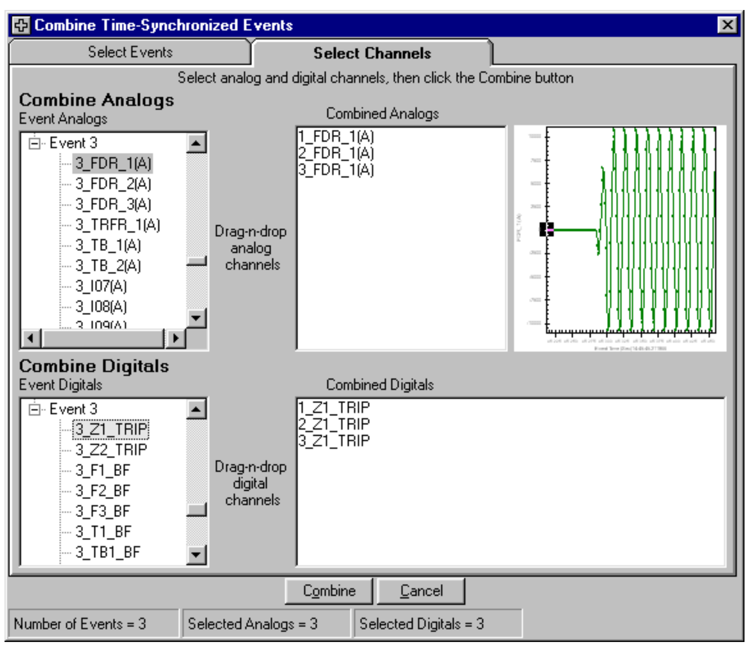


Figure 3.27 Selection of Analog Channels and Digital Relay Word Bits

Figure 3.27 also shows the differential element from each event report: **Relay Word bit 1_Z1_TRIP** from Event Report 1, **Relay Word bit, 2_ Z1_TRIP** from Event Report 2, and **Relay Word bit, 3_ Z1_TRIP** from Event Report 3.

Step 36. Click on the **Combine** button to create a single, combined report comprising the selected analog and digital selections from three individual event reports.

Step 37. On the graph preference form, select the values of interest from the **Analogs** window.

Step 38. Drop these selections in any one of the six available **Axis** windows.

You can select up to 12 analog channels.

Figure 3.28 shows an example after selecting all three analog channels on Axis 1 for analysis.

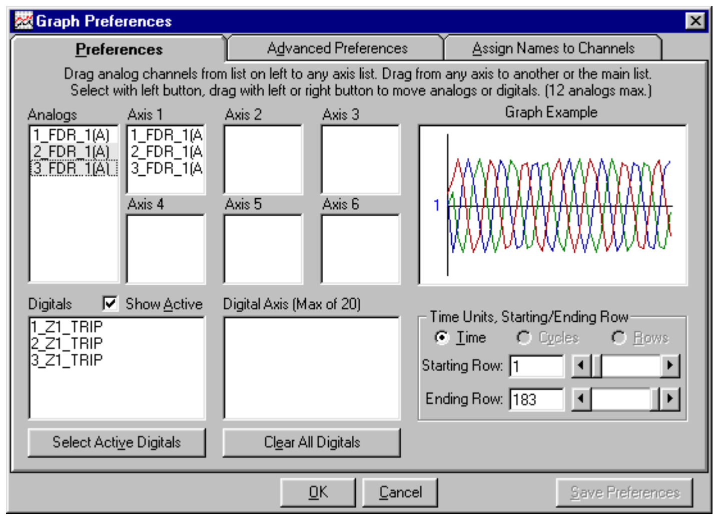


Figure 3.28 Data From Three Separate Event Reports Combined in a Single Report

Step 39. Click **OK** to view the report.

The software displays the three traces on the same screen, as shown in *Figure 3.29*.

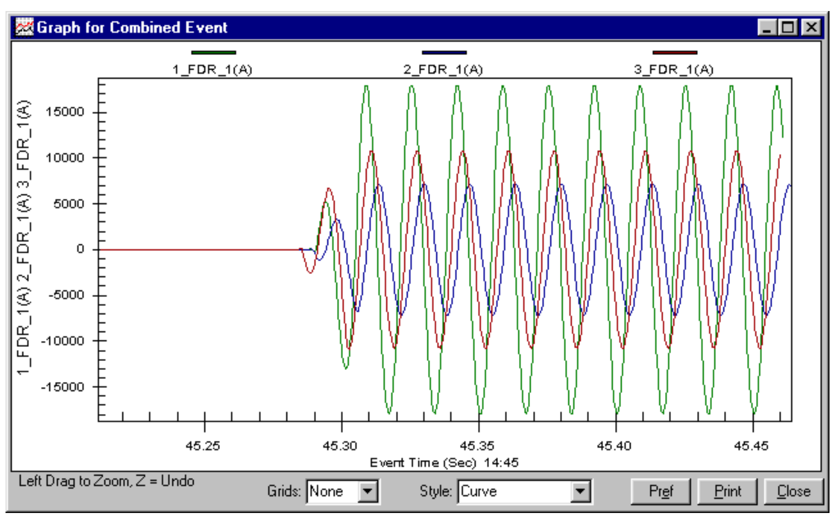


Figure 3.29 Traces of the Three Analog Channels

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Section 4

Basic Relay Operations

Overview

The SEL-487B Relay is a powerful tool for power system protection and control. Understanding basic relay operation principles will help you use the relay effectively using the front panel and a computer terminal emulation program. See *Section 3: PC Software* for information about the ACSELERATOR QuickSet® SEL-5030 software.

This section presents the fundamental knowledge you need to operate the SEL-487B 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 event reports and SER (Sequential Events Recorder)
- Operating the relay inputs and outputs
- Configuring 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-487B Relay
- Printed volume of the SEL-487B Relay *User's Guide* (on request)
- CD-ROM containing the electronic version of the SEL-487B Relay Instruction Manual and the Customer Label Templates

- ➤ CD-ROM containing ACSELERATOR
- ➤ 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-487B. 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-487B. 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 when 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.

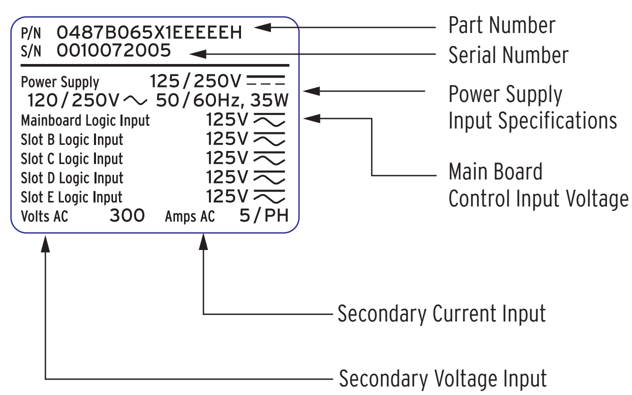

Figure 4.1 SEL-487B Serial Number Label

This example serial number label is for a 5 A secondary current input relay. For information on CT and PT inputs, see *Secondary Circuits on page U.2.7*.

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. 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 170 VA for ac inputs. See *Power Supply on page U.1.11* for more information on power supply specifications.

The part number lists the relay composition and ordering options (see the SEL website at www.selinc.com for more Model Option Table detail).

Connecting and Applying Power

Connect external power to the SEL-487B to perform the initial checkout and familiarization procedures in this section. For complete information on power connections, see *Power Connections on page U.2.30*. *Figure 4.2* shows the portion of the relay rear panel where you connect the power input.

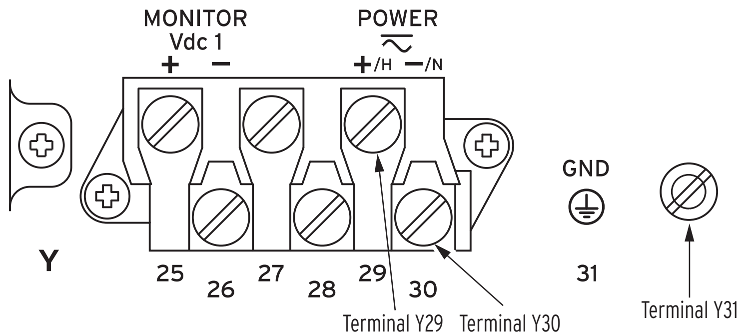

Figure 4.2 Power Connection Areas of the Rear Panel

Always attach a safety ground as the first connection you make to the SEL-487B. You must connect the grounding terminal (#Y31) next to the symbol labeled **GND** on the rear panel to the rack grounding bar for proper safety and performance.

You can order the SEL-487B 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 or 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	85–140 Vac <170 VA
125/250 Vdc	85–300 Vdc <35 W	85–264 Vac <180 VA

Use 16 AWG (1.5 mm^2) wire (or thicker) 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 #Y29) and – (Terminal #Y30) 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 power supply operates from 30 to 120 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-487B front panel, see *Section 5: Front-Panel Operations*.

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.5.4*.

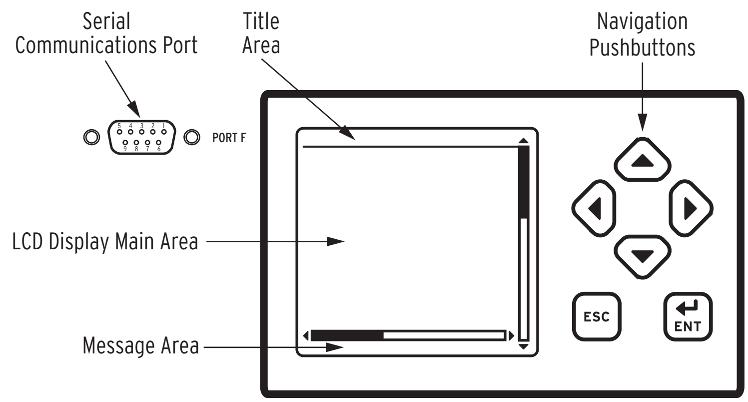

Figure 4.3 PORT F, LCD Display, and Navigation Pushbuttons

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 computer terminal emulation. These programs are inexpensive and widely available. Use the cable connections appropriate for your terminal configuration. See *Section 3: 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 lowercase characters without distinction, except in passwords, which are case sensitive. For a list of ASCII commands see *Section 7: ASCII Command Reference in the Reference Manual*.

Help

When you are using a computer 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 an SEL serial cable to connect to the SEL-487B. Use SEL Cable C234A to connect a 9-pin computer serial port to the SEL-487B. Use SEL Cable C227A to connect a 25-pin computer serial port to the relay. See *Section 3: 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-487B 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-487B communications port settings are listed in *Table 4.2*.

a. Set your computer terminal emulation program to the parameters in the Default column.

b. Set the computer 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)	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.

a. Press the **<Enter>** key on the computer keyboard to confirm that you can communicate with the relay.

You will see the = prompt at the left side of your computer screen (column 1).

b. 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 computer terminal emulation program.

Step 6. View the relay report header.

a. Type **QUIT <Enter>**.

You will see a computer screen display similar to *Figure 4.4*.

b. 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: 2003001234

=
```

Figure 4.4 Report Header

When you communicate with the relay at the = prompt, you are in 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 on page U.4.6*.

Changing the Default Passwords

NOTE: Perform the password-change steps described in Changing the Default Passwords: Terminal on page U.4.9.

It is extremely important that you change the factory default passwords programmed in the SEL-487B. 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-487B and includes an example for changing the default passwords.

Access Levels

Access levels control whether you can perform different operations within the SEL-487B. These security levels are labeled 0, 1, B, P, A, O, 2, and C. *Figure 4.5* presents an overview of the general access level structure in the relay.

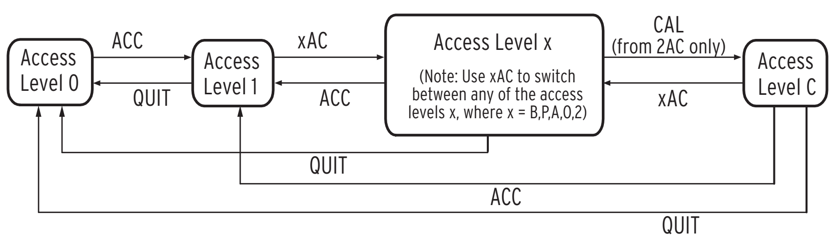

Figure 4.5 Access Level Structure

Access Level 0 is the least secure and most limited access level, and Access Level 2 is the most secure level where you have total relay functionality. (Access Level C is reserved for SEL factory operations. Only go to Access Level C to change the Level C password or under the direction of an SEL employee.) 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-487B.

Table 4.3 SEL-487B Access Levels (Sheet 1 of 2)

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.
P	P=>	Access Level B functions plus protection settings.
A	A=>	Access Level B functions plus automation settings.

Table 4.3 SEL-487B Access Levels (Sheet 2 of 2)

Access Level	Prompt	Allowed Operations
O	0=>	Access Level B functions plus output settings.
2	=>>	Perform all relay access level functions.
C	==>>	SEL calibration-specific functions. For a list of commands available, contact SEL.

The SEL-487B 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* 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
C	**CAL**	Sel-1

Communications Ports Access Levels

⚠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.

Entrance to the higher security levels is sequential. 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, 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.

To enter Access Level C, you must enter a correct password from Access Level 2.

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, use the access level commands and passwords to log in to that previous access level.

When a connection with the SEL-487B times out, the relay reduces the access level to Access Level 0 for that communications port connection.

The MAXACC port setting can be used to limit the maximum access level permitted on a port. This can be useful to restrict what remote users can do.

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, 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.5.13*.) 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 6: ASCII Command Reference in the Reference Manual for more information.

Use the **ACCESS** command to change to Access Level 1. Passwords are case sensitive; enter a password exactly as set. If you enter the password correctly, the SEL-487B moves you to Access Level 1 from Access Level 0. The Access Level 1 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* to enter access levels above Access Level 1. For example, use the **2ACCESS** command to change to Access Level 2. If you are presently at Access Level 1, B, P, A, or O, type **2AC <Enter>**. The SEL-487B prompts you to type the Access Level 2 password. If the present level is Access Level 0, the SEL-487B responds with the following:

```
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-487B asserts the SALARM and BADPASS Relay Word bits and displays this error message on a communications terminal screen:

```
WARNING: ACCESS BY UNAUTHORIZED PERSONS STRICTLY PROHIBITED
```

In addition, you cannot make further access level entry attempts for 30 seconds.

The relay will also terminate the communications connection after the third failed password entry attempt when you use any of the following communications modes: Ethernet via an Ethernet card, DNP3 (Distributed Network Protocol Version 3.0), and MIRRORED BITS® communications virtual terminal mode. For more information on these protocols, see *Section 4: SEL Communications Protocols in the Reference Manual* and *Section 5: DNP3 Communications in the Reference Manual*.

If your connection to the SEL-487B has a valid inactivity time-out setting other than OFF (in the **SET P** port settings), the SEL-487B automatically closes the communications connection and changes to Access Level 0 when the timeout occurs.

⚠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.

Valid passwords are character sequences of as many as 12 characters. Valid password characters are any printable ASCII character. HMI password entry is limited to upper- and lower-case letters, numbers, underscore, and period, so you must limit your password to these characters if you need to do privileged operations from the front panel. Passwords are case sensitive.

It is important that you change all of the passwords from their default values. This will protect you from unauthorized access.

Use strong passwords. These contain a mix of valid password characters in a combination that does not spell common words in any portion of the password.

Changing the Default Passwords: Terminal

Step 1. Confirm that the relay is operating.

See *Connecting and Applying Power on page U.4.3*.

Step 2. Establish communication with the SEL-487B (see *Making an EIA-232 Serial Port Connection on page U.4.5* to learn how to use a computer terminal to communicate with the relay).

Step 3. Prepare to control the relay at Access Level C (Access Level 2 is sufficient except when changing Access Level C password).

a. Type **ACC <Enter>** at a communications terminal.

b. Type **OTTER <Enter>** (Access Level 1).

You will see the => prompt.

c. Type **2AC <Enter>**.

d. At the password prompt, type **TAIL <Enter>**.

e. Type **CAL <Enter>**.

f. At the password prompt, type **Sel-1 <Enter>**.

You will see the Access Level C ==>> prompt.

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

Step 4. Set a new password for Access Level 2.

a. Type **PAS 2 nE2Pw- <Enter>**.

nE2Pw- is the new strong password. The relay will display the following:

```
Set
=>>
```

Step 5. Set new passwords for each access level.

a. In a similar manner as the previous step, create new strong passwords for each access level.

b. 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 with the following:

```
Set

=>>
```

If you used the DISABLE parameter, the relay responds with the following message:

```
Password Disabled

=>>
```

If you forget a password, or encounter difficulty changing the default passwords in *Changing the Default Passwords: Terminal on page U.4.9*, you can temporarily disable password verification. See *Jumpers on page U.2.16* for information on the password disable jumper J18B.

Checking Relay Status

With continual self-testing the SEL-487B 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.6.34*.

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

Computer Terminal

The procedure in the following steps assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 2. Type **STA <Enter>**. The relay returns a status terminal screen similar to that in *Figure 4.6*.

```
=>>STA <Enter>

Busbar Protection                            Date: 07/24/2003  Time: 15:32:45.492
Atlantis                                     Serial Number: 0000000001

FID=SEL-487B-R102-V0-Z001001-D20030724 CID=0xd930
Failures
  No Failures

Warnings
  No Warnings

SELogic Relay Programming Environment Errors
  No Errors
Relay Enabled

=>>
```

Figure 4.6 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.7.40*.

Front Panel

Use the front-panel display and navigation pushbuttons to check SEL-487B status. See *Section 5: Front-Panel Operations* for information on using the relay front panel.

Step 1. Apply 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. Press the {ENT} pushbutton to display the MAIN MENU shown in *Figure 4.7*.

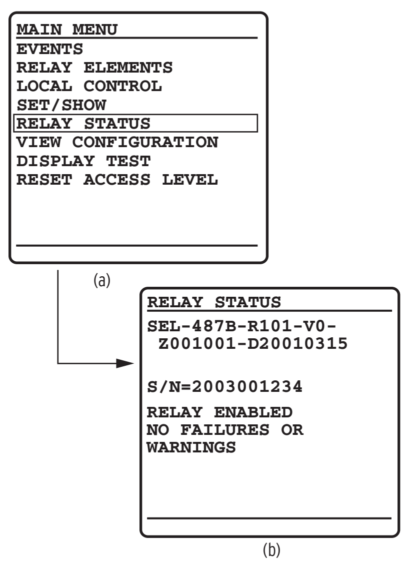

Figure 4.7 Checking Relay Status: Front-Panel LCD

Step 3. View relay status.

a. Press the {Up Arrow} and {Down Arrow} pushbuttons to highlight the RELAY STATUS action item (see *Figure 4.7*).

b. Press the {ENT} pushbutton. You will see the RELAY STATUS screen (the second screen of *Figure 4.7*).

Step 4. Normalize the front-panel display.

a. To return to the MAIN MENU, press the **{ESC}** key.

b. 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.5.29*.

Making Simple Settings Changes

The SEL-487B 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.

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* for more information on the ACSELERATOR software.

Settings Structure

The SEL-487B 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 4.8* to understand the settings structure in the SEL-487B. 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-487B are listed in *Table 4.5*.

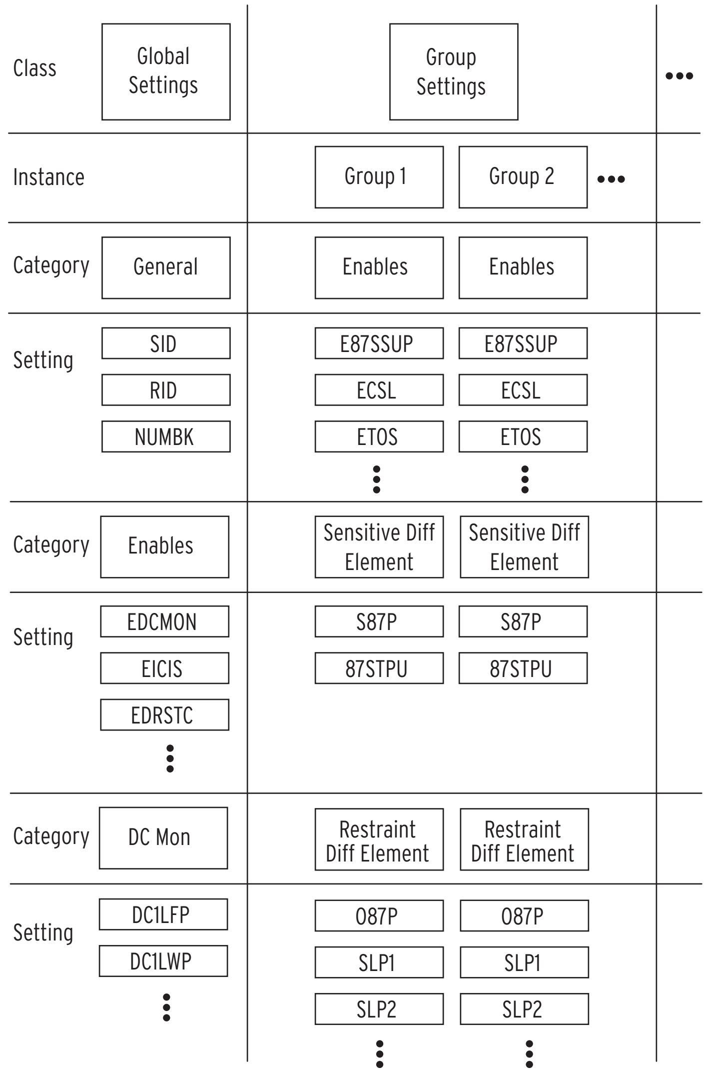

Figure 4.8 Relay Settings Structure Overview

Table 4.5 Settings Classes and Instances (Sheet 1 of 3)

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**

Table 4.5 Settings Classes and Instances (Sheet 2 of 3)

Class	Description	Instance	Description	ASCII Command
Port	Communications port settings	Port F	Front-panel port	**SET P F**
		Port 1	Port 1 settings	**SET P 1**
		• • •	• • •	• • •
		Port 3	Port 3 settings	**SET P 3**
		Port 5	Communications card settings	**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 1 protection SELOGIC control equations	**SET L 1**
		• • •	• • •	• • •
		Group 6	Group 6 protection SELOGIC control equations	**SET L 6**
Automation SELOGIC control equations	Automation-related SELOGIC control equations	Block 1	Block 1 automation SELOGIC control equations	**SET A 1**
		• • •	• • •	• • •
		Block 10	Block 10 automation SELOGIC control equations	**SET A 10**
DNP	Distributed Network Protocol data remapping	DNP		**SET D**

Table 4.5 Settings Classes and Instances (Sheet 3 of 3)

Class	Description	Instance	Description	ASCII Command
Alias	Set aliases	Analog or digital quantities		**SET T**
Zone configuration	Terminal and Bus-zone to Bus-zone connections	Group 1 • • • Group 6	Group 1 zone configuration settings • • • Group 6 zone configuration settings	**SET Z 1** • • • **SET Z 6**
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.3.31.

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*. 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: Computer Terminal

When you change settings (with any **SET** command) from a terminal, the relay shows the setting category, prompt, present value, and prompt. *Figure 4.9* 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 a prompt. You have many options for navigating the settings at the ? prompt. *Table 4.6* lists the operations possible from a settings prompt.

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

General Global Settings                          Category

Station Identifier (40 characters)               Prompt
SID := "Station A"                               Present Value
?<Enter>                                         Prompt
Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>                                         Settings Prompt
Number of Breakers (N, 1-18)     NUMBK   := 5 ?  Prompt
                                                 Present Value
=>
```

Figure 4.9 Components of SET Commands

Table 4.6 Actions at Settings Prompts

Action	Relay Response
<Enter>	Accept setting and move to the next setting; if at the last setting, exit settings.
[value] <Enter>	Enter the given value and move to the next setting if valid; if at the last setting, exit settings.
^ <Enter>	Move to the previous setting; if at the top of settings, stay at the present setting.
< <Enter>	Move to the top of the previous settings category; if at the top of settings, stay at the present setting.
> <Enter>	Move to the top of the next settings category; if in the last category, exit settings.
END <Enter>	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.

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

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 U.4.5* 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 U.4.9* 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. 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.

a. Type **ACC <Enter>** using a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type the **2AC <Enter>** command.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Type **SET G NFREQ <Enter>** to set the nominal system frequency.

The NFREQ setting has options of 50 Hz and 60 Hz.

The relay responds with a terminal screen display similar to the beginning of *Figure 4.10*.

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

Global

General Global Settings

Nominal System Frequency (50,60 Hz)                NFREQ   := 60     ?<Enter>
Date Format (MDY,YMD,DMY)                          DATE_F  := MDY    ?YMD <Enter>

Global Enables

Station DC Battery Monitor (Y,N)                   EDCMON  := N      ?END <Enter>
Global

General Global Settings

SID     := "Station A"
RID     := "Relay 1"
NUMBK   := 5        NUMDS   := N        NFREQ   := 60       DATE_F  := YMD

Global Enables

EDCMON  := N        EICIS   := N        EDRSTC  := N

Control Inputs (Global)

GINPU   := 0.17     GINDO   := 0.17

Settings Group Selection

SS1     := NA
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 4.10 Initial Global Settings

Vertical dots represent the relay information during readback.

Step 3. For a 60 Hz system, press **<Enter>** to accept the NFREQ existing value of 60 (Hz).

The relay presents the next setting, DATE_F (date).

Step 4. Set the date format.

The SEL-487B reports dates in three formats: MDY, YMD, and DMY (where M = month, D = date, and Y = year).

a. Type **YMD <Enter>**.

At each setting in turn, the relay presents the settings prompt, name, present value, and prompt.

b. Type **^ <Enter>** if you make a mistake or want to go backward through the settings.

Refer to *Table 4.6* for this and other navigational aids.

Step 5. End the settings session.

a. Type **END <Enter>** at the `EDCMON` prompt.

The EDCMON remains unchanged. The relay next scrolls a readback of all the Global settings, eventually displaying:

```
Save settings (Y, N) ?
```

b. Examine the settings readback to verify your new settings.

c. Type **Y <Enter>** to save your new settings.

Text-Edit Mode Line Editing

Some SEL-487B 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* 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	Relay Response
<Enter>	Accept the setting and move to the next line; if at the last line or at a blank line, exit settings.
>*n* <Enter>	Move to line *n*. If this is beyond the end of the list, move to a blank line following the last line.
^ <Enter>	Move to the previous line; if at the first line, stay at the present line.
< <Enter>	Move to the first line.
> <Enter>	Move to a blank line following the last line.
LIST <Enter>	List all settings and return to the present prompt.
DELETE *n* <Enter>	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 <Enter>	Insert a blank line at the present location; the present line and subsequent lines shift down.
END <Enter>	Go to the end of the present settings session. Prepare to exit settings via the save settings prompt.
<Ctrl+X>	Abort editing session without saving changes.

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. For this example, we use inputs IN106 and Remote Bit RB01. You can use other inputs for your particular application. See *Control Inputs on page U.2.8* for more information on control inputs.

This procedure assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords; see *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Access the display point settings.

a. Type **SET F <Enter>** to modify the front-panel settings.

b. Type **> <Enter>** repeatedly to advance through the front-panel settings until you reach the Display Points category.

Figure 4.11 shows a representative terminal screen. The relay displays the first line that you can edit.

Step 3. Set Display Point 1.

a. Type **IN106,"Terminal 1",Closed,Open <Enter>** at the Line 1 ? settings prompt 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 prompt (see *Figure 4.11*).

Step 4. Set Display Point 2.

a. Type **RB01,"Message",Received <Enter>** at the Line 2 ? settings prompt, 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 prompt (see *Figure 4.11*.)

Step 5. List active display points.

At the Display Points, use the text-edit mode line editing commands to list the active display points.

a. Type **LIST <Enter>**.

After showing the active display points, the relay returns you to line 3: followed by the ? settings prompt.

Step 6. End the settings session.

a. Type **END <Enter>**.

The relay scrolls a readback of all the Front-Panel settings, eventually displaying the `Save settings (Y, N) ?` prompt. At the end of the readback information, just before the `Save settings (Y, N) ?` prompt, you can verify the new display point information.

b. Type **Y <Enter>** to save the new settings.

```
Front Panel

Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)       FP_TO   := 15     ?> <Enter>

Selectable Screens for the Front Panel

Station Battery Screen (Y,N)                        STA_BAT := N      ?> <Enter>

Display Points
(Boolean): RWB Name,"Label","Set String","Clear String","Text Size"
(Analog): Analog Quantity Name,"User Text and Formatting","Text Size"

1:
?  IN106,"Terminal 1",Closed,Open <Enter>
2:
?  RB01,"Message",Received <Enter>
3:
?  LIST <Enter>

1: IN106,"Terminal 1","Closed","Open",S
2: RB01,"Message","Received",S
3:
?  END <Enter>
Front Panel

Front Panel Settings
.
.
.

Display Points
(Boolean): RWB Name,"Label","Set String","Clear String","Text Size"
(Analog): Analog Quantity Name,"User Text and Formatting","Text Size"

1: IN106,"Terminal 1","Closed","Open",S
2: RB01,"Message","Received",S

Local Control
(Local Bit, Local Name, Local Set State, Local Clear State, Pulse Enable)

1: LB01,"F1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
2: LB02,"F2 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
3: LB03,"F3 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
4: LB04,"T1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
5: LB05,"TB OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N

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

=>>
```

Figure 4.11 Using Text-Edit Mode Line Editing to Set Display Points

The three dotted lines below the Front Panel Settings represent the readback.

This procedure proposes connecting circuit breaker auxiliary contacts from Terminal 1 to input contact IN106 of the main board. In the **SET G** (GLOBAL) command, verify that the debounce time (setting IN106PU and IN106DO) are correct for the circuit breaker auxiliary contact. To enter separate input debounce values, first enable the independent control input settings with setting EICIS. To change the input debounce time, enter these settings:

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

Press the **<Enter>** key repeatedly until you get to the IN106PU setting:

IN106PU := **0.2** Input IN106 De-bounce Pickup Time (0.00–1.00 cycles)

IN106DO := **0.2** Input IN106 De-bounce Dropout Time (0.00–1.00 cycles)

Use the appropriate interface hardware to connect the circuit breaker auxiliary contact to IN106 of the main board. See *Control Inputs on page U.2.8* for more information on SEL-487B 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 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 Terminal 1 and Remote Bit 1. Relay control input IN106 is the Relay Word bit for Terminal 1 display point (see *Making Text-Edit Mode Settings Changes on page U.4.19*). You can use other inputs for your particular application. See *Control Inputs on page U.2.8* 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 U.4.5* 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 U.4.9* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Access the Display Points prompt.

a. Type **SET F <Enter>**.

b. Type **> <Enter>** repeatedly to advance through the front-panel settings until you reach the Display Points category.

Figure 4.12 shows a representative terminal screen. The relay displays the first line that you can edit.

```
=>>SET F <Enter>
Front Panel

Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)        FP_TO   := 15      ?> <Enter>

Selectable Screens for the Front Panel

Station Battery Screen (Y,N)                         STA_BAT := N       ?> <Enter>

Display Points
(Boolean): RWB Name,"Label","Set String","Clear String","Text Size"
(Analog): Analog Quantity Name,"User Text and Formatting","Text Size"

1: IN106,"Terminal 1","Closed","Open",S
?  LIST <Enter>

1: IN106,"Terminal 1","Closed","Open",S
2: RB01,"Message","Received",S

1: IN106,"Terminal 1","Closed","Open",S
?  <Enter>
2: RB01,"Message","Received",S
?  DELETE <Enter>
2:
?  LIST <Enter>

1: IN106,"Terminal 1","Closed","Open",S
2:

?  END <Enter>

Front Panel

Front Panel Settings

.
.
.

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

=>>
```

Figure 4.12 Using Text-Edit Mode Line Editing to Delete a Display Point
A vertical ellipsis represents this scrolling readback.

Step 3. Type **LIST <Enter>** at the `?` prompt to list the present display points.

After showing the active display points, the relay returns you to line `1:` followed by the `?` settings prompt.

Step 4. Type **<Enter>** once to proceed to the line 2 present value and `?` settings prompt.

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

Step 6. Type **LIST <Enter>** to examine the remaining display points.

Former Display Point 2 is eliminated. The relay returns you to line `2:` followed by the `?` settings prompt.

Step 7. Type **END <Enter>** to end the settings process.

The relay next scrolls a readback of all the front-panel settings, eventually displaying the `Save settings (Y, N) ?` prompt.

At the end of the readback information, just before the `Save settings (Y, N) ?` prompt, you can verify the new display point information.

Step 8. Type **Y <Enter>** to save your new settings.

Alias Settings

Rename, or assign up to 200 alias names to any Relay Word bit or analog quantity in the relay. This is very useful when programming using SELOGIC® control equations or analyzing SER and event report data. Assigning alias names is also a text-edit type entry, with the same syntax as the display point entries.

Use the **SHO T** command to view the default settings, as shown in *Figure 4.13*.

```
=>>SHO T <Enter>
Alias

Relay Aliases
(RW Bit,Analog Qty.,Terminal,Bus-Zone, or Check Zone, 7 Char. Alias [0-9 A-Z _])


1: I01,"FDR_1"
2: I02,"FDR_2"
3: I03,"FDR_3"
4: I04,"TRFR_1"
5: I05,"TB_1"
6: I06,"TB_2"
7: BZ1,"BUS_1"
8: BZ2,"BUS_2"
9: FBF01,"F1_BF"
10: FBF02,"F2_BF"
11: FBF03,"F3_BF"
12: FBF04,"T1_BF"
13: FBF05,"TB1_BF"
14: FBF06,"TB2_BF"
15: 87Z1,"Z1_TRIP"
16: 87Z2,"Z2_TRIP"
17: IN101,"F1_BFI"
18: IN102,"F2_BFI"
19: IN103,"F3_BFI"
20: IN104,"T1_BFI"
21: IN105,"TB_BFI"
22: PLT01,"DIFF_EN"
23: PLT02,"BF_EN"
24: PLT03,"TNS_SW"
25: 87ST1,"CTZ1_AN"
26: 87ST2,"CTZ2_AN"
27: SBFTR01,"F1_BFT"
28: SBFTR02,"F2_BFT"
29: SBFTR03,"F3_BFT"
30: SBFTR04,"T1_BFT"
31: SBFTR05,"TB1_BFT"
32: SBFTR06,"TB2_BFT"
33: 87BTR01,"F1_DPT"
34: 87BTR02,"F2_DPT"
35: 87BTR03,"F3_DPT"
36: 87BTR04,"T1_DPT"
37: 87BTR05,"TB1_DPT"
38: 87BTR06,"TB2_DPT"
39: OUT101,"F1_TRIP"
40: OUT102,"F2_TRIP"
41: OUT103,"F3_TRIP"
42: OUT104,"T1_TRIP"
43: OUT105,"TB_TRIP"
44: OUT107,"TEST"
45: OUT108,"ALARM"
46: TLED_1,"87_DIFF"
47: TLED_2,"BK_FAIL"
48: TLED_3,"ZONE_1"
49: TLED_4,"ZONE_2"
50: TLED_5,"ZONE_3"
51: TLED_6,"ZONE_4"
52: TLED_7,"ZONE_5"
53: TLED_8,"ZONE_6"
54: TLED_9,"50_TRIP"
55: TLED_10,"51_TRIP"
56: TLED_11,"CT_ALRM"
57: TLED_12,"87_BLK"
58: TLED_13,"TOS"
59: TLED_14,"89_OIP"
60: TLED_15,"89_ALRM"
61: TLED_16,"PT_ALRM"
62: TLED_17,"27_LED"
63: TLED_18,"59_LED"
64: TLED_19,"V01_ON"
```

```
65: TLED_20,"V02_ON"
66: TLED_21,"V03_ON"
67: TLED_22,"FLT_LED"
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"

=>>
```

Figure 4.13 Default Alias Settings

Making Text-Edit Mode Alias Changes

Assign the alias name THETA to math variable PMV01 and the alias TAN to math variable PMV02. These variables are then used in calculating the tangent of theta, using their alias names in the equation.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Type **SET T <Enter>** to access the alias settings.

Figure 4.14 shows a representative computer terminal screen.

Step 3. Type **> <Enter>** for the relay to display the first line that you can edit.

Step 4. Type **PMV01,THETA <Enter>** at the Line 60 ? settings prompt to set the alias for PMV01.

The relay verifies that this is a valid entry, then responds with the next line prompt 61: followed by the ? settings prompt.

Step 5. Type **PMV02,TAN <Enter>** at the Line 61 ? settings prompt to set the alias for PMV02.

The relay verifies that this is a valid entry, then responds with the next line prompt 62: followed by the ? settings prompt.

Step 6. Type **END <Enter>** to end the settings session.

The relay scrolls a readback of all the front-panel settings, eventually displaying the `Save settings (Y, N) ?` prompt. At the end of the readback information, just before the `Save settings (Y, N) ?` prompt, you can verify the new display point information.

Step 7. Type **Y <Enter>** to save the new settings.

```
=>>SET T <Enter>

Alias

Relay Aliases
(RW Bit, Analog Qty., Terminal, Bus-Zone, or Check Zone, 7 Char. Alias [0-9 A-Z _])

1: IO1,"FDR_1"
?  > <Enter>
62:
?  PMV01,THETA <Enter>
63:
?  PMV02,TAN <Enter>

64:

?  END <Enter>

Alias

Relay Aliases
(RW Bit, Analog Qty., Terminal, Bus-Zone, or Check Zone, 7 Char. Alias [0-9 A-Z _])

1: IO1,"FDR_1"
.
.
.

62: PMV01,"THETA"
63: PMV02,"TAN"

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

=>>
```

Figure 4.14 Using Text-Edit Mode Line Editing to Set Aliases

Three dotted lines below IO1 represent the readback.

Use the alias names, instead of the Relay Word bits, in SELOGIC control equation programming. *Figure 4.15* shows an example of an alias used in protection logic programming.

```
=>>SET L <Enter>

Protection 1

1: PLT01S := PCT02Q AND NOT DIFF_EN # DIFFERENTIAL ENABLED
?  > <Enter>
15:
?  THETA:=IO1FA <Enter>
16:
?  TAN:=SIN(THETA)/COS(THETA) <Enter>
17:
?  END <Enter>
Protection 1
.
.
.

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

=>>
```

Figure 4.15 Using Text-Edit Mode Line Editing to Set Protection Logic

Settings: Front Panel

You can use the relay front panel to enter some of the relay settings. The SEL-487B 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.

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-487B front panel. Refer to *Connecting and Applying Power on page U.4.3* before performing this example.

Step 1. 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. Press the **{ENT}** pushbutton to display the MAIN MENU as shown in *Figure 4.16*.

Step 3. View settings screens.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the SET/SHOW action item (see *Figure 4.16*).

b. Press the **{ENT}** pushbutton.

You will see the SET/SHOW submenu.

Step 4. View the date/time screen.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the DATE/TIME action item.

b. Press the **{ENT}** pushbutton.

The relay next displays the DATE/TIME submenu.

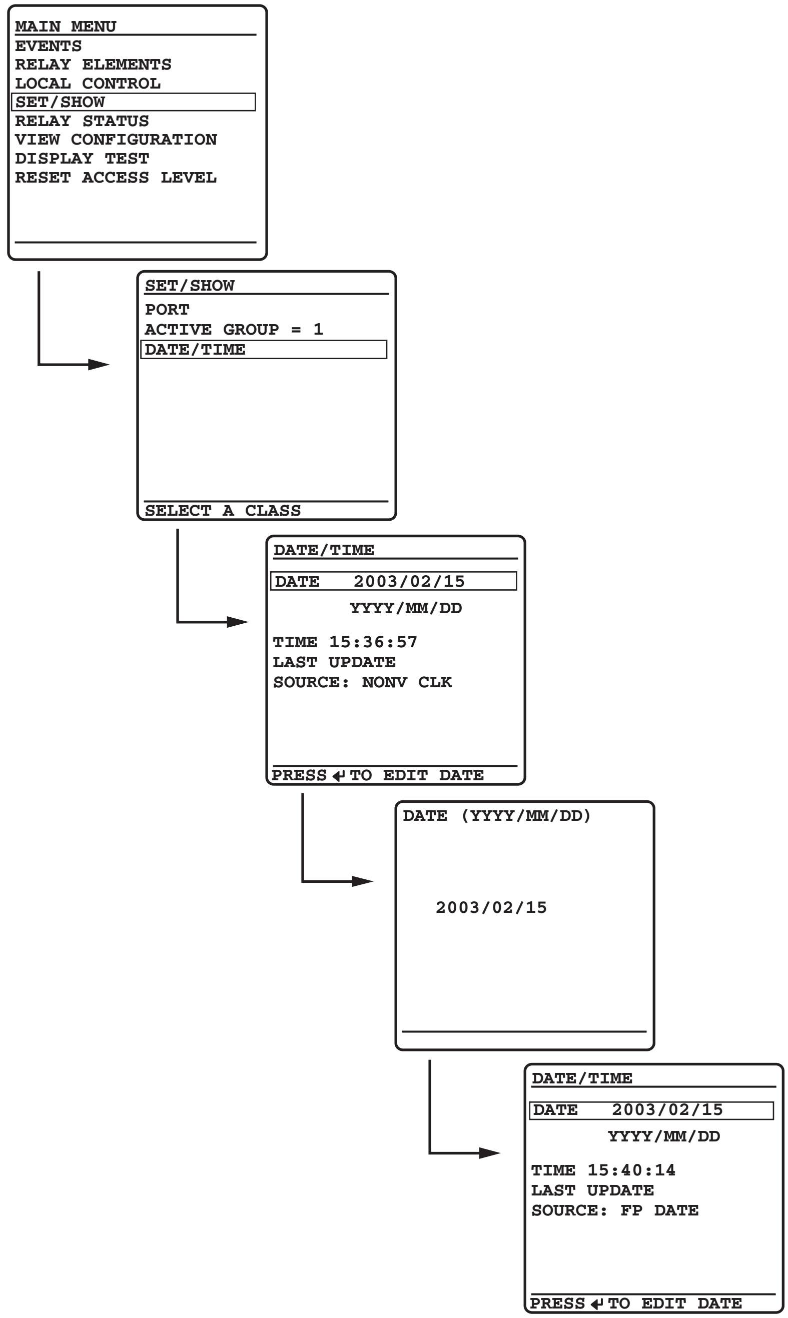

Figure 4.16 DATE and TIME Settings: Front-Panel LCD

Step 5. Set the date.

a. Press the **{ENT}** pushbutton.

The relay shows the second last screen of *Figure 4.16*, the DATE edit screen.

b. Use the **{Up Arrow}** and **{Down Arrow}** pushbuttons to increase and decrease the date position numbers.

c. Move to the next or previous position by using the **{Left Arrow}** and **{Right Arrow}** pushbuttons.

d. 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. Press **{ESC}** repeatedly to normalize the front-panel display.

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 4.17* shows the MAIN MENU.

Step 2. View the settings screens.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the SET/SHOW action item (see *Figure 4.17*).

b. Press the **{ENT}** pushbutton.

You will see the SET/SHOW submenu (the second screen in *Figure 4.17*).

c. Press the **{ENT}** pushbutton.

Step 3. Select Port F.

a. Highlight Port and press the **{ENT}** pushbutton.

Next, the relay displays the Port instances (the third screen of *Figure 4.17*).

b. Move the screen arrow **{Up Arrow}** and **{Down Arrow}** pushbuttons to choose the port you want to configure.

For this example, select Port F and press **{ENT}**.

Step 4. View the Communications Settings category screen.

The relay shows the Port F category screen (the fourth screen of *Figure 4.17*).

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the Communications Settings settings category.

b. Press **{ENT}**.

The relay displays the Communications Settings screen (the fifth screen of *Figure 4.17*).

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 5. Change settings.

a. Highlight the SPEED setting.

b. Press **{ENT}**.

(The relay possibly requires a password here; see *Passwords on page U.4.8* and *Section 5: Front-Panel Operations*.)

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 4.17* indicates the default setting of 9600 (bps).

c. Use the **{Up Arrow}** and **{Down Arrow}** pushbuttons to select a different speed.

d. Press the **{ENT}** pushbutton once you have selected a data speed.

Step 6. End the settings session.

The relay returns to the previous category settings list screen.

a. Press **{ESC}** to return to the categories screen where you see the Save Settings ? prompt.

b. Press **{ENT}** to save the settings.

The relay validates the setting and returns you to the Port screen (the third screen of *Figure 4.17*).

Step 7. Press **{ESC}** repeatedly to return to the MAIN MENU.

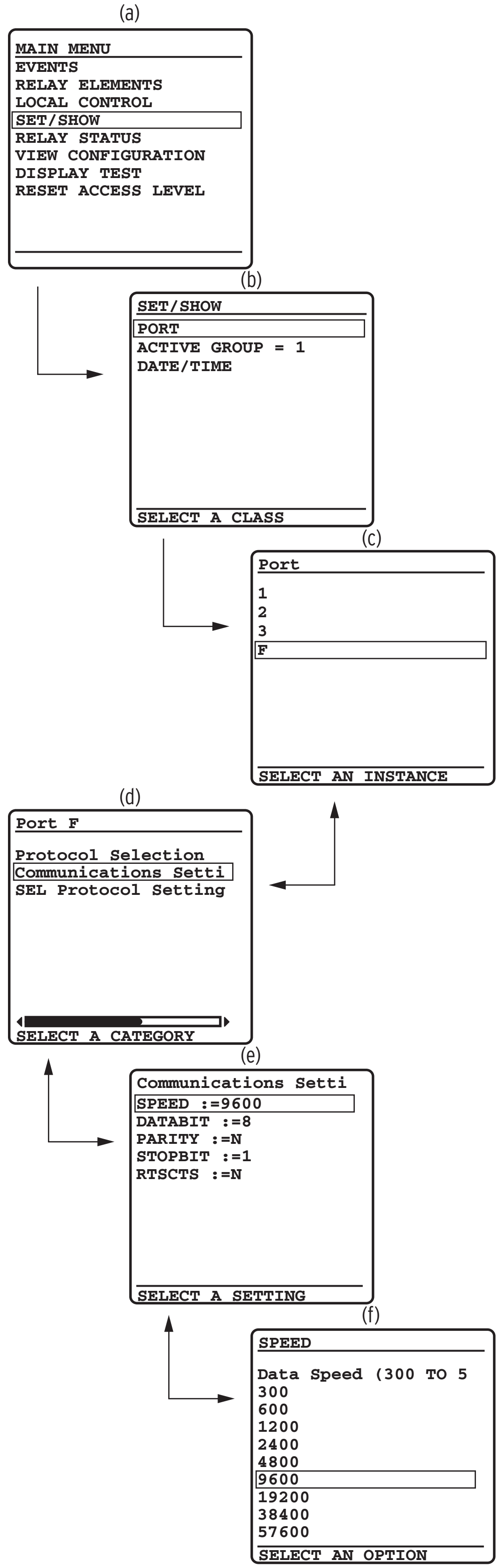

Figure 4.17 Changing a Setting From the Front Panel

Examining Metering Quantities

You can view the SEL-487B metering quantities by using a communications terminal, the ACSELERATOR software, or the front panel. For more information on SEL-487B metering, see *Metering on page A.2.7*.

View Metering: Terminal

The procedure in the following steps shows how to use a computer terminal or computer 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*.

This example assumes that you have successfully established communication with the relay, and that three voltage sources and three current sources are available. In addition, you must be familiar with relay access levels and passwords. See *Changing the Default Passwords: Terminal on page U.4.9* to change the default access level passwords.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Confirm the default CT and PT ratios.

a. Type **SHO Z <Enter>** at the terminal to confirm the Group 1 PTR and CTR settings.

Figure 4.18 shows an extract of the result.

```
=>>SHO Z <Enter>
Zone Config Group 1

Potential Transformer Ratio

PTR1    := 2000     PTR2    := 2000     PTR3    := 2000

Current Transformer Ratio

CTR01   := 600      CTR02   := 600      CTR03   := 600      CTR04   := 600
CTR05   := 600      CTR06   := 600      CTR07   := 600      CTR08   := 600
CTR09   := 600      CTR10   := 600      CTR11   := 600      CTR12   := 600
CTR13   := 600      CTR14   := 600      CTR15   := 600      CTR16   := 600
CTR17   := 600      CTR18   := 600

Zone Configuration: Terminal to Bus-Zone Connections
.
.
.

Current Normalization Factor

TAP01   := 5.00     TAP02   := 5.00     TAP03   := 5.00     TAP04   := 5.00
TAP05   := 5.00     TAP06   := 5.00

=>>
```

Figure 4.18 Confirm Settings With the SHO Z Command

Step 3. Turn relay power off.

Step 4. Connect analog inputs as shown in *Figure 4.19*.

a. Apply 67 V per phase (line-to-neutral) in ABC phase rotation.

b. Insert quantities as shown in *Table 4.8*.

Table 4.8 Quantities for Secondary Injection

Phase	Quantity
IA	$2\angle 0°$
IB	$2\angle -120°$
IC	$2\angle 120°$
VA	$67\angle 0°$
VB	$67\angle -120°$
VC	$67\angle 120°$

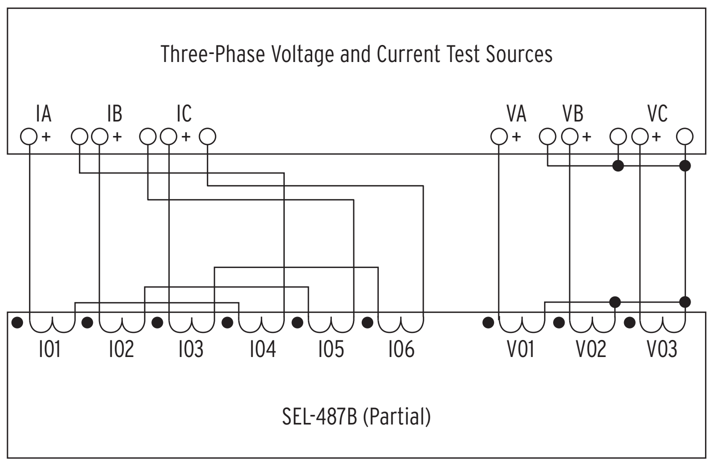

Figure 4.19 Test Connections Using Three Voltage Sources/Three Current Sources

Step 5. Turn relay power on.

Step 6. View metering.

a. Type **ACC <Enter>** to log in to relay Access Level 1.

b. Type your password and press **<Enter>**.

c. Type **MET <Enter>**.

The relay displays the fundamental frequency primary metering information in a manner similar to that shown in *Figure 4.20*.

```
==>>MET <Enter>
Relay 1                                   Date: 05/08/2003  Time: 14:45:57.186
Station A                                 Serial Number: 2003000208

       Primary Currents
Terminal    MAG(A)   ANG(DEG)          Terminal    MAG(A)   ANG(DEG)
 FDR_1     1197.502     0.00            I10         0.000   -69.88
 FDR_2     1197.502  -120.00            I11         0.000   -66.94
 FDR_3     1197.502   120.00            I12         0.000   -69.24
 TRFR_1    1197.502     0.00            I13         0.000   -65.57
 TB_1      1197.502  -120.00            I14         0.000   -66.29
 TB_2      1197.502   120.00            I15         0.000   104.11
 I07          0.000   114.52            I16         0.000   -68.26
 I08          0.000   113.08            I17         0.000   -65.91
 I09          0.000   115.07            I18         0.000   111.67

       Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01        133.991     0.00
 V02        133.991  -120.00
 V03        133.991   120.00

==>>
```

Figure 4.20 Terminal Screen MET Metering Quantities

The metering quantities of *Figure 4.20* are the fundamental primary quantities. Other variants of the **MET** command give different relay metering quantities. See *Metering on page A.2.7* and *METER on page R.7.22* for more information on the **MET** command.

View Metering: Front Panel

View the metering quantities of the SEL-487B on the ROTATING DISPLAY screen of the front-panel display. Metering information available in the relay consists of the following screen(s):

- Station Battery Screen
- Fundamental Voltage and Current Screen
- Differential Metering Screen
- Terminals Associated with Zones Screen

By default, the Fundamental Voltage and Current Screen, Differential Metering Screen, and Terminals Associated with Zones Screen are enabled. To enable the Station Battery Screen, proceed with the following steps.

Step 1. Type **SET F <Enter>**.

Step 2. Type **> <Enter>**.

Step 3. Type **Y** at the prompt, as shown in *Figure 4.21*.

Step 4. Save the settings.

```
=>>SET F <Enter>
Front Panel

Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)       FP_TO   := 15      ?> <Enter>

Selectable Screens for the Front Panel

Station Battery Screen (Y,N)                        STA_BAT := N       ?Y <Enter>
Fundamental Voltage and Current Screen (Y,N)        FUND_VI := Y       ?END <Enter>
Front Panel
.
.
.

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

=>>
```

Figure 4.21 Steps to Enable the Station Battery Front-Panel Display Screen

After applying power to the relay, note that the LCD shows a sequence of screens called the ROTATING DISPLAY. The display shows the display points (if any) and the metering screen. To freeze any one of these screens, press either the {Up Arrow} or {Down Arrow} pushbutton. Further use of the {Up Arrow} and {Down Arrow} pushbuttons allows the viewing of the remaining screens on a per-screen basis.

Metering information is not available on the MAIN MENU screen, only on the ROTATING DISPLAY screen. If you are in the MAIN MENU or other submenus, press the {ESC} pushbutton repeatedly until you reach the ROTATING DISPLAY screen as shown in *Figure 4.22*.

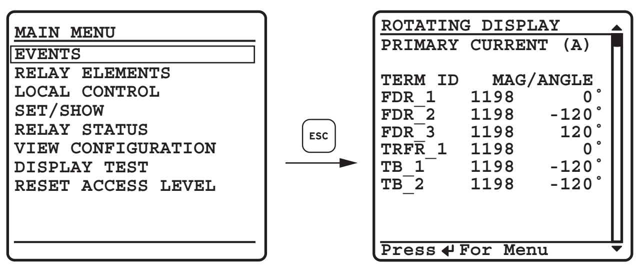

Figure 4.22 Press {ESC} to Go to the Rotating Display When in the Main Menu Display

Reading Event Reports and SER

The SEL-487B has great capabilities for storing and reporting power system events. These include oscillography with a sampling rate of 24 samples per power system cycle, 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 event reports taken from instantaneous raw data or from filtered event report data. Each type of presentation gives you a unique view of the power system. Raw or unfiltered event reports are useful for viewing system transients and dc transients. Filtered event reports 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 raw data event reports, generate a relay event. All event reports use the same event triggering methods. The relay uses five event type sources to initiate a data capture, as shown in *Table 4.9*.

NOTE: 87BTR asserts when any one of Relay Word bits 87BTR01 through 87BTR18 asserts, SBFTR asserts when any one of Relay Word bits SBFTR01 through SBFTR18 asserts, and TRIP asserts when any one of Relay Word bits TRIP01 through TRIP18 asserts.

Table 4.9 The Five Event Type Sources That Initiate a Data Capture in the Relay

Event	Description
87BTR	Rising edge of Relay Word bit 87BTR on or after trigger
SBFTR	Rising edge of Relay Word bit SBFTR on or after trigger
TRIP	Rising edge of Relay Word bit TRIP on or after trigger
ER	Rising edge of ER, the event report trigger
TRI	Execution of the ASCII **TRIGGER** command

Triggering an Event

You can use an event trigger to initiate capturing power system data. The procedure in the following steps shows how to trigger an event capture with the **TRI** command. In this example, the relay uses default parameters to record the event. These parameters are at a pretrigger or prefault recording length (PRE) of 5 cycles and an event report length (LER) of 15 cycles.

This example assumes that you have successfully established communication with the relay. In addition, you should connect secondary test voltages and currents, and set the relay to meter these quantities correctly.

Step 1. Connect voltage and current sources to the relay secondary voltage and secondary current inputs using the connections shown in *View Metering: Terminal on page U.4.31* and *Figure 4.19* and the quantities in *Table 4.8*.

Step 2. Type **TRI <Enter>**.

The relay triggers and captures the power system data.

Reading the Event History

The SEL-487B 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: Terminal Emulation Software

The procedure in the following steps shows how to use the SEL-487B 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 and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 2. Type **HIS <Enter>** to display the event history.

You will see a screen display similar to *Figure 4.23*.

```
=>>HIS <Enter>

Relay 1                                     Date: 02/19/2003  Time: 12:03:49.988
Station A                                   Serial Number: 0000000001

#       DATE        TIME      EVENT  GRP  TARGETS
10000 02/19/2003 11:45:17.256  TRIG    1

=>>
```

Figure 4.23 Sample HIS Command Output: Terminal Emulation Software

For more information on event history, see *Event History on page A.3.27*.

Viewing Event Report Data

The relay stores filtered and unfiltered event reports. Examine either filtered or unfiltered relay event reports to inspect the quantities used when the SEL-487B triggered an event. For more information on event reports, see *Event Report on page A.3.6*. *Table 4.10* shows the types of event report files available in the relay.

Table 4.10 Types of Event Report Files Available in the Relay

Event File Types	Description
E4_10000.TXT	4-sample/cycle filtered ASCII event report
E1210000.TXT	12-sample/cycle filtered ASCII event report
E2410000.TXT	24-sample/cycle raw ASCII event report
D1210000.TXT	12-sample/cycle ASCII differential element report
C1210000.TXT	12-sample/cycle filtered Compressed ASCII event report
C2410000.TXT	24-sample/cycle raw Compressed ASCII event report
Z2410000.TXT	Combination of C2410000.TXT and D1210000.TXT event reports

Retrieving Event Report Data Files: Terminal Emulation Software

NOTE: See FTP Session on page A.5.11 for more information on file retrieval using the Ethernet card.

The relay records the event triggered in *Triggering an Event on page U.4.35* in the EVENTS directory. Follow the procedure in the following steps to retrieve the event report data files for this event. Perform the steps listed in *Triggering an Event* before executing the instructions in this example. For this procedure, use a terminal program capable of Ymodem protocol file transfer.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 2. Type **FILE DIR EVENTS <Enter>** to view the events file directory.

The relay lists file names for recently recorded events in a manner similar to that shown in *Figure 4.24*.

```
=>>FILE DIR EVENTS <Enter>
C1210000.TXT                R   03/05/2003 10:37:23
C2410000.TXT                R   03/05/2003 10:37:23
CHISTORY.TXT                R
D1210000.TXT                R   03/05/2003 10:37:23
E1210000.TXT                R   03/05/2003 10:37:23
E2410000.TXT                R   03/05/2003 10:37:23
E4_10000.TXT                R   03/05/2003 10:37:23
HISTORY.TXT                 R
Z2410000.TXT                R   03/05/2003 10:37:23

=>>
```

Figure 4.24 Sample FILE DIR EVENTS Display

Step 3. Type **FILE READ EVENTS C1210000.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. The steps below are typical file transfer steps:

a. Specify the destination file location in your computer file storage system and file name.

b. Select the transfer type as Ymodem (if not already enabled).

c. Click on Receive. You will usually see a confirmation message when the file transfer is complete.

When this file has transferred successfully, use the SEL-5030 Analytic Assistant to play back the event report oscillograms of the 12-samples/cycle event report file you just transferred.

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 pick up/drop out, etc. The SEL-487B 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*. The latest 200 SER events are viewable from the front panel. For more information, see *Section 5: Front-Panel Operations in the User's Guide*.

Setting and Examining the SER Record: Terminal Emulation Software

The procedure in the following steps shows how to use a terminal connected to an SEL-487B 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 U.4.18*. 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.3.31*.

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Enter SER trigger data.

a. Type **SET R <Enter>** to access the Report settings (see *Figure 4.25*).

b. Type **<Enter>** to move past the SER Chatter Criteria setting.

c. At the SER Points prompt line, type **TRGTR,"TARGET RESET PB",TEST,OFF <Enter>**.

d. At the next line, type **END <Enter>**.

e. Type **Y <Enter>** when the relay prompts you to save the new setting.

Figure 4.25 shows the steps to set an SER monitoring point.

```
=>>SET R <Enter>
Report

SER Chatter Criteria

Automatic Removal of Chattering SER Points (Y,N)     ESERDEL := N      ?<Enter>

SER Points
(Relay Word Bit, Reporting Name, Set State Name, Clear State Name, HMI Alarm)
1:
?  TRGTR,"TARGET RESET PB",TEST,OFF <Enter>
2:
?  END <Enter>
Report
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved
```

Figure 4.25 Setting an SER Element: Terminal Emulation Software

Step 3. Press and release the front-panel {TARGET RESET} pushbutton to generate an SER record.

Step 4. Type **SER <Enter>** (at the Access Level 1 prompt or higher) to view the SER report.

The relay presents a screen similar to the SER display of *Figure 4.26*.

```
=>>SER <Enter>

Relay 1                                     Date: 07/24/2003  Time: 10:52:10.104
Station A                                   Serial Number: 2003000040

FID=SEL-487B-R102-V0-Z001001-D20030724

#      DATE        TIME          ELEMENT             STATE
5    03/05/2003  08:09:50.300   Power-up             Group 1
4    03/05/2003  08:09:50.300   Relay                Enabled
3    03/05/2003  08:20:54.006   Settings changed     Class R 1
2    03/05/2003  08:21:12.674   TARGET RESET PB      TEST
1    03/05/2003  08:21:13.695   TARGET RESET PB      OFF

=>>
```

Figure 4.26 Sample SER Report

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 computer terminal emulation program with file transfer capability. For more information on the SER, see *SER (Sequential Events Recorder) on page A.3.31*.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 2. Type **FILE DIR REPORTS <Enter>** to view the events file directory.

The terminal lists the file names for standard reports as shown in *Figure 4.27*.

Step 3. Prepare the relay to download an SER report.

a. Type **FILE READ REPORTS SER.TXT <Enter>**.

b. If you want the Compressed ASCII file, type **FILE READ REPORTS CSER.TXT <Enter>**.

```
=>FILE DIR REPORTS <Enter>
CHISTORY.TXT                    R
CSER.TXT                        R
HISTORY.TXT                     R
SER.TXT                         R

=>
```

Figure 4.27 Reports File Structure

Step 4. Download the SER report.

NOTE: Transferring SER files (or CSER files) with the **FILE READ REPORTS SER.TXT** command, performs an **SER CV** command as part of the transfer. **SER CV** clears the SER information from the present port. With the SER information cleared, there is no data available for subsequent SER or CSER transfers from the same port.

Perform the steps necessary for your terminal emulation program to receive a file. Typically, these are the file transfer steps:

a. Specify the destination file location in your computer file storage system and file name.

b. Select the transfer type as Ymodem (if not already enabled).

c. Click on Receive.

You will usually see a confirmation message when the file transfer is complete.

Step 5. Use a word-processing program to view the contents of the file to confirm a successful download.

The CSER.TXT file viewed with a word-processing program is similar to the example in *CSER on page A.3.33*.

Operating the Relay Inputs and Outputs

The SEL-487B gives you great ability to perform control actions at terminal and substation locations via the relay control outputs. The control outputs 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-487B control outputs and control inputs. For more information on connecting and applying the control outputs and control inputs, see *Section 2: Installation*.

Control Output

The SEL-487B features Standard and Hybrid (High-Speed, 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.2.9* for more information on control outputs.

Pulsing a Control Output: Terminal Emulation Software

NOTE: To **PULSE** an output, the circuit breaker control enable jumper, J18C, must be installed on the main board.

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.7.29*.

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to control the relay at Access Level B.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **BAC <Enter>**.

d. Type the correct password to go to Access Level B.

You will see the ==> prompt.

Step 2. Attach an indicating device (ohmmeter with a beep sounder or a test set) to the terminals for control output OUT104 on the main board.

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.2.9*.

Step 3. Type **PULSE OUT104 <Enter>** to perform the pulse operation.

The relay confirms your request to pulse an output with a prompt such as that shown in *Figure 4.28*. Output OUT104 has been renamed with the alias name T1_TRIP, and the alias name appears in the prompt.

Step 4. Type **Y <Enter>** at the prompt.

You will see or hear the indicating device turn on for one second and then turn off.

You can also pulse an output for longer than the default one-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 three seconds.

```
==>PULSE OUT104 <Enter>
Pulse contact T1_TRP for 1 seconds (Y/N)? Y <Enter>

==>
```

Figure 4.28 Terminal Display for PULSE Command

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-487B control outputs. See *Section 5: Front-Panel Operations* for information on using the relay front panel.

Step 1. Attach an indicating device (an ohmmeter with a beep sounder or a test set) to the terminals for control output OUT104 on the main board.

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.2.9*.

Step 2. Apply 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. Press the **{ENT}** pushbutton to view the MAIN MENU similar to the top screen in *Figure 4.29*.

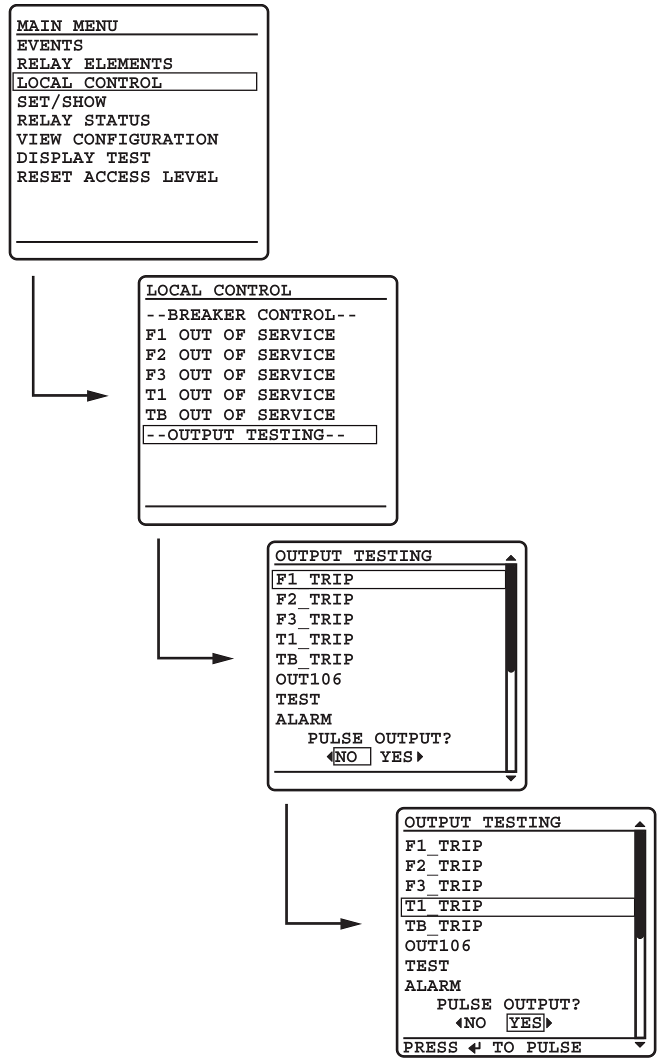

Figure 4.29 Front-Panel Menus for Pulsing T1_TRP

Step 4. View the local control screen.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the `LOCAL CONTROL` action item (see *Figure 4.29*).

b. Press the **{ENT}** pushbutton.

You will see the `LOCAL CONTROL` submenu.

Step 5. View the output testing screen.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the `--OUTPUT TESTING--` action item.

b. Press the **{ENT}** pushbutton.

The relay next displays the `OUTPUT TESTING` submenu.

Step 6. Command the relay to pulse the control output.

a. Press the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight `T1_TRIP` (OUT104).

b. Press the **{Right Arrow}** pushbutton to highlight `YES` under `PULSE OUTPUT?`

c. 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 4.30*.

```
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 4.30 Password Entry Screen

Step 7. Input a password and pulse the output.

a. Enter a valid Access Level B, P, A, O, or 2 password by using the navigation pushbuttons to select the alphanumeric characters that correspond to your password.

(The front panel is always at Access Level 1, so you do not enter the Access Level 1 password.)

b. 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.)

c. After entering all password characters, press the **{Up Arrow}** or **{Down Arrow}** pushbuttons to highlight ACCEPT.

d. 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 6 to start the transformer cooling fans of the transformer at the station. You can use the LCD screen and navigation pushbuttons to toggle relay Local Bit 6 to control the state of the cooling fans. Relay Word bit LB_SP06 provides supervision for Local Bit 6. Relay Word bit LB_SP06 must be asserted for successful Local Bit 6 operations. For more information on local bits, see *Local Control Bits on page U.5.22*.

The procedure in the following steps proposes connecting the transformer bank fan control to relay output OUT106 on the main board. You can choose any relay output that conforms to your requirements. See *Control Outputs on page U.2.9* for more information on SEL-487B control outputs.

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>.**

d. Type the correct password to go to Access Level 2.

You will see the =>> prompt.

Step 2. Access the local control settings.

a. Type **SET F <Enter>**.

b. Repeatedly type **> <Enter>** to advance through the front-panel settings until you reach the Display Points category.

c. Press **<Enter>** to access the Local Control Points Category.

Figure 4.31 shows a representative terminal screen.

```
=>>SET F <Enter>
Front Panel

Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)       FP_TO   := 15     ?> <Enter>

Selectable Screens for the Front Panel

Station Battery Screen (Y,N)                        STA_BAT := N      ?> <Enter>

Display Points
(Relay Word Bit, Display Name, Display Set State, Display Clear State)

1: <Enter>
?

Local Control
(Local Bit, Local Name, Local Set State, Local Clear State, Pulse Enable)

1: LB01,"TB1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  LIST <Enter>

1: LB01,"F1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
2: LB02,"F2 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
3: LB03,"F3 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
4: LB04,"T1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
5: LB05,"TB OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N

1: LB01,"TB1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N

?  > <Enter>
6:
?  LB06,"5 MVA XFMR FANS",ON,OFF <Enter>
7:
?  END <Enter>
Front Panel

Front Panel Settings

.
.
.
6: LB06,"5 MVA XFMR FANS","ON","OFF",N

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

=>>
```

Figure 4.31 Using Text-Edit Mode Line Editing to Set Local Bit 6

Step 3. Type **LIST <Enter>** at the Local Control prompt ? to list the active control points.

The relay displays the default settings.

Step 4. Type **> <Enter>** to move to the end of the list.

Step 5. Type **LB06,"5 MVA XFMR FANS",ON,OFF <Enter>** at the line 6 prompt to assign Local Bit 6.

The relay checks that this is a valid entry and responds with the next line prompt `7:` followed by the `?` settings prompt.

Step 6. Type **END <Enter>** to end the settings session.

The relay scrolls a readback of all the front-panel settings, eventually displaying the `Save settings (Y, N) ?` prompt.

Step 7. Type **Y <Enter>** to save your new settings.

Step 8. Set OUT106 to respond to Local Bit 6.

a. Type **SET O OUT106 <Enter>** (see *Figure 4.32*).

b. Type **LB06 <Enter>** at the `?` prompt.

c. Type **END <Enter>** at the next `?` prompt.

d. Type **Y <Enter>** when prompted to save settings.

```
=>>SET O OUT106 <Enter>
Output
Main Board
OUT106 := NA
? LB06 <Enter>
OUT107 := TNS_SW #RELAY TEST MODE
? END <Enter>
Output
Main Board
.
.
.
Save settings (Y,N) ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 4.32 Setting Control Output OUT106: Terminal Emulation Software

Step 9. Test the connection and programming.

a. Use the appropriate interface hardware to connect the fan control start circuit to terminal OUT106 of the main board.

b. Select `LOCAL CONTROL` at the relay front-panel `MAIN MENU`.

c. Press the **{ENT}** pushbutton (see *Figure 4.33*).

d. Select `5 MVA XFMR FANS` on the `LOCAL CONTROL` screen as shown in *Figure 4.33*.

e. Press **{ENT}** and highlight `1 ON` and press **{ENT}** again.

The graphical local control handle moves to the 1 position. At this time, the transformer fans will begin running.

f. Press **{ESC}** repeatedly to return to the `MAIN MENU`.

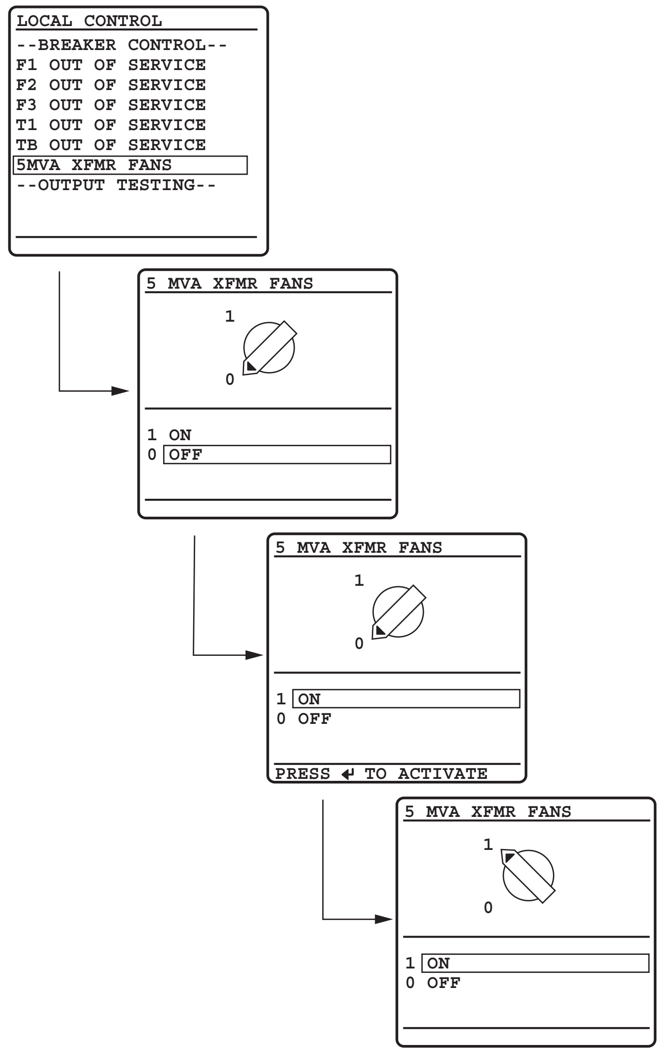

Figure 4.33 Front-Panel LOCAL CONTROL Screens

Setting Outputs for Tripping

To actuate power system circuit breakers, you must configure the SEL-487B control outputs to operate the trip bus. The relay uses internal logic and SELOGIC control equations to activate the control outputs.

Trip Output Signals

Although the SEL-487B is capable of single-pole and three-pole tripping, the traditional application for busbar protection is for three-pole tripping only. There are many Relay Word bits available that you can use to program 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*.

Assigning a Control Output for Tripping

The procedure in the following steps shows a method for setting the relay to operate the trip bus at a typical substation. Relay factory defaults assign main board control outputs OUT101 through OUT105 on the main board to trip the circuit breakers, as well as relay test mode to OUT107 and the alarms SALARM and HALARM to OUT108. The following procedure assigns an additional trip output at OUT106 on the main board.

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

From Access Level 2, type **SHO O <Enter>** to view the present output settings, as shown in *Figure 4.34*.

```
=>>SHO O <Enter>
Output

Main Board

OUT101  := TRIP01 AND NOT TNS_SW
OUT102  := TRIP02 AND NOT TNS_SW
OUT103  := TRIP03 AND NOT TNS_SW
OUT104  := TRIP04 AND NOT TNS_SW
OUT105  := TRIP05 AND NOT TNS_SW
OUT106  := NA
OUT107  := TNS_SW #RELAY TEST MODE
OUT108  := NOT (SALARM OR HALARM)

.
.
.

=>>
```

Figure 4.34 Result of the SHO O Command, Showing the Output Contacts from the Main Board

As *Figure 4.34* shows, OUT106 is not used. Follow the steps in *Figure 4.35* to assign Relay Word bit TRIP06 to output OUT106 of the main board.

```
=>>SET O OUT106 <Enter>
Output

Main Board

OUT106 := NA
?   TRIP06 <Enter>

OUT107 := TNS_SW #RELAY TEST MODE
?   END <Enter>
.
.
.

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

=>>
```

Figure 4.35 Assign Relay Word Bit TRIP06 to Output OUT106 of the Main Board

Control Input Assignment

The SEL-487B 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.2.8* 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 GINPU and GINDO for global input pickup time and global input dropout time settings respectively. See *Global Settings on page R.8.6* for more information. When you enable setting EICIS (Enable

Independent Control Input Settings), you can set separate input pickup and dropout time settings for control inputs that are exceptions to these global control input settings.

Setting a Control Input: Circuit Breaker Auxiliary Contacts (52A01): Computer Terminal Emulation Software

Following is a step-by-step procedure to configure a control input that reflects the state of the circuit breaker auxiliary (52A01) NO (normally open) contact. Commonly, a circuit breaker auxiliary contact is wired to the relay input to detect the closed/open status of the circuit breaker. Perform the following steps to configure a circuit breaker auxiliary contact in the SEL-487B.

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Prepare to control the relay at Access Level 2.

- a. Type **ACC <Enter>** at a communications terminal.
- b. Type the Access Level 1 password and press **<Enter>**.

  You will see the `=>` prompt.
- c. Type **2AC <Enter>**.
- d. Type the correct password to go to Access Level 2.

  You will see the `=>>` prompt.

Step 2. Configure the relay to read the circuit breaker auxiliary contact.

Relay Word bits 52A01 through 52A05 are enabled in the relay default settings.

- a. Type **SET G <Enter>** (see *Figure 4.36*) to enter the Global settings.
- b. Type **> <Enter>** successively until you reach the 52A01 prompt.
- c. Type **IN101 <Enter>** at the `?` prompt to specify input IN101 as the control input that represents the close/open state of Circuit Breaker 1.
- d. Type **IN102 <Enter>** and **IN103 <Enter>** at the next two `?` prompts to specify input IN102 and IN103 as the control inputs that represent the close/open state of Circuit Breaker 2 and Circuit Breaker 3 respectively.
- e. Type **END <Enter>** at the next prompt.

Step 3. Confirm the new control information in the readback of all the Global settings, just before the `Save settings (Y, N) ?` prompt.

Step 4. Type **Y <Enter>** to save your new settings.

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

General Global Settings

Station Identifier (40 characters)
SID := "Station A"
?  >

Global Enables

Station DC Battery Monitor (Y,N)                    EDCMON  := N      ?> <Enter>

Control Inputs (Global)

Input Pickup Delay (0.00-1 cyc)                     GINPU   := 0.17   ?> <Enter

Settings Group Selection

Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  >

Breaker Inputs

N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  IN101 <Enter>
N/O Contact Input -BK02 (SELogic Equation)
52A02 := NA
?  IN102 <Enter>
N/O Contact Input -BK03 (SELogic Equation)
52A03 := NA
?  IN103 <Enter>
N/O Contact Input -BK04 (SELogic Equation)
52A04 := NA
?  END <Enter>
Global

.
.
.

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

=>>
```

Figure 4.36 Setting 52A01, 52A02, and 52A03: Terminal Emulation Software

Configuring Timekeeping

IRIG-B

You can connect time signals from many sources that produce the IRIG-B (Inter-Range Instrumentation Group-B) time code format (SEL-20xx family of communications processors, GPS receiver, etc.). The IRIG-B serial data format consists of a one-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. The IRIG-B signal includes code for time-of-day and day-of-year time stamping, but does not include a code to identify the year. To verify that the SEL-487B calendar is set to the proper year, use the **DATE** command to view or change the date (see *DATE on page R.7.13*). 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.

Each SEL-487B provides two IRIG-B BNC connectors, labeled IN and OUT.

Step 1. Referring to the external source connections in *Figure 4.37*, connect the IRIG-B signals to the IN connection of Relay A to update the clock of Relay A.

Step 2. Connect the **OUT** connection of Relay A to the **IN** connector of Relay B to update the clock in Relay B.

A similar connection between Relay B and Relay C updates the time in Relay C.

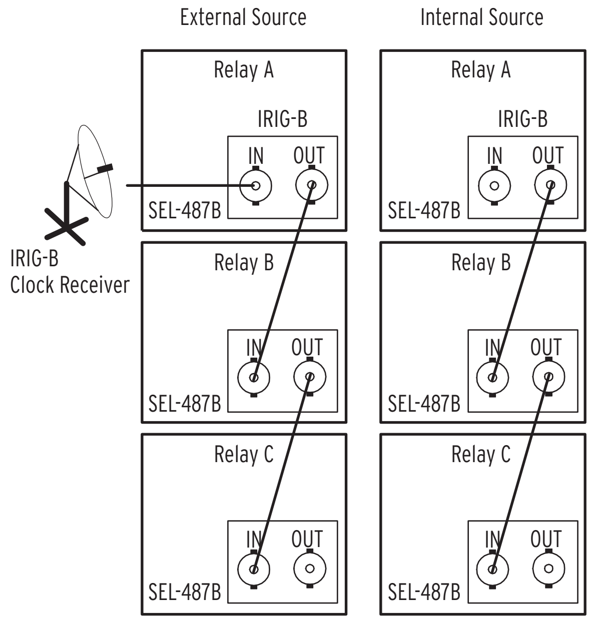

Figure 4.37 Time Synchronization Connections Between Three Relays

In the absence of an external IRIG-B signal, connect the relays as shown by the internal source connections in *Figure 4.37*. Connected this way, Relay B uses the clock of Relay A as time reference, and Relay C uses the clock of Relay B as time reference.

Automatic Time Source Selection

The SEL-487B automatically detects time source inputs. If the IRIG-B time source is unavailable or is unreliable, then the relay switches to a lower-priority source (DNP3, MIRRORED BITS®, and ASCII, for example). The relay automatically switches up to a higher priority time source when the relay measures an acceptable time source in terms of 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 connector outputs for an IRIG-B. Use a communications terminal to send commands and receive data from the relay (see *Making an EIA-232 Serial Port Connection on page U.4.5*).

This example assumes that you have successfully established communication with the relay and are familiar with relay access levels and passwords. See *Making an EIA-232 Serial Port Connection on page U.4.5* and *Changing the Default Passwords: Terminal on page U.4.9*.

Step 1. Confirm that the relay is operating. See *Connecting and Applying Power on page U.4.3*.

Step 2. Prepare to control the relay at Access Level 2.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

c. Type **2AC <Enter>**.

d. Type the correct password to go to Access Level 2.

You will see the `=>>` prompt.

Step 3. Connect cables.

a. Attach the IRIG-B signal with a BNC-to-BNC coaxial jumper cable from the GPS receiver IRIG-B output to the SEL-487B **TIME IRIG-B BNC** connector.

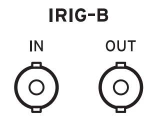

Figure 4.38 IRIG-B IN and IRIG-B OUT Connections at the Back of the Relay (BNC Connectors)

TIME Q Descriptions

The **TIME Q** command provides details about relay timekeeping (see *Figure 4.39*). The header line internal clock setting is initially calibrated at the SEL factory. The `Time Source` provides the present timing input source; entries for this line are `IRIG` and `OTHER`.

```
=>>TIME Q <Enter>

Relay 1                                     Date: 01/14/2003  Time: 17:25:10.920
Station A                                   Serial Number: 0000000001

Time Source: OTHER
Last Update Source: NONV CLK

IRIG Time Mark Period:    0.000 ms

Internal Clock Period:  25.000000 ns


=>>
```

Figure 4.39 Results of the TIME Q Command

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 4.11* lists the possible `Last Update Source` values for the SEL-487B.

Table 4.11 Date/Time Last Update Sources (Sheet 1 of 2)

Time Input Source Mode (QQQQQ)	Accuracy	Time Source	Front Panel Editing?
`IRIG`	High	Time/date from the IRIG-B format time base signal	No
`COMM CARD`	Low	Time/date signal from the communications card	Date and Time
`DNP`	Low	Time/date from the DNP3 communications port	Date and Time
`MIRRORED BITS`	Low	Time/date from the MIRRORED BITS port	Date and Time
`ASCII TIME`	Low	Time from the relay serial ports	Date only
`ASCII 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

Table 4.11 Date/Time Last Update Sources (Sheet 2 of 2)

Time Input Source Mode (QQQQQ)	Accuracy	Time Source	Front Panel Editing?
FRONT PANEL TIME	Low	Time from the front-panel TIME entry screen	Date and Time
FRONT PANEL DATE	Low	Time from the front-panel DATE entry screen	Date and Time

Readying the Relay for Field Application

Before applying the SEL-487B 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).

a. Remove fuses to verify removal of control power and ac signals from the SEL-487B.

b. Isolate the relay TRIP control output.

Step 2. Perform point-to-point continuity checks on the circuits associated with the SEL-487B 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 U.4.3*. 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.

a. Start the terminal (usually a PC with terminal emulation software).

b. Establish communication with the relay at Access Level 0.

c. Proceed to Access Level 2.

Step 5. Change the default passwords.

See *Changing the Default Passwords: Terminal on page U.4.9*.

Step 6. Use test sources to verify relay ac connections.

See *Examining Metering Quantities on page U.4.31*.

Step 7. Verify control input connections.

See *Operating the Relay Inputs and Outputs on page U.4.40* and *Control Inputs on page U.2.8*.

Step 8. Verify control output connections.

See *Operating the Relay Inputs and Outputs on page U.4.40* and *Control Outputs on page U.2.9*.

Step 9. Perform protection element tests.

See *Checking Relay Operation on page U.6.18*.

Step 10. Set the relay.

See *Making Simple Settings Changes on page U.4.12*, *Section 1: System Configuration Guideline and Application Examples in the Applications Handbook*, and *Section 1: Protection Functions in the Reference Manual*.

Step 11. Connect the relay for tripping duty.

See *AC/DC Connection Diagrams on page U.2.38*.

Step 12. Clear the relay data buffers.

a. From Access Level 2, use a communications terminal to issue the commands listed in *Table 4.12*.

Table 4.12 Communications Port Commands That Clear Relay Buffers

Communications Port Command	Task Performed
HIS CA	Reset event report and history buffers
SER CA	Reset Sequential Events Recorder data

Step 13. Connect the secondary voltage (if required) and current inputs.

See *Section 2: Installation*.

Step 14. Confirm secondary connections.

Use the **MET** command to view relay metering. See *Examining Metering Quantities on page U.4.31*.

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Section 5
Front-Panel Operations

Overview

The SEL-487B Relay front panel makes power system data collection and system control quick and efficient. Using the front panel, you can examine power system operating information, view and change port 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 (light-emitting diodes) indicators give a quick look at SEL-487B 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 the following:

- ➤ Reading metering
- ➤ Inspecting targets
- ➤ Accessing port, date and time settings
- ➤ Controlling relay operations

Front-Panel Layout

Figure 5.1 shows the front panel of the SEL-487B.

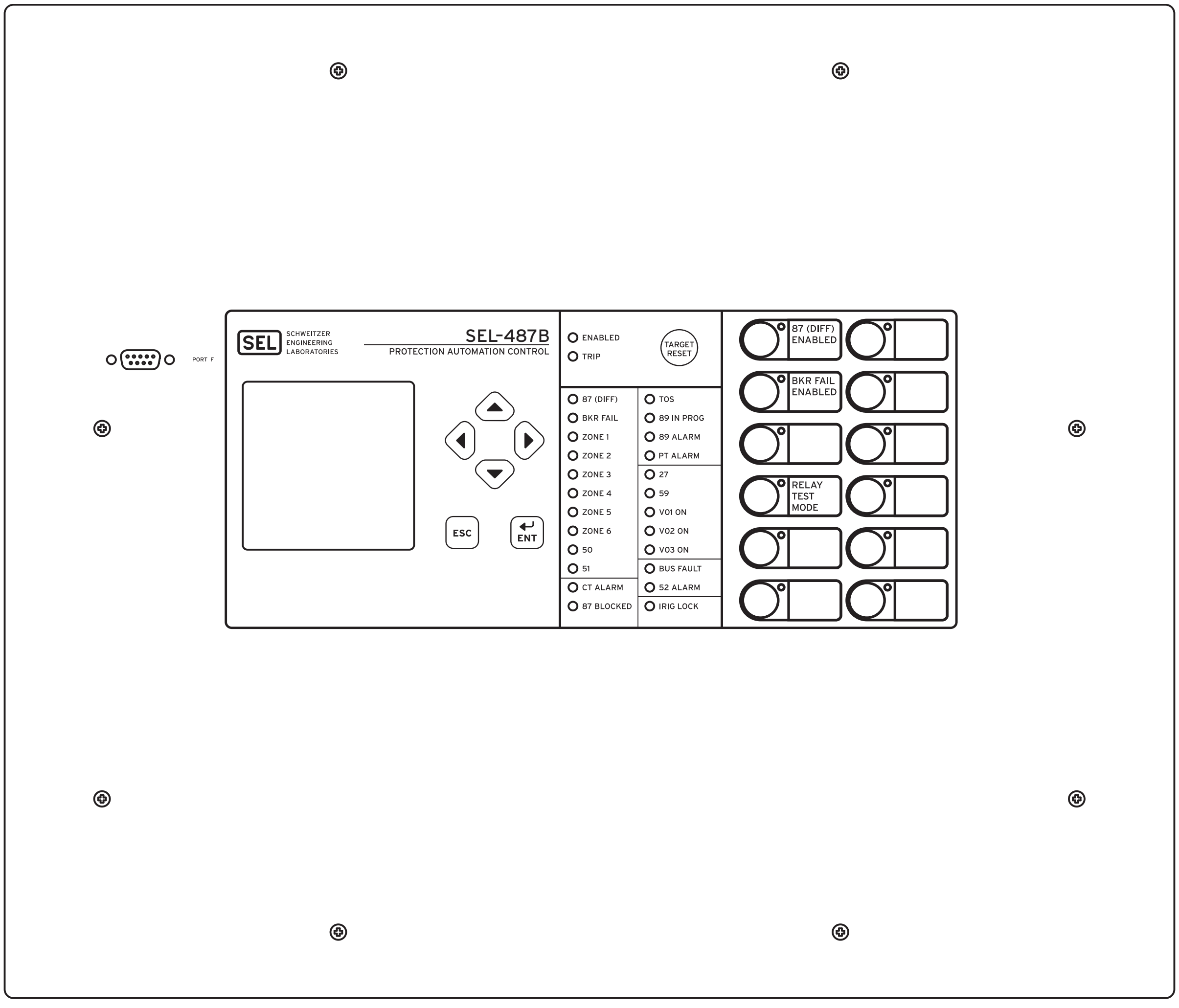

Figure 5.1 Front Panel, 12 Pushbutton (9U Version)

A 128 x 128 pixel LCD 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 terminal and Bus-Zone metering and configuration parameters; you can easily change this ROTATING DISPLAY to suit your particular on-site monitoring needs. Use the simple and efficient menu structure to operate the relay from the front panel. With these menus you can quickly access SEL-487B metering, control, and settings.

Front-panel LEDs indicate the relay operating status. You can confirm that the SEL-487B 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 asserted and deasserted colors for the LEDs are programmable (12-pushbutton version).

The SEL-487B front panel features operator control pushbutton switches with annunciator LEDs that facilitate local control. Factory-default settings associate specific relay functions with these direct-action pushbuttons and LEDs. Using SELOGIC® control equations or front-panel settings PB*n*_HMI, you can 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. The asserted and deasserted colors for the LEDs are programmable (12-pushbutton version).

The SEL-487B front panel includes an EIA-232 serial port (labeled **PORT F**) for connecting a communications terminal or using the ACSELERATOR QuickSet® SEL-5030 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 optional DNP3. For more information on communications protocols and Port F, see *Establishing Communication on page U.4.4*.

Front-Panel LCD

The LCD is the prominent feature of the SEL-487B front panel. *Figure 5.2* 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.

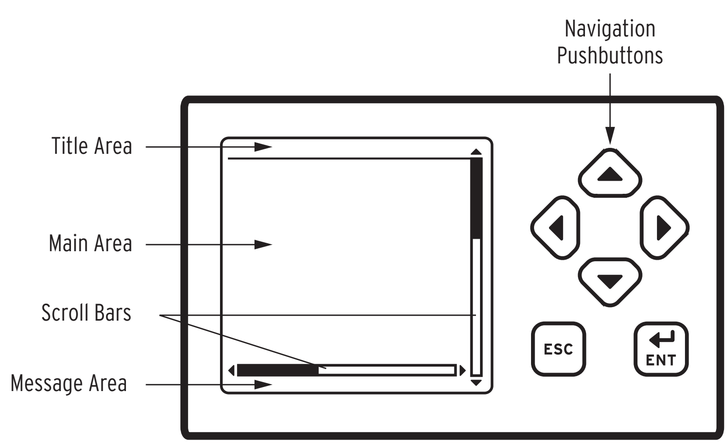

Figure 5.2 LCD Display and Navigation Pushbuttons

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 in *Screen Scrolling on page U.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-487B front panel presents a menu system for accessing port 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 Arrow}, {Right Arrow}, {Up Arrow}, and {Down Arrow}—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* 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.

Figure 5.3 RELAY ELEMENTS Highlighted in MAIN MENU

The {Up Arrow} pushbutton and {Down Arrow} pushbutton scroll the highlight box to the previous or next menu selection, respectively.

Pressing the {ESC} pushbutton reverts the LCD display to the previous screen. Pressing {ESC} repeatedly returns you to the ROTATING DISPLAY. If a status warning, alarm condition, or event condition is active (not acknowledged or reset), the relay displays the full-screen status warning, alarm screen, or event screen in place of the ROTATING DISPLAY.

Screen Scrolling

The SEL-487B has two screen scrolling modes: autoscrolling and manual scrolling. After the initial relay power up, or after front-panel time out, the LCD presents each of the display screens in this sequence:

- Any active (filled) alarm points screens
- Any active (filled) display points screens
- Enabled metering screens
- Zone configuration screens

If enabled, the relay displays the metering and zone configuration screens in the order listed in *Table 5.2* (see *Figure 5.18* for samples of the metering screens). This sequence comprises the ROTATING DISPLAY.

Table 5.2 Metering Screens Enable Settings

Name	Description	Range	Default
STA_BAT	Station Battery Screen	Y, N	N
FUND_VI	Fundamental Voltage and Current Screens	Y, N	Y
DIFF	Differential Metering	Y, N	Y
ZONECFG	Terminals Associated With Zones	Y, N	Y

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 enable settings. Entering a **Y** (Yes) for a metering screen enable setting results in the corresponding metering screen appearing in the ROTATING DISPLAY. Entering an **N** (No) hides the metering screen from presentation in the ROTATING DISPLAY. If all metering screen enable settings are set to **N** (No) and there are no configured display points screens, the DIFF screen appears by default in the ROTATING DISPLAY. *Figure 5.4* shows a ROTATING DISPLAY example consisting of an example alarm points screen, a display points screen, and one of the factory-default metering screens (the screen values in *Figure 5.4* are representative values).

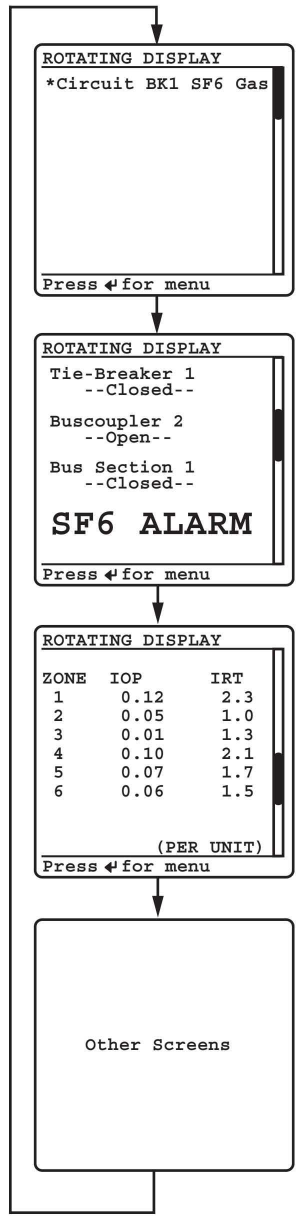

Figure 5.4 ROTATING DISPLAY

The active alarm points are the first screens in the ROTATING DISPLAY (see *Alarm Points on page U.5.7*). Each alarm points screen shows as many as 11 alarm conditions. The SEL-487B Relay can present a maximum of six alarm points screens. The active display points are the next screens in the ROTATING DISPLAY (see *Display Points on page U.5.9*). Each display points screen shows as many as 11 enabled display points. 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 a user-settable period of time. Front-panel setting SCROLD defines the period of time each screen is shown. When you first apply power to the relay, the LCD shows the autoscrolling ROTATING DISPLAY. With SCROLD := OFF, the screen remains on the first screen in the rotating display order, and automatic rotation of additional screens is disabled.

The autoscrolling ROTATING DISPLAY also appears after a front-panel inactivity time out (see *Front-Panel Inactivity Time Out on page U.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 Arrow}** or **{Right Arrow}** pushbuttons switches the display to the next screen; pressing the **{Up Arrow}** or **{Left Arrow}** 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.

Alarm Points

You can display messages on the SEL-487B front-panel LCD that indicate alarm conditions in the power system. The relay uses alarm points to place these messages on the LCD.

Figure 5.5 shows a sample alarm points screen. The relay is capable of displaying as many as 66 alarm points. The relay automatically displays new alarm points while in manual-scrolling mode and in autoscrolling mode. While you navigate the HMI menu structure, the relay does not automatically display the alarm points. Instead, ALARM EVENT displays in the footer. When you escape the HMI menu structure, the relay will display the alarm points screen.

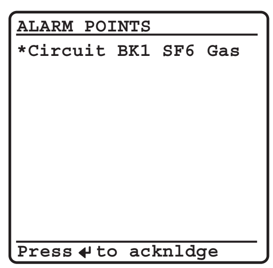

Figure 5.5 Sample Alarm Points Screen

The alarm point setting is an element of the SER settings. To enable an alarm point, enable the HMI alarm parameter of the SER Point Settings listed in *Table 5.3*. The format for entering the SER point data is the following comma-delimited string:

> Relay Word Bit, Reporting Name, Set State Name, Clear State Name, HMI Alarm

Names can contain any valid ASCII character. Enclose the name in double quotation marks. See *Example 5.1* for particular information on the format for entering SER point data.

Table 5.3 SER Point Settings

Description	Range
Relay Word Bit	Any valid relay element
Reporting Name	20-character maximum ASCII string
SET State Name (logical 1)	20-character maximum ASCII string
CLR State Name (logical 0)	20-character maximum ASCII string
HMI Alarm	Y, N

If you enter a Relay Word bit that does not match a valid relay element, the relay displays `Unknown relay word reference`. If you enter an alias or name that is too long, the relay displays `Alias label too long`.

The relay displays alarm points in a similar fashion as the SER. As many as 19 characters of the given alias are displayed, with a character reserved for the asterisk (*). The asterisk denotes if the element is asserted. Initially, an alarm point must be asserted in order to be displayed; after the corresponding element deasserts, the asterisk is removed, but the alias is not. The relay displays alarm points in reverse chronological order, just as in the SER, with the most recently asserted alarm displayed on the top. Deasserted alarms may be removed from the display with user acknowledgement, as shown in *Example 5.1*.

EXAMPLE 5.1 Creating an Alarm Point

Alarm points screens provide operator feedback about the status of system conditions. An alarm points screen contains 11 alarm points; this example demonstrates a method to set the alarm point message that is shown in Figure 5.5. This example is based on the Relay Word bit IN101 asserting when Circuit Breaker 1 is in an alarm condition. In the Report settings (**SET R**), enter the following after the SER Points Line 1 prompt:

1: **IN101,"Circuit BK1 SF6 Gas","Alarm","Normal","Y"**

The circuit breaker alarm condition is indicated by the set state, "Alarm" and the circuit breaker normal condition is indicated by the clear state "Normal." The HMI Alarm parameter is set to "Y" in order to enable alarm points screen display of this element.

While in the scrolling mode, the assertion of IN101 will cause Figure 5.5 to be automatically displayed. Upon the deassertion of IN101, the asterisk will disappear, as in Figure 5.6.

While in the scrolling mode, the assertion of IN101 will cause Figure 5.5 to be automatically displayed. Upon the deassertion of IN101, the asterisk will disappear, as in Figure 5.6.

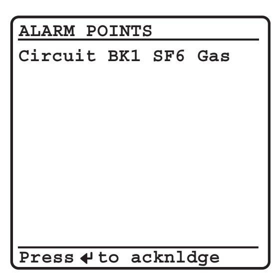

Figure 5.6 Deasserted Alarm Point

Pressing the **{ENT}** pushbutton will allow the user to acknowledge and clear deasserted alarms. Before clearing, the user will be prompted to confirm that this is the intended action, as in Figure 5.7.

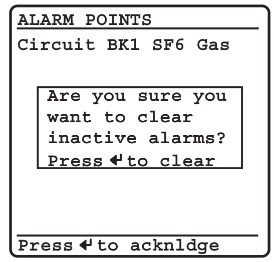

Figure 5.7 Clear Alarm Points Confirmation Screen

In the case that all alarms are deasserted, pressing the **{ENT}** pushbutton will allow the user to acknowledge and clear all alarms. After clearing, a screen showing the results of the action will be shown, as in Figure 5.8.

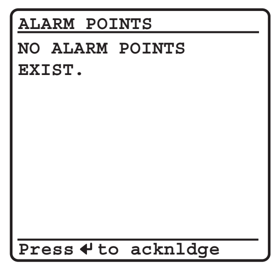

Figure 5.8 No Alarm Points Screen

Alarm Points are not updated for a particular element if it has been deleted from the SER because of chatter criteria (see Automatic Deletion and Reinsertion on page A.3.34). Upon reinsertion, the element state will be updated on the alarm points display. If the relay enters a period of SER data loss because of a rapidly toggling element, the status of alarm points cannot be determined. The screen shown in Figure 5.9 will be shown until the data loss condition has been exited, at which point the alarm point elements will be polled and displayed if asserted and the data loss message will be deasserted. Subsequent alarm point assertions will be displayed above the data loss message.

Figure 5.9 Alarm Points Data Loss Screen

Display Points

You can display messages on the SEL-487B front-panel LCD that indicate conditions in the power system. The relay uses display points to place these messages on the LCD. *Figure 5.10* shows a display points screen example. Display points can show the status of Relay Word bits or display the value of analog quantities. The relay has 96 possible display points; *Table 5.4* and *Table 5.5* list 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.

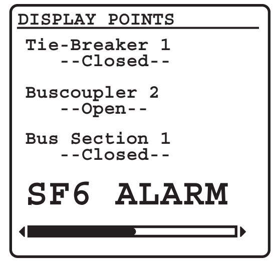

Figure 5.10 Display Points Screen

To enable a display point, enter the display point settings listed in *Table 5.4* or *Table 5.5*. All display points occupy one, and only one, line on the display at all times. The height of the line is determined by the “Text Size” setting parameter. Display points of single-line height span one screen in total width. Display points of double-line height span two screens in total width. You can use multiple display points to simulate multiple lines.

Use the following syntax to display the given Relay Word bit exactly as seen in the navigational menu (name and value).

DPxx := **Name**

Use the following syntax to display the given Relay Word bit as seen in the navigational menu, replacing the name of the value with the given alias string. The text size determines if the display will be in single font or double font. If the text size is empty, the display will be in single font.

DPxx := **Name, "Alias", "Text Size"**

Use the following syntax to display the given Relay Word bit with the given alias. If the Relay Word bit is asserted (logical 1), the LCD displays the set string in the place of the value. If the Relay Word bit is deasserted (logical 0), the LCD displays the clear string in the place of the value. One or all of Alias, Set String, or Clear String can be empty. If Alias is empty, then the LCD displays only the Set or Clear Strings. If either Set String or Clear String is empty, then an empty line is displayed when the bit matches that state. The text size determines if the display will be in single font or double font. If the text size is empty, the display will be in single font.

DPxx := **Name, "Alias", "Set String", "Clear String", "Text Size"**

Use the following syntax to display the given analog quantity with the given text and formatting. Formatting must be in the form {Width.Decimal,Scale} with the value of Name, scaled by “Scale,” formatted with total width “Width” and “"Decimal” decimal places. The width value includes the decimal point and sign character, if applicable. The “scale” value is optional; if omitted, the scale factor is processed as 1. If the numeric value is smaller than the field size requested, the field is padded with spaces to the left of the number. If the numeric value will not fit within the field width given, “$” characters are displayed. The text size determines if the display will be in single font or double font. If the text size is empty, the display will be in single font.

DPxx := **Name, "Text1 {Width.Decimal,Scale} Text2", "Text Size"**

Table 5.4 Display Point Settings—Boolean

Description	Range
Relay Word Bit Name	*Appendix A: Relay Word Bits in the Reference Manual*
Alias	ASCII string
Set String	ASCII string
Clear String	ASCII string
Text Size	S, D

Table 5.5 Display Point Settings—Analog

Description	Range
Analog Quantity Name	*Appendix B: Analog Quantities in the Reference Manual*
"User Text and Formatting"	ASCII string
Text Size	S, D

Table 5.6 Display Point Settings—Boolean and Analog Examples

Example Display Point Setting Value	Example Display 12345678901234567890
IN101	IN101=1 IN101=0
I01FIM,"{7.2}"	1234.56
50P01,Overcurrent,,	Overcurrent=1 Overcurrent=0
PSV01,Control,On,Off	Control=On Control=Off
PSV02,Breaker,Tripped,	Breaker=Tripped ***Empty Line***
50P01,,,Overcurrent	***Empty Line*** Overcurrent
I01FIM,"Terminal 01={7.2}"	Terminal 01=1234.56
I01FIM,"Terminal 01={7.3}"	Terminal 01=$$$.$$$
I01FIM,"Terminal 01 {4} A"	Terminal 01 1234 A
IOP1,"{7.2}"	1234.56
IOP1,"Zone1 Operate={4.1}"	Zone1 Operate=1234.5
IRT1,"Restraint1={5}"	Restraint1=1230
IRT1,"Restraint1={4.2,0.001} PU"	Restraint1=1.23 PU
V01FIM,"Term 01 Volt={3, 1000}"	Term 01 Volt=1234
V01FIM,"Term 01 Volt={3, 1000} kV"	Term 01 Volt=$$$ kV
1,"Fixed Text"	Fixed Text
0,"Fixed Text"	Fixed Text
1,	***Empty Line***
0,	***Empty Line*** ***Display Point is hidden***

EXAMPLE 5.2 Creating a Display Point

Display points screens provide operator feedback about the readiness of equipment connected to the SEL-487B. A display points screen contains 11 display points; this example demonstrates a method to set the top (first) display point message that is shown in Figure 5.10. The SEL-487B 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.

In the Front Panel settings (**SET F**), enter the following after the Display Points and Aliases line 1 prompt:

1: **"Tie-Breaker 1"**

2: **IN201,," --Closed--"," --Open--"**

3: **0**

This example sets input IN201, represented by Relay Word bit IN201, as Tie-Breaker 1. Fixed text is set by assigning an alias to a "1" or "0." Blank lines are set by assigning a blank alias to a "1" or "0." 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 5.3 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 5.11 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.)

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.

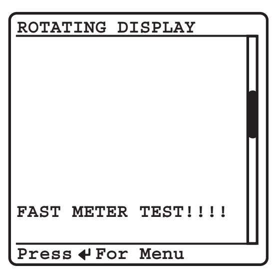

Figure 5.11 Fast Meter Display Points Screen

Front-Panel Menus and Screens

Operate the SEL-487B 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*). These additional menus allow you on-site access to control and port settings. Use the following menus and screens to set the relay and perform local control actions:

- Support Screens
  - Adjust Contrast
  - Password
- MAIN MENU
  - EVENTS
  - 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 5.12* shows the contrast adjustment box with the MAIN MENU screen in the background. Pressing the **{Right Arrow}** pushbutton increases the contrast. Pressing the **{Left Arrow}** pushbutton decreases the screen contrast. When you finish adjusting the screen contrast, press the **{ENT}** pushbutton.

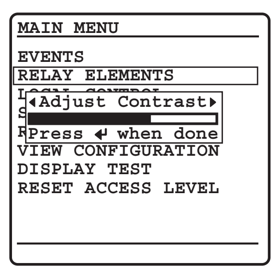

Figure 5.12 Contrast Adjustment

Password

The SEL-487B 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.4.6* for more information on access levels and setting passwords. The SEL-487B 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 5.13*. This screen has a blank password field and an area containing alphabetic, numeric, and special password characters with a movable highlight box.

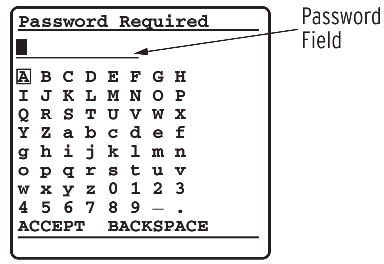

Figure 5.13 Enter Password Screen

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 option 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 5.14*. 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 5.14 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 5.15*. When the front-panel LCD is in the ROTATING DISPLAY, press the **{ENT}** pushbutton to show the MAIN MENU.

Figure 5.15 MAIN MENU

METER

From the MAIN MENU shown in *Figure 5.15*, press the **{ESC}** key to return to the auto-scrolling rotating display. In the manual-scrolling mode, press the **{Up Arrow}** or **{Down Arrow}** keys repeatedly to get to and move between the metering screens. Factory-enabled metering screens scroll through the following metering screens:

- ➤ Differential quantities
- ➤ Zone configuration (when active)
- ➤ Fundamental Current
- ➤ Fundamental Voltage

Figure 5.16 shows the differential metering screen. The display shows the Bus-Zone number and the operating and restraint current for each active zone. An active zone is a zone with at least one terminal in the zone. Zones become inactive when there are no terminals connected to the zone or when the zone was merged with other zones. Inactive zones are not displayed. *Figure 5.16* shows an example with four zones active.

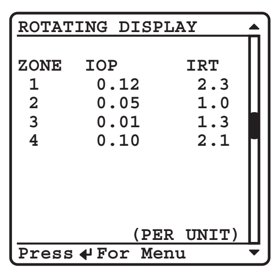

Figure 5.16 Differential Screen

Figure 5.17 shows the screen displaying the terminal(s) present in each active zone. For each active zone, the relay displays the terminals connected to that particular zone. When two zones merge, the new zone carries the zone number of the lower of the two zones. For example, when Zones 2 and 4 merge, the new combined zone becomes Zone 2.

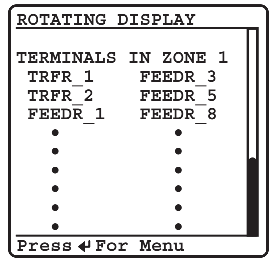

Figure 5.17 Terminals in Zone Screen

Figure 5.18 shows the fundamental current screens, displaying the primary current and phase angle for each terminal.

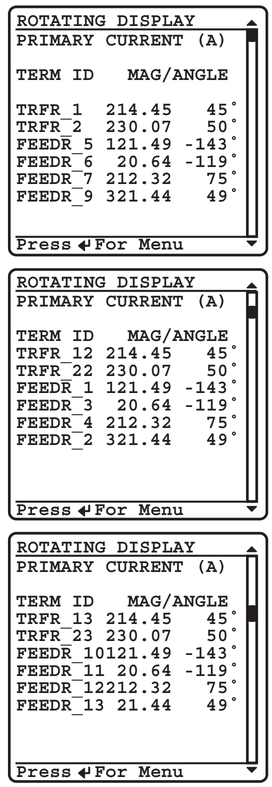

Figure 5.18 Fundamental Primary Current Screens

All angles are referenced to the voltage connected to voltage terminal V01. If voltage at terminal V01 is not available, the relay selects V02, and then V03. In the absence of voltage inputs, the relay references the current input of I01, provided the current is above 0.05 • I_{NOM}. If I01 is not above this current level, the relay references the current from I02, if available. If I02 is not available, the relay continues to I03, I04, and so on until it finds a current input above 0.05 • I_{NOM}.

Figure 5.19 shows the primary voltage magnitudes and angles from the three voltage inputs in kV.

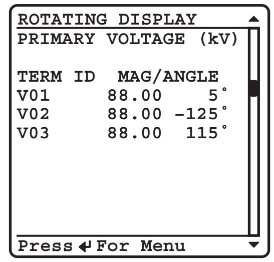

Figure 5.19 Fundamental Primary Voltage Screen

Use the **SET F** command and set STA_BAT = Y to enable the station battery screen, as displayed in *Figure 5.20*.

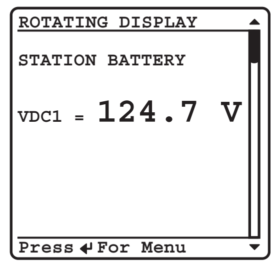

Figure 5.20 Station Battery Screen

EVENTS

The SEL-487B front panel features summary event reporting showing event number, group, time and date, and event trigger. See *Event Report on page A.3.6* for more information on event reports.

The front-panel event buffer size is at least 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`. The relay presents the `Events Menu` as shown in *Figure 5.21*. Select `Event Summary` from the `Events Menu` to view event summary data.

Figure 5.21 Events Menu Screen

Figure 5.22 shows a sample `EVENT SUMMARY` screen of a busbar fault. The vertical scroll bar indicates that there are more events available. Use the **{Up Arrow}** and **{Down Arrow}** pushbuttons to move among the events in the summary buffer. Press **{ESC}** to return to the `MAIN MENU`. Event reports can also be viewed via a front-panel automatic message (see *Front-Panel Automatic Messages on page U.5.31*).

```
EVENT SUMMARY  10005

12/28/2002    GROUP1
10:45:12.738
EVENT:         87BTR
TARGETS:
87_DIFF
ZONE_1
```

Figure 5.22 EVENT SUMMARY Screen

SER

The Sequential Events Recorder (SER) records state changes of user-programmable Relay Word bits. State changes are time-tagged for future analysis of relay operations during an event. See *Automatic Deletion and Reinsertion on page A.3.34* for more information on SER events. To view SER events from the front panel, select `EVENTS` from the `MAIN MENU` and SER Events from the `Events Menu` as shown in *Figure 5.21*. SER events are also viewable using programmable front-panel operator-control pushbuttons (see *Front-Panel Operator Control Pushbuttons on page U.5.36*).

Figure 5.23 illustrates the `SER Events` display screen. Data reported in this screen for each event are the SER number, SER Point Alias Name, Asserted or Deasserted state, and the Date and Time of the event. When in the `SER Events` screen, three SER records are displayed. Using the navigation pushbuttons, the most recent 200 SER events are viewable on the front-panel display. The topmost event is the most recent event and the bottommost event is the oldest. The upper right of the screen displays the number of the SER events currently being viewed. If a new event occurs while viewing the SER events, the display does not update with the new event automatically. To include the new SER event in the display, exit the SER screen by pressing **{ESC}** and re-enter the `SER Events` screen by pressing **{ENT}** with the `SER Events` selection highlighted. This rebuilds the `SER Events` display and contains the latest SER events triggered.

```
SER Events   001-003
Local
Disabled
02/16/06 11:11:01.993

Local
Enabled
02/16/06 10:11:19.090

IN101
Asserted
02/16/06 03:22:01.988
```

Figure 5.23 SER Events Screen

If no SER events are available, *Figure 5.24* is displayed.

```
SER Events

     No SER Events
       Available
```

Figure 5.24 No SER Events Screen

While viewing the SER events, front-panel pushbuttons provide navigation and control functions as indicated in *Table 5.7*.

Table 5.7 Front-Panel Pushbutton Functions While Viewing SER Events

Pushbutton	Description
{Up Arrow}, {Down Arrow}	Navigates one screen at a time up or down. Each screen contains three SER events. Accelerated scrolling is obtained when the pushbutton remains pressed (see accelerated scrolling behavior below).
{Left Arrow}, {Right Arrow}	Navigates between SER events to allow adjacent SER events to be displayed on one screen. For example, if events 1, 2, and 3 are displayed, press the {Right Arrow} once to display events 2, 3, and 4 in the same screen. No accelerated scrolling is provided with the {Left Arrow} and {Right Arrow} pushbuttons.
{ESC}	Returns to the Events Menu.
{ENT}	Does nothing.

Hold down either the {Up Arrow} or {Down Arrow} to achieve accelerated scrolling. Holding down the {Up Arrow} or {Down Arrow} navigates one screen at a time for the first five screens and then increases to five screens at a time if the button remains pressed. Accelerated scrolling stops at the newest or oldest SER event record available, depending on the direction of the scrolling. When the upper limit of the SER events is reached, press the {Down Arrow} one more time and the report will wrap around to display the screen containing the first SER event. Similarly, when the lower limit of the SER events is reached, press the {Up Arrow} one more time and the report will wrap around to display the screen containing the last SER event.

RELAY ELEMENTS (Relay Word Bits)

You can view the RELAY ELEMENTS screen to check the state of the Relay Word bits in the SEL-487B. 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 5.25* shows an example of the RELAY ELEMENTS screen. If an alias exists for an element, the alias name is displayed instead of the element name. Notice the labels 89BF1, 89CLF1, 89OIPF1, and 89ALF1, which are alias names for 89B44, 89CL44, 89OIP44 and 89AL44.

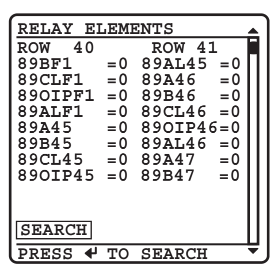

Figure 5.25 RELAY ELEMENTS Screen

When you move screen by screen through the Relay Word bit table, pressing the {Up Arrow} or {Down Arrow} pushbuttons shows each previous or next screen in turn. Accelerated navigation occurs when you press and hold the {Up Arrow} or {Down Arrow} pushbuttons.

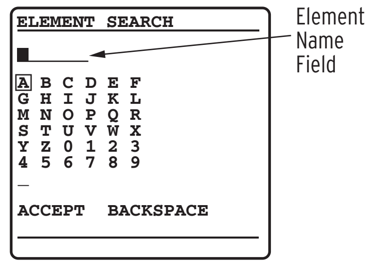

Figure 5.26 ELEMENT SEARCH Screen

Search mode allows you to find a specific relay target element quickly. *Figure 5.26* shows the menu screen that the relay displays when you select the SEARCH option of the RELAY ELEMENTS main screen. 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. 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 first searches for alias names, seeking an exact match. If the relay does not find an exact alias name match, it searches for an exact primitive name match. If there is no exact primitive name match, the relay initiates a partial alias name string search, followed by a partial primitive name 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-487B 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 circuit breakers (password required)
- ➤ Switch terminals IN and OUT of service
- ➤ Test relay outputs (password required)

If the NUMBK setting (Global settings) is 1 or more, the relay displays the BREAKER CONTROL option, as shown in *Figure 5.27*. Other options are the local bit control and --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.4.40* and *Password and Circuit Breaker Jumpers on page U.2.16*. The submenu does not display either the --OUTPUT TESTING-- or --BREAKER CONTROL-- options if the breaker jumper is not installed. (The relay checks the status of the breaker jumper 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. Because there is no operation possible, the screen returns to the MAIN MENU following a short delay.

Local bit names appear in the local control bit names field, as shown in *Figure 5.27*. Use the **{Up Arrow}** and **{Down Arrow}** 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--
F1 OUT OF SERVICE
F2 OUT OF SERVICE
F3 OUT OF SERVICE
T1 OUT OF SERVICE
TB OUT OF SERVICE
--OUTPUT TESTING--
```

Figure 5.27 LOCAL CONTROL Initial Menu

BREAKER CONTROL

NOTE: If NUMBK = 1, selecting BREAKER CONTROL takes you directly to the BREAKER CONTROL screen.

NOTE: Default settings for the trip and output SELogic control equations do not include Relay Word bits OCnn. Include Relay Word bits OCnn in the TRnn SELogic control equations for those terminals you want to control from the front panel.

The BREAKER CONTROL option presents a circuit breaker selection submenu to open up to 18 breakers. Circuit breakers cannot be closed from this menu. NUMBK (Global settings) sets the number of breakers available. For example, if NUMBK is set to 5, then breakers one through five are presented for control. Operations from this submenu directly assert the OC*nn* Relay Word bits. For example, if BREAKER 5 is selected, the relay asserts the OC05 Relay Word bit for one processing interval. The relay uses the status of Relay Word bits 52CL*nn* (*nn* = 1 through 18) to display the breaker status. Relay Word bits 52CL*nn* are the outputs from the circuit breaker status logic (see *Section 1: Protection Functions in the Reference Manual* for more detail). Use the navigation pushbuttons and **{ENT}** to select the circuit breaker you want to control. *Figure 5.28* shows the BREAKER CONTROL submenu with NUMBK:=5, and circuit breaker control screens for BREAKER 1. Use the **{Right Arrow}** pushbutton to select the YES control action. When you highlight the YES option and press **{ENT}**, the relay displays the confirmation message OPEN COMMAND ISSUED and trips Circuit Breaker 1.

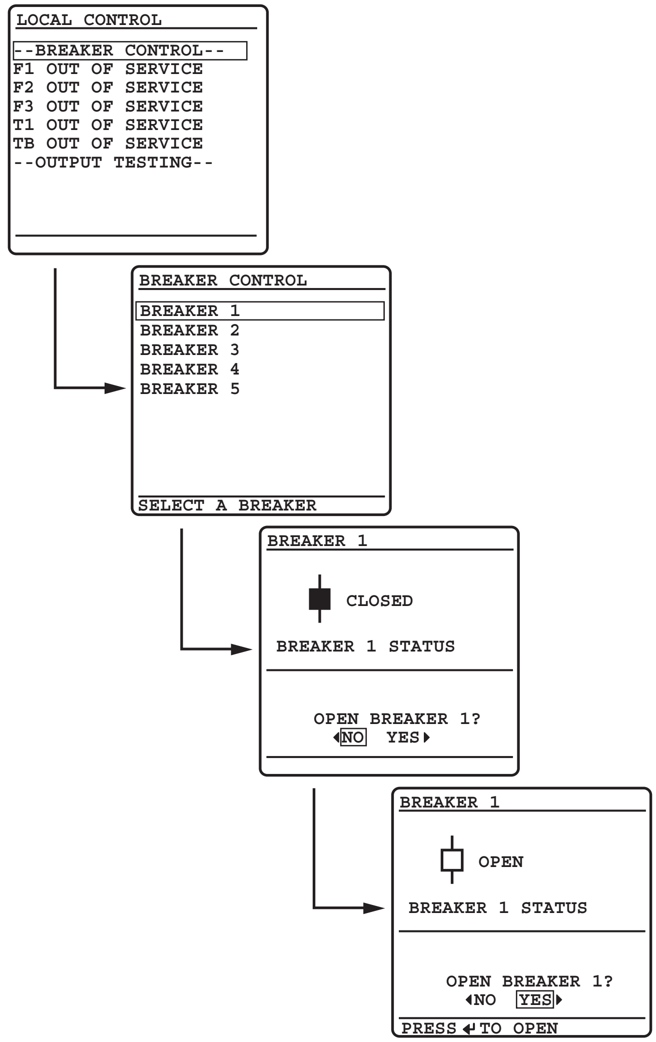

Figure 5.28 BREAKER CONTROL Screens

Local Control Bits

NOTE: The default setting for LB_SPnn is "1." The default settings satisfy the local bit supervision logic so that local bit operations can take place.

The relay provides 32 local control bits with SELOGIC control equation supervision. These local bits replace substation control handles to perform switching. The SEL-487B saves the states of the local bits in nonvolatile memory and restores the local bit states at relay power up.

Local control bit supervision is available through a SELOGIC control equation provided in the Front-Panel settings (LB_SP*nn*). For local bit operations to take place, the corresponding LB_SP*nn* must be asserted. *Table 5.9* defines the local bit SELOGIC settings available in the Front-Panel settings class. *Figure 5.40* illustrates the logic that supervises all local bit operations (Set, Clear, Pulse).

NOTE: The default settings for LB_DPnn are LBnn. The default settings cause the local bit switch to move to the corresponding state of the local bit (asserted = 1, deasserted = 0).

The SELOGIC control equation local bit status (LB_DP*nn*) is provided to return the status of a device that is being controlled by the local bit. The LB_DP*nn* Relay Word bit drives the state of the graphical switch on the display, i.e., with LB_DP*nn* deasserted, the switch points to 0.

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, unless set to momentary, in which case it goes to logical 0. Deleting a local bit sets that bit to the clear (logical 0) state.

Figure 5.29 shows a control example using the LOCAL CONTROL menus. The LCD shows a graphic representation of a substation control handle. The LB_DP*nn* SELOGIC control equation determines the state of the switch position on the LCD. If the LB_DP*nn* Relay Word bit is deasserted, the graphic control handle points to 0; if the LB_DP*nn* Relay Word bit is asserted, 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. Labels OUT OF SERVICE and IN SERVICE in *Figure 5.29* are examples of such labels. Use the **{Up Arrow}** and **{Down Arrow}** pushbuttons to highlight the set (1) or clear (0) control actions. Highlighting the set option (shown in *Figure 5.29* as OUT OF SERVICE and pressing **{ENT}** changes the local control bit and performs the required control action. If the LB_DP*nn* Relay Word bit asserts, the graphical switch moves to 1 to indicate the asserted local bit status.

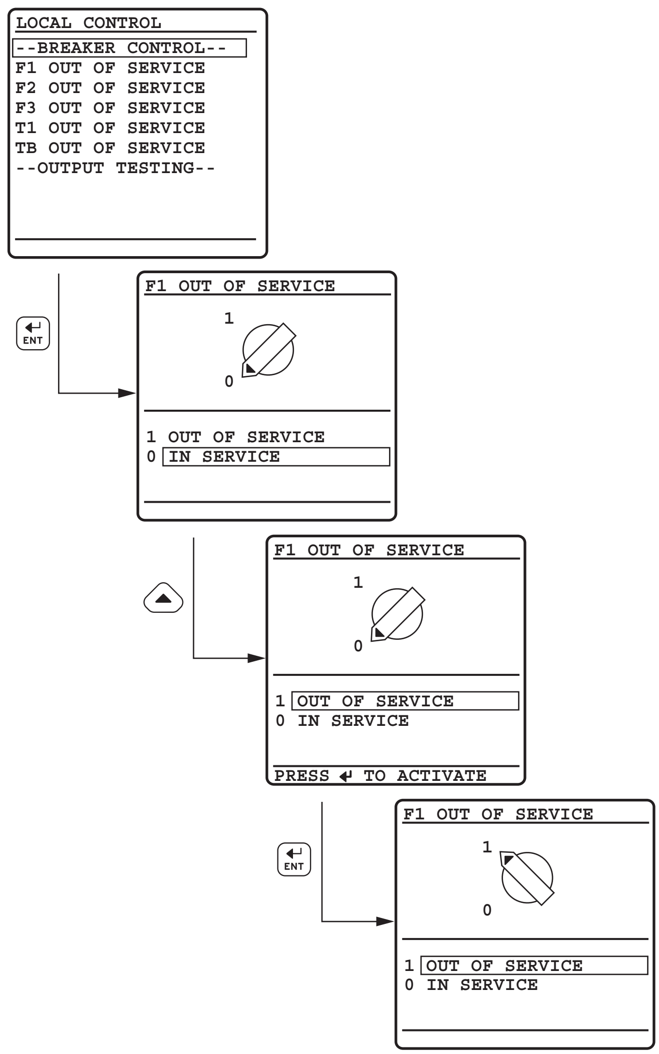

Figure 5.29 LOCAL CONTROL Example Menus

To enable a local bit, enter the local bit settings in *Table 5.8*. The format for entering the local bit data is the comma-delimited string listed below:

> 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 5.4* for particular information on enabling a local control bit.

Table 5.8 Local Bit Control Settings

Description	Range	Default
Local Bit *nn*[a]	1–32	1
Local Bit *nn* Name	20-character maximum ASCII string	(blank)
Local Bit *nn* Set Alias (1 state)	20-character maximum ASCII string	(blank)
Local Bit *nn* Clear Alias (0 state)	20-character maximum ASCII string	(blank)
Pulse Local Bit *nn*	Y, N	N

[a] nn = 01–32.

The pulse 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 element must be entered`. If you enter a local bit number and that local bit is already in use, the relay displays `The local bit element is already in use`. Likewise, if you do not enter a 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`.

Table 5.9 Local Bit SELogic[a]

Description	Range	Default
Local Bit Supervision *nn*	SELogic Equation, NA	1
Local Bit Status Display *nn*	SELogic Equation, NA	LB*nn*

[a] nn = 01–32, only available if the corresponding local bit is defined.

Local Bit Supervision SELogic control equation provides supervision of Local Bit Set, Clear, and Pulse operations.

Local Bit Status Display SELogic control equation returns the status of the local bit switch state.

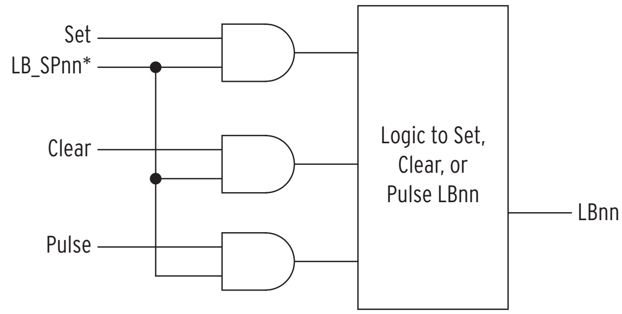

Figure 5.30 Local Bit Supervision Logic

EXAMPLE 5.4 Enabling Local Bit Control

This application example demonstrates a method to create one of the control points in the LOCAL CONTROL screens of Figure 5.30 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.4.18 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 (NoTIE)",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.2.16.

You can check for proper operation of the SEL-487B control outputs by using the OUTPUT TESTING submenu of the LOCAL CONTROL menu. A menu screen similar to *Figure 5.31* displays a list of the control outputs available in your relay configuration. For more information on output testing, see *Control Output on page U.4.40*.

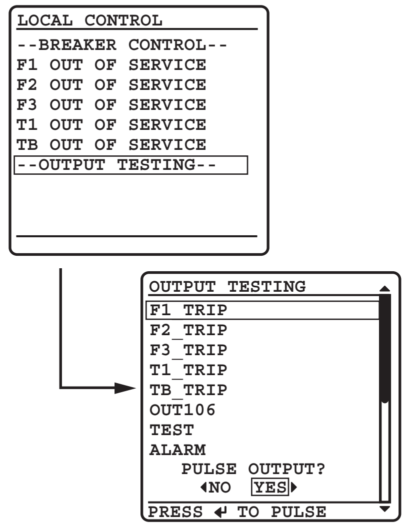

Figure 5.31 OUTPUT TESTING Screen

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-487B port settings, active setting group, and date/time. From the front panel you can change only the settings class and settings listed in *Table 5.10*.

Table 5.10 Settings Available From the Front Panel

Class/Setting	Description
PORT	Relay communications port settings
ACTIVE GROUP	Active settings group number 1–6
DATE/TIME	Date and time settings

At the MAIN MENU, select the SET/SHOW item and press **{ENT}**. Use the navigation pushbuttons to select the relay PORT settings or to change the ACTIVE GROUP or the DATE/TIME.

Next, select the particular instance of the settings class. For the PORT settings class, the instances are Port 1, Port 2, Port 3, and Port F. 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.

Figure 5.32 shows the major navigational steps to select MBA on Port 1. Select the PORT class.

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.

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).

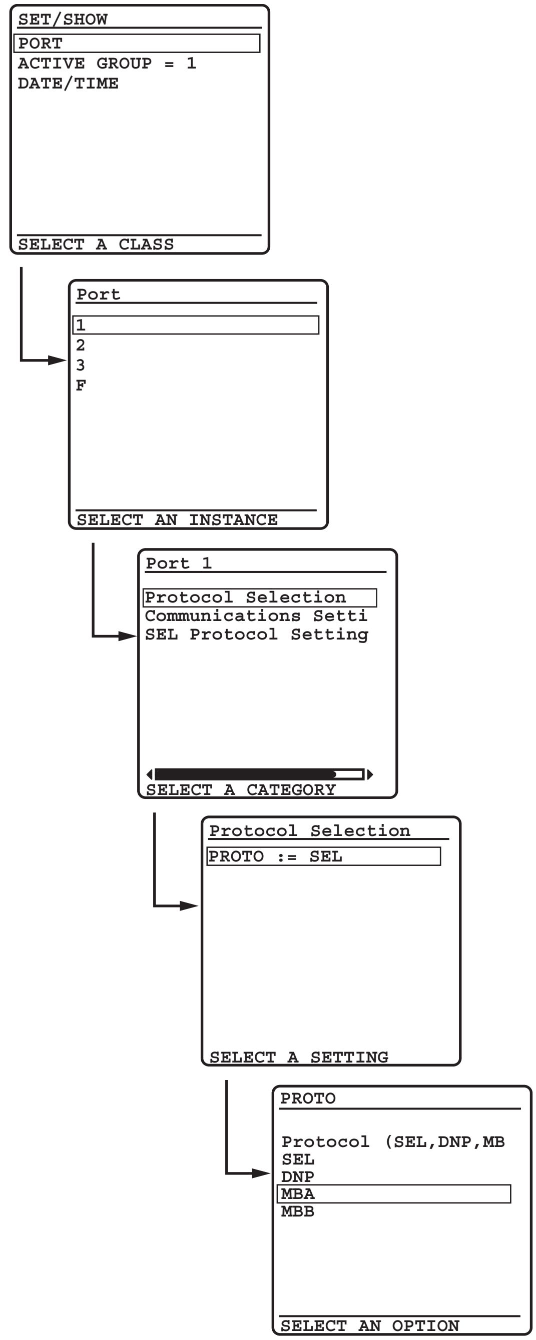

Figure 5.32 SET/SHOW Screens

ACTIVE GROUP

Select the ACTIVE GROUP option of the SET/SHOW submenu screen (shown in *Figure 5.33*) 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 5.33*. The relay shows the active group and underlines the group number after NEW GROUP =. Use the **{Up Arrow}** and **{Down Arrow}** 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.

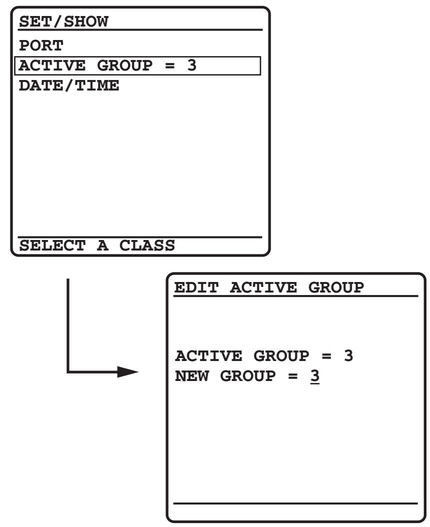

Figure 5.33 Changing the ACTIVE GROUP

DATE/TIME

Another submenu item of the SET/SHOW first screen (*Figure 5.32*) is the DATE/TIME screen shown in *Figure 5.34*. The SEL-487B generates date and time information internally, or you can use external high-accuracy time modes with time sources such as a GPS receiver.

Figure 5.34 is the relay date/time screen when a high accuracy source is in use. Possible time sources, qqqqq, are listed in *Table 4.9*. 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.

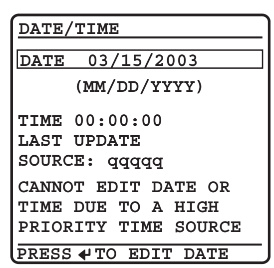

Figure 5.34 DATE/TIME Screen

When operating from a nonhigh-accuracy time source, you can use the front-panel DATE and TIME entry screens to set the date and time. *Figure 5.35* shows an example of these edit screens. Use the **{Left Arrow}** and **{Right Arrow}** navigation pushbuttons to move the underscore cursor; use the **{Up Arrow}** and **{Down Arrow}** 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 Timekeeping on page U.4.49*.

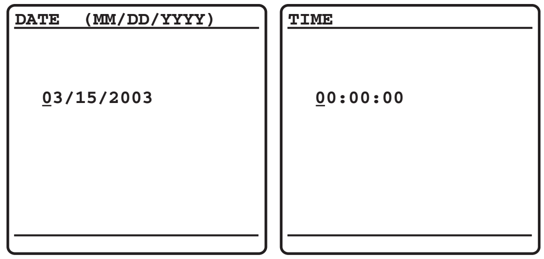

Figure 5.35 Edit DATE and Edit TIME Screens

To enable a high-accuracy external time source, connect a GPS receiver to the relay. For a discussion of the IRIG timing mode in the SEL-487B see *Configuring Timekeeping on page U.4.49*.

RELAY STATUS

The SEL-487B 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 RELAY STATUS screen immediately and freezes the front-panel display showing the failure report. 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 5.36* 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.6.34*.

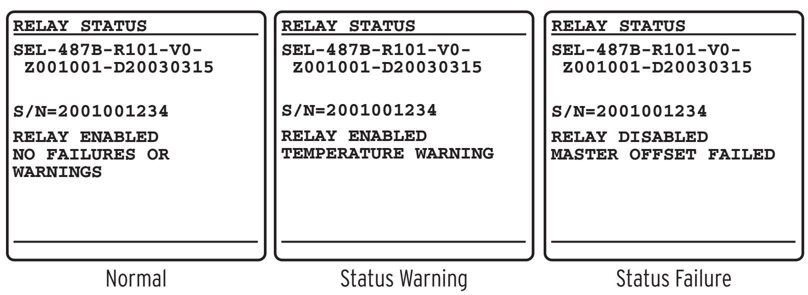

Figure 5.36 Relay STATUS Screens

VIEW CONFIGURATION

You can use the front panel to view detailed information about the configuration of the firmware and hardware components in the SEL-487B. 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 5.37*. Use the navigation pushbuttons to scroll through these screens. When finished viewing these screens, press **{ESC}** to return to the MAIN MENU.

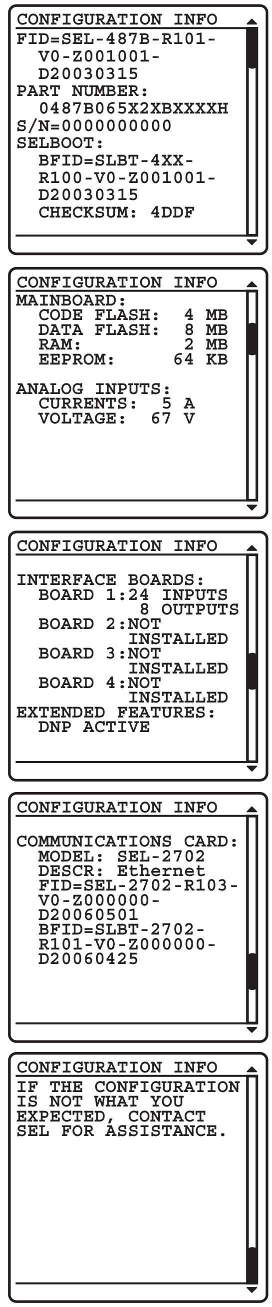

Figure 5.37 VIEW CONFIGURATION Sample Screens

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 5.38* 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.

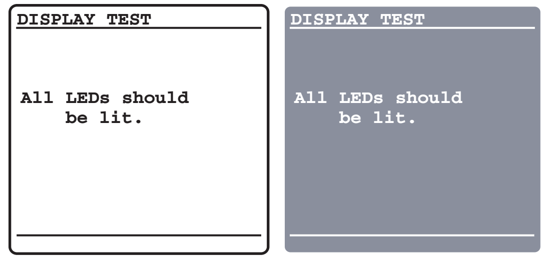

Figure 5.38 DISPLAY TEST Screens

RESET ACCESS LEVEL

The SEL-487B 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. 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 5.39* and places the front panel at Access Level 1.

The relay automatically resets the access level to Access Level 1 upon front-panel time-out (setting FP_TO is not set to OFF). Use this feature to reduce the front-panel access level before the time-out occurs.

Figure 5.39 RESET ACCESS LEVEL Screen

Front-Panel Automatic Messages

The SEL-487B 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:

- Alarm point asserts
- Event reports and trips
- Status warnings
- Status failures

In order to display event reports automatically from the ROTATING DISPLAY, you must set front-panel setting DISP_ER to Y. Front-panel setting TYPE_ER allows the user to define what types of event reports will be automatically displayed from the normal ROTATING DISPLAY; ALL will display all event types described in *Table 3.2 on page A.3.3* and TRIP will display only the event types that include the assertion of the TRIP Relay Word bit. For alarm point assertions, qualified event reports (including trip events) and status warnings, the relay displays the corresponding full-screen automatic message 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).

If you are on site using the SEL-487B front panel in menus and screens other than the MAIN MENU and a status warning occurs, alarm point asserts, 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 5.40* 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.

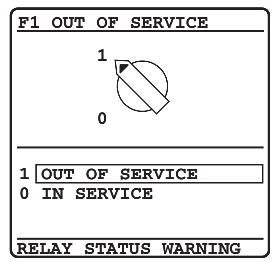

Figure 5.40 Sample Status Warning in the LCD Message Area

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 *Technical Support on page U.6.38*).

Operation and Target LEDs

The SEL-487B 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. The SEL-487B provides either 16 or 24 LEDs depending on ordering options selected.

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 24 that indicates each LED. LED positions are described in parenthesis next to each LED in *Figure 5.41*. 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. With T*n*LEDL := Y, the relay reports these targets in event report summaries. The asserted and deasserted colors for the LED are determined with settings T*n*LEDC (12-pushbutton version). Options include red, green, amber, or off. 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.8.23*.

Use the slide-in labels to mark the LEDs with custom names. Included on the SEL-487B Product Literature CD are Customer Label Templates to print labels for the slide-in label carrier. *Figure 5.41* shows the arrangement of the operation and target LEDs region into several areas described in *Table 5.11*.

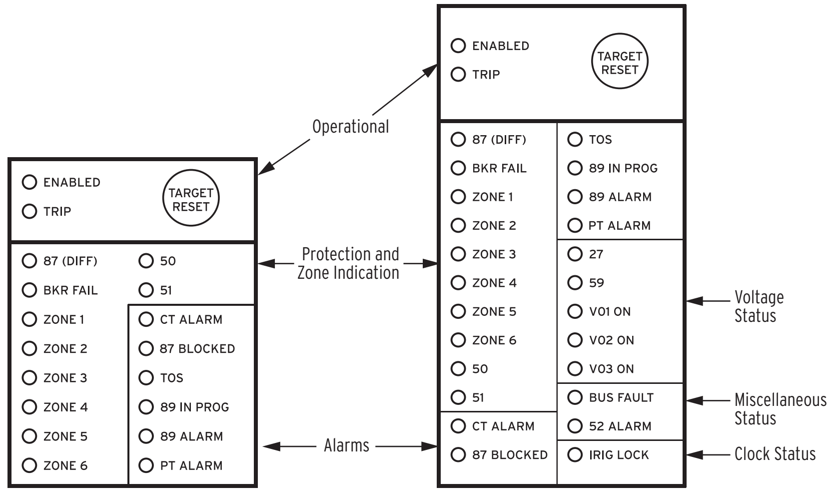

Figure 5.41 Factory Default Front-Panel Target Areas (16 or 24 LEDs)

Table 5.11 Front-Panel Target LEDs

Label	Function
ENABLED, TRIP	Operational
87 (DIFF), BKR FAIL, ZONE 1, ZONE 2, ZONE 3, ZONE 4, ZONE 5, ZONE 6, 50, 51	Protection and Zone Indication
CT ALARM, 87 BLOCKED, TOS, 89 IN PROG, 89 ALARM, PT ALARM	Alarms
27[a], 59[a], V01 ON[a], V02 ON[a], V03 ON[a]	Voltage Status
BUS FAULT[a], 52 ALARM[a]	Miscellaneous Status
IRIG LOCK[a]	Clock Status

[a] Only available in 24 LED models.

Operational

The ENABLED LED indicates that the relay is active. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area helps you recognize a trip event quickly. Program settings EN_LEDc and TR_LEDc to determine the color of the respective LED (12-pushbutton version). Options include red or green.

TARGET RESET and Lamp Test

For a trip event, the relay latches the trip-involved target. 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, one of two possible trip situations can exist:

- the conditions that caused the relay to trip have cleared
- 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 U.5.30*).

Other Target Reset Options

You can reset the target LEDs with the **TAR R** ASCII command; see *TARGET on page R.7.42* for more information. 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. You also need to assign the RSTTRGT Relay Word bit to the corresponding ULTR*nn* SELOGIC control equation.

Protection and Zone Indication

The SEL-487B indicates essential information about the most recent relay trip event with the LEDs of the Protection and Zone Indication area. These trip types are 87 (DIFF), BKR FAIL, ZONE 1–6, 50, 51.

The 87 (DIFF) target LED illuminates and latches the indication, indicating operation of any one of the six SEL-487B differential elements.

The BKR FAIL target LED illuminates and latches the indication, indicating operation of any one of the 18 SEL-487B breaker failure elements.

The ZONE 1–6 target LEDs illuminate and latches the indication, indicating the zone(s) in which the fault occurred.

The 50 target LED illuminates and latches the indication, indicating operation of any one of the 18 nondirectional, instantaneous elements.

The 51 target LED illuminates and latches the indication, indicating operation of any one of the 18 nondirectional, time-delayed overcurrent elements.

Alarms

The alarm area target indicators are the CT ALARM, 87 BLOCKED, TOS, 89 IN PROG, 89 ALARM, PT ALARM LEDs.

The CT ALARM (current transformer) target illuminates but does not latch the indication when any one of the six sensitive differential elements times out.

The 87 BLOCKED target illuminates and latches the indication when any one of the six Zone Supervision (Z*n*S) SELOGIC control equations becomes a logical 0.

The TOS (Terminal Out of Service) target illuminates but does not latch the indication when any one of the 18 terminals is out of service.

The 89 IN PROG target illuminates but does not latch the indication when a disconnect operation is in progress on any one of the 48 disconnects.

The 89 ALARM (Disconnect Alarm) target illuminates but does not latch the indication when the disconnect alarm 89AL asserts.

The PT ALARM (potential transformer) target illuminates and latches after a 240-cycle time delay, indicating the presence of a negative- or zero-sequence voltage. This function works on the assumption that all three phases from the PTs are available in the same relay. In a three-relay application, wire the three phases from the PTs to the same SEL-487B.

Voltage Status

The 27 target LED illuminates when any one of the terminal undervoltage elements operates.

The 59 target LED illuminates when any one of the terminal overvoltage elements operates.

The V01 ON, V02 ON, and V03 ON LEDs illuminate when the terminal filtered instantaneous voltages are greater than 55 V. See *Table 8.51 on page R.8.23* for setting default values. The default setting of 55 V is 82 percent of the line-to-neutral nominal voltage of 67 V to coincide with the nominal line-to-line voltage of 115 V.

Miscellaneous Status

The BUS FAULT target LED illuminates when a busbar fault is detected (Relay Word bit FAULT is asserted).

The 52 ALARM target LED illuminates when the relay detects any circuit breaker alarm (Relay Word bit 52AL is asserted).

Clock Status

The IRIG LOCK target LED illuminates in the SEL-487B when the relay detects synchronization to an external clock with less than 3 ms of jitter (Relay Word bit TIRIG is asserted). See *IRIG-B on page U.4.49* for complete details.

Front-Panel Operator Control Pushbuttons

The SEL-487B front panel features large operator control pushbuttons coupled with amber annunciator LEDs for local control. *Figure 5.42* shows this region of the relay front panel with factory default configurable front-panel label text. The SEL-487B provides either 8 or 12 pushbuttons depending on ordering options selected.

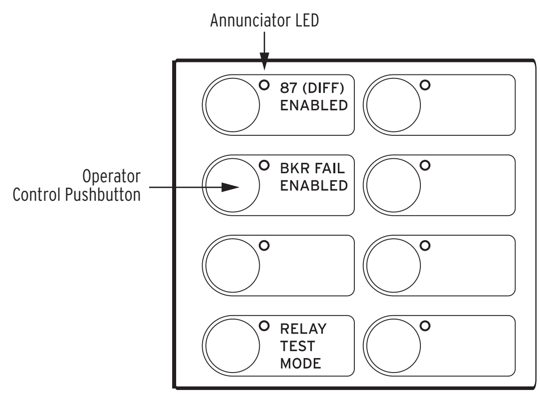

Figure 5.42 Operator Control Pushbuttons and LEDs (8 Pushbutton Version)

Factory default programming associates specific relay functions with the eight pushbuttons and LEDs. The SEL-487B default setting uses only three of the eight pushbuttons, as listed in *Table 5.12*. For a concise listing of the default programming for the front-panel pushbuttons and LEDs, see *Front-Panel Settings on page R.8.23*.

Table 5.12 Operator Control Pushbuttons and LEDs—Factory Defaults

LED	Function
{87 (DIFF) ENABLED}	Enable the differential protection
{BKR FAIL ENABLED}	Enable the breaker failure protection
{RELAY TEST MODE}	Enable the differential and breaker failure protection, but inhibit trip outputs

Press the operator control pushbuttons momentarily to toggle on and off the functions listed adjacent to each LED/pushbutton combination. The operator control pushbuttons and LEDs are programmable. *Figure 5.43* describes the factory defaults for the three operator controls.

There are two ways to program the operator control pushbuttons. The first is through front-panel settings PB*n*_HMI. These settings allow any of the operator control pushbuttons to be programmed to display a particular HMI screen category. The HMI screen categories available are Alarm Points, Display Points, Event Summaries, and SER. Front-panel setting NUM_ER allows the user to define the number of event summaries that are displayed via the operator control pushbutton; it has no effect on the event summaries automatically displayed or the event summaries available through the main menu. Each HMI screen category can be assigned to a single pushbutton. Attempting to program more than one pushbutton to a single HMI screen category will result in an error. After assigning a pushbutton to an HMI screen category, pressing the pushbutton will jump to the first available HMI screen in that particular category. If more than one screen is available, a navigation scroll bar will be displayed. Pressing the navigation arrows will scroll through the available screens. Subsequent pressing of the operator control pushbutton will advance through the available screens, behaving the same as the **{Right Arrow}** or the **{Down Arrow}** pushbutton. Pressing the **{ESC}** pushbutton will return the user to the `ROTATING DISPLAY`. The second way to program the operator control pushbutton is through SELOGIC control equations, using the pushbutton output as a programming element. Using SELOGIC control equations, you can 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. Word processor templates for printing slide-in labels are included on the SEL-487B Product Literature CD. See *Relay Placement on page U.2.22* for more information on changing the slide-in labels.

The SEL-487B 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 PB12 are the "follow" outputs of operator control pushbuttons. Relay Word bits PB1_PUL through PB12PUL are the "pulsed" outputs.

Annunciator LEDs for each operator control pushbutton are **PB1_LED** through **PB12LED**. The factory defaults programmed for three LEDs used are protection latches (PLT01, for example), settings groups, and Relay Word bits. The asserted and deasserted colors for the LED are determined with settings PB*n*COL (12-pushbutton version). Options include red, green, amber, or off. 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.

NOTE: The pushbutton outputs are delayed by approximately one-half of a second to prevent inadvertent operation.

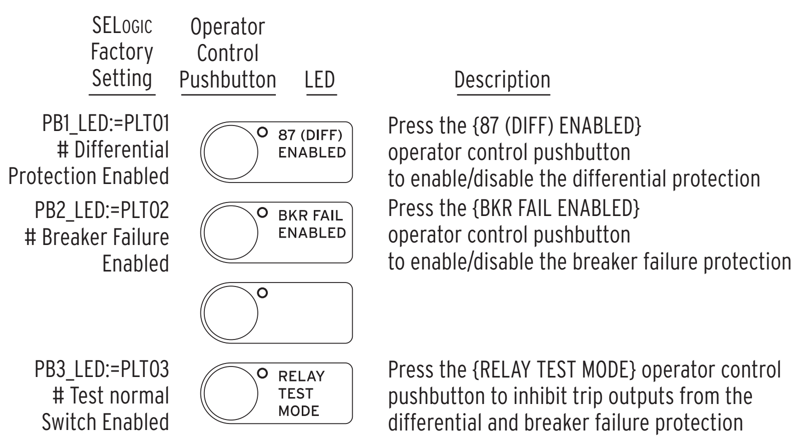

Figure 5.43 Factory Default Operator Control Pushbuttons

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Section 6
Testing and Troubleshooting

Overview

This section contains guidelines for determining and establishing test routines for the SEL-487B Relay. Follow the standard practices of your company in choosing testing philosophies, methods, and tools. The SEL-487B incorporates self-tests to help you diagnose any potential difficulties. The subsection *Relay Troubleshooting on page U.6.36* contains a quick-reference table for common relay operation problems.

This section includes the following topics, tests, and troubleshooting procedures:

- ➤ Testing philosophy
- ➤ Testing features and tools
- ➤ Test methods
- ➤ Checking relay operation
- ➤ Relay self-tests
- ➤ Relay troubleshooting
- ➤ Factory assistance

The SEL-487B 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 the testing takes place in the life of the relay. Each testing category includes particular details as to when to perform the test, the testing goals, and the relay functions that you need to test. This information is a guide to testing the SEL-487B; 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. 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. *Table 6.1* presents a summary of acceptance testing guidelines.

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-487B 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.

Step 1. Check control signal inputs and outputs.

Step 2. Check disconnect auxiliary contact inputs, circuit breaker auxiliary contact inputs, breaker failure inputs, SCADA control inputs, trip outputs, and monitoring outputs.

Step 3. Use an ac test set to verify that the relay current and voltage inputs have the proper magnitude and angles.

Step 4. Conduct brief fault tests to 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.

Step 5. At commissioning, use the relay **METER** command to verify the ac current and voltage magnitudes and angles.

Step 6. Use the **PUL** command to pulse relay control output operation.

Step 7. Use the **TAR** command to view relay targets and verify that control inputs are operational.

Step 8. Use the **TEST DB, TEST FM**, and **TEST DNP** commands to check SCADA interfaces.

Table 6.2 lists guidelines for commissioning testing. For further discussion of these tests, see *Checking Relay Operation on page U.6.18*.

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	a) Test all connected inputs, outputs, and CT polarities. b) Make simple checks of protection elements. c) Test communications interfaces.

Maintenance Testing

The SEL-487B uses extensive self-testing routines and includes detailed metering and event reporting functions. These features reduce your dependence on routine maintenance testing. 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-487B reporting features as maintenance tools. Periodically compare the relay **METER** command output to other online meter readings to verify that the relay measures currents and voltages correctly and accurately.

Each occurrence of a power system 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 whether the relay protection elements operated 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, test only those items that have not operated (via fault conditions) during the maintenance interval. You do not need to perform further maintenance testing for a correctly set and connected relay that measures the power system properly and has not failed relay self-tests.

The SEL-487B 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*. 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-487B provides the following features to assist you during relay testing:

- Metering
- 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-487B incorporates a low-level test interface you can use to 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 to the relay; 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 or secondary values. In addition, metering shows many other quantities such as the voltage input to the station dc battery monitor. Compare these measured quantities in the relay against quantities from other devices of known accuracy. The metering data are available at the serial ports and communications card and at the front-panel ROTATING DISPLAY screen.

Event Reports

The relay also generates filtered and unfiltered event reports in response to faults or disturbances. Each event report contains information on currents, voltages, relay elements, 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 event report data gives you a visual tool for testing relay operating quantities. You can use the communications ports and the ACSELERATOR software to view event reports. See *Event Reports, Summaries, and Histories on page A.3.6* 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 check 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 for a more detailed analysis.

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.3.31*.

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.7.42* and *Operation and Target LEDs on page U.5.32*.

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 from the front-panel LCD. See *PULSE on page R.7.29*.

TEST DB Command

Use the **TEST DB** command for testing the communications card relay database. The **TEST DB** command can be used to override any value in the relay database. Since the relay database provides data to the communications card interfaces, the **TEST DB** command can also be used to test the data read operations of the DNP3, LAN/WAN or IEC 61850 protocols on an installed Ethernet card. Use the **MAP 1** command and the **VIEW1** command to inspect the relay database (see *MAP on page R.7.21 in the Reference Manual* and *VIEW on page R.7.50 in the Reference Manual*). You must be familiar with the relay database structure to use the **TEST DB** command effectively.

TEST DNP Command

Use the **TEST DNP** command to test the serial DNP3 interface. Values you enter in the DNP3 map are override values. Use the **TEST DNP** command to write override values in the serial DNP3 map. For more information on serial DNP3 and the SEL-487B, see *Section 5: DNP3 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 (voltages and currents). For more information on Fast Meter and the SEL-487B, see *Section 7: ASCII Command Reference in the Reference Manual*.

TEST Switch

When testing the relay, use front-panel PB4 (labeled {RELAY TEST MODE}) to disable the trip output from the relay. All protection elements are available for testing, but the pushbutton prevents the output contacts from asserting. This pushbutton only asserts after a time delay of approximately half a second to prevent the inadvertent assertion of the pushbutton. Output OUT107 asserts when PB4 asserts and can be used to assert an alarm.

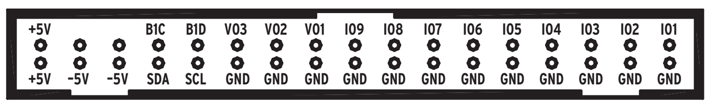
Low-Level Test Interface

> ⚠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.

The SEL-487B has a low-level test interface between the two calibrated input modules and the processing module. You can test the relay in two ways: by using secondary injection testing or by applying low-magnitude ac voltage signals to the low-level test interface.

Access the test interface by removing the relay front panel. At the right side of the relay main board is the processing module. Inputs to the processing module are multipin connectors J20 and J21, the analog or low-level test interface connections. Receptacle J20 is on the right side of the main board, with J21 located 5 cm (2 inches) behind J20; for a locating diagram, see *Figure 2.11*.

Figure 6.1 shows the connections for low-level interface J20 and *Figure 6.2* the connections for low-level interface J21. Apply only the nominal voltage levels and current levels listed in the figures to the relay. Never apply voltage signals greater than 6.6 V peak-to-peak 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 and J21 receptacles and substitute a test cable with the signals specified in *Figure 6.1* and *Figure 6.2*.

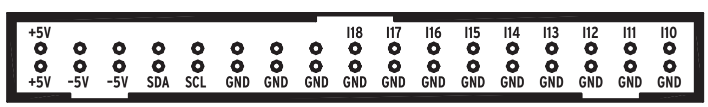


Input Module Output (J3): 66.6 mV at Nominal Current (1 A or 5 A).
446 mV at Nominal Voltage (67 V_{LN}).

Processing Module Input (J20): 6.6 $V_{p\text{-}p}$ Maximum.

U.S. Patent 5,479,315.

Figure 6.1 Low-Level Test Interface J20



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 (J21): 6.6 $V_{p\text{-}p}$ Maximum.

U.S. Patent 5,479,315.

Figure 6.2 Low-Level Test Interface J21

Main Board Processing Module Tests

Use signals from the Low-Level Relay Test System to test the relay processing module. Apply appropriate signals to the low-level test interface connections J20 and J21 from the Relay Test System (see *Figure 6.1*and *Figure 6.2*). 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-487B in the SEL-5401 Relay Test System Software are shown in *Table 6.4*, *Table 6.5*, *Table 6.6*, and *Table 6.7*.

Table 6.4 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Y)—5 A Relay

Channel	Label	Scale Factor	Unit
1	I01	75	A
2	I02	75	A
3	I03	75	A
4	I04	75	A
5	I05	75	A
6	I06	75	A
7	I07	75	A
8	I08	75	A
9	I09	75	A
10	V01	150	V
11	V02	150	V
12	V03	150	V

Table 6.5 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Z)—5 A Relay

Channel	Label	Scale Factor	Unit
1	I10	75	A
2	I11	75	A
3	I12	75	A
4	I13	75	A
5	I14	75	A
6	I15	75	A
7	I16	75	A
8	I17	75	A
9	I18	75	A

Table 6.6 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Y)—1 A Relay

Channel	Label	Scale Factor	Unit
1	I01	15	A
2	I02	15	A
3	I03	15	A
4	I04	15	A
5	I05	15	A
6	I06	15	A
7	I07	15	A
8	I08	15	A
9	I09	15	A
10	V01	150	V
11	V02	150	V
12	V03	150	V

Table 6.7 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Z)—1 A Relay

Channel	Label	Scale Factor	Unit
1	I10	15	A
2	I11	15	A
3	I12	15	A
4	I13	15	A
5	I14	15	A
6	I15	15	A
7	I16	15	A
8	I17	15	A
9	I18	15	A

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 5 A relays. Scale values appropriately for 1 A relays. The CD included with purchase of your SEL-487B contains text files with the relay default settings. On completion of each test, use the **FILE WRITE** command to reload the default settings. See *Section 7: ASCII Command Reference in the Reference Manual* for more information.

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 Terminal Emulation Software

Use the procedure in the following steps to view a change in state of Relay Word bit I01BZ1V from a communications port. When Relay Word bit I01BZ1V asserts, the relay considers the current input from Terminal I01 in the differential calculations of Bus-Zone 1. The relay does not consider the current input from Terminal I01 in the differential calculations of Bus-Zone 1 when Relay Word bit I01BZ1V deasserts. See *Bus-Zone Configurations on page A.1.21*. From Access Level 2, use the **SHO Z** command to generate a report of the default values of the zone configuration settings. *Figure 6.3* shows an extract of the relay response.

```
=>>SHO Z <Enter>
Zone Config Group 1

.
.
.

Zone Configuration: Terminal to Bus-Zone Connections

Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := FDR_1, BUS_1, P
FDR_1 to BUS_1 Connection (SELogic Equation)
I01BZ1V := DIFF_EN AND NOT TOS01
.
.
.

=>>
```

Figure 6.3 An Extract of the Relay Response to the SHO Z Command

From *Figure 6.3*, we see that Relay Word bit I01BZ1V becomes a logical 1 when DIFF_EN asserts and while TOS01 is not asserted. DIFF_EN is the front-panel pushbutton labeled {87 (DIFF) ENABLED}. The pushbutton settings include a short time delay to prevent an inadvertent assertion of Relay Word bit I01BZ1V. Press the pushbutton for half a second before the Relay Word bit asserts.

For this procedure, you must have a computer with terminal emulation software and a variable current source for relay testing. This example assumes that you have successfully established communications with the relay; see *Making an EIA-232 Serial Port Connection on page U.4.5* for a step-by-step procedure. Review *Changing the Default Passwords on page U.4.6* for information on how to change the default access level passwords and enter higher relay access levels.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Type **ACC <Enter>** at a communications terminal.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the => prompt.

Step 2. View the initial element status.

a. Type **TAR I01BZ1V <Enter>**.

The relay returns a target terminal screen similar to *Figure 6.4*.

```
=>>TAR I01BZ1V <Enter>

I08BZ1V I07BZ1V I06BZ1V I05BZ1V I04BZ1V I03BZ1V I02BZ1V I01BZ1V
0       0       0       0       0       0       0       0

=>>
```

Figure 6.4 Sample Targets Display on a Serial Terminal

Step 3. View the element status change.

a. Type **TAR I01BZ1V 1000 <Enter>**.

This command causes the relay to repeat the **TAR I01BZ1V** command 1000 times.

b. Push the front-panel pushbutton labeled {87 (DIFF) ENABLED} for longer than half a second.

You will see Relay Word bit I01BZ1V (as well as Relay Word bits I05BZ1V and I02BZ1V) change status from a logical 0 to a logical 1 after half a second.

c. Press pushbutton **{87 (DIFF) ENABLED}** one more time. All Relay Word bits will deassert.

d. Press **<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* for more information on using the relay front panel. The following procedure again uses Relay Word bit I01BZ1V as an example.

Step 1. Display the `MAIN MENU`.

a. If the relay LCD is in the `ROTATING DISPLAY`, press the **{ENT}** pushbutton to display the `MAIN MENU` similar to the first screen of *Figure 6.5*.

Step 2. Prepare to view the elements on the front-panel LCD.

a. Press the **{Down Arrow}** navigation pushbutton to highlight the `RELAY ELEMENTS` action item (see the first screen of *Figure 6.5*).

b. Press the **{ENT}** pushbutton. You will see a `RELAY ELEMENTS` screen (the second screen of *Figure 6.5*).

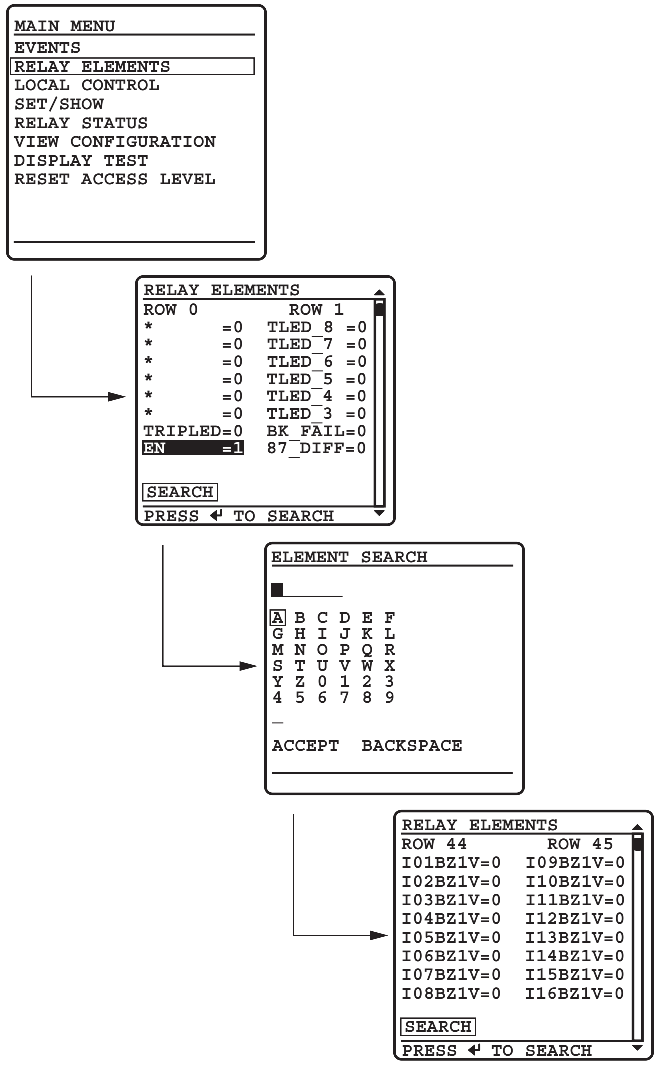


Figure 6.5 Viewing Relay Word Bits From the Front-Panel LCD

Step 3. Display Relay Word bit I01BZ1V on the front-panel LCD screen.

a. Press **{ENT}** to go to the `ELEMENT SEARCH` submenu of *Figure 6.5*.

b. Use the navigation keys to highlight `I` and then press **{ENT}** to enter the character `I` in the text input field.

c. Enter the `0`, `1`, `B`, `Z`, `1`, and `V` characters in the same manner.

d. Press **{ENT}** when the cursor jumps to `ACCEPT`. The relay displays the LCD screen containing the `I01BZ1V` element, as shown in the last screen of *Figure 6.5*.

Step 4. View the target status change.

a. Push the front-panel pushbutton labeled **{87 (DIFF) ENABLED}** for at least half a second.

b. Observe the `I01BZ1V` target on the front-panel display.

You will see the I01BZ1V element status change to 1 after half a second (I02BZ1V and I05BZ1V also assert because pushbutton **{87 (DIFF) ENABLED}** also controls these equations).

Step 5. Press pushbutton **{87 (DIFF) ENABLED}** once more. The Relay Word bits will deassert.

Step 6. Press **{ESC}** to return to the MAIN MENU.

View Relay Element Change With a Front-Panel LED

The following procedure is an example of how to use a front-panel LED to view a change-in-state for Relay Word bit I01BZ1V.

Step 1. Establish Level 2 communications with the relay.

Step 2. Set a pushbutton LED SELOGIC® control equation.

Figure 6.6 shows the steps involved in configuring the LED of front-panel pushbutton **{PB3_LED}** to assert when Relay Word bit I01BZ1V asserts.

a. From Access Level 2, use the serial port command **SET F** and press **<Enter>** three times.

b. Enter **I01BZ1V <Enter>** at the ? prompt for pushbutton PB3_LED.

c. Enter **END <Enter>** at the next prompt and **Y <Enter>** to save settings.

```
=>>SET F <Enter>
Front Panel

Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)       FP_TO   := 15     ? <Enter>
Pushbutton LED 1 (SELogic Equation)
PB1_LED := DIFF_EN # Differential Protection Enabled
? <Enter>
Pushbutton LED 2 (SELogic Equation)
PB2_LED := BF_EN # Breaker Failure Enabled
? <Enter>
Pushbutton LED 3 (SELogic Equation)
PB3_LED := NA
?  I01BZ1V <Enter>
Pushbutton LED 4 (SELogic Equation)
PB4_LED := TNS_SW # Test normal Switch Enabled
?  END <Enter>
Front Panel

Front Panel Settings

.
.
.

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

=>>
```

Figure 6.6 Assigning Relay Word Bit I01BZ1V to Pushbutton LED 3

Step 3. Push the front-panel pushbutton labeled **{87 (DIFF) ENABLED}** for longer than half a second. Both LED 1 (**{PB1}**) and LED 3 (**{PB3}**) assert after half a second.

Step 4. Press pushbutton **{87 (DIFF) ENABLED}** once more. Both LEDs deassert.

Step 5. Repeat *Step 2* and set PB3_LED = NA.

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.4.40* for information on configuring control inputs and control outputs. *Appendix A: Relay Word Bits in the Reference Manual* lists the names of the relay element logic outputs.

Testing Relay Word Bit I01BZ1V With a Control Output

The following procedure is an example of how to set control output OUT106 to test Relay Word bit I01BZ1V. You must have a computer communicating with the SEL-487B and a device such as a test set or a VOM (volt ohmmeter) to indicate control output closure.

Step 1. Establish Level 2 communications with the relay.

Step 2. Type **SHO O <Enter>** to view output settings.

Figure 6.7 shows an extract of the relay response to the **SHO O** command, from which we see that output contact OUT106 of the main board is not used.

```
=>>SHO O <Enter>
Output

Main Board

OUT101  := TRIP01 AND NOT TNS_SW
OUT102  := TRIP02 AND NOT TNS_SW
OUT103  := TRIP03 AND NOT TNS_SW
OUT104  := TRIP04 AND NOT TNS_SW
OUT105  := TRIP05 AND NOT TNS_SW
OUT106  := NA
OUT107  := TNS_SW #RELAY TEST MODE
OUT108  := NOT (SALARM OR HALARM)

.
.
.

=>>
```

Figure 6.7 Relay Response to the SHO O Command, Showing the Main Board Information

Step 3. Assign Relay Word bit I01BZ1V to output contact OUT106 on the main board.

a. Type **SET O OUT106 <Enter>**, followed by **I01BZ1V <Enter>** at the prompt.

b. Type **END <Enter>** and **Y <Enter>** to save the settings. *Figure 6.8* shows the steps.

```
=>>SET O OUT106 <Enter>
Output

Main Board

OUT106 := NA
?   I01BZ1V <Enter>

OUT107 := TNS_SW #RELAY TEST MODE
?   END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.8 Steps to Assign Relay Word Bit I01BZ1V to the Main Board Output Contact OUT106

Step 4. Connect an indicating device to OUT106 on the relay rear panel. A VOM multitester on a low resistance scale can indicate an OUT106 control output closure.

Step 5. Push the front-panel pushbutton labeled **{87 (DIFF) ENABLED}** for longer than half a second.

When the pushbutton asserts, Relay Word bit I01BZ1V changes to logical 1 and closes the output contacts of control output OUT106. The indicating device operates.

Step 6. Push pushbutton **{87 (DIFF) ENABLED}** once more. Output contact OUT106 will deassert.

Step 7. Type **SET O OUT 106 <Enter>**.

Step 8. Set OUT106 to NA.

Step 9. Save the settings.

Testing With SER

You can set the relay to generate a report from the SER to test relay elements.

Use the **SET R** command to enter the elements that you want to test in the SER points.

Step 1. Type **SET R <Enter>**.

Step 2. Give descriptive names for the set state and clear state in the SEL-487B SER to simplify reading of the SER report.

See *SER (Sequential Events Recorder) on page A.3.31* for complete information on the SER.

Using SER to Test Overcurrent Elements

This test combines the SER test with inverse-time overcurrent element and definite-time overcurrent element tests. Each of the 18 terminals has an inverse-time overcurrent element as well as a definite-time overcurrent element. For this example, we will test the definite-time overcurrent element of Terminal 02 and the inverse-time overcurrent element of Terminal 01. The SER gives exact time data for testing time-overcurrent element timeouts. Subtract the time-delayed element (50P02T and 51P01T) assertion times from the instantaneous pick-up element (50P02 and 51P01) assertion times to check the operating time of the elements. Use factory default settings of the elements for the test.

The procedure in the following example shows how to set the SER trigger lists to capture the operating times of the overcurrent elements. The relay uses *Equation 6.1* and *Equation 6.2* to determine the operating time, t_p, for the 51P01 element. For a current input 50 percent greater than the default pickup, the test value, I_{TEST}, is shown below:

$$I_{TEST} = M \bullet 51P01P = 1.5 \bullet 0.5 = 0.75A \qquad \textbf{Equation 6.1}$$

where:

M = The pickup multiple

51P01P = The element default pickup value (see *Table 6.8*)

Table 6.8 Time-Overcurrent Element (51P01) Default Settings

Setting	Description	Default 5 A
51P01P	Overcurrent Pickup (0.5–16 amps, secondary)	0.5
51P01C	Inverse-Time Overcurrent Curve (U1–U5, C1–C5)	U1
51P01TD	Inverse-Time Overcurrent Time Dial (0.50–15)	0.5
51P01RS	Inverse-Time Overcurrent EM Reset (Y, N)	Y
51P01TC	Inverse-Time Overcurrent Torque Cont (SELOGIC control equation)	1

The operating time (t_p) for a time dial (T_D) equal to 0.5 for the U1 (Moderately Inverse) Curve is:

$$\begin{aligned} t_p &= TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right) \text{seconds} \\ &= 0.5 \bullet \left(0.0226 + \frac{0.0104}{1.5^{0.02} - 1}\right) \text{seconds} \\ &= 0.650 \text{ seconds} \end{aligned} \qquad \textbf{Equation 6.2}$$

where:

TD = Time dial

For more information on inverse-time overcurrent elements, see *Inverse Time-Overcurrent Elements on page R.1.18*. For this example, you need a computer communicating with the SEL-487B and a variable current source for relay testing.

Step 1. Establish Level 2 communications with the relay.

Step 2. Enable overcurrent elements by typing the commands as shown in *Figure 6.9*.

```
=>>SET <Enter>
Group 1

Relay Configuration

Sensitive Differential Element Supervision (Y,N)     E87SSUP := Y       ?<Enter>
Coupler Security Logic (N,1-4)                       ECSL    := N       ?<Enter>
Terminal Out of Service (N,1-18)                     ETOS    := 5       ?N <Enter>
Breaker Failure Logic (N,1-18)                       EBFL    := 6       ?N <Enter>
Definite Time Overcurrent Elements (N,1-18)          E50     := N       ?2 <Enter>
Inverse Time Overcurrent Elements (N,1-18)           E51     := N       ?1 <Enter>
Voltage Elements (Y,N)                               EVOLT   := Y       ?> <Enter>

Sensitive Differential Element

Sensitive Differential Element Pickup (0.05-1 pu)    S87P    := 0.10    ?> <Enter>

Restrained Differential Element

Restrained Diff Element Pickup (0.10-4 pu)           O87P    := 1.00    ?> <Enter>

Directional Element

Dir Element O/C Supervision Pickup (0.05-3 pu)       50DSP   := 0.05    ?> <Enter>

Definite Time Overcurrent Elements

Terminal 01 Pickup (OFF, 0.25-100 amps,sec)          50P01P  := OFF     ? <Enter>
Terminal 02 Pickup (OFF, 0.25-100 amps,sec)          50P02P  := OFF     ?0.5 <Enter>
Terminal 02 Pickup Delay (0.00-99999 cyc)            50P02D  := 10.00   ?60 <Enter>
Inverse Time Overcurrent Element 01
51P01 O/C Pickup (0.50-16 amps,sec)                  51P01P  := 0.50    ?0.5 <Enter>
51P01 Inv-Time O/C Curve (U1-U5,C1-C5)               51P01C  := U1      ?END <Enter>
Group 1
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.9 Setting Change Description to Enable Overcurrent Elements 51P01 and 51P02

Step 3. Enter SER information. *Figure 6.10* shows how to use the **SET R** command to enter the four Relay Word bits, 51P01, 51P01T, 50P02, and 50P02T, the reporting names, set names, and clear names into the relay.

```
=>>SET R <Enter>
Report

SER Chatter Criteria

Automatic Removal of Chattering SER Points (Y,N)     ESERDEL := N       ? <Enter>

SER Points
(Relay Word Bit, Reporting Name, Set State Name, Clear State Name)

1:
?  51P01,"I01 TOC","Picked up" <Enter>
2:
?  51P01T,"I01 TOC Trip","Timed out" <Enter>
3:
?  50P02,"I02 Def. O/C","Picked up" <Enter>
4:
?  50P02T,"I02 Def. O/C Trip","Timed out" <Enter>
5:
?  END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........

=>>
```

Figure 6.10 Using the SET R Command to Enter SER Information

Step 4. Connect a test source to the relay.

a. Set the current output of a test source to zero output level.

b. Connect a single-phase current output of the test source to analog input I01 and analog input I02, as shown in *Figure 6.11*.

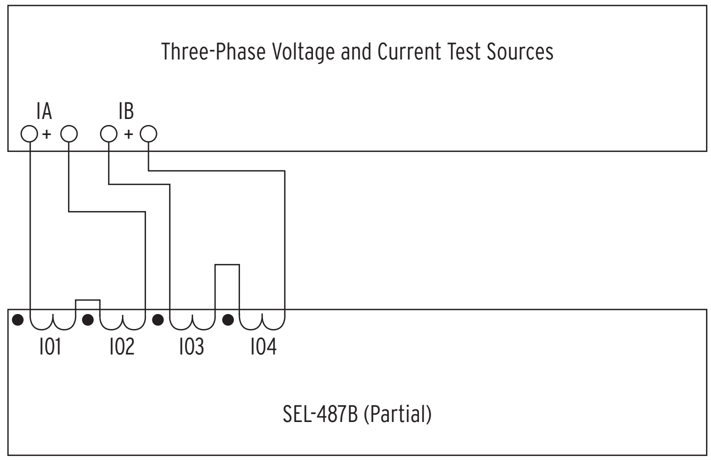


Figure 6.11 Test Connections Using Two Current Sources

Step 5. Type **SER C <Enter>**, **Y <Enter>** to clear the SER.

Step 6. Test the element.

a. Inject IA = 0.75 A and IB = 0.75 A into the relay, and keep the current source at this level longer than one second.

b. Return the current source to zero after the elements time out.

Step 7. Type **SER <Enter>** to produce an SER report (similar to that shown in *Figure 6.12*) that you can examine.

```
=>>SER <Enter>

Relay 1                                    Date: 07/24/2003  Time: 14:19:26.674
Station A                                  Serial Number: 2003005010

FID=SEL-487B-R102-V0-Z001001-D20030724

#      DATE        TIME          ELEMENT             STATE
8    04/09/2003  14:19:22.110   I02 Def. O/C         Picked up
7    04/09/2003  14:19:22.110   I01 TOC              Picked up
6    04/09/2003  14:19:22.773   I01 TOC Trip         Timed out
5    04/09/2003  14:19:23.110   I02 Def. O/C Trip    Timed out
4    04/09/2003  14:19:23.982   I02 Def. O/C         Deasserted
3    04/09/2003  14:19:23.982   I02 Def. O/C Trip    Deasserted
2    04/09/2003  14:19:23.982   I01 TOC              Deasserted
1    04/09/2003  14:19:23.982   I01 TOC Trip         Deasserted

=>>
```

Figure 6.12 Relay Response to the SER Command, Showing the TOC and Definite-Time Element Operations

Step 8. Use the SER data Point 5 and Point 8 to calculate the element operating time of the definite-time element as follows:

Operating time = Timed out–Picked up

Operating time = 23.110–22.110

Operating time = 1.0 second

Step 9. Use the SER data Point 6 and Point 7 to calculate the element operating time of the TOC element as follows:

Operating time = Timed out–Picked up

Operating time = 22.773–22.110

Operating time = 0.663 seconds

Step 10. Apply the default settings.

Checking Relay Operation

Your SEL-487B comes with all functions fully checked and calibrated so that the relay operates correctly and accurately. You can test 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-487B 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 have the proper magnitude and phase angle (see *Examining Metering Quantities on page U.4.31*). 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.4.40*). Brief functional tests and element verification confirm correct internal relay processing.

This subsection discusses tests for the following:

- Alias settings
- Zone selection function
- Sensitive differential elements
- Differential elements
- Directional element
- Voltage elements

Before you perform element tests, however, you should be aware of your substation layout, and you should apply the appropriate settings to the relay.

Example Substation

Figure 6.13 shows an example of a substation that requires two protection zones. The station layout consists of two busbars (BUS_1 and BUS_2), a tie breaker (TB_1 and TB_2), and two feeders (FDR_1 and FDR_2).

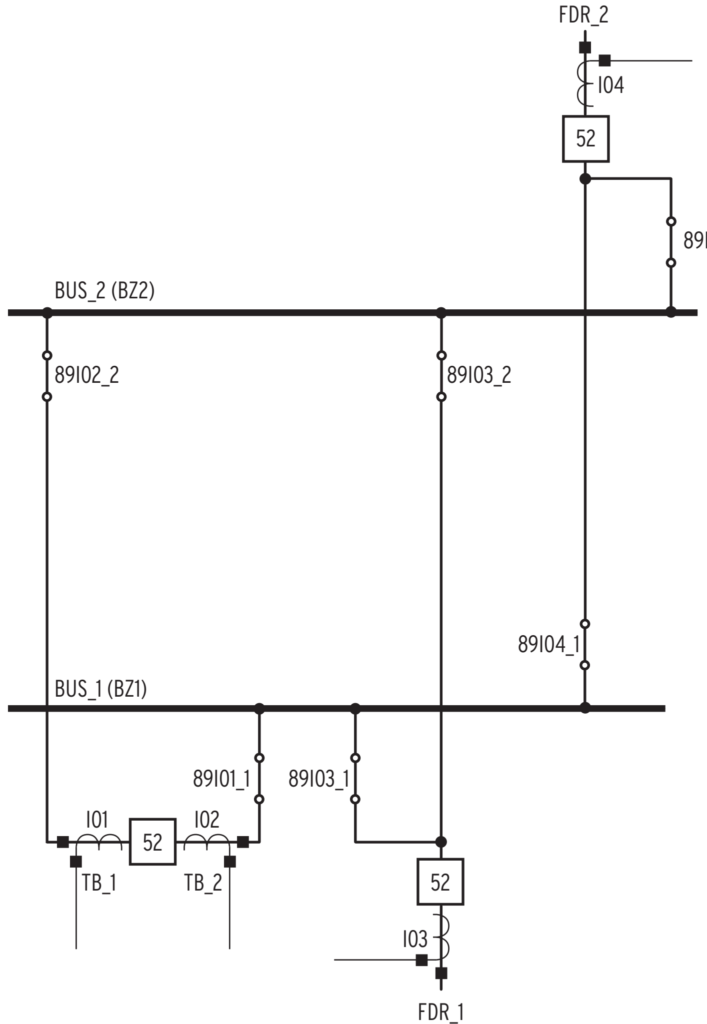


Figure 6.13 Station Layout, Comprising a Tie Breaker, Two Feeders and Two Busbars

Use front-panel pushbuttons to simulate the disconnect auxiliary contacts for the terminal-to-bus-zone SELOGIC control equations as shown in *Figure 6.14*. *Table 6.9 on page U.6.20* shows the SELOGIC control equation assignments.

NOTE: Pushbutton labels PB1 through PB8 (shown in Figure 6.14) identify the pushbuttons for this test; these labels do not appear on the relay front panel.

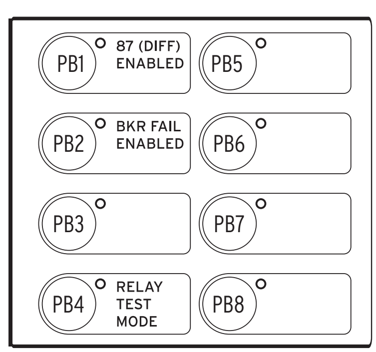


Figure 6.14 Front-Panel Operator Pushbuttons

Table 6.9 Pushbutton Assignments to Simulate Disconnect Auxiliary Contacts

Pushbutton	Relay Word Bits	Description
PB5	I01BZ1V	Connects TB_1 to BUS_1 when closed
PB6	I02BZ2V	Connects TB_2 to BUS_2 when closed
PB7	I03BZ1V	Connects FDR_1 to BUS_1 when closed
PB8	I04BZ2V	Connects FDR_2 to BUS_2 when closed

Relay Settings

Apply the appropriate settings to the relay. For the relay to match the station layout in *Figure 6.13*, change the following setting categories:

- Alias settings
- Zone configuration settings
- Protection group settings
- Protection logic settings
- Front-panel settings

Alias Settings

Change the default alias names for the four analog channels to the names indicated in *Figure 6.14*. From Access Level 2, use the **SET T** command to rename the analog channels, as shown in *Figure 6.15*.

```
=>>SET T <Enter>
Alias

Relay Aliases
(RW Bit,Analog Qty.,Terminal,Bus-Zone, or Check Zone, 7 Char. Alias [0-9 A-Z _])

1: I01,"FDR_1"
?  I01,TB_1 <Enter>
2: I02,"FDR_2"
?  I02,TB_2 <Enter>
3: I03,"FDR_3"
?  I03,FDR_1 <Enter>
4: I04,"TRFR_1"
?  I04,FDR_2 <Enter>
5: I05,"TB_1"
?  DELETE <Enter>
5: I06,"TB_2"
?  DELETE <Enter>
5: BZ1,"BUS_1"
?  END <Enter>
.
.
.

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

=>>
```

Figure 6.15 Alias Names for the Four Analog Channels

Zone Configuration Settings

Set the terminal-to-bus-zone connections to determine when the input currents from the terminals are considered in the differential calculations. We use protection latch bits in the terminal-to-bus-zone connections to emulate disconnect auxiliary contacts (see *Protection Logic Settings*). *Figure 6.16* shows the steps to enter the zone configuration settings.

```
=>>SET Z <Enter>
Zone Config Group 1

Potential Transformer Ratio

Potential Transformer Ratio -V01 (1-10000)          PTR1    := 2000   ?> <Enter>

Current Transformer Ratio

Current Transformer Ratio -I01 (1-50000)            CTR01   := 600    ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections

Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TB_1, BUS_1, P
?  TB_1,BUS_1,P <Enter>
TB_1 to BUS_1 Connection (SELogic Equation)
I01BZ1V := DIFF_EN AND NOT TOS01
?  PLT05 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I02BZ1C := TB_2, BUS_1, P
?  TB_2,BUS_2,P <Enter>
TB_2 to BUS_2 Connection (SELogic Equation)
I02BZ2V := NA
?  PLT06 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I03BZ2C := FDR_1, BUS_2, P
?  FDR_1,BUS_1,P <Enter>
FDR_1 to BUS_1 Connection (SELogic Equation)
I03BZ1V := NA
?  PLT07 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I04BZ2C := FDR_2, BUS_2, P
?  FDR_2,BUS_2,P <Enter>
FDR_2 to BUS_2 Connection (SELogic Equation)
I04BZ2V := DIFF_EN AND NOT TOS04
?  PLT08 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I05BZ1C := I05, BUS_1, P
?  END <Enter>
.
.
.

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

=>>
```

Figure 6.16 Zone Configuration Settings

Protection Group Settings

The sensitive differential element default settings block the differential elements from operating during CT open-circuit conditions. Disable the sensitive differential elements to prevent these elements from blocking the differential elements when we inject unbalanced test values. *Figure 6.17* shows the steps to disable the sensitive differential elements.

```
=>>SET <Enter>
Group 1

Relay Configuration

Sensitive Differential Element Supervision (Y,N)     E87SSUP := Y      ?N <Enter>
Coupler Security Logic (N,1-4)                       ECSL    := N      ?END <Enter>
Group 1

.
.
.

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

=>>
```

Figure 6.17 Steps to Disable the Sensitive Differential Elements

Protection Logic Settings

We use four protection latch bits, operated from four front-panel pushbuttons to simulate disconnect auxiliary contacts. *Figure 6.18* shows the steps to program the protection latch bits.

```
=>>SET L <Enter>
Protection 1
1: PLT01S := NOT DIFF_EN AND PLT04 # DIFFERENTIAL ENABLED
?  > <Enter>
21:
?  PLT07S:=PB5_PUL AND NOT PLT07 <Enter>
22:
?  PLT07R:=PB5_PUL AND PLT07 <Enter>
23:
?  PLT08S:=PB6_PUL AND NOT PLT08 <Enter>
24:
?  PLT08R:=PB6_PUL AND PLT08 <Enter>
25:
?  PLT09S:=PB7_PUL AND NOT PLT09 <Enter>
26:
?  PLT09R:=PB7_PUL AND PLT09 <Enter>
27:
?  PLT10S:=PB8_PUL AND NOT PLT10 <Enter>
28:
?  PLT10R:=PB8_PUL AND PLT10 <Enter>
29:
?  END <Enter>
Protection 1
.
.
.

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

=>>
```

Figure 6.18 Steps to Program Protection Latch Bits

Front-Panel Settings

We use four protection latch bits, operated from four front-panel pushbuttons to simulate disconnect auxiliary contacts. Each front-panel pushbutton has an LED in close proximity to the pushbutton. Program these LEDs to illuminate when the pushbuttons are in the closed position. Pushbutton assertion simulates closing disconnect auxiliary contacts, assigning the input currents to the appropriate differential elements. *Figure 6.19* shows the steps to program the LEDs.

```
=>>SET F <Enter>
Front Panel
Front Panel Settings

Front Panel Display Time-Out (OFF, 1-60 mins)        FP_TO   := 15     ? <Enter>
Pushbutton LED 1 (SELogic Equation)
PB1_LED := DIFF_EN # Differential Protection Enabled
? <Enter>
Pushbutton LED 2 (SELogic Equation)
PB2_LED := BF_EN # Breaker Failure Enabled
? <Enter>
Pushbutton LED 3 (SELogic Equation)
PB3_LED := NA
? <Enter>
Pushbutton LED 4 (SELogic Equation)
PB4_LED := TNS_SW # Test Normal Switch Enabled
? <Enter>
Pushbutton LED 5 (SELogic Equation)
PB5_LED := NA
?  PLT05 <Enter>
Pushbutton LED 6 (SELogic Equation)
PB6_LED := NA
?  PLT06 <Enter>
Pushbutton LED 7 (SELogic Equation)
PB7_LED := NA
?  PLT07 <Enter>
Pushbutton LED 8 (SELogic Equation)
PB8_LED := NA
?  PLT08 <Enter>
Target LED 1 (SELogic Equation)
T1_LED := 87BTR
?  END <Enter>
Front Panel

.
.
.

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

=>>
```

Figure 6.19 Steps to Program the LEDs

Verify the Relay Settings

Step 1. Use the serial port **SHO Z** ASCII command to generate a report similar to that shown in *Figure 6.20*.

Information shown in *Figure 6.20* is an extract of important settings, not the complete relay response.

Step 2. In particular, verify the following values:

a. PTR1, PTR2, and PTR3 are all equal to 2000.

b. CTR01, CTR02, CTR03, and CTR04 are all equal to 600.

c. TAP01, TAP02, TAP03, and TAP04 are all equal to 5.

d. The terminal-to-bus-zone settings are as shown.

```
=>>SHO Z <Enter>
Zone Config Group 1

Potential Transformer Ratio

PTR1    := 2000     PTR2    := 2000     PTR3    := 2000

Current Transformer Ratio

CTR01   := 600      CTR02   := 600      CTR03   := 600      CTR04   := 600

.
.
.

Zone Configuration: Terminal to Bus-Zone Connections

Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TB_1, BUS_1, P
FDR_1 to BUS_1 Connection (SELogic Equation)
I01BZ1V := PLT05
Terminal, Bus-Zone, Polarity (P,N)
I02BZ2C := TB_2, BUS_2, P
FDR_2 to BUS_2 Connection (SELogic Equation)
I02BZ2V := PLT06
Terminal, Bus-Zone, Polarity (P,N)
I03BZ1C := FDR_1, BUS_1, P
FDR_3 to BUS_1 Connection (SELogic Equation)
I03BZ1V := PLT07
Terminal, Bus-Zone, Polarity (P,N)
I04BZ2C := FDR_2, BUS_2, P
TRFR_1 to BUS_2 Connection (SELogic Equation)
I04BZ2V := PLT08

.
.
.

TAP01   := 5.00     TAP02   := 5.00     TAP03   := 5.00     TAP04   := 5.00
TAP05   := 5.00     TAP06   := 5.00
=>>
```

Figure 6.20 Selected Information From the Relay Response to the SHO Z Command

Selected Element Tests

Zone Selection Function

Step 1. Test the zone selection logic (terminal-to-bus-zone connection).

a. Press the **{PB5}** pushbutton to simulate the closing of disconnect 89I01_1, assigning TB_1 to BUS_1.

b. Confirm that the relay assigns Terminal TB_1 to BUS_1, and includes the bus-zone BUS_1 in Protection Zone 1.

c. Type **MET Z1 <Enter>** to generate a Zone 1 meter report.

Figure 6.21 shows the relay response, confirming that Terminal TB_1 is an active terminal in BUS_1.

NOTE: 5 A relays are rated for continuous current injection of 15 A.

NOTE: When a terminal is active, the terminal name appears under the heading "Primary Currents." The heading "Bus-Zones in Protection Zone 1" shows the Bus-Zones in Protection Zone 1.

```
=>>MET Z1 <Enter>

Relay 1                                    Date: 02/21/2003  Time: 10:24:38.363
Station A                                  Serial Number: 2003001324

Current Terminals in Protection Zone 1

Primary Currents
Terminal    MAG(A)   ANG(DEG)  POL
 TB_1        0.800    -5.54    P

Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01         0.011   -36.01
 V02         0.006    59.56
 V03         0.011   147.47

Bus-Zones in Protection Zone 1
BUS_1

=>>
```

Figure 6.21 Relay Response to the MET Z1 Command

Sensitive Differential Element

Step 1. Use the test connections shown in *Figure 6.11* for this test.

Step 2. Inject the current values listed in *Table 6.10* into the relay.

Table 6.10 Current for Testing the Threshold Point, O87P

Current	Value
IA	4.8∠0°
IB	4.8∠180°

Current flows through all four terminals, but because only the {PB5} pushbutton (*Step 1*, *Step a on page U.6.24*) is closed, the relay only considers the CT input from TB_1.

The CT ALARM LED asserts after approximately five seconds, and the relay triggers an event report. The relay does not trip, because the differential current is below the O87P threshold.

Step 3. Stop the injection. The CT ALARM LED deasserts.

Differential Elements

The following test verifies the characteristics for two of the six differential elements in the SEL-487B. The test plots the relay characteristic at two points. The first point is at the pickup threshold (O87P); the second point is at three per-unit restraint current. Three per unit is an arbitrary value; you may use any other convenient restraint current value.

Figure 6.22 shows the default O87P setting and the default Slope 1 setting.

Use the following equation to calculate IOP(IRT), the operating current value for any specified restraint current value:

$$\mathrm{IOP(IRT)} = \frac{\mathrm{SLP1}}{100} \bullet \mathrm{IRT}$$

Equation 6.3

where:

IOP(IRT) = Operating current as a function of the restraint current
SLP1 = Differential element Slope 1 setting
IRT = Differential element restraint current

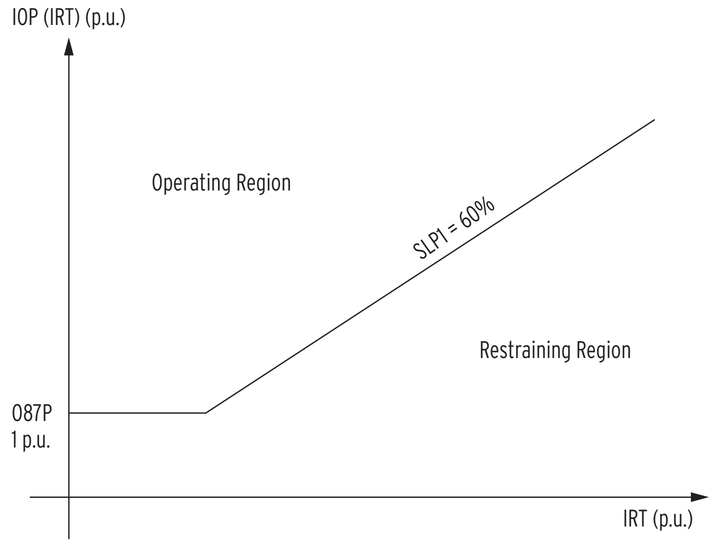


Figure 6.22 Differential Element Characteristic

Test the first point on the differential element characteristic.

Step 1. Obtain the operate current value and restraint current value.

a. Inject the current values listed in *Table 6.10* into the relay.

b. Type **MET DIF <Enter>**.

The current values should approximate those shown in *Figure 6.23*:

```
=>>MET DIF <Enter>

Relay 1                                     Date: 02/20/2003  Time: 16:58:30.046
Station A                                   Serial Number: 2003001324

Operate Currents     Restraint Currents
          (Per Unit)           (Per Unit)
ZONE          IOP                 IRT
  1           0.96                0.96
  2           0.00                0.00
Current Reference (A)
IREF
3000

=>>
```

Figure 6.23 Example Values Below the 87O1 Element Pickup Value in Response to the MET DIF Command

Step 2. Test the threshold point, O87P. (Pushbutton **{PB5}** is still asserted.)

a. Type **TAR 87O1 9999 <Enter>** to monitor the status of Relay Word bit 87O1.

b. Increase current IA until the status of Relay Word bit 87O1 changes from logical 0 to logical 1.

When the bit changes state, the **TRIP**, **87 (DIFF)**, and **ZONE 1** LEDs illuminate.

c. Record the value of the injected current.

This value should be 5 A ±5% and ±0.02 • I_{NOM}.

d. Type **<Ctrl>X** to end the scrolling of Relay Word bit 87O1 status values.

e. Type **MET DIF <Enter>** to obtain the differential operate current value and differential restraint current value.

These values should approximate the differential operate current values and differential restraint current values shown in *Figure 6.24*.

f. Stop the injection.

g. Press the **{TARGET RESET}** pushbutton.

```
=>>MET DIF <Enter>

Relay 1                                     Date: 02/21/2003  Time: 10:41:35.989

Station A                                   Serial Number: 2003001324

Operate Currents     Restraint Currents
           (Per Unit)           (Per Unit)
ZONE          IOP                  IRT
  1           1.02                 1.02
  2           0.00                 0.00

Current Reference (A)
IREF
3000

=>>
```

Figure 6.24 Example Values Above the 87O1 Element Pickup Value in Response to the MET DIF Command

Test the second point on Zone 1 and Zone 2 differential element characteristic.

Step 1. Use *Equation 6.3* to calculate the per-unit operating current for a restraint current of 3 per unit.

This operating current is for the second point on the differential characteristic.

$$\begin{aligned} \mathrm{IOP(IRT)} &= \frac{\mathrm{SLP1}}{100} \bullet \mathrm{IRT} \\ &= 0.6 \bullet 3 \text{ per unit} \\ &= 1.8 \text{ per unit} \end{aligned}$$

Step 2. Use *Equation 6.4* and *Equation 6.5* to calculate the two current values that result in an operating current of 1.8 per unit at a restraint current of 3 per unit.

$$\begin{aligned} I1_{pu} &= \frac{\mathrm{IRT} + \mathrm{IOP(IRT)}}{2} \text{per unit} \\ &= \frac{3.0 + 1.8}{2} \text{per unit} \\ &= 2.4 \text{ per unit} \end{aligned} \quad \textbf{Equation 6.4}$$

$$\begin{aligned} I2_{pu} &= \mathrm{IRT} - I1_{pu} \text{ per unit} \\ &= 3.0 - 2.4 \text{ per unit} \\ &= 0.6 \text{ per unit} \end{aligned} \quad \textbf{Equation 6.5}$$

Step 3. Use *Equation 6.6* to convert the current values from per-unit values to current values in amperes:

$$
\begin{aligned}
I1_A &= TAP01 \bullet I1_{pu}\ A \\
&= 5 \bullet 2.4\ A \\
&= 12.0\ A \\[1em]
I2_A &= TAP02 \bullet I2_{pu}\ A \\
&= 5 \bullet 0.6\ A \\
&= 3.0\ A
\end{aligned}
$$

Equation 6.6

where:
TAP01 = Terminal 01 normalization factor.
TAP02 = Terminal 02 normalization factor.

Step 4. Press pushbuttons **{PB6}**, **{PB7}**, and **{PB8}**.

Step 5. Inject the current values listed in *Table 6.11* into the relay.

Table 6.11 Current for Testing the Second Point on the Relay Characteristic

Current	Value
IA	12.0∠0°
IB	3.2∠180°

The CT ALARM LED asserts after approximately five seconds, but the relay does not trip, because the differential current is below the operating value.

Step 6. Type **MET DIF <Enter>** to obtain the operate current value and restraint current value.

These values should approximate the operate current values and restraint current values shown in *Figure 6.25*:

```
>>MET DIF <Enter>

Relay 1                                    Date: 02/21/2003  Time: 11:51:01.794
Station A                                  Serial Number: 2003001324

Operate Currents     Restraint Currents
           (Per Unit)           (Per Unit)
ZONE          IOP                  IRT
  1           1.76                 3.04
  2           1.76                 3.04

Current Reference (A)
IREF
3000

=>>
```

Figure 6.25 Example Values in Response to the MET DIF Command With Two Active Zones

Step 7. Type **TAR 87R1 9999 <Enter>** to monitor the status of Relay Word bit 87R1.

Step 8. Decrease current IB until the status of Relay Word bit 87R1 changes from logical 0 to logical 1.

After this bit changes state, the **TRIP**, **87 (DIFF)**, **ZONE 1**, and **ZONE 2** LEDs illuminate.

Step 9. Record the value of IB.

Use IB to calculate IRT and IOP at the test point. IOP and IRT should each be within ±5% of the injected quantities (IRT = 15 ±5%, IOP = 9 ±5%).

Step 10. Type **<Ctrl>X** to end the scrolling of the status values of Relay Word bit 87R1.

Step 11. Type **MET DIF <Enter>** to obtain the operate current value and restraint current value.

These values should approximate the operate current values and restraint current values shown in *Figure 6.26*.

```
=>>MET DIF <Enter>

Relay 1                                     Date: 02/21/2003  Time: 12:33:53.073
Station A                                   Serial Number: 2003001324

Operate Currents     Restraint Currents
           (Per Unit)            (Per Unit)
ZONE          IOP                  IRT
  1           1.80                 3.00
  2           1.80                 3.00

Current Reference (A)
IREF
3000

=>>
```

Figure 6.26 Example Values in Response to the MET DIF Command With Two Differential Elements Asserted

Step 12. Turn off the test set.

Step 13. Press pushbuttons {PB5}–{PB8} and {TARGET RESET}.

Directional Element

Use the steps in the following example to test the directional element. Apply the same relay settings as when testing the differential element. To test the directional element characteristic, use the test connections as shown in *Figure 6.27*.

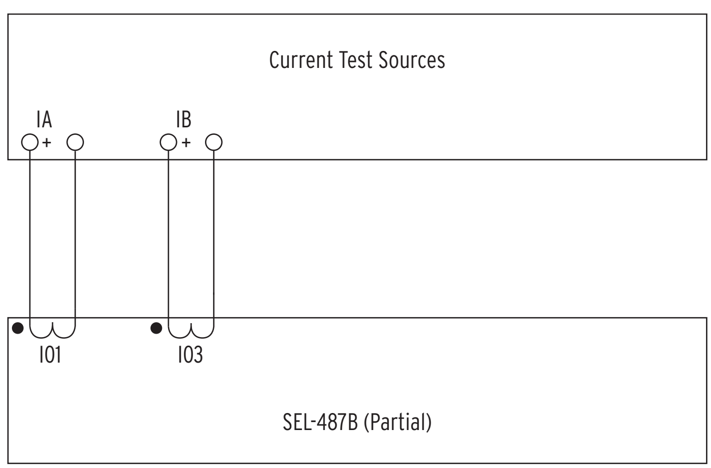


Figure 6.27 Test Connections for Testing the Directional Element

Figure 6.28 shows the directional element characteristic, the shaded area indicating an internal fault.

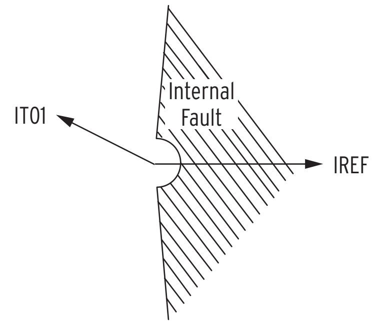


Figure 6.28 Directional Element Characteristic

The test consists of two parts. In the first part, we test the threshold of the directional element. The directional element only considers terminals with current values exceeding the threshold value in the directional calculations. In the second part, we test the boundaries of the element characteristic.

Step 1. Test the threshold value by injecting the current values shown in *Table 6.12* into the relay.

Table 6.12 Current Values for Testing the Threshold Value of the Directional Element

Current	Current Injected
IA	0.2∠0°
IB	2.0∠180°

a. Type **TAR 50DS01 <Enter>** to obtain the relay response as shown in *Figure 6.29*.

b. Verify that only Relay Word bit 50DS03 has a value of logical 1.

```
=>>TAR 50DS01 <Enter>

50DS08   50DS07   50DS06   50DS05   50DS04   50DS03   50DS02   50DS01
0        0        0        0        0        1        0        0

=>>
```

Figure 6.29 Relay Response to the TAR 50DS01 Command

c. Type **TAR 50DS01 9999 <Enter>** and slowly increase current IA.

Relay Word bit 50DS01 asserts when IA reaches a value of approximately 0.26 A.

d. Stop the injection.

e. Type **<Ctrl>X** to end the scrolling of the Relay Word bit 50DS01 status values.

Step 2. Test the boundary values.

a. Press pushbuttons **{PB5}** and **{PB7}**.

b. Inject the current values shown in *Table 6.13* into the relay.

Table 6.13 Current Values for Testing the Boundary Values of the Directional Element

Current	Current Injected
IA	2.0∠0°
IB	2.0∠90°

c. Type **TAR DE1F <Enter>** to obtain a relay response similar to that shown in *Figure 6.30*.

d. Verify that Relay Word bit DE1F is deasserted.

```
=>>TAR DE1F <Enter>

*       *       DE6F    DE5F    DE4F    DE3F    DE2F    DE1F
0       0       0       0       0       0       0       0

=>>
```

Figure 6.30 Relay Response to the TAR DE1F Command

e. Type **TAR DE1F 9999 <Enter>** and slowly decrease the angle of current IB.

   Relay Word bit DE1F asserts when the angle reaches a value of approximately 74°.

f. Quickly move the angle to –70° and continue to slowly decrease the angle of current IB.

   Relay Word bit DE1F deasserts when the angle reaches a value of approximately –74°.

g. Type **<Ctrl>X** to end the scrolling of the status values of Relay Word bit DE1F.

h. Stop the injection.

Voltage Elements

The SEL-487B includes two over- and two undervoltage elements per voltage input. We will test the four phase voltage elements for Voltage Input 1. The SEL-487B also includes two levels of negative-sequence and two levels of zero-sequence overvoltage elements. We will use the default settings for the negative-sequence and zero-sequence overvoltage elements.

Phase Over-/Undervoltage Elements

Figure 6.31 shows the steps to apply settings to the four phase voltage elements.

```
=>>SET 27P11P <Enter>
Group 1

Phase Inst Under/Over Voltage Elements
Voltage 1 Level 1 U/V Pickup (OFF, 1.0-200 volts)    27P11P  := OFF     ?60 <Enter>
Voltage 1 Level 2 U/V Pickup (OFF, 1.0-200 volts)    27P12P  := OFF     ?55 <Enter>
Voltage 1 Level 1 O/V Pickup (OFF, 1.0-200 volts)    59P11P  := OFF     ?70 <Enter>
Voltage 1 Level 2 O/V Pickup (OFF, 1.0-200 volts)    59P12P  := OFF     ?75 <Enter>
Voltage 2 Level 1 U/V Pickup (OFF, 1.0-200 volts)    27P21P  := OFF     ?END <Enter>
Group 1
.
.
.

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

=>>
```

Figure 6.31 Over- and Undervoltage Element Settings

Verify the operation of the phase over- and undervoltage elements.

Step 1. Connect a source of variable three-phase voltage to the relay as shown in *Figure 6.32*.

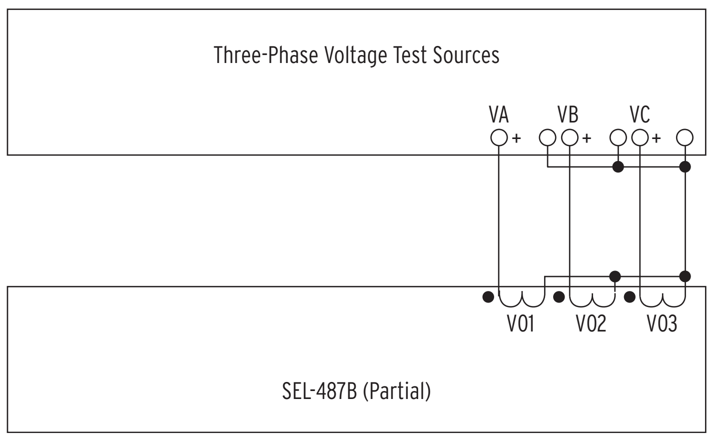


Figure 6.32 Test Connections for Testing the Voltage Elements

Step 2. Test the overvoltage elements by applying the voltage values shown in *Table 6.14* to the relay.

Table 6.14 Injected Voltage Values for Testing the Overvoltage Elements

Channel	Voltage Value
VA	67∠0°
VB	67∠–120°
VC	67∠120°

a. Type in **TAR 59P11 9999 <Enter>** and raise the VA voltage until Relay Word bit 59P11 asserts.

The voltage should equal 70 V ±0.5 V and ±5%.

b. Continue to increase the applied voltage until Relay Word bit 59P12 asserts.

The voltage value should equal 75 V ±0.5 V and ±5%.

c. Type **<Ctrl>X <Enter>** to end the scrolling of the Relay Word bits status values.

d. Stop the injection.

Step 3. Test the undervoltage elements.

a. Apply the voltage values shown in *Table 6.14* to the relay.

b. Type **TAR 27P11 9999 <Enter>** and lower the VA voltage until Relay Word bit 27P11 asserts.

The voltage should equal 60 V ±0.5 V and ±5%.

c. Continue to lower the applied voltage until Relay Word bit 27P12 asserts.

The voltage value should equal 55 V ±0.5 V and ±5%.

d. Type **<Ctrl>X** to end the scrolling of Relay Word bit 27P11 status values.

e. Stop the injection.

Negative- and Zero-Sequence Voltage Elements

Verify the operation of the negative- and zero-sequence overvoltage elements.

Step 1. Use the **SHO** serial port command and verify the settings shown in *Table 6.15*.

Table 6.15 Voltage Element Settings for Testing the Negative- and Zero-Sequence Overvoltage Elements

Setting	Value
59Q1P	20
59Q2P	40
59N1P	20
59N2P	40

Step 2. Apply the voltage values shown in *Table 6.14* to the relay.

a. Type in **TAR 59Q1 9999 <Enter>** and lower the VA voltage until Relay Word bits 59Q1 and 59N1 assert.

The voltage should equal 47 V ±1 V and ±5% of setting.

b. Continue to lower the applied voltage until 59Q2 and 59N2 assert.

The voltage should equal 27 V ±1 V and ±5% of setting.

c. Type **<Ctrl>X** to end the scrolling of Relay Word bit status values.

d. Stop the injection.

Relay Self-Tests

The SEL-487B continuously runs many self-tests to detect out-of-tolerance conditions. These tests run simultaneously with relay protection and automation logic without degrading SEL-487B performance.

Status Warning and Status Failure

The relay reports out-of-tolerance conditions as a status warning or 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 logic processing and de-energizes 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. SEL-487B relays will restart on certain diagnostic failures. When this occurs, the relay will log a `Diagnostic Restart` in the SER, and the HALARM Relay Word bit will assert for five seconds. See *Appendix A: Firmware and Manual Versions* for affected firmware revisions.

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.2.33* for information on connecting this alarm output for the SEL-487B.

If you repeatedly receive status warnings, check 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 *Technical Support on page U.6.38*).

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 Warning and Status Failure on page U.6.34*), but includes the power supply information from the **STA A** response. The relay also displays status warning and status failure automatic messages on the front-panel LCD. Use the serial port **STATUS** and **CSTATUS** commands and the front-panel `RELAY STATUS` menu to display status warnings and status failures. See *STATUS on page R.7.40*, *Checking Relay Status on page U.4.10*, and *RELAY STATUS on page U.5.29* for more information on automatic status notifications and on viewing relay status.

Status

Figure 6.33 on page U.6.35 is the **STATUS A** report showing all status information obtained with terminal emulation software.

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 6.33*, the firmware version number is R100. SEL numbers subsequent firmware releases sequentially; the next revision following R100 is R101. See *Appendix A: Firmware and Manual Versions* for firmware version information.

```
=>>STA A <Enter>

Relay 1                 Date: 07/24/2003 Time: 13:53:00.359
Station A               Serial Number: 2003003020

FID=SEL-487B-R102-V0-Z001001-D20030724 CID=0xf418

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
  -2  -2  -2  -2  -2  -2  -2  -2  -2  -9  -9  -9  -3
 CH13 CH14 CH15 CH16 CH17 CH18 CH19 CH20 CH21       MOF2
  -9  -9  -9  -9  -9  -9  -2  -2  -3         -9

Power Supply Voltages (V) W=Warn  F=Fail
 3.3V_PS 5V_PS N5V_PS 15V_PS  N15V_PS
   3.30  5.01  -4.96  14.95  -15.03

Temperature
  28.3 degrees Celsius

Communication Interfaces
 Communications Card 1
 SEL-2701-R103-V0-Z000000-D20020501 Ethernet
  Normal 0x0000

Active High Accuracy Time Synchronization Source: NONE
 IRIG-B Source ABSENT

SELogic Relay Programming Environment Errors
 No Errors

Relay Enabled

=>>
```

Figure 6.33 Relay Status Information Obtained With the STATUS A Serial Port Command

CSTATUS

The relay reports status information in Compressed ASCII format when you issue the **CST** command. The Compressed ASCII status message is similar to the following:

```
=>>CSTA <Enter>
"RID","SID","FID","03e2"
"Relay 1",">>","SEL-487B-R102-V0-Z001001-D20030724","0b81"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
2,19,2003,10,50,23,526,"045D"
"CPU_RAM","CPU_Prog","SELBOOT","CPU_Settings","DSP_RAM","DSP","DSP_Chksum","DSP_
TIMEOUT","CPU_CARD_RAM","CPU_DSP_RAM","FRONT_PANEL","CAL_BOARDA","CAL_BOARDB","C
omm_Card","Comm_Card_Code","QUART","Analog_Conv","IO_1","IO_2","IO_3","IO_4","42
45"
"Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok"," "," ","Ok","O
k","Ok","Ok","Ok","Ok","173E"
"AtoD_Offset","Master_Offset","Master_Offset2","3.3V_PS","5V_PS","N5V_PS","15V_P
S","N15V_PS","Temp_Status","Temp","FPGA","ADC_FPGA","2694"
"Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok","Ok",31.5,"Ok","Ok","0DC1"
"Fast_Fiber_Port","MBA","MBB","Active_Time_Source","SELogic_Math","FM_Test","CCr
d_Test","DNP_Test","Relay_Status","Port_F_Transp","Port_1_Transp","Port_2_Transp
","Port_3_Transp","Port_5_Transp","4029"
"Not_Installed","Inac","Inac"," ","Ok","Disabled","Disabled","Disabled","Enabled
","0","0","0","0","0","1C03"

=>>
```

Figure 6.34 Relay Status Information Obtained With the CSTATUS Serial Port Command

Relay Troubleshooting

Inspection Procedure

Complete the following inspection procedure before disturbing the system. After you finish this inspection, proceed to *Troubleshooting Procedures*.

Step 1. Confirm that 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 6.16*. The table lists each symptom, possible causes, and corresponding diagnoses/solutions. Related SEL-487B commands are listed in bold capitals. See *Section 7: ASCII Command Reference in the Reference Manual* for details on SEL-487B commands and *Section 8: Settings in the Reference Manual* for details on relay settings.

Table 6.16 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.2.31*.
Poor contrast adjustment.	Press and hold **{ESC}** for two seconds. Press **{Up Arrow}** and **{Down Arrow}** 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.2.33*.
Alarm Output Asserts	
Power is off.	Restore power.
Blown power supply fuse.	Replace the fuse. See *Power Supply Fuse Replacement on page U.2.31*.
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 6.16 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.5.26*.
Incorrect communications cables.	Use SEL communications cables, or cables you build according to SEL specifications. See *Communications Ports Connections on page U.2.35*.
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.2.35*.
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.2.35*.
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: System Configuration Guideline and 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*.
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*.
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 U.6.34* and *Checking Relay Status on page U.4.10*.

Table 6.16 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.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 USA
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

Appendix A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

To find the firmware revision number in your relay, view the status report using the serial port **STATUS** command. The status report displays the Firmware Identification (FID) label:

FID=SEL-487B-Rxxx-Vx-Z001001-Dxxxxxxxx

You can also view the FID label from the front panel. From the ROTATING DISPLAY front-panel screen, press the **{ENT}** pushbutton to advance to the MAIN MENU screen. Use the **{Down Arrow}** pushbutton to highlight the RELAY STATUS option, and press the **{ENT}** pushbutton. The FID label displays on the screen:

SEL-487B-Rxxx-Vx-Z001001-Dxxxxxxxx

In the FID label, the firmware revision number follows the R and the release date follows the D.

For example:

FID=SEL-487B-R102-V0-Z001001-D20030724

is firmware revision number 102, release date July 24, 2003.

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History (Sheet 1 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-R124-V0-Z008004-D20131111	➤ Manual update only (see *Table A.5*).	20140516
SEL-487B-R124-V0-Z008004-D20131111	➤ Corrected Display Point settings conversion to preserve the Display Point layout on the HMI after an upgrade (if the Display Point settings contain 20 or more characters the SEL-487B relays could disable when firmware versions R100–R115 are upgraded to firmware versions R116–R123).	20131111
SEL-487B-R123-V0-Z008004-D20130220	➤ Improved DNP Multidrop (EIA-485) communication to operate at data rates faster than 9600 bps. ➤ Corrected DNP SER Reporting in the Extended DNP Map for Serial DNP. ➤ Fixed rotating display to show correct configuration zones. ➤ Add out-of-range check for DC Offset calculation. ➤ Corrected erroneous error messages when front panel LB_ELE1 and LB_ELE2 have blank settings. ➤ Corrected a possible relay vector when two relays, configured to use SEL protocol, are connected through serial ports.	20130220

Table A.1 Firmware Revision History (Sheet 2 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-R122-V0-Z008004-D20111031	➤ Manual update only (see *Table A.5*).	20120810
SEL-487B-R122-V0-Z008004-D20111031	➤ Ethernet card firmware (see *Table A.2*) and manual update only (see *Table A.5*).	20111215
SEL-487B-R122-V0-Z008004-D20111031	➤ Manual update only (see *Table A.5*).	20111109
SEL-487B-R122-V0-Z008004-D20111031	➤ Added CCOK bit to indicate the Ethernet card is alive. ➤ Added real-time watchdog to quickly detect Ethernet card failures. ➤ Added setting warning when native Relay Word bit names are used as alias name settings.	20111031
SEL-487B-R121-V0-Z006004-D20101109	➤ Manual update only (see *Table A.5*).	20110211
SEL-487B-R121-V0-Z006004-D20101109	➤ Updated for compatibility with SEL-2702 R111.	20101109
SEL-487B-R120-V0-Z005004-D20100628	➤ Added the ability to recognize additional interface board 4 ordering options.	20100628
SEL-487B-R119-V0-Z005004-D20100506	➤ Corrected the mechanism by which the secondary meter command accesses the setting data to calculate secondary meter values.	20100506
SEL-487B-R118-V0-Z005004-D20090519	➤ Corrected handling of DNP fault summary records when EVELOCK = 0.	20090519
SEL-487B-R117-V0-Z005004-D20090205	➤ Added EPORT port setting so user can disable ports. ➤ Added MAXACC port setting so user can restrict maximum privileges on a port. ➤ Extended password length from 6 to 12 characters.	20090205
SEL-487B-R116-V0-Z004004-D20080110	➤ Ethernet card firmware (see *Table A.2*) and manual update only (see *Table A.5*).	20081022
SEL-487B-R116-V0-Z004004-D20080110	➤ Added Check Zone 1. ➤ Added Open CT Detector logic. ➤ Added alarm points and SER settings parameter HMI Alarm in order to enable automatic HMI display of alarm points. ➤ Added analog display points. ➤ Expanded to 96 display points and changed format to display on a single line. ➤ Added support for expanded HMI features: 12 operator control pushbuttons, 24 target LEDs, double-height display points and tri-colored LEDs. ➤ Added settings PB1_HMI through PB12HMI for assigning alarm point, display point, SER or event summary screens to the selectable operator pushbuttons. ➤ Added SER events on the front-panel screen. ➤ Added settings DISP_ER and TYPE_ER for enabling and configuring automatic HMI display of event summary screens. ➤ Added setting NUM_ER to specify the number of event summary screens viewed through the operator pushbutton. ➤ Added programmable supervision and position status feedback to the standard Local Bits. ➤ Added setting SCROLD for changing the ROTATING DISPLAY update rate. ➤ Corrected transition from ROTATING DISPLAY to manual mode when using navigational arrows.	20080110

Table A.1 Firmware Revision History (Sheet 3 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Added new DNP setting MAPSEL and implemented extended binary input map. ➤ Implemented DNP single-event mode. ➤ Added Fast Message commands to read database regions. ➤ Modified HMI password entry so that characters are not echoed to the screen. ➤ Added Ethernet card information in the **ID** command. ➤ Updated how SER points are reported through DNP after initial DNP setup. ➤ Updated **EVE C** command to default to full length.	
SEL-487B-R115-V0-Z003003-D20070315	➤ Made improvements for manufacturability.	20070315
SEL-487B-R114-V0-Z003003-D20070220	➤ Expanded diagnostics coverage to include additional failure modes that will result in a relay restart.	20070220
SEL-487B-R113-V0-Z003003-D20060905	➤ Corrected measurement errors found in R110, R111, and R112 firmware for SEL-487B relays configured for 1 A nominal current inputs.	20060905
SEL-487B-R112-V0-Z003003-D20060814	➤ Modified diagnostic failure mode management. Certain diagnostic test errors will result in a relay restart. Relay will log `Diagnostic Restart` in the SER if this event occurs.	20060814
SEL-487B-R111-V0-Z003003-D20060727	➤ Fixed problem found in firmware version R110 that caused the SEL-487B to disable when serial port communications were autoconfigured using an SEL-2032 or SEL-2030 Communications Processor.	20060727
SEL-487B-R110-V0-Z003003-D20060630	➤ Added IEC 61850 support for optional Ethernet card.	20060703
SEL-487B-R109-V0-Z002002-D20060413	Note: This firmware version requires the use of R109 or higher firmware on any installed SEL-2701 Ethernet Card. ➤ Improved accuracy of time-tagged DNP LAN/WAN binary inputs.	20060413
SEL-487B-R108-V0-Z002002-D20051123	Note: This firmware version requires the use of R108 or higher firmware on any installed SEL-2701 Ethernet Card. ➤ Added DNP LAN/WAN support when using the SEL-2701 Ethernet Card. ➤ Added second file transfer session to allow access to SEL-2701 settings files (SET_DNP*n*.TXT) via FTP. ➤ SET_DNP*n*.TXT files from the SEL-2701 are available in the relay file system and can be accessed via FTP or the ASCII **FILE** command. ➤ Added time-stamped SER data from the relay into TARGET region of the SEL-2701 DNP3 database. ➤ Added the D1 region to DNP LAN/WAN in order to make incoming analog data available to the relay via objects RA001 to RA256. ➤ Zone supervision Setting E87ZSUP from “Y” to “N” will now reset individual zone supervision logic to “1”. ➤ Enhanced the **PORT 5** command to allow transparent access to the SEL-2701 user interface from the host relay.	20051123
SEL-487B-R107-V0-Z001001-D20051121	➤ Corrected Zone Supervision Setting E87ZSUP so that changing this setting from “Y” to “N” resets individual zone supervision logic settings to 1.	20051121
SEL-487B-R106-V0-Z001001-D20050220	➤ Corrected issue where a conflict in DNP processing and communications could suspend all relay communications.	20050220

Table A.1 Firmware Revision History (Sheet 4 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-R105-V0-Z001001-D20041129	➤ Modified the Protection Math Variable (PMV) function to prevent equations containing parentheses from overwriting existing values. ➤ Added Security Enhancement when used with the SEL-2701 Ethernet Processor.	20041129
SEL-487B-R104-V0-Z001001-D20040609	➤ Corrected issue where the dc battery monitor may report incorrect values for Vdc. ➤ Corrected issue where turning off power may cause a low-set 87, 50, or 51 element to inadvertently operate.	20040609
SEL-487B-R103-V0-Z001001-D20031112	➤ Manual update only (see *Table A.5*).	20040401
SEL-487B-R103-V0-Z001001-D20031112	➤ Includes RSTTRGT in the trip unlatch logic. ➤ MIRRORED BITS® communications underrun value changed from 1 in 3 to 1 in 7 for paced mode.	20031112
SEL-487B-R102-V0-Z001001-D20030724	➤ Initial version.	20030724

Table A.2 lists the Ethernet card firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.2 Ethernet Card Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2702-R115-V0-Z002002-D20190325 SLBT-2701-R103-V0-Z000000-D20080820	➤ Resolved an issue where certain Ethernet traffic could cause the relay to safely restart.	20190325
SEL-2702-R114-V0-Z002002-D20190308 SLBT-2701-R103-V0-Z000000-D20080820	Note: This firmware did not production release.	—
SEL-2702-R113-V0-Z002002-D20111215 SLBT-2701-R103-V0-Z000000-D20080820	➤ Added support for database references in IEC 61850 configuration files.	20111215
SEL-2702-R112-V0-Z002002-D20110715 SLBT-2701-R103-V0-Z000000-D20080820	➤ Improved port failover performance of 100BASE-FX fiber channel.	20111031
SEL-2702-R111-V0-Z002002-D20101109 SLBT-2701-R103-V0-Z000000-D20080820	➤ Added HTTP server for SEL-487B web services.	20101109
SEL-2702-R110-V0-Z001001-D20090205 SLBT-2701-R103-V0-Z000000-D20080820	➤ Improved security (see www.selinc.com/privacy.htm for details).	20090205
SEL-2702-R109-V0-Z001001-D20081022 SLBT-2701-R103-V0-Z000000-D20080820	➤ Updated IEC 61850 firmware to streamline MMS processing and improve TCP/IP connections. ➤ Improved security (see www.selinc.com/privacy.htm for details). ➤ Corrected issue that could cause the Ethernet card to fail under heavy DNP traffic.	20081022
SEL-2702-R107-V0-Z001001-D20080107 SLBT-2701-R102-V0-Z000000-D20051107	➤ Enhanced IEC 61850 with KEMA certifications updates. ➤ Added indication of ICD/CID file parse failure to the SEL-2702 User interface (**ID**, **STA**, **GOO** commands).	20080110

Table A.2 Ethernet Card Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2702-R101-V0-Z000000-D20060808 SLBT-2701-R102-V0-Z000000-D20051107	➤ Added support for pulse operations on DNP LAN/WAN control points, both paired and unpaired. ➤ Added ability to sense local operations and update IEC 61850 origination category.	20060808
SEL-2702-R100-V0-Z000000-D20060630 SLBT-2701-R102-V0-Z000000-D20051107	➤ Initial version.	20060703

The optional Ethernet card must be paired with a compatible SEL-487B version. You may need to upgrade your SEL-487B firmware to access features in new versions of the Ethernet cards. *Table A.1* include notes on SEL-487B modifications that support new features of the Ethernet cards.

To find the firmware revision number in your Ethernet card, first connect to the SEL-487B with the **ACC** command. View the Firmware Identification (FID) labels with the **VERSION** command. Look for the Ethernet card FID label in the response under Communications Card:

FID=SEL-2701-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx

In the FID label, the 4 digits after "SEL" indicate which Ethernet card is installed. The firmware revision number follows the R and the release date follows the D.

For example:

SEL-2701-R108-V0-Z002001-D20051205

is for an SEL-2701 Ethernet card, firmware revision number 108, release date December 5, 2005.

Table A.3 lists Ethernet card firmware versions with compatible SEL-487B firmware versions.

Table A.3 Compatible SEL-487B and Ethernet Card Firmware Versions

SEL-487B Firmware	Ethernet Card	Ethernet Card Firmware
R121 or higher	SEL-2702	R111 or higher
R116–R120	SEL-2702	R103–R110
R110–R115	SEL-2702	R100–R101
R108–R109	SEL-2701	R108 or higher
R107 or lower	SEL-2701	R105 or lower

Newer Ethernet card firmware (R106 and higher) uses a different software library from earlier versions and is unable to process version 001 CID files. ACSELERATOR Architect® SEL-5032 Software generates CID files from ICD files so the ICD file version number and CID file version number are the same. If downloaded to the Ethernet port, an incompatible CID file will generate file parse errors during processing and disable the IEC 61850 protocol.

If you perform an Ethernet card firmware upgrade that spans different file version compatibilities, the relay may not be able to process the stored CID file. See the *Ethernet Port Firmware Upgrade Instructions* for CID file conversion procedures.

See *Table A.4* for compatibilities between ACSELERATOR Architect software ICD/CID file, and Ethernet card firmware versions.

Table A.4 ACSELERATOR Architect CID File Compatibility

Architect Software Version	Architect ICD/CID File Version	Ethernet Card Firmware
All versions	Ver 001	R100–R106
1.1.69.0 or higher	Ver 002 (all)	R107 or higher

Instruction Manual

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

Table A.5 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.5 Instruction Manual Revision History (Sheet 1 of 10)

Revision Date	Summary of Revisions
20210514	**Applications Handbook** Section 1 ➤ Updated *End-Zone Protection*, *Breaker Status Logic*, *End-Zone Protection* in *Application 2: Single Bus and Tie Breaker (Single Relay)*. ➤ Updated *Zone Configuration Group Settings* in *Application 4: Single Bus and Transfer Bus With Buscoupler.* ➤ Updated *Zone Configuration Group Settings* and *Protection Group Settings* in *Application 7: Double and Transfer Bus (Outboard CTs)*. **Reference Manual** Section 1 ➤ Updated *Table 1.29: Summary of the Event for Fault F3 Shown in Figure 1.49* and *Table 1.30: Summary of the Event for Fault F3 Using the Accelerated Trip Function*. ➤ Updated *Single CT Application* and *Circuit Breaker Status Logic*.
20190308	**User's Guide** Appendix A ➤ Updated for Ethernet firmware version R114-V0.
20140516	**User's Guide** Section 1 ➤ Edited AC Voltage Inputs information in *Specifications.* Section 5 ➤ Edited Clock Status information in *Operation and Target LEDs.* Appendix B ➤ Replaced entire appendix with updated *SEL-400 Series Upgrade/Conversion Instructions.* **Application Handbook** Section 1 ➤ Edited CT Connections information in *CT Requirements.* **Reference Manual** Section 3 ➤ Edited *Table 3.1: SEL-487B Communications Protocols.* ➤ Edited *Table 3.4: Ethernet Card Network Configuration Settings.*

Table A.5 Instruction Manual Revision History (Sheet 2 of 10)

Revision Date	Summary of Revisions
	Section 5 ➤ Edited *Table 5.10: SEL-487B DNP3 Default Data Map.* ➤ Edited *Table 5.25: DNP LAN/WAN Application Example Custom Data Map.* Section 6 ➤ Edited Firmware Upgrades in *Features.* Section 8 ➤ Edited *Table 8.69: Ethernet Settings.* Appendix A ➤ Edited *Table A.1: Alphabetical List of Relay Word Bits.* ➤ Edited *Table A.2: Row List of Relay Word Bits.*
20131111	**User's Guide** Appendix A ➤ Updated for firmware version R124.
20130220	**User's Guide** Appendix A ➤ Updated for firmware version R123.
20120810	**User's Guide** Section 1 ➤ Updated *Specifications*. **Application Handbook** Section 2 ➤ Updated *Figure 2.1: Typical Station DC Battery System*.
20111215	**User's Guide** Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.14: Relay Chassis Dimensions*. ➤ Updated *Figure 2.28: Typical External AC/DC Connections for a Three-Relay Application*. ➤ Updated *Differential Elements*. Appendix A ➤ Updated for Ethernet card firmware version R113.
20111109	**User's Guide** Section 1 ➤ Updated Type Test information in *Specifications*.
20111031	**User's Guide** Section 1 ➤ Added UL Compliance information in *Specifications*. Appendix A ➤ Updated for firmware version R122. Appendix B ➤ Added filename information to *Table B.1: Firmware File Name*.
20110211	**User's Guide** Appendix B ➤ Added *EPORT Setting*.

Table A.5 Instruction Manual Revision History (Sheet 3 of 10)

Revision Date	Summary of Revisions
20101109	**User's Guide** Appendix A ➤ Updated for firmware version R121. **Applications Handbook** **Section 5** ➤ Added *HTTP*. **Reference Manual** **Section 8** ➤ Added *Table 8.75 HTTP Settings*.
20100628	**User's Guide** Section 1 ➤ Updated for additional standard contact output I/O boards. Appendix A ➤ Updated for firmware version R120.
20100506	**User's Guide** Appendix A ➤ Updated for firmware version R119.
20090519	**User's Guide** Appendix A ➤ Updated for firmware version R118.
20090205	**User's Guide** Section 4 ➤ Updated *Changing the Default Passwords* to reflect added Access Level C. ➤ Updated *Figure 4.5: Access Level Structure*. ➤ Updated *Table 4.3: SEL-487B Access Levels* and *Table 4.4: SEL-487B Access Level Commands and Passwords*. ➤ Updated *Communications Ports Access Levels* to reflect new Access Level C port settings. ➤ Updated steps under *Passwords*. Appendix A ➤ Updated for firmware version R117. ➤ Updated for Ethernet card firmware version R110. **Reference Manual** Section 7 ➤ Added **CAL** command. ➤ Modified *Password* to reflect the extended password length from 6 to 12 characters. Section 8 ➤ Updated *Table 8.64: Protocol Selection*.
20081022	**User's Guide** Appendix A ➤ Updated for Ethernet card firmware version R109 and SELBOOT firmware version R103.
20080110	**User's Guide** Section 1 ➤ Added *Check Zone* to *Functional Overview*. ➤ Updated *Table 1.1: Application Highlights* to include the independent Check Zone in application highlights. ➤ Updated *Operating Temperature* in *Specifications* to include Ethernet card information. ➤ Corrected 10BASE-FL and 100BASE-FX ordering options in *Communication Ports: Fiber Optic (optional)* in *Specifications*.

Table A.5 Instruction Manual Revision History (Sheet 4 of 10)

Revision Date	Summary of Revisions
	Section 4 ➤ Updated *Figure 4.12: Using Text-Edit Mode Line Editing* to SET Display Points and *Figure 4.13: Using Text-Edit Mode Line Editing to Delete a Display Point* for new Display Point format. ➤ Updated *Figure 4.14: Default Alias Settings* and *Figure 4.15: Using Text-Edit Mode Line Editing to Set Aliases* for new Aliases and prompt format. ➤ Added note to indicate that the latest 200 SER events are viewable on the front panel. ➤ Updated *Figure 4.26: Setting an SER Element: Terminal Emulation Software* to reflect new SER setting parameter HMI Alarm. ➤ Edited *Operating the Relay Inputs and Outputs* to include Local Bit supervision. Section 5 ➤ Updated *Figure 5.1: Front Panel, 12 Pushbutton (9U Version)* for 12 pushbuttons. ➤ Updated *Front-Panel Layout* for HMI changes: expanded pushbuttons, expanded target LEDs, and tri-color LEDs. ➤ Updated *Screen Scrolling* to include Alarm Points. ➤ Added alarm points screen to *Figure 5.4: ROTATING DISPLAY* and updated to include double-height Display Points. ➤ Edited *Front-Panel Layout* to include SCROLD setting option. ➤ Added *Alarm Points* and *Example 5.1: Creating an Alarm Point*. ➤ Updated *Display Points* to allow for analog quantity display points and to include Text Size parameter. ➤ Updated *Figure 5.10: Display Points Screen* and *Table 5.4* to include double-height Display Points. ➤ Added *Table 5.5: Display Point Settings—Analog* and *Table 5.6: Display Point Settings—Boolean and Analog Examples*. ➤ Modified *Events* to explain event summary access options. ➤ Added description of SER event viewing on the front panel in the *Front-Panel Menu and Screens*. ➤ Added Local Control bit supervision and display logic to *Local Control Bits*. ➤ Modified *Front-Panel Automatic Messages* to include alarm points. ➤ Updated *Operation and Target LEDs* for HMI changes: expanded target LEDs and tricolor LEDs. ➤ Updated *Figure 5.41: Factory Default Front-Panel Target Areas (16 or 24 LEDs)* and *Table 5.11: Front-Panel Target LEDs* for expanded target LEDs. ➤ Added *Voltage Status, Miscellaneous Status and Clock Status* for expanded target LEDs. ➤ Modified *Front-Panel Operator Control Pushbuttons* to include alarm points, display points, SER and event summary viewing options. Section 6 ➤ Updated *Figure 6.15: Alias Names for the Four Analog Channels* for new Aliases and prompt format. ➤ Updated *Figure 6.18: Steps to Program Protection Latch Bits* to reflect new Protection Logic default settings. ➤ Updated *Figure 6.25: Example Values in Response to the MET DIF Command With Two Active Zones* and *Figure 6.26: Example Values in Response to the MET DIF Command With Two Differential Elements Asserted* to correct IOP and IRT calculated values. Appendix A ➤ Updated for firmware version R116. ➤ Updated for Ethernet card firmware version R107. ➤ Added *Table A.3: Compatible SEL-487B and Ethernet Card Firmware Versions* and explanatory text for multiple ICD/CID versions. **Application Handbook** Section 1 ➤ Updated *Figure 1.23: Assigning Alias Names* for new aliases and prompt format. ➤ Updated *Zone Supervision* to include the independent Check Zone. ➤ Updated *Table 1.4: Primary Plant Data* to include the independent Check Zone. ➤ Updated *Application 1: Single Bus and Tie Breaker (Three Relays)* to include the independent Check Zone and new Aliases. ➤ Added *Table 1.15: Alias Name for the Check Zone*.

Table A.5 Instruction Manual Revision History (Sheet 5 of 10)

Revision Date	Summary of Revisions
	Section 2 ➤ Corrected *Equation 2.2*. ➤ Added MET CZ1 and MET SEC CZ1 to *Metering*. ➤ Updated *MET DIF* to include the independent Check Zone and explained derivation of IREF. Section 3 ➤ Updated *Duration of Data Captures and Event Reports* to include 60 and 120 cycle event reports. ➤ Updated *Table 3.5: EVE Command* to specify that EVE C defaults to full length. ➤ Added note to indicate the latest 200 SER events are viewable on the front panel. ➤ Modified *Setting SER Points and Reporting Names* to reflect new SER setting parameter HMI Alarm. Section 4 ➤ Updated *Table 4.3: SEL Communications Processor Data Collection Automessages* to include the following: 20METER2, 20TARGET2, 20STATUS2, 20HISTORY2, 20LOCAL2, 20ANALOGS2, 20STATE2, 20D12. ➤ Updated *Figure 4.6* for new Aliases and prompt format. **Reference Manual** Section 1 ➤ Updated *Busbar Protection Element* to include independent Check Zone. ➤ Updated *External Fault Detection Logic* and *Figure 1.9: External Fault Detection Logic* to remove EXFDO setting. ➤ Added *Check Zone Protection Elements*. ➤ Added *Check Zone Sensitive Differential Element*. ➤ Updated *Zone Supervision Logic* to include independent Check Zone. ➤ Added *Table 1.7: Default Values for the Check Zone Supervision Settings*. ➤ Added *Check Zone Selection*. ➤ Added *Open CT Detector Logic*. ➤ Added *Figure 1.41: Breaker Failure Clearing Times* to show breaker failure clearing times. ➤ Added *Check Zone Differential Trip Output*. Section 2 ➤ Added Multiple Setting Groups. Section 3 ➤ Updated **ID**, **STA**, and **GOO** commands to describe ICD/CID file parse failure indication. ➤ Updated titles in *Table 3.23: SEL-487B Communications Card Database Structure—LOCAL Region* through *Table 3.30: SEL-487B Communications Card Database Structure—D1 Region*. ➤ Added details and examples to indicate how to get SOE-quality timestamped data over a DNP LAN/WAN connection in *Communications Card Database*. Section 5 ➤ Updated *Table 5.6: SEL-487B Port DNP Protocol Settings* for new setting EVELOCK. ➤ Updated *Table 5.7: SEL-487B DNP Map Settings* for new setting MAPSEL. ➤ Edited *Default Data Map* to explain new reference maps. ➤ Updated *Table 5.10: SEL-487B DNP3 Default Data Map* to include two reference maps and new indices 76, 79, and 178. ➤ Added new bit values to *Table 5.12: SEL-487B Object 1, 2 Relay Word Bit Mapping*. ➤ Added new bit values to *Table 5.13: Object 1, 2 Front-Panel Targets*. ➤ Updated *Reading Relay Even Data* for new single-event mode. ➤ Updated *Figure 5.3: SEL-487B Example Settings* for new setting MAPSEL. ➤ Updated *Table 5.17: SEL-487B Port 3 Example Settings* for new setting EVELOCK. ➤ Updated *Custom Data Mapping* to indicate how to get SOE-quality timestamped data over a DNP LAN/WAN connection. ➤ Corrected settings type, range and descriptions in *Table 5.20: SEL-487B DNP LAN/WAN Map Settings*. ➤ Added *Binary Inputs*, *Analog Inputs*, *Binary Outputs*, *Analog Outputs*, and *DNP Map Command* sections and added details to indicate how to get SOE-quality timestamped data over a DNP LAN/WAN connection. ➤ Corrected setting menu paths and descriptions in *Table 5.27: DNP LAN/WAN Application Example Binary Input Map*.

Table A.5 Instruction Manual Revision History (Sheet 6 of 10)

Revision Date	Summary of Revisions
	➤ Added *Figure 5.5: Add Binary Inputs to SER Point List* and explanatory text in order to indicate how to get SOE-quality timestamped data over a DNP LAN/WAN connection. ➤ Corrected *Table 5.24: SEL-487B DNP LAN/WAN Object 12 Control Point Operation* code selection operation for Control Points CB1–CB18. Section 6 ➤ Added *Binary Inputs*, *Analog Inputs*, *Binary Outputs*, *Analog Outputs*, and *DNP Map Command* sections and added details to indicate how to get SOE-quality timestamped data over a DNP LAN/WAN connection. ➤ Added and edited tables to document new ICD file versions supported by ACSELERATOR Architect Revision 1.1.69.0. ➤ Added Table 6.7: Logical Node Summary. ➤ Updated *Table 6.8: Logical Device: PRO (Protection)* through *Table 6.11, Logical Device: ANN (Annunciation)* to document new ICD file versions. ➤ Updated *Table 6.11: Logical Device: ANN (Annunciation)* to document new ICD file versions and correct PB LED Bits. Section 7 ➤ Updated *Table 7.9: CEV Command Options Description* to specify that CEV C command defaults to full length. ➤ Updated *Table 7.33: EVE Command Options Description* to specify that EVE C command defaults to full length. ➤ Added information to the ID subsection to specify that the ID command contains Ethernet card information. ➤ Added MET CZ1 command. ➤ Added MET SEC CZ1 command. ➤ Updated SET Z command to include independent Check Zone. ➤ Updated SHO Z command to include independent Check Zone. Section 8 ➤ Added Check Zone name to Alias Settings. ➤ Updated *Figure 8.1: Changing a Default Name to an Alias* for new Alias prompt format. ➤ Updated *Table 8.1: Default Alias Settings* for new Aliases. ➤ Updated *Table 8.13: Data Reset Control for RSTDNPE*. ➤ Updated *Table 8.16: Zone Configuration Settings Categories* to include Open CT Detection and independent Check Zone. ➤ Added *Table 8.23: Zone Open CT Detection*. ➤ Added *Table 8.24: Terminal-to-Check-Zone Connections*. ➤ Added *Table 8.25: Check Zone Supervision*. ➤ Updated *Table 8.26: Group Settings Categories* to include independent Check Zone. ➤ Added *Table 8.29: Check Zone Sensitive Differential Element*. ➤ Added *Table 8.31: Check Zone Restrained Differential Element*. ➤ Updated *Table 8.41: Protection Free-Form* SELogic *Control Equation* to reflect new Protection Logic default settings. ➤ Added new front-panel settings categories to *Table 8.50: Front-Panel Settings Categories*. ➤ Updated *Table 8.51: Front-Panel Setting* for HMI changes: tricolor LEDs, expanded pushbuttons, and expanded target LEDs. ➤ Added new setting SCROLD to *Table 8.52: Selectable Screens for the Front Panel*. ➤ Added new front-panel settings *Table 8.53: Selectable Operator Pushbuttons* and *Table 8.54: Front-Panel Event Display*. ➤ Split Display Points and Aliases table into two separate tables, *Table 8.55: Boolean Display Points and Aliases* and *Table 8.56: Analog Display Points and User Text and Formatting*. ➤ Added *Table 8.58: Local Bit* SELOGIC. ➤ Updated SER Points and *Figure 8.2: Setting an SER Point to Report TRGTR Relay Word Bit Status* to reflect new SER setting parameter HMI Alarm. ➤ Updated *Table 8.61: Event Reporting* for new 60 and 120 cycle event report lengths. ➤ Clarified Event Reporting Digital Elements capacity. ➤ Updated *Figure 8.3: Steps to Add the Output From Coupler Security Logic 1* to the Event Report to reflect new SER setting parameter HMI Alarm. ➤ Updated *Table 8.67: DNP3 Protocol Serial Port Settings* for new setting EVELOCK. ➤ Added *Table 8.75: DNP3 Reference Map Selection*.

Table A.5 Instruction Manual Revision History (Sheet 7 of 10)

Revision Date	Summary of Revisions
	Appendix A ➤ Updated *Table A.1: Alphabetic List of Relay Word Bits* to include Check Zone, front-panel expanded HMI, and DNP event control information. ➤ Added *Table A.2: Row List of Relay Word Bits*. Appendix B ➤ Added IOPCZ1, IOPCZ1F, IRTCZ1 and IRTCZ1F to *Table B.1, Analog Quantities Sorted by Function* and *Table B.2, Analog Quantities Sorted Alphabetically.*
20070315	**User's Guide** Appendix A ➤ Updated for firmware version R115.
20070220	**User's Guide** Appendix A ➤ Updated for firmware version R114.
20060905	**User's Guide** Appendix A ➤ Updated for firmware version R113.
20060814	**User's Guide** Preface ➤ Added cautions and a warning in English and French. Section 2 ➤ Corrected two 7U Version rear-panel diagrams. ➤ Updated Ethernet card rear-panel layouts. Section 6 ➤ In *Status Warning and Status Failure* added information about the relay restarting on certain diagnostic failures. Appendix A ➤ Updated for firmware version R112. ➤ Updated for Ethernet card firmware version R101. Appendix B ➤ Replaced SEL-487B firmware upgrade instructions with SEL-400 Series Relays Firmware Upgrade Instructions. **Applications Handbook** Section 3 ➤ Added diagnostic restart to the list of conditions captured by the SER. Section 4 ➤ Deleted incorrect information about analog quantities. Section 5 ➤ Documented additional support for paired control outputs (BO). Section 8 ➤ Clarified multiple client access for Unbuffered Reports. ➤ Added Protocol Implementation Conformance Statement (PICS).
20060727	**User's Guide** Appendix A ➤ Updated for firmware version R111.

Table A.5 Instruction Manual Revision History (Sheet 8 of 10)

Revision Date	Summary of Revisions
20060703	**User's Guide** Section 2 ➤ Included network port configurations and safety warnings in *Network Connections*. Appendix A ➤ Updated for firmware revision R110. **Applications Handbook** Section 5 ➤ Revised FTP File Structure description in *FTP*. ➤ Specified CID file location in *FTP*. **Reference Manual** Section 3 ➤ Added Ethernet card commands to *Ethernet Card Commands*. ➤ Added "keep alive" settings ETCPKA, KAIDLE, KAINTV, and KACNT to *Ethernet Network Operation Settings*. ➤ Revised FTP File Structure description in *File Structure*. Section 5 ➤ Increased CCINs from 32 to 128 (DNP LAN/WAN map) and adjusted indices as necessary. Section 6 ➤ Added new IEC 61850 section (replaced the UCA2 section). Section 7 ➤ Added information about new **ID** command response for an Ethernet card with IEC 61850 support. Appendix A ➤ Increased CCINs from 32 to 128 (Relay Word bits) and adjusted row numbers for those and all subsequent rows. Glossary ➤ Added IEC 61850 entries. Miscellaneous ➤ Removed GOMSFE appendix. ➤ Removed references to UCA2 and GOMSFE. ➤ Modified GOOSE references to describe IEC 61850 GOOSE.
20060413	**User's Guide** Appendix A ➤ Updated for firmware version R109.
20051123	Revised entire manual to include new DNP3 LAN/WAN functionality. **User's Guide** Appendix A ➤ Updated for firmware version R108.
20051121	**User's Guide** Appendix A ➤ Updated for firmware version R107.
20050220	**User's Guide** Section 1 ➤ Added 7U chassis information. ➤ Corrected minimum wire insulation rating. ➤ Removed references to ACSELERATOR QuickSet® SEL-5030 software HMI screen. ➤ Corrected specifications. Section 2 ➤ Added 7U chassis information. ➤ Added instructions on how to use optoisolated inputs with ac control signals.

Table A.5 Instruction Manual Revision History (Sheet 9 of 10)

Revision Date	Summary of Revisions
	Section 4 ➤ Removed references to ACSELERATOR HMI screen. Section 5 ➤ Removed references to ACSELERATOR HMI screen. Section 6 ➤ Removed references to ACSELERATOR HMI screen. Appendix A ➤ Updated for firmware version R106. **Applications Handbook** Section 1 ➤ Removed reference to "SEL TWO_CT" program. Section 4 ➤ Explained restrictions for Fast Meter protocol. **Reference Manual** Section 1 ➤ Corrected coupler security logic. Section 2 ➤ Corrected *Figure 2.9: R_TRIG Timing Diagram* and *Figure 2.10: F_TRIG Timing Diagram*. Section 4 ➤ Corrected RBADPU range. Section 6l ➤ Corrected **SHO P** description ➤ Corrected Directional Element Test. Section 7 ➤ Corrected RBADPU range.
20041129	**User's Guide** Appendix A ➤ Updated for firmware version R105.
20040609	**User's Guide** Section 4 ➤ Deleted space between C and V in **SER CV** command. Appendix A ➤ Updated for firmware version R104. **Applications Handbook** Section 1 ➤ Corrected paragraph following *CT Grounding*. ➤ Corrected text following *Figure 1.40: Forming Bus-Zone-to-Bus-Zone Connections With and Without a Circuit Breaker*. ➤ Corrected text in figure *Figure 1.66: Differential Trip Logic for Differential Element 1*. **Reference Manual** Section 5 ➤ Corrected text following *Collision Avoidance*.

Table A.5 Instruction Manual Revision History (Sheet 10 of 10)

Revision Date	Summary of Revisions
20040401	**User's Guide** Section 1 ➤ Updated Metering Accuracy information in *Specifications*. **Applications Handbook** Section 1 ➤ Changed the zone supervision settings (SELOGIC equation) of the check zone in Application 1 to prevent loss of multiple zones.
20031112	**User's Guide** Appendix A ➤ Updated for firmware version R103. **Reference Manual** Section 1 ➤ Added SELOGIC control equation setting RSTTRGT to *Figure 1.58: Trip Logic for Breaker 1* logic diagram. ➤ Added text explaining that assertion of SELOGIC control equation setting RSTTRGT is one of four methods to unlatch the trip logic. Section 2 ➤ Clarified description of first execution bit PFRTEX in *Table 2.6: First Execution Bit Operation on Power Up; Table 2.7: First Execution Bit Operation on Automation Settings Change;* and *Table 2.8: First Execution Bit Operation on Protection Settings Change and Group Switch.*
20030724	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

This instruction will guide you through the process of upgrading the relay's firmware.

Important Considerations

EPORT Setting

SEL-421, SEL-451, and SEL-487B relays with the Enable Port (EPORT) setting found in each Port 1, Port 2, and Port 3 setting class must have the port enabled (EPORT = Y) on all serial ports prior to beginning this procedure. Failure to do so will result in the relay failing to respond after the **L_D** command is given in *Start SELBOOT on page U.B.10*. The factory default for the EPORT settings for Port 1, Port 2, and Port 3 is EPORT = Y.

The EPORT setting was added to the relays at different times. If your relay has a firmware version prior to those listed below, the EPORT setting is not available and there is no need to check the EPORT setting. If your relay presently has SELBOOT firmware revision R101 or later, there is no need to check the EPORT setting.

SEL-400 Series Relay	Firmware Version
SEL-421-0, -1	No EPORT settings
SEL-421-2,-3	R120 and later
SEL-451-1	R202 and later
SEL-451-2,-4	R120 and later
SEL-487B	R117 and later

Display Point Settings

When upgrading an SEL-487B-0 Relay from firmware version R115 or earlier to firmware versions R116-R123, a problem occurs if the relay Display Point labels exceed 19 characters per setting. To prevent this problem, reduce Display Point settings to 19 characters or fewer prior to upgrading the relay. Failure to do so could result in the relay disabling upon restart. Once the firmware upgrade is complete, the Display Point settings can be relabeled.

To prevent this firmware upgrade issue, an upgrade to the latest firmware version (R124 or higher) is recommended.

Required Equipment

You will need the following items before beginning the firmware upgrade process:

- ➤ Personal computer (PC)
- ➤ Terminal emulation software that supports Xmodem/CRC protocol
- ➤ SEL-C234A cable, SEL-C662 USB-to-232 converter, or equivalent
- ➤ Disk containing the firmware upgrade file(s)
- ➤ Relay Firmware Upgrade Instructions

Optional Equipment

These items help you manage relay settings and understand procedures in the relay upgrade process:

- ➤ ACSELERATOR® SEL-5030 Software program
- ➤ SEL-487B Relay manual

Upgrade Procedure

The upgrade kit you received contains the firmware needed to upgrade the SEL-487B Relay. The kit may also contain firmware needed to upgrade the Ethernet card and SELBOOT program. See *Table B.1* to identify which firmware files you received in the upgrade kit.

Table B.1 Firmware Upgrade Files

Product	File Name	File Type
SEL-400 series relays SELBOOT	S*nnn*4*xx*.s19[a]	SEL-400 series SELBOOT firmware (can be downloaded to an SEL-400 series relay).
SEL-400 series relays	R*nnn*4*xx*.s19[a]	SEL-400 series relay firmware (can be downloaded to an SEL-400 series relay).
SEL-2701/SEL-2702 Ethernet Processor	R*nnn*27*xx*.s19[a]	SEL-2701/SEL-2702 firmware (can be downloaded to an Ethernet card).
SEL-2701/SEL-2702 SELBOOT	S*nnn*27*xx*.s19[a]	SEL-2701/SEL-2702 SELBOOT firmware (can be downloaded to an Ethernet card).

[a] *nnn* in the file name will always represent the device firmware revision number.

NOTE: SEL strongly recommends that you upgrade firmware at the location of the relay and with a direct connection from the personal computer to one of the relay serial ports. Do not load firmware from a remote location; problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the relay through an SEL communications processor.

The firmware upgrade can be performed in one of two ways:

- ➤ Method One: Use the Firmware Loader provided within ACSELERATOR QuickSet® SEL-5030 Software. The Firmware Loader automates the firmware upgrade process and is the preferred method. The Firmware Loader can be used to upgrade only relay firmware (R*nnn*4*xx* files). If upgrading SELBOOT (S*nnn*4*xx*) or SEL-2701 (S*nnn*27*xx*) firmware is required, use Method Two.
- ➤ Method Two: Connect to the relay in a terminal session and upgrade the firmware using the steps documented in *Method Two: Using a Terminal Emulator on page U.B.8*.

Method One: Using ACSELERATOR QuickSet Firmware Loader

To use the ACSELERATOR QuickSet Firmware Loader, you must have ACSELERATOR QuickSet. See the PC Software section of the relay instruction manual for instructions on how to obtain and install the software. Once the software is installed, perform the firmware upgrade as follows.

A Obtain Firmware File

NOTE: The Firmware Loader can be used to load only relay firmware (Rnnn4xx). If you need to upgrade relay SELBOOT or Ethernet card firmware, use Method Two.

The firmware file is usually provided on a CD-ROM. Locate the firmware file on the disk. The file name is of the form R*nnn*4*xx*, where R*nnn* is the firmware revision number, 4*xx* indicates the relay type, and .s19 is the firmware file extension. Copy the firmware file to an easily accessible location on the PC.

Firmware is designed to be used with specific relays. A list of relay serial numbers is provided as part of the firmware upgrade package. The firmware provided is for use with the listed relays only. Attempts to upgrade relays not listed might not be successful and can result in relay failure.

B Remove Relay From Service

Step 1. If the relay is in service, follow your company practices for removing a relay from service. Typically, these practices include disabling input and output control functions.

Step 2. Apply power to the relay.

Step 3. Connect a communications cable and determine the port speed.

If using the EIA-232 front port to upgrade firmware, determine the port speed as follows:

a. From the relay front panel, press the **ENTER (ENT)** pushbutton.

b. Use the arrow pushbuttons to navigate to `SET/SHOW`.

c. Press the **ENTER (ENT)** pushbutton.

d. Use the arrow pushbuttons to navigate to `PORT`.

e. Press the **ENTER (ENT)** pushbutton.

f. Use the arrow pushbuttons to navigate to the relay serial port you plan to use (usually the front port, Port F).

g. Press the **ENTER (ENT)** pushbutton.

h. Use the arrow pushbuttons to navigate to `Communication Settings`.

i. Press the **<Enter>** key to view the selected port communications settings. Write down the value for each setting.

j. Once the port settings have been recorded, press the **<Esc>** key four times to return to the `MAIN MENU`.

k. Connect an SEL C234A EIA-232 serial cable, SEL C662 USB-to-232 converter, or equivalent communications cable to the relay serial port and to the PC.

C Establish Communications With the Relay

Use the **Communications > Parameters** menu of ACSELERATOR QuickSet to establish a connection using the communications settings determined in *Step 3*. See the PC Software section of the relay instruction manual for additional information.

D Save Settings and Other Data

It is possible for data to be lost during the firmware upgrade process. Follow the steps in this section carefully to ensure that important data are saved.

Step 1. Select **Tools > Firmware Loader** and follow the on-screen prompts.

Step 2. In the Step 1 of 4 window of the Firmware Loader, click the ellipsis button and browse to the location of the firmware file. Select the file and click **Open**. See *Figure B.1*.

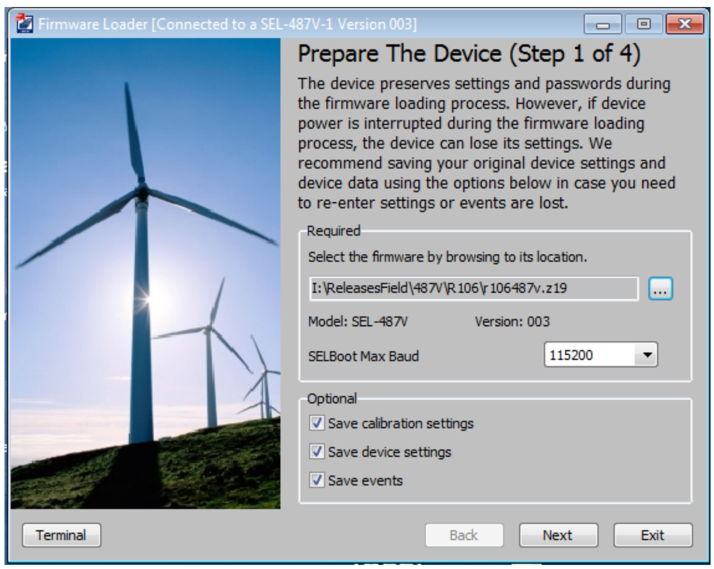

Figure B.1 Prepare the Device (Step 1 of 4)

Step 3. Check the **Save calibration settings** box in the Step 1 of 4 window of the Firmware Loader. These factory settings are required for proper operation of the relay and must be reentered in the unlikely event they are erased during the firmware upgrade process. The Firmware Loader saves the settings in a text file on the PC.

Step 4. Check the **Save device settings** box if you do not have a copy of the relay settings. It is possible for relay settings to be lost during the upgrade process.

Step 5. Check the **Save events** box if there are any event reports that have not been previously saved. The event history is cleared during the upgrade process.

Step 6. Click **Next**.

The Firmware Loader reads the calibration settings and saves them in a text file on the PC. Make note of the file name and the location.

If **Save device settings** was selected, the Firmware Loader reads all of the settings from the relay. The software may ask if you want to merge the settings read from the relay with existing design templates on the PC. Click **No, do not merge settings with Design Template**. The Firmware Loader will suggest a name for the settings, but the suggested name can be modified as desired.

If **Save events** was selected, the Event History window will open to allow the events to be saved. See the PC Software section of the relay instruction manual for more information.

Step 7. If you use the Breaker Wear Monitor, click the **Terminal** button in the lower left portion of the Firmware Loader to open the terminal window. From the Access Level 1 prompt, issue the **BRE** command and record the internal and external trip counters, internal and external trip currents for each phase, and breaker wear percentages for each phase.

Step 8. Enable Terminal Logging capture (see the PC Software section of the relay instruction manual) and issue the following commands to save stored data. It is possible for these data to be lost during the firmware upgrade process.

a. **MET E**—accumulated energy metering

b. **MET D**—demand and peak demand

c. **MET M**—maximum/minimum metering

d. **COMM A** and **COMM B**—MIRRORED BITS® communications logs

e. **PROFILE**—Load Profile

f. **SER**—Sequential Events Report

E Start SELBOOT

In the Step 2 of 4 window of the Firmware Loader, click **Next** to disable the relay and enter SELBOOT. See *Figure B.2*.

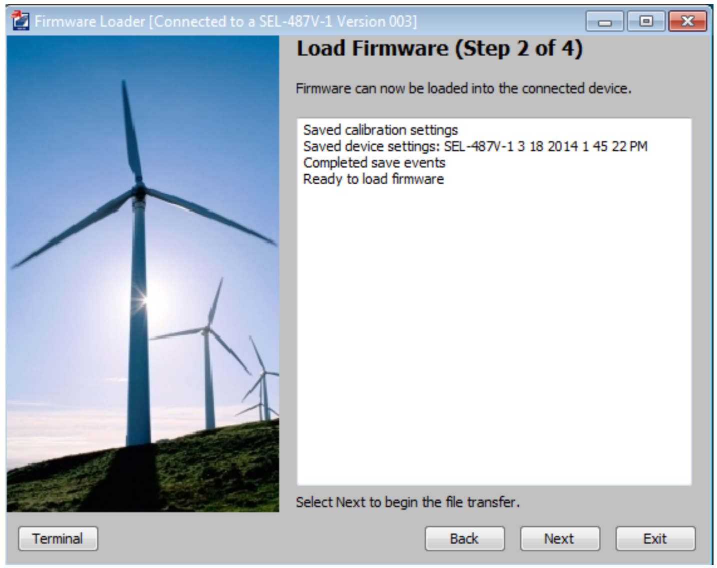

Figure B.2 Load Firmware (Step 2 of 4)

F Maximize Port Baud Rate

This step is performed automatically by the software.

G Upload New Relay Firmware

This step is performed automatically by the software. The software will erase the existing firmware and start the file transfer to upload the new firmware. Upload progress will be shown in the **Transfer Status** window. The entire firmware upload process can take longer than 10 minutes to complete.

When the firmware upload is complete, the relay will restart. The Firmware Loader automatically re-establishes communications and issues an **STA** command to the relay.

In cases where the relay does not restart within two minutes of the firmware upload completion (as indicated by the PC application), and no error messages appear on the relay HMI, cycle power to the relay. The firmware loader application should then resume. Answer **Yes** if the Firmware Loader prompts you to continue.

H Verify Relay Self-Tests

The Step 3 of 4 window of the Firmware Loader will indicate that it is checking the device status and when the check is complete (see *Figure B.3*).

The software will notify you if any problems are detected. You can view the relay status by opening the terminal using the Terminal button in the lower left portion of the Firmware Loader. If status failures are shown, open the terminal and see *Solving Firmware Upgrade Issues on page U.B.18*.

Click **Next** to go to the completion step.

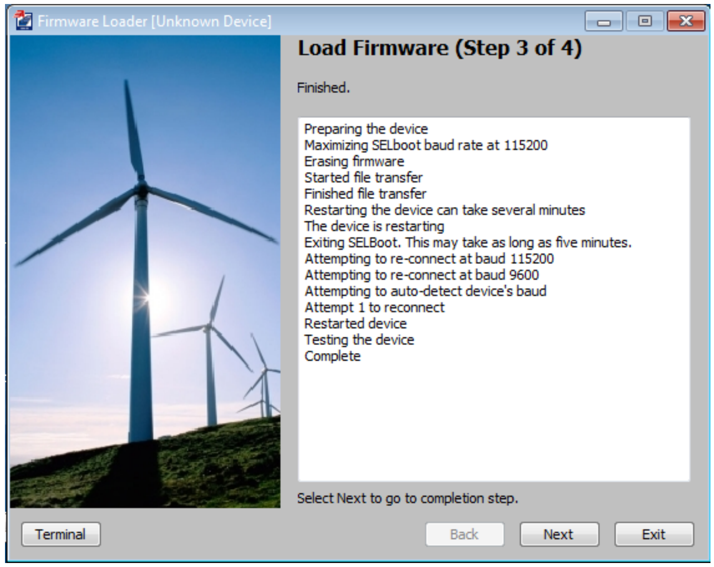

Figure B.3 Load Firmware (Step 3 of 4)

I Verify Relay Settings

If there are no failures, the relay will enable. In the Step 4 of 4 window (see *Figure B.4*), the Firmware Loader will give you the option to compare the device settings. If any differences are found, the software will provide the opportunity to restore the settings.

Figure B.4 Verify Device Settings (Step 4 of 4)

J Return Relay to Service

Step 1. Open the terminal window using the **Terminal** button in the lower left portion of the Firmware Loader.

Step 2. Use the **ACC** command with the associated password to enter Access Level 1.

Step 3. Issue the **ID** command and compare the firmware revision (R*nnn*) displayed in the FID string against the number from the firmware envelope label. If the numbers match, proceed to *Step 5*.

Step 4. For a mismatch between a displayed FID and the firmware envelope label, reattempt the upgrade or contact SEL for assistance.

Step 5. If you use the Breaker Wear Monitor, type **BRE <Enter>** to check the data to see if the relay retained breaker wear data through the upgrade procedure. If the relay did not retain these data, use the **BRE W** command to reload the percent contact wear values recorded in *Save Settings and Other Data on page U.B.4*.

Step 6. Apply current and voltage signals to the relay.

Step 7. Type **MET <Enter>** or use the ACSELERATOR QuickSet HMI to verify that the current and voltage signals are correct.

Step 8. Use the **TRI** and **EVE/CEV** commands or **Tools > Events > Get Events** menu in ACSELERATOR QuickSet to verify that the magnitudes of the current and voltage signals you applied to the relay match those displayed in the event report. If these values do not match, check the relay settings and wiring.

Step 9. Autoconfigure the SEL communications processor port if you have an SEL communications processor connected to the relay. This step reestablishes automatic data collection between the SEL communications processor and the relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Step 10. Follow your company procedures for returning a relay to service.

Method Two: Using a Terminal Emulator

These instructions assume you have a working knowledge of your PC terminal emulation software. In particular, you must be able to modify the serial communications parameters (data speed or baud rate, data bits, parity, and similar parameters), disable any hardware or software flow control in the computer terminal emulation software, select a transfer protocol (1K Xmodem, for example), and transfer files (send and receive binary files).

The programs (firmware) that run in the SEL-400 series relays and Ethernet cards reside in Flash memory. To load new firmware versions, follow these instructions. The SEL-400 series relays and Ethernet cards have two programs that you may need to upgrade: the regular, or “executable” program and the SELBOOT program.

A Obtain Firmware File

The firmware file is usually provided on a CD-ROM. Locate the firmware file on the disk. The file name is of the form R*nnn*4*xx*, where R*nnn* is the firmware revision number, 4*xx* indicates the relay type, and .s19 is the firmware file extension. Copy the firmware file to an easily accessible location on the PC.

Firmware is designed to be used with specific relays. A list of relay serial numbers is provided as part of the firmware upgrade package. The firmware provided is for use with the listed relays only. Attempts to upgrade relays not listed might not be successful and can result in relay failure.

B Prepare the Relay

If the relay is in service, follow your company practices for removing a relay from service. Typically, these practices include disabling input and output control functions.

C Save Settings and Other Data

It is possible for data to be lost during the firmware upgrade process. Follow the steps in this section carefully to ensure that important data are saved.

Enter Access Level 2

Step 1. Using the communications terminal, at Access Level 0 type **ACC <Enter>**.

Step 2. Type the Access Level 1 password and press **<Enter>**.

You will see the Access Level 1 => prompt.

Step 3. Type **2AC <Enter>**, and then type the correct password to go to Access Level 2.

You will see the Access Level 2 =>> prompt.

For more information, see *Making an EIA-232 Serial Port Connection on page U.4.5*.

View FID

Step 4. Type **STA A <Enter>** to view the SEL-400 series relay and Ethernet card status and firmware identifier (FID). The results of a typical **STA A** command are shown in *Figure B.5*.

Note the FID identifier number(s) for use in *Download Existing Firmware to Your Computer on page U.B.11* and *Verify Relay Self-Tests on page U.B.16* of this document.

```
=>>STA A <Enter>
Relay 1                                 Date: 12/07/2005  Time: 11:10:25.246
Station A                               Serial Number: 200405xxxx

FID=SEL-451-1-R106-V0-Z003003-D20051107     CID=0xd806

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
    1      1     1     1     1     1     1     1     1      1     1     1    1

Power Supply Voltages (V)   W=Warn   F=Fail

3.3V_PS   5V_PS   N5V_PS   15V_PS   N15V_PS
   3.28    5.02    -4.99    14.94    -14.98

Temperature
  34.7 degrees Celsius

Communication Interfaces
  Communications Card 1
   SEL-2701-R107-V2-Z002001-D20051123  Enet All
   Normal 0x0000
   Active virtual terminal sessions: 0

Active High Accuracy Time Synchronization Source: IRIG-B
   IRIG-B Source PRESENT

SELogic Relay Programming Environment Errors
   No Errors

Relay Enabled
```

Figure B.5 Example Relay STA A Command Results

Backup Relay Settings

The relay preserves the settings and passwords during the firmware upgrade process. However, if relay power is interrupted during the firmware upgrade process, the relay can lose the settings. Make a copy of the original relay settings in case you need to reenter settings.

Use one of the following methods to back up relay settings.

- ➤ If you have not already saved copies of the relay settings, use ACSELERATOR QuickSet to read and save the relay settings. See *Create and Manage Relay Settings on page U.3.8*.
- ➤ Alternatively, you can use the terminal to download all the relay settings.

  See the **FILE READ** command in *Section 7: ASCII Command Reference*.

  For file retrieval procedures see *Event Report Oscillography on page A.3.6*.

D Start SELBOOT

Step 1. Establish/confirm binary transfer terminal communication.

Use a terminal program that supports 1K Xmodem transfer protocol to communicate with the relay.

Step 2. Prepare to control the relay at Access Level 2. If the relay is not already at Access Level 2, use the procedure in *Enter Access Level 2 on page U.B.9*.

Step 3. Start the relay SELBOOT program.

a. Type **L_D <Enter>**.

The relay responds with the following message:

`Disable relay to send or receive firmware (Y/N)?`

b. Type **Y <Enter>**.

The relay responds with the following message:

`Are you sure (Y/N)?`

c. Type **Y <Enter>**.

The relay responds with the following message:

`Relay Disabled`

Step 4. Wait for the SELBOOT program to load.

The front-panel LCD screen displays the SELBOOT R*yyy* firmware number (e.g., `SELBOOT R100`); R*yyy* is the SELBOOT revision number and is a different revision number from the relay firmware revision number. The LCD also displays the present relay firmware (e.g., `SEL-451-R102`), and `INITIALIZING`.

When finished loading the SELBOOT program, the relay responds to the terminal with the SELBOOT !> prompt; the LCD shows the SELBOOT and relay firmware revision numbers.

Step 5. Press **<Enter>** to confirm that the relay is in SELBOOT; you will see another SELBOOT !> prompt.

Establish a High-Speed Serial Connection

Step 1. At the SELBOOT prompt, type **BAU 115200 <Enter>** (see *Figure B.6)*.

Step 2. Set your terminal program for a data speed of 115200 bps.

Step 3. Press **<Enter>** to check for the SELBOOT !> prompt indicating that serial communication at 115200 bps is successful.

E Download Existing Firmware to Your Computer

Only follow this step if you want to save a backup copy of the existing relay firmware on your computer. If you do not need to perform this step, proceed to *Upload New Relay Firmware on page U.B.12*.

The PC needs approximately 4 MB of free disk space to store the relay firmware.

Step 1. Type **SEN <Enter>** to initiate the firmware transfer from the relay to the PC.

The relay responds as shown in *Figure B.6*.

Step 2. Select the **Receive File** function with **1K Xmodem** protocol in your terminal emulation software.

Step 3. Name the file with the R-number from the FID from *View FID on page U.B.9* to clearly identify the firmware version (e.g., 451_R102.s19).

Be sure to add the .s19 suffix.

Step 4. Start the terminal emulation software receive program.

Receiving firmware takes approximately 10 minutes at 115200 bps. The front-panel LCD shows `SENDING CODE`. After the transfer, the relay responds with the following message:

`Transfer completed successfully`

F Upload New SELBOOT Firmware to the Relay

NOTE: Loading the incorrect SELBOOT firmware to either the relay or Ethernet card may cause the relay to malfunction, requiring factory repair.

NOTE: Do not cycle power to the relay during the SELBOOT firmware upgrade process. Doing so may cause the relay to malfunction, requiring factory repair.

Upgrading SELBOOT firmware in SEL-400 series relays is typically not required as part of a normal relay firmware upgrade process. However, occasionally core functions of the relay are enhanced, and the SELBOOT firmware must be upgraded to enable the enhanced functions. If a SELBOOT upgrade for the relay is not indicated in your upgrade kit, skip this step, and continue on to *Upload New Relay Firmware on page U.B.12*. Please note that there may also be SELBOOT upgrades for the Ethernet card of the relay. The Ethernet card uses a separate SELBOOT firmware file. See *Table B.1* for file names.

To begin the relay SELBOOT upgrade, start at the SELBOOT prompt !>.

Step 1. Type **REC BOOT** command at the SELBOOT prompt, and answer **Y** when prompted to erase the existing SELBOOT firmware.

```
!>REC BOOT <Enter>

Caution! -  This command erases the SELboot firmware.
Are you sure you want to erase the existing firmware? (Y/N)
```

Step 2. After erasing the existing SELBOOT firmware, the relay will prompt to begin file transfer. Press any key to begin the file transfer to the relay.

Step 3. Using an Xmodem file transfer protocol, point the sending software tool to the relay SELBOOT file (S*nnn*4*xx*.s19) that is to be uploaded to the relay.

Upon successful negotiation of the new SELBOOT firmware file, the old SELBOOT software will be erased, and the new SELBOOT firmware will be written to the relay's Flash memory. SELBOOT will then automatically restart using the new SELBOOT firmware.

```
Erasing old SELboot

Writing new SELboot to flash

Press any key to begin transfer, then start transfer at the PCC
Restarting SELboot
```

Step 4. Once the relay has restarted in SELBOOT, the SELBOOT !> prompt will appear in the terminal window. Remain in SELBOOT and continue to *Upload New Relay Firmware*.

G Upload New Relay Firmware

Step 1. From the SELBOOT !> prompt, type **REC <Enter>**.

The relay responds with the prompt shown in *Figure B.6*. The end of the relay response is

`Are you sure you want to erase the existing firmware? (Y/N)`

Step 2. Type **Y <Enter>**.

The relay responds, `Erasing`, and erases the existing firmware. The front-panel LCD shows `ERASING MEMORY`.

When finished erasing, the relay responds, `Erase successful`, and prompts you to press any key to begin transferring the new firmware. The front-panel LCD shows only the SELBOOT program revision number.

```
!>BAU 115200 <Enter>
!><Enter>
!>SEN <Enter>

Program is ready to be transmitted.
Begin transfer at PC.
Transfer completed successfully.

!>REC <Enter>
Caution! - This command erases the device firmware.
If you erase the firmware, new firmware must be loaded into the device
before it can be put back into service.
Are you sure you want to erase the existing firmware? (Y/N) Y <Enter>
Erasing

Erase successful
Press any key to begin transfer, then start transfer at the PCCC <Enter>
```

Figure B.6 Transferring New Firmware

NOTE: The relay displays one or more "C" characters while waiting for your PC terminal emulation program to send the new firmware. If you do not start the transfer quickly (within about 18 seconds), the relay times out and responds `Remote system is not responding`. If this happens, begin again at Upload New Relay Firmware.

Step 3. Press **<Enter>** to begin uploading the new firmware.

Step 4. Start the **Transfer** or **Send** process in your terminal emulation program.

Use 1K Xmodem for fast transfer of the new firmware to the relay.

Step 5. Point the terminal program to the location of the new firmware file (the file that ends in .s19).

NOTE: The relay restarts in SELBOOT if relay power fails while receiving new firmware after the old firmware is erased. At power-up, the relay defaults to a data speed of 9600 bps. Continue the upgrade procedure beginning at Establish a High-Speed Serial Connection on page U.B.11 to increase the serial connection data speed. Then continue the firmware upgrade process again at Upload New Relay Firmware on page U.B.12.

Step 6. Begin thUpload New Relay Firmware on page U.B.12e file transfer.

The usual transfer time at 115200 bps with 1K Xmodem is about 10 minutes. The LCD screen shows `SELBOOT Ryyy LOADING CODE` while the relay loads the new firmware.

Step 7. Wait for firmware load completion.

When finished loading the new firmware, the relay responds, `Transfer completed successfully` and displays the SELBOOT !> prompt. The LCD screen displays `SELBOOT Ryyy SEL-4xx-Rnnn`, where *yyy* is the SELBOOT revision number, *xx* is the particular model of the SEL-400 series relays being upgraded, and *nnn* is the firmware revision number of the relay, e.g., R100 SEL-487B-R105.

H Download Existing Ethernet Card Firmware to the Host Computer

Only follow this step if you want to save a backup copy of the existing SEL-2701 or SEL-2702 Ethernet card firmware on your computer. If you do not need to perform this step, proceed to *Upload New Firmware to the Ethernet Card on page U.B.14*.

The PC needs approximately 4 MB of free disk space to store the Ethernet card firmware.

IMPORTANT: When the Ethernet card is part of a relay upgrade, you **must** stay in SELBOOT for the entire upgrade process (relay and Ethernet card). Exiting SELBOOT at any point other than Step K (Return Serial Data Speed to Nominal Operating Speed and Exit SELBOOT on page U.B.15) during the upgrade process may cause the relay to reset to an incorrect part number.

Step 1. From the relay SELBOOT prompt !> type **SEN 5 <Enter>** to initiate the firmware transfer from the Ethernet card to the PC.

The relay responds as shown in *Figure B.7*.

Step 2. Select the **Receive File** function with **1K Xmodem** protocol in your terminal emulation software.

Step 3. Name the file with the R-number of the FID from *View FID on page U.B.9* to clearly identify the firmware version (e.g., 2701_R100.s19).

Be sure to add the .s19 suffix.

Step 4. Start the terminal emulation software receive program.

Receiving firmware takes approximately 10 minutes at 115200 bps. The front-panel LCD shows `SENDING CODE`. After the transfer, the relay responds with the following message:

```
Transfer completed successfully
```

```
!>SEN 5 <Enter>

Program is ready to be transmitted.
Begin transfer at PC from card.
```

Figure B.7 Sending Ethernet Card Firmware to the Host Computer

I Upload New SELBOOT Firmware to the Ethernet Card

Some upgrades of the Ethernet card require an upload of a new version of the SEL-2701 or SEL-2702 SELBOOT firmware. Refer to the SEL-400 Series Relays Upgrade and Conversion Paths document found on the upgrade CD-ROM to determine if your relay needs new SELBOOT firmware. If your relay does not need new SELBOOT firmware, proceed to *Upload New Firmware to the Ethernet Card on page U.B.14*. The following steps describe how to complete this operation. Note that it is important that power be maintained continuously to the relay during this process.

Upgrade Warning

SEL-2701 firmware releases prior to R108 are not compatible with the SEL-2701 SELBOOT version R102. A `SLBT FAIL` (Hex 0x0004) message will appear if a **STA <Enter>** command is issued as shown in *Verify Relay Self-Tests on page U.B.16*. If the `SLBT FAIL` message is shown after the **STA** command is issued, contact SEL for assistance.

Step 1. While still in SELBOOT, type **REC BOOT 5 <Enter>** at the SELBOOT !> prompt. This will prompt the Ethernet card to begin receiving new SELBOOT firmware.

The Ethernet card responds with the prompt shown in *Figure B.8*.

Step 2. Type **Y <Enter>** when the relay responds `Are you sure you want to erase the existing firmware? (Y/N)`.

The relay responds `Erasing` and erases the existing firmware. The front-panel LCD shows `ERASING MEMORY`.

When finished erasing, the relay prompts you to press any key to begin transferring the new firmware. The front-panel LCD shows only the SELBOOT program revision number.

```
!>REC BOOT 5 <Enter>
Caution! - This transfer erases the card's SELboot firmware.
Are you sure you want to erase the existing firmware? (Y/N) Y <Enter>
Erasing

Press any key to begin transfer, PCC <Enter>
```

Figure B.8 Transferring New SELBOOT Firmware to the Ethernet Card

Step 3. Press **<Enter>** to begin uploading the new firmware to the Ethernet card.

Step 4. Start the **Transfer** or **Send** process in your terminal emulation program.

Use 1K Xmodem for fast transfer of the new firmware to the relay.

Step 5. Point the terminal program to the location of the new firmware file (the file that ends in .s19).

Step 6. Begin the file transfer.

The usual transfer time at 115200 bps with 1K Xmodem is about five minutes. The LCD screen shows `SELBOOT Ryyy LOADING CODE` while the relay loads the new firmware.

Step 7. Wait for firmware load completion.

When finishing loading the new firmware, the relay responds `File Successfully Transferred to Card` after which the relay will respond `Card will now attempt to restart`. Once the Ethernet card re-initializes, the relay will respond with `Card has successfully restarted`, and displays the SELBOOT !> prompt. The LCD screen displays `SELBOOT, Ryyy SEL-4xx-Rnnn`, where *yyy* is the SELboot revision number, *xx* is the particular model of SEL-400 series relay being upgraded, and *nnn* is the firmware revision number of the relay, e.g., R100 SEL-487B-R105.

J Upload New Firmware to the Ethernet Card

If your relay has an Ethernet card, read the SEL-400 Series Relays Upgrade and Conversion Paths document found on the upgrade CD-ROM to determine if new Ethernet card firmware is needed as part of the upgrade process. If your relay does not need new Ethernet card firmware, proceed directly to *Verify Relay Self-Tests on page U.B.16*.

Step 1. While the relay is still in SELBOOT, type **REC 5 <Enter>** at the SELBOOT prompt !>. This will prompt the Ethernet card to begin receiving new firmware.

Step 2. Type **Y <Enter>** when the relay responds `Are you sure you want to erase the existing firmware? (Y/N)`, as shown in *Figure B.9*.

The relay responds `Erasing`, and erases the existing firmware. The front-panel LCD shows `ERASING MEMORY`.

When finished erasing, the relay prompts you to press any key to begin transferring the new firmware. The front-panel LCD shows only the SELBOOT program revision number.

```
!>REC 5 <Enter>
Caution! - This transfer erases the card's firmware.
Are you sure you want to erase the existing firmware? (Y/N) Y <Enter>
Erasing

Press any key to begin transfer, PCC <Enter>
```

Figure B.9 Transferring New Firmware to the Ethernet Card

Step 3. Press **<Enter>** to begin uploading the new firmware to the Ethernet card.

Step 4. Start the **Transfer** or **Send** process in your terminal emulation program.

Use 1K Xmodem for fast transfer of the new firmware to the relay.

Step 5. Point the terminal program to the location of the new firmware file (the file that ends in .s19).

Step 6. Begin the file transfer.

The usual transfer time at 115200 bps with 1K Xmodem is about 5 minutes. The LCD screen shows `SELBOOT Ryyy LOADING CODE` while the relay loads the new firmware.

IMPORTANT: When the Ethernet card is part of a relay upgrade, you **must** stay in SELBOOT for the entire upgrade process (relay and Ethernet card). Exiting SELBOOT at any point other than Step K (Return Serial Data Speed to Nominal Operating Speed and Exit SELBOOT on page U.B.15) during the upgrade process may cause the relay to reset to an incorrect part number.

Step 7. Wait for firmware load completion.

When finished loading the new firmware, the relay responds `File Successfully Transferred to Card.` and displays the SELBOOT !> prompt. The LCD screen displays `SELBOOT, Ryyy SEL-4xx-Rnnn`, where *yyy* is the SELBOOT revision number, *xx* is the particular model of SEL-400 series relay being upgraded, and *nnn* is the firmware revision number of the relay, e.g., R100 SEL-487B-R105.

K Return Serial Data Speed to Nominal Operating Speed and Exit SELBOOT

Step 1. Type **<Enter>** to confirm relay communication.

The terminal displays the SELBOOT !> prompt.

Step 2. Type **BAU 9600 <Enter>** to reduce the data speed to your nominal serial communications speed (9600 bps in this example).

Step 3. Set your terminal emulation program to match the nominal data speed.

Step 4. Type **<Enter>** to confirm that you have reestablished communication with the relay.

The relay responds with the SELBOOT !> prompt.

Exit SELBOOT

Step 5. Type **EXI <Enter>** to exit the SELBOOT program.

After a slight delay, the relay responds with the following message:

```
CAUTION: Initial relay restart. DO NOT cycle power
during this time. Please wait 3 minutes for restart
completion.
```

L Verify Relay Self-Tests

Step 1. Press **<Enter>** and confirm that the Access Level 0 = prompt appears on your terminal screen.

Step 2. Remove input power to the relay.

a. Allow at least 10 seconds during the removal of relay power to ensure that the power supply has shut down.

b. Reapply input power to the relay.

c. Wait 5 minutes after power-up of the relay to allow the relay to detect any hardware changes made during the upgrade process.

Step 3. Enter Access Level 1 using the **ACC** command and Access Level 1 password.

Step 4. Enter Access Level 2 using the **2AC** command and Access Level 2 password.

Step 5. Type **STA <Enter>** to check the relay status and accept new hardware changes if needed.

Step 6. Verify that all relay self-test parameters are within tolerance.

Step 7. View the front-panel **ENABLED** LED and confirm that the LED is illuminated.

Unless there is a serious problem, the **ENABLED** LED illuminates without any intervention, and the relay retains all settings.

If the relay does not enable within five minutes of the `Initial relay restart` message, contact your Technical Service Center or the SEL factory for assistance (see *Technical Support on page B.20).*

M Verify Relay Settings

Step 1. Prepare to control the relay at Access Level 2; use the procedure in *Enter Access Level 2 on page B.9*.

Step 2. Type **VER <Enter>** to confirm the new firmware.

Step 3. Match the firmware revision number with the FID number on the screen.

Step 4. Use one of the following methods to review your settings.

- Use the ACSELERATOR QuickSet **Read** menu.

  If the settings do not match the settings that you recorded in *Backup Relay Settings on page B.10*, use ACSELERATOR QuickSet to restore relay settings.

- Type **SHOW <Enter>**.

You can reissue the settings with the **SET** commands (see *Section 7: ASCII Command Reference* for information on the **SHOW** and **SET** commands).

Step 5. Type **STA <Enter>** to check relay status.

Step 6. Verify that all relay self-test parameters are within tolerance.

N Return the Relay to Service

Step 1. Follow your company procedures for returning a relay to service.

Step 2. Type **MET <Enter>** to view power system metering.

Step 3. Verify that the current and voltage signals are correct.

Step 4. Type **TRI <Enter>** and then type **EVE <Enter>** to view the event report for the event just triggered.

Step 5. Verify that the current and voltage signals are correct in the event report.

Step 6. Autoconfigure the communications processor port if an SEL-2032, SEL-2030, or SEL-2020 Communications Processor is connected to the relay.

This step reestablishes automatic data collection between the SEL communications processor and the SEL-400 series relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

The relay is now ready for your commissioning procedure.

Verify IEC 61850 Operation (Optional)

SEL-400 series relays with optional IEC 61850 protocol require the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new Ethernet card firmware does not support the current CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol, as it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after an Ethernet port firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the Ethernet port firmware upgrade. If the IEC 61850 protocol was not configured prior to the upgrade, skip to *Solving Firmware Upgrade Issues on page U.B.18*. Refer to *Section 6: IEC 61850 Communications* for help with IEC 61850 configuration.

Step 1. Establish a Telnet connection to the Ethernet card.

a. From a command line prompt, type **Telnet [IP address] port** (e.g., **Telnet 192.168.0.213 1024**).

b. Press **<Enter>** until you see the = prompt.

Step 2. Issue the **STA**, **ID**, and **GOO** commands.

Step 3. Verify that there are no error messages regarding IEC 61850 or CID file parsing.

If the responses to the **STA**, **ID**, or **GOO** commands contain IEC 61850 or CID error messages, continue with the following steps to re-enable the IEC 61850 protocol. Otherwise, skip to *Solving Firmware Upgrade Issues*.

If the IEC 61850 protocol has been disabled due to an upgrade-induced CID file incompatibility, you can use ACSELERATOR Architect® SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the ACSELERATOR Architect upgrade that supports your required CID file version.

b. Run ACSELERATOR Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Upon connecting to the relay, ACSELERATOR Architect will detect the upgraded Ethernet port firmware and prompt you before converting the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, issue the **STA**, **ID**, and **GOO** commands.

Step 5. Verify that no IEC 61850 error messages are in the **STA** or **ID** command responses.

Step 6. Verify the GOOSE transmitted and received messages are as expected.

Solving Firmware Upgrade Issues

If a status failure message is returned in response to the **STA** command, perform the following steps.

Step 1. Use the **ACC** and **2AC** commands with the associated passwords to enter Access Level 2.

Step 2. Type **STA C <Enter>**. Answer **Y <Enter>** to the `Reboot the relay and clear status` prompt. The relay will respond with `Rebooting the relay`. Wait for about 30 seconds, then press **<Enter>** until you see the Access Level 0 = prompt.

Step 3. Use the **ACC** command with the associated password to enter Access Level 1.

Step 4. Type **STA <Enter>**.

If there are no fail messages and you are using Method One, click **Next** in Step 3 of 4 of the Firmware Loader and go to *Verify Relay Settings on page U.B.7*.

If there are no fail messages and you are using Method Two, go to *Verify Relay Settings on page U.B.16*.

If there are fail messages, continue with *Step 5*.

IMPORTANT: Step 6 will cause the loss of settings and other important data. Be sure to retain relay settings and other data downloaded from the relay at the start of the firmware upgrade process. Relay calibration level settings will not be lost.

Step 5. Use the **2AC** command with the associated password to enter Access Level 2.

Step 6. Type **R_S <Enter>** to restore factory default settings in the relay.

The relay asks whether to restore default settings. If the relay does not accept the **R_S** command, contact SEL for assistance.

Step 7. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the ENABLED LED illuminates. This LED is labeled either EN or ENABLED, depending on the relay model.

Step 8. Press **<Enter>** to check for the Access Level 0 = prompt indicating that serial communication is successful.

Step 9. Use the **ACC** and **2AC** commands and type the corresponding passwords to reenter Access Level 2.

Step 10. Use the **CAL** command and type the corresponding password to enter the relay Calibration settings level.

Step 11. Type **SHO C <Enter>** to verify the relay calibration settings.

If using Method One and the settings do not match the settings contained in the text file you recorded in *Save Settings and Other Data on page U.B.4*, contact SEL for assistance.

If using Method Two and the settings do not match the settings contained in the text file you recorded in *Prepare the Relay on page U.B.9*, contact SEL for assistance.

Step 12. Use the **PAS *n*** (***n* = 0**, **1**, **2**, **B**, **P**, **A**, **O**, **C**) command to set the relay passwords.

Step 13. Restore the relay settings:

a. If you have SEL-5010 Relay Assistant software or ACSELERATOR QuickSet, restore the original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 Relay Assistant software or ACSELERATOR QuickSet, restore the original settings by issuing the necessary **SET *n*** commands.

Step 14. If any failure status messages still appear on the relay display, see the Testing and Troubleshooting section in your relay instruction manual or contact SEL for assistance.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Glossary

9U The designation of the vertical height of a device in rack units. Nine rack units, 9U, total approximately 400 mm (15.75 inches).

7U The designation of the vertical height of a device in rack units. Seven rack units, 7U, total approximately 311 mm (12.25 inches).

A Abbreviation for amps or amperes; unit of electrical current flow.

a contact A normally open auxiliary contact that closes when the device is closed and opens when the device is open.

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. This 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. All access levels, except for Access Level 0, require the correct password.

Access Level 0 The least secure and most limited access level; not password protected. You must enter a password from this level to go to a higher level.

Access Level 1 The default access level for the relay front panel, used to monitor (view) relay information.

Access Level 2 The most secure access level, from which you have total relay functionality and control of all settings types.

Access Level A A relay command level used to access all Access Level 1 and Access Level B (Breaker) functions, plus Alias, Automation, Global, Front Panel, Report, Port, and DNP settings.

Access Level B A relay command level used for Access Level 1 functions, plus circuit breaker control and data.

Access Level O A relay command level used to access all Access Level 1 and Access Level B (Breaker) functions, plus Alias, Output, Global, Front Panel, Report, Port, and DNP settings.

Access Level P A relay command level used to access all Access Level 1 and Access Level B (Breaker) functions, plus Protection, Global, Group, Front Panel, Report, Port, Alias, Zone configuration, and DNP settings.

ACSELERATOR Architect® SEL-5032 Software
ACSELERATOR Architect is an add-on to the ACSELERATOR Suite that utilizes the IEC 61850 Substation Configuration Language to configure SEL IEDs.

ACSELERATOR QuickSet® SEL-5030 Software
A Windows®-based program that simplifies settings and provides analysis support.

ACSI
Abstract Communications Service Interface for the IEC 61850 protocol. Defines a set of objects, a set of services to manipulate and access those objects, and a base set of data types for describing objects.

Active Settings Group
The settings group that the SEL-487B is presently using from among six settings groups available in the relay.

Active Zone
A zone is active when any I*qq*BZ*p*V (*qq* = 01–18, *p* = 1–6) Relay Word bit asserts. For example, Zone 1 becomes active when Relay Word bit I01BZ1V asserts.

Advanced Settings
Settings for customizing protection functions; these settings are hidden unless you set EADVS := Y.

Alias
An alternative name assigned to Relay Word bits, analog quantities, default terminals, and bus-zone names.

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:

27	Undervoltage Element
50	Overcurrent Element
51	Inverse Time-Overcurrent Element
52	AC Circuit Breaker
59	Overvoltage Element
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
N	Neutral/Ground Element
Q	Negative-Sequence Element

Anti-Aliasing Filter
A low pass filter that blocks frequencies too high for the given sampling rate.

ASCII
Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters. The SEL-487B uses ASCII text characters to communicate, through front- and rear-panel EIA-232 serial ports and 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-487B 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 (e.g., SEL-2020/2030/2032 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.

Automation Variables Variables that are included in automation SELOGIC control equations.

AX-S4 MMS “Access for MMS” is an IEC 61850, UCA2, and MMS client application produced by SISCO, Inc., for real-time data integration in Microsoft Windows-based systems supporting OPC and DDE. Included with AX-S4 MMS is the interactive MMS Object Explorer for browser-like access to IEC 61850 / UCA2 and MMS device objects.

b contact A normally closed auxiliary contact that opens when the device is closed and closes when the device is open.

Bandpass Filter A filter that passes frequencies within a certain range and blocks all frequencies outside this range.

Bit Label The identifier for a particular bit.

Bit Value Logical 0 or logical 1.

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.

Breaker Differential Differential zone of protection configured exclusively across the tie breaker; the breaker differential protects only the area between the two tie-breaker CTs.

Buffered Report IEC 61850 IEDs can issue buffered reports of internal events (caused by trigger options data-change, quality-change, and data-update). These event reports can be sent immediately or buffered (to some practical limit) for transmission, such that values of data are not lost due to transport flow control constraints or loss of connection. Buffered reporting provides sequence-of-events (SOE) functionality.

Busbar Electrical junction of two or more primary circuits. For a single busbar, there could be multiple bus-zones; there can be more bus-zones than busbars, but not more busbars than bus-zones.

Buscoupler (see also Tie Breaker) Equipment with at least a current transformer and circuit breaker, connecting two busbars when the circuit breaker is closed. Disconnects of other terminals at the station (feeders, lines, etc.) are normally arranged in parallel with the buscoupler. Closing two or more disconnects of the other terminals bypasses the buscoupler, forming a connection without a circuit breaker between two or more busbars.

Busbar Protection Element Each of the six busbar protection elements comprise a differential element, a directional element, and a fault detection logic.

Bus Sectionalizer (see also Buscoupler) Equipment with at least a current transformer and circuit breaker, connecting two busbars when the circuit breaker is closed.

Bus-Zone-to-Bus-Zone Connection Variable SELOGIC variable stating the conditions when the relay merges two zones to form a single protection zone.

Bus-Zone (see also Protection Zone) Area of protection formed by a minimum of two terminals.

Category A collection of similar relay settings.

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.

Check Zone Protection zone formed by two or more terminals where the differential calculation is independent of the status of the disconnect auxiliary contacts.

CID Checksum identification of the firmware.

CID File IEC 61850 Configured IED Description file. XML file that contains the configuration for a specific IED.

Circuit Breaker Failure Logic This logic within the SEL-487B detects and warns of failure or incomplete operation of a circuit breaker in clearing a fault or in performing a trip or close sequence.

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.

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 Data Class IEC 61850 grouping of data objects that model substation functions. Common Data Classes include Status information, Measured information, Controllable status, Controllable analog, Status settings, Analog settings, and Description information.

Common Inputs Relay control inputs that share a common terminal.

Communications Protocol A language for communication between devices.

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.

Computer 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.

COMTRADE Abbreviation for Common Format for Transient Data Exchange.

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.

Control Input Relay input for monitoring the state of external circuits. Connects auxiliary relay and circuit breaker contacts to the control inputs.

Control Output Relay output that affects the state of other equipment. Connects control outputs to circuit breaker trip and close coils, breaker failure auxiliary relays, communications-assisted tripping circuits, and SCADA systems.

Coordination Timer A timer that delays an overreaching element so that a downstream device has time to operate.

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.

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 Transformer Saturation CT condition when the CT does not reproduce the primary current with the specified accuracy.

Data Attribute In the IEC 61850 protocol, the name, format, range of possible values, and representation of values being communicated.

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 Class In the IEC 61850 protocol, an aggregation of classes or data attributes.

Data Label The identifier for a particular data item.

Data Object In the IEC 61850 protocol, part of a logical node representing specific information (status or measurement, for example). From an object-oriented point of view, a data object is an instance of a data class.

DC Offset A dc component of fault current that results from the physical phenomenon preventing an instantaneous change of current in an inductive circuit.

DCE Devices Data communication equipment devices (modems).

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-487B 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-487B uses in DNP protocol.

Differential Element Using the busbar as reference, the differential element calculates the difference between current towards the busbars and away from the busbars.

Directional Element The directional element compares the direction of current at the reference terminal to the direction of current at all other terminals in each protection zone.

Disconnect (Isolator) Mechanical switch that isolates primary equipment such as circuit breakers from the electrical system.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware-independent communications protocol primarily intended for SCADA applications; owned and controlled by the DNP User's Group (www.dnp.org).

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.

Dynamic Zone Selection The process by which the currents from the CTs are assigned to or removed from the differential calculations as a function of the boolean value (logical 0 or logical 1) of a particular SELOGIC equation.

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 between the circuit breaker and the CT of a terminal.

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, time source, etc. 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 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.

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.

Fault Detection Logic Logic that distinguishes between internal and external faults.

Float High The highest charging voltage supplied by a battery charger.

Float Low The lowest charging voltage supplied by a battery charger.

Form C Output An output with both an a output and b output sharing a common post.

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 In IEC 61850, task(s) performed by the substation automation system, i.e., by application functions. Generally, functions exchange data with other functions. Details are dependent on the functions involved.

Functions are performed by IEDs (physical devices). A function may be split into parts residing in different IEDs but communicating with each other (distributed function) and with parts of other functions. These communicating parts are called logical nodes.

Function Code A code that defines how you manipulate an object in DNP3 protocol.

Functional Component Portion of an IEC 61850 Logical Node 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, number of disconnects, date format, nominal system frequency, enables, station dc monitoring, control inputs, settings group selection, and data reset controls.

GOMSFE Generic Object Model for Substation and Feeder Equipment; a system for presenting and exchanging IED data.

GOOSE IEC 61850 Generic Object Oriented Substation Event. GOOSE objects can quickly and conveniently transfer status, controls, and measured values among peers on an IEC 61850 network.

GPS Global Positioning System. Source of position and high-accuracy time information.

GUI Graphical user interface.

Hexadecimal Address An address reference represented as a base-16 value. Hexadecimal number representation is typically indicated by a 0x prefix or an h suffix.

HMI Human machine interface.

Local HMI: the LCD display on each of the SEL-487B relays.

System HMI: the display connected to the SEL-2030 that dynamically shows the station linking arrangement.

Station HMI: the equipment from which station-wide data acquisition and control are performed.

HV High voltage. System voltage greater than or equal to 100 kV and less than 230 kV.

I01–I18 Input phase currents.

ICD File IEC 61850 IED Capability Description file. XML file that describes IED capabilities, including information on logical node and GOOSE support.

IEC 61850 Internationally standardized method of communications and integration conceived with the goal of supporting systems of multivendor IEDs networked together to perform protection, monitoring, automation, metering, and control.

IED Intelligent electronic device.

IGBT Insulated gate bipolar junction transistor.

Inboard CT (bushing CT) Current transformer physically positioned in such a way that the CT is bypassed when the feeder is on transfer.

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.

IP Address An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address.

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.

Local Bits The Relay Word bit outputs of local control switches that you access through the SEL-487B 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 manually.

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.

Logical Node In IEC 61850, the smallest part of a function that exchanges data. A logical node (LN) is an object defined by its data and methods. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function.

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.

MAC Address The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

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.

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.

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.

MIRRORED BITS® Communications Patented relay-to-relay communications protocol 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 IEC 61850 and UCA.

MOD Motor-operated disconnect.

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 Use the following expression to calculate the negative-sequence voltage:

$$3V_2 = V_A + a^2V_B + aV_C$$

where a = 1 ∠ 120°

NEMA National Electrical Manufacturers' Association.

Nonvolatile Memory Relay memory that persists over time to maintain the contained data even when the relay is de-energized.

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.

Outboard CT Current transformer physically positioned in such a way that the CT remains in circuit when the feeder is on transfer.

Overlap Configuration Configuration of the tie-breaker protection whereby the area between the tie-breaker CTs are part of two bus-zones, i.e., a fault between the tie-breaker CTs is common to two bus-zones.

Override Values Test values you enter in Fast Meter and DNP storage.

Parentheses Operator Math operator. Use paired parentheses to control the execution of operations in a SELOGIC control equation.

PC Personal computer.

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.

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.

Port Settings Communications port settings such as Data Bits, Speed, and Stop Bits.

Positive-Sequence Use the following expression to calculate the positive-sequence voltage:

$$3V_1 = V_A + aV_B + a^2V_C$$

Where a = 1 ∠ 120°

Primitive Name The mnemonic current labels (I01, I02 through I18), voltage labels (V01, V02 and V03) and bus-zone labels (BZ1, BZ2 through BZ6).

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 de-energization of all control outputs.

Protection Zone (also see Bus-Zone) Area of protection formed by a minimum of one bus-zone. A protection zone can include more than one bus-zone. For example, merging two bus-zones results in a single protection zone. When no bus-zones are merged, a protection zone and a bus-zone have the same meanings.

PT Potential transformer. Also referred to as a voltage transformer or VT.

PTR Potential transformer ratio.

Qualifier Code Specifies type of range for DNP3 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.

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 an IEC 61850 control operation.

Report Settings Event report and Sequential Events Recorder settings.

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.

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.

RTU Remote Terminal Unit.

RXD Received data.

SCADA Supervisory control and data acquisition.

SCD File IEC 61850 Substation Configuration Description file. XML file that contains information on all IEDs within a substation, communications configuration data, and a substation description.

SCL IEC 61850 Substation Configuration Language. An XML-based configuration language that supports the exchange of database configuration data among different software tools that can be from different manufacturers. There are four types of SCL files used within IEC 61850: CID, ICD, SCD, and SSD.

Self-Description A feature of the IEC 61850 protocol. A master device can request a description of all of the Logical Nodes 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-487B has self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.

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.

SELOGIC Expression Builder A rules-based editor within the ACSELERATOR software for programming SELOGIC control equations.

SELOGIC Math Variables Math calculation result storage locations.

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.

Settle/Settling Time Time required for an input signal to result in an unvarying output signal within a specified range.

Single-CT Application Tie breaker with only one CT available for busbar protection.

Single Relay Application Stations with as many as 18 per-phase CTs require only one SEL-487B. Stations with more than 18 and as many as 54 per-phase CTs require three SEL-487B relays.

SIN Operator Operator in math SELOGIC control equations that provides the sine function.

SQRT Operator Math SELOGIC control equation operator that provides square root.

SSD File IEC 61850 System Specification Description file. XML file that describes the single-line diagram of the substation and the required logical nodes.

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 lowercase alphabetic characters, period (.), and hyphen (-).

Subnet Mask The subnet mask divides the local node IP address into two parts, a network number and a node address on that network. A subnet mask is four bytes of information and is expressed in the same format as an IP address.

Subsidence Current See CT subsidence current.

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 Any equipment with at least a current transformer and a circuit breaker.

Terminal-to-Bus-Zone Connection Variable SELOGIC variable stating the conditions when the relay considers the current input from a particular terminal in the differential calculations of a particular bus-zone.

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.

Three-Relay Application Stations with more than 18 and as many as 54 per-phase CTs require three SEL-487B relays. Stations with as many as 18 per-phase CTs require only one SEL-487B.

Tie Breaker See buscoupler and bus sectionalizer.

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 predetermined 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.

TXD Transmitted data.

UCA2 Utility Communications Architecture version 2. 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.

Unbuffered Report IEC 61850 IEDs can issue immediate unbuffered reports of internal events (caused by trigger options data-change, quality-change, and data-update) on a "best efforts" basis. If no association exists, or if the transport data flow is not fast enough to support it, events may be lost.

User ST Region in GOOSE for user-specified applications.

V01, V02, V03 Voltage input terminals.

Virtual Terminal Connection A mechanism that uses a virtual serial port to provide the equivalent functions of a dedicated serial port and a terminal.

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.

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.

XML Extensible Markup Language. This specification developed by the W3C (World Wide Web Consortium) is a pared-down version of SGML designed especially for web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data among applications and organizations.

Zero Sequence Use the following expression to calculate the zero-sequence voltage:

$$3V_0 = V_A + V_B + V_C$$

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.

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Page numbers appearing in bold mark the location of the topic's primary discussion.

A=Applications Handbook U=User's Guide R=Reference Manual

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SEL-487B Relay Command Summary

Command[a, b]	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)
CASCII	Generate the Compressed ASCII response configuration message
CEVENT	**EVENT** command for the Compressed ASCII response
CHISTORY	**HISTORY** command for the Compressed ASCII response
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 01–96)
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 serial port DNP3 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
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* = 1–18)
PACCESS	Go to Access Level P (protection control)
PASSWORD	Change relay passwords
PORT	Connect to a remote relay via MIRRORED BITS® virtual terminal (for port number *p* = 1–3 and F), or to the Ethernet card (port *p* = 5)
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

Command[a, b]	Description
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 (useful for Ethernet protocol read tests)
TEST DNP	Display or place values in the serial port DNP3 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
ZONE	Display the terminal and bus names associated with all active protective zones

[a] See Section 7: ASCII Command Reference in the 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	DNP3	Direct Network Protocol remapping (serial port only)
F	Front Panel	Front-panel HMI settings
G	Global	Relay-wide settings
L *n*	Protection Logic Group 1–6	Protection SELOGIC control equations
O	Outputs	Output SELOGIC control equations
P *n*	Port 1–3, F, 5	Communications port settings
R	Report	Event report and SER settings
T	Alias	Alias names for analog quantities and Relay Word bits
Z *n*	Zone Configuration Group 1–6	Zone configuration settings

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