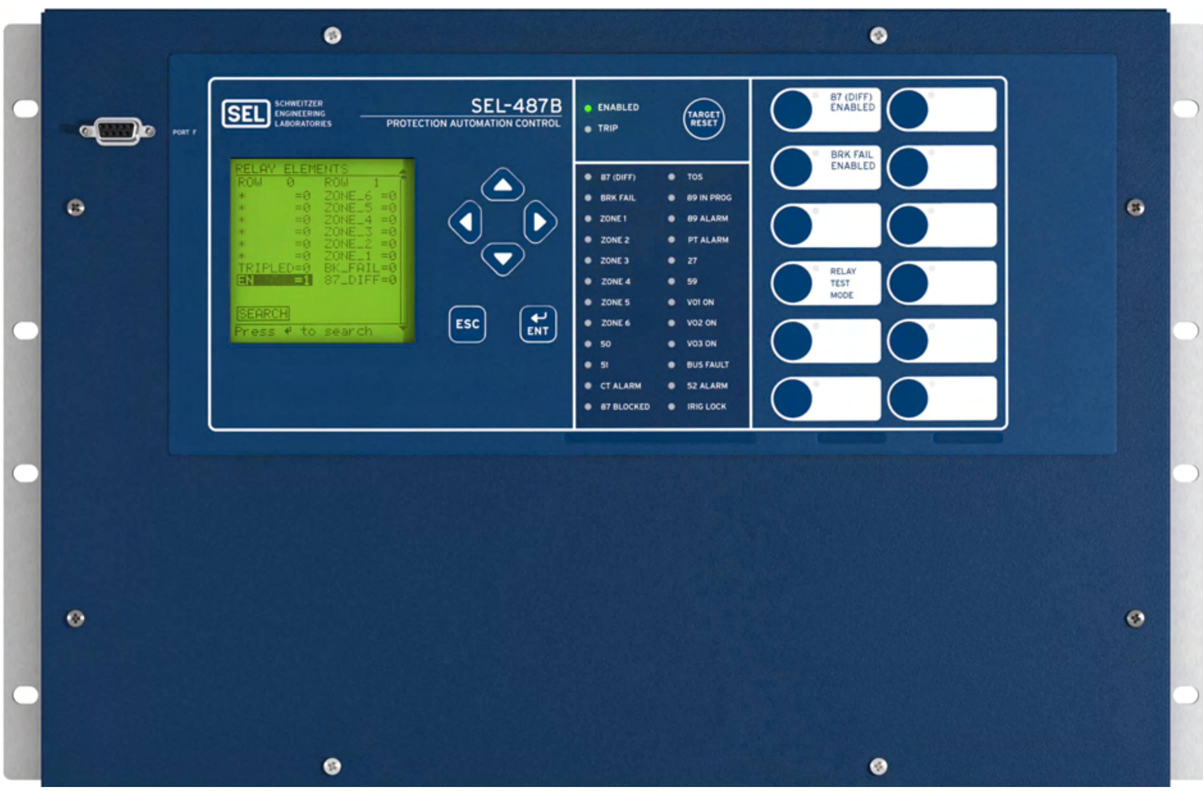
SEL-487B-1

Bus Differential and Breaker Failure Relay

Instruction Manual



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SEL SCHWEITZER ENGINEERING LABORATORIES

Part Number: PM487B-04

Table of Contents

Section 6: Protection Application Examples

Section 7: Metering, Monitoring, and Reporting

Section 8: Settings

Section 9: ASCII Command Reference

Section 10: Communications Interfaces

Section 11: Relay Word Bits

Section 12: Analog Quantities

Appendix A: Firmware, ICD File, and Manual Versions

Appendix B: Converting Settings From SEL-487B-0 to SEL-487B-1

SEL-487B-1 Relay Command Summary

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List of Tables

List of Figures

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Preface

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 set consists of two volumes:

- SEL-487B Instruction Manual
- SEL-400 Series Relays Instruction 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.

SEL-487B Instruction Manual

Preface. Describes manual organization and conventions used to present information, as well as safety information.

Section 1: Introduction and Specifications. Introduces SEL-487B Relay features, summarizes relay functions and applications, and lists relay specifications, type tests, and ratings.

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

Section 3: Testing. Describes techniques for testing the relay.

Section 4: Front-Panel Operations. Describes the LCD display messages and menu screens that are unique to the SEL-487B.

Section 5: Protection Functions. Describes the function of various relay protection elements. Describes how the relay processes these elements. Gives detailed specifics on protection scheme logic for POTT, DCB, DCUB, and DTT. Provides trip logic diagrams, and current and voltage source selection details. Also describes basic 87L communications channel options and configuration parameters.

Section 6: Protection Application Examples. Provides examples of configuring the SEL-487B for some common applications.

Section 7: Metering, Monitoring, and Reporting. Describes SEL-487B-specific metering, monitoring, and reporting features.

Section 8: Settings. Provides a list of all relay settings and defaults. The settings list is organized in the same order as in the relay and in the ACSELERATOR QuickSet SEL-5030 Software.

Section 9: ASCII Command Reference. Provides an alphabetical listing of all ASCII commands with examples for each ASCII command option.

Section 10: Communications Interfaces. Describes the SEL-487B specific communications characteristics.

Section 11: Relay Word Bits. Contains a summary of Relay Word bits.

Section 12: Analog Quantities. Contains a summary of analog quantities.

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

Appendix B: Converting Settings From SEL-487B-0 to SEL-487B-1. Describes differences in settings, Relay Word bits, analog quantities, and DNP3 maps between these versions of the relay.

SEL-400 Series Relays Instruction Manual

Preface. Describes manual organization and conventions used to present information, as well as safety information.

Section 1: Introduction. Introduces SEL-400 Series Relay common features.

Section 2: PC Software. Explains how to use SEL Grid Configurator and ACSELERATOR QuickSet SEL-5030 Software.

Section 3: 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 Sequential Events Recorder (SER) records, operating relay control outputs and control inputs, and using relay features to make relay commissioning easier.

Section 4: 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 5: Control. Describes various control features of the relay, including circuit breaker operation, disconnect operation, remote bits, and one-line diagrams.

Section 6: Autoreclosing. Explains how to operate the two-circuit breaker multishot recloser. Describes how to set the relay for single-pole reclosing, three-pole reclosing, or both. Shows selection of the lead and follow circuit breakers.

Section 7: Metering. Provides information on viewing current, voltage, power, and energy quantities. Describes how to view other common internal operating quantities.

Section 8: Monitoring. Describes how to use the circuit breaker monitors and the substation dc battery monitors.

Section 9: Reporting. Explains how to obtain and interpret high-resolution raw data oscillograms, filtered event reports, event summaries, history reports, and SER reports. Discusses how to enter SER trigger settings.

Section 10: Testing, Troubleshooting, and Maintenance. Describes techniques for testing, troubleshooting, and maintaining the relay. Includes the list of status notification messages and a troubleshooting chart.

Section 11: Time and Date Management. Explains time keeping principles, synchronized phasor measurements, and estimation of power system states using the high-accuracy time-stamping capability. Presents real-time load flow/power flow application ideas.

Section 12: Settings. Provides a list of all common SEL-400 Series Relay settings and defaults.

Section 13: SELogic Control Equation Programming. Describes multiple setting groups and 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 freeform equations.

Section 14: ASCII Command Reference. Provides an alphabetical listing of all ASCII commands with examples for each ASCII command option.

Section 15: Communications Interfaces. Explains the physical connection of the relay to various communications network topologies. Describes the various software protocols and how to apply these protocols to substation integration and automation. Includes details about Ethernet IP protocols, SEL ASCII, SEL Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, and enhanced Mirrored Bits communications.

Section 16: DNP3 Communication. Describes the DNP3 communications protocol and how to apply this protocol to substation integration and automation. Provides a Job Done example for implementing DNP3 in a substation.

Section 17: IEC 61850 Communication. Describes the IEC 61850 protocol and how to apply this protocol to substation automation and integration. Includes IEC 61850 protocol compliance statements.

Section 18: Synchrophasors. Describes the phasor measurement unit (PMU) functions of the relay. Provides details on synchrophasor measurement and real-time control. Describes the IEEE C37.118 synchrophasor protocol settings. Describes the SEL Fast Message synchrophasor protocol settings.

Section 19: Digital Secondary Systems. Describes the basic concepts of digital secondary systems (DSS). This includes both the Time-Domain Link (TiDL) system and UCA 61850-9-2LE Sampled Values.

Appendix A: Manual Versions. Lists the current manual version and details differences between the current and previous versions.

Appendix B: Firmware Upgrade Instructions. Describes the procedure to update the firmware stored in Flash memory.

Appendix C: Cybersecurity Features. Describes the various features of the relay that impact cybersecurity.

Glossary. Defines various technical terms used in the SEL-400 series instruction manuals.

Safety Information

Dangers, Warnings, and Cautions

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

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

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

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

Safety Symbols

The following symbols are often marked on SEL products.

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

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Rayovac no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
⚠CAUTION To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.	⚠ATTENTION Pour assurer la sécurité et le bon fonctionnement, il faut vérifier les classements d'équipement ainsi que les instructions d'installation et d'opération avant la mise en service ou l'entretien de l'équipement. Il faut vérifier l'intégrité de toute connexion de conducteur de protection avant de réaliser d'autres actions. L'utilisateur est responsable d'assurer l'installation, l'opération et l'utilisation de l'équipement pour la fonction prévue et de la manière indiquée dans ce manuel. Une mauvaise utilisation pourrait diminuer toute protection de sécurité fournie par l'équipement.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.

Other Safety Marks (Sheet 1 of 3)

⚠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 blessures ou la mort.
⚠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.
⚠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 ports/connectors.	⚠AVERTISSEMENT Ne pas regarder vers les ports ou connecteurs de fibres optiques.
⚠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.

Other Safety Marks (Sheet 2 of 3)

⚠WARNING Incorporated components, such as LEDs and transceivers are not user serviceable. Return units to SEL for repair or replacement.	⚠AVERTISSEMENT Les composants internes tels que les leds (diodes électroluminescentes) et émetteurs-récepteurs ne peuvent pas être entretenus par l'usager. Retourner les unités à SEL pour réparation ou remplacement.
⚠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 Equipment damage can result from connecting ac circuits to Hybrid (high-current interrupting) control outputs. Do not connect ac circuits to Hybrid control outputs. Use only dc circuits with Hybrid control outputs.	⚠ATTENTION Des dommages à l'appareil pourraient survenir si un circuit CA était raccordé aux contacts de sortie à haut pouvoir de coupure de type "Hybrid." Ne pas raccorder de circuit CA aux contacts de sortie de type "Hybrid." Utiliser uniquement du CC avec les contacts de sortie de type "Hybrid."
⚠CAUTION Substation battery systems that have either a high resistance to ground (greater than 10 kΩ) or are ungrounded when used in conjunction with many direct-coupled inputs can reflect a dc voltage offset between battery rails. Similar conditions can exist for battery monitoring systems that have high-resistance balancing circuits or floating grounds. For these applications, SEL provides optional ground-isolated (optoisolated) contact inputs. In addition, SEL has published an application advisory on this issue. Contact the factory for more information.	⚠ATTENTION Les circuits de batterie de postes qui présentent une haute résistance à la terre (plus grande que 10 kΩ) ou sont isolés peuvent présenter un biais de tension CC entre les deux polarités de la batterie quand utilisés avec plusieurs entrées à couplage direct. Des conditions similaires peuvent exister pour des systèmes de surveillance de batterie qui utilisent des circuits d'équilibrage à haute résistance ou des masses flottantes. Pour ce type d'applications, SEL peut fournir en option des contacts d'entrée isolés (par couplage optoélectronique). De surcroît, SEL a publié des recommandations relativement à cette application. Contacter l'usine pour plus d'informations.
⚠CAUTION If you are planning to install an INT4 I/O interface board in your relay, first check the firmware version of the relay. If the firmware version is R111 or lower, you must first upgrade the relay firmware to the newest version and verify that the firmware upgrade was successful before installing the new board. Failure to install the new firmware first will cause the I/O interface board to fail, and it may require factory service. Complete firmware upgrade instructions are provided when new firmware is ordered.	⚠ATTENTION Si vous avez l'intention d'installer une Carte d'Interface INT4 I/O dans votre relais, vérifiez en premier la version du logiciel du relais. Si la version est R111 ou antérieure, vous devez mettre à jour le logiciel du relais avec la version la plus récente et vérifier que la mise à jour a été correctement installée sur la nouvelle carte. Les instructions complètes de mise à jour sont fournies quand le nouveau logiciel est commandé.
⚠CAUTION Field replacement of I/O boards INT1, INT2, INT5, INT6, INT7, or INT8 with INT4 can cause I/O contact failure. The INT4 board has a pickup and dropout delay setting range of 0–1 cycle. For all other I/O boards, pickup and dropout delay settings (IN201PU–IN224PU, IN201DO–IN224DO, IN301PU–IN324PU, and IN301DO–IN324DO) have a range of 0–5 cycles. Upon replacing any I/O board with an INT4 board, manually confirm reset of pickup and dropout delays to within the expected range of 0–1 cycle.	⚠ATTENTION Le remplacement en chantier des cartes d'entrées/sorties INT1, INT2, INT5, INT6, INT7 ou INT8 par une carte INT4 peut causer la défaillance du contact d'entrée/sortie. La carte INT4 présente un intervalle d'ajustement pour les délais de montée et de retombée de 0 à 1 cycle. Pour toutes les autres cartes, l'intervalle de réglage du délai de montée et retombée (IN201PU–IN224PU, IN201DO– IN224DO, IN301PU–IN324PU, et IN301DO–IN324DO) est de 0 à 5 cycles. Quand une carte d'entrées/sorties est remplacée par une carte INT4, vérifier manuellement que les délais de montée et retombée sont dans l'intervalle de 0 à 1 cycle.
⚠CAUTION Do not install a jumper on positions A or D of the main board J21 header. Relay misoperation can result if you install jumpers on positions J21A and J21D.	⚠ATTENTION Ne pas installer de cavalier sur les positions A ou D sur le connecteur J21 de la carte principale. Une opération intempestive du relais pourrait résulter suite à l'installation d'un cavalier entre les positions J21A et J21D.
⚠CAUTION Insufficiently rated insulation can deteriorate under abnormal operating conditions and cause equipment damage. For external circuits, use wiring of sufficiently rated insulation that will not break down under abnormal operating conditions.	⚠ATTENTION Un niveau d'isolation insuffisant peut entraîner une détérioration sous des conditions anormales et causer des dommages à l'équipement. Pour les circuits externes, utiliser des conducteurs avec une isolation suffisante de façon à éviter les claquages durant les conditions anormales d'opération.
⚠CAUTION Relay misoperation can result from applying other than specified secondary voltages and currents. Before making any secondary circuit connections, check the nominal voltage and nominal current specified on the rear-panel nameplate.	⚠ATTENTION Une opération intempestive du relais peut résulter par le branchement de tensions et courants secondaires non conformes aux spécifications. Avant de brancher un circuit secondaire, vérifier la tension ou le courant nominal sur la plaque signalétique à l'arrière.

Other Safety Marks (Sheet 3 of 3)

⚠**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 graves d'alimentation et de terre peuvent survenir sur les ports de communication de cet appareil si des câbles d'origine autre que SEL sont utilisés. Ne jamais utiliser de câble de modem nul avec cet équipement.
⚠**CAUTION** Do not connect power to the relay until you have completed these procedures and receive instruction to apply power. Equipment damage can result otherwise.	⚠**ATTENTION** Ne pas mettre le relais sous tension avant d'avoir complété ces procédures et d'avoir reçu l'instruction de brancher l'alimentation. Des dommages à l'équipement pourraient survenir autrement.
⚠**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.

General Information

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-400 Series Relays:

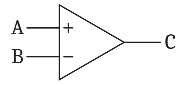
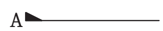
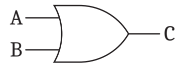
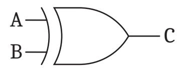
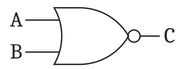
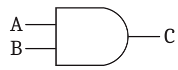
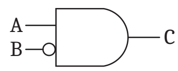
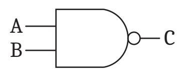
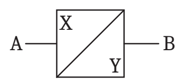
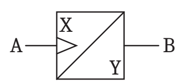
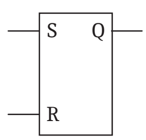
- ➤ Using a command line interface on a PC terminal emulation window, such as Microsoft HyperTerminal
- ➤ Using the front-panel menus and pushbuttons
- ➤ Using ACSELERATOR QuickSet SEL-5030 Software

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.
ENABLE	Relay front- or rear-panel labels and pushbuttons.
`MAIN > METER`	Relay front-panel LCD menus and relay responses visible on the PC screen. The > character indicates submenus.

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 Input A is greater than Input B.
Input Flag		Input A comes from other logic.
OR		If either Input A or Input B asserts, Output C asserts.
Exclusive OR		If either Input A or Input B asserts, Output C asserts. If Input A and Input B are of the same state, Output C deasserts.
NOR		If neither Input A nor Input B asserts, Output C asserts.
AND		If Input A and Input B assert, Output C asserts.
AND w/ Inverted Input		If Input A asserts and Input B deasserts, Output C asserts. Inverter "O" inverts any input or output on any gate.
NAND		If Input A and/or Input B deassert, Output C asserts.
Time-Delayed Pick Up and/or Time-Delayed Drop Out		X is a time-delay-pickup value; Y is a time-delay-dropout value. Output B asserts Time X after Input A asserts; Output B does not assert if Input A does not remain asserted for Time X. If Time X is zero, Output B asserts when Input A asserts. If Time Y is zero, Input B deasserts when Input A deasserts.
Edge Trigger Timer		Rising edge of Input A starts timers. Output B asserts Time X after the rising edge of Input A. Output B remains asserted for Time Y. If Time Y is zero, Output B asserts 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 Input R asserts.
Falling Edge		Output B asserts at the falling edge of Input A.
Rising Edge		Output B asserts at the rising edge of Input A.

Trademarks

All brand or product names appearing in this document are the trademark or registered trademark of their respective holders. No SEL trademarks may be used without written permission.

SEL trademarks appearing in this manual are shown in the following table.

acSELerator Architect®	Mirrored Bits®
acSELerator QuickSet®	SELogic®
Connectorized®	

EtherCAT is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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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Email: info@selinc.com

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SECTION 1

Introduction and Specifications

The SEL-487B 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 21 analog current inputs and 3 analog voltage inputs. For buses with no more than seven terminals, use one SEL-487B in a single-relay application. For buses with as many as 21 terminals, use three SEL-487B relays in a three-relay application; each relay provides as many as 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, for a total of 1000 lines of automation programming. Use as many as 100 lines in the separate protection programming area to program custom protection functions. 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 common industry communications tools, including Telnet, FTP, IEC 61850 Edition 2.1, and DNP3 LAN/WAN protocols.

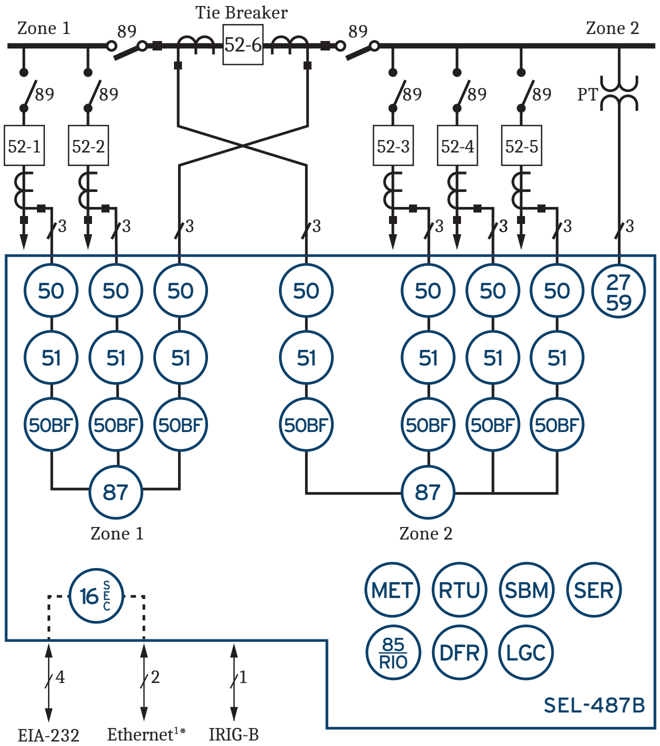
Included with the SEL-487B is the ACSELERATOR QuickSet SEL-5030 Software program. Use QuickSet to assist you in setting, controlling, and acquiring data from the relays both locally and remotely. ACSELERATOR Architect SEL-5032 Software is included with purchase of the optional Ethernet card with IEC 61850 protocol support. Architect enables you to view and configure IEC 61850 settings via a graphical user interface (GUI), tightly integrated with 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:

Features

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



ANSI NUMBERS/ACRONYMS AND FUNCTIONS	
27/59	Over- and Undervoltage
50	Overcurrent (Phase)
50BF	Breaker Failure Overcurrent
51	Time-Overcurrent (Phase)
87	Current Differential

ADDITIONAL FUNCTIONS	
16 SEC	Access Security (Serial, Ethernet)
85 RIO	SEL MIRRORED BITS Communications
DFR	Event Reports
LGC	SELOGIC Control Equations
MET	High-Accuracy Metering
RTU	Remote Terminal Unit
SBM	Station Battery Monitor
SER	Sequential Events Recorder

ADDITIONAL FEATURES
Open CT Detection
Three Independent Check Zones
Disconnect Status and Monitoring Logic for 60 Disconnects
Single-Relay Application: 2 Three-Phase Zones for as many as 7 Terminals
Two-Relay Application: 3 Three-Phase Zones for as many as 10 Terminals
Three-Relay Application: 6 Single-Phase Zones for as many as 21 Terminals

[1] Copper or Fiber Optic   * Optional Feature

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, use as many as three independent check zones available in the relay.

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 21 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 21 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 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 21 terminals, phase voltages and angles, CT polarities, and the operating and restraint values from all protection zones.

Oscillography and Event Reporting. Record raw currents of all 21 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, restarts, 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 QuickSet software, to develop settings offline.

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

Models and Options

Consider the following options when ordering and configuring the SEL-487B.

- Chassis size
  - 7U and 9U (U is one rack unit—44.45 mm or 1.75 in)

The 9U chassis size supports as many as four additional expansion I/O boards. For applications not requiring as many contact I/O points, the 7U chassis size supports as many as two additional expansion I/O boards. For the three-relay application, three units are required. Features not labeled as ordering options are standard.

Table 1.1 Interface Board Information

Board Name	Inputs	Description	Outputs	Description
INT4	18	Two sets of 9 common optoisolated, level-sensitive	6	High-speed, high-current interrupting, Form A
	6	Optoisolated, independent, level-sensitive	2	Standard Form A
INT4	18	Two sets of 9 common optoisolated, level-sensitive	8	Standard Form A
	6	Optoisolated, independent, level-sensitive		

- Voltage ranges for the inputs on the main board as well as for the inputs on the four interface boards
  - 24 Vdc
  - 48 Vdc
  - 110 Vdc
  - 125 Vdc
  - 220 Vdc
  - 250 Vdc
- Power supply (ordering option)
  - 24–48 Vdc
  - 48–125 Vdc or 110–120 Vac
  - 125–250 Vdc or 110–240 Vac
- Secondary current inputs (ordering option)
  - 1 A nominal or 5 A nominal CT inputs
- Communications card (ordering option)
  - Ethernet card with combinations of 10/100BASE-T and 100BASE-FX media connections on each of two ports
- Secondary voltage inputs (standard feature)
  - 300 V maximum per voltage input

- Ethernet communication protocols
  - Standard (FTP, Telnet, DNP3, PRP)
  - Standard plus IEC 61850 Edition 2.1
- Connector type for PT and CT inputs
  - Screw-terminal block inputs (standard feature)
  - Connectorized (ordering option)
- Conformal coat
  - Conformal coating provides an additional barrier to harsh environments, such as high humidity and airborne contaminants. See selinc.com/conformalcoating/ for more information.

Contact the SEL factory or your local Technical Service Center for particular part number and ordering information (see *Technical Support on page xxvii in the Preface*). You can also view the latest part number and ordering information on the SEL website at selinc.com.

Applications

NOTE: TiDL (EtherCAT) technology is no longer offered in the SEL-487B-1. TiDL (T-Protocol) is available in the SEL-487B-2.

Use the SEL-487B for most bus protection applications. For information on connecting the relay, see *Section 2: Installation*. See *Section 6: Protection Application Examples* for discussions of protection and automation applications using the SEL-487B. The figures in this subsection illustrate common relay applications. Each SEL-487B has 21 analog current inputs (I01–I21) and three analog voltage inputs (V01, V02, and V03).

The SEL-487B-1 Relay supports DSS through use of the SEL-2240 Axion. The Axion provides analog and digital data over an IEC 61158 EtherCAT TiDL network. This technology provides very low and deterministic latency over a point-to-point architecture. The SEL-487B-1 Relay can receive as many as eight fiber-optic links from as many as eight Axion nodes. See *Section 2: Installation* for more details about TiDL (EtherCAT) applications.

Single Busbar—As Many As 7 Terminals

Use one SEL-487B for the application in *Figure 1.2*. In this application, the relay has 2 three-phase bus-zones available. Wire the disconnect status to the relay to dynamically assign the terminal currents to the differential elements for each zone.

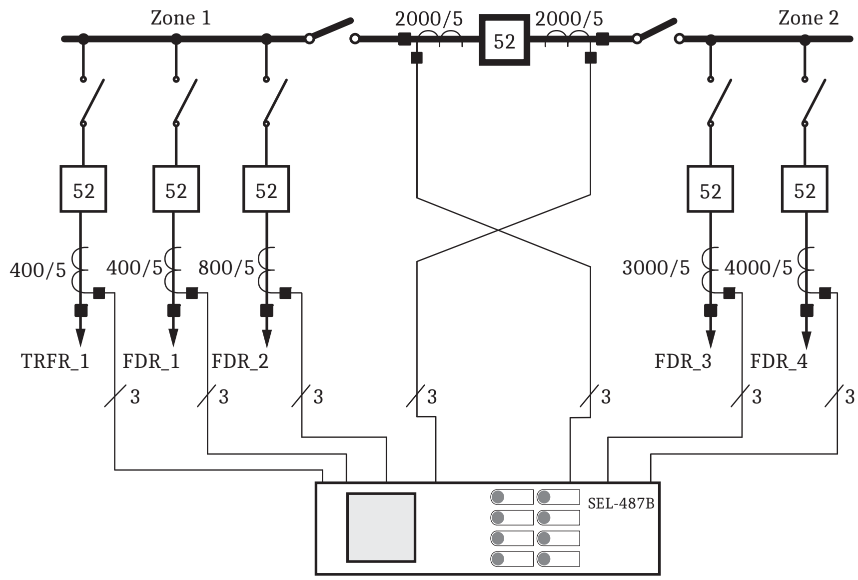


Figure 1.2 Single SEL-487B Protecting Double Bus Sections With Bus Tie Breaker

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 seven or fewer terminals on either busbar, use one SEL-487B per busbar.

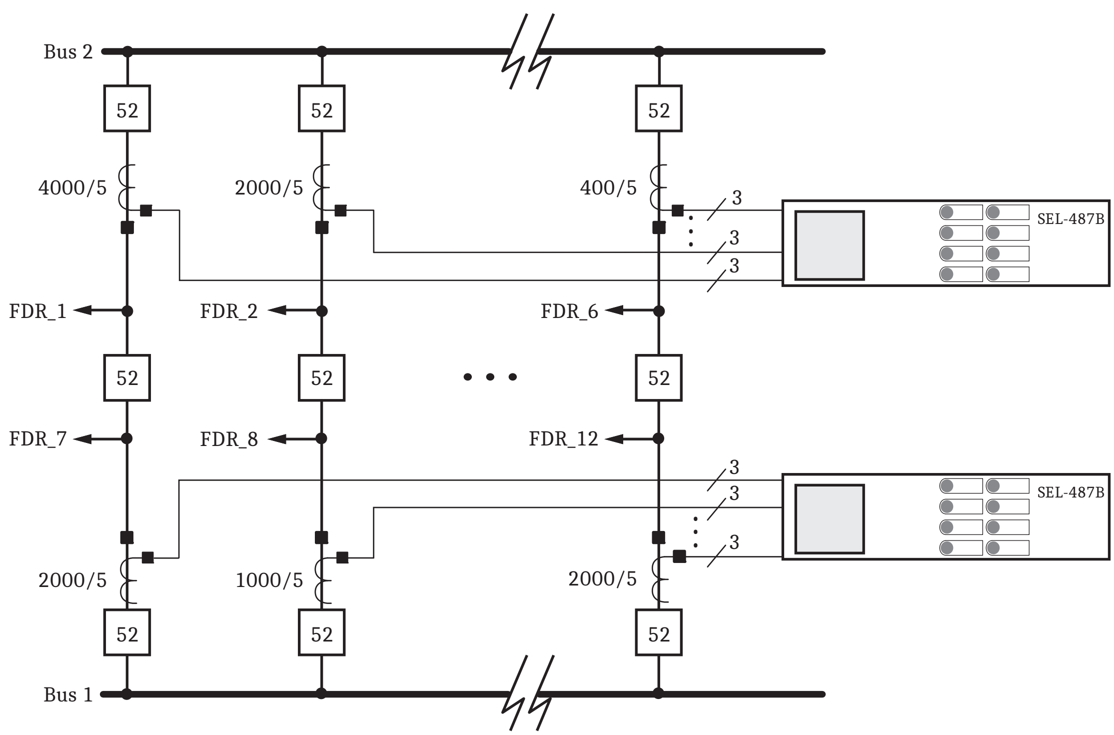


Figure 1.3 Two Single SEL-487B Relays Protecting the Two Busbars in a Breaker-and-a-Half Busbar Configuration

Triple Busbar—As Many As 21 Terminals

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

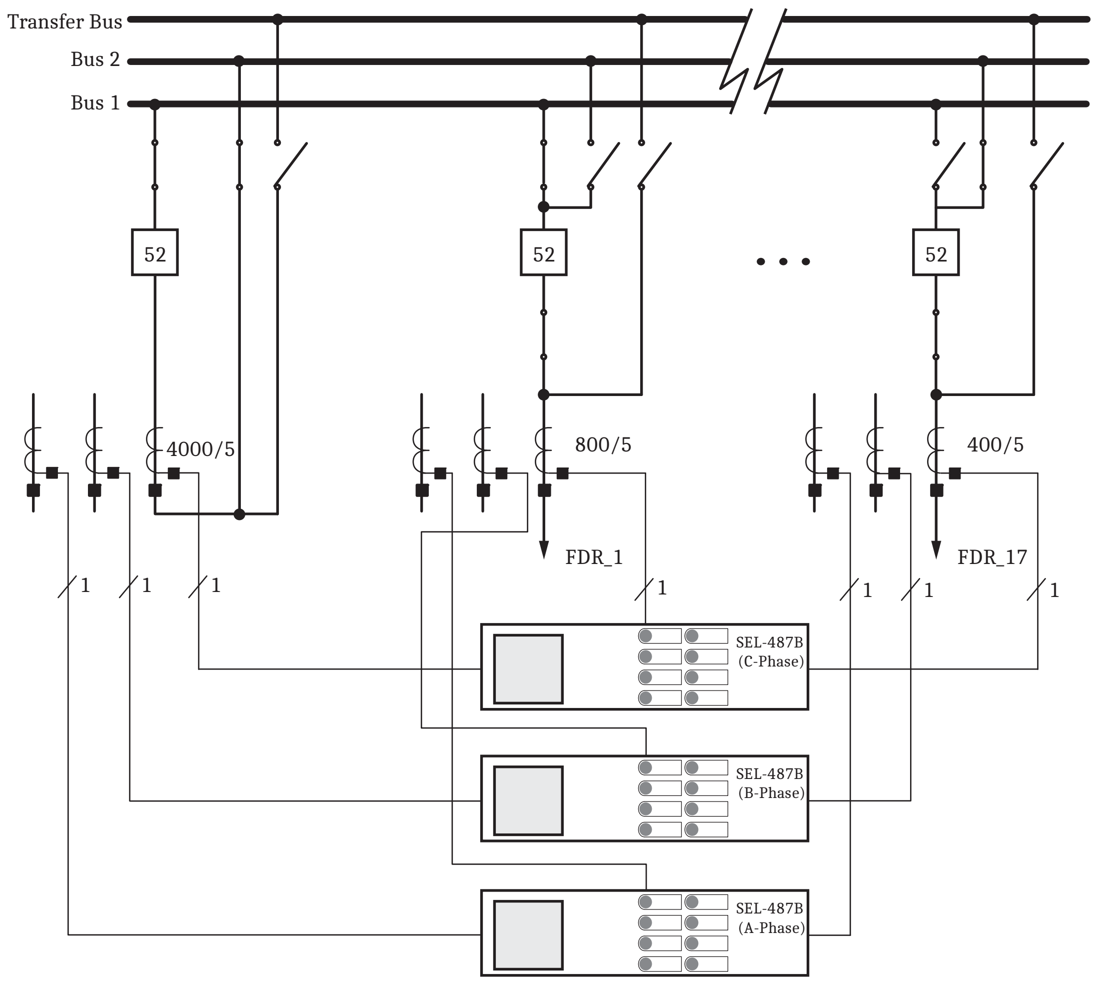


Figure 1.4 Three SEL-487B Relays Protect 2 Main Busbars and a Transfer Busbar, 1 Bus Coupler, and 17 Terminals

Table 1.2 Application Highlights (Sheet 1 of 2)

Application	Key Feature
High number of terminals and zones	Three-relay applications provide six zones of protection for as many as 21 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 tripping 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.

Table 1.2 Application Highlights (Sheet 2 of 2)

Application	Key Feature
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 any of the three the available independent check zones.
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, DNP3 Serial. Additionally, you can choose these optional protocols: Ethernet, IEC 61850, FTP, Telnet, DNP3 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.

Product Characteristics

Each SEL-400 Series Relay shares common features but has unique characteristics. *Table 1.3* summarizes the unique characteristics of the SEL-487B Relay.

Table 1.3 SEL-487B Relay Characteristics (Sheet 1 of 2)

Characteristic	Value
Standard Processing Rate	12 times per cycle
Battery Monitor	One
Autorecloser	none
MBG Protocol	Not supported
SELOGIC	
Protection Free Form	100 lines
Automation Free Form	10 blocks of 100 lines each
SELOGIC Variables	64 protection 256 automation
SELOGIC Math Variables	64 protection 256 automation

Table 1.3 SEL-487B Relay Characteristics (Sheet 2 of 2)

Characteristic	Value
Conditioning Timers	16 protection 32 automation
Sequencing Timers	32 protection 32 automation
Counters	32 protection 32 automation
Latch Bits	32 automation 32 protection
Control	
Remote Bits	96
Breakers	21: 1–21 (open control only)
Disconnects	60 (status only)
Bay Control	Not supported
Metering	
Maximum/Minimum Metering	Not supported
Energy Metering	Not supported

Additionally, the SEL-487B does not support the following typical SEL-400 Series features:

- Synchrophasors
- One-line diagrams on the front panel
- Breaker close operations
- Circuit breaker monitor
- Communications with the SEL-2600A RTD Module

Specifications

Note: TiDL (EtherCAT) technology is no longer offered in the SEL-487B-1. TiDL (T-Protocol) is available in the SEL-487B-2. If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay. Element operate times will also have this small added delay.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

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

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

CE Mark

General

AC Current Inputs (Secondary Circuits)

Note: Current transformers are Measurement Category II.

Current Rating (With DC Offset at X/R = 10, 1.5 Cycles)

1 A Nominal:	18.2 A
5 A Nominal:	91 A

Continuous Thermal Rating

1 A Nominal:	3 A 4 A (+55°C)
5 A Nominal:	15 A 20 A (+55°C)

Saturation Current (Linear) Rating

1 A Nominal:	20 A
5 A Nominal:	100 A

A/D Current Limit

Note: Signal clipping may occur beyond this limit.

1 A Nominal:	49.5 A
5 A Nominal:	247.5 A

One-Second Thermal Rating

1 A Nominal:	100 A
5 A Nominal:	500 A

One-Cycle Thermal Rating (Peak)

1 A Nominal:	250 A
5 A Nominal:	1250 A

Burden Rating

1 A Nominal:	≤0.1 VA @ 1 A
5 A Nominal:	≤0.5 VA @ 5 A

AC Voltage Inputs

Three-phase, four-wire (wye) connections are supported.

Rated Voltage Range:	55–250 V_{L-N}
Operational Voltage Range:	0–300 V_{L-N}
Ten-Second Thermal Rating:	600 Vac
Burden:	≤0.1 VA @ 125 V

Frequency and Rotation

System Frequency:	50/60 Hz
Phase Rotation:	ABC

Power Supply

24–48 Vdc

Rated Voltage:	24–48 Vdc
Operational Voltage Range:	18–60 Vdc
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	20 ms at 24 Vdc, 100 ms at 48 Vdc per IEC 60255-26:2013
Burden:	<35 W

48–125 Vdc or 110–120 Vac

Rated Voltage:	48–125 Vdc, 110–120 Vac
Operational Voltage Range:	38–140 Vdc 85–140 Vac
Rated Frequency:	50/60 Hz
Operational Frequency Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	14 ms at 48 Vdc, 160 ms at 125 Vdc per IEC 60255-26:2013
Burden:	<35 W, <90 VA

125–250 Vdc or 110–240 Vac

Rated Voltage:	125–250 Vdc, 110–240 Vac
Operational Voltage Range:	85–300 Vdc 85–264 Vac
Rated Frequency:	50/60 Hz
Operational Frequency Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	46 ms at 125 Vdc, 250 ms at 250 Vdc per IEC 60255-26:2013
Burden:	<35 W, <90 VA

Control Outputs

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

Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 20 ms

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994
Rate: 2.5 cycles/second for 4 seconds followed by 2 minutes idle for thermal dissipation

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 20 ms

Hybrid (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):	330 Vdc
Pickup/Dropout Time:	≤6 ms, resistive load
Update Rate:	1/12 cycle

Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

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

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994
Rate: 2.5 cycles/second for 4 seconds followed by 2 minutes idle for thermal dissipation

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

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

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

Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

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

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994
Rate: 2.5 cycles/second for 4 seconds, followed by 2 minutes idle for thermal dissipation

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

Note: Make rating per IEEE C37.90-2005.
Note: Per IEC 61810-2:2005.
Note: Do not use hybrid control outputs to switch ac control signals.

Control 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, 48, 110, 125, 220, 250 V
Current Drawn:	<5 mA at nominal voltage <8 mA for 110 V option
Sampling Rate:	2 kHz

DC Thresholds (Dropout thresholds indicate level-sensitive option)

24 Vdc:	Pickup 19.2–30.0 Vdc; Dropout <14.4 Vdc
48 Vdc:	Pickup 38.4–60.0 Vdc; Dropout <28.8 Vdc
110 Vdc:	Pickup 88.0–132.0 Vdc; Dropout <66.0 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout <75 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout <132 Vdc
250 Vdc:	Pickup 200–300 Vdc; Dropout <150 Vdc

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

24 Vac:	Pickup 16.4–30.0 Vac rms; Dropout <10.1 Vac rms
48 Vac:	Pickup 32.8–60.0 Vac rms; Dropout <20.3 Vac rms
110 Vac:	Pickup 75.1–132.0 Vac rms; Dropout <46.6 Vac rms
125 Vac:	Pickup 89.6–150.0 Vac rms; Dropout <53.0 Vac rms
220 Vac:	Pickup 150.3–264.0 Vac rms; Dropout <93.2 Vac rms
250 Vac:	Pickup 170.6–264.0 Vac rms; Dropout <106 Vac rms

Communications Ports

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

Communications Card Slot for Optional Ethernet Card

Ordering Options:	10/100BASE-T
Connector Type:	RJ45
Ordering Option:	100BASE-FX Fiber-Optic
Connector Type:	LC
Fiber Type:	Multimode
Wavelength:	1300 nm
Source:	LED
Min. TX Power:	–19 dBm
Max. TX Power:	–14 dBm
RX Sensitivity:	–32 dBm
Sys. Gain:	13 dB

Communications Ports for Optional TiDL (EtherCAT) Interface

EtherCAT Fiber-Optic Ports:	8
Data Rate:	Automatic
Connector Type:	LC fiber
Protocols:	Dedicated EtherCAT
Class 1 LASER/LED	
Wavelength:	1300 nm
Fiber Type:	Multimode
Link Budget:	11 dB
Min. TX Power:	–20 dBm
Min. RX Sensitivity:	–31 dBm
Fiber Size:	50–200 µm
Approximate Range:	2 km

Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Time Inputs

IRIG-B Input—Serial Port 1

Input:	Demodulated IRIG-B
Rated I/O Voltage:	5 Vdc
Operating Voltage Range:	0–8 Vdc
Logic High Threshold:	≥2.8 Vdc
Logic Low Threshold:	≤0.8 Vdc
Input Impedance:	2.5 kΩ

IRIG-B Input—BNC Connector

Input:	Demodulated IRIG-B
Rated I/O Voltage:	5 Vdc
Operating Voltage Range:	0–8 Vdc
Logic High Threshold:	≥2.2 Vdc
Logic Low Threshold:	≤0.8 Vdc
Input Impedance:	> 1 kΩ
Dielectric Test Voltage:	0.5 kVac

PTP—Ethernet Port 5A, 5B

Input:	IEEE 1588 PTPv2
Profiles:	Default, C37.238-2011 (Power Profile), IEC/IEEE 61850-9-3-2016 (Power Utility Automation Profile)
Synchronization Accuracy:	±100 ns @ 1-second Sync Intervals when communicating directly with master clock

IRIG Time Output

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

The IRIG time output does not support high-accuracy IRIG-B timekeeping.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20° and above +70°C.

Humidity

5% to 95% without condensation

Weight (Maximum)

4U Rack Unit (TiDL [EtherCAT] only):	6.4 kg (14.1 lb)
7U Rack Unit:	16.8 kg (36.9 lb)
9U Rack Unit:	20.8 kg (45.9 lb)

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. The grounding conductor should be as short as possible and sized equal to or greater than any other conductor connected to the device, unless otherwise required by local or national wiring regulations.

Connection Type	Min. Wire Size	Max. Wire Size
Grounding (Earthing) Connection	14 AWG (2.5 mm^2)	N/A
Current Connection	16 AWG (1.5 mm^2)	10 AWG (5.3 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)	10 AWG (5.3 mm^2)
Other Connection	18 AWG (0.8 mm^2)	10 AWG (5.3 mm^2)

Type Tests

Installation Requirements

Overvoltage Category:	2
Pollution Degree:	2

Safety

Product Standards	IEC 60255-27:2013 IEEE C37.90-2005 21 CFR 1040.10
Dielectric Strength:	IEC 60255-27:2013, Section 10.6.4.3 2.5 kVac, 50/60 Hz for 1 min: Analog Inputs, Contact Outputs, Digital Inputs 3.6 kVdc for 1 min: Power Supply, Battery Monitors 2.2 kVdc for 1 min: IRIG-B 1.1 kVdc for 1 min: Ethernet
Impulse Withstand:	IEC 60255-27:2013, Section 10.6.4.2 IEEE C37.90-2005 Common Mode: ±1.0 kV: Ethernet ±2.5 kV: IRIG-B ±5.0 kV: All other ports Differential Mode: 0 kV: Analog Inputs, Ethernet, IRIG-B, Digital Inputs ±5.0 kV: Standard Contact Outputs, Power Supply Battery Monitors +5.0 kV: Hybrid Contact Outputs
Insulation Resistance:	IEC 60255-27:2013, Section 10.6.4.4 >100 MΩ @ 500 Vdc
Protective Bonding:	IEC 60255-27:2013, Section 10.6.4.5.2 <0.1 Ω @ 12 Vdc, 30 A for 1 min
Ingress Protection:	IEC 60529:2001 + CRGD:2003 IEC 60255-27:2013 IP30 for front and rear panel IP10 for rear terminals with installation of ring lug IP40 for front panel with installation of serial port cover IP52 for front panel with installation of dust protection accessory
Max Temperature of Parts and Materials:	IEC 60255-27:2013, Section 7.3
Flammability of Insulating Materials:	IEC 60255-27:2013, Section 7.6 Compliant

Electromagnetic (EMC) Immunity

Product Standards:	IEC 60255-26:2013 IEC 60255-27:2013 IEEE C37.90-2005
Surge Withstand Capability (SWC):	IEC 61000-4-18:2006 + A:2010 IEEE C37.90.1-2012 Slow Damped Oscillatory, Common and Differential Mode: ±1.0 kV ±2.5 kV Fast Transient, Common and Differential Mode: ±4.0 kV
Electrostatic Discharge (ESD):	IEC 61000-4-2:2008 IEEE C37.90.3-2001 Contact: ±8 kV Air Discharge: ±15 kV
Radiated RF Immunity:	IEEE C37.90.2-2004 IEC 61000-4-3:2006 + A1:2007 + A2:2010 20 V/m (>35 V/m, 80% AM, 1 kHz) Sweep: 80 MHz to 1 GHz Spot: 80, 160, 450, 900 MHz 10 V/m (>15 V/m, 80% AM, 1 kHz) Sweep: 80 MHz to 1 GHz Sweep: 1.4 GHz to 2.7 GHz Spot: 80, 160, 380, 450, 900, 1850, 2150 MHz
Electrical Fast Transient Burst (EFTB):	IEC 61000-4-4:2012 Zone A: ±2 kV: Communication ports ±4 kV: All other ports
Surge Immunity:	IEC 61000-4-5:2005 Zone A: ±2 kV_{L-L} ±4 kV_{L-E} ±4 kV: communication ports (Ethernet and IRIG-B) **Note:** Cables connected to EIA-232 communications ports shall be less than 10 m in length for Zone A compliance. Zone B: ±2 kV: communication ports (except Ethernet and IRIG-B) **Note:** Cables connected to EIA-232 communications ports shall be less than 10 m in length for Zone B compliance.
Conducted Immunity:	IEC 61000-4-6:2013 20 V/m; (>35 V/m, 80% AM, 1 kHz) Sweep: 150 kHz–80 MHz Spot: 27, 68 MHz
Power Frequency Immunity (DC Inputs):	IEC 61000-4-16:2015 Zone A: Differential: 150 V_{RMS} Common Mode: 300 V_{RMS}
Power Frequency Magnetic Field:	IEC 61000-4-8:2009 Level 5: 100 A/m; ≥60 Seconds; 50/60 Hz 1000 A/m 1 to 3 Seconds; 50/60 Hz **Note:** 50G1P ≥0.05 (ESS = N, 1, 2) 50G1P ≥0.1 (ESS = 3, 4)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999/A1:2001/A2:2008 IEC 61000-4-29:2000 AC Dips & Interruptions Ripple on DC Power Input DC Dips & Interruptions Gradual Shutdown/Startup (DC only) Discharge of Capacitors Slow Ramp Down/Up Reverse Polarity (DC only)
Damped Oscillatory Magnetic Field:	IEC 61000-4-10:2016 Level 5: 100 A/m

EMC Compatibility

Product Standards:	IEC 60255-26:2013
Emissions:	IEC 60255-26:2013, Section 7.1 Class A 47 CFR Part 15B Class A Canada ICES-001 (A) / NMB-001 (A)

Environmental

Product Standards:	IEC 60255-27:2013
Cold, Operational:	IEC 60068-2-1:2007 Test Ad: 16 hours at –40°C
Cold, Storage:	IEC 60068-2-1:2007 Test Ad: 16 hours at –40°C
Dry Heat, Operational:	IEC 60068-2-2:2007 Test Bd: 16 hours at +85°C
Dry Heat, Storage:	IEC 60068-2-2:2007 Test Bd: 16 hours at +85°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Test Db: +25 °C to +55 °C, 6 cycles (12 + 12-hour cycle), 95% RH
Damp Heat, Steady State:	IEC 60068-2-78:2013 Severity: 93% RH, +40°C, 10 days
Cyclic Temperature:	IEC 60068-2-14:2009 Test Nb: –40°C to +80°C, 5 cycles
Vibration Resistance:	IEC 60255-21-1:1988 Class 2 Endurance, Class 2 Response
Shock Resistance:	IEC 60255-21-2:1988 Class 1 Shock Withstand, Class 1 Bump Withstand, Class 2 Shock Response
Seismic:	IEC 60255-21-3:1993 Class 2 Quake Response

Reporting Functions

High-Resolution Data

Rate:	8000 samples/second 4000 samples/second 2000 samples/second 1000 samples/second
Output Format:	Binary COMTRADE

Note: Per IEEE C37.111-1999 and -2013, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*.

Event Reports

Length:	0.25–24 seconds (depending on LER setting)
Resolution:	4 and 12 samples/cycle
Volatile Memory:	3 seconds of back-to-back event reports sampled at 8 kHz
Nonvolatile Memory:	At least 4 event reports of a 3-second duration sampled at 8 kHz

Oscillography

Volatile Memory:	3 seconds of back-to-back event reports sampled at 8 kHz
Nonvolatile Memory:	At least 5 event reports of a 3-second duration sampled at 8 kHz

Event Summary

Storage:	100 summaries

Sequential Events Recorder

Storage:	1000 entries
Trigger Elements:	250 relay elements
Resolution:	0.5 ms for contact inputs
Resolution:	1/12 cycle for all elements

Processing Specifications

AC Voltage and Current Inputs

12 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

96 remote bits
64 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 Check Zones:	3
Number of Terminals:	
Three-Relay Application:	21
Single-Relay Application:	7
Pickup Range:	0.10–4.00 pu
Pickup Accuracy:	1 A nominal: ±5% ± 0.02 A 5 A nominal: ±5% ± 0.10 A
Slope 1	
Setting Range:	15%–90%
Slope 2	
Setting Range:	50%–90%

Supervising Differential Element

Quantity:	9 total, 1 per zone (6 standard zones, 3 check zones)
Setting Range:	0.05–3.00 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:	9 total, 1 per zone (6 standard zones, 3 check zones)
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
Maximum Operating Time:	1.5 cycles

Time-Overcurrent Elements

Pickup Range	
5 A Model:	0.25–16.00 A secondary, 0.01 A steps
1 A Model:	0.05–3.20 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	
US:	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- and Overvoltage Elements (27, 59)

Processing Rate:	1/6 cycle
Phase Under- and Overvoltage (2 Level/Phase)	
Setting Range:	2.00–300 V_{L-N} in 0.01 steps
Accuracy:	±3% of setting, ±0.5 V
Transient Overreach:	<5% of pickup
Maximum Delay:	1.5 cycles
Zero- and Negative-Sequence Overvoltage Elements	
Setting Range:	2.00–300 V_{L-N} in 0.01 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:	60
Timer Setting Range:	0–99999 cycles, 1 cycle step

Breaker Status

Number:	21

Coupler Security Logic

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

Control Input Timers

Setting Range

Pickup:	0.00–30 ms
Dropout:	0.00–30 ms

Station DC Battery System Monitor Specifications

Rated Voltage:	24–250 Vdc
Operational Voltage Range:	0–350 Vdc
Input Sampling Rate:	2 kHz
Processing Rate:	1/6 cycle
Operating Time:	≤1.5 seconds (element DC1R) ≤1.5 cycles (all elements but DC1R)

Setting Range

DC Settings:	1 Vdc Steps (OFF, 15–300 Vdc)
AC Ripple Setting:	1 Vac Steps (1–300 Vac)
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.

Currents

Phase Current Magnitude

5 A Model:	±0.2% plus ± 4 mA (2.5–15 A sec)
1 A Model:	±0.2% plus ± 0.8 mA (0.5–3.0 A sec)

Phase Current Angle

All Models:	±0.2° in the current range (0.5–3.0) • I_{NOM}

Differential Currents per Zone (Steady State)

IOP, IRT:	±5.0% ± 0.02 • I_{NOM}
IOPCZ, IRTCA:	±5.0% ± 0.02 • I_{NOM}

Voltages

Phase Voltage Magnitude

300 V Maximum Inputs:	±2.5% ± 1 V (5–33.5 V) ±0.1% (33.5–300 V)

Phase Angle

300 V Maximum Inputs:	±1.0° (5–33.5 V) ±0.5° (33.5–300 V)

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SECTION 2

Installation

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 as many as four interface boards, or in a 7U version, with as many as two interface boards. This section contains drawings of typical ac and dc connections to the SEL-487B (*Figure 2.42* and *Figure 2.43*). Use these drawings as a starting point for planning your particular relay application.

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 on page 2.1*
- ➤ *Plug-In Boards on page 2.13*
- ➤ *Jumpers on page 2.15*
- ➤ *Relay Placement on page 2.21*
- ➤ *Connection on page 2.23*
- ➤ *AC/DC Connection Diagrams on page 2.46*

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 *Access Levels and Passwords on page 3.7 in the SEL-400 Series Relays Instruction Manual*.

For more introductory information on using the SEL-487B, see *Section 2: PC Software* and *Section 3: Basic Relay Operations in the SEL-400 Series Relays Instruction 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 Sizes

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 as many as four optional I/O boards, and the 7U version is capable of supporting as many as 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 labels 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.

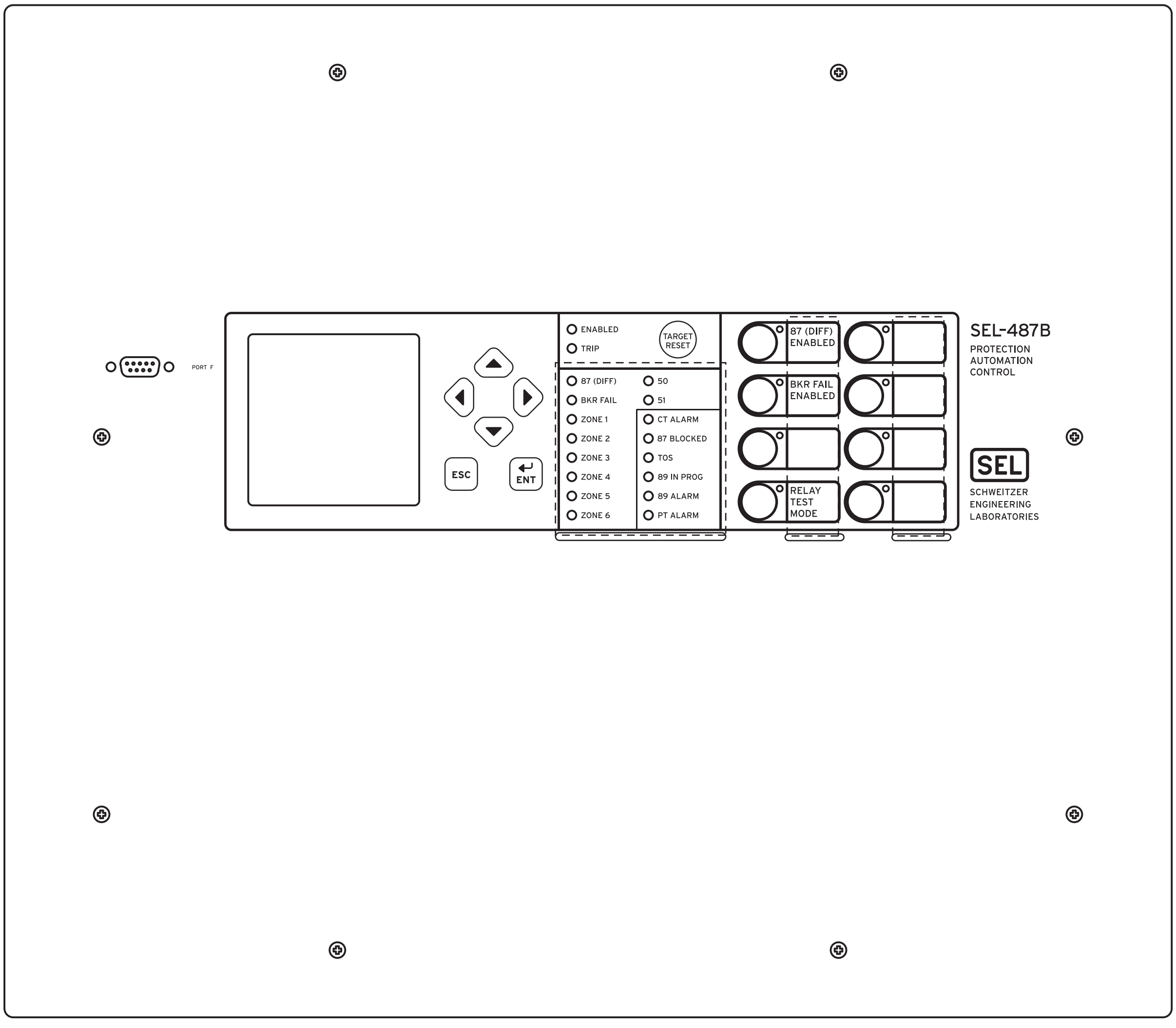


Figure 2.1 Front-Panel Diagram, Panel-Mount Option, 9U Version, Showing the Front Panel With LCD, Navigation Pushbuttons, Programmable LEDs, Reset, and Programmable Pushbuttons

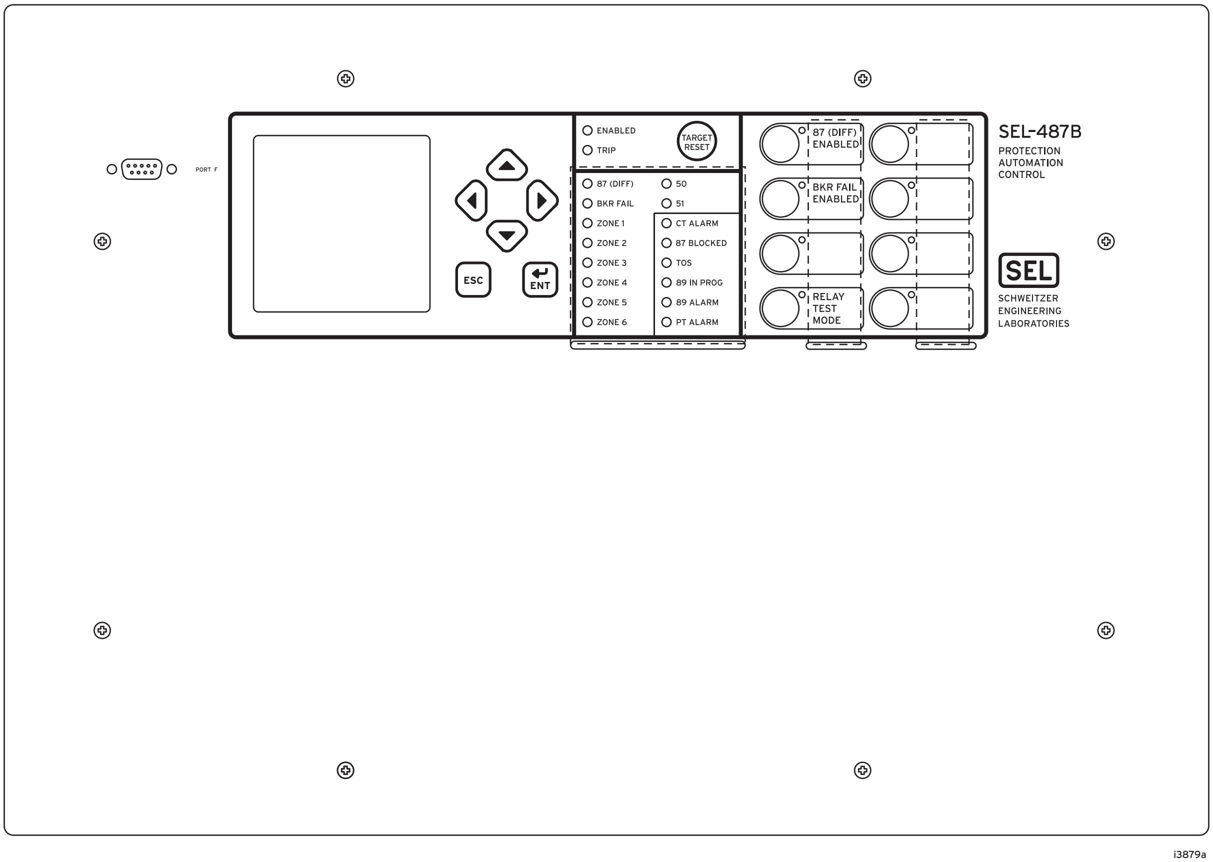


Figure 2.2 Front-Panel Diagram, Panel-Mount Option, 7U Version, Showing the Front Panel With LCD, Navigation Pushbuttons, Programmable LEDs, Reset, and Programmable Pushbuttons

Rear Panels

Figure 2.3 and *Figure 2.4* show examples of a rear panel with fixed terminal block analog inputs.

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 2.21*), 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.

Connectorized

The Connectorized SEL-478B features receptacles that accept plug-in/plug-out connectors for terminating PT and CT inputs. This requires ordering a wiring harness (SEL-WA0487B) with mating plugs and wire leads. *Figure 2.5* shows the relay with Connectorized CT and PT analog inputs. (See *Connectorized on page 2.30* for more information.)

Time-Domain Link

NOTE: TiDL (EtherCAT) technology is no longer offered in the SEL-487B-1. TiDL (T-Protocol) is available in the SEL-487B-2.

The TiDL (EtherCAT) SEL-487B has eight fiber-optic EtherCAT connections instead of the standard CT and PT analog inputs (see *TiDL (EtherCAT) Connections on page 2.32* for more information).

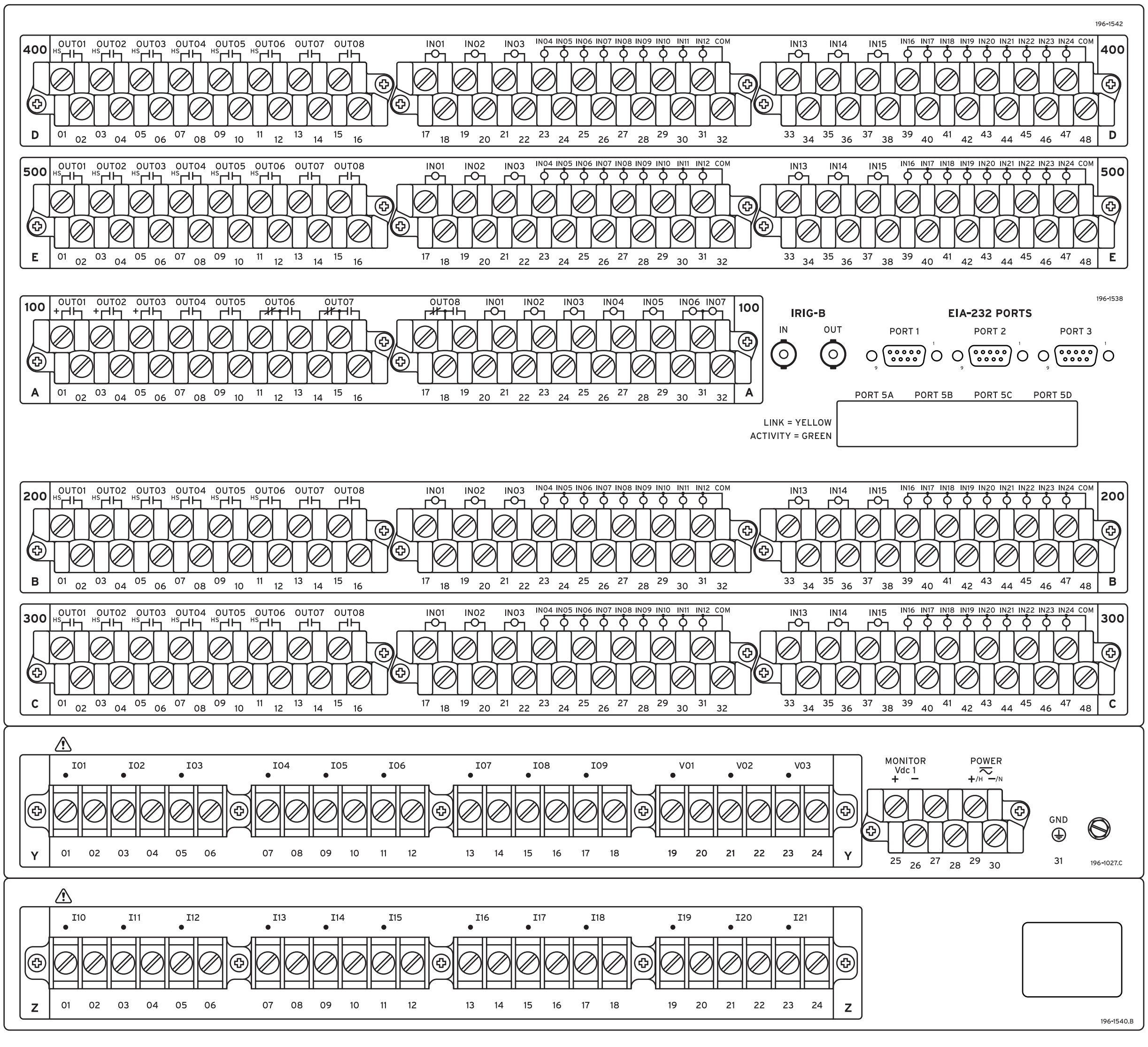


Figure 2.3 Rear-Panel Diagram of SEL-487B With Four Interface Boards (9U Version)

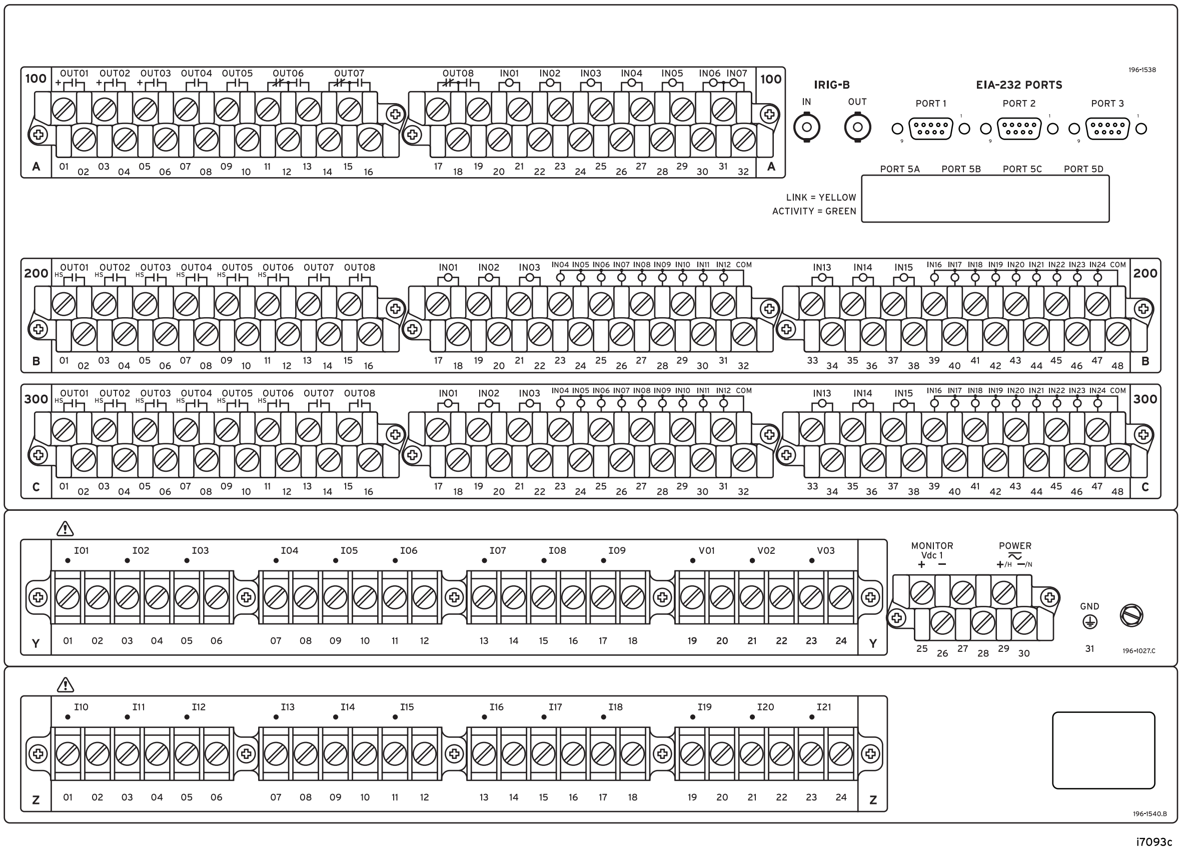


Figure 2.4 Rear-Panel Diagram of SEL-487B With Two Interface Boards (7U Version)

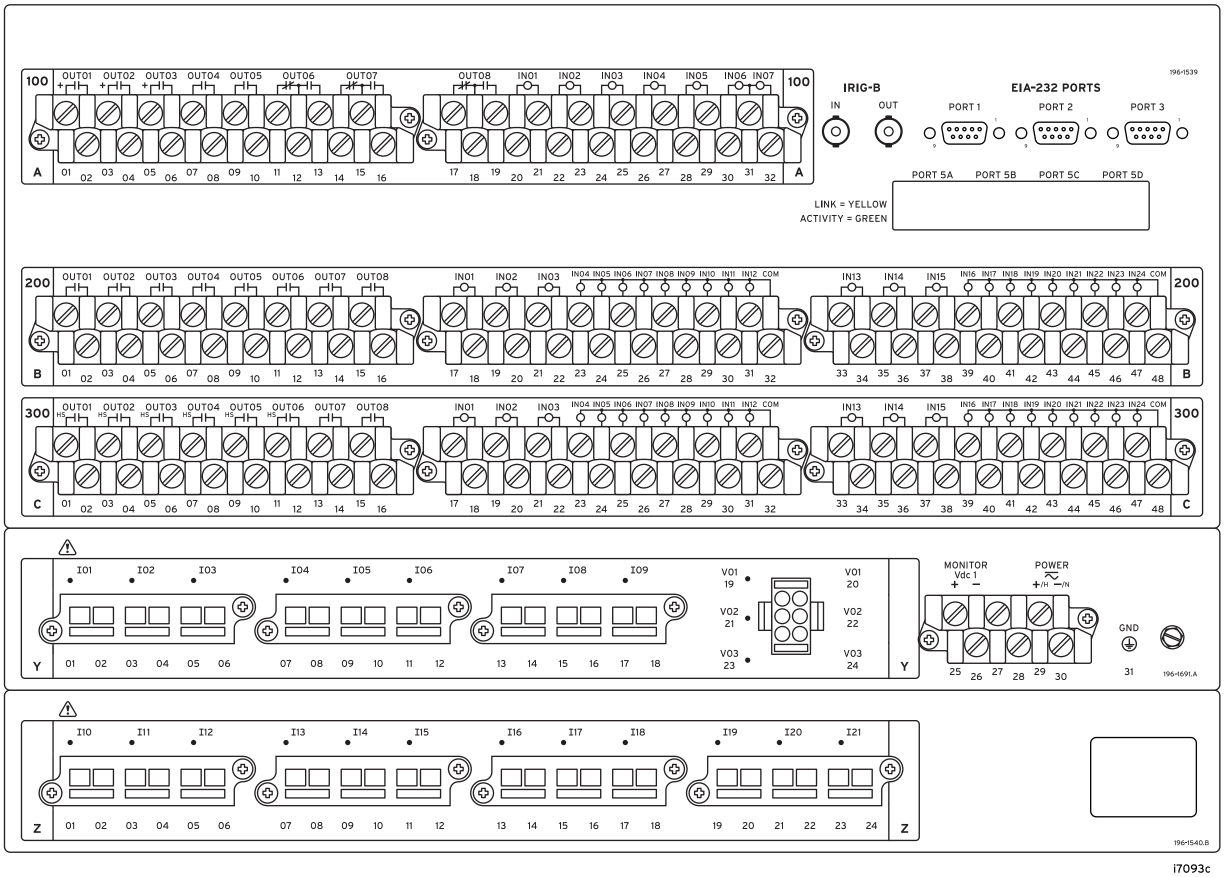


Figure 2.5 Rear-Panel Diagram of SEL-487B Connectorized Boards (7U Version)

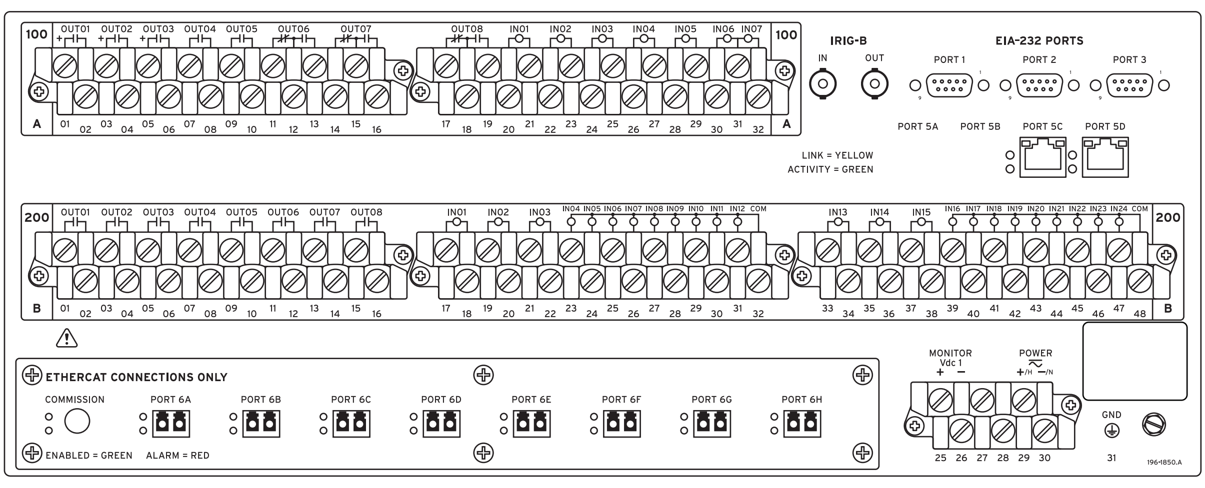


Figure 2.6 EtherCAT Board for TiDL

Secondary Circuits

The SEL-487B presents a low burden to the CT and PT secondaries (see *Specifications on page 1.10*).

The relay accepts 21 analog current inputs from the power system. CT inputs are labeled as follows: I01, I02–I21. Because the relay impedance is low, the current elements can be wired in series with current elements from other relays.

Figure 2.7 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.

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

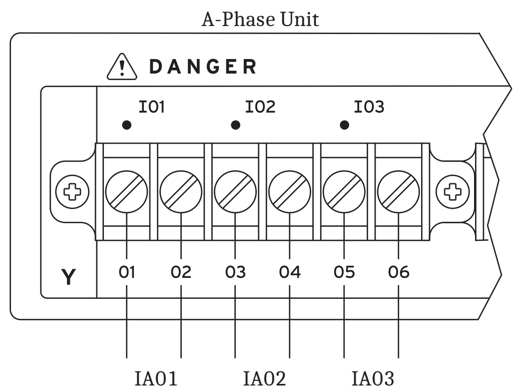


Figure 2.7 CT Connections for a Three-Relay Application

Figure 2.8 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.

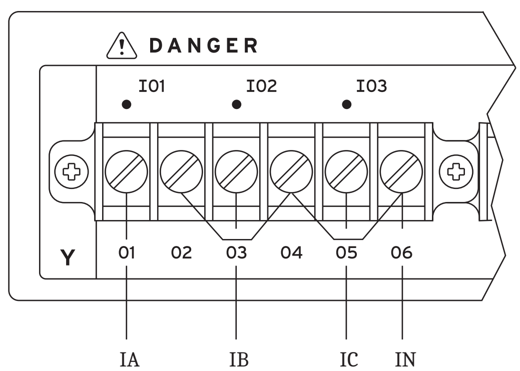


Figure 2.8 CT Connections for a Single-Relay Application When the SEL-487B Is the Last in the CT Circuit

Figure 2.9 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.

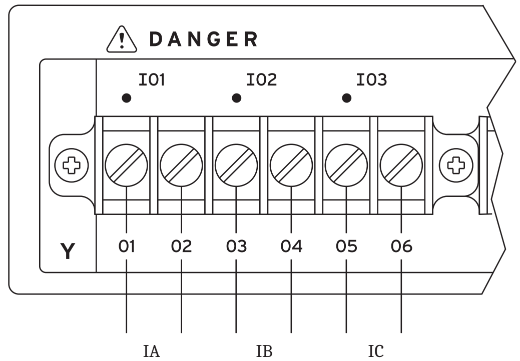


Figure 2.9 CT Connections for a Single-Relay Application When the SEL-487B Is in Series With Other Relays

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} (or 4 • I_{NOM} at +55°C). See *AC Current Inputs (Secondary Circuits) on page 1.10* for complete CT input specifications.

The relay also accepts one set of three, 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 and a burden of less than 0.1 VA at 125 V, L-N. The PT inputs and elements are independent of each other for both the single-relay or three-relay applications.

NOTE: TiDL (EtherCAT) technology is no longer offered in the SEL-487B-1. TiDL (T-Protocol) is available in the SEL-487B-2.

Relays that use the TiDL (EtherCAT) system do not contain secondary circuits on the relay. The secondary circuit uses an SEL-2240 Axion to supply the voltages and currents through a direct fiber link; however, the nominal current must be selected to appropriately apply scaling through various protection functions. The relay, by default, assumes 5 A as the nominal current selection. If you use 1 A scaling, use the **CFG CTNOM** command (see *Table 14.28 in the SEL-400 Series Relays Instruction Manual* for more information). The SEL-2245-42 AC Analog Input Module also sets its internal calculations based on this command. The relay internally transmits these data to the Axion modules and adjusts the appropriate scaling in the Axion module when this command is used.

In addition to the CT nominal values, TiDL relays also require you to set the nominal frequency by issuing the **CFG NFREQ** command. At Access Level 2, issue a **CFG NFREQ 60** to set the relay to 60 Hz nominal or issue a **CFG NFREQ 50** to set the relay to 50 Hz nominal. This command changes the NFREQ setting and restarts the relay, and it is only available in TiDL relays. The relay defaults to 60 Hz, so only use this command if you want to switch to 50 Hz nominal. Issue this command after the **CFG CTNOM** command but before sending settings to the relay.

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., the relay will detect input changes with voltage applied at either polarity. For more information on control input specifications, see *Specifications on page 1.10*.

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 six voltage options covering a wide range of voltages, as published in the *Specifications on page 1.10*. 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 *Control Inputs on page 1.11*. Specific pickup and dropout time-delay settings are required to achieve the specified ac thresholds, as shown in *Table 2.1*.

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	2.0 ms at 60 Hz 2.5 ms at 50 Hz (approximately 1/8 cycle)	0.625 cycles maximum (assertion)
IN201DO–IN224DO, IN301DO–IN324DO, IN401DO–IN424DO, IN501DO–IN524DO	Dropout Delay	16.5 ms at 60 Hz 20.0 ms at 50 Hz (approximately 1 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 *Control Inputs on page 1.11*.
- ➤ The signal contains no dc offset.

The SEL-487B samples the optoisolated inputs at 2 kHz.

Control Outputs

Control outputs from the relay include standard outputs and high-speed (high-current interrupting) outputs. A Metal-Oxide Varistor (MOV) 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 (NO) contacts. Ratings for standard outputs are 30 A make, 6 A continuous, and 0.75 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 2.10* shows a representative connection for a Form A Standard control output on the main board I/O terminals.

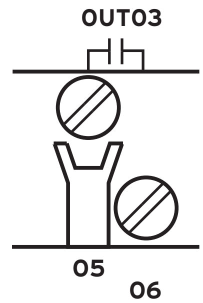


Figure 2.10 Standard Control Output Connection

See *Control Outputs on page 1.10* for complete standard control output specifications.

Hybrid (High-Current Interrupting) Control Outputs

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

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

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

The maximum contact closing time for the hybrid control outputs is 6 ms. *Figure 2.11* shows a representative connection for a Form A hybrid control output on the main board I/O terminals.

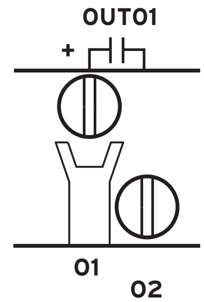


Figure 2.11 Hybrid Control Output Connection

See *Control Outputs on page 1.10* for complete hybrid control output specifications.

High-Speed, High-Current Interrupting Control Outputs

NOTE: You can use only dc circuits with high-speed, high-current interrupting outputs.

In addition to the standard control outputs, the INT4 I/O interface board offers high-speed, high-current interrupting control outputs. These control outputs have a resistive load pickup time of 10 µs, which is much faster than the 6 ms pickup time of the standard and hybrid control outputs. The high-speed, high-current interrupting control outputs drop out at a maximum time of 8 ms. The maximum voltage rating is 330 Vdc. See *Control Outputs on page 1.10* for complete high-speed, high-current interrupting control output specifications.

Figure 2.12 shows a representative connection for a Form A high-speed, high-current interrupting control output on the INT4 I/O interface terminals. The HS marks are included to indicate that this is a high-speed control output.

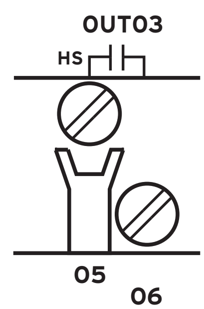


Figure 2.12 High-Speed, High-Current Interrupting Control Output Connection, INT4

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

Figure 2.13 shows some possible connections for external resistors that will eliminate the false pickup transients when closing an external switch. In general, you must connect external resistors to the dc rail (positive or negative) that is on the same side as the open external switch condition. If an open switch exists on either side of the output contact, then you can accommodate only one condition because two open switches (one on each side of the contact) defeat the precharge circuit.

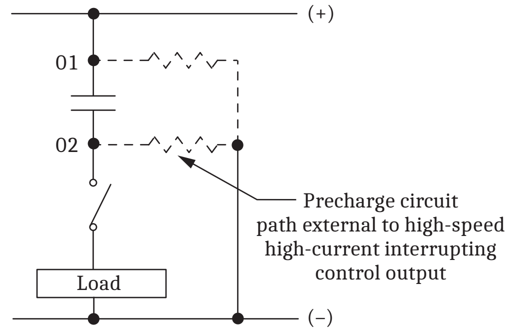


Figure 2.13 Precharging Internal Capacitance of High-Speed, High-Current Interrupting Output Contacts, INT4

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 2.18* for representative views of the 9U chassis rear panel and *Figure 2.4* and *Figure 2.19* for representative views of the 7U chassis rear panel.

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

- Three hybrid (high-current interrupting) Form A outputs
- Two standard Form A outputs
- Three standard Form C outputs
- Seven level-sensitive optoisolated control inputs (five independent and two common)

IRIG-B Inputs

Supply high-accuracy time to the SEL-487B via the IRIG-B IN BNC connector on the rear of the relay. You can use the IRIG OUT BNC connector to output IRIG, but you cannot use the output signal for high-accuracy timekeeping because it lacks the IEEE C37.118 IRIG control bits. If you need high-accuracy IRIG timekeeping, do not use the IRIG OUT connection as a high-accuracy IRIG source. Instead, use the connections external to the relay to distribute the IRIG signal between relays. In a three-relay application, 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 11: Time and Date Management in the SEL-400 Series Relays Instruction Manual* for more information on the use and benefits of high-accuracy timekeeping.

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 *IRIG-B Input Connections on page 2.41* for information on enabling IRIG-B timekeeping.

IRIG-B Pins of Serial Port 1

This IRIG-B input is capable of regular IRIG mode timekeeping only. Timing accuracy for the IRIG time mode is 500 µs.

IRIG-B BNC Connector

This IRIG-B input is capable of both modes of timekeeping. If the connected timekeeping source is qualified as high-accuracy, the relay enters the HIRIG mode, which has a timing accuracy of 1 µs. If both inputs are connected, the SEL-487B uses the IRIG-B signal from the BNC connection (if a signal is available).

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, Rayovac 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 is very small. Thus, battery life can extend well beyond the nominal 10-year period. The battery cannot be recharged. *Figure 2.14* 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 10.27 in the SEL-400 Series Relays Instruction Manual*).

Communications Interfaces

The SEL-487B has several communications interfaces you can use to communicate with other intelligent electronic devices (IEDs) via EIA-232 ports: **PORT 1**, **PORT 2**, **PORT 3**, and **PORT F**. See *Section 15: Communications Interfaces in the SEL-400 Series Relays Instruction Manual* for more information and options for connecting your relay to the communications interfaces.

An optional Ethernet card provides Ethernet capability for the SEL-487B. An Ethernet 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 16: DNP3 Communication in the SEL-400 Series Relays Instruction Manual*. For more information on IEC 61850 applications, see *Section 17: IEC 61850 Communication in the SEL-400 Series Relays Instruction Manual*.

Plug-In Boards

The SEL-487B supports as many as 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 as many as four additional interface boards. A 7U chassis option provides support for as many as 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 as many as 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 as many as 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 *Main Board I/O on page 2.12*). 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 2.15* for more information on I/O board jumpers.

I/O Interface Board Inputs

The INT4 I/O interface board has two groups of nine common contacts (18 total) and six 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 *Control Inputs on page 1.11* for complete control input specifications.

Table 2.2 Control Inputs

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

I/O Interface Board Outputs

The INT4 I/O interface board is available with either six high-speed and two standard output contacts, or eight 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 1.10* for complete control output specifications.

Table 2.3 Control Outputs

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

[a] High-current interrupting.

Ethernet Card

You can add Ethernet 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 process data traffic between the SEL-487B and a local area network (LAN).

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 2.15 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.

There are four jumpers, denoted as D, BREAKER, PASSWORD, and A, from left to right (position D being on the left). Positions D and A are for SEL use, position PASSWORD is the password disable jumper, and position BREAKER is the circuit breaker control enable jumper. *Figure 2.15* 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.

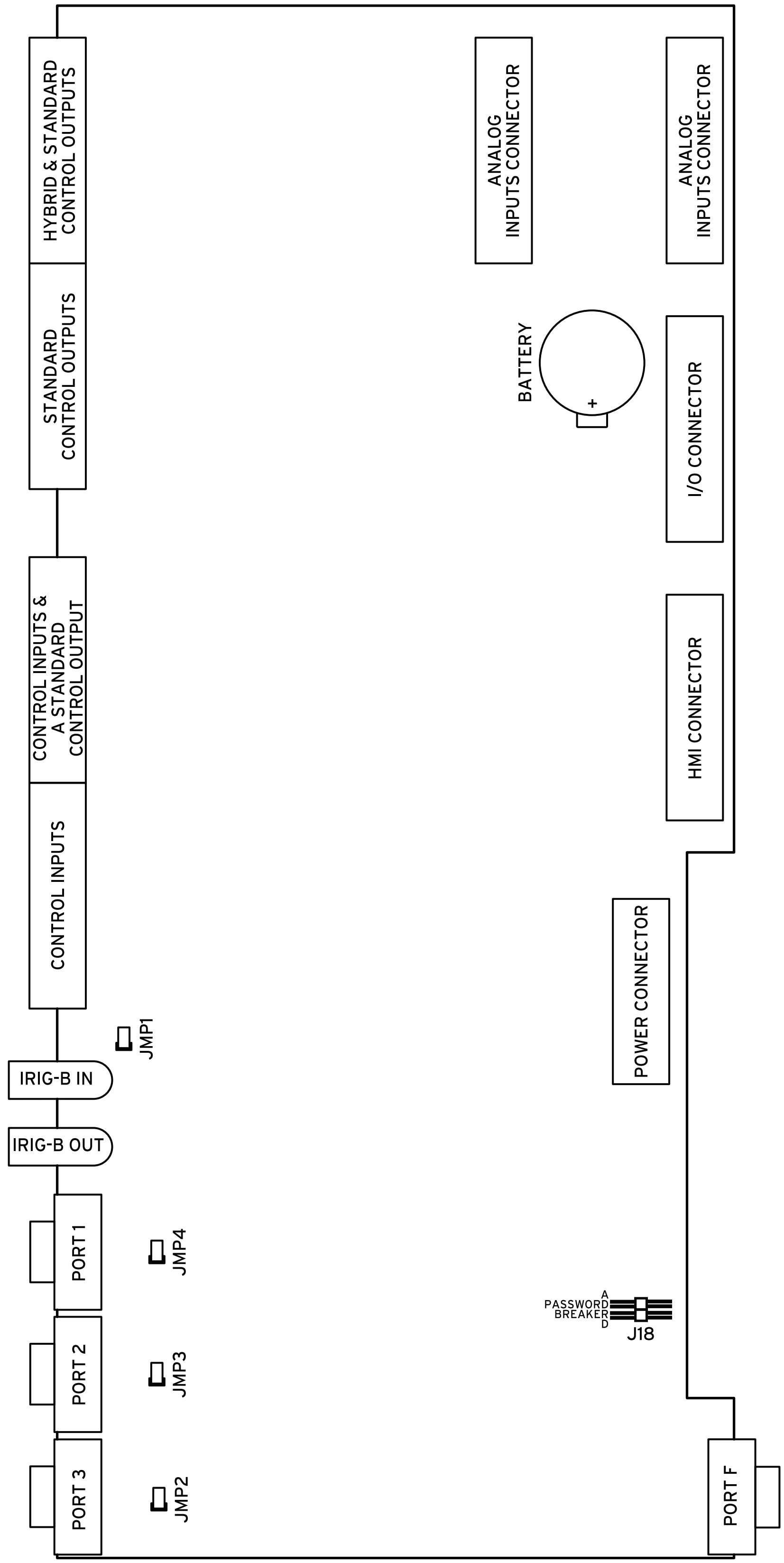


Figure 2.14 Major Component Locations on the SEL-487B Main Board

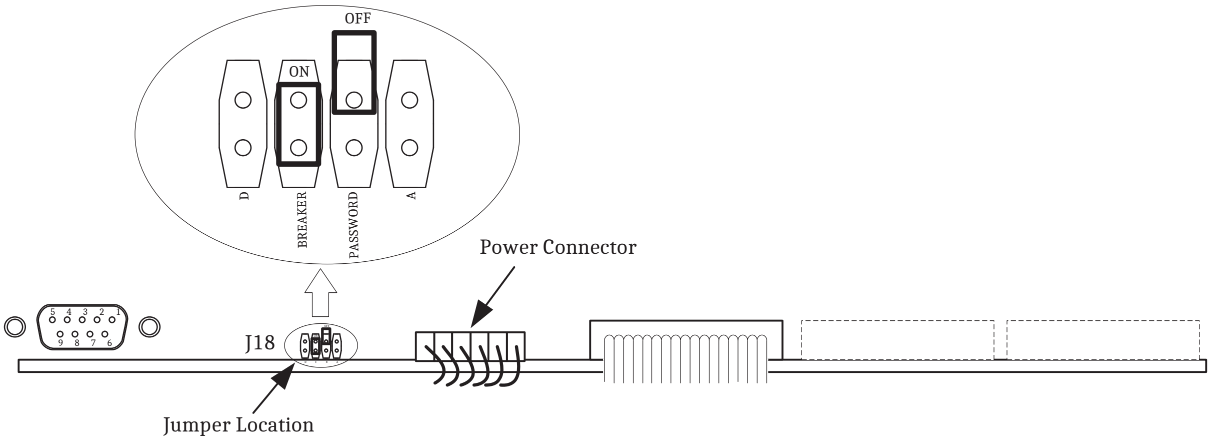


Figure 2.15 Jumper Location on the Main Board

Table 2.4 Main Board Jumpers

Jumper	Jumper Location	Jumper Position[a]	Function
A	Front	OFF	For SEL use only
PASSWORD	Front	OFF	Enable password protection (normal and shipped position)
		ON	Disable password protection (temporary or emergency only)
BREAKER	Front	OFF	Disable circuit breaker commands (**OPEN** and **CLOSE**) and output **PULSE** commands[b] (shipped position)
		ON	Enable circuit breaker commands (**OPEN** and **CLOSE**) and output **PULSE** commands[b]
D	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`.

[b] Also affects the availability of SCADA Control Messages and the front-panel `LOCAL CONTROL > BREAKER CONTROL`, and front-panel `LOCAL CONTROL > OUTPUT TESTING` screens.

The password disable jumper, PASSWORD, is for temporary or emergency suspension of the relay password protection mechanisms. Under no circumstance should you install PASSWORD on a long-term basis. The SEL-487B ships with password disable jumper PASSWORD OFF (passwords enabled).

The circuit breaker control enable jumper, BREAKER, supervises the **OPEN *n*** command, the **PULSE OUT*nnn*** command, and front-panel local bit control. To use these functions, you must install Jumper BREAKER. The relay checks the status of the circuit breaker control jumper when you issue **OPEN *n***, **PULSE OUT*nnn***, and when you use the front panel to close or open circuit breakers, control a local bit, or pulse an output. The SEL-487B ships with circuit breaker Jumper BREAKER OFF. For commissioning and testing of the SEL-487B contact outputs, it may be convenient to set BREAKER ON, so that the **PULSE OUT*nnn*** commands can be used to check output wiring. BREAKER must also be set ON if SCADA (DNP, Fast Operate, IEC 61850) control of the circuit breaker is required or if the `LOCAL CONTROL > BREAKER CONTROL` screens are going to be used.

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 JMP2, JMP3, and JMP4 positions. Refer to *Figure 2.15* for the locations of these jumpers. The SEL-487B ships with JMP2, JMP3, and JMP4 OFF (no +5 Vdc on Pin 1).

Table 2.5 Main Board Jumpers—JMP2, JMP3, and JMP4[a]

Jumper	Jumper Location	Jumper Position	Pin Connections
JMP2	Rear	OFF ON	Serial Port 3, Pin 1 = not connected Serial Port 3, Pin 1 = +5 V
JMP3	Rear	OFF ON	Serial Port 2, Pin 1 = not connected Serial Port 2, Pin 1 = +5 V
JMP4	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 JMP2, JMP3, and JMP4 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 communications cable connected to the front-panel serial port, if applicable.

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

Step 4. Disconnect the front-panel cable at the front panel.

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

Step 6. 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 7. Remove any Ethernet and IRIG-B connections.

Step 8. Carefully pull out the drawout assembly containing the main board.

Step 9. Locate the jumper you want to change.

Jumpers JMP2, JMP3, and JMP4 are located at the rear of the main board, directly in front of **PORT 3**, **PORT 2**, and **PORT 1**, respectively (see *Figure 2.15*).

Step 10. Install or remove the jumper as needed.

See *Table 2.5* for jumper position descriptions.

Step 11. Reinstall the SEL-487B main board.

Step 12. Reconnect the power cable, the interface board cable(s), and the input board analog cable.

Step 13. Reattach the front panel.

Step 14. Reconnect any external cables that you removed in the disassembly process.

Step 15. 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 2.14* 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 2.16*.

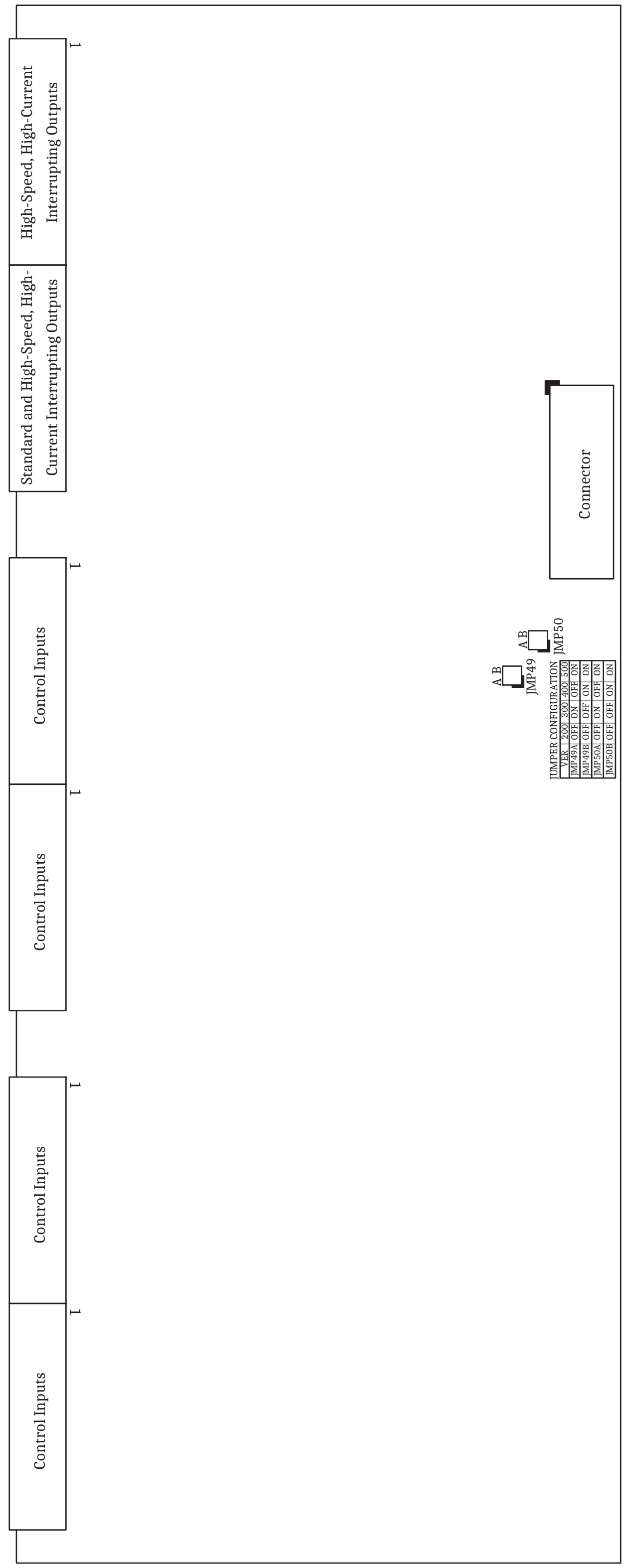


Figure 2.16 Major Component Locations on the SEL-487B INT4 I/O Board

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 2.17* for the locations of these jumpers.

The I/O board control address has a hundreds-series prefix attached to the control inputs and control outputs for that particular I/O board chassis slot.

A 7U chassis has a 200-address slot for inputs IN201, IN202, etc. and outputs OUT201, OUT202, etc., and a 300-address slot for IN301, IN302, etc. A 9U chassis also has a 400-address slot and 500-address slot for as many as two additional I/O boards. The drawout tray on which each I/O board is mounted is keyed. See *Installing Optional I/O Interface Boards on page 10.30 in the SEL-400 Series Relays Instruction Manual* for information on the key positions for the 200-addresses slot trays and the 300-addresses slot trays.

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.

Relay Placement

Proper placement of the SEL-487B helps make certain that you receive years of trouble-free power system protection. 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.

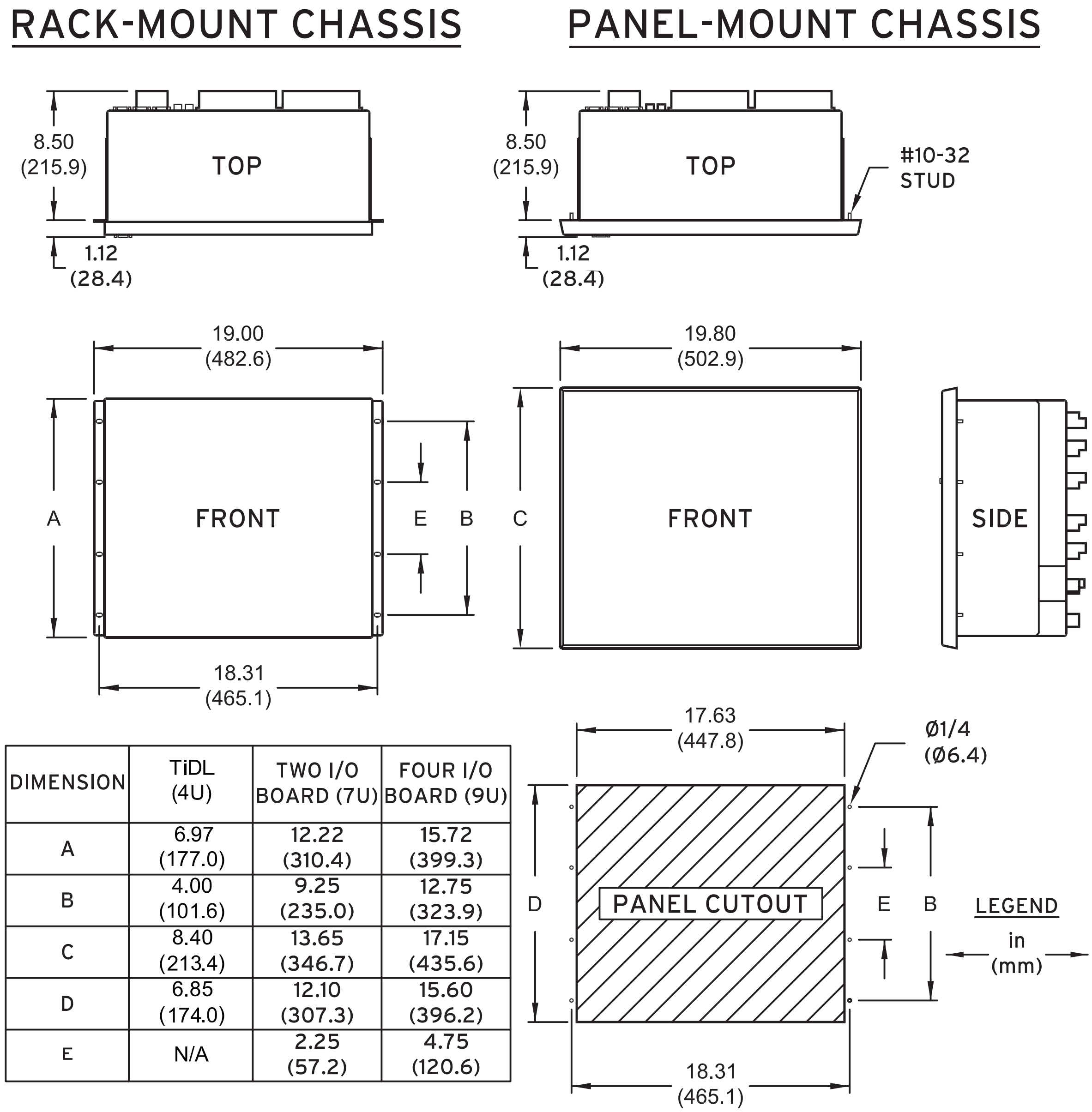
This rating allows mounting the relay indoors or in an outdoor (extended) enclosure where the relay is protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity are controlled. You can place the relay in extreme temperature and humidity locations. The relay operates in –40° to +85°C (–40° to +185°F) temperatures (see *Operating Temperature on page 1.12*). With no condensation present, the relay operates in humidity ranging from 5 percent to 95 percent.

Rack Mounting

When mounting the SEL-487B in a rack, use the reversible front flanges to either semiflush-mount or projection mount the relay.

The semiflush mount gives a small panel protrusion from the relay rack rails of approximately 1.1 inches (27.9 mm). The projection mount places the front panel approximately 3.5 inches (88.9 mm) in front of the relay rack rails.

See *Figure 2.17* for exact mounting dimensions for both the horizontal and vertical rack-mount relays. Use four screws of the appropriate size for your rack.



DIMENSION	TiDL (4U)	TWO I/O BOARD (7U)	FOUR I/O BOARD (9U)
A	6.97 (177.0)	12.22 (310.4)	15.72 (399.3)
B	4.00 (101.6)	9.25 (235.0)	12.75 (323.9)
C	8.40 (213.4)	13.65 (346.7)	17.15 (435.6)
D	6.85 (174.0)	12.10 (307.3)	15.60 (396.2)
E	N/A	2.25 (57.2)	4.75 (120.6)

Figure 2.17 Relay Chassis Dimensions

Panel Mounting

Place the panel-mount versions of the SEL-487B in a switchboard panel. See the drawings in *Figure 2.17* for panel cut and drill dimensions. Use the supplied mounting hardware to attach the relay.

Connection

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

The SEL-487B is available with a main board and as many as four INT4 interface boards. The INT4 interface board is available to expand the control inputs and control outputs only. There are two relay size options: a 9U chassis capable of supporting as many as the maximum of four interface boards, or a 7U chassis capable of supporting as many as 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 2.18 and *Figure 2.19* show the rear panel of the relay with only the main board installed, and *Figure 2.3*, *Figure 2.4*, and *Figure 2.5* show the rear panel of the relay fully equipped. For clarity, the figures do not show a communications card installed in **PORT 5**.

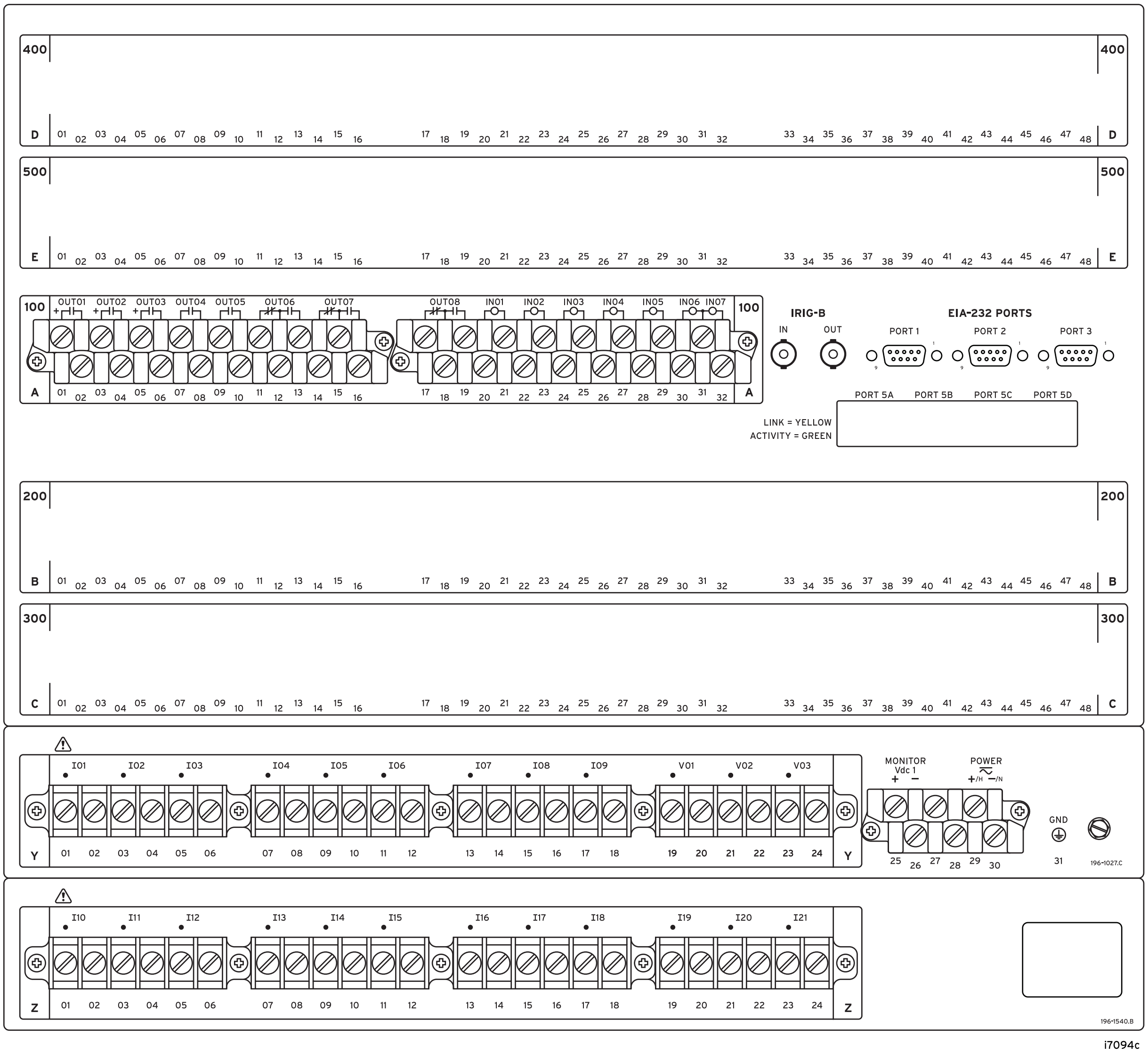


Figure 2.18 Rear Panel With Only Main Board (9U Version)

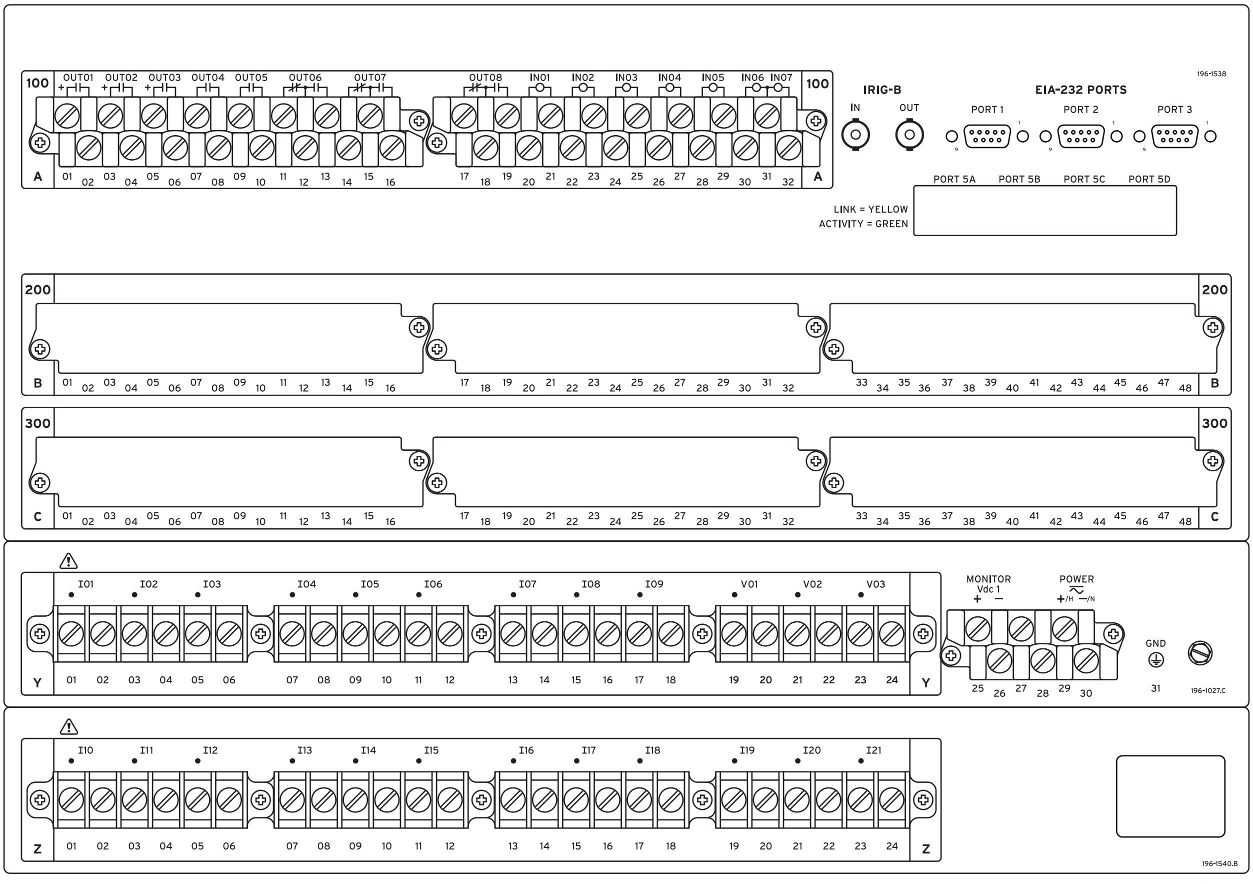


Figure 2.19 Rear Panel With Only Main Board (7U Version)

Rear-Panel Symbols

Figure 2.20 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.

Danger (Caution, risk of danger) Symbol | Grounding Terminal Symbol | AC/DC Input Symbol | DC Input Symbol

Figure 2.20 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 (0.36 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 2.21*). 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 2.22* shows the factory-default key positions.

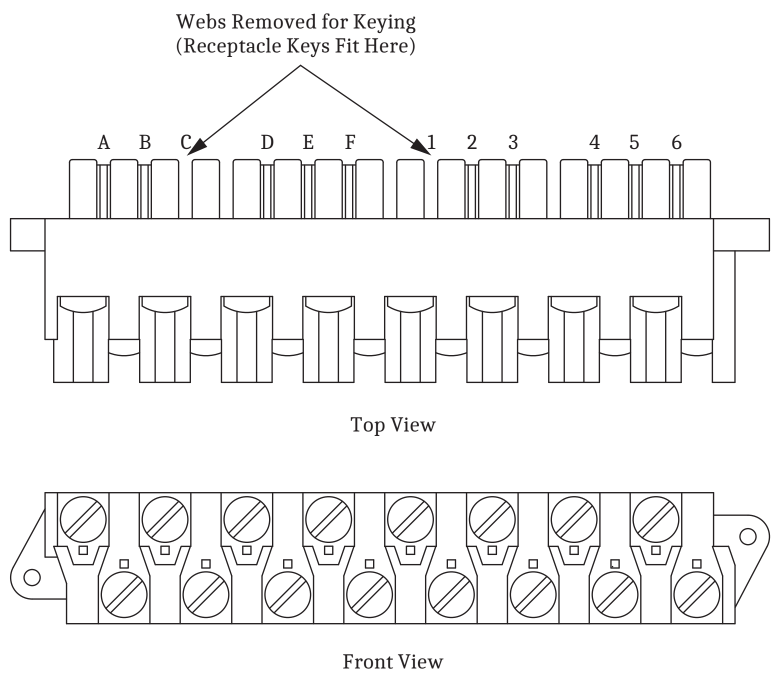


Figure 2.21 Screw-Terminal Connector Keying

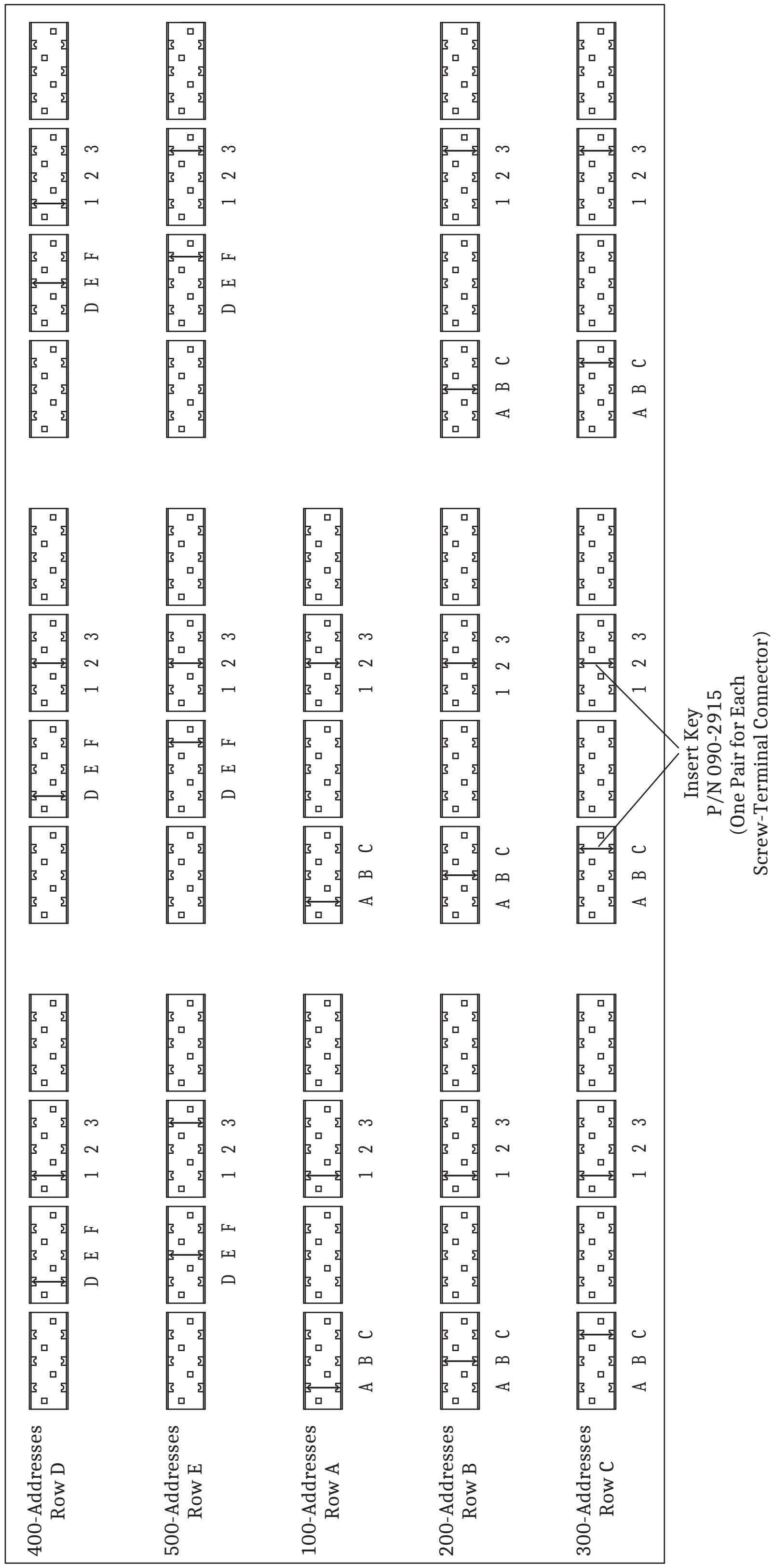


Figure 2.22 Rear-Panel Receptacle Keying

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 2.18*. The symbol that indicates the grounding terminal is shown in *Figure 2.20*. Use 14 AWG (2.5 mm^2) or larger wire, less than 2 m (6.6 feet) in length for this connection. This terminal connects directly to the internal chassis ground of the SEL-487B.

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 1.10* for complete power input specifications.)

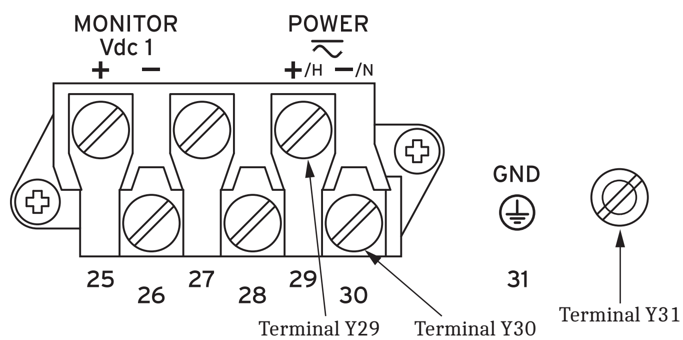


Figure 2.23 Power Connection Areas of the Rear Panel

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 18 AWG (0.8 mm^2) or larger 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.

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 0487B1*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 Power Supply

Rated Voltage	Operational Voltage Range	Fuse F1	Fuse Description
24–48 Vdc	18–60 Vdc	T5.0AH250V	5x20 mm, time-lag, 5.0 A, high-break capacity, 250 V
48–125 Vdc or 110–120 Vac	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 Vdc or 110–240 Vac	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 110–120 Vac; the 125–250 Vdc supply also accepts 110–240 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 1.10*.

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 8.21 in the SEL-400 Series Relays Instruction Manual*. 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

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

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

Each SEL-487B has 21 current inputs and 3 voltage inputs. *Shared Configuration Attributes on page 2.1* describes these inputs in detail. Use appropriate safety precautions when connecting secondary circuits to these terminals.

To verify these connections, use SEL-487B metering (see *Examining Metering Quantities on page 3.34 in the SEL-400 Series Relays Instruction Manual*). You can also review metering data in an event report that results when you issue the **TRIGGER** command.

Fixed Terminal Blocks

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–Z24).

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

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–Z23) for the analog inputs.

Connectorized

For the Connectorized SEL-487B, order the wiring harness kit, SEL-WA0487B. The wiring harness contains eight prewired connectors for the relay current and voltage inputs.

You can order the wiring harness with various wire sizes and lengths. Contact your local Technical Service Center or the SEL factory for ordering information.

Perform the following steps to install the wiring harness:

Step 1. Plug the CT shorting connectors into terminals **#Z01** through **#Z24** and **#Y01** through **#Y18**, as appropriate.

Odd-numbered terminals are the polarity terminals.

Step 2. Secure the connector to the relay chassis with the two screws located on each end of the connector.

When you remove the CT shorting connector, pull straight away from the relay rear panel.

As you remove the connector, internal mechanisms within the connector separately short each power system current transformer.

You can install these connectors in only one orientation.

Step 3. Plug the PT voltage connectors into terminals **#Y19** to **#Y24**, as appropriate.

Odd numbered terminals are the polarity terminals. You can install these connectors in only one orientation.

Control Circuit Connections

You can configure the SEL-487B with many combinations of control inputs and control outputs. See *Main Board I/O on page 2.12* and *I/O Interface Boards on page 2.14* 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 3.55 in the SEL-400 Series Relays Instruction Manual* for more details. You can also use ACSELERATOR QuickSet SEL-5030 Software to set and verify operation of the inputs.

Control Outputs

The SEL-487B has three types of outputs:

- Standard outputs (for example: main board OUT104)
- Hybrid (high-current interrupting) outputs (for example: main board OUT101)
- High-speed, high-current interrupting (for example: INT4 board OUT01). See *Control Outputs on page 2.9* for more information.

You can connect the standard outputs and the high-speed, high-current interrupting outputs in either ac or dc circuits. Connect the high-current interrupting outputs to dc circuits only. The screw-terminal connector legends alert you about these requirements by showing polarity marks on the hybrid (high-current interrupting) contacts and HS marks on the high-speed, high-current interrupting contacts. 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 2.24* shows the configuration of the a and b contacts of control output OUT108.

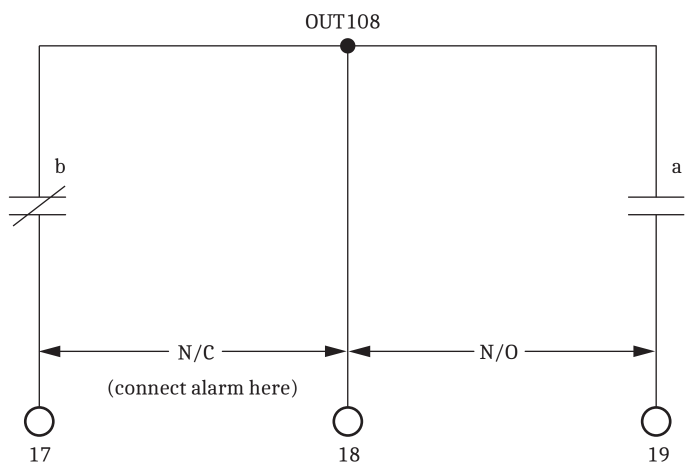


Figure 2.24 Control Output OUT108

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 10.19 in the SEL-400 Series Relays Instruction Manual* 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, alarming after three unsuccessful password entry attempts, and Ethernet firmware upgrade attempts.

Tripping and Closing Outputs

To assign the control outputs for tripping, see *Setting Outputs for Tripping and Closing on page 3.61 in the SEL-400 Series Relays Instruction Manual*. In addition, you can use the **SET O** command; see *SET on page 9.6* for more details.

TiDL (EtherCAT) Connections

NOTE: TiDL (EtherCAT) technology is no longer offered in the SEL-487B-1. TiDL (T-Protocol) is available in the SEL-487B-2.

The SEL-487B Relays that support TiDL have a 4U chassis. The relay supports I/O on the main board as well as one additional I/O board. The main board and additional I/O board map to the 100- and 200-level inputs and outputs. The Axion modules provide additional I/O for the 300, 400, and 500 levels and analog channels.

The protection functions remain unchanged from the standard SEL-487B Relay.

Axion Modules

The SEL-2240 Axion is a fully integrated analog and digital I/O control solution that is suitable for DSS. An Axion node consists of a 10-slot, 4-slot, or dual 4-slot chassis that is configurable to contain a power module and combinations of CT/PT, digital input (DI), or digital output (DO) modules.

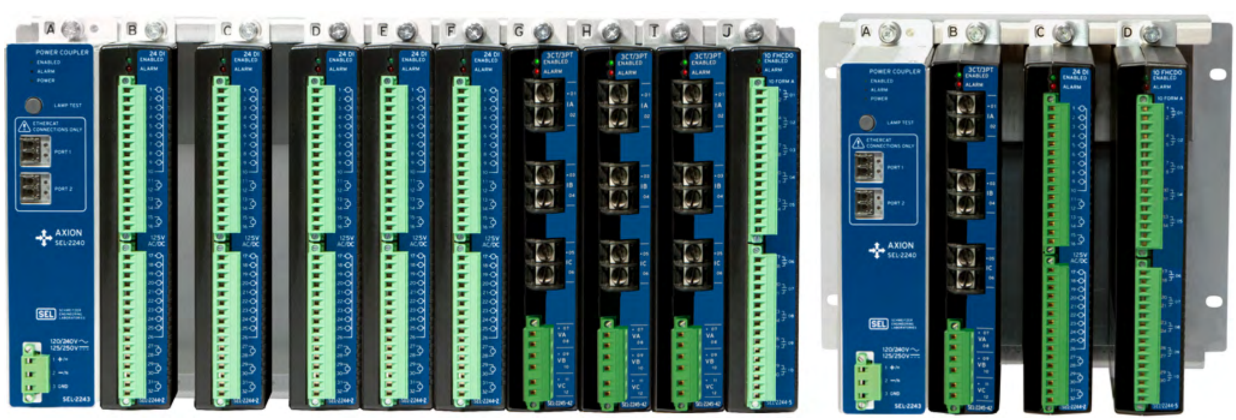


Figure 2.25 Axion Chassis

SEL-2243 Power Coupler

Each chassis requires an SEL-2243 Power Coupler (see *Figure 2.26*). This module supplies power to the rest of the node and transmits the data to the relay through fiber-optic communication. Although the power coupler has two fiber-optic ports, only **PORT 1** is currently used for TiDL.

Figure 2.26 SEL-2243 Power Coupler

The SEL-2243 has sufficient power capacity to accommodate an entire Axion node. The terminal strip at the bottom of the unit (shown in *Figure 2.26*) is the connection point for incoming power. All Axion modules have a 55-position IEC C-style connector that provides a communications and power interface to the backplane. See the *SEL-2240 Axion Instruction Manual* for more information.

SEL-2244-2 Digital Input Module

The SEL-2244-2 Digital Input Module (see *Figure 2.27*) consists of 24 optoisolated inputs that are not polarity dependent. These inputs can be configured to respond to ac or dc control signals. The TiDL system maps as many as 72 DI points to the relay in the 300, 400, and 500 I/O board levels, based on the modules that occur in the network. Only the first 12 of 24 inputs are used in each module to help distribute the I/O around the network more efficiently. The inputs are mapped to the relay inputs based on the order in which the DI module occurs in the TiDL network.

There can be multiple DI modules in an Axion node, and the order of the DI modules will proceed from left to right in the node to determine the mapping of the inputs.

The first DI module that exists in the system, for example, on **PORT 6A**, will map to **IN301**–**IN312**, and if a second module is available on **PORT 6A**, it will map to **IN313**–**IN324**. If a second module does not exist on **PORT 6A**, **IN313**–**IN324** will be mapped from the next module appearing in the TiDL system. Mapping order determination starts with **PORT 6A** and ends with the last port, **PORT 6H**.

First SEL-2244-2 DI module	**IN301–IN312**
Second SEL-2244-2 DI module	**IN313–IN324**
Third SEL-2244-2 DI module	**IN401–IN412**
Fourth SEL-2244-2 DI module	**IN413–IN424**

Fifth SEL-2244-2 DI module	IN501–IN512
Sixth SEL-2244-2 DI module	IN513–IN524

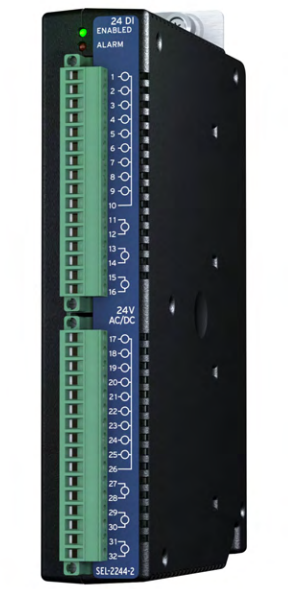


Figure 2.27 SEL-2244-2 Digital Input Module

SEL-2244-5 Fast High-Current Digital Output Module

The SEL-2244-5 Fast High-Current Digital Output Module consists of 10 fast, high-current output contacts. The outputs use the first 8 of the10 outputs and map as follows:

First SEL-2244-5 DO Module	OUT301–OUT308
Second SEL-2244-5 DO Module	OUT309–OUT316
Third SEL-2244-5 DO Module	OUT401–OUT408
Fourth SEL-2244-5 DO Module	OUT409–OUT416
Fifth SEL-2244-5 DO Module	OUT501–OUT508
Sixth SEL-2244-5 DO Module	OUT509–OUT516

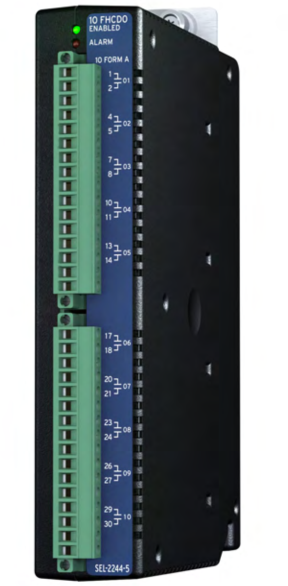


Figure 2.28 SEL-2244-5 Fast High-Current Digital Output Module

For both the DI and DO modules, use 24–12 AWG (0.2–3.31 mm^2) wire of sufficient current capacity to connect to the digital input and output terminals for your application.

The order of mapping for DO modules is the same as that for DI modules.

SEL-2245-42 AC Analog Input Module

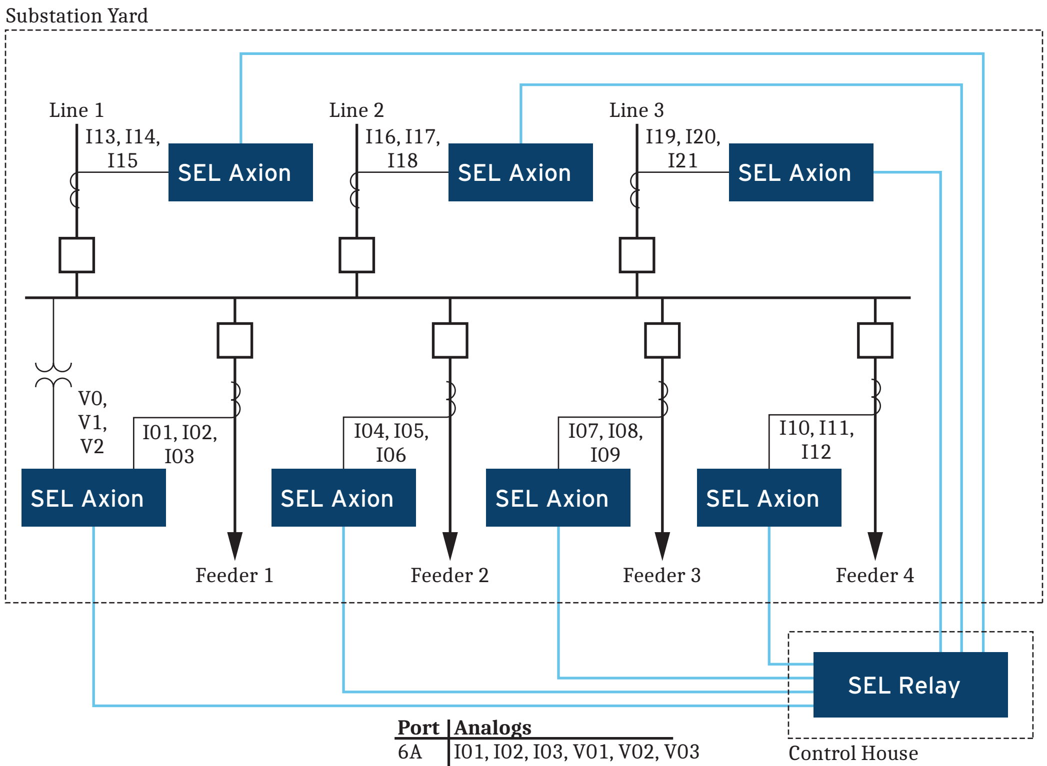
The SEL-2245-42 AC Analog Input Module (see *Figure 2.29*) provides protection-class ac analog input (CT/PT) and can accept three voltage and three current inputs. The module samples at 24 kHz and is 1 A or 5 A software-selectable. Depending on the supported fixed topology, multiple CT/PT input modules can function in each node. Some topologies only support one CT/PT module per node. See *Topologies on page 2.36* for more information on supported relay topologies and their connections.

Figure 2.29 SEL-2245-42 AC Analog Input Module

Topologies

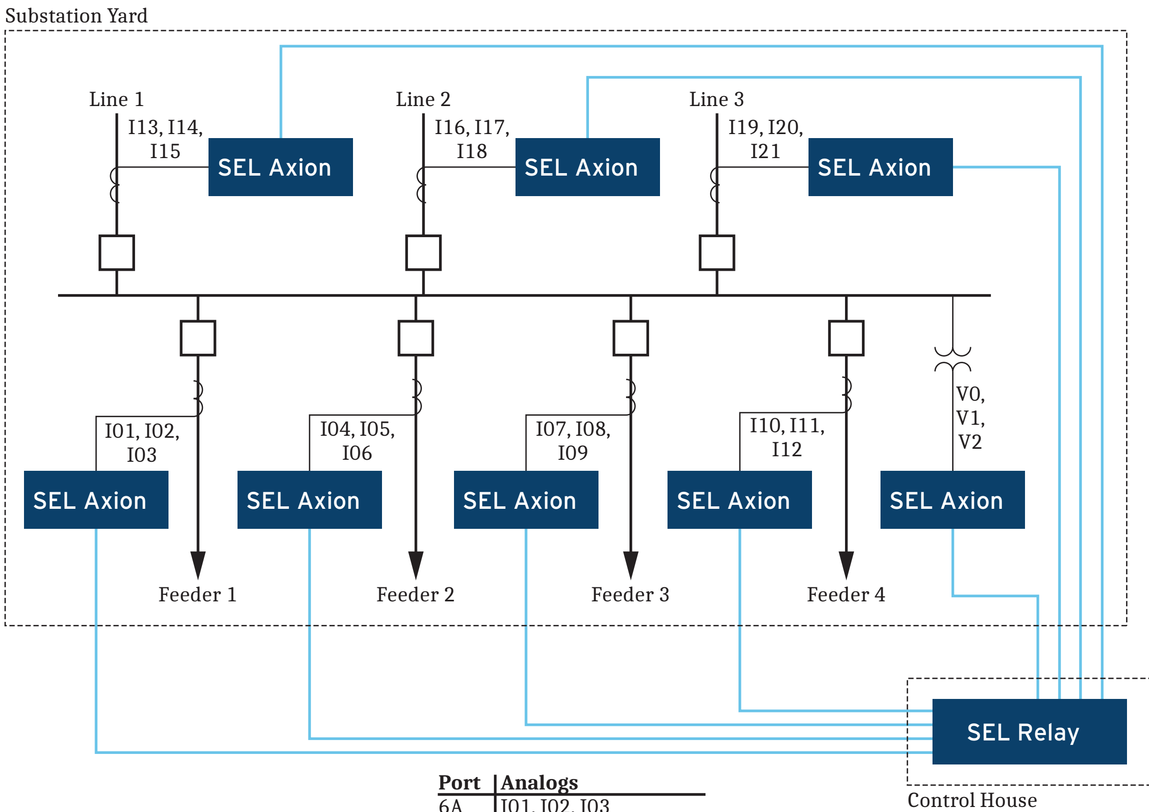
The SEL-487B Relay has a set of fixed topologies. These topologies map the voltages and currents internally in the relay to maintain existing settings and functionality. When the TiDL system is commissioned (see *Commissioning on page 2.39*), the firmware validates the connected Axion nodes and identifies if the installed CT/PT modules in the system match one of the supported topologies for the SEL-487B.

Ports listed as optional in the following topology diagrams do not require a CT/PT module to be connected to them. All other ports require a CT/PT module to be connected for the relay to verify the topology.



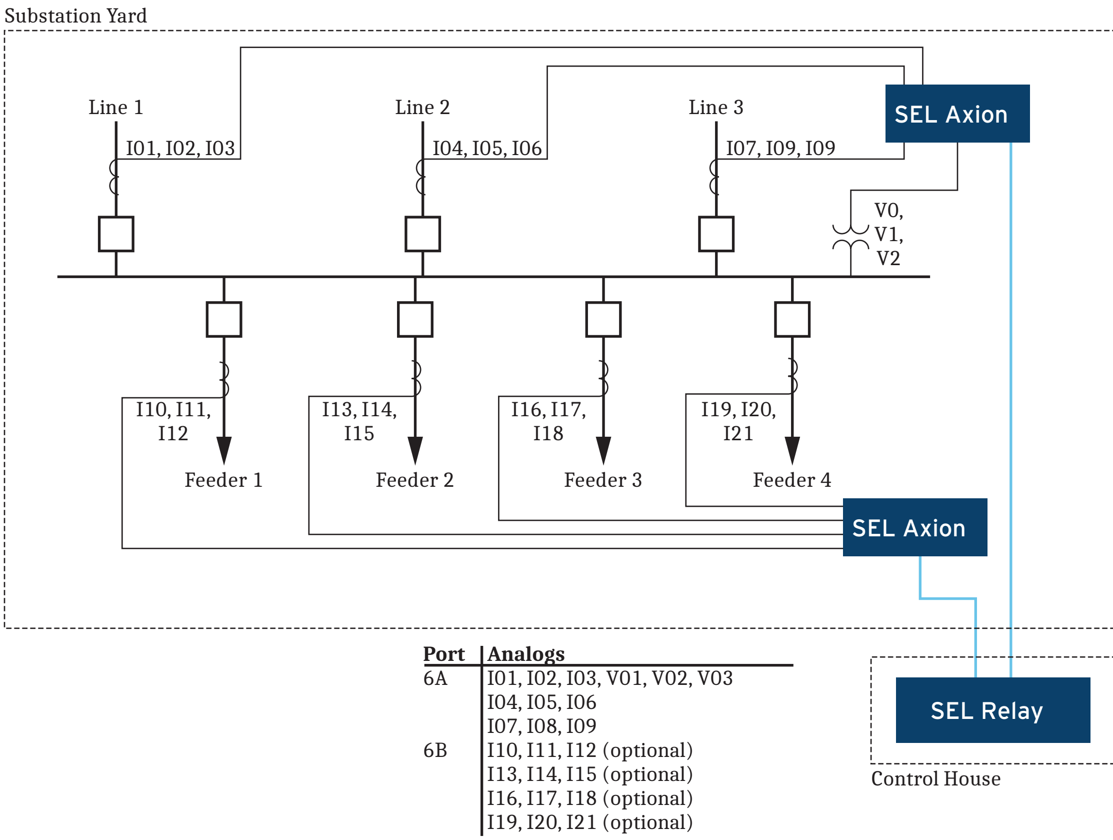
Port	Analogs
6A	I01, I02, I03, V01, V02, V03
6B	I04, I05, I06
6C	I07, I08, I09
6D	I10, I11, I12 (optional)
6E	I13, I14, I15 (optional)
6F	I16, I17, I18 (optional)
6G	I19, I20, I21 (optional)

Figure 2.30 Topology 1



Port	Analogs
6A	I01, I02, I03
6B	I04, I05, I06
6C	I07, I08, I09
6D	I10, I11, I12 (optional)
6E	I13, I14, I15 (optional)
6F	I16, I17, I18 (optional)
6G	I19, I20, I21 (optional)
6H	V01, V02, V03

Figure 2.31 Topology 2



Note: This topology uses three or four CT/PT modules installed in one Axion node. The first module maps to the I01–I03 currents and V01–V03 voltages, the second module maps to the I04–I06 currents, and the third maps to the I07–I09 currents. Similar mapping occurs in the second Axion.

Figure 2.32 Topology 3

Commissioning

In TiDL applications, the relay receives currents from an Axion module. You must set the nominal current input of the relay to either 1 A or 5 A. Many settings and ranges of settings depend on the nominal current. Use the **CFG CTNOM** command to set the nominal current value. At Access level 2, issue a **CFG CTNOM 1** to set the relay to 1 A values or use the command **CFG CTNOM 5** to set it to 5 A values. This command is only available in relays that support TiDL technology. Note that after issuing this command, the relay settings are forced to their default values and the relay turns off and back on again to reinitialize the settings. The relay defaults to 5 A nominal, so only use this command if you are switching to a 1 A setting (see *Section 14: ASCII Command Reference in the SEL-400 Series Relays Instruction Manual* for more information). The SEL-2245-42 AC Analog Input Module also sets its internal calculations based on this command. The relay internally transmits these data to the Axion modules and adjusts the scaling in the appropriate Axion module when this command is used.

In addition to the CT nominal values, TiDL relays also require that the nominal frequency be set by issuing the **CFG NFREQ** command. At Access level 2, issue a **CFG NFREQ 60** to set the relay to 60 Hz nominal or issue a **CFG NFREQ 50** to set the relay to 50 Hz nominal. This command changes the NFREQ setting and restarts the relay, and it is only available in TiDL relays. The relay defaults to 60 Hz. This command should be issued after the **CFG CTNOM** command but before settings are sent to the relay.

The TiDL system uses a commissioning feature to identify that the connected Axion nodes meet the requirements of the supported topologies for the applied relay. These topologies are a balance between copper reduction and number of nodes. The nodes must be connected in one of the supported topologies so that the relay will map the voltages and currents accordingly.

The SEL-487B has a new interface on its back panel that replaces the original CT and PT input connections. These standard inputs are replaced with a module interface that supports eight fiber ports, labeled PORT 6A–PORT 6H (see *Figure 2.33*).

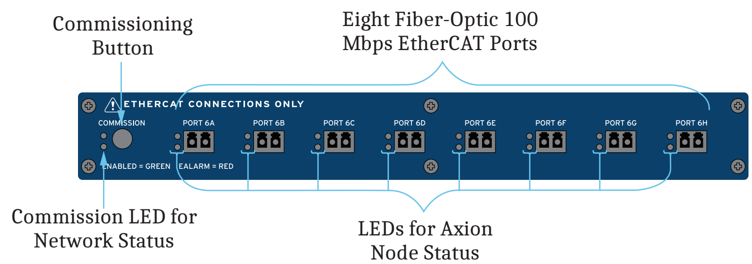


Figure 2.33 TiDL (EtherCAT) Module Interface

Once all the Axion nodes are connected to the relay, press the COMMISSION pushbutton on the module interface. This process verifies that the connected ports and Axion nodes are installed according to one of the supported topologies. Once the process is complete, the topology is stored in memory. At each additional startup of the relay, the firmware validates that the connected modules match those of the stored configuration. It recognizes whether any of the CT/PT modules within the node have changed. If the topology needs to be changed (e.g., modules are added or replaced), the system will need to be recommissioned by pressing the COMMISSION pushbutton.

When the commissioning and validation of the topology is complete, the voltages and currents map according to the topology assignments (see *Topologies on page 2.36*). Secondary injection testing takes place at each Axion node. Test sources must inject voltages and currents to the Axion node to verify correct installation and mapping. Monitoring of the voltages and currents remains in the control house with the relay.

LED Status

As shown in *Figure 2.33*, the TiDL relay provides LED status indication about the network and configuration. Once the system is connected, and the COMMISSION button pressed, the LEDs will provide the status of the commissioning process. *Table 2.8* shows the status of the rear-panel LEDs for each commissioning state.

Table 2.8 TiDL (EtherCAT) LED Status (Sheet 1 of 2)

State	Description	LED Status	
Initial State	Determining if topology exists	Green COMMISSION LED	OFF
		Red COMMISSION LED	ON
		Green LED: PORT 6A–PORT 6H	OFF
		Red LED: PORT 6A–PORT 6H	ON

Table 2.8 TiDL (EtherCAT) LED Status (Sheet 2 of 2)

State	Description	LED Status	
Verify Topology	Determining if topology is supported	Green **COMMISSION** LED	Blinking
		Red **COMMISSION** LED	ON
		Green LED: **PORT 6A–PORT 6H**	Blinking
		Red LED: **PORT 6A–PORT 6H**	ON
Topology Mismatch	Connection does not match supported topology	Green **COMMISSION** LED	Blinking
		Red **COMMISSION** LED	ON
		Green LED: **PORT 6A–PORT 6H**	OFF—mismatched/unused
			ON—matched
		Red LED: **PORT 6A–PORT 6H**	Blinking—mismatched
			ON—matched
			OFF—ports unused
Topology Matched	Connection matches topology	Green **COMMISSION** LED	ON
		Red **COMMISSION** LED	OFF
		Green LED: **PORT 6A–PORT 6H**	ON
		Red LED: **PORT 6A–PORT 6H**	OFF
N/A	A commissioned port experiences an error	Green **COMMISSION** LED	ON
		Red **COMMISSION** LED	OFF
		Green LED: **PORT 6A–PORT 6H**	ON
		Red LED: **PORT 6A–PORT 6H**	Blinking—failed port

IRIG-B Input Connections

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 2.42* for other DB-9 connector pinouts and additional details.

These inputs accept the dc shift time code generator output (demodulated) IRIG-B signal with a positive edge on the time mark. For more information on IRIG-B and the SEL-487B, see *IRIG-B Inputs on page 2.12*.

The **PORT 1** IRIG-B input connects to a 2.5-kΩ grounded resistor and goes through a single logic signal buffer. The **PORT 1** IRIG-B is equipped with robust ESD and overvoltage protection but is not optically isolated. When you are using the **PORT 1** input, ensure that you connect Pin 4 (+) and Pin 6 (–) with the proper polarity.

The IRIG Network should be properly terminated with an external termination resistor (SEL 240-1802, BNC Tee, and 240-1800, BNC terminator 50 ohms) placed on the unit that is farthest from the source. This termination provides impedance matching of the cable for the best possible signal-to-noise ratio.

When the 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 as long as 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.

Each SEL-487B provides two IRIG-B BNC connectors, labeled IN and OUT. The IRIG OUT connector does not support high-accuracy IRIG timekeeping. It lacks the C37.118 IRIG Control Bits.

Step 1. Referring to the external source connections in *Figure 2.34*, 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.

NOTE: The IRIG OUT connection works regardless of the type of external time source connected to the relay.

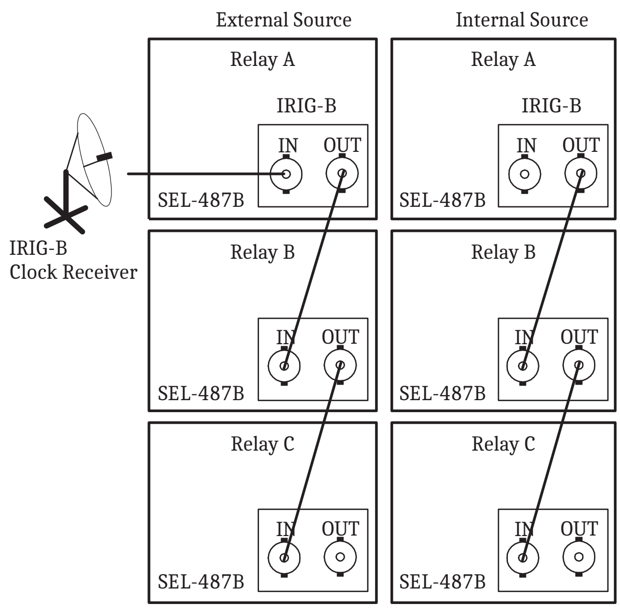


Figure 2.34 Time Synchronization Connections Between Three Relays

In the absence of an external IRIG-B signal, connect the relays as shown by the internal source connections in *Figure 2.34*. 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.

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 3.3 in the SEL-400 Series Relays Instruction Manual.*

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 10: Communications Interfaces* in this manual and *Section 15: Communications Interfaces, Section 16: DNP3 Communication*, and *Section 17: IEC 61850 Communication in the SEL-400 Series Relays Instruction Manual*.

Serial Ports

The SEL-487B serial communications ports use EIA-232 standard signal levels in a D-subminiature 9-pin (DB-9) connector. To establish communication between the relay and a DTE device (a computer terminal, for example) with a DB-9 connector, use an SEL-C234A cable. Alternatively, you can use an SEL-C662 cable to connect to a USB port.

Figure 2.34 shows the configuration of SEL-C234A cable that you can use for basic ASCII and binary communication with the relay. A properly configured ASCII terminal, terminal emulation program, or QuickSet along with the SEL-C234A cable provides communication with the relay in most cases.

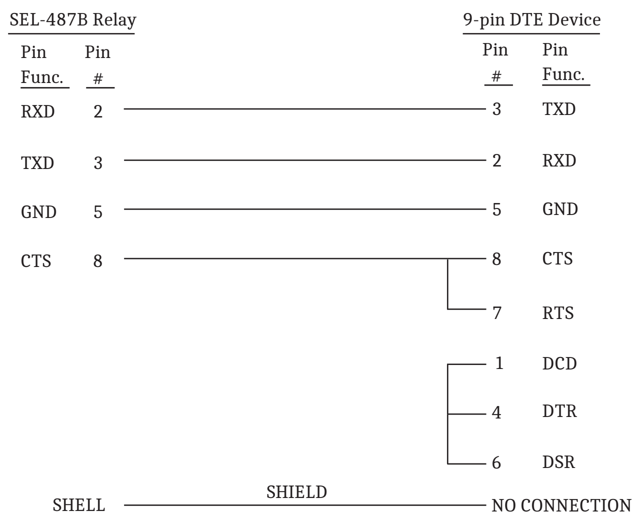


Figure 2.35 SEL-487B-to-Computer DB-9 Connector

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:

⚠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.

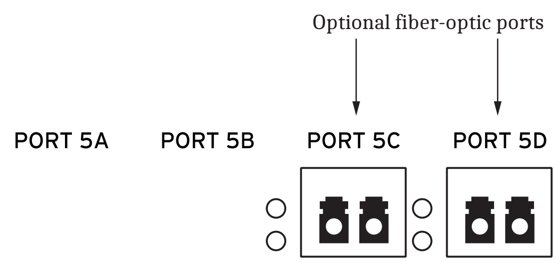
- ➤ Route communications cables well away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in the communications circuits if power and control circuits are not adequately separated from communications cables.
- ➤ You should keep the length of 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-2800-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.

Ethernet Network Connections

The optional Ethernet card for the SEL-487B comes with two ports, either A and B or C and D. You can use either installed port. These ports can work together to provide a primary and backup interface. Other operating modes (FIXED and SWITCHED) are also available. 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 RJ45 connector
- ➤ 100BASE-FX. 100 Mbps communications over multimode fiber-optic cable using an LC connector



Ethernet Card Rear-Panel Layout

⚠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 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.

Rear-panel layouts for the three Ethernet card port configurations are shown in *Figure 2.36–Figure 2.41*.

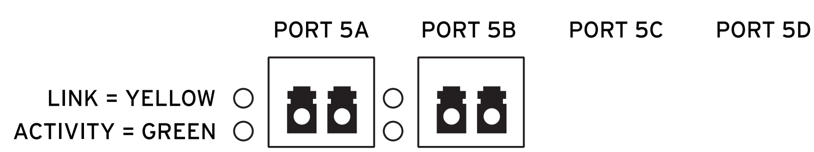


Figure 2.36 Two 100BASE-FX Port Configuration on Ports 5A and 5B

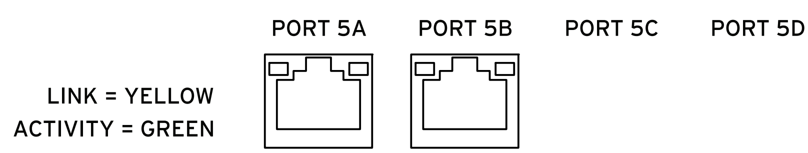


Figure 2.37 Two 100BASE-T Port Configuration on Ports 5A and 5B

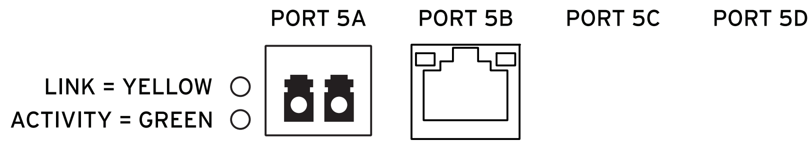


Figure 2.38 100BASE-FX and 10/100BASE-T Port Configuration on Ports 5A and 5B

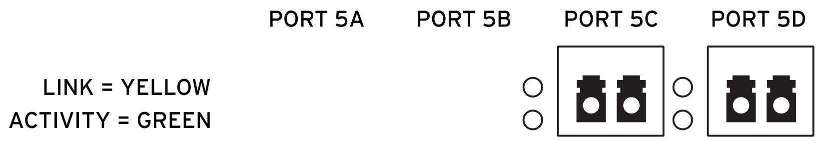


Figure 2.39 Two 100BASE-FX Port Configuration on Ports 5C and 5D

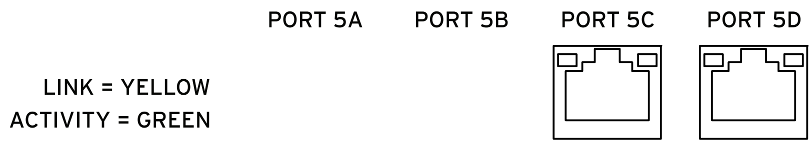


Figure 2.40 Two 10/100BASE-T Port Configuration on Ports 5C and 5D

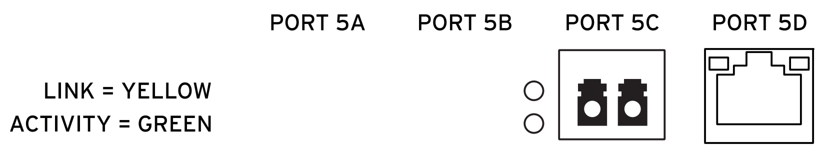


Figure 2.41 100BASE-FX and 10/100BASE-T Port Configuration on Ports 5C and 5D

⚠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 and transceivers, are not user serviceable. Return units to SEL for repair or replacement.

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 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 cables or shield UTP cables, 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 enclosure.

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 RJ45 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 2.42* shows one particular application scheme with connections that represent typical interfaces to the relay for a single zone layout. *Figure 2.43* depicts typical connections for a three-relay application.

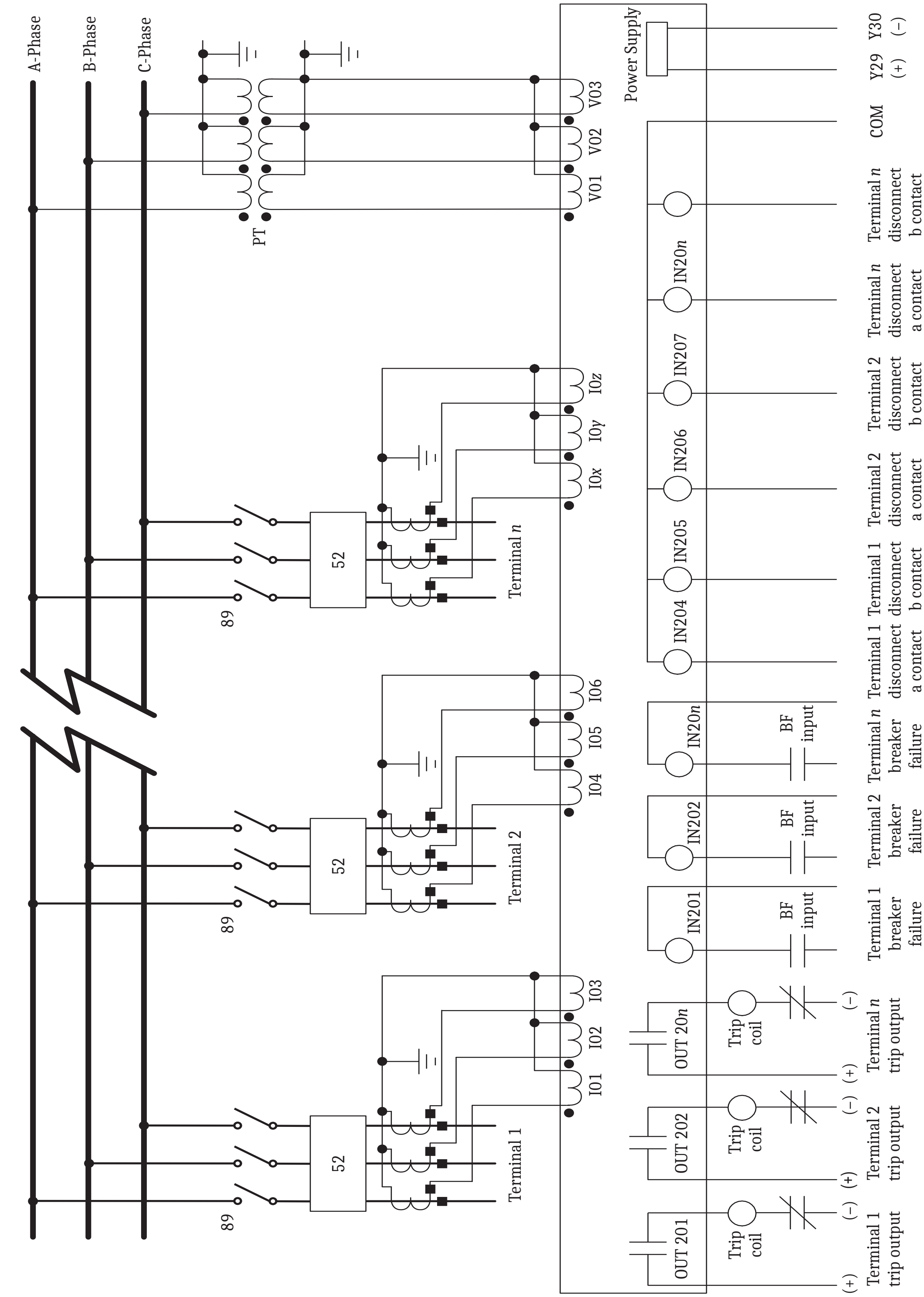


Figure 2.42 Typical External AC/DC Connections for a Single-Relay Application

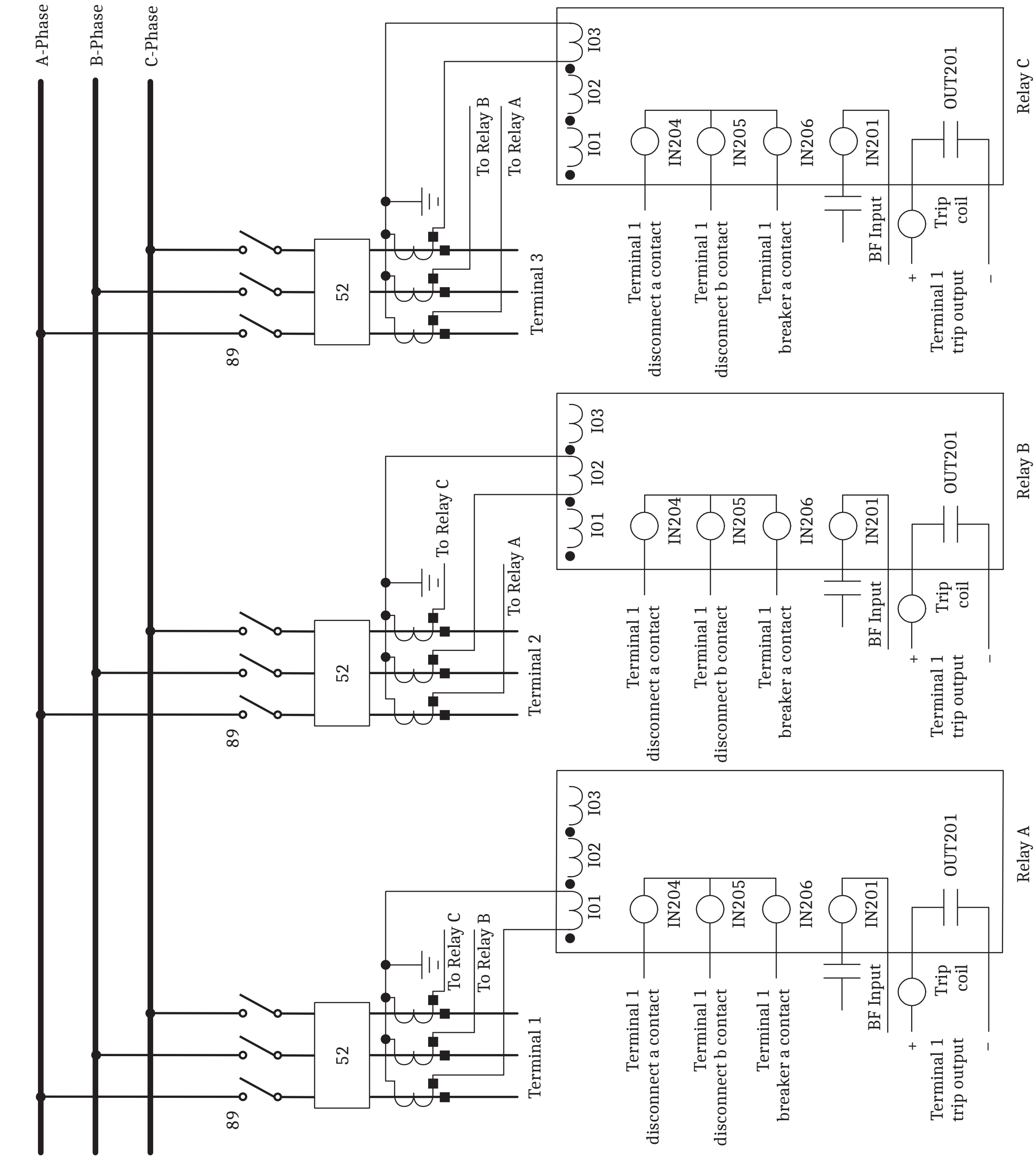


Figure 2.43 Typical External AC/DC Connections for a Three-Relay Application

SECTION 3

Testing

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. *Section 10: Testing, Troubleshooting, and Maintenance in the SEL-400 Series Relays Instruction Manual* addresses the concepts related to testing. This section provides supplemental information specific to testing the SEL-487B.

This section includes the following topics:

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.

Low-Level Test Interface

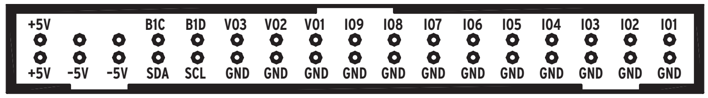
You can test the relay in two ways: by using secondary injection testing or by applying low-magnitude ac voltage signals to the low-level test interface. This section describes the low-level test interface between the two calibrated input modules and the processing module.

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 J14 and J24, the analog or low-level test interface connections. Receptacle J24 is on the right side of the main board, with J14 located 5 cm (2 inches) behind J20; for a locating diagram, see *Figure 2.14*.

⚠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.

NOTE: The relay front, I/O, and CAL boards are not hot-swappable. Remove all power from the relay before altering ribbon cable connections.

Figure 3.1 shows the connections for low-level interface J24 and *Figure 3.2* the connections for low-level interface J14. 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 J14 and J24 receptacles and substitute a test cable with the signals specified in *Figure 3.1* and *Figure 3.2*.

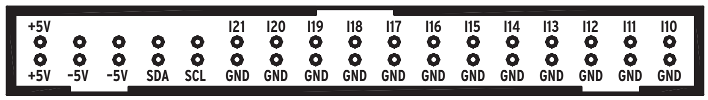


Input Module Output (J3): 66.6 mV at Nominal Current (1 A or 5 A).
446 mV at Nominal Voltage (67 V_{LN}).

Processing Module Input (J24): 6.6 V_{p-p} Maximum.

U.S. Patent 5,479,315.

Figure 3.1 Low-Level Test Interface J24



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 (J14): 6.6 V_{p-p} Maximum.

U.S. Patent 5,479,315.

Figure 3.2 Low-Level Test Interface J14

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 J14 and J24 from the Relay Test System (see *Figure 3.1* and *Figure 3.2*). 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 3.1*, *Table 3.2*, *Table 3.3*, and *Table 3.4*.

Table 3.1 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 3.2 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
10	I19	75	A
11	I20	75	A
12	I21	75	A

Table 3.3 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 3.4 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Z)—1 A Relay (Sheet 1 of 2)

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

Table 3.4 UUT Database Entries for SEL-5401 Relay Test System Software (Analog Input Board Z)—1 A Relay (Sheet 2 of 2)

Channel	Label	Scale Factor	Unit
10	I19	15	A
11	I20	15	A
12	I21	15	A

Relay Test Connections

The SEL-487B is a flexible tool that you can use to implement many protection and control schemes. Although you can connect the relay to the power system in many ways, connecting basic bench test sources helps you model and understand more complex relay field connection schemes.

NOTE: The procedures specified in this subsection are for initial relay testing only. Follow your company policy for connecting the relay to the power system.

For each relay element test, you must apply ac voltage and current signals to the relay. The text and figures in this subsection describe the test source connections you need for relay protection element checks. You can use these connections to test protective elements and simulate all fault types. These examples show connections on I01, I02, and I03. You can make similar connections to any of the current inputs: I01–I21.

Connections for Three Voltage Sources and Three Current Sources

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

Figure 3.3 shows the connections to use when you have three voltage sources and three current sources available.

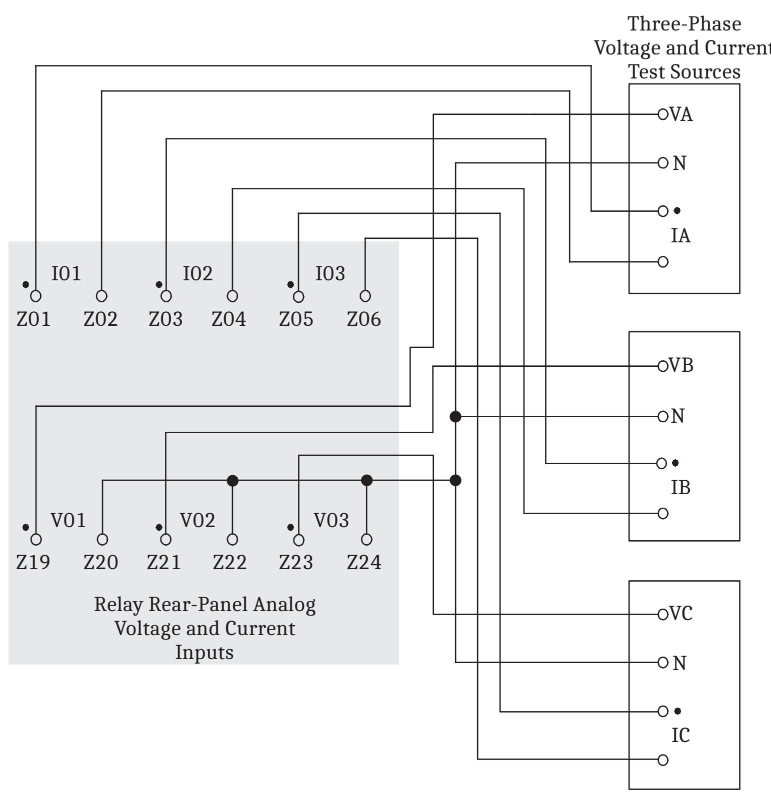


Figure 3.3 Test Connections Using Three Voltage and Three Current Sources

Connections for Three Voltage Sources and Two Current Sources

Figure 3.4 and *Figure 3.5* show connections to use when you have three voltage sources and two current sources. You can use the connections shown in *Figure 3.4* to simulate phase-to-phase, phase-to-ground, and two-phase-to-ground faults. Use the connections shown in *Figure 3.5* to simulate three-phase faults.

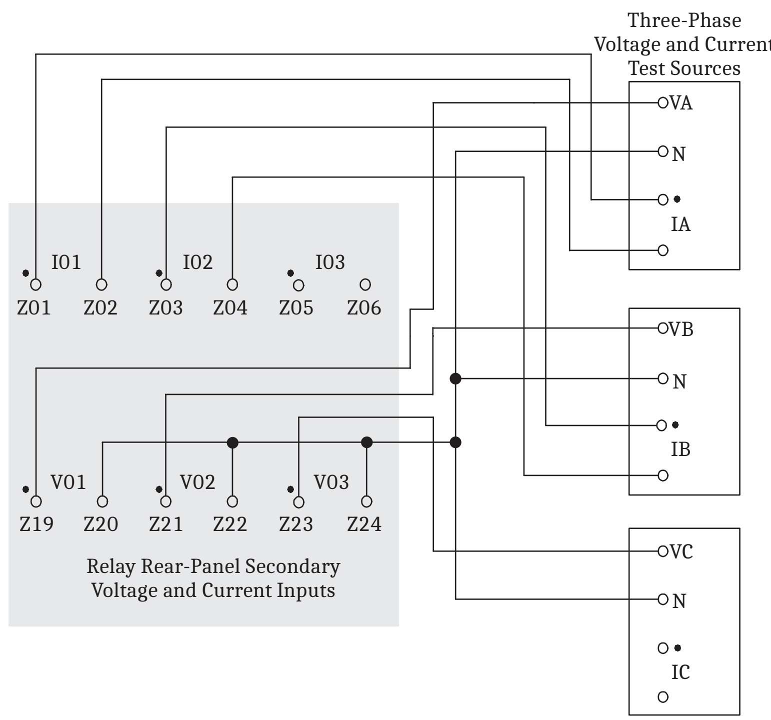


Figure 3.4 Test Connections Using Two Current Sources for Phase-to-Phase, Phase-to-Ground, and Two-Phase-to-Ground Faults

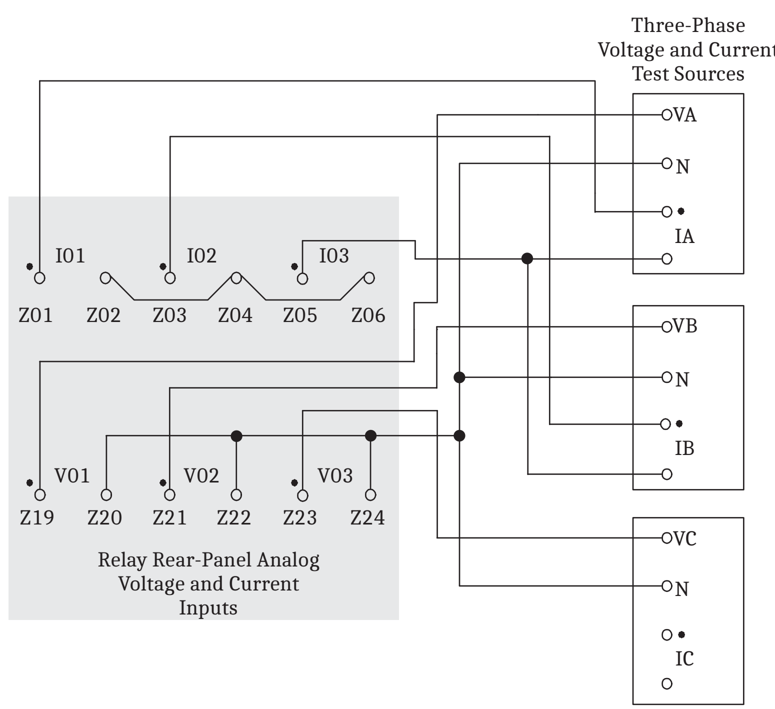


Figure 3.5 Test Connections Using Two Current Sources for Three-Phase Faults

Connections for Three Voltage Sources and One Current Source

Figure 3.6 and *Figure 3.7* show connections to use when you have three voltage sources and a single current source. You can use the connections shown in *Figure 3.6* to simulate phase-to-ground faults. Use the connections shown in *Figure 3.7* to simulate phase-to-phase faults.

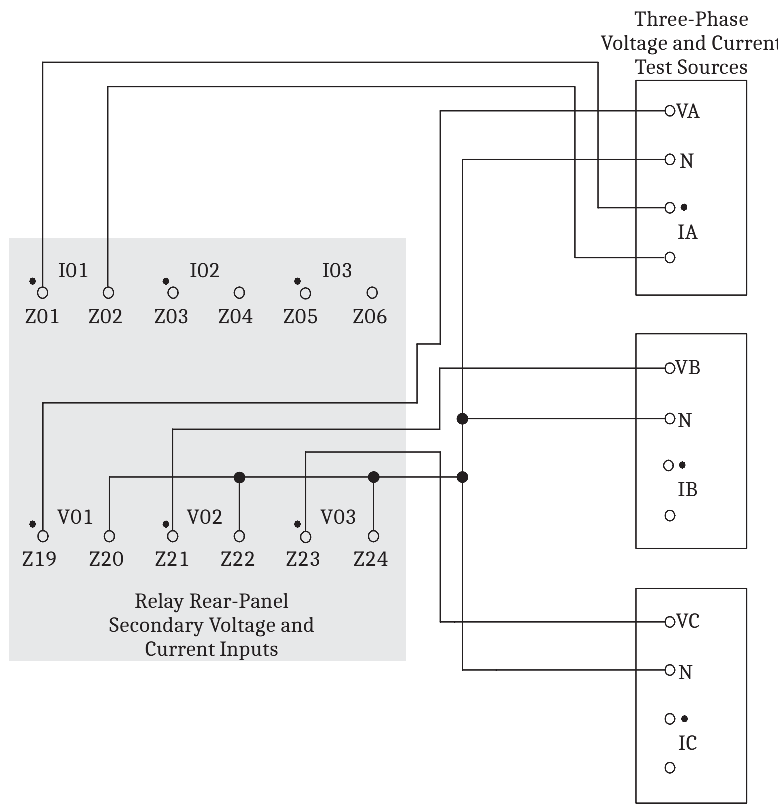


Figure 3.6 Test Connections Using a Single Current Source for a Phase-to-Ground Fault

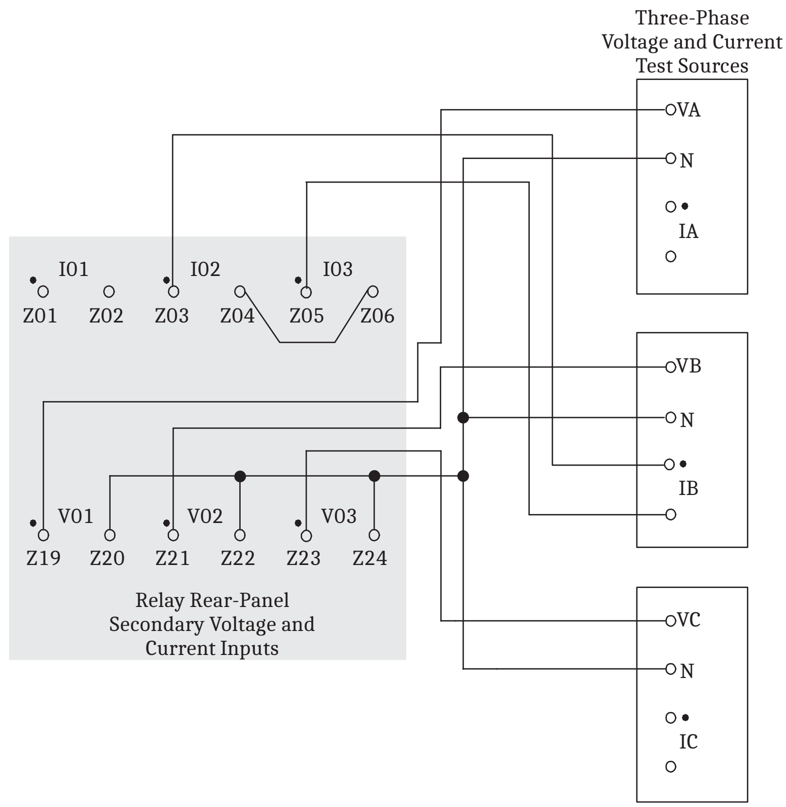


Figure 3.7 Test Connections Using a Single Current Source for a Phase-to-Phase Fault

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 3.34 in the SEL-400 Series Relays Instruction Manual*). 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 3.55 in the SEL-400 Series Relays Instruction Manual*). 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 apply the appropriate settings to the relay.

Example Substation

Figure 3.8 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).

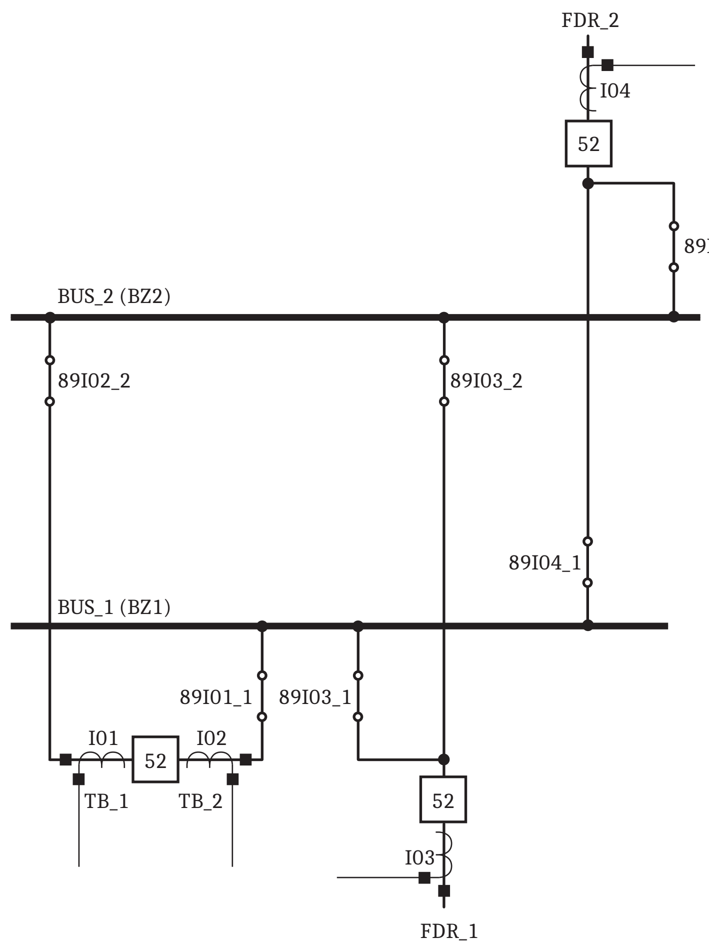


Figure 3.8 Station Layout, Comprising a Tie Breaker, Two Feeders and Two Busbars

Use front-panel pushbuttons to simulate the disconnect auxiliary contacts for the terminal-to-bus-zone SELOGIC control equations as shown in *Figure 3.8*. *Table 3.5* shows the SELOGIC control equation assignments.

NOTE: Pushbutton labels PB1–PB8 (shown in Figure 3.9) identify the pushbuttons for this test; these labels do not appear on the relay front panel.

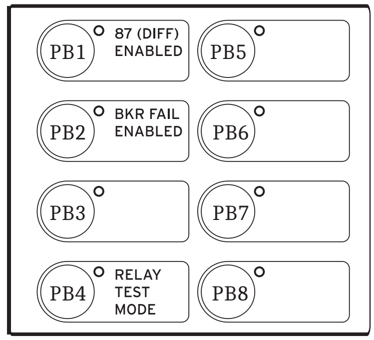


Figure 3.9 Front-Panel Operator Pushbuttons

Table 3.5 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 3.8*, 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 3.8*. From Access Level 2, use the **SET T** command to rename the analog channels, as shown in *Figure 3.10*. Some of the alias names assigned in this example are default alias names in the relay. If an alias name is duplicated, type **Delete <Enter>** to clear the default alias names that are not relevant to this example.

```
=>>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"
?  IO1,TB_1 <Enter>
2: IO2,"FDR_2"
?  IO2,TB_2 <Enter>
3: IO3,"FDR_3"
?  IO3,FDR_1 <Enter>
4: IO4,"TRFR_1"
?  IO4,FDR_2 <Enter>
5: IO5,"TB_1"
?  BZ1, BUS_1 <Enter>
6: IO6,"TB_2"
?  BZ2, BUS_2 <Enter>
7: BZ1,"BUS_1"
?  DELETE <Enter>   (Note, this is to clear default alias settings for this
   example)
7: BZ2,"BUS_2"
?  DELETE <Enter>
7: FBF01,"F1_BF"
?  END <Enter>
Alias
.
.
.
Save settings (Y,N) ? Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 3.10 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 on page 3.12*). *Figure 3.11* 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
?  PLT07 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I02BZ1C := TB_2, BUS_1, P
?  TB_2, BUS_1, P <Enter>
TB_2 to BUS_1 Connection (SELogic Equation)
I02BZ1V := DIFF_EN AND NOT TOS02
?  PLT08 <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
?  PLT09 <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
?  PLT10 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I05BZ1C := I05, BUS_1, P
?  DELETE <Enter>
Terminal, Bus-Zone, Polarity (P,N)
I06BZ2C := I06, BUS_2, P
?  DELETE <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 3.11 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 3.12* shows the steps to disable the sensitive differential elements.

```
=>>SET <Enter>

Relay Configuration
Sensitive Differential Element Supervision (Y,N)     E87SSUP := Y      ?N <Enter>
.
Save settings (Y,N)  ?Y <Enter>

=>>
```

Figure 3.12 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 3.13* shows the steps to program the protection latch bits.

```
=>>SET L <Enter>

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 3.13 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 3.14* 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
?  PLT07 <Enter>
Pushbutton LED 6 (SELogic Equation)
PB6_LED := NA
?  PLT08 <Enter>
Pushbutton LED 7 (SELogic Equation)
PB7_LED := NA
?  PLT09 <Enter>
Pushbutton LED 8 (SELogic Equation)
PB8_LED := NA
?  PLT10 <Enter>
Target LED 1 (SELogic Equation)
T1_LED := 87BTR
?  END <Enter>
.
.
.
Save settings (Y,N)  ? Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 3.14 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 3.15*.

Information shown in *Figure 3.15* 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
TB_1 to BUS_1 Connection (SELogic Equation)
I01BZ1V := PLT07
Terminal, Bus-Zone, Polarity (P,N)
I02BZ1C := TB_2, BUS_1, P
TB_2 to BUS_1 Connection (SELogic Equation)
I02BZ1V := PLT08
Terminal, Bus-Zone, Polarity (P,N)
I03BZ1C := FDR_1, BUS_1, P
FDR_1 to BUS_1 Connection (SELogic Equation)
I03BZ1V := PLT09
Terminal, Bus-Zone, Polarity (P,N)
I04BZ2C := FDR_2, BUS_2, P
FDR_2 to BUS_2 Connection (SELogic Equation)
I04BZ2V := PLT10

.
.
.

Current Normalization Factor

TAP01   := 5.00     TAP02   := 5.00     TAP03   := 5.00     TAP04   := 5.00

=>>
```

Figure 3.15 Selected Information From the Relay Response to the SHO Z Command

Selected Element Tests

Zone Selection Function

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.

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 3.16 shows the relay response, confirming that Terminal TB_1 is an active terminal in BUS_1.

```
=>>MET Z1 <ENTER>

Relay 1                                    Date: 09/10/2015  Time: 07:41:32.970
Station A                                  Serial Number: 1150010001

Current Terminals in Protection Zone 1

       Primary Currents
Terminal    MAG(A)   ANG(DEG)  POL
 TB_1         0.291    -6.94    P

       Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01          0.002   -37.06
 V02          0.003   -53.56
 V03          0.001  -169.73

Bus-Zones in Protection Zone 1
BUS_1

=>>
```

Figure 3.16 Relay Response to the MET Z1 Command

Sensitive Differential Element

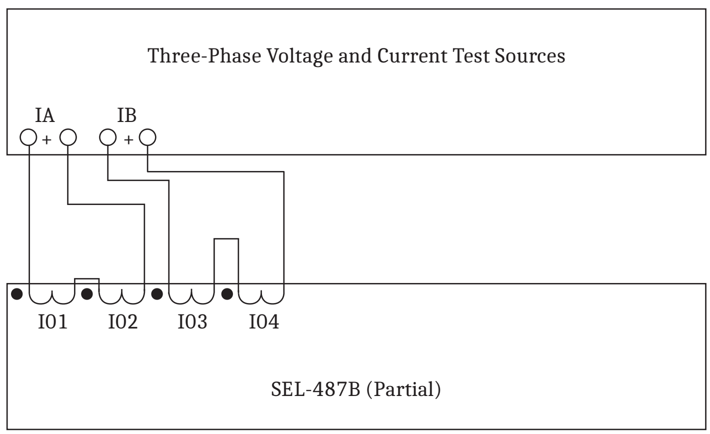


Figure 3.17 Test Connections Using Two Current Sources

Step 1. Use the test connections shown in *Figure 3.17* for this test.

Step 2. Inject the current values listed in *Table 3.6* into the relay.

Table 3.6 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 3.14*) is closed, the relay only considers the CT input from TB_1.

The CT ALARM LED illuminates 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 turns off.

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 3.18 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:

$$IOP(IRT) = \frac{SLP1}{100} \bullet IRT$$

Equation 3.1

where:

IOP(IRT) = Operating current as a function of the restraint current
SLP1 = Differential element Slope 1 setting
IRT = Differential element restraint current

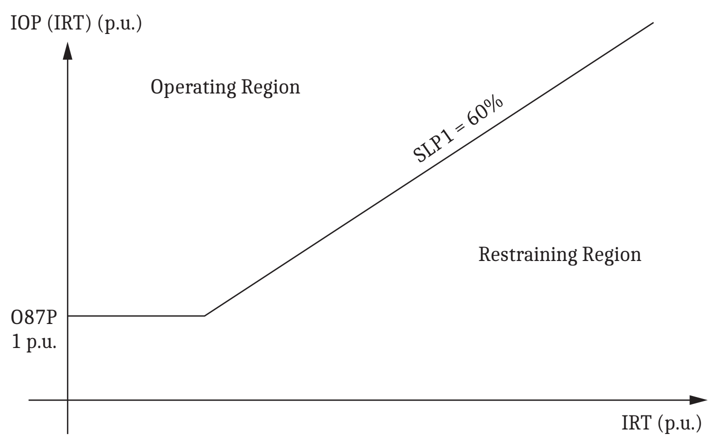


Figure 3.18 Differential Element Characteristic

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 in *Table 3.6* into the relay.

b. Type **MET DIF <Enter>**.

The current values should approximate those in *Figure 3.19*:

```
=>>MET DIF <Enter>

Relay 1                                     Date: 09/10/2015  Time: 07:41:32.970
Station A                                   Serial Number: 1150010001

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 3.19 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 in *Figure 3.20*.

f. Stop the injection.

g. Press the **TARGET RESET** pushbutton.

```
=>>MET DIF <Enter>

Relay 1                                     Date: 09/10/2015  Time: 07:41:32.970
Station A                                   Serial Number: 1150010001

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 3.20 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 3.1* 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.

$$\begin{aligned}\text{IOP(IRT)} &= \frac{\text{SLP1}}{100} \bullet \text{IRT}\\ &= 0.6 \bullet 3 \text{ per unit}\\ &= 1.8 \text{ per unit}\end{aligned}$$

Step 2. Use *Equation 3.2* and *Equation 3.3* 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.

$$\begin{aligned}\text{I1}_{\text{pu}} &= \frac{\text{IRT + IOP(IRT)}}{2} \text{per unit}\\ &= \frac{3.0 + 1.8}{2} \text{per unit}\\ &= 2.4 \text{ per unit}\end{aligned}$$

Equation 3.2

$$\begin{aligned}\text{I2}_{\text{pu}} &= \text{IRT–I1}_{\text{pu}} \text{ per unit}\\ &= 3.0\text{–}2.4 \text{ per unit}\\ &= 0.6 \text{ per unit}\end{aligned}$$

Equation 3.3

Step 3. Use *Equation 3.4* to convert the current values from per-unit values to current values in amperes:

$$\begin{aligned}\text{I1}_{\text{A}} &= \text{TAP01} \bullet \text{I1}_{\text{pu}} \text{ A}\\ &= 5 \bullet 2.4 \text{ A}\\ &= 12.0 \text{ A}\end{aligned}$$

$$\begin{aligned}\text{I2}_{\text{A}} &= \text{TAP02} \bullet \text{I2}_{\text{pu}} \text{ A}\\ &= 5 \bullet 0.6 \text{ A}\\ &= 3.0 \text{ A}\end{aligned}$$

Equation 3.4

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 3.7* into the relay.

Table 3.7 Current for Testing the Second Point on the Relay Characteristic

Current	Value
IA	12.0∠0°
IB	3.2∠180°

The CT ALARM LED illuminates 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 3.21*:

```
=>>MET DIF <Enter>

Relay 1                                     Date: 09/10/2015  Time: 07:41:32.970
Station A                                   Serial Number: 1150010001

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 3.21 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.

IB should be 3 A ±5% and ±0.02 • I_{NOM}.

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 3.22*.

```
=>>MET DIF <Enter>

Relay 1                                     Date: 09/10/2015  Time: 07:41:32.970
Station A                                   Serial Number: 1150010001

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 3.22 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 3.23*.

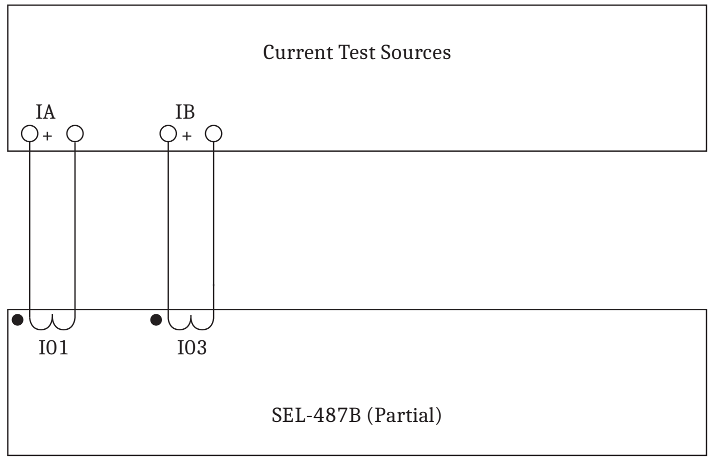


Figure 3.23 Test Connections for Testing the Directional Element

Figure 3.24 shows the directional element characteristic, the shaded area indicating an internal fault.

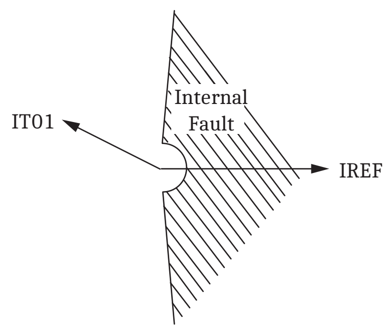


Figure 3.24 Directional Element Characteristic

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 3.8* into the relay.

Table 3.8 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 3.25*.

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 3.25 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 3.9* into the relay.

Table 3.9 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 3.26*.

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 3.26 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 degrees.

f. Quickly move the angle to –70 degrees and continue to slowly decrease the angle of current IB.

   Relay Word bit DE1F deasserts when the angle reaches a value of approximately –74 degrees.

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-1 includes six overvoltage and six undervoltage elements. Each element has two pickup level settings, with a definite-time delay assigned to Level 1. The operating quantity for the input to each voltage element is selectable, with phase, zero-sequence, and negative-sequence voltage quantities available for selection. We will test the phase voltage elements for the voltage inputs.

Phase Over- and Undervoltage Elements

Figure 3.27 shows the steps to apply settings to the over- and undervoltage elements to V01.

```
=>>SET E27 <Enter>

Group 1

Relay Configuration

Enable Under Voltage Elements (N,1-6)               E27     := N      ?1 <Enter>
Enable Over Voltage Elements (N,1-6)                E59     := N      ?1 <Enter>
Advanced Settings (Y,N)                             EADVS   := N      ? <Enter>

.
.
.

Under Voltage (27) Element 1

U/V Element 1 Operating Quantity                    2701    := V01FIM ? <Enter>
U/V Element 1 Level 1 P/U (2.00-300 V,sec)          27P1P1  := 20.00  ?60 <Enter>
U/V Element 1 Torque Control (SELogic Eqn)
27TC1 := 1
?  <Enter>
U/V Element 1 Level 1 Delay (0.00-16000 cyc)        27P1D1  := 10.00  ? <Enter>
U/V Element 1 Level 2 P/U (2.00-300 V,sec)          27P1P2  := 15.00  ?55 <Enter>


Over Voltage (59) Element 1

O/V Element 1 Operating Quantity                    5901    := V01FIM ? <Enter>
O/V Element 1 Level 1 P/U (2.00-300 V,sec)          59P1P1  := 76.00  ?70 <Enter>
O/V Element 1 Torque Control (SELogic Eqn)
59TC1 := 1
?  <Enter>
O/V Element 1 Level 1 Delay (0.00-16000 cyc)        59P1D1  := 10.00  ? <Enter>
O/V Element 1 Level 2 P/U (2.00-300 V,sec)          59P1P2  := 80.00  ?75 <Enter>


Trip Logic

Trip 01 (SELogic Equation)
TR01 := 0
?  END <Enter>
.
.
.

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

=>>
```

Figure 3.27 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 3.28*.

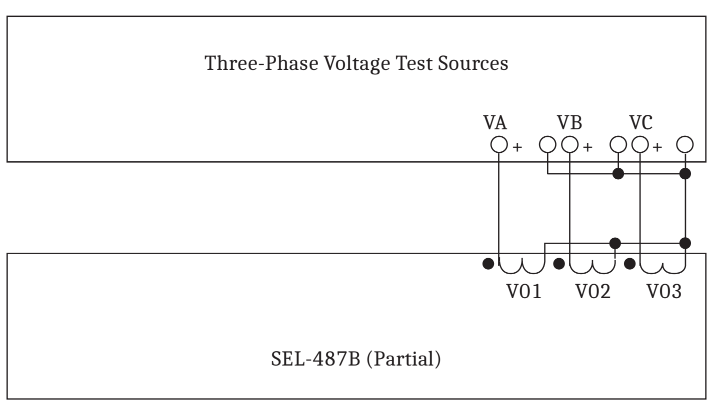


Figure 3.28 Test Connections for Testing the Voltage Elements

Step 2. Test the overvoltage elements by applying the voltage values shown in *Table 3.10* to the relay.

Table 3.10 Injected Voltage Values for Testing the Overvoltage Elements

Channel	Voltage Value
VA	67∠0°
VB	67∠–120°
VC	67∠120°

The voltage elements are on a per-phase basis, with V01 (A-phase) assigned to voltage Element 1. Similar steps can be followed to assign V02 (B-phase) to voltage Element 2 and V03 (C-phase) to voltage Element 3. Relay Word bits 591P1T, 591P2, 592P1T, and 592P2 are in the same row.

a. Type **TAR 591P1T 999 <Enter>** to see the status of these Relay Word bits.

b. Raise the A-phase voltage (V01) until Relay Word bit 591P1 asserts.

   The voltage should equal 70 V ±0.5 V and ±5%.

c. Continue to increase the voltage until Relay Word bit 591P2 asserts.

   The voltage should equal 75 V ±0.5 V and ±5%.

d. Type **<Ctrl+X> <Enter>** to end the scrolling of the Relay Word bits status values.

e. Stop the injection.

Step 3. Test the undervoltage elements.

a. Apply the voltage values shown in *Table 3.10* to the relay.

b. Type **TAR 271P1T 999 <Enter>** to see the status of these Relay Word bits.

c. Lower the A-phase voltage (V01) until Relay Word bit 271P1 asserts.

   The voltage should equal 60 V ±0.5 V and ±5%.

d. Continue to lower the applied voltage until Relay Word bit 271P2 asserts.

   The voltage should equal 55 V ±0.5 V and ±5%.

e. Type **<Ctrl+X> <Enter>** to end the scrolling of the Relay Word bits status values.

f. Stop the injection.

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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SECTION 4

Front-Panel Operations

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, group, and global 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, group, global, date, and time settings
- Controlling relay operations

General front-panel operations are described in *Section 4: Front-Panel Operations in the SEL-400 Series Relays Instruction Manual*. This section provides additional information that is unique to the SEL-487B. This section includes the following:

- *Front-Panel LCD Default Displays on page 4.1*
- *Front-Panel Menus and Screens on page 4.5*
- *Target LEDs on page 4.7*
- *Front-Panel Operator Control Pushbuttons on page 4.9*

Front-Panel LCD Default Displays

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 4.1* (see *Figure 4.4* for samples of the metering screens). This sequence comprises the ROTATING DISPLAY.

Table 4.1 Metering Screens Enable Settings (Sheet 1 of 2)

Name	Description	Range	Default
STA_BAT	Station Battery Screen	Y, N	N
FUND_VI	Fundamental Voltage and Current Screens	Y, N	Y

Table 4.1 Metering Screens Enable Settings (Sheet 2 of 2)

Name	Description	Range	Default
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 ACSELERATOR QuickSet SEL-5030 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 4.1* 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 4.1* are representative values).

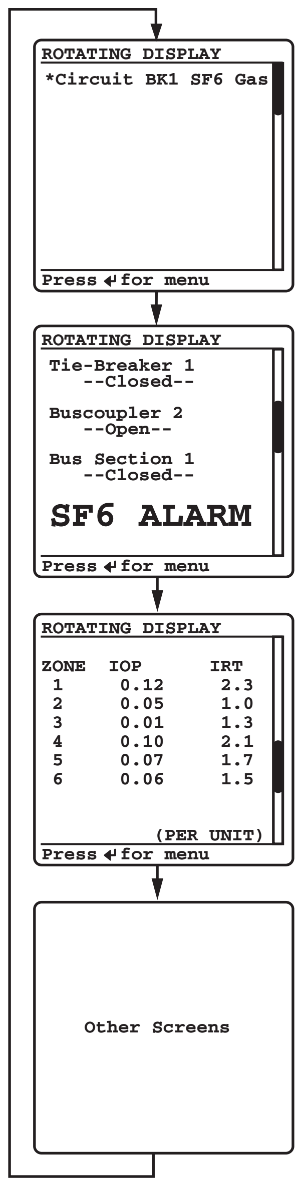

Figure 4.1 ROTATING DISPLAY

The active alarm points are the first screens in the ROTATING DISPLAY (see *Alarm Points on page 4.7 in the SEL-400 Series Relays Instruction Manual*). Each alarm points screen shows as many as 11 alarm conditions. The SEL-487B 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 4.10 in the SEL-400 Series Relays Instruction Manual*). Each display points screen shows as many as 11 enabled display points. (With 94 display points, the SEL-487B can present a maximum of 9 display point screens.) If a display point does not have text to display, the screen space for that display point is maintained.

METER

Factory-enabled metering screens scroll through the following metering screens:

- ➤ Differential quantities
- ➤ Zone configuration (when active)
- ➤ Fundamental Current
- ➤ Fundamental Voltage

Figure 4.2 shows the zone specific and check zone differential metering screens. 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 4.2* shows an example with two zones active.

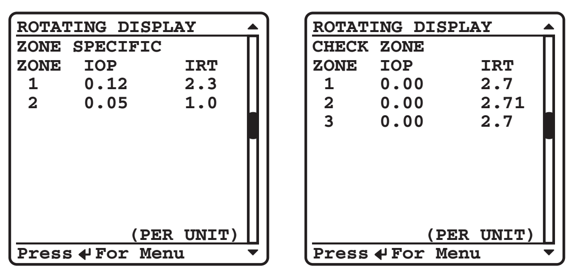

Figure 4.2 Differential Screens

Figure 4.3 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.

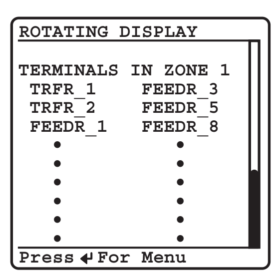

Figure 4.3 Terminals in Zone Screen

Figure 4.4 shows the fundamental current screens, displaying the primary current and phase angle for each terminal.

```
ROTATING DISPLAY
PRIMARY CURRENT (A)

TERM ID   MAG/ANGLE

FDR_1   214.45   45°
FDR_2   230.07   50°
FDR_3   121.49 -143°
TRFR_1   20.64 -119°
TB_1    212.32   75°
TB_1    321.44   49°

Press ↵ For Menu
```

```
ROTATING DISPLAY
PRIMARY CURRENT (A)

TERM ID   MAG/ANGLE
I07     214.45   45°
I08     230.07   50°
I09     121.49 -143°
I10      20.64 -119°
I11     212.32   75°
I12     321.44   49°

Press ↵ For Menu
```

```
ROTATING DISPLAY
PRIMARY CURRENT (A)

TERM ID   MAG/ANGLE
I13     214.45   45°
I14     230.07   50°
I15     121.49 -143°
I16      20.64 -119°
I17     212.32   75°
I18      21.44   49°

Press ↵ For Menu
```

```
ROTATING DISPLAY
PRIMARY CURRENT (A)

TERM ID   MAG/ANGLE
I19     214.45   45°
I20     230.07   50°
I21     121.49 -143°

Press ↵ For Menu
```

Figure 4.4 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 4.5 shows the primary voltage magnitudes and angles from the three voltage inputs in kV.

```
ROTATING DISPLAY
PRIMARY VOLTAGE (kV)

TERM ID  MAG/ANGLE
V01     88.00    5°
V02     88.00 -125°
V03     88.00  115°

Press ↵ For Menu
```

Figure 4.5 Fundamental Primary Voltage Screen

Use the **SET F** command and set STA_BAT = Y to enable the station battery screen, as displayed in *Figure 4.6*.

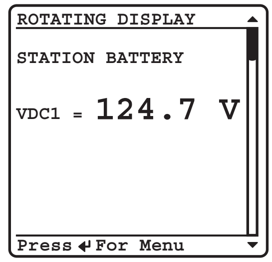

Figure 4.6 Station Battery Screen

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. 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`

See *Section 4: Front-Panel Operations in the SEL-400 Series Relays Instruction Manual* for information on most of these screens. The following screen descriptions are unique to the SEL-487B.

Events

Section 4: Front-Panel Operations in the SEL-400 Series Relays Instruction Manual describes viewing summary events from the front panel. *Figure 4.7* illustrates what a summary event report looks like in an SEL-487B.

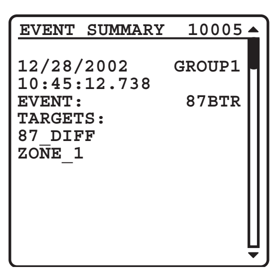

Figure 4.7 EVENT SUMMARY Screen

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 4.8*. Use the navigation pushbuttons to scroll through these screens. When finished viewing these screens, press **ESC** to return to the MAIN MENU.

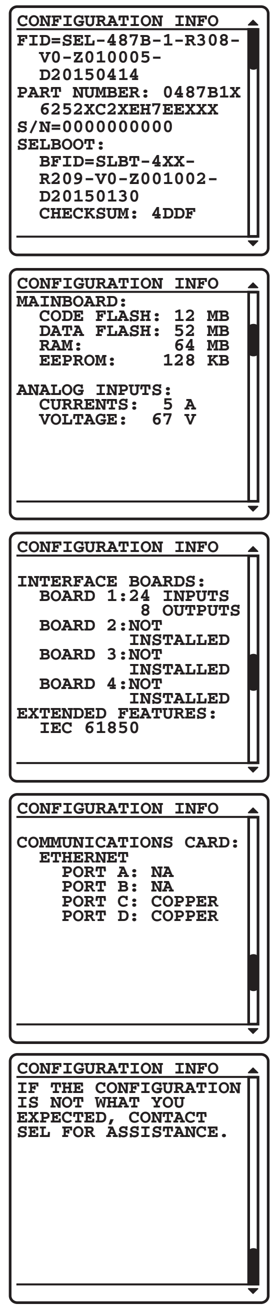

Figure 4.8 VIEW CONFIGURATION Sample Screens

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.

The general operation and configuration of these LEDs is described in *Section 4: Front-Panel Operations in the SEL-400 Series Relays Instruction Manual*. Please note that the SEL-487B has the alternate behavior on the T*n*_LED bits: they latch independently of the trip condition. For a concise listing of the default programming on the front-panel LEDs, see *Front-Panel Settings on page 12.20 in the SEL-400 Series Relays Instruction Manual*.

Use the slide-in labels to mark the LEDs with custom names. Download the word processor configurable label templates for printing slide-in labels from selinc.com. *Figure 4.9* shows the arrangement of the operation and target LEDs region into several areas described in *Table 4.2*.

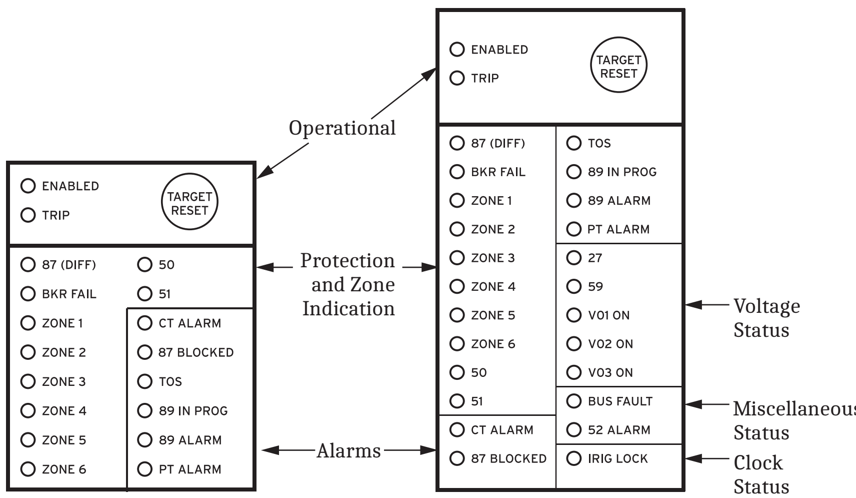

Figure 4.9 Factory-Default Front-Panel Target Areas (16 or 24 LEDs)

Table 4.2 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] BUS FAULT[a], 52 ALARM[a] IRIG LOCK[a]	Voltage Status Miscellaneous Status Clock Status

[a] Only available in 24 LED models.

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 21 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 21 nondirectional, instantaneous elements.

The **51** target LED illuminates and latches the indication, indicating operation of any one of the 21 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 21 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 60 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 with an ABC phase rotation. 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 8.50* 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 500 ns of jitter (Relay Word bit TIRIG is asserted). See *IRIG-B Timekeeping on page 11.1 in the SEL-400 Series Relays Instruction Manual* 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 4.10* 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.

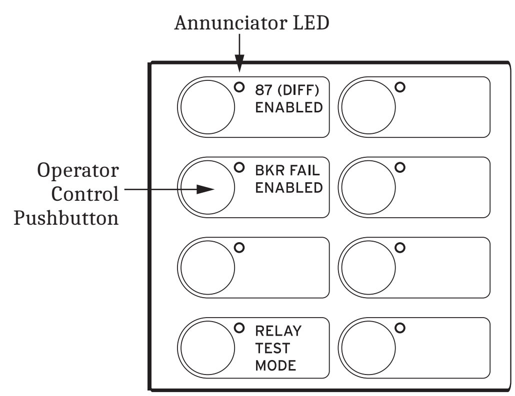

Figure 4.10 Operator Control Pushbuttons and LEDs (8 Pushbutton Version)

Factory-default programming associates specific relay functions with the pushbuttons and LEDs. The SEL-487B default setting uses only three of the pushbuttons, as listed in *Table 4.3*. For a concise listing of the default programming for the front-panel pushbuttons and LEDs, see *Front-Panel Settings on page 8.21*.

Table 4.3 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 4.11* 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. All PB*n*_HMI settings are OFF by default. 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. Download the word processor configurable label templates for printing slide-in labels from selinc.com. See *Front-Panel Templates on page 2.2* 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–PB12 are the “follow” outputs of operator control pushbuttons. Relay Word bits PB1_PUL–PB12PUL are the “pulsed” outputs.

Annunciator LEDs for each operator control pushbutton are PB1_LED–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 PB1COL–PB12COL (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.

SELOGIC Factory Setting	Operator Control Pushbutton	LED Label	Description
PB1_LED = DIFF_EN # Differential Protection Enabled		87 (DIFF) ENABLED	Press this operator control pushbutton enable differential protection. The corresponding **87 (DIFF) ENABLED** LED is illuminated amber indicating that DIFF_EN=1. DIFF_EN is the default alias setting for the Relay Word bit PLT01. DIFF_EN is included in the Terminal to Bus Connection Logic setting for I*qq*BZ*p*V (*qq* = 00–21, *p* = 1–6) and effectively supervises the terminal to bus-zone connection. Therefore, if PB1 is not pressed, DIFF_EN = 0 and the terminal Iqq will not be connected to bus zone BZp. To disable differential protection, press and hold this pushbutton for one second until the LED is no longer illuminated. If the LED is off, DIFF_EN = 0.
PB2_LED = BF_EN # Breaker Failure Enabled		BKR FAIL ENABLED	Press this operator control pushbutton enable breaker failure initiate settings. The corresponding **BKR FAIL ENABLED** LED is illuminated amber indicating that BF_EN = 1. BF_EN is the default alias setting for the Relay Word bit PLT02. BF_EN is included in the Breaker Failure Initiate setting for BFI01–BFI06. Therefore, if PB2 is not pressed, BF_EN = 0 and the breaker failure initiate equation cannot be true. To disable breaker failure protection, press and hold this pushbutton for one second until the LED is no longer illuminated. If the LED is off, BF_EN = 0.
PB3_LED = NA			
PB4_LED = TNS_SW # Test normal Switch Enabled		RELAY TEST MODE	Press this operator control pushbutton to disable outputs OUT101–OUT105 and close OUT107. The corresponding **RELAY TEST MODE** LED is illuminated amber indicating that TNS_SW = 1. TNS_SW is the default alias setting for the Relay Word bit PLT03. TNS_SW is included in the output equation for OUT101–OUT105. Therefore, if PB4 is pressed, TNS_SW = 1 and the output equations supervised by this Relay Word bit cannot be true and the associated outputs will not close. This is useful functionality for testing TRIP01–TRIP05 equations during commissioning, but preventing the output operation. To disable the test mode, press and hold this pushbutton for one second until the LED is no longer illuminated. If the LED is off, TNS_SW = 0.
PB5_LED = NA PB6_LED = NA PB7_LED = NA PB8_LED = NA PB9_LED = NA PB10LED = NA PB11LED = NA PB12LED = NA			

Figure 4.11 Factory-Default Operator Control Pushbuttons

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SECTION 5

Protection Functions

NOTE: If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay.

This section provides a detailed explanation of the SEL-487B relay protection functions. Each subsection provides an explanation of the function, along with a list of the corresponding settings and Relay Word bits. Logic diagrams and other figures are included.

Functions discussed in this section are listed below.

Busbar Protection Elements

Busbar protection philosophy traditionally calls for two-out-of-two trip criteria, where two separate measuring elements must agree before protection issues a trip signal. Realization of the two-out-of-two trip criteria can occur by using one of the combinations of measuring elements listed below:

- Dual differential element combination (main zone and check zone)
- Differential element and directional element combination (main zone and directional element)

Each combination has an advantage over the other; the weakness of one being the strength of the other. In particular, differential elements (amplitude comparators) are more vulnerable to CT saturation than directional elements (phase comparators), but directional elements (phase comparators) are more vulnerable to high-impedance faults.

CT saturation is a concern in networks with high fault currents. Poor CT selection increases the potential for CT saturation. In networks with impedance grounding, all ground faults are high-impedance faults. Although relays may have been correctly selected in the initial network design, changes in the network may adversely influence the network parameters. For example, network extensions or reduced source impedance result in higher fault current, and deterioration of the substation grounding mat at the substation may result in higher fault impedance for ground faults.

Modern busbar protection relays should not only include protection elements to allow for diverse network parameters, but the implementation of these elements in the relays must ensure continual, uncompromising relay performance, despite changes in network parameters. In general, busbar protection must comply with the following performance requirements:

- Fast operating times for all busbar faults
- Security for external faults with heavy CT saturation
- Minimum delay for evolving faults

The SEL-487B meets the above performance requirements during all system operating conditions. The relay includes six busbar protection elements for the protection of as many as six zones. Each of the six busbar protection elements consists of the following three elements (see *Figure 5.1*):

- Differential element using phasor values
- Directional element using phasor values
- Fault detection logic using instantaneous values

Figure 5.1 shows a block diagram of one of the six busbar protection elements, with only two (I01 and I02) of the available 21 current inputs connected. The relay uses the highest CT ratio (CTR_{MAX}) divided by the lowest CT ratio (CTR_{MIN}) to verify that the CT ratio mismatch for the differential protection is less than 10:1. Only CT ratios associated with terminals that are used in the terminal-to-bus-zone settings will be used to determine CTR_{MAX} and CTR_{MIN}. Because the relay accepts current inputs from CTs with a 10:1 ratio mismatch, the calculations for the differential elements are performed on per unit values. The relay uses the highest CT ratio (CTR_{MAX}) of the installed CT ratios as a reference value in converting the input currents from ampere to per unit values. Using *Equation 5.1*, the relay calculates a normalization factor value (TAP) for each terminal:

$$\mathrm{TAP}nn = \frac{\mathrm{CTR_{MAX}} \bullet \mathrm{I_{NOM}}}{\mathrm{CTR}nn}$$

Equation 5.1

where:

TAP*nn* =	TAP value for each terminal to convert current from ampere to per unit (*nn* = 01–21)
CTR_{MAX} =	Highest CT ratio of the terminals used in the terminal-to-bus-zone settings
I_{NOM} =	Nominal CT secondary current (1 A or 5 A)
CTR*nn* =	CT ratio of the specific terminal

Using the TAP*nn* values, the relay calculates the current in per unit values for each terminal as shown in *Equation 5.2*:

$$\mathrm{I}nn\mathrm{CR} = \frac{\mathrm{I}nn}{\mathrm{TAP}nn}\mathrm{pu}$$

Equation 5.2

where:

I*nn*CR = Per unit current for Terminals I01–I21
I*nn* = Current in amperes for Terminals I01–I21
pu = per unit

Figure 5.1 shows the block diagram for Busbar Protection Element 1, one of six busbar protection elements available in the relay. Throughout the following element descriptions, the numerical part of the Relay Word bits refers either to elements from a specific busbar protection element (1–6) or the specific terminal number (01–21). In most cases, the protection element descriptions refer to elements from Busbar Protection Element 1. For example, FDIF1 in *Figure 5.1* refers to the output from the filtered differential element of Busbar Protection Element 1. I01 and I02 refer to current inputs from Terminal I01 and Terminal I02.

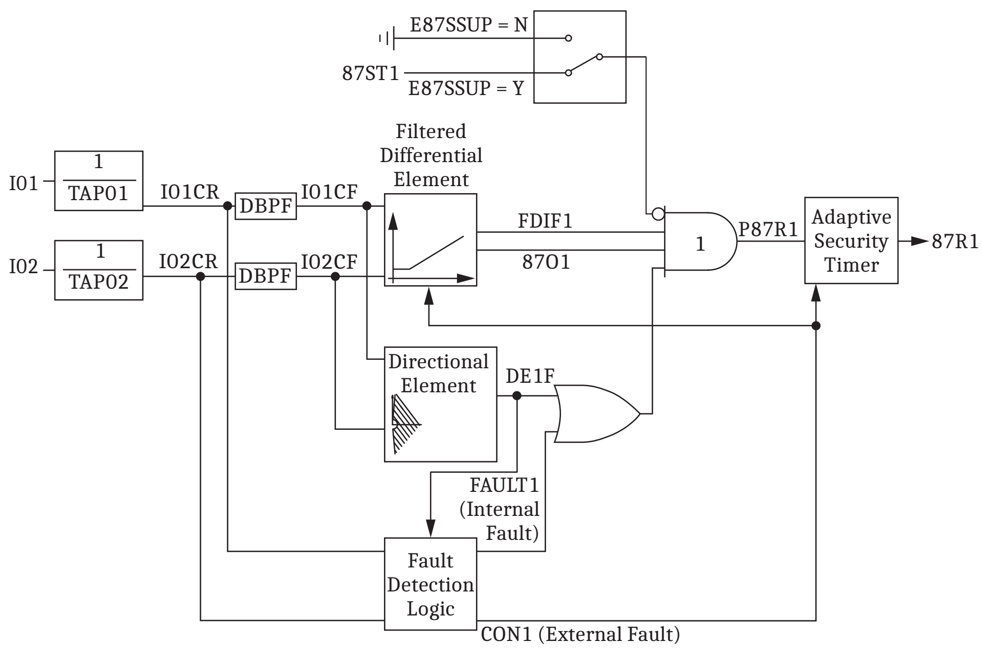


Figure 5.1 Block Diagram Showing the Logic for Busbar Protection Element 1

Referring to *Figure 5.1*, after the per unit conversion, the data (I01CR and I02CR) follow two separate paths. One path is through a digital band-pass filter (DBPF) to the filtered differential element and the directional element; the other path brings the instantaneous values to the fault detection logic.

The filtered differential element uses the input currents from each terminal in a protection zone to calculate the operate and restraint currents. The directional element compares the direction of current at a reference terminal to the direction of current at all other terminals in a protection zone to calculate fault direction. Several elements combine in the fault detection logic to distinguish between internal or busbar faults (FAULT1) and external faults (CON1).

AND Gate 1 combines the OR combination of the directional element (DE1F) and internal fault element (FAULT1) with the sensitive differential element (87ST1) to supervise the filtered differential element. P87R1, the output from Gate 1, drives a security timer that controls the final output (87R1) of the busbar protection element.

The logic includes three dedicated check zones (see *Check Zone Protection Elements on page 5.10*). This flexibility provides the opportunity to configure the dual differential (main zone and check zone) element combination.

Filtered Differential Element

The following discussion refers to the Filtered Differential Element 1, (with only Terminals 01 and 02 connected to the element) but applies equally well to the remaining five filtered differential elements. Using the output quantities from the digital band-pass filter (cosine filter), the filtered differential element calculates a restraint quantity, IRT1, and an operating quantity, IOP1, according to *Equation 5.3* and *Equation 5.4*:

$$\mathrm{IRT1} = |\mathrm{I01CF}| + |\mathrm{I02CF}|$$

Equation 5.3

and

$$\mathrm{IOP1} = |\mathrm{I01CF} + \mathrm{I02CF}|$$

Equation 5.4

where:

I01CF and I02CF = Filtered per unit current values from Terminals I01 and I02

Figure 5.2 shows a block diagram of the elements necessary for obtaining the differential and restraint quantities used in the filtered differential elements. Relay Word bit FDIF1 is the output from the differential calculation. Relay Word bit 87O1 asserts when the differential current exceeds the O87P threshold. Together these two Relay Word bits form the filtered differential element characteristic.

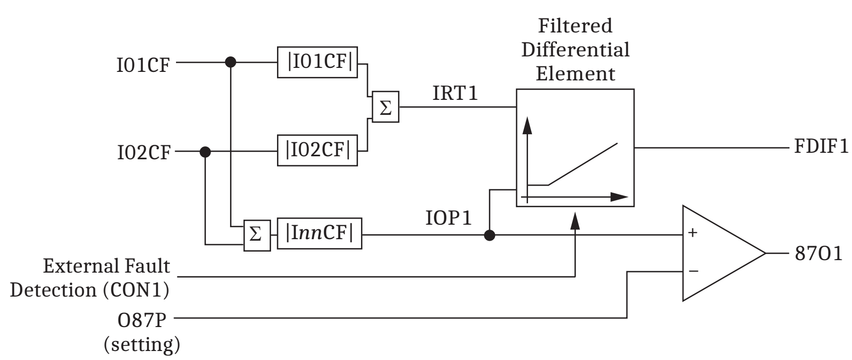


Figure 5.2 Filtered Differential Element 1

Figure 5.3 shows the characteristic of the differential element as a straight line through the origin of the form:

$$\mathrm{IOP1(IRT1)} = \mathrm{SLP1} \bullet \mathrm{IRT1}$$

Equation 5.5

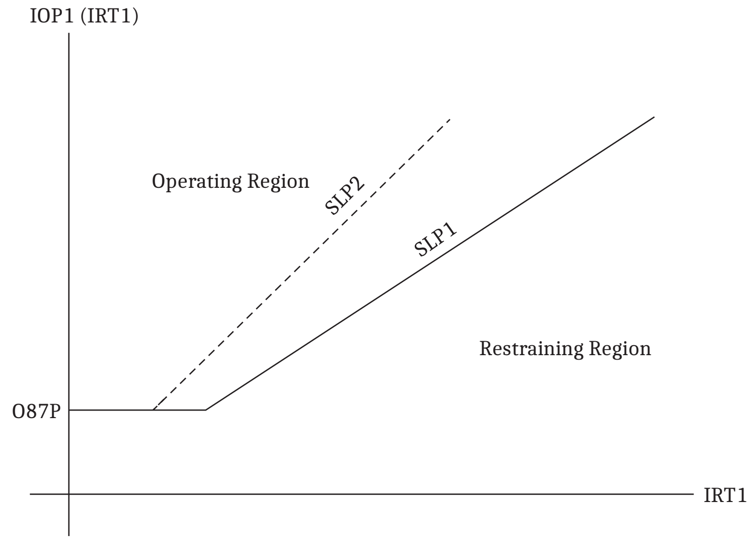


Figure 5.3 Filtered Differential Element Characteristic

For operating quantities (IOP1) exceeding the threshold level O87P and falling in the operate region of *Figure 5.3*, the filtered differential element issues an output. There are two slope settings. Slope 1 (SLP1) is effective for internal faults, and Slope 2 (SLP2) is effective for external faults. To change the slope values, first enable the advanced settings by setting EADVS := Y in Group Settings and then proceed to change the slope values. When the fault detection logic detects an external fault condition, Relay Word bit CON1 asserts. CON1 switches the slope of the differential characteristic from Slope 1 to Slope 2 to add security to the filtered differential element (see *Fault Detection Logic on page 5.7*).

Directional Element

The relay includes directional elements that supervise the filtered differential elements. In particular, the directional elements provide additional security to the filtered differential elements during external faults with heavy CT saturation conditions. Each of the six busbar protection elements has a directional element specific to that differential element.

The directional element compares the direction of current at the reference terminal to the direction of current at all other qualifying terminals in each zone. A qualifying terminal is a terminal with current value greater than the 50DSP threshold setting; the relay selects one of these currents as a reference. For each calculation, the relay uses the real part of the product of the terminal current and the conjugate of the current at the reference terminal, as depicted in *Figure 5.4*.

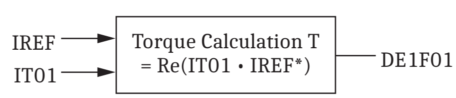


Figure 5.4 Torque Calculation Used in the Directional Element to Determine Fault Direction

The relay declares an internal fault condition when the direction of current at all the remaining terminals coincides with the direction of current at the reference terminal. For the directional element to begin processing, the current values of at least two terminals within the zone must exceed the 50DSP threshold. *Figure 5.5* shows the directional element characteristic, the shaded area indicating an internal fault.

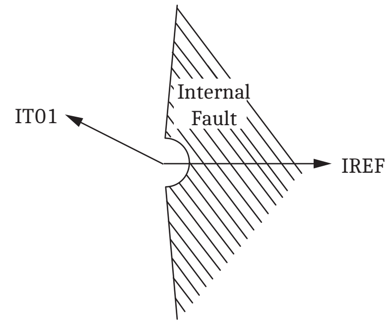


Figure 5.5 Directional Element Characteristic, the Shaded Area Indicating an Internal Fault

The relay acquires the terminals within each specific protection zone from the zone selection logic. The relay determines the terminals with phase current greater than the 50DSP threshold and selects one of the currents greater than the 50DSP threshold as a reference. The relay establishes fault direction by comparing the direction of current at the reference terminal to that at the remaining terminals in the zone with phase current greater than the 50DSP threshold.

Referring to *Figure 5.6*, consider the case of four terminals in Zone 1, with inputs labeled I01CF, I02CF, I03CF, and I04CF. Further, assume that the current magnitude in terminal I04CF is below the 50DSP threshold.

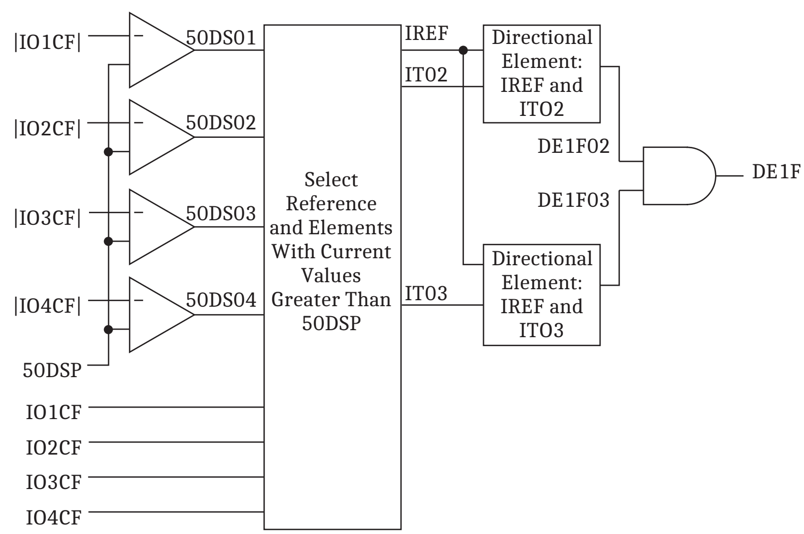


Figure 5.6 Directional Element Logic

First, the directional element determines which terminals have phase current magnitude greater than the 50DSP threshold. Because the current magnitude of input I04CF is below the 50DSP threshold, the relay selects only inputs I01CF, I02CF, and I03CF for further processing. The relay selects input I01CF as the reference (IREF) and compares the direction of current I02CF (IT02) and current I03CF (IT03) to this reference. DE1F asserts only if the direction of current at both IT02 and IT03 coincides with the direction of current at the reference terminal according to the directional element characteristic shown in *Figure 5.5*.

Fault Detection Logic

The fault detection logic distinguishes between external faults (external fault detection logic) and internal faults (internal fault detection logic), as shown in *Figure 5.7*. When the fault detection logic detects an external fault, Relay Word bit CON1 asserts, and when the fault detection logic detects an internal fault, Relay Word bit FAULT1 asserts.

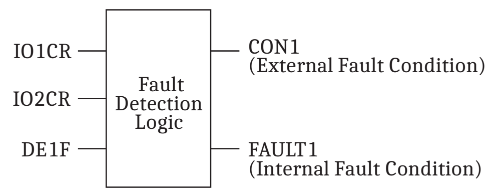


Figure 5.7 Fault Detection Logic That Distinguishes Between External and Internal Faults

Elements in the fault detection logic use instantaneous per unit currents to calculate a restraint quantity, IRT1R, and an operating quantity, IOP1R, according to *Equation 5.6* and *Equation 5.7*:

$$\mathrm{IRT1R} = |(\mathrm{I01CR})| + |(\mathrm{I02CR})|$$

Equation 5.6

and

$$\mathrm{IOP1R} = |(\mathrm{I01CR} + \mathrm{I02CR})|$$

Equation 5.7

where:

I01CR and I02CR = Instantaneous per unit current from Terminals 01 and 02.

Figure 5.8 shows a block diagram of how the fault detection logic obtains restraint quantity IRT1R and operating quantity IOP1R.

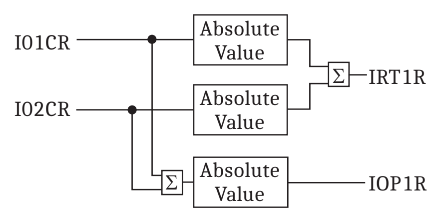


Figure 5.8 Fault Detection Logic Obtaining Restraint and Operating Quantities

External Fault Detection Logic

In general, operating and restraint currents increase simultaneously for internal faults; for external faults, only the restraint current increases if there is no CT saturation. By comparing the change in operating current (ΔIOP1R) to the change in restraint current (ΔIRT1R), the relay detects external fault conditions. Because CTs can saturate during external faults, the relay asserts the external fault condition (Relay Word bit CON1) for 60 cycles after detecting an external fault. *Figure 5.9* shows the logic for detecting external fault conditions.

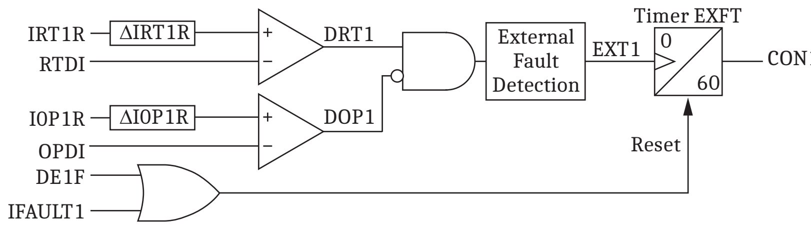


Figure 5.9 External Fault Detection Logic

Asserting CON1 for 60 cycles can slow relay operation for evolving faults (where the fault starts as an external fault and then develops into an internal fault). To prevent delayed tripping, CON1 resets when either the directional element (DE1F) detects an evolving fault or the internal fault detection logic (IFAULT1) confirms an internal fault condition.

Relay Word bit CON1 controls the operating mode of the relay by asserting when the relay detects an external fault. The relay operates normally with CON1 deasserted but switches to a high-security mode when CON1 asserts. High security causes the following in the relay:

- ➤ Slope 1 changes to Slope 2.
- ➤ Delay time of the adaptive security timer increases.

Resetting CON1 releases the relay from the high-security mode, and the relay operates with the normal settings.

Internal Fault Detection Logic

For the internal fault detection logic, the relay uses a characteristic similar to the filtered differential element characteristic.

Figure 5.10 shows the internal fault detection logic consisting of the instantaneous differential element, the consecutive measurement fault detection logic, and the fast fault detection logic. When the raw operate current (IOP1R) exceeds the active slope and the O87P setting, RDIF1 asserts. RDIF1 forms the input into the consecutive measurement fault detection logic and the fast fault detection logic.

The consecutive measurement fault detection logic declares an internal fault when differential current still exists on a consecutive measurement one-half cycle after the instantaneous differential element asserted. When this logic detects an internal fault, the IFAULT1 Relay Word bit asserts.

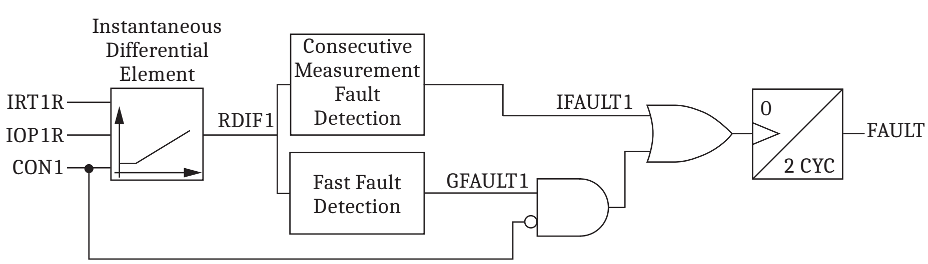


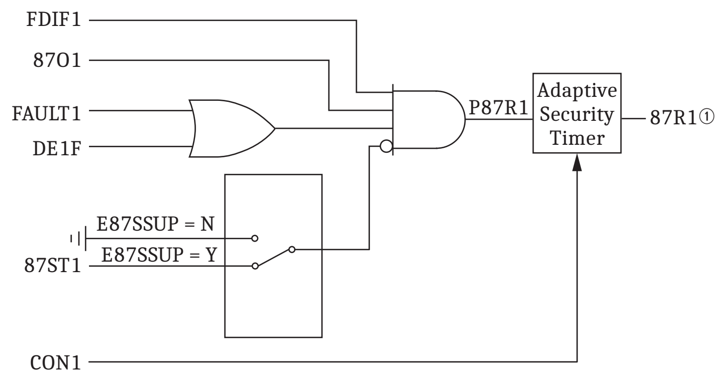
Figure 5.10 Internal Fault Detection, Instantaneous Differential Element, Consecutive Measurement Fault Detection, and Fast Fault Detection Logics

If surge (lightning) arresters are installed on busbars, a path to ground exists when these devices conduct, resulting in operating current in the differential elements. The fast fault detection logic qualifies the operating current with a time delay to differentiate between operating current resulting from surge arrester conduction and operating current because of internal faults. If the fast fault detection logic detects an internal fault, Relay Word bit GFAULT1 asserts.

Protection Element Output Logic

Figure 5.11 shows the four conditions from the relay measuring and control logic that must be fulfilled to start the security timer (the final stage in asserting the protection element output, Relay Word bit 87R1):

- ➤ An output from the filtered differential element, FDIF1
- ➤ An output from the filtered differential element threshold, 87O1
- ➤ An output from either the directional element (DE1F) or the internal fault detection logic (FAULT1)
- ➤ No output from the sensitive differential element (87ST1) with E87SSUP := Y



① See Figure 5.47.

Figure 5.11 Differential Element Output: Final Conditions and Adaptive Security Timer

When the four differential element output logic conditions are met, the output P87R1 starts the adaptive security timer. CON1 also controls the security timer time setting; when CON1 asserts, the relay increases the time delay by 0.4 cycles to increase security for the protection element.

Table 5.1 shows operating times for the bus differential elements. *Figure 5.12* shows the average operating times (minimum of five trials) for the differential element. Operating times include the time it takes for the 87R element to assert and does not take into consideration the output contact closure time. Tests were performed for 1, 2, 3, 4, 5, 6, and 7 multiples of pickup setting. At 7 times the setting, the deviation was 0.02 cycles. These tests do not include fault resistance. Operating times are the same for 50 Hz and 60 Hz.

Table 5.1 Restrained Differential Element (87R) Operating Times (Cycles) (Sheet 1 of 2)

Multiples of Pickup	Average
1	1.48
2	0.94
3	0.85
4	0.83
5	0.52

Table 5.1 Restrained Differential Element (87R) Operating Times (Cycles) (Sheet 2 of 2)

Multiples of Pickup	Average
6	0.51
7	0.52

Figure 5.12 Average 87R Operating Times

Check Zone Protection Elements

The SEL-487B logic includes three dedicated check zones, providing the flexibility and opportunity to configure the dual differential (main zone and check zone) element combination.

Figure 5.13 shows the block diagram for a Check Zone 1 Protection Element (Check Zones 2 and 3 are similar). Throughout the following element descriptions, the numerical part of the Relay Word bits refers to the specific terminal number (01–21). I01 and I02 refer to current inputs from Terminal I01 and Terminal I02.

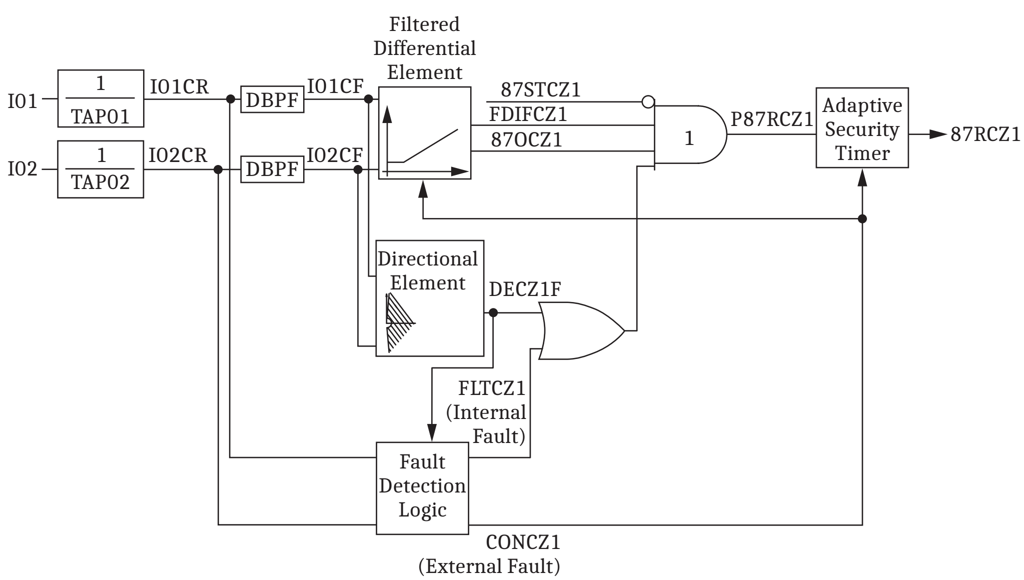


Figure 5.13 Block Diagram Showing Logic for Check Zone Protection Element 1

Check Zone Filtered Differential Element

Figure 5.14 shows a block diagram of the elements necessary for obtaining the differential and restraint quantities used in the check zone filtered differential elements. Relay Word bit FDIFCZ1 is the output from the check zone differential calculation. Relay Word bit 87OCZ1 asserts when the differential current exceeds the CZO87P threshold. Together these two Relay Word bits form the check zone filtered differential element characteristic.

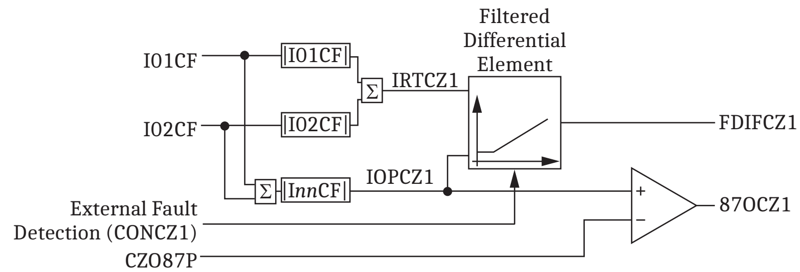


Figure 5.14 Check Zone Filtered Differential Element 1

Check Zone External Fault Detection Logic

Figure 5.15 shows the logic for detecting external fault conditions.

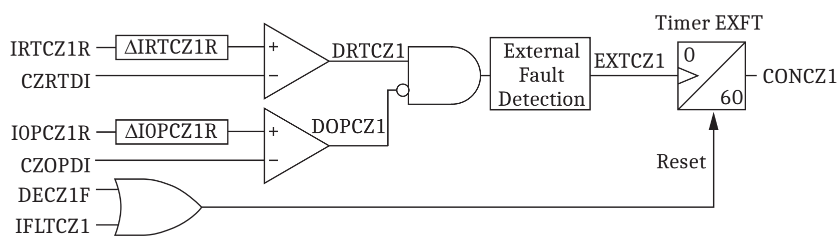


Figure 5.15 Check Zone External Fault Detection Logic

To change the threshold values, first enable the advanced settings (see *Section 8: Settings* for more information on setting the relay) by setting EADVS := Y in Group Settings and then enable the check zone settings by setting ECHKZN := Y.

Check Zone Internal Fault Detection Logic

For the internal fault detection logic, the relay uses a characteristic similar to the filtered differential element characteristic.

Figure 5.16 shows the internal fault detection logic consisting of the instantaneous differential element, the consecutive measurement fault detection logic, and the fast fault detection logic. RDIFCZ1, the output from the instantaneous differential element, forms the input into the consecutive measurement fault detection logic and the fast fault detection logic.

The consecutive measurement fault detection logic declares an internal fault when differential current still exists on a consecutive measurement one-half cycle after the instantaneous differential element asserted. When this logic detects an internal fault, the Relay Word bit IFLTCZ1 asserts.

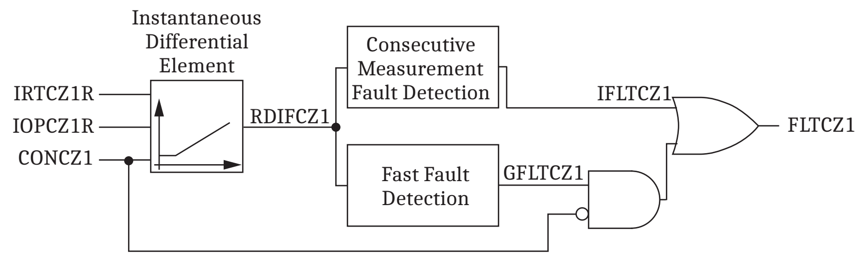


Figure 5.16 Check Zone Internal Fault Detection, Instantaneous Differential Element, Consecutive Measurements Fault Detection, and Fast Fault Detection Logics

Check Zone Protection Element Output Logic

Figure 5.17 shows the four conditions from the relay measuring and control logic that must be fulfilled to start the security timer (the final stage in asserting the Check Zone Protection Element output, Relay Word bit 87RCZ1):

- ➤ An output from the check zone filtered differential element (FDIFCZ1)
- ➤ An output from the check zone filtered differential element threshold (87OCZ1)
- ➤ An output from either the check zone directional element (DECZ1F) or the check zone internal fault detection logic (FLTCZ1)
- ➤ No output from the check zone sensitive differential element (87STCZ1) with E87SSUP := Y

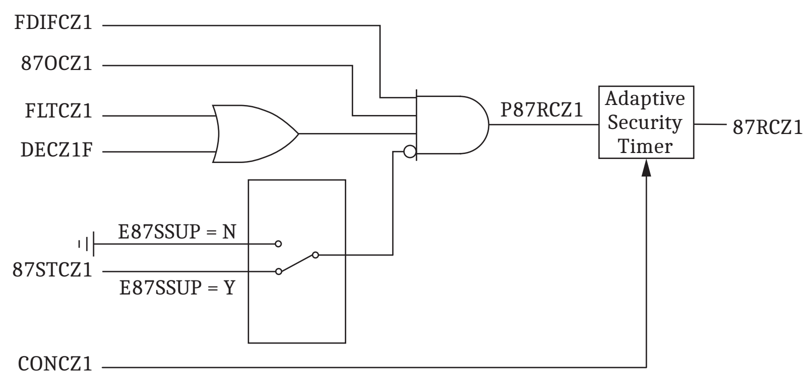


Figure 5.17 Check Zone Differential Element Output: Final Conditions and Adaptive Security Timer

When the four differential element output logic conditions are met, the output P87RCZ1 starts the adaptive security timer. CONCZ1 also controls the security timer time setting; when CONCZ1 asserts, the relay increases the time delay by 0.4 cycles to increase security for the protection element.

Sensitive Differential Element

For each zone, sensitive differential elements detect differential current resulting from CT open or short circuits conditions. If such a condition exceeds a settable delay, the element asserts an alarm. There are two Relay Word bits per zone: an instantaneous Relay Word bit, 87S1, and a time-delayed Relay Word bit, 87ST1.

Use 87ST1, the time-delayed output, for alarming and supervision. Each sensitive differential element compares the sensitive differential element operating quantity, IOP1, against the S87P threshold.

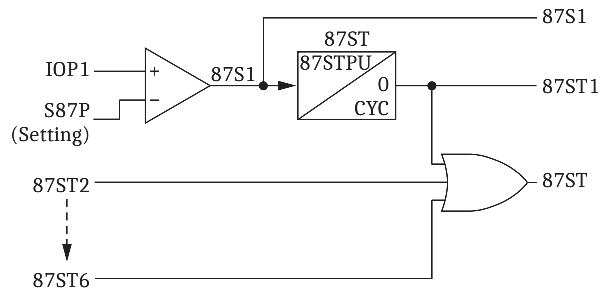


Figure 5.18 Sensitive Differential Element (87S)

The status of the sensitive differential element is one of the four conditions considered in the final output logic of the differential protection element (see *Figure 5.18*). With E87SSUP := Y, the output 87ST*n* supervises the differential protection element. When E87SSUP := N the sensitive differential (87ST*n*) element does not supervise the differential protection elements (87R*n*). Setting E87SSUP := N only removes the supervision function from the differential element, but does not disable the sensitive differential elements. The sensitive differential elements are still running and available for other functions such as asserting an alarm.

The sensitive differential elements may assert under load conditions if not set properly. To prevent these elements from asserting under load conditions, set the differential threshold setting 50 percent higher than the natural out-of-balance current at the station. Be sure to measure the worst natural out-of-balance current at the station. For example, in a double busbar layout with bus-zone-to-bus-zone connections, first merge the bus-zones before making the measurement (see *Dynamic Zone Selection Logic on page 5.14* and *Bus-Zone-to-Bus-Zone Connections on page 6.33* for more information). Use the **MET DIF** command to read the per unit operating current values from each protection zone.

Check Zone Sensitive Differential Element

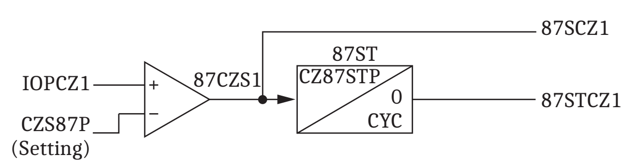


Figure 5.19 Check Zone Sensitive Differential Element (87S)

Each check zone has an independent sensitive differential element. There are two Relay Word bits per zone: an instantaneous Relay Word bit, 87SCZ1, and a time-delayed Relay Word bit, 87STCZ1. Use 87STCZ1, the time-delayed output, for alarming and supervision. Each sensitive differential element compares the sensitive differential element operating quantity, IOPCZ1, against the CZS87P threshold.

Zone Supervision Logic

This logic provides final supervision criteria before a trip signal is issued. *Figure 5.20* shows the logic for Differential Element 1, but similar logic is available for all six differential elements. Relay Word bit 87R1 is the output from the differential element, and Z1S is a SELOGIC control equation in the zone configuration settings. The differential trip logic uses Relay Word bit 87Z1, the output from this logic, to determine which terminals to trip. See *Differential Trip Logic on page 5.47* for more detail.

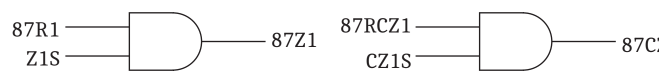


Figure 5.20 Zone and Check Zone Supervision Logic

NOTE: Setting E87ZSUP := N sets ZnS to logical 1. This setting prevents the inadvertent blocking of the differential elements.

⚠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.

Setting Z1S is a SELOGIC control equation in which you can program the conditions for supervising the differential element (87R1). For example, this is the setting in which you enter the output from the check zone differential element during check zone configuration. Consider the case where a check zone is configured and 87CZ1 is the check zone element output. Both the check zone and the sensitive differential elements must supervise the 87R1 element. With E87SSUP := Y, 87ST1 is already included in the differential element supervision (one of the four final conditions; see *Figure 5.11*). Only the check zone information is required:

Z1S := **87CZ1**

Dynamic Zone Selection Logic

Busbar protection involves assigning the appropriate input current values to the corresponding differential elements for calculation of per zone operating and restraint quantities and determining the breakers to trip for differential and breaker failure protection operation. To allow flexible substation configuration without compromising busbar protection, the relay dynamically reassigns input currents to the appropriate differential elements when the station configuration changes.

Disconnect and breaker auxiliary contacts typically provide station configuration information in the form of control inputs, entered into the relay as SELOGIC control equations. By evaluating these SELOGIC control equations, the zone selection logic assigns the currents to the appropriate differential elements. When disconnects are closed in such a way that a solid connection exists between two (or more) zones, the zones merge, and only one zone is active. The active zone after a merge is always the zone with the lowest number. For example, if Zone 3 and Zone 4 merge, Zone 3 encompasses Zone 4.

When the SELOGIC control equation representing the Terminal-to-Bus-Zone becomes a logical 1, the zone selection algorithm processes the current values associated with that particular terminal (see *Table 5.2*). When the equation is logical 0, the current values are neither processed nor considered in the differential calculations. This is also true for the trip output. When the SELOGIC control equation of a terminal is a logical 0, the differential element issues no trip signals to that terminal.

Table 5.2 Current Values Assigned to the Differential Element as a Function of the Disconnect Status

SELogic Control Equation	Status	Meaning in the Differential Calculation
I01BZ1V := D891	D891 = 1 (closed)	I01 is part of differential Bus-Zone 1
I01BZ1V := D891	D891 = 0 (open)	I01 is not part of differential Bus-Zone 1

where:

I01BZ1V = SELogic control equation declaring the conditions when Terminal 1 connects to Bus-Zone 1

D891 = input from Terminal 1 disconnect auxiliary contact that changes state when the disconnect switch changes state

To properly configure the station, the zone selection algorithm requires the following information:

- Terminals to bus-zones connections, I*qq*BZ*p*V.
- Interconnections between bus-zones, BZ*p*BZ*p*V.

where:

qq = 01–21 (Terminal 1 to Terminal 21)

p = 1–6 (Bus-Zone 1 to 6)

Both I*qq*BZ*p*V and BZ*p*BZ*p*V are SELogic control equation variables that you enter in the relay when using the **SET Z** command to set the relay. In QuickSet, I*qq*BZ*p*V is found in **Group > Zone Configuration > Terminal To Bus-Zone Connections** and BZ*p*BZ*p*V is found in **Group > Zone Configuration > Bus-Zone To Bus-Zone Connections**.

Selecting the Zones

The relay runs the zone selection algorithm every protection processing interval and sets the appropriate zone switching operation (ZSWOP*p*) Relay Word bits for one cycle when there is a status change in either I*qq*BZ*p*V (terminal is connected to or disconnected from a bus-zone) or BZ*p*BZ*p*V (two or more bus-zones are connected together).

Based on the SELogic control equations I*qq*BZ*p*V and BZ*p*BZ*p*V, the zone selection logic determines the following:

- The bus-zone(s) to be included in each protection zone
- The active terminals to be included in each protection zone
- The terminals to trip for differential and breaker failure protection operations

Table 5.3 shows the Relay Word bits available in the zone selection logic with their descriptions.

Table 5.3 Relay Word Bits in the Zone Selection Logic (Sheet 1 of 2)

Quantity	Description
ZSWOP*p*	Picks up following a change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone *p*
ZONE*p*	Differential Zone *p* is active
I*qq*BZ*p*V	Terminal *qq* connected to BZ*p*
BZ*p*BZ*p*V	A connection exists between BZ*p* and BZ*p*

Table 5.3 Relay Word Bits in the Zone Selection Logic (Sheet 2 of 2)

Quantity	Description
ZN*p*I*qq*	Terminal *qq* connected to Zone *p*
ZN*p*I*qq*T	Terminal *qq* connected to Zone *p* and will be tripped
BZ*p*BZ*p*R	A connection exists between BZ*p* and BZ*p* and the coupler is removed
Z*p*BZ*p*	Bus-Zone *p* is part of Protective Zone *p*

Check Zone Selection

The check zone function in the SEL-487B-1 differs in three ways from the check zone in the SEL-487B-0:

- Each SEL-487B-1 has three check zones
- There are no Terminal-to-Check-Zone Connection Logic settings, I*qq*CZ1V, in the SEL-487B-1
- The SEL-487B-1 includes Advance Check Zone settings

The single check zone in each SEL-487B-0 means that you can use the check zone only in a three-relay application. The three check zones in each SEL-487B-1 makes it possible to configure a check zone for each of the three phases in a single-relay application.

On the basis that terminals in the check zone are independent of the disconnect auxiliary contact status, there is no need to configure Terminal-to-Check-Zone Connection Logic (i.e., I*qq*CZ1V in the SEL-487B-0) in the SEL-487B-1. Therefore, to include a terminal in the check zone, just enter the Terminal, Check-Zone, Polarity (P,N) settings, as shown below.

```
Check Zone Configuration

Enable Check Zones at Station (Y,N)                ECHKZN  := N      ?Y

Check Zone Configuration: Terminal to Check Zone Connections

Terminal, Check-Zone, Polarity (P,N)
?  I01 CZ1 P
Terminal, Check-Zone, Polarity (P,N)
?  I02 CZ1 P
Terminal, Check-Zone, Polarity (P,N)
?  I03 CZ1 P
Terminal, Check-Zone, Polarity (P,N)
?  I04 CZ1 P
Terminal, Check-Zone, Polarity (P,N)
?
Enable Advance Check Zone Settings (Y,N)           EADVCZ  := N      ?N
```

In QuickSet, go to **Check Zone Configuration > Terminal *qq* To Check Zone Connections** and set CT*qq*CZ*p* (*p* = 1–3) to Y to include a terminal in a check zone as shown in *Figure 5.21*.

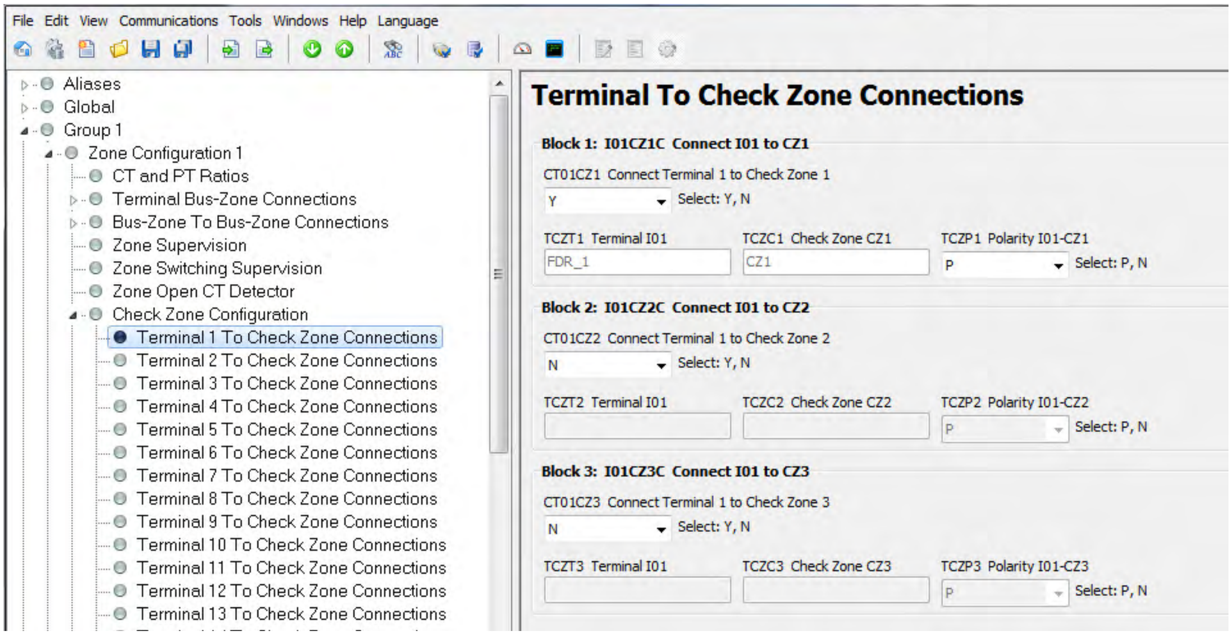


Figure 5.21 Check Zone Settings

When you enter a check zone in the Terminal-to-Check-Zone settings, the corresponding CZONE*x* (*x* = 1–3) Relay Word bit asserts. For example, in the above example, Relay Word bit CZONE1 asserts, but not Relay Word bits CZONE2 or CZONE3. Use the **TAR** ASCII command to verify the status of these Relay Word bits.

```
=>>TAR CZONE1<Enter>
*       *       *       *       *       CZONE3  CZONE2  CZONE1
0       0       0       0       0       0       0       1
```

The Advance Check Zone Settings provide a method to configure a check zone for applications with in-board CTs (see *Example of Check Zone With In-Board (Bushing) CTs on page 6.23*).

The SEL-487B-1 still includes Check Zone Supervision setting. Use these settings to disable the entire check zone. In the following example, CZ1S is set to 1 (the default setting), meaning that the check zone is always in service.

```
Check Zone Supervision
Differential Element Check Zone Supervision (Y,N)    E87CZSP := N      ?Y
Check Zone 1 Supervision (SELogic Equation)
CZ1S := 1
```

Instantaneous/Delayed Overcurrent Elements

NOTE: If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay.

Each of the 21 terminals includes a single level of phase instantaneous and time-delayed overcurrent elements. *Figure 5.22* shows the logic for the 50P*nn* element. Labels FIM (Filtered, Instantaneous, Magnitude) are included for informational purposes and indicate specific processes used in the relay (see *Section 12: Analog Quantities* for more information about analog quantities).

The logic compares the magnitudes of phase input current I*nn*FIM to a pickup setting 50P*nn*P. If the current magnitude exceeds the pickup level, Relay Word bit 50P*nn* asserts and the timer starts timing. After the time specified by the delay setting 50P*nn*D expires, a second Relay Word bit, 50P*nn*T, asserts. Relay Word bit 50P*nn*T only asserts if Relay Word bit 50P*nn* remains asserted for the duration of the 50P*nn*D time setting. When Relay Word bit 50P*nn* deasserts, the timer resets without delay, along with 50P*nn*T if it has asserted.

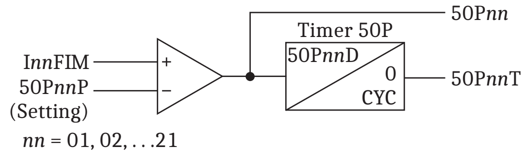


Figure 5.22 Phase Instantaneous and Time-Delayed Overcurrent Elements

The definite-time overcurrent elements are not enabled in the default settings. Enable the elements by setting E50 := *nn* (*nn* = 01–21). After enabling the elements, the definite-time overcurrent elements of all 21 terminals are available but are still set to OFF. For example, assume we want definite-time overcurrent protection for Terminal 05. Set E50 := 5, making the definite-time overcurrent elements of Terminal 01–Terminal 05 available. Because the default settings for the definite-time overcurrent elements are OFF, the elements are not active. Only enter settings at the definite-time overcurrent protection prompt of Terminal 05. Terminal 05 is the only terminal with definite-time overcurrent protection; the definite-time overcurrent protection for Terminal 01–Terminal 04 remains switched OFF.

Selectable Time-Overcurrent Elements (51)

NOTE: If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay.

Instead of having dedicated inverse-time overcurrent elements for each current channel, the relay offers the flexibility of an unassigned time-overcurrent element, each with the choice of five US and five IEC operating curves. Unassigned means that the 51 element operating quantities are available for assignment, as the application requires (see *Table 5.6*).

The inverse-time overcurrent elements are not enabled in the default settings. Enable the desired number of elements by setting E51 := *nn* (*nn* = 01–21). Choose from any filtered instantaneous phase current quantity magnitudes (I01FIM–I21FIM) to set as the operate quantity, 51Onn.

Table 5.4 shows the five US characteristics, and *Table 5.5* shows the five IEC characteristics. Each table shows the five operating time equations, together with the five electromechanical reset characteristic equations.

Table 5.4 U.S. Time-Overcurrent Equations[a] (Sheet 1 of 2)

Curve Type	Operating Time	Reset Time
U1 (Moderately Inverse)	$T_p = TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{1.08}{1 - M^2}\right)$
U2 (Inverse)	$T_p = TD \bullet \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{5.95}{1 - M^2}\right)$
U3 (Very Inverse)	$T_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{3.88}{1 - M^2}\right)$

Table 5.4 U.S. Time-Overcurrent Equations[a] (Sheet 2 of 2)

Curve Type	Operating Time	Reset Time
U4 (Extremely Inverse)	$Tp = TD \bullet \left(0.02434 + \frac{5.64}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{5.64}{1 - M^2}\right)$
U5 (Short-Time Inverse)	$Tp = TD \bullet \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{0.323}{1 - M^2}\right)$

[a] T_P = Operating Time
T_R = Reset Time
TD = Time-Delay Setting
M = Measured Current / Pickup Current

Table 5.5 IEC Time-Overcurrent Equations

Curve Type	Operating Time	Reset Time
C1 (Standard Inverse)	$Tp = TD \bullet \left(\frac{0.14}{M^{0.02} - 1}\right)$	$T_R = TD \bullet \left(\frac{13.5}{1 - M^2}\right)$
C2 (Very Inverse)	$Tp = TD \bullet \left(\frac{13.5}{M - 1}\right)$	$T_R = TD \bullet \left(\frac{47.3}{1 - M^2}\right)$
C3 (Extremely Inverse)	$Tp = TD \bullet \left(\frac{80}{M^2 - 1}\right)$	$T_R = TD \bullet \left(\frac{80}{1 - M^2}\right)$
C4 (Long-Time Inverse)	$Tp = TD \bullet \left(\frac{120}{M - 1}\right)$	$T_R = TD \bullet \left(\frac{120}{1 - M}\right)$
C5 (Short-Time Inverse)	$Tp = TD \bullet \left(\frac{0.05}{M^{0.04} - 1}\right)$	$T_R = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$

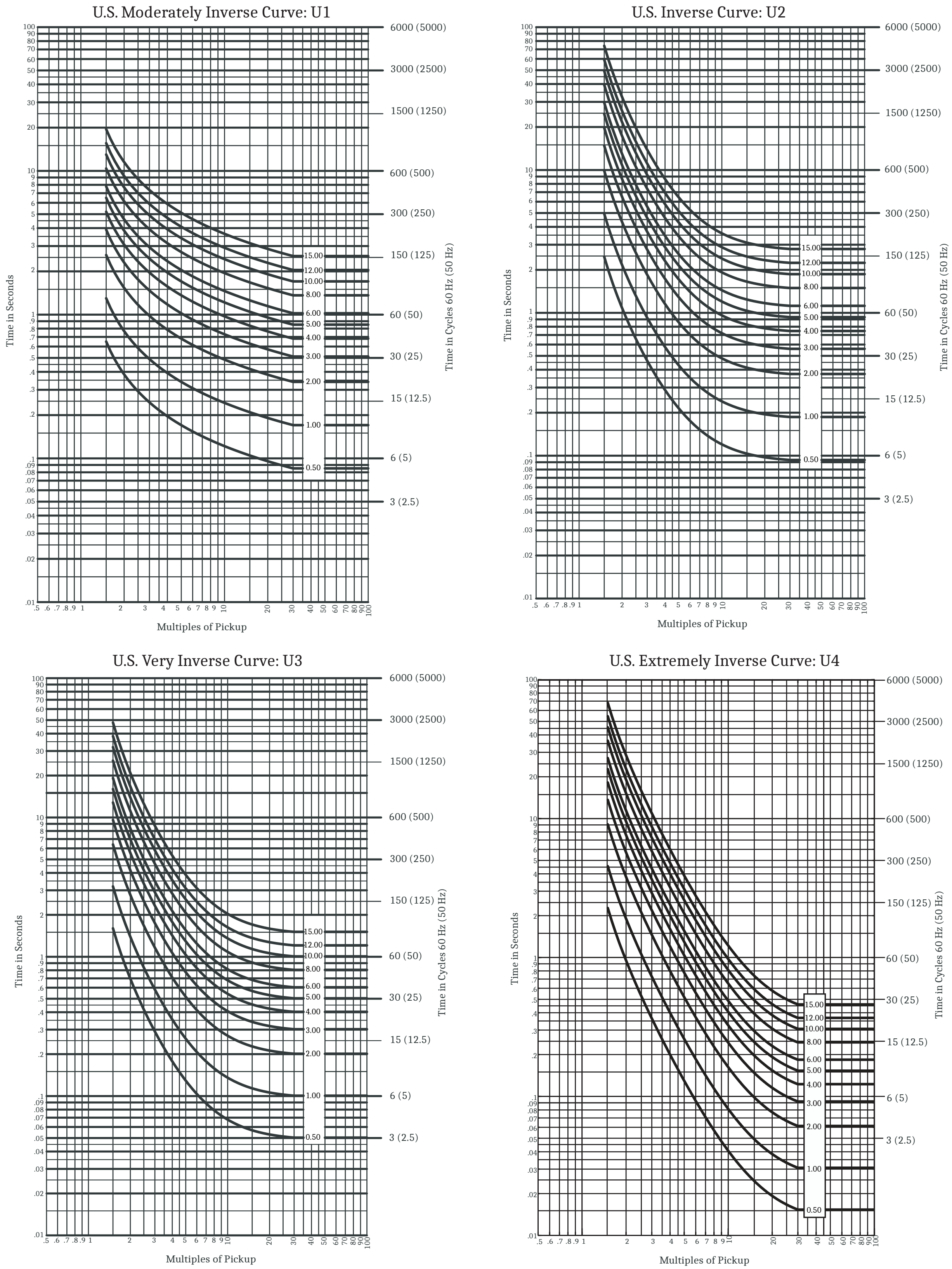


Figure 5.23 U.S. Curves U1, U2, U3, and U4

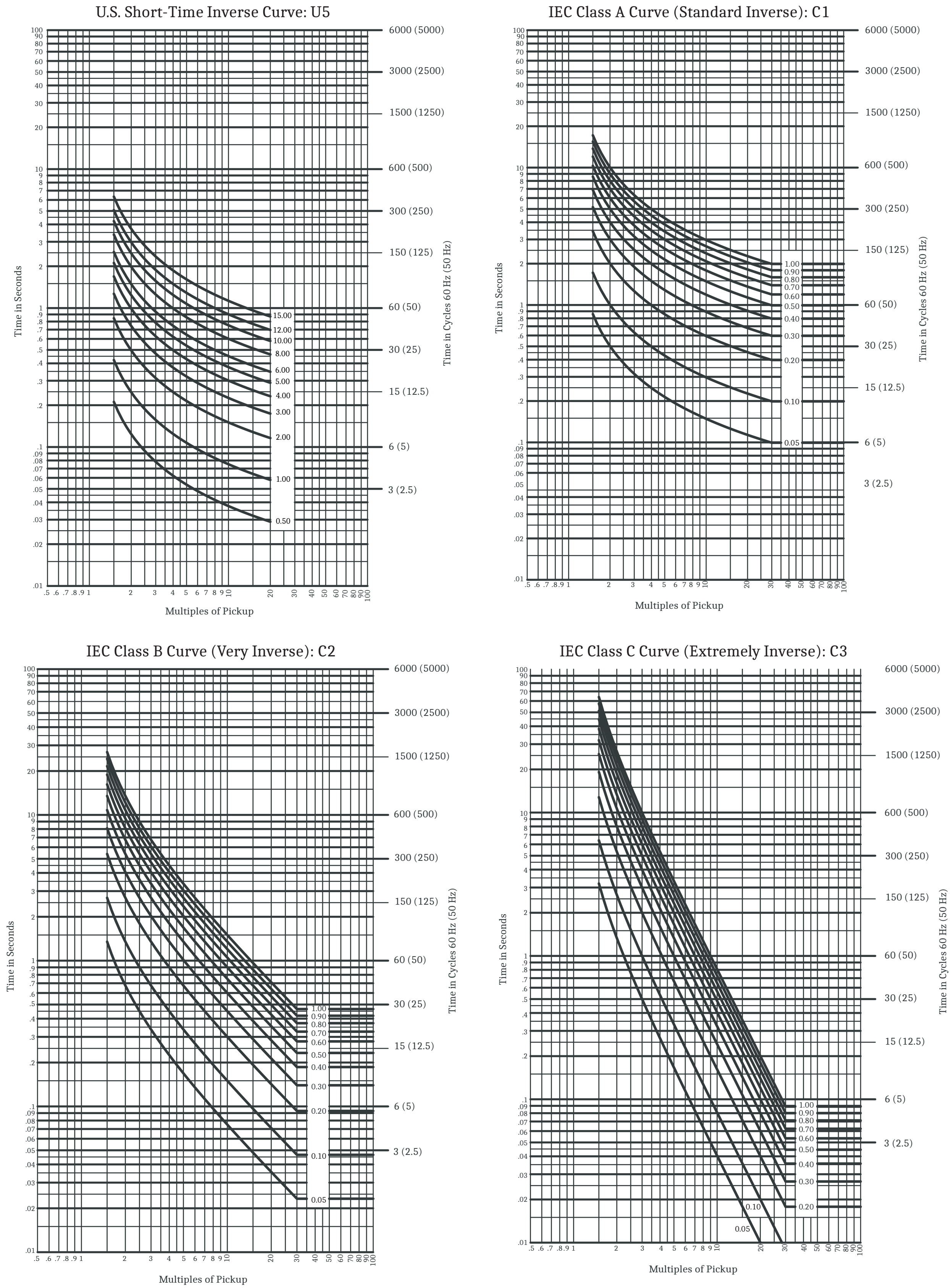


Figure 5.24 U.S. Curve U5 and IEC Curves C1, C2, and C3

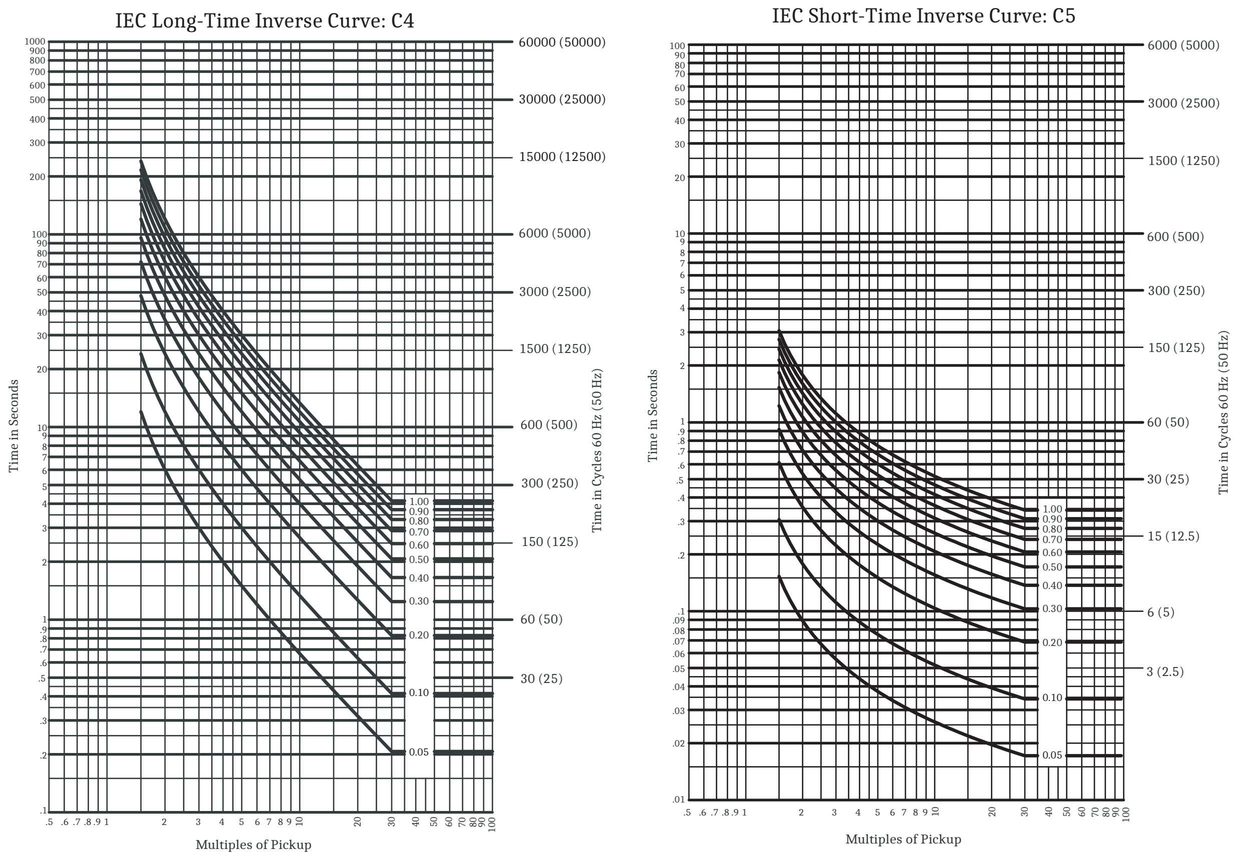


Figure 5.25 IEC Curves C4 and C5

The 51 overcurrent elements of the relay have dynamic pickup (51P*xx*) and time-delay (51TD*xx*) values. Because these settings can be programmed by means of protection math variables (PMVs), their actual value cannot be checked at setting time. To ensure that the pickup and time-delay values are within their predefined limits, the relay uses a limit check to verify the validity of setting values. Relay Word bits 51TM*xx* (time-dial limit check) and 51MM*xx* (pickup-limit check) are used to indicate a setting that is outside of the limit check thresholds. If the maximum limit thresholds are exceeded, the relay uses the maximum limit value. If the minimum limit thresholds are exceeded, the relay uses the minimum limit value (see *Figure 5.26*).

Example 5.1

The Terminal 01 current channel input is 5 A nominal …. From relay part number

51O01 := I01FIM

Therefore 51B101 := 0.25 (lower limit)

And 51B201 := 16.0 (upper limit)

5 A Current Terminal: (Determined by Relay part number and the operating quantity)

B_1 := 0.25 and B_2 := 16.0

Example 5.1 (Continued)

The Terminal 01 current channel input is 1 A nominal …. From relay part number

51O01 := I01FIM

Therefore 51B101 := 0.05 (lower limit)

And 51B201 := 3.2 (upper limit)

1 A Current Terminal: (Determined by relay part number and the operating quantity)

B_1 := 0.05 and B_2 := 3.2

If the calculated pickup value is greater than 3.2, the relay logic clamps the pickup value at 3.2. Similarly, if the value is less than 0.05, the relay logic clamps the pickup value at 0.05. At the same time that it clamps the values to these limits, the logic sets a limit bit (51MM*xx*) to indicate to the user that the read-in value is outside the specified limits.

Logic

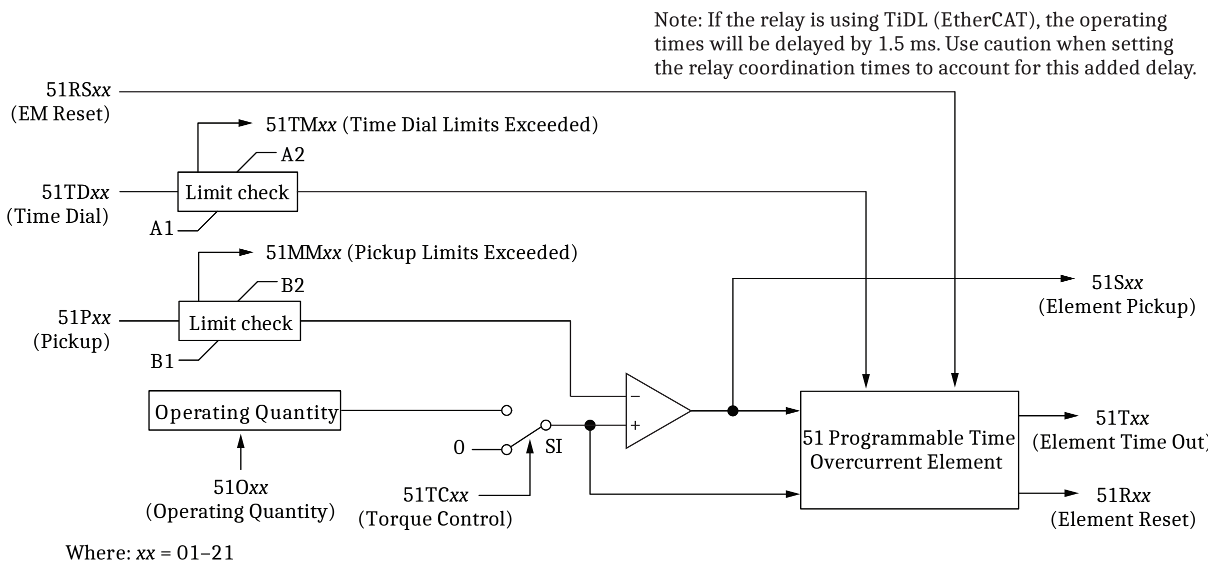


Figure 5.26 Time-Overcurrent Logic

Settings Description

Operating Quantity

The 51 elements are unassigned, so you can select the operating quantity from *Table 5.6*.

Table 5.6 Time-Overcurrent Operating Quantity List

Analog Quantity	Description
I*nn*FIM[a]	Filtered Instantaneous Terminal *nn* Current Magnitude

[a] Where nn = 01–21.

Pickup and Time-Dial Settings

Pickup setting 51P01, operating on the ratio of the measured current to the pickup setting (multiple of pickup setting), moves the characteristic horizontally to vary the pickup current; time-dial (multiplier) setting 51TD01 moves the curve vertically to vary the operating time for a given multiple of pickup.

Both pickup (51P01) and time-dial (51TD01) settings are math variables instead of fixed settings. SEL math variables, unlike fixed settings that cannot be dynamically changed, allow for the adaptive changing of pickup and time- dial settings without the need for changing relay setting groups. However, if your installation does not require adaptive pickup and/or time-dial settings changes, use the time-overcurrent element as a conventional 51 element. For a conventional element, simply enter the pickup and time-dial settings as numbers, such as:

51P01 = **1.5**

51TD01 = **1**

Upper and Lower Range Limits

When you use SEL math variables, the selected analog value can exceed the upper value of the pickup range, or it can fall below the lower value of the pickup range. When this happens, the relay assigns the appropriate threshold value to the element and continues to calculate the trip time. For the 51P*nn* pickup settings, the upper threshold is 3.2 for 1 A relays and 16 for 5 A relays. The lower threshold is 0.05 for 1 A relays and 0.25 for 5 A relays. For the 51TD*nn* time-dial settings, the U.S. curve thresholds are 0.5 and 15, and the IEC thresholds are 0.05 and 1.0. In addition, the relay also asserts the appropriate Relay Word bits: 51MM01 (pickup value out of bounds) and/or 51TM01 (time-dial value out of bounds).

Example 5.2

For example, you want a 1 A relay to pick up at 1.5 A when IN201 asserts and to pick up at 2 A when IN202 asserts (IN201 deasserted). Program the following:

51P01 := IN201 • 1.5 + IN202 • 2

With IN201 asserted (logical 1), and IN202 deasserted (logical 0), the 51P01 setting is:

(1 • 1.5) + (0 • 2) = 1.5 + 0 = 1.5

When IN202 asserts (IN201 deasserted), the 51P01 setting is:

(0 • 1.5) + (1 • 2) = 0 + 2 = 2

If, however, IN202 asserts while IN201 is still asserted, the 51P01 setting is:

(1 • 1.5) + (1 • 2) = 1.5 + 2 = 3.5

Because 3.5 exceeds the upper range value of 3.2, the relay clamps the setting at 3.2 and asserts Relay Word bit 51MM01.

Torque Control

SELOGIC control equation 51TC01 allows you to state the conditions when the element must run. When 51TC01 asserts (logical 1), switch S1 in *Figure 5.26* closes, and the relay evaluates input 51O01. For example, if the element should only measure when the circuit breaker is closed, enter the following:

51TC01 := **IN201** (Breaker auxiliary "A" contact connected to IN201)

With this setting, switch S1 closes only when IN201 is a logical 1. If the element must measure all the time, enter the following:

51TC01 := **1**

EM Reset

Setting 51RS01 defines whether the curve resets like an electromechanical disk or after one power system cycle when current drops below pickup. If you set 51RS01 = Y, then the relay resets according to the reset timer equations for that particular curve (see *Table 5.4* or *Table 5.5*). If you set 51RS01 = N, then the relay resets after one power system cycle when current drops below pickup.

Over- and Undervoltage Elements

NOTE: If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay.

The SEL-487B offers as many as six undervoltage and six overvoltage elements. Each of these 12 elements has two levels, for a total of 24 over- and undervoltage elements. *Figure 5.27* shows the over- and undervoltage element logic.

Use the E27 and E59 settings to enable as many over- and undervoltage elements as you need.

Select any operating quantity shown in *Table 5.7* for the 27O*k* settings, and any value from *Table 5.8* for the 59O*k* settings as an input quantity (27O*k* and 59O*k* settings). You can select the same quantity for an undervoltage element as for an overvoltage element.

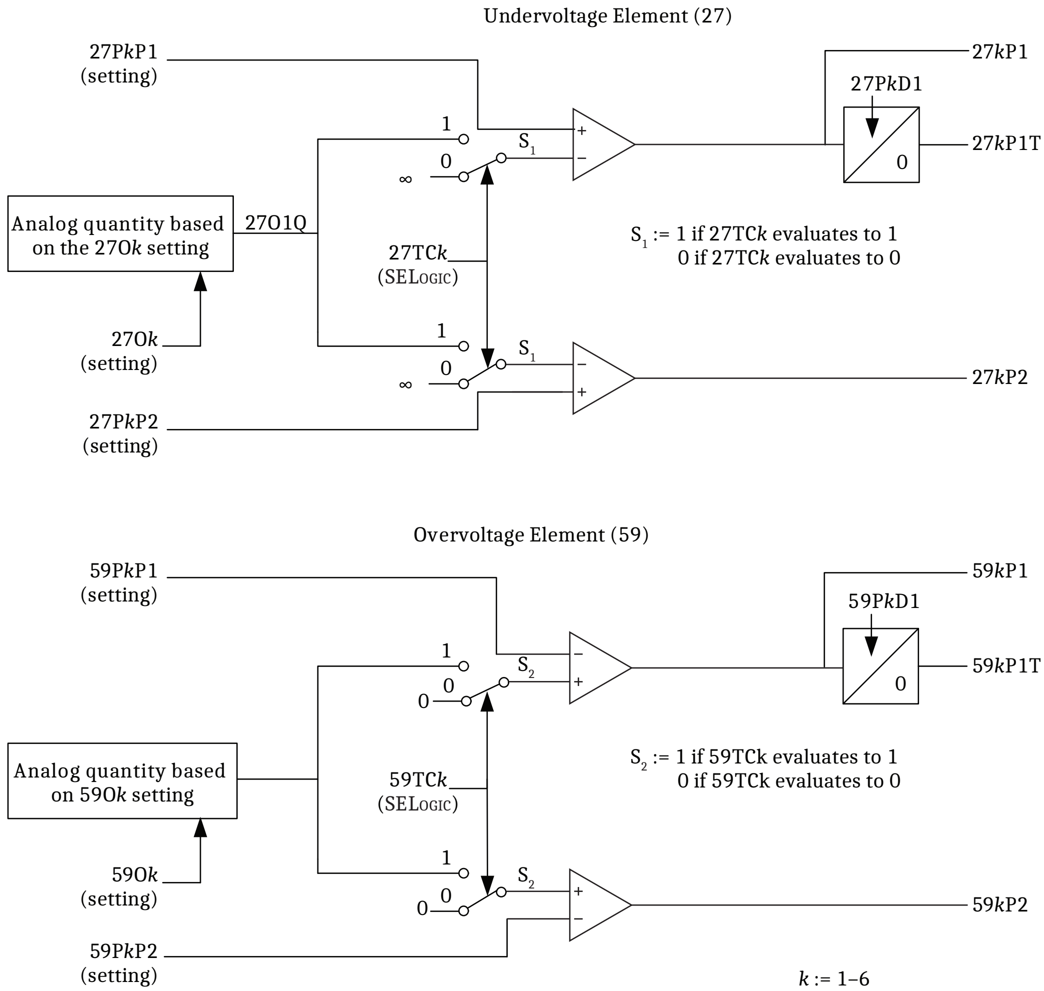


Figure 5.27 Over- and Undervoltage Logic

Settings Descriptions

E27 Enable Undervoltage Elements

Use the E27 setting to enable the number of undervoltage elements you want the relay to use. Each undervoltage element provides two pickup settings levels.

27Ok Undervoltage Element Operating Quantity

Select the operating quantity 27O*k* (*k* = 1–6) you want for each voltage element from *Table 5.7*.

Table 5.7 Undervoltage Operating Quantity List

Label	Description
V01FIM	Voltage Element 01 fundamental filtered voltage
V02FIM	Voltage Element 02 fundamental filtered voltage
V03FIM	Voltage Element 03 fundamental filtered voltage
V1FIM	Positive-sequence fundamental filtered voltage

27PkP1 Undervoltage Element Level 1 Pickup

The 27P*k*P1 (*k* = 1–6) undervoltage element Level 1 pickup setting is typically used for alarm level indication of undervoltage conditions. The setting is in secondary voltage. The Level 1 pickup has a definite-time delay (27P*k*D1) that can be used to provide a time delay on the assertion of the undervoltage element.

27PkP2 Undervoltage Element Level 2 Pickup

The 27P*k*P2 (*k* = 1–6) undervoltage element Level 2 pickup setting is typically used for undervoltage tripping conditions. The setting is in secondary voltage. The Level 2 pickup has no definite-time delay.

27TCk Undervoltage Element Torque Control

The 27TC*k* (*k* = 1–6) undervoltage element torque control uses a SELOGIC control equation to provide torque control of the undervoltage elements. All undervoltage elements are blocked from operation when the 27TC*k* input evaluates to a zero. The default setting of 1 allows the undervoltage elements to always operate.

27PkD1 Undervoltage Element Level 1 Delay

When the system voltage falls below the undervoltage setting value, the undervoltage timer starts timing. Set the delay (in cycles) for which the timer must run before the 27P*k*D1 (*k* = 1–6) setting asserts the output.

E59 Enable Overvoltage Elements

Use the E59 setting to enable the number of overvoltage elements you want to use in the relay. Each overvoltage element provides two pickup setting levels.

59Ok Overvoltage Element Operating Quantity

Select the operating quantity 59O*k* (*k* = 1–6) you want for each voltage terminal from *Table 5.8*.

Table 5.8 Overvoltage Operating Quantity List

Label	Description
V01FIM	Voltage Element 01 fundamental filtered voltage
V02FIM	Voltage Element 02 fundamental filtered voltage
V03FIM	Voltage Element 03 fundamental filtered voltage
V1FIM	Positive-sequence fundamental filtered voltage
3V2FIM	Negative-sequence fundamental filtered voltage
3V0FIM	Zero-sequence fundamental filtered voltage

59PkP1 Overvoltage Element Level 1 Pickup

Set pickup thresholds for the voltage values above which you want the Level 1 overvoltage elements to assert. The Level 1 pickup has a definite-time delay (59P*k*D1) that can be used to provide a time delay on the assertion of the overvoltage element.

59PkP2 Overvoltage Element Level 2 Pickup

Set pickup thresholds for the voltage values above which you want the Level 2 overvoltage elements to assert.

The 59P*k*P2 (*k* = 1–6) overvoltage element Level 2 pickup setting is typically used for overvoltage tripping conditions. The setting is in secondary voltage. The Level 2 pickup has no definite-time delay.

59TCk Overvoltage Element Torque Control

The 59TC*k* (*k* = 1–6) overvoltage element torque control uses a SELOGIC control equation to provide torque control of the overvoltage elements. All overvoltage elements are blocked from operation when the 59TC*k* input evaluates to a zero. The default setting of 1 allows the overvoltage elements to always operate.

59PkD1 Overvoltage Element Level 1 Delay

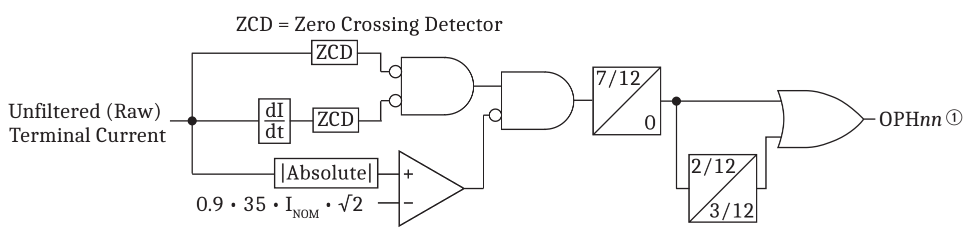
When the system voltage exceeds the overvoltage setting value, the overvoltage timer starts timing. Set the delay (in cycles) for which the timer must run before the 59P*k*D1 (*k* = 1–6) setting asserts the output.

Certain protection philosophies require voltage supervision for a trip. Each SEL-487B provides two levels of negative-sequence voltage and two levels of zero-sequence voltage elements to satisfy this requirement. In addition, the relay also provides two levels of phase undervoltage (27) and overvoltage (59) elements for each of the three phases.

Open-Phase Detection Logic

NOTE: Zero Crossing Detection is only enabled when the current is greater than advanced Global setting OPHDO.

Subsidence current results from energy trapped in a CT magnetizing branch after a circuit breaker opens to clear a fault or interrupt load. This current exponentially decays and delays the resetting of instantaneous overcurrent elements used for breaker failure protection. Breaker failure protection requires fast open-phase detection to ensure fast resetting of instantaneous overcurrent elements. *Figure 5.28* shows open-phase logic that asserts SEL-487B open-phase detection elements OPH*nn* (*nn* = 01, 02, …21) in less than one cycle, even during subsidence current conditions.



① See Figure 5.51.

Figure 5.28 Open-Phase Detection

The relay declares an open phase when the logic does not detect a zero crossing or current value within 7/12 of a power system cycle since the previous measurement. The bottom path in *Figure 5.28* is used to detect when the nominal current input for any channel is nearing the point of clipping at the analog to digital converter. If current channel clipping is imminent, current is above subsidence levels and the open-phase logic is forced to a false condition.

Open CT Detection Logic

When a CT opens, there is an incremental increase in operating current and a corresponding incremental decrease in restraint current. The two increments should result in a summation equal to zero.

Figure 5.29 shows the open current transformer detection logic. The change in operating current (ΔIOP*n*R), the change in restraint current (ΔIRT*n*R), and operating current (IOP*n*) are the analog inputs to the logic.

The AND gate output asserts when the following conditions are true:

- ΔIOP*n*R is a positive value (greater than or equal to 0.05 pu)
- ΔIRT*n*R is a negative value (less than –0.05 pu)
- The sum of ΔIOP*n*R and ΔIRT*n*R is very small (less than 0.05 pu)
- The filtered operating current (IOP*n*) is greater than or equal to Group Setting S87P

When the AND gate output is asserted, Relay Word bit OCTZ*n* asserts and is latched. SELOGIC control equation ROCTZ*n* resets the latch and Relay Word bit OCTZ*n* clears. Reset has priority over set.

The lower portion of the logic asserts Relay Word bit RSTOCT*n*, the default value for SELOGIC control equation ROCTZ*n*. RSTOCT*n* asserts when any of the following conditions are true:

- IOP*n* is less than 90 percent of group setting S87P
- IOP*n* is less than 0.05

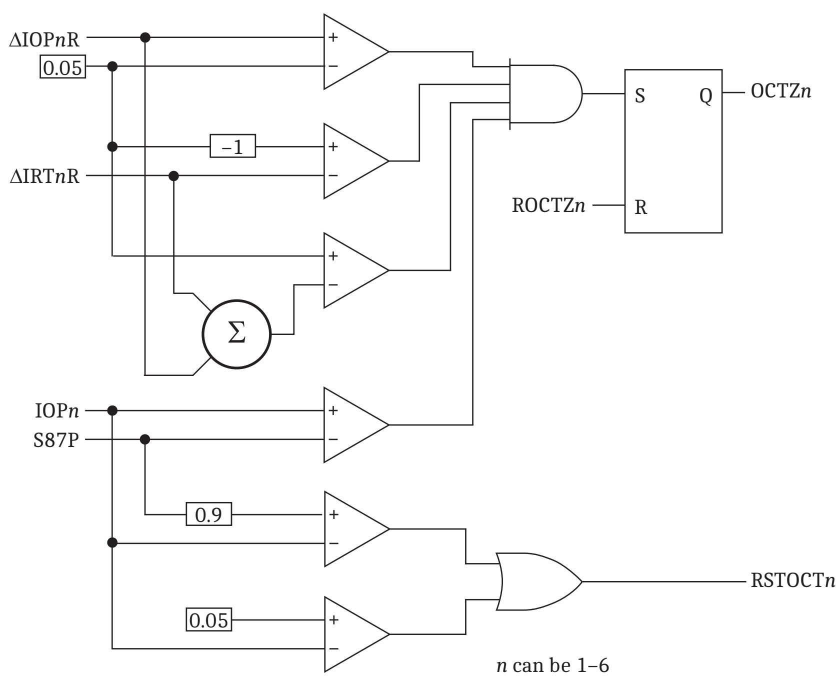


Figure 5.29 Zone n Open CT Detector

Table 5.9 shows the Relay Word bits available in the check zone selection logic with their descriptions.

Table 5.9 Relay Word Bits in the Open CT Detection Logic

Quantity	Description
OCTZ*n*	Zone *n* Open CT detected
ROCTZ*n*	Reset Zone *n* Open CT detector (SELOGIC control equation)
RSTOCT*n*	Zone *n* Open CT detection reset

Circuit Breaker Failure Protection

The SEL-487B has complete breaker failure protection that includes retrip for each of the 21 terminals. This protection uses open-phase detection logic, provided with subcycle current reset, to reduce breaker failure coordination times. Two options are available for application of breaker failure protection:

- Schemes equipped with external breaker failure relays. These schemes send a bus trip (output from the breaker failure relay on the terminal panel) command to the bus protection relay (SEL-487B) that requires only the zone selection and output contacts to operate the appropriate breakers.
- Schemes using the internal breaker failure protection of the SEL-487B. These schemes send a breaker failure initiate (normally a trip output) command to the bus protection relay. The SEL-487B includes breaker failure logic, as well as zone selection and output contacts, to operate the appropriate breakers.

Apply either option exclusively, or use a combination of the two options at the same station. For example, use the breaker failure relays on the feeder panels for protection philosophies requiring discrete breaker failure relays, but use the built-in breaker failure protection in the SEL-487B for all other terminals at the station. Connect breaker failure initiate signals from these terminals to any one of six independent optoisolated inputs. These inputs are available on each INT4 interface board. *Figure 5.30* shows logic for Terminal 01; similar logic is available for all 21 terminals.

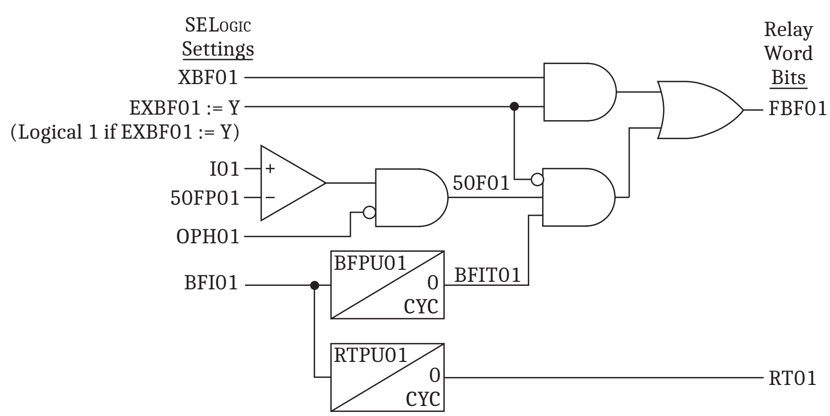


Figure 5.30 Breaker Failure Logic

Schemes Using Internal Breaker Failure Relays

The basic breaker failure logic does not include logic to seal-in the breaker failure initiate signals. For applications where BFI seal-in and extension are required, alternate BFI logic is provided. Set EXBF01 := N to enable the internal breaker failure logic for Terminal 01. Refer to *Figure 5.30*.

Breaker Failure Logic

The breaker failure logic requires the trip signal to be continuously present for the duration of the breaker failure timer because the BFI signal is not sealed in. If an external BFI signal falls away for one processing interval longer than the debounce dropout time setting of the input, the breaker failure timers reset. Wire breaker failure initiate circuitry, typically a trip output contact from a protection relay, to one of the six independent optoisolated inputs and assign the input to BFI01.

When the trip contact from the protection relay closes to assert BFI01, timers BFPU01 (Terminal I01 circuit breaker failure timer) and RTPU01 (Terminal I01 retrip timer) start timing. If BF101 remains asserted when the retrip timer expires, Relay Word bit RT01 asserts. Use this Relay Word bit as an output to attempt another trip pulse to the circuit breaker before the relay issues a bus trip command. When timer BFPU01 expires, Relay Word bit FBF01 asserts if 50F01 is asserted. Use this Relay Word bit in the circuit breaker tripping logic to cause a circuit breaker failure trip.

If the circuit breaker opens successfully before timer BFPU01 or timer RTPU01 expires, the cessation of current flow on the circuit will cause the fast breaker open detector element OPH01 to assert, dropping out element 50F01. This will block the assertion of the breaker failure Relay Word bit FBF01. If the trip contact from the protection relay opens before timer RTP01 expires, the BFPU01 timer and RTPU01 timers will drop out and neither RT01 nor FBF01 will assert.

This logic is suitable for applications where two breakers must open to interrupt fault current, such as in breaker-and-a-half and ring-bus configurations. For these applications, breaker failure logic that requires both BFI and 50F to be asserted before the timer starts is often not suitable. The problem occurs because the 50F element may not assert until the first of the two breakers opens and the current redistributes so that all of it goes through the failed breaker. This situation results in a delay of the Breaker 2 breaker failure time equal to the time for Breaker 1 to interrupt the current. The 50 breaker failure logic does not have this problem.

Alternate Breaker Failure Initiating Input With Extension and/or Seal In Logic

The alternate BFI logic lets you choose to either extend the breaker failure initiate signal or seal in the breaker failure initiate signal. *Figure 5.31* shows the combined logic for both breaker failure initiating input extension (AND Gate 1) and seal-in (AND Gates 1 and 2) functions. This logic can also be used for applications where it is required to have 50F01 asserted before the breaker failure timer can start.

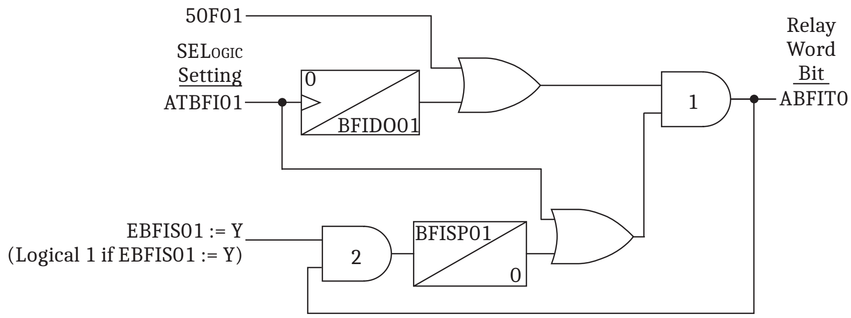


Figure 5.31 Circuit Breaker Failure Initiation Extension and Seal In

Breaker Failure Initiating Input Seal In

Use the seal-in option if the breaker failure initiation signal is not continuous and fault current is immediately available (single-breaker applications). Referring to *Figure 5.31*, set EXBF01 := N to enable the internal breaker failure logic. Set EBFIS01 := Y to set the top input of AND Gate 2 to a logical 1. Wire the breaker failure initiate signal to the SEL-487B, and assign the input to ATBFI01. Then assign Relay Word bit ABFIT01 to BFI01 (*Figure 5.30*). On receipt of the breaker failure initiate signal, AND Gate 1 turns on. The output from AND Gate 1 starts the breaker failure timers (*Figure 5.30*) and turns AND Gate 2 on. If the initiate signal is present for longer than the Timer BFISP01 setting, the output from Gate 1 seals in for as long as the current exceeds the 50FP01 threshold. Set the Timer BFISP01 setting longer than a quarter cycle to prevent seal-in for spurious signals, but set it shorter than the initiate signal to ensure seal-in.

NOTE: Coordinate Timer BFISP01 setting with the contact debounce settings.

Breaker Failure Initiating Input Extension

Use the extension option in conjunction with the seal in option if the breaker failure initiation signal is not continuous, but fault current is not immediately available to start the breaker failure timers (double-breaker applications).

The logic still requires the current to be above the 50FP01 threshold after timer BFIDO01 times out to keep Gate 1 turned on. Set EXBF01 := N to enable the internal breaker failure logic. Referring to *Figure 5.31*, wire the breaker failure initiate signal to the SEL-487B, and assign the input to ATBFI01. Then assign Relay Word bit ABFIT01 to BFI01 (*Figure 5.30*). In the absence of fault current, and on receipt of the rising edge of the breaker failure initiate signal at input ATBFI01, AND Gate 1 turns on. When AND Gate 1 turns on, Relay Word bit ABFIT01 asserts, causing timers BFPU01 and RTP01 to start timing (*Figure 5.30*).

When Breaker 1 opens, enough current flows through Breaker 2 to assert the 50F01 Relay Word bit. Refer to *Figure 5.31* and note that the current flowing through Breaker 2 replaces the output from timer BFIDO01 and keeps Gate 1 turned on, sustaining the input to the breaker failure timers. Set Timer BFIDO01 longer than the time Breaker 1 takes to interrupt the current, but shorter than the Timer BFPU01setting. This setting ensures that, after Breaker 1 opens, Timer BFPU01 will continue to run while current greater than 50FP01 is present.

Supervising Breaker Failure Initiate With the Fault Detector

NOTE: Although BFIDO01 is set to 0.0, the timer picks up for one processing interval after assertion.

Use the alternate BFI logic if the breaker failure initiation signal must be supervised by current before the BFPU01 timer can start. Set EXBF01 := N to enable the internal breaker failure logic. Referring to *Figure 5.31*, wire the breaker failure initiate signal to the SEL-487B and assign the input to ATBFI01. Then assign

Relay Word bit ABFIT01 to BFI01 (*Figure 5.30*). Set BFIDO01 to 0.0 CYC. In this configuration, the upper input to AND Gate 1 is controlled by 50F01 and the lower input to AND Gate 1 is controlled by ATBFI01. Thus, ABFIT01 will not assert and start the BFPU01 and RTP01 timers (*Figure 5.30*) unless both ATBFI01 and 50F01 are asserted.

Schemes Equipped With External Breaker Failure Relays

Set EXBF01 := Y to enable the external breaker failure logic. This setting effectively reduces the logic to that shown in *Figure 5.32*.

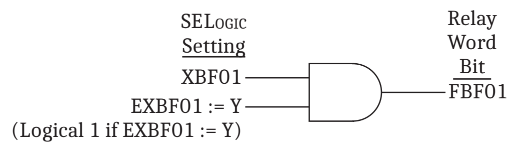


Figure 5.32 Breaker Failure Logic for External Breaker Failure

Wire breaker failure initiate circuitry to one of the SEL-487B inputs, and assign the input to XBF01. Relay Word bit FBF01 immediately asserts upon assertion of the input signal.

Retrip

Some circuit breakers have two separate trip coils. If one trip coil fails, local protection can attempt to energize the second trip coil (often connected to a separate battery) to prevent an impending circuit breaker failure operation. Configure your protection system to always attempt a local retrip using the second trip coil before the circuit breaker failure pickup timer expires. RTPU01 (Retrip Time Delay on Pickup Timer) begins timing when BFI01 asserts. Relay Word bit RT01 (Breaker 1 Retrip) asserts immediately after RTPU01 times out. Assign a control output to trip the circuit breaker when Relay Word bit RT01 asserts.

Breaker Failure Clearing Times

Figure 5.33 is based on actual test data at room temperature using various settings. Relay element specifications given in *Section 1: Introduction and Specifications* include the entire temperature range of the relay. Output contact times are not included.

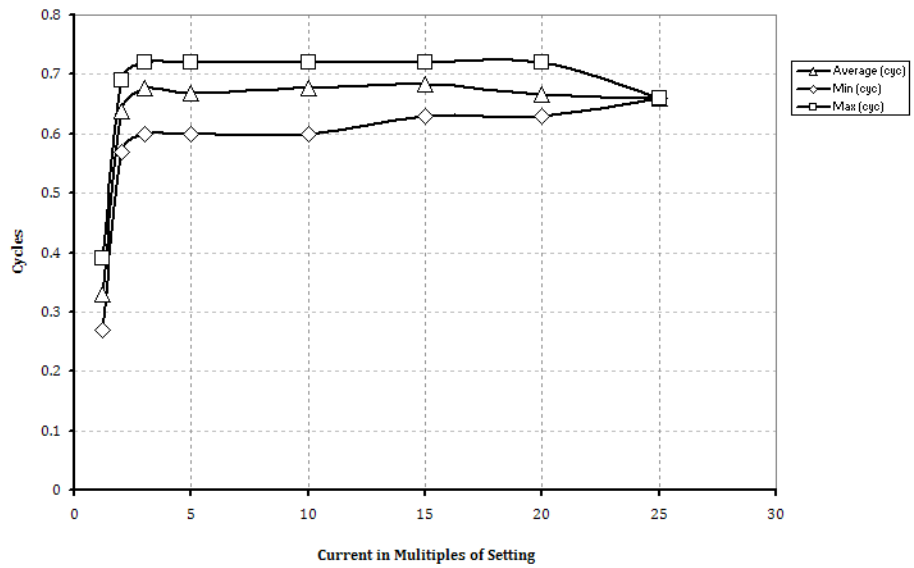


Figure 5.33 Breaker Failure Clearing Times

Circuit Breaker Failure Trip Logic

Following a breaker failure relay operation, the SEL-487B breaker failure trip logic sends trip signals to all of the breakers the logic identifies as being in the same bus-zone as the faulted breaker. The logic uses breaker failure trip information from the internal breaker failure logic and zone selection information to determine which breakers to trip. *Figure 5.34* shows the processing sequence for tripping the breakers according to the breaker failure operation FBF01.

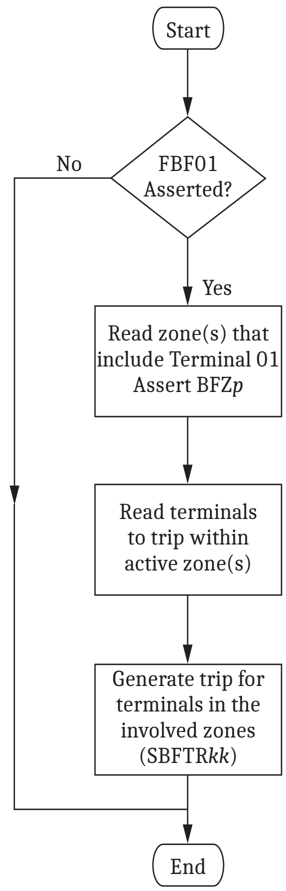


Figure 5.34 Station Breaker Failure Trip Logic

For example, assume Terminals I01, I02, I03, and I04 are in Bus-Zone 1, with Terminal 01 failing for an external fault. The logic determines that Terminal 01 is in Bus-Zone 1, just as Terminals 02, 03, and 04 are also in Bus-Zone 1. The relay asserts Relay Word bits SBFTR01, SBFTR02, SBFTR03, and SBFTR04. With the assumption that there are four breakers, assign these four Relay Word bits to the corresponding TR01, TR02, TR03, and TR04 trip equations.

The breaker failure trip logic asserts the breaker failure trips as shown in *Table 5.10*.

Table 5.10 Station Breaker Failure Trips (Sheet 1 of 2)

Terminal Within a Zone	Station Breaker Failure Trip Bit
I01	SBFTR01
I02	SBFTR02
I03	SBFTR03
104	SBFTR04
105	SBFTR05
106	SBFTR06
107	SBFTR07
108	SBFTR08
109	SBFTR09
110	SBFTR10

Table 5.10 Station Breaker Failure Trips (Sheet 2 of 2)

Terminal Within a Zone	Station Breaker Failure Trip Bit
I11	SBFTR11
I12	SBFTR12
I13	SBFTR13
I14	SBFTR14
I15	SBFTR15
I16	SBFTR16
I17	SBFTR17
I18	SBFTR18
I19	SBFTR19
I20	SBFTR20
I21	SBFTR21

SBFTR is the OR combination of SBFTR01 to SBFTR21.

Bus Coupler/Bus Sectionalizer Configurations

With the flexibility of SELOGIC control equations, you can configure any one of the bus sectionalizer (tie breaker) configurations in *Figure 5.35–Figure 5.37* without additional wiring; it is simply a software configuration change.

CT Either Side of the Breaker With Overlap

Figure 5.35 shows a bus sectionalizer with a CT on either side of the circuit breaker with the protection arranged in overlap. For an overlap application, connect the CTs so that each zone of protection (B1 and B2) includes the tie-breaker circuit breaker. For example, for Fault 1, only the differential element of Busbar B2 operates; the differential element of Busbar B1 is stable. However, because of the overlap connections, both differential elements operate for Fault F2.

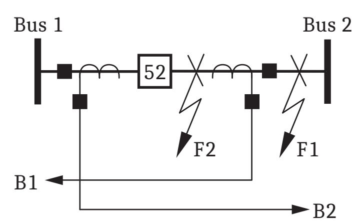


Figure 5.35 Two CTs With the Busbar Protection Configured in Overlap

CT Either Side of the Breaker With Breaker Differential

Figure 5.36 also shows a bus sectionalizer with a CT on either side of the circuit breaker with the protection arranged in a breaker differential application. For a breaker differential application, connect the CTs so that each zone of protection (B1 and B2) excludes the tie-breaker circuit breaker. For example, for Fault F1, the differential element of Busbar B2 operates; the differential element of Busbar

B1 is stable. The differential element of both Busbar B1 and Busbar B2 is stable for Fault F2. To provide protection for Fault F2, configure an additional differential zone of protection across the tie-breaker circuit breaker.

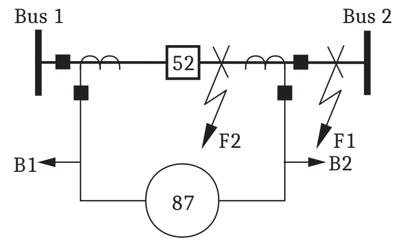


Figure 5.36 Two CTs With the Busbar Protection Configured as Breaker Differential

Single CT, Single or Two Cores With Overlap

Figure 5.37 shows a bus sectionalizer with a single CT on one side of the circuit breaker with the protection arranged in overlap.

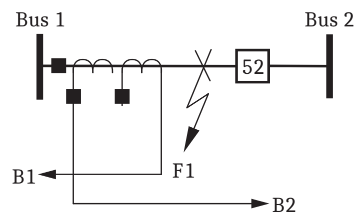


Figure 5.37 Single CT With the Busbar Protection Configured in Overlap

Refer to the application examples in *Section 6: Protection Application Examples* for more information.

Coupler Security Logic

A fault between bus coupler circuit breaker and CT usually results in the loss of multiple zones as well as in delayed fault clearance, except for where the bus coupler has overlapping zones of protection where both zones are tripped instantaneously. For bus coupler configurations such as breaker differential and single CT applications, fault clearance time usually equals the bus coupler breaker failure time for faults between the CT and the breaker. The coupler security logic includes logic to shorten this time so that it equals the operating time of the bus coupler circuit breaker. Coupler security logic also includes logic to prevent tripping of multiple bus-zones instead of just the faulted bus-zone. Although identifying the faulted bus-zone introduces a trip delay, this delay is still shorter than the bus coupler breaker failure time.

Preventing the loss of multiple bus-zones requires two steps. First, the coupler security logic allows the differential elements to trip only the bus coupler circuit breaker, thereby interrupting the fault current from the unfaulted bus-zone. Then, this logic removes the bus coupler CTs from all differential calculations. Removing the bus coupler CTs from the differential calculations of the unfaulted bus-zone has no effect on the stability of this bus-zone because it no longer contributes to the fault current. However, removing the bus coupler CTs from the differential calculations of the faulted bus-zone causes the differential elements of the faulted bus-zone to operate. This application trips only the faulted bus-zone, thereby preventing the indiscriminate loss of multiple zones, irrespective of the fault position or CT location.

In most cases, breaker auxiliary contacts provide circuit breaker status information. However, circuit breaker auxiliary contact failure or misalignment can result in relay misoperation instead of accelerated tripping. The following discussion describes network operating conditions that may result in relay misoperation and shows how the coupler security logic in the SEL-487B prevents these possible misoperations. Two examples of accelerated tripping show how to apply the coupler security logic to breaker differential and single CT applications. In all cases, assume circuit breaker operating times to be two cycles.

Network Operating Condition 1

Figure 5.38 depicts a subset of a substation showing Bus Sectionalizer Breaker Z, and two terminals labeled Feeder 1 and Feeder 2. Zone 1 and Zone 2 are the two bus sections at the station, with the bus sectionalizer busbar protection arranged in overlap. Because both sectionalizer disconnects (Z891 and Z892) are closed, the currents from the sectionalizer CTs are considered in the differential calculations. In this example, the bus sectionalizer circuit breaker is open, and both feeder circuit breakers are closed. *Table 5.11* summarizes the prevailing network operating conditions.

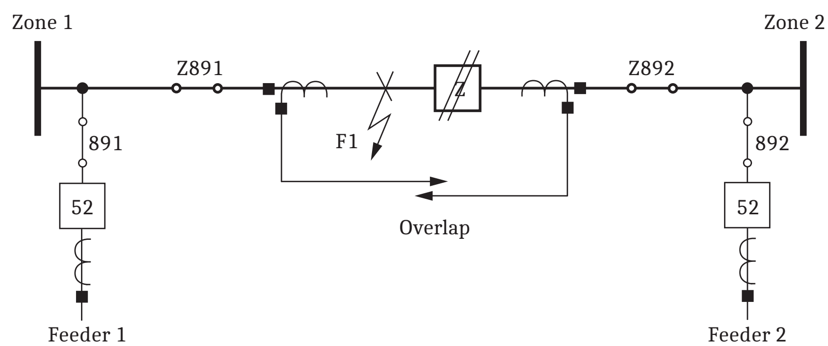


Figure 5.38 Fault F1 Between Bus Sectionalizer and CT With the Bus Sectionalizer Circuit Breaker Open

Table 5.11 Summary of the Network Conditions Shown in Figure 5.38

Station Conditions	Fault Description
Bus sectionalizer Circuit Breaker Z open Both bus sectionalizer disconnects (Z891 and Z892) closed All other breakers and disconnects closed	Fault F1 develops between the sectionalizer circuit breaker and CT

Assume now that Fault F1 occurs as indicated in *Figure 5.38*. Because the currents from the sectionalizer CTs are considered in the differential calculations, and because the bus sectionalizer busbar protection is arranged in overlap, both zones trip. *Table 5.12* summarizes the event.

Table 5.12 Summary of the Event for Fault F1 Shown in Figure 5.38

Tripping for Fault F1	Clearing Time	Zones Lost	Comment
All breakers in both zones trip without time delay	2 cycles	2	Zone 2 tripped unnecessarily

One solution for overcoming this problem is to include the bus sectionalizer circuit breaker auxiliary contact together with the disconnect auxiliary contact as a condition for CT consideration in the differential calculations. With the bus sectionalizer circuit breaker auxiliary contact included in the conditions, the current inputs from the bus sectionalizer CTs are not considered in the differential calculations when the bus sectionalizer circuit breaker is open. In this case, only Zone 1 trips for Fault F1 in *Figure 5.38*.

Including the bus sectionalizer circuit breaker auxiliary contact solves the problem in Network Operating Condition 1. However, Network Operating Condition 2 shows that the busbar protection is still not completely secure, although the conditions for CT consideration in the differential calculations now include the bus sectionalizer circuit breaker auxiliary contact.

Network Operating Condition 2

Figure 5.39 shows the same substation under different operating conditions. The bus sectionalizer circuit breaker auxiliary contact 52A forms part of the conditions for CT consideration in the differential calculations. Although the disconnects are closed, the bus sectionalizer circuit breaker is open and the differential calculations do not consider the bus sectionalizer CT inputs in the differential calculation. Fault F2 in *Figure 5.39* represents grounding straps that were inadvertently left on the busbars in Zone 1. The Feeder 1 circuit breaker is open, and the bus sectionalizing circuit breaker is about to close. *Table 5.13* summarizes the prevailing network operating conditions.

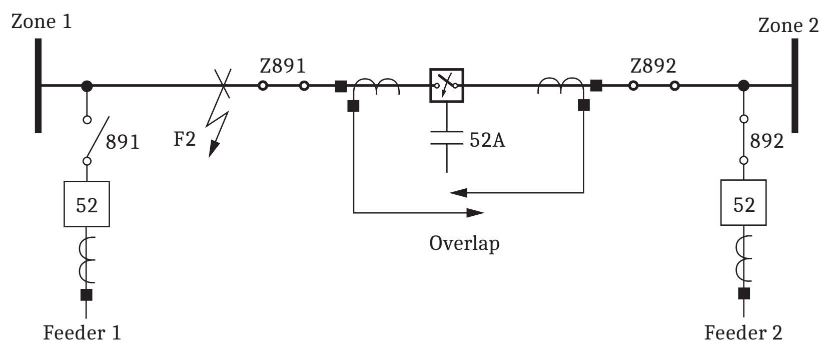


Figure 5.39 Closing the Bus Sectionalizing Circuit Breaker Onto a Faulted Busbar

Table 5.13 Summary of the Events for Fault F2 Shown in Figure 5.39

Station Conditions	Fault Description
Bus sectionalizer Breaker Z closing Both bus sectionalizer disconnects (Z891 and Z892) are closed All Zone 2 feeder breakers and disconnects (892) are closed All Zone 1 feeder disconnects (891) are open	Sectionalizer breaker closes onto Fault F2

If the bus sectionalizing circuit breaker auxiliary contacts are misaligned or fail in such a way that the CTs from the sectionalizer are not considered in the differential calculation at fault inception, the Zone 2 differential elements misoperate. *Table 5.14* summarizes the event.

Table 5.14 Summary of the Event for Fault F2 Shown in Figure 5.39

Tripping for F2	Clearing Time	Zones Lost	Comment
All breakers in Zone 2 trip without time delay (Feeder 2 and Circuit Breaker Z)	2 cycles	1	Incorrect tripping for terminals connected to Zone 2; only terminals connected to Zone 1 (Breaker Z) should have tripped.

Use the coupler security logic (see *Figure 5.40*) in the SEL-487B to prevent relay misoperation for network conditions 1 and 2.

Coupler Security Logic

Inserting the bus sectionalizer CTs into the differential calculations before fault inception prevents relay misoperation for Network Operating Condition 2. *Figure 5.40* shows one of the four coupler security logics available in the relay. Wire a bus sectionalizer auxiliary contact to input CB52A1, and wire the bus sectionalizer circuit breaker closing signal to input CBCLS1. Inputs CB52A1 and CBCLS1 coordinate the bus sectionalizer CT insertion into and removal from the differential calculation. For breaker differential applications, enter **CSL1**, the output from the coupler security logic, instead of the bus sectionalizer circuit breaker auxiliary contact, as a condition for CT consideration in the differential calculations.

As shown in *Figure 5.40*, the breaker auxiliary contact (CB52A1) and the close signal (CBCLS1) are in parallel. Issuing the close signal to the bus sectionalizer circuit breaker close coil also asserts Relay Word bit CSL1. Timer CBCLD01 maintains the close signal for five cycles (default setting), allowing ample time for the bus sectionalizer circuit breaker auxiliary contact to change state. When Relay Word bit CSL1 asserts, the CTs are immediately considered in the differential calculation. Because the bus sectionalizer CTs are considered in the differential calculation before fault inception, Zone 2 is stable for Network Operating Condition 2.

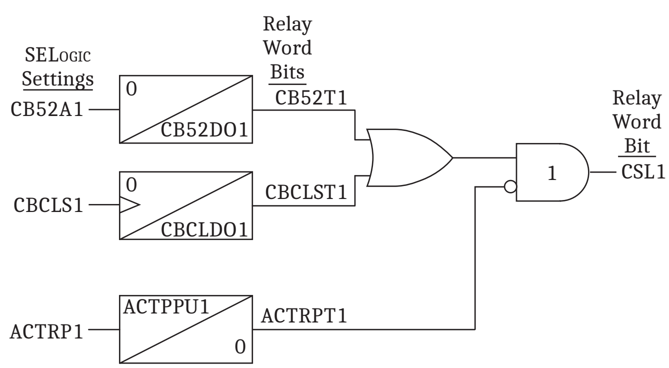


Figure 5.40 Coupler Security Logic for Accelerated Tripping and Busbar Protection Security for Circuit Breaker Auxiliary Contact Misalignment

When the bus sectionalizer circuit breaker trips, misaligned circuit breaker auxiliary contacts can remove the bus sectionalizer CTs from the differential calculation while current still flows through the bus sectionalizer circuit breaker. Timer CB52D01 maintains the status of the bus sectionalizer circuit breaker auxiliary contact as closed for four cycles (default setting) after the contact changes state. During this four-cycle time delay, the bus sectionalizer CTs are still considered in the differential calculation, allowing the bus sectionalizer circuit breaker ample time to interrupt the current.

ACTRP1, the third input into the coupler security logic provides an input to accelerate tripping of the bus sectionalizer circuit breaker for faults between bus sectionalizer circuit breaker and CT. Accelerated tripping operating time is the time period greater than the bus sectionalizer circuit breaker operating time (typically 2 cycles) but shorter than the breaker failure time (typically 6–10 cycles).

Breaker Differential

Figure 5.41 shows an application of breaker differential protection. There are CTs on either side of the bus sectionalizing circuit breaker, and we configure a differential zone of protection across the bus sectionalizing circuit breaker. This is in addition to Zone 1 and Zone 2 of the busbar protection. Any of the six zones may be used for breaker differential protection. Breaker differential protection is a good choice for stations where preservation of supply is more important than a very fast clearing time.

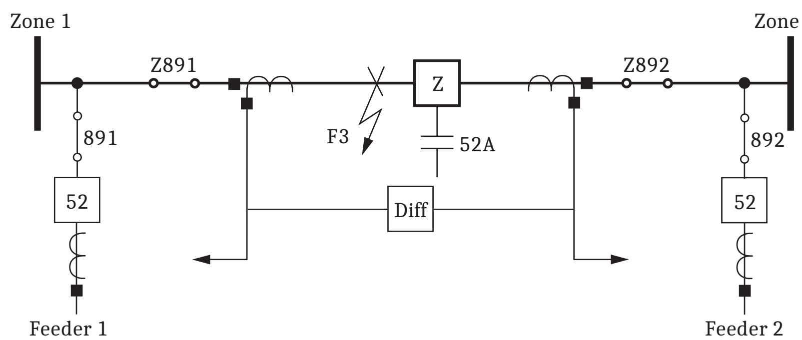


Figure 5.41 CTs on Either Side of the Sectionalizer Circuit Breaker With Breaker Differential Across Breaker Z

We use the coupler security logic (initially without an ACTRP1 input) and consider the relay operation for Fault F3 in *Figure 5.41*. Circuit Breaker Z opens after two cycles, deasserting the input to CB52A1. When Circuit Breaker Z trips, fault current no longer flows from Zone 2, but Zone 1 still contributes to the fault. Four cycles after Circuit Breaker Z trips (CB52D01 default time), Relay Word bit CSL1 deasserts, removing both bus sectionalizing CTs from all three differential elements (breaker differential, Zone 1, and Zone 2). Zone 2 is stable after removing the CTs from the Zone 2 differential calculations because Zone 2 no longer contributes to the fault. However, Zone 1 still contributes to the fault, and removing the CTs from the Zone 1 differential calculations causes the Zone 1 differential elements to operate, clearing the fault. Only one zone is lost, although this loss occurs after a time delay. *Table 5.15* summarizes the events.

Table 5.15 Summary of the Event for Fault F3 Shown in Figure 5.41

Relay and Circuit Breaker Operation for F3	Time Delay	Zones Lost	Comment
Breaker differential (87R3) asserts	1 cycle	0	Typical operating time is 0.75 cycles
Bus sectionalizer trips	2 cycles	0	Correct tripping
Timer CB52A1 expires	4 cycles	0	Relay Word bit CSL1 deasserts, unbalancing Zone 1
SEL-487B operating time	1 cycle	0	Typical operating time is 0.75 cycles
All circuit breakers in Zone 1 trip	2 cycles	1	Total clearing time is 10 cycles

Because Fault F3 is external to Zone 1 and Zone 2, both of these zones are stable for as long as the sectionalizing breaker CTs are considered in the differential calculations. If the sectionalizing breaker fails, both Zone 1 and Zone 2 trip only after breaker failure time.

Function ACTRP1 provides an input for removing the bus sectionalizing CTs sooner. One solution is to assign 87R3, the output from the sectionalizer breaker differential element to input ACTRP1. Relay Word bit 87R3 asserts when there is a fault within the sectionalizer zone. With ACTPPU1 set to 4 cycles, Relay Word bit CSL1 deasserts about 2 cycles after the sectionalizing circuit breaker interrupts the fault current. *Table 5.16* summarizes the events.

Table 5.16 Summary of the Event for Fault F3 Using the Accelerated Trip Function

Relay and Circuit Breaker Operation for F3	Time Delay	Zones Lost	Comment
Breaker differential (87R3) asserts	1 cycle	0	Typical operating time is 0.75 cycles. Timer ACTPPU1 starts timing
Bus sectionalizer trips	2 cycles	0	Correct tripping
Timer ACTPPU1 expires	2 cycles	0	Reduce this setting for faster clearance
SEL-487B operating time	1 cycle	0	Typical operating time is 0.75 cycles
All circuit breakers in Zone 1 trip	2 cycles	1	Total clearing time is 8 cycles

Single CT Application

Figure 5.42 shows the same substation, now with only one CT installed on the bus sectionalizer. The busbar protection is connected in overlap. The challenge for the busbar protection is to distinguish between faults F4 and F5. When Fault F5 occurs, Zone 1 is stable and the Zone 2 protection immediately trips Feeder 2 and the bus sectionalizer circuit breaker. Tripping Feeder 2 and the bus sectionalizer circuit breaker clears Fault F5.

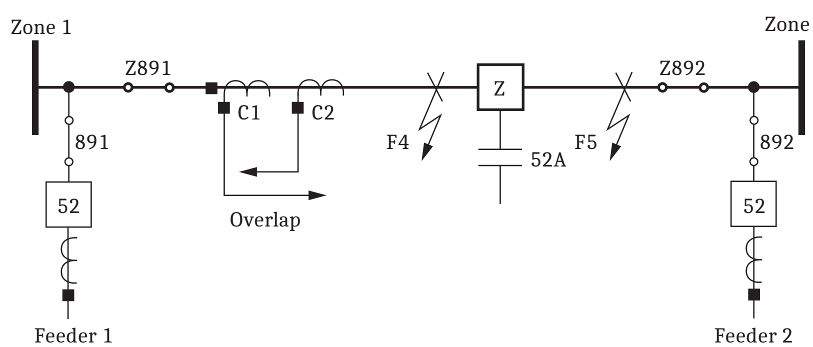


Figure 5.42 Single CT Application With Fault F4 Between the Bus Sectionalizer Circuit Breaker and CT

When Fault F4 occurs, Zone 1 is stable, and, as before, the Zone 2 protection immediately trips Feeder 2 and the bus sectionalizer circuit breaker. Tripping Feeder 2 and the bus sectionalizer circuit breaker, however, does not clear Fault F4, and fault current still flows through the bus sectionalizer CT. At the same time, the busbar protection also initiates breaker failure protection on Feeder 2 and the bus sectionalizer. This fault current causes the breaker failure protection of the bus sectionalizer to continue timing, although the bus sectionalizer circuit breaker tripped. After the bus sectionalizer breaker failure timer times out, all circuit breakers in Zone 1 trip. Both Zone 1 and Zone 2 trip to clear this fault.

If delayed tripping time for Zone 2 busbar faults is in order, use a combination of the zone supervision and coupler security logic to prevent losing both zones. Assign 87R2, the output from the Zone 2 differential element, to ACTRP1, the accelerated trip input of the coupler security logic. Assign the negated output from the coupler security logic (NOT CSL1) to supervise the Zone 2 differential element output (Z2S := NOT CSL1). For single CT applications, enter **CB52A1**, the bus sectionalizer circuit breaker auxiliary contact, as a condition for CT consideration in the differential calculations for the zone supervised by CSL1 (Zone 2 in this case). Then, enter **CB52T1**, the coupler status timed-out bit, as a condition for CT consideration in the differential calculations for the unsupervised zone (Zone 1 in this case).

For faults in Zone 2, trip only the bus sectionalizer circuit breaker. After the bus sectionalizer opens, remove the bus sectionalizer CT from the differential calculations of Zone 2. After a set delay of at least 2 cycles (to allow the 87R2 element to reset), remove the Zone 2 supervision and the bus sectionalizer CT from the differential calculations of Zone 1. The operation of the logic is as follows:

> When either Fault F4 or Fault F5 occurs, the Zone 2 differential element operates to clear the fault. The Zone 2 zone supervision prevents Relay Word bit 87Z2 from asserting and only the bus sectionalizer circuit breaker receives a trip signal. The circuit breaker trips two cycles later, removing CT cores C1 and eventually C2 from the differential calculations for Zone 1 and Zone 2.
>
> For Fault F4, the bus sectionalizer circuit breaker is open, but fault current still flows through CT Cores C1 and C2. Removing the bus sectionalizer CTs from all differential calculations prevents Zone 2 from operating (current from CT Core C1 removed) but causes Zone 1 to operate (balancing current from CT Core C2 removed).
>
> For Fault F5, tripping the bus sectionalizer circuit breaker interrupts the fault current contribution from Zone 1, and the Zone 1 differential element is stable. The Zone 2 zone supervision prevents tripping of terminals in Zone 2, until Accelerate Trip Timer ACTRP1 times out. When ACTRP1 times out, coupler security logic output CSL1 deasserts. When Relay Word bit CSL1 deasserts, Relay Word bit Z2S asserts, allowing the Zone 2 differential element (87Z2) to operate and issuing a trip signal to all circuit breakers in Zone 2. See *Application 7: Double and Transfer Bus (Outboard CTs) on page 6.181* for an example.

Disconnect Monitor

Disconnect auxiliary contacts provide the zone selection logic with the information required to dynamically assign current inputs to the appropriate differential elements. *Figure 5.43* depicts the logic for Disconnect Logic Circuit 01 in the relay, one of 60 disconnect logic circuits available in the relay. This logic requires both normally open (89A) and/or normally closed (89B) disconnect auxiliary contacts.

Table 5.17 shows the four possible disconnect auxiliary contact combinations, and the way in which the relay interprets these combinations. Applying the principle of (disconnect) NOT OPEN = (disconnect) CLOSED, the relay properly coordinates the primary current flow and the CT current assignment to the appropriate differential element.

Table 5.17 Disconnect 89A and 89B Auxiliary Contact Status Interpretation

Case	89A01	89B01	Disconnect Status (89CL01)
1	0	0	Closed (1)
2	0	1	Open (0)
3	1	0	Closed (1)
4	1	1	Closed (1)

The following description of the contact combinations assumes the disconnect auxiliary contacts are the only conditions declared in the terminal-to-bus-zone variable settings.

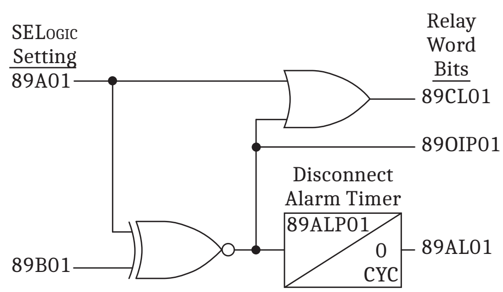


Figure 5.43 Disconnecting Switch Status Logic

Case 1 occurs when disconnect auxiliary contact 89A and auxiliary contacts 89B are open simultaneously. This case is the intermediate position in an open-to-close or close-to-open operation. Timer 89ALP01 times for this condition and asserts Relay Word bit 89AL01 when the disconnect auxiliary contacts remain in the intermediate position for a period exceeding the 89ALP01 timer setting. Relay Word bit 89OIP01 also asserts during this period, indicating a disconnect operation in progress condition. The relay considers the disconnect main contact closed during this period, and the CTs are considered in the differential calculations.

Case 2 is the only combination of disconnect auxiliary contacts for which the relay considers the disconnect main contact to be open. This is also the only combination for which the CTs are not considered in the differential calculations.

NOTE: Use Relay Word bit 89CL01 in SELOGIC control equations when entering the conditions in the terminal-to-bus-zone settings.

Case 3 is the only combination of disconnect auxiliary contacts for which the relay confirms the disconnect main contacts to be closed. Relay Word bit 89CL01 asserts to indicate the main contact close position. The CTs are considered in the differential calculations.

Case 4 is an illegitimate condition, with the disconnect auxiliary contacts showing the disconnect main contact to be open and closed simultaneously. Timer 89ALP01 times for this condition and asserts Relay Word bit 89AL01 when the disconnect auxiliary contacts remain in this condition for a period exceeding the timer setting. The relay considers the disconnect main contact closed during this period, and the CTs are considered in the differential calculations.

The relay includes 60 alarm timers that provide individual time settings for 60 disconnect logic circuits. These individual timers are useful in installations where the disconnect travel times differ substantially. In particular, sequentially operated devices (pantographs, for example) have travel times much longer than normal disconnects.

Relay Word bit 89OIP represents the OR combination of Relay Word bits 89OIP01–89OIP60, and Relay Word bit 89AL (not shown) is respectively the OR combination of Relay Word bits 89AL01–89AL60.

To ensure correct differential element operation, the contacts must comply with the requirements listed in *Table 5.18*.

Table 5.18 Disconnect Auxiliary Contact Requirements to Ensure Correct Differential Element Operation

Operation	Requirement
From disconnect open to disconnect close operation	Assign the currents to the applicable differential element before the disconnect reaches the arcing point (the point where primary current starts to flow).
From disconnect close to disconnect open operation	Remove the current from the applicable differential element only once the disconnect has passed the arcing point (the point where primary current has stopped flowing).

Figure 5.44 shows the disconnect auxiliary contact requirements with respect to the arcing point.

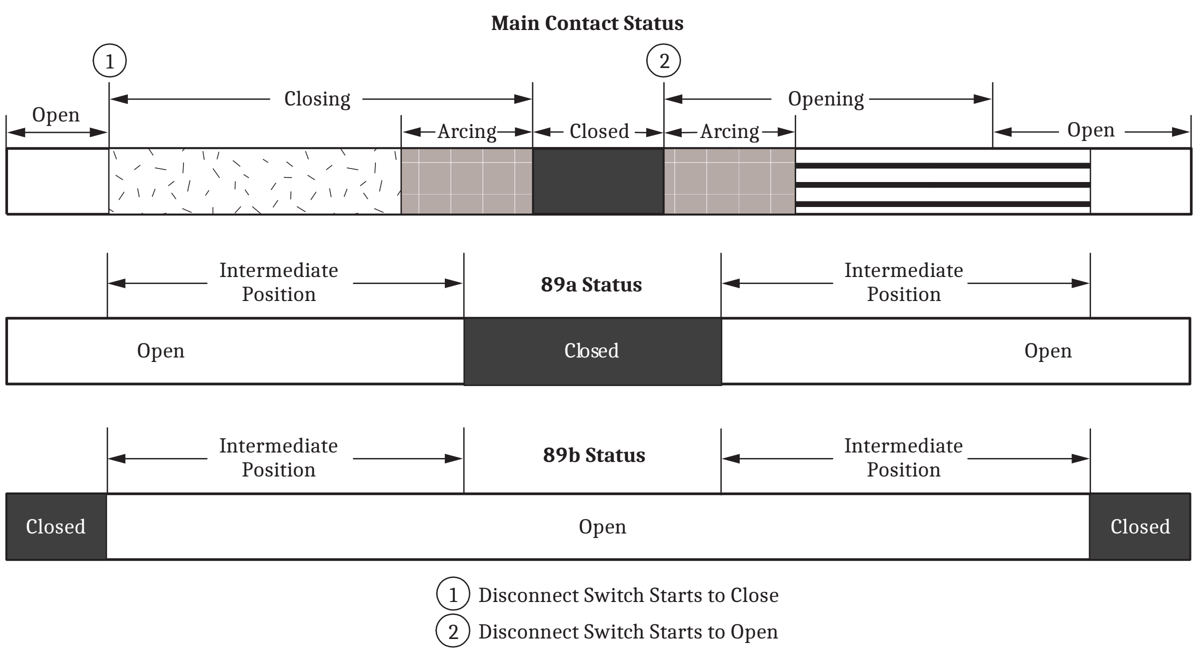


Figure 5.44 Disconnecting Switch Main Contact, 89a, and 89b Status for Open-to-Close and Close-to-Open Conditions

Zone-Switching Supervision Logic

Because the disconnect monitoring logic requires both 89A and 89B disconnect auxiliary contacts, installations with only an 89A (or 89B) contact available cannot use the disconnect monitoring logic. In these installations, there is always uncertainty whether the disconnect auxiliary contact actually changed status.

This is important information because busbar protection will misoperate if input currents are assigned to the incorrect differential elements. Zone-switching supervision logic uses the ZSWOP Relay Word bit (see *Dynamic Zone Selection Logic on page 5.14*) that asserts for any terminal-to-bus-zone or bus-zone-to-bus-zone change. In other words, the ZSWOP Relay Word bit provides an acknowledgment that the relay has recognized a change in disconnect auxiliary contact status. *Figure 5.45* shows the logic.

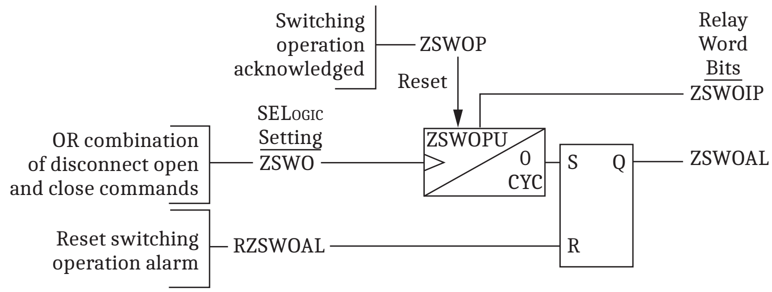


Figure 5.45 Zone-Switching Supervision Logic

Asserting Relay Word bit ZSWO activates the logic (i.e., the rising edge of ZSWO starts Timer ZSWOPU) and asserts the ZSWOIP bit for the period when the timer is timing. When the zone selection logic acknowledges a change in disconnect status, the ZSWOP Relay Word bit asserts and resets the timer. If the Zone Selection does not acknowledge the switching operation within the ZSWOPU time setting, the logic asserts the switching operation alarm ZSWOAL. SELOGIC control equation RZSWOAL provides the input to reset the alarm.

There is only one zone-switching supervision logic in the relay; disconnect open and close commands must be combined externally to the relay for electrically operated disconnects, as shown in *Figure 5.46*.

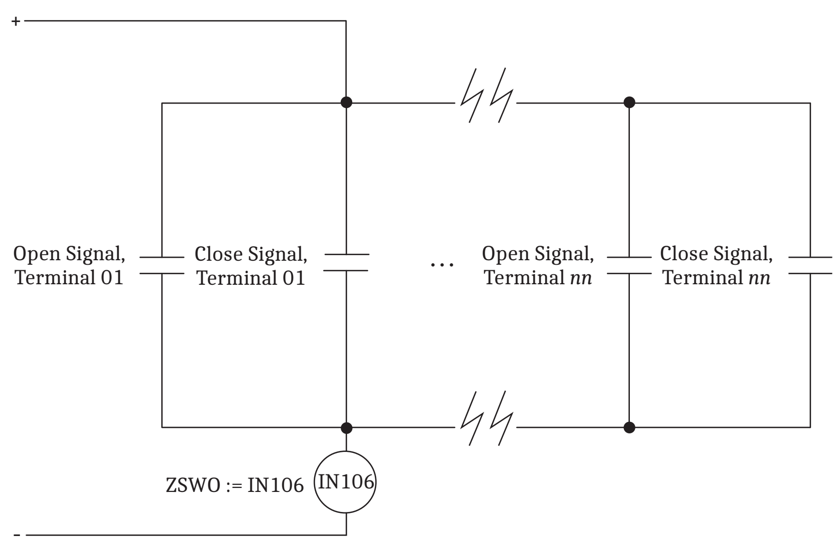
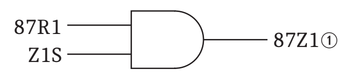


Figure 5.46 External Wiring and Initiation Input for Zone-Switching Supervision

For manually operated disconnects, configure one of the SEL-487B front-panel pushbuttons as an input to assert the ZSWO Relay Word bit. Timer ZSWOPU has a range of more than 27 minutes, allowing ample time for the operating procedures.

Differential Trip Logic

This is the final stage of the differential trip output. *Figure 5.47* is the Bus-Zone portion of *Figure 5.20* from the zone supervision logic. At this point, the differential element has operated (87R1), and all supervising criteria are met (Z1S). The differential trip logic now acquires all Zone 1 terminals and generates a trip output to the appropriate breakers.



① See Figure 5.11.

Figure 5.47 Differential Element Zone Supervision for Zone 1

Figure 5.48 shows the processing sequence for tripping the breakers as a function of the differential element operation, 87Z*n*, where *n* = 1–6.

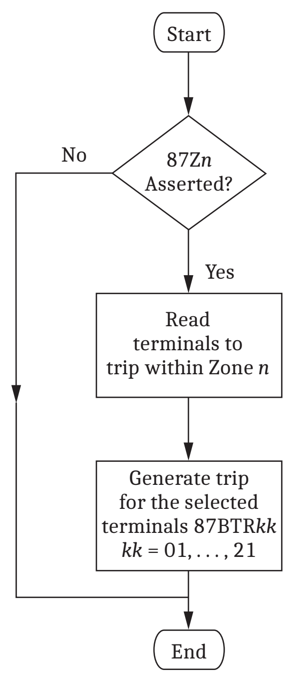


Figure 5.48 Bus Differential Trip Logic

The differential trip logic asserts differential trips as shown in *Table 5.19*.

Table 5.19 Differential Trips (Sheet 1 of 2)

Terminal Within a Zone	Differential Trip Bit
I01	87BTR01
I02	87BTR02
I03	87BTR03
104	87BTR04
105	87BTR05
106	87BTR06
107	87BTR07
108	87BTR08

Table 5.19 Differential Trips (Sheet 2 of 2)

Terminal Within a Zone	Differential Trip Bit
I09	87BTR09
I10	87BTR10
I11	87BTR11
I12	87BTR12
I13	87BTR13
I14	87BTR14
I15	87BTR15
I16	87BTR16
I17	87BTR17
I18	87BTR18
I19	87BTR19
I20	87BTR20
I21	87BTR21

This is the final stage of the check zone differential trip output. *Figure 5.49* is the check zone portion of *Figure 5.20* from the zone supervision logic. At this point, the Check Zone Differential Element has operated (87RCZ1), and all supervising criteria are met (CZ1S). The supervised trip output is then asserted (87CZ1). The check zone output is independent of the bus zones and is not processed by the differential trip logic shown in *Figure 5.48*.

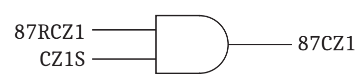


Figure 5.49 Differential Element Zone Supervision for Check Zone

Breaker Trip Logic

Figure 5.50 shows the tripping logic for Terminal 01 in the SEL-487B. The remaining logic for Terminal 02–Terminal 21 is identical and uses variables TR02–TR21 and ULTR02–ULTR21, and TRIP02–TRIP21, respectively.

NOTE: In the trip logic, the set or latch function (TRkk) has priority over the reset or unlatch (ULTRkk) function (kk = 1–21).

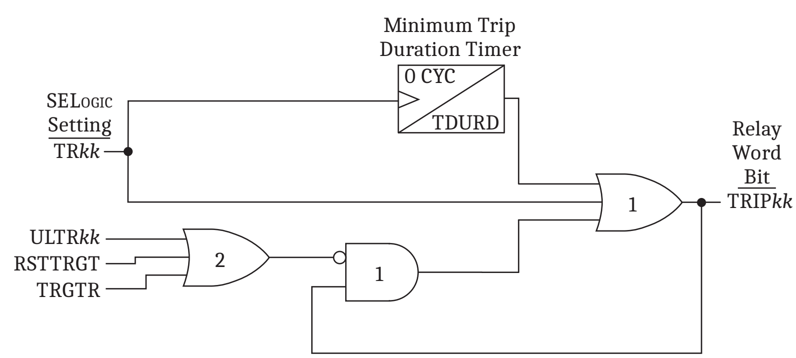


Figure 5.50 Trip Logic for Breaker 1

Enable the trip logic settings by setting the Global setting NUMBK = *kk*, where *kk* is the number of breakers at the station. For example, if you have 12 terminals installed at a substation, set NUMBK = 12.

Asserting TR01 directly asserts TRIP01 via input OR Gate 1 and starts the Minimum Trip Duration Timer (TDURD). TRIP01 asserts for a minimum of TDURD cycles, even if TR01 is asserted for as little as one processing interval, or if the unlatch portion of the logic is asserted before TDURD expires. The default setting of TDURD is twelve cycles.

TRIP01 also seals itself in via AND Gate 1. This AND gate receives the negated inputs from the unlatching functions. As long as ULTR01 or TRGTR are not asserted, TRIP01 remains sealed in. TRIP01 is used to drive an output contact to initiate tripping of the breaker.

You can use one of four methods to unlatch the trip logic. One method is to assert either one of SELOGIC control equation setting ULTR01 or SELOGIC control equation setting RSTTRGT. You can also push the **TARGET RESET** pushbutton on the front panel or send the **TAR R** serial port command to assert Relay Word bit TRGTR for one processing interval. Relay Word bit TRGTR also resets the LED targets on the front panel. In the trip logic, assertion of ULTR01, RSTTRGT, or TRGTR places a zero input on AND Gate 1 and, thereby, breaks the TRIP01 seal-in loop.

Note that TRIP01 is always asserted when TR01 is asserted, regardless of the action of ULTR01 or the **TARGET RESET** commands, and that TRIP01 will be asserted for a minimum of TDURD cycles no matter how short the length of time TR01 has been asserted.

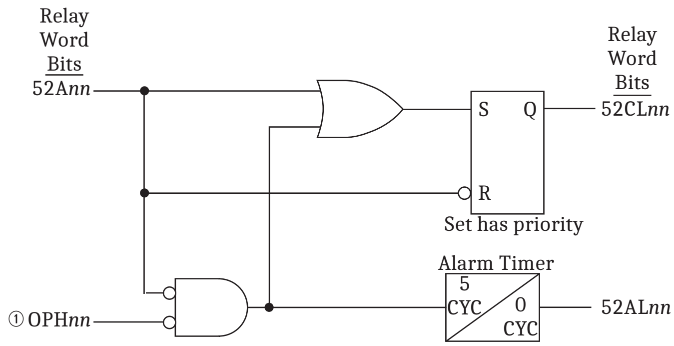
Circuit Breaker Status Logic

Figure 5.51 shows the circuit breaker status logic, which uses the combination of breaker 52A (normally open) auxiliary contact and the open-phase detection function, OPH. Because 52B (normally closed) contacts are not always available and as a means to reduce the number of I/O required, the 52B contacts are not required in the logic. However, for applications where the protection philosophy requires a 52B (normally closed) contact, wire the 52B contact into the relay, but use the negated form of the 52B contact in the logic, i.e., NOT 52B (52A01 := NOT IN301).

Relay Word bits 52CL01–52CL21 assert when the breaker is closed. Open-phase detection logic (OPH*nn*) Relay Word bits are included in the circuit breaker status logic to guard against delayed breaker status declaration resulting from possible breaker auxiliary contact misalignment. If a discrepancy between the open-phase detection logic and the breaker auxiliary contact exists for as long as five cycles, the logic generates an alarm that indicates one of the following:

- Possible auxiliary contact supply voltage failure
- Possible failure in an auxiliary contact connection circuit
- Possible failure of auxiliary contact mechanism

The logic in *Figure 5.51* is generic for three-pole or single-pole breaker mechanisms.



① See Figure 5.28.

Figure 5.51 Breaker Status and Alarm Logic

Note that OPH*nn* Relay Word bits assert when no current flows through the circuit breaker and that set has priority over reset in the circuit breaker status logic. *Table 5.20* shows the output states for all possible breaker conditions.

Table 5.20 Conditions and Results for the Circuit Breaker Status Logic

Breaker Status	52A01 or NOT 52B01	OPH01	52CL01	52AL01
Open	0	1 (no current)	0	0
Closed	1	1 (no current)	1	0
Open	0	0 (current flow)	1	1 (after 5 cyc)
Closed	1	0 (current flow)	1	0

SECTION 6

Protection Application Examples

Configuring the system is the most challenging of the many activities associated with using the SEL-487B relay. System configuration includes renaming (aliasing) terminals and bus-zones, assigning input contacts to selected relay logics, declaring terminal-to-bus-zone connections, declaring bus-zone-to-bus-zone connections, configuring bus couplers and check zones, and assigning logics to relay outputs. System configuration requires careful consideration of the following items because they both influence the number of SEL-487B relays and ordering options needed:

- primary layout of the substation
- choice of protection elements

For example, substations with seven or fewer terminals require only one relay. To monitor both 89A and 89B contacts, however, you must equip this relay with the correct number of interface boards to ensure an adequate number of input contacts.

The following discussion provides general guidelines and outlines general factors that should be considered when using ASCII commands to configure your relay. The section also provides application examples for some of the more common busbar layouts. Included in this section are the following topics:

➤ *Application 7: Double and Transfer Bus (Outboard CTs) on page 6.181*

➤ *Application 8: Double and Transfer Bus (Inboard CTs) on page 6.207*

Input, Logic, and Output Assigning Process

Figure 6.1 shows a block diagram of the SEL-487B input, logic, and output assigning process for system configuration and protection element settings. Digital input sources include disconnect and breaker auxiliary contacts, breaker failure initiate signals, and breaker close signals. Current and potential transformers provide analog inputs. Use alias settings to assign more meaningful names to primitive Relay Word bits and/or analog names, or use the primitive names of the input quantities to configure and set the relay. The relay has many ready-made logic functions available; however, assign these functions before they become operative. System configuration includes terminal-to-bus-zone and bus-zone-to-bus-zone assignments, zone supervision, and zone-switching supervision settings. Scheme settings include enable settings, differential and sensitive differential element settings, directional element settings, selected relay logic settings, and output assignment.

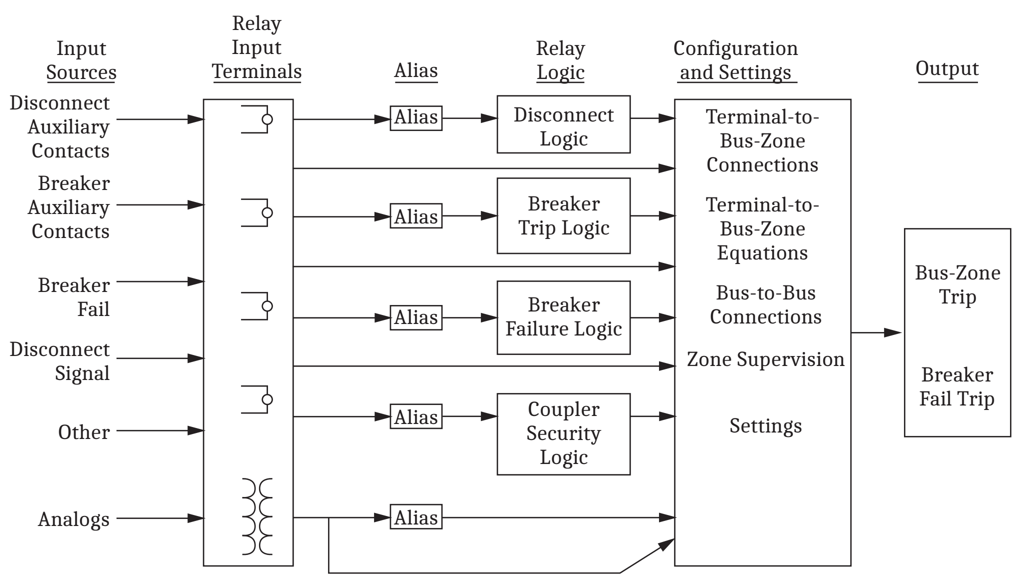


Figure 6.1 Block Diagram of the Input, Logic, and Output Assigning Process for System Configuration Protection Element Settings

Relay Differential Element Composition

Each SEL-487B accepts as many as 21 current inputs (I01–I21) and then assigns these inputs to any of six differential elements (BZ1–BZ6). *Figure 6.2* shows a block diagram of the arrangement.

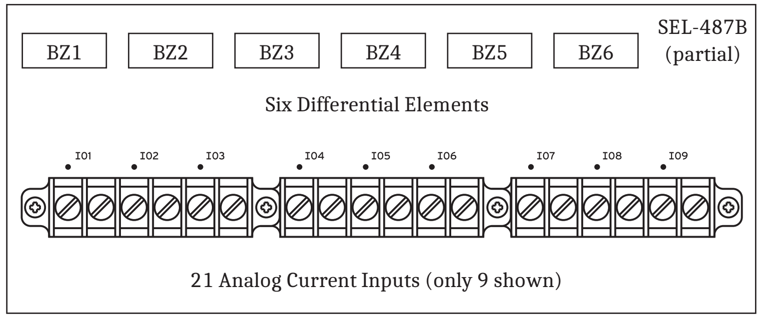


Figure 6.2 Block Diagram Showing Nine Current Inputs and Six Differential Elements

Single-Relay Application

Because differential calculations occur on a per-phase basis, each phase of a three-phase system must bear a unique identification. *Figure 6.3* shows a typical single-line diagram of a station consisting of two busbars (NORTH and SOUTH), a tie breaker (Z), and four terminals.

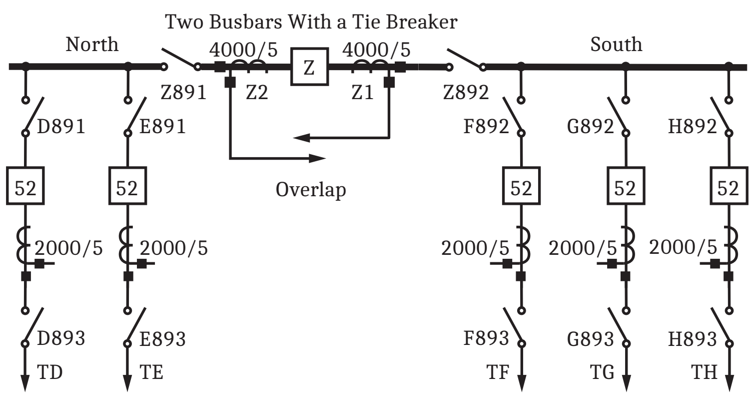


Figure 6.3 Single-Line Diagram of a Station With Two Busbars and a Tie Breaker

Because the station has no more than seven terminals, a single SEL-487B suffices. *Figure 6.4* shows the SEL-487B and a three-phase representation of TD, one of the terminals at the station.

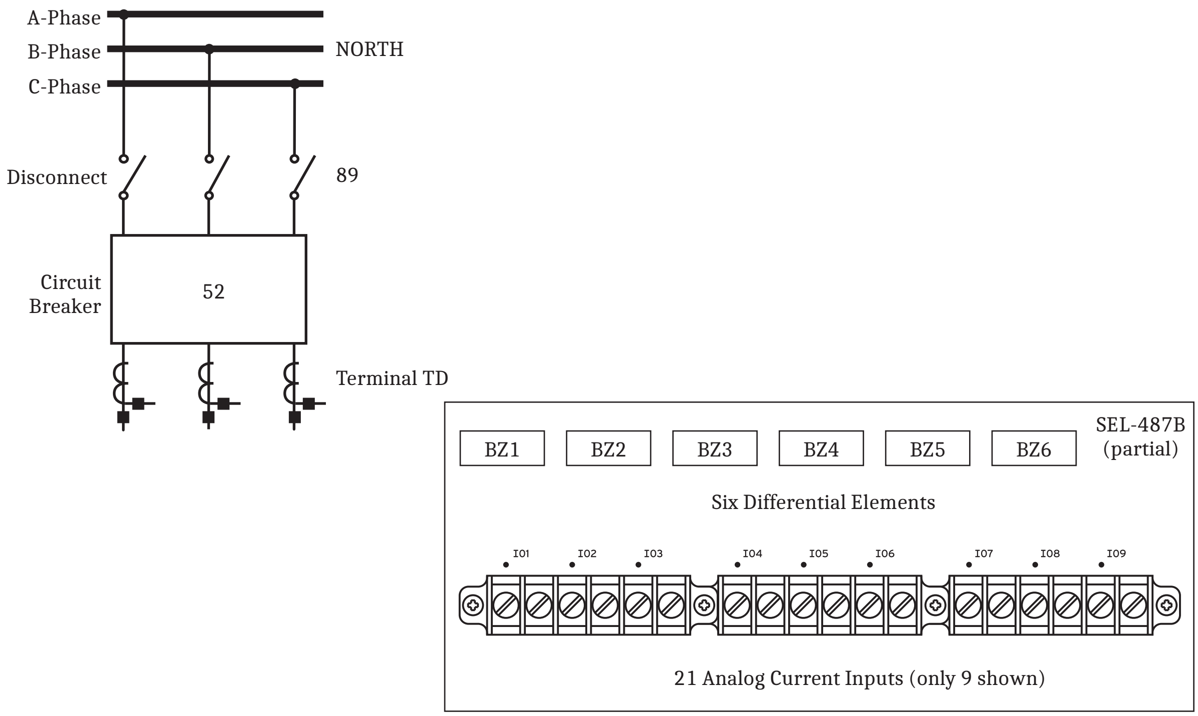


Figure 6.4 Three-Phase Diagram of Terminal TD, the NORTH Busbar, and the SEL-487B

Because differential calculations for each protection zone require an individual differential element, assign an individual differential element to each phase. This assignment uses three of the available six differential elements in the relay for Busbar NORTH. In this example, assign the phases and differential elements as shown in *Figure 6.5*. Each assignment is a software assignment, as indicated by the dotted lines; no electrical wires are required.

Assign the A-phase differential element of Busbar NORTH to differential element BZ1

Assign the B-phase differential element of Busbar NORTH to differential element BZ2

Assign the C-phase differential element of Busbar NORTH to differential element BZ3

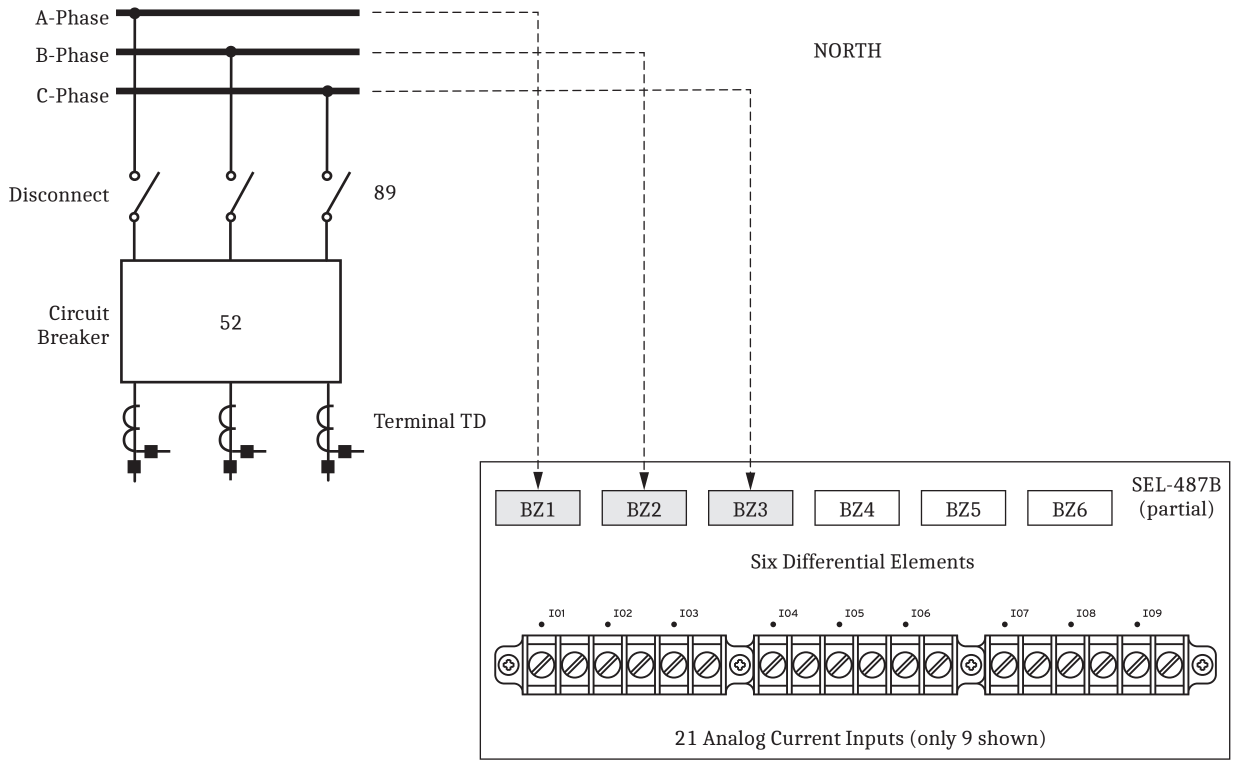


Figure 6.5 A Three-Phase Zone Requires Three Differential Elements

To make the bus-zone labels more substation specific, assign the following alias names to the bus-zones, as shown in *Figure 6.6*:

For the A-phase differential element BZ1, assign NORTH_A

For the B-phase differential element BZ2, assign NORTH_B

For the C-phase differential element BZ3, assign NORTH_C

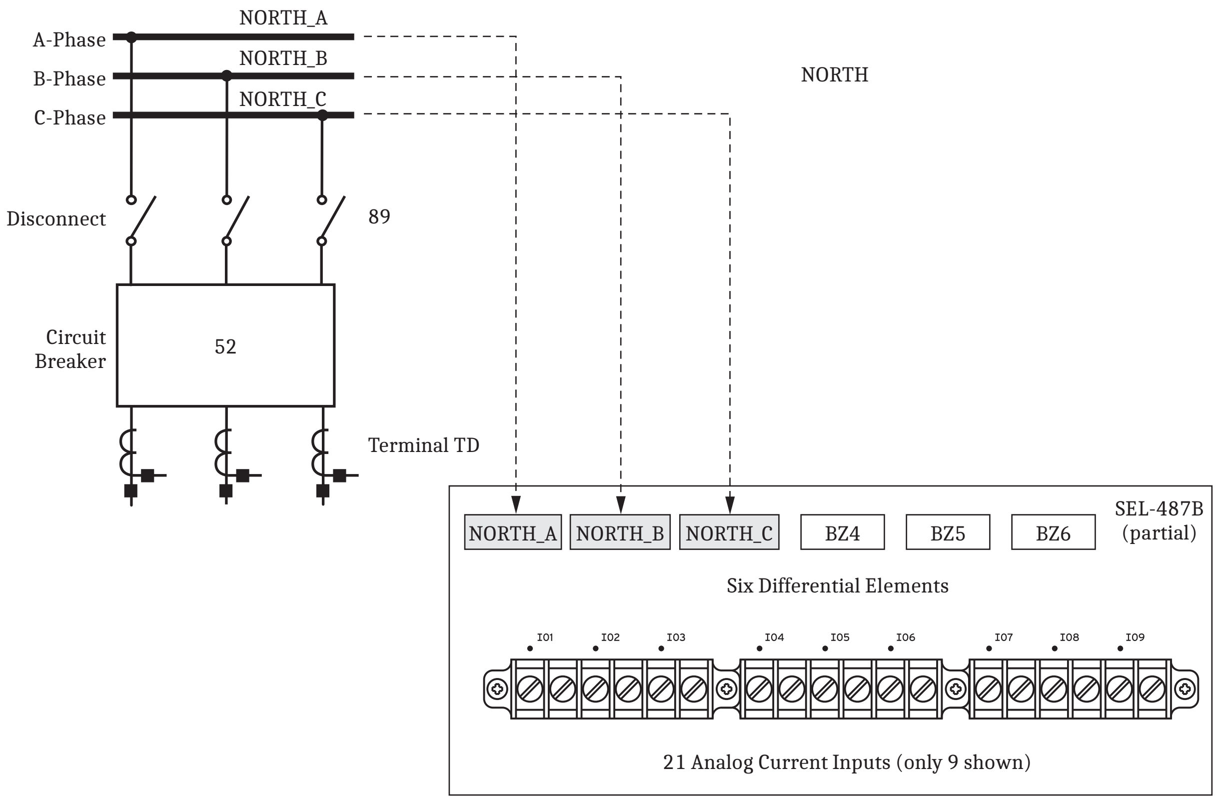


Figure 6.6 Three Differential Elements With Alias Names for a Three-Phase Bus-Zone in a Single Relay Application

For the current inputs in a single-relay application, wire A-phase, B-phase, and C-phase to adjacent terminal connections such as I01, I02, and I03, as shown in *Figure 6.7*. These connections are copper wires connecting the CTs to the relay.

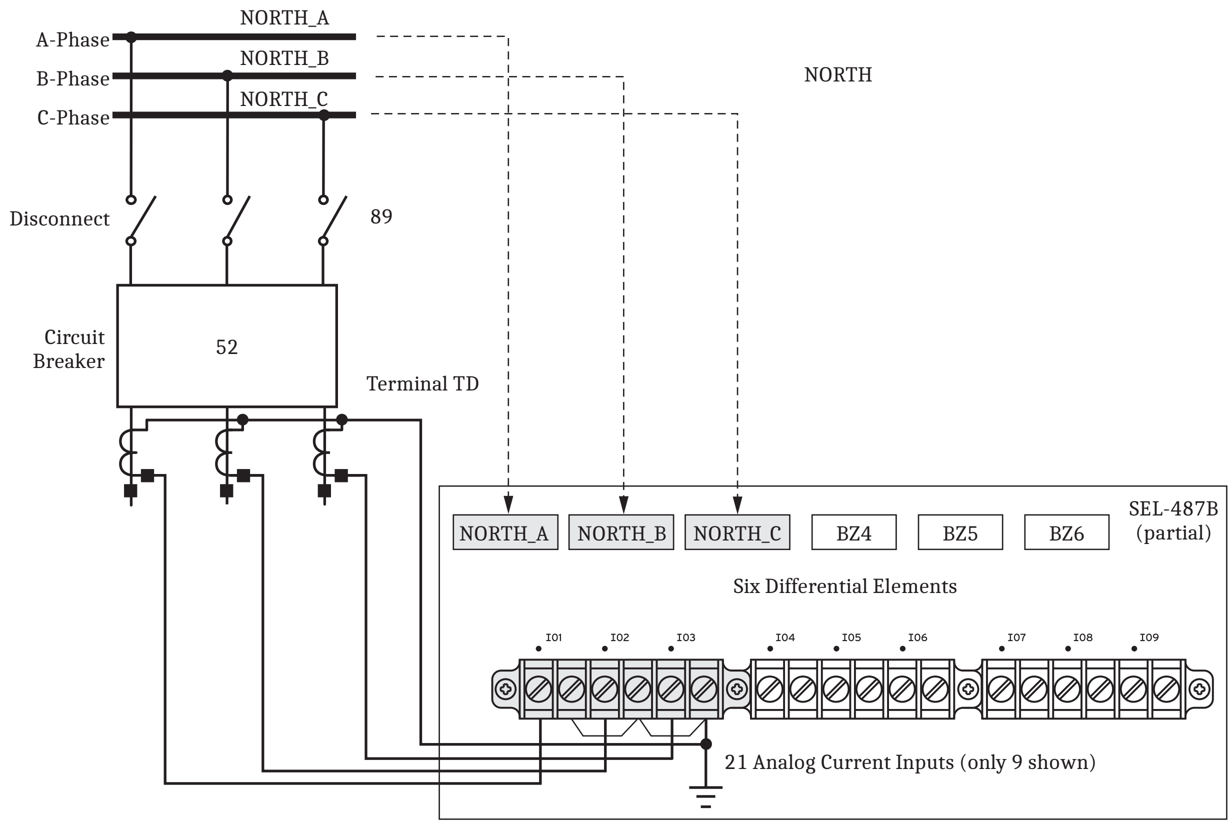


Figure 6.7 Three Differential Elements and Three CT Inputs in a Single-Relay Application

Reference *Figure 6.3* and continue CT connections by wiring the CT inputs from TE (I04–I06) and Z1 (tie breaker configured in overlap) to I07–I09. Connect the CTs from Z2, TF, and TG, following the same procedure to complete protection for both bus-zones.

Digital inputs control the dynamic assignment of input currents to differential elements. If you need dynamic zone selection, wire into the relay the auxiliary contacts from the disconnect (89), the circuit breaker (52), or any other conditions that must ultimately be considered in the zone selection logic. *Figure 6.8* shows the disconnect and circuit breaker wiring for Terminal TD.

Only the differential elements are enabled for this example. If you need other functions such as breaker failure protection, wire those inputs to the relay. You need all six zones and all 21 current channels to configure the remaining terminals in the same way. *Figure 6.9* shows the complete station analog channel configuration.

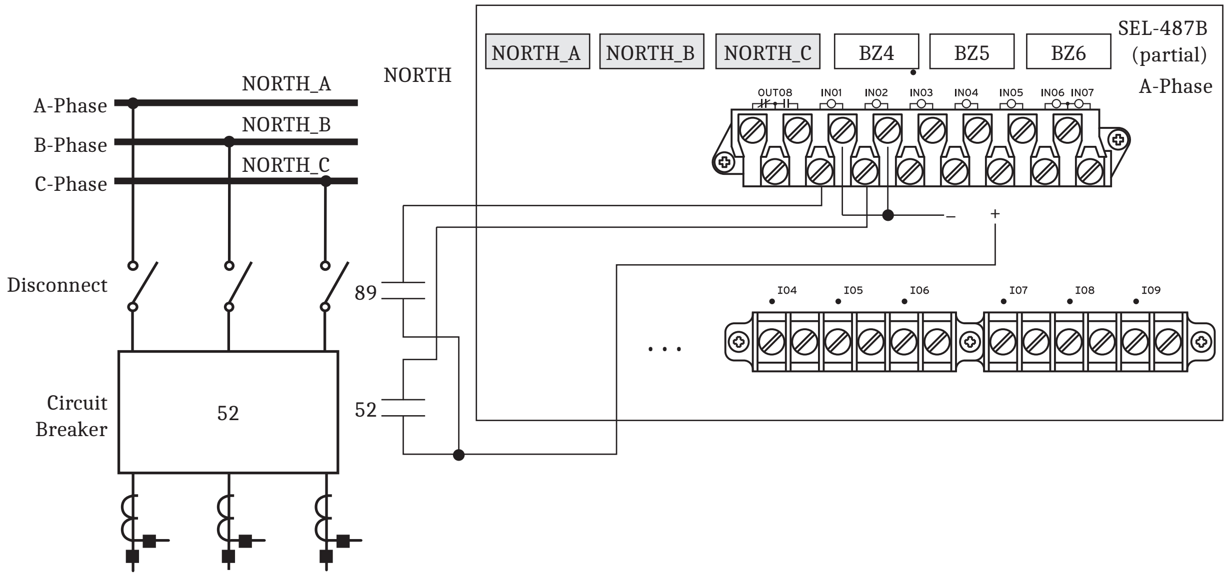


Figure 6.8 Disconnect and Circuit Breaker Wiring for Terminal TD

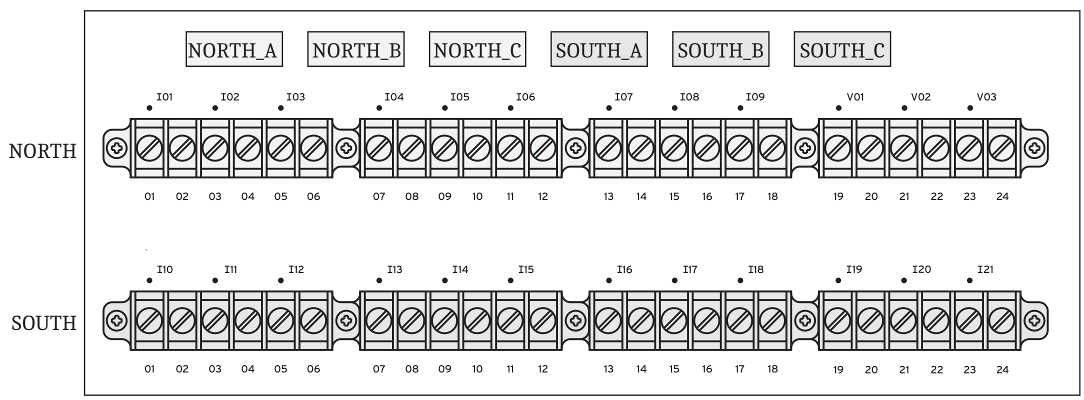


Figure 6.9 Complete Station Configuration, Using Two Three-Phase Bus-Zones and All 21 Current Inputs in a Single-Relay Application

Three-Relay Application

Consider now the same station, configured with three relays instead of one. In the three-relay application, a total of 21 current inputs are available. As before, the label NORTH in the single-line diagram consists of A-phase, B-phase, and C-phase, and each of the three phases is assigned to a differential element. NORTH still requires three differential elements, but the application uses one differential element from each of the three relays, as shown in *Figure 6.10*, instead of three elements in the same relay.

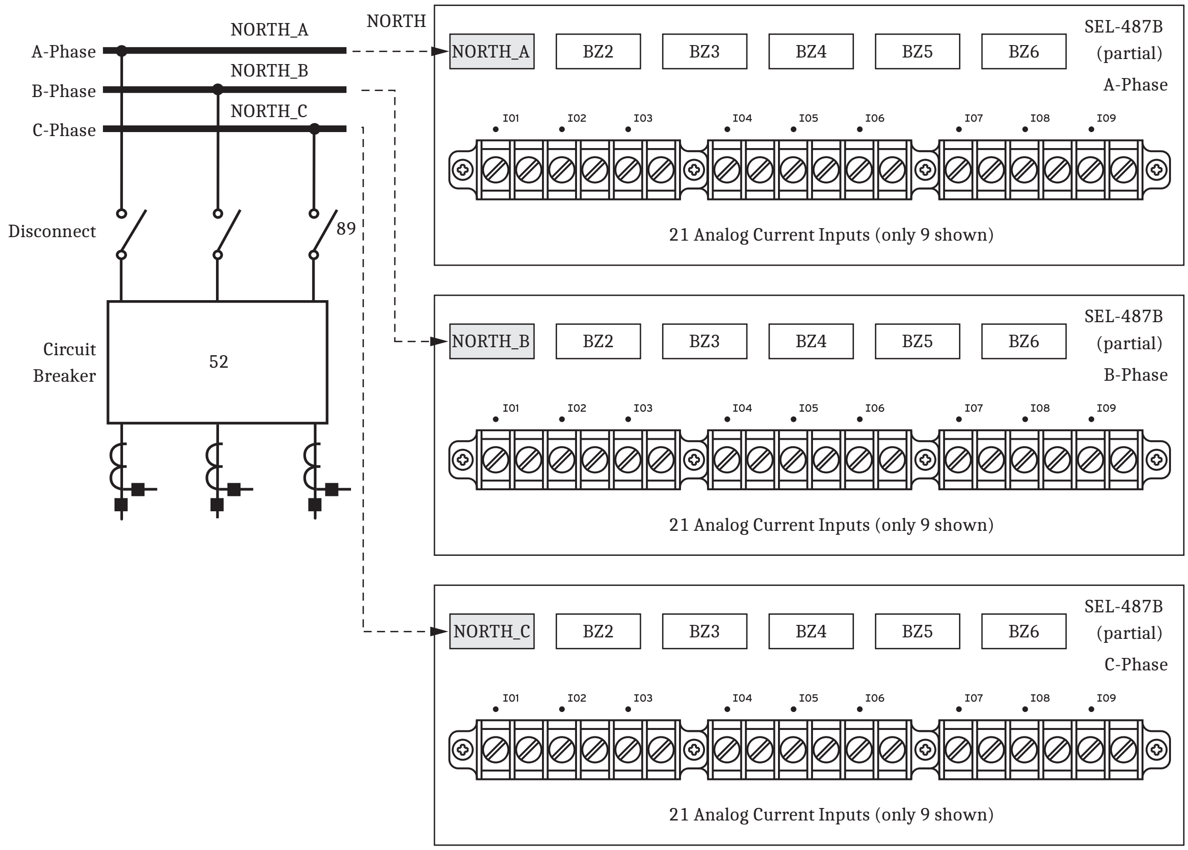


Figure 6.10 One Differential Element From Each of the Three Relays in a Three-Relay Application

Instead of wiring A-phase, B-phase, and C-phase to adjacent terminal connections on the same relay, as with the single-relay application shown in *Figure 6.7*, wire each phase to a separate relay. For example, wire A-phase to the A-Phase SEL-487B Terminal I01, B-phase to the B-Phase SEL-487B Terminal I01, and C-phase to the C-Phase SEL-487B Terminal I01, as shown in *Figure 6.11*.

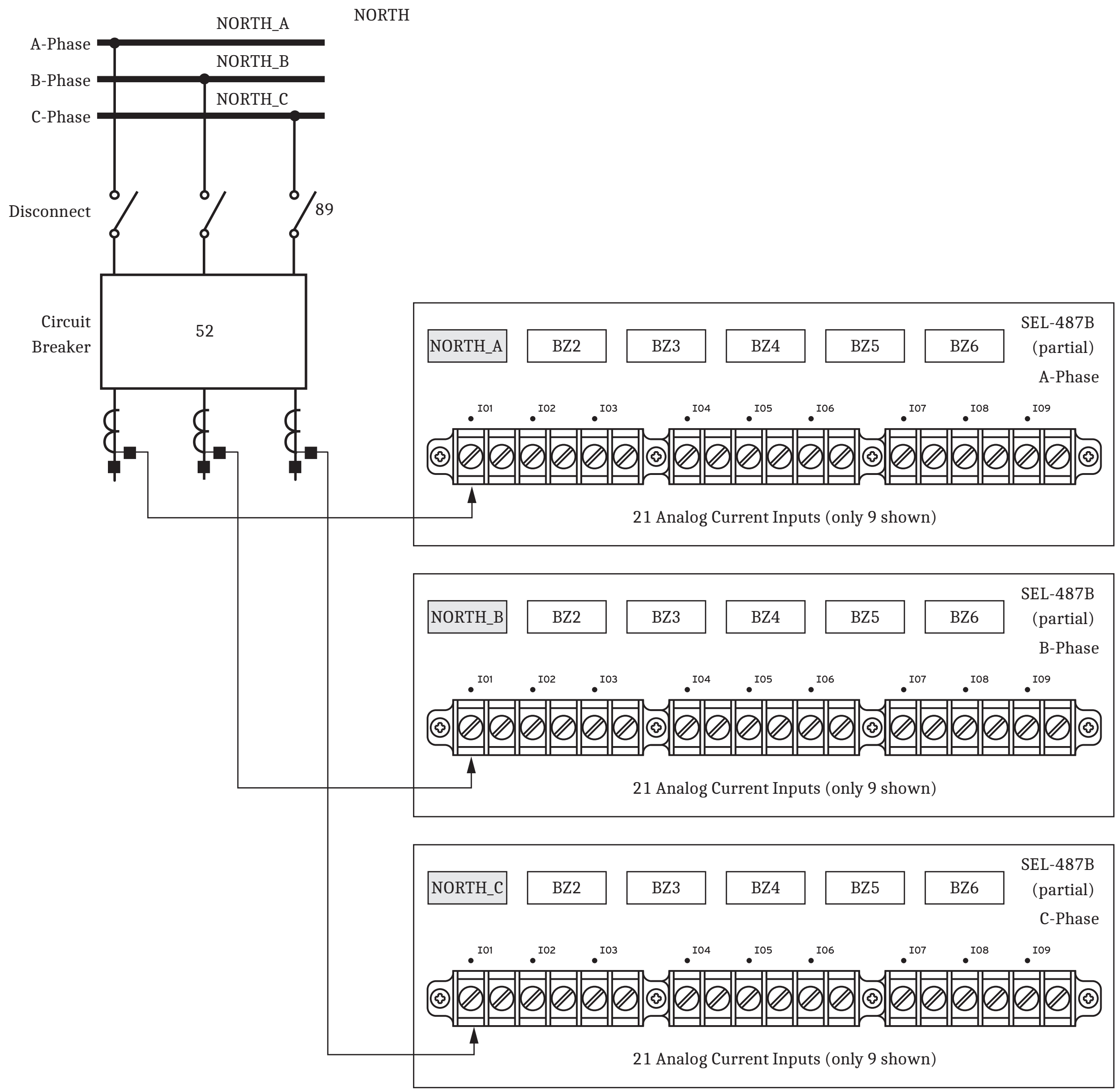


Figure 6.11 CT Wiring in a Three-Relay Application Showing One CT Input to Each of the Three Relays

Figure 6.12 shows the CT wiring for one of the three relays with all A-phase inputs of the station and two bus-zones assigned. B-phase and C-phase relays have similar arrangements.

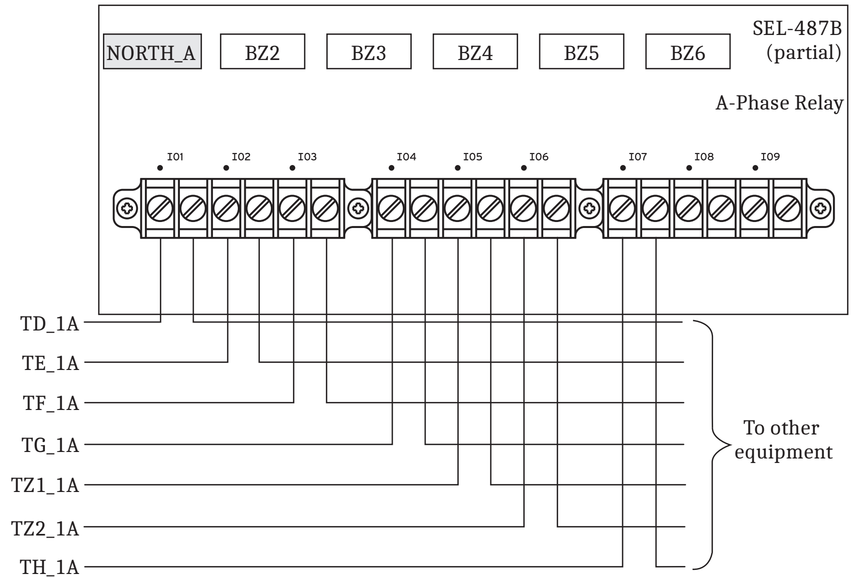


Figure 6.12 CT Wiring for A-Phase Relay, With All A-Phase Inputs of the Station and Two Bus-Zones Assigned

Because the differential elements are in three different relays, each of these relays must receive the same information from the digital inputs. *Figure 6.13* shows jumpers between relays for the case where only one 89 contact and one 52 auxiliary contact are available.

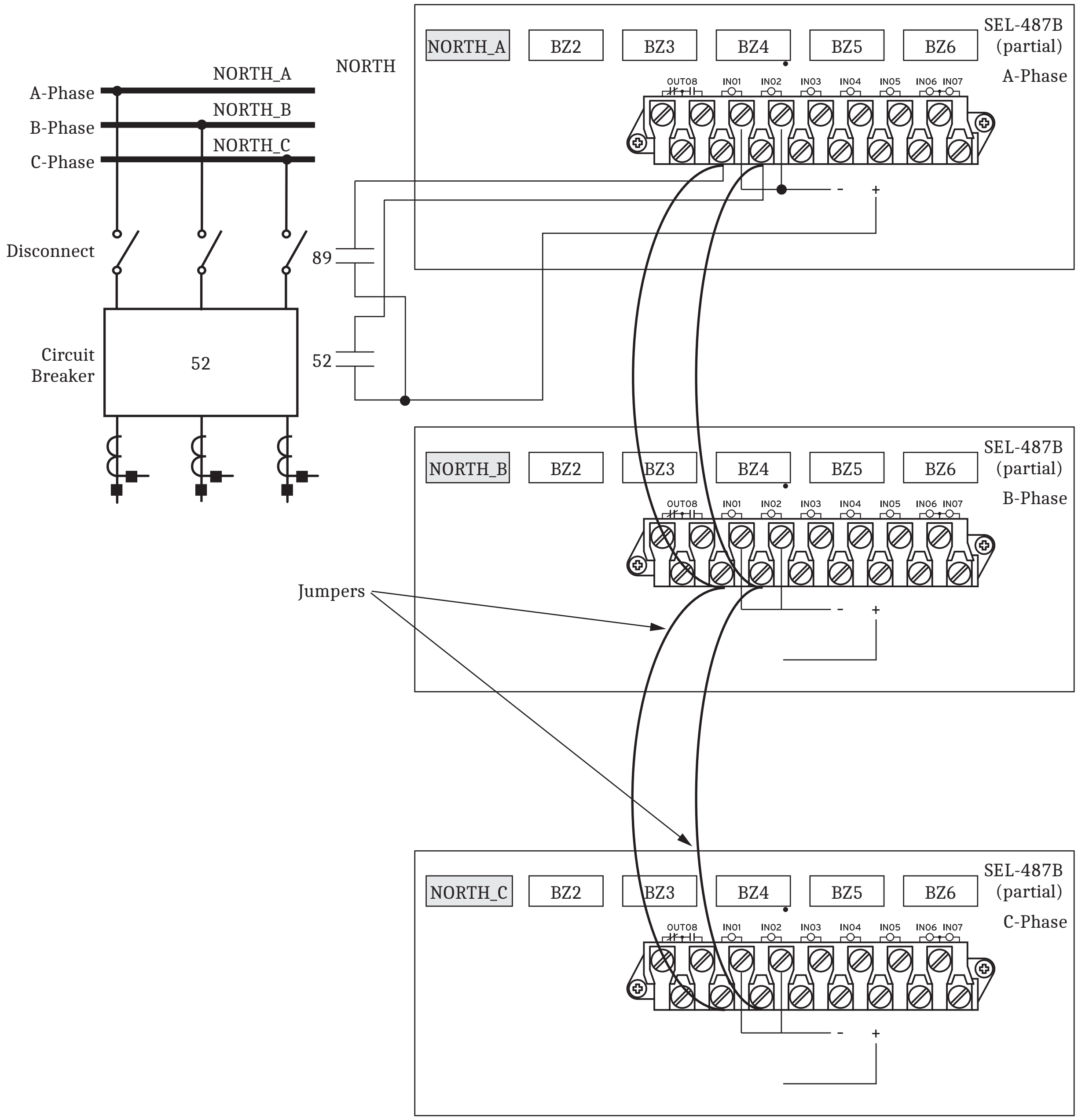


Figure 6.13 Jumpers Between Relays From Digital Inputs 52 and 89

CT Requirements

CT Connections

Connect all CTs to the relay in wye configuration. The SEL-487B does not account for delta-connected CTs.

CT Sizing

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

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

For correct operation, the relay algorithm requires that the CTs not saturate for 2 ms following an external fault inception. The IEEE Document *C37.110 Guide for the Application of Current Transformers Used for Protective Relaying Purposes* contains guidelines that will provide a conservative recommendation of the proper CT characteristics needed for low impedance bus differential protection using the SEL-487B. SEL also offers an executable CT saturation program called SEL Two_CTs to assist in determining the CT performance.

CT Ratio Selection

For installations with different CT ratios, be sure that the highest/lowest CT ratio does not exceed 10. The SEL-487B selects the highest CT ratio and calculates settings TAP01–TAP21, provided that the ratio TAP_{MAX}/TAP_{MIN} is less than or equal to 10. If the ratio TAP_{MAX}/TAP_{MIN} is greater than 10, select a different CT ratio.

CT Grounding

Because each of the 21 current channels is independent, be sure to apply a ground to each set of three CTs forming the current input from each terminal. Such grounding connections are usually in the form of short jumpers on the rear of the relay that together create a common connection among terminals. For example, in a three-relay application that uses all 21 terminals, apply 20 jumpers to create a common ground connection point (a single-relay that uses all 21 terminals requires 6 jumpers). Then connect this common point at one location to the station ground mat. Be sure to make ground connections in accordance with ANSI/IEEE C57.13.3-1983.

Polarity

IEEE Std C37.110-1996 provides the following definition of polarity:

> The designation of the relative instantaneous directions of the currents entering the primary terminals and leaving the secondary terminals during most of each half cycle. Primary and secondary terminals are said to have the same polarity when, at a given instant during most of each cycle, the current enters the identified, similarly marked primary lead and leaves the identified, similarly marked secondary terminals in the same direction, as though the two terminals formed a continuous circuit.

Figure 6.14 shows some of the common polarity marks used to indicate CT polarity.

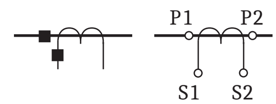


Figure 6.14 Polarity Marks

Polarity marks are also declared on the relay analog input terminals as dots above the relay terminal, as shown in *Figure 6.15*.

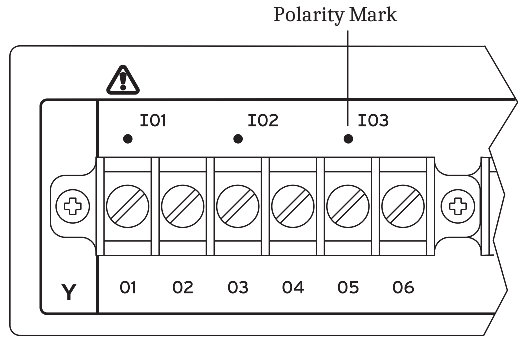


Figure 6.15 Polarity Marks Above the Odd-Numbered CT Terminals at the Rear of the Relay

Guideline for Establishing CT Polarity

Configure a CT to have a positive polarity when the primary current entering the zone of protection is in phase with the secondary current entering the polarity marked terminal on the relay. Because CTs are commonly positioned to point toward the zone of protection, secondary connections are generally polarity-to-polarity or "dot-to-dot." If a CT points away from the zone of protection, apply a polarity-to-nonpolarity connection to continue a positive convention. This results in positive polarity declarations for all CTs in software.

If a single CT has two zone boundaries or is shared by an adjacent zone, you cannot use a positive convention for both zones. In this case, configure the CT polarity to be negative for the non-conforming zone.

Figure 6.16 and *Figure 6.17* show examples for determining polarity.

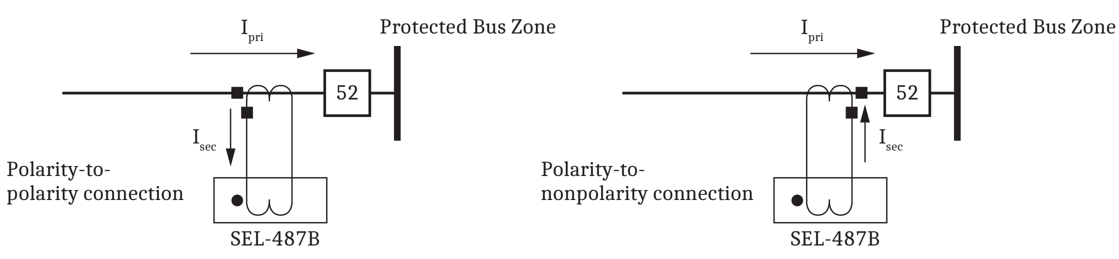


Figure 6.16 Declare Positive Polarity in Software (Preferred)

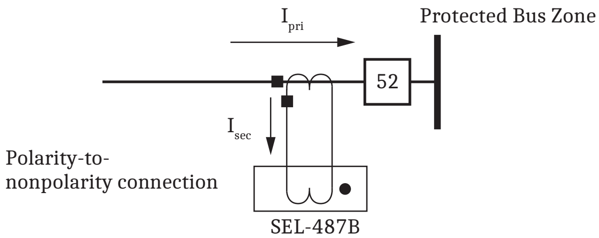


Figure 6.17 Declare Negative Polarity in Software

For simplicity, all application examples in this manual assume polarity-to-polarity connections between the CTs and relay.

Disconnect Requirements

Disconnect auxiliary contacts provide Zone Selection Logic with the information required to dynamically assign the appropriate current inputs to the correct differential elements. To ensure correct differential element operation, the contacts must comply with the requirements listed in *Table 6.1*.

Table 6.1 Disconnect Auxiliary Contact Requirements to Ensure Correct Differential Element Operation

Operation	Requirement
From disconnect open to disconnect close operation	Assign the currents to the applicable differential element before the disconnect reaches the "arcing" point, the point where primary current starts to flow.
From disconnect close to disconnect open operation	Remove the current from the applicable differential element only once the disconnect has passed the "arcing" point, the point where primary current has stopped flowing.

Figure 6.18 shows the disconnect auxiliary contact requirements with respect to the arcing point. The position of 0% travel in *Figure 6.18* indicates the position when the main contacts are fully open, and the 100% position indicates when the main contacts are fully closed.

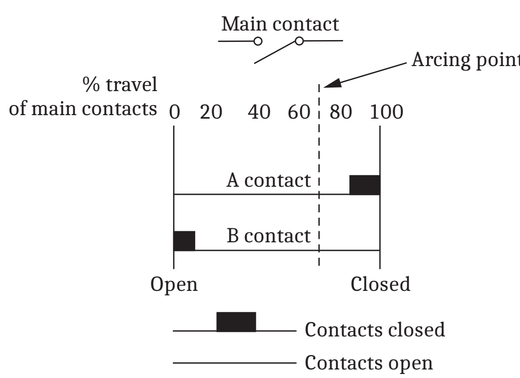


Figure 6.18 Disconnect Auxiliary Contact Requirements With Respect to the Arcing Point for an Open-to-Close Disconnect Operation

When both 89A and 89B contacts are available, use the disconnect monitoring logic in the SEL-487B to establish the principle of

(disconnect) NOT OPEN = (disconnect) CLOSED

Applying this principle, the relay properly coordinates the primary current flow and the CT current assignment to the appropriate differential element. When both 89A and 89B disconnect auxiliary contacts are available, use the disconnect monitoring logic to monitor the disconnect operating time and disconnect status. *Table 6.2* shows the four possible disconnect auxiliary contact combinations and the way the relay interprets these combinations.

Table 6.2 Disconnect A and B Auxiliary Contact Status Interpretation

Case	89A01	89B01	Disconnect Status (89 CLnn)
1	0	0	Closed (1)
2	0	1	Open (0)
3	1	0	Closed (1)
4	1	1	Closed (1)

Table 6.2 (Disconnect Status column) shows that the output from the disconnect monitor logic interprets the disconnect as always closed, except for Case 2. With this interpretation, the relay assigns the input currents to the applicable differential elements for Case 1, Case 3, and Case 4. The following discussion considers the four cases in more detail.

Disconnect Open to Close Operation

Figure 6.19 shows the disconnect main contact starting to travel in an open-to-close operation. Auxiliary contact B is still closed, and auxiliary contact A is open. *Table 6.2* shows this as Case 2; the disconnect is considered open, and the current is removed from all differential elements. This is the only combination of auxiliary contacts for which the relay considers the disconnect main contacts to be open.

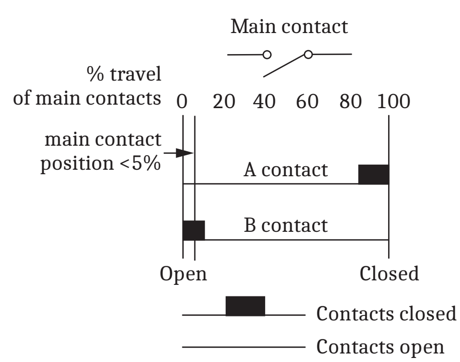


Figure 6.19 Disconnect Main Contacts and Auxiliary Contact A Open, Auxiliary Contact B Closed; Disconnect Is Considered Open

Intermediate Position

Figure 6.20 shows the intermediate position (Case 1 in *Table 6.2*) in a disconnect open-to-close operation, with both A and B auxiliary contacts open for a period of time. Enter this time duration as the disconnect switch alarm timer setting value (89ALP*nn*). By choosing the auxiliary contacts that will change status as soon as disconnect travel starts and close only near the end of travel, the intermediate position time duration can be accurately measured. Should the disconnect remain in the intermediate position for longer than the 89ALP*nn* (*nn* = 1–60) time setting, the disconnect switch alarm timer expires and asserts 89AL*nn*, the disconnect monitor alarm.

NOTE: The relay includes 60 alarm timers that provide individual time settings for 60 disconnect logic circuits. These individual timers are useful in installations where the disconnect travel times differ substantially. In particular, sequentially operated devices (pantographs, for example) have travel times much longer than normal disconnects. Relay Word bit 89OIP represents the OR combination of Relay Word bits 89OIP01–89OIP60, and Relay Word bit 89AL is respectively the OR combination of Relay Word bits 89AL01–89AL60.

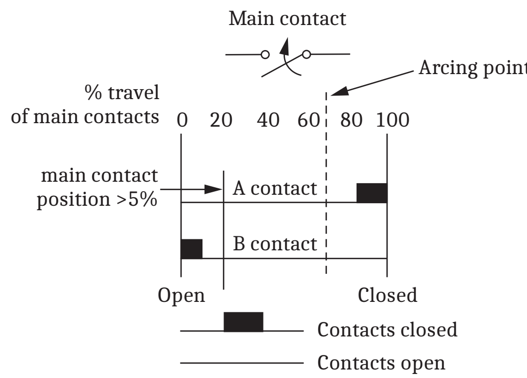


Figure 6.20 Intermediate Position With Both Auxiliary Contacts Open; the Disconnect Is Considered Closed

When auxiliary contact B opens, the disconnect is considered closed (Case 1 in *Table 6.2*). When the disconnect is considered closed, the CT currents are assigned to applicable differential elements, and the disconnect switch alarm timer starts to time. Because disconnect auxiliary contact B opens well in advance of the arcing point, the CT currents are assigned to applicable differential elements before primary current flows.

Auxiliary Contact A Closes

Figure 6.21 shows contact status after auxiliary contact A closes, with the main contact past the arcing point and approaching the end of the close operation.

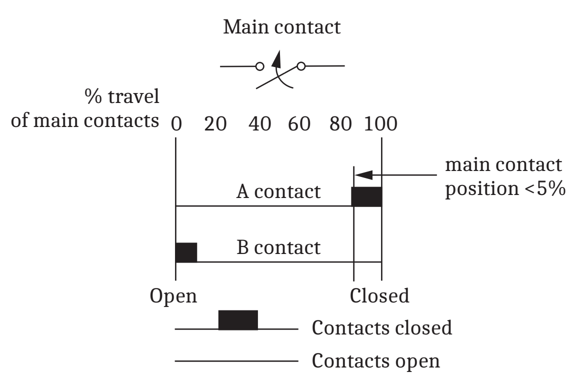


Figure 6.21 The Main Contact Has Completed 95% of Travel; Contact A Is Closed, Contact B Is Open, and the Disconnect Is Considered Closed

When the A contact closes, the disconnect switch alarm timer stops and the Disconnect Monitoring Logic considers the disconnect main contact to be closed.

Disconnect Open and Closed Simultaneously

Case 4 is an illegitimate condition, with the disconnect auxiliary contacts showing the disconnect main contact to be open and closed simultaneously. Timer 89ALP*nn* times for this condition and asserts Relay Word bit 89AL*nn* when the disconnect auxiliary contacts remain in this condition for a period exceeding the timer setting. The relay considers the disconnect main contact closed during this period, and the CTs are considered in the differential calculations.

Close-to-Open Operation

For the close-to-open operation, CT currents must remain assigned to the differential elements for as long as primary current flows. When the auxiliary contact A opens (Case 1), we again enter the intermediate position, as depicted in *Figure 6.20*. In the intermediate position, the CT currents are still assigned to the differential elements, and the disconnect switch alarm timer (89AL*nn*) starts to time. Only when auxiliary contact B closes (*Figure 6.19*) are the CT currents removed from the differential elements, which are safely past the arcing point.

Many disconnect switches provide only auxiliary contact B. *Table 6.3* shows the two possible disconnect auxiliary contact positions and status interpretations.

Table 6.3 Disconnect Auxiliary Contact Status Interpretation When Only Auxiliary Contact B Is Available

89B01	Disconnect Position
0	Closed
1	Open

Alias Names

Any Relay Word bit, analog quantity, or default terminal name can be renamed with more meaningful names to improve the readability of fault analysis and customized programming. See the description in *Alias Settings on page 12.25 in the SEL-400 Series Relays Instruction Manual* for more details.

Bus-Zone Configurations

Dynamic zone selection is the process the relay uses to assign or remove CT currents from the differential elements as a function of the Boolean value (logical 0 or logical 1) of a particular SELOGIC control equation. The SELOGIC control equation is a setting in the form of I*nn*BZ*k*C and I*nn*BZ*k*V (*nn* = 01–21, and *k* = 1–6). When setting SELOGIC control equations, use a separate SELOGIC control equation for each busbar to which the terminal can connect.

NOTE: In Quickset, the Terminal-to-Bus-Zone connection setting, InnBZkC, is broken down into two setting: CTnnBZk and TBZPx (x = 1-126). CTnnBZk enables Terminal nn to be connected to Bus-Zone k. TBZPx sets the polarity of the Terminal nn to Bus-Zone k connection.

In general, a terminal can be identified as either a normal terminal (feeders, lines, transformers, etc.) or as a tie breaker (bus coupler). For terminals, typical inputs are disconnect auxiliary contacts and, in some cases, circuit breaker auxiliary contacts. Bus couplers have specific logic and configuration options that require inputs in addition to disconnect and circuit breaker auxiliary contacts to ensure security and dependability.

When configuring bus-zone protection, the goal is to accomplish the following:

- Protect the busbars for all operating conditions
- Eliminate all dead zones
- Open the minimum number of breakers when tripping
- Implement the check zone without disconnect supervision, if a check zone is required

When the terminal-to-bus-zone SELOGIC control equation (I*nn*BZ*k*V Terminal to Bus Connection Logic) is logical 0, differential calculations do not consider the CT inputs from that specific terminal, and no trip outputs from the differential elements are issued to that terminal. Of particular concern are instances when more than one disconnect for any particular terminal are closed at the same time. When this happens, parallel paths form, possibly resulting in the unbalance of multiple zones, as shown in *Figure 6.22* and *Figure 6.23*. Under balanced conditions, the current toward the busbars equals the current away from the busbars, and the differential current in any differential element is practically zero.

In practice, the most popular implementation for preventing misoperation when parallel paths form is to combine the parallel paths into a single zone and route the CTs to a single differential element. Another option is to use a check zone by combining all terminals at a specific voltage level into a single zone independent of the terminal-to-bus-zone SELOGIC control equations. Using the check zone as a second trip criterion prevents relay misoperation in the case of parallel paths.

In general, apply the following rules when setting terminal-to-bus-zone SELOGIC control equations:

- Observe the correct CT polarity
- Avoid parallel operating conditions
- When parallel paths are unavoidable, take necessary precautions

Two situations exist where parallel paths are unavoidable: when two disconnects are closed simultaneously and when using inboard (bushing) CTs.

Two Disconnects Closed Simultaneously

Figure 6.22 shows a double busbar layout in which two disconnects can be closed simultaneously. With the tie breaker (TZ) connected in overlap, CT1 and CT2 form Differential Element 1, and CT3 and CT4 form Differential Element 2. There are no parallel paths in *Figure 6.22*, and both differential elements are balanced. Calculate the differential currents with the following expression:

$$I_{DIFF1} = \sum_{1}^{n} I_n$$

Equation 6.1

where:

I_{DIFF1} = The differential current calculated in Differential Element 1
I_n = CT currents from the *n* terminals assigned to Differential Element 1

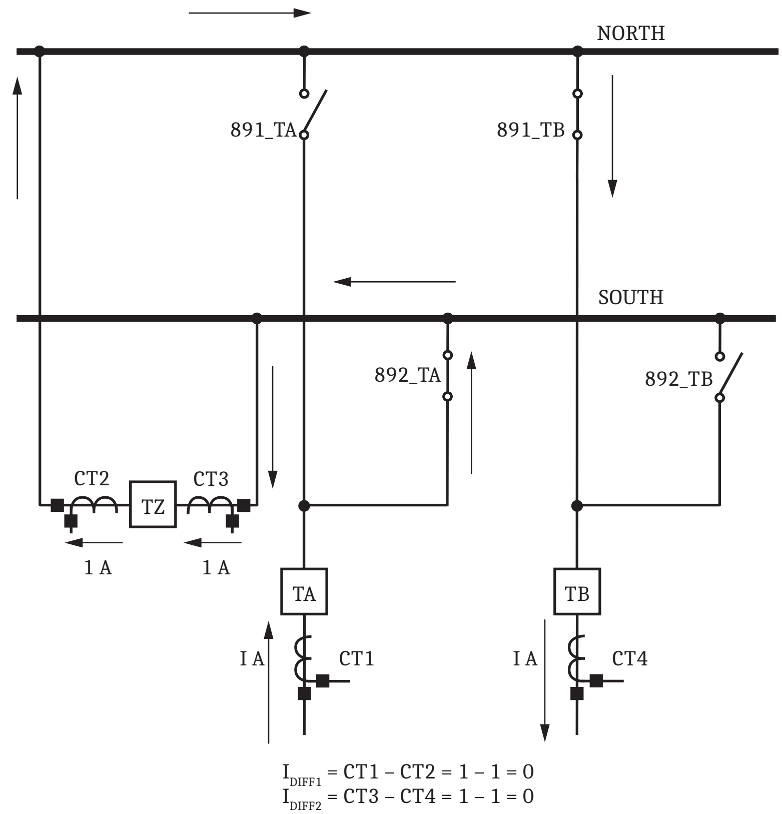


Figure 6.22 Both Differential Elements Balanced

Closing 891_TA in *Figure 6.23* forms a parallel path between the two busbars, and both differential elements are unbalanced.

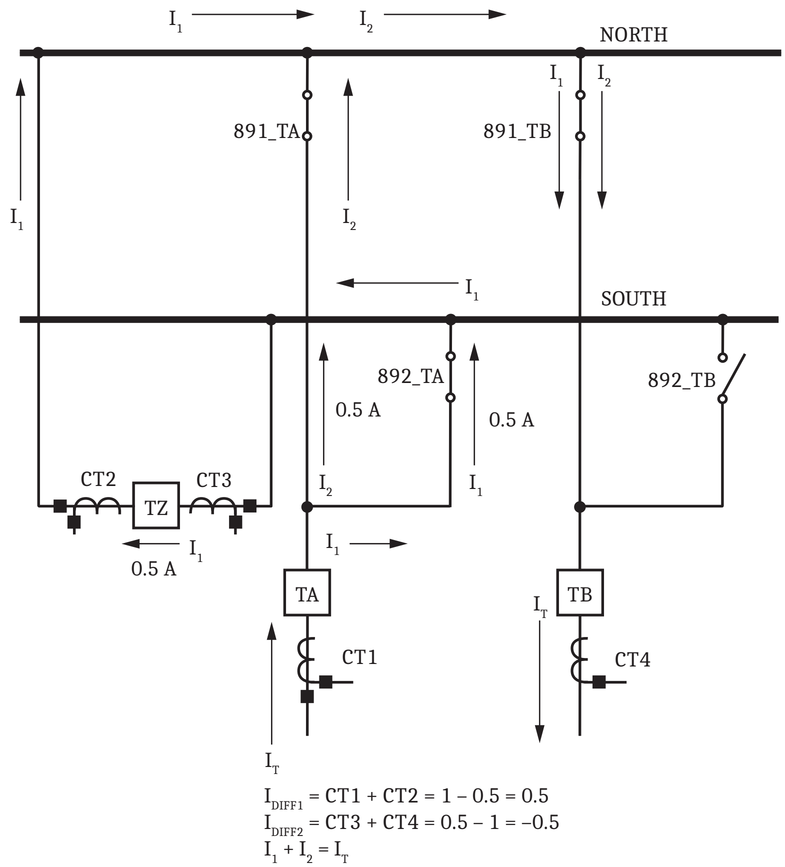


Figure 6.23 Both Differential Elements Unbalanced

To prevent misoperation, combine the two bus-zones by stating the conditions governing the combinations during setting of bus-zones-to-bus-zones connections. When using bushing (inboard) CTs, combining bus-zones involves including a circuit breaker as part of the connection. You can include a circuit breaker provided that the circuit breaker auxiliary contact is wired to the relay and included in the bus-zones-to-bus-zones settings.

Inboard (Bushing) CTs

Figure 6.24 shows an outboard CT, and *Figure 6.25* shows an inboard CT. Defining a CT as inboard or outboard only has meaning when a terminal is on transfer. To define the terms, refer to the area between the circuit breaker and the CT, and determine the connection to the transfer bus.

- ➤ Outboard CT: the connection to the transfer bus is between the circuit breaker and the CT (*Figure 6.24*).
- ➤ Inboard CT: the connection to the transfer bus is not between the circuit breaker and the CT (*Figure 6.25*).

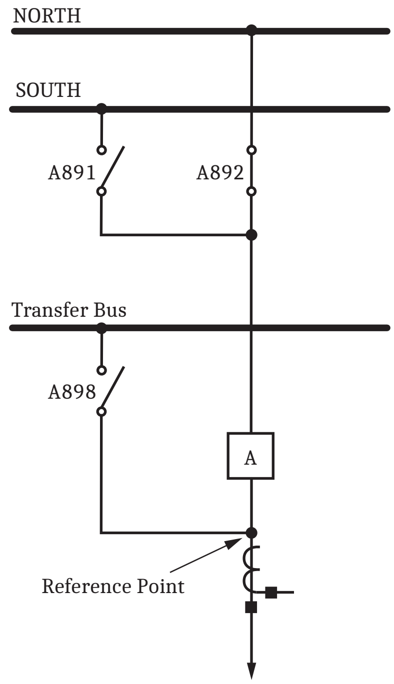


Figure 6.24 Outboard CT

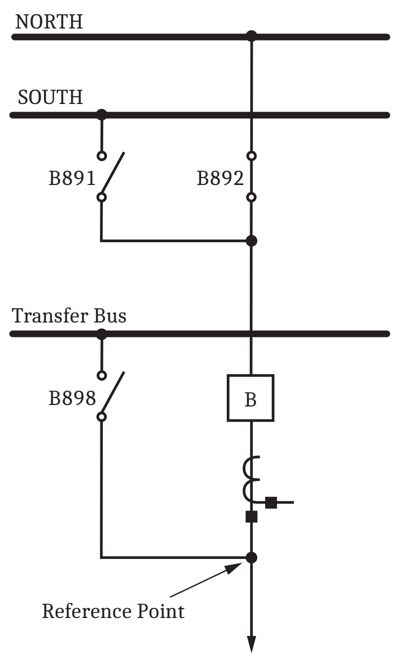


Figure 6.25 Inboard CT

Bushing CTs (typically the source of inboard CTs) present two difficulties to bus protection when a terminal is on transfer:

- A transfer differential zone cannot be formed because of a lack of CT inputs.
- The check zone is unbalanced.

Not having a transfer differential zone is not a major problem if it is understood that the transfer busbar becomes part of the line and forms part of the line protection when a terminal is on transfer. However, the unbalanced check zone usually necessitates blocking busbar protection when a terminal is on transfer.

Example of Check Zone With In-Board (Bushing) CTs

Instead of blocking the check zone protection when a terminal is on transfer, you can use the Advance Check Zone function to include a terminal from the bus coupler in the check zone differential element calculations. Although this approach deviates from the practice of having the check zone CTs independent of disconnect auxiliary contacts, it provides an opportunity to still have a check zone for in-board CT applications. *Figure 6.26* shows an example of an application with in-board CTs that includes a check zone. In *Figure 6.26*, Feeder 1 connects to Bus 1 (i.e., not on transfer). Under these conditions, Zone 1 (formed by I01 and I03), Zone 2 (formed by I02 and I04), and the check zone (formed by I01 and I04) are all balanced.

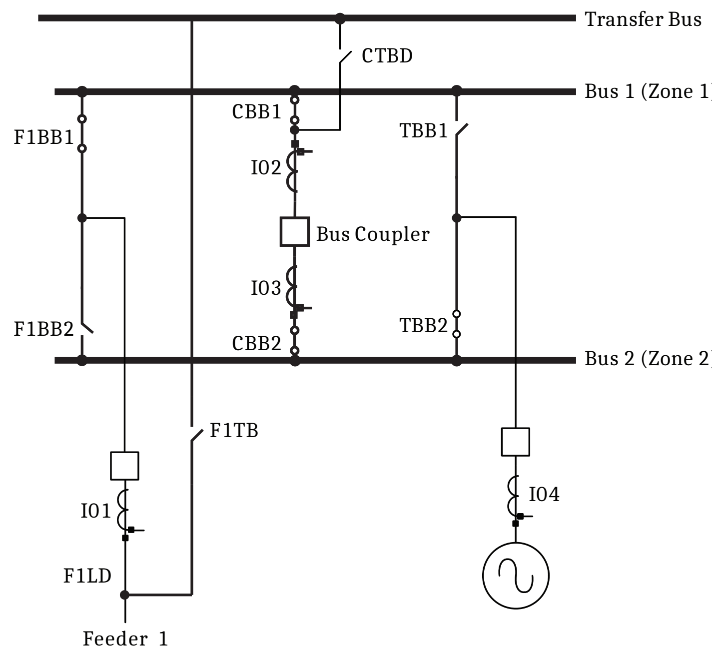


Figure 6.26 Normal Operating Conditions

In *Figure 6.27*, Feeder 1 connects to the Transfer busbar. When Feeder 1 connects to the Transfer busbar, note the following conditions:

1. Line CT I01 of Feeder 1 is no longer in the circuit.
2. Without I01, the current to balance I03 is missing, resulting in an unbalanced Zone 1.
3. Without I01, the current to balance I04 is missing, resulting in an unbalanced check zone.
4. I02 and I04 are still available so that Zone 2 is balanced.

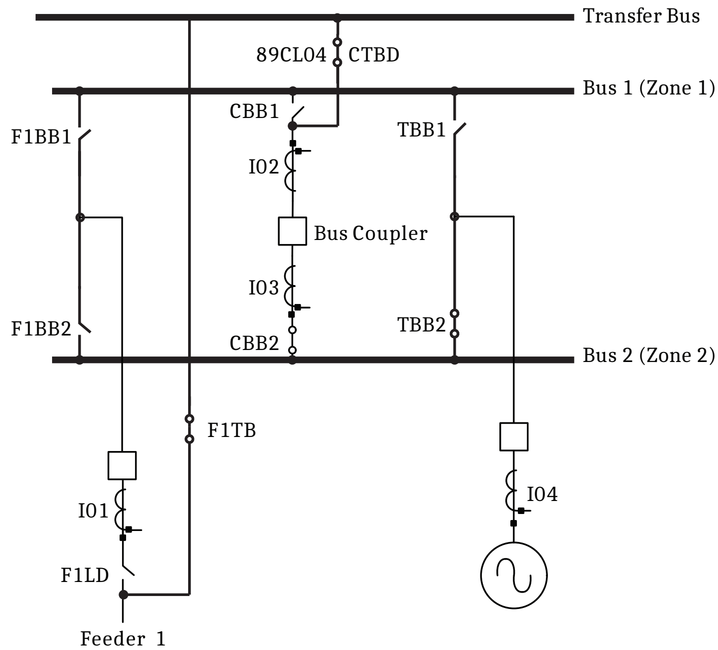


Figure 6.27 Feeder With Inboard CTs

To balance Zone 1, we need to remove I03 from the Zone 1 differential element calculations. You can remove I03 with existing settings; either by means of the Terminal-to-Bus-Zone settings, or by means of the Zone Supervision settings (see *Application 6: Double and Transfer Bus With Two Busbars on page 6.157*).

To balance the Check Zone, we need to add I02 to the Check Zone differential element calculations by means of the Advanced Check Zone settings. The steps are as follows:

1. Include I02 in the Terminal to Check Zone Connection settings.
2. Use the Advanced Check Zone settings to remove I02 from the Check Zone differential element calculations, except when Feeder 1 is on transfer.

Following is an example of how to use the Advance Check Zone function to balance the Check Zone for this application.

NOTE: In Quickset, these settings are made in **Group > Zone Configuration > Check Zone Configuration > Terminal nn to Check Zone Connections**.

```
Check Zone Configuration

Enable Check Zones at Station (Y,N)              ECHKZN  := N      ?Y <Enter>

Check Zone Configuration: Terminal to Check Zone Connections


Terminal, Check-Zone, Polarity (P,N)
?  I01 CZ1 P <Enter>
Terminal, Check-Zone, Polarity (P,N)
?  I02 CZ1 P <Enter>
Terminal, Check-Zone, Polarity (P,N)
?  I04 CZ1 P <Enter>
Terminal, Check-Zone, Polarity (P,N)
?  <Enter>
Enable Advance Check Zone Settings (Y,N)         EADVCZ  := N      ? Y <Enter>
Include coupler 1 in check zone 1 (SELogic Eq.)
CZ11R := NA
?  89CL04 <Enter>
Terminal associated with coupler 1 in CZ1 (Inn)  CZ11M   :=        ?I02 <Enter>
Include coupler 2 in check zone 1 (SELogic Eq.)
CZ12R := NA
?END <Enter>
```

Table 6.4 discusses the settings mentioned above. Please pay close attention to the comments mentioned in Step 4.

Table 6.4 Discussion of the Advanced Check Zone Settings

Step Number	Setting	Comment
Step 1	`ECHKZN := Y`	Enable the three Check Zones.
Step 2	`Terminal, Check-Zone, Polarity (P,N) ? ` **`I02 CZ1 P <Enter>`**	This is the non-conventional setting. Here we add the bus coupler CT to the Check Zone. This is the first part of the solution. Under normal operating conditions (when no terminal is on transfer) the bus coupler CTs must be EXCLUDED from the Check Zone differential element calculations. You MUST complete the second part of this setting under the Advance Check Zone Settings.
Step 3	`EADVCZ := Y`	Enable the Advance Check Zone Settings.
Step 4	`Include coupler 1 in check zone 1 (SELogic Eq.)` `CZ11R := NA ? ` **`89CL04 <Enter>`**	This is the second part of the solution. CZ11R is similar to the Terminal to Bus-Zone Connections (i.e., here is where you enter the conditions when the bus coupler CT must be included in the Check Zone differential element calculations). Assuming you assigned Disconnect Logic 89CL04 to the Transfer Disconnect for I02, enter **89CL04**. CZ11R defeats the Check zone setting of Step 2. This means that, although the list of Check Zone terminals (Step 2) includes I02, I02 is only included in the Check Zone differential element calculations when CZ11R evaluates to logical 1.
Step 5	`CZ11M := I02`	Enter the bus coupler terminal (I02 in this example) you want to include in the Check Zone differential element calculations when CZ11R evaluates to logical 1.

Table 6.5 shows the settings for the Advance Check Zone.

Table 6.5 Advance Check Zone Settings

Label	Prompt	Default Value
EADVCZ	Enable Advance Check Zone Settings (Y, N)	N
CZ*pq*R	Include Coupler *q* in Check Zone *p* (SELOGIC Eq.)	NA
CZ*pq*M	Terminal associated with Coupler *q* in CZ*p* (I*nn*)	

Terminal Configurations

In essence, busbar protection is assigning the correct CT currents to the appropriate differential elements. Disconnect auxiliary contacts provide the information necessary for busbar protection, and breaker auxiliary contacts provide the breaker status for refining the protection. SELOGIC control equations provide the mechanism for declaring the conditions when the currents are assigned to the appropriate differential elements. Entering data in the relay requires two steps. The first identifies the terminal and attributes, and the second involves creation of the SELOGIC control equation stating the conditions for the CTs to be considered in the differential calculation. Bus couplers (tie breakers) require more condition information when two or more bus-zones are combined.

Step 1. Identify the terminal, the bus-zone to which the terminal can connect, and the CT polarity when this connection is made.

The following is the relay prompt for the Step 1 entry:

```
Terminal, Bus-Zone, Polarity (P,N)
?
```

Step 2. State the conditions when **Terminal** will be connected to the **Bus-Zone**:

I01BZ2V :=

Think of **Terminal** as the CT of that particular terminal and **Bus-Zone** as the busbar to which the CT will be connected for differential and restraint current calculations. In other words, assign the CT (**Terminal**) to busbar (**Bus-Zone**) under the following conditions: **I01BZ2V := <conditions>**.

Figure 6.28 shows Terminal NEW_YRK. The differential calculations consider the CT when disconnect NEW891 closes to complete the connection to Bus-Zone NORTH.

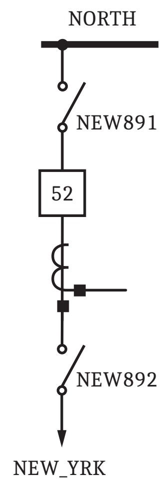


Figure 6.28 Terminal NEW_YRK Disconnects NEW892 and NEW891 and Bus-Zone NORTH

Step 3. Enter the data as follows:

```
Terminal, Bus-Zone, Polarity (P,N)
?NEW_YRK,NORTH,P <Enter>
```

Entering incorrect information may result in relay misoperation. To reduce potential entry of incorrect information, the relay provides a double check to verify that terminal and bus-zone connections are indeed as intended. The next prompt has two parts:

- The relay states terminal and bus-zone alias names just entered.
- The relay generates a prompt with the primitive terminal and bus-zone names.

Thus, the prompt now appears as follows:

```
NEW_YRK to NORTH Connection (SELogic Equation)
I01BZ1V :=
```

Step 4. Enter the conditions under which Terminal NEW_YRK is to be assigned to Busbar NORTH by specifying the particular disconnect (89) auxiliary contact that will connect the terminal to the busbar.

For example, when Disconnect NEW891 is closed, Terminal NEW_YRK is connected to Busbar NORTH. A Terminal, Bus-Zone, Polarity (P, N), and I01BZ1V setting is required for each 89 contact that results in a terminal-to-busbar connection. Consider a terminal that can be connected to Busbar 1, Busbar 2, and the transfer bus. Because the terminal connects to three busbars, provide terminal-to-bus-zone (Terminal, Bus-Zone, Polarity) and conditions for consideration in the differential calculations [I01BZ*n*V (*n* = 3)] for each of the three busbars.

Step 5. Enter the following settings for Terminal NEW_YRK:

```
NEW_YRK to NORTH Connection (SELogic Equation)
I01BZ1V := NEW891 <Enter>
```

Entries here assign CT currents to differential elements. Take care to first investigate the position of the CT for each entry. For example, refer to *Figure 6.24*, and observe that regardless of which disconnect closes (A891, A892 or A898), current always flows through the CT. This is not the case with inboard CTs; closing B898 in *Figure 6.25* bypasses the CT, and no current flows in the inboard CT.

Step 6. Determine the CT polarity, assuming a polarity-to-polarity connection. *Figure 6.29* shows that the CT polarity is positive.

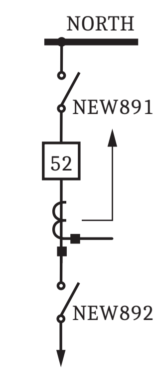


Figure 6.29 Positive CT Polarity for Terminal NEW_YRK

Step 7. Omit the final argument if the CT polarity is positive. For example,

```
Terminal, Bus-Zone, Polarity (P,N)
?NEW_YRK,NORTH,P <Enter>
```

has the same meaning as

```
Terminal, Bus-Zone, Polarity (P,N)
?NEW_YRK,NORTH <Enter>
```

In Quickset, go to **Group 1 > Zone Configuration 1 > Terminal Bus-Zone Connections > Terminal 1 To Bus-Zone Connections**. Set CT01BZ1 = Y, TBZP1 = P, and I01BZ1V = NEW891. NEW_YRK and NORTH are automatically populated into the TBZT1 and TBZB1 fields as the alias names for I01 and BZ1.

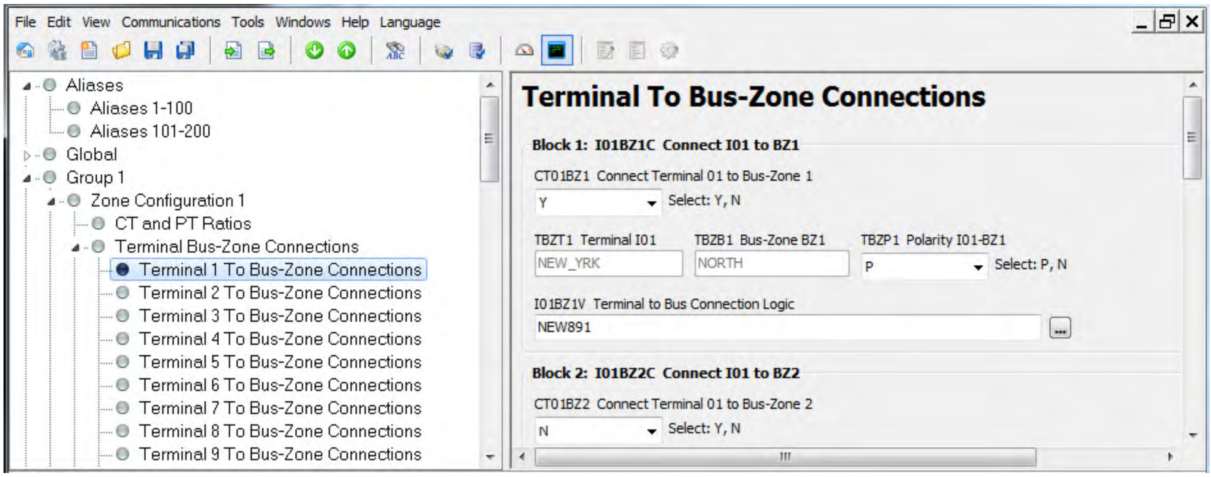


Figure 6.30 Terminal to Bus-Zone Connections Screen

Bus Coupler (Tie Breaker) Configurations

In general, bus couplers are usually configured according to one of the three cases shown in *Figure 6.31*:

- ➤ Case 1: Single CT, single or two cores (two cores shown) with overlap
- ➤ Case 2: CT either side of the breaker, configured in overlap
- ➤ Case 3: CT either side of the breaker with breaker differential

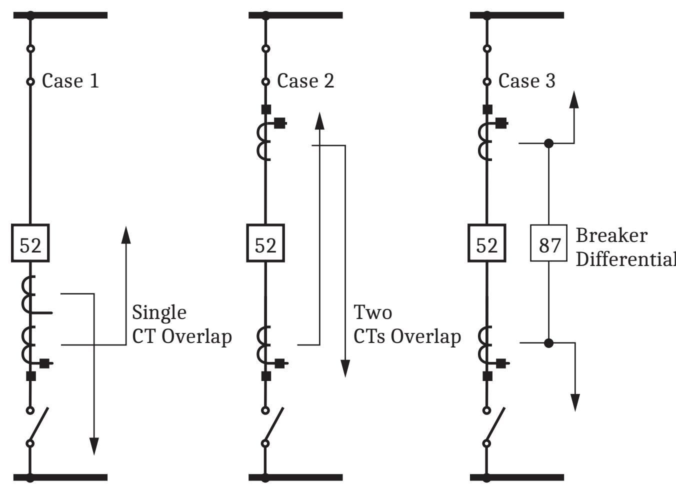


Figure 6.31 Three Typical Cases of Bus Coupler Configurations

A discussion on how to set the three configurations follows.

Label all CTs as indicated in *Figure 6.32* (i.e., CPL1 and CPL2) with the understanding that CPL1 is wired to Terminal I01, and CPL2 to Terminal I02 of the SEL-487B.

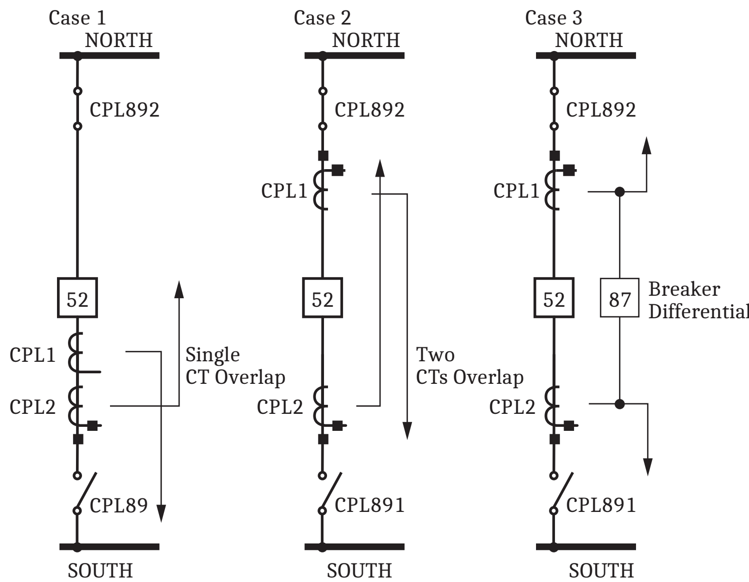


Figure 6.32 General Information Regarding the Three Typical Bus Coupler Configurations

Case 1: Single CT, Single or Two Cores (Two Cores Shown) With Overlap

Step 1. For an overlap, establish the following relationships:

- ➢ CPL1 and SOUTH when CPL891 is closed
- ➢ CPL2 and NORTH when CPL892 is closed

Step 2. Determine the polarity of Terminal CPL1, assuming a polarity-to-polarity connection. *Figure 6.33* shows that the polarity of Terminal CPL1 is negative.

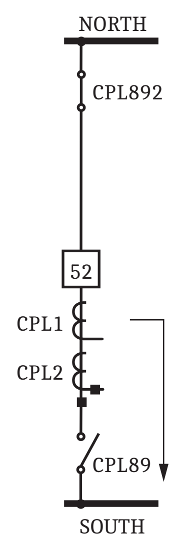


Figure 6.33 Negative CT Polarity for Terminal CPL1

Step 3. Determine the polarity of Terminal CPL2, assuming a polarity-to-polarity connection. *Figure 6.34* shows that the polarity of Terminal CPL2 is positive.

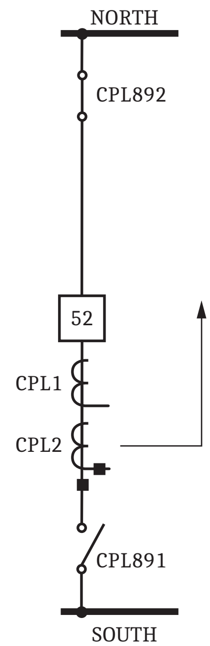


Figure 6.34 Positive CT Polarity for Terminal CPL2

Step 4. *Figure 6.35* shows an extract from the **SET Z 1** ASCII command in determining the terminal-to-bus-zone settings in the relay.

```
Terminal, Bus-Zone, Polarity (P,N)
? CPL1,SOUTH,N <Enter>
CPL1 to SOUTH Connection (SELogic Equation)
IO1BZ2V := CPL891 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
? CPL2,NORTH,P <Enter>
CPL2 to NORTH Connection (SELogic Equation)
IO2BZ1V := CPL892 <Enter>
```

Figure 6.35 Using the SET Z 1 Command to Determine Terminal-to-Bus-Zone Settings

This concludes the Case 1 configuration.

Case 2: CT Either Side of the Breaker, Configured in Overlap

Step 1. As we did before for an overlap, establish the following relationships:

- ➢ CPL1 and SOUTH when CPL891 is closed
- ➢ CPL2 and NORTH when CPL892 is closed

Step 2. Determine the polarity of Terminals CPL1 and CPL2, assuming polarity-to-polarity connections. *Figure 6.36* shows that the polarities of Terminals CPL1 and CPL2 are positive.

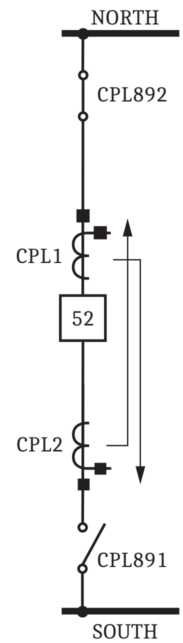


Figure 6.36 Positive CT Polarity for Both Terminals CPL1 and CPL2

Figure 6.37 shows an extract from use of the **SET Z 1** ASCII command to set the terminal-to-bus-zone settings in the relay.

```
Terminal, Bus-Zone, Polarity (P,N)
? CPL1,SOUTH,P <Enter>
CPL1 to SOUTH Connection (SELogic Equation)
I01BZ2V := CPL891 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
? CPL2,NORTH,P <Enter>
CPL21 to NORTH Connection (SELogic Equation)
I02BZ1V := CPL892 <Enter>
```

Figure 6.37 Using the SET Z 1 Command to Set the Terminal-to-Bus-Zone Settings

This concludes the configuration for Case 2.

Case 3: CT Either Side of the Breaker With Breaker Differential

Step 1. Use one of the six available differential elements to configure the breaker differential.

For the bus coupler in the example, three differential elements are required; the third differential element covers only the common area between the two CTs.

In addition to the breaker differential, configure the same CTs (CPL1 and CPL2) to balance SOUTH and NORTH. For the breaker differential, establish the following relationships:

For balancing SOUTH and NORTH:

- CPL1 and NORTH when CPL892 is closed
- CPL2 and SOUTH when CPL891 is closed

For the breaker differential:

- CPL1 and ZONE3 when CPL891 or CPL892 is closed
- CPL2 and ZONE3 when CPL891 or CPL892 is closed

Considering both Terminals CPL1 and CPL2, we determine that both polarities are negative, when we balance SOUTH and NORTH, as shown in *Figure 6.38*.

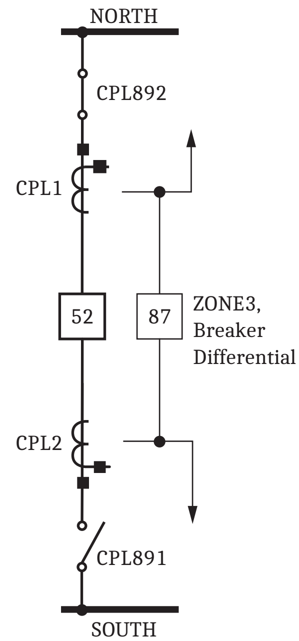


Figure 6.38 Negative CT Polarities for Both Terminals CPL1 and CPL2 When Balancing SOUTH and NORTH

Step 2. Determine the polarity of Terminals CPL1 and CPL2 for the breaker differential (ZONE3), assuming polarity-to-polarity connections. *Figure 6.39* shows that the polarities of Terminals CPL1 and CPL2 for the breaker differential are positive.

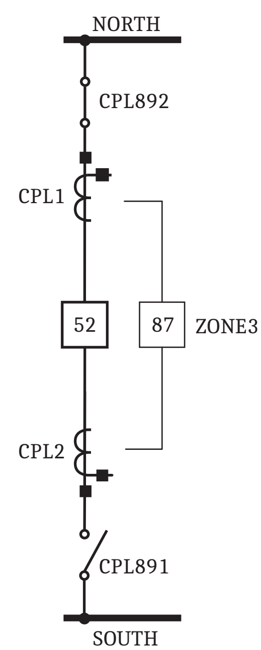


Figure 6.39 Positive CT Polarities for Both Terminals CPL1 and CPL2 for the Breaker Differential

Figure 6.40 shows the entries for Terminals CPL1 and CPL2.

```
Terminal, Bus-Zone, Polarity (P,N)
? CPL1,NORTH,N <Enter>
CPL1 to NORTH Connection (SELogic Equation)
IO1BZ1V := CPL892 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
? CPL1,ZONE3,P <Enter>
CPL1 to ZONE3 Connection (SELogic Equation)
IO1BZ3V := CPL891 OR CPL892 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
? CPL2,SOUTH,N <Enter>
CPL2 to SOUTH Connection (SELogic Equation)
IO2BZ2V := CPL891 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
? CPL2,ZONE3,P <Enter>
CPL2 to ZONE3 Connection (SELogic Equation)
IO2BZ3V := CPL891 OR CPL892 <Enter>
```

Figure 6.40 Entries for Terminals CPL1 and CPL2

Bus-Zone-to-Bus-Zone Connections

Bus-zone-to-bus-zone settings are used only when bus-zone-to-bus-zone connections are formed between two or more busbars, particularly when the connection is formed without a circuit breaker between the busbars. For example, closing disconnects D891 and D892 in *Figure 6.41* forms a solid connection between NORTH and SOUTH, and there is no circuit breaker between the busbars.

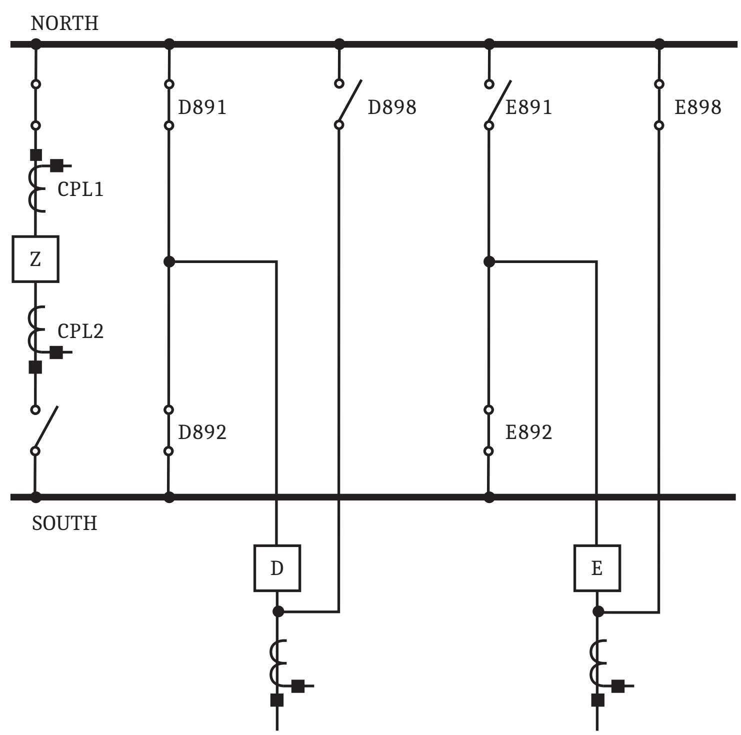


Figure 6.41 Forming Bus-Zone-to-Bus-Zone Connections With and Without a Circuit Breaker

By contrast, closing E892 and E898 or E891, E892, and E898 also forms a connection between Busbar 1 and Busbar 2, but now there exists a circuit breaker between the busbars, namely the Terminal E circuit breaker. The significance of the bus-zone-to-bus-zone connection is twofold.

- ➤ Both differential zones (SOUTH and NORTH) must operate when a fault develops on either zone during the time when the two differential zones are connected via disconnects D891 and D892 (or similar connections).
- ➤ Parallel paths are formed, and both differential zones may be unbalanced (see *Figure 6.23*).

When two bus-zones are combined, bus coupler CTs are redundant and are removed from the differential calculations.

One protection philosophy requires the tripping of only those circuit breakers that can contribute fault current to optimize breaker maintenance. However, there is also the protection philosophy that requires all breakers in the faulted differential zone to be tripped. To satisfy both protection philosophies, the SEL-487B offers the choice of leaving the bus coupler closed or issuing a trip signal. The first prompt in this group asks you for the two busbars that will be combined.

Step 1. From *Figure 6.41*, we see that we would enter SOUTH and NORTH at the prompt (without spaces between the differential zone names or the comma).

```
Bus-Zone,Bus-Zone?
SOUTH,NORTH <Enter>
```

Step 2. Next, the SELOGIC control equation that declares the digital input conditions which must be a logical 1 for the relay to recognize the combination of SOUTH and NORTH. Again, the relay states the names you enter and then generates a prompt with the primitive names as a double check.

List all of the several possible combinations, separating each combination with the OR function. From *Figure 6.41*, NORTH and SOUTH are combined when D891 and D892 are closed, or when E891 and E892 are closed:

```
SOUTH to NORTH Connection (SELogic Equation)
BZ1BZ2V := (D891 AND D892) OR (E891 AND E892) <Enter>
```

NOTE: When the bus-zone-to-bus-zone SELOGIC control equation includes the circuit breaker, be sure to also include the breaker auxiliary contact status (not only the disconnect status) to ensure separate bus-zones when the circuit breaker is open.

This setting identifies the particular differential zones that can be combined and the conditions under which this combination can take place.

Step 3. The next setting allows you to select a subset of the conditions stated in the previous setting. In the present example, there is no subset, and the setting is a repeat of the previous setting.

```
Remove Terminals when NORTH and SOUTH Bus-Zones merge (SELogic Equation)
BZ1BZ2R := NA
?  (D891 AND D892) OR (E891 AND E892) <Enter>
```

Step 4. Next, state the terminals to be removed when the two differential zones are combined. In most cases, these terminals are the bus coupler CTs, as is the case in *Figure 6.41*. You would, therefore, enter the bus coupler terminal names at the prompt.

```
Terminals Removed when NORTH and SOUTH Bus-Zone merge (Ter k,...,Ter n)
BZ1BZ2M :=
?CPL1,CPL2 <Enter>
```

Step 5. To end this group, select whether the bus coupler must be tripped (Y) when a fault occurs in the combined protection zone during the time when the two bus-zones are merged, or whether the bus coupler must not be issued a trip signal (N). Again, as a double check, the relay states the primitive names of the terminals that must be removed:

```
Trip Terminals CPL1, CPL2 (Y,N)
BZ1BZ2T := N
?  Y <Enter>
```

In Quickset, go to **Group 1 > Zone Configuration 1 > Bus-Zone to Bus-Zone Connections > Bus-Zone to Bus-Zone Connections Blocks 1–5**. Set CBZ1BZ2 = Y, BZ1BZ2V = (D891 AND D892) OR (E891 AND E892), BZ1BZ2V = (D891 AND D892) OR (E891 AND E892), CPT11 = CPL1, CPT21 = CPL2, and BZBZT1 = Y. NORTH and SOUTH are automatically populated into the BZBZ11 and BZBZ21 fields as the alias names for BZ1 and BZ2.

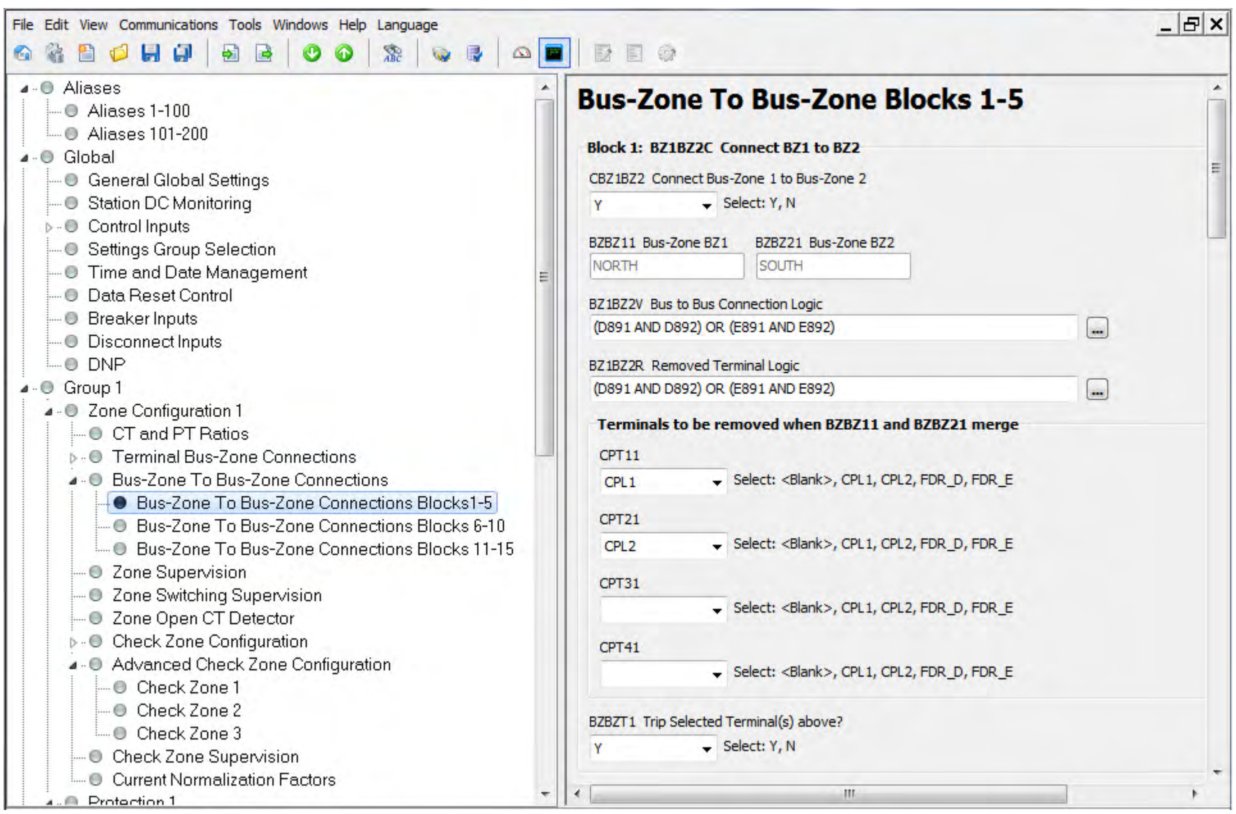


Figure 6.42 Bus-Zone to Bus-Zone Blocks 1-5

Zone Supervision

This is the final check before a bus-zone trip (87Z1) is issued for each of the six differential zones. *Figure 6.43* shows the relay logic for this function, where the output from the differential calculations (87R1) is ANDed with the zone supervision conditions. See *Section 5: Protection Functions* for more information.

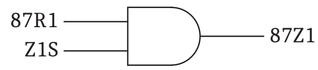


Figure 6.43 Zone Supervision Logic

This is a good place to include the overall check zone differential element output, if one was configured.

Assume Check Zone 1 was configured. Enter the following to include the check zone.

```
Z1S:= 87CZ1 <Enter>
```

Trip Logic

Figure 6.44 shows the steps necessary for assigning protection functions to the trip logic.

Make sure all selected protection functions appear in the trip equation.

For example, having selected the breaker failure protection, assign the output from this logic to the output contact, or the contact will not assert when the breaker failure protection operates. For Terminal I06 wired to OUT201, the following includes differential protection, internal breaker failure protection, and time-overcurrent protection.

```
=>>SET TR06 <Enter>
Group 1
Trip Logic
Trip 06 (SELogic Equation)
TR06 := NA
?  87BTR06 OR SBFTR06 OR 51P01T <Enter>
Unlatch Trip 06 (SELogic Equation)
ULTR06 := NA
?  END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.44 Assign the Protection Functions to the Trip Logic

Output Assignments

Figure 6.45 shows the steps necessary for assigning the output from the trip logic (TRIP06) to output contact OUT201.

```
=>>SET O OUT201 <Enter>
Output
Interface Board #1
OUT201 := NA
?  TRIP06 <Enter>
OUT202 := NA
?  END <Enter>
Output
Main Board
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.45 Assigning the Output From the Trip Logic to an Output Contact

Summary

In general, system configuration can be summarized in the four-step approach shown in *Figure 6.46*.

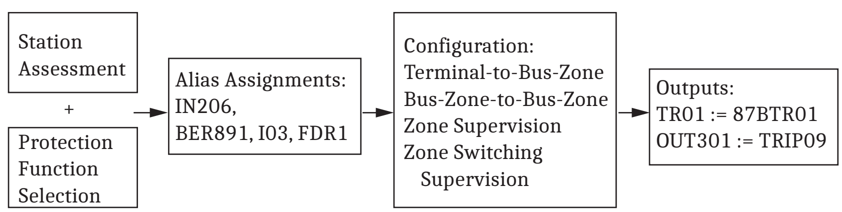


Figure 6.46 Information Flow Diagram

Step 1. Assess your station and select appropriate protection functions.

Inspect the substation layout to make the appropriate selection in terms of number of bus-zones, number of terminals, CT ratio mismatch, I/O count, etc.

As for protection functions, decide whether to use internal or external breaker failure protection, breaker differential, or an overlap coupler CT application (if two sets of CTs are available), etc.

Step 2. Assign alias names.

Because configuration settings use terminal names, assign alias names at this point.

Step 3. Configure your system.

Entries here determine the CT/differential element assignment with the terminal-to-bus-zone and bus-zone-to-bus-zone settings, while zone supervision and zone-switching supervision provide for additional control and information.

Step 4. Assign outputs.

For each terminal, select the relay functions for which the terminal will be issued a trip signal.

Use *Table 6.6–Table 6.11* to assist with Step 1 of the configuration process.

Table 6.6 Primary Plant Data

Items	Requirement for Your Plant
Number of terminals (maximum 21)	
Number of busbars (maximum 6)	
Number of main zones (maximum 6)	
Number of check zones (maximum 3)	
Number of bus couplers or tie breakers (maximum 4)[a]	
Inboard CTs (Y,N)	
Maximum/minimum CT ratio	

[a] Mutually exclusive; sum of bus couplers and bus sections cannot exceed four.

Table 6.7 Data for Bus Coupler 1 and Bus Coupler 2

Bus Coupler 1 Data		Bus Coupler 2 Data	
Number of CTs		Number of CTs	
Overlap or differential		Overlap or differential	
Coupler security logic? Y, N[a]		Coupler security logic? Y, N[a]	
Breaker status logic? Y, N[b]		Breaker status logic? Y, N[b]	

[a] Allocate independent optoisolated inputs to the selected logic.
[b] Allocate one grouped optoisolated input to the selected logic for each logic.

Table 6.8 Data for Bus Coupler 3 and Bus Coupler 4

Bus Coupler 3 Data		Bus Coupler 4 Data	
Number of CTs		Number of CTs	
Overlap or differential		Overlap or differential	
Coupler security logic? Y, N[a]		Coupler security logic? Y, N[a]	
Breaker status logic? Y, N[b]		Breaker status logic? Y, N[b]	

[a] Allocate independent optoisolated inputs to the selected logic.
[b] Allocate one grouped optoisolated input to the selected logic for each logic.

Table 6.9 Disconnect, Breaker, and Input Data

Items	Requirement for Your Plant
Number of 89A (N/O) contacts?[a]	
Number of 89B (N/C) contacts?[a]	
Disconnect Monitoring Logic? (maximum 60)	
Zone-Switching Supervision Logic?	
Number of 52A contacts	

[a] Allocate independent optoisolated inputs to the selected logic.

Table 6.10 Breaker Failure Data

Items	Requirement for Your Plant
Number of internal breaker failure circuits	
Number of external breaker failure circuits	
Additional security?[a]	

[a] Allocate independent optoisolated inputs to the selected logic.

Table 6.11 End-Zone Protection

Items	Requirement for Your Plant
Number of 52A (N/O) contacts?[a]	
Number of communication outputs required?[b]	

[a] Allocate this number of common optoisolated input contacts.
[b] Allocate this number of independent output contacts.

Application 1: Single Bus and Tie Breaker (Three Relays)

This application describes the busbar arrangement shown in *Figure 6.47*, a single bus with bus sectionalizer (tie breaker), three-relay application. The busbar arrangement consists of two busbar sections, four feeders, and a tie breaker. Consider the following to set and configure the relay:

- Busbar classification
- Protection philosophy
- Protection functions selection
- Number of SEL-487B Relays and I/O boards
- Input, logic, and output allocation and alias name assignment
- Station layout update
- Relay setting and configuration

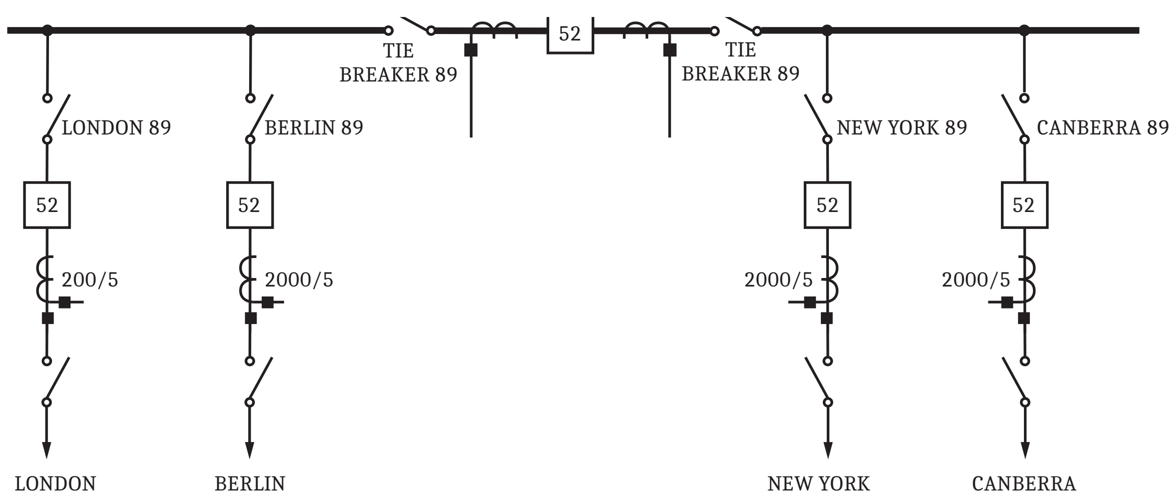


Figure 6.47 Single Bus With Bus Sectionalizer (Tie Breaker)

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information and declares the tie-breaker (bus coupler or sectionalizing breaker) configuration. The classification for this application is:

- Description
  - Single bus with tie breaker
- Current Transformers

- Outboard (free standing)
- Disconnects
  - Both 89A and 89B disconnect auxiliary contacts are available
- Sectionalizing breaker (tie-breaker) configuration
  - Overlap
- Future expansion
  - Four feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not all of these functions are applied at every substation. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Use the 89 disconnect auxiliary contacts to dynamically configure the station.
2. Use the Disconnect Monitoring Logic.
3. Block the busbar protection for an open-circuit CT.
4. Configure check-zone protection.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs required for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. For example, in this application the protection philosophy calls for a check zone, but not for breaker failure protection.

The SEL-487B offers a number of protection functions as standard features, but also includes the capability through SELOGIC control equations to create user-configurable functions. To properly identify and categorize the protection philosophy requirements, group the protection functions as follows:

- standard protection functions (available in the relay)
- user-defined protection functions (created using SELOGIC control equations)

Standard Functions

Refer to *Protection Philosophy on page 6.61* and select the standard functions required for the application. *Table 6.12* shows the selection of the standard functions.

Table 6.12 Selection of the Standard Protection Functions

Protection Function	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available

Table 6.12 Selection of the Standard Protection Functions

Protection Function	Selection	Comment
Differential protection	Yes	Busbar protection, zone specific Check-zone protection
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions
Sensitive differential protection	Yes	CT open circuit detection
Zone supervision logic	Yes	Enter the check zone and zone-specific conditions to supervise the zone-specific differential elements
Zone-switching supervision logic	No	89A and 89B disconnect contacts available; therefore, this logic is not required
Coupler security logic	No	Two CTs with overlap configuration do not require the coupler security logic
Circuit breaker failure protection	No	Not required
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Because the SEL-487B includes all protection functions necessary for this application as standard protection functions, we do not need any user-defined functions.

Check-Zone Protection

Figure 6.48 shows a station with check-zone protection. Check-zone protection stems from the philosophy of providing an additional trip criterion before issuing a busbar protection trip signal. This philosophy encompasses additional trip criteria such as directional elements and overcurrent elements.

When using check-zone protection as an additional criterion, the practice is to provide a measurement from a second differential element that is independent of the disconnect auxiliary contact status. Using a measurement independent of the disconnect auxiliary contact status prevents differential element misoperation resulting from disconnect auxiliary contact failure.

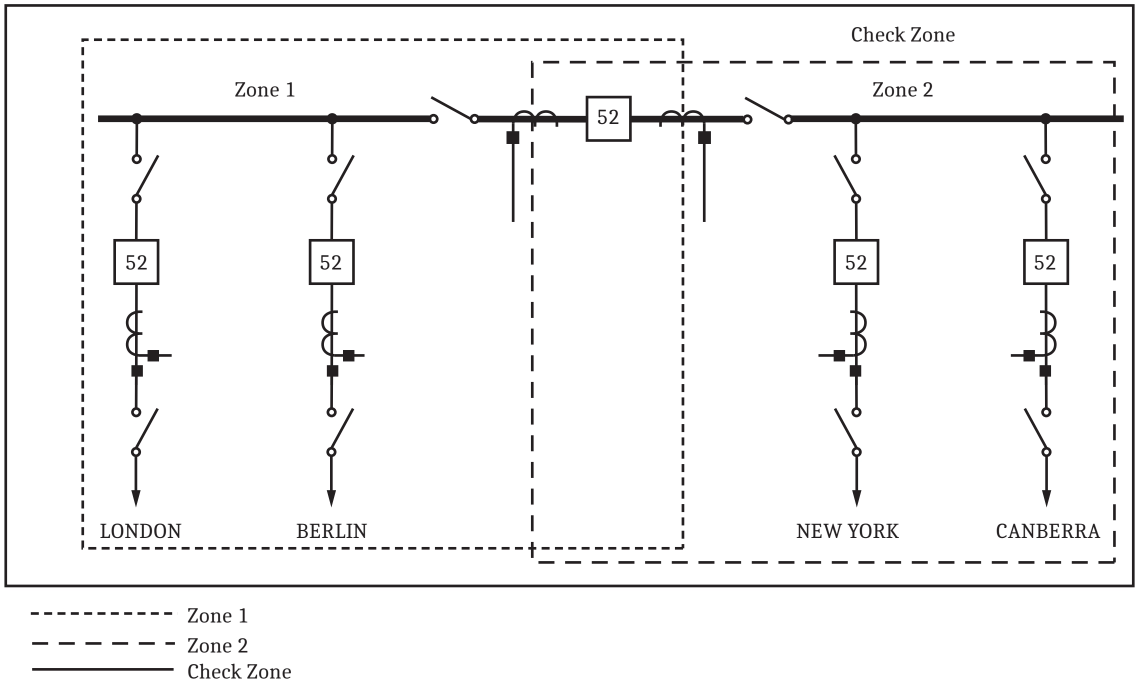


Figure 6.48 Station With Two Zone-Specific Bus-Zones and an Overall Check Zone

Both the Check Zone and either Zone 1 or Zone 2 differential elements must assert before a busbar protection trip output asserts. Use the Differential Element Zone Supervision setting to comply with the requirement for both check zone and zone-specific differential elements to assert. *Figure 6.49* shows the zone supervision logic. Relay Word bit 87R1 is the output from the Zone 1 differential element and Z1S is the SELOGIC control equation where we enter conditions for supervising the Zone 1 differential element. (See *Zone Configuration Group Settings on page 6.54* for more detail.)

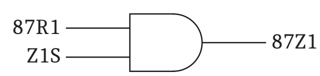


Figure 6.49 Zone Supervision Logic

Create the check-zone protection by configuring a check zone when entering the zone configuration settings (ECHKZN := Y).

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 7 three-phase terminals (21 CTs), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.2* to calculate the number of current channels at the station, and use *Equation 6.3* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.2

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.3

The number of per-phase CTs at the station is 18 and the number of bus-zones required is 2 (Zone 1 and Zone 2). The number of check zones required is 1 (Check Zone 1). One SEL-487B suffices for these requirements, but the requirement for 4 future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need 3 relays. This is known as a three-relay application.

In a three-relay application, each relay provides six zones and three check zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, the B-phase CTs to Relay 2, and the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information. Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hard wiring) the input and output contacts to the other two relays. This example shows the setting and configuration for the A-phase relay, so identified with an appended letter A (LOND_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding LOND_A setting is LOND_B in the B-phase relay and LOND_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, each of the four feeders requires one disconnect monitoring logic and the tie breaker requires two; therefore, the number of disconnect logics required is six. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.4* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.4

Table 6.13 summarizes the input contact required for this application.

Table 6.13 Number of Relay Input Contacts Required

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	6 • 2 = 12
Total number of inputs	12

The relay main board has seven input contacts, which are not enough input contacts for our application. Each interface board provides two sets of nine grouped input contacts and six independent input contacts. Use the grouped input contacts for the disconnect auxiliary contact inputs. From the input contact perspective, we need one interface board. It is not necessary to include I/O for future expansion with the initial order; install additional I/O if and when required.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all breakers are part of the busbar differential protection, we want to trip each breaker upon differential protection operation. *Table 6.14* shows the breakdown and the total number of relay output contacts required.

Table 6.14 Breakdown and the Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for tripping	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the RELAY TEST MODE pushbutton on the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board contacts are all standard output contacts.

The interface boards may have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board can be ordered with an option that provides six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with a single interface board.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point we have determined the following:

- the number of SEL-487B Relays required for the application
- the number of input contacts
- the number of output contacts
- the selected functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- link specific CT inputs to specific relay analog channels
- link specific disconnect and circuit breaker inputs to specific relay input contacts
- link relay element/logic outputs to specific relay output contacts
- assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- ➤ Relay Word bit
- ➤ Analog quantity
- ➤ Terminal name
- ➤ Bus-Zone name
- ➤ Check-Zone name

Alias names are valid when they consist of a maximum of seven characters and they are constructed with characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

Table 6.15 shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT1 to relay channel I01, and assign to this CT the alias name SEC1_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.15* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left to right from *Figure 6.47*.

Table 6.15 CTs-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT1, A-phase	I01	SEC1_A
TIE-BREAKER CT2, A-Phase	I02	SEC2_A
LONDON, A-phase	I03	LOND_A
BERLIN, A-phase	I04	BERL_A
NEW YORK, A-phase	I05	NEWY_A
CANBERRA, A-phase	I06	CANB_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. For the A-phase relay, we use two bus-zones with alias names as shown in *Table 6.16*.

Table 6.16 Alias Names for the Two Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	WEST_A
BZ2	Bus-Zone 2	EAST_A

Check-Zone Alias Assignment

Each SEL-487B provides three check zones. For the A-phase relay, we use the check zone with the alias name as shown in *Table 6.17*.

Table 6.17 Alias Name for the Check Zone

Check-Zone Name	Description	Alias
CZ1	Check Zone	CHECK_A

Input to Logic Allocation and Alias Assignment

Table 6.13 shows that we require 12 digital inputs. We now assign the 12 digital input contacts to the selected logic and assign alias names to the input contacts and logic elements. Because of the functional requirement of this application, we do not need to use any digital inputs on the main board.

Input Contact to Logic Allocation and Alias Assignment, Interface Board 1 (200)

Table 6.18 shows the disconnect auxiliary contact input allocations and the alias names. Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs for breaker failure initiate inputs; these inputs are not used in the present application.

Table 6.18 Alias Names for the Breaker Status Logic Output Relay Word Bits

Input	Description	Alias
IN204	TIE-BREAKER disconnect (WEST) NO contact	ISE891A
IN205	TIE-BREAKER disconnect (WEST) NC contact	ISE891B
IN206	TIE-BREAKER disconnect (EAST) NO contact	ISE892A
IN207	TIE-BREAKER disconnect (EAST) NC contact	ISE892B
IN208	LONDON disconnect N/O contact	ILON89A
IN209	LONDON disconnect N/C contact	ILON89B
IN210	BERLIN disconnect N/O contact	IBER89A
IN211	BERLIN disconnect N/C contact	IBER89B
IN212	NEW YORK disconnect NO contact	INEW89A
IN216	NEW YORK disconnect NC contact	INEW89B
IN217	CANBERRA disconnect NO contact	ICAN89A
IN218	CANBERRA disconnect NC contact	ICAN89B

Assign Alias Names to the Selected Standard Logic

Referring to *Table 6.12*, the following is a discussion on each selected function. Alias name assignments are also included.

Disconnect Monitoring Logic and Disconnect Alias Assignment

Figure 6.50 shows one of the 60 disconnect monitor logic circuits available in the relay. (See *Disconnect Requirements on page 6.15* for more information on the disconnect auxiliary contact requirements).

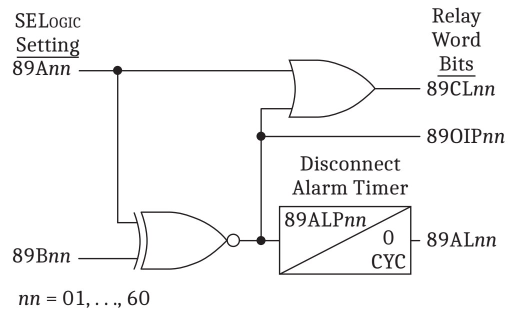


Figure 6.50 One of the Disconnect Monitoring Logic Circuits Available in the Relay

Table 6.19 shows the alias names for the disconnect auxiliary contact Relay Word bits.

Table 6.19 Alias Names for the Disconnect Auxiliary Contact Relay Word Bits

Input	Description	Alias
89A01	TIE-BREAKER disconnect (WEST) NO contact	SEC891A
89B01	TIE-BREAKER disconnect (WEST) NC contact	SEC891B
89A02	TIE-BREAKER disconnect (EAST) NO contact	SEC892A
89B02	TIE-BREAKER disconnect (EAST) NC contact	SEC892B
89A03	LONDON disconnect NO contact	LON89A
89B03	LONDON disconnect NC contact	LON89B
89A04	BERLIN disconnect NO contact	BER89A
89B04	BERLIN disconnect NC contact	BER89B
89A05	NEW YORK disconnect NO contact	NEW89A
89B05	NEW YORK disconnect NC contact	NEW89B
89A06	CANBERRA disconnect NO contact	CAN89A
89B06	CANBERRA disconnect NC contact	CAN89B

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs on the A-phase relay. Jumper (hardwire) the disconnect input contacts to the other two relays. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets that the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations. We also assign alias names to the alarm Relay Word bits (89AL*nn*). *Table 6.20* shows the alias names.

Table 6.20 Alias Names for the Disconnect Monitor Logic Output Relay Word Bits (Sheet 1 of 2)

Primitive Name	Description	Alias
89CL01	TIE-BREAKER disconnect (WEST) is closed	SEC189C
89CL02	TIE-BREAKER disconnect (EAST) is closed	SEC289C
89CL03	LONDON disconnect is closed	LOND89C
89CL04	BERLIN disconnect is closed	BERL89C
89CL05	NEW YORK disconnect is closed	NEWY89C
89CL06	CANBERRA disconnect is closed	CANB89C

Table 6.20 Alias Names for the Disconnect Monitor Logic Output Relay Word Bits (Sheet 2 of 2)

Primitive Name	Description	Alias
89AL01	TIE-BREAKER disconnect (WEST) alarm	SEC189A
89AL02	TIE-BREAKER disconnect (EAST) alarm	SEC289A
89AL03	LONDON disconnect alarm	LOND89A
89AL04	BERLIN disconnect alarm	BERL89A
89AL05	NEW YORK disconnect alarm	NEWY89A
89AL06	CANBERRA disconnect alarm	CANB89A

Differential Trip Logic and Differential Element Alias Assignment

Figure 6.51 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information). *Table 6.21* shows the Relay Word bits and the alias names for the zone differential protection outputs.

Table 6.21 Alias Names for the Zone Differential Protection Output Relay Word Bits

Primitive Name	Description	Alias
87Z1	Zone 1 differential element trip	WESTA_T
87Z2	Zone 2 differential element trip	EASTA_T
87CZ1	Check Zone differential element trip	CHECA_T

Differential trip bits 87BTR01–87BTR06 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information).

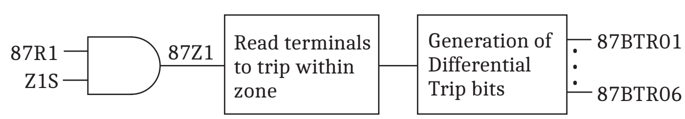


Figure 6.51 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.53* for more information). *Table 6.22* shows the primitive differential trip bit names, the alias names for the differential trip bits, and the terminal with which the relay associates each differential trip bit.

Table 6.22 Primitive Differential Trip Bit Names, Alias Names for the Differential Trip Bits, and Associated Terminals

Differential Trip Bit	Alias	Comments
87BTR01	87SEC1A	Associated with Terminal 01
87BTR02	87SEC2A	Associated with Terminal 02
87BTR03	87LON_A	Associated with Terminal 03
87BTR04	87BER_A	Associated with Terminal 04
87BTR05	87NEW_A	Associated with Terminal 05
87BTR06	87CAN_A	Associated with Terminal 06

Breaker Trip Logic and Trip Alias Assignment

Figure 6.52 shows the general tripping logic in the SEL-487B. (See *Section 5: Protection Functions* for more information.)

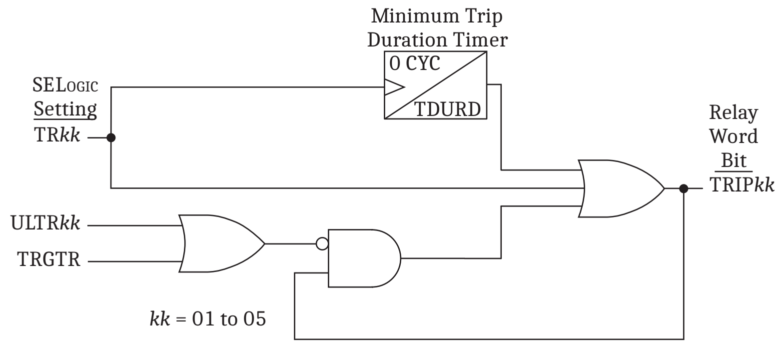


Figure 6.52 Breaker Trip Logic

There exists a direct relationship between the number of circuit breakers setting (NUMBK) and the number of trip equations, i.e., the number of trip equations (TR*kk*) equals the number of circuit breakers (NUMBK) setting. *Table 6.23* shows the five primitive and alias names for the trip logic of each terminal.

Table 6.23 Primitive and Alias Names for the Trip Logic of Each Terminal

Primitive Name	Description	Alias Name
TRIP01	Trip output of the sectionalizing breaker asserted	TRSEC_A
TRIP02	Trip output of the LONDON Terminal asserted	TRLON_A
TRIP03	Trip output of the BERLIN Terminal asserted	TRBER_A
TRIP04	Trip output of the NEW YORK Terminal asserted	TRNEW_A
TRIP05	Trip output of the CANBERRA Terminal asserted	TRCAN_A

Assign Alias Names to the User-Defined Logic

This application requires no user-defined logic.

Relay Logic-to-Output Contact Allocation and Output Contact Alias Assignments

At this point, we have assigned alias names to all relay functions. *Table 6.14* shows the breakdown of the five relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts and assign alias names to the relay output contacts. *Table 6.24* shows TEST and ALARM protection logic assigned to the output contacts of the main board output contacts. *Table 6.25* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1 and the alias names of the of the interface board output contacts.

Output Alias Assignment, Main Board

This application requires no output contacts from the main board.

Table 6.24 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Alias Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can be ordered to include six high-speed, high-interrupting output contacts. *Table 6.25* shows the alias assignment for the five terminals of the A-phase relay.

Table 6.25 Alias Assignment for the Five Terminals in Our Example

Output Contact Assignment	Description	Output Contact Alias
OUT201[a]	TIE-BREAKER trip logic output	SECTR_A
OUT202[a]	LONDON trip logic output	LONTR_A
OUT203[a]	BERLIN trip logic output	BERTR_A
OUT204[a]	NEW YORK trip logic output	NEWTR_A
OUT205[a]	CANBERRA trip logic output	CANTR_A

[a] High-speed, high-interrupting outputs.

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all the relevant information on the station diagram, as shown in *Figure 6.53*.

1. Write down the bus-zone, terminal, and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal/zone allocation.
3. Allocate the terminal CTs to the relay input current channels.
4. Allocate the auxiliary terminal contacts to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals

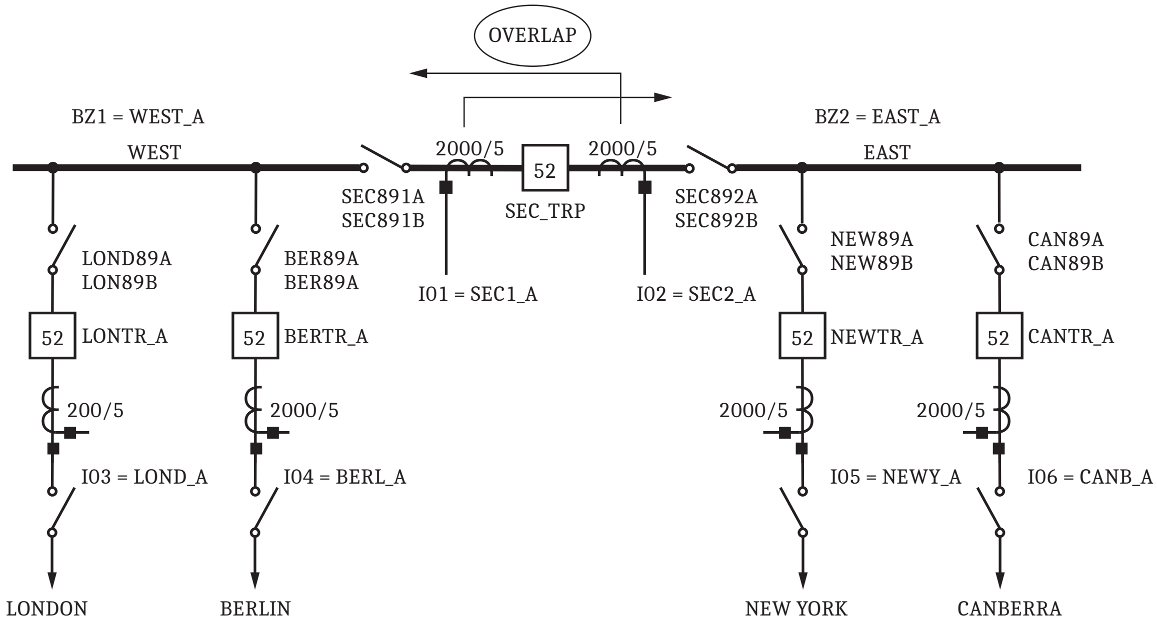


Figure 6.53 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. We set the following settings classes:

- ➤ Alias Settings
- ➤ Global Settings
- ➤ Zone Configuration Group Settings
- ➤ Protection Group Settings
- ➤ Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias settings class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.54*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>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"
?  LIST <Enter>
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"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: I01,"FDR_1"
?
```

Figure 6.54 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.55*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.55 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the setting list. Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.56*.

```
1: OUT107,"TEST"
?  > <Enter>
19:
?  I01,SEC1_A <Enter>
20:
?  I02,SEC2_A <Enter>
21:
?  I03,LOND_A <Enter>
22:
?  I04,BERL_A <Enter>
23:
?  I05,NEWY_A <Enter>
24:
?  I06,CANB_A <Enter>
25:
?  BZ1,WEST_A <Enter>
26:
?  BZ2,EAST_A <Enter>
27:
?  CZ1,CHECK_A <Enter>
28:
?  IN204,ISE891A <Enter>
29:
?  IN205,ISE891B <Enter>
30:
.
.
.
?  OUT204,NEWTR_A <Enter>
92:
?  OUT205,CANTR_A <Enter>
93:
?  END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.56 Analog Quantities and Relay Word Bit Alias Names

This concludes the alias settings. The next settings class is the global settings.

Global Settings

Global settings comprise settings that apply to all protection settings groups. For example, when changing from protection setting Group 1 to protection setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.57* shows the setting changes we need for our example. Because we declared the alias names in the alias settings class, use either alias names or primitive names when entering settings.

NOTE: The relay interprets the number of circuit breakers (NUMBK) as the number of circuit breaker poles, not as the number of circuit breakers.

Setting NUMBK equal to five makes five corresponding circuit breaker auxiliary input equations (52A01–52A05) and five corresponding trip equations (TR01–TR05) available for setting. Because we do not need circuit breaker auxiliary contacts for this application, set 52A01–52A05 to NA.

Setting NUMDS declares the number of disconnect logics we need, not the number of disconnect inputs. In our example, we need six disconnect logics. You can set each disconnect travel time individually with the 89ALP*pp* setting (*pp* = 01–06). Travel time is the time period when both disconnect auxiliary contacts are in the open position (see *Figure 6.20* for more information). Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings

Station Identifier (40 characters)
SID := "Station A"
?  <Enter>
Relay Identifier (40 characters)
RID := "Relay 1"
?  <Enter>
Number of Breakers (N,1-21)                          NUMBK   := 5      ? <Enter>
Number of Disconnects (N,1-60)                       NUMDS   := N      ?6<Enter>
Nominal System Frequency (50,60 Hz)                  NFREQ   := 60     ? <Enter>

Global Enables

Station DC Battery Monitor (Y,N)                     EDCMON  := N      ? <Enter>
Independent Control Input Settings (Y,N)             EICIS   := N      ? <Enter>
Data Reset Control (Y,N)                             EDRSTC  := N      ? <Enter>

Control Inputs (Global)

Input Pickup Delay (0.0-30 ms)                       GINPU   := 2.0    ?> <Enter>

Settings Group Selection

Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  ><Enter>

Time and Date Management

Date Format (MDY,YMD,DMY)                            DATE_F  := MDY    ?> <Enter>

Breaker Inputs

N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  ><Enter>
```

Figure 6.57 Global Settings for Application 1

```
Disconnect Inputs and Timers

N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  ISE891A<Enter>
N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  ISE891B<Enter>
DS01 Alarm Pickup Delay (0-99999 cyc)            89ALP01 := 300    ?400<Enter>
N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  ISE892A<Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  ISE892B<Enter>
DS02 Alarm Pickup Delay (0-99999 cyc)            89ALP02 := 300    ?400<Enter>
N/O Contact Input -DS03 (SELogic Equation)
89A03 := NA
?  ILON89A<Enter>

.
.
.

DS06 Alarm Pickup Delay (0-99999 cyc)            89ALP06 := 300    ?400<Enter>

DNP

Event Summary Lock Period (0-1000 s)             EVELOCK := 0      ? <Enter>
DNP Session Time Base (LOCAL, UTC)               DNPSRC  := UTC    ? <Enter>

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

=>>
```

Figure 6.57 Global Settings for Application 1 (Continued)

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism to automatically reconfigure the zone of protection, without any wiring changes (See *Dynamic Zone Selection Logic on page 5.14* for more information). In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration and assign the input currents from the CTs to the appropriate differential elements. For each terminal, wire an 89A and an 89B disconnect auxiliary contact to the relay.

Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays. Because we wire disconnect auxiliary contacts to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the LONDON feeder, all three phases (LOND_A, LOND_B, and LOND_C) operate together. Because the relay measures the three phases in three separate relays (phase LOND_A in the A-phase relay, phase LOND_B in B-phase relay, etc.), we need to convey the disconnect status to all three relays.

The check zone performs supervision, so you must first determine zone configuration settings for the check zone before determining settings for Zone 1 and Zone 2. Configure the check zone by declaring all terminals but the tie-breaker (bus sectionalizer) CTs in the terminal-to-check-zone SELOGIC control equations. Never include the tie-breaker CTs in the check zone. *Figure 6.61* shows the zone configuration group settings.

Use the Differential Element Zone Supervision setting to comply with the requirement for both check zone and zone-specific differential elements to assert before a busbar protection trip output asserts. For this application, we allocated BZ1 for Zone 1, BZ2 for Zone 2, and CZ1 for the overall check zone (see *Table 6.16*). Because the check zone is independent from any other zone, the relay does not follow the differential trip logic shown in *Figure 6.58* when the check zone asserts.

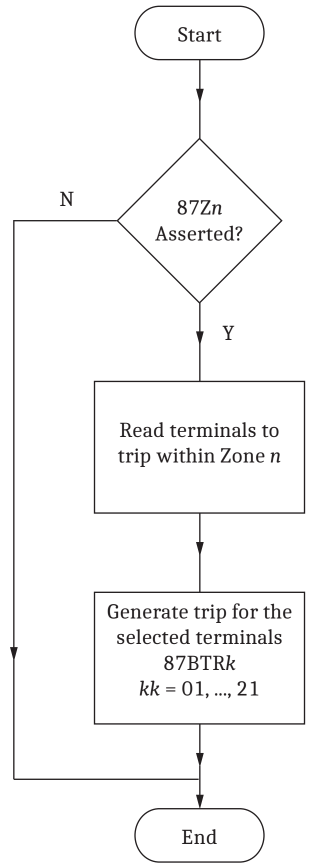


Figure 6.58 Bus Differential Trip Logic

The implication of this independence is that the Check Zone Supervision Logic can be left to its default value of 1 as seen in *Figure 6.59*. The same effect is achieved by setting E87CZSP = N.

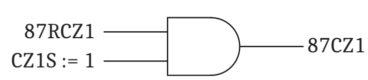


Figure 6.59 Check-Zone Supervision Logic

For the zone-specific elements, enter the Check Zone differential element trip output 87CZ1 as a supervisory condition for each zone, as shown in *Figure 6.60*.

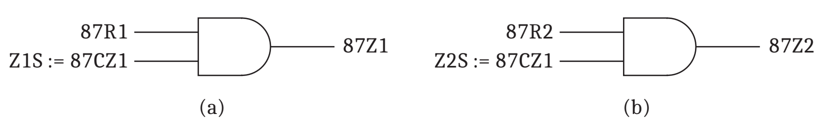


Figure 6.60 Zone Supervision for Zone 1 (a) and Zone 2 (b)

Be sure to include Relay Word bit 87CZ1 as the supervisory condition for all zones encompassed by the Check Zone. Set E87ZSUP = Y to enable the Differential Element Zone Supervision settings, then enter the supervision settings.

For the ease of setting the zone configuration settings for the new substation, delete the existing zone configuration group default settings. With the zone configuration group default settings deleted, the setting prompts no longer reference the default settings. The zone configuration group default settings are for a specific substation with arbitrarily selected alias names, serving only as an example.

```
=>>SET Z TE<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    ?400<Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?400<Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?40<Enter>
Current Transformer Ratio -I04 (1-50000)            CTR04   := 600    ?400<Enter>
Current Transformer Ratio -I05 (1-50000)            CTR05   := 600    ?400<Enter>
Current Transformer Ratio -I06 (1-50000)            CTR06   := 600    ?400<Enter>
Current Transformer Ratio -I07 (1-50000)            CTR07   := 600    ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections

Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := SEC1_A, WEAT_A, P
?  DELETE 100<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01 BZ2 P<Enter>
SEC1_A to EAST_A Connection (SELogic Equation)
I01BZ2V := NA
?  SEC189C AND SEC289C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02 BZ1 P<Enter>
SEC2_A to WEAT_A Connection (SELogic Equation)
I02BZ1V := NA
?  SEC189C AND SEC289C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I03 BZ1 P<Enter>
LOND_A to WEAT_A Connection (SELogic Equation)
I03BZ1V := NA
?  LOND89C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I04 BZ1 P<Enter>
BERL_A to WEAT_A Connection (SELogic Equation)
I04BZ1V := NA
?  BERL89C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I05 BZ2 P<Enter>
NEWY_A to EAST_A Connection (SELogic Equation)
I05BZ2V := NA
?  NEWY89C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I06 BZ2 P<Enter>
CANB_A to EAST_A Connection (SELogic Equation)
I06BZ2V := NA
?  CANB89C<Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  <Enter>


Zone Configuration: Bus-Zone to Bus-Zone Connections

Bus-Zone, Bus-Zone
?  <Enter>

Zone Supervision

Differential Element Zone Supervision (Y,N)         E87ZSUP := N      ?Y<Enter>
Zone 1 Supervision (SELogic Equation)
Z1S := 1
?  87CZ1<Enter>
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?  87CZ1<Enter>
```

Figure 6.61 Zone Configuration Group Settings for Application 1

```
Zone Switching Supervision

Zone Switching Supervision (Y,N)                  EZSWSUP := N      ? <Enter>


Zone Open CT Detector

Reset Zone 1 Open CT Detector (SELogic Equation)
ROCTZ1 := RSTOCT1
?  <Enter>
Reset Zone 2 Open CT Detector (SELogic Equation)
ROCTZ2 := RSTOCT2
?  <Enter>
Check Zone Configuration
Enable Check Zones at Station (Y,N)               ECHKZN  := N      ?Y<Enter>
Check Zone Configuration: Terminal to Check Zone Connections

Terminal, Check-Zone, Polarity (P,N)
?  I03 CZ1 P<Enter>
Terminal, Check-Zone, Polarity (P,N)
?  I04 CZ1 P<Enter>
Terminal, Check-Zone, Polarity (P,N)
?  I05 CZ1 P<Enter>
Terminal, Check-Zone, Polarity (P,N)
?  I06 CZ1 P<Enter>
Terminal, Check-Zone, Polarity (P,N)
?
Enable Advance Check Zone Settings (Y,N)          EADVCZ  := N      ? <Enter>


Check Zone Supervision

Differential Element Check Zone Supervision (Y,N)    E87CZSP := N      ? <Enter>

Current Normalization Factor

Normalization Factor -I01                         TAP01   := 5.00   ?
Normalization Factor -I02                         TAP02   := 5.00   ?
Normalization Factor -I03                         TAP03   := 50.00  ?
Normalization Factor -I04                         TAP04   := 5.00   ?
Normalization Factor -I05                         TAP05   := 5.00   ?
Normalization Factor -I06                         TAP06   := 5.00   ?
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 6.61 Zone Configuration Group Settings for Application 1 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y.

With EADVS := Y, the slope settings and incremental restrained and operating current settings become available.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Use the sensitive differential element by setting E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information). Set ECSL := N, ETOS := N, EBFL := N, E50 := N, E51 := N, and EVOLT := N because we do not use the coupler security logic, terminal out of service, breaker failure protection, overcurrent elements, or voltage elements in this application.

Setting NUMBK equal to five makes five corresponding circuit breaker auxiliary input equations (52A01–52A05) and five corresponding trip equations (TR01–TR05) available for setting. There are five trip equations available, but there are six analog channels (I01–I06) at the station. Each of the six analog channels has a corresponding differential trip bit that asserts (*Table 6.22*) when the differential element asserts. Be sure to include these differential trip bits in the trip equations of all circuit breakers you want to trip. Because the tie breaker has two analog channels but only one circuit breaker, include both differential trip bits (87SEC1A and 87SEC2A) in trip equation TR01.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative method is to enter specific reset conditions at the ULTR*kk* settings.

Although each SEL-487B includes 21 trip logics, there is only one Minimum Trip Duration Time Delay (TDURD) setting. Set the timer TDURD longer than the clearing time of the slowest circuit breaker at the station. For this application, we use the default values for the Sensitive Differential Element, the Restrained Differential Element, the Directional Element, and the Trip Duration Timer. *Figure 6.62* shows the group settings.

```
=>>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,1-21)                     ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ?N <Enter>
Definite Time Overcurrent Elements (N,1-21)          E50     := N      ? <Enter>
Inverse Time Overcurrent Elements (N,1-21)           E51     := N      ? <Enter>
Enable Under Voltage Elements (N,1-6)                E27     := N      ? <Enter>
Enable Over Voltage Elements (N,1-6)                 E59     := N      ? <Enter>
Advanced Settings (Y,N)                              EADVS   := N      ? <Enter>


Sensitive Differential Element

Sensitive Differential Element Pickup (0.05-1 pu)    S87P    := 0.10   ?> <Enter>

Check Zone Sensitive Differential Element

CZ Sensitive Diff. Element Pickup (0.05-1 pu)        CZS87P  := 0.10   ?> <Enter>

Restrained Differential Element

Restrained Diff Element Pickup (0.10-4 pu)           O87P    := 1.00   ?> <Enter>

Check Zone Restrained Differential Element

CZ Restrained Diff Element Pickup (0.10-4 pu)        CZO87P  := 1.00   ?> <Enter>


Directional Element

Dir Element O/C Supervision Pickup (0.05-3 pu)       50DSP   := 0.05   ?> <Enter>


Trip Logic

Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87SEC1A
?  87SEC1A OR 87SEC2A <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
?

Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87SEC2A
?  87LON_A <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
?

Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87LON_A
?  87BER_A <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
?
```

Figure 6.62 Protection Group Settings for Application 1

```
Trip 04 (SELogic Equation)
TR04 := SBFTR04 OR 87BER_A
?  87NEW_A<Enter>
Unlatch Trip 04 (SELogic Equation)
ULTR04 := NA
?

Trip 05 (SELogic Equation)
TR05 := SBFTR05 OR 87NEW_A OR SBFTR06 OR 87CAN_A
?  87CAN_A<Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
?

Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ?> <Enter>
Group 1
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved
=>>
```

Figure 6.62 Protection Group Settings for Application 1 (Continued)

This concludes the protection group settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings.

Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay, and connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts. Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA. *Figure 6.63* shows the control output settings.

```
=>>SET O <Enter>

Output
Main Board
OUT101 := TRSEC_A AND NOT PLT03
?  NA <Enter>

OUT102 := TRLON_A AND NOT PLT03
?  NA <Enter>
OUT103 := TRBER_A AND NOT PLT03
?  NA <Enter>

OUT104 := TRNEW_A AND NOT PLT03
?  NA <Enter>
OUT105 := TRCAN_A AND NOT PLT03
?  NA <Enter>

OUT106 := NA
? > <Enter>

Interface Board #1
OUT201 := NA
?  TRSEC_A AND NOT PLT03 <Enter>
OUT202 := NA
?  TRLON_A AND NOT PLT03 <Enter>
```

Figure 6.63 Control Output Settings for Application 1

```
OUT203 := NA
?  TRBER_A AND NOT PLT03 <Enter>
OUT204 := NA
?  TRNEW_A AND NOT PLT03 <Enter>
OUT205 := NA
?  TRCAN_A AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.63 Control Output Settings for Application 1 (Continued)

This concludes the settings for Application 1.

Application 2: Single Bus and Tie Breaker (Single Relay)

This application describes the busbar arrangement shown in *Figure 6.64*, a single bus with bus sectionalizer (tie breaker), single-relay application. The busbar arrangement consists of two busbar sections, four feeders, and a tie breaker. Consider the following to set and configure the relay:

- ➤ Busbar classification
- ➤ Protection philosophy
- ➤ Protection functions selection
- ➤ Number of SEL-487B Relays and I/O boards
- ➤ Input, logic, and output allocation and alias name assignment
- ➤ Station layout update
- ➤ Relay setting and configuration

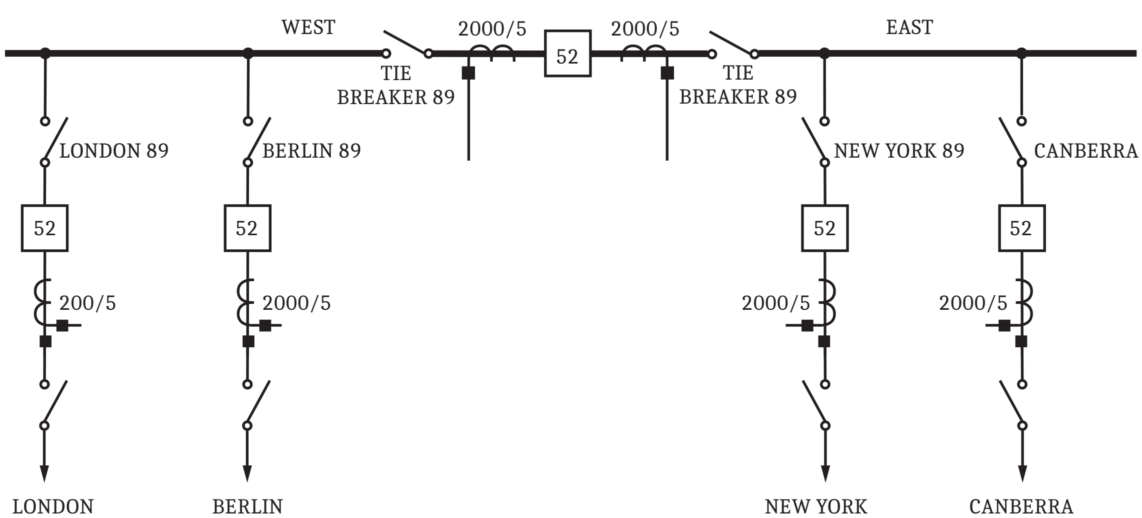


Figure 6.64 Single Bus With Bus Sectionalizer (Tie Breaker)

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information, and declares the tie breaker (bus coupler or sectionalizing breaker) configuration.

- Description:
  - Single bus with tie breaker
- Current Transformers:
  - Outboard
- Disconnect:
  - Both 89A and 89B disconnect auxiliary contacts are available
- Sectionalizing breaker (tie-breaker) configuration:
  - Overlap

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not all of these functions are applied at every substation. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Use the 89 disconnect auxiliary contacts to dynamically configure the station.
2. Block the busbar protection for an open-circuit CT.
3. Use the Disconnect Monitoring Logic.
4. Include end-zone protection with direct transfer tripping for the four feeders.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs required for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. For example, in this application the protection philosophy calls for end-zone protection, but not for breaker failure protection.

The SEL-487B offers a number of protection functions as standard features, but also includes the capability through SELOGIC control equations to create user-configurable functions. Breaker failure protection is a standard function but end-zone protection is not. To properly identify and categorize the protection philosophy requirements, group the protection functions as follows:

- standard protection functions (available in the relay)
- user-defined protection functions (created using SELOGIC control equations)

Standard Functions

Refer to *Protection Philosophy on page 6.86* and select the standard functions required for the application. *Table 6.26* shows the selection of the standard functions.

Table 6.26 Selection of the Standard Protection Functions

Protection Function	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch.
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available.
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions
Sensitive differential protection	Yes	CT open circuit detection.
Zone supervision logic	No	Not required
Zone-switching supervision logic	No	89A and 89B disconnect contacts available, so this logic is not required.
Coupler security logic	No	Two CTs configured in overlap configuration do not require the coupler security logic.
Circuit breaker failure protection	No	Not required
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Identify logic functions we need for the application that are not part of the standard logic in the relay. For this application, end-zone protection for the four feeders is not a standard function; we use SELOGIC control equations to create this logic.

End-Zone Protection

Figure 6.65 shows end-zone fault F1, which is a fault between the feeder CT and circuit breaker. The busbar protection at Busbar S operates for this fault and trips Circuit Breaker 1, but the line still feeds the fault from the source at Busbar R.

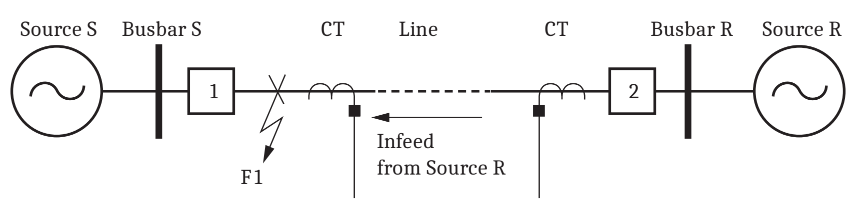


Figure 6.65 Fault Between Circuit Breaker 1 and the CT at Busbar S

Fault F1 is only cleared when Circuit Breaker 2 at Busbar R trips. In step-distance protection schemes, Circuit Breaker 2 trips after a time delay, typically on the order of 400 ms. Using end-zone protection, we can shorten this time by sending a direct transfer trip (DTT) from Station S to Circuit Breaker 2 at Station R to trip Circuit Breaker 2.

This logic detects faults under the following three conditions:

- The differential protection has issued a trip signal to the circuit breaker.
- There is still current flowing in the feeder CT after Circuit Breaker 1 has been open for 5 cycles.
- The busbar disconnect of the feeder is closed.

Create the above-mentioned end-zone logic by programming four protection SELOGIC control variables (PSV01–PSV04) when setting the protection logic, and assign the alias names as described in Assign Alias Names to the User-Defined Logic.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and 3 voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.5* to calculate the number of current channels at the station, and use *Equation 6.6* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.5

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.6

The number of per-phase CTs at the station is 18 and the number of bus-zones required is 6. Because each SEL-487B has 21 analog input channels and 6 zones, we need only one SEL-487B. This is known as a single-relay application.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, each of the four feeders requires one disconnect monitoring logic and the tie breaker requires two; the number of disconnect logics required is therefore six. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.7* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.7

The protection philosophy calls for end-zone protection. Because there are four feeder circuit breakers at the station the number of circuit breaker auxiliary inputs we need is four. *Table 6.27* summarizes the input contact required for this application.

Table 6.27 Number of Relay Input Contacts Required

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	2 • 6 = 12
Number of relay inputs required for end-zone protection	4
Total number of inputs	16

The relay main board has seven input contacts, which are not enough input contacts for our application. Each interface board provides two sets of nine grouped input contacts and six independent input contacts. Use the grouped input contacts for the disconnect auxiliary contact inputs; the six independent input contacts are available for breaker failure initiate inputs. Because this application has no circuit breaker failure protection, the independent input contacts are available for circuit breaker auxiliary contact inputs. However, in anticipation of future circuit breaker failure protection installation, instead use the grouped input contacts on the interface board for the circuit breaker auxiliary contact inputs and disconnect contact inputs. From the input contact perspective, we need one interface board.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all breakers are part of the busbar differential protection, we want to trip each breaker upon differential protection operation. We also need direct transfer trip output contacts for the end-zone protection for each of the four feeders. *Table 6.28* shows the breakdown and the total number of relay output contacts required.

Table 6.28 Breakdown and the Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for tripping	5
Number of relay output contacts required for direct transfer tripping	4
Total number of relay output contacts	9

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the RELAY TEST MODE pushbutton on the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). *Table 6.28* shows that we need nine output contacts; the eight main board output contacts are insufficient for our application. Also, the main board contacts are all standard output contacts.

The interface boards can have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board provides six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign the circuit breaker trip outputs to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. Although the standard output contacts are slightly slower (6 ms for resistive loads) than the high-speed, high-interrupting output contacts, we use the main board output contact for direct transfer tripping. From the output contact perspective, we need one interface board. If you require fast output contacts for direct transfer tripping, add another interface board to the relay.

The conclusion from the preceding analysis is that we need one SEL-487B, equipped with a single interface board, for this application.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point we have determined the following:

- the number of SEL-487B Relays required for the application
- the number of input contacts
- the number of output contacts
- the selected protection functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

NOTE: Alias names cannot exceed seven characters.

- link specific CT inputs to specific relay analog channels
- link specific disconnect and circuit breaker inputs to specific relay input contacts
- link relay element/logic outputs to specific relay output contacts
- assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog quantity
- Terminal name
- Bus-Zone name

Alias names are valid when they consist of a maximum of seven characters and they are constructed with characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

Table 6.29 shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie breaker CT1 to relay channel I01, and assign to this CT the alias name SEC1_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.29* shows the assignment taken from *Figure 6.64*.

Table 6.29 CTs to Analog Channel Allocations and Alias Assignments (Sheet 1 of 2)

CTs	Analog Channel	Alias
LONDON, A-phase	I01	LOND_A
LONDON, B-phase	I02	LOND_B
LONDON, C-phase	I03	LOND_C
BERLIN, A-phase	I04	BERL_A
BERLIN, B-phase	I05	BERL_B
BERLIN, C-phase	I06	BERL_C
NEW YORK, A-phase	I07	NEWY_A
NEW YORK, B-phase	I08	NEWY_B
NEW YORK, C-phase	I09	NEWY_C

Table 6.29 CTs to Analog Channel Allocations and Alias Assignments (Sheet 2 of 2)

CTs	Analog Channel	Alias
CANBERRA, A-phase	I10	CANB_A
CANBERRA, B-phase	I11	CANB_B
CANBERRA, C-phase	I12	CANB_C
TIE-BREAKER CT1, A-phase	I13	SEC1_A
TIE-BREAKER CT1, B-phase	I14	SEC1_B
TIE-BREAKER CT1, C-phase	I15	SEC1_C
TIE-BREAKER CT2, A-phase	I16	SEC2_A
TIE-BREAKER CT2, B-phase	I17	SEC2_B
TIE-BREAKER CT2, C-phase	I18	SEC2_C

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. In this application, we use all six zones with alias names as shown in *Table 6.30*.

Table 6.30 Alias Names for the Six Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	WEST_A
BZ2	Bus-Zone 2	WEST_B
BZ3	Bus-Zone 3	WEST_C
BZ4	Bus-Zone 4	EAST_A
BZ5	Bus-Zone 5	EAST_B
BZ6	Bus-Zone 6	EAST_C

Input-to-Logic Allocation and Alias Assignment

Table 6.27 shows that we require 16 digital inputs. We now assign the digital inputs to the selected logic, and apply alias names to the inputs and logic elements. Because of the functional requirement of this application, we do not need to use any digital inputs on the main board.

Input-to-Logic-Allocation and Alias Assignment, Interface Board 1 (200)

Table 6.31 shows the circuit breaker auxiliary contact input allocations, the disconnect auxiliary contact input allocations, and the alias names. Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs for breaker failure initiate inputs; these inputs are not used in this application.

Table 6.31 Alias Names and Assignment for the Digital Inputs (Sheet 1 of 2)

Input	Description	Alias
IN204	LONDON circuit breaker	ILON52A
IN205	BERLIN circuit breaker	IBER52A
IN206	NEW YORK circuit breaker	INEW52A
IN207	CANBERRA circuit breaker	ICAN52A

Table 6.31 Alias Names and Assignment for the Digital Inputs (Sheet 2 of 2)

Input	Description	Alias
IN208	LONDON disconnect NO contact	ILON89A
IN209	LONDON disconnect NC contact	ILON89B
IN210	BERLIN disconnect NO contact	IBER89A
IN211	BERLIN disconnect NC contact	IBER89B
IN212	NEW YORK disconnect NO contact	INEW89A
IN216	NEW YORK disconnect NC contact	INEW89B
IN217	CANBERRA disconnect NO contact	ICAN89A
IN218	CANBERRA disconnect NC contact	ICAN89B
IN219	TIE-BREAKER disconnect (WEST) NO contact	ISE891A
IN220	TIE-BREAKER disconnect (WEST) NC contact	ISE891B
IN221	TIE-BREAKER disconnect (EAST) NO contact	ISE892A
IN222	TIE-BREAKER disconnect (EAST) NC contact	ISE892B

Assign Alias Names to the Selected Standard Logic

Referring to *Table 6.26*, the following is a discussion on each selected function. Alias name assignments are also included.

Disconnect Monitoring Logic and Disconnect Alias Assignment

Figure 6.66 shows one of the 60 disconnect monitor logic circuits available in the relay. (See *Disconnect Requirements on page 6.15* for more information on the disconnect auxiliary contact requirements.)

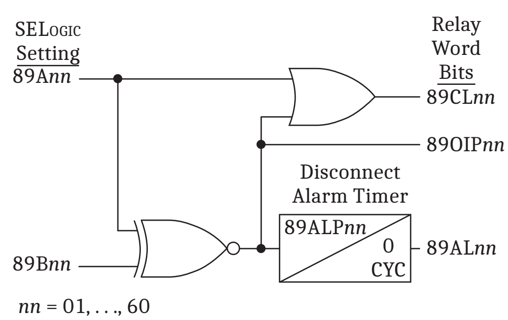


Figure 6.66 One of the Disconnect Monitoring Logic Circuits Available in the Relay

Table 6.32 shows the alias names for the disconnect auxiliary contact Relay Word bits.

Table 6.32 Alias Names for the Disconnect Auxiliary Contact Relay Word Bits (Sheet 1 of 2)

Input	Description	Alias
89A01	LONDON disconnect NO contact	LON89A
89B01	LONDON disconnect NC contact	LON89B
89A02	BERLIN disconnect NO contact	BER89A
89B02	BERLIN disconnect NC contact	BER89B
89A03	NEW YORK disconnect NO contact	NEW89A

Table 6.32 Alias Names for the Disconnect Auxiliary Contact Relay Word Bits (Sheet 2 of 2)

Input	Description	Alias
89B03	NEW YORK disconnect NC contact	NEW89B
89A04	CANBERRA disconnect NO contact	CAN89A
89B04	CANBERRA disconnect NC contact	CAN89B
89A05	TIE-BREAKER disconnect (WEST) NO contact	SEC891A
89B05	TIE-BREAKER disconnect (WEST) NC contact	SEC891B
89A06	TIE-BREAKER disconnect (EAST) NO contact	SEC892A
89B06	TIE-BREAKER disconnect (EAST) NC contact	SEC892B

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations. We also assign alias names to the alarm Relay Word bits (89AL*nn*). *Table 6.33* shows the alias names.

Table 6.33 Alias Names for the Disconnect Monitor Logic Output Relay Word Bits

Primitive Name	Description	Alias
89CL01	LONDON disconnect is closed	LOND89C
89CL02	BERLIN disconnect is closed	BERL89C
89CL03	NEW YORK disconnect is closed	NEWY89C
89CL04	CANBERRA disconnect is closed	CANB89C
89CL05	TIE-BREAKER disconnect (WEST) is closed	SEC189C
89CL06	TIE-BREAKER disconnect (EAST) is closed	SEC289C
89AL01	LONDON disconnect alarm	LON89AL
89AL02	BERLIN disconnect alarm	BER89AL
89AL03	NEW YORK disconnect alarm	NEW89AL
89AL04	CANBERRA disconnect alarm	CAN89AL
89AL05	TIE-BREAKER disconnect (WEST) alarm	SE189AL
89AL06	TIE-BREAKER disconnect (EAST) alarm	SE289AL

Breaker Status Logic

Figure 6.67 shows the breaker status logic circuit associated with current channel I01. This logic includes an OPH01 input from the open-phase detection logic. Open-phase detection logic asserts the OPH01 Relay Word bit when the logic measures no current in that specific phase. Alarm output 52AL01 asserts when the 52A01 and OPH01 inputs are both deasserted for longer than 5 cycles. For example, when the circuit breaker is open (52A01 is logical 0), Relay Word bit OPH01 asserts (changes to logical 1) when current stops flowing. AND Gate 2 in *Figure 6.67* outputs a logical 0 and the timer does not run. However, if current still flows through the CT when the circuit breaker is open (end-zone fault, for example), Relay Word bit OPH01 does not assert (remains at logical 0) and the timer starts.

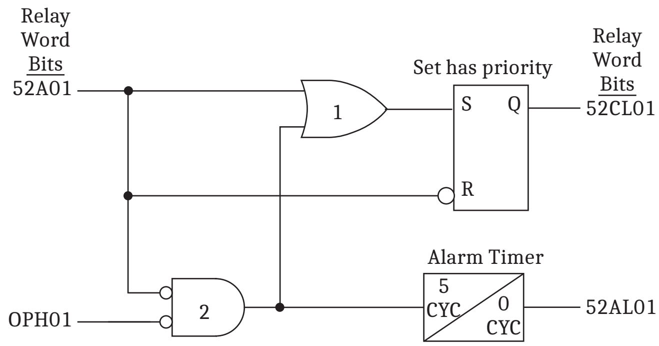


Figure 6.67 Breaker Status Logic

Wire a single, normally open circuit breaker auxiliary contact from each of the four feeder circuit breakers to an individual relay input (IN204, IN205, IN206, and IN207). In this example, we do not assign alias names to the Relay Word bits; we use the primitive names instead. Because this is a single-relay application, the three phases of each terminal are in the same relay. *Table 6.34* shows the breaker status logic input and output Relay Word bits.

Table 6.34 Breaker Status Logic Input and Output Relay Word Bits

Primitive Name	Description
52A01	LONDON A-phase NO contact
52AL01	LONDON A-phase discrepancy alarm
52A02	LONDON B-phase NO contact
52AL02	LONDON B-phase discrepancy alarm
52A03	LONDON C-phase NO contact
52AL03	LONDON C-phase discrepancy alarm
52A04	BERLIN A-phase NO contact
52AL04	BERLIN A-phase discrepancy alarm
52A05	BERLIN B-phase NO contact
52AL05	BERLIN B-phase discrepancy alarm
52A06	BERLIN C-phase NO contact
52AL06	BERLIN C-phase discrepancy alarm
52A07	NEW YORK A-phase NO contact
52AL07	NEW YORK A-phase discrepancy alarm
52A08	NEW YORK B-phase NO contact
52AL08	NEW YORK B-phase discrepancy alarm
52A09	NEW YORK C-phase NO contact
52AL09	NEW YORK C-phase discrepancy alarm
52A10	CANBERRA A-phase NO contact
52AL10	CANBERRA A-phase discrepancy alarm
52A11	CANBERRA B-phase NO contact
52AL11	CANBERRA B-phase discrepancy alarm
52A12	CANBERRA C-phase NO contact
52AL12	CANBERRA C-phase discrepancy alarm

Differential Trip Logic and Differential Element Alias Assignment

Figure 6.68 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information). *Table 6.35* shows the Relay Word bits and the alias names for the zone differential protection outputs.

Table 6.35 Alias Names for the Zone Differential Protection Output Relay Word Bits

Primitive Name	Description	Alias
87Z1	Zone 1 differential element trip	WESTA_T
87Z2	Zone 2 differential element trip	WESTB_T
87Z3	Zone 3 differential element trip	WESTC_T
87Z4	Zone 4 differential element trip	EASTA_T
87Z5	Zone 5 differential element trip	EASTB_T
87Z6	Zone 6 differential element trip	EASTC_T

Differential trip bits 87BTR01–87BTR21 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

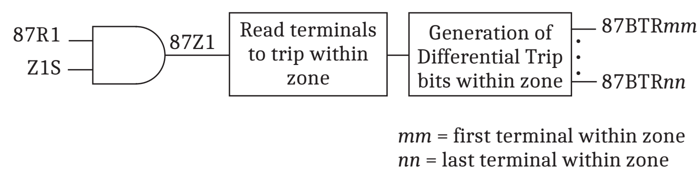


Figure 6.68 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate. In our example, we will use 18 of the 87BTR*mm* (*mm* = 01–21) Relay Word bits. *Table 6.36* shows the primitive differential trip bit names and the alias names for the differential trip bits.

Table 6.36 Primitive Terminal and Differential Trip Bit Names and the Alias Names for the Differential Trip Bits (Sheet 1 of 2)

Differential Trip Bit	Alias	Comments
87BTR01	87LON_A	Associated with Terminal 01
87BTR02	87LON_B	Associated with Terminal 02
87BTR03	87LON_C	Associated with Terminal 03
87BTR04	87BER_A	Associated with Terminal 04
87BTR05	87BER_B	Associated with Terminal 05
87BTR06	87BER_C	Associated with Terminal 06
87BTR07	87NEW_A	Associated with Terminal 07
87BTR08	87NEW_B	Associated with Terminal 08
87BTR09	87NEW_C	Associated with Terminal 09
87BTR10	87CAN_A	Associated with Terminal 10
87BTR11	87CAN_B	Associated with Terminal 11
87BTR12	87CAN_C	Associated with Terminal 12

Table 6.36 Primitive Terminal and Differential Trip Bit Names and the Alias Names for the Differential Trip Bits (Sheet 2 of 2)

Differential Trip Bit	Alias	Comments
87BTR13	87SEC1A	Associated with Terminal 13
87BTR14	87SEC1B	Associated with Terminal 14
87BTR15	87SEC1C	Associated with Terminal 15
87BTR16	87SEC2A	Associated with Terminal 16
87BTR17	87SEC2B	Associated with Terminal 17
87BTR18	87SEC2C	Associated with Terminal 18

Breaker Trip Logic and Trip Alias Assignment

Figure 6.69 shows the general tripping logic for the 15 trip outputs used in this application. (See *Section 5: Protection Functions* for more information).

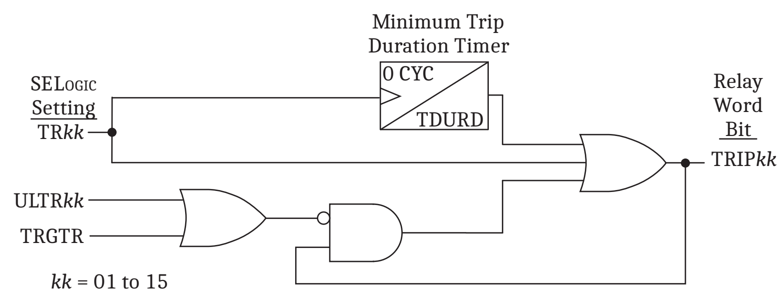


Figure 6.69 Breaker Trip Logic

There exists a direct relationship between the number of circuit breakers and the number of trip equations, i.e., the number of trip equations (TR*kk*) equals the number of circuit breakers (NUMBK). Because the relay interprets the number of circuit breakers (NUMBK) as the number of circuit breaker poles, the setting of NUMBK in this application equals 15.

After setting the TR*nn* trip equations, the relay associates each TR*nn* trip equation with a particular circuit breaker pole; we must combine the trip equations in the output settings to form a single output for the tie breaker (see the *Protection Group Settings on page 6.80*). For example, after setting TR01 := 87BTR01 and TR02 := 87BTR02, the relay associates Trip Equation TR01 with Terminal 01 (LOND_A), Trip Equation TR02 with Terminal 02 (LOND_B), and so on. *Table 6.37* shows the 15 primitive and alias names for the trip logic of each terminal.

Table 6.37 Primitive and Alias Names for the Trip Logic of Each Terminal (Sheet 1 of 2)

Primitive Name	Description	Alias
TRIP01	Trip output of the LONDON terminal A-Phase asserted	TRLON_A
TRIP02	Trip output of the LONDON terminal B-Phase asserted	TRLON_B
TRIP03	Trip output of the LONDON terminal C-Phase asserted	TRLON_C
TRIP04	Trip output of the BERLIN terminal A-Phase asserted	TRBER_A
TRIP05	Trip output of the BERLIN terminal B-Phase asserted	TRBER_B
TRIP06	Trip output of the BERLIN terminal C-Phase asserted	TRBER_C
TRIP07	Trip output of the NEW YORK terminal A-Phase asserted	TRNEW_A

Table 6.37 Primitive and Alias Names for the Trip Logic of Each Terminal (Sheet 2 of 2)

Primitive Name	Description	Alias
TRIP08	Trip output of the NEW YORK terminal B-Phase asserted	TRNEW_B
TRIP09	Trip output of the NEW YORK terminal C-Phase asserted	TRNEW_C
TRIP10	Trip output of the CANBERRA terminal A-Phase asserted	TRCAN_A
TRIP11	Trip output of the CANBERRA terminal B-Phase asserted	TRCAN_B
TRIP12	Trip output of the CANBERRA terminal C-Phase asserted	TRCAN_C
TRIP13	Trip output of the sectionalizing breaker A-Phase asserted	TRSEC_A
TRIP14	Trip output of the sectionalizing breaker B-Phase asserted	TRSEC_B
TRIP15	Trip output of the sectionalizing breaker C-Phase asserted	TRSEC_C

Assign Alias Names to the User-Defined Logic

We created the general end-zone protection logic under *User-Defined Functions on page 6.62*. We now assign the application-specific alias names to all the appropriate Relay Word bits in the end-zone protection logic.

End-Zone Protection

Table 6.38 shows the alias names for the four protection SELOGIC control equation variables (PSV01–PSV04).

Table 6.38 Alias Names for the End-Zone Protection Logic

Primitive Name	Description	Alias
PSV01	End-zone element for LONDON terminal	LOND_EZ
PSV02	End-zone element for BERLIN terminal	BERL_EZ
PSV03	End-zone element for NEW YORK terminal	NEWY_EZ
PSV04	End-zone element for CANBERRA terminal	CANB_EZ

Figure 6.70 shows the end-zone logic with the alias names instead of the primitive names. The logic declares an end-zone fault when the following three conditions are met:

- A differential trip signal has been issued to the circuit breaker
- Current continues to flow through the feeder CT after a 5-cycle delay
- The busbar disconnect of the feeder is closed.

Note that the second condition is met by using the built-in 5-cycle delay of 52AL*nn*, which is the alarm timer output of the circuit breaker status logic. Create similar logic for the other three feeders with the protection logic settings.

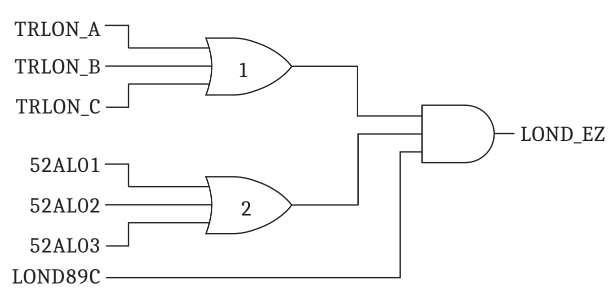


Figure 6.70 End-Zone Logic With the Alias Names for the London Feeder

Relay Logic-to-Output Contact Allocation and Output Contact Alias Assignments

At this point, we have assigned alias names to all relay functions. *Table 6.28* shows the breakdown of the nine relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts and assign alias names to the relay output contacts. *Table 6.39* shows the linking of the end-zone protection logic to the output contacts of the main board and the alias names of the relay main board output contacts. *Table 6.40* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1 and the alias names of the of the interface board output contacts.

Output Alias Assignment—Main Board

We assign the outputs from the end-zone protection logics as direct transfer trip (DTT) functions to the output contacts of the main board. Wire the direct transfer trip outputs to the communications equipment or terminal panel to transmit the signal to the remote busbar.

Table 6.39 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT101	DTT for an end zone fault on LONDON Feeder	LON_DTT
OUT102	DTT for an end zone fault on BERLIN Feeder	BER_DTT
OUT103	DTT for an end zone fault on NEW YORK Feeder	NEW_DTT
OUT104	DTT for an end zone fault on CANBERRA Feeder	CAN_DTT
OUT105	NA	NA
OUT106	NA	NA
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Alias Assignment—Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.40* shows the alias assignment for the five terminals in our example.

Table 6.40 Alias Assignment for the Five Terminals in Our Example

Output Contact Assignment	Description	Output Contact Alias
OUT201[a]	LONDON trip logic output	LON_TRP
OUT202[a]	BERLIN trip logic output	BER_TRP
OUT203[a]	NEW YORK trip logic output	NEW_TRP
OUT204[a]	CANBERRA trip logic output	CAN_TRP
OUT205[a]	TIE-BREAKER trip logic output	SEC_TRP

[a] High-speed, high-interrupting outputs.

Station Layout Update

We are now ready to set and configure the relay. Write all the relevant information on the station diagram, as shown in *Figure 6.71*.

1. Write down the bus-zone, terminal, and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal/zone allocation.
3. Allocate the terminals CTs to the relay input current channels.
4. Allocate the auxiliary contacts to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals.

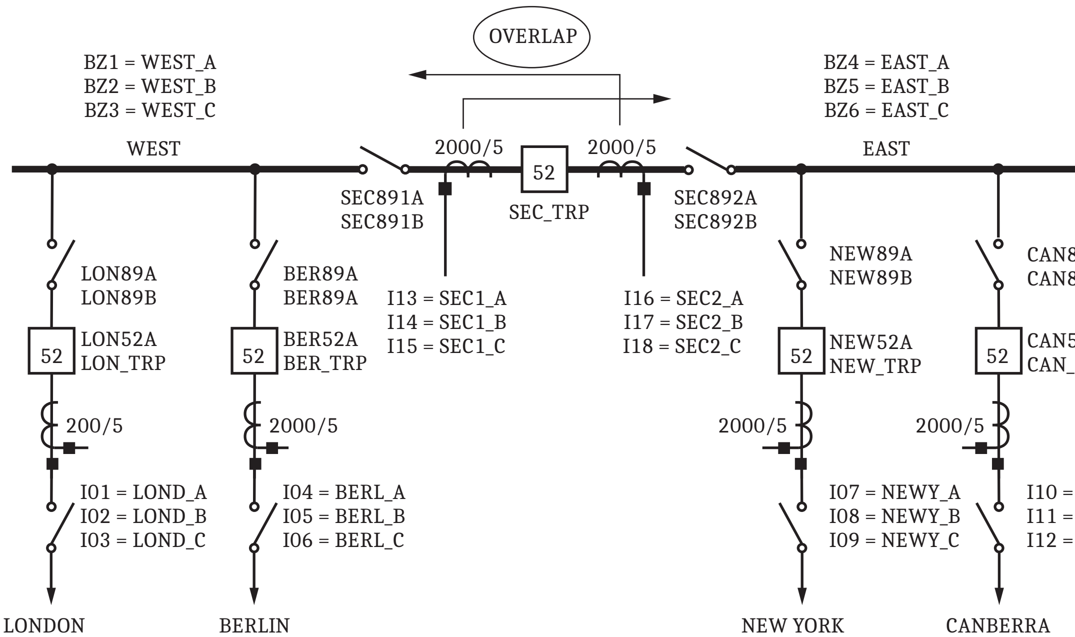


Figure 6.71 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. For this application, we set the following settings classes:

- ➤ Alias Settings
- ➤ Global Settings
- ➤ Zone Configuration Group Settings
- ➤ Protection Group Settings
- ➤ Protection Logic Settings
- ➤ Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.72*.

After inspecting the list, we decide that the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: I01,"FDR_1"
?  LIST <Enter>
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"
.
.
.
60: TLED_15,"89_ALRM"
61: TLED_16,"PT_ALRM"
1: I01,"FDR_1"
?
```

Figure 6.72 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.73*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.73 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the settings list. Enter the alias names for the 18 analog channels and Relay Word bits, as shown in *Figure 6.74*.

```
1:OUT107,"TEST"
?  <Enter>
19:
?  I01,LOND_A <Enter>
20:
?  I02,LOND_B <Enter>
21:
?  I03,LOND_C <Enter>
22:
?  I04,BERL_A <Enter>
23:
?  I05,BERL_B <Enter>
24:
?  I06,BERL_C <Enter>
.
.
.
133:
?  OUT204,CAN_TRP <Enter>
134:
?  OUT205,SEC_TRP <Enter>
135:
?  END <Enter>
Alias
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.74 Analog Quantities and Relay Word Bit Alias Names for Application 2

This concludes the alias settings. The next settings class is the global settings.

Global Settings

Global settings comprise settings that apply to all protection setting groups. For example, when changing from Protection Settings Group 1 to Protection Settings Group 2, global settings such as station name and relay name still apply. *Figure 6.75* shows the setting changes we need for our example. Because we declared the alias names in the alias setting class, use either alias names or primitive names when entering settings.

Carefully consider circuit breaker related settings when applying the relay in a single-relay application. The relay considers all applications to be three-relay applications; there is no setting distinguishing a single-relay application from a three-relay application. In particular, the relay interprets the number of circuit breakers (NUMBK) as the number of circuit breaker poles, not as the number of circuit breakers.

In this single-relay application example, there are 15 circuit breaker poles at the substation, and the value of NUMBK is 15. However, wire only one circuit breaker auxiliary contact from each circuit breaker to the relay; see the TR*kk*, TRIP*kk*, and the output settings for information on how to set the relay for this application.

There exists a direct relationship between the number of circuit breakers and the number of breaker status logics, i.e., the number of breaker input equations (52A*kk*) equals the number of circuit breakers (NUMBK). Enter the number of poles at the station for the NUMBK setting. Because the relay interprets the number of circuit breakers (NUMBK) as the number of circuit breaker poles, the setting of NUMBK in this application equals 15.

Setting NUMBK equal to 15 makes 15 corresponding circuit breaker auxiliary input equations (52A01–52A15), and 15 corresponding trip equations (TR01–TR15) available for setting. Although 15 circuit breaker auxiliary input equations are available, there are only four circuit breaker auxiliary contacts wired to the relay, one contact from each of the four feeder circuit breakers at the station. Group three circuit breaker auxiliary input equations to form an association with a circuit breaker, and enter the same contact name for the three circuit breaker auxiliary input equations. For example, group circuit breaker auxiliary input equations 52A01, 52A02, and 52A03 to form an association with the LONDON circuit breaker.

Table 6.31 shows the allocation of ILON52A, the circuit breaker auxiliary contact to relay input IN204. We use relay input IN204 to monitor the status of the LONDON circuit breaker. All three circuit breaker auxiliary input equations (52A01, 52A02, and 52A03) must assert when ILON52A asserts, so ILON52A must appear in all three circuit breaker auxiliary input equations. Because we do not need a circuit breaker auxiliary contact from the tie breaker, set 52A13–52A15 to NA.

Setting NUMDS declares the number of disconnect logics we need, not the number of disconnect inputs. In our example, we need six disconnect logics although there are 12 disconnect inputs. You can set each disconnect travel time individually with the 89ALP*nn* setting (*nn* = 01–06). Travel time is the time period when both disconnect auxiliary contacts are in the open position (see *Figure 6.20* for more information). Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>

Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>
Number of Breakers (N,1-21)                        NUMBK   := 5      ?15 <Enter>
Number of Disconnects (N,1-60)                     NUMDS   := N      ?6 <Enter>
Nominal System Frequency (50,60 Hz)                NFREQ   := 60     ?<Enter>
Date Format (MDY,YMD,DMY)                          DATE_F  := MDY    ?> <Enter>


Global Enables

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

Time and Date Management

Date Format (MDY,YMD,DMY)                          DATE_F  := MDY    ?> <Enter>

Control Inputs (Global)


Input Pickup Delay (0.00-30 ms)                    GINPU   := 2.0    ?> <Enter>
Settings Group Selection
Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  > <Enter>


Breaker Inputs

N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  ILON52A <Enter>
N/O Contact Input -BK02 (SELogic Equation)
52A02 := NA
?  ILON52A <Enter>
N/O Contact Input -BK03 (SELogic Equation)
52A03 := NA
?  ILON52A <Enter>
N/O Contact Input -BK04 (SELogic Equation)
52A04 := NA
?  IBER52A <Enter>

N/O Contact Input -BK05 (SELogic Equation)
52A05 := NA
?  IBER52A <Enter>
N/O Contact Input -BK06 (SELogic Equation)
52A06 := NA
?  IBER52A <Enter>
N/O Contact Input -BK07 (SELogic Equation)
.
.
.

52A13 := NA
?  <Enter>
N/O Contact Input -BK13 (SELogic Equation)
52A14 := NA
?  <Enter>
N/O Contact Input -BK14 (SELogic Equation)
52A15 := NA
?  <Enter>

N/O Contact Input -BK15 (SELogic Equation)
Disconnect Inputs and Timers
N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  ILON89A <Enter>
N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  ILON89B <Enter>
```

Figure 6.75 Global Settings for Application 2

```
DS01 Alarm Pickup Delay (0-99999 cyc)              89ALP01 := 300    ? <Enter>
N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  IBER89A <Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  IBER89B <Enter>
DS02 Alarm Pickup Delay (0-99999 cyc)              89ALP02 := 300    ? <Enter>
.
.
.

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

Figure 6.75 Global Settings for Application 2 (Continued)

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism to automatically reconfigure the zone of protection, without any wiring changes (See *Dynamic Zone Selection Logic on page 5.14* for more information).

In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration and to assign the input currents from the CTs to the appropriate differential elements. For each terminal, wire an 89A and an 89B disconnect auxiliary contact to the relay.

Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three phases. For example, when we close the busbar disconnect on the LONDON feeder, all three phases (LOND_A, LOND_B, and LOND_C) operate together. Because the relay measures the three phases in three separate differential elements (phase LOND_A in differential element WEST_A, phase LOND_B in differential element WEST_B, etc.), we need to convey the disconnect status to all three differential elements. *Table 6.33* shows the alias names of the disconnect status Relay Word bits; *Figure 6.76* shows the zone configuration group settings.

The zone configuration group default settings are for a specific substation with arbitrarily selected alias names, serving only as an example. For the ease of setting the zone configuration group settings for the new substation, delete the existing zone configuration default settings. With the zone configuration group default settings deleted, the setting prompts no longer reference the default 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    ?40 <Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?40 <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?40 <Enter>
Current Transformer Ratio -I04 (1-50000)            CTR04   := 600    ?400 <Enter>
Current Transformer Ratio -I05 (1-50000)            CTR05   := 600    ?400 <Enter>
Current Transformer Ratio -I06 (1-50000)            CTR06   := 600    ?400 <Enter>
Current Transformer Ratio -I07 (1-50000)            CTR07   := 600    ?400 <Enter>
Current Transformer Ratio -I08 (1-50000)            CTR08   := 600    ?400 <Enter>
Current Transformer Ratio -I09 (1-50000)            CTR09   := 600    ?400 <Enter>
Current Transformer Ratio -I10 (1-50000)            CTR10   := 600    ?400 <Enter>
Current Transformer Ratio -I11 (1-50000)            CTR11   := 600    ?400 <Enter>
.
.
.
Current Transformer Ratio -I18 (1-50000)            CTR18   := 600    ?400 <Enter>
Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := SEC1_A, WEST_A, P
?  DELETE 200 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,BZ1,P <Enter>

LOND_A to WEST_A Connection (SELogic Equation)
I01BZ1V := NA
?  LOND89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02,BZ2,P <Enter>
LOND_B to WEST_B Connection (SELogic Equation)
I02BZ2V := NA
?  LOND89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I03,BZ3,P <Enter>

LOND_C to WEST_C Connection (SELogic Equation)
I03BZ3V := NA
?  LOND89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I04,BZ1,P <Enter>
BERL_A to WEST_A Connection (SELogic Equation)
I04BZ1V := NA
?  BERL89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I05,BZ2,P <Enter>

BERL_B to WEST_B Connection (SELogic Equation)
I05BZ2V := NA
?  BERL89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I06,BZ3,P <Enter>
BERL_C to WEST_C Connection (SELogic Equation)
I06BZ3V := NA
?  BERL89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I07,BZ4,P <Enter>

NEWY_A to EAST_A Connection (SELogic Equation)
I07BZ4V := NA
?  NEWY89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I08,BZ5,P <Enter>
NEWY_B to EAST_B Connection (SELogic Equation)
I08BZ5V := NA
?  NEWY89C <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I09,BZ6,P <Enter>
NEWY_C to EAST_C Connection (SELogic Equation)
I09BZ6V := NA
?  NEWY89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I10,BZ4,P <Enter>

CANB_A to EAST_A Connection (SELogic Equation)
I10BZ4V := NA
?  CANB89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I11,BZ5,P <Enter>
CANB_B to EAST_B Connection (SELogic Equation)
I11BZ5V := NA
?  CANB89C <Enter>
```

Figure 6.76 Zone Configuration Group Settings for Application 2

```
Terminal, Bus-Zone, Polarity (P,N)
?  I12,BZ6,P <Enter>
CANB_C to EAST_C Connection (SELogic Equation)
I12BZ6V := NA
?  CANB89C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I13,BZ4,P <Enter>

SEC1_A to EAST_A Connection (SELogic Equation)
I13BZ4V := NA
?  SEC189C AND SEC298C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I14,BZ5,P <Enter>
SEC1_B to EAST_B Connection (SELogic Equation)
I14BZ5V := NA
?  SEC189C AND SEC298C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I15,BZ6,P <Enter>

SEC1_C to EAST_C Connection (SELogic Equation)
I15BZ6V := NA
?  SEC189C AND SEC298C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I16,BZ1,P <Enter>
SEC2_A to WEST_A Connection (SELogic Equation)
I16BZ1V := NA
?  SEC189C AND SEC298C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I17,BZ2,P <Enter>
SEC2_B to WEST_B Connection (SELogic Equation)
I17BZ2V := NA
?  SEC189C AND SEC298C <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I18,BZ3,P <Enter>
SEC2_C to WEST_C Connection (SELogic Equation)
I18BZ3V := NA
?  SEC189C AND SEC298C <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?<Enter>
Zone Configuration: Bus-Zone to Bus-Zone Connections


Bus-Zone, Bus-Zone
?<Enter>
Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?<Enter>
Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.76 Zone Configuration Group Settings for Application 2 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Set E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information) to use the sensitive differential element for this requirement. Set ECSL := N, ETOS := N, EBFL := N, E50 := N, E51 := N, E27 := N, and E59 := N because we do not use the Coupler Security Logic, terminal out of service, breaker failure protection, overcurrent elements, or voltage elements in this application. Pay close attention to the trip logic (TR01–TR15) settings.

Because we use one SEL-487B, CTs from the three phases (A-phase, B-phase, and C-phase) from each terminal are assigned to three different differential elements (see *Single-Relay Application on page 6.3*).

Setting NUMBK (Global Settings) equal to 15 also makes 15 corresponding trip equations (TR01–TR15) available for setting. *Table 6.36* shows the 18 differential trip bits that assert when the differential protection operates. Setting the trip equations involves assigning the 18 differential trip bits to the correct 15 trip equations. There are six differential elements in the relay, and because there are six bus-zones at the station, we use all six differential elements.

For the per-phase differential calculations, the relay assigns the individual phases of each terminal to three separate differential elements. (Strictly speaking, the relay assigns the phases according to the zone configuration group settings. However, correct zone configuration group settings cause the relay to assign the individual phases of each terminal to three separate differential elements.) The tie breaker has six CTs; one CT assigned to each of the six differential elements. Because the tie breaker has only one circuit breaker, operation of any one of the six differential elements must trip the tie-breaker circuit breaker. For this reason, we include the two A-phase differential trip bits (87SEC1A and 87SEC2A) in the same trip equation, the two B-phase differential trip bits (87SEC1B and 87SEC2B) in the same trip equation, and so on.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. Press the **TARGET RESET** pushbutton on the front panel to deassert the trip outputs. Alternatively, enter specific reset conditions at the ULTR*kk* settings.

Although the SEL-487B includes 21 trip logics, there is only one Minimum Trip Duration Time Delay (TDURD) setting. Set the timer TDURD longer than the clearing time of the slowest circuit breaker at the station.

For this application, we use the default values for the Sensitive Differential Element, the Restrained Differential Element, the Directional Element, and the Trip Duration Timer. *Figure 6.77* shows the group settings.

```
=>>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,1-21)                     ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ?N <Enter>
Definite Time Overcurrent Elements (N,1-21)          E50     := N      ?<Enter>
Inverse Time Overcurrent Elements (N,1-21)           E51     := N      ?<Enter>
Enable Under Voltage Elements (N,1-6)                E27     := N      ?<Enter>
Enable Over Voltage Elements (N,1-6)                 E59     := N      ?<Enter>
Advanced Settings (Y,N)                              EADVS   := N      ?<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>

Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87LON_A
?  87LON_A <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
?<Enter>

Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87LON_B
?  87LON_B <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
?<Enter>
```

Figure 6.77 Protection Group Settings for Application 2

```
Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87LON_C
?  87LON_C <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
?<Enter>
.
.
.
Trip 12 (SELogic Equation)
TR12 := NA
?  87CAN_C <Enter>
Unlatch Trip 12 (SELogic Equation)
ULTR12 := NA
?<Enter>

Trip 13 (SELogic Equation)
TR13 := NA
?  87SEC1A OR 87SEC2A <Enter>
Unlatch Trip 13 (SELogic Equation)
ULTR13 := NA
?<Enter>

Trip 14 (SELogic Equation)
TR14 := NA
?  87SEC1B OR 87SEC2B <Enter>
Unlatch Trip 14 (SELogic Equation)
ULTR14 := NA
?<Enter>

Trip 15 (SELogic Equation)
TR15 := NA
?  87SEC1C AND 87SEC2C <Enter>
Unlatch Trip 15 (SELogic Equation)
ULTR15 := NA
?  <Enter>

Trip Logic
Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ?> <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.77 Protection Group Settings for Application 2 (Continued)

This concludes the protection group settings. The next settings class is the protection logic settings.

Protection Logic Settings

Use the protection logic settings to create logics in the relay. *Figure 6.78* shows the settings in our example. Protection Latch Bit PLT01 constitutes the differential enable function on the front-panel pushbutton labeled 87(DIFF) ENABLED. Lines 22–27 show the programming for the end-zone protection. *Figure 6.78* shows the protection logic settings.

```
=>>SET L <Enter>

Protection 1

1: PLT01S := NOT PLT01 AND PLT04 # DIFFERENTIAL ENABLED
?  ><Enter>
21:
?  # END-ZONE PROTECTION FOR THE LONDON FEEDER <Enter>
22:
? LOND_EZ:=(TRLON_A OR TRLON_B OR TRLON_C) AND (52AL01 OR 52AL02 OR 52AL03) AND
   LOND89C <Enter>
7:
? # END-ZONE PROTECTION FOR THE BERLIN FEEDER <Enter>
23:
? BERL_EZ:=(TRBER_A OR TRBER_B OR TRBER_C) AND (52AL04 OR 52AL05 or 52AL06) AND
   BERL89C <Enter>
24:
? # END-ZONE PROTECTION FOR THE NEW YORK FEEDER <Enter>
25:
? NEWY_EZ:=(TRNEW_A OR TRNEW_B OR TRNEW_C) AND (52AL07 or 52AL08 or 52AL09) \ AND
   NEWY89C <Enter>
26:
? # END-ZONE PROTECTION FOR THE CANBERRA FEEDER <Enter>
27:
? CANB_EZ:=(TRCAN_A OR TRCAN_B OR TRCAN_C) AND (52AL10 OR 52AL11 OR 52AL12) \ AND
   CANB89C <Enter>
28:
? END <Enter>

Protection 1
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.78 Protection Logic Settings for Application 2

This concludes the protection logic settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need nine output contacts for our example:

- four for the direct transfer trip outputs
- five for the bus-bar protection trip outputs

Although not specifically called for in the protection philosophy, it is good practice to also include the TEST and ALARM outputs in the relay settings.

Because the relay interprets the NUMBK setting as the number of poles, there are 15 trip equations for this application. There is, of course, only one circuit breaker for each terminal. We, therefore, combine the appropriate trip outputs from the breaker trip logic (TRIP01–TRIP15, see *Figure 6.69*) to provide a single trip output for each circuit breaker. For example, we set the trip equations (Protection Group Settings) for the London terminal to TR01 := 87LON_A, TR02 := 87LON_B, and TR03 := 87LON_C, with the corresponding breaker trip logic output alias names of TRLON_A, TRLON_B, and TRLON_C. Because Terminal LONDON has only one circuit breaker, we assign only one trip output contact (OUT201) to trip the circuit breaker. Therefore, assertion of any one of the three breaker trip logic outputs (TRLON_A, TRLON_B, or TRLON_C) must trip the circuit breaker of the London terminal. To achieve this tripping, set Output OUT201 equal to the OR combination of the three breaker trip logic outputs.

NOTE: The tie-breaker trip equations (TR13–TR15) already include the combination of two differential elements (87SEC1A OR 87SEC2A, etc.).

Figure 6.79 shows the settings. We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts. We assign the direct transfer trip outputs to the main board contacts and the bus-zone protection to the trip outputs of the interface board. *Figure 6.79* shows the output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRSEC_A AND NOT PLT03
?  LOND_EZ AND NOT PLT03 <Enter>
OUT102 := TRSEC_B AND NOT PLT03
?  BERL_EZ AND NOT PLT03 <Enter>
OUT103 := TRSEC_C AND NOT PLT03
?  NEWY_EZ AND NOT PLT03 <Enter>
OUT104 := TRLON_A AND NOT PLT03
?  CANB_EZ AND NOT PLT03 <Enter>
OUT105 := TRLON_B AND NOT PLT03
?  NA <Enter>
OUT106 := NA
?  > <Enter>
Interface Board #1
OUT201 := NA
?  (TRLON_A OR TRLON_B OR TRLON_C) AND NOT PLT03 <Enter>
OUT202 := NA
?  (TRBER_A OR TRBER_B OR TRBER_C) AND NOT PLT03 <Enter>
OUT203 := NA
?  (TRNEW_A OR TRNEW_B OR TRNEW_C) AND NOT PLT03 <Enter>
OUT204 := NA
?  (TRCAN_A OR TRCAN_B OR TRCAN_C) AND NOT PLT03 <Enter>
OUT205 := NA
?  (TRSEC_A OR TRSEC_B OR TRSEC_C) AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved
=>>
```

Figure 6.79 Control Output Settings for Application 2

This concludes the settings for Application 2.

Application 3: Breaker-and-a-Half

This application describes the breaker-and-a-half busbar arrangement shown in *Figure 6.80*. Consider the following to set and configure the relay:

- Busbar classification
- Protection philosophy
- Protection functions selection
- Number of SEL-487B Relays and I/O boards
- Input, logic, and output allocation and alias name assignment
- Station layout update
- Relay setting and configuration

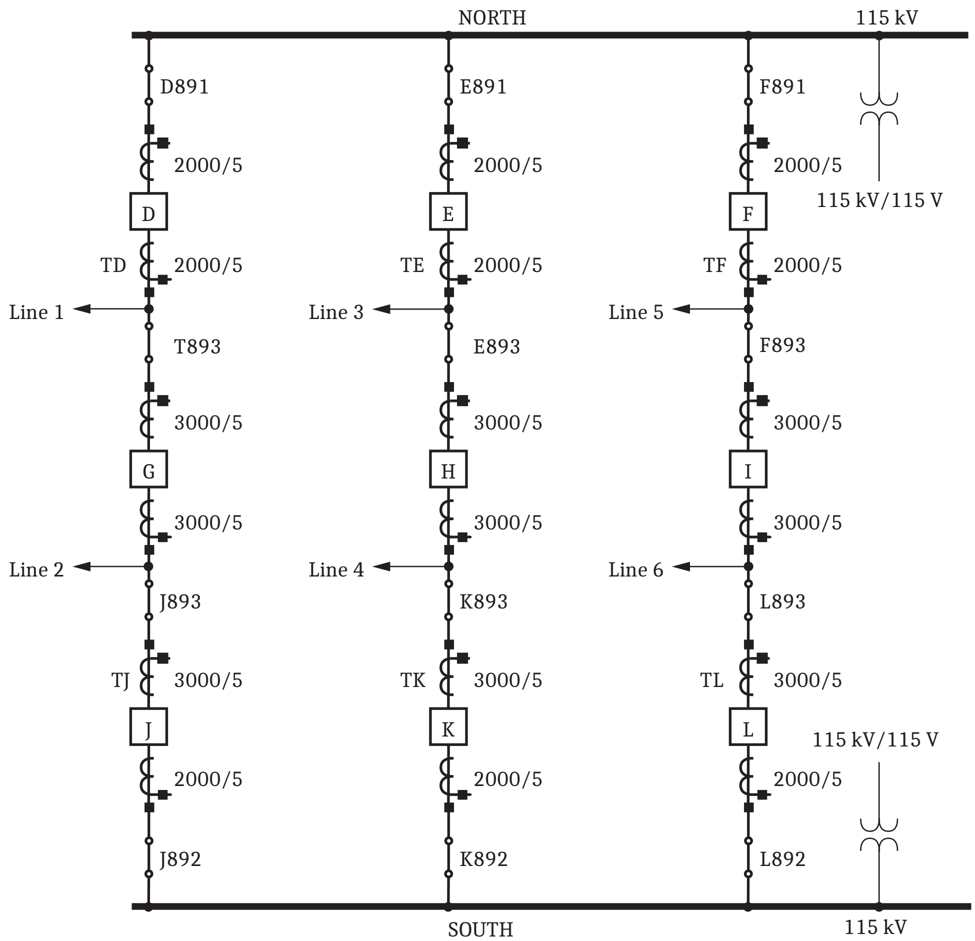


Figure 6.80 Breaker-and-a-Half Busbar Layout

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information.

- Description:
  - Breaker-and-a-half
- Current Transformers:
  - Outboard (free standing)
- Disconnects:
  - No disconnect auxiliary contacts are available
- Future expansion:
  - One feeder

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not every substation uses all of these functions. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Use the terminal out-of-service function.
2. Use the voltage elements as an additional trip criterion, and generate an event report when the voltage elements assert.
3. Block the busbar protection for an open-circuit CT.
4. Use the internal breaker failure protection in the relay for Terminals TD, TE, and TF and include retrip for each terminal.
5. Protect the two busbars with separate relays.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs necessary for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. The SEL-487B offers a number of protection functions as standard features, but it also includes the capability through SELOGIC control equations to create user-configurable functions. To properly identify and categorize the protection philosophy requirements, group the protection functions as follows:

- standard protection functions (available in the relay)
- user-defined protection functions (created with SELOGIC control equations)

Standard Functions

Refer to the protection philosophy and select the standard functions necessary for the application. *Table 6.41* shows the selection of the standard functions.

Table 6.41 Section of Standard Protection Functions (Sheet 1 of 2)

Protection Function	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	No	No disconnect auxiliary contacts available
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	No	No disconnect auxiliary contacts available
Sensitive differential protection	Yes	CT open circuit detection
Zone supervision logic	Yes	Supervise tripping with the undervoltage elements as well as the negative- and zero-sequence overvoltage elements
Zone-switching supervision logic	No	No disconnect auxiliary contacts available
Coupler security logic	No	Breaker-and-a-half busbar layout does not require this function

Table 6.41 Section of Standard Protection Functions (Sheet 2 of 2)

Protection Function	Selection	Comment
Circuit breaker failure protection	Yes	Use the internal circuit breaker failure protection
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	Yes	Use these elements as an additional trip criterion
Zero- or negative-sequence voltage elements	Yes	Use these elements as an additional trip criterion

User-Defined Functions

Because the SEL-487B includes all protection functions necessary for this application as standard protection functions, we do not need any user-defined functions.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.8* to calculate the number of current channels at the station, and use *Equation 6.9* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.8

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.9

The protection philosophy calls for a separate relay for each busbar. There are three terminals in each zone, for a total of nine analog channels. Because of future expansion, however, add 3 more channels for a total of 12. Each SEL-487B has 21 analog channels, so that one relay has enough analog inputs to protect one of the busbars; we need 2 relays to protect both busbars.

Therefore, an SEL-487B protects busbar NORTH, and a separate SEL-487B protects the SOUTH busbar. This is known as a single-relay application. The following discussion describes setting the relay that protects the NORTH busbar. Configuration settings for the relay protecting the SOUTH busbar are the same, except for the alias names. System settings such as CT ratios may be different.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application. The protection philosophy calls for breaker failure protection. We, therefore, need a breaker failure initiate input contact for each of the three terminals. *Table 6.42* summarizes the input contact requirement for this application.

Table 6.42 Number of Relay Input Contacts Required

Input Description	Inputs
Number of relay inputs required for circuit breaker failure protection	3
Total number of inputs	3

The relay main board has seven input contacts, sufficient for our application. From the input contact perspective, we only need the main board; we do not need an interface board.

Number of Relay Output Contacts

Circuit breakers TD, TE, and TF each need a trip output contact as well as a direct transfer trip (DTT). *Table 6.43* shows the breakdown and the total number of relay output contacts required.

Table 6.43 Breakdown and the Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for differential, breaker failure tripping, and direct transfer trip	3
Number of relay output contacts required for direct transfer tripping	3
Total number of relay output contacts	6

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the **RELAY TEST MODE** pushbutton on the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). There are enough output contacts on the main board, but these contacts are all standard output contacts. The interface boards can have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board provides six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need one SEL-487B per busbar, each relay equipped with a single interface board.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point, we have determined the following:

- the number of SEL-487B Relays necessary for the application
- the number of input contacts
- the number of output contacts
- the selected functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- link specific CT inputs to specific relay analog channels
- link relay element/logic outputs to specific relay output contacts
- assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog quantity
- Terminal name
- Bus-zone name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed using characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

Table 6.44 shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase CT from Terminal TD to relay channel I01, and assign to this CT the alias name TD_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.44* shows the assignment starting with Terminal TD, followed by Terminal TE, and Terminal TF, taken left-to-right from *Figure 6.80*.

Table 6.44 CTs-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
Terminal TD, A-phase	I01	TD_A
Terminal TD, B-phase	I02	TD_B
Terminal TD, C-phase	I03	TD_C
Terminal TE, A-phase	I04	TE_A
Terminal TE, B-phase	I05	TE_B
Terminal TE, C-phase	I06	TE_C
Terminal TF, A-phase	I07	TF_A
Terminal TF, B-phase	I08	TF_B
Terminal TF, C-phase	I09	TF_C

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. In this application, we use three of the six zones with alias names as shown in *Table 6.45*.

Table 6.45 Alias Names for Three of the Six Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	NORTH_A
BZ2	Bus-Zone 2	NORTH_B
BZ3	Bus-Zone 3	NORTH_C

Input-to-Logic Allocation and Alias Assignment

Table 6.42 shows that we require three digital inputs. We now assign the digital inputs to the selected logic and apply alias names to the inputs and logic elements. Because we installed an interface board, we use the independent inputs on the interface board for the breaker failure initiate inputs, instead of the inputs on the main board.

Input-to-Logic Allocation and Alias Assignment, Interface Board 1 (200)

Table 6.46 shows the breaker failure initiate input allocations.

Table 6.46 Alias Names for the Breaker Failure Input Contacts

Input	Description	Alias
IN201	Terminal TD breaker failure initiate	ITD_BFI
IN202	Terminal TE breaker failure initiate	ITE_BFI
IN203	Terminal TF breaker failure initiate	ITF_BFI

Assign Alias Names to the Selected Standard Logic

The following explains each selected function in reference to *Table 6.41*. Alias name assignments are also included.

Breaker Failure

This application is a breaker-and-a-half busbar layout. For such busbar layouts, two circuit breakers must operate to clear a fault. *Figure 6.81* shows fault F1, for which both Circuit Breaker TD and Circuit Breaker TG must operate to clear the fault. For certain faults, the current distribution may be such that Circuit Breaker TD carries the bulk of the fault current, as shown in *Figure 6.81*.

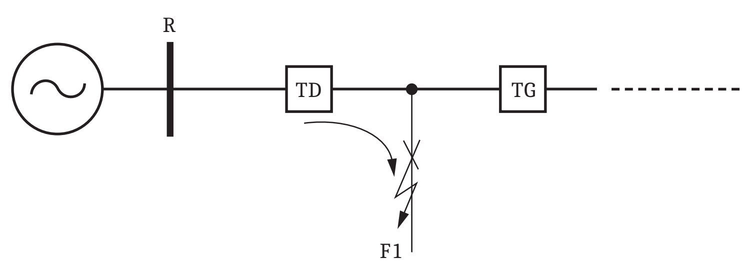


Figure 6.81 Current Distribution for Fault F1 With Circuit Breaker TD and Circuit Breaker TG Closed

Because of the current distribution, Terminal TG may only have enough current to assert the breaker failure current element threshold (50F*nn*) when Circuit Breaker TD opens, as shown in *Figure 6.82*.

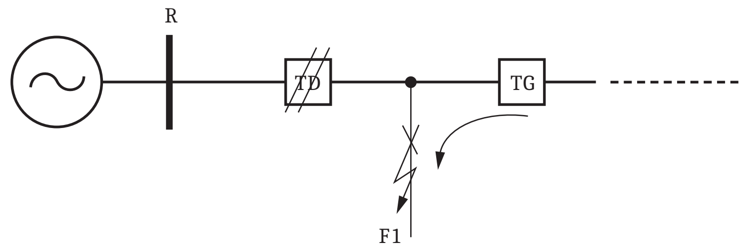


Figure 6.82 Current Flow for Fault F1 After Circuit Breaker TD Opened

This situation delays initiation of the breaker failure protection of Terminal TG until Circuit Breaker TD interrupts the current. However, both circuit breakers receive the trip signal at the same time and are expected to operate at the same time. Use breaker failure protection Scheme 2 to prevent this delay. See *Circuit Breaker Failure Protection on page 5.30* for more information.

Because the protection philosophy calls for use of the internal breaker failure protection, wire a breaker failure initiate contact from each feeder panel to an independent relay input contact. *Table 6.47* shows the primitive names and the alias names of the breaker failure initiate Relay Word bits (see the *Protection Group Settings on page 6.101* for more information).

Table 6.47 Alias Names for the Breaker Failure Initiate Relay Word Bits

Logic Name	Description	Alias
ATBFI01	Terminal TD A-phase breaker failure protection initiate input	TDA_BFI
ATBFI02	Terminal TD B-phase breaker failure protection initiate input	TDB_BFI
ATBFI03	Terminal TD C-phase breaker failure protection initiate input	TDC_BFI
ATBFI04	Terminal TE A-phase breaker failure protection initiate input	TEA_BFI
ATBFI05	Terminal TE B-phase breaker failure protection initiate input	TEB_BFI
ATBFI06	Terminal TE C-phase breaker failure protection initiate input	TEC_BFI
ATBFI07	Terminal TF A-phase breaker failure protection initiate input	TFA_BFI
ATBFI08	Terminal TF B-phase breaker failure protection initiate input	TFB_BFI
ATBFI09	Terminal TF C-phase breaker failure protection initiate input	TFC_BFI

We also assign alias names to breaker failure logic output Relay Word bits. *Table 6.48* shows the primitive names and the alias names.

Table 6.48 Alias Names for the Breaker Failure Logic Output Relay Word Bits

Logic Name	Description	Alias
FBF01	Terminal TD A-phase breaker failure protection asserted	TDA_BF
FBF02	Terminal TD B-phase breaker failure protection asserted	TDB_BF
FBF03	Terminal TD C-phase breaker failure protection asserted	TDC_BF
FBF04	Terminal TE A-phase breaker failure protection asserted	TEA_BF
FBF05	Terminal TE B-phase breaker failure protection asserted	TEB_BF
FBF06	Terminal TE C-phase breaker failure protection asserted	TEC_BF
FBF07	Terminal TF A-phase breaker failure protection asserted	TFA_BF
FBF08	Terminal TF B-phase breaker failure protection asserted	TFB_BF
FBF09	Terminal TF C-phase breaker failure protection asserted	TFC_BF

Breaker Failure Trip Logic and Station Breaker Failure Logic Output Alias Assignment

Figure 6.83 shows the station breaker failure trip logic. Relay Word bits FBF01–FBF09 are the inputs to the station breaker failure trip logic; Relay Word bits SBFTR01–SBFTR09 are the outputs from the station breaker failure trip logic. Relay Breaker failure trip bits SBFTR01–SBFTR09 assert to trip the circuit breakers of the terminals in the bus-zone with the failed circuit breaker. (See *Section 5: Protection Functions* for more information.)

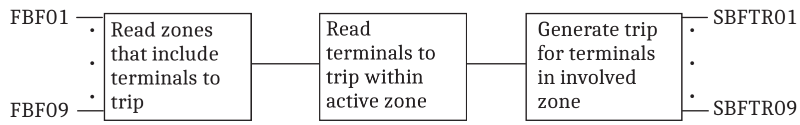


Figure 6.83 Station Breaker Failure Trip Logic

Table 6.49 shows the station breaker failure Relay Word bits and the alias names for the breaker failure protection outputs.

Table 6.49 Primitive Terminal and Station Breaker Failure Trip Relay Word Bit Names and the Alias Names for the Breaker Failure Trip Bits

Primitive Name	Description	Alias Names
SBFTR01	Terminal TD A-phase station breaker failure protection asserted	TDA_SBF
SBFTR02	Terminal TD B-phase station breaker failure protection asserted	TDB_SBF
SBFTR03	Terminal TD C-phase station breaker failure protection asserted	TDC_SBF
SBFTR04	Terminal TE A-phase station breaker failure protection asserted	TEA_SBF
SBFTR05	Terminal TE B-phase station breaker failure protection asserted	TEB_SBF
SBFTR06	Terminal TE C-phase station breaker failure protection asserted	TEC_SBF
SBFTR07	Terminal TF A-phase station breaker failure protection asserted	TFA_SBF
SBFTR08	Terminal TF B-phase station breaker failure protection asserted	TFB_SBF
SBFTR09	Terminal TF C-phase station breaker failure protection asserted	TFC_SBF

Be sure to include the station breaker failure trip bits in the trip equations of all the terminals you want to trip for breaker failure protection (see the *Control Output Settings on page 6.111* for more information).

Differential Trip Logic and Differential Element Alias Assignment

Figure 6.84 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.)

Differential trip bits 87BTR01–87BTR09 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

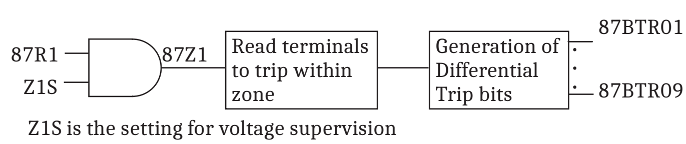


Figure 6.84 Differential Trip Logic for Differential Element 1

Table 6.50 shows the Relay Word bits and the alias names for the zone differential protection outputs.

Table 6.50 Alias Names for the Zone Differential Protection Output Relay Word Bits

Primitive Name	Description	Alias
87Z1	Zone 1 differential element trip	NORTA_T
87Z2	Zone 2 differential element trip	NORTB_T
87Z3	Zone 3 differential element trip	NORTC_T

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate. In our example, we want to trip three terminals. *Table 6.51* shows the primitive terminal names, the differential trip bit names, and the alias names for the differential trip bits.

Table 6.51 Primitive Terminal and Differential Trip Bit Names and the Alias Names for the Differential Trip Bits

Primitive Name	Description	Alias
87BTR01	Terminal TD A-phase differential protection trip asserted	TD_TA
87BTR02	Terminal TD B-phase differential protection trip asserted	TD_TB
87BTR03	Terminal TD C-phase differential protection trip asserted	TD_TC
87BTR04	Terminal TE A-phase differential protection trip asserted	TE_TA
87BTR05	Terminal TE B-phase differential protection trip asserted	TE_TB
87BTR06	Terminal TE C-phase differential protection trip asserted	TE_TC
87BTR07	Terminal TF A-phase differential protection trip asserted	TF_TA
87BTR08	Terminal TF B-phase differential protection trip asserted	TF_TB
87BTR09	Terminal TF C-phase differential protection trip asserted	TF_TC

Breaker Trip Logic and Trip Alias Assignment

Figure 6.85 shows the general tripping logic in the SEL-487B. (See *Section 5: Protection Functions* for more information.)

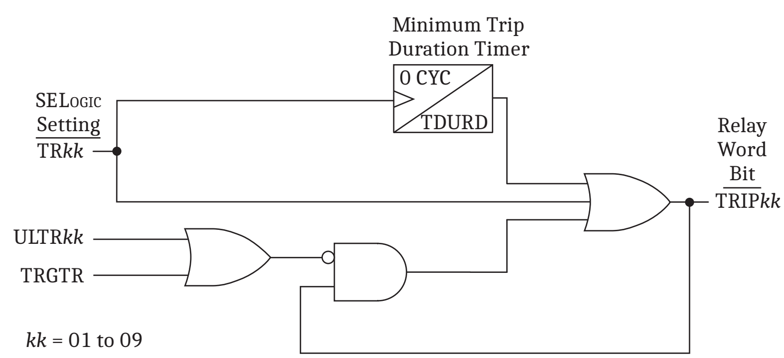


Figure 6.85 Breaker Trip Logic

There exists a direct relationship between the number of circuit breakers and the number of trip equations, i.e., the number of trip equations (TR*kk*) equals the number of circuit breakers (NUMBK). Because the relay interprets the number of circuit breakers (NUMBK) as the number of circuit breaker poles, the setting of NUMBK in this application equals nine. After setting the TR*kk* trip equations, the relay associates each TR*kk* trip equation with a particular circuit breaker pole; we must combine the trip equations in the output settings to form a single output for the circuit breaker (see *Control Output Settings on page 6.111* for more information). For example, after setting TR01 := 87BTR01 OR SBFTR01 and TR02 := 87BTR02 OR SBFTR02, the relay associates Trip Equation TR01 with Terminal 01 (TD_A), Trip Equation TR02 with Terminal 02 (TD_B), and so on. *Table 6.52* shows the primitive and alias names for the trip logic of each terminal.

Table 6.52 Primitive and Alias Names for the Trip Logic of Each Terminal

Primitive Name	Description	Alias Name
TRIP01	Terminal TD A-phase trip output asserted	TRTD_A
TRIP02	Terminal TD B-phase trip output asserted	TRTD_B
TRIP03	Terminal TD C-phase trip output asserted	TRTD_C
TRIP04	Terminal TE A-phase trip output asserted	TRTE_A
TRIP05	Terminal TE B-phase trip output asserted	TRTE_B
TRIP06	Terminal TE C-phase trip output asserted	TRTE_C
TRIP07	Terminal TF A-phase trip output asserted	TRTF_A
TRIP08	Terminal TF B-phase trip output asserted	TRTF_B
TRIP09	Terminal TF C-phase trip output asserted	TRTF_C

Assign Alias Names to the User-Defined Logic

This application requires no user-defined logic.

Relay Logic-to-Output Contact Allocation and Output Contact Alias Assignments

At this point, we have assigned alias names to all relay functions. *Table 6.43* shows the breakdown of the relay outputs that we need for this application. We now assign specific relay output contacts to the relay functions and assign alias names to the relay output contacts. *Table 6.53* shows the main board assignments and alias names.

Output Alias Assignment, Main Board

This application requires no main board output contacts.

Table 6.53 Alias Assignment for the Trip Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Alias Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.54* shows the assignments and alias names for Interface Board 1.

Table 6.54 Alias Assignments for the Output Contacts of Interface Board 1

Output Contact Assignment	Description	Output Contact Alias
OUT201[a]	Terminal TD trip output	TD_TRIP
OUT202[a]	Terminal TE trip output	TE_TRIP
OUT203[a]	Terminal TF trip output	TF_TRIP
OUT204[a]	Terminal TD direct transfer trip output	TD_DTT
OUT205[a]	Terminal TE direct transfer trip output	TE_DTT
OUT206[a]	Terminal TF direct transfer trip output	TF_DTT

[a] High-speed, high-interrupting outputs.

Station Layout Update

We are now ready to set and configure the relay. Write down all the relevant information onto the station diagram, as shown in *Figure 6.86*. *Figure 6.86* shows the updated station layout for both relays.

1. Write down the bus-zone, terminal, and disconnect names.
2. Allocate the terminals CTs to the relay input current channels.
3. Allocate the auxiliary contacts to the relay digital inputs.
4. Allocate the digital outputs from the relay to the station terminals.

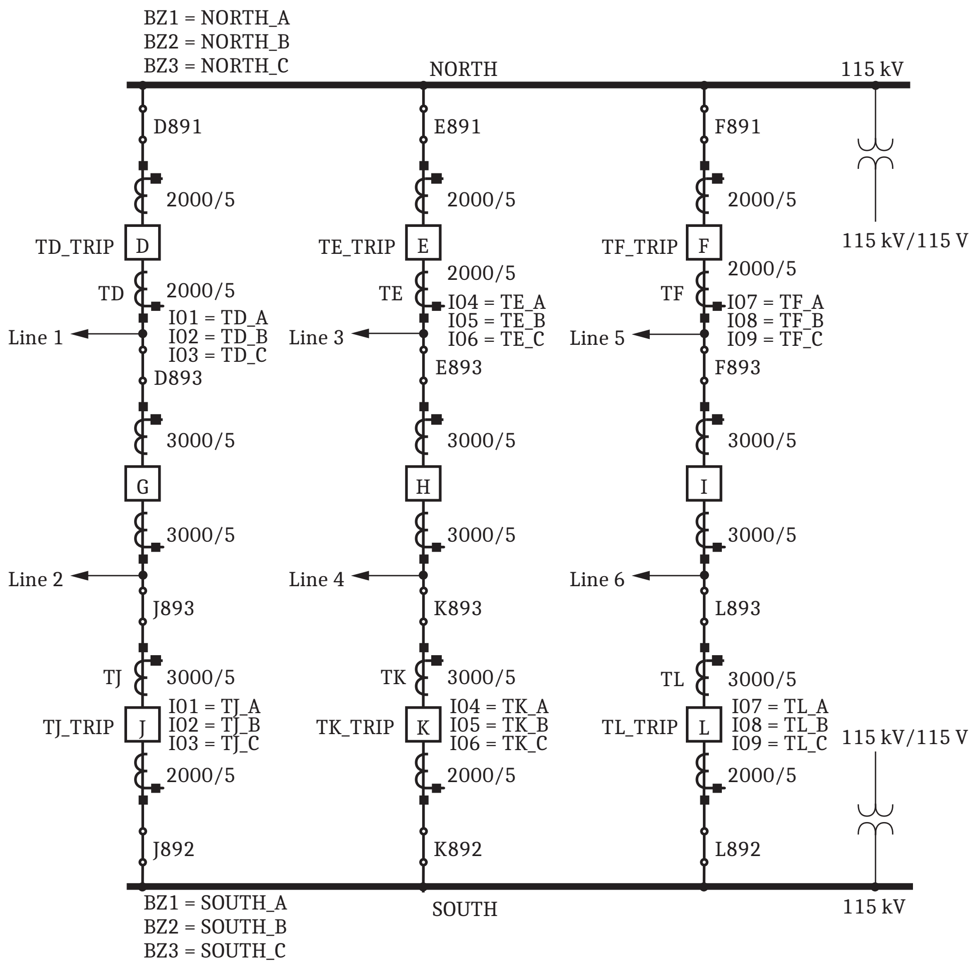


Figure 6.86 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. For this application, we set the following settings classes:

- ➤ Alias Settings
- ➤ Global Settings
- ➤ Zone Configuration Group Settings
- ➤ Protection Group Settings
- ➤ Front Panel Settings
- ➤ Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.87*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>

Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: I01,"FDR_1"
?  LIST <Enter>
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"
.
.
.
60: TLED_15,"89_ALRM"
61: TLED_16,"PT_ALRM"
1: I01,"FDR_1"
?
```

Figure 6.87 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.88*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.88 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the settings list. Enter the alias names for the analog channels and Relay Word bits, as shown in *Figure 6.89*.

We include the alias names for the three protection latch bits (PLT01, PLT02, and PLT03). We use these protection latch bits for local control of the differential elements (PLT01), the breaker fail protection (PLT02), and the relay test mode (PLT03). Because the protection logic default settings include these three protection latch bits as default settings, we did not select these protection latch bits as user-defined logic.

```
1: OUT107,"TEST"
?  > <Enter>
19:
?  I01,TD_A <Enter>
20:
?  I02,TD_B <Enter>
21:
?  I03,TD_C <Enter>
22:
?  I04,TE_A <Enter>
23:
?  I05,TE_B <Enter>
24:
?  I06,TE_C <Enter>
.
.
.
136:
?  PLT01,DIFF_EN <Enter>
137:
?  PLT02,BF_EN <Enter>
138:
?  PLT03,TNS_SW <Enter>
139:
?  END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.89 Analog Quantities and Relay Word Bits Alias Names

This concludes the alias settings. The next settings class is the Global settings.

Global Settings

Global settings comprise settings that apply to all protection settings groups. For example, when changing from Protection Setting Group 1 to Protection Setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.90* shows the setting changes we need for our example. Because we declared the alias names in the alias settings class, use either the alias names or the primitive names when entering settings.

Enter the number of poles at the station for the NUMBK settings. There are three terminals in the differential equation, each with three poles. The total number of poles, therefore, equals nine poles, and we set NUMBK to 9.

Setting NUMBK to 9 makes 9 corresponding circuit breaker auxiliary input equations (52A01–52A09) and nine corresponding trip equations (TR01–TR09) available for setting. Because we do not need circuit breaker auxiliary inputs for this example, we need not enter values for the circuit breaker auxiliary input equations. For this example, the only Global setting change is the number of circuit breakers; all other settings remain at default settings.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>
Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>
Number of Breakers (N,1-21)                    NUMBK   := 5      ?9 <Enter>
Number of Disconnects (N,1-60)                 NUMDS   := N      ?END <Enter>
Global
.
.
.
52A08 := NA
52A09 := NA
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.90 Global Settings for Application 3

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. In this application, there are no disconnect auxiliary contacts available, and we permanently assign analog channels to the appropriate differential elements. All 21 channels are available for setting, but only the first 9 are part of the differential protection. We, therefore, assign only the first nine analog channels to the differential elements. The protection philosophy calls for the use of the voltage elements as an additional trip criterion.

Calculate the ratio settings as follows:

$$\begin{aligned} \text{PTR} &= \frac{\text{Primary Nominal Voltage}}{\text{Secondary Nominal Voltage}} \\ &= \frac{115000}{115} \\ &= 1000 \end{aligned}$$

Equation 6.10

Figure 6.91 shows the zone configuration settings.

Because there are no disconnects available at this station, we cannot use the dynamic zone selection logic. Because we cannot use the dynamic zone selection logic, the CTs are always considered in the differential equations.

When we consider only the disconnect auxiliary contacts as conditions in the terminal-to-bus-zone connection settings, we would have entered a 1 for each of the terminal-to-bus-zone connection settings.

This example, however, also includes two other conditions that must be a logical 1 before the relay considers the CTs in the differential equations. The two conditions are

- ➤ the differential enable switch (Alias DIFF_EN)
- ➤ and the terminal-out-of-service switch (TOS*nn*, where *nn* is the terminal number)

Front-panel pushbutton PB1 controls DIFF_EN. The function of DIFF_EN is to remove all the terminals from the differential equations with a single command. Enter **DIFF_EN** at every terminal-to-bus-zone variable.

The terminal out-of-service switch, which removes individual terminals from the differential calculations, is part of the front-panel local controls. Include an individual terminal out-of-service (TOS*nn*) for each terminal.

The zone configuration default settings are for a specific substation with arbitrarily selected alias names, serving only as an example. Delete the terminal-to-bus-zone default settings for ease of setting zone configuration settings for the new substation. With the terminal-to-bus-zone default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone settings. *Figure 6.91* shows the Zone configuration settings for this application. Instead of entering **1 AND DIFF_EN AND NOT TOS*nn***, we omit the 1, and enter only **DIFF_EN AND NOT TOS*nn*** for each setting.

```
=>>SET Z <Enter>

Zone Config Group 1
Potential Transformer Ratio
Potential Transformer Ratio -V01 (1-10000)        PTR1    := 2000   ?1000 <Enter>
Potential Transformer Ratio -V02 (1-10000)        PTR2    := 2000   ?1000 <Enter>
Potential Transformer Ratio -V03 (1-10000)        PTR3    := 2000   ?1000 <Enter>
Current Transformer Ratio
Current Transformer Ratio -I01 (1-50000)          CTR01   := 600    ?400 <Enter>
Current Transformer Ratio -I02 (1-50000)          CTR02   := 600    ?400 <Enter>
.
.
.
Current Transformer Ratio -I09 (1-50000)          CTR09   := 600    ?400 <Enter>
Current Transformer Ratio -I10 (1-50000)          CTR10   := 600    ?> <Enter>
```

Figure 6.91 Zone Configuration Group Settings for Application 3

```
Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
IO1BZ1C := TD_A, NORTH_A, P
?  DELETE 100 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO1,BZ1,P <Enter>
TD_A to NORTH_A Connection (SELogic Equation)
IO1BZ1V := NA
?  PLT01 AND NOT TOS01 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO2,BZ2,P <Enter>
TD_B to NORTH_B Connection (SELogic Equation)
IO2BZ2V := NA
?  PLT01 AND NOT TOS01 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,BZ3,P <Enter>
TD_C to NORTH_C Connection (SELogic Equation)
IO3BZ3V := NA
?  PLT01 AND NOT TOS01 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO4,BZ1,P <Enter>
TE_A to NORTH_A Connection (SELogic Equation)
IO4BZ1V := NA
?  PLT01 AND NOT TOS02 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,BZ2,P <Enter>

TE_B to NORTH_B Connection (SELogic Equation)
IO5BZ2V := NA
?  PLT01 AND NOT TOS02 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,BZ3,P <Enter>
TE_C to NORTH_C Connection (SELogic Equation)
IO6BZ3V := NA
?  PLT01 AND NOT TOS02 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO7,BZ1,P <Enter>
TF_A to NORTH_A Connection (SELogic Equation)
IO7BZ1V := NA
?  PLT01 AND NOT TOS03 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO8,BZ2,P <Enter>

TF_B to NORTH_B Connection (SELogic Equation)
IO8BZ2V := NA
?  PLT01 AND NOT TOS03 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO9,BZ3,P <Enter>
TF_C to NORTH_C Connection (SELogic Equation)
IO9BZ3V := NA
?  PLT01 AND NOT TOS03 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?<Enter>
Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
? DELETE 100 <Enter>
Bus-Zone, Bus-Zone
?<Enter>

Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?Y <Enter>
Zone 1 Supervision (SELogic Equation)
Z1S := 1
?  591P1 OR 592P1 OR 271P1 <Enter>
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?  592P1 OR 592P1 OR 271P1 <Enter>
Zone 3 Supervision (SELogic Equation)
Z3S := 1
?  591P1 OR 592P1 OR 271P1 <Enter>

Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.91 Zone Configuration Group Settings for Application 3 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, beginning with the function enable settings.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Set E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information) to use the sensitive differential element for this requirement. Set ECSL := N because we do not use the Coupler Security Logic.

Terminal out of service is a local bit (local bits provide programming capabilities for functions available on the front-panel screen under LOCAL CONTROL). Include the terminal out of service in the trip equations to disable the outputs from individual terminals.

This local control selectively takes a terminal out of service, whereas the **87(DIFF) ENABLED** pushbutton disables all the trip outputs. Set ETOS := 3 because there are three breakers in the bus-zone differential protection.

There are nine breaker poles (NUMBK := 9), all of which need relay breaker failure protection. Set EBFL := 9 to enable nine breaker failure logics. Set E50 := N and E51 := N because we do not need overcurrent protection for this application.

The protection philosophy calls for undervoltage as an additional trip criterion. Because the voltage elements are enabled in the default settings, leave EVOLT := Y.

Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. Enable the advanced settings by setting EADVS := Y to change the slope setting.

With EADVS := Y, the slope settings and incremental restrained and operating current settings become available. For this application, we use the default values for the sensitive differential element, the restrained differential element, and the directional element.

The protection philosophy calls for breaker failure protection. This application shows an example of how to calculate breaker failure settings for the Terminal TD circuit breaker. In this example, we apply the settings calculated for Terminal TD to all the terminals at the station. Because network parameters are different, be sure to calculate values for the other terminals; do not assume that settings for one terminal apply to all other terminals at the same station.

EBFL, Enable Breaker Fail Setting

Enter the number of per-pole breaker fail logics you want to enable.

In this single-relay application, we need nine per-pole breaker fail logics, because we must provide breaker failure protection for three breakers.

EBFL := **9** Enable breaker fail

Figure 6.92 shows the components of breaker failure protection for line protection. Do not consider remote terminal information when considering breaker failure protection for equipment such as capacitor banks, transformers, etc.

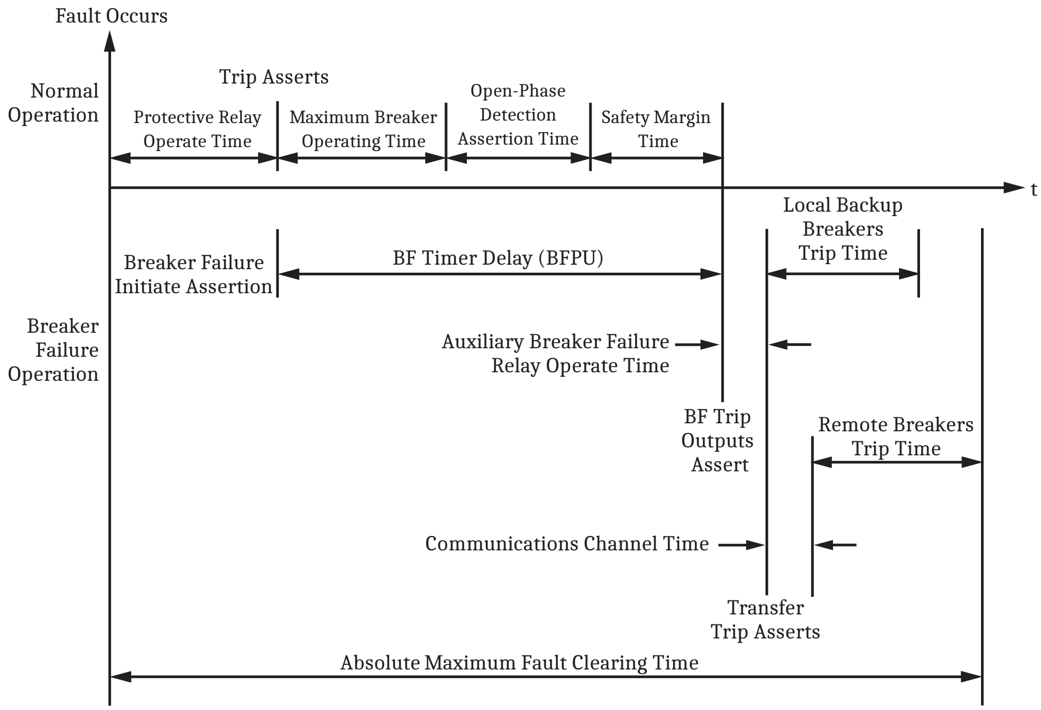


Figure 6.92 Breaker Failure Timing Diagram

Use the SEL-487B to provide circuit breaker failure protection for Circuit Breaker TD in *Figure 6.93*.

Figure 6.93 shows the power system for this example. Line 1 and Line 2 connect Station S and Station R. We set the breaker failure protection in the SEL-487B to detect circuit breaker failures for Terminal TD at Station S. This example uses a line with three-pole tripping, but the relay provides the flexibility to also apply circuit breaker failure for single-pole trip circuit breakers. This flexibility is possible because the current measurement and timers are available on a per-phase basis.

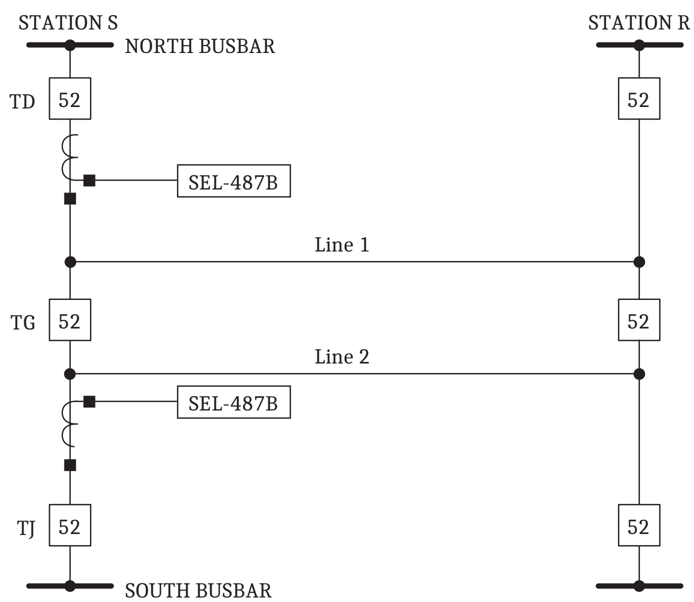


Figure 6.93 Power System for Circuit Breaker Failure Scheme 2

50FP01, Phase Current Level Detector Setting

NOTE: This is one method for calculating setting 50FP01. Use your company's practices and policies for determining the pickup setting for your particular application.

Set the current pickup (50FP01) greater than maximum load and less than the fault current that flows through Terminal TD. Assume that the total load current (I_S) is 3.25 A secondary, supplied from Substation S. Calculate setting 50FP01 with all the load current I_S through Terminal TD.

$$\begin{aligned} 50FP01 &= 120\%(\text{Percent Current} \bullet I_S) \\ &= 120\%(100\%\ \text{Current} \bullet 3.25\ \text{A}) \\ &= 3.91\ \text{A secondary} \end{aligned}$$

Equation 6.11

A fault study shows that the minimum ground fault current, $I_{\text{fault minimum}}$, is 4.2 A secondary when the parallel line is in service at minimum generation. Calculate the 50FP01 setting for dependability at half the minimum fault current.

$$\begin{aligned} 50FP01 &= 0.5(\text{Percent Current} \bullet I_{\text{fault minimum}}) \\ &= 0.5(100\%\ \text{Current} \bullet 4.20\text{A}) \\ &= 2.10\ \text{A secondary} \end{aligned}$$

Equation 6.12

Although the result of this setting calculation is less than maximum load, obtain greater dependability by using this calculation to set the 50FP01 element to 2.10 A.

BFPU01, Circuit Breaker Failure Time Delay Setting

BFPU01 (Breaker Failure Time Delay-Terminal TD) is the time for which the input (BFI01) to Timer BFPU01 must be continuously present to result in a circuit breaker failure trip operation. The recommended setting for BFPU1 is the sum of the following:

➤ Maximum circuit breaker operating time
➤ OPH01 maximum dropout time
➤ Safety margin

Figure 6.94 shows the timing diagram for setting Timer BFPU01.

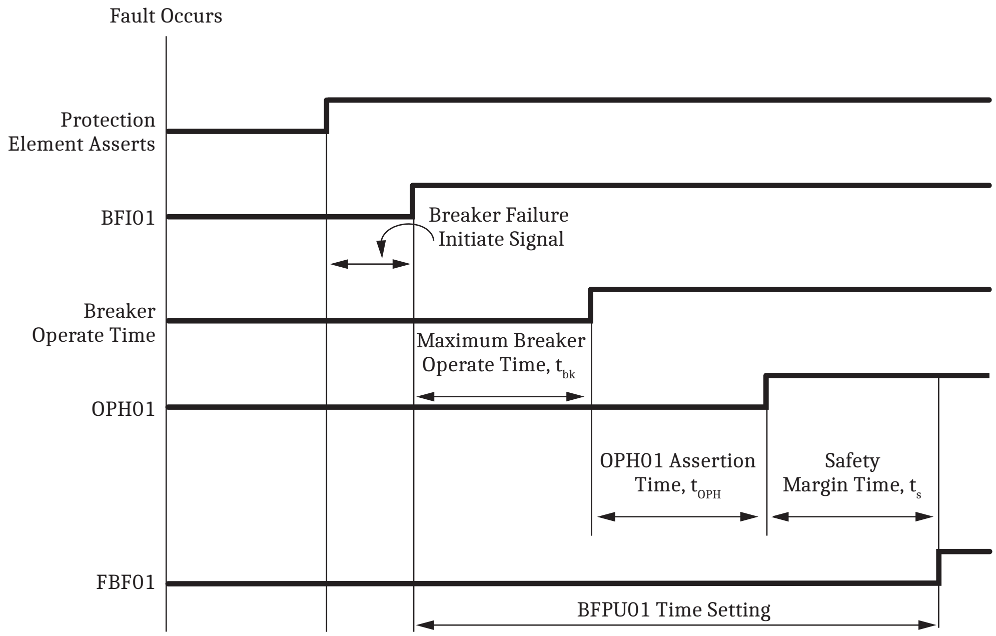


Figure 6.94 Timing Diagram for Setting BFPU01–Scheme 2

NOTE: If the relay is using TiDL (EtherCAT), the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay.

To maintain system stability, you must clear the fault within the total clearing time, assumed to be 17 cycles for this example. Use the maximum operating time of the local and remote circuit breakers. The maximum circuit breaker operating time, t_{bk}, is 3 cycles for this example.

Use 0.75 cycle for tOPH, the maximum assertion time of the open-phase detector, OPH01. You must also include the communications channel time, t_{ch}, for remote circuit breaker tripping. To determine setting BFPU1, you must find the safety margin, t_s. Use *Equation 6.13* to calculate the safety margin:

$$\begin{aligned} t_s &= tt - (t_{1r} + t_{1bk} + t_{OPH} + t_{86} + t_{ch} + t_{rbk}) \\ &= 17 - (2 + 3 + 0.75 + 1 + 1 + 3) \\ &= 5.75 \text{ cycles} \end{aligned}$$

Equation 6.13

where:

t_s = safety margin
t_t = total clearing time (17 cycles)
t_{1r} = line protection maximum operating time (2 cycles)
t_{1bk} = local circuit breaker maximum operating time (3 cycles)
t_{OPH} = open-phase detection OPH01 maximum assertion time (0.75 cycle)
t_{86} = auxiliary breaker failure relay operating time (1 cycle)
t_{ch} = communications channel maximum operating time (1 cycle)
t_{rbk} = remote circuit breaker maximum operating time (3 cycles)

Use the safety margin result from *Equation 6.13* to calculate BFPU01:

$$\begin{aligned} \text{BFPU01} &= t_{1bk} + t_{OPH} + t_s \\ &= 3 + 0.75 + 5.75 \\ &= 9.5 \text{ cycles} \end{aligned}$$

Equation 6.14

BFPU01 := **9.50** cycles Breaker Failure Time Delay

RTPU01, Retrip Time Delay Setting

If the circuit breaker is equipped with two trip coils, the relay should attempt to retrip the protected circuit breaker before a circuit breaker failure trip asserts. In this example, local circuit breaker maximum operating time is 3 cycles, and the open-phase detection assertion is 0.75 cycle. Wait 4 cycles for the retrip.

RTPU01 := **4.00** Retrip Time Delay

BFI01 and ABFI01, Circuit Breaker Initiation Settings

Figure 6.95 shows the breaker failure initiate contact for Terminal TD. Wire similar contacts for Terminal TE and Terminal TF into the SEL-487B.

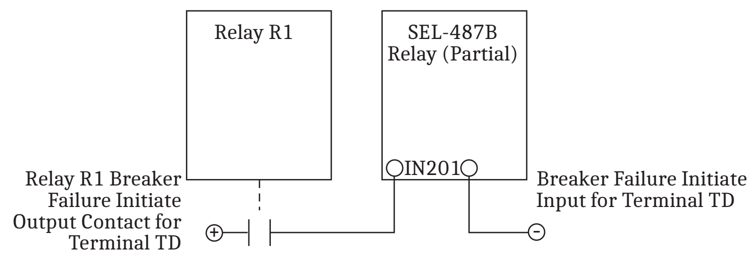


Figure 6.95 Breaker Failure Protection Wiring for Terminal TD

For this example, assume the breaker failure initiate signal is continuous. Because this is a breaker-and-a-half busbar layout, use the input extension option of *Alternate Breaker Failure Initiating Input With Extension and/or Seal In Logic on page 5.31* (see *Circuit Breaker Failure Protection on page 5.30* for more information).

Figure 6.96 shows the circuit breaker failure initiation extension and seal-in logic, and *Figure 6.97* shows the circuit breaker failure logic.

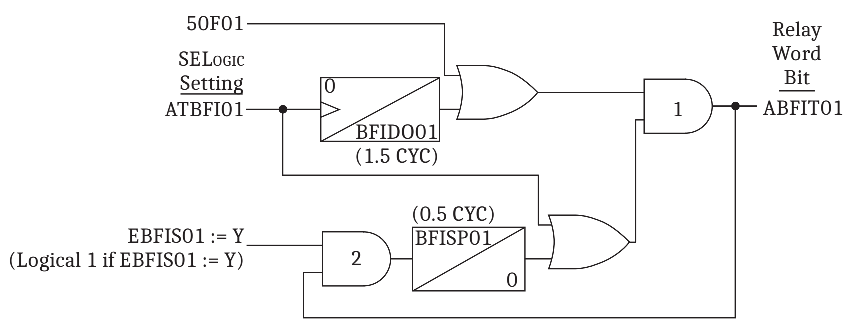


Figure 6.96 Circuit Breaker Failure Initiation Extension and Seal-In Logic

Scheme 2 uses a combination of the logic in *Figure 6.96* and *Figure 6.97* by setting the output from the circuit breaker failure initiation extension and seal-in logic (ABFIT01, *Figure 6.96*) as the breaker failure initiate input of the breaker failure logic (BFI01, *Figure 6.97*).

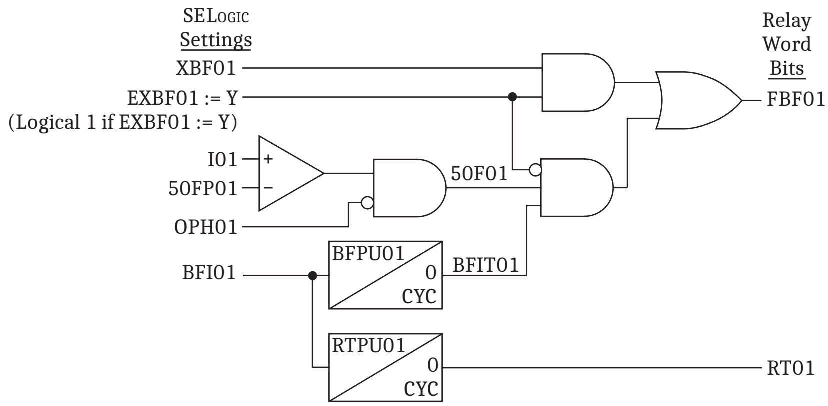


Figure 6.97 Circuit Breaker Failure Logic

Because this is an example of a three-pole circuit breaker, enter the same breaker failure initiate input (IN201) for all three phases (ATBFI01–ATBFI03) for Terminal TD.

Table 6.55 shows the breaker failure initiate input (IN201) and the assignment and setting to combine the logic for Terminal TD, stating the alias names where applicable. Settings for the remaining terminals are similar.

Table 6.55 Input and Relay Word Bit Assignments and Settings for the Combined Logic

Assignment	Setting to Achieve the Assignment
IN201 to ATBFI01	TDA_BFI := ITD_BFI
IN201 to ATBFI02	TDB_BFI := ITD_BFI
IN201 to ATBFI03	TDC_BFI := ITD_BFI
ABFIT01 to BFI01	BFI01 := ABFIT01
ABFIT02 to BFI02	BFI02 := ABFIT02
ABFIT03 to BFI03	BFI03 := ABFIT03

BFIDO01, Circuit Breaker Failure Protection Initiation Dropout Delay Setting

Setting EBFIS01 applies to the case where the breaker failure initiate signal is not continuous. Because the breaker failure initiate signal is continuous in this example, leave EBFIS01 at the default value of N. Consider the case where the entire fault current initially flows through Terminal TG, and no current flows through Terminal TD. Timer BFIDO01 replaces the current input 50FI01 (*Figure 6.96*) for the period when the entire fault current flows through Circuit Breaker TG. During this period, not enough current is available to assert Relay Word bit 50FI01 to turn AND Gate 1 on (*Figure 6.96*). Timer BFIDO01 extends the breaker failure initiate signal, waiting for Terminal TD to interrupt the fault current. The maximum circuit breaker operating time for Terminal TG is 3 cycles; allow a short safety margin and set Timer BFIDO01 to 4 cycles.

BFIDO1 := **4.00** Breaker Failure Initiate Dropout Delay-BK1

Negative- and Zero-Sequence Overvoltage, Thresholds and Phase Undervoltage Settings

Conduct fault studies to obtain appropriate settings for the negative-sequence and zero-sequence overvoltage elements.

For this example, assume a setting of 15 V for both negative-sequence and zero-sequence overvoltage elements and 45 V for the undervoltage elements.

59P1P1 := **15** Overvoltage Element 1 pickup setting. Use 59O1 = 3V2FIM for the negative-sequence operating quantity.

59P2P1 := **15** Overvoltage Element 2 pickup setting. Use 59O2 = 3V0FIM for the zero-sequence operating quantity.

27P1P1 := **45** Undervoltage Element 1 pickup setting. Use V0*n*FIM (*n* = 1–3) for the undervoltage operating quantity.

TR01–TR09, Trip Equations Settings

Pay close attention to the trip logic (TR01–TR09) settings. Because this is a single-relay application, CTs from the three phases (A-phase, B-phase, and C-phase) from each terminal are assigned to three different differential elements (see *Single-Relay Application on page 6.3*). Setting NUMBK (Global settings) to 9 also makes 9 corresponding trip equations (TR01–TR09) available for setting. All nine channels are part of the breaker failure protection, as well as part of the bus-zone protection. Therefore, we include the differential trip outputs as well as the station breaker fail trip outputs in the trip equation of each terminal. Setting the trip equations involves assigning the nine differential trip bits to the correct nine trip equations, and assigning the nine station breaker failure trip bits to the correct nine trip equations.

TDURD, Minimum Trip Duration Time Delay Setting

Although the SEL-487B includes nine trip logics, there is only one Minimum Trip Duration Time Delay setting. Set the timer TDURD longer than the operating time of the slowest circuit breaker at the station, using the default value of 12 cycles.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. Press the **TARGET RESET** pushbutton on the front panel to deassert the trip outputs. Alternatively, enter specific reset conditions at the ULTR*kk* settings.

The SEL-487B triggers an event report when any one of the following Relay Word bits asserts:

- 87BTR (any one of the differential trip bits)
- SBFTR (any one of the station breaker failure trip bits)
- TRIP (any one of the nine trip logic outputs)
- ER (user-defined functions)
- **TRI** (ASCII command)

The protection philosophy calls for the relay to generate an event report when the negative-sequence and zero-sequence overvoltage elements assert. To achieve this, enter Relay Word bit 591P1 and 592P1 at the ER prompt.

ER := **591P1 OR 592P1 OR 87S1 OR 87S2 OR 87S3**

Protection Latch bit PLT02 enables/disables the breaker failure protection in the default settings. Include PLT02 in each breaker failure initiate setting for the **BKR FAIL ENABLE** pushbutton to control the breaker failure protection. *Figure 6.98* shows the group settings.

```
=>>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,1-21)                     ETOS    := 5      ?3 <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ?9 <Enter>
Definite Time Overcurrent Elements (N,1-21)          E50     := N      ?> <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>
Terminal Out-of-Service
Terminal 01 Out-of-Service (SELogic Equation)
TOS01 := LB01
?  > <Enter>
Breaker 01 Failure Logic
External Breaker Fail -BK01 (Y,N)                    EXBF01  := N      ?<Enter>
Fault Current Pickup -BK01 (0.50-50 amps,sec)        50FP01  := 3.00   ?2.1 <Enter>
Brkr Fail Init Pickup Delay -BK01 (0.00-6000 cyc)    BFPU01  := 6.00   ?9.5 <Enter>
Retrip Delay -BK01 (0.00-6000 cyc)                   RTPU01  := 3.00   ?4 <Enter>

Breaker Fail Initiate -BK01 (SELogic Equation)
BFI01 := IN101 AND BF_EN
?  ABFIT01 <Enter>
Alt Breaker Fail Initiate -BK01 (SELogic Equation)
ATBFI01 := NA
?  IN201 AND PLT02 <Enter>
Breaker Fail Initiate Seal-In -BK01 (Y,N)            EBFIS01 := N      ?<Enter>
Brkr Fail Init Dropout Delay -BK01 (0.00-1000 cyc)   BFIDO01 := 1.50   ?4 <Enter>

Breaker 02 Failure Logic
External Breaker Fail -BK02 (Y,N)                    EXBF02  := N      ?<Enter>
Fault Current Pickup -BK02 (0.50-50 amps,sec)        50FP02  := 3.00   ?2.1 <Enter>
Brkr Fail Init Pickup Delay -BK02 (0.00-6000 cyc)    BFPU02  := 6.00   ?9.5 <Enter>
Retrip Delay -BK02 (0.00-6000 cyc)                   RTPU02  := 3.00   ?4 <Enter>
Breaker Fail Initiate -BK02 (SELogic Equation)
BFI02 := IN102 AND BF_EN
?  ABFIT02 <Enter>

Alt Breaker Fail Initiate -BK02 (SELogic Equation)
ATBFI02 := NA
?  IN201 AND PLT02 <Enter>
Breaker Fail Initiate Seal-In -BK02 (Y,N)            EBFIS02 := N      ?<Enter>
Brkr Fail Init Dropout Delay -BK02 (0.00-1000 cyc)   BFIDO02 := 1.50   ?4 <Enter>
.
.
.
Trip Logic
Trip 01 (SELogic Equation)
TR01 := TDA_SBF OR TD_TA
?<Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
?<Enter>

Trip 02 (SELogic Equation)
TR02 := TDB_SBF OR TD_TB
?<Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
?<Enter>
Trip 03 (SELogic Equation)
TR03 := TDC_SBF OR TD_TC
?<Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
?<Enter>

Trip 04 (SELogic Equation)
TR04 := TEA_SBF OR TE_TA
?<Enter>
Unlatch Trip 04 (SELogic Equation)
ULTR04 := NA
?<Enter>
```

Figure 6.98 Protection Group Settings for Application 3

```
Trip 05 (SELogic Equation)
TR05 := TEB_SBF OR TE_TB OR TEC_SBF OR TE_TC
?  TEB_SBF OR TE_TB <Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
?<Enter>

Trip 06 (SELogic Equation)
TR06 := NA
?  TEC_SBF OR TE_TC
Unlatch Trip 06 (SELogic Equation)
ULTR06 := NA
?<Enter>
.
.
.
Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000  ? <Enter>

Event Report Trigger Equation (SELogic Equation)
ER := R_TRIG 87ST
?  591P1 OR 592P1 OR 87S1 OR 87S2 OR 87S3 <Enter>
Group 1
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.98 Protection Group Settings for Application 3 (Continued)

This concludes the protection group settings. The next settings class is the front-panel settings.

Front-Panel Settings

The front-panel settings class is where we set functions visible and accessible from the front panel. Settings include LEDs, pushbuttons, front-panel screen selection, display point, and local control. All of these functions have default settings, except five pushbuttons and the display points.

Because not all functions are required in this application, change the settings according to the protection philosophy. Remove the following LED settings:

- ZONE 4 trip indication (LED 6)
- ZONE 5 trip indication (LED 7)
- ZONE 6 trip indication (LED 8)
- 50 indication (LED 9)
- 51 indication (LED 10)
- 89 IN PROG (LED 14)
- 89 ALARM (LED 15)

Also, change the number of Local bits for the TOS (Terminal Out of Service) function to the correct number, 3. *Figure 6.99* shows the settings.

```
=>>SET F <Enter>
Front Panel
Front Panel Settings
Front Panel Display Time-Out (OFF,1-60 mins)        FP_TO   := 15     ? <Enter>
Enable LED Asserted Color (R,G)                     EN_LEDC := G      ? <Enter>
Trip LED Asserted Color (R,G)                       TR_LEDC := R      ? <Enter>

Pushbutton LED 1 (SELogic Equation)
PB1_LED := PLT01 # DIFFERENTIAL PROTECTION ENABLED
?  <Enter>
PB1_LED Assert & Deassert Color (Enter 2: R,G,A,O)   PB1_COL := AO     ? <Enter>
Pushbutton LED 2 (SELogic Equation)

PB2_LED := PLT02 # BREAKER FAILURE ENABLED
.
.
.
PB12LED Assert & Deassert Color (Enter 2: R,G,A,O)   PB12COL := AO     ? <Enter>

Target LED 1 (SELogic Equation)
T1_LED := 87BTR
?  <Enter>
Target LED 1 Latch (Y,N)                            T1LEDL  := Y      ? <Enter>
T1_LED Assert & Deassert Color (Enter 2: R,G,A,O)    T1LEDC  := RO     ? <Enter>
Target LED 2 (SELogic Equation)
T2_LED := SBFTR
?  <Enter>
.
.
.
Target LED 6 Latch (Y,N)                            T6LEDL  := Y      ?N <Enter>
T6_LED Assert & Deassert Color (Enter 2: R,G,A,O)    T6LEDC  := RO     ? <Enter>
Target LED 7 (SELogic Equation)
T7_LED := 87Z5
?  <Enter>
Target LED 7 Latch (Y,N)                            T7LEDL  := Y      ?N <Enter>
T7_LED Assert & Deassert Color (Enter 2: R,G,A,O)    T7LEDC  := RO     ? <Enter>
Target LED 8 (SELogic Equation)
T8_LED := 87Z6
?  <Enter>
Target LED 8 Latch (Y,N)                            T8LEDL  := Y      ?N <Enter>
T8_LED Assert & Deassert Color (Enter 2: R,G,A,O)    T8LEDC  := RO     ? <Enter>

Target LED 9 (SELogic Equation)
T9_LED  := 50P01T OR 50P02T OR 50P03T OR 50P04T OR 50P05T OR 50P06T OR \
            50P07T OR 50P08T OR 50P09T OR 50P10T OR 50P11T OR 50P12T OR \
            50P13T OR 50P14T OR 50P15T OR 50P16T OR 50P17T OR 50P18T OR \
            50P19T OR 50P20T OR 50P21T
?  <Enter>
Target LED 9 Latch (Y,N)                            T9LEDL  := Y      ?N <Enter>
T9_LED Assert & Deassert Color (Enter 2: R,G,A,O)    T9LEDC  := RO     ? <Enter>
Target LED 10 (SELogic Equation)
T10_LED := 51T01 OR 51T02 OR 51T03 OR 51T04 OR 51T05 OR 51T06 OR \
            51T07 OR 51T08 OR 51T09 OR 51T10 OR 51T11 OR 51T12 OR \
            51T13 OR 51T14 OR 51T15 OR 51T16 OR 51T17 OR 51T18 OR \
            51T19 OR 51T20 OR 51T21
?  <Enter>
Target LED 10 Latch (Y,N)                           T10LEDL := Y      ?N <Enter>
T10LED Assert & Deassert Color (Enter 2: R,G,A,O)    T10LEDC := RO     ? <Enter>

Target LED 11 (SELogic Equation)
T11_LED := 87ST
?  <Enter>
.
.
.
?  <Enter>
Target LED 24 Latch (Y,N)                           T24LEDL := N      ? <Enter>
T24LED Assert & Deassert Color (Enter 2: R,G,A,O)    T24LEDC := RO     ? <Enter>


Selectable Screens for the Front Panel

Front Panel Display Update Rate (OFF,1-15 seconds)   SCROLD  := 5      ? <Enter>
Station Battery Screen (Y,N)                        STA_BAT := N      ? <Enter>
Fundamental Voltage and Current Screen (Y,N)        FUND_VI := Y      ? <Enter>
Differential Metering (Y,N)                         DIFF    := Y      ? <Enter>
Terminals Associated with Zones (Y,N)               ZONECFG := Y      ? <Enter>

Selectable Operator Pushbuttons

Pushbutton 1 HMI Screen (OFF,AP,DP,EVE,SER)         PB1_HMI := OFF    ?> <Enter>
```

Figure 6.99 Front-Panel Settings for Application 3

```
Front Panel Event Display

Enable HMI Auto Display of Event Summaries (Y,N)     DISP_ER := Y      ?> <Enter>

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

1:
?  <Enter>


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

1: LB01,"F1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  LB01,"Terminal TD","OUT OF SERVICE","IN SERVICE",N<Enter>
2: LB02,"F2 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  LB02,"Terminal TE","OUT OF SERVICE","IN SERVICE",N<Enter>
3: LB03,"F3 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  LB03,"tERMINAL TF","OUT OF SERVICE","IN SERVICE",N<Enter>
4: LB04,"T1 OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  DELETE<Enter>
4: LB05,"TB OUT OF SERVICE","OUT OF SERVICE","IN SERVICE",N
?  END<Enter>

Front Panel

Front Panel Settings

.
.
.

SER Parameters

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

=>>
```

Figure 6.99 Front-Panel Settings for Application 3 (Continued)

This concludes the front-panel settings. The next settings class is the control output settings.

Control Output Settings

In this setting class, we assign the logic or Relay Word bits in the relay to output contacts. We need six output contacts for our example:

- three for the differential and breaker failure trip outputs
- three for direct transfer trip outputs

Although not specifically called for in the protection philosophy, it is good practice to also include the TEST and ALARM outputs in the relay settings.

Because the relay interprets the NUMBK setting as the number of poles, there are nine trip equations for this application. There is, of course, only one circuit breaker for each terminal. We therefore combine the appropriate trip outputs from the breaker trip logic (TRIP01–TRIP09, see *Figure 6.85*) to provide a single trip output for each circuit breaker. For example, we set (Group settings) the trip equations for Terminal TD to TR01 := TDA_SBF OR TD_TA, TR02 := TDB_SBF OR TD_TB, and TR03 := TDC_SBF OR TD_TC, with the corresponding breaker trip logic output alias names of TRTD_A, TRTD_B, and TRTD_C. Because Terminal TD has only one circuit breaker, assertion of any one of the three breaker trip logic outputs (TRTD_A, TRTD_B, or TRTD_C) must trip the circuit breaker of Terminal TD. To achieve this combination, enter all three of the breaker trip logic output Relay Word bits in the output equation of the circuit breaker of Terminal TD. We assign the output Relay Word bits of the breaker failure logic to output contacts OUT204, OUT205, and OUT206 for direct transfer tripping.

Figure 6.100 shows the output settings. We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRTD_A AND NOT TNS_SW
?  NA <Enter>
OUT102 := TRTD_B AND NOT TNS_SW
?  NA <Enter>
OUT103 := TRTD_C AND NOT TNS_SW
?  NA <Enter>
OUT104 := TRTE_A AND NOT TNS_SW
?  NA <Enter>
OUT105 := TRTE_B AND NOT TNS_SW
?  NA <Enter>
OUT106 := NA
?  > <Enter>
Interface Board #1
OUT201 := NA
?  (TRTD_A OR TRTD_B OR TRTD_C) AND NOT PLT03 <Enter>
OUT202 := NA
?  (TRTE_A OR TRTE_B OR TRTE_C) AND NOT PLT03 <Enter>
OUT203 := NA
?  (TRTF_A OR TRTF_B OR TRTF_C) AND NOT PLT03 <Enter>
OUT204 := NA
?  (TDA_SBF OR TDB_SBF OR TDC_SBF) AND NOT PLT03 <Enter>
OUT205 := NA
?  (TEA_SBF OR TEB_SBF OR TEC_SBF) AND NOT PLT03 <Enter>
OUT206 := NA
?  TFA_SBF OR TFB_SBF OR TFC_SBF AND NOT PLT03 <Enter>
OUT207 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.100 Output Settings for Application 3

This concludes the settings for Application 3.

Application 4: Single Bus and Transfer Bus With Bus Coupler

This application describes the busbar arrangement shown in *Figure 6.101*, single bus and transfer bus with tie breaker (bus coupler). The busbar arrangement consists of two busbars (main busbar and transfer busbar), four feeders and a tie breaker. Consider the following to set and configure the relay:

- Busbar classification
- Protection philosophy
- Protection functions selection
- Number of SEL-487B Relays and I/O boards
- Input, logic, and output allocation and alias name assignment

- ➤ Station layout update
- ➤ Relay setting and configuration

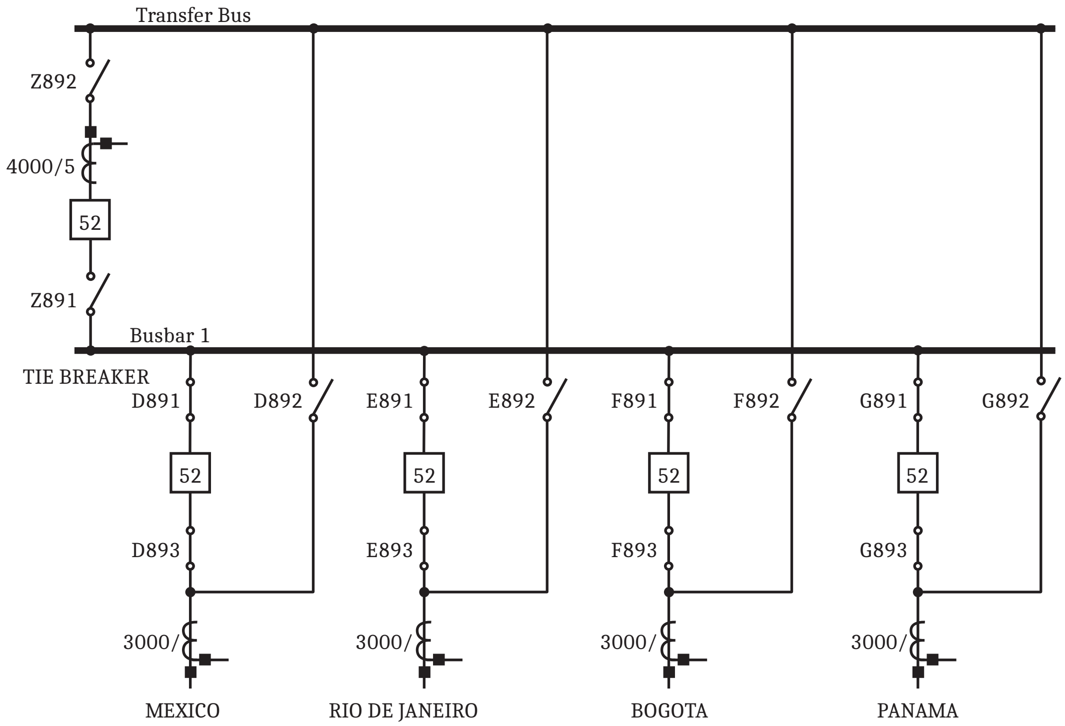


Figure 6.101 Single Bus and Transfer Bus With Bus Coupler (Tie Breaker)

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information, and declares the tie-breaker (bus coupler) configuration.

- ➤ Description:
  - ➢ Single bus and transfer bus with tie breaker
- ➤ Current transformers:
  - ➢ Outboard (free standing)
- ➤ Disconnects:
  - ➢ Only 89A disconnect auxiliary contacts are available
- ➤ Bus coupler (tie breaker):
  - ➢ Single CT with one CT core for busbar protection
- ➤ Future expansion:
  - ➢ Five feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not every substation uses all of these functions. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Rename only the terminals and bus-zones with alias names.
2. Block the busbar protection for an open-circuit CT.
3. Use the 89B disconnect auxiliary contacts to dynamically configure the station.
4. Use the zone-switching supervision logic.
5. Prevent the loss of Busbar 1 for a fault between the tie breaker and tie-breaker CT.
6. Ensure bus-zone protection stability for all operating conditions.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs necessary for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. For example, in this application the protection philosophy calls for the use of the zone-switching supervision, but not for breaker failure protection. The SEL-487B offers a number of protection functions as standard features, but it also includes the capability through SELOGIC control equations to create user-configurable functions.

To prevent tripping of Busbar 1 when there is a fault between the tie breaker and tie-breaker CT, we can delay tripping of Busbar 1 and trip the tie breaker first (see *Protection Group Settings on page 6.128*). We then remove the tie-breaker currents from the differential calculations. To remove the tie-breaker currents from the differential calculations, we use the breaker auxiliary contact from the tie breaker and a combination of the coupler security logic and zone supervision.

To properly identify and categorize the protection philosophy requirements, group the protection functions as follows:

- ➤ standard protection functions (available in the relay)
- ➤ user-defined protection functions (created with SELOGIC control equations)

Standard Functions

Refer to the protection philosophy and select the standard functions required for the application. *Table 6.56* shows the selection of the standard functions.

Table 6.56 Selection of the Standard Protection Functions (Sheet 1 of 2)

Protection Function	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	No	We need both 89A and 89B disconnect; only the 89A contact is available.
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions.
Sensitive differential protection	Yes	CT open circuit detection

Table 6.56 Selection of the Standard Protection Functions (Sheet 2 of 2)

Protection Function	Selection	Comment
Zone supervision logic	Yes	Use the zone supervision logic as part of preventing the loss of Busbar 1 for a fault between the tie breaker and the tie-breaker CT.
Zone-switching supervision logic	Yes	Use this logic when only one (either 89A or 89B) disconnect contact is available.
Coupler security logic	Yes	Use the coupler security logic in a single CT application for enhanced protection for faults between the tie-breaker CT and circuit breaker.
Circuit breaker failure protection	No	Not required
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

This application requires no user-defined functions.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- ➤ the number of relays (single-relay application or three-relay application)
- ➤ and the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.15* to calculate the number of current channels at the station, and use *Equation 6.16* to calculate the number of zones at the station.

# of current channels required = # of per-phase station CTs

Equation 6.15

# of bus-zones required = # of per-phase station bus sections

Equation 6.16

The number of per-phase CTs at the station is 15 (the tie breaker has three CT cores), and one SEL-487B suffices. However, the requirement for five future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need three relays. This is known as a three-relay application.

In a three-relay application, each relay provides six zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, the B-phase CTs to Relay 2, and the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information. Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hardwire) the input and output contacts to the other two relays.

This example shows the setting and configuration for the A-phase relay, identified with an appended letter A (MEXCO_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding MEXCO_A setting is MEXCO_B in the B-phase relay, and MEXCO_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The protection philosophy calls for disconnect auxiliary contacts to dynamically configure the station. Because each terminal provides only one disconnect auxiliary contact, we cannot use the disconnect monitoring logic. Each feeder has two busbar disconnects (891 and 892), and the tie breaker also has two disconnects (891 and 892). Each feeder therefore requires two inputs, and the tie breaker requires two inputs, for a total number of ten disconnect logics.

The protection philosophy also calls for zone-switching supervision logic, and we will use the coupler security logic to prevent tripping of Busbar 1 when there is a fault between the tie breaker and tie-breaker CT. For the zone-switching supervision logic, connect the close and open signals from each disconnect in parallel, and wire the parallel combination as a single input into the relay (see *Zone Configuration Group Settings on page 6.124*).

The coupler security logic requires three inputs:

- ➤ a close signal
- ➤ a circuit breaker 52A auxiliary contact
- ➤ an input for the accelerated tripping function (see *Figure 6.110* for more information)

We need one input for the circuit breaker 52A auxiliary contact and one input for the closing signal. For the accelerated tripping input (ACTRP1), we use the output from the BZ1 differential element (87R1). *Table 6.57* summarizes the input contacts necessary for this application.

Table 6.57 Number of Required Relay Inputs

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	(4 • 2) + 2 = 10
Number of relay inputs required for disconnect open/close signal	1
Number of relay inputs required for the coupler security logic on the tie breaker	2 (one closing signal and one circuit breaker auxiliary contact)
Total number of inputs	13

The relay main board has seven inputs, insufficient inputs for our application. Each interface board provides two sets of nine grouped inputs and six independent inputs. Use the grouped inputs for the disconnect auxiliary contact inputs; the six independent inputs are available for breaker failure initiate inputs. Because this application has no circuit breaker failure protection, and the circuit breaker closing signals are best suited for independent inputs, use the independent inputs on the interface board for the circuit breaker closing signal. From the input perspective, we need one interface board. It is not necessary to include I/O for future expansion with the initial order; install additional I/O if and when required.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all circuit breakers are part of the busbar differential protection, we want to trip each breaker when the differential protection operates. *Table 6.58* shows the breakdown and the total number of relay output contacts required for tripping.

Table 6.58 Breakdown and the Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for tripping the circuit breakers	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the **RELAY TEST MODE** pushbutton on the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board contacts are all standard output contacts. The interface boards can have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board provides six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with a single interface board.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point, we have determined the following:

- The number of SEL-487B Relays necessary for the application
- The number of inputs
- The number of output contacts
- The selected protection functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- Link specific CT inputs to specific relay analog channels
- Link specific disconnect and circuit breaker inputs to specific relay input contacts
- Link relay element/logic outputs to specific relay output contacts
- Assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog quantity
- Terminal name
- Bus-Zone name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed using characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation, and CT Alias Assignment

The protection philosophy specifies that only the terminals and bus-zones need alias names. *Table 6.59* shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT to relay Channel I01, and assign to this CT the alias name TIE_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.59* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left-to-right from *Figure 6.101*.

Table 6.59 CTs-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT, A-phase	I01	TIE_A
MEXICO terminal, A-phase	I02	MEXCO_A
RIO DE JANEIRO terminal, A-phase	I03	RIODJ_A
BOGOTA terminal, A-phase	I04	BOGOT_A
PANAMA terminal, A-phase	I05	PANAM_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. For the A-phase relay, we use two bus-zones with alias names as shown in *Table 6.60*.

Table 6.60 Alias Names for the Two Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	BUS_A
BZ2	Bus-Zone 2	TRANS_A

Input-to-Logic Allocation

Table 6.57 shows that we require 13 digital inputs. We now assign the 13 digital input contacts to the selected logic. There are 18 grouped and 6 independent input contacts on the interface board. We assign the 10 disconnect inputs to the grouped terminals and the remaining 3 inputs to the independent relay inputs on the interface board.

Input Contact to Logic Allocation, Main Board

This application requires no main board inputs.

Input Contact-to-Logic Allocation, Interface Board 1 (200)

Table 6.61 shows the disconnect and circuit breaker auxiliary contact input allocations. Because inputs IN201–IN203 and IN213–IN215 are independent inputs, assign the inputs for the coupler security logic and the open/closing signals to these relay inputs.

Table 6.61 Relay Input-to-Relay Logic Assignment

Input	Description
IN201	TIE-BREAKER circuit breaker 52A auxiliary contact
IN202	TIE-BREAKER circuit breaker closing signal
IN203	Disconnect open/closing signal
IN204	TIE-BREAKER disconnect (BUS_A) NO contact
IN205	TIE-BREAKER disconnect (TRANS_A) NO contact
IN206	MEXICO terminal disconnect (BUS_A) NO contact
IN207	MEXICO terminal disconnect (TRANS_A) NO contact
IN208	RIO DE JANEIRO terminal disconnect (BUS_A) NO contact
IN209	RIO DE JANEIRO terminal disconnect (TRANS_A) NO contact
IN210	BOGOTA terminal disconnect (BUS_A) NO contact
IN211	BOGOTA terminal disconnect (TRANS_A) NO contact
IN212	PANAMA terminal disconnect (BUS_A) NO contact
IN216	PANAMA terminal disconnect (TRANS_A) NO contact

Identification of the Selected Standard Logic

The following explains each selected function in reference to *Table 6.56*. Alias name assignments are also included.

Differential Trip Logic Identification

Figure 6.102 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.) *Table 6.62* shows the Relay Word bits and description for the zone differential protection outputs.

Table 6.62 Zone Differential Protection Output Relay Word Bits

Primitive Name	Description
87Z1	Zone 1 differential element trip
87Z2	Zone 2 differential element trip

Differential trip bits 87BTR01–87BTR05 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

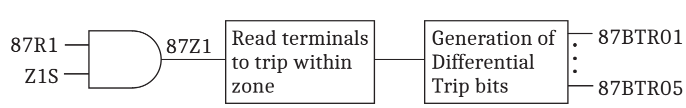


Figure 6.102 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.123* for more information). *Table 6.63* shows the differential trip bit and the associated terminals.

Table 6.63 Differential Trip Bit and Associated Terminals

Differential Trip Bit	Description
87BTR01	Associated with Terminal 01
87BTR02	Associated with Terminal 02
87BTR03	Associated with Terminal 03
87BTR04	Associated with Terminal 04
87BTR05	Associated with Terminal 05

Relay Logic-to-Output Contact Allocation

Table 6.58 shows the breakdown of the five relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts. *Table 6.64* shows TEST and ALARM protection logic assigned to the output contacts of the main board output contacts. *Table 6.65* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1.

Output Contact Allocation, Main Board

This application requires only the TEST and ALARM output contacts from the main board.

Table 6.64 Alias Names and Contact Allocation of the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Contact Allocation, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.65* shows the assignment for the five terminals of the A-phase relay.

Table 6.65 Allocation of the Interface Board Output Contacts

Output Contact Assignment	Description
OUT201[a]	Tie-breaker trip logic output
OUT202[a]	MEXICO trip logic output
OUT203[a]	RIO DE JANERO trip logic output
OUT204[a]	BOGOTA trip logic output
OUT205[a]	PANAMA trip logic output

[a] High-speed, high-interrupting outputs.

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all the relevant information on the station diagram, as shown in *Figure 6.103*.

1. Write down the bus-zone, terminal, and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal/zone allocation.
3. Allocate the terminal CTs to the relay input current channels.
4. Allocate the terminal digital inputs to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals.

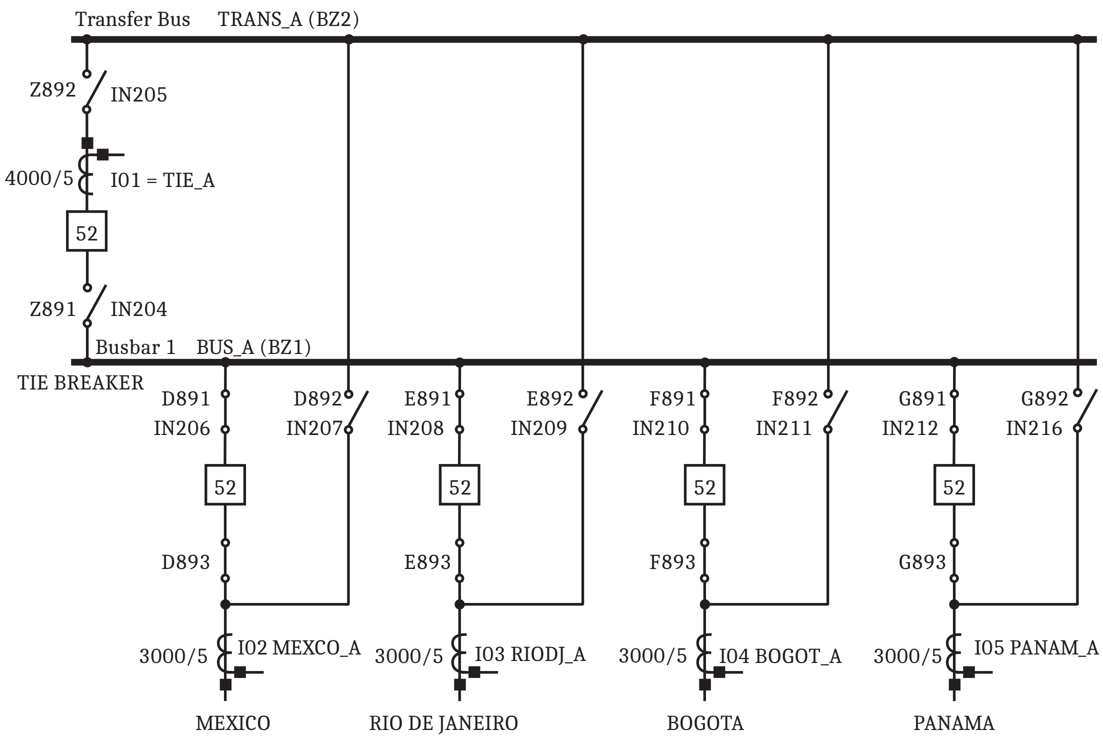


Figure 6.103 Substation Layout With Specific Information

Setting the Relay

The following describes the settings for this application. For this application example, we set the following setting classes:

- Alias Settings
- Global Settings
- Zone Configuration Group Settings
- Protection Group Settings
- Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay.

Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.104*.

After inspecting the list, we decide the only useful alias names are those of the 24 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: I01,"FDR_1"
?  LIST <Enter>

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"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: I01,"FDR_1"
?
```

Figure 6.104 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.105*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.105 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the setting list. Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.106*.

```
v1: OUT107,"TEST"
?  > <Enter>
27:
?  I01,TIE_A <Enter>
28:
?  I02,MEXCO_A <Enter>
29:
?  I03,RIODJ_A <Enter>
30:
?  I04,BOGOT_A <Enter>
31:
?  I05,PANAM_A <Enter>
32:
?  BZ1,BUS_A <Enter>
33:
?  BZ2,TRANS_A <Enter>
34:
?  PLT01,DIFF_EN <Enter>
35:
? PLT03,TNS_SW <Enter>
36:
? END <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.106 Analog Quantities and Relay Word Bits Alias Names

This concludes the alias settings. The next settings class is global settings.

Global Settings

Global settings comprise settings that apply to all protection setting groups. For example, when changing from Protection Setting Group 1 to Protection Setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.107* shows the setting changes we need for our example.

Because there are five circuit breakers at the station, set NUMBK to 5. Setting NUMBK to 5 makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting.

Declare here the input contact for the tie-breaker auxiliary contact (52A01 := IN201). Set the remaining four circuit breaker auxiliary input equations (52A02–52A05) to NA.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?  <Enter>
Relay Identifier (40 characters)
RID := "Relay 1"
?  <Enter>
Number of Breakers (N,1-21)                          NUMBK   := 5      ?> <Enter>

Global Enables

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

Control Inputs (Global)

Input Pickup Delay (0.0-30 ms)                       GINPU   := 2.0    ?> <Enter>

Settings Group Selection

Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  ><Enter>

Time and Date Management

Date Format (MDY,YMD,DMY)                            DATE_F  := MDY    ?> <Enter>

Breaker Inputs

N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  IN201<Enter>
N/O Contact Input -BK02 (SELogic Equation)
52A02 := NA
? <Enter>
N/O Contact Input -BK03 (SELogic Equation)
52A03 := NA
?  > <Enter>

DNP

Event Summary Lock Period (0-1000 s)                 EVELOCK := 0      ?> <Enter>
Global
.
.
.
EVELOCK := 0        DNPSRC  := UTC
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.107 Global Settings for Application 4

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism to automatically reconfigure the zone of protection, without any wiring changes (See *Dynamic Zone Selection Logic on page 5.14* for more information).

In this example, the dynamic zone selection logic uses the disconnect auxiliary contact status to determine the station configuration and assign the input currents from the CTs to the appropriate differential elements. For each terminal, wire an 89B disconnect auxiliary contact to the relay.

Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays. Because we wire a disconnect auxiliary contacts to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the Mexico feeder, all three phases (MEXCO_A, MEXCO_B, and MEXCO_C) operate together. Because the relay measures the three phases in three separate relays (phase MEXCO_A in the A-phase relay, phase MEXCO_B in B-phase relay, etc.), we must convey the disconnect status to all three relays.

For this discussion, we define the following terms:

- ➤ Source busbar: the busbar to which all terminals are connected, except the terminal on transfer
- ➤ Transfer busbar: the busbar to which the terminal on transfer is connected
- ➤ Transfer disconnect: the disconnect that connects the terminal to the transfer busbar (disconnect G892 on the Panama Feeder)

Although the relay is flexible enough to accept settings for many disconnect combinations, we will configure the relay according to the following operating conditions:

- ➤ Only one feeder will be on transfer at any given time, i.e., the tie-breaker disconnects and the feeder transfer disconnect (*n*892, *n* = D, E, F, G) of only one of the four feeders can be closed simultaneously.
- ➤ Only Busbar 1 can be the source busbar.
- ➤ The operating sequence to put a feeder on transfer is fixed.

Because the operating sequence defines a set of operating rules, settings engineers can decide on appropriate terminal-to-bus-zone and bus-zone-to-bus-zone settings for each step.

Table 6.66 shows the operating sequence for the settings in this application; many other operating sequences are possible and in use.

Refer to *Figure 6.103* and consider a case in which we put the PANAMA Feeder on transfer.

Assume the tie breaker is open and both tie-breaker disconnects are open.

Table 6.66 Fixed Operating Sequence to Put a Feeder on Transfer

Step Number	Description	Comment
1	Close tie-breaker disconnects Z892 and Z891. Close the tie-breaker circuit breaker.	Feeder Disconnects D891, E891, F891, and G891 as well as D893, E893, F893, and G893 are now closed. Feeder Disconnects D892, E892, F892, and G892 are open. Closing the tie breaker brings both busbars to the same potential.
2	Close the Panama G892 disconnect.	Closing Disconnect G892 forms a bus-zone-to-bus-zone connection, resulting in a parallel path between the tie breaker and the Panama Feeder. Merge the two zones to prevent possible relay misoperation.
3	Open the Panama circuit breaker.	Although the current distribution is known at this point, the feeder is still considered in the intermediate position and the two zones are still merged.
4	Open the line disconnect (G893) of the Panama feeder. Open the Busbar 1 (G891) disconnect.	Opening G891 removes the bus-zone-to-bus-zone connection, forming two independent zones. The Panama feeder is now on transfer.

Because the operating sequence prevents connections that could result in relay misoperation, we must merge the zones during the intermediate position (Step 2 in *Table 6.66*). We define this intermediate position as the time when disconnects *n*891 and *n*892 of any feeder are closed simultaneously.

Enter this state to merge the zones in the bus-zone-to-bus-zone connections:

BZ1BZ2V := **(IN206 AND IN207) OR (IN208 AND IN209) OR (IN210 AND IN211) OR (IN212 AND IN216)**

We use a combination of the zone supervision and coupler security logics to prevent tripping Busbar 1 for a fault between the tie-breaker circuit breaker and CT. For the zone supervision setting, we supervise the BZ1 differential element output by the negated coupler security output (ZS1 := NOT CSL1) (see *Protection Group Settings on page 6.128* for more information).

I01BZ1V and I01BZ2V, the tie-breaker terminal-to-bus-zone settings, comprise the disconnect auxiliary contacts (IN204 and IN205), the circuit breaker auxiliary contact (CB52A1), the circuit breaker closing signal (CBCLST1), and the coupler status timed out bit (CB52T1). (See *Figure 6.110* and *Protection Group Settings on page 6.128* for more detail.)

In this application, the disconnect provides only one (89B) disconnect auxiliary contact. We cannot use the disconnect monitoring logic because the disconnect monitoring logic requires two disconnect auxiliary contacts. For installations with only one disconnect auxiliary contact, use the zone-switching supervision logic. (See *Section 5: Protection Functions* for more information.) Enable the zone switching supervision by setting EZSWSUP := Y. Connect the open and close signals from the disconnects in parallel (see *Figure 6.108*).

In this application, we assign this parallel connection to relay input IN203. Set ZSWO := IN203.

Alarm ZSWOAL stays asserted indefinitely in the event of the disconnect auxiliary contact failing to change status. Use pushbutton PB5 to reset Alarm ZSWOAL when a disconnect auxiliary contact fails to change status. Set RZSWOAL := PB5.

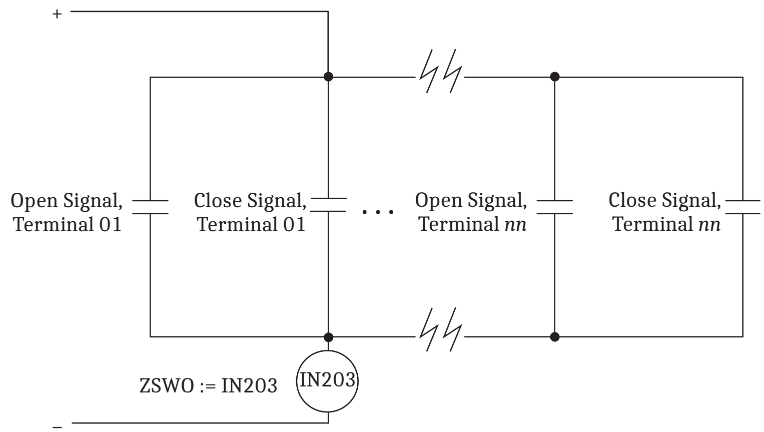


Figure 6.108 External Wiring and Initiation Input for Zone-Switching Supervision

Measure each disconnect travel time.

Set the zone-switching operation pickup delay (ZSWOPU) to a value longer than the time necessary for the slowest disconnect to complete an open-to-close, or close-to-open operation. Based on previous experience with similar equipment, we set the ZSWOPU to 3600 cycles in this example. *Figure 6.109* shows the zone configuration settings for this application.

The zone configuration default settings are for a specific substation with arbitrarily selected alias names, serving only as an example.

For ease of setting zone configuration settings for the new substation, delete the terminal-to-bus-zone connections default settings. With the terminal-to-bus-zone connections default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone connection settings. *Figure 6.109* shows the zone configuration settings for this application.

```
=>>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    ?800 <Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?600 <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TIE_A, BUS_A, P
?  DELETE 100 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,BZ1,P <Enter>
TIE_A to BUS_A Connection (SELogic Equation)
I01BZ1V := NA
?  IN204 AND IN205 AND (CB52A1 OR CBCLST1) <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I01,BZ2,N <Enter>
TIE_A to TRANS_A Connection (SELogic Equation)
I01BZ2V := NA
?  IN204 AND IN205 AND (CB52T1 OR CBCLST1) <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02,BZ1,P <Enter>
MEXCO_A to BUS_A Connection (SELogic Equation)
I02BZ1V := NA
?  IN206 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02,BZ2,P <Enter>
```

Figure 6.109 Zone Configuration Group Settings for Application 4

```
MEXCO_A to TRANS_A Connection (SELogic Equation)
IO2BZ2V := NA
?  IN207 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,BZ1,P <Enter>
RIODJ_A to BUS_A Connection (SELogic Equation)
IO3BZ1V := NA
?  IN208 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,BZ2,P <Enter>

RIODJ_A to TRANS_A Connection (SELogic Equation)
IO3BZ2V := NA
?  IN209 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,BZ1,P <Enter>
BOGOT_A to BUS_A Connection (SELogic Equation)
IO4BZ1V := NA
?  IN210 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,BZ2,P <Enter>

BOGOT_A to TRANS_A Connection (SELogic Equation)
IO4BZ2V := NA
?  IN211 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,BZ1,P <Enter>
PANAM_A to BUS_A Connection (SELogic Equation)
IO5BZ1V := NA
?  IN212 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,BZ2,P <Enter>

PANAM_A to TRANS_A Connection (SELogic Equation)
IO5BZ2V := NA
?  IN216 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?
Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
?  BZ1,BZ2 <Enter>

BUS_A to TRANS_A Connection (SELogic Equation)
BZ1BZ2V := NA
?  (IN206 AND IN207) OR (IN208 AND IN209) OR (IN210 AND IN211) OR (IN212 AND IN\
216) <Enter>
Connection to Remove Terminals when BUS_A and TRANS_A merge (SELogic Equation)
BZ1BZ2R := NA
?  (IN206 AND IN207) OR (IN208 AND IN209) OR (IN210 AND IN211) OR (IN212 AND IN\
216) <Enter>

Terminals Removed when BUS_A and TRANS_A Bus-Zones merge (Ter k,...,Ter n)
BZ1BZ2M :=
?  IO1 <Enter>
Trip Terminals TIE_A (Y,N)
BZ1BZ2T := N
?  Y <Enter>
Bus-Zone, Bus-Zone
?

Zone Supervision
Differential Element Zone Supervision (Y,N)        E87ZSUP := N      ?Y <Enter>
Zone 1 Supervision (SELogic Equation)
Z1S := 1
?  NOT CSL1 <Enter>
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?  > <Enter>

Zone Switching Supervision (Y,N)                   EZSWSUP := N      ?Y <Enter>
Zone Switching Operation (SELogic Equation)
ZSWO := NA
?  IN203 <Enter>
Reset Zone Switching Op Alarm (SELogic Equation)
RZSWOAL := NA
?  PB5 <Enter>
Zone Switching Op Pickup Delay (0-99999 cyc)       ZSWOPU  := 1800   ?3600 <Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.109 Zone Configuration Group Settings for Application 4 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, beginning with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available. For this application, we use the default values for the sensitive differential element, the restrained differential element and the directional element.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Use the sensitive differential element for this requirement by setting E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information).

We need one coupler security logic for this application. Set ECSL := 1. Set ETOS := N, EBFL := N, E50 := N, E51 := N, E27 := N, E59 := N, and EADVS := N because we do not use the terminal out of service function, breaker failure protection, overcurrent elements, voltage elements, or advanced settings in this application.

Setting NUMBK to 5 (Global settings) makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting. Each of the five analog channels has a corresponding differential trip bit that asserts (*Table 6.63*) when the differential element asserts.

Be sure to include these differential trip bits in the trip equations of all circuit breakers you want to trip. When applying the coupler security logic as in this example, include the differential element trip output (87R1) and the 87BTR01 differential trip bit in the tie-breaker trip logic.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative method is to enter specific reset conditions at the ULTR*kk* settings.

Figure 6.110 shows the combination of the coupler security logic and the zone supervision with the input settings applied. Notice that Gate 1 and Gate 2 represent the tie-breaker terminal-to-bus-zone connection settings; they are not part of the fixed logic.

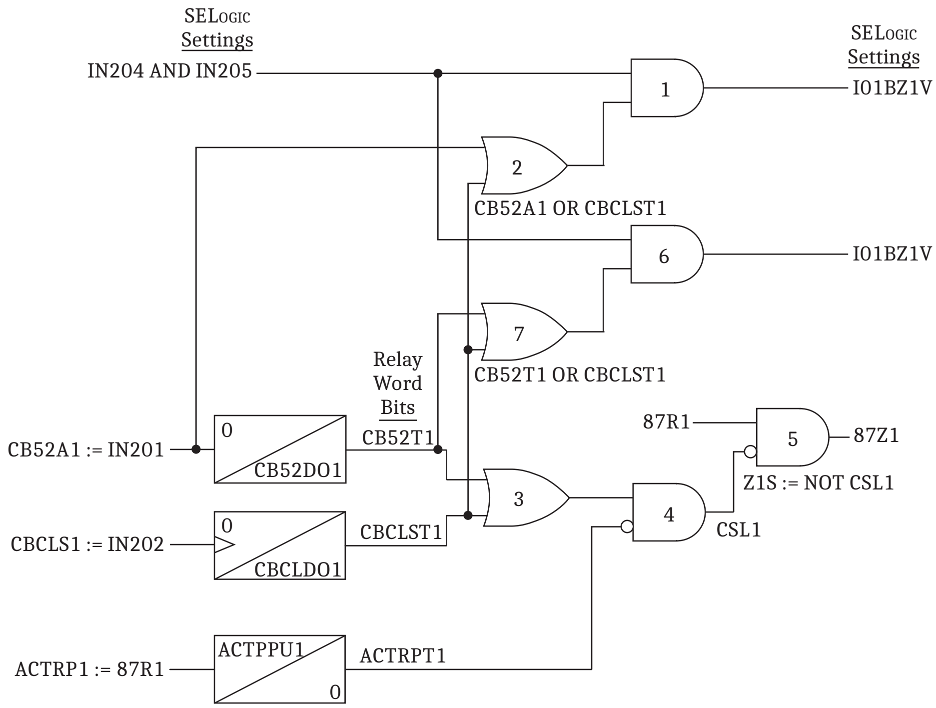


Figure 6.110 Coupler Security Logic With Applied Input Settings

The protection philosophy calls for the loss of only one zone when a fault between the tie-breaker CT and circuit breaker occurs. Use the coupler security logic to prevent the loss of Busbar 1 for a fault between the tie-breaker CT and circuit breaker. Be aware, however, that using this logic delays relay operation for all busbar faults on Busbar 1.

Assume for this application that the maximum circuit breaker tripping time is two cycles and that the maximum closing time is four cycles. Refer to *Figure 6.110*, and notice the difference in the CB52A1 and CBCLS1 inputs from the regular coupler security application. Input CBCLS1 provides the closing signal information to the relay. For an open-to-close operation, Input CBCLS1 asserts when the operator issues a closing signal to the circuit breaker, asserting Relay Word bits I01BZ1V and I01BZ2V. When Relay Word bits I01BZ1V and I01BZ2V assert, the relay considers the CT in the differential equations. Inserting the CTs in the differential equations before primary current flows emulates the early make, late break timing requirement for the disconnect auxiliary contacts. Set the timer dropout time (CBCLDO1) to a value longer than the maximum breaker closing time. In this example, allow a short safety margin and set CBCLDO1 to 5 cycles (default value). A setting of five cycles allows the circuit breaker ample time to change state, during which time Relay Word bit CB52A1 asserts.

When opening the circuit breaker, the inverse applies. For a close-to-open circuit breaker operation, we must guard against prematurely removing the CTs from the differential equations due to circuit breaker auxiliary contact misalignment. We use CB52T1 in the tie-breaker terminal-to-bus-zone connection settings to accomplish this for Zone 2. However, because we supervise all Zone 1 faults, premature removal of the CTs does not adversely affect Zone 1 differential elements.

Figure 6.111 shows just the tie breaker and two terminals of the application. The single CT on the tie breaker has one core, providing CT information to both differential elements. The challenge to the coupler security logic is to trip BZ2 and not BZ1 for Fault F1. This requirement contradicts the existing configuration, for it calls for the coupler security logic to prevent BZ1 from operating for an in-zone fault (fault on Busbar 1) and for BZ2 to operate for an out-of-zone fault (fault on Busbar 1).

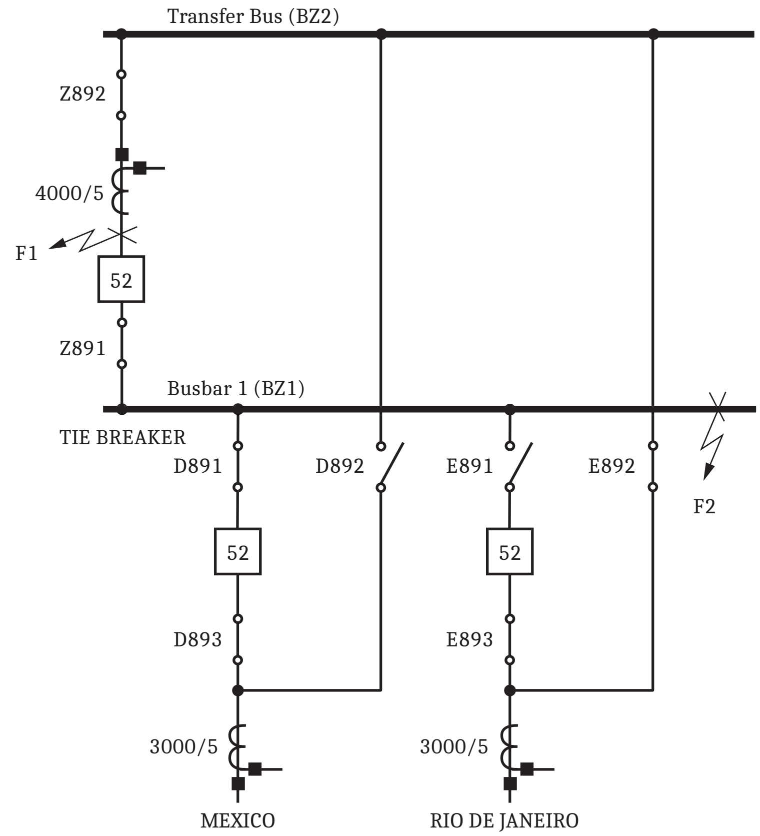


Figure 6.111 Single CT Application With Faults Between the Circuit Breaker and Tie-Breaker CT

Consider the operation when Fault F1 occurs without the coupler security logic. Differential protection BZ2 is stable, and differential protection BZ1 immediately trips the Mexico circuit breaker and the tie-breaker circuit breaker. However, tripping the Mexico circuit breaker and the tie-breaker circuit breaker does not clear Fault F1. Fault current still flows from the Rio de Janeiro Feeder, through the transfer bus, and into the fault. Although breaker failure protection will operate to trip the Rio de Janeiro circuit breaker, this operation takes place after the breaker failure time delay. After the tie-breaker breaker failure timer times out, all circuit breakers in BZ2 zone trip, resulting in both BZ1 and BZ2 tripping to clear Fault F1.

If a delay in bus-zone protection operation is in order, implement the coupler security logic in such a way that tripping of the BZ1 bus-zone is only permitted when the tie-breaker circuit breaker is open. To prevent tripping BZ1, configure the relay to achieve the following:

- Check if the tie-breaker circuit breaker is closed.
- If the tie-breaker circuit breaker is closed, trip only the tie breaker to interrupt the fault current from BZ1; trip no other circuit breakers.
- If the tie breaker is open, allow normal busbar protection tripping.
- When the tie breaker is open, remove the tie-breaker CT from the differential calculations of BZ1 and eventually BZ2.

To check the tie-breaker status and remove the CT from the supervised zone when the tie breaker is open, use the tie-breaker auxiliary contact in the tie-breaker terminal-to-bus-zone connection settings. To remove the CT from the unsupervised zone, use the coupler status timed-out bit (CB52T1) in the tie-breaker terminal-to-bus-zone connection settings. To trip only the tie breaker for a fault on Busbar 1 requires the following two settings:

- ➤ Supervising the BZ1 differential element
- ➤ Issuing a trip signal to the tie breaker first

Supervise the BZ1 differential element output with the negated output from the coupler security logic (Z1S := NOT CSL1). We assign 87R1, the unsupervised output from the BZ1 differential element, to ACTRP1, the accelerated trip input of the coupler security logic. When accelerated trip timer output (ACTRPT1) asserts, Gate 4 in *Figure 6.110* turns off and Relay Word bit CSL1 deasserts. When Relay Word bit CSL1 deasserts, Relay Word bit Z1S asserts, removing the supervision from the BZ1 differential element.

Supervising the BZ1 differential element in this way prevents the tripping of all terminals in BZ1, including the tie breaker. To trip the tie breaker, include 87R1, the unsupervised output from Differential Element 1 in the trip equation of the tie breaker.

After the tie breaker opens (two cycles), we remove the tie-breaker CT from the differential calculations of BZ1, but not the BZ1 supervision. Maintain the BZ1 supervision for at least another 1.25 cycles (add a safety margin of 0.75 cycle) to allow the differential element to reset. Achieve this delay by setting ACTPPU1 to at least 4 cycles.

For Fault F1, BZ1 operates, asserting Relay Word bit 87R1. When Relay Word bit 87R1 asserts, the accelerated trip timer starts timing. Because of the BZ1 zone supervision (NOT CSL1), 87Z1 cannot assert, and only the bus tie breaker receives a trip signal.

Two cycles later, the tie-breaker trips, interrupting the fault current contribution from BZ1. Assume the circuit breaker auxiliary contact changes state at the same time. When the auxiliary contact changes state, Relay Word bit CB52A1 deasserts, causing Relay Word bits I01BZ1V and eventually I01BZ2V to also deassert. When Relay Word bits I01BZ1V and I01BZ2V deassert, the relay removes the CTs from the differential calculations for BZ1 and BZ2. For Fault F1, the tie breaker is open, but fault current still flows through the CT. Removing the tie-breaker CTs from all differential calculations does not trip BZ1 (no fault current contribution from BZ1) but causes BZ2 to operate (BZ2 balancing tie-breaker CT removed), tripping all circuit breakers on the transfer bus. Removing the bus sectionalizer CTs also deasserts Relay Word bit 87R1, causing the accelerated trip timer to stop timing. Fault F1 is now cleared, although there is a time delay.

For Fault F2, the initial tripping is the same as for Fault F1: BZ1 operates, asserting Relay Word bit 87R1. When Relay Word bit 87R1 asserts, the accelerated trip timer starts timing. Because of the BZ1 zone supervision (NOT CSL1), 87Z1 cannot assert, and only the bus coupler circuit breaker receives a trip signal.

Two cycles later, the tie-breaker circuit breaker trips, and the auxiliary contact changes state at the same time. When the auxiliary contact changes state, Relay Word bit CB52A1 deasserts, causing Relay Word bits I01BZ1V and eventually I01BZ2V to also deassert. When Relay Word bits I01BZ1V and I01BZ2V deassert, the relay removes the CTs from the differential calculations for BZ1 and BZ2. Because the circuit breaker is open, terminals from BZ2 no longer contribute to the fault, and BZ2 is stable. However, the BZ1 zone supervision (NOT CSL1) still supervises the BZ1 trip output for another two cycles. Two cycles later, Accelerate Trip Timer ACTRP1 times out, causing CSL1 to deassert. When Relay Word bit CSL1 deasserts, Relay Word bit Z1S asserts, removing the zone supervision from BZ1, issuing a trip signal to all circuit breakers on Busbar 1.

Although each SEL-487B includes 21 trip logics, there is only one Minimum Trip Duration Time Delay (TDURD) setting.

Because the default setting is longer than the slowest tripping time, use the default setting of 12 cycles. *Figure 6.112* shows the group settings.

```
=>>SET <Enter>

Group 1
Relay Configuration
Sensitive Differential Element Supervision (Y,N)     E87SSUP := Y      ?<Enter>
Coupler Security Logic (N,1-4)                       ECSL    := N      ?1 <Enter>
Terminal Out of Service (N,1-21)                     ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ?N <Enter>
Definite Time Overcurrent Elements (N,1-21)          E50     := N      ?<Enter>
Inverse Time Overcurrent Elements (N,1-21)           E51     := N      ?<Enter>
Enable Under Voltage Elements (N,1-6)                E27     := N      ?<Enter>
Enable Over Voltage Elements (N,1-6)                 E59     := N      ?<Enter>
Advanced Settings (Y,N)                              EADVS   := N      ?<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>
Coupler 1 Security Logic
Coupler 1 Status (SELogic Equation)
CB52A1 := NA
?  IN201 <Enter>

Coupler 1 Status Dropout Delay (0.00-1000 cyc)       CB52D01 := 4.00   ?<Enter>
Coupler 1 Close Command (SELogic Equation)
CBCLS1 := NA
?  IN202 <Enter>
Coupler 1 Close Command D/O Delay (0.00-1000 cyc)    CBCLD01 := 5.00   ?<Enter>
Coupler 1 Acc Trip (SELogic Equation)
ACTRP1 := NA
?  87R1 <Enter>

Coupler 1 Acc Trip Pickup Delay (0.00-1000 cyc)      ACTPPU1 := 4.00   ?<Enter>
Trip Logic
Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87BTR01
?  87R1 OR 87BTR01 <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
?<Enter>

Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87BTR02
?  87BTR02 <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
?<Enter>

Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87BTR03
?  87BTR03 <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
?<Enter>

Trip 04 (SELogic Equation)
TR04 := SBFTR04 OR 87BTR04
?  87BTR04 <Enter>
Unlatch Trip 04 (SELogic Equation)
ULTR04 := NA
?<Enter>

Trip 05 (SELogic Equation)
TR05 := SBFTR05 OR 87BTR05 OR SBFTR06 OR 87BTR06
?  87BTR05 <Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
?<Enter>
```

Figure 6.112 Protection Group Settings for Application 4

```
Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ?<Enter>
Event Report Trigger Equation (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.112 Protection Group Settings for Application 4 (Continued)

This concludes the protection group settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings. Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay. Connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts.

Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA. *Figure 6.113* shows the control output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRIP01 AND NOT TNS_SW
?  > <Enter>
.
.
.
Interface Board #1
OUT201 := NA
?  TRIP01 AND NOT PLT03 <Enter>
OUT202 := NA
?  TRIP02 AND NOT PLT03 <Enter>
OUT203 := NA
?  TRIP03 AND NOT PLT03 <Enter>
OUT204 := NA
?  TRIP04 AND NOT PLT03 <Enter>
OUT205 := NA
?  TRIP05 AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.113 Control Output Settings for Application

This concludes the settings for Application 4.

Application 5: Double Bus With Bus Coupler

This application describes the busbar arrangement shown in *Figure 6.114*, double bus with tie breaker (bus coupler). The busbar arrangement consists of two busbars (main busbar and transfer busbar), four terminals and a tie breaker. Consider the following to set and configure the relay:

- ➤ Busbar classification
- ➤ Protection philosophy
- ➤ Protection functions selection
- ➤ Number of SEL-487B Relays and I/O boards
- ➤ Input, logic, and output allocation and alias name assignment
- ➤ Station layout update
- ➤ Relay setting and configuration

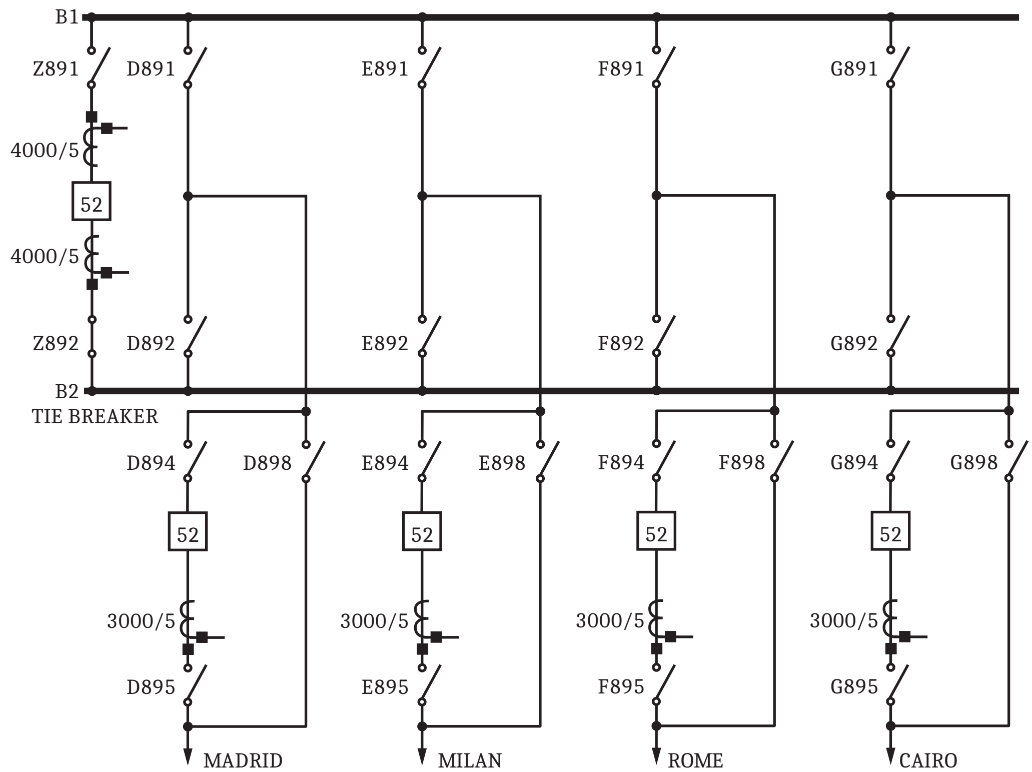


Figure 6.114 Double Bus With Bus Coupler (Tie Breaker)

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information, and declares the tie-breaker (bus coupler) configuration.

- ➤ Description:
  - ➢ Double bus with tie breaker
- ➤ Current Transformers:
  - ➢ Inboard

- Disconnects:
  - 89A and 89B disconnect auxiliary contacts are available
- Bus coupler (tie breaker):
  - Two CTs, configured in overlap
- Future expansion:
  - Four feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not all of these functions are applied at every substation. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Rename only the terminals and bus-zones with alias names.
2. Block the busbar protection for an open circuit CT.
3. Use the disconnect auxiliary contacts to dynamically configure the differential protection.
4. Use the disconnect monitor logic
5. Use external breaker failure protection.
6. Ensure stable differential protection for all operating conditions.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs required for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. Requirement 6 of the protection philosophy calls for stable differential protection for all operating conditions. There are two network conditions when the differential protection can become unstable:

- When disconnects *n*891 and *n*892 (*n* = D, E, F, G) of any feeder are closed at the same time
- When the transfer disconnect of any feeder is closed

By declaring the appropriate conditions in the bus-zone-to-bus-zone connection settings of the zone selection logic, the relay is stable when disconnects *n*891 and *n*892 are closed simultaneously. We use the zone supervision logic to ensure stable differential protection during the time when one of the transfer disconnects is closed.

Standard Functions

Refer to the protection philosophy and select the standard functions required for the application. *Table 6.67* shows the selection of the standard functions.

Table 6.67 Selection of the Standard Protection Functions (Sheet 1 of 2)

Protection Function	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available

Table 6.67 Selection of the Standard Protection Functions (Sheet 2 of 2)

Protection Function	Selection	Comment
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions
Sensitive differential protection	Yes	Use the sensitive differential element as CT open circuit detection
Zone supervision logic	Yes	Use the zone supervision logic to ensure stable differential protection for all operating conditions
Zone-switching supervision logic	No	89A and 89B disconnect contacts available so this logic is not required
Coupler security logic	No	Two CTs in overlap configuration do not require the coupler security logic
Circuit breaker failure protection	Yes	External breaker failure
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Identify logic functions we need for the application that is not part of the standard logic in the relay. We comply with the protection philosophy using the standard functions in the relay.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and 3 voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs we install 3 SEL-487B Relays. Use *Equation 6.17* to calculate the number of current channels at the station, and use *Equation 6.18* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.17

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.18

The number of per-phase CTs at the station is 18 (tie breaker has 6 CT cores), and one SEL-487B suffices. However, the requirement for 4 future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need 3 relays. This is known as a three-relay application.

In a three-relay application, each relay provides six zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, the B-phase CTs to Relay 2, and the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information. Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hardwire) the input and output contacts to the other two relays. This example shows the setting and configuration for the A-phase relay, so identified with an appended letter A (MADRI_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding MADRI_A setting is MADRI_B in the B-phase relay, and MADRI_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, each of the four feeders requires three disconnect monitoring logic and the tie breaker requires two; the number of disconnect logics required is therefore six. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.19* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.19

The protection philosophy calls for external breaker failure as well as dynamic zone selection. Use the external breaker failure logic when the breaker failure relays are integrated in the terminal protection. The zone selection dynamically reconfigures the station according to the disconnect positions and records the terminals in each bus-zone. The relay then uses this information to only trip the terminals in the bus-zone with the failed breaker, when a circuit breaker fails. Wire an output from each breaker failure relay on each of the terminals to the SEL-487B. *Table 6.68* summarizes the input contact required for this application.

Table 6.68 Number of Relay Input Contacts Required

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	2 • 14 = 28
Number of relay inputs required for breaker failure protection	5
Total number of inputs	33

The relay main board has seven input contacts, which are not enough input contacts for our application. Each interface board provides two sets of nine grouped input contacts and six independent input contacts. Use the grouped input contacts for the disconnect auxiliary contact inputs; and five of the six independent input contacts for the breaker failure inputs. From the input contact perspective, we need two interface boards.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all circuit breakers are part of the busbar differential protection, we want to trip each breaker when the differential protection operates. *Table 6.69* shows the breakdown and the total number of relay output contacts required for tripping.

Table 6.69 Breakdown and Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for breaker tripping	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the RELAY TEST MODE pushbutton on the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board contacts are all standard output contacts; high-speed, high-interrupting output contacts provide for faster contact closure. Each interface board can provide six high-speed, high-interrupting output contacts, and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with two interface boards.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point we have determined the number of the following:

- the number of SEL-487B Relays required for the application
- the number of input contacts
- the number of output contacts
- selected protection functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- link specific CT inputs to specific relay analog channels
- link specific disconnect and external circuit breaker failure inputs to specific relay input contacts
- link relay element/logic outputs to specific relay output contacts
- assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog quantity

- Terminal name
- Bus-Zone name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed using characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

The protection philosophy specifies that only the terminals and bus-zones need alias names. *Table 6.70* shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT to relay channel I01, and assign to this CT the alias name TIE1_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.70* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left-to-right from *Figure 6.114*.

Table 6.70 CT-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT1, A-phase	I01	TIE1_A
TIE-BREAKER CT2, A-phase	I02	TIE2_A
MADRID terminal, A-phase	I03	MADRI_A
MILAN terminal, A-phase	I04	MILAN_A
ROME terminal, A-phase	I05	ROME_A
CAIRO terminal, A-phase	I06	CAIRO_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. For the A-phase relay, we use two bus-zones with alias names as shown in *Table 6.71*.

Table 6.71 Alias Names for the Six Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	ZONE1_A
BZ2	Bus-Zone 2	ZONE2_A

Input to Logic Allocation

Table 6.68 shows that we require 33 digital inputs. We now assign the 33 digital input contacts to the selected logic. Because of the functional requirements of this application, we do not need any digital inputs on the main board.

Input Contact to Logic Allocation, Interface Board 1 (200)

Table 6.72 and *Table 6.73* show the disconnect and circuit breaker failure contact input allocations. Because Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs, we assign the circuit breaker failure input signals to these relay inputs.

Table 6.72 Disconnect and Circuit Breaker Failure Contact Input Allocation

Input	Description
IN201	TIE-BREAKER breaker failure input
IN202	MADRID breaker failure input
IN203	MILAN breaker failure input
IN204	TIE-BREAKER disconnect (ZONE2_A) NO contact
IN205	TIE-BREAKER disconnect (ZONE2_A) NC contact
IN206	TIE-BREAKER disconnect (ZONE1_A) NO contact
IN207	TIE-BREAKER disconnect (ZONE1_A) NC contact
IN208	MADRID terminal disconnect (ZONE1_A) NO contact
IN209	MADRID terminal disconnect (ZONE1_A) NC contact
IN210	MADRID terminal disconnect (ZONE2_A) NO contact
IN211	MADRID terminal disconnect (ZONE2_A) NC contact
IN212	MADRID terminal disconnect (TRANS _A) NO contact
IN216	MADRID terminal disconnect (TRANS _A) NC contact
IN217	MILAN terminal disconnect (ZONE1_A) NO contact
IN218	MILAN terminal disconnect (ZONE1_A) NC contact
IN219	MILAN terminal disconnect (ZONE2_A) NO contact
IN220	MILAN terminal disconnect (ZONE2_A) NC contact
IN221	MILAN terminal disconnect (TRANS _A) NO contact
IN222	MILAN terminal disconnect (TRANS _A) NC contact

Input Contact to Logic Allocation, Interface Board 2 (300)

Table 6.73 shows the disconnect and circuit breaker auxiliary contact input allocations. Because Inputs IN301, IN302, IN303, IN313, IN314, and IN315 are independent inputs, we assign the circuit breaker failure input signals to these relay inputs.

Table 6.73 Disconnect and Circuit Breaker Failure Contact Input Allocations

Input	Description
IN301	ROME breaker failure input
IN302	CAIRO breaker failure input
IN304	ROME terminal disconnect (ZONE1_A) NO contact
IN305	ROME terminal disconnect (ZONE1_A) NC contact
IN306	ROME terminal disconnect (ZONE2_A) NO contact
IN307	ROME terminal disconnect (ZONE2_A) NC contact
IN308	ROME terminal disconnect (TRANS _A) NO contact
IN309	ROME terminal disconnect (TRANS _A) NC contact
IN310	CAIRO terminal disconnect (ZONE1_A) NO contact
IN311	CAIRO terminal disconnect (ZONE1_A) NC contact
IN312	CAIRO terminal disconnect (ZONE2_A) NO contact
IN316	CAIRO terminal disconnect (ZONE2_A) NC contact
IN317	CAIRO terminal disconnect (TRANS _A) NO contact
IN318	CAIRO terminal disconnect (TRANS _A) NC contact

Assignment of the Selected Standard Logic

Referring to *Table 6.67*, the following is a discussion on each selected function.

Disconnect Monitoring Logic

Figure 6.115 shows one of the 60 disconnect monitor logic circuits available in the relay. (See *Dynamic Zone Selection Logic on page 5.14* for more information on the disconnect auxiliary contact requirements).

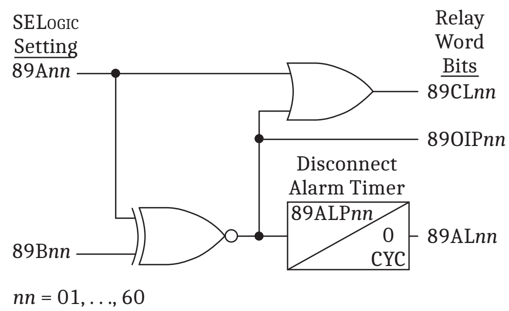


Figure 6.115 One of the Disconnect Monitoring Logic Circuits Available in the Relay

Table 6.74 shows the assignment of the disconnect auxiliary contact Relay Word bits.

Table 6.74 Disconnect Auxiliary Contact Relay Word Bits (Sheet 1 of 2)

Input	Description
89A01	TIE-BREAKER disconnect (ZONE1_A) NO contact
89B01	TIE-BREAKER disconnect (ZONE1_A) NC contact
89A02	TIE-BREAKER disconnect (ZONE2_A) NO
89B02	TIE-BREAKER disconnect (ZONE2_A) NC
89A03	MADRI_A disconnect (ZONE1_A) NO contact
89B03	MADRI_A disconnect (ZONE1_A) NC contact
89A04	MADRI_A disconnect (ZONE2_A) NO contact
89B04	MADRI_A disconnect (ZONE2_A) NC contact
89A05	MADRI_A disconnect (TRANS_A) NO contact
89B05	MADRI_A disconnect (TRANS_A) NC contact
89A06	MILAN_A disconnect (ZONE1_A) NO contact
89B06	MILAN _A disconnect (ZONE1_A) NC contact
89A07	MILAN _A disconnect (ZONE2_A) NO contact
89B07	MILAN _A disconnect (ZONE2_A) NC contact
89A08	MILAN _A disconnect (TRANS_A) NO contact
89B08	MILAN _A disconnect (TRANS_A) NC contact
89A09	ROME_A disconnect (ZONE1_A) NO contact
89B09	ROME _A disconnect (ZONE1_A) NC contact
89A10	ROME _A disconnect (ZONE2_A) NO contact
89B10	ROME _A disconnect (ZONE2_A) NC contact
89A11	ROME _A disconnect (TRANS_A) NO contact

Table 6.74 Disconnect Auxiliary Contact Relay Word Bits (Sheet 2 of 2)

Input	Description
89B11	ROME _A disconnect (TRANS_A) NC contact
89A12	CAIRO _A disconnect (ZONE1_A) NO contact
89B12	CAIRO _A disconnect (ZONE1_A) NC contact
89A13	CAIRO _A disconnect (ZONE2_A) NO contact
89B13	CAIRO _A disconnect (ZONE2_A) NC contact
89A14	CAIRO _A disconnect (TRANS_A) NO contact
89B14	CAIRO _A disconnect (TRANS_A) NC contact

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs on the A-phase relay. Jumper (hardwire) the disconnect input contacts to the other two relays. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations.

Differential Trip Logic and Differential Element Assignment

Figure 6.116 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.) *Table 6.75* shows the Relay Word bits and description for the zone differential protection outputs.

Table 6.75 Zone Differential Protection Output Relay Word Bits

Primitive Name	Description
87Z1	Zone 1 differential element trip
87Z2	Zone 2 differential element trip

Differential trip bits 87BTR01–87BTR06 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

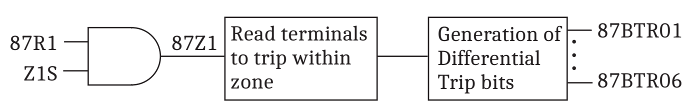


Figure 6.116 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.148* for more information). *Table 6.76* shows the primitive analog channel names and the differential trip bit names for the differential trip bits.

Table 6.76 Differential Trip Bit Names and Associated Terminal Names (Sheet 1 of 2)

Differential Trip Bit	Description
87BTR01	Associated with Terminal 01
87BTR02	Associated with Terminal 02
87BTR03	Associated with Terminal 03
87BTR04	Associated with Terminal 04

Table 6.76 Differential Trip Bit Names and Associated Terminal Names (Sheet 2 of 2)

Differential Trip Bit	Description
87BTR05	Associated with Terminal 05
87BTR06	Associated with Terminal 06

Breaker Failure Trip Logic and Station Breaker Failure Logic Output Assignment

Figure 6.117 shows the station breaker failure trip logic. Relay Word bits FBF01–FBF06 are the inputs to the station breaker failure logic; Relay Word bits SBFTR01–SBFTR06 are the outputs from the station breaker failure logic. Relay Breaker failure trip bits SBFTR01–SBFTR06 assert to trip the circuit breakers of the terminals in the bus-zone with the failed circuit breaker. (See *Section 5: Protection Functions* for more information.)

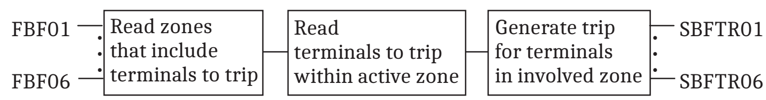


Figure 6.117 Breaker Failure Trip Logic

Table 6.77 shows the station breaker failure Relay Word bits and the primitive names for the breaker failure protection outputs.

Table 6.77 Station Breaker Failure Trip Bit Names and Associated Terminal Names

Station Breaker Failure Trip Bits	Description
SBFTR01	Associated with Terminal 01
SBFTR02	Associated with Terminal 02
SBFTR03	Associated with Terminal 03
SBFTR04	Associated with Terminal 04
SBFTR05	Associated with Terminal 05
SBFTR06	Associated with Terminal 06

Be sure to include the station breaker failure trip bits in the trip equations of all the terminals you want to trip for breaker failure protection. In this example, we want to trip six terminals.

Breaker Failure Input Assignments

This application uses external breaker failure protection. *Figure 6.118* shows the logic for the external breaker failure function.

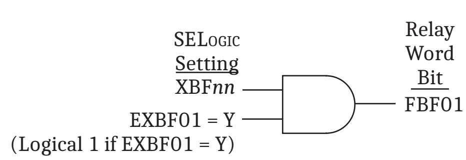


Figure 6.118 Breaker Failure Logic for External Breaker Failure

We assign the relay breaker failure inputs shown in *Table 6.72* to the appropriate XBF*nn* (*nn* = 01–06) of the breaker failure protection logic (see *Protection Group Settings on page 6.154*). *Table 6.78* shows the primitive names and assignments.

Table 6.78 Breaker Failure Logic Output Relay Word Bits

Logic Name	Description
IN201	TIE1_A breaker failure protection asserted
IN201	TIE2_A breaker failure protection asserted
IN202	MADRI_A breaker failure protection asserted
IN203	MILAN_A breaker failure protection asserted
IN301	ROME_A breaker failure protection asserted
IN302	CAIRO_A breaker failure protection asserted

Relay Logic-to-Output Contact Allocation and Output Contact Assignments

Table 6.69 shows the breakdown of the five relay outputs we need for Application 5. We now link the appropriate relay logic outputs to specific relay output contacts. *Table 6.79* shows TEST and ALARM protection logic assigned to the output contacts of the main board output contacts. *Table 6.80* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1.

Output Assignment, Main Board

This application requires no other output contacts from the main board.

Table 6.79 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.80* shows the assignment for the five terminals of the A-phase relay.

Table 6.80 Assignment of the Output Contacts

Output Contact Assignment	Description
OUT201[a]	Tie-Breaker trip logic output
OUT202[a]	MADRID trip logic output
OUT203[a]	MILAN trip logic output
OUT204[a]	ROME trip logic output
OUT205[a]	CAIRO trip logic output

[a] High-speed, high-interrupting outputs.

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all relevant information on the station diagram, as shown in *Figure 6.119*.

1. Write down the bus-zone, terminal and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal zone allocation.
3. Allocate the terminal CTs to the relay input current channels.
4. Allocate the terminal digital inputs to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals.

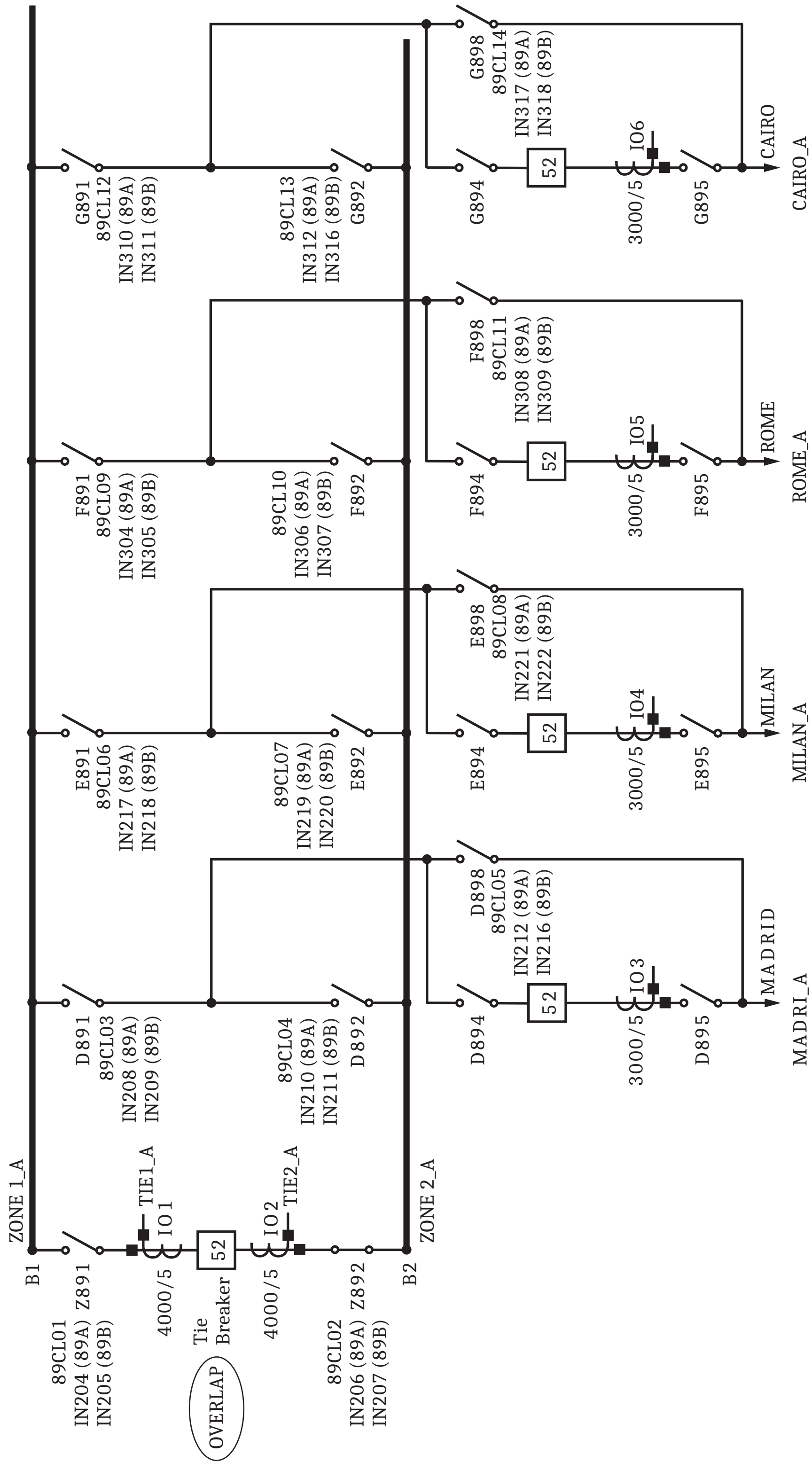


Figure 6.119 Substation Layout With Specific Information

Setting the Relay

The following describes the settings for this application. For this application example, we set the following setting classes:

- Alias Settings
- Global Settings
- Zone Configuration Group Settings
- Protection Group Settings
- Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.120*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: I01,"FDR_1"
?  LIST <Enter>
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"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: I01,"FDR_1"
?
```

Figure 6.120 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.121*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.121 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the setting list. Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.122*.

```
1: OUT107,"TEST"
?  > <Enter>
27:
?  IO1,TIE1_A <Enter>
28:
?  IO2,TIE2_A <Enter>
29:
?  IO3,MADRI_A <Enter>
30:
?  IO4,MILAN_A <Enter>
31:
?  IO5,ROME_A <Enter>
32:
?  IO6,CAIRO_A <Enter>
33:
?  BZ1,ZONE1_A <Enter>
34:
?  BZ2,ZONE2_A <Enter>
35:
?  END <Enter>
Alias
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.122 Analog Quantities and Relay Word Bits Alias Names

This concludes the alias settings. The next settings class is Global settings.

Global Settings

Global settings comprise settings that apply to all protection setting groups. For example, when changing from protection setting Group 1 to protection setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.123* shows the setting changes we need for our example.

Because we declared the alias names in the previous setting class, use either the alias names or the primitive names when entering settings.

Setting NUMDS declares the number of disconnect logics we need, not the number of disconnect inputs. In our example, we need 14 disconnect logics although there are 28 disconnect inputs. You can set each disconnect travel time individually with the 89ALP*pp* setting (*pp* = 01–60). Travel time is the time period when both disconnect auxiliary contacts are in the open position (see *Figure 6.20* for more information). Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>
Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>

Number of Breakers (N,1-21)                          NUMBK   := 5      ?<Enter>
Number of Disconnects (N,1-60)                       NUMDS   := N      ?14 <Enter>
Nominal System Frequency (50,60 Hz)                  NFREQ   := 60     ?> <Enter>
Global Enables
Station DC Battery Monitor (Y,N)                     EDCMON  := N      ?> <Enter>
Control Inputs (Global)
Input Pickup Delay (0.00-30 ms)                      GINPU   := 2.0   ?> <Enter>

Settings Group Selection
Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  > <Enter>


Time and Date Management

Date Format (MDY,YMD,DMY)                            DATE_F  := MDY    ?> <Enter>
Breaker Inputs
N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  > <Enter>
Disconnect Inputs and Timers
N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  IN204 <Enter>

N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  IN205 <Enter>
DS01 Alarm Pickup Delay (0-99999 cyc)                89ALP01 := 300    ?400 <Enter>
N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  IN206 <Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  IN207 <Enter>

DS02 Alarm Pickup Delay (0-99999 cyc)                89ALP02 := 300    ?400 <Enter>
N/O Contact Input -DS03 (SELogic Equation)
89A03 := NA
?  IN208 <Enter>
N/C Contact Input -DS03 (SELogic Equation)
89B03 := NA
?  IN209 <Enter>
DS03 Alarm Pickup Delay (0-99999 cyc)                89ALP03 := 300    ?<Enter>

N/O Contact Input -DS04 (SELogic Equation)
89A04 := NA
?  IN210 <Enter>
N/C Contact Input -DS04 (SELogic Equation)
89B04 := NA
?  IN211 <Enter>
DS04 Alarm Pickup Delay (0-99999 cyc)                89ALP04 := 300    ?<Enter>
N/O Contact Input -DS05 (SELogic Equation)
.
.
.

N/O Contact Input -DS14 (SELogic Equation)
89A14 := NA
?  IN317 <Enter>
N/C Contact Input -DS14 (SELogic Equation)
89B14 := NA
?  IN318 <Enter>
DS14 Alarm Pickup Delay (0-99999 cyc)                89ALP14 := 300    ? <Enter>
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.123 Global Settings for Application 5

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism to automatically reconfigure the zone of protection, without any wiring changes (See *Dynamic Zone Selection Logic on page 5.14* for more information).

In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration and assign the input currents from the CTs to the appropriate differential elements. For each disconnect, wire an 89A and an 89B disconnect auxiliary contact to the relay.

Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays. Because we wire a disconnect auxiliary contacts to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the London feeder, all three phases (MILAN_A, MILAN_B, and MILAN_C) operate together. Because the relay measures the three phases in three separate relays (phase MILAN_A in the A-phase relay, phase MILAN_B in B-phase relay, etc.), we need to convey the disconnect status to all three relays.

For this discussion we define the following terms:

- ➤ Source busbar: the busbar to which all terminals are connected, except the terminal on transfer.
- ➤ Transfer busbar: the busbar to which the terminal on transfer is connected.
- ➤ Transfer disconnect: the disconnect, when closed, bypasses the circuit breaker (e.g., disconnect G898 on the CAIRO Terminal).

Although the relay is flexible enough to accept settings for the many disconnect combinations, we will configure the relay according to the following operating conditions:

- ➤ Only one terminal will be on transfer at any given time, i.e., the tie-breaker transfer disconnect (Z892 or Z891) and the transfer disconnect (*n*898, *n* = D, E, F, and G) of only one of the four feeders can be closed simultaneously.
- ➤ Either Busbar B1 or Busbar B2 can be the source busbar.
- ➤ When closing the transfer disconnect, the protection of the transfer busbar becomes part of the line protection.
- ➤ The operating sequence to put a terminal on transfer is fixed. Because the operating sequence defines a set of operating rules, settings engineers can decide on appropriate terminal-to-bus-zone and bus-zone-to-bus-zone connection settings for each step.

Table 6.81 shows the operating sequence for the settings in this application; many other operating sequences are possible and in use.

Assume that the tie breaker and tie-breaker disconnects are closed. For brevity, we consider only the MADRID and CAIRO Feeders in the following discussion. Consider a case where we put the CAIRO Feeder on transfer, with Busbar B2 selected as the source busbar.

Table 6.81 Fixed Operating Sequence to Put a Feeder on Transfer

Step Number	Description	Comment
1	Switch Terminals TD, TE, and TF to the source busbar (B2).	Assume that all FDRs are connected to B1. Close the disconnects that connect the terminals to Busbar B2 (D892, E892, F892, and G892), and open the disconnects that connect the terminals to Busbar B1 (D891, E891, and F891). After Step 1, CAIRO is the only feeder connected to Busbar B1, see *Figure 6.124*. Both Bus-zone B2 (I03 + I01 = $I_s - I_s = 0$) and Bus-Zone B1 are balanced (I02 + I06 = $I_s - I_s = 0$).
2	Close the transfer disconnect (G898) of the terminal going on transfer.	This operation forms a parallel path, with current IS splitting at the G894 and G898 junction; not all current flows through the CAIRO CT. There are still two bus-zones (B1 and B2), but because the current from the CAIRO CT is missing (worst case), Bus-Zone B1 can misoperate. Remove Bus-Zone B1 by removing the CAIRO CT and tie-breaker channel I02 from the differential calculations. (See the ensuing discussion and *Figure 6.125*). The transfer busbar is now part of the line protection.
3	Open the circuit breaker of the terminal going on transfer.	Opening the CAIRO circuit breaker interrupts the current path through the circuit breaker. Tie-breaker channel I01 remains part of the differential calculations to balance the current flow to the CAIRO Feeder.
4	Open the source busbar disconnect (G894) and the line disconnect (G895) to isolate the circuit breaker.	Step 4 is shown here to complete the operating sequence; the operation has no effect on the busbar protection.

Figure 6.124 shows the station after Step 1 in *Table 6.81*. Step 1 is standard operating procedure and requires no special busbar protection settings. With all transfer disconnects open, all the CT secondary currents are available, and both Bus-Zones B1 and B2 are balanced.

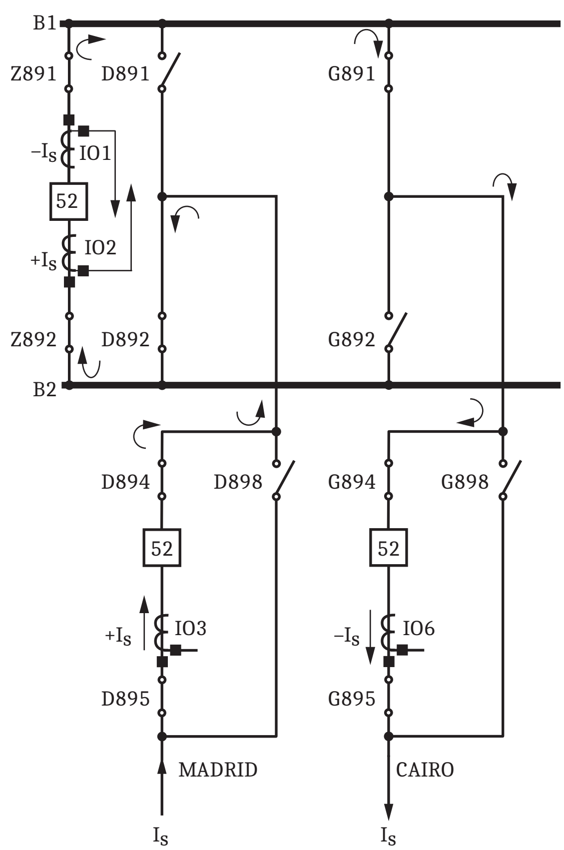


Figure 6.124 Bus-Zone B1 and Bus-Zone B2 Are Balanced When Both Transfer Disconnects Are Open

Figure 6.125 shows the current distribution for the condition when disconnect G891 and disconnect G898 are both closed. Current I_S enters the MADRID terminal, flows through the tie breaker, busbar B1, and as far as the junction between disconnect G894 and G898. At this junction, the current splits into i_a and i_b. As a worst-case scenario, assume the entire current, IS, flows through disconnect G898, with no current flowing through the CAIRO CT. To balance the B1 differential element, we need the sum of the currents in the B1 element to equal zero. Without the CAIRO CT current contribution, the differential element is unbalanced and can result in misoperation. To conclude, the current input from the CAIRO CT is uncertain when disconnect G891 and disconnect G898 are both closed, and disappears when the circuit breaker opens. For these reasons, Bus-Zone B1 cannot form a reliable differential zone when disconnect G898 closes. Differential Element B2 remains stable, and the B2 Busbar protection is secure.

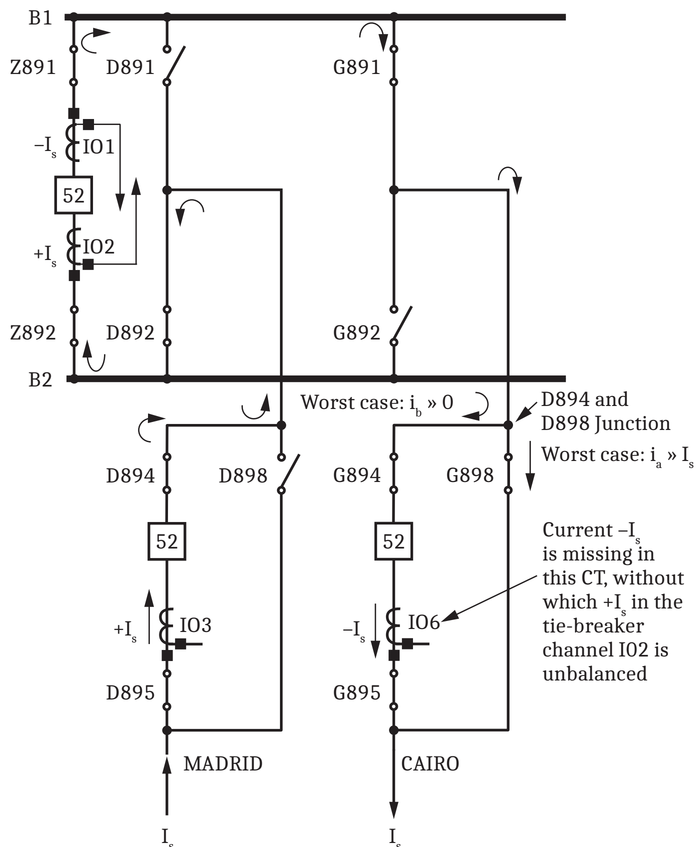


Figure 6.125 Current Distribution During Transfer Procedure Using Inboard CTs

By removing the CAIRO CT as well as the tie-breaker I02 channel from the differential calculations, we effectively remove Differential element B1. We can achieve the same result in two ways:

- by using the zone supervision setting (Z*n*S)
- entering values for each of the terminal-to-bus-zone settings

This example uses the first option (i.e., the zone supervision setting).

Consider also that by removing Differential Element B1, the transfer busbar is without protection. One solution is to use the tie-breaker I02 CT for the line protection, thereby including the transfer busbar as part of the line. When using the SEL-421 as line protection, program the selection functions in the relay to select current I02 as an alternate current source.

To configure the correct disconnect combinations, use the following conditions:

1. With no feeder on transfer, manipulate the tie-breaker CTs with the bus-zone-to-bus-zone connections.
2. A feeder is on transfer when any *n*898 AND *n*891, or any *n*898 AND *n*892 (*n* = D, E, F, and G) disconnects are closed simultaneously.
3. When a feeder is on transfer and B2 is the source busbar, remove I02. B2 is the source busbar when *n*891 AND *n*898 (*n* = D, E, F, and G) disconnects are closed.
4. When a feeder is on transfer and B1 is the source busbar, remove I01. B1 is the source busbar when *n*892 AND *n*898 (*n* = D, E, F, and G) disconnects are closed.

Z1S:= **NOT ((89CL03 AND 89CL05) OR (89CL06 AND 89CL08) OR (89CL09 AND 89CL11) OR (89CL12 AND 89CL14))**

Z2S:= **NOT ((89CL04 AND 89CL05) OR (89CL07 AND 89CL08) OR (89CL10 AND 89CL11) OR (89CL13 AND 89CL14))**

The zone configuration default setting are settings for a specific substation with arbitrarily selected alias names, serving only as an example.

For the ease of setting the zone configuration settings for the new substation, delete the existing zone configuration default settings.

With the zone configuration default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone connection settings. *Figure 6.126* shows the zone configuration settings for this application.

```
=>>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    ?800 <Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?800 <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TIE1_A, ZONE1_A, P
?  DELETE 200 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,ZONE2_A,P <Enter>
TIE1_A to ZONE2_A Connection (SELogic Equation)
I01BZ2V := NA
?  89CL02 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I02,ZONE1_A <Enter>
TIE2_A to ZONE1_A Connection (SELogic Equation)
I02BZ1V := NA
?  89CL01 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I03,ZONE1_A,P <Enter>
MADRI_A to ZONE1_A Connection (SELogic Equation)
I03BZ1V := NA
?  89CL03 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I03,ZONE2_A,P <Enter>
MADRI_A to ZONE2_A Connection (SELogic Equation)
I03BZ2V := NA
?  89CL04 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I04,ZONE1_A,P <Enter>
MILAN_A to ZONE1_A Connection (SELogic Equation)
I04BZ1V := NA
?  89CL06 <Enter>
```

Figure 6.126 Zone Configuration Group Settings for Application 5

```
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,ZONE2_A,P <Enter>
MILAN_A to ZONE2_A Connection (SELogic Equation)
IO4BZ2V := NA
?  89CL07 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE1_A,P <Enter>
ROME_A to ZONE1_A Connection (SELogic Equation)
IO5BZ1V := NA
?  89CL09 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE2_A,P <Enter>
ROME_A to ZONE2_A Connection (SELogic Equation)
IO5BZ2V := NA
?  89CL10 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,ZONE1_A,P <Enter>

CAIRO_A to ZONE1_A Connection (SELogic Equation)
IO6BZ1V := NA
?  89CL12 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,ZONE2_A,P <Enter>
CAIRO_A to ZONE2_A Connection (SELogic Equation)
IO6BZ2V := NA
?  89CL13 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?<Enter>

Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
?  ZONE1_A,ZONE2_A <Enter>
ZONE1_A to ZONE2_A Connection (SELogic Equation)
BZ1BZ2V := NA
?  (89CL03 AND 89CL04) OR (89CL06 AND 89CL07) OR (89CL09 AND 89CL10) OR (89CL12\
 AND 89CL13) <Enter>
Connection to Remove Terminals when ZONE1_A and ZONE2_A merge (SELogic Equation)
BZ1BZ2R := NA
?  BZ1BZ2V <Enter>

Terminals Removed when ZONE1_A and ZONE2_A Bus-Zones merge (Ter k,...,Ter n)
BZ1BZ2M :=
?  TIE1_A,TIE2_A <Enter>
Trip Terminals TIE1_A, TIE2_A (Y,N)
BZ1BZ2T := N
?  Y <Enter>
Bus-Zone, Bus-Zone
? <Enter>
Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?Y <Enter>

Zone 1 Supervision (SELogic Equation)
Z1S := 1
?  NOT ((89CL03 AND 89CL05) OR (89CL06 AND 89CL08) OR (89CL09 AND 89CL11) OR (8\
9CL12 AND 89CL14)) <Enter>
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?  NOT ((89CL04 AND 89CL05) OR (89CL07 AND 89CL08) OR (89CL10 AND 89CL11) OR (8\
9CL13 AND 89CL14)) <Enter>

Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.126 Zone Configuration Group Settings for Application 5 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available. For this application, we use the default values for the Sensitive Differential Element, the Restrained Differential Element, and the Directional Element.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Set E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information) to use the sensitive differential element for this requirement. Set TOS := N, E50 := N, E51 := N, E27 := N, E59 := N, and EADVS := N because we do not use the Coupler Security Logic, overcurrent elements, terminal out of service, or voltage elements in this application.

Because breaker failure protection measures each current channel, select the number of breaker failure logics (EBFL setting) equal to the number of current channels, not the number of circuit breakers.

This application has five circuit breakers, but six current channels (tie breaker has two CTs). Select six as the number of breaker failure logics for this application.

This application assumes a single breaker failure input from the tie-breaker protection. With a single breaker failure input from the tie-breaker protection, set both tie-breaker breaker failure initiate setting (XBF01 and XBF02) equal to IN201. For tie breakers with two breaker failure relays, allocate an additional relay input for the second breaker failure input, and equate each relay input to an XBF*nn* settings. For example, assume the two breaker failure inputs are assigned to relay input IN201 and relay input IN202. With these input assignments, set XBF01 := IN201 and XBF02 := IN202.

Setting NUMBK equal to five makes five corresponding trip equations (TR01–TR05) available for setting. There are five trip equations available, but there are six analog channels (I01–I06) at the station. Each of the six analog channels has a corresponding differential trip bit that asserts (*Table 6.76*) when the differential element asserts. Be sure to include these differential trip bits in the trip equations of all circuit breakers you want to trip.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative method is to enter specific reset conditions at the ULTR*kk* settings.

Each of the six analog channels also has a corresponding station breaker failure trip bit that asserts (*Table 6.77*) when the breaker failure element asserts. Be sure to include these station breaker failure trip bits in the trip equations of all circuit breakers you want to trip.

Because the tie breaker has two analog channels, but only one circuit breaker, include both Differential Trip bits (87BTR01 and 87BTR02) as well as both station breaker failure trip bits (SBFTR01 and SBFTR02) in the trip equation of the tie breaker (TR01).

Figure 6.127 shows the protection group settings for this application.

```
=>>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,1-21)                     ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ? <Enter>

Definite Time Overcurrent Elements (N,1-21)          E50     := N      ? <Enter>
Inverse Time Overcurrent Elements (N,1-21)           E51     := N      ? <Enter>
Enable Under Voltage Elements (N,1-6)                E27     := N      ? <Enter>
Enable Over Voltage Elements (N,1-6)                 E59     := N      ? <Enter>
Advanced Settings (Y,N)                              EADVS   := N      ? <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>

Breaker 01 Failure Logic
External Breaker Fail -BK01 (Y,N)                    EXBF01  := N      ?Y <Enter>
External Brkr Fail Init -BK01 (SELogic Equation)
XBF01 := NA
?  IN201 <Enter>
Brkr Fail Init Dropout Delay -BK01 (0.00-1000 cyc)   BFIDO01 := 1.50   ? <Enter>
Breaker 02 Failure Logic
External Breaker Fail -BK02 (Y,N)                    EXBF02  := N      ?Y <Enter>
External Brkr Fail Init -BK02 (SELogic Equation)
XBF02 := NA
?  IN201 <Enter>
Brkr Fail Init Dropout Delay -BK02 (0.00-1000 cyc)   BFIDO02 := 1.50   ? <Enter>

.
.
.
External Breaker Fail -BK06 (Y,N)                    EXBF06  := N      ?Y <Enter>
External Brkr Fail Init -BK06 (SELogic Equation)
XBF06 := NA
?  IN302 <Enter>
Brkr Fail Init Dropout Delay -BK06 (0.00-1000 cyc)   BFIDO06 := 1.50   ? <Enter>

Trip Logic
Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87BTR01
?  SBFTR01 OR 87BTR01 OR SBFTR02 OR 87BTR02 <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
?<Enter>
Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87BTR02
?  SBFTR03 OR 87BTR03 <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
?<Enter>

Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87BTR03
?  SBFTR04 OR 87BTR04 <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
?<Enter>
.
.
.

Trip 05 (SELogic Equation)
TR05 := SBFTR05 OR 87BTR05 OR SBFTR06 OR 87BTR06
?  SBFTR06 OR 87BTR06 <Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
?<Enter>
Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ? <Enter>

Event Report Trigger Equation (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.127 Protection Group Settings for Application 5

This concludes the protection group settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings. Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay, and connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts. Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA.

Figure 6.128 shows the control output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRIP01 AND NOT TNS_SW
?  NA <Enter>
OUT102 := TRIP02 AND NOT TNS_SW
?  NA <Enter>
OUT103 := TRIP03 AND NOT TNS_SW
?  NA <Enter>
OUT104 := TRIP04 AND NOT TNS_SW
?  NA <Enter>
OUT105 := TRIP05 AND NOT TNS_SW
?  NA <Enter>
OUT106 := NA
?  > <Enter>
Interface Board #1
OUT201 := NA
?  TRIP01 AND NOT PLT03 <Enter>
OUT202 := NA
?  TRIP02 AND NOT PLT03 <Enter>
OUT203 := NA
?  TRIP03 AND NOT PLT03 <Enter>
OUT204 := NA
?  TRIP04 AND NOT PLT03 <Enter>
OUT205 := NA
?  TRIP05 AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.128 Control Output Settings for Application 5

This concludes the settings for Application 5.

Application 6: Double and Transfer Bus With Two Busbars

This describes the busbar arrangement shown in *Figure 6.129*. The busbar arrangement consists of two busbars (main busbar and transfer busbar), four terminals and a tie breaker. Consider the following to set and configure the relay:

- ➤ Busbar classification
- ➤ Protection philosophy

- ➤ Protection functions selection
- ➤ Number of SEL-487B Relays and I/O boards
- ➤ Input, logic, and output allocation and alias name assignment
- ➤ Station layout update
- ➤ Relay setting and configuration

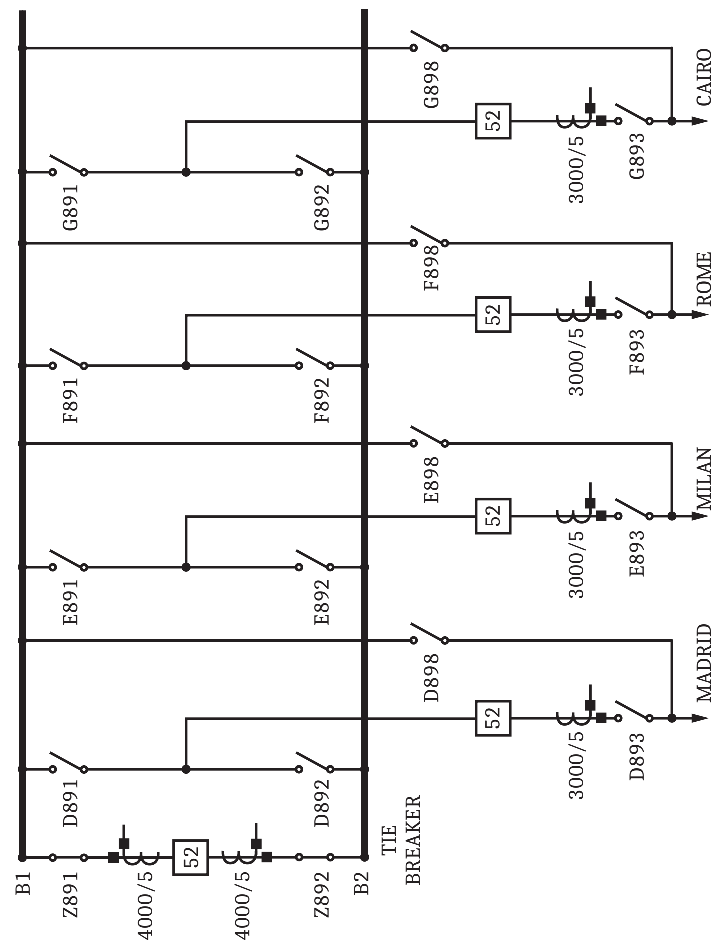


Figure 6.129 Double Bus and Transfer Bus With Bus Coupler (Tie Breaker)

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information, and declares the tie-breaker (bus coupler) configuration.

- ➤ Description:
  - ➢ Double bus with tie breaker
- ➤ Current Transformers:
  - ➢ Inboard
- ➤ Disconnects:
  - ➢ 89A and 89B disconnect auxiliary contacts are available
- ➤ Bus coupler (tie breaker):
  - ➢ Two CTs, configured in overlap

- Future expansion:
  - Four feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not all of these functions are applied at every substation. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Rename only the terminals and bus-zones with alias names.
2. Block the busbar protection for an open circuit CT.
3. Ensure stable differential protection for all operating conditions.
4. Use the disconnect auxiliary contacts to dynamically configure the station.
5. Use the disconnect monitor logic.
6. Use external breaker failure protection.

Protection Functions Selection

We select the protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs required for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. Requirement 3 of the protection philosophy calls for stable differential protection for all operating conditions.

There are two network conditions when the differential protection can become unstable: when disconnects *n*891 and *n*892 (*n* = D, E, F, G) of any feeder are closed at the same time, or when the transfer disconnect of any feeder is closed. By declaring the appropriate conditions in the bus-zone-to-bus-zone connection settings of the zone selection logic, the relay is stable when disconnects *n*891 and *n*892 are closed simultaneously. We use the zone supervision logic to ensure stable differential protection during the time when one of the transfer disconnects is closed.

Standard Functions

Refer to the protection philosophy and select the standard functions required for the application. *Table 6.82* shows the selection of the standard functions.

Table 6.82 Selection of the Standard Protection Functions (Sheet 1 of 2)

Protection Functions	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the station according to the disconnect positions.
Sensitive differential protection	Yes	Use the sensitive differential element as CT open circuit detection.
Zone supervision logic	Yes	Use the zone supervision logic to compensate for the inboard CTs during the bypass period, as well as when a feeder is on transfer.

Table 6.82 Selection of the Standard Protection Functions (Sheet 2 of 2)

Protection Functions	Selection	Comment
Zone-switching supervision logic	No	89A and 89B disconnect contacts available, so this logic is not required.
Coupler security logic	No	Not required
Circuit breaker failure protection	Yes	External breaker failure
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Identify logic functions we need for the application that is not part of the standard logic in the relay. We comply with the protection philosophy using the standard functions in the relay.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.20* to calculate the number of current channels at the station, and use *Equation 6.21* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.20

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.21

The number of per-phase CTs at the station is 18 (tie breaker has 6 CT cores), and one SEL-487B suffices. However, the requirement for 4 future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need 3 relays. This is known as a three-relay application.

In a three-relay application, each relay provides six zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, the B-phase CTs to Relay 2, and the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information.

Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hardwire) the input and output contacts to the other two relays.

This example shows the setting and configuration for the A-phase relay, so identified with an appended letter A (MADRI_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding MADRI_A setting is MADRI_B in the B-phase relay, and MADRI_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, each of the 4 feeders requires 3 disconnect monitoring logic and the tie breaker requires 2; the number of disconnect logics required is therefore 14. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.22* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.22

The protection philosophy calls for external breaker failure as well as dynamic zone selection. Use the external breaker failure logic when the breaker failure relays are integrated in the terminal protection. The zone selection dynamically reconfigures the station according to the disconnect positions and records the terminals in each bus-zone. The relay then uses this information to only trip the terminals in the bus-zone with the failed breaker, when a circuit breaker fails. Wire an output from each breaker failure relay on each of the terminals to the SEL-487B. *Table 6.83* summarizes the input contact required for this application.

Table 6.83 Number of Relay Input Contacts Required

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	2 • 14 = 28
Number of relay inputs required for breaker failure protection	5
Total number of inputs	33

The relay main board has seven inputs, which are not enough inputs for our application. Each interface board provides two sets of nine grouped inputs and six independent input contacts. Use the grouped inputs for the disconnect auxiliary contact inputs and the six independent inputs for the breaker failure inputs. From the input perspective, we need two interface boards.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all circuit breakers are part of the busbar differential protection, we want to trip each breaker when the differential protection operates. *Table 6.84* shows the breakdown and the total number of relay output contacts required for tripping.

Table 6.84 Breakdown and Total Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for breaker tripping	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the RELAY TEST MODE pushbutton from the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board contacts are all standard output contacts. The interface boards have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board can provide six high-speed, high-interrupting output contacts, and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with two interface boards.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point we have determined the following:

- The number of SEL-487B Relays required for the application
- The number of input contacts
- The number of output contacts
- Selected functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay.

However, we still need to do the following:

- Link specific CT inputs to specific relay analog channels
- Link specific disconnect and circuit breaker inputs to specific relay input contacts
- Link relay element/logic outputs to specific relay output contacts
- Assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog quantity
- Terminal name
- Bus-Zone name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed using characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

The protection philosophy specifies that only the terminals and bus-zones need alias names. *Table 6.85* shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT to relay Channel I01, and assign to this CT the alias name TIE1_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.85* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left-to-right from *Figure 6.129*.

Table 6.85 CT-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT1, A-phase	I01	TIE1_A
TIE-BREAKER CT2, A-phase	I02	TIE2_A
MADRID terminal, A-phase	I03	MADRI_A
MILAN terminal, A-phase	I04	MILAN_A
ROME terminal, A-phase	I05	ROME_A
CAIRO terminal, A-phase	I06	CAIRO_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. For the A-phase relay, we use two bus-zones with alias names as shown in *Table 6.86*.

Table 6.86 Alias Names for the Two Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	ZONE1_A
BZ2	Bus-Zone 2	ZONE2_A

Input-to-Logic Allocation

Table 6.83 shows that we require 33 digital inputs. We now assign the digital input contacts to the selected logic. Because of the functional requirements of this application, we do not need any digital inputs on the main board.

Input Contact-to-Logic Allocation, Interface Board 1 (200)

Table 6.87 and *Table 6.88* show the disconnect and circuit breaker failure contact input allocations. Because Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs, we assign the circuit breaker failure input signals to these relay inputs.

Table 6.87 Disconnect and Circuit Breaker Failure Contact Input Allocations (Sheet 1 of 2)

Input	Description
IN201	TIE-BREAKER breaker failure input
IN202	MADRID breaker failure input
IN203	MILAN breaker failure input
IN204	TIE-BREAKER disconnect (ZONE2_A) NO contact
IN205	TIE-BREAKER disconnect (ZONE2_A) NC contact
IN206	TIE-BREAKER disconnect (ZONE1_A) NO contact
IN207	TIE-BREAKER disconnect (ZONE1_A) NC contact
IN208	MADRID terminal disconnect (ZONE1_A) NO contact
IN209	MADRID terminal disconnect (ZONE1_A) NC contact
IN210	MADRID terminal disconnect (ZONE2_A) NO contact

Table 6.87 Disconnect and Circuit Breaker Failure Contact Input Allocations (Sheet 2 of 2)

Input	Description
IN211	MADRID terminal disconnect (ZONE2_A) NC contact
IN212	MADRID terminal disconnect (TRANS _A) NO contact
IN216	MADRID terminal disconnect (TRANS _A) NC contact
IN217	MILAN terminal disconnect (ZONE1_A) NO contact
IN218	MILAN terminal disconnect (ZONE1_A) NC contact
IN219	MILAN terminal disconnect (ZONE2_A) NO contact
IN220	MILAN terminal disconnect (ZONE2_A) NC contact
IN221	MILAN terminal disconnect (TRANS _A) NO contact
IN222	MILAN terminal disconnect (TRANS _A) NC contact

Input Contact to Logic Allocation, Interface Board 2 (300)

Table 6.88 shows the disconnect and circuit breaker auxiliary contact input allocations. Because Inputs IN301, IN302, IN303, IN313, IN314, and IN315 are independent inputs, we assign the circuit breaker failure input signals to these relay inputs.

Table 6.88 Disconnect and Circuit Breaker Failure Contact Input Allocations

Input	Description
IN301	ROME breaker failure input
IN302	CAIRO breaker failure input
IN304	ROME terminal disconnect (ZONE1_A) NO contact
IN305	ROME terminal disconnect (ZONE1_A) NC contact
IN306	ROME terminal disconnect (ZONE2_A) NO contact
IN307	ROME terminal disconnect (ZONE2_A) NC contact
IN308	ROME terminal disconnect (TRANS _A) NO contact
IN309	ROME terminal disconnect (TRANS _A) NC contact
IN310	CAIRO terminal disconnect (ZONE1_A) NO contact
IN311	CAIRO terminal disconnect (ZONE1_A) NC contact
IN312	CAIRO terminal disconnect (ZONE2_A) NO contact
IN316	CAIRO terminal disconnect (ZONE2_A) NC contact
IN317	CAIRO terminal disconnect (TRANS _A) NO contact
IN318	CAIRO terminal disconnect (TRANS _A) NC contact

Assignment of the Selected Standard Logic

Referring to *Table 6.82*, the following is a discussion on each selected function.

Disconnect Monitoring Logic

Figure 6.130 shows one of the 60 disconnect monitor logic circuits available in the relay (see *Figure 6.20*).

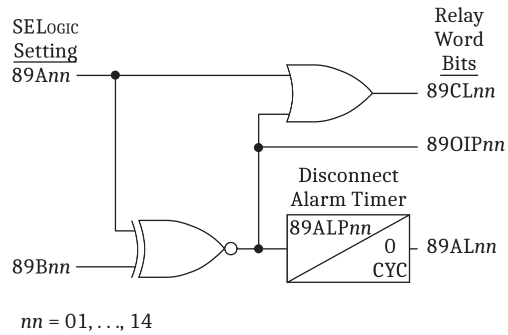


Figure 6.130 One of the Disconnect Monitoring Logic Circuits Available in the Relay

Table 6.89 shows the assignment of the disconnect auxiliary contact Relay Word bits.

Table 6.89 Disconnect Auxiliary Contact Relay Word Bits (Sheet 1 of 2)

Disconnect Input	Description
89A01	TIE-BREAKER disconnect (ZONE1_A) NO contact
89B01	TIE-BREAKER disconnect (ZONE1_A) NC contact
89A02	TIE-BREAKER disconnect (ZONE2_A) NO contact
89B02	TIE-BREAKER disconnect (ZONE2_A) NC contact
89A03	MADRI_A disconnect (ZONE1_A) NO contact
89B03	MADRI_A disconnect (ZONE1_A) NC contact
89A04	MADRI_A disconnect (ZONE2_A) NO contact
89B04	MADRI_A disconnect (ZONE2_A) NC contact
89A05	MADRI_A disconnect (TRANS_A) NO contact
89B05	MADRI_A disconnect (TRANS_A) NC contact
89A06	MILAN_A disconnect (ZONE1_A) NO contact
89B06	MILAN _A disconnect (ZONE1_A) NC contact
89A07	MILAN _A disconnect (ZONE2_A) NO contact
89B07	MILAN _A disconnect (ZONE2_A) NC contact
89A08	MILAN _A disconnect (TRANS_A) NO contact
89B08	MILAN _A disconnect (TRANS_A) NC contact
89A09	ROME_A disconnect (ZONE1_A) NO contact
89B09	ROME _A disconnect (ZONE1_A) NC contact
89A10	ROME _A disconnect (ZONE2_A) NO contact
89B10	ROME _A disconnect (ZONE2_A) NC contact
89A11	ROME _A disconnect (TRANS_A) NO contact
89B11	ROME _A disconnect (TRANS_A) NC contact
89A12	CAIRO _A disconnect (ZONE1_A) NO contact
89B12	CAIRO _A disconnect (ZONE1_A) NC contact
89A13	CAIRO _A disconnect (ZONE2_A) NO contact

Table 6.89 Disconnect Auxiliary Contact Relay Word Bits (Sheet 2 of 2)

Disconnect Input	Description
89B13	CAIRO _A disconnect (ZONE2_A) NC contact
89A14	CAIRO _A disconnect (TRANS_A) NO contact
89B14	CAIRO _A disconnect (TRANS_A) NC contact

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs on the A-phase relay. Jumper (hardwire) the disconnect input contacts to the other two relays. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations.

Differential Trip Logic and Differential Element Assignment

Figure 6.131 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.) *Table 6.90* shows the Relay Word bits and description for the zone differential protection outputs.

Table 6.90 Zone Differential Protection Output Relay Word Bits

Primitive Name	Description
87Z1	Zone 1 differential element trip
87Z2	Zone 2 differential element trip

Differential trip bits 87BTR01–87BTR06 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

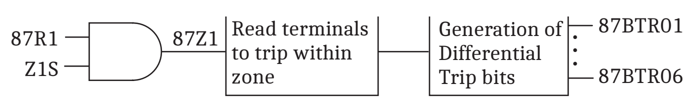


Figure 6.131 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.171* for more information). *Table 6.91* shows the primitive analog channel names and the differential trip bit names for the differential trip bits.

Table 6.91 Differential Trip Bit Names and the Associated Terminals

Differential Trip Bit	Description
87BTR01	Associated with Terminal 01
87BTR02	Associated with Terminal 02
87BTR03	Associated with Terminal 03
87BTR04	Associated with Terminal 04
87BTR05	Associated with Terminal 05
87BTR06	Associated with Terminal 06

Breaker Failure Trip Logic and Station Breaker Failure Logic Output Assignment

Figure 6.132 shows the station breaker failure trip logic. Relay Word bits FBF01–FBF06 are the inputs to the station breaker failure logic; Relay Word bits SBFTR01–SBFTR06 are the outputs from the station breaker failure logic. Relay Breaker failure trip bits SBFTR01–SBFTR06 assert to trip the circuit breakers of the terminals in the bus-zone with the failed circuit breaker. (See *Section 5: Protection Functions* for more information.)

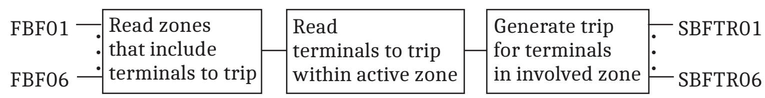


Figure 6.132 Breaker Failure Trip Logic

Table 6.92 shows the station breaker failure Relay Word bits and the primitive names for the breaker failure protection outputs.

Table 6.92 Station Breaker Failure Trip Relay Word Bit Names and Associated Terminals

Station Breaker Failure Trip Bits	Description
SBFTR01	Associated with Terminal 01
SBFTR02	Associated with Terminal 02
SBFTR03	Associated with Terminal 03
SBFTR04	Associated with Terminal 04
SBFTR05	Associated with Terminal 05
SBFTR06	Associated with Terminal 06

Be sure to include the station breaker failure trip bits in the trip equations of all the terminals you want to trip for breaker failure protection. In this example, we want to trip six terminals.

Breaker Failure Input Assignments

This application uses external breaker failure protection. *Figure 6.133* shows the logic for the external breaker failure function.

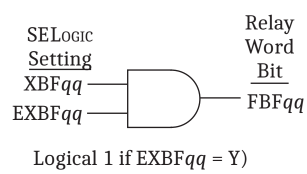


Figure 6.133 Breaker Failure Logic for External Breaker Failure

Table 6.87 and *Table 6.88* show the appropriate XBF*qq* (*qq* = 1–6) and relay input assignment (see *Protection Group Settings on page 6.178*).

Relay Logic-to-Output Contact Allocation and Output Contact Assignments

Table 6.84 shows the breakdown of the five relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts. *Table 6.93* shows TEST and ALARM protection logic assigned to the output contacts of the main board output contacts. *Table 6.94* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1.

Output Assignment, Main Board

This application requires no other output contacts from the main board.

Table 6.93 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.94* shows the assignment for the five terminals of the A-phase relay.

Table 6.94 Assignment of the Output Contacts

Output Contact Assignment	Description
OUT201[a]	TIE-BREAKER trip logic output
OUT202[a]	MADRID trip logic output
OUT203[a]	MILAN trip logic output
OUT204[a]	ROME trip logic output
OUT205[a]	CAIRO trip logic output

[a] High-speed, high-interrupting outputs.

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all relevant information on the station diagram, as shown in *Figure 6.134*.

1. Write down the bus-zone, terminal and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal/zone allocation.
3. Allocate the terminal CTs to the relay input current channels.
4. Allocate the auxiliary contacts to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals.

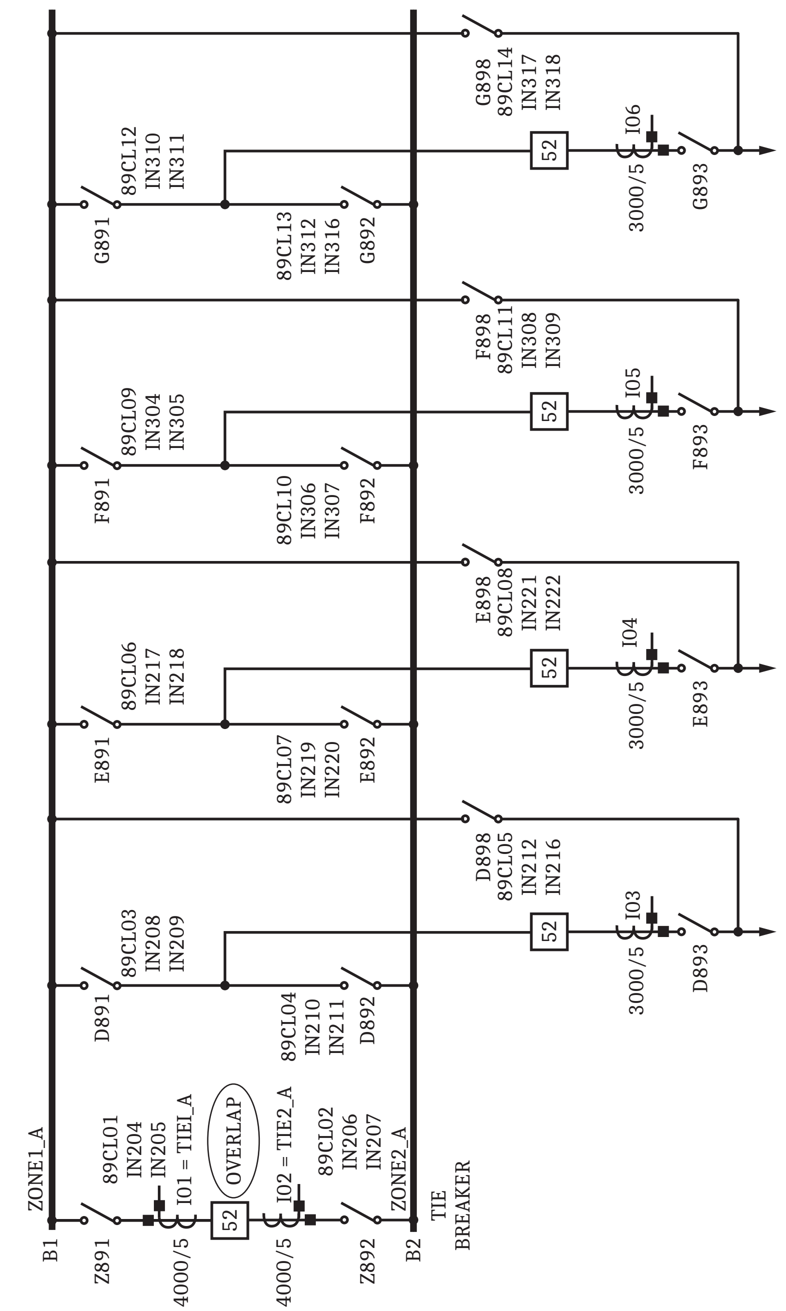


Figure 6.134 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. For this application, we set the following setting classes:

- Alias Settings
- Global Settings
- Zone Configuration Group Settings
- Protection Group Settings
- Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.135*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: I01,"FDR_1"
?  LIST <Enter>
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"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: I01,"FDR_1"
?
```

Figure 6.135 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.136*.

```
1: I01,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.136 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the setting list. Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.137*.

```
1: OUT107,"TEST"
?  > <Enter>
27:
?  I01,TIE1_A <Enter>
28:
?  I02,TIE2_A <Enter>
29:
?  I03,MADRI_A <Enter>
30:
?  I04,MILAN_A <Enter>
31:
?  I05,ROME_A <Enter>
32:
?  I06,CAIRO_A <Enter>
33:
?  BZ1,ZONE1_A <Enter>
```

Figure 6.137 Analog Quantities and Relay Word Bit Alias Names

```
34:
?  BZ2,ZONE2_A <Enter>
35:
?  END <Enter>

Alias
.
.
.

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

=>>
```

Figure 6.137 Analog Quantities and Relay Word Bit Alias Names (Continued)

This concludes the alias settings. The next settings class is global settings.

Global Settings

Global settings comprise settings that apply to all protection setting groups. For example, when changing from Protection Setting Group 1 to Protection Setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.138* shows the setting changes we need for our example. Because we declared the alias names in the previous setting class, use either the alias names or the primitive names when entering settings.

Setting NUMDS declares the number of disconnect logics we need, not the number of disconnect inputs. In our example, we need 14 disconnect logics although there are 28 disconnect inputs. You can set each disconnect travel time individually with the 89ALP*pp* setting (*pp* = 01–14). Travel time is the time period when both disconnect auxiliary contacts are in the open position (see *Figure 6.20* for more information). Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>

Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>
Number of Breakers (N,1-21)                         NUMBK   := 5      ?<Enter>
Number of Disconnects (N,1-60)                      NUMDS   := N      ?14 <Enter>
Nominal System Frequency (50,60 Hz)                 NFREQ   := 60     ?> <Enter>

Global Enables
Station DC Battery Monitor (Y,N)                    EDCMON  := N      ?> <Enter>
Control Inputs (Global)
Input Pickup Delay (0.00-30 ms)                     GINPU   := 2.0   ?> <Enter>

Settings Group Selection
Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  > <Enter>
Time and Date Management
Date Format (MDY,YMD,DMY)                           DATE_F  := MDY    ?> <Enter>

Breaker Inputs
N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  > <Enter>
Disconnect Inputs and Timers
N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  IN204 <Enter>
N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  IN205 <Enter>
```

Figure 6.138 Global Settings for Application 6

```
DS01 Alarm Pickup Delay (0-99999 cyc)                89ALP01 := 300    ?400 <Enter>
N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  IN206 <Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  IN207 <Enter>
DS02 Alarm Pickup Delay (0-99999 cyc)                89ALP02 := 300    ?400 <Enter>
N/O Contact Input -DS03 (SELogic Equation)
89A03 := NA
?  IN208 <Enter>
N/C Contact Input -DS03 (SELogic Equation)
89B03 := NA
?  IN209 <Enter>

DS03 Alarm Pickup Delay (0-99999 cyc)                89ALP03 := 300    ?<Enter>
N/O Contact Input -DS04 (SELogic Equation)
89A04 := NA
?  IN210 <Enter>
N/C Contact Input -DS04 (SELogic Equation)
89B04 := NA
?  IN211 <Enter>
DS04 Alarm Pickup Delay (0-99999 cyc)                89ALP04 := 300    ?<Enter>
N/O Contact Input -DS05 (SELogic Equation)
.
.
.
N/O Contact Input -DS14 (SELogic Equation)
89A14 := NA
?  IN317 <Enter>
N/C Contact Input -DS14 (SELogic Equation)
89B14 := NA
?  IN318 <Enter>
DS14 Alarm Pickup Delay (0-99999 cyc)                89ALP14 := 300    ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.138 Global Settings for Application 6 (Continued)

This concludes the global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism to automatically reconfiguring the zone of protection, without any wiring changes (See *Dynamic Zone Selection Logic on page 5.14* for more information). In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration, and assign the input currents from the CTs to the appropriate differential elements. For each disconnect, wire an 89A and an 89B disconnect auxiliary contact to the relay.

Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays. Because we wire a disconnect auxiliary contacts to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the Milan feeder, all three phases (MILAN_A, MILAN_B, and MILAN_C) operate together. Because the relay measures the three phases in three separate relays (phase MILAN_A in the A-phase relay, phase MILAN_B in B-phase relay, etc.), we need to convey the disconnect status to all three relays.

For this discussion we define the following terms:

➤ Source busbar: the busbar to which all terminals are connected, except the terminal on transfer.

➤ Transfer busbar: the busbar to which the terminal on transfer is connected (B1).

➤ Transfer disconnect: the disconnect, when closed, bypasses the circuit breaker (e.g., Disconnect G898 on the Cairo Terminal).

Although the relay is flexible enough to accept settings for the many disconnect combinations, we will configure the relay according to the following operating conditions:

➤ Only one terminal will be on transfer at any given time, i.e., the transfer Disconnect (*n*898, *n* = D, E, F, and G) of only one of the four feeders can be closed at a time.

➤ Only Busbar B2 can be the source busbar.

➤ The transfer busbar (B1) becomes part of the line protection when a terminal is on transfer.

➤ The operating sequence to put a terminal on transfer is fixed. Because the operating sequence defines a set of operating rules, settings engineers can decide on appropriate terminal-to-bus-zone and bus-zone-to-bus-zone connection settings for each step.

Table 6.95 shows the operating sequence for the settings in this application; many other operating sequences are possible and in use.

Assume that Disconnects Z891 and Z892 and the tie-breaker circuit breaker are closed. For brevity, we consider only the MADRID and CAIRO terminals in the following discussion. Consider the case where we put Terminal CAIRO on transfer.

Table 6.95 Fixed Operating Sequence to Put a Terminal on Transfer

Step Number	Description	Comment
1	Switch terminals TD, TE, and TF to the source busbar (B2).	Close all disconnects that connect the terminals to busbar B2 (D892, E892, F892, and G892), and open all disconnects that connect the terminals to busbar B1 (D891, E891, F891, and G891). No current flows through the tie breaker, see *Figure 6.139*. Bus-Zone B1 does not operate because no current flows through the tie breaker. Bus-Zone B2 is balanced because I03 + I06 = 0.
2	Close the transfer Disconnect (G898) of the terminal going on transfer.	This operation forms a parallel path, with ($i_a + i_b - i_a - i_b$) current I_s splitting into i_a and i_b at the D892 and Busbar B2 junction, as shown in *Figure 6.140*. To overcome this problem, remove tie-breaker Channel I02 from the B1 differential calculations when G898 closes. (See the ensuing discussion and *Figure 6.140*).
3	Open the circuit breaker of the terminal going on transfer.	Opening the CAIRO circuit breaker interrupts the current path through the circuit breaker. Tie-breaker Channel I01 remains part of the B2 differential calculations to balance the current flow to the CAIRO Terminal.
4	Open the source busbar Disconnect (G892) and the line Disconnect (G893) to isolate the circuit breaker.	Step 4 is shown here to complete the operating sequence; the operation has no effect on the busbar protection.

Figure 6.139 shows the station after Step 1 in *Table 6.95*. Step 1 is standard operating procedure and requires no special busbar protection settings. Because tie-breaker Disconnect Z891 is still closed, both bus-zones B1 and B2 are active. Bus-Zone B1 has only one CT (tie-breaker Channel I02) in place, but because no

current flows through the tie breaker, the relay does not operate. Having both zones active provides the benefit of detecting faults on B1 during these operating conditions.

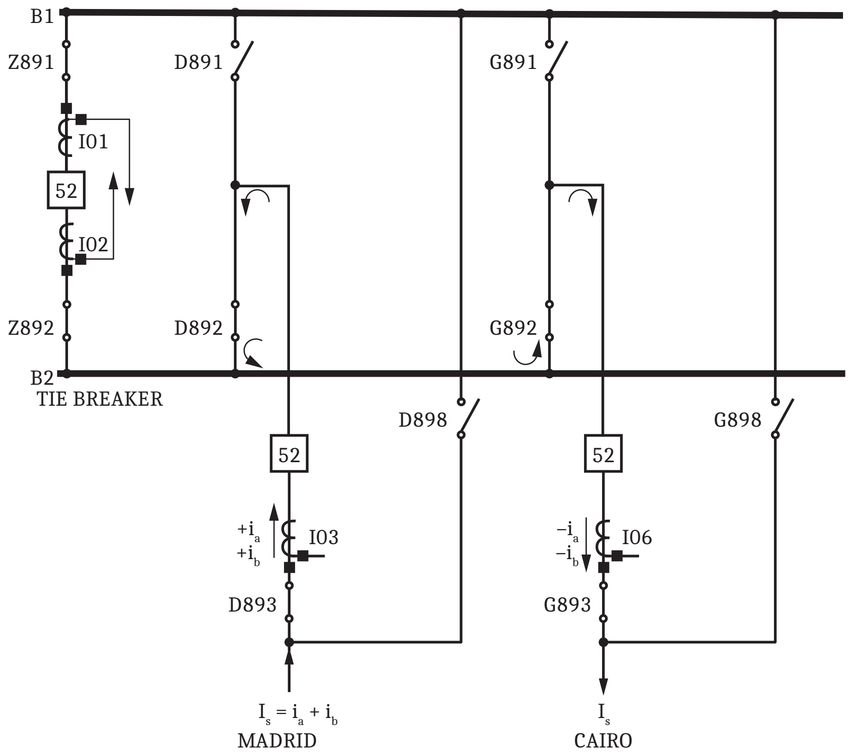


Figure 6.139 Bus-Zones B1 and B2 Are Balanced When All Transfer Disconnects Are Open

Closing Disconnect G898 in Step 2 of *Table 6.95* forms a parallel path. Current Is enters at the MADRID terminal and splits into i_a and i_b at the D892 and Busbar B2 junction. This current distribution unbalances B1 because current $-i_a$ is missing in the CAIRO CT. The two differential elements calculate the differential currents as follows:

Element for Busbar B1:

$$\begin{aligned} I_{diff} &= (I02) + 0 \text{ (no other CT in place)} \\ &= i_a + 0 \\ &= i_a \text{ (element is unbalanced)} \end{aligned}$$ **Equation 6.23**

Element for Busbar B2:

$$\begin{aligned} I_{diff} &= (I01) + (I03) + (I06) \\ &= (i_a + i_b) - i_a - i_b \\ &= 0 \text{ (element is balanced)} \end{aligned}$$ **Equation 6.24**

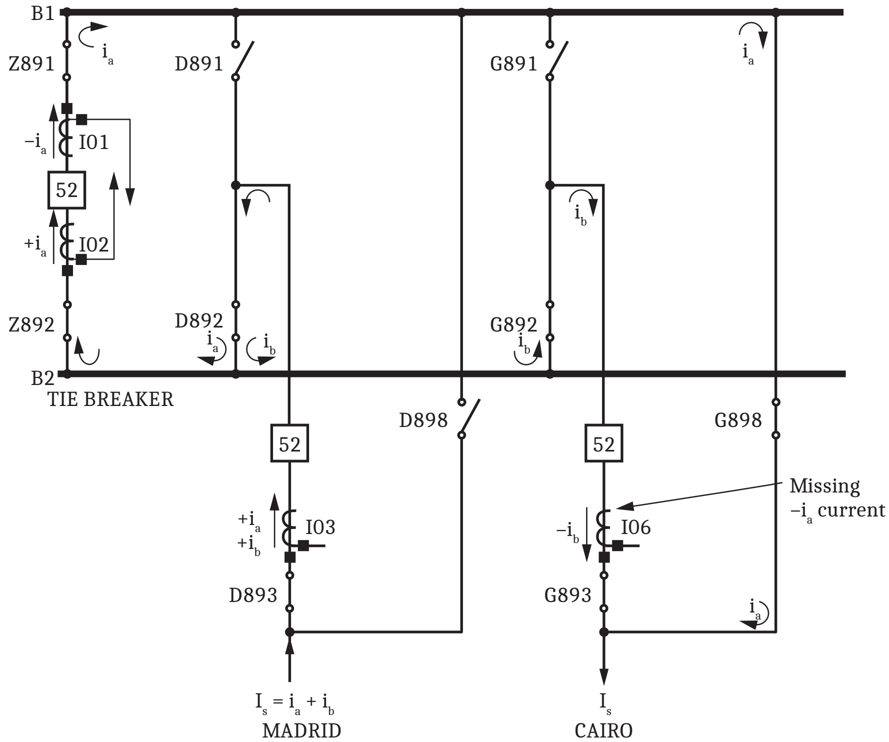


Figure 6.140 Current Distribution During Transfer Procedure Using Inboard CTs

In Step 3 of *Table 6.95*, we open the CAIRO circuit breaker and the parallel path no longer exists. Current i_b disappears and I_s flows as shown in *Figure 6.141*. The differential element for Busbar B2 is stable (I01 + I03 = 0), but the differential element for Busbar B1 is unbalanced. To conclude, the differential element for Busbar B1 is unbalanced during the transition period (when a parallel path exists) as well as when the terminal is on transfer.

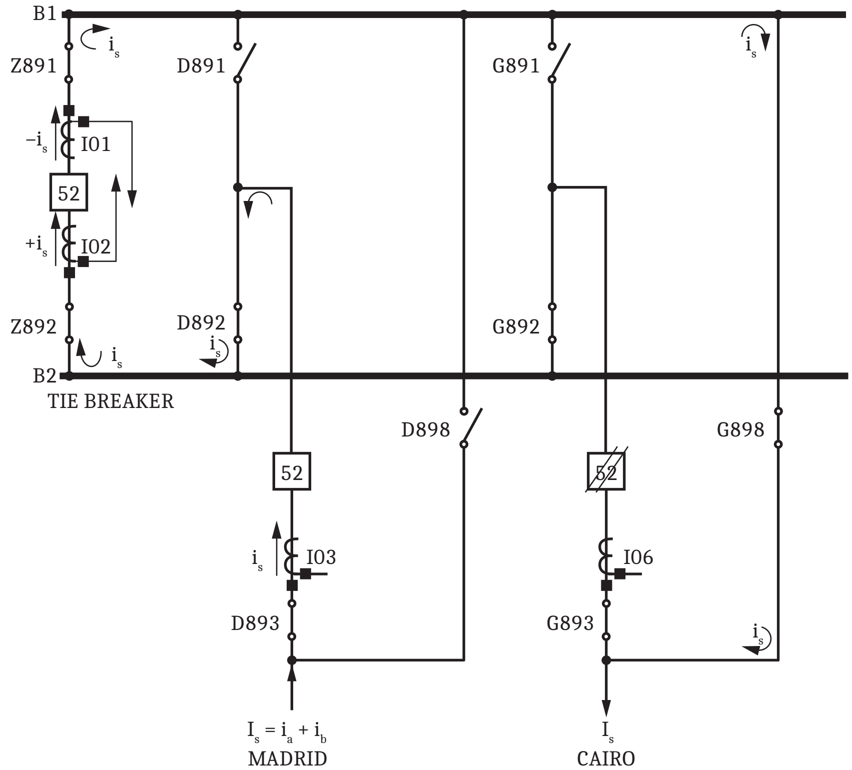


Figure 6.141 Current Distribution After Opening the Circuit Breaker of the Terminal Going on Transfer

Because Disconnect G898 bypasses the CAIRO CT, we cannot provide differential protection for Busbar B1. Because we cannot provide differential protection for Busbar B1, we need to remove the existing differential B1 element to prevent misoperation. We remove differential B1 element by using a zone supervision setting (Z*n*S).

In this application, the tie-breaker current assignment to the differential elements depends on the position of only one of the tie-breaker disconnects: current Channel I01 is assigned to B2 when Z892 is closed. Likewise, current Channel I02 is assigned to B1 when Z891 is closed. The assignment of the feeder currents to the differential elements depends solely on the corresponding B1 and B2 disconnect positions (*n*891 and *n*892).

Consider also that by removing Differential Element B1, the transfer busbar is without protection. One solution is to use the tie-breaker I02 CT for the line protection, thereby including the transfer busbar as part of the line. When using the SEL-421 as line protection, program the selection functions in the relay to select Current I02 as an alternate current source.

To configure the correct disconnect combinations, use the following conditions:

- With no terminal on transfer, manipulate the tie-breaker CTs with the bus-zone-to-bus-zone connections.
- A terminal is on transfer when any *n*898 (*n* = D, E, F, and G) disconnect is closed.
- When a terminal is on transfer, disable the differential element for Busbar B1.

Set the Zone Supervision setting for Busbar B1 as follows: Z1S := NOT (89CL05 OR 89CL08 OR 89CL11 OR 89CL14). *Figure 6.142* shows the Zone Configuration settings for this application.

The zone configuration default settings are settings for a specific substation with arbitrarily selected alias names, serving only as an example. For the ease of setting the zone configuration settings for the new substation, delete the terminal-to-bus-zone default settings. With the terminal-to-bus-zone default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone connection settings. *Figure 6.142* shows the Zone Configuration settings for this application.

```
=>>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    ?800 <Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?800 <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TIE1_A, ZONE1_A, P
?  DELETE 200 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,ZONE2_A,P <Enter>
TIE1_A to ZONE2_A Connection (SELogic Equation)
I01BZ2V := NA
?  89CL02 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02,ZONE1_A,P <Enter>
TIE2_A to ZONE1_A Connection (SELogic Equation)
I02BZ1V := NA
?  89CL01 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I03,ZONE1_A,P <Enter>
MADRI_A to ZONE1_A Connection (SELogic Equation)
I03BZ1V := NA
?  89CL03 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I03,ZONE2_A,P <Enter>
MADRI_A to ZONE2_A Connection (SELogic Equation)
I03BZ2V := NA
?  89CL04 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I04,ZONE1_A,P <Enter>
MILAN_A to ZONE1_A Connection (SELogic Equation)
I04BZ1V := NA
?  89CL06 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I04,ZONE2_A,P <Enter>
MILAN_A to ZONE2_A Connection (SELogic Equation)
I04BZ2V := NA
?  89CL07 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I05,ZONE1_A, <Enter>
ROME_A to ZONE1_A Connection (SELogic Equation)
I05BZ1V := NA
?  89CL09 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I05,ZONE2_A,P <Enter>
ROME_A to ZONE2_A Connection (SELogic Equation)
I05BZ2V := NA
?  89CL10 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I06,ZONE1_A,P <Enter>
CAIRO_A to ZONE1_A Connection (SELogic Equation)
I06BZ1V := NA
?  89CL12 <Enter>
```

Figure 6.142 Zone Configuration Group Settings for Application 6

```
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,ZONE2_A,P <Enter>
CAIRO_A to ZONE2_A Connection (SELogic Equation)
IO6BZ2V := NA
?  89CL13 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?<Enter>

Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
?  ZONE1_A,ZONE2_A <Enter>
ZONE1_A to ZONE2_A Connection (SELogic Equation)
BZ1BZ2V := NA
?  (89CL03 AND 89CL04) OR (89CL06 AND 89CL07) OR (89CL09 AND 89CL10) OR (89CL12\
 AND 89CL13) <Enter>
Connection to Remove Terminals when ZONE1_A and ZONE2_A merge (SELogic Equation)
BZ1BZ2R := NA
?  BZ1BZ2V <Enter>
Terminals Removed when ZONE1_A and ZONE2_A Bus-Zones merge (Ter k,...,Ter n)
BZ1BZ2M :=
?  TIE1_A,TIE2_A <Enter>

Trip Terminals TIE1_A, TIE2_A (Y,N)
BZ1BZ2T := N
?  Y <Enter>
Bus-Zone, Bus-Zone
?<Enter>
Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?Y <Enter>
Zone 1 Supervision (SELogic Equation)
Z1S := 1
?  NOT(89CL05 OR 89CL08 OR 89CL11 OR 89CL14) <Enter>
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?<Enter>

Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.142 Zone Configuration Group Settings for Application 6 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available.

For this application, we use the default values for the Sensitive Differential Element, the Restrained Differential Element and the Directional Element.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Set E87SSUP := Y (see *Figure 5.11* and *Figure 5.18* for more information) to use the sensitive differential element for this requirement. Set TOS := N, E50 := N, E51 := N, E27 := N, E59 := N, and EADVS := N because we do not use the Coupler Security Logic, overcurrent elements, terminal out of service, or voltage elements in this application.

Because breaker failure protection measures each current channel, select the number of breaker failure logics (EBFL setting) equal to the number of current channels, not the number of circuit breakers.

This application has five circuit breakers, but six current channels (tie breaker has two CTs). Therefore, select six as the number of breaker failure logics for this application.

This application assumes a single breaker failure input from the tie-breaker protection. With a single breaker failure input from the tie-breaker protection, set both tie-breaker breaker failure initiate setting (XBF01 and XBF02) equal to IN201. For tie breakers with two breaker failure relays, allocate an additional relay input for the second breaker failure input, and equate each relay input to an XBF*nn* settings. For example, assume the two breaker failure inputs are assigned to relay input IN201 and relay input IN202. With these input assignments, set XBF01 := IN201 and XBF02 := IN202.

Setting NUMBK equal to five makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting. There are five trip equations available, but there are six analog channels (I01–I06) at the station. Each of the six analog channels has a corresponding differential trip bit that asserts (*Table 6.91*) when the differential element asserts. Be sure to include these differential trip bits in the trip equations of all circuit breakers you want to trip.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative method is to enter specific reset conditions at the ULTR*kk* settings.

Each of the six analog channels also has a corresponding station breaker failure trip bit that asserts (*Table 6.92*) when the breaker failure element asserts. Be sure to include these station breaker failure trip bits in the trip equations of all circuit breakers you want to trip.

Because the tie breaker has two analog channels, but only one circuit breaker, include both differential trip bits (87BTR01 and 87BTR02) as well as both station breaker failure trip bits (SBFTR01 and SBFTR02) in the trip equation of the tie breaker (TR01). *Figure 6.143* shows the protection group settings for this application.

```
=>>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,1-21)                      ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                        EBFL    := 6      ? <Enter>
Definite Time Overcurrent Elements (N,1-21)           E50     := N      ? <Enter>
Inverse Time Overcurrent Elements (N,1-21)            E51     := N      ? <Enter>
Enable Under Voltage Elements (N,1-6)                 E27     := N      ? <Enter>
Enable Over Voltage Elements (N,1-6)                  E59     := N      ? <Enter>

Advanced Settings (Y,N)                               EADVS   := N      ? <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>

Breaker 01 Failure Logic
External Breaker Fail -BK01 (Y,N)                     EXBF01  := N      ?Y <Enter>
External Brkr Fail Init -BK01 (SELogic Equation)
XBF01 := NA
?  IN201 <Enter>
Brkr Fail Init Dropout Delay -BK01 (0.00-1000 cyc)    BFIDO01 := 1.50   ? <Enter>
```

Figure 6.143 Protection Group Settings for Application 6

```
Breaker 02 Failure Logic
External Breaker Fail -BK02 (Y,N)                   EXBF02  := N      ?Y <Enter>
External Brkr Fail Init -BK02 (SELogic Equation)
XBF02 := NA
?  IN201 <Enter>
Brkr Fail Init Dropout Delay -BK02 (0.00-1000 cyc)  BFIDO02 := 1.50   ? <Enter>
.
.
.
External Breaker Fail -BK06 (Y,N)                   EXBF06  := N      ?Y <Enter>
External Brkr Fail Init -BK06 (SELogic Equation)
XBF05 := NA
?  IN302<Enter>
Brkr Fail Init Dropout Delay -BK05 (0.00-1000 cyc)  BFIDO05 := 1.50   ? <Enter>

Trip Logic
Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87BTR01
?  SBFTR01 OR 87BTR01 OR SBFTR02 OR 87BTR02 <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
? <Enter>
Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87BTR02
?  SBFTR03 OR 87BTR03 <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
? <Enter>

Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87BTR03
?  SBFTR04 OR 87BTR04 <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
? <Enter>
.
.
.
Minimum Trip Duration Time Delay (2.000-8000 cyc)   TDURD   := 12.000 ?4 <Enter>
Event Report Trigger Equation (SELogic Equation)
.
.
.
Trip 05 (SELogic Equation)
TR05 := SBFTR05 OR 87BTR05 OR SBFTR06 OR 87BTR06
?  SBFTR06 OR 87BTR06 <Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
? <Enter>
Minimum Trip Duration Time Delay (2.000-8000 cyc)   TDURD   := 12.000 ?4 <Enter>
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.143 Protection Group Settings for Application 6 (Continued)

This concludes the protection group settings. The next settings class is control output settings.

Control Output Settings

In this setting class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings. Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay, and connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts.

Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA. *Figure 6.144* shows the control output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRIP01 AND NOT TNS_SW
?  NA <Enter>
OUT102 := TRIP02 AND NOT TNS_SW
?  NA <Enter>

OUT103 := TRIP03 AND NOT TNS_SW
?  NA <Enter>
OUT104 := TRIP04 AND NOT TNS_SW
?  NA <Enter>
OUT105 := TRIP05 AND NOT TNS_SW
?  NA <Enter>
OUT106 := NA
?  > <Enter>

Interface Board #1
OUT201 := NA
?  TRIP01 AND NOT PLT03 <Enter>
OUT202 := NA
?  TRIP02 AND NOT PLT03 <Enter>
OUT203 := NA
?  TRIP03 AND NOT PLT03 <Enter>
OUT204 := NA
?  TRIP04 AND NOT PLT03 <Enter>
OUT205 := NA
?  TRIP05 AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>

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

=>>
```

Figure 6.144 Control Output Settings for Application 6

Application 7: Double and Transfer Bus (Outboard CTs)

This application describes the busbar arrangement shown in *Figure 6.145*. The busbar arrangement consists of three busbars, four terminals, and a tie breaker. Use the following to set and configure the relay:

- ➤ Busbar classification
- ➤ Protection philosophy
- ➤ Protection function selection
- ➤ Number of SEL-487B Relays and I/O boards
- ➤ Input, logic, and output allocation
- ➤ Station layout update
- ➤ Relay setting and configuration

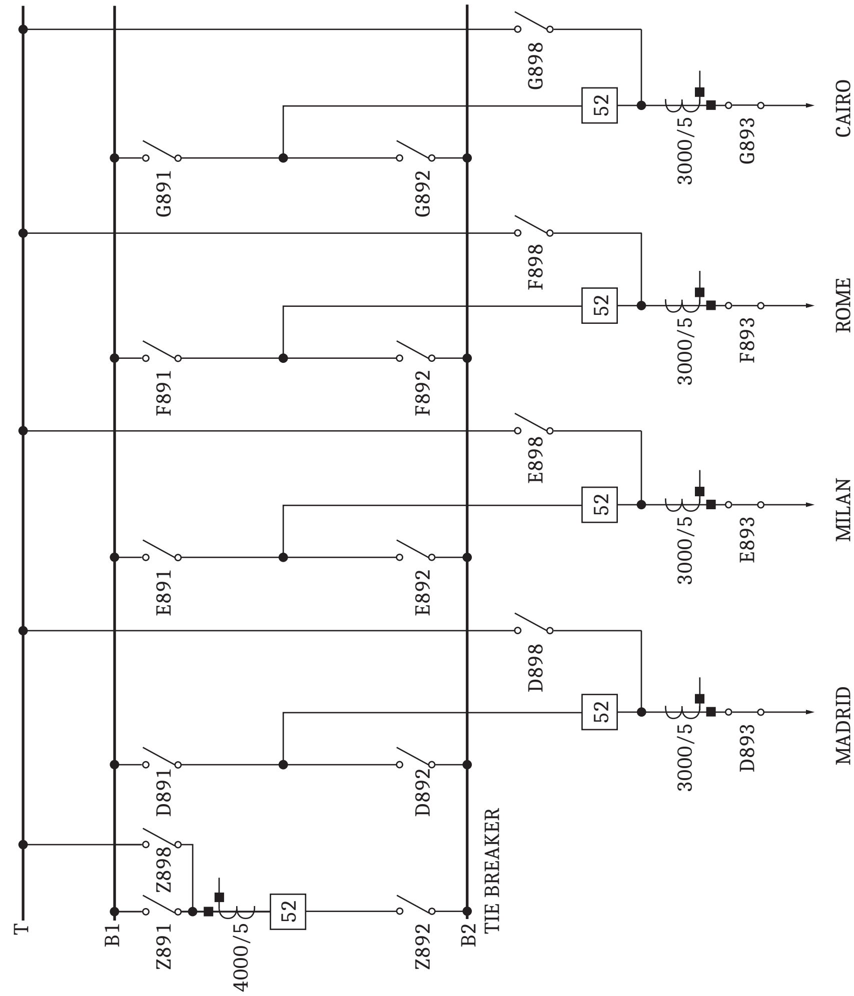


Figure 6.145 Double Bus and Transfer Bus With Bus Coupler (Tie Breaker) and Outboard CTs

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information and it declares the tie-breaker (bus coupler) configuration.

- Description:
  - Double bus with transfer busbar
- Current transformers:
  - Outboard (free standing)
- Disconnects:
  - 89A and 89B disconnect auxiliary contacts are available
- Bus coupler (tie breaker):
  - Single CT with one core used for busbar protection
- Future expansion:
  - Five feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not every application uses all these functions. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Rename only the terminals and bus-zones with alias names.
2. Block the busbar protection for an open-circuit CT.
3. Use the disconnect auxiliary contacts to dynamically configure the station.
4. Use the disconnect monitor logic.
5. Use external breaker failure protection.
6. Prevent the loss of Busbar B2 for a fault between the tie breaker and tie-breaker CT.

Protection Functions Selection

We select protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs necessary for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. For example, in this application, the protection philosophy calls for the use of breaker failure protection but not for overcurrent protection. The SEL-487B offers a number of protection functions as standard features, but it also offers the capability through SELOGIC control equations for you to create user-configurable functions.

To prevent tripping of Busbar B2 when there is a fault between the tie breaker and tie-breaker CT, we can delay tripping of Busbar B2 and trip the tie breaker first (see *Protection Group Settings on page 6.201*). We then remove the tie-breaker currents from the differential calculations of both zones to trip Busbar B1 and not Busbar B2.

To properly identify and categorize the protection philosophy requirements, group the protection functions as follows:

- standard protection functions (available in the relay)
- user-defined protection functions (created with SELOGIC control equations).

Standard Functions

Refer to *Protection Philosophy on page 6.183* and select the standard functions necessary for the application. *Table 6.96* shows the selection of standard functions.

Table 6.96 Selection of the Standard Protection Functions (Sheet 1 of 2)

Protection Functions	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available
Differential protection	Yes	Busbar protection (zone specific and check zone)

Table 6.96 Selection of the Standard Protection Functions (Sheet 2 of 2)

Protection Functions	Selection	Comment
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions.
Sensitive differential protection	Yes	CT open circuit detection
Zone supervision logic	Yes	Use the zone supervision logic as part of preventing the loss of Busbar B2 for a fault between the tie breaker and the tie-breaker CT.
Zone-switching supervision logic	No	89A and 89B disconnect contacts available, so this logic is not required.
Coupler security logic	Yes	Use the coupler security logic in a single CT application for enhanced protection for faults between the tie-breaker CT and the circuit breaker.
Circuit breaker failure protection	Yes	External breaker failure
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Identify logic functions we need that is not part of the standard relay logic in the relay. In this application, we comply with the protection philosophy using the standard functions in the relay.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay).

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.25* to calculate the number of current channels at the station, and use *Equation 6.26* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.25

$$\text{\# of bus-zones required} = \text{\# of per-phase station CTs}$$

Equation 6.26

The number of per-phase CTs at the station is 15 (tie breaker has three CT cores), so one SEL-487B suffices. However, the requirement for 5 future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need 3 relays. This is known as a three-relay application.

In a three-relay application, each relay provides six zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, the B-phase CTs to Relay 2, and the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information. Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hardwire) the input and output contacts to the other two relays.

This example shows the setting and configuration for the A-phase relay, so identified with an appended letter A (MADRI_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding MADRI_A setting is MADRI_B in the B-phase relay, and MADRI_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, the tie breaker and each of the 4 feeders require 3 disconnect monitoring logics; the number of disconnect logics required therefore is 15. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.27* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.27

The protection philosophy calls for external breaker failure as well as dynamic zone selection. Use the external breaker failure logic when the breaker failure relays are integrated in the terminal protection. The zone selection dynamically reconfigures the station according to the disconnect positions and records the terminals in each bus-zone. When a circuit breaker fails, the relay uses this information to only trip the terminals in the bus-zone with the failed circuit breaker. Wire a breaker failure output contact from each breaker failure relay on each of the terminals to the SEL-487B.

We will use the coupler security logic to prevent tripping of Busbar B2 when there is a fault between the tie breaker and the tie-breaker CT. The coupler security logic requires three inputs: a close signal, a circuit breaker 52A auxiliary contact, and an input for the accelerated tripping function (see *Figure 6.110* for more information). We need one input for the circuit breaker 52A auxiliary contact and one input for the closing signal. For the accelerated tripping input (ACTRP1), we use the output from the B2 differential element (87R2). *Table 6.97* summarizes the input contact necessary for this application.

Table 6.97 Relay Input Contacts Requirement

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	2 • 15 = 30
Number of relay inputs required for breaker failure protection	5
Number of relay inputs required for the coupler security logic on the tie breaker	2 (one closing signal and one circuit breaker auxiliary 52A contact)
Total number of inputs	37

The relay main board has seven input contacts, an insufficient number of inputs for our application. Each interface board provides two sets of nine grouped inputs and six independent inputs. Use the grouped inputs for the disconnect auxiliary contact inputs, and use the six independent inputs for the breaker failure inputs. From the input perspective, we need two interface boards.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all circuit breakers are part of the busbar differential protection, we want to trip each breaker when the differential protection operates. *Table 6.98* shows the breakdown and the number of relay output contacts necessary for tripping.

Table 6.98 Breakdown and Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for breaker tripping	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the **RELAY TEST MODE** pushbutton from the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board contacts are all standard output contacts. The interface boards have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board can provide six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with two interface boards.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point, we have determined the following:

- The number of SEL-487B Relays required for the application
- The number of inputs
- The number of output contacts
- The selected protection functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- Link specific CT inputs to specific relay analog channels
- Link specific disconnect and circuit breaker inputs to specific relay inputs
- Link relay element/logic outputs to specific relay output contacts
- Assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog Quantity
- Terminal Name
- Bus-Zone Name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed with characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

The protection philosophy specifies that only the terminals and bus-zones need alias names. *Table 6.99* shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT to relay channel I01, and assign to this CT the alias name TIE_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.99* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left-to-right from *Figure 6.145*.

Table 6.99 CTs-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT, A-phase	I01	TIE_A
MADRID terminal, A-phase	I02	MADRI_A
MILAN terminal, A-phase	I03	MILAN_A
ROME terminal, A-phase	I04	ROME_A
CAIRO terminal, A-phase	I05	CAIRO_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. For the A-phase relay, we use three bus-zone alias names, as shown in *Table 6.100*.

Table 6.100 Alias Names for the Three Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	ZONE1_A
BZ2	Bus-Zone 2	ZONE2_A
BZ3	Transfer busbar	TRANS_A

Input-to-Logic Allocation

Table 6.97 shows that we require 37 digital inputs. We now assign the digital inputs to the selected logic. Because of the functional requirements of this application, we do not need any digital inputs on the main board.

Input-to-Logic Allocation, Interface Board 1 (200)

Table 6.101 and *Table 6.102* show the disconnect and circuit breaker failure contact input allocations. Because Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs, we assign the circuit breaker failure (only one breaker failure initiate input for the tie breaker) initiate input signals, tie-breaker 52A auxiliary contact, and the tie-breaker closing signal to these relay inputs.

Table 6.101 Disconnect and Circuit Breaker Failure Contact Input Allocations

Input	Description
IN201	TIE-BREAKER breaker failure input
IN202	MADRID breaker failure input
IN203	MILAN breaker failure input
IN204	TIE-BREAKER disconnect (ZONE1_A) NO contact
IN205	TIE-BREAKER disconnect (ZONE1_A) NC contact
IN206	TIE-BREAKER disconnect (ZONE2_A) NO contact
IN207	TIE-BREAKER disconnect (ZONE2_A) NC contact
IN208	TIE-BREAKER disconnect (TRANS _A) NO contact
IN209	TIE-BREAKER disconnect (TRANS _A) NC contact
IN210	MADRID terminal disconnect (ZONE1_A) NO contact
IN211	MADRID terminal disconnect (ZONE1_A) NC contact
IN212	MADRID terminal disconnect (ZONE2_A) NO contact
IN213	TIE-BREAKER circuit breaker 52A auxiliary contact
IN214	TIE-BREAKER circuit breaker closing signal
IN216	MADRID terminal disconnect (ZONE2_A) NC contact
IN217	MADRID terminal disconnect (TRANS _A) NO contact
IN218	MADRID terminal disconnect (TRANS _A) NC contact
IN219	MILAN terminal disconnect (ZONE1_A) NO contact
IN220	MILAN terminal disconnect (ZONE1_A) NC contact
IN221	MILAN terminal disconnect (ZONE2_A) NO contact
IN222	MILAN terminal disconnect (ZONE2_A) NC contact
IN223	MILAN terminal disconnect (TRANS _A) NO contact
IN224	MILAN terminal disconnect (TRANS _A) NC contact

Input-to-Logic Allocation, Interface Board 2 (300)

Table 6.102 shows the disconnect and circuit breaker auxiliary contact input allocations. Because Inputs IN301, IN302, IN303, IN313, IN314, and IN315 are independent inputs, we assign the circuit breaker failure input signals to these relay inputs.

Table 6.102 Disconnect and Circuit Breaker Failure Contact Input Allocations

Input	Description
IN301	ROME breaker failure input
IN302	CAIRO breaker failure input
IN304	ROME terminal disconnect (ZONE1_A) NO contact
IN305	ROME terminal disconnect (ZONE1_A) NC contact
IN306	ROME terminal disconnect (ZONE2_A) NO contact
IN307	ROME terminal disconnect (ZONE2_A) NC contact
IN308	ROME terminal disconnect (TRANS _A) NO contact
IN309	ROME terminal disconnect (TRANS _A) NC contact
IN310	CAIRO terminal disconnect (ZONE1_A) NO contact
IN311	CAIRO terminal disconnect (ZONE1_A) NC contact
IN312	CAIRO terminal disconnect (ZONE2_A) NO contact
IN316	CAIRO terminal disconnect (ZONE2_A) NC contact
IN317	CAIRO terminal disconnect (TRANS _A) NO contact
IN318	CAIRO terminal disconnect (TRANS _A) NC contact

Assignment of the Selected Standard Logic

The following discussion references *Table 6.96* in explaining each selected function.

Disconnect Monitoring Logic

Figure 6.146 shows one of the 60 disconnect monitor logic circuits available in the relay.

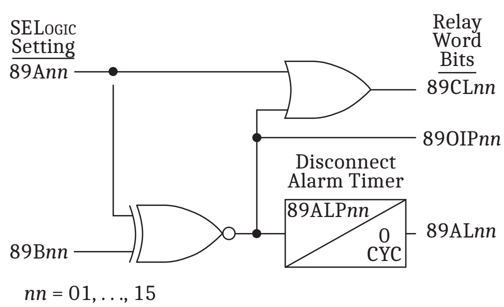


Figure 6.146 Disconnect Monitoring Logic Circuit for Terminal 01

Table 6.103 shows the assignment of the disconnect auxiliary contact Relay Word bits.

Table 6.103 Disconnect Auxiliary Contact Relay Word Bits (Sheet 1 of 2)

Input	Description
89A01	TIE-BREAKER disconnect (ZONE1_A) NO contact
89B01	TIE-BREAKER disconnect (ZONE1_A) NC contact
89A02	TIE-BREAKER disconnect (ZONE2_A) NO contact
89B02	TIE-BREAKER disconnect (ZONE2_A) NC contact
89A03	TIE-BREAKER disconnect (TRANS_A) NO contact
89B03	TIE-BREAKER disconnect (TRANS_A) NC contact

Table 6.103 Disconnect Auxiliary Contact Relay Word Bits (Sheet 2 of 2)

Input	Description
89A04	MADRI_A disconnect (ZONE1_A) NO contact
89B04	MADRI_A disconnect (ZONE1_A) NC contact
89A05	MADRI_A disconnect (ZONE2_A) NO contact
89B05	MADRI_A disconnect (ZONE2_A) NC contact
89A06	MADRI_A disconnect (TRANS_A) NO contact
89B06	MADRI_A disconnect (TRANS_A) NC contact
89A07	MILAN_A disconnect (ZONE1_A) NO contact
89B07	MILAN_A disconnect (ZONE1_A) NC contact
89A08	MILAN_A disconnect (ZONE2_A) NO contact
89B08	MILAN_A disconnect (ZONE2_A) NC contact
89A09	MILAN_A disconnect (TRANS_A) NO contact
89B09	MILAN_A disconnect (TRANS_A) NC contact
89A10	ROME_A disconnect (ZONE1_A) NO contact
89B10	ROME_A disconnect (ZONE1_A) NC contact
89A11	ROME_A disconnect (ZONE2_A) NO contact
89B11	ROME_A disconnect (ZONE2_A) NC contact
89A12	ROME_A disconnect (TRANS_A) NO contact
89B12	ROME_A disconnect (TRANS_A) NC contact
89A13	CAIRO_A disconnect (ZONE1_A) NO contact
89B13	CAIRO_A disconnect (ZONE1_A) NC contact
89A14	CAIRO_A disconnect (ZONE2_A) NO contact
89B14	CAIRO_A disconnect (ZONE2_A) NC contact
89A15	CAIRO_A disconnect (TRANS_A) NO contact
89B15	CAIRO_A disconnect (TRANS_A) NC contact

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs on the A-phase relay. Jumper (hardwire) the disconnect inputs to the other two relays. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations.

Differential Trip Logic and Differential Element Assignment

Figure 6.147 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.) *Table 6.104* shows Relay Word bits and description for the differential protection outputs.

Table 6.104 Zone Differential Protection Output Relay Word Bits

Primitive Name	Description
87Z1	Zone 1 differential element trip
87Z2	Zone 2 differential element trip
87Z3	Transfer zone differential element trip

Differential trip bits 87BTR01–87BTR05 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

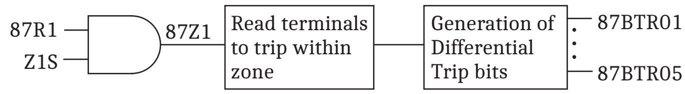


Figure 6.147 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.196*). *Table 6.105* shows the differential trip bit names and the associated terminal current channels.

Table 6.105 Differential Trip Bit and Associated Terminals

Differential Trip Bit	Description
87BTR01	Associated with Terminal 01
87BTR02	Associated with Terminal 02
87BTR03	Associated with Terminal 03
87BTR04	Associated with Terminal 04
87BTR05	Associated with Terminal 05

Breaker Failure Trip Logic and Station Breaker Failure Logic Output Assignment

Figure 6.148 shows the station breaker failure trip logic. Relay Word bits FBF01–FBF05 are the inputs to the station breaker failure logic; Relay Word bits SBFTR01–SBFTR05 are the outputs from the station breaker failure logic. Breaker failure trip bits SBFTR01–SBFTR05 assert to trip the circuit breakers of the terminals in the bus-zone with the failed circuit breaker. (See *Section 5: Protection Functions* for more information.)

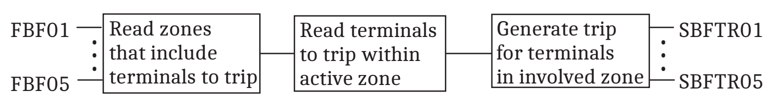


Figure 6.148 Breaker Failure Trip Logic

Table 6.106 shows the station breaker failure Relay Word bits and the primitive names for the breaker failure protection outputs.

Table 6.106 Station Breaker Failure Trip Bits and Associated Terminals

Station Breaker Failure Trip Bits	Description
SBFTR01	Associated with Terminal 01
SBFTR02	Associated with Terminal 02
SBFTR03	Associated with Terminal 03
SBFTR04	Associated with Terminal 04
SBFTR05	Associated with Terminal 05

Be sure to include the station breaker failure trip bits in the trip equations of all the terminals you want to trip for breaker failure protection. In this example, we want to trip five circuit breakers.

Breaker Failure Input Assignments

This application uses external breaker failure protection. *Figure 6.149* shows the logic for the external breaker failure function.

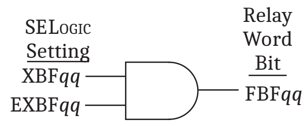


Figure 6.149 Breaker Failure Logic for External Breaker Failure

We assign the relay breaker failure inputs shown in *Table 6.101* and *Table 6.102* to the appropriate XBF*qq* (*qq* = 01–05) of the breaker failure protection logic (see *Protection Group Settings on page 6.201*). *Table 6.107* shows the relay input and terminal assignments.

Table 6.107 Breaker Failure Logic Input Relay Word Bits

Logic Name	Description
IN201	TIE_A breaker failure protection asserted
IN202	MADRI_A breaker failure protection asserted
IN203	MILAN_A breaker failure protection asserted
IN301	ROME_A breaker failure protection asserted
IN302	CAIRO_A breaker failure protection asserted

Relay Logic-to-Output Contact Allocation and Output Contact Assignments

Table 6.98 shows the breakdown of the five relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts. *Table 6.108* shows TEST and ALARM protection logic output assignment to the main board output contacts. *Table 6.109* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1.

Output Assignment, Main Board

This application requires no other output contacts from the main board.

Table 6.108 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.109* shows the assignments for the five terminals of the A-phase relay.

Table 6.109 Assignment of the Output Terminals

Output Contact Assignment	Description
OUT201[a]	TIE-BREAKER trip output
OUT202[a]	MADRID trip output
OUT203[a]	MILAN trip output
OUT204[a]	ROME trip output
OUT205[a]	CAIRO trip output

[a] High-speed, high-interrupting outputs.

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all relevant information on the station diagram, as shown in *Figure 6.150*.

1. Write down the bus-zone, terminal, and disconnect names.
2. Allocate the terminal CTs to the relay input current channels.
3. Allocate the terminal auxiliary contacts to the relay digital inputs.
4. Allocate the digital outputs from the relay to the terminals.

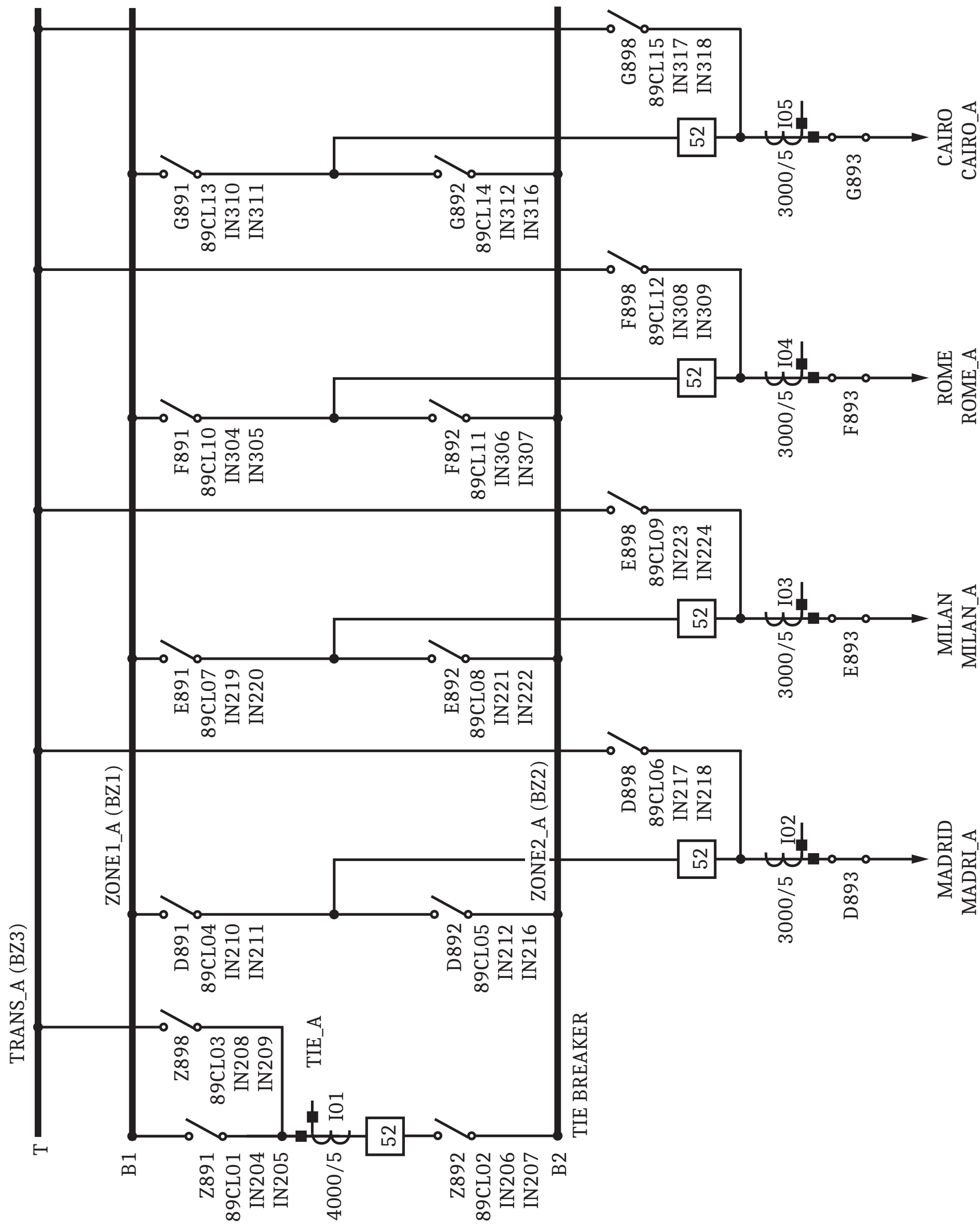


Figure 6.150 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. We set the following settings classes:

- ➤ Alias Settings
- ➤ Global Settings
- ➤ Zone Configuration Group Settings
- ➤ Protection Group Settings
- ➤ Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias settings class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.151*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: IO1,"FDR_1"
?  LIST <Enter>
1: IO1,"FDR_1"
2: IO2,"FDR_2"
3: IO3,"FDR_3"
4: IO4,"TRFR_1"
5: IO5,"TB_1"
6: IO6,"TB_2"
7: BZ1,"BUS_1"
8: BZ2,"BUS_2"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: IO1,"FDR_1"
?
```

Figure 6.151 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.152*.

```
1: IO1,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.152 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the settings list.

Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.153*.

```
1: OUT107,"TEST"
? > <Enter>
27:
? IO1,TIE_A <Enter>
28:
? IO2,MADRI_A <Enter>
29:
? IO3, MILAN_A <Enter>

30:
? IO4, ROME_A <Enter>
31:
? IO5, CAIRO_A <Enter>
32:
? BZ1,ZONE1_A <Enter>
33:
? BZ2,ZONE2_A <Enter>
34:
? BZ3,TRANS_A <Enter>

35:
? END <Enter>
Alias
.
.
.
Save settings (Y,N) ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.153 Analog Quantities and Relay Word Bit Alias Names

This concludes the alias settings. The next settings class is Global settings.

Global Settings

Global settings comprise settings that apply to all protection settings groups. For example, when changing from Protection Setting Group 1 to Protection Setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.154* shows the settings changes we need for our example. Because we declared the alias names in the previous settings class, use either the alias names or the primitive names when entering settings.

Set NUMBK to 5 because there are five circuit breakers at the station. Setting NUMBK to 5 makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting.

Declare here the input for the breaker status logic (52A01) for current channel I01 (52A01 := IN213). Set the remaining four circuit breaker auxiliary input equations (52A02–52A05) to NA.

Setting NUMDS declares the number of disconnect logics we need, not the number of disconnect inputs. In our example, we need 15 disconnect logics. You can set each disconnect travel time individually with the 89ALP*pp* setting (*pp* = 01–15). Travel time is the period during which both disconnect auxiliary contacts are in the open position. Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>
Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>

Number of Breakers (N,1-21)                          NUMBK   := 5      ?<Enter>
Number of Disconnects (N,1-60)                       NUMDS   := N      ?15 <Enter>
Nominal System Frequency (50,60 Hz)                  NFREQ   := 60     ?> <Enter>
Global Enables
Station DC Battery Monitor (Y,N)                     EDCMON  := N      ?> <Enter>
Control Inputs (Global)
Input Pickup Delay (0.00-30 ms)                      GINPU   := 2.0   ?> <Enter>

Settings Group Selection
Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  > <Enter>
Time and Date Management
Date Format (MDY,YMD,DMY)                            DATE_F  := MDY    ?> <Enter>

Breaker Inputs
N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  IN213 <Enter>
N/O Contact Input -BK02 (SELogic Equation)
52A02 := NA
? <Enter>
N/O Contact Input -BK03 (SELogic Equation)
52A03 := NA
?  > <Enter>

Disconnect Inputs and Timers
N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  IN204 <Enter>
N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  IN205 <Enter>
DS01 Alarm Pickup Delay (0-99999 cyc)                89ALP01 := 300    ?400 <Enter>

N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  IN206 <Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  IN207 <Enter>
DS02 Alarm Pickup Delay (0-99999 cyc)                89ALP02 := 300    ?400 <Enter>
N/O Contact Input -DS03 (SELogic Equation)
89A03 := NA
?  IN208 <Enter>

N/C Contact Input -DS03 (SELogic Equation)
89B03 := NA
?  IN209 <Enter>
DS03 Alarm Pickup Delay (0-99999 cyc)                89ALP03 := 300    ?400 <Enter>
N/O Contact Input -DS04 (SELogic Equation)
89A04 := NA
?  IN210 <Enter>
N/C Contact Input -DS04 (SELogic Equation)
89B04 := NA
?  IN211 <Enter>

DS04 Alarm Pickup Delay (0-99999 cyc)                89ALP04 := 300    ?<Enter>
N/O Contact Input -DS05 (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.154 Global Settings

This concludes the Global settings. The next settings class is the zone configuration Group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism for automatically reconfiguring the zone of protection, without any wiring changes (see *Dynamic Zone Selection Logic on page 5.14* for more information).

In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration and assign the input currents from the CTs to the appropriate differential elements.

For each disconnect, wire an 89A and an 89B disconnect auxiliary contact to the relay. Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays. Because we wire a disconnect auxiliary contacts to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the Milan feeder, all three phases (MILAN_A, MILAN_B, and MILAN_C) operate together. Because the relay measures the three phases in three separate relays (phase MILAN_A in the A-phase relay, phase MILAN_B in B-phase relay, etc.), we need to convey the disconnect status to all three relays.

For this discussion, we define the following terms:

- Source busbar: the busbar to which all terminals are connected, except the terminal on transfer
- Transfer busbar: the busbar to which the terminal on transfer is connected
- Transfer disconnect: the disconnect that connects the feeder to the transfer busbar (Disconnect G898 on the CAIRO Feeder)

Although the relay is flexible enough to accept settings for many possible disconnect combinations, we will configure the relay according to the following operating conditions:

1. Only one terminal will be on transfer at any given time, i.e., the tie-breaker transfer disconnect (Z898) and the transfer disconnect (*n*898, *n* = D, E, F, G) of only one of the four terminals can be closed simultaneously.
2. Only Busbar B2 can be the source busbar.
3. The operating sequence to put a terminal on transfer is fixed. Because the operating sequence defines a set of operating rules, settings engineers can decide on appropriate terminal-to-bus-zone and bus-zone-to-bus-zone connection settings for each step. *Table 6.110* shows the operating sequence for the settings in this application; many other operating sequences are possible and in use.

Refer to *Figure 6.157* and consider a case in which we put the CAIRO Feeder on transfer. Assume that the tie breaker is closed and that tie-breaker disconnect Z891 and disconnect Z892 are closed.

Table 6.110 Fixed Operating Sequence to Put a Feeder on Transfer

Step Number	Description	Comment
1	Switch all terminals to the source busbar (B2).	Close all the disconnects that connect the terminals to ZONE2_A (D892, E892, etc.)
2	Open the tie-breaker circuit breaker. Open Disconnect Z891, and close Disconnect Z898.	Closing Disconnects Z891 and Z898 forms the path from source busbar to transfer busbar (Busbar B2 to Busbar T).
3	Close the tie-breaker circuit breaker.	Busbar B2 and Busbar T are at the same potential.
4	Close the transfer disconnect of the terminal going on transfer (G898).	The relay now forms a differential zone for the transfer busbar.
5	Open the circuit breaker of the terminal going on transfer (Cairo circuit breaker).	Terminal G is now on transfer. Operation of disconnect G893 does not affect the busbar protection, and is not mentioned.

The zone configuration default settings are settings for a specific substation with arbitrarily selected alias names serving only as an example.

We use a combination of the zone supervision and coupler security logic to prevent tripping Busbar 2 for a fault between the tie-breaker circuit breaker and CT. For the zone supervision setting, we supervise the BZ2 differential element output by the negated coupler security output (ZS2 := NOT CSL1) see the *Protection Group Settings on page 6.201* for more information.

For ease of setting the zone configuration settings for the new substation, delete the terminal-to-bus-zone default settings. With the terminal-to-bus-zone default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone connection settings. *Figure 6.155* shows the zone configuration settings for this application.

```
=>>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     ?800 <Enter>
Current Transformer Ratio -I02 (1-50000)            CTR02   := 600     ? <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600     ?> <Enter>

Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TIE_A, ZONE1_A, P
?  DELETE 200 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,ZONE2_A,P <Enter>

TIE_A to ZONE2_A Connection (SELogic Equation)
I01BZ2V := NA
? (89CL01 OR 89CL03) AND 89CL02 AND (CB52A1 OR CBCLST1) <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,ZONE1_A,N <Enter>
TIE_A to ZONE1_A Connection (SELogic Equation)
I01BZ1V := NA
?  89CL01 AND 89CL02 AND (CB52T1 OR CBCLST1) <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I01,TRANS_A,N <Enter>

TIE_A to TRANS_A Connection (SELogic Equation)
I01BZ3V := NA
?  89CL03 AND 89CL02 AND (CB52T1 OR CBCLST1) <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  I02,ZONE1_A,P <Enter>
MADRI_A to ZONE1_A Connection (SELogic Equation)
I02BZ1V := NA
?  89CL04 <Enter>
```

Figure 6.155 Zone Configuration Group Settings

```
Terminal, Bus-Zone, Polarity (P,N)
?  IO2,ZONE2_A,P <Enter>
MADRI_A to ZONE2_A Connection (SELogic Equation)
IO2BZ2V := NA
?  89CL05 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO2,TRANS_A,P <Enter>

MADRI_A to TRANS_A Connection (SELogic Equation)
IO2BZ3V := NA
?  89CL06 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,ZONE1_A,P <Enter>
MILAN_A to ZONE1_A Connection (SELogic Equation)
IO3BZ1V := NA
?  89CL07 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,ZONE2_A,P <Enter>
MILAN_A to ZONE2_A Connection (SELogic Equation)
IO3BZ2V := NA
?  89CL08 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO3,TRANS_A,P <Enter>
MILAN_A to TRANS_A Connection (SELogic Equation)
IO3BZ3V := NA
?  89CL09 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,ZONE1_A,P <Enter>
ROME_A to ZONE1_A Connection (SELogic Equation)
IO4BZ1V := NA
?  89CL10 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO4,ZONE2_A,P <Enter>
ROME_A to ZONE2_A Connection (SELogic Equation)
IO4BZ2V := NA
?  89CL11 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,TRANS_A,P <Enter>
ROME_A to TRANS_A Connection (SELogic Equation)
IO4BZ3V := NA
?  89CL12 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE1_A,P <Enter>
CAIRO_A to ZONE1_A Connection (SELogic Equation)
IO5BZ1V := NA
?  89CL13 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE2_A,P <Enter>
CAIRO_A to ZONE2_A Connection (SELogic Equation)
IO5BZ2V := NA
?  89CL14 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO5,TRANS_A,P <Enter>
CAIRO_A to TRANS_A Connection (SELogic Equation)
IO5BZ3V := NA
?  89CL15 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?<Enter>
Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
?  ZONE1_A,ZONE2_A <Enter>

ZONE1_A to ZONE2_A Connection (SELogic Equation)
BZ1BZ2V := NA
?  (89CL04 AND 89CL05) OR (89CL07 AND 89CL08) OR (89CL10 AND 89CL11) OR (89CL13\
 AND 89CL14) <Enter>
Connection to Remove Terminals when ZONE1_A and ZONE2_A merge (SELogic Equation)
BZ1BZ2R := NA
?  BZ1BZ2V <Enter>
Terminals Removed when ZONE1_A and ZONE2_A Bus-Zones merge (Ter k,...,Ter n)
BZ1BZ2M :=
?  IO1 <Enter>

Trip Terminals TIE_A (Y,N)
BZ1BZ2T := N
?  Y <Enter>
Bus-Zone, Bus-Zone
?<Enter>
Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?Y <Enter>
Zone 1 Supervision (SELogic Equation)
Z1S := 1
?<Enter>
```

Figure 6.155 Zone Configuration Group Settings (Continued)

```
Zone 2 Supervision (SELogic Equation)
Z2S := 1
?  NOT CSL1 <Enter>
Zone 3 Supervision (SELogic Equation)
Z3S := 1
?  <Enter>
Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.

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

=>>
```

Figure 6.155 Zone Configuration Group Settings (Continued)

This concludes the zone configuration Group settings. The next settings class is the protection Group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available.

For this application, we use the default values for the sensitive differential element, the restrained differential element and the directional element.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Use the sensitive differential element for this requirement by setting E87SSUP := Y (see *Figure 6.11* and *Figure 6.17*). Because we do not use the terminal out of service, overcurrent elements, or voltage elements in this application, set ETOS := N, E50 := N, E51 := N, E27 := N, E59 := N, and EADVS := N.

Because the relay associates breaker failure protection with each current channel, select the number of breaker failure logics (EBFL setting) equal to the number of current channels, not the number of circuit breakers.

This application has five circuit breakers, and also five current channels (tie breaker has one CT channel). Therefore, select 5 as the number of breaker failure logics for this application. Setting NUMBK equal to 5 makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting. Be sure to include the Differential Trip bits in the trip equations of all circuit breakers you want to trip.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative way is to enter specific reset conditions at the ULTR*kk* settings.

Each of the five analog channels also has a corresponding station breaker failure trip bit that asserts (*Table 6.107*) when the breaker failure element asserts.

Be sure to include these station breaker failure trip bits in the trip equations of all circuit breakers you want to trip.

We use a combination of the zone supervision and coupler security logics to prevent tripping Busbar 2 for faults between the tie-breaker circuit breaker and the CT.

Figure 6.156 shows the combination of the coupler security logic and the zone supervision, with the input settings applied. Notice that Gate 1 and Gate 2 represent the tie-breaker terminal-to-bus-zone connection settings; they are not part of the logic.

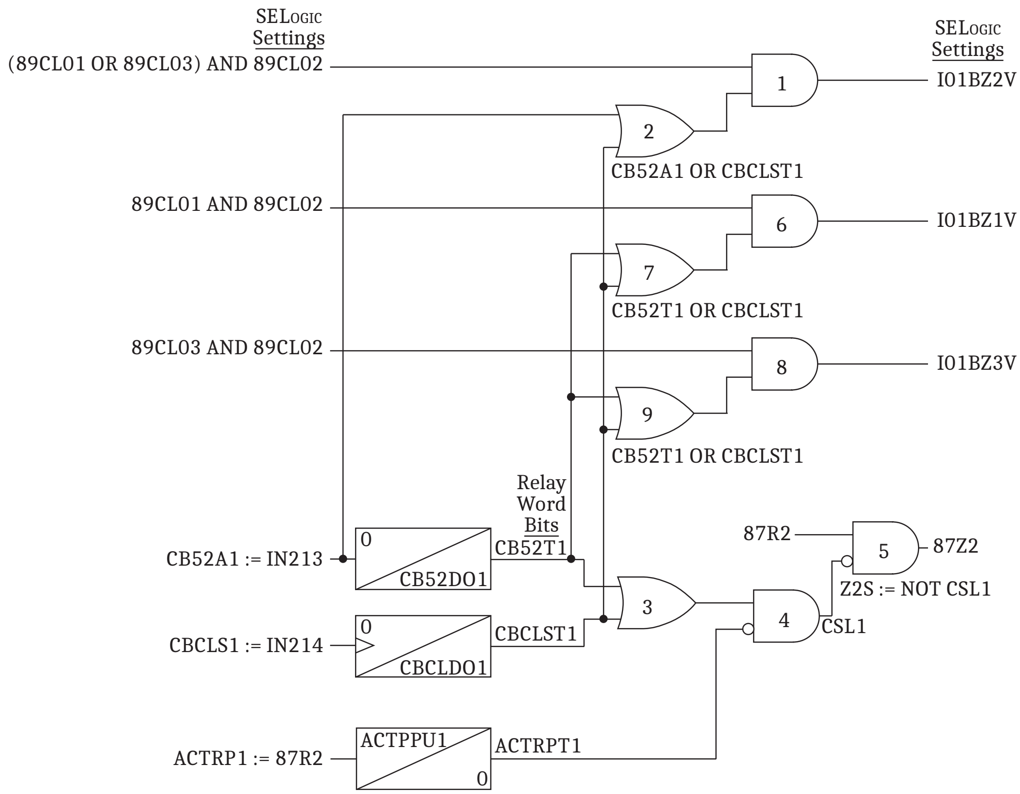


Figure 6.156 Combination of the Coupler Security Logic and the Zone Supervision to Prevent the Loss of Two Zones

Assume for this application that the maximum circuit breaker tripping time is 2 cycles and that the maximum closing time is 3 cycles. Refer to *Figure 6.156*, and notice that Inputs CB52A1 and CBCLS1 provide the circuit breaker status and the closing signal information to the relay. These two inputs are in parallel, complementing each other to provide accurate circuit breaker status during open-to-close and close-to-open circuit breaker operations.

When the operator issues a closing signal to the circuit breaker, Input CBCLS1 asserts, asserting Relay Word bit CBCLST1. We used CBCLST1 in the I01BZ1V, I01BZ2V, and I01BZ3V terminal-to-bus-zone settings. When Relay Word bits I01BZ1V, I01BZ2V, and I01BZ3V assert, the relay considers the CT in the differential calculations.

Set the timer dropout time (CBCLDO1) to a value longer than the maximum breaker closing time. In this example, allow a short safety margin and set CBCLDO1 to 5 cycles (default value).

Inserting the CTs in the differential equations before primary current flows emulates the early make, late break timing requirement for the disconnect auxiliary contacts. A setting of 5 cycles allows the circuit breaker ample time to change state, during which time the CB52A1 Relay Word bit asserts.

When opening the circuit breaker, the inverse applies. For a close-to-open circuit breaker operation, we must guard against prematurely removing the CTs from the differential equations due to circuit breaker auxiliary contact misalignment. We use CB52T1 in the tie-breaker terminal-to-bus-zone connection settings to accomplish this for Zone 1 and Zone 3. However, because we supervise all Zone 2 faults, premature removal of the CTs does not adversely affect Zone 2 differential elements.

Two tie-breaker operating conditions are possible: when the tie breaker connects between Busbar B1 and Busbar B2 (Disconnect Z891 and Disconnect Z892 are closed) or when the tie breaker connects between Busbar B2 and the Transfer busbar (Disconnect Z892 and Disconnect Z898 are closed).

The following discussion describes the prevention of the loss of Busbar 2 when the tie breaker connects between Busbar B1 and Busbar B2, but the same argument applies when a feeder is on transfer.

Figure 6.157 shows Busbar B1, Busbar B2, the tie breaker, and two of the four terminals at the station. The challenge to the coupler security logic is to trip Busbar B1 and not Busbar B2 for Fault F1. This requirement contradicts the existing configuration because it calls for the coupler security logic to prevent the differential element of Busbar B2 from operating for an in-zone fault (fault on Busbar 2), and for the differential element of Busbar B1 to operate for an out-of-zone fault (fault on Busbar 2).

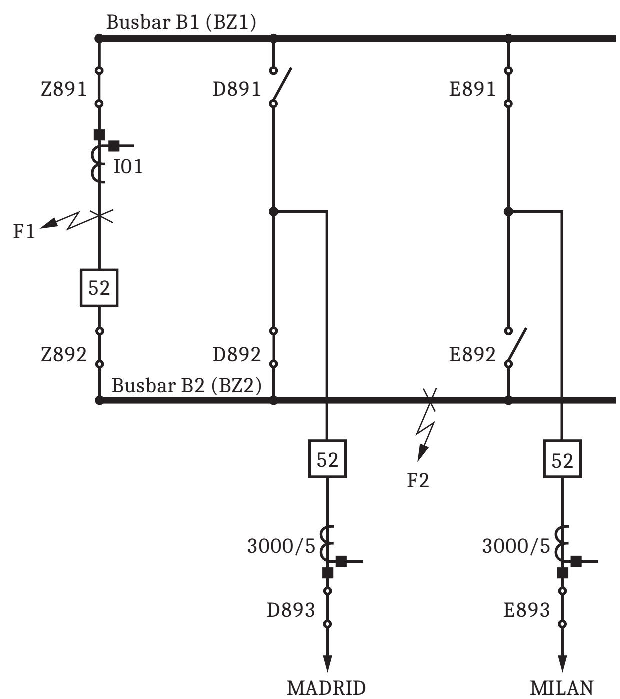


Figure 6.157 Single CT Application With Faults Between the Circuit Breaker and Tie-Breaker CT

Consider the operation when Fault F1 occurs without the coupler security logic. Differential protection B1 is stable, and differential protection B2 immediately trips the MADRID circuit breaker and the tie-breaker circuit breaker. However, tripping the MADRID circuit breaker and the tie-breaker circuit breaker does not clear Fault F1. Fault current still flows from the MILAN Feeder through Busbar B1 and into the fault. Although breaker failure protection will operate to trip the MILAN circuit breaker, this operation takes place after the breaker failure time delay. After the tie-breaker breaker failure timer times out, all circuit breakers in B1 trip, resulting in both B1 and B2 tripping to clear Fault F1.

If a delay in bus-zone protection operation is in order, implement the coupler security logic in a way that trips bus-zone B2 only when the tie-breaker circuit breaker is open. To prevent tripping of bus-zone B2, configure the relay to achieve the following:

1. Check if the tie breaker is closed. If the tie breaker is closed, trip only the tie breaker to interrupt the fault current from B2; trip no other circuit breakers. If the tie breaker is open, allow normal busbar protection tripping.
2. When the tie breaker is open, remove the tie-breaker CT from the differential calculations of B2 and eventually B1.

To check the tie-breaker status and remove the CT from the supervised zone when the tie breaker is open, use the tie-breaker auxiliary contact in the tie-breaker terminal-to-bus-zone connection settings. To remove the CT from the unsupervised zone, use the coupler status timed-out bit (CB52T1) in the tie-breaker terminal-to-bus-zone connection settings. To trip only the tie breaker for a fault on Busbar 2 requires the following two settings:

- supervising the BZ2 differential element
- issuing a trip signal to the tie breaker first

Supervise the BZ2 differential element output with the negated output from the coupler security logic (Z2S := NOT CSL1). We assign 87R2, the unsupervised output from the BZ2 differential element, to ACTRP1, the accelerated trip input of the coupler security logic. When accelerated trip timer output (ACTRPT1) asserts, Gate 4 in *Figure 6.156* turns off and Relay Word bit CSL1 deasserts. When Relay Word bit CSL1 deasserts, Relay Word bit Z2S asserts, removing the supervision from the BZ2 differential element.

Supervising the BZ2 differential element in this way prevents the tripping of all terminals in BZ2, including the tie breaker. To still trip the tie breaker, include 87R2, the unsupervised output from Differential Element 2, in the trip equation of the tie breaker.

After the tie breaker opens, we remove the tie-breaker CT from the differential calculations of BZ2, but not the BZ2 supervision. Maintain the BZ2 supervision for at least another 1.25 cycles (add a safety margin of 0.75 cycles) to allow the differential element to reset. Achieve this delay by setting ACTPPU1 to at least 4 cycles.

For Fault F1, BZ2 operates, asserting Relay Word bit 87R2. When Relay Word bit 87R2 asserts, the accelerated trip timer starts timing. Because of the BZ2 zone supervision (NOT CSL1), 87Z2 cannot assert, and only the bus coupler circuit breaker receives a trip signal.

Two cycles later, the tie breaker trips, interrupting the fault current contribution from BZ2. Assume the circuit breaker auxiliary contact changes state at the same time. When the auxiliary contact changes state, Relay Word bit CB52A1 deasserts, causing Relay Word bits I01BZ2V and eventually I01BZ1V to also deassert. When Relay Word bits I01BZ1V and I01BZ2V deassert, the relay removes the CTs from the differential calculations for BZ1 and BZ2. For Fault F1, the bus coupler circuit breaker is open, but fault current still flows through the CT. BZ2 is stable when the relay removes the CTs because the bus coupler circuit breaker is open, and terminals from BZ2 no longer contribute to the fault. However, removing the CTs causes BZ1 to operate because the BZ1 balancing current from the bus coupler CT disappeared. Removing the bus sectionalizer CTs also deasserts Relay Word bit 87R2, causing the accelerated trip timer to stop timing. Fault F1 is now cleared, by tripping the correct busbar, although after a time delay.

For Fault F2, the initial tripping is the same as for Fault F1: BZ2 operates, asserting Relay Word bit 87R2. When Relay Word bit 87R2 asserts, the accelerated trip timer starts timing. Because of the BZ2 zone supervision (NOT CSL1), 87Z2 cannot assert, and only the bus coupler circuit breaker receives a trip signal.

Two cycles later, the tie breaker trips, and the auxiliary contact changes state at the same time. When the auxiliary contact changes state, Relay Word bit CB52A1 deasserts, causing Relay Word bits I01BZ2V and eventually I01BZ1V to also deassert. When Relay Word bits I01BZ1V and I01BZ2V deassert, the relay removes the CTs from the differential calculations for BZ1 and BZ2. Because the bus coupler circuit breaker is open, terminals from BZ1 no longer contribute to the fault and BZ1 is stable. However, the BZ2 zone supervision (NOT CSL1) still supervises the BZ2 trip output for another two cycles. Two cycles later, Accelerate Trip Timer ACTRP1 times out, causing CSL1 to deassert. When Relay Word bit CSL1 deasserts, Relay Word bit Z2S asserts, removing the zone supervision from BZ2 and issuing a trip signal to all circuit breakers on Busbar 2.

Although each SEL-487B includes 21 trip logics, there is only one Minimum Trip Duration Time Delay (TDURD) setting.

Because the default setting is longer than the slowest tripping time, use the default setting of 12 cycles. *Figure 6.158* shows the Group 1 settings.

```
=>>SET <Enter>
Group 1
Relay Configuration
Sensitive Differential Element Supervision (Y,N)    E87SSUP := Y      ? <Enter>
Coupler Security Logic (N,1-4)                      ECSL    := N      ?1 <Enter>
Terminal Out of Service (N,1-21)                    ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                      EBFL    := 6      ?5 <Enter>
Definite Time Overcurrent Elements (N,1-21)         E50     := N      ? <Enter>
Inverse Time Overcurrent Elements (N,1-21)          E51     := N      ? <Enter>
Voltage Elements (Y,N)                              EVOLT   := Y      ?N <Enter>
Advanced Settings (Y,N)                             EADVS   := N      ? <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>
Coupler 1 Security Logic
Coupler 1 Status (SELogic Equation)
CB52A1 := NA
?  IN213 <Enter>

Coupler 1 Status Dropout Delay (0.00-1000 cyc)      CB52DO1 := 4.00   ? <Enter>
Coupler 1 Close Command (SELogic Equation)
CBCLS1 := NA
?  IN214 <Enter>
Coupler 1 Close Command D/O Delay (0.00-1000 cyc)   CBCLDO1 := 5.00   ? <Enter>
Coupler 1 Acc Trip (SELogic Equation)
ACTRP1 := NA
?  87R2 <Enter>
Coupler 1 Acc Trip Pickup Delay (0.00-1000 cyc)     ACTPPU1 := 4.00   ? <Enter>

Breaker 01 Failure Logic
External Breaker Fail -BK01 (Y,N)                   EXBF01  := N      ?Y <Enter>
External Brkr Fail Init -BK01 (SELogic Equation)
XBF01 := NA
?  IN201 <Enter>
Breaker 02 Failure Logic
External Breaker Fail -BK02 (Y,N)                   EXBF02  := N      ?Y <Enter>
External Brkr Fail Init -BK02 (SELogic Equation)
XBF02 := NA
?  IN202 <Enter>
```

Figure 6.158 Protection Group Settings for Application 7

```
Breaker 03 Failure Logic
External Breaker Fail -BK03 (Y,N)                EXBF03  := N      ?Y <Enter>
External Brkr Fail Init -BK03 (SELogic Equation)
XBF03 := NA
?  IN203 <Enter>
Breaker 04 Failure Logic
External Breaker Fail -BK04 (Y,N)                EXBF04  := N      ?Y <Enter>
External Brkr Fail Init -BK04 (SELogic Equation)
XBF04 := NA
?  IN301<Enter>

External Breaker Fail -BK05 (Y,N)                EXBF05  := N      ?Y <Enter>
External Brkr Fail Init -BK05 (SELogic Equation)
XBF05 := NA
?  IN302 <Enter>
Brkr Fail Init Dropout Delay -BK05 (0.00-1000 cyc)   BFIDO05 := 1.50   ? <Enter>
Trip Logic
Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87BTR01
?  SBFTR01 OR 87BTR01 OR 87R2 <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
? <Enter>
Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87BTR02
?  <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
? <Enter>
Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87BTR03
?  <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
? <Enter>
.
.
.
Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ? <Enter>
Event Report Trigger Equation (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.158 Protection Group Settings for Application 7 (Continued)

This concludes the protection group settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings.

Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay. Connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts.

Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA. *Figure 6.159* shows the control output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRIP01 AND NOT TNS_SW
?  NA <Enter>

OUT102 := TRIP02 AND NOT TNS_SW
?  NA <Enter>
OUT103 := TRIP03 AND NOT TNS_SW
?  NA <Enter>

OUT104 := TRIP04 AND NOT TNS_SW
?  NA <Enter>

OUT105 := TRIP05 AND NOT TNS_SW
?  NA <Enter>
OUT106 := NA
?  > <Enter>

Interface Board #1
OUT201 := NA
?  TRIP01 AND NOT PLT03 <Enter>
OUT202 := NA
?  TRIP02 AND NOT PLT03 <Enter>
OUT203 := NA
?  TRIP03 AND NOT PLT03 <Enter>
OUT204 := NA
?  TRIP04 AND NOT PLT03 <Enter>

OUT205 := NA
?  TRIP05 AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.159 Control Output Settings for Application 7

This concludes the settings for Application 7.

Application 8: Double and Transfer Bus (Inboard CTs)

This application describes the busbar arrangement shown in *Figure 6.160*. The busbar arrangement consists of three busbars, four terminals, and a tie breaker. Use the following to set and configure the relay:

- ➤ Busbar classification
- ➤ Protection philosophy
- ➤ Protection function selection
- ➤ Number of SEL-487B Relays and I/O boards
- ➤ Input, logic, and output allocation
- ➤ Station layout update
- ➤ Relay setting and configuration

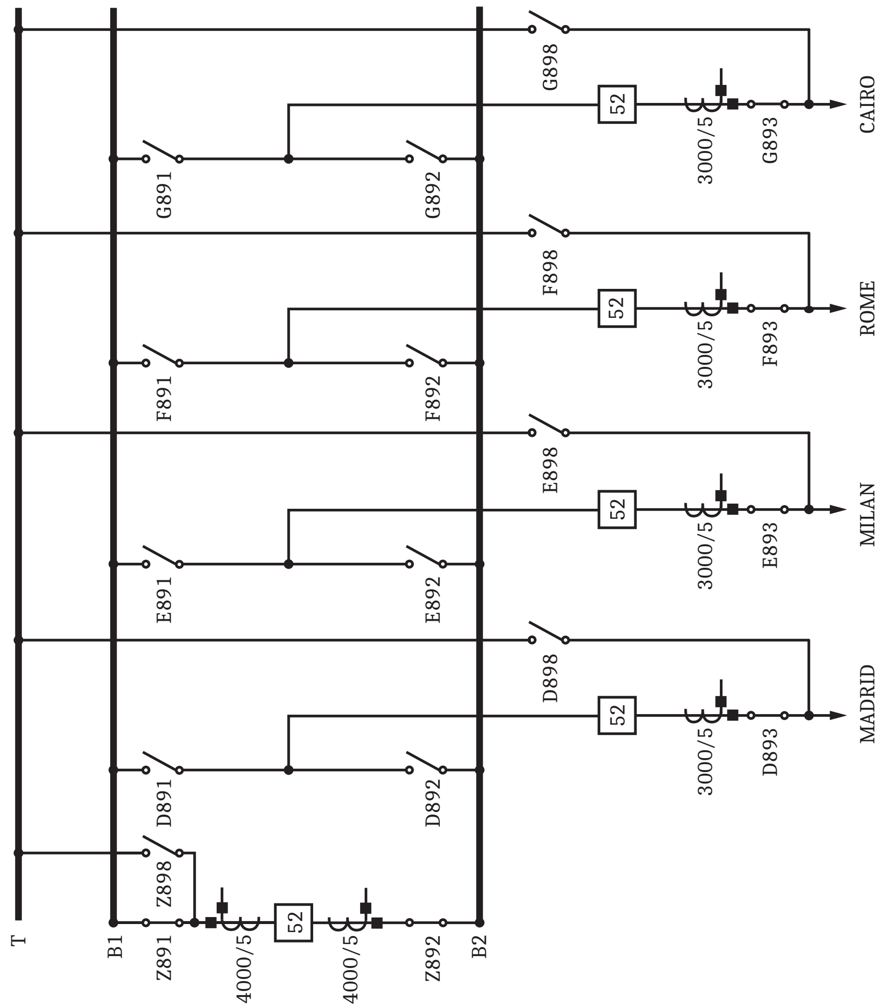


Figure 6.160 Double Bus and Transfer Bus With Bus Coupler (Tie Breaker) and Inboard CTs

Busbar Classification

The busbar classification provides general busbar layout and CT positioning (inboard or outboard) information and declares the tie-breaker (bus coupler) configuration.

- ➤ Description: Double bus with transfer busbar
- ➤ Current transformers: Bushing (inboard)
- ➤ Disconnects: 89A and 89B disconnect auxiliary contacts are available
- ➤ Bus coupler (tie breaker): Two CTs, configured in overlap
- ➤ Future expansion: Four feeders

Protection Philosophy

Although the SEL-487B offers a variety of protection and control functions, not every application uses all these functions. Carefully consider each application before stating the functional requirements. The protection philosophy for this application is as follows:

1. Rename the terminals and bus-zones with alias names.
2. Block the busbar protection for an open-circuit CT.
3. Use the disconnect auxiliary contacts to dynamically configure the station.
4. Use the disconnect monitor logic.
5. Ensure stable differential protection for all operating conditions.

Protection Functions Selection

We select protection functions early in the relay setting and configuration process because the choice of protection functions determines the number of relay digital inputs and outputs necessary for the application. Study the protection philosophy to determine which protection and/or control functions to apply to any particular substation. The SEL-487B offers a number of protection functions as standard features, but it also offers the capability through SELOGIC control equations for you to create user-configurable functions. Requirement 5 of the protection philosophy calls for stable differential protection for all operating conditions. There are two network conditions when the differential protection can become unstable:

➤ when disconnects *n*891 and *n*892 (*n* = D, E, F, G) of any feeder are closed at the same time

➤ when the transfer disconnect of any feeder is closed

By following the correct operating sequence, and by declaring the appropriate conditions in the terminal-to-bus-zone and bus-zone-to-bus-zone connection settings of the zone selection logic, the relay is stable for all operating conditions.

Standard Functions

Refer to *Protection Philosophy on page 6.209* and select the standard functions necessary for the application. *Table 6.111* shows the selection of standard functions.

Table 6.111 Selection of the Standard Protection Functions (Sheet 1 of 2)

Protection Functions	Selection	Comment
CT ratio mismatch ≤ 10:1	Yes	10:1 mismatch is the maximum allowable mismatch
Circuit breaker status logic	No	Not required
Disconnect monitor logic	Yes	89A and 89B disconnect contacts available
Differential protection	Yes	Busbar protection (zone specific and check zone)
Dynamic zone selection logic	Yes	Use the zone selection to reconfigure the differential protection according to the disconnect positions.
Sensitive differential protection	Yes	Use the sensitive differential element as CT open-circuit detection.

Table 6.111 Selection of the Standard Protection Functions (Sheet 2 of 2)

Protection Functions	Selection	Comment
Zone supervision logic	No	Not required. We achieve relay stability with terminal-to-bus-zone and bus-zone-to-bus-zone connection settings.
Zone-switching supervision logic	No	89A and 89B disconnect contacts available, so this logic is not required.
Coupler security logic	No	Two CTs configured in overlap do not require the coupler security logic.
Circuit breaker failure protection	No	Not required
Instantaneous overcurrent protection	No	Not required
Time-overcurrent protection	No	Not required
Phase voltage elements	No	Not required
Zero- or negative-sequence voltage elements	No	Not required

User-Defined Functions

Identify logic functions we need that is not part of the standard relay logic in the relay. In this application, we comply with the protection philosophy using the standard functions in the relay.

Number of Relays and I/O Boards

Selecting the relay has two parts:

- the number of relays (single-relay application or three-relay application)
- the number of interface boards (as many as four interface boards per relay)

The number of analog (CT) inputs determines the number of relays, and the number of digital inputs and outputs determines the number of interface boards.

Number of Relays

Each SEL-487B has 21 current channels and three voltage channels. For stations with as many as 21 CTs (per phase), we can install a single SEL-487B. For stations with more than 21 and as many as 63 CTs, we install 3 SEL-487B Relays. Use *Equation 6.28* to calculate the number of current channels at the station, and use *Equation 6.29* to calculate the number of zones at the station.

$$\text{\# of current channels required} = \text{\# of per-phase station CTs}$$

Equation 6.28

$$\text{\# of bus-zones required} = \text{\# of per-phase station bus sections}$$

Equation 6.29

The number of per-phase CTs at the station is 18 (tie breaker has six CT cores), so one SEL-487B suffices. However, the requirement for four future feeders increases the number of per-phase CTs to 30. Because each SEL-487B has 21 analog input channels, we need three relays. This is known as a three-relay application. In a three-relay application, each relay provides six zones of protection for one of the three phases of the power system. For example, wire all the A-phase CTs to Relay 1, all the B-phase CTs to Relay 2, and all the C-phase CTs to Relay 3. Settings for the three relays are identical; all three relays require the same information. Wire input and output contacts (from the circuit breaker or disconnects, for example) to one of the three relays, then jumper (hardwire) the input and output contacts to the other two relays.

This example shows the setting and configuration for the A-phase relay, so identified with an appended letter A (MADRI_A). For the other two relays, the settings and configuration are the same as for the A-phase relay, but the appended letter changes according to the letter designation of the relay. For example, the corresponding MADRI_A setting is MADRI_B in the B-phase relay, and MADRI_C in the C-phase relay.

Number of Relay Inputs

The protection philosophy and protection function selection determine the number of digital relay inputs and outputs required for each application.

The number of disconnect logics (NUMDS) required is the number of disconnects for which the protection philosophy requires disconnect monitoring logic. In this example, the tie breaker and each of the 4 feeders require 3 disconnect monitoring logics; the number of disconnect logics required is therefore 15. Each disconnect monitoring logic requires two disconnect auxiliary contact inputs: an 89A and an 89B contact. Use *Equation 6.30* to calculate the number of relay inputs required for the disconnect auxiliary contacts.

$$\text{\# relay inputs required} = 2 \bullet \text{\# disconnect monitoring logics}$$

Equation 6.30

Table 6.112 summarizes the input contact required for this application.

Table 6.112 Relay Input Contacts Requirement

Input Description	Inputs
Number of relay inputs required for the disconnect contacts	2 • 15 = 30
Total number of inputs	30

The relay main board has seven inputs, an insufficient number of inputs for our application. Each interface board provides two sets of nine grouped inputs and six independent inputs. Use the grouped inputs for the disconnect auxiliary contact inputs, and use the six independent inputs for future breaker failure inputs. From the input perspective, we need two interface boards.

Number of Relay Output Contacts

Our example station has five circuit breakers, all of which are part of the busbar differential protection. Because all circuit breakers are part of the busbar differential protection, we want to trip each breaker when the differential protection operates. *Table 6.113* shows the breakdown and the number of relay output contacts necessary for tripping.

Table 6.113 Breakdown and Number of Relay Outputs Required

Output Description	Outputs
Number of relay output contacts required for breaker tripping	5
Total number of relay output contacts	5

The relay main board has eight standard output contacts (Output Contact 7 is used to assert when the **RELAY TEST MODE** pushbutton from the front panel is selected, and Output Contact 8 is used for alarming purposes in the default settings). However, the main board output contacts are all standard output contacts. The interface boards have high-speed, high-interrupting output contacts that provide faster contact closure. Each interface board can provide six high-speed, high-interrupting output contacts and two standard output contacts. For fast busbar fault clearance, assign each circuit breaker trip output to a high-speed, high-interrupting output contact for each of the circuit breakers at the station. From the output contact perspective, we need one interface board.

The conclusion from the preceding analysis is that we need three SEL-487B Relays, each relay equipped with two interface boards.

Input, Logic, and Output Allocation and Alias Name Assignment

At this point, we have determined the following:

- The number of SEL-487B Relays required for the application
- The number of input contacts
- The number of output contacts
- The selected functions

For example, we have matched the number of CTs at the station with the number of available analog channels in the relay. However, we still need to do the following:

- Assign each CT input to a specific relay analog channel
- Assign each disconnect input to specific relay inputs
- Link relay element/logic outputs to specific relay output contacts
- Assign alias names where appropriate

Assign a valid seven-character alias name to any of the following:

- Relay Word bit
- Analog Quantity
- Terminal Name
- Bus-Zone Name

Alias names are valid when they consist of a maximum of seven characters, and they are constructed with characters 0–9, uppercase A–Z, or the underscore (_).

CT-to-Analog Channel Allocation and CT Alias Assignment

The protection philosophy specifies that only the terminals and bus-zones need alias names. *Table 6.114* shows CT-to-relay analog channel allocations and alias assignments. For example, allocate the A-phase tie-breaker CT to relay channel I01, and assign to this CT the alias name TIE1_A. The choice of CT-to-analog channel allocation is arbitrary; you can assign the CTs randomly to relay analog channels. *Table 6.114* shows the assignment for the A-phase relay starting with the tie-breaker CTs, followed by the four terminals, taken left-to-right from *Figure 6.160*.

Table 6.114 CTs-to-Analog Channel Allocations and Alias Assignments

CTs	Analog Channel	Alias
TIE-BREAKER CT1, A-phase	I01	TIE1_A
TIE-BREAKER CT2, A-phase	I02	TIE2_A
MADRID terminal, A-phase	I03	MADRI_A
MILAN terminal, A-phase	I04	MILAN_A
ROME terminal, A-phase	I05	ROME_A
CAIRO terminal, A-phase	I06	CAIRO_A

Bus-Zone Alias Assignment

Each SEL-487B provides six zones of protection. Although there are three busbars at the station, we only provide differential protection for Busbar B1 and Busbar B2. Because the feeders have bushing CTs, the transfer busbar never forms part of the busbar protection. For the A-phase relay, we use two bus-zones with alias names as shown in *Table 6.115*.

Table 6.115 Alias Names for the Two Bus-Zones

Bus-Zone Name	Description	Alias
BZ1	Bus-Zone 1	ZONE1_A
BZ2	Bus-Zone 2	ZONE2_A

Input-to-Logic Allocation

Table 6.112 shows that we require 30 digital inputs. We now assign the digital input contacts to the selected logic. Because of the functional requirements of this application, we do not need any digital inputs on the main board.

Input-to-Logic Allocation, Interface Board 1 (200)

Table 6.116 and *Table 6.117* show the disconnect auxiliary contact input allocations. Because Inputs IN201, IN202, IN203, IN213, IN214, and IN215 are independent inputs, we preserve these for future circuit breaker failure inputs.

Table 6.116 Disconnect Contact Input Allocations (Sheet 1 of 2)

Input	Description
IN204	TIE-BREAKER disconnect (ZONE1_A) NO contact
IN205	TIE-BREAKER disconnect (ZONE1_A) NC contact
IN206	TIE-BREAKER disconnect (ZONE2_A) NO contact
IN207	TIE-BREAKER disconnect (ZONE2_A) NC contact
IN208	TIE-BREAKER disconnect (TRANS_A) NO contact
IN209	TIE-BREAKER disconnect (TRANS_A) NC contact
IN210	MADRID terminal disconnect (ZONE1_A) NO contact
IN211	MADRID terminal disconnect (ZONE1_A) NC contact
IN212	MADRID terminal disconnect (ZONE2_A) NO contact
IN216	MADRID terminal disconnect (ZONE2_A) NC contact
IN217	MADRID terminal disconnect (TRANS_A) NO contact
IN218	MADRID terminal disconnect (TRANS_A) NC contact

Table 6.116 Disconnect Contact Input Allocations (Sheet 2 of 2)

Input	Description
IN219	MILAN terminal disconnect (ZONE1_A) NO contact
IN220	MILAN terminal disconnect (ZONE1_A) NC contact
IN221	MILAN terminal disconnect (ZONE2_A) NO contact
IN222	MILAN terminal disconnect (ZONE2_A) NC contact
IN223	MILAN terminal disconnect (TRANS_A) NO contact
IN224	MILAN terminal disconnect (TRANS_A) NC contact

Input-to-Logic Allocation, Interface Board 2 (300)

Table 6.117 shows the disconnect and auxiliary contact input allocations. Because Inputs IN301, IN302, IN303, IN313, IN314, and IN315 are independent inputs, we preserve these inputs for future circuit breaker failure inputs.

Table 6.117 Disconnect Contact Input Allocations

Input	Description
IN304	ROME terminal disconnect (ZONE1_A) NO contact
IN305	ROME terminal disconnect (ZONE1_A) NC contact
IN306	ROME terminal disconnect (ZONE2_A) NO contact
IN307	ROME terminal disconnect (ZONE2_A) NC contact
IN308	ROME terminal disconnect (TRANS _A) NO contact
IN309	ROME terminal disconnect (TRANS _A) NC contact
IN310	CAIRO terminal disconnect (ZONE1_A) NO contact
IN311	CAIRO terminal disconnect (ZONE1_A) NC contact
IN312	CAIRO terminal disconnect (ZONE2_A) NO contact
IN316	CAIRO terminal disconnect (ZONE2_A) NC contact
IN317	CAIRO terminal disconnect (TRANS _A) NO contact
IN318	CAIRO terminal disconnect (TRANS _A) NC contact

Assignment of the Selected Standard Logic

The following discussion references *Table 6.111* in explaining each selected function.

Disconnect Monitoring Logic

Figure 6.161 shows the disconnect monitor logic circuit available in the relay. See *Figure 6.120* for more information.

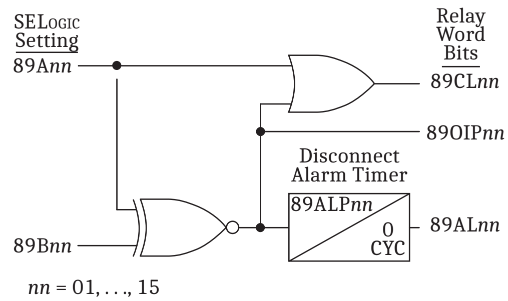


Figure 6.161 One of the Disconnect Monitoring Logic Circuits Available in the Relay

Table 6.118 shows the assignment of the disconnect auxiliary contact Relay Word bits.

Table 6.118 Disconnect Auxiliary Contact Relay Word Bits (Sheet 1 of 2)

Input	Description
89A01	TIE-BREAKER disconnect (ZONE1_A) NO contact
89B01	TIE-BREAKER disconnect (ZONE1_A) NC contact
89A02	TIE-BREAKER disconnect (ZONE2_A) NO
89B02	TIE-BREAKER disconnect (ZONE2_A) NC
89A03	TIE-BREAKER disconnect (TRANS_A) NO
89B03	TIE-BREAKER disconnect (TRANS _A) NC
89A04	MADRI_A disconnect (ZONE1_A) NO contact
89B04	MADRI_A disconnect (ZONE1_A) NC contact
89A05	MADRI_A disconnect (ZONE2_A) NO contact
89B05	MADRI_A disconnect (ZONE2_A) NC contact
89A06	MADRI_A disconnect (TRANS_A) NO contact
89B06	MADRI_A disconnect (TRANS_A) NC contact
89A07	MILAN_A disconnect (ZONE1_A) NO contact
89B07	MILAN _A disconnect (ZONE1_A) NC contact
89A08	MILAN _A disconnect (ZONE2_A) NO contact
89B08	MILAN _A disconnect (ZONE2_A) NC contact
89A09	MILAN _A disconnect (TRANS_A) NO contact
89B09	MILAN _A disconnect (TRANS_A) NC contact
89A10	ROME_A disconnect (ZONE1_A) NO contact
89B10	ROME _A disconnect (ZONE1_A) NC contact
89A11	ROME _A disconnect (ZONE2_A) NO contact
89B11	ROME _A disconnect (ZONE2_A) NC contact
89A12	ROME _A disconnect (TRANS_A) NO contact
89B12	ROME _A disconnect (TRANS_A) NC contact
89A13	CAIRO _A disconnect (ZONE1_A) NO contact
89B13	CAIRO _A disconnect (ZONE1_A) NC contact
89A14	CAIRO _A disconnect (ZONE2_A) NO contact
89B14	CAIRO _A disconnect (ZONE2_A) NC contact

Table 6.118 Disconnect Auxiliary Contact Relay Word Bits (Sheet 2 of 2)

Input	Description
89A15	CAIRO _A disconnect (TRANS_A) NO contact
89B15	CAIRO _A disconnect (TRANS_A) NC contact

Wire a normally open disconnect auxiliary contact (89A) and a normally closed disconnect auxiliary contact (89B) from each disconnect to individual relay inputs on the A-phase relay. Jumper (hardwire) the disconnect input contacts to the other two relays. Relay Word bits 89CL*nn* assert when the disconnect monitoring logic interprets the disconnect main contacts as closed. Use Relay Word bits 89CL*nn* as conditions in the terminal-to-bus-zone SELOGIC control equations.

Differential Trip Logic and Differential Element Assignment

Figure 6.162 shows the differential trip logic for Differential Element 1. Relay Word bit 87Z1 asserts only if the zone supervision conditions permit an output from the AND gate. (See *Section 5: Protection Functions* for more information.) *Table 6.119* shows Relay Word bits and description for the zone differential protection outputs. Because of the bushing (inboard) CTs, we cannot provide differential protection for the transfer busbar.

Table 6.119 Zone Differential Protection Output Relay Word Bits

Primitive Name	Description
87Z1	Zone 1 differential element trip
87Z2	Zone 2 differential element trip

Differential trip bits 87BTR01–87BTR06 assert to trip the circuit breakers of the terminals in the faulted bus-zone. (See *Section 5: Protection Functions* for more information.)

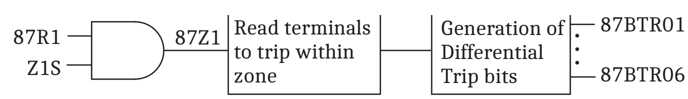


Figure 6.162 Differential Trip Logic for Differential Element 1

Be sure to include the differential trip bits in the trip equations of all the terminals you want to trip when the differential elements operate (see *Global Settings on page 6.220* for more information). *Table 6.120* shows the differential trip bit names and the associated terminal current channels.

Table 6.120 Differential Trip Bit Names and Associated Terminal Names

Differential Trip Bit	Description
87BTR01	Associated with Terminal 01
87BTR02	Associated with Terminal 02
87BTR03	Associated with Terminal 03
87BTR04	Associated with Terminal 04
87BTR05	Associated with Terminal 05
87BTR06	Associated with Terminal 06

Relay Logic-to-Output Contact Allocation and Output Contact Assignments

Table 6.113 shows the relay outputs we need for this application. We now link the appropriate relay logic outputs to specific relay output contacts. *Table 6.121* shows TEST and ALARM protection logic output assignment to the main board output contacts. *Table 6.122* shows the linking of the trip logic outputs to the relay output contacts of Interface Board 1.

Output Assignment, Main Board

This application requires no other output contacts from the main board.

Table 6.121 Alias Names for the Main Board Output Contacts

Output Contact Assignment	Description	Output Contact Alias
OUT107	Relay in test mode	TEST
OUT108	Relay alarm	ALARM

Output Assignment, Interface Board 1 (200)

Each interface board of the SEL-487B can include six high-speed, high-interrupting output contacts. *Table 6.122* shows the assignment of the A-phase relay output terminals.

Table 6.122 Assignment of the Output Terminals

Output Contact Assignment	Description
OUT201	TIE-BREAKER trip logic output
OUT202a	MADRID trip logic output
OUT203a	MILAN trip logic output
OUT204a	ROME trip logic output
OUT205a	CAIRO trip logic output

Station Layout Update (A-Phase)

We are now ready to set and configure the relay. Write all the relevant information on the station diagram, as shown in *Figure 6.163*.

1. Write down the bus-zone, terminal, and disconnect names.
2. Draw in the overlapping zone on the bus section to clearly identify the terminal/zone allocation.
3. Allocate the terminal CTs to the relay input current channels.
4. Allocate the terminal auxiliary contacts to the relay digital inputs.
5. Allocate the digital outputs from the relay to the terminals.

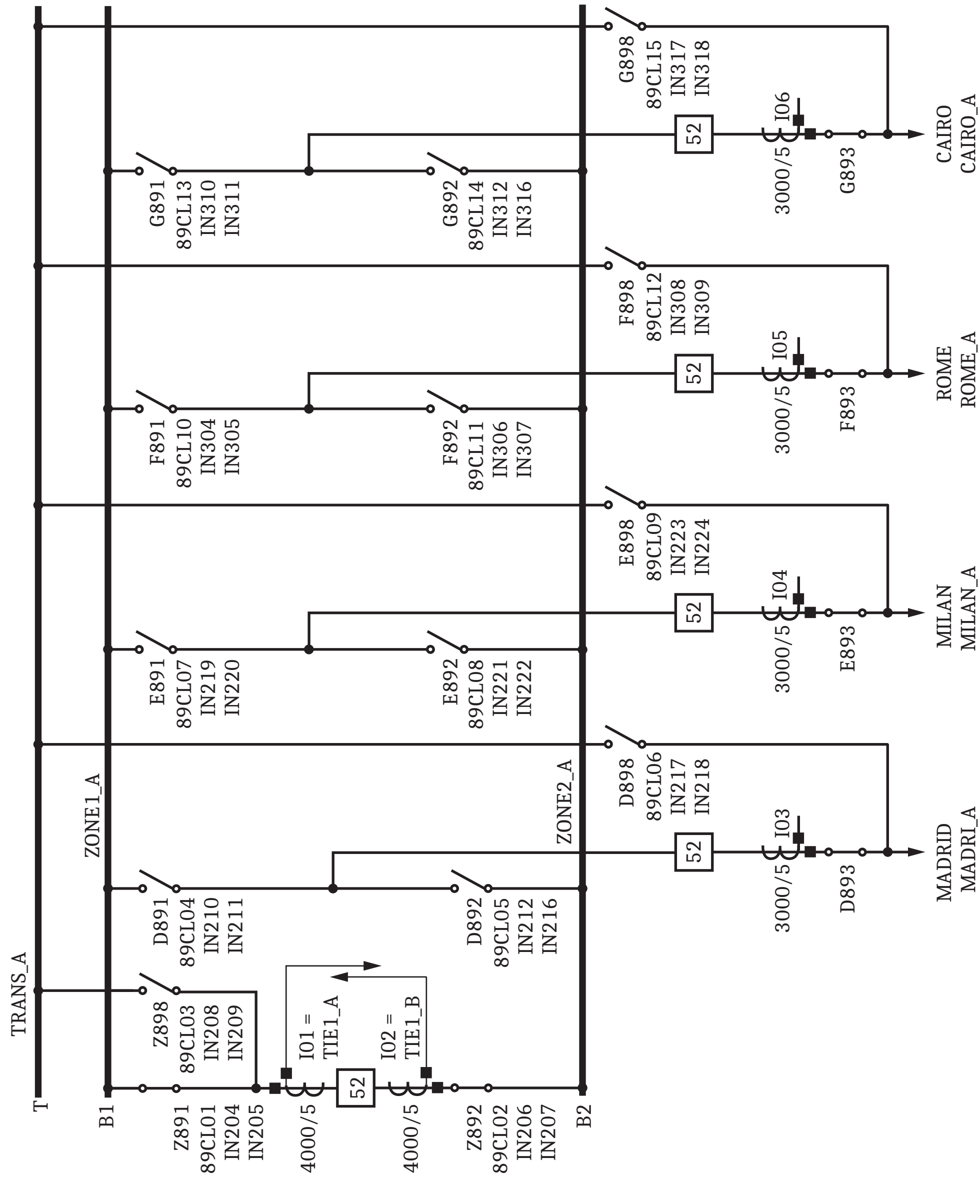


Figure 6.163 Substation Layout With Specific Terminal Information

Setting the Relay

The following describes the settings for this application. For this application, we set the following setting classes:

- ➤ Alias Settings
- ➤ Global Settings
- ➤ Zone Configuration Group Settings
- ➤ Protection Group Settings
- ➤ Control Output Settings

Alias Settings

We have identified and allocated the alias names to the analog channels and Relay Word bits. We now enter the alias names in the relay. Type **SET T <Enter>** to enter the alias setting class. Many default Relay Word bits have useful alias names ready for use. Type **LIST <Enter>** to see a list of default primitive names and associated alias names, as shown in *Figure 6.164*.

After inspecting the list, we decide the only useful alias names are those of the 16 LEDs, TEST, and ALARM.

```
=>>SET T <Enter>
Alias
Relay Aliases
(RW Bit or Analog Qty. or Terminal or Bus-Zone, 7 Character Alias [0-9 A-Z _])
1: IO1,"FDR_1"
?  LIST <Enter>
1: IO1,"FDR_1"
2: IO2,"FDR_2"
3: IO3,"FDR_3"
4: IO4,"TRFR_1"
5: IO5,"TB_1"
6: IO6,"TB_2"
7: BZ1,"BUS_1"
8: BZ2,"BUS_2"
.
.
.
68: TLED_23,"52_ALRM"
69: TLED_24,"IRIGLED"
1: IO1,"FDR_1"
?
```

Figure 6.164 List of Default Primitive Names and Associated Alias Names

Type **DELETE 43 <Enter>** at the first action prompt to delete the first 43 default alias names, as shown in *Figure 6.165*.

```
1: IO1,"FDR_1"
?  DELETE 43 <Enter>
```

Figure 6.165 Deletion of the First 43 Alias Names

Type **> <Enter>** to advance to the next available line in the settings list.

Enter the alias names for the six analog channels and Relay Word bits, as shown in *Figure 6.166*.

```
1: OUT107,"TEST"
?  > <Enter>
27:
?  IO1,TIE1_A <Enter>
28:
?  IO2,TIE2_A <Enter>
29:
?  IO3,MADRI_A <Enter>
30:
?  IO4,MILAN_A <Enter>
31:
?  IO5,ROME_A <Enter>
32:
?  IO6,CAIRO_A <Enter>
33:
?  BZ1,ZONE1_A <Enter>
```

Figure 6.166 Analog Quantities and Relay Word Bits Alias Names

```
34:
?  BZ2,ZONE2_A <Enter>
35:
?  END <Enter>
Alias
.
.
.

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

=>>
```

Figure 6.166 Analog Quantities and Relay Word Bits Alias Names (Continued)

This concludes the alias settings. The next settings class is Global settings.

Global Settings

Global settings comprise settings that apply to all protection settings groups. For example, when changing from Protection Setting Group 1 to Protection Setting Group 2, Global settings such as station name and relay name still apply. *Figure 6.167* shows the setting changes we need for our example. Because we declared the alias names in the alias setting class, use either the alias names or the primitive names when entering settings.

The NUMBK setting declares the number of circuit breakers at the station. In our example, there are five circuit breakers at the station, and we set NUMBK to 5. Setting NUMBK to 5 makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting.

In this application, we do not require circuit breaker auxiliary contacts, therefore set all circuit breaker auxiliary input equations to NA.

The NUMDS setting declares the number of disconnect monitor logics we need, not the number of disconnect inputs. In our example, we need 15 disconnect monitor logics. You can set each disconnect travel time individually with the 89ALP*pp* setting (*pp* = 01–15). Travel time is the period during which both disconnect auxiliary contacts are in the open position. Measure the travel time during commissioning and adjust the settings appropriately. Based on previous experience with similar equipment, we set the tie-breaker disconnect travel time to 400 cycles in this example.

```
=>>SET G <Enter>
Global
General Global Settings
Station Identifier (40 characters)
SID := "Station A"
?<Enter>

Relay Identifier (40 characters)
RID := "Relay 1"
?<Enter>
Number of Breakers (N,1-21)                          NUMBK   := 5      ? <Enter>
Number of Disconnects (N,1-60)                       NUMDS   := N      ?15 <Enter>
Nominal System Frequency (50,60 Hz)                  NFREQ   := 60     ?> <Enter>

Global Enables
Station DC Battery Monitor (Y,N)                     EDCMON  := N      ?> <Enter>
Control Inputs (Global)
Input Pickup Delay (0.00-30 ms)                      GINPU   := 2.0    ?> <Enter>
```

Figure 6.167 Global Settings for Application 8

```
Settings Group Selection
Select Setting Group 1 (SELogic Equation)
SS1 := NA
?  > <Enter>
Time and Date Management
Date Format (MDY,YMD,DMY)                          DATE_F  := MDY    ?> <Enter>

Breaker Inputs
N/O Contact Input -BK01 (SELogic Equation)
52A01 := NA
?  > <Enter>
Disconnect Inputs and Timers
N/O Contact Input -DS01 (SELogic Equation)
89A01 := NA
?  IN204 <Enter>

N/C Contact Input -DS01 (SELogic Equation)
89B01 := NA
?  IN205 <Enter>
DS01 Alarm Pickup Delay (0-99999 cyc)              89ALP01 := 300    ?400 <Enter>
N/O Contact Input -DS02 (SELogic Equation)
89A02 := NA
?  IN206 <Enter>
N/C Contact Input -DS02 (SELogic Equation)
89B02 := NA
?  IN207 <Enter>
DS02 Alarm Pickup Delay (0-99999 cyc)              89ALP02 := 300    ?400 <Enter>

N/O Contact Input -DS03 (SELogic Equation)
89A03 := NA
?  IN208 <Enter>
N/C Contact Input -DS03 (SELogic Equation)
89B03 := NA
?  IN209 <Enter>
DS03 Alarm Pickup Delay (0-99999 cyc)              89ALP03 := 300    ? <Enter>
N/O Contact Input -DS04 (SELogic Equation)
89A04 := NA
?  IN210 <Enter>
N/C Contact Input -DS04 (SELogic Equation)
89B04 := NA
?  IN211 <Enter>
DS04 Alarm Pickup Delay (0-99999 cyc)              89ALP04 := 300    ? <Enter>

N/O Contact Input -DS05 (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.167 Global Settings for Application 8 (Continued)

This concludes the Global settings. The next settings class is the zone configuration group settings.

Zone Configuration Group Settings

The terminal-to-bus-zone SELOGIC control equations identify an analog channel, a differential element, and the conditions for which the relay assigns the analog channel to the differential element. Dynamic zone selection provides a mechanism for automatically reconfiguring the zone of protection, without any wiring changes. In this example, the dynamic zone selection logic uses the disconnect auxiliary contacts status to determine the station configuration and assign the input currents from the CTs to the appropriate differential elements.

For each terminal, wire an 89A and an 89B disconnect auxiliary contact to the relay. Because the disconnect simultaneously operates all three phases of the terminal, we state the disconnect status in the terminal-to-bus-zone SELOGIC control equations of all three relays.

Because we wire a disconnect auxiliary contact to only one relay, jumper (hardwire) the contact to the two other relays. For example, when we close the busbar disconnect on the MILAN feeder, all three phases (MILAN_A, MILAN_B, and

MILAN_C) operate together. Because the relay measures the three phases in three separate relays (phase MILAN_A in the A-phase relay, phase MILAN_B in B-phase relay, etc.), we need to convey the disconnect status to all three relays.

For this discussion, we define the following terms:

- ➤ Source busbar: the busbar to which all terminals are connected, except the terminal on transfer
- ➤ Transfer busbar: the busbar to which the terminal on transfer is connected
- ➤ Transfer disconnect: the disconnect, when closed, bypasses the feeder circuit breaker (e.g., Disconnect G898 on the CAIRO Feeder)

Although the relay is flexible enough to accept settings for many disconnect combinations, we will configure the relay according to a fixed operating sequence. Because the operating sequence defines a set of operating rules, settings engineers can decide on appropriate terminal-to-bus-zone and bus-zone-to-bus-zone settings for each step. The following defines the operating sequence for this application; many other operating sequences are possible and in use:

1. Only one feeder will be on transfer at any given time, i.e., the tie-breaker transfer disconnect (Z898) and the transfer disconnect (*n*898, *n* = D, E, F, and G) of only one of the four terminals can be closed simultaneously.
2. Only Busbar B2 can be the source busbar.
3. No busbar protection exists for the transfer busbar. The transfer busbar is always part of the line protection. This is the key statement from the setting viewpoint. By declaring appropriate terminal-to-bus-zone connection conditions, we can prevent relay misoperation when putting a feeder on transfer. In particular, we do not assign a differential element for the transfer busbar. Remove channel I02 from Busbar B1 differential calculations when any transfer disconnect closes.

The zone configuration default setting are settings for a specific substation with arbitrarily selected alias names, serving only as an example.

For ease of setting the zone configuration settings for the new substation, delete the terminal-to-bus-zone default settings. With the terminal-to-bus-zone default settings deleted, the setting prompts no longer reference the default settings.

You can use a combination of primitive and alias names when entering the terminal-to-bus-zone and bus-zone-to-bus-zone settings. *Figure 6.168* shows the Zone configuration settings for this application.

```
=>>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    ?800 <Enter>

Current Transformer Ratio -I02 (1-50000)            CTR02   := 600    ?800 <Enter>
Current Transformer Ratio -I03 (1-50000)            CTR03   := 600    ?> <Enter>
Zone Configuration: Terminal to Bus-Zone Connections
Terminal, Bus-Zone, Polarity (P,N)
I01BZ1C := TIE1_A, ZONE1_A, P
?  DELETE 200 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  I01,ZONE2_A,P <Enter>
TIE1_A to ZONE2_A Connection (SELogic Equation)
I01BZ2V := NA
?  89CL02 <Enter>
```

Figure 6.168 Zone Configuration Group Settings for Application 8

```
Terminal, Bus-Zone, Polarity (P,N)
?  IO2,ZONE1_A,P <Enter>
TIE2_A to ZONE1_A Connection (SELogic Equation)
IO2BZ1V := NA
?  89CL02 AND 89CL01 AND NOT(89CL03 OR 89CL06 OR 89CL09 OR 89CL12 OR 89CL15)
   <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO3,ZONE1_A,P <Enter>
MADRI_A to ZONE1_A Connection (SELogic Equation)
IO3BZ1V := NA
?  89CL04 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO3,ZONE2_A,P <Enter>
MADRI_A to ZONE2_A Connection (SELogic Equation)
IO3BZ2V := NA
?  89CL05 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO4,ZONE1_A,P <Enter>
MILAN_A to ZONE1_A Connection (SELogic Equation)
IO4BZ1V := NA
?  89CL07 <Enter>

Terminal, Bus-Zone, Polarity (P,N)
?  IO4,ZONE2_A,P <Enter>
MILAN_A to ZONE2_A Connection (SELogic Equation)
IO4BZ2V := NA
?  89CL08 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE1_A,P <Enter>
ROME_A to ZONE1_A Connection (SELogic Equation)
IO5BZ1V := NA
?  89CL10 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO5,ZONE2_A,P <Enter>

ROME_A to ZONE2_A Connection (SELogic Equation)
IO5BZ2V := NA
?  89CL11 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,ZONE1_A,P <Enter>
CAIRO_A to ZONE1_A Connection (SELogic Equation)
IO6BZ1V := NA
?  89CL13 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?  IO6,ZONE2_A,P <Enter>

CAIRO_A to ZONE2_A Connection (SELogic Equation)
IO6BZ2V := NA
?  89CL14 <Enter>
Terminal, Bus-Zone, Polarity (P,N)
?<Enter>
Zone Configuration: Bus-Zone to Bus-Zone Connections
Bus-Zone, Bus-Zone
?  ZONE1_A,ZONE2_A <Enter>
ZONE1_A to ZONE2_A Connection (SELogic Equation)
BZ1BZ2V := NA
?  (89CL04 AND 89CL05) OR (89CL07 AND 89CL08) OR (89CL10 AND 89CL11) OR (89CL13\
 AND 89CL14) <Enter>

Connection to Remove Terminals when ZONE1_A and ZONE2_A merge (SELogic Equation)
BZ1BZ2R := NA
?  (89CL04 AND 89CL05) OR (89CL07 AND 89CL08) OR (89CL10 AND 89CL11) OR (89CL13\
 AND 89CL14) <Enter>
Terminals Removed when ZONE1_A and ZONE2_A Bus-Zones merge (Ter k,...,Ter n)
BZ1BZ2M :=
?  TIE1_A,TIE2_A <Enter>

Trip Terminals TIE1_A, TIE2_A (Y,N)
BZ1BZ2T := N
?  Y <Enter>
Bus-Zone, Bus-Zone
?<Enter>
Zone Supervision
Differential Element Zone Supervision (Y,N)          E87ZSUP := N      ?<Enter>
Zone Switching Supervision
Zone Switching Supervision (Y,N)                     EZSWSUP := N      ?<Enter>
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait..........
Settings Saved

=>>
```

Figure 6.168 Zone Configuration Group Settings for Application 8 (Continued)

This concludes the zone configuration group settings. The next settings class is the protection group settings.

Protection Group Settings

Settings of this class comprise the protection functions, starting with the function enable settings. Default settings for the differential elements are 60 percent for Slope 1 and 80 percent for Slope 2. To change the slope settings, first enable the advanced settings by setting EADVS := Y. With EADVS := Y, the slope settings and incremental restrained and operating current settings become available.

For this application, we use the default values for the sensitive differential element, the restrained differential element, and the directional element.

The protection philosophy calls for the blocking of the busbar protection for an open CT condition. Use the sensitive differential element for this requirement by setting E87SSUP := Y (see *Figure 6.11* and *Figure 6.17* for more information).

Because we do not use the coupler security logic, overcurrent elements, terminal out of service, breaker failure protection, or voltage elements in this application, set ESCL := N, ETOS := N, EBFL := N, E50 := N, E51 := N, E27 := N, E59 := N, and EADVS := N.

Setting NUMBK equal to 5 makes five corresponding circuit breaker auxiliary input equations (52A01–52A05), and five corresponding trip equations (TR01–TR05) available for setting. There are five trip equations available, but there are six analog channels (I01–I06) at the station. Each of the six analog channels has a corresponding differential trip bit that asserts (*Table 6.120*) when the differential element asserts. Be sure to include these differential trip bits in the trip equations of all circuit breakers you want to trip.

The trip logic latches the trip outputs TRIP*kk* after TR*kk* assertion. One way to deassert the trip outputs is to press the **TARGET RESET** pushbutton on the front panel. An alternative method is to enter specific reset conditions at the ULTR*kk* settings.

Although each SEL-487B includes 21 trip logics, there is only one Minimum Trip Duration Time Delay (TDURD) setting.

Because the default setting is longer than the slowest tripping time, use the default setting of 12 cycles. *Figure 6.169* shows the Group 1 settings.

```
=>>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,1-21)                     ETOS    := 5      ?N <Enter>
Breaker Failure Logic (N,1-21)                       EBFL    := 6      ?N <Enter>
Definite Time Overcurrent Elements (N,1-21)          E50     := N      ? <Enter>

Inverse Time Overcurrent Elements (N,1-21)           E51     := N      ? <Enter>
Voltage Elements (Y,N)                               EVOLT   := Y      ?N <Enter>
Advanced Settings (Y,N)                              EADVS   := N      ? <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>
```

Figure 6.169 Protection Group Settings for Application 8

```
Trip Logic
Trip 01 (SELogic Equation)
TR01 := SBFTR01 OR 87BTR01
?  87BTR01 OR 87BTR02 <Enter>
Unlatch Trip 01 (SELogic Equation)
ULTR01 := NA
? <Enter>

Trip 02 (SELogic Equation)
TR02 := SBFTR02 OR 87BTR02
?  87BTR03 <Enter>
Unlatch Trip 02 (SELogic Equation)
ULTR02 := NA
? <Enter>
Trip 03 (SELogic Equation)
TR03 := SBFTR03 OR 87BTR03
?  87BTR04 <Enter>
Unlatch Trip 03 (SELogic Equation)
ULTR03 := NA
? <Enter>

Trip 04 (SELogic Equation)
TR04 := SBFTR04 OR 87BTR04
?  87BTR05 <Enter>
Unlatch Trip 04 (SELogic Equation)
ULTR04 := NA
? <Enter>
Trip 05 (SELogic Equation)
TR05 := SBFTR05 OR 87BTR05 OR SBFTR06 OR 87BTR06
?  87BTR06 <Enter>
Unlatch Trip 05 (SELogic Equation)
ULTR05 := NA
? <Enter>

Minimum Trip Duration Time Delay (2.000-8000 cyc)    TDURD   := 12.000 ? <Enter>
Event Report Trigger Equation (SELogic Equation)
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.169 Protection Group Settings for Application 8 (Continued)

This concludes the protection group settings. The next settings class is the control output settings.

Control Output Settings

In this settings class, we assign the logic or Relay Word bits in the relay to output contacts. We need five output contacts for our example. Although not specifically called for in the protection philosophy, it is good practice to also include the default TEST and ALARM outputs in the relay settings.

Because each relay protects only one phase of the power system, combine the trip outputs from the three relays in a single output to the circuit breaker. Jumper (hardwire) the trip output from each relay. Connect the cable to the circuit breaker trip coil to any one of the three relays.

We include Protection Latch Bit PLT03 in the output equation. With PLT03 included in every output equation, the **RELAY TEST MODE** pushbutton disables all output contacts.

Because we do not use any output contacts from the main board for protection functions (OUT107 and OUT108 are used for alarming purposes), set OUT101–OUT106 = NA. *Figure 6.170* shows the control output settings.

```
=>>SET O <Enter>
Output
Main Board
OUT101 := TRIP01 AND NOT TNS_SW
?  NA <Enter>
OUT102 := TRIP02 AND NOT TNS_SW
?  NA <Enter>
OUT103 := TRIP03 AND NOT TNS_SW
?  NA <Enter>
OUT104 := TRIP04 AND NOT TNS_SW
?  NA <Enter>
OUT105 := TRIP05 AND NOT TNS_SW
?  NA <Enter>
OUT106 := NA
?  > <Enter>

Interface Board #1
OUT201 := NA
?  TRIP01 AND NOT PLT03 <Enter>
OUT202 := NA
?  TRIP02 AND NOT PLT03 <Enter>
OUT203 := NA
?  TRIP03 AND NOT PLT03 <Enter>
OUT204 := NA
?  TRIP04 AND NOT PLT03 <Enter>
OUT205 := NA
?  TRIP05 AND NOT PLT03 <Enter>
OUT206 := NA
?  END <Enter>
Output
.
.
.
Save settings (Y,N)  ?Y <Enter>
Saving Settings, Please Wait...........
Settings Saved

=>>
```

Figure 6.170 Control Output Settings for Application 8

This concludes the settings for Application 8.

SECTION 7

Metering, Monitoring, and Reporting

The SEL-487B relay provides extensive capabilities for monitoring substation components, metering important power system parameters, and reporting on power system performance. The relay provides the following useful features:

- *Metering on page 7.1*
- *Station DC Battery System Monitor on page 7.7*
- *Reporting on page 7.8*

See *Section 7: Metering*, *Section 8: Monitoring*, and *Section 9: Reporting in the SEL-400 Series Relays Instruction Manual* for general information. This section contains details specific to the SEL-487B.

Metering

The SEL-487B provides one-cycle average metering for measuring power system conditions and differential protection values. Each SEL-487B processes 21 currents, 3 voltages, and 1 battery monitor.

Use the **MET** command to access the metering functions. Issuing the **MET** command with no options returns the fundamental frequency primary measurement quantities listed in *Table 7.1*.

Table 7.1 Instantaneous Metering Quantities—Voltages and Currents

Metered Quantity	Symbol	Units
Phase voltage magnitude	V01–V03	kV
Phase voltage angle	∠V01, –∠V03	degrees
Phase current magnitude	I01–I21	A
Phase current angle	∠I01, –∠I21	degrees

The **MET** command followed by a number, **MET *k***, specifies the number of times the command will repeat (*k* can range from 1 to 32767). This is useful for troubleshooting or investigating uncharacteristic power system conditions. With other command options, you can view currents from the terminals.

Table 7.2 shows the **MET** command options, followed by a short description of each option.

Table 7.2 MET Command—Metering Only (Sheet 1 of 2)

Name[a]	Description
MET *k*	Displays fundamental primary phase information *k* times for all terminals
MET *k* CZ*q*	Displays fundamental primary phase information *k* times for all terminals in Check Zone *q*
MET *k* Z*n*	Displays fundamental primary phase information *k* times for all terminals in Zone *n*

Table 7.2 MET Command—Metering Only (Sheet 2 of 2)

Name[a]	Description
MET SEC k	Displays fundamental secondary phase information *k* times for all terminals
MET SEC *k* CZ*q*	Displays fundamental secondary phase information *k* times for all terminals in Check Zone *q*
MET SEC *k* Z*n*	Displays fundamental secondary phase information *k* times for all terminals in Zone *n*
MET DIF	Displays per unit operating and restraint currents for all active zones
MET BAT	Displays station battery measurements
MET RBM	Reset station battery max/min measurements
MET ANA	Displays the analog values used with MIRRORED BITS communications
MET PMV	Displays all the Protection Math Variables
MET AMV	Displays all the Automation Math Variables

[a] k = 1–32767; n = 1–6; q = 1–3.

Instantaneous Metering

NOTE: The SEL-487B-1 does not support frequency tracking. Metering accuracies are specified at nominal frequency.

Use the **MET** command to obtain the current and voltage quantities in primary values, as shown in *Table 7.3*.

Table 7.3 Information Available With the MET Command

Command	Information
MET	Primary current magnitudes and angles from all 21 terminals in amperes. Primary voltage magnitudes and angles from the 3 voltage inputs in kV.

Figure 7.1 shows the relay response to the **MET** command.

```
=>>MET <Enter>

Relay 1                                      Date: 04/21/2011  Time: 15:55:01.820
Station A                                    Serial Number: 1131840172

       Primary Currents
Terminal    MAG(A)   ANG(DEG)           Terminal    MAG(A)   ANG(DEG)
 FDR_1     2397.801     0.00             I12         0.000    24.81
 FDR_2     2997.321     0.00             I13         0.000    58.82
 FDR_3     1797.586   180.00             I14         0.000    28.81
 TRFR_1    3597.324   180.00             I15         0.000    83.86
 TB_1      5398.234   180.00             I16         0.000  -130.34
 TB_2      5397.541     0.00             I17         0.000  -142.62
 I07          0.000    37.69             I18         0.000  -118.68
 I08          0.000   168.78             I19         0.000  -146.11
 I09          0.000   169.83             I20         0.000    80.32
 I10          0.000   96.44              I21         0.000   -19.29
 I11          0.000   136.89

       Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01        141.969     0.00
 V02        132.001  -120.06
 V03        128.031   119.99

=>>
```

Figure 7.1 Relay Response to the MET Command

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 as reference. 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 $0.05 \cdot I_{NOM}$.

For check-zone-specific primary values information, use the **MET CZ*q*** (*q* = 1–3) command. *Table 7.4* shows the information, including the CT polarity, included in Check Zone *q*.

Table 7.4 Information Available With the MET CZq Command

Command[a]	Information
MET CZ*q*	Primary current magnitudes, angles, and CT polarities from the active terminals in amperes. Primary voltage magnitudes and angles from the three voltage inputs in kV.

[a] q = 1–3.

For the relay to display any measured values, at least one Terminal-to-Check-Zone equation must be a logical 1 (i.e., at least one terminal must be connected to the Check Zone). *Figure 7.2* shows the relay response to the **MET CZ1** command if no such connection exists.

```
=>>MET CZ1 <Enter>

Specified zone is inactive
```

Figure 7.2 Response to MET CZ1 Command When All Terminals Are Inactive

Figure 7.3 shows the relay response of one phase in a three-relay application when Terminals I01 and I02 are connected to Check Zone 1.

```
=>>MET CZ1 <Enter>

Relay 1                                     Date: 02/06/2015 Time: 23:51:51.027
Station A                                   Serial Number: 1131840172

Current Terminals in Check Zone 1

       Primary Currents
Terminal    MAG(A)   ANG(DEG)  POL
 FDR_1       98.131     0.00    P
 FDR_2       98.677   180.00    P

       Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01        133.990     0.00
 V02        133.990  -119.99
 V03        133.990   120.00


=>>
```

Figure 7.3 Response to the MET CZ1 Command of One Phase in a Three-Relay Application

For zone-specific primary values information, use the **MET Z*n*** (*n* = 1–6) command. *Table 7.5* shows the information, including the CT polarity and Bus-Zones, included in Protection Zone *n*, if two Bus-Zones are combined.

Table 7.5 Information Available With the MET Zn Command

Command[a]	Information
MET Z*n*	Primary current magnitudes, angles, and CT polarities from the active terminals in Amperes. Primary voltage magnitudes and angles from the three voltage inputs in kV. Bus-Zones in Protection Zone *n*.

[a] n = 1–6.

For the relay to display any measured values, at least one Terminal-to-Bus-Zone equation must be a logical 1 (i.e., at least one terminal must be connected to the specified Bus-Zone). *Figure 7.4* shows the relay response to the **MET Z*n*** command if no such connection exists.

```
=>>MET Z1 <Enter>

All terminals in the specified zone are inactive
```

Figure 7.4 Response to MET Z1 Command When All Terminals Are Inactive

Figure 7.5 shows the relay response of one phase in a three-relay application when Terminals I01 and I02 are connected to Bus-Zone 1.

```
=>>MET Z1 <Enter>

Relay 1                                   Date: 02/27/2015 Time: 13:56:37.718
Station A                                 Serial Number: 1131840172
Current Terminals in Protection Zone 1
       Primary Currents
Terminal    MAG(A)   ANG(DEG)  POL
 FDR_1       98.131     0.00    P
 FDR_2       98.677   180.00    P
       Primary Voltages
Terminal    MAG(kV)  ANG(DEG)
 V01        133.990     0.00
 V02        133.990  -119.99
 V03        133.990   120.00
Bus-Zones in Protection Zone 1
BUS_1

=>>
```

Figure 7.5 Response to the MET Z1 Command of One Phase in a Three-Relay Application

MET SEC provides secondary information similar to the **MET** command, but includes the CT and PT ratios, as shown in *Table 7.6*.

Table 7.6 Information Available With the MET SEC Command

Command	Information
MET SEC	Secondary current magnitudes, angles, and CT ratios from all 21 terminals in amperes. Secondary voltage magnitudes and angles from the three voltage inputs in volts, and each PT ratio.

Figure 7.6 shows the relay response to the **MET SEC** command of one phase in a three-relay application.

```
=>>MET SEC <Enter>

Relay 1                                     Date: 04/21/2015 Time: 17:05:15.192
Station A                                   Serial Number: 1131840172

          Secondary Currents
Terminal   MAG(A)  ANG(DEG)  CTR        Terminal   MAG(A)  ANG(DEG)  CTR
 FDR_1      3.996     0.00   600         I12        0.000   164.98    600
 FDR_2      4.997     0.00   600         I13        0.001   -44.57    600
 FDR_3      2.996   180.00   600         I14        0.001   -77.58    600
 TRFR_1     5.996   180.00   600         I15        0.001    -2.76    600
 TB_1       8.997   180.00   600         I16        0.002   -35.83    600
 TB_2       8.993     0.00   600         I17        0.000   -42.29    600
 I07        0.002   -71.23   600         I18        0.001  -133.51    600
 I08        0.002  -108.60   600         I19        0.002  -177.14    600
 I09        0.002   -22.11   600         I20        0.001   165.61    600
 I10        0.000    34.53   600         I21        0.002   -21.72    600
 I11        0.000   -58.25   600

          Secondary Voltages
Terminal   MAG(V)  ANG(DEG)  PTR
 V01       63.982     0.00   2000
 V02       64.011  -120.06   2000
 V03       64.021   120.00   2000


=>>
```

Figure 7.6 Relay Response to the MET SEC Command of One Phase of a Three-Relay Application

For check-zone-specific secondary information, use the **MET SEC CZ*q*** (*q* = 1–3) command. The information includes the CT polarity, as shown in *Table 7.7*.

Table 7.7 Information Available With the MET SEC CZq Command

Command[a]	Information
MET SEC CZ*q*	Secondary current magnitudes, angles, CT ratios, and polarities from the active terminals in Check Zone *q* in amperes. Secondary voltage magnitudes and angles from the three voltage inputs in volts, and each PT ratio.

[a] q = 1–3.

Figure 7.7 shows the relay response to the **MET SEC CZ1** command of one phase in a three-relay application with these terminals connected to Check Zone 1.

```
=>>MET SEC CZ1 <Enter>

Relay 1                                     Date: 02/06/2015 Time: 23:51:51.027
Station A                                   Serial Number: 1131840172

Current Terminals in Check Zone 1

          Secondary Currents
Terminal   MAG(A)  ANG(DEG)  CTR  POL
 FDR_1      3.996    0.00     600  P
 FDR_2      4.997    0.00     600  P

          Secondary Voltages
Terminal   MAG(V)  ANG(DEG)  PTR
 V01       66.996     0.00   1000
 V02       66.996  -120.00   2000

=>>
```

Figure 7.7 Response to the MET SEC CZ1 Command of One Phase in a Three-Relay Application

For zone-specific secondary information, use the **MET SEC Z*n*** (*n* = 1–6) command. The information includes the CT polarity, as shown in *Table 7.8*.

Table 7.8 Information Available With the MET SEC Zn Command

Command[a]	Information
MET SEC Z*n*	Secondary current magnitudes, angles, CT ratios, and polarities from the active terminals in the specific zone in amperes. Secondary voltage magnitudes and angles from the three voltage inputs in volts, and each PT ratio. Bus-Zones in Protection Zone *n*.

[a] n = 1–6.

Figure 7.8 shows the relay response to the **MET SEC Z*n*** command of one phase in a three-relay application with these terminals connected to Bus-Zone 1.

```
=>>MET SEC Z1 <Enter>

Relay 1                                     Date: 05/14/2015 Time: 15:00:43.237
Station A                                   Serial Number: 1131840172
Current Terminals in Protection Zone 1
          Secondary Currents
Terminal   MAG(A)  ANG(DEG)  CTR  POL
 FDR_1      3.996     0.00    600  P
 FDR_2      4.997     0.00    600  P
 TB_1       8.997   180.00    600  P
          Secondary Voltages
Terminal   MAG(V)  ANG(DEG)  PTR
 V01       66.996     0.00   1000
 V02       66.996  -120.00   2000
 V03       66.996   120.00   2000
Bus-Zones in Protection Zone 1
BUS_1

=>>
```

Figure 7.8 Relay Response to the MET SEC Z1 Command of One Phase in a Three-Relay Application

Differential Metering

NOTE: A zone is active when any IqqBZpV (qq = 01–21, p = 1–6) Relay Word bit asserts. For example, Zone 1 becomes active when Relay Word bit I01BZ1V asserts. The check zone is active when any IqqCZ1V (qq = 01–21) Relay Word bit asserts and ECHKZN := Y.

View the differential currents of all active zones with the **MET DIF** command. The information includes per unit operating and restraint currents from each active zone, as well as the reference current, as shown in *Table 7.9*. The reference current is the product of the SEL-487B nominal current and the maximum CT ratio in an active zone as defined in the zone configuration settings.

Table 7.9 Information Available With the MET DIF Command

Command	Information
MET DIF	Operate current of all active zones and check zones in per unit. Restraint current of all active zones and check zones in per unit. Product of relay nominal current and highest CT ratio of the connected CTs, used as reference current.

Figure 7.9 shows the relay response to the **MET DIF** command of one phase in a three-relay application when Bus-Zones 1 and 2 are active.

```
=>>MET DIF <Enter>

Relay 1                                    Date: 02/27/2015 Time: 14:28:06.955
Station A                                  Serial Number: 1131840172
       Operate Currents     Restraint Currents
           (Per Unit)           (Per Unit)
ZONE          IOP                  IRT
  1           0.00                 0.25
  2           0.01                 0.44
Current Reference (A)
IREF
800

=>>
```

Figure 7.9 Relay Response to the MET DIF Command of One Phase in a Three-Relay Application

Station DC Battery System Monitor

The SEL-487B automatically monitors station battery system health by measuring the dc voltage, ac ripple, and voltage between each battery terminal and ground. Each relay provides one dc monitor channel, Vdc1. See *Section 8: Monitoring in the SEL-400 Series Relays Instruction Manual* for a complete description of the battery monitor.

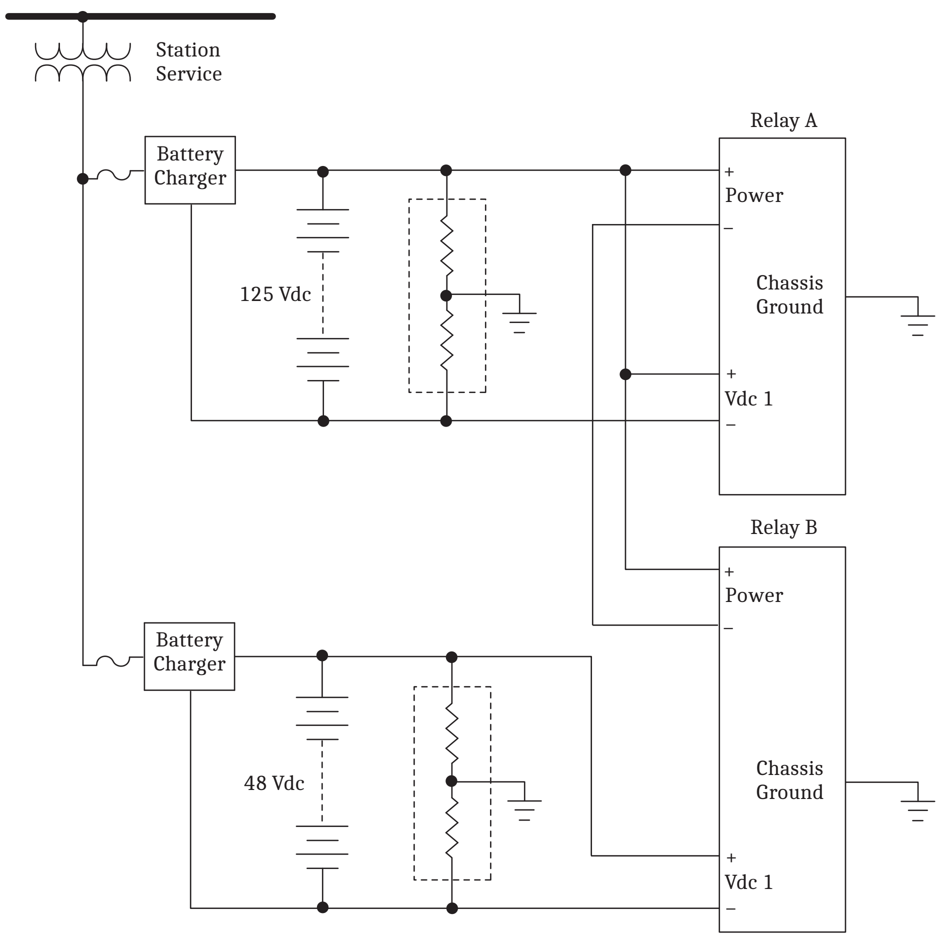


Figure 7.10 Typical Station DC Battery System

The dc battery monitor measures the station battery voltage applied at the rear-panel terminals labeled **Vdc1** (+ and –). In a three-relay application, connect the 125 Vdc supply to the monitoring connections of the first relay, and the 48 Vdc supply to the monitoring connections of the second relay. See *Section 6: Protection Application Examples* for more information about single- and three-relay applications.

Reporting

The SEL-487B Relay features comprehensive power system data analysis capabilities. These are described in *Section 9: Reporting in the SEL-400 Series Relays Instruction Manual*. This section describes reporting characteristics that are unique to the SEL-487B.

Data Processing

The SEL-487B processes protection logic at a different rate than other SEL-400 Series Relays. *Table 7.10* summarizes the available analog quantities from protection elements and the processing rate of each. Notice that the relay processes the protection elements at two different rates:

- ➤ Current Differential Elements, Check Zone Elements, Breaker Failure Protection, Under- and Overvoltage Elements = every 1/12 cycle
- ➤ Overcurrent Elements (50/51) protection elements = every 1/6 cycle

Table 7.10 Protection Element Analog Quantities and Processing Rates

Analog Quantity	Description	Sample Rate (Power System Cycle)
I*nn*FIM, I*nn*FIA(*nn* = 1–21)	Filtered Instantaneous Phase Current Magnitude, Angle	1/12
V*mm*FM, V*mm*FA (*mm* = 01–03)	Filtered Instantaneous Phase Voltage Magnitude, Angle	1/12
DC1	DC Monitor Voltage	1/12
PMV*nn* (*nn* = 01–64)	Protection Math Variable	1/12
51P*mm* (*mm* = 1–21)	51 Element Pickup Setting	1/6
51TD*mm* (*mm* = 1–21)	51 Element Time Dial Setting	1/6

Table 7.11 summarizes the available digital inputs and the processing rate of each.

Table 7.11 Processing Rates of Digital Inputs

Digitals	Sample Rate (Power System Cycle)
100 rows of event reporting digital elements	1/12
Un-debounced digital contact inputs	2 kHz

Duration of Data Captures and Event Reports

The SEL-487B stores high-resolution raw and filtered data. The number of stored high-resolution raw data captures and event reports is a function of the quantity of data contained in each capture.

Table 7.12 lists the maximum number of data captures/event reports the relay stores in nonvolatile memory when ERDIG = S for various report lengths and sample rates. The relay automatically overwrites the oldest events with the newest events when the nonvolatile storage capacity is exceeded.

NOTE: Consider the total capture time when choosing a value for setting LER at the SRATE := 8 kHz. At LER := 3.0, the relay records at least 11 data captures when ERDIG = S. These and smaller LER settings are sufficient for most power system disturbances.

The relay stores high-resolution raw and filtered event data in nonvolatile memory. *Table 7.12* lists the storage capability of the SEL-487B for common event reports.

The lower rows of *Table 7.12* show the number of event reports the relay stores with the maximum data capture lengths (LER) for each SRATE sampling rate setting. Table entries are the maximum number of stored events; these can vary by 10 percent according to relay memory usage.

Table 7.12 Event Report Nonvolatile Storage Capability When ERDIG = S

Event Report Length	Maximum Number of Stored Reports			
	8 kHz	4 kHz	2 kHz	1 kHz
0.25 seconds	103	128	147	168
0.50 seconds	71	70	85	114
1.0 seconds	37	40	45	55
3.0 seconds	11	14	15	20
6.0 seconds	N/A	6	8	10
12.0 seconds	N/A	N/A	4	5
24.0 seconds	N/A	N/A	N/A	2

When the event report digital setting is set to include all Relay Word bits in the event report (ERDIG = A), the maximum number of stored reports is reduced as shown in *Table 7.13*.

Table 7.13 Event Report Nonvolatile Storage Capability When ERDIG = A

Event Report Length	Maximum Number of Stored Reports			
	8 kHz	4 kHz	2 kHz	1 kHz
0.25 seconds	78	92	102	113
0.50 seconds	43	52	58	65
1.0 seconds	N/A	27	31	35
3.0 seconds	N/A	N/A	10	12
6.0 seconds	N/A	N/A	N/A	5
12.0 seconds	N/A	N/A	N/A	N/A
24.0 seconds	N/A	N/A	N/A	N/A

Event Reports, Event Summaries, and Event Histories

See *Section 9: Reporting in the SEL-400 Series Relays Instruction Manual* for an overview of event reports, event summaries, and event histories. This section describes the characteristics of these that are unique to the SEL-487B.

Base Set of Relay Word Bits

The following Relay Word bits are always included in COMTRADE event reports: ZONE1–ZONE6, CZONE1–CZONE3, 87BTR, 87BTR01–87BTR21, SBFTR, SBFTR01–SBFTR21, TRIP, TRIP01–TRIP21, 87Z1–87Z6, BFZ1–BFZ6, ER, RMB*n*A, TMB*n*A, RMB*n*B, TMB*n*B, ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, LBOKB, TLED_1, TLED_2, TLED_3, TLED_4, TLED_5, TLED_6, TLED_7, TLED_8, TLED_9, TLED_10, TLED_11, TLED_12, TLED_13, TLED_14, TLED_15, TLED_16, TLED_17, TLED_18, TLED_19, TLED_20, TLED_21, TLED_22, TLED_23, TLED_24, Z1BZ1, Z1BZ2, Z1BZ3, Z1BZ4, Z1BZ5, Z1BZ6, Z2BZ2, Z2BZ3, Z2BZ4, Z2BZ5, Z2BZ6, Z3BZ3, Z3BZ4, Z3BZ5, Z3BZ6, Z4BZ4, Z4BZ5, Z4BZ6, Z5BZ5, Z5BZ6, Z6BZ6.

COMTRADE Relay Word Bit Behavior

The ERDG setting specifies Relay Word bits to include in event reporting. In COMTRADE files, the relay captures and records the status of all Relay Word bits in the same row of a Relay Word bit specified in the ERDG setting list. Therefore, additional Relay Word bit statuses is captured in a COMTRADE file that are not specified in the ERDG setting list. See *Section 11: Relay Word Bits* for Relay Word bits and their common row with other bits.

Event Reports

Report Header and Analog Section of the Event Report

The first portion of an event report is the report header and the analog section. See *Figure 7.11* for the location of items included in a sample analog section of an event report. If you want to view only the analog portion of an event report, use the **EVE A** command.

The report header is the standard SEL-487B header, listing the relay identifiers, event number, date, and time. Report headers help you organize report data. Each event report begins with information about the relay and the event, such as the RID setting (Relay ID), the SID setting (Station ID), and the firmware checksum (CID). The FID string identifies the relay model, Flash firmware version, and the date code of the firmware. See *Appendix A: Firmware, ICD File, and Manual Versions* for a description of the FID string. To complete the header, the relay reports a date and time stamp to indicate the internal clock time when the relay triggered the event.

The event report column labels follow the header. The data underneath the analog column labels contain samples of power system voltages and currents in primary kilovolts and primary amperes, respectively. These quantities are instantaneous values scaled by $\sqrt{2}/2$ (0.707). Although you may not use all 24 channels of the SEL-487B in your application, all 24 channels' samples are always displayed in the event report. To display all 24 channels, the event report consists of three groups. Current channels I01–I11 are displayed in the first group as shown in *Figure 7.11*. The second group contains I12–I21, and the third group contains voltage channels V01–V03.

Figure 7.11 contains selected data from the analog section of a 4-samples/cycle event report. The bracketed numbers at the left of the report (for example, [5]) indicate the cycle number; *Figure 7.11* presents eight cycles of 4-samples/cycle data. The trigger row includes a > character to indicate the trigger point. This is the dividing point between the pre-fault or PRE time and the fault or remainder of the data capture.

The row that the relay uses for the fault analogs in the event summary is the row 1.25 cycles after the event trigger. The relay marks this row on the event report with an asterisk (*) character immediately after the last analog column.

```
=>>EVE <Enter>

Relay 1                                         Date: 06/06/2015  Time: 16:27:50.514     Header
Station A                                       Serial Number: 1131840172

FID=SEL-487B-1-R309-V1-Z010005-D20151102   Event Number = 10006     CID=0xA0B5        Firmware ID

  Currents (Pri. Amps)
  I01    I02    I03    I04    I05    I06    I07    I08    I09    I10    I11
 [1]
  -596   -595    596    595   1194  -1191     -1     -2     -1      0      0
   -79    -82     80     79    159   -157     -1      0      2      0      0       One Cycle of Data
   596    595   -595   -594  -1193   1190      1      0      0      0      0
    80     82    -80    -80   -160    158      1     -1     -2      0      0

[2]
  -595   -595    594    594   1194  -1190     -1      0      0      0      0
   -80    -83     80     80    159   -159     -1      1      2      0      0
   595    595   -594   -594  -1193   1190      1      1      0      0      1
    81     84    -80    -81   -160    160      2      0     -2      0      0
[3]
  -596   -596    595    594   1192  -1190     -1     -1      0      0      0
   -81    -82     80     81    161   -160     -1      0      2      0      0
   595    595   -595   -594  -1193   1190      2      1      0      0     -1
    81     83    -81    -81   -162    160      0     -1     -2      0      0
[4]
  -596   -594    595    594   1193  -1190     -2     -1      1      0      1
   -82    -84     81     81    163   -161      0      1      2      0      0
   596    595   -594   -594  -1193   1190      1      0      0      0      0
    82     84    -81    -82   -163    161      1      0     -2      0      0
[5]
  -596   -595    595    595   1192  -1189     -1      0      0      0      0
   -82    -85     81     82    164   -163     -1      0      2      0      0
   595    595   -594   -594  -1193   1190      1      0      0      0      0
    82     85    -81    -82   -165    163      1      0     -2     -1      1
[6]
  -595   -594    595    594   1193  -1190     -1      0      1      0      0
   -83    -86     82     82    166   -162      0      1      3     -1     -1
  1955    595   -595   -594  -1193   1189      1      1     -1      1      0
   479     86    -83    -82   -166    164      0     -1     -2      1      0

[7]
 -4938   -595    594    593   1193  -1189     -1     -1      1     -2      0>      Trigger

   -891    -86     83     83    166   -166      0      0      2      1      0
   6552    594   -595   -594  -1192   1190      1      1      0      0      0
    910     86    -83    -83   -167    165      0      0     -2      0      1
[8]
 -6550   -595    594    594   1192  -1190     -1      0      0      0     -1
  -910    -86     84     84    168   -165     -1      0      2     -1      0*
  6551    595   -593   -593  -1191   1189      1      0      0      1      1
   910     86    -84    -84   -169    166      1      1     -1      0      0

 .
 .
 .

 =>>
```

Figure 7.11 Analog Section of the Event Report

Table 7.14 Event Report Metered Analog Quantities

Analog Quantity	Description
I01–I21	Filtered current vector
V01–V03	Filtered voltage vector

For the event report (different from the raw data oscillography), you can select as many as 20 additional analog quantities from the available analog quantities in the relay (see *Section 12: Analog Quantities*). These user-defined analog quantities follow the 24 fixed channels.

Differential Report

The differential report is not a part of the **EVE** command (without any parameters) response. Use the **EVE DIF** command to specify that the differential report is to be displayed. If so specified, the fixed and user-configurable analog quantities will no longer be displayed, although the event summary and relay settings will be appended following the differential quantities. The analog part of the differential report only displays differential current for each active differential zone and active check zone, as shown in *Figure 7.12*.

```
=>>EVE DIF <Enter>

Relay 1                                     Date: 06/06/2015 Time: 16:27:50.514
Station A                                   Serial Number: 1131840172
FID=SEL-487B-1-R309-V1-Z010005-D20151102   Event Number = 10006     CID=0xA0B5

                  Differential Quantities (Per Unit)
 IOP1  IRT1  IOP2  IRT2


[1]
 0.00  0.80  0.00  0.80
 0.00  0.80  0.00  0.80
 0.00  0.80  0.00  0.80
 0.00  0.80  0.00  0.80
.
.
.

[7]
 1.45  2.26  0.00  0.80>
 1.47  2.27  0.00  0.80
 2.00  2.81  0.00  0.80
 2.00  2.81  0.00  0.80
[8]
 2.00  2.81  0.00  0.80
 2.00  2.81  0.00  0.80*
 2.00  2.81  0.00  0.80
 2.00  2.81  0.00  0.80

Differential Quantities (Per Unit)
 IOPCZ1 IRTCZ1

[1]
 0.00   0.80
 0.00   0.80
 0.00   0.80
 0.00   0.80
.
.
.

[7]
 1.45   2.25 >
 1.47   2.27
 2.00   2.80
 2.01   2.81

[8]
 2.01   2.80
 2.01   2.80 *
 2.01   2.80
 2.01   2.80

[9]
 2.01   2.80
 2.01   2.80
 2.01   2.80
 2.01   2.80
```

Figure 7.12 Differential Report

Digital Section of the Event Report

The second portion of an event report is the digital section. Inspect the digital data to evaluate relay element response during an event. See *Figure 7.13* for the locations of items in a sample event report digital section. If you want to view only the digital portion of an event report, use the **EVE D** command (see *Section 14: ASCII Command Reference in the SEL-400 Series Relays Instruction*

Manual for details). In the digital portion of the event report, the relay indicates deasserted elements with a period (.) and asserted elements with an asterisk (*) character.

The element and digital information labels are single character columns. Read these columns from top to bottom. The trigger row includes a > character following immediately after the last digital element column to indicate the trigger point. The relay marks the row used in event summary (1.25 cycles after the trigger point) with an asterisk (*) character at the right of the last digital element column.

```
ZZ        D         FFFTT   N
12     TT I T FFFTT 1231B0  O
__ FFFTBB FBN 1231B _____U  A
TT 123112 FFS _____ TTTTTT TL
RR ______ ___ BBBBB RRRRR1 EA
II BBBBBB EES FFFFF IIIII0 SR
PP FFFFFF NNW IIIII PPPPP6 TM


[1]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[2]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[3]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[4]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[5]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[6]
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
.. ...... ... ..... ...... .*
[7]
*. ...... ... ..... **..*. .*>
*. ...... ... ..... **..*. .*
*. ...... ... ..... **..*. .*
*. ...... ... ..... **..*. .*
[8]
*. ...... ... ..... **..*. .*
*. ...... ... ..... **..*. .*
*. ...... ... ..... **..*. .*
*. ...... ... ..... **..*. .*
```

Figure 7.13 Digital Section of the Event Report

Event Summary Section of the Event Report

The third portion of an event report is the summary section. See *Figure 7.14* for the location of items included in a sample summary section of an event report. If you want to exclude the summary portion from an event report, use the **EVE NSUM** command. See *EVENT on page 14.33 in the SEL-400 Series Relays Instruction Manual* for details.

The information in the summary portion of the event report is the same information in the event summary, except that the report header does not appear immediately before the event information when you view a summary in the event report. See *Event Summary on page 7.14* for a description of the items in the summary portion of the event report.

```
=>>SUM <Enter>

Relay 1                               Date: 03/02/2015          Time: 12:33:51.078
                                      Serial Number: 1131840172
Event: 87BTR                                                    Time Source: OTHER
Event Number: 10057                                             Group: 1
Targets: TLED_1 TLED_6 TLED_7 TLED_8

Fault:  I01    I02    I03    I04    I05    I06    I07    I08    I09     I10    I11
MAG(A) 14964  14966  14968  14969  14957  14966  22146  22138  22135   14960  14959
ANG(DEG) 178    59     -61    179    59     -61     0    -120    120    -179     61

        I12    I13    I14    I15    I16    I17    I18     I19    I20     I21
MAG(A) 14973  14967  14964  14968  22140  22134  22136  1167.8 1167.8  1167.8
ANG(DEG) -59   -178    62     -58     2    -117   123       0    -120    121


        V01   V02    V03
MAG(kV) 67.8  67.8   67.8
ANG(DEG) 0   -120    121

Tripped Terminals
I07     I08    I09    I10    I11    I12    I16    I17    I18

Bus-Zones in Protection Zone 4
BZ4
.
.
.
Bus-Zones in Protection Zone 6
BZ6


=>>
```

Figure 7.14 Summary Section of the Event Report

Event Summary

You can retrieve a summary version of stored event reports as event summaries. These short-form reports present vital information about a triggered event. The relay generates an event in response to power system faults and other trigger events. See *Figure 7.15* for a sample event summary.

```
Relay SEL-487B-1                           Date: 06/18/2014  Time: 19:49:20.975
Station A                                  Serial Number: 2014237527
```

Report Header

```
Event: ER                                                Time Source: HIRIG

Event Number: 10004                                                Group: 1

Targets:TLED_1 TLED_2 TLED_3
```

Event Information

```
Fault:   I01    I02    I03    I04    I05    I06    I07    I08    I09    I10    I11
MAG(A)   15783  12343  15669  15789  12344  15671  15794  12348  15672  11615  512
ANG(DEG)  -32   -140    102    -32   -140    102    -32   -140    102    -45   -161

         I12    I13    I14    I15    I16    I17    I18    I19    I20    I21
MAG(A)    1845  11616    512   1846  11616    512   1846  11625    512   1846
ANG(DEG)   90    -45   -161     90    -45   -161     90    -45   -161     90

         V01     V02     V03
MAG(kV)   26.9    38.6    32.5
ANG(DEG)    0    -104     124
```

Fault Data

Figure 7.15 Sample Event Summary Report

The event summary contains the following information:

- Standard report header
  - Relay and terminal identification
  - Event date and time
- Event type
- Time source
- Event number
- Active settings group at trigger time
- Targets
- Fault currents and voltages
- Tripped terminals
- Bus-Zone in protection zone

Targets are displayed only if a rising edge of Relay Word bits 87BTR, SBFTR, or TRIP asserted before the end of the event report. When a trip occurs, the relay displays the aliases of the latched targeting bits asserted on the last row of the event. Current and voltage analog quantities in the summary are the values 1.25 cycles after the event trigger.

Table 7.15 defines the various event types in fault reporting priority. Fault event type 87BTR (busbar protection trip) has reporting priority over event type SBFTR (breaker failure). If more than one event type asserts, the relay reports only the highest priority event type. For example, you can trigger an event when there is no fault condition on the power system by using the **TRI** command. In this case, when there is no fault, the relay reports the event type as TRIG.

Table 7.15 Event Types

Event Type	Event Trigger
87BTR	Rising edge of Relay Word Bit 87BTR, the OR combination of a busbar -protection trip output to any Terminal.
SBFTR	Rising edge of Relay Word Bit SBFTR, the OR combination of a breaker failure trip output to any Terminal.
TRIP	Rising edge of Relay Word Bit TRIP.
ER	The relay generates the event with elements in the SELOGIC control equation ER.
TRIG	The relay generates the event in response to the **TRI** command.

Event History

The event history gives you a quick look at recent relay activity. The relay labels each new event with a unique number from 10000 to 42767. (At 42767, the top of the numbering range, the relay returns to 10000 for the next event number and then continues to increment.) See *Figure 7.16* for a sample event history.

The event history contains the following:

- Standard report header
- Relay and terminal identification
- Event date and time
- Event type
- Time source
- Event number

- Active settings group at trigger time
- Targets
- Fault currents and voltages
- Tripped terminals
- Bus-Zones in protection zones

Figure 7.16 is a sample event history from a computer terminal.

```
=>>HIS<Enter>

Relay 1                                      Date: 06/07/2015  Time: 14:44:27.063
Station A                                    Serial Number: 1131840172

#        DATE        TIME         EVENT  GRP  TARGETS
10006 06/06/2015 16:27:50.514 87BTR    1   87_DIFF ZONE_1
10005 06/06/2015 15:52:39.732 ER       1
10004 06/06/2015 15:52:34.742 87BTR    1   87_DIFF ZONE_1 ZONE_2

10003 05/25/2015 20:37:20.899 87BTR    1   87_DIFF ZONE_1 ZONE_2
10002 05/19/2015 10:53:59.742 87BTR    1   87_DIFF ZONE_1 ZONE_2
10001 05/18/2015 21:15:45.369 87BTR    1   87_DIFF ZONE_1 ZONE_2
10000 05/18/2015 20:46:13.497 87BTR    1   87_DIFF ZONE_1 ZONE_2
 Event                         Event  Active
Number                          Type  Group
```

Figure 7.16 Sample Event History

The event types in the event history are the same as the event types in the event summary. See *Table 7.15* for event types.

SECTION 8

Settings

Section 12: Settings in the SEL-400 Series Relays Instruction Manual describes common platform settings. This section contains tables of relay settings for the SEL-487B relay.

⚠WARNING
Isolate the relay trip circuits while changing settings. When changing settings for multiple classes, it is possible to be in an intermediate state that will cause an unexpected trip.

The relay hides some settings based upon other settings. If you set an Enable setting to OFF, for example, the relay hides all settings associated with that Enable setting. This section does not explain rules for hiding settings; these rules are discussed in the applications sections of the instruction manual where appropriate.

The settings prompts in this section are similar to the ASCII terminal and ACSELERATOR QuickSet SEL-5030 Software prompts. The prompts in this section are unabbreviated and show all possible setting options.

For information on using settings in protection and automation, see the examples in *Section 6: Protection Application Examples*. The section contains information on the following settings classes.

Alias Settings

See *Alias Settings on page 12.25 in the SEL-400 Series Relays Instruction Manual* for a complete description of alias settings. The SEL-487B supports aliases for terminal names and bus-zone names, in addition to Relay Word bits and analog quantities. *Table 8.1* lists the default alias settings for the SEL-487B.

Table 8.1 Default Alias Settings (Sheet 1 of 3)

Label	Default
I01	FDR_1
I02	FDR_2
I03	FDR_3

Table 8.1 Default Alias Settings (Sheet 2 of 3)

Label	Default
I04	TRFR_1
I05	TB_1
I06	TB_2
BZ1	BUS_1
BZ2	BUS_2
FBF01	F1_BF
FBF02	F2_BF
FBF03	F3_BF
FBF04	T1_BF
FBF05	TB1_BF
FBF06	TB2_BF
87Z1	Z1_TRIP
87Z2	Z2_TRIP
IN101	F1_BFI
IN102	F2_BFI
IN103	F3_BFI
IN104	T1_BFI
IN105	TB_BFI
PLT01	DIFF_EN
PLT02	BF_EN
PLT03	TNS_SW
87ST1	CTZ1_AN
87ST2	CTZ2_AN
SBFTR01	F1_BFT
SBFTR02	F2_BFT
SBFTR03	F3_BFT
SBFTR04	T1_BFT
SBFTR05	TB1_BFT
SBFTR06	TB2_BFT
87BTR01	F1_DPT
87BTR02	F2_ DPT
87BTR03	F3_ DPT
87BTR04	T1_ DPT
87BTR05	TB1_ DPT
87BTR06	TB2_ DPT
OUT101	F1_TRP
OUT102	F2_TRP
OUT103	F3_TRP
OUT104	T1_TRP
OUT105	TB_TRP
OUT107	TEST

Table 8.1 Default Alias Settings (Sheet 3 of 3)

Label	Default
OUT108	NOALARM
TLED_1	87_DIFF
TLED_2	BK_FAIL
TLED_3	ZONE_1
TLED_4	ZONE_2
TLED_5	ZONE_3
TLED_6	ZONE_4
TLED_7	ZONE_5
TLED_8	ZONE_6
TLED_9	50_TRIP
TLED_10	51_TRIP
TLED_11	CT_ALRM
TLED_12	87_BLK
TLED_13	TOS
TLED_14	89_OIP
TLED_15	89_ALRM
TLED_16	PT_ALRM
TLED_17	27_LED
TLED_18	59_LED
TLED_19	V01_ON
TLED_20	V02_ON
TLED_21	V03_ON
TLED_22	FLT_LED
TLED_23	52_ALRM
TLED_24	IRIGLED

Global Settings

Table 8.2 Global Settings Categories (Sheet 1 of 2)

Settings	Reference
General Global Settings	*Table 8.3*
Global Enables	*Table 8.4*
Station DC Monitor	*Table 8.5*
Control Inputs (Global)	*Table 8.6*
Main Board Control Inputs	*Table 8.7*
Interface Board #1 Control Inputs	*Table 8.8*
Interface Board #2 Control Inputs	*Table 8.9*
Interface Board #3 Control Inputs	*Table 8.10*
Interface Board #4 Control Inputs	*Table 8.11*
Settings Group Selection	*Table 8.12*

Table 8.2 Global Settings Categories (Sheet 2 of 2)

Settings	Reference
Time and Date Management	*Table 8.13*
Data Reset Control	*Table 8.14*
Breaker Inputs	*Table 8.15*
Disconnects Inputs and Timers	*Table 8.16*
DNP	*Table 8.18*

Table 8.3 General Global Settings

Setting	Prompt	Default
SID	Station Identifier (40 characters)	Station A
RID	Relay Identifier (40 characters)	Relay 1
CONAM	Company Name (5 characters)	abcde
NUMBK	Number of Breakers (N, 1–21)	5
NUMDS	Number of Disconnects (N, 1–60)	N
NFREQ	Nominal System Frequency (50, 60 Hz)	60

Table 8.4 Global Enables

Setting	Prompt	Default
EDCMON	Station DC Battery Monitor (Y, N)	N
EICIS	Independent Control Input Settings (Y, N)	N
EDRSTC	Data Reset Control (Y, N)	N
EGADVS	Advanced Global Settings (Y, N)	N

Table 8.5 Station DC Monitor

Setting	Prompt	Default
DC1LFP	Low Level Fail Pickup (OFF, 15–300 Vdc)	100
DC1LWP	Low Level Warn Pickup (OFF, 15–300 Vdc)	127
DC1HWP	High Level Warn Pickup (OFF, 15–300 Vdc)	137
DC1HFP	High Level Fail Pickup (OFF, 15–300 Vdc)	142
DC1RP	Peak-to-Peak AC Ripple Pickup (1–300 Vac)	9
DC1GF	Ground Detection Factor (1.00–2.00)	1.05

Table 8.6 Control Inputs (Global)

Setting	Prompt	Default	Increment
GINPU	Input Pickup Delay (0.0–30 ms)	2.0	0.5
GINDO	Input Dropout Delay (0.0–30 ms)	2.0	0.5

Table 8.7 Main Board Control Inputs

Setting	Prompt	Default	Increment
IN101PU	Input IN101 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN101DO	Input IN101 Dropout Delay (0.0–30 ms)	2.0[a]	0.5
• • •	• • •	• • •	• • •
IN107PU	Input IN107 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN107DO	Input IN107 Dropout Delay (0.0–30 ms)	2.0[a]	0.5

[a] If EICIS = N, these settings are the same as GINPU and GINDO.

Table 8.8 Interface Board #1 Control Inputs

Setting	Prompt	Default	Increment
IN201PU	Input IN201 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN201DO	Input IN201 Dropout Delay (0.0–30 ms)	2.0[a]	0.5
• • •	• • •	• • •	• • •
IN224PU	Input IN224 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN224DO	Input IN224 Dropout Delay (0.0–30 ms)	2.0[a]	0.5

[a] If EICIS = N, these settings are the same as GINPU and GINDO.

Table 8.9 Interface Board #2 Control Inputs

Setting	Prompt	Default	Increment
IN301PU	Input IN301 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN301DO	Input IN301 Dropout Delay (0.0–30 ms)	2.0[a]	0.5
• • •	• • •	• • •	• • •
IN324PU	Input IN324 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN324DO	Input IN324 Dropout Delay (0.0–30 ms)	2.0[a]	0.5

[a] If EICIS = N, these settings are the same as GINPU and GINDO.

Table 8.10 Interface Board #3 Control Inputs

Setting	Prompt	Default	Increment
IN401PU	Input IN401 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN401DO	Input IN401 Dropout Delay (0.0–30 ms)	2.0[a]	0.5
• • •	• • •	• • •	• • •
IN424PU	Input IN424 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN424DO	Input IN424 Dropout Delay (0.0–30 ms)	2.0[a]	0.5

[a] If EICIS = N, these settings are the same as GINPU and GINDO.

Table 8.11 Interface Board #4 Control Inputs

Setting	Prompt	Default	Increment
IN501PU	Input IN501 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN501DO	Input IN501 Dropout Delay (0.0–30 ms)	2.0[a]	0.5
• • •	• • •	• • •	• • •
IN524PU	Input IN524 Pickup Delay (0.0–30 ms)	2.0[a]	0.5
IN524DO	Input IN524 Dropout Delay (0.0–30 ms)	2.0[a]	0.5

[a] If EICIS = N, these settings are the same as GINPU and GINDO.

Table 8.12 Settings Group Selection

Setting	Prompt	Default
SS1	Select Setting Group 1 (SELOGIC Equation)	NA
SS2	Select Setting Group 2 (SELOGIC Equation)	NA
SS3	Select Setting Group 3 (SELOGIC Equation)	NA
SS4	Select Setting Group 4 (SELOGIC Equation)	NA
SS5	Select Setting Group 5 (SELOGIC Equation)	NA
SS6	Select Setting Group 6 (SELOGIC Equation)	NA
TGR	Group Change Delay (1–54000 cycles)	180

Table 8.13 Time and Date Management

Setting	Prompt	Default
DATE_F	Date Format (MDY, YMD, DMY)	MDY
IRIGC	IRIG-B Control Bits Definition (NONE, C37.118)	NONE
UTCOFF[a]	Offset From UTC to Local Time (–15.5 to 15.5)	–8
BEG_DST[b]	Begin DST (*hh*, *n*, *d*, *mm*, or OFF)	"2, 2, 1, 3"
END_DST	End DST (*hh*, *n*, *d*, or *mm*)	"2, 1, 1, 11"

[a] All data, reports, and commands from the relay are displayed in local time, referenced to an internal UTC master clock. Use the UTCOFF setting to specify the time offset from UTC time reference with respect to the relay location. (The only data still displayed in UTC time is streaming IEC 61850 data.)

[b] The BEG_DST (and END_DST) daylight-saving time setting consists of four fields or OFF:
hh = local time hour (0–23); defines when daylight-saving time begins.
n = the week of the month when daylight-saving time begins (1–3, L); occurs in either the 1st, 2nd, 3rd, or last week of the month.
d = day of week (1–7); Sunday is the first day of the week.
mm = month (1–12).
OFF = hides the daylight-saving time settings.

Table 8.14 Data Reset Control

Setting	Prompt	Default
RST_BAT	Reset Battery Monitoring (SELOGIC Equation)	NA
RSTTRGT	Target Reset (SELOGIC Equation)	NA
RSTDNPE	Reset DNP Fault Summary Data (SELOGIC Equation)	TRGTR
RST_HAL	Reset Warning Alarm Pulsing (SELOGIC Equation)	NA

Table 8.15 Breaker Inputs

Setting	Prompt	Default
52A01	N/O Contact Input–BK01 (SELOGIC Equation)	NA
• • •	• • •	• • •
52A21	N/O Contact Input–BK21 (SELOGIC Equation)	NA

Table 8.16 Disconnect Inputs

Setting	Prompt	Default	Increment
89A01	N/O Contact Inputs–DS01 (SELOGIC Equation)	NA	
89B01	N/C Contact Inputs–DS01 (SELOGIC Equation)	NA	
89ALP01	DS01 Alarm Pickup Delay (0–99999 cyc)	300	1
• • •	• • •	• • •	
89A60	N/O Contact Inputs–DS60 (SELOGIC Equation)	NA	
89B60	N/C Contact Inputs–DS60 (SELOGIC Equation)	NA	
89ALP60	DS60 Alarm Pickup Delay (0–99999 cyc)	300	1

Table 8.17 Access Control

Setting	Prompt	Default
EACC	Enable ACC access level (SELOGIC Equation)	1
E2AC	Enable ACC–2AC access levels (SELOGIC Equation)	1

Table 8.18 DNP

Setting	Prompt	Default	Increment
EVELOCK	Event Summary Lock Period (0–1000 s)	0	1
DNPSRC	DNP Session Time Base (LOCAL,UTC)	UTC	

Make *Table 8.19* settings when advanced Global settings are enabled (EGADVS := Y) and only for unique system configurations. Changing the OPHDO setting affects the filtered current level that declares an open phase, which has effects throughout the protection logic. SEL recommends leaving the OPHDO setting at the default value.

Table 8.19 Open-Phase Logic

Setting	Prompt	Default
OPHDO[a]	Line Open Phase Threshold (0.01–5 A, sec)	0.2

[a] Range and default value shown are for a 5 A relay. For a 1 A relay, divide the range and default value by 5.

Zone Configuration Settings

The following zone configuration settings are the default settings for all six settings groups. You can set each of the six zone configuration settings groups independently.

Table 8.20 Zone Configuration Settings Categories

Settings	Reference
Potential Transformer Ratios	*Table 8.21*
Current Transformer Ratios	*Table 8.22*
Terminal-to-Bus-Zone Connections	*Table 8.23*, *Table 8.24*
Bus-Zone-to-Bus-Zone Connections	*Table 8.25*, *Table 8.26*
Zone Supervision	*Table 8.27*
Zone Switching Supervision	*Table 8.28*
Zone Open CT Detection	*Table 8.29*
Check Zone Configuration and Terminal-to-Check-Zone Connections	*Table 8.30*, *Table 8.31*
Check Zone Supervision	*Table 8.32*
Current Normalization Factor	[a]

[a] This setting is included here because it appears in the read-back information as TAPnn values (nn = 01–21). However, the user cannot set these values; the SEL-487B calculates these internally using the nominal current and CT ratios. See Section 5: Protection Functions for more information.

Table 8.21 Potential Transformer Ratios

Setting	Prompt	Default
PTR1	Potential Transformer Ratio–V01 (1–10000)	2000
PTR2	Potential Transformer Ratio–V02 (1–10000)	2000
PTR3	Potential Transformer Ratio–V03 (1–10000)	2000

Table 8.22 Current Transformer Ratios

Setting	Prompt	Default
CTR01	Current Transformer Ratio–I01 (1–50000)	600
CTR02	Current Transformer Ratio–I02 (1–50000)	600
• • •	• • •	• • •
CTR21	Current Transformer Ratio–I21 (1–50000)	600

Table 8.23 Terminal-to-Bus-Zone Connections, Terminal Emulation Program View (Sheet 1 of 2)

Setting	Prompt	Default
I01BZ1C	Terminal, Bus-Zone, Polarity (P, N)	FDR_1, BUS_1,P
I01BZ1V	FDR_1 to BUS_1 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS01
I02BZ1C	Terminal, Bus-Zone, Polarity (P, N)	FDR_2, BUS_1,P
I02BZ1V	FDR_2 to BUS_1 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS02
I03BZ2C	Terminal, Bus-Zone, Polarity (P, N)	FDR_3, BUS_2,P
I03BZ2V	FDR_3 to BUS_2 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS03
I04BZ2C	Terminal, Bus-Zone, Polarity (P, N)	TRFR_1, BUS_2,P
I04BZ2V	TRFR_1 to BUS_2 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS04
I05BZ1C	Terminal, Bus-Zone, Polarity (P, N)	TB_1, BUS_1,P
I05BZ1V	TB_1 to BUS_1 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS05

Table 8.23 Terminal-to-Bus-Zone Connections, Terminal Emulation Program View (Sheet 2 of 2)

Setting	Prompt	Default
I06BZ2C	Terminal, Bus-Zone, Polarity (P, N)	TB_2, BUS_2,P
I06BZ2V	TB_2 to BUS_2 Connection (SELOGIC Equation)	DIFF_EN AND NOT TOS05
• • •	• • •	• • •
I*nn*BZ*p*C[a, b]	Terminal, Bus-Zone, Polarity (P, N)	None
I*nn*BZ*p*V	I*nn* to BZ*p* Connection (SELOGIC Equation)	NA

[a] nn = 1–21.
[b] p = 1–6.

Table 8.24 Terminal-to-Bus-Zone Connections, QuickSet View

Setting	Prompt	Default
CT01BZ1	Connect Terminal 01 to Bus-Zone 1 (Select: Y, N)	Y
TBZT1	Terminal I01	FDR_1[d]
TBZB1	Bus-Zone BZ1	BUS_1[d]
TBZP1	Polarity I01-BZ1 (Select: P, N)	P
I01BZ1V	Terminal to Bus Connection Logic (SELOGIC Equation)	DIFF_EN AND NOT TOS01
CT01BZ2	Connect Terminal 01 to Bus-Zone 2 (Select: Y, N)	N
TBZT2	Terminal I01	[d]
TBZB2	Bus-Zone BZ2	[d]
TBZP2	Polarity I01-BZ2 (Select: P,N)	P
I01BZ2V	Terminal to Bus Connection Logic (SELOGIC Equation)	NA
• • •	• • •	• • •
CT*nn*BZ*p*[a,b]	Connect Terminal *nn* to Bus-Zone *p* (Select: Y, N)	Y
TBZT*b*[c]	Terminal I*nn*	[d]
TBZB*b*[c]	Bus-Zone BZ*p*	[d]
TBZP*b*[c]	Polarity I*nn*-BZ*p* (Select: P, N)	P
I*nn*BZ*p*V[a,b]	Terminal to Bus Connection Logic (SELOGIC Equation)	NA

[a] nn = 1–21.
[b] p = 1–6.
[c] b = 1–126. The setting shown in the Terminal Emulation Program, InnBZpC, is equivalent to the combination of the three block settings: TBZTb, TBZBb, TBZPb. These settings are separated into 126 blocks in the QuickSet view to show configuration options for every terminal to bus-zone connection option. (21 terminals • 6 bus zones = 126 blocks).
[d] This setting is shown for clarity and not user configurable. It is active when CTnnBZp = Y and defaults to the terminal, bus, or alias name.

Table 8.25 Bus-Zone-to-Bus-Zone Connections, Terminal Emulation Program View (Sheet 1 of 2)

Setting	Prompt	Default
BZ*p*BZ*m*C[a, b]	Bus-Zone, Bus-Zone	None
BZ*p*BZ*m*V[a, b]	BZ*p* to BZ*m* Connection (SELOGIC Equation)	NA

Table 8.25 Bus-Zone-to-Bus-Zone Connections, Terminal Emulation Program View (Sheet 2 of 2)

Setting	Prompt	Default
BZ*p*BZ*m*R[a, b]	Connection to Remove Terminals when BZ*p* and BZ*m* merge (SELOGIC Equation)	NA
BZ*p*BZ*m*M[a, b]	Terminals Removed when BZ*p* and BZ*m* Bus-Zones merge (Ter *k*,. . .,Ter *n*)[c]	None
BZ*p*BZ*m*T[a, b]	Trip Terminals Ter *k*, . . ., Ter *n* (Y, N)	N

[a] p = 1–6.

[b] m = 1–6.

[c] Terminal k, Terminal 1, or Terminal n (maximum of four terminals from 01–21).

Table 8.26 Bus-Zone-to-Bus-Zone Connections, QuickSet View (Sheet 1 of 2)

Setting	Prompt	Default
CBZ1BZ2	Connect Bus-Zone 1 to Bus-Zone 2 (Select: Y, N)	N
BZBZ11	Bus-Zone BZ1	BUS_1[a]
BZBZ21	Bus-Zone BZ2	BUS_2[a]
BZ1BZ2V	Bus to Bus Connection Logic (SELOGIC Equation)	NA
BZ1BZ2R	Removed Terminal Logic (SELOGIC Equation)	NA
CPT11	Terminals to be removed when BZBZ11 and BZBZ21 merge (Select: <Blank>, FDR_1, FDR_2, FDR_3, TRFR_1, TB_1, TB_2)	<Blank>
CPT21	Terminals to be removed when BZBZ11 and BZBZ21 merge (Select: <Blank>, FDR_1, FDR_2, FDR_3, TRFR_1, TB_1, TB_2)	<Blank>
CPT31	Terminals to be removed when BZBZ11 and BZBZ21 merge (Select: <Blank>, FDR_1, FDR_2, FDR_3, TRFR_1, TB_1, TB_2)	<Blank>
CPT41	Terminals to be removed when BZBZ11 and BZBZ21 merge (Select: <Blank>, FDR_1, FDR_2, FDR_3, TRFR_1, TB_1, TB_2)	<Blank>
BZBZT1	Trip Selected Terminal(s) above? (Select: Y, N)	N
• • •	• • •	• • •
CBZ*p*BZ*m*[b, c]	Connect Bus-Zone *p* to Bus-Zone *m* (Select: Y, N)	N
BZBZ1*b*[d]	Bus-Zone BZ*p*	BZ*p*[a]
BZBZ2*b*	Bus-Zone BZ*m*	BZ*m*[a]
BZ*p*BZ*m*V	Bus to Bus Connection Logic (SELOGIC Equation)	NA
BZ*p*BZ*m*R	Removed Terminal Logic (SELOGIC Equation)	NA
CPT1*b*[e]	Terminals to be removed when BZBZ1*b* and BZBZ2*b* merge (Select: <Blank>)	<Blank>
CPT2*b*	Terminals to be removed when BZBZ1*b* and BZBZ2*b* merge (Select: <Blank>)	<Blank>
CPT3*b*	Terminals to be removed when BZBZ1*b* and BZBZ2*b* merge (Select: <Blank>)	<Blank>

Table 8.26 Bus-Zone-to-Bus-Zone Connections, QuickSet View (Sheet 2 of 2)

Setting	Prompt	Default
CPT4*b*	Terminals to be removed when BZBZ1*b* and BZBZ2*b* merge (Select: <Blank>)	<Blank>
BZBZT*b*	Trip Selected Terminal(s) above? (Select: Y, N)	N

[a] This setting is shown for clarity and not user configurable. It is active when CBZpBZm =Y and defaults to the bus or alias name.
[b] p = 1–6.
[c] m = 1–6.
[d] b = 1–15. These settings are separated into 15 blocks in the QuickSet view to show configuration options for every bus-zone-to-bus-zone connection option.
[e] The setting shown in the Terminal Emulation Program, BZpBZmM, is equivalent to the combination of the four QuickSet block settings: CPT1b, CPT2b, CPT3b, CPT4b.

Table 8.27 Zone Supervision

Setting	Prompt	Default
E87ZSUP	Differential Element Zone Supervision (Y, N)	N
Z1S	Zone 1 Supervision (SELOGIC Equation)	1
Z2S	Zone 2 Supervision (SELOGIC Equation)	1
Z3S	Zone 3 Supervision (SELOGIC Equation)	1
Z4S	Zone 4 Supervision (SELOGIC Equation)	1
Z5S	Zone 5 Supervision (SELOGIC Equation)	1
Z6S	Zone 6 Supervision (SELOGIC Equation)	1

Table 8.28 Zone Switching Supervision

Setting	Prompt	Default
EZSWSUP	Zone Switching Supervision (Y, N)	N
ZSWO	Zone Switching Operation (SELOGIC Equation)	NA
RZSWOAL	Reset Zone Switching Op Alarm (SELOGIC Equation)	NA
ZSWOPU	Zone Switching Op Pickup Delay (0–99999 cyc)	1800

Table 8.29 Zone Open CT Detection

Setting	Prompt	Default
ROCTZ1	Reset Zone 1 Open CT Detector (SELOGIC Equation)	RSTOCT1
ROCTZ2	Reset Zone 2 Open CT Detector (SELOGIC Equation)	RSTOCT2
ROCTZ3	Reset Zone 3 Open CT Detector (SELOGIC Equation)	RSTOCT3
ROCTZ4	Reset Zone 4 Open CT Detector (SELOGIC Equation)	RSTOCT4
ROCTZ5	Reset Zone 5 Open CT Detector (SELOGIC Equation)	RSTOCT5
ROCTZ6	Reset Zone 6 Open CT Detector (SELOGIC Equation)	RSTOCT6

Table 8.30 Check Zone Configuration and Terminal-to-Check-Zone Connections, Terminal Emulation Program View

Setting	Prompt	Default
ECHKZN	Enable Check Zones at Station (Y, N)	N
I*nn*CZ*p*C[a, b]	Terminal, Check-Zone, Polarity (P, N)	None
EADVCZ	Enable Advance Check Zone Settings (Y, N)	N

Table 8.30 Check Zone Configuration and Terminal-to-Check-Zone Connections, Terminal Emulation Program View

Setting	Prompt	Default
CZ*pq*R[b, c]	Include Coupler *q* in Check Zone *p* (SELOGIC Equation)	NA
CZ*pq*M[a, b, c]	I*nn* to CZ*p* Connection (SELOGIC Equation)	

[a] nn = 1–21.
[b] p = 1–3.
[c] q = 1–4.

Table 8.31 Check Zone Configuration and Terminal-to-Check-Zone Connections, QuickSet View

Setting	Prompt	Default
CT01CZ1	Connect Terminal 1 to Check-Zone 1 (Select: Y, N)	N
TCZT1	Terminal I01	FDR_1[a]
TCZC1	Check Zone CZ1	CZ1[a]
TCZP1	Polarity I01-CZ1 (Select: P, N)	P
• • •	• • •	• • •
CT*nn*CZ*p*[b,c]	Connect Terminal I*nn* to Check-Zone *p* (Select: Y, N)	N
TCZT*b*[d]	Terminal I*nn*	I*nn*[a]
TCZC*b*	Check Zone CZ*p*	CZ*p*[a]
TCZP*b*	Polarity I*nn*-CZ*p* (Select: P, N)	P

[a] This setting is shown for clarity and not user configurable. It is active when CTnnCZp = Y and defaults to the terminal, check zone or alias name.
[b] nn = 1–21.
[c] p = 1–3.
[d] b = 1–63. These settings are separated into 63 blocks in the QuickSet view to show configuration options for every terminal-to-check-zone connection option (21 terminals • 3 check zones). The setting shown in the Terminal Emulation Program, InnCZpC, is equivalent to the combination of the three QuickSet block settings: TCZTb, TCZCb, TCZPb.

Table 8.32 Check Zone Supervision

Setting	Prompt	Default
E87CZSP	Differential Element Check Zone Supervision (Y, N)	N
CZ*n*S[a]	Check Zone *n* Supervision (SELOGIC Control Equation)[b]	1

[a] n = 1–3.
[b] 0 is not a valid value for this setting.

Group Settings

Table 8.33 Group Settings Categories (Sheet 1 of 2)

Settings	Reference
Relay Configuration	*Table 8.34*
Sensitive Differential Elements	*Table 8.35*
Check Zone Sensitive Differential Elements	*Table 8.36*
Restrained Differential Elements	*Table 8.37*

Table 8.33 Group Settings Categories (Sheet 2 of 2)

Settings	Reference
Check Zone Restrained Differential Elements	*Table 8.38*
Phase Directional Element	*Table 8.39*
Coupler Security Logic	*Table 8.40*
Terminal Out of Service	*Table 8.41*
Breaker Failure Logic	*Table 8.42*
Definite-Time Overcurrent Elements	*Table 8.43*
Inverse-Time Overcurrent Elements	*Table 8.44*
Under- and Overvoltage Elements	*Table 8.45*, *Table 8.46*
Trip Logic	*Table 8.47*

Table 8.34 Relay Configuration

Setting	Prompt	Default
E87SSUP	Sensitive Differential Element Supervision (Y, N)	Y
ECSL	Coupler Security Logic (N, 1–4)	N
ETOS	Terminal Out of Service (N, 1–21)	5
EBFL	Breaker Failure Logic (N, 1–21)	6
E50	Definite-Time Overcurrent Elements (N, 1–21)	N
E51	Inverse-Time Overcurrent Elements (N, 1–21)	N
EADVS	Advanced Settings (Y, N)	N
E27	Enable Under Voltage Elements (N, 1–6)	N
E59	Enable Over Voltage Elements (N, 1–6)	N

Table 8.35 Sensitive Differential Elements

Setting	Prompt	Default	Increment
S87P	Sensitive Differential Element Pickup (0.05–1 pu)	0.10	0.01
87STPU	87S Timer Pickup Delay (50–6000 cyc)	300	1

Table 8.36 Check Zone Sensitive Differential Elements[a]

Setting	Prompt	Default	Increment
CZS87P	Check Zone Sensitive Differential Element Pickup (0.05–1 pu)	0.10	0.01
CZ87STP	Check Zone 87S Time Pickup Delay (50–6000 cyc)	300	1

[a] Available when ECHKZN := Y.

Table 8.37 Restrained Differential Elements

Setting	Prompt	Default	Increment
O87P	Restrained Diff Element Pickup (0.10–4 pu)	1.00	0.01
SLP1	Restrained Slope 1 Percentage (15–90%)	60	1
SLP2	Restrained Slope 2 Percentage (50–90%)	80	1
RTDI	Incr Restrained Current Threshold (0.10–10 pu)	1.20	0.01
OPDI	Incr Operating Current Threshold (0.10–10 pu)	1.20	0.01

Table 8.38 Check Zone Restrained Differential Elements[a]

Setting	Prompt	Default	Increment
CZO87P	Check Zone Restrained Diff Element Pickup (0.10–4 pu)	1.00	0.01
CZSLP1	Check Zone Restrained Slope 1 Percentage (5–90%)	60	1
CZSLP2	Check Zone Restrained Slope 2 Percentage (15–90%)	80	1
CZRTDI	Check Zone Incr Restrained Current Threshold (0.10–10 pu)	1.20	0.01
CZOPDI	Check Zone Incr Operating Current Threshold (0.10–10 pu)	1.20	0.01

[a] Available when ECHKZN := Y.

Table 8.39 Phase Directional Element

Setting	Prompt	Default	Increment
50DSP	Dir Element O/C Supervision Pickup (0.05–3 pu)	0.05	0.01

Table 8.40 Coupler Security Logic (1–4)

Setting	Prompt	Default	Increment
CB52A1	Coupler 1 Status (SELOGIC Equation)	NA	
CB52DO1	Coupler 1 Status Dropout Delay (0.00–1000 cyc)	4	0.083
CBCLS1	Coupler 1 Close Command (SELOGIC Equation)	NA	
CBCLDO1	Coupler 1 Close Command D/O Delay (0.00–1000 cyc)	5	0.083
ACTRP1	Coupler 1 Acc Trip (SELOGIC Equation)	NA	
ACTPPU1	Coupler 1 Acc Trip Pickup Delay (0.00–1000 cyc)	4	0.083
• • •	• • •	• • •	• • •
CB52A4	Coupler 4 Status (SELOGIC Equation)	NA	
CB52DO4	Coupler 4 Status Dropout Delay (0.00–1000 cyc)	4	0.083
CBCLS4	Coupler 4 Close Command (SELOGIC Equation)	NA	
CBCLDO4	Coupler 4 Close Command D/O Delay (0.00–1000 cyc)	5	0.083
ACTRP4	Coupler 4 Acc Trip (SELOGIC Equation)	NA	
ACTPPU4	Coupler 4 Acc Trip Pickup Delay (0.00–1000 cyc)	4	0.083

Table 8.41 Terminal Out of Service (1–21)

Setting	Prompt	Default
TOS01	Terminal 01 Out-of-Service (SELOGIC Equation)	LB01
TOS02	Terminal 02 Out-of-Service (SELOGIC Equation)	LB02
TOS03	Terminal 03 Out-of-Service (SELOGIC Equation)	LB03
TOS04	Terminal 04 Out-of-Service (SELOGIC Equation)	LB04
TOS05	Terminal 05 Out-of-Service (SELOGIC Equation)	LB05
TOS06	Terminal 06 Out-of-Service (SELOGIC Equation)	NA
• • •	• • •	• • •
TOS21	Terminal 21 Out-of-Service (SELOGIC Equation)	NA

Table 8.42 Breaker Failure Logic (1–21) (Sheet 1 of 3)

Setting	Prompt	Default	Increment
Breaker 01 Failure Logic			
EXBF01	External Breaker Fail–BK01 (Y, N)	N	
XBF01	External Brkr Fail Init–BK01 (SELOGIC Equation)	NA	
50FP01	Fault Current Pickup–BK01 (0.50–50 amps, sec)	3.00	0.01
BFPU01	Brkr Fail Init Pickup Delay–BK01 (0.00–6000 cyc)	6.00	0.083
RTPU01	Retrip Delay–BK01 (0.00–6000 cyc)	3.00	0.083
BFI01	Breaker Fail Initiate–BK01 (SELOGIC Equation)	F1_BFI AND BF_EN	
ATBFI01	Alt Breaker Fail Initiate–BK01 (SELOGIC Equation)	NA	
EBFIS01	Breaker Fail Initiate Seal-In–BK01 (Y, N)	N	
BFISP01	Breaker Fail Init Seal-In Delay–BK01 (0.00–1000 cyc)	0.50	0.083
BFIDO01	Brkr Fail Init Dropout Delay–BK01 (0.00–1000 cyc)	1.50	0.083
Breaker 02 Failure Logic			
EXBF02	External Breaker Fail–BK02 (Y, N)	N	
XBF02	External Brkr Fail Init–BK02 (SELOGIC Equation)	NA	
50FP02	Fault Current Pickup–BK02 (0.50–50 amps, sec)	3.00	0.01
BFPU02	Brkr Fail Init Pickup Delay–BK02 (0.00–6000 cyc)	6.00	0.083
RTPU02	Retrip Delay–BK02 (0.00–6000 cyc)	3.00	0.083
BFI02	Breaker Fail Initiate–BK02 (SELOGIC Equation)	F2_BFI AND BF_EN	
ATBFI02	Alt Breaker Fail Initiate–BK02 (SELOGIC Equation)	NA	
EBFIS02	Breaker Fail Initiate Seal-In–BK02 (Y, N)	N	
BFISP02	Breaker Fail Init Seal-In Delay–BK02 (0.00–1000 cyc)	0.50	0.083
BFIDO02	Brkr Fail Init Dropout Delay–BK02 (0.00–1000 cyc)	1.50	0.083
Breaker 03 Failure Logic			
EXBF03	External Breaker Fail–BK03 (Y, N)	N	
XBF03	External Brkr Fail Init–BK03 (SELOGIC Equation)	NA	
50FP03	Fault Current Pickup–BK03 (0.50–50 amps, sec)	3.00	0.01
BFPU03	Brkr Fail Init Pickup Delay–BK03 (0.00–6000 cyc)	6.00	0.083
RTPU03	Retrip Delay–BK03 (0.00–6000 cyc)	3.00	0.083
BFI03	Breaker Fail Initiate–BK03 (SELOGIC Equation)	F3_BFI AND BF_EN	
ATBFI03	Alt Breaker Fail Initiate–BK03 (SELOGIC Equation)	NA	
EBFIS03	Breaker Fail Initiate Seal-In–BK03 (Y, N)	N	
BFISP03	Breaker Fail Init Seal-In Delay–BK03 (0.00–1000 cyc)	0.50	0.083
BFIDO03	Brkr Fail Init Dropout Delay–BK03 (0.00–1000 cyc)	1.50	0.083

Table 8.42 Breaker Failure Logic (1–21) (Sheet 2 of 3)

Setting	Prompt	Default	Increment
Breaker 04 Failure Logic			
EXBF04	External Breaker Fail–BK04 (Y, N)	N	
XBF04	External Brkr Fail Init–BK04 (SELOGIC Equation)	NA	
50FP04	Fault Current Pickup–BK04 (0.50–50 amps, sec)	3.00	0.01
BFPU04	Brkr Fail Init Pickup Delay–BK04 (0.00–6000 cyc)	6.00	0.083
RTPU04	Retrip Time Delay–BK04 (0.00–6000 cyc)	3.00	0.083
BFI04	Breaker Fail Initiate–BK04 (SELOGIC Equation)	T1_BFI AND BF_EN	
ATBFI04	Alt Breaker Fail Initiate–BK04 (SELOGIC Equation)	NA	
EBFIS04	Breaker Fail Initiate Seal-In–BK04 (Y, N)	N	
BFISP04	Breaker Fail Init Seal-In Delay–BK04 (0.00–1000 cyc)	0.50	0.083
BFIDO04	Brkr Fail Init Dropout Delay–BK04 (0.00–1000 cyc)	1.50	0.083
Breaker 05 Failure Logic			
EXBF05	External Breaker Fail–BK05 (Y, N)	N	
XBF05	External Brkr Fail Init–BK05 (SELOGIC Equation)	NA	
50FP05	Fault Current Pickup–BK05 (0.50–50 amps, sec)	3.00	0.01
BFPU05	Brkr Fail Init Pickup Delay–BK05 (0.00–6000 cyc)	6.00	0.083
RTPU05	Retrip Delay–BK05 (0.00–6000 cyc)	3.00	0.083
BFI05	Breaker Fail Initiate–BK05 (SELOGIC Equation)	TB_BFI AND BF_EN	
ATBFI05	Alt Breaker Fail Initiate–BK05 (SELOGIC Equation)	NA	
EBFIS05	Breaker Fail Initiate Seal-In–BK05 (Y, N)	N	
BFISP05	Breaker Fail Init Seal-In Delay–BK05 (0.00–1000 cyc)	0.50	0.083
BFIDO05	Brkr Fail Init Dropout Delay–BK05 (0.00–1000 cyc)	1.50	0.083
Breaker 06 Failure Logic			
EXBF06	Enable External Breaker Fail–BK06 (Y, N)	N	
XBF06	External Brkr Fail Init–BK06 (SELOGIC Equation)	NA	
50FP06	Fault Current Pickup–BK06 (0.50–50 amps, sec)	3.00	0.01
BFPU06	Brkr Fail Init Pickup Delay–BK06 (0.00–6000 cyc)	6.00	0.083
RTPU06	Retrip Delay–BK06 (0.00–6000 cyc)	3.00	0.083
BFI06	Breaker Fail Initiate–BK06 (SELOGIC Equation)	IN106 AND BF_EN	
ATBFI06	Alt Breaker Fail Initiate–BK06 (SELOGIC Equation)	NA	
EBFIS06	Breaker Fail Initiate Seal-In–BK06 (Y, N)	N	
BFISP06	Breaker Fail Init Seal-In Delay–BK06 (0.00–1000 cyc)	0.50	0.083
BFIDO06	Brkr Fail Init Dropout Delay–BK06 (0.00–1000 cyc)	1.50	0.083

Table 8.42 Breaker Failure Logic (1–21) (Sheet 3 of 3)

Setting	Prompt	Default	Increment
Breaker 07 Failure Logic			
EXBF07	External Breaker Fail–BK07 (Y, N)	N	
XBF07	External Brkr Fail Init–BK07 (SELOGIC Equation)	NA	
50FP07	Fault Current Pickup–BK07 (0.50–50 amps, sec)	3.00	0.01
BFPU07	Brkr Fail Init Pickup Delay–BK07 (0.00–6000 cyc)	6.00	0.083
RTPU07	Retrip Delay–BK07 (0.00–6000 cyc)	3.00	0.083
BFI07	Breaker Fail Initiate–BK07 (SELOGIC Equation)	NA	
ATBFI07	Alt Breaker Fail Initiate–BK07 (SELOGIC Equation)	NA	
EBFIS07	Breaker Fail Initiate Seal-In–BK07 (Y, N)	N	
BFISP07	Breaker Fail Init Seal-In Delay–BK07 (0.00–1000 cyc)	0.50	0.083
BFIDO07	Brkr Fail Init Dropout Delay–BK07 (0.00–1000 cyc)	1.50	0.083
Breaker 08 Failure Logic			
EXBF08	External Breaker Fail–BK08 (Y, N)	Y	
XBF08	External Brkr Fail Init–BK08 (SELOGIC Equation)	NA	
50FP08	Fault Current Pickup–BK08 (0.50–50 amps, sec)	3.00	0.01
BFPU08	Brkr Fail Init Pickup Delay–BK08 (0.00–6000 cyc)	6.00	0.083
RTPU08	Retrip Delay–BK08 (0.00–6000 cyc)	3.00	0.083
BFI08	Breaker Fail Initiate–BK08 (SELOGIC Equation)	NA	
ATBFI08	Alt Breaker Fail Initiate–BK08 (SELOGIC Equation)	NA	
EBFIS08	Breaker Fail Initiate Seal-In–BK08 (Y, N)	N	
BFISP08	Breaker Fail Init Seal-In Delay–BK08 (0.00–1000 cyc)	0.50	0.083
BFIDO08	Brkr Fail Init Dropout Delay–BK08 (0.00–1000 cyc)	1.50	0.083
• • •	• • •	• • •	• • •
Breaker 21 Failure Logic			
EXBF21	External Breaker Fail–BK21 (Y, N)	Y	
XBF21	External Brkr Fail Init–BK21 (SELOGIC Equation)	NA	
50FP21	Fault Current Pickup–BK21 (0.50–50 amps, sec)	3.00	0.01
BFPU21	Brkr Fail Init Pickup Delay–BK21 (0.00–6000 cyc)	6.00	0.083
RTPU21	Retrip Delay–BK21 (0.00–6000 cyc)	3.00	0.083
BFI21	Breaker Fail Initiate–BK21 (SELOGIC Equation)	NA	
ATBFI21	Alt Breaker Fail Initiate–BK21 (SELOGIC Equation)	NA	
EBFIS21	Breaker Fail Initiate Seal-In–BK21 (Y, N)	N	
BFISP21	Breaker Fail Init Seal-In Delay–BK21 (0.00–1000 cyc)	0.50	0.083
BFIDO21	Brkr Fail Init Dropout Delay–BK21 (0.00–1000 cyc)	1.50	0.083

Table 8.43 Definite-Time Overcurrent Elements

Setting	Prompt	Default	Increment
50P01P	Terminal 01 Pickup (OFF, 0.25–100 amps, sec)	OFF	0.01
50P01D	Terminal 01 Pickup Delay (0.00–99999 cyc)	10.00	0.167
• • •	• • •	• • •	• • •
50P21P	Terminal 21 Pickup (OFF, 0.25–100 amps, sec)	OFF	0.01
50P21D	Terminal 21 Pickup Delay (0.00–99999 cyc)	10.00	0.167

Table 8.44 Inverse-Time Overcurrent Elements

Setting	Prompt	Default
51O01	Inverse Time O/C 01 Operate Quantity	I01FIM
51P01[a]	Inverse Time O/C 01 Pickup (SELOGIC Equation) (0.25–16 A, sec)	0.50
51C01	Inverse Time O/C 01 Curve (U1–U5, C1–C5)	U1
51TD01	Inverse Time O/C 01 Time Dial (0.50–15) [U1–U5] or Inverse Time O/C 01 Time Dial (0.05–1) [C1–C5]	0.50
51RS01	Inverse Time O/C 01 EM Reset (Y, N)	Y
51TC01	Inverse Time O/C 01 Torque Cont (SELOGIC Equation)	1
• • •	• • •	• • •
51O21	Inverse Time O/C 21 Operate Quantity	I21FIM
51P21[a]	Inverse Time O/C 21 Pickup (SELOGIC Equation) (0.50–16 A, sec)	0.50
51C21	Inverse Time O/C 21 Curve (U1–U5, C1–C5)	U1
51TD21	Inverse Time O/C 21 Time Dial (0.50–15) [U1–U5] or Inverse Time O/C 21 Time Dial (0.05–1) [C1–C5]	0.50
51RS21	Inverse Time O/C 21 EM Reset (Y, N)	Y
51TC21	Inverse Time O/C 21 Torque Cont (SELOGIC Equation)	1

[a] The acceptable range of result of the math equation must be within specific limits depending on the nominal current. For 5 A nominal current input, the range is 0.25–16.0 A, sec. For 1 A nominal current input, 0.05–3.2 A, sec. See Section 5: Protection Functions for more information.

Table 8.45 Undervoltage Elements

Setting	Prompt	Default	Increment
270*n*[a]	U/V Element *n* Operating Quantity	V1FIM	
27P*n*P1[a]	U/V Element *n* Level 1 P/U (2.00–300 V, sec)	20.00	0.01
27TC*n*[a]	U/V Element *n* Torque Control (SELOGIC Eqn)	1	
27P*n*D1[a]	U/V Element *n* Level 1 Delay (0.00–16000 cyc)	10.00	0.167
27P*n*P2[a]	U/V Element *n* Level 2 P/U (2.00–300 V, sec)	15.00	0.01

[a] n = 1–6.

Table 8.46 Overvoltage Elements

Setting	Prompt	Default	Increment
590*n*[a]	O/V Element *n* Operating Quantity	V1FIM	
59P*n*P1[a]	O/V Element *n* Level 1 P/U (2.00–300 V, sec)	76.00	0.01
59TC*n*[a]	O/V Element *n* Torque Control (SELOGIC Eqn)	1	
59P*n*D1[a]	O/V Element *n* Level 1 Delay (0.00–16000 cyc)	10.00	0.167
59P*n*P2[a]	O/V Element *n* Level 2 P/U (2.00–300 V, sec)	80.00	0.01

[a] n = 1–6.

Table 8.47 Trip Logic

Setting	Prompt	Default	Increment
TR01	Trip 01 (SELOGIC Equation)	F1_BFT OR F1_DPT	
ULTR01	Unlatch Trip 01 (SELOGIC Equation)	NA	
TR02	Trip 02 (SELOGIC Equation)	F2_BFT OR F2_DPT	
ULTR02	Unlatch Trip 02 (SELOGIC Equation)	NA	
TR03	Trip 03 (SELOGIC Equation)	F3_BFT OR F3_DPT	
ULTR03	Unlatch Trip 03 (SELOGIC Equation)	NA	
TR04	Trip 04 (SELOGIC Equation)	T1_BFT OR T1_DPT	
ULTR04	Unlatch Trip 04 (SELOGIC Equation)	NA	
TR05	Trip 05 (SELOGIC Equation)	TB1_BFT OR TB1_DPT OR TB2_BFT OR TB2_DPT	
ULTR05	Unlatch Trip 05 (SELOGIC Equation)	NA	
TR06	Trip 06 (SELOGIC Equation)	NA	
ULTR06	Unlatch Trip 06 (SELOGIC Equation)	NA	
• • •	• • •	• • •	
TR21	Trip 21 (SELOGIC Equation)	NA	
ULTR21	Unlatch Trip 21 (SELOGIC Equation)	NA	
TDURD	Minimum Trip Duration Time Delay (2.000–8000 cyc)	12.000	0.083
ER	Event Report Trigger Equation (SELOGIC Equation)	R_TRIG 87ST	

Protection Freeform SELOGIC Control Equations

The following protection freeform SELOGIC control equation settings are the default settings for all six settings groups. You can set each of the six protection freeform SELOGIC control equation settings groups independently. See *Multiple Setting Groups on page 12.4 in the SEL-400 Series Relays Instruction Manual*.

Table 8.48 Protection Freeform SELOGIC Control Equations

Label	Default
PLT01S :=	NOT DIFF_EN AND PLT04 # DIFFERENTIAL ENABLED
PLT01R :=	PCT02Q AND DIFF_EN AND NOT PLT04
PLT02S :=	NOT BF_EN AND PLT05 # BREAKER FAILURE ENABLED
PLT02R :=	PCT03Q AND BF_EN AND NOT PLT05
PLT03S :=	NOT TNS_SW AND PLT06 # RELAY TEST MODE
PLT03R :=	PCT04Q AND TNS_SW AND NOT PLT06
PLT04S :=	PB1_PUL AND NOT DIFF_EN # ONLY ONE OP PER PB1 PRESS
PLT04R :=	PB1_PUL AND DIFF_EN
PLT05S :=	PB2_PUL AND NOT BF_EN # ONLY ONE OP PER PB2 PRESS
PLT05R :=	PB2_PUL AND BF_EN
PLT06S :=	PB4_PUL AND NOT TNS_SW # ONLY ONE OP PER PB4 PRESS
PLT06R :=	PB4_PUL AND TNS_SW
PCT01PU :=	240
PCT01IN :=	PCT01IN := 3V2FIM > 20 OR 3V0FIM > 20
PCT02PU :=	60 # 1 SEC DELAY DISABLE ON PB1
PCT02IN :=	PB1
PCT03PU :=	60 # 1 SEC DELAY DISABLE ON PB2
PCT03IN :=	PB2
PCT04PU :=	60 # 1 SEC DELAY DISABLE ON PB4
PCT04IN :=	PB4

Automation Freeform SELOGIC Control Equations

See *Automation Freeform SELOGIC Control Equations on page 12.26 in the SEL-400 Series Relays Instruction Manual* for a description of automation SELOGIC control equations. The SEL-487B supports 10 blocks of 100 lines.

Notes Settings

Use the Notes settings like a text pad to leave notes about the relay. See *Notes Settings on page 12.29 in the SEL-400 Series Relays Instruction Manual* for additional information on Notes settings.

Output Settings

Output Settings on page 12.26 in the SEL-400 Series Relays Instruction Manual contains a description of the relay's output settings. This subsection describes SEL-487B-specific default values.

Table 8.49 Main Board

Setting	Default
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)

All interface board default output SELOGIC equations default to NA.

Front-Panel Settings

See *Front-Panel Settings on page 12.20 in the SEL-400 Series Relays Instruction Manual* for a complete description of front-panel settings. This subsection lists the SEL-487B-specific default settings values.

Table 8.50 Front-Panel Settings (Sheet 1 of 4)

Setting	Default
FP_TO	15
EN_LEDC[a]	G
TR_LEDC[a]	R
PB1_LED	DIFF_EN # Differential Protection Enabled
PB1_COL[a]	AO
PB2_LED	BF_EN # Breaker Failure Enabled
PB2_COL[a]	AO
PB3_LED	NA
PB3_COL[a]	AO
PB4_LED	TNS_SW # Test Normal Switch Enabled
PB4_COL[a]	AO
PB5_LED	NA
PB5_COL[a]	AO
PB6_LED	NA
PB6_COL[a]	AO
PB7_LED	NA
PB7_COL[a]	AO

Table 8.50 Front-Panel Settings (Sheet 2 of 4)

Setting	Default
PB8_LED	NA
PB8_COL[a,b]	AO
PB9_LED[b]	NA
PB9_COL[a,b]	AO
PB10LEDb	NA
PB10COL[a,b]	AO
PB11LED[b]	NA
PB11COL[a,b]	AO
PB12LED[b]	NA
PB12COL[a,b]	AO
T1_LED	87BTR
T1LEDL	Y
T1LEDC[a]	RO
T2_LED	SBFTR
T2LEDL	Y
T2LEDC[a]	RO
T3_LED	Z1_TRIP
T3LEDL	Y
T3LEDC[a]	RO
T4_LED	Z2_TRIP
T4LEDL	Y
T4LEDC[a]	RO
T5_LED	87Z3
T5LEDL	Y
T5LEDC[a]	RO
T6_LED	87Z4
T6LEDL	Y
T6LEDC[a]	RO
T7_LED	87Z5
T7LEDL	Y
T7LEDC[a]	RO
T8_LED	87Z6
T8LEDL	Y
T8LEDC[a]	RO
T9_LED	50P01T OR 50P02T OR. . .50P21T
T9LEDL	Y
T91LEDC[a]	RO
T10_LED	51T01 OR 51T02 OR. . .51T21
T10LEDL	Y
T10LEDC[a]	RO

Table 8.50 Front-Panel Settings (Sheet 3 of 4)

Setting	Default
T11_LED	87ST
T11LEDL	N
T11LEDC[a]	RO
T12_LED	NOT (Z1S AND Z2S AND. . .Z6S)
T12LEDL	Y
T12LEDC[a]	RO
T13_LED	TOS01 OR TOS02 OR. . .TOS21
T13LEDL	N
T13LEDC[a]	RO
T14_LED	89IOP
T14LEDL	N
T14LEDC[a]	RO
T15_LED	89AL
T15LEDL	N
T15LEDC[a]	RO
T16_LED	PCT01Q
T16LEDL	Y
T16LEDC[a]	RO
T17_LED[c]	271P1 OR 272P1 OR 272P2 OR 273P1 OR 273P2
T17LEDLc	N
T17LEDC[a,c]	RO
T18_LED[c]	591P1 OR 591P2 OR 292P1 OR 592P2 OR 593P1 OR 593P2
T18LEDL[c]	N
T18LEDC[a,c]	RO
T19_LED[c]	V01FIM>55
T19LEDL[c]	N
T19LEDC[a,c]	RO
T20_LED[c]	V02FIM>55
T20LEDL[c]	N
T20LEDC[a,c]	RO
T21_LED[c]	V03FIM>55
T21LEDL[c]	N
T21LEDC[a,c]	RO
T22_LED[c]	FAULT
T22LEDL[c]	N
T22LEDC[a,c]	RO
T23_LED[c]	52AL
T23LEDL[c]	N
T23LEDC[a,c]	RO
T24_LED[c]	TIRIG

Table 8.50 Front-Panel Settings (Sheet 4 of 4)

Setting	Default
T24LEDL[c]	N
T24LEDC[a,c]	RO

[a] LED color settings are only available on HMI2 models.
[b] PB9–PB12 settings are only available on 12-pushbutton models.
[c] T17LED–T24LED settings are only available on 12-pushbutton models.

The SEL-487B supports the SCROLD, STA_BAT, FUND_VI, DIFF, and ZONECFG choices for selectable screens, as described in *Table 12.38 in the SEL-400 Series Relays Instruction Manual*.

Report Settings

The SEL-487B contains the Report Settings described in *Report Settings on page 12.28 in the SEL-400 Series Relays Instruction Manual*.

Table 8.51 Default Event Report Settings (Sheet 1 of 2)

Position	Primitive Name	Alias Name
1	87Z1	Z1_TRIP
2	87Z2	Z2_TRIP
3	#	
4	FBF01	F1_BF
5	FBF02	F2_BF
6	FBF03	F3_BF
7	FBF04	T1_BF
8	FBF05	TB1_BF
9	FBF06	TB2_BF
10	#	
11	PLT01	DIFF_EN
12	PLT02	BF_EN
13	PLT03	TNS_SW
14	#	
15	IN101	F1_BFI
16	IN102	F2_BFI
17	IN103	F3_BFI
18	IN104	T1_BFI
19	IN105	TB_BFI
20	#	
21	OUT101	F1_TRIP
22	OUT102	F2_TRIP
23	OUT103	F3_TRIP
24	OUT104	T1_TRIP
25	OUT105	TB_TRIP

Table 8.51 Default Event Report Settings (Sheet 2 of 2)

Position	Primitive Name	Alias Name
26	OUT106	
27	#	
28	OUT107	TEST
29	OUT108	NOALARM

Port Settings

The SEL-487B Port settings are described in *Port Settings on page 12.6 in the SEL-400 Series Relays Instruction Manual*.

The Fast Message read data access settings listed in *Table 12.8 in the SEL-400 Series Relays Instruction Manual* are included in the SEL-487B, except FMRDMND and FMRBRKR.

Table 8.52 MIRRORED BITS Protocol Default Settings

Setting	Default
MBANA1	PMV58
MBANA2	PMV59
MBANA3	PMV60
MBANA4	PMV61
MBANA5	PMV62
MBANA6	PMV63
MBANA7	PMV64

DNP3 Settings—Custom Maps

The SEL-487B DNP3 custom map settings operate as described in *DNP3 Settings—Custom Maps on page 12.19 in the SEL-400 Series Relays Instruction Manual*. See *Section 10: Communications Interfaces* for the default map configuration.

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SECTION 9

ASCII Command Reference

You can use a communications terminal or terminal emulation program to set and operate the SEL-487B relay. This section explains the commands that you send to the SEL-487B using SEL ASCII communications protocol. The relay responds to commands such as settings, metering, and control operations.

This section lists all the commands supported by the relay, but most are described in *Section 14: ASCII Command Reference in the SEL-400 Series Relays Instruction Manual*. This section provides information on commands and command options that are unique to the SEL-487B.

This section lists American National Standard Code for Information Interchange (ASCII) commands alphabetically. Commands, command options, and command variables that you enter are shown in bold. Lowercase italic letters and words in a command represent command variables that you determine based on the application (for example, Zone *n* = 1–6, remote bit number *nn* = 01–96, and *level*).

Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the relay function corresponding to the command or examples of the relay response to the command.

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 **ACC <Enter>**.

Tables in this section show the access level(s) where the command or command option is active. Access levels in the SEL-487B are Access Level 0, Access Level 1, Access Level B (breaker), Access Level P (protection), Access Level A (automation), Access Level O (output), and Access Level 2.

Description of Commands

Table 9.1 lists all the commands supported by the relay with the corresponding links to the descriptions in *Section 14: ASCII Command Reference in the SEL-400 Series Relays Instruction Manual*.

Command List

Table 9.1 SEL-487B List of Commands (Sheet 1 of 2)

Command	Location of Command in *Section 14: ASCII Command Reference* in the SEL-400 Series Relays Instruction Manual
2ACCESS	*2ACCESS on page 14.1*
AACCESS	*AACCESS on page 14.3*
ACCESS	*ACCESS on page 14.3*
BACCESS	*BACCESS on page 14.3*
BNAME	*BNAME on page 14.4*
CAL	*CAL on page 14.5*
CASCII	*CASCII on page 14.6*
CEVENT	*CEVENT on page 14.7* (In the SEL-487B, **CEV L** provides a 12-samples/cycle large-resolution event report.)
CFG CTNOM ***i***	*CFG CTNOM on page 14.10* (in the SEL-487B, the nominal current choices are 1 and 5 for 1 A nominal and 5 A nominal CT inputs.)
CFG NFREQ ***f***	*CFG NFREQ on page 14.11*
CHISTORY	*CHISTORY on page 14.11*
COMMUNICATIONS ***c***	*COMMUNICATIONS on page 14.12*
CONTROL ***nn***	*CONTROL nn on page 14.25*
COPY	*COPY on page 14.26* (In addition to the typical classes, the zone (Z) class can also be copied using the **COPY** command.)
CPR	*CPR on page 14.27*
CSER	*CSER on page 14.27*
CSTATUS	*CSTATUS on page 14.29*
CSUMMARY	*CSUMMARY on page 14.29*
DATE	*DATE on page 14.30*
DNAME X	*DNAME X on page 14.31*
DNP	*DNP on page 14.31*
ETHERNET	*ETHERNET on page 14.31*
EVENT	*EVENT on page 14.33* (The SEL-487B supports large resolution 12-samples/cycle event reports.)
EXIT	*EXIT on page 14.37*
FILE	*FILE on page 14.37*
GOOSE	*GOOSE on page 14.38*
GROUP	*GROUP on page 14.41*
HELP	*HELP on page 14.41*
HISTORY	*HISTORY on page 14.41*
ID	*ID on page 14.43*
LOOPBACK	*LOOPBACK on page 14.44*
MAC	*MAC on page 14.46*
MAP	*MAP on page 14.46*
METER	*METER on page 14.47* (For all other **METER** options, see *METER on page 9.4* in this section.)
MET AMV	*MET AMV on page 14.47*
MET ANA	*MET ANA on page 14.48*

Table 9.1 SEL-487B List of Commands (Sheet 2 of 2)

Command	Location of Command in *Section 14: ASCII Command Reference* in the SEL-400 Series Relays Instruction Manual
MET BAT	*MET BAT on page 14.48* (The SEL-487B provides battery metering for one battery monitor channel.)
MET CZ*q*	See *MET CZq on page 9.4* in this section.
MET DIF	See *MET DIF on page 9.4* in this section.
MET PMV	*MET PMV on page 14.50*
MET SEC	See *MET SEC on page 9.5* in this section.
MET SEC CZ*n*	See *MET SEC CZq on page 9.5* in this section.
MET SEC Z*n*	See *MET SEC Zn on page 9.5* in this section.
MET Z*n*	See *MET Zn on page 9.5* in this section.
OACCESS	*OACCESS on page 14.51*
OPEN *n*	*OPEN n on page 14.51* (The SEL-487B supports 21 circuit breakers, designated 1–21.)
PACCESS	*PACCESS on page 14.52*
PASSWORD	*PASSWORD on page 14.52*
PING	*PING on page 14.53*
PORT	*PORT on page 14.53*
PROFILE	*PROFILE on page 14.54*
PULSE	*PULSE on page 14.55*
QUIT	*QUIT on page 14.55*
SER	*SER on page 14.56*
SET	*SET on page 14.58* (*Table 9.9* lists the options available in the SEL-487B.)
SHOW	*SHOW on page 14.59* (*Table 9.10* lists the class and instance options available in the SEL-487B.)
SNS	*SNS on page 14.60*
STATUS	*STATUS on page 14.60*
SUMMARY	*SUMMARY on page 14.62*
TARGET	*TARGET on page 14.63*
TEST DB	*TEST DB on page 14.65*
TEST DB2	*TEST DB2 on page 14.66*
TEST FM	*TEST FM on page 14.68*
TIME	*TIME on page 14.71*
TRIGGER	*TRIGGER on page 14.73*
VECTOR	*VECTOR on page 14.73*
VERSION	*VERSION on page 14.73*
VIEW	*VIEW on page 14.75*
ZONE	See *ZONE on page 9.7* in this section.
ZON T	See *ZON T on page 9.8* in this section.
ZON *k*	See *ZON k on page 9.8* in this section.

METER

The **METER** command displays reports about quantities the relay measures in the power system and internal relay operating quantities. For more information on power system measurements, see *Section 7: Metering, Monitoring, and Reporting*.

MET

NOTE: Data obtained with the **MET** command during dynamic zone selection may be unreliable.

Use the **MET** command to view fundamental metering quantities. The relay filters harmonics to present only measured quantities at the power system fundamental operating frequency.

Table 9.2 MET Command

Command	Description	Access Level
MET	Display fundamental metering data.	1, B, P, A, O, 2
MET *k*	Display fundamental metering data successively for *k* times.	1, B, P, A, O, 2

Some situations require that you repeatedly monitor the power system for a brief period; specify a number after any **MET** command to automatically repeat the command.

MET CZq

Use the **MET CZ*q*** (*q* = 1–3) command to view the current magnitude, angle, and polarity of each terminal in Check Zone *q* and the voltage in primary values.

Table 9.3 MET CZq Command

Command[a]	Description	Access Level
MET CZ*q*	Display primary metering data for Check Zone *q*.	1, B, P, A, O, 2
MET CZ*q k*	Display primary metering data for Check Zone *q* successively for *k* times.	1, B, P, A, O, 2

[a] q = 1–3.

If an alias name for the terminal exists, the relay displays the alias name.

MET DIF

Use the **MET DIF** command to view the operate and restraint differential currents in the active zones in per unit values as well as the reference current (IREF).

Table 9.4 MET DIF Command

Command	Description	Access Level
MET DIF	Display the operate and restraint differential currents and IREF metering data.	1, B, P, A, O, 2
MET DIF *k*	Display the operate and restraint differential currents and IREF metering data successively for *k* times.	1, B, P, A, O, 2

MET SEC

Use the **MET SEC** command to view the current magnitude, angle, and CT ratio of each terminal. The view also includes voltage magnitudes in secondary values.

Table 9.5 MET SEC Command

Command	Description	Access Level
MET SEC	Display secondary metering data.	1, B, P, A, O, 2
MET SEC *k*	Display secondary metering data successively for *k* times.	1, B, P, A, O, 2

If an alias name for the terminal exists, the relay displays the alias name.

MET SEC CZq

Use the **MET SEC CZ*q*** (*q* = 1–3) command to view the current magnitude, angle, CT ratio, and polarity of each terminal in Check Zone *q* and the voltage in secondary values.

Table 9.6 MET SEC CZq Command

Command[a]	Description	Access Level
MET SEC CZ*q*	Display secondary metering data for Check Zone *q*.	1, B, P, A, O, 2
MET SEC CZ*q k*	Display secondary metering data for Check Zone *q* successively for *k* times.	1, B, P, A, O, 2

[a] q = 1–3.

If an alias name for the terminal exists, the relay displays the alias name.

MET SEC Zn

Use the **MET SEC Z*n*** command to view the current magnitude, angle, CT ratio, and polarity of each terminal in a particular protection zone (*n* = 1–6), the bus-zones in Protection Zone *n*, and the voltage in secondary values.

Table 9.7 MET SEC Zn Command

Command[a]	Description	Access Level
MET SEC Z*n*	Display secondary metering data.	1, B, P, A, O, 2
MET SEC Z*n k*	Display secondary metering data successively for *k* times.	1, B, P, A, O, 2

[a] Parameter n is 1–6 to indicate 6 zones.

If an alias name for the terminal exists, the relay displays the alias name.

MET Zn

Use the **MET Z*n*** command to view the current magnitude, angle, and polarity of each terminal in a particular protection zone (*n* = 1–6), the bus-zones in Protection Zone *n*, and the voltage in primary values.

Table 9.8 MET Zn Command

Command	Description	Access Level
MET Z*n*	Display primary metering data.	1, B, P, A, O, 2
MET Z*n k*	Display primary metering data successively for *k* times.	1, B, P, A, O, 2

If an alias name for the terminal exists, the relay displays the alias name.

SET

Table 9.9 lists the options specifically available in the SEL-487B.

Table 9.9 SET Command Overview

Command	Description	Access Level
SET	Set the Group relay settings, beginning at the first setting in the active group.	P, 2
SET *n*[a]	Set the Group *n* relay settings, beginning at the first setting in the group.	P, 2
SET A	Set the Automation SELOGIC control equation relay settings in Block 1.	A, 2
SET A *m*[b]	Set the Automation SELOGIC control equation relay settings in Block *m*.	A, 2
SET D	Set the serial port DNP3 remapping settings, beginning at the first setting in this class.	P, A, O, 2
SET F	Set the Front Panel relay settings, beginning at the first setting in this class.	P, A, O, 2
SET G	Set the Global relay settings, beginning at the first setting in this class.	P, A, O, 2
SET L	Set the Protection SELOGIC control equation relay settings for the active group.	P, 2
SET L *n*[a]	Set the Protection SELOGIC relay settings for Group *n*.	P, 2
SET O	Set the Output SELOGIC control equation relay settings, beginning at OUT101.	O, 2
SET P	Set the port presently in use, beginning at the first setting for this port.	P, A, O, 2
SET P *p*[c]	Set the communications Port relay settings for Port *p*, beginning at the first setting for this port.	P, A, O, 2
SET R	Set the Report relay settings, beginning at the first setting for this class.	P, A, O, 2
SET T	Set the alias settings.	P, A, O, 2
SET Z	Set the active group zone configuration settings, beginning at the first setting.	P, 2
SET Z *n*[a]	Set the configuration setting for Group *n*, beginning at the first setting.	P, 2

[a] Parameter n = 1–6, representing Group 1–Group 6.
[b] Parameter m = 1–10, representing Block 1–Block 10.
[c] Parameter p = 1–3, F, or 5, corresponding to Port 1–Port 3, Port F, or Port 5.

SHOW

Table 9.10 lists the class and instance options available in the SEL-487B.

Table 9.10 SHO Command Overview

Command	Description	Access Level
SHO	Show the Group relay settings, beginning at the first setting in the active group.	1, B, P, A, O, 2
SHO *n*[a]	Show Group n settings, beginning at the first setting in Group *n*.	1, B, P, A, O, 2
SHO A	Show the Automation SELOGIC control equation relay settings in Block 1.	1, B, P, A, O, 2
SHO A *m*[b]	Show the Automation SELOGIC control equation relay settings in Block *m*.	1, B, P, A, O, 2
SHO D	Show the serial DNP3 remapping settings.	1, B, P, A, O, 2
SHO F	Show the Front Panel relay settings, beginning at the first setting in this class.	1, B, P, A, O, 2
SHO G	Show the Global relay settings, beginning at the first setting in this class.	1, B, P, A, O, 2
SHO L	Show the Protection SELOGIC control equation relay settings for the active group.	1, B, P, A, O, 2
SHO L *n*[a]	Show the Protection SELOGIC control equation relay settings for Group *n*.	1, B, P, A, O, 2
SHO O	Show the Output SELOGIC control equation relay settings, beginning at OUT101.	1, B, P, A, O, 2
SHO P	Show the relay settings for the port presently in use, beginning at the first setting.	1, B, P, A, O, 2
SHO P *p*[c]	Show the communications Port relay settings for Port *p*, beginning at the first setting for this port.	1, B, P, A, O, 2
SHO R	Show the Report relay settings, beginning at the first setting for this class.	1, B, P, A, O, 2
SHO T	Show the alias settings.	1, B, P, A, O, 2
SHO Z	Show the zone configuration settings for the active group.	1, B, P, A, O, 2
SHO Z *n*[a]	Show the zone configuration settings for Group *n*.	1, B, P, A, O, 2

[a] Parameter n = 1–6, representing Group 1–Group 6.
[b] Parameter m = 1–10, representing Block 1–Block 10.
[c] Parameter p = 1–3, F, and 5 which corresponds to Port 1–Port 3, Port F, and Port 5.

ZONE

The **ZONE** command causes the relay to display the active protection zones and the terminal and bus-zone names in each active protection zone, where active means a zone with at least one terminal in the zone.

Use the **ZON** command to display the terminal and bus-names associated with all active zones.

Table 9.11 ZON Command

Command	Description	Access Level
ZON	Display the terminal and bus-zone names associated with all active zones.	1, B, P, A, O, 2

ZON T

Use the **ZON T** command to display the terminal names in each active zone, selected for tripping by differential and breaker failure protection.

Table 9.12 ZON T Command

Command	Description	Access Level
ZON T	Display the terminals programmed for tripping in all zones.	1, B, P, A, O, 2

When two zones combine, the combined zone includes the terminals from both merged zones. Not all terminals in the combined zone may be required to trip for a differential element operation. **ZON T** provides a list of all terminals assigned to trip in all the zones at the station, and **ZON T *k*** provides a list of the terminals to trip in a specific zone.

ZON k

Use the **ZON *k*** (*k* = 1–6) command to display the terminals in Zone *k*, if Zone *k* is active.

Table 9.13 ZON k Command

Command	Description	Access Level
ZON *k*[a]	Display the terminals in Zone *k*.	1, B, P, A, O, 2

[a] Parameter k is 1–6.

SECTION 10

Communications Interfaces

Section 15: Communications Interfaces through *Section 18: Synchrophasors in the SEL-400 Series Relays Instruction Manual* describe the various communications interfaces and protocols used in SEL-400 series relays. This section describes aspects of the communications protocols that are unique to the SEL-487B. The following topics are discussed:

Communications Database

The SEL-487B maintains a database to describe itself to external devices via the SEL Fast Message Data Access protocol. This database includes a variety of data within the relay that are available to devices connected in a serial or Ethernet network. The database includes the regions and data described in *Table 10.1*. Use the **MAP** and **VIEW** commands to display maps and contents of the database regions. See *Section 14: ASCII Command Reference in the SEL-400 Series Relays Instruction Manual* for more information on the **MAP** and **VIEW** commands.

Table 10.1 SEL-487B Database Regions

Region Name	Contents	Update Rate
LOCAL	Relay identification data including FID, Relay ID, Station ID, and active protection settings group	Updated on settings change and whenever monitored values change
METER	Metering and measurement data	0.5 s
TARGET	Selected rows of Relay Word bit data	0.5 s
HISTORY	Relay event history records for the 10 most recent events	Within 15 s of any new event
STATUS	Self-test diagnostic status data	5 s
ANALOGS	Protection and automation math variables	0.5 s

Data within the Ethernet card regions are available for access by external devices via the SEL Fast Message protocol.

The LOCAL region contains the device FID, SID, and RID. It will also provide appropriate status points. This region is updated on settings changes and whenever monitored status points change (see *Table 10.2*).

Table 10.2 SEL-487B Database Structure—LOCAL Region

Address (Hex)	Name	Type	Description
0000	FID	char[48]	FID string
0030	BFID	char[48]	SELBOOT FID string
0060	SER_NUM	char[16]	Device Serial number, from factory settings
0070	PART_NUM	char[24]	Device part number, from factory settings
0088	CONFIG	char[8]	Device configuration string (as reported in **ID** command)
0090	SPECIAL	char[8]	Special device configuration string (as reported in **ID** command)
0098	DEVICE_ID	char[40]	Relay ID setting, from global settings
00C0	NODE_ID	char[40]	Station ID from global settings
00E8	GROUP	int	Active group
00E9	STATUS	int	Status indication: 0 for okay, 1 for failure

The METER region contains all the basic meter and energy information. This region is updated every 0.5 seconds. See *Table 10.3* for the map.

Table 10.3 SEL-487B Database Structure—METER Region (Sheet 1 of 3)

Address (Hex)	Name	Type	Description
1000	_YEAR	int	4-digit year when data were sampled
1001	DAY_OF_YEAR	int	1–366 day when data were sampled
1002	TIME(ms)	long int	Time of day in ms when data were sampled (0–86,400,000)
1004	FREQ	float	System frequency (Hertz)
1006	VDC	float	Battery voltage (Volts)
1008, 100A	I01	float[2]	I01 current magnitude (amperes primary) and phase (degrees)
100C, 100E	I02	float[2]	I02 current magnitude (amperes primary) and phase (degrees)
1010, 1012	I03	float[2]	I03 current magnitude (amperes primary) and phase (degrees)
1014, 1016	I04	float[2]	I04 current magnitude (amperes primary) and phase (degrees)
1018. 101A	I05	float[2]	I05 current magnitude (amperes primary) and phase (degrees)
101C, 101E	I06	float[2]	I06 current magnitude (amperes primary) and phase (degrees)
1020, 1022	I07	float[2]	I07 current magnitude (amperes primary) and phase (degrees)
1024, 1026	I08	float[2]	I08 current magnitude (amperes primary) and phase (degrees)
1028, 102A	I09	float[2]	I09 current magnitude (amperes primary) and phase (degrees)
102C, 102E	I10	float[2]	I10 current magnitude (amperes primary) and phase (degrees)
1030, 1032	I11	float[2]	I11 current magnitude (amperes primary) and phase (degrees)

Table 10.3 SEL-487B Database Structure—METER Region (Sheet 2 of 3)

Address (Hex)	Name	Type	Description
1034, 1036	I12	float[2]	I12 current magnitude (amperes primary) and phase (degrees)
1038, 103A	I13	float[2]	I13 current magnitude (amperes primary) and phase (degrees)
103C, 103E	I14	float[2]	I14 current magnitude (amperes primary) and phase (degrees)
1040, 1042	I15	float[2]	I15 current magnitude (amperes primary) and phase (degrees)
1044, 1046	I16	float[2]	I16 current magnitude (amperes primary) and phase (degrees)
1048, 104A	I17	float[2]	I17 current magnitude (amperes primary) and phase (degrees)
104C, 104E	I18	float[2]	I18 current magnitude (amperes primary) and phase (degrees)
1050, 1052	I19	float[2]	I19 current magnitude (amperes primary) and phase (degrees)
1054, 1056	I20	float[2]	I20 current magnitude (amperes primary) and phase (degrees)
1058, 105A	I21	float[2]	I21 current magnitude (amperes primary) and phase (degrees)
105C	RSRVD1	float[6]	Reserved for 3 future currents; always report as 0
1068, 106A	V01	float[2]	V01 voltage magnitude (Volts primary) and phase (degrees)
106C, 106E	V02	float[2]	V02 voltage magnitude (Volts primary) and phase (degrees)
1070, 1072	V03	float[2]	V03 voltage magnitude (Volts primary) and phase (degrees)
1074	RSRVD2	float[6]	Reserved for 3 future voltages; always report as 0
1080	IOP1	float	Zone 1 Operating Current (per unit)
1082	IOP2	float	Zone 2 Operating Current (per unit)
1084	IOP3	float	Zone 3 Operating Current (per unit)
1086	IOP4	float	Zone 4 Operating Current (per unit)
1088	IOP5	float	Zone 5 Operating Current (per unit)
108A	IOP6	float	Zone 6 Operating Current (per unit)
108C	IRT1	float	Zone 1 Restraint Current (per unit)
108E	IRT2	float	Zone 2 Restraint Current (per unit)
1090	IRT3	float	Zone 3 Restraint Current (per unit)
1092	IRT4	float	Zone 4 Restraint Current (per unit)
1094	IRT5	float	Zone 5 Restraint Current (per unit)
1096	IRT6	float	Zone 6 Restraint Current (per unit)
1098	IOPCZ1	float	Check Zone 1 Operating Current (per unit)
109A	IRTCZ1	float	Check Zone 1 Restraint Current (per unit)
109C	IOPCZ2	float	Check Zone 2 Operating Current (per unit)
109E	IRTCZ2	float	Check Zone 2 Restraint Current (per unit)

Table 10.3 SEL-487B Database Structure—METER Region (Sheet 3 of 3)

Address (Hex)	Name	Type	Description
10A0	IOPCZ3	float	Check Zone 3 Operating Current (per unit)
10A2	IRTCZ3	float	Check Zone 3 Restraint Current (per unit)

The TARGET region contains the entire visible Relay Word plus the rows designated specifically for the TARGET region. This region is updated every 0.5 seconds. See *Table 10.4* for the map. See *Section 11: Relay Word Bits* for detailed information on the Relay Word bits.

Table 10.4 SEL-487B Database Structure—TARGET Region

Address (Hex)	Name	Type	Description
3000	_YEAR	int	4-digit year when data were sampled
3001	DAY_OF_YEAR	int	1–366 day when data were sampled
3002	TIME(ms)	long int	Time of day in ms when data were sampled (0–86,400,000)
3004	TARGET	char[~499]	Entire Relay Word with bit labels

The HISTORY region contains all information available in a History report for the most recent 10 events. This region is updated within 15 seconds of any new events. See *Table 10.5* for the map.

Table 10.5 SEL-487B Database Structure—HISTORY Region

Address (Hex)	Name	Type	Description
4000	_YEAR	int	4-digit year when data were sampled
4001	DAY_OF_YEAR	int	1–366 day when data were sampled
4002	TIME(ms)	long int	Time of day in ms when data were sampled (0–86,400,000)
4004	REF_NUM	int[10]	Event serial number (10000–42767)
400E	MONTH	int[10]	Month of event
4018	DAY	int[10]	Day of event
4022	YEAR	int[10]	Year of event
402C	HOUR	int[10]	Hour of event
4036	MIN	int[10]	Minute of event
4040	SEC	int[10]	Second of event
404A	MSEC	int[10]	Milliseconds of event
4054	EVENT	char[100]	Event type string
40B8	GROUP	int[10]	Active group during fault
40C2	TARGETS	char[1000]	System targets from event (100 characters per event)

The STATUS region contains complete relay status information. This region is updated every 5 seconds. See *Table 10.6* for the map.

Table 10.6 SEL-487B Database Structure—STATUS Region

Address (Hex)	Name	Type	Description
6000	_YEAR	int	4-digit year when data were sampled
6001	DAY_OF_YEAR	int	1–366 day when data were sampled
6002	TIME(ms)	long int	Time of day in ms when data were sampled (0–86,400,000)
6004	CH1_24(mV)	int[24]	Channel offsets, use 0 if not measured
601C	MOF(mV)	int	Master offset
601D	MOF2(mV)	int	Master offset 2
601E	OFF_WARN	char[8]	Offset warning string
6026	OFF_FAIL	char[8]	Offset failure string
602E	PS3(V)	float	3.3 Volt power supply voltage
6030	PS5(V)	float	5 Volt power supply voltage
6032	PS_N5(V)	float	–5 Volt regulated voltage
6034	PS15(V)	float	15 Volt power supply voltage
6036	PS_N15(V)	float	–15 Volt power supply voltage
6038	PS_WARN	char[8]	Power supply warning string
6040	PS_FAIL	char[8]	Power supply failure string
6048	HW_FAIL	char[40]	Hardware failure strings
6070	CC_STA	char[40]	Comm. card status strings
6098	PORT_STA	char[160]	Serial port status strings
6138	TIME_SRC	char[10]	Time source
6142	LOG_ERR	char[40]	SELOGIC error strings
616A	TEST_MD	char[160]	Test mode string
620A	WARN	char[32]	Warning strings for any active warnings
622A	FAIL	char[64]	Failure strings for any active failures

The ANALOGS region contains protection and automation variables. This region is updated every 0.5 seconds. See *Table 10.7* for the map.

Table 10.7 SEL-487B Database Structure—ANALOGS Region

Address (Hex)	Name	Type	Description
7000	_YEAR	int	4-digit year when data were sampled
7001	DAY_OF_YEAR	int	1–366 day when data were sampled
7002	TIME(ms)	long int	Time of day in ms when data were sampled (0–86,400,000)
7004	PMV01_64	float[64]	PMV01–PMV64
7084	AMV001_256	float[256]	AMV001–AMV256

The database is virtual device 1 in the relay. You can display the contents of a region using the **MAP 1:region** command (where region is one of the database region names listed in *Table 10.1*). An example of the **MAP** command is shown in *Figure 10.1*.

```
=>>MAP 1:METER <Enter>

Virtual Device 1, Data Region METER Map

Data Item    Starting Address   Type

_YEAR        1000h              int
DAY_OF_YEAR  1001h              int
TIME(ms)     1002h              int[2]
FREQ         1004h              float
VDC          1006h              float
I01          1008h              float[2]
I02          100ch              float[2]
I03          1010h              float[2]
I04          1014h              float[2]
I05          1018h              float[2]
I06          101ch              float[2]
I07          1020h              float[2]
I08          1024h              float[2]
I09          1028h              float[2]
I10          102ch              float[2]
I11          1030h              float[2]
I12          1034h              float[2]
I13          1038h              float[2]
I14          103ch              float[2]
I15          1040h              float[2]
I16          1044h              float[2]
I17          1048h              float[2]
I18          104ch              float[2]
I19          1050h              float[2]
I20          1054h              float[2]
I21          1058h              float[2]
RSRVD1       105ch              float[6]
V01          1068h              float[2]
V02          106ch              float[2]
V03          1070h              float[2]
RSRVD2       1074h              float[6]
IOP1         1080h              float
IOP2         1082h              float
IOP3         1084h              float
IOP4         1086h              float
IOP5         1088h              float
IOP6         108ah              float
IRT1         108ch              float
IRT2         108eh              float
IRT3         1090h              float
IRT4         1092h              float
IRT5         1094h              float
IRT6         1096h              float
IOPCZ1       1098h              float
IRTCZ1       109ah              float
IOPCZ2       109ch              float
IRTCZ2       109eh              float
IOPCZ3       10a0h              float
IRTCZ3       10a2h              float
```

Figure 10.1 MAP 1:METER Command Example

DNP3 Communication

DNP3 operation is described in *Section 16: DNP3 Communication* in the *SEL-400 Series Relay Instruction Manual*. This subsection describes aspects of DNP3 communications that are unique to the SEL-487B.

Reference Data Map

Table 10.8 shows the SEL-487B DNP3 reference data map. The reference data map contains all of the data available to the DNP3 protocol. You can use the default map or the custom DNP3 mapping functions of the SEL-487B to include only the points required by your application.

The entire Relay Word (*Table 11.1*) is part of the DNP3 reference map. You may include any label in the Relay Word as part of a DNP3 custom map. Note that Binary Inputs registered as SER points (SET R settings) will maintain SER-quality time stamps for DNP3 events.

The SEL-487B scales analog values by the indicated settings or fixed scaling. Analog inputs for event (fault) summary reporting use a default scale factor of 1 and deadband of ANADBM. Per-point scaling and deadband settings specified in a custom DNP3 map will override defaults.

Table 10.8 SEL-487B DNP3 Reference Data Map (Sheet 1 of 3)

Object	Label	Description
Binary Inputs		
01, 02	RLYDIS	Relay disabled
01, 02	STFAIL	Relay diagnostic failure
01, 02	STWARN	Relay diagnostic warning
01, 02	STSET	Settings change or relay restart
01, 02	UNRDEV	New relay event available
01, 02	NUNREV	An unread event exists, newer than the event in the event summary AIs
01, 02	Relay Word	Relay Word bit label. See *Section 11: Relay Word Bits*.
Binary Outputs		
10, 12	RB01–RB96	Remote bits RB01–RB96
10, 12	RB01:RB02 RB03:RB04 RB05:RB06 • • • RB93:RB94 RB95:RB96	Remote bit pairs RB01–RB96
10, 12	OC*n*	Pulse Open Circuit Breaker *n* command, where *n* = 1–21
10, 12	OC*n*:NOOP	Open/Close pair for Circuit Breaker *n*, where *n* = 1–21 (the close portion has no action)
10, 12	RST_BAT	Reset battery monitor data
10, 12	RSTTRGT	Reset front-panel targets
10, 12	RSTDNPE	Reset (clear) DNP3 Event Summary AIs
10, 12	NXTEVE	Load next fault event into DNP3 Event Summary AIs
Binary Counters		
20, 22	ACTGRP	Active settings group
20, 22	ACN01CV–ACN32CV	Automation SELOGIC counter value 1–32
20, 22	PCN01CV–PCN32CV	Protection SELOGIC counter value 1–32
Analog Inputs		
30, 32	I*nn*FM[a]	1-cycle average phase current (magnitude), where *nn* = 01–21
30, 32	I*nn*FA[a]	1-cycle average phase current (angle), where *nn* = 01–21
30, 32	V*mm*FM[b]	1-cycle average phase voltage (magnitude), where *mm* = 01–03
30, 32	V*mm*FA[b]	1-cycle average phase voltage (angle), where *mm* = 01–03

Table 10.8 SEL-487B DNP3 Reference Data Map (Sheet 2 of 3)

Object	Label	Description
30, 32	DC1[c]	Station battery 1 dc voltage
30, 32	IOP*k*F[d]	Zone *k* one-cycle average operating current (*k* = 1–6)
30, 32	IRT*k*F[d]	Zone *k* one-cycle average restraint current (*k* = 1–6)
30, 32	IOPCZ*p*F[d]	Check Zone *p* one-cycle average operating current (*p* = 1–3)
30, 32	IRTCZ*p*F[d]	Check Zone *p* one-cycle average restraint current (*p* = 1–3)
30, 32	PMV001–PMV064[c]	Protection SELOGIC math variables
30, 32	AMV001–AMV256[c]	Automation SELOGIC math variables
30, 32	PNC01CV–PNC32CV[c]	Protection SELOGIC counter current value
30, 32	TODMS[c]	UTC time of day in milliseconds (0–86400000)
30, 32	ANC01CV–ANC32CV[c]	Automation SELOGIC counter current value
30, 32	ACTGRP[c]	Active group setting
30, 32	THR[c]	UTC time, hour (0–23)
30, 32	TMIN[c]	UTC time, minute (0–59)
30, 32	TSEC[c]	UTC time, seconds (0–59)
30, 32	TMSEC[c]	UTC time, milliseconds (0–999)
30, 32	DDOM[c]	UTC date, day of the month (1–31)
30, 32	DMON[c]	UTC date, month (1–12)
30, 32	DYEAR[c]	UTC date, year (2000–2200)
30, 32	TLODMS[c]	Local time of day in milliseconds (0–86400000)
30, 32	TLHR[c]	Local time, hour (0–23)
30, 32	TLMIN[c]	Local time, minute (0–59)
30, 32	TLSEC[c]	Local time, seconds (0–59)
30, 32	TLMSEC[c]	Local time, milliseconds (0–999)
30, 32	DLDOM[c]	Local date, day of the month (1–31)
30, 32	DLDOY[c]	Local date, day of the year (1–366)
30, 32	DLMON[c]	Local date, month (1–12)
30, 32	DLYEAR[c]	Local date, year (2000–2200)
30, 32	RA001–RA256[c]	Remote analogs from Ethernet card
30, 32	RAO01–RAO64[c]	Remote analog output
30, 32	RLYTEMP[c]	Relay internal temperature (deg. C)
30, 32	MAXGRP[c]	Maximum number of protection groups
30, 32	I850MOD[c]	IEC 61850 Mode/Behavior status
Event Summary Analog Inputs		
30, 32[e]	FTYPE[c, e]	Fault type
30, 32[e]	FTAR1[c, e]	Fault targets (upper byte is 1st target row, lower byte is 2nd target row)
30, 32[e]	FTAR2[c, e]	Fault targets (upper byte is 3rd target row, lower byte is 0)
30, 32[e]	FGRP[c, e]	Fault settings group
30, 32[e]	FTIMEUH, FTIMEUM, FTIMEUL[c, e]	Fault time (UTC) in DNP3 format—high, middle, and low 16 bits
30, 32[e]	FTIMEH, FTIMEM, FTIMEL[c, e]	Fault time (local) in DNP3 format—high, middle, and low 16 bits
30, 32[e]	FUNR[c, e]	Number of unread fault summaries

Table 10.8 SEL-487B DNP3 Reference Data Map (Sheet 3 of 3)

Object	Label	Description
Analog Outputs		
40, 41	ACTGRP	Active settings group
40, 41	RA001–RA256	Remote Analogs

[a] Default current scaling DECPLA on magnitudes and scale factor of 100 on angles. Dead band ANADBA on magnitudes and ANADBM on angles.
[b] Default voltage scaling DECPLV on magnitudes and scale factor of 100 on angles. Dead band ANADBV on magnitudes and ANADBM on angles.
[c] Default scale factor of 1 and dead band ANADBM.
[d] Default miscellaneous scaling DECPLM and dead band ANADBM.
[e] Event data shall be generated for all Event Summary Analog Inputs if any of them change beyond their dead band after scaling.

Binary Outputs

Use the Trip and Close, Latch On/Off, and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table 10.9*. Pulse operations provide a pulse with duration of one protection processing interval. Cancel an operation in progress by issuing a NUL Trip/Close Code with a NUL Operation Type.

Table 10.9 SEL-487B Object 12 Control Operations

Label	Close/Any	Trip/Any	NUL/Latch On	NUL/Latch Off	NUL/Pulse On	NUL/Pulse Off
RB01–RB96	Pulse on Remote Bit RB01–RB96	Pulse on Remote Bit RB01–RB96	Set Remote Bit RB01–RB96	Clear Remote Bit RB01–RB96	Pulse on Remote Bit RB01–RB96	Clear Remote Bit RB01–RB96
RB*xx*: RB*yy*	Pulse on RB*yy* RB01–RB96	Pulse on RB*xx* RB01–RB96	Pulse RB*yy*	Pulse RB*xx*	Pulse RB*yy*	Pulse RB*xx*
OC*x*	Open Circuit Breaker *x* (Pulse on OC*x*) *x* = 01–21	Open Circuit Breaker *x* (Pulse on OC*x*) *x* = 01–21	Set OC*x* *x* = 01–21	Clear OC*x* *x* = 01–21	Open Circuit Breaker *x* (Pulse on OC*x*) *x* = 01–21	Clear OC*x* *x* = 01–21
OC*x*: NOOP	No action	Open Circuit Breaker *x* (Pulse on OCx) *x* = 1–21	No action	Pulse On OC*x*	No action	Pulse OC*x*
RST_BAT	Reset battery monitoring	Reset breaker monitoring	Reset battery monitoring	No action	Reset battery monitoring	No action
RSTTRGT	Reset front-panel targets	Reset front-panel targets	Reset front-panel targets	No action	Reset front-panel targets	No action
RSTDNPE	Reset DNP3 event summary	Reset DNP3 event summary	Reset DNP3 event summary	No action	Reset DNP3 event summary	No action
NXTEVE	Load oldest unread relay event summary (FIFO)	Load oldest unread relay event summary (FIFO)	Load oldest unread relay event summary (FIFO)	Load newest relay event (LIFO)	Load oldest unread relay event summary (FIFO)	Load newest event summary (LIFO)

Relay Fault Summary Data

When a relay event occurs (TRIP asserts, ER asserts, or TRI asserts), whose fault location is in the range of MINDIST to MAXDIST, the data shall be made available to DNP. If MINDIST is set to OFF, then there is no minimum. Similarly, if MAXDIST is set to OFF, there is no maximum.

In either mode, DNP3 events for all event summary analog inputs (see *Table 10.8*) will be generated if any of them change beyond their dead-band value after scaling (usually whenever a new relay event occurs and is loaded into the event summary analog inputs). Events are detected approximately twice a second by the scanning process.

See *Table 10.10* for the components of the FTYPE analog input point. The bit asserted in the upper byte indicates the event cause (Trigger, Trip, ER element, etc.). The lower byte of FTYPE is always 0. If no bits are asserted in the upper byte, there is no valid fault summary loaded.

Table 10.10 Object 30, 32, FTYPE Upper Byte-Event Cause

Bit Position								Value	Event Cause
7	6	5	4	3	2	1	0		
								0	No fault summary loaded
							X	1	Trigger command
					X			4	Trip element
				X				8	Event report element
			X					16	Breaker failure trip
		X						32	Differential trip

Default Data Map

Table 10.11 shows the SEL-487B default DNP3 data map. The default data map is an automatically generated subset of the reference map. All data maps are initialized to the default values. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET D *n*** and **SHOW D *n***, where *n* is the map number, to edit or create the map required for your application.

Table 10.11 SEL-487B DNP3 Default Data Map (Sheet 1 of 4)

Object	Index	Label	Description
Binary Inputs			
01, 02	0	RLYDIS	Relay disabled
01, 02	1	TRIPLED	Trip LED
01, 02	2	STFAIL	Relay diagnostic failure
01, 02	3	STWARN	Relay diagnostic warning
01, 02	4	STSET	Settings have changed or relay restarted
01, 02	5	SALARM	Software alarm
01, 02	6	HALARM	Hardware alarm
01, 02	7	BADPASS	Invalid password attempt alarm
01, 02	8	UNRDEV	Unread fault summary available
01, 02	9	OPH01	Terminal 1 open-phase detector
01, 02	10	OPH02	Terminal 2 open-phase detector
01, 02	11	OPH03	Terminal 3 open-phase detector
01, 02	12	OPH04	Terminal 4 open-phase detector
01, 02	13	OPH05	Terminal 5 open-phase detector
01, 02	14	OPH06	Terminal 6 open-phase detector
01, 02	15	52A01	Circuit Breaker 1 open status
01, 02	16	52AL01	Circuit Breaker 1 alarm
01, 02	17	52A02	Circuit Breaker 2 open status
01, 02	18	52AL02	Circuit Breaker 2 alarm
01, 02	19	52A03	Circuit Breaker 3 open status

Table 10.11 SEL-487B DNP3 Default Data Map (Sheet 2 of 4)

Object	Index	Label	Description
01, 02	20	52AL03	Circuit Breaker 3 alarm
01, 02	21	52A04	Circuit Breaker 4 open status
01, 02	22	52AL04	Circuit Breaker 4 alarm
01, 02	23	89A01	Disconnect 1 closed status
01, 02	24	89AL01	Disconnect 1 alarm
01, 02	25	89A02	Disconnect 2 closed status
01, 02	26	89AL02	Disconnect 2 alarm
01, 02	27	89A03	Disconnect 3 closed status
01, 02	28	89AL03	Disconnect 3 alarm
01, 02	29	89A04	Disconnect 4 closed status
01, 02	30	89AL04	Disconnect 4 alarm
01, 02	31	89A05	Disconnect 5 closed status
01, 02	32	89AL05	Disconnect 5 alarm
01, 02	33	89A06	Disconnect 6 closed status
01, 02	34	89AL06	Disconnect 6 alarm
01, 02	35	89A07	Disconnect 7 closed status
01, 02	36	89AL07	Disconnect 7 alarm
01, 02	37	89A08	Disconnect 8 closed status
01, 02	38	89AL08	Disconnect 8 alarm
01, 02	39	TLED_1	Target LED 1 on relay front panel
01, 02	40	TLED_2	Target LED 2 on relay front panel
01, 02	41	TLED_3	Target LED 3 on relay front panel
01, 02	42	TLED_4	Target LED 4 on relay front panel
01, 02	43	TLED_5	Target LED 5 on relay front panel
01, 02	44	TLED_6	Target LED 6 on relay front panel
01, 02	45	TLED_7	Target LED 7 on relay front panel
01, 02	46	TLED_8	Target LED 8 on relay front panel
01, 02	47	TLED_9	Target LED 9 on relay front panel
01, 02	48	TLED_10	Target LED 10 on relay front panel
01, 02	49	TLED_11	Target LED 11 on relay front panel
01, 02	50	TLED_12	Target LED 12 on relay front panel
01, 02	51	TLED_13	Target LED 13 on relay front panel
01, 02	52	TLED_14	Target LED 14 on relay front panel
01, 02	53	TLED_15	Target LED 15 on relay front panel
01, 02	54	TLED_16	Target LED 16 on relay front panel
01, 02	55	IN101	Main Board Input 1
01, 02	56	IN102	Main Board Input 2
01, 02	57	IN103	Main Board Input 3
01, 02	58	IN104	Main Board Input 4
01, 02	59	IN105	Main Board Input 5
01, 02	60	IN106	Main Board Input 6

Table 10.11 SEL-487B DNP3 Default Data Map (Sheet 3 of 4)

Object	Index	Label	Description
01, 02	61	IN107	Main Board Input 7
01, 02	62	PSV01	Protection SELOGIC Variable 1
01, 02	63	PSV02	Protection SELOGIC Variable 2
01, 02	64	PSV03	Protection SELOGIC Variable 3
01, 02	65	PSV04	Protection SELOGIC Variable 4
01, 02	66	PSV05	Protection SELOGIC Variable 5
01, 02	67	PSV06	Protection SELOGIC Variable 6
01, 02	68	PSV07	Protection SELOGIC Variable 7
01, 02	69	PSV08	Protection SELOGIC Variable 8
01, 02	70	ASV001	Automation SELOGIC Variable 1
01, 02	71	ASV002	Automation SELOGIC Variable 2
01, 02	72	ASV003	Automation SELOGIC Variable 3
01, 02	73	ASV004	Automation SELOGIC Variable 4
01, 02	74	ASV005	Automation SELOGIC Variable 5
01, 02	75	ASV006	Automation SELOGIC Variable 6
01, 02	76	ASV007	Automation SELOGIC Variable 7
01, 02	77	ASV008	Automation SELOGIC Variable 8
01, 02	78	OUT101	Main Board Output 1
01, 02	79	OUT102	Main Board Output 2
01, 02	80	OUT103	Main Board Output 3
01, 02	81	OUT104	Main Board Output 4
01, 02	82	OUT105	Main Board Output 5
01, 02	83	OUT106	Main Board Output 6
01, 02	84	OUT107	Main Board Output 7
Binary Outputs			
10, 12	0–31	RB01–RB32	Remote bits RB01–RB32
10, 12	32	OC01	Pulse Open Circuit Breaker 1 command
10, 12	33	OC02	Pulse Open Circuit Breaker 2 command
10, 12	34	OC03	Pulse Open Circuit Breaker 3 command
10, 12	35	OC04	Pulse Open Circuit Breaker 4 command
10, 12	36	RST_BAT	Reset battery monitor data
10, 12	37	RSTTRGT	Reset front-panel targets
10, 12	38	RSTDNPE	Reset (clear) DNP3 Event Summary AIs
Binary Counters			
20, 22	0	ACTGRP	Active settings group
Analog Inputs			
30, 32	0	I01FM	1-cycle average Terminal 1 current (magnitude)
30, 32	1	I01FA	1-cycle average Terminal 1 current (angle)
30, 32	2	I02FM	1-cycle average Terminal 2 current (magnitude)
30, 32	3	I02FA	1-cycle average Terminal 2 current (angle)
30, 32	4	I03FM	1-cycle average Terminal 3 current (magnitude)

Table 10.11 SEL-487B DNP3 Default Data Map (Sheet 4 of 4)

Object	Index	Label	Description
30, 32	5	I03FA	1-cycle average Terminal 3 current (angle)
30, 32	6	I04FM	1-cycle average Terminal 4 current (magnitude)
30, 32	7	I04FA	1-cycle average Terminal 4 current (angle)
30, 32	8	I05FM	1-cycle average Terminal 5 current (magnitude)
30, 32	9	I05FA	1-cycle average Terminal 5 current (angle)
30, 32	10	I06FM	1-cycle average Terminal 6 current (magnitude)
30, 32	11	I06FA	1-cycle average Terminal 6 current (angle)
30, 32	12	V01FM	1-cycle average Terminal 1 voltage (magnitude)
30, 32	13	V01FA	1-cycle average Terminal 1 voltage (angle)
30, 32	14	V02FM	1-cycle average Terminal 2 voltage (magnitude)
30, 32	15	V02FA	1-cycle average Terminal 2 voltage (angle)
30, 32	16	V03FM	1-cycle average Terminal 3 voltage (magnitude)
30, 32	17	V03FA	1-cycle average Terminal 3 voltage (angle)
30, 32	18	FTYPE	Fault type
30, 32	19	FTAR1	Fault targets (Upper byte is 1st target row, lower byte is 2nd target row)
30, 32	20	FTAR2	Fault targets (Upper byte is 3rd target row, lower byte is 0)
30, 32	21	FGRP	Fault settings group
30, 32	22	FTIMEUH	Fault time (UTC) in DNP3 format (high 16 bits)
30, 32	23	FTIMEUM	Fault time (UTC) in DNP3 format (middle 16 bits)
30, 32	24	FTIMEUL	Fault time (UTC) in DNP3 format (low 16 bits)
30, 32	25	FUNR	Number of unread fault summaries
30, 32	26	RLYTEMP	Internal box temperature in degrees Celsius
Analog Outputs			
40, 41	0	ACTGRP	Active settings group

IEC 61850 Communication

General IEC 61850 operation is described in *Section 17: IEC 61850 Communication in the SEL-400 Series Relays Instruction Manual*. This section describes characteristics of IEC 61850 that are specific to the SEL-487B.

Logical Nodes

NOTE: With the introduction of the Flexible Server Model (FSM) in Architect for ICD files ClassFileVersion 010 or later, use FSM as the primary reference to view and edit the mapping between IEC 61850 data attributes and relay variables. The LN tables provided in this section serve as general guidelines.

Table 10.12 and *Table 10.13* show the logical nodes (LNs) supported in the SEL-487B and the Relay Word bits or Measured Values mapped to those LNs. Additionally, the relay supports the CFG Logical Device logical nodes as described in *Section 17: IEC 61850 Communication in the SEL-400 Series Relays Instruction Manual*.

Table 10.12 shows the LNs associated with protection elements, defined as Logical Device PRO.

Table 10.12 Logical Device: PRO (Protection) (Sheet 1 of 11)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BKR01CSWI1	Pos.Oper.ctlVal	OC01:NOOP[a]	Circuit Breaker 1 open command
BKR02CSWI1	Pos.Oper.ctlVal	OC02:NOOP[a]	Circuit Breaker 2 open command
BKR03CSWI1	Pos.Oper.ctlVal	OC03:NOOP[a]	Circuit Breaker 3 open command
BKR04CSWI1	Pos.Oper.ctlVal	OC04:NOOP[a]	Circuit Breaker 4 open command
BKR05CSWI1	Pos.Oper.ctlVal	OC05:NOOP[a]	Circuit Breaker 5 open command
BKR06CSWI1	Pos.Oper.ctlVal	OC06:NOOP[a]	Circuit Breaker 6 open command
BKR07CSWI1	Pos.Oper.ctlVal	OC07:NOOP[a]	Circuit Breaker 7 open command
BKR08CSWI1	Pos.Oper.ctlVal	OC08:NOOP[a]	Circuit Breaker 8 open command
BKR09CSWI1	Pos.Oper.ctlVal	OC09:NOOP[a]	Circuit Breaker 9 open command
BKR10CSWI1	Pos.Oper.ctlVal	OC10:NOOP[a]	Circuit Breaker 10 open command
BKR11CSWI1	Pos.Oper.ctlVal	OC11:NOOP[a]	Circuit Breaker 11 open command
BKR12CSWI1	Pos.Oper.ctlVal	OC12:NOOP[a]	Circuit Breaker 12 open command
BKR13CSWI1	Pos.Oper.ctlVal	OC13:NOOP[a]	Circuit Breaker 13 open command
BKR14CSWI1	Pos.Oper.ctlVal	OC14:NOOP[a]	Circuit Breaker 14 open command
BKR15CSWI1	Pos.Oper.ctlVal	OC15:NOOP[a]	Circuit Breaker 15 open command
BKR16CSWI1	Pos.Oper.ctlVal	OC16:NOOP[a]	Circuit Breaker 16 open command
BKR17CSWI1	Pos.Oper.ctlVal	OC17:NOOP[a]	Circuit Breaker 17 open command
BKR18CSWI1	Pos.Oper.ctlVal	OC18:NOOP[a]	Circuit Breaker 18 open command
BKR19CSWI1	Pos.Oper.ctlVal	OC19:NOOP[a]	Circuit Breaker 19 open command
BKR20CSWI1	Pos.Oper.ctlVal	OC20:NOOP[a]	Circuit Breaker 20 open command
BKR21CSWI1	Pos.Oper.ctlVal	OC21:NOOP[a]	Circuit Breaker 21 open command
Functional Constraint = ST			
LLN0	LocKey.stVal	NOOP	Physical key indication for switching LD in local mode
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LLN0	Mod.stVal	I60MOD[b]	IEC 61850 mode/behavior status
BFR01RBRF1	Str.general	BFI01	Circuit Breaker 1 breaker failure initiate SELOGIC control equation
BFR01RBRF1	OpEx.general	FBF01	Circuit Breaker 1 failure
BFR01RBRF1	OpIn.general	RT01	Circuit Breaker 1 retrip
BFR02RBRF1	Str.general	BFI02	Circuit Breaker 2 breaker failure initiate SELOGIC control equation
BFR02RBRF1	OpEx.general	FBF02	Circuit Breaker 2 failure
BFR02RBRF1	OpIn.general	RT02	Circuit Breaker 2 retrip
BFR03RBRF1	Str.general	BFI03	Circuit Breaker 3 breaker failure initiate SELOGIC control equation
BFR03RBRF1	OpEx.general	FBF03	Circuit Breaker 3 failure
BFR03RBRF1	OpIn.general	RT03	Circuit Breaker 3 retrip
BFR04RBRF1	Str.general	BFI04	Circuit Breaker 4 breaker failure initiate SELOGIC control equation
BFR04RBRF1	OpEx.general	FBF04	Circuit Breaker 4 failure
BFR04RBRF1	OpIn.general	RT04	Circuit Breaker 4 retrip
BFR05RBRF1	Str.general	BFI05	Circuit Breaker 5 breaker failure initiate SELOGIC control equation

Table 10.12 Logical Device: PRO (Protection) (Sheet 2 of 11)

Logical Node	Attribute	Data Source	Comment
BFR05RBRF1	OpEx.general	FBF05	Circuit Breaker 5 failure
BFR05RBRF1	OpIn.general	RT05	Circuit Breaker 5 retrip
BFR06RBRF1	Str.general	BFI06	Circuit Breaker 6 breaker failure initiate SELOGIC control equation
BFR06RBRF1	OpEx.general	FBF06	Circuit Breaker 6 failure
BFR06RBRF1	OpIn.general	RT06	Circuit Breaker 6 retrip
BFR07RBRF1	Str.general	BFI07	Circuit Breaker 7 breaker failure initiate SELOGIC control equation
BFR07RBRF1	OpEx.general	FBF07	Circuit Breaker 7 failure
BFR07RBRF1	OpIn.general	RT07	Circuit Breaker 7 retrip
BFR08RBRF1	Str.general	BFI08	Circuit Breaker 8 breaker failure initiate SELOGIC control equation
BFR08RBRF1	OpEx.general	FBF08	Circuit Breaker 8 failure
BFR08RBRF1	OpIn.general	RT08	Circuit Breaker 8 retrip
BFR09RBRF1	Str.general	BFI09	Circuit Breaker 9 breaker failure initiate SELOGIC control equation
BFR09RBRF1	OpEx.general	FBF09	Circuit Breaker 9 failure
BFR09RBRF1	OpIn.general	RT09	Circuit Breaker 9 retrip
BFR10RBRF1	Str.general	BFI10	Circuit Breaker 10 breaker failure initiate SELOGIC control equation
BFR10RBRF1	OpEx.general	FBF10	Circuit Breaker 10 failure
BFR10RBRF1	OpIn.general	RT10	Circuit Breaker 10 retrip
BFR11RBRF1	Str.general	BFI11	Circuit Breaker 11 breaker failure initiate SELOGIC control equation
BFR11RBRF1	OpEx.general	FBF11	Circuit Breaker 11 failure
BFR11RBRF1	OpIn.general	RT11	Circuit Breaker 11 retrip
BFR12RBRF1	Str.general	BFI12	Circuit Breaker 12 breaker failure initiate SELOGIC control equation
BFR12RBRF1	OpEx.general	FBF12	Circuit Breaker 12 failure
BFR12RBRF1	OpIn.general	RT12	Circuit Breaker 12 retrip
BFR13RBRF1	Str.general	BFI13	Circuit Breaker 13 breaker failure initiate SELOGIC control equation
BFR13RBRF1	OpEx.general	FBF13	Circuit Breaker 13 failure
BFR13RBRF1	OpIn.general	RT13	Circuit Breaker 13 retrip
BFR14RBRF1	Str.general	BFI14	Circuit Breaker 14 breaker failure initiate SELOGIC control equation
BFR14RBRF1	OpEx.general	FBF14	Circuit Breaker 14 failure
BFR14RBRF1	OpIn.general	RT14	Circuit Breaker 14 retrip
BFR15RBRF1	Str.general	BFI15	Circuit Breaker 15 breaker failure initiate SELOGIC control equation
BFR15RBRF1	OpEx.general	FBF15	Circuit Breaker 15 failure
BFR15RBRF1	OpIn.general	RT15	Circuit Breaker 15 retrip
BFR16RBRF1	Str.general	BFI16	Circuit Breaker 16 breaker failure initiate SELOGIC control equation
BFR16RBRF1	OpEx.general	FBF16	Circuit Breaker 16 failure
BFR16RBRF1	OpIn.general	RT16	Circuit Breaker 16 retrip
BFR17RBRF1	Str.general	BFI17	Circuit Breaker 17 breaker failure initiate SELOGIC control equation
BFR17RBRF1	OpEx.general	FBF17	Circuit Breaker 17 failure
BFR17RBRF1	OpIn.general	RT17	Circuit Breaker 17 retrip
BFR18RBRF1	Str.general	BFI18	Circuit Breaker 18 breaker failure initiate SELOGIC control equation
BFR18RBRF1	OpEx.general	FBF18	Circuit Breaker 18 failure
BFR18RBRF1	OpIn.general	RT18	Circuit Breaker 18 retrip

Table 10.12 Logical Device: PRO (Protection) (Sheet 3 of 11)

Logical Node	Attribute	Data Source	Comment
BFR19RBRF1	Str.general	BFI19	Circuit Breaker 19 breaker failure initiate SELOGIC control equation
BFR19RBRF1	OpEx.general	FBF19	Circuit Breaker 19 failure
BFR19RBRF1	OpIn.general	RT19	Circuit Breaker 19 retrip
BFR20RBRF1	Str.general	BFI20	Circuit Breaker 20 breaker failure initiate SELOGIC control equation
BFR20RBRF1	OpEx.general	FBF20	Circuit Breaker 20 failure
BFR20RBRF1	OpIn.general	RT20	Circuit Breaker 20 retrip
BFR21RBRF1	Str.general	BFI21	Circuit Breaker 21 breaker failure initiate SELOGIC control equation
BFR21RBRF1	OpEx.general	FBF21	Circuit Breaker 21 failure
BFR21RBRF1	OpIn.general	RT21	Circuit Breaker 21 retrip
BKR01CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR01CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR01CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR01CSWI1	OpOpn.general	OC01	Circuit Breaker 1 open command
BKR01CSWI1	Pos.stVal	52CL01?1:2[c]	Circuit Breaker 1 closed
BKR02CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR02CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR02CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR02CSWI1	OpOpn.general	OC02	Circuit Breaker 2 open command
BKR02CSWI1	Pos.stVal	52CL02?1:2[c]	Circuit Breaker 2 closed
BKR03CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR03CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR03CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR03CSWI1	OpOpn.general	OC03	Circuit Breaker 3 open command
BKR03CSWI1	Pos.stVal	52CL03?1:2[c]	Circuit Breaker 3 closed
BKR04CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR04CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR04CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR04CSWI1	OpOpn.general	OC04	Circuit Breaker 4 open command
BKR04CSWI1	Pos.stVal	52CL04?1:2[c]	Circuit Breaker 4 closed
BKR05CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR05CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR05CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR05CSWI1	OpOpn.general	OC05	Circuit Breaker 5 open command
BKR05CSWI1	Pos.stVal	52CL05?1:2[c]	Circuit Breaker 5 closed
BKR06CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR06CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR06CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR06CSWI1	OpOpn.general	OC06	Circuit Breaker 6 open command
BKR06CSWI1	Pos.stVal	52CL06?1:2[c]	Circuit Breaker 6 closed
BKR07CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR07CSWI1	Loc.stVal	LOC	Control authority at local (bay) level

Table 10.12 Logical Device: PRO (Protection) (Sheet 4 of 11)

Logical Node	Attribute	Data Source	Comment
BKR07CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR07CSWI1	OpOpn.general	OC07	Circuit Breaker 7 open command
BKR07CSWI1	Pos.stVal	52CL07?1:2[c]	Circuit Breaker 7 closed
BKR08CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR08CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR08CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR08CSWI1	OpOpn.general	OC08	Circuit Breaker 8 open command
BKR08CSWI1	Pos.stVal	52CL08?1:2[c]	Circuit Breaker 8 closed
BKR09CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR09CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR09CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR09CSWI1	OpOpn.general	OC09	Circuit Breaker 9 open command
BKR09CSWI1	Pos.stVal	52CL09?1:2[c]	Circuit Breaker 9 closed
BKR10CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR10CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR10CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR10CSWI1	OpOpn.general	OC10	Circuit Breaker 10 open command
BKR10CSWI1	Pos.stVal	52CL10?1:2[c]	Circuit Breaker 10 closed
BKR11CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR11CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR11CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR11CSWI1	OpOpn.general	OC11	Circuit Breaker 11 open command
BKR11CSWI1	Pos.stVal	52CL11?1:2[c]	Circuit Breaker 11 closed
BKR12CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR12CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR12CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR12CSWI1	OpOpn.general	OC12	Circuit Breaker 12 open command
BKR12CSWI1	Pos.stVal	52CL12?1:2[c]	Circuit Breaker 12 closed
BKR13CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR13CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR13CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR13CSWI1	OpOpn.general	OC13	Circuit Breaker 13 open command
BKR13CSWI1	Pos.stVal	52CL13?1:2[c]	Circuit Breaker 13 closed
BKR14CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR14CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR14CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR14CSWI1	OpOpn.general	OC14	Circuit Breaker 14 open command
BKR14CSWI1	Pos.stVal	52CL14?1:2[c]	Circuit Breaker 14 closed
BKR15CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR15CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR15CSWI1	LocSta.stVal	LOCSTA	Control authority at station level

Table 10.12 Logical Device: PRO (Protection) (Sheet 5 of 11)

Logical Node	Attribute	Data Source	Comment
BKR15CSWI1	OpOpn.general	OC15	Circuit Breaker 15 open command
BKR15CSWI1	Pos.stVal	52CL15?1:2[c]	Circuit Breaker 15 closed
BKR16CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR16CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR16CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR16CSWI1	OpOpn.general	OC16	Circuit Breaker 16 open command
BKR16CSWI1	Pos.stVal	52CL16?1:2[c]	Circuit Breaker 16 closed
BKR17CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR17CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR17CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR17CSWI1	OpOpn.general	OC17	Circuit Breaker 17 open command
BKR17CSWI1	Pos.stVal	52CL17?1:2[c]	Circuit Breaker 17 closed
BKR18CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR18CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR18CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR18CSWI1	OpOpn.general	OC18	Circuit Breaker 18 open command
BKR18CSWI1	Pos.stVal	52CL18?1:2[c]	Circuit Breaker 18 closed
BKR19CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR19CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR19CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR19CSWI1	OpOpn.general	OC19	Circuit Breaker 19 open command
BKR19CSWI1	Pos.stVal	52CL19?1:2[c]	Circuit Breaker 19 closed
BKR20CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR20CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR20CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR20CSWI1	OpOpn.general	OC20	Circuit Breaker 20 open command
BKR20CSWI1	Pos.stVal	52CL20?1:2[c]	Circuit Breaker 20 closed
BKR21CSWI1	LocKey.stVal	NOOP	Physical key indication for switching LN in local mode
BKR21CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BKR21CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BKR21CSWI1	OpOpn.general	OC21	Circuit Breaker 21 open command
BKR21CSWI1	Pos.stVal	52CL21?1:2[c]	Circuit Breaker 21 closed
D87R1PDIF1	Op.general	87R1	Zone 1 restraint differential element picked
D87R1PDIF1	Str.general	P87R1	Zone 1 instantaneous differential element picked
D87R2PDIF1	Op.general	87R2	Zone 2 restraint differential element picked
D87R2PDIF1	Str.general	P87R2	Zone 2 instantaneous differential element picked
D87R3PDIF1	Op.general	87R3	Zone 3 restraint differential element picked
D87R3PDIF1	Str.general	P87R3	Zone 3 instantaneous differential element picked
D87R4PDIF1	Op.general	87R4	Zone 4 restraint differential element picked
D87R4PDIF1	Str.general	P87R4	Zone 4 instantaneous differential element picked
D87R5PDIF1	Op.general	87R5	Zone 5 restraint differential element picked

Table 10.12 Logical Device: PRO (Protection) (Sheet 6 of 11)

Logical Node	Attribute	Data Source	Comment
D87R5PDIF1	Str.general	P87R5	Zone 5 instantaneous differential element picked
D87R6PDIF1	Op.general	87R6	Zone 6 restraint differential element picked
D87R6PDIF1	Str.general	P87R6	Zone 6 instantaneous differential element picked
FLTRRDRE1	FltTyp.stVal	FLTYPE[d]	Affected phases for the latest event
FLTRRDRE1	FltCaus.stVal	FLTCAUS[e]	Event cause for the latest event
FLTRRDRE1	FltNum.stVal	FLRNUM	Event number
FLTRRDRE1	RcdMade.stVal	FLREP	Event report present
PROLPHD1	PhyHealth.stVal	EN?3:1[f]	Relay enabled
T87Z01PTRC1	Tr.general	87Z1	Zone 1 differential element trip
T87Z02PTRC1	Tr.general	87Z2	Zone 2 differential element trip
T87Z03PTRC1	Tr.general	87Z3	Zone 3 differential element trip
T87Z04PTRC1	Tr.general	87Z4	Zone 4 differential element trip
T87Z05PTRC1	Tr.general	87Z5	Zone 5 differential element trip
T87Z06PTRC1	Tr.general	87Z6	Zone 6 differential element trip
TRIP01PTRC1	Tr.general	TRIP01	Terminal 1 trip output
TRIP02PTRC1	Tr.general	TRIP02	Terminal 2 trip output
TRIP03PTRC1	Tr.general	TRIP03	Terminal 3 trip output
TRIP04PTRC1	Tr.general	TRIP04	Terminal 4 trip output
TRIP05PTRC1	Tr.general	TRIP05	Terminal 5 trip output
TRIP06PTRC1	Tr.general	TRIP06	Terminal 6 trip output
TRIP07PTRC1	Tr.general	TRIP07	Terminal 7 trip output
TRIP08PTRC1	Tr.general	TRIP08	Terminal 8 trip output
TRIP09PTRC1	Tr.general	TRIP09	Terminal 9 trip output
TRIP10PTRC1	Tr.general	TRIP10	Terminal 10 trip output
TRIP11PTRC1	Tr.general	TRIP11	Terminal 11 trip output
TRIP12PTRC1	Tr.general	TRIP12	Terminal 12 trip output
TRIP13PTRC1	Tr.general	TRIP13	Terminal 13 trip output
TRIP14PTRC1	Tr.general	TRIP14	Terminal 14 trip output
TRIP15PTRC1	Tr.general	TRIP15	Terminal 15 trip output
TRIP16PTRC1	Tr.general	TRIP16	Terminal 16 trip output
TRIP17PTRC1	Tr.general	TRIP17	Terminal 17 trip output
TRIP18PTRC1	Tr.general	TRIP18	Terminal 18 trip output
TRIP19PTRC1	Tr.general	TRIP19	Terminal 19 trip output
TRIP20PTRC1	Tr.general	TRIP20	Terminal 20 trip output
TRIP21PTRC1	Tr.general	TRIP21	Terminal 21 trip output
X52A01XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A01XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A01XCBR1	Pos.stVal	52CL01?1:2[c]	Circuit Breaker 1 closed
X52A02XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A02XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A02XCBR1	Pos.stVal	52CL02?1:2[c]	Circuit Breaker 2 closed

Table 10.12 Logical Device: PRO (Protection) (Sheet 7 of 11)

Logical Node	Attribute	Data Source	Comment
X52A03XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A03XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A03XCBR1	Pos.stVal	52CL03?1:2[c]	Circuit Breaker 3 closed
X52A04XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A04XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A04XCBR1	Pos.stVal	52CL04?1:2[c]	Circuit Breaker 4 closed
X52A05XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A05XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A05XCBR1	Pos.stVal	52CL05?1:2[c]	Circuit Breaker 5 closed
X52A06XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A06XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A06XCBR1	Pos.stVal	52CL06?1:2[c]	Circuit Breaker 6 closed
X52A07XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A07XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A07XCBR1	Pos.stVal	52CL07?1:2[c]	Circuit Breaker 7 closed
X52A08XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A08XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A08XCBR1	Pos.stVal	52CL08?1:2[c]	Circuit Breaker 8 closed
X52A09XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A09XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A09XCBR1	Pos.stVal	52CL09?1:2[c]	Circuit Breaker 9 closed
X52A10XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A10XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A10XCBR1	Pos.stVal	52CL10?1:2[c]	Circuit Breaker 10 closed
X52A11XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A11XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A11XCBR1	Pos.stVal	52CL11?1:2[c]	Circuit Breaker 11 closed
X52A12XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A12XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A12XCBR1	Pos.stVal	52CL12?1:2[c]	Circuit Breaker 12 closed
X52A13XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A13XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A13XCBR1	Pos.stVal	52CL13?1:2[c]	Circuit Breaker 13 closed
X52A14XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A14XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A14XCBR1	Pos.stVal	52CL14?1:2[c]	Circuit Breaker 14 closed
X52A15XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A15XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A15XCBR1	Pos.stVal	52CL15?1:2[c]	Circuit Breaker 15 closed
X52A16XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A16XCBR1	Loc.stVal	LOC	Control authority at local (bay) level

Table 10.12 Logical Device: PRO (Protection) (Sheet 8 of 11)

Logical Node	Attribute	Data Source	Comment
X52A16XCBR1	Pos.stVal	52CL16?1:2[c]	Circuit Breaker 16 closed
X52AXCBR17	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A17XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A17XCBR1	Pos.stVal	52CL17?1:2[c]	Circuit Breaker 17 closed
X52A17XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A18XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A18XCBR1	Pos.stVal	52CL18?1:2[c]	Circuit Breaker 18 closed
X52A18XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A19XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A19XCBR1	Pos.stVal	52CL19?1:2[c]	Circuit Breaker 19 closed
X52A19XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A20XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A20XCBR1	Pos.stVal	52CL20?1:2[c]	Circuit Breaker 20 closed
X52A20XCBR1	LocKey.stVal	NOOP	Physical key indication for switchgear local mode
X52A21XCBR1	Loc.stVal	LOC	Control authority at local (bay) level
X52A21XCBR1	Pos.stVal	52CL21?1:2[c]	Circuit Breaker 21 closed
X89CL01XSWI1	Loc.stVal	LOC	IED local status
X89CL01XSWI1	Pos.stVal	89CL01?1:2[c]	Disconnect 1 closed
X89CL02XSWI1	Loc.stVal	LOC	IED local status
X89CL02XSWI1	Pos.stVal	89CL02?1:2[c]	Disconnect 2 closed
X89CL03XSWI1	Loc.stVal	LOC	IED local status
X89CL03XSWI1	Pos.stVal	89CL03?1:2[c]	Disconnect 3 closed
X89CL04XSWI1	Loc.stVal	LOC	IED local status
X89CL04XSWI1	Pos.stVal	89CL04?1:2[c]	Disconnect 4 closed
X89CL05XSWI1	Loc.stVal	LOC	IED local status
X89CL05XSWI1	Pos.stVal	89CL05?1:2[c]	Disconnect 5 closed
X89CL06XSWI1	Loc.stVal	LOC	IED local status
X89CL06XSWI1	Pos.stVal	89CL06?1:2[c]	Disconnect 6 closed
X89CL07XSWI1	Loc.stVal	LOC	IED local status
X89CL07XSWI1	Pos.stVal	89CL07?1:2[c]	Disconnect 7 closed
X89CL08XSWI1	Loc.stVal	LOC	IED local status
X89CL08XSWI1	Pos.stVal	89CL08?1:2[c]	Disconnect 8 closed
X89CL09XSWI1	Loc.stVal	LOC	IED local status
X89CL09XSWI1	Pos.stVal	89CL09?1:2[c]	Disconnect 9 closed
X89CL10XSWI1	Loc.stVal	LOC	IED local status
X89CL10XSWI1	Pos.stVal	89CL10?1:2[c]	Disconnect 10 closed
X89CL11XSWI1	Loc.stVal	LOC	IED local status
X89CL11XSWI1	Pos.stVal	89CL11?1:2[c]	Disconnect 11 closed
X89CL12XSWI1	Loc.stVal	LOC	IED local status
X89CL12XSWI1	Pos.stVal	89CL12?1:2[c]	Disconnect 12 closed
X89CL13XSWI1	Loc.stVal	LOC	IED local status

Table 10.12 Logical Device: PRO (Protection) (Sheet 9 of 11)

Logical Node	Attribute	Data Source	Comment
X89CL13XSWI1	Pos.stVal	89CL13?1:2[c]	Disconnect 13 closed
X89CL14XSWI1	Loc.stVal	LOC	IED local status
X89CL14XSWI1	Pos.stVal	89CL14?1:2[c]	Disconnect 14 closed
X89CL15XSWI1	Loc.stVal	LOC	IED local status
X89CL15XSWI1	Pos.stVal	89CL15?1:2[c]	Disconnect 15 closed
X89CL16XSWI1	Loc.stVal	LOC	IED local status
X89CL16XSWI1	Pos.stVal	89CL16?1:2[c]	Disconnect 16 closed
X89CL17XSWI1	Loc.stVal	LOC	IED local status
X89CL17XSWI1	Pos.stVal	89CL17?1:2[c]	Disconnect 17 closed
X89CL18XSWI1	Loc.stVal	LOC	IED local status
X89CL18XSWI1	Pos.stVal	89CL18?1:2[c]	Disconnect 18 closed
X89CL19XSWI1	Loc.stVal	LOC	IED local status
X89CL19XSWI1	Pos.stVal	89CL19?1:2[c]	Disconnect 19 closed
X89CL20XSWI1	Loc.stVal	LOC	IED local status
X89CL20XSWI1	Pos.stVal	89CL20?1:2[c]	Disconnect 20 closed
X89CL21XSWI1	Loc.stVal	LOC	IED local status
X89CL21XSWI1	Pos.stVal	89CL21?1:2[c]	Disconnect 21 closed
X89CL22XSWI1	Loc.stVal	LOC	IED local status
X89CL22XSWI1	Pos.stVal	89CL22?1:2[c]	Disconnect 22 closed
X89CL23XSWI1	Loc.stVal	LOC	IED local status
X89CL23XSWI1	Pos.stVal	89CL23?1:2[c]	Disconnect 23 closed
X89CL24XSWI1	Loc.stVal	LOC	IED local status
X89CL24XSWI1	Pos.stVal	89CL24?1:2[c]	Disconnect 24 closed
X89CL25XSWI1	Loc.stVal	LOC	IED local status
X89CL25XSWI1	Pos.stVal	89CL25?1:2[c]	Disconnect 25 closed
X89CL26XSWI1	Loc.stVal	LOC	IED local status
X89CL26XSWI1	Pos.stVal	89CL26?1:2[c]	Disconnect 26 closed
X89CL27XSWI1	Loc.stVal	LOC	IED local status
X89CL27XSWI1	Pos.stVal	89CL27?1:2[c]	Disconnect 27 closed
X89CL28XSWI1	Loc.stVal	LOC	IED local status
X89CL28XSWI1	Pos.stVal	89CL28?1:2[c]	Disconnect 28 closed
X89CL29XSWI1	Loc.stVal	LOC	IED local status
X89CL29XSWI1	Pos.stVal	89CL29?1:2[c]	Disconnect 29 closed
X89CL30XSWI1	Loc.stVal	LOC	IED local status
X89CL30XSWI1	Pos.stVal	89CL30?1:2[c]	Disconnect 30 closed
X89CL31XSWI1	Loc.stVal	LOC	IED local status
X89CL31XSWI1	Pos.stVal	89CL31?1:2[c]	Disconnect 31 closed
X89CL32XSWI1	Loc.stVal	LOC	IED local status
X89CL32XSWI1	Pos.stVal	89CL32?1:2[c]	Disconnect 32 closed
X89CL33XSWI1	Loc.stVal	LOC	IED local status
X89CL33XSWI1	Pos.stVal	89CL33?1:2[c]	Disconnect 33 closed

Table 10.12 Logical Device: PRO (Protection) (Sheet 10 of 11)

Logical Node	Attribute	Data Source	Comment
X89CL34XSWI1	Loc.stVal	LOC	IED local status
X89CL34XSWI1	Pos.stVal	89CL34?1:2[c]	Disconnect 34 closed
X89CL35XSWI1	Loc.stVal	LOC	IED local status
X89CL35XSWI1	Pos.stVal	89CL35?1:2[c]	Disconnect 35 closed
X89CL36XSWI1	Loc.stVal	LOC	IED local status
X89CL36XSWI1	Pos.stVal	89CL36?1:2[c]	Disconnect 36 closed
X89CL37XSWI1	Loc.stVal	LOC	IED local status
X89CL37XSWI1	Pos.stVal	89CL37?1:2[c]	Disconnect 37 closed
X89CL38XSWI1	Loc.stVal	LOC	IED local status
X89CL38XSWI1	Pos.stVal	89CL38?1:2[c]	Disconnect 38 closed
X89CL39XSWI1	Loc.stVal	LOC	IED local status
X89CL39XSWI1	Pos.stVal	89CL39?1:2[c]	Disconnect 39 closed
X89CL40XSWI1	Loc.stVal	LOC	IED local status
X89CL40XSWI1	Pos.stVal	89CL40?1:2[c]	Disconnect 40 closed
X89CL41XSWI1	Loc.stVal	LOC	IED local status
X89CL41XSWI1	Pos.stVal	89CL41?1:2[c]	Disconnect 41 closed
X89CL42XSWI1	Loc.stVal	LOC	IED local status
X89CL42XSWI1	Pos.stVal	89CL42?1:2[c]	Disconnect 42 closed
X89CL43XSWI1	Loc.stVal	LOC	IED local status
X89CL43XSWI1	Pos.stVal	89CL43?1:2[c]	Disconnect 43 closed
X89CL44XSWI1	Loc.stVal	LOC	IED local status
X89CL44XSWI1	Pos.stVal	89CL44?1:2[c]	Disconnect 44 closed
X89CL45XSWI1	Loc.stVal	LOC	IED local status
X89CL45XSWI1	Pos.stVal	89CL45?1:2[c]	Disconnect 45 closed
X89CL46XSWI1	Loc.stVal	LOC	IED local status
X89CL46XSWI1	Pos.stVal	89CL46?1:2[c]	Disconnect 46 closed
X89CL47XSWI1	Loc.stVal	LOC	IED local status
X89CL47XSWI1	Pos.stVal	89CL47?1:2[c]	Disconnect 47 closed
X89CL48XSWI1	Loc.stVal	LOC	IED local status
X89CL48XSWI1	Pos.stVal	89CL48?1:2[c]	Disconnect 48 closed
X89CL49XSWI1	Loc.stVal	LOC	IED local status
X89CL49XSWI1	Pos.stVal	89CL49?1:2[c]	Disconnect 49 closed
X89CL50XSWI1	Loc.stVal	LOC	IED local status
X89CL50XSWI1	Pos.stVal	89CL50?1:2[c]	Disconnect 50 closed
X89CL51XSWI1	Loc.stVal	LOC	IED local status
X89CL51XSWI1	Pos.stVal	89CL51?1:2[c]	Disconnect 51 closed
X89CL52XSWI1	Loc.stVal	LOC	IED local status
X89CL52XSWI1	Pos.stVal	89CL52?1:2[c]	Disconnect 52 closed
X89CL53XSWI1	Loc.stVal	LOC	IED local status
X89CL53XSWI1	Pos.stVal	89CL53?1:2[c]	Disconnect 53 closed
X89CL54XSWI1	Loc.stVal	LOC	IED local status

Table 10.12 Logical Device: PRO (Protection) (Sheet 11 of 11)

Logical Node	Attribute	Data Source	Comment
X89CL54XSWI1	Pos.stVal	89CL54?1:2[c]	Disconnect 54 closed
X89CL55XSWI1	Loc.stVal	LOC	IED local status
X89CL55XSWI1	Pos.stVal	89CL55?1:2[c]	Disconnect 55 closed
X89CL56XSWI1	Loc.stVal	LOC	IED local status
X89CL56XSWI1	Pos.stVal	89CL56?1:2[c]	Disconnect 56 closed
X89CL57XSWI1	Loc.stVal	LOC	IED local status
X89CL57XSWI1	Pos.stVal	89CL57?1:2[c]	Disconnect 57 closed
X89CL58XSWI1	Loc.stVal	LOC	IED local status
X89CL58XSWI1	Pos.stVal	89CL58?1:2[c]	Disconnect 58 closed
X89CL59XSWI1	Loc.stVal	LOC	IED local status
X89CL59XSWI1	Pos.stVal	89CL59?1:2[c]	Disconnect 59 closed
X89CL60XSWI1	Loc.stVal	LOC	IED local status
X89CL60XSWI1	Pos.stVal	89CL60?1:2[c]	Disconnect 60 closed
Functional Constraint = DC			
LLN0	NamPlt.swRev	VERFID	Relay FID string
PROLPHD1	PhyNam.hwRev	HWREV[g]	Hardware version of the relay mainboard
PROLPHD1	PhyNam.model	PARNUM	Relay part number
PROLPHD1	PhyNam.ser-Num	SERNUM	Relay serial number
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multi-level control authority

[a] Writing a value of 1 pulses the first bit. Writing a value of 0 results in no operation.
[b] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[c] If closed, value = 2. If open, value = 1.
[d] FLTYPE is an internal data source derived from the event summary and is not available to the user. Refer to Table 10.14 for more details.
[e] FLTCAUS is an internal data source derived from the event summary and is not available to the user. Refer to Table 10.15 for more details.
[f] If enabled, value = 1. If disabled, value = 3.
[g] HWREV is an internal data source and is not available to the user.

Table 10.13 shows the LNs associated with measuring elements, defined as Logical Device MET.

Table 10.13 Logical Device: MET (Metering) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment	Relay Word Bit
Functional Constraint = ST				
LLN0	LocKey.stVal	NOOP	Physical key indication for switching LD in local mode	NOOP
LLN0	Loc.stVal	LOC	Control authority at local (bay) level	LOC
LLN0	LocSta.stVal	LOCSTA	Control authority at station level	LOCSTA
LLN0	Mod.stVal	I60MOD[a]	IEC 61850 mode/behavior status	I60MOD
DC1ZBAT1	BatWrn.stVal	DC1W	DC monitor warning alarm	DC1W
DC1ZBAT1	BatFail.stVal	DC1F	DC monitor fail alarm	DC1F
DC1ZBAT1	BatGndFlt.st.Val	DC1G	DC monitor ground fault alarm	DC1G

Table 10.13 Logical Device: MET (Metering) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment	Relay Word Bit
DC1ZBAT1	BatDvAlm.stVal	DC1R	DC monitor alarm for ac ripple	DC1R
METLPHD1	PhyHealth.stVal	EN?3:1[b]	Relay enabled	EN?3:1
Functional Constraint = MX				
DC1ZBAT1	Vol.instMag.f	DC1	Station battery dc voltage	DC1
IOPZ1MMXN1	Amp.instMag.f	IOP1F	1-cycle average Zone 1 operating current	IOP1F
IOPZ2MMXN1	Amp.instMag.f	IOP2F	1-cycle average Zone 2 operating current	IOP2F
IOPZ3MMXN1	Amp.instMag.f	IOP3F	1-cycle average Zone 3 operating current	IOP3F
IOPZ4MMXN1	Amp.instMag.f	IOP4F	1-cycle average Zone 4 operating current	IOP4F
IOPZ5MMXN1	Amp.instMag.f	IOP5F	1-cycle average Zone 5 operating current	IOP5F
IOPZ6MMXN1	Amp.instMag.f	IOP6F	1-cycle average Zone 6 operating current	IOP6F
IRTZ1MMXN1	Amp.instMag.f	IRT1F	1-cycle average Zone 1 restraint current	IRT1F
IRTZ2MMXN1	Amp.instMag.f	IRT2F	1-cycle average Zone 2 restraint current	IRT2F
IRTZ3MMXN1	Amp.instMag.f	IRT3F	1-cycle average Zone 3 restraint current	IRT3F
IRTZ4MMXN1	Amp.instMag.f	IRT4F	1-cycle average Zone 4 restraint current	IRT4F
IRTZ5MMXN1	Amp.instMag.f	IRT5F	1-cycle average Zone 5 restraint current	IRT5F
IRTZ6MMXN1	Amp.instMag.f	IRT6F	1-cycle average Zone 6 restraint current	IRT6F
METI01MMXN1	Amp.instMag.f	I01FM	1-cycle average Phase 01 current (magnitude)	I01FM
METI02MMXN1	Amp.instMag.f	I02FM	1-cycle average Phase 02 current (magnitude)	I02FM
METI03MMXN1	Amp.instMag.f	I03FM	1-cycle average Phase 03 current (magnitude)	I03FM
METI04MMXN1	Amp.instMag.f	I04FM	1-cycle average Phase 04 current (magnitude)	I04FM
METI05MMXN1	Amp.instMag.f	I05FM	1-cycle average Phase 05 current (magnitude)	I05FM
METI06MMXN1	Amp.instMag.f	I06FM	1-cycle average Phase 06 current (magnitude)	I06FM
METI07MMXN1	Amp.instMag.f	I07FM	1-cycle average Phase 07 current (magnitude)	I07FM
METI08MMXN1	Amp.instMag.f	I08FM	1-cycle average Phase 08 current (magnitude)	I08FM
METI09MMXN1	Amp.instMag.f	I09FM	1-cycle average Phase 09 current (magnitude)	I09FM
METI10MMXN1	Amp.instMag.f	I10FM	1-cycle average Phase 10 current (magnitude)	I10FM
METI11MMXN1	Amp.instMag.f	I11FM	1-cycle average Phase 11 current (magnitude)	I11FM
METI12MMXN1	Amp.instMag.f	I12FM	1-cycle average Phase 12 current (magnitude)	I12FM
METI13MMXN1	Amp.instMag.f	I13FM	1-cycle average Phase 13 current (magnitude)	I13FM
METI14MMXN1	Amp.instMag.f	I14FM	1-cycle average Phase 14 current (magnitude)	I14FM
METI15MMXN1	Amp.instMag.f	I15FM	1-cycle average Phase 15 current (magnitude)	I15FM
METI16MMXN1	Amp.instMag.f	I16FM	1-cycle average Phase 16 current (magnitude)	I16FM
METI17MMXN1	Amp.instMag.f	I17FM	1-cycle average Phase 17 current (magnitude)	I17FM
METI18MMXN1	Amp.instMag.f	I18FM	1-cycle average Phase 18 current (magnitude)	I18FM
METI19MMXN1	Amp.instMag.f	I19FM	1-cycle average Phase 19 current (magnitude)	I19FM
METI20MMXN1	Amp.instMag.f	I20FM	1-cycle average Phase 20 current (magnitude)	I20FM
METI21MMXN1	Amp.instMag.f	I21FM	1-cycle average Phase 21 current (magnitude)	I21FM
METV01MMXN1	Vol.instMag.f	V01FM	1-cycle average Phase 01 voltage (magnitude)	V01FM
METV02MMXN1	Vol.instMag.f	V02FM	1-cycle average Phase 02 voltage (magnitude)	V02FM
METV03MMXN1	Vol.instMag.f	V03FM	1-cycle average Phase 03 voltage (magnitude)	V03FM

Table 10.13 Logical Device: MET (Metering) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment	Relay Word Bit
Functional Constraint = DC				
LLN0	NamPlt.swRev	VERFID	Relay FID string	VERFID
METLPHD1	PhyNam.hwRev	HWREV[c]	Hardware version of the relay mainboard	HWREV
METLPHD1	PhyNam.model	PARNUM	Relay part number	PARNUM
METLPHD1	PhyNam.serNum	SERNUM	Relay serial number	SERNUM
Functional Constraint = DC				
LLN0	GrRef.setSrcRef	IdName	Functional name	IdNam
LLN0	MltLev.setVal	MLTLEV	Multi-level control authority	MLTLEV

[a] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[b] b If enabled, value = 1. If disabled, value = 3.
[c] HWREV is an internal data source and is not available to the user.

Table 10.14 FLTYPE—Fault Type

Value	Fault Type
0	No fault type identified/present

Table 10.15 FLTCAUS—Fault Cause

Value	Fault Cause
0	No fault summary loaded
1	Trigger command
2	Trip element
3	Event report element
4	Differential trip
5	Breaker failure trip

SECTION 11

Relay Word Bits

This section contains tables of the Relay Word bits available in the SEL-487B relay. *Table 11.1* lists the Relay Word bits in alphabetical order; *Table 11.2* lists every Relay Word bit row and the bits contained within each row.

Alphabetical List

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 1 of 79)

Name	Bit Description	Row
271P1	Undervoltage Element 1, Level 1 asserted	221
271P1T	Undervoltage Element 1, Level 1 timed out	221
271P2	Undervoltage Element 1, Level 2 asserted	221
272P1	Undervoltage Element 2, Level 1 asserted	221
272P1T	Undervoltage Element 2, Level 1 timed out	221
272P2	Undervoltage Element 2, Level 2 asserted	221
273P1	Undervoltage Element 3, Level 1 asserted	222
273P1T	Undervoltage Element 3, Level 1 timed out	222
273P2	Undervoltage Element 3, Level 2 asserted	222
274P1	Undervoltage Element 4, Level 1 asserted	222
274P1T	Undervoltage Element 4, Level 1 timed out	222
274P2	Undervoltage Element 4, Level 2 asserted	222
275P1	Undervoltage Element 5, Level 1 asserted	223
275P1T	Undervoltage Element 5, Level 1 timed out	223
275P2	Undervoltage Element 5, Level 2 asserted	223
276P1	Undervoltage Element 6, Level 1 asserted	223
276P1T	Undervoltage Element 6, Level 1 timed out	223
276P2	Undervoltage Element 6, Level 2 asserted	223
27TC1	Undervoltage Element 1, torque control	221
27TC2	Undervoltage Element 2, torque control	221
27TC3	Undervoltage Element 3, torque control	222
27TC4	Undervoltage Element 4, torque control	222
27TC5	Undervoltage Element 5, torque control	223
27TC6	Undervoltage Element 6, torque control	223
50DS01	Terminal 01 directional element current threshold exceeded	173
50DS02	Terminal 02 directional element current threshold exceeded	173
50DS03	Terminal 03 directional element current threshold exceeded	173
50DS04	Terminal 04 directional element current threshold exceeded	173

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 2 of 79)

Name	Bit Description	Row
50DS05	Terminal 05 directional element current threshold exceeded	173
50DS06	Terminal 06 directional element current threshold exceeded	173
50DS07	Terminal 07 directional element current threshold exceeded	173
50DS08	Terminal 08 directional element current threshold exceeded	173
50DS09	Terminal 09 directional element current threshold exceeded	174
50DS10	Terminal 10 directional element current threshold exceeded	174
50DS11	Terminal 11 directional element current threshold exceeded	174
50DS12	Terminal 12 directional element current threshold exceeded	174
50DS13	Terminal 13 directional element current threshold exceeded	174
50DS14	Terminal 14 directional element current threshold exceeded	174
50DS15	Terminal 15 directional element current threshold exceeded	174
50DS16	Terminal 16 directional element current threshold exceeded	174
50DS17	Terminal 17 directional element current threshold exceeded	175
50DS18	Terminal 18 directional element current threshold exceeded	175
50DS19	Terminal 19 directional element current threshold exceeded	175
50DS20	Terminal 20 directional element current threshold exceeded	175
50DS21	Terminal 21 directional element current threshold exceeded	175
50F01	Circuit Breaker 1 breaker failure current threshold exceeded	183
50F02	Circuit Breaker 2 breaker failure current threshold exceeded	184
50F03	Circuit Breaker 3 breaker failure current threshold exceeded	185
50F04	Circuit Breaker 4 breaker failure current threshold exceeded	186
50F05	Circuit Breaker 5 breaker failure current threshold exceeded	187
50F06	Circuit Breaker 6 breaker failure current threshold exceeded	188
50F07	Circuit Breaker 7 breaker failure current threshold exceeded	189
50F08	Circuit Breaker 8 breaker failure current threshold exceeded	190
50F09	Circuit Breaker 9 breaker failure current threshold exceeded	191
50F10	Circuit Breaker 10 breaker failure current threshold exceeded	192
50F11	Circuit Breaker 11 breaker failure current threshold exceeded	193
50F12	Circuit Breaker 12 breaker failure current threshold exceeded	194
50F13	Circuit Breaker 13 breaker failure current threshold exceeded	195
50F14	Circuit Breaker 14 breaker failure current threshold exceeded	196
50F15	Circuit Breaker 15 breaker failure current threshold exceeded	197
50F16	Circuit Breaker 16 breaker failure current threshold exceeded	198
50F17	Circuit Breaker 17 breaker failure current threshold exceeded	199
50F18	Circuit Breaker 18 breaker failure current threshold exceeded	200
50F19	Circuit Breaker 19 breaker failure current threshold exceeded	201
50F20	Circuit Breaker 20 breaker failure current threshold exceeded	202
50F21	Circuit Breaker 21 breaker failure current threshold exceeded	203
50P01	Terminal 01 instantaneous overcurrent element	207
50P01T	Terminal 01 definite-time overcurrent element timed out	207
50P02	Terminal 02 instantaneous overcurrent element	207

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 3 of 79)

Name	Bit Description	Row
50P02T	Terminal 02 definite-time overcurrent element timed out	207
50P03	Terminal 03 instantaneous overcurrent element	207
50P03T	Terminal 03 definite-time overcurrent element timed out	207
50P04	Terminal 04 instantaneous overcurrent element	207
50P04T	Terminal 04 definite-time overcurrent element timed out	207
50P05	Terminal 05 instantaneous overcurrent element	208
50P05T	Terminal 05 definite-time overcurrent element timed out	208
50P06	Terminal 06 instantaneous overcurrent element	208
50P06T	Terminal 06 definite-time overcurrent element timed out	208
50P07	Terminal 07 instantaneous overcurrent element	208
50P07T	Terminal 07 definite-time overcurrent element timed out	208
50P08	Terminal 08 instantaneous overcurrent element	208
50P08T	Terminal 08 definite-time overcurrent element timed out	208
50P09	Terminal 09 instantaneous overcurrent element	209
50P09T	Terminal 09 definite-time overcurrent element timed out	209
50P10	Terminal 10 instantaneous overcurrent element	209
50P10T	Terminal 10 definite-time overcurrent element timed out	209
50P11	Terminal 11 instantaneous overcurrent element	209
50P11T	Terminal 11 definite-time overcurrent element timed out	209
50P12	Terminal 12 instantaneous overcurrent element	209
50P12T	Terminal 12 definite-time overcurrent element timed out	209
50P13	Terminal 13 instantaneous overcurrent element	210
50P13T	Terminal 13 definite-time overcurrent element timed out	210
50P14	Terminal 14 instantaneous overcurrent element	210
50P14T	Terminal 14 definite-time overcurrent element timed out	210
50P15	Terminal 15 instantaneous overcurrent element	210
50P15T	Terminal 15 definite-time overcurrent element timed out	210
50P16	Terminal 16 instantaneous overcurrent element	210
50P16T	Terminal 16 definite-time overcurrent element timed out	210
50P17	Terminal 17 instantaneous overcurrent element	211
50P17T	Terminal 17 definite-time overcurrent element timed out	211
50P18	Terminal 18 instantaneous overcurrent element	211
50P18T	Terminal 18 definite-time overcurrent element timed out	211
50P19	Terminal 19 instantaneous overcurrent element	211
50P19T	Terminal 19 definite-time overcurrent element timed out	211
50P20	Terminal 20 instantaneous overcurrent element	211
50P20T	Terminal 20 definite-time overcurrent element timed out	211
50P21	Terminal 21 instantaneous overcurrent element	212
50P21T	Terminal 21 definite-time overcurrent element timed out	212
51MM01	Inverse-time Element 01 pickup setting outside of specified limits	219
51MM02	Inverse-time Element 02 pickup setting outside of specified limits	219

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 4 of 79)

Name	Bit Description	Row
51MM03	Inverse-time Element 03 pickup setting outside of specified limits	219
51MM04	Inverse-time Element 04 pickup setting outside of specified limits	219
51MM05	Inverse-time Element 05 pickup setting outside of specified limits	220
51MM06	Inverse-time Element 06 pickup setting outside of specified limits	220
51MM07	Inverse-time Element 07 pickup setting outside of specified limits	220
51MM08	Inverse-time Element 08 pickup setting outside of specified limits	220
51MM09	Inverse-time Element 09 pickup setting outside of specified limits	232
51MM10	Inverse-time Element 10 pickup setting outside of specified limits	232
51MM11	Inverse-time Element 11 pickup setting outside of specified limits	232
51MM12	Inverse-time Element 12 pickup setting outside of specified limits	232
51MM13	Inverse-time Element 13 pickup setting outside of specified limits	233
51MM14	Inverse-time Element 14 pickup setting outside of specified limits	233
51MM15	Inverse-time Element 15 pickup setting outside of specified limits	233
51MM16	Inverse-time Element 16 pickup setting outside of specified limits	233
51MM17	Inverse-time Element 17 pickup setting outside of specified limits	234
51MM18	Inverse-time Element 18 pickup setting outside of specified limits	234
51MM19	Inverse-time Element 19 pickup setting outside of specified limits	234
51MM20	Inverse-time Element 20 pickup setting outside of specified limits	234
51MM21	Inverse-time Element 21 pickup setting outside of specified limits	252
51R01	Inverse-time Element 01 reset	254
51R02	Inverse-time Element 02 reset	254
51R03	Inverse-time Element 03 reset	254
51R04	Inverse-time Element 04 reset	254
51R05	Inverse-time Element 05 reset	254
51R06	Inverse-time Element 06 reset	254
51R07	Inverse-time Element 07 reset	254
51R08	Inverse-time Element 08 reset	254
51R09	Inverse-time Element 09 reset	253
51R10	Inverse-time Element 10 reset	253
51R11	Inverse-time Element 11 reset	253
51R12	Inverse-time Element 12 reset	253
51R13	Inverse-time Element 13 reset	253
51R14	Inverse-time Element 14 reset	253
51R15	Inverse-time Element 15 reset	253
51R16	Inverse-time Element 16 reset	253
51R17	Inverse-time Element 17 reset	381
51R18	Inverse-time Element 18 reset	381
51R19	Inverse-time Element 19 reset	381
51R20	Inverse-time Element 20 reset	381
51R21	Inverse-time Element 21 reset	381
51S01	Inverse-time Element 01 picked up	213

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 5 of 79)

Name	Bit Description	Row
51S02	Inverse-time Element 02 picked up	213
51S03	Inverse-time Element 03 picked up	213
51S04	Inverse-time Element 04 picked up	213
51S05	Inverse-time Element 05 picked up	214
51S06	Inverse-time Element 06 picked up	214
51S07	Inverse-time Element 07 picked up	214
51S08	Inverse-time Element 08 picked up	214
51S09	Inverse-time Element 09 picked up	215
51S10	Inverse-time Element 10 picked up	215
51S11	Inverse-time Element 11 picked up	215
51S12	Inverse-time Element 12 picked up	215
51S13	Inverse-time Element 13 picked up	216
51S14	Inverse-time Element 14 picked up	216
51S15	Inverse-time Element 15 picked up	216
51S16	Inverse-time Element 16 picked up	216
51S17	Inverse-time Element 17 picked up	217
51S18	Inverse-time Element 18 picked up	217
51S19	Inverse-time Element 19 picked up	217
51S20	Inverse-time Element 20 picked up	217
51S21	Inverse-time Element 21 picked up	218
51T01	Inverse-time Element 01 timed out	213
51T02	Inverse-time Element 02 timed out	213
51T03	Inverse-time Element 03 timed out	213
51T04	Inverse-time Element 04 timed out	213
51T05	Inverse-time Element 05 timed out	214
51T06	Inverse-time Element 06 timed out	214
51T07	Inverse-time Element 07 timed out	214
51T08	Inverse-time Element 08 timed out	214
51T09	Inverse-time Element 09 timed out	215
51T10	Inverse-time Element 10 timed out	215
51T11	Inverse-time Element 11 timed out	215
51T12	Inverse-time Element 12 timed out	215
51T13	Inverse-time Element 13 timed out	216
51T14	Inverse-time Element 14 timed out	216
51T15	Inverse-time Element 15 timed out	216
51T16	Inverse-time Element 16 timed out	216
51T17	Inverse-time Element 17 timed out	217
51T18	Inverse-time Element 18 timed out	217
51T19	Inverse-time Element 19 timed out	217
51T20	Inverse-time Element 20 timed out	217
51T21	Inverse-time Element 21 timed out	218

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 6 of 79)

Name	Bit Description	Row
51TM01	Inverse-time Element 01 time-dial setting outside of specified limits	219
51TM02	Inverse-time Element 02 time-dial setting outside of specified limits	219
51TM03	Inverse-time Element 03 time-dial setting outside of specified limits	219
51TM04	Inverse-time Element 04 time-dial setting outside of specified limits	219
51TM05	Inverse-time Element 05 time-dial setting outside of specified limits	220
51TM06	Inverse-time Element 06 time-dial setting outside of specified limits	220
51TM07	Inverse-time Element 07 time-dial setting outside of specified limits	220
51TM08	Inverse-time Element 08 time-dial setting outside of specified limits	220
51TM09	Inverse-time Element 09 time-dial setting outside of specified limits	232
51TM10	Inverse-time Element 10 time-dial setting outside of specified limits	232
51TM11	Inverse-time Element 11 time-dial setting outside of specified limits	232
51TM12	Inverse-time Element 12 time-dial setting outside of specified limits	232
51TM13	Inverse-time Element 13 time-dial setting outside of specified limits	233
51TM14	Inverse-time Element 14 time-dial setting outside of specified limits	233
51TM15	Inverse-time Element 15 time-dial setting outside of specified limits	233
51TM16	Inverse-time Element 16 time-dial setting outside of specified limits	233
51TM17	Inverse-time Element 17 time-dial setting outside of specified limits	234
51TM18	Inverse-time Element 18 time-dial setting outside of specified limits	234
51TM19	Inverse-time Element 19 time-dial setting outside of specified limits	234
51TM20	Inverse-time Element 20 time-dial setting outside of specified limits	234
51TM21	Inverse-time Element 21 time-dial setting outside of specified limits	252
52A01	Circuit Breaker 01 status	7
52A02	Circuit Breaker 02 status	7
52A03	Circuit Breaker 03 status	7
52A04	Circuit Breaker 04 status	8
52A05	Circuit Breaker 05 status	8
52A06	Circuit Breaker 06 status	8
52A07	Circuit Breaker 07 status	9
52A08	Circuit Breaker 08 status	9
52A09	Circuit Breaker 09 status	10
52A10	Circuit Breaker 10 status	10
52A11	Circuit Breaker 11 status	10
52A12	Circuit Breaker 12 status	11
52A13	Circuit Breaker 13 status	11
52A14	Circuit Breaker 14 status	11
52A15	Circuit Breaker 15 status	12
52A16	Circuit Breaker 16 status	12
52A17	Circuit Breaker 17 status	13
52A18	Circuit Breaker 18 status	13
52A19	Circuit Breaker 19 status	13
52A20	Circuit Breaker 20 status	14

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 7 of 79)

Name	Bit Description	Row
52A21	Circuit Breaker 21 status	14
52AL	Any circuit breaker alarm	14
52AL01	Circuit Breaker 01 alarm	7
52AL02	Circuit Breaker 02 alarm	7
52AL03	Circuit Breaker 03 alarm	7
52AL04	Circuit Breaker 04 alarm	8
52AL05	Circuit Breaker 05 alarm	8
52AL06	Circuit Breaker 06 alarm	9
52AL07	Circuit Breaker 07 alarm	9
52AL08	Circuit Breaker 08 alarm	9
52AL09	Circuit Breaker 09 alarm	10
52AL10	Circuit Breaker 10 alarm	10
52AL11	Circuit Breaker 11 alarm	10
52AL12	Circuit Breaker 12 alarm	11
52AL13	Circuit Breaker 13 alarm	11
52AL14	Circuit Breaker 14 alarm	12
52AL15	Circuit Breaker 15 alarm	12
52AL16	Circuit Breaker 16 alarm	12
52AL17	Circuit Breaker 17 alarm	13
52AL18	Circuit Breaker 18 alarm	13
52AL19	Circuit Breaker 19 alarm	13
52AL20	Circuit Breaker 20 alarm	14
52AL21	Circuit Breaker 21 alarm	14
52CL01	Circuit Breaker 01 closed	7
52CL02	Circuit Breaker 02 closed	7
52CL03	Circuit Breaker 03 closed	8
52CL04	Circuit Breaker 04 closed	8
52CL05	Circuit Breaker 05 closed	8
52CL06	Circuit Breaker 06 closed	9
52CL07	Circuit Breaker 07 closed	9
52CL08	Circuit Breaker 08 closed	9
52CL09	Circuit Breaker 09 closed	10
52CL10	Circuit Breaker 10 closed	10
52CL11	Circuit Breaker 11 closed	11
52CL12	Circuit Breaker 12 closed	11
52CL13	Circuit Breaker 13 closed	11
52CL14	Circuit Breaker 14 closed	12
52CL15	Circuit Breaker 15 closed	12
52CL16	Circuit Breaker 16 closed	12
52CL17	Circuit Breaker 17 closed	13
52CL18	Circuit Breaker 18 closed	13

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 8 of 79)

Name	Bit Description	Row
52CL19	Circuit Breaker 19 closed	14
52CL20	Circuit Breaker 20 closed	14
52CL21	Circuit Breaker 21 closed	14
591P1	Overvoltage Element 1, Level 1 asserted	224
591P1T	Overvoltage Element 1, Level 1 timed out	224
591P2	Overvoltage Element 1, Level 2 asserted	224
592P1	Overvoltage Element 2, Level 1 asserted	224
592P1T	Overvoltage Element 2, Level 1 timed out	224
592P2	Overvoltage Element 2, Level 2 asserted	224
593P1	Overvoltage Element 3, Level 1 asserted	225
593P1T	Overvoltage Element 3, Level 1 timed out	225
593P2	Overvoltage Element 3, Level 2 asserted	225
594P1	Overvoltage Element 4, Level 1 asserted	225
594P1T	Overvoltage Element 4, Level 1 timed out	225
594P2	Overvoltage Element 4, Level 2 asserted	225
595P1	Overvoltage Element 5, Level 1 asserted	226
595P1T	Overvoltage Element 5, Level 1 timed out	226
595P2	Overvoltage Element 5, Level 2 asserted	226
596P1	Overvoltage Element 6, Level 1 asserted	226
596P1T	Overvoltage Element 6, Level 1 timed out	226
596P2	Overvoltage Element 6, Level 2 asserted	226
59TC1	Overvoltage Element 1, torque control	224
59TC2	Overvoltage Element 2, torque control	224
59TC3	Overvoltage Element 3, torque control	225
59TC4	Overvoltage Element 4, torque control	225
59TC5	Overvoltage Element 5, torque control	226
59TC6	Overvoltage Element 6, torque control	226
87BTR	Any terminal bus-zone differential trip asserted	231
87BTR01	Terminal 01 bus-zone differential trip asserted	228
87BTR02	Terminal 02 bus-zone differential trip asserted	228
87BTR03	Terminal 03 bus-zone differential trip asserted	228
87BTR04	Terminal 04 bus-zone differential trip asserted	228
87BTR05	Terminal 05 bus-zone differential trip asserted	228
87BTR06	Terminal 06 bus-zone differential trip asserted	228
87BTR07	Terminal 07 bus-zone differential trip asserted	228
87BTR08	Terminal 08 bus-zone differential trip asserted	228
87BTR09	Terminal 09 bus-zone differential trip asserted	229
87BTR10	Terminal 10 bus-zone differential trip asserted	229
87BTR11	Terminal 11 bus-zone differential trip asserted	229
87BTR12	Terminal 12 bus-zone differential trip asserted	229
87BTR13	Terminal 13 bus-zone differential trip asserted	229

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 9 of 79)

Name	Bit Description	Row
87BTR14	Terminal 14 bus-zone differential trip asserted	229
87BTR15	Terminal 15 bus-zone differential trip asserted	229
87BTR16	Terminal 16 bus-zone differential trip asserted	229
87BTR17	Terminal 17 bus-zone differential trip asserted	230
87BTR18	Terminal 18 bus-zone differential trip asserted	230
87BTR19	Terminal 19 bus-zone differential trip asserted	230
87BTR20	Terminal 20 bus-zone differential trip asserted	230
87BTR21	Terminal 21 bus-zone differential trip asserted	230
87CZ1	Check Zone 1 differential element trip	447
87CZ2	Check Zone 2 differential element trip	447
87CZ3	Check Zone 3 differential element trip	447
87O1	Zone 1 restraint differential operating current above O87P	159
87O2	Zone 2 restraint differential operating current above O87P	161
87O3	Zone 3 restraint differential operating current above O87P	163
87O4	Zone 4 restraint differential operating current above O87P	165
87O5	Zone 5 restraint differential operating current above O87P	167
87O6	Zone 6 restraint differential operating current above O87P	169
87OCZ1	Check Zone 1 restraint differential operating current above CZO87P	450
87OCZ2	Check Zone 2 restraint differential operating current above CZO87P	452
87OCZ3	Check Zone 3 restraint differential operating current above CZO87P	454
87R1	Zone 1 restraint differential element picked up	159
87R2	Zone 2 restraint differential element picked up	161
87R3	Zone 3 restraint differential element picked up	163
87R4	Zone 4 restraint differential element picked up	165
87R5	Zone 5 restraint differential element picked up	167
87R6	Zone 6 restraint differential element picked up	169
87RCZ1	Check Zone 1 restraint differential element picked up	450
87RCZ2	Check Zone 2 restraint differential element picked up	452
87RCZ3	Check Zone 3 restraint differential element picked up	454
87S1	Zone 1 sensitive differential element picked up	157
87S2	Zone 2 sensitive differential element picked up	157
87S3	Zone 3 sensitive differential element picked up	157
87S4	Zone 4 sensitive differential element picked up	157
87S5	Zone 5 sensitive differential element picked up	157
87S6	Zone 6 sensitive differential element picked up	157
87SCZ1	Check Zone 1 sensitive differential element picked up	448
87SCZ2	Check Zone 2 sensitive differential element picked up	448
87SCZ3	Check Zone 3 sensitive differential element picked up	448
87ST	Any sensitive differential element timer timed out	158
87ST1	Zone 1 sensitive differential element timed out	158
87ST2	Zone 2 sensitive differential element timed out	158

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 10 of 79)

Name	Bit Description	Row
87ST3	Zone 3 sensitive differential element timed out	158
87ST4	Zone 4 sensitive differential element timed out	158
87ST5	Zone 5 sensitive differential element timed out	158
87ST6	Zone 6 sensitive differential element timed out	158
87STCZ1	Check Zone 1 sensitive differential element timed out	449
87STCZ2	Check Zone 2 sensitive differential element timed out	449
87STCZ3	Check Zone 3 sensitive differential element timed out	449
87Z1	Zone 1 differential element trip	235
87Z2	Zone 2 differential element trip	235
87Z3	Zone 3 differential element trip	235
87Z4	Zone 4 differential element trip	235
87Z5	Zone 5 differential element trip	235
87Z6	Zone 6 differential element trip	235
89A01	Disconnect 01 A auxiliary contact closed	17
89A02	Disconnect 02 A auxiliary contact closed	17
89A03	Disconnect 03 A auxiliary contact closed	18
89A04	Disconnect 04 A auxiliary contact closed	18
89A05	Disconnect 05 A auxiliary contact closed	19
89A06	Disconnect 06 A auxiliary contact closed	20
89A07	Disconnect 07 A auxiliary contact closed	20
89A08	Disconnect 08 A auxiliary contact closed	21
89A09	Disconnect 09 A auxiliary contact closed	22
89A10	Disconnect 10 A auxiliary contact closed	22
89A11	Disconnect 11 A auxiliary contact closed	23
89A12	Disconnect 12 A auxiliary contact closed	23
89A13	Disconnect 13 A auxiliary contact closed	24
89A14	Disconnect 14 A auxiliary contact closed	25
89A15	Disconnect 15 A auxiliary contact closed	25
89A16	Disconnect 16 A auxiliary contact closed	26
89A17	Disconnect 17 A auxiliary contact closed	27
89A18	Disconnect 18 A auxiliary contact closed	27
89A19	Disconnect 19 A auxiliary contact closed	28
89A20	Disconnect 20 A auxiliary contact closed	28
89A21	Disconnect 21 A auxiliary contact closed	29
89A22	Disconnect 22 A auxiliary contact closed	30
89A23	Disconnect 23 A auxiliary contact closed	30
89A24	Disconnect 24 A auxiliary contact closed	31
89A25	Disconnect 25 A auxiliary contact closed	32
89A26	Disconnect 26 A auxiliary contact closed	32
89A27	Disconnect 27 A auxiliary contact closed	33
89A28	Disconnect 28 A auxiliary contact closed	33

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 11 of 79)

Name	Bit Description	Row
89A29	Disconnect 29 A auxiliary contact closed	34
89A30	Disconnect 30 A auxiliary contact closed	35
89A31	Disconnect 31 A auxiliary contact closed	35
89A32	Disconnect 32 A auxiliary contact closed	36
89A33	Disconnect 33 A auxiliary contact closed	37
89A34	Disconnect 34 A auxiliary contact closed	37
89A35	Disconnect 35 A auxiliary contact closed	38
89A36	Disconnect 36 A auxiliary contact closed	38
89A37	Disconnect 37 A auxiliary contact closed	39
89A38	Disconnect 38 A auxiliary contact closed	40
89A39	Disconnect 39 A auxiliary contact closed	40
89A40	Disconnect 40 A auxiliary contact closed	41
89A41	Disconnect 41 A auxiliary contact closed	42
89A42	Disconnect 42 A auxiliary contact closed	42
89A43	Disconnect 43 A auxiliary contact closed	43
89A44	Disconnect 44 A auxiliary contact closed	43
89A45	Disconnect 45 A auxiliary contact closed	44
89A46	Disconnect 46 A auxiliary contact closed	45
89A47	Disconnect 47 A auxiliary contact closed	45
89A48	Disconnect 48 A auxiliary contact closed	46
89A49	Disconnect 49 A auxiliary contact closed	47
89A50	Disconnect 50 A auxiliary contact closed	47
89A51	Disconnect 51 A auxiliary contact closed	48
89A52	Disconnect 52 A auxiliary contact closed	48
89A53	Disconnect 53 A auxiliary contact closed	49
89A54	Disconnect 54 A auxiliary contact closed	50
89A55	Disconnect 55 A auxiliary contact closed	50
89A56	Disconnect 56 A auxiliary contact closed	51
89A57	Disconnect 57 A auxiliary contact closed	52
89A58	Disconnect 58 A auxiliary contact closed	52
89A59	Disconnect 59 A auxiliary contact closed	53
89A60	Disconnect 60 A auxiliary contact closed	53
89AL	Any disconnect auxiliary contact discrepancy alarm	55
89AL01	Disconnect 01 auxiliary contact discrepancy alarm	17
89AL02	Disconnect 02 auxiliary contact discrepancy alarm	18
89AL03	Disconnect 03 auxiliary contact discrepancy alarm	18
89AL04	Disconnect 04 auxiliary contact discrepancy alarm	19
89AL05	Disconnect 05 auxiliary contact discrepancy alarm	20
89AL06	Disconnect 06 auxiliary contact discrepancy alarm	20
89AL07	Disconnect 07 auxiliary contact discrepancy alarm	21
89AL08	Disconnect 08 auxiliary contact discrepancy alarm	21

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 12 of 79)

Name	Bit Description	Row
89AL09	Disconnect 09 auxiliary contact discrepancy alarm	22
89AL10	Disconnect 10 auxiliary contact discrepancy alarm	23
89AL11	Disconnect 11 auxiliary contact discrepancy alarm	23
89AL12	Disconnect 12 auxiliary contact discrepancy alarm	24
89AL13	Disconnect 13 auxiliary contact discrepancy alarm	25
89AL14	Disconnect 14 auxiliary contact discrepancy alarm	25
89AL15	Disconnect 15 auxiliary contact discrepancy alarm	26
89AL16	Disconnect 16 auxiliary contact discrepancy alarm	26
89AL17	Disconnect 17 auxiliary contact discrepancy alarm	27
89AL18	Disconnect 18 auxiliary contact discrepancy alarm	28
89AL19	Disconnect 19 auxiliary contact discrepancy alarm	28
89AL20	Disconnect 20 auxiliary contact discrepancy alarm	29
89AL21	Disconnect 21 auxiliary contact discrepancy alarm	30
89AL22	Disconnect 22 auxiliary contact discrepancy alarm	30
89AL23	Disconnect 23 auxiliary contact discrepancy alarm	31
89AL24	Disconnect 24 auxiliary contact discrepancy alarm	31
89AL25	Disconnect 25 auxiliary contact discrepancy alarm	32
89AL26	Disconnect 26 auxiliary contact discrepancy alarm	33
89AL27	Disconnect 27 auxiliary contact discrepancy alarm	33
89AL28	Disconnect 28 auxiliary contact discrepancy alarm	34
89AL29	Disconnect 29 auxiliary contact discrepancy alarm	35
89AL30	Disconnect 30 auxiliary contact discrepancy alarm	35
89AL31	Disconnect 31 auxiliary contact discrepancy alarm	36
89AL32	Disconnect 32 auxiliary contact discrepancy alarm	36
89AL33	Disconnect 33 auxiliary contact discrepancy alarm	37
89AL34	Disconnect 34 auxiliary contact discrepancy alarm	38
89AL35	Disconnect 35 auxiliary contact discrepancy alarm	38
89AL36	Disconnect 36 auxiliary contact discrepancy alarm	39
89AL37	Disconnect 37 auxiliary contact discrepancy alarm	40
89AL38	Disconnect 38 auxiliary contact discrepancy alarm	40
89AL39	Disconnect 39 auxiliary contact discrepancy alarm	41
89AL40	Disconnect 40 auxiliary contact discrepancy alarm	41
89AL41	Disconnect 41 auxiliary contact discrepancy alarm	42
89AL42	Disconnect 42 auxiliary contact discrepancy alarm	43
89AL43	Disconnect 43 auxiliary contact discrepancy alarm	43
89AL44	Disconnect 44 auxiliary contact discrepancy alarm	44
89AL45	Disconnect 45 auxiliary contact discrepancy alarm	45
89AL46	Disconnect 46 auxiliary contact discrepancy alarm	45
89AL47	Disconnect 47 auxiliary contact discrepancy alarm	46
89AL48	Disconnect 48 auxiliary contact discrepancy alarm	46
89AL49	Disconnect 49 auxiliary contact discrepancy alarm	47

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 13 of 79)

Name	Bit Description	Row
89AL50	Disconnect 50 auxiliary contact discrepancy alarm	48
89AL51	Disconnect 51 auxiliary contact discrepancy alarm	48
89AL52	Disconnect 52 auxiliary contact discrepancy alarm	49
89AL53	Disconnect 53 auxiliary contact discrepancy alarm	50
89AL54	Disconnect 54 auxiliary contact discrepancy alarm	50
89AL55	Disconnect 55 auxiliary contact discrepancy alarm	51
89AL56	Disconnect 56 auxiliary contact discrepancy alarm	51
89AL57	Disconnect 57 auxiliary contact discrepancy alarm	52
89AL58	Disconnect 58 auxiliary contact discrepancy alarm	53
89AL59	Disconnect 59 auxiliary contact discrepancy alarm	53
89AL60	Disconnect 60 auxiliary contact discrepancy alarm	54
89B01	Disconnect 01 B auxiliary contact closed	17
89B02	Disconnect 02 B auxiliary contact closed	17
89B03	Disconnect 03 B auxiliary contact closed	18
89B04	Disconnect 04 B auxiliary contact closed	19
89B05	Disconnect 05 B auxiliary contact closed	19
89B06	Disconnect 06 B auxiliary contact closed	20
89B07	Disconnect 07 B auxiliary contact closed	20
89B08	Disconnect 08 B auxiliary contact closed	21
89B09	Disconnect 09 B auxiliary contact closed	22
89B10	Disconnect 10 B auxiliary contact closed	22
89B11	Disconnect 11 B auxiliary contact closed	23
89B12	Disconnect 12 B auxiliary contact closed	24
89B13	Disconnect 13 B auxiliary contact closed	24
89B14	Disconnect 14 B auxiliary contact closed	25
89B15	Disconnect 15 B auxiliary contact closed	25
89B16	Disconnect 16 B auxiliary contact closed	26
89B17	Disconnect 17 B auxiliary contact closed	27
89B18	Disconnect 18 B auxiliary contact closed	27
89B19	Disconnect 19 B auxiliary contact closed	28
89B20	Disconnect 20 B auxiliary contact closed	29
89B21	Disconnect 21 B auxiliary contact closed	29
89B22	Disconnect 22 B auxiliary contact closed	30
89B23	Disconnect 23 B auxiliary contact closed	30
89B24	Disconnect 24 B auxiliary contact closed	31
89B25	Disconnect 25 B auxiliary contact closed	32
89B26	Disconnect 26 B auxiliary contact closed	32
89B27	Disconnect 27 B auxiliary contact closed	33
89B28	Disconnect 28 B auxiliary contact closed	34
89B29	Disconnect 29 B auxiliary contact closed	34
89B30	Disconnect 30 B auxiliary contact closed	35

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 14 of 79)

Name	Bit Description	Row
89B31	Disconnect 31 B auxiliary contact closed	35
89B32	Disconnect 32 B auxiliary contact closed	36
89B33	Disconnect 33 B auxiliary contact closed	37
89B34	Disconnect 34 B auxiliary contact closed	37
89B35	Disconnect 35 B auxiliary contact closed	38
89B36	Disconnect 36 B auxiliary contact closed	39
89B37	Disconnect 37 B auxiliary contact closed	39
89B38	Disconnect 38 B auxiliary contact closed	40
89B39	Disconnect 39 B auxiliary contact closed	40
89B40	Disconnect 40 B auxiliary contact closed	41
89B41	Disconnect 41 B auxiliary contact closed	42
89B42	Disconnect 42 B auxiliary contact closed	42
89B43	Disconnect 43 B auxiliary contact closed	43
89B44	Disconnect 44 B auxiliary contact closed	44
89B45	Disconnect 45 B auxiliary contact closed	44
89B46	Disconnect 46 B auxiliary contact closed	45
89B47	Disconnect 47 B auxiliary contact closed	45
89B48	Disconnect 48 B auxiliary contact closed	46
89B49	Disconnect 49 B auxiliary contact closed	47
89B50	Disconnect 50 B auxiliary contact closed	47
89B51	Disconnect 51 B auxiliary contact closed	48
89B52	Disconnect 52 B auxiliary contact closed	49
89B53	Disconnect 53 B auxiliary contact closed	49
89B54	Disconnect 54 B auxiliary contact closed	50
89B55	Disconnect 55 B auxiliary contact closed	50
89B56	Disconnect 56 B auxiliary contact closed	51
89B57	Disconnect 57 B auxiliary contact closed	52
89B58	Disconnect 58 B auxiliary contact closed	52
89B59	Disconnect 59 B auxiliary contact closed	53
89B60	Disconnect 60 B auxiliary contact closed	54
89CL01	Disconnect 01 closed	17
89CL02	Disconnect 02 closed	17
89CL03	Disconnect 03 closed	18
89CL04	Disconnect 04 closed	19
89CL05	Disconnect 05 closed	19
89CL06	Disconnect 06 closed	20
89CL07	Disconnect 07 closed	21
89CL08	Disconnect 08 closed	21
89CL09	Disconnect 09 closed	22
89CL10	Disconnect 10 closed	22
89CL11	Disconnect 11 closed	23

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 15 of 79)

Name	Bit Description	Row
89CL12	Disconnect 12 closed	24
89CL13	Disconnect 13 closed	24
89CL14	Disconnect 14 closed	25
89CL15	Disconnect 15 closed	26
89CL16	Disconnect 16 closed	26
89CL17	Disconnect 17 closed	27
89CL18	Disconnect 18 closed	27
89CL19	Disconnect 19 closed	28
89CL20	Disconnect 20 closed	29
89CL21	Disconnect 21 closed	29
89CL22	Disconnect 22 closed	30
89CL23	Disconnect 23 closed	31
89CL24	Disconnect 24 closed	31
89CL25	Disconnect 25 closed	32
89CL26	Disconnect 26 closed	32
89CL27	Disconnect 27 closed	33
89CL28	Disconnect 28 closed	34
89CL29	Disconnect 29 closed	34
89CL30	Disconnect 30 closed	35
89CL31	Disconnect 31 closed	36
89CL32	Disconnect 32 closed	36
89CL33	Disconnect 33 closed	37
89CL34	Disconnect 34 closed	37
89CL35	Disconnect 35 closed	38
89CL36	Disconnect 36 closed	39
89CL37	Disconnect 37 closed	39
89CL38	Disconnect 38 closed	40
89CL39	Disconnect 39 closed	41
89CL40	Disconnect 40 closed	41
89CL41	Disconnect 41 closed	42
89CL42	Disconnect 42 closed	42
89CL43	Disconnect 43 closed	43
89CL44	Disconnect 44 closed	44
89CL45	Disconnect 45 closed	44
89CL46	Disconnect 46 closed	45
89CL47	Disconnect 47 closed	46
89CL48	Disconnect 48 closed	46
89CL49	Disconnect 49 closed	47
89CL50	Disconnect 50 closed	47
89CL51	Disconnect 51 closed	48
89CL52	Disconnect 52 closed	49

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 16 of 79)

Name	Bit Description	Row
89CL53	Disconnect 53 closed	49
89CL54	Disconnect 54 closed	50
89CL55	Disconnect 55 closed	51
89CL56	Disconnect 56 closed	51
89CL57	Disconnect 57 closed	52
89CL58	Disconnect 58 closed	52
89CL59	Disconnect 59 closed	53
89CL60	Disconnect 60 closed	54
89OIP	Any disconnect operation in progress	55
89OIP01	Disconnect 01 operation in progress	17
89OIP02	Disconnect 02 operation in progress	18
89OIP03	Disconnect 03 operation in progress	18
89OIP04	Disconnect 04 operation in progress	19
89OIP05	Disconnect 05 operation in progress	19
89OIP06	Disconnect 06 operation in progress	20
89OIP07	Disconnect 07 operation in progress	21
89OIP08	Disconnect 08 operation in progress	21
89OIP09	Disconnect 09 operation in progress	22
89OIP10	Disconnect 10 operation in progress	23
89OIP11	Disconnect 11 operation in progress	23
89OIP12	Disconnect 12 operation in progress	24
89OIP13	Disconnect 13 operation in progress	24
89OIP14	Disconnect 14 operation in progress	25
89OIP15	Disconnect 15 operation in progress	26
89OIP16	Disconnect 16 operation in progress	26
89OIP17	Disconnect 17 operation in progress	27
89OIP18	Disconnect 18 operation in progress	28
89OIP19	Disconnect 19 operation in progress	28
89OIP20	Disconnect 20 operation in progress	29
89OIP21	Disconnect 21 operation in progress	29
89OIP22	Disconnect 22 operation in progress	30
89OIP23	Disconnect 23 operation in progress	31
89OIP24	Disconnect 24 operation in progress	31
89OIP25	Disconnect 25 operation in progress	32
89OIP26	Disconnect 26 operation in progress	33
89OIP27	Disconnect 27 operation in progress	33
89OIP28	Disconnect 28 operation in progress	34
89OIP29	Disconnect 29 operation in progress	34
89OIP30	Disconnect 30 operation in progress	35
89OIP31	Disconnect 31 operation in progress	36
89OIP32	Disconnect 32 operation in progress	36

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 17 of 79)

Name	Bit Description	Row
89OIP33	Disconnect 33 operation in progress	37
89OIP34	Disconnect 34 operation in progress	38
89OIP35	Disconnect 35 operation in progress	38
89OIP36	Disconnect 36 operation in progress	39
89OIP37	Disconnect 37 operation in progress	39
89OIP38	Disconnect 38 operation in progress	40
89OIP39	Disconnect 39 operation in progress	41
89OIP40	Disconnect 40 operation in progress	41
89OIP41	Disconnect 41 operation in progress	42
89OIP42	Disconnect 42 operation in progress	43
89OIP43	Disconnect 43 operation in progress	43
89OIP44	Disconnect 44 operation in progress	44
89OIP45	Disconnect 45 operation in progress	44
89OIP46	Disconnect 46 operation in progress	45
89OIP47	Disconnect 47 operation in progress	46
89OIP48	Disconnect 48 operation in progress	46
89OIP49	Disconnect 49 operation in progress	47
89OIP50	Disconnect 50 operation in progress	48
89OIP51	Disconnect 51 operation in progress	48
89OIP52	Disconnect 52 operation in progress	49
89OIP53	Disconnect 53 operation in progress	49
89OIP54	Disconnect 54 operation in progress	50
89OIP55	Disconnect 55 operation in progress	51
89OIP56	Disconnect 56 operation in progress	51
89OIP57	Disconnect 57 operation in progress	52
89OIP58	Disconnect 58 operation in progress	53
89OIP59	Disconnect 59 operation in progress	53
89OIP60	Disconnect 60 operation in progress	54
ABFIT01	Circuit Breaker 1 alternate circuit breaker failure initiate	183
ABFIT02	Circuit Breaker 2 alternate circuit breaker failure initiate	184
ABFIT03	Circuit Breaker 3 alternate circuit breaker failure initiate	185
ABFIT04	Circuit Breaker 4 alternate circuit breaker failure initiate	186
ABFIT05	Circuit Breaker 5 alternate circuit breaker failure initiate	187
ABFIT06	Circuit Breaker 6 alternate circuit breaker failure initiate	188
ABFIT07	Circuit Breaker 7 alternate circuit breaker failure initiate	189
ABFIT08	Circuit Breaker 8 alternate circuit breaker failure initiate	190
ABFIT09	Circuit Breaker 9 alternate circuit breaker failure initiate	191
ABFIT10	Circuit Breaker 10 alternate circuit breaker failure initiate	192
ABFIT11	Circuit Breaker 11 alternate circuit breaker failure initiate	193
ABFIT12	Circuit Breaker 12 alternate circuit breaker failure initiate	194
ABFIT13	Circuit Breaker 13 alternate circuit breaker failure initiate	195

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 18 of 79)

Name	Bit Description	Row
ABFIT14	Circuit Breaker 14 alternate circuit breaker failure initiate	196
ABFIT15	Circuit Breaker 15 alternate circuit breaker failure initiate	197
ABFIT16	Circuit Breaker 16 alternate circuit breaker failure initiate	198
ABFIT17	Circuit Breaker 17 alternate circuit breaker failure initiate	199
ABFIT18	Circuit Breaker 18 alternate circuit breaker failure initiate	200
ABFIT19	Circuit Breaker 19 alternate circuit breaker failure initiate	201
ABFIT20	Circuit Breaker 20 alternate circuit breaker failure initiate	202
ABFIT21	Circuit Breaker 21 alternate circuit breaker failure initiate	203
ACCESS	A user is connected at Access Level B or higher	377
ACCESSP	Pulsed when higher level access achieved	377
ACN01Q	Automation counter Output 1	366
ACN01R	Automation counter Reset 1	370
ACN02Q	Automation counter Output 2	366
ACN02R	Automation counter Reset 2	370
ACN03Q	Automation counter Output 3	366
ACN03R	Automation counter Reset 3	370
ACN04Q	Automation counter Output 4	366
ACN04R	Automation counter Reset 4	370
ACN05Q	Automation counter Output 5	366
ACN05R	Automation counter Reset 5	370
ACN06Q	Automation counter Output 6	366
ACN06R	Automation counter Reset 6	370
ACN07Q	Automation counter Output 7	366
ACN07R	Automation counter Reset 7	370
ACN08Q	Automation counter Output 8	366
ACN08R	Automation counter Reset 8	370
ACN09Q	Automation counter Output 9	367
ACN09R	Automation counter Reset 9	371
ACN10Q	Automation counter Output 10	367
ACN10R	Automation counter Reset 10	371
ACN11Q	Automation counter Output 11	367
ACN11R	Automation counter Reset 11	371
ACN12Q	Automation counter Output 12	367
ACN12R	Automation counter Reset 12	371
ACN13Q	Automation counter Output 13	367
ACN13R	Automation counter Reset 13	371
ACN14Q	Automation counter Output 14	367
ACN14R	Automation counter Reset 14	371
ACN15Q	Automation counter Output 15	367
ACN15R	Automation counter Reset 15	371
ACN16Q	Automation counter Output 16	367

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 19 of 79)

Name	Bit Description	Row
ACN16R	Automation counter Reset 16	371
ACN17Q	Automation counter Output 17	368
ACN17R	Automation counter Reset 17	372
ACN18Q	Automation counter Output 18	368
ACN18R	Automation counter Reset 18	372
ACN19Q	Automation counter Output 19	368
ACN19R	Automation counter Reset 19	372
ACN20Q	Automation counter Output 20	368
ACN20R	Automation counter Reset 20	372
ACN21Q	Automation counter Output 21	368
ACN21R	Automation counter Reset 21	372
ACN22Q	Automation counter Output 22	368
ACN22R	Automation counter Reset 22	372
ACN23Q	Automation counter Output 23	368
ACN23R	Automation counter Reset 23	372
ACN24Q	Automation counter Output 24	368
ACN24R	Automation counter Reset 24	372
ACN25Q	Automation counter Output 25	369
ACN25R	Automation counter Reset 25	373
ACN26Q	Automation counter Output 26	369
ACN26R	Automation counter Reset 26	373
ACN27Q	Automation counter Output 27	369
ACN27R	Automation counter Reset 27	373
ACN28Q	Automation counter Output 28	369
ACN28R	Automation counter Reset 28	373
ACN29Q	Automation counter Output 29	369
ACN29R	Automation counter Reset 29	373
ACN30Q	Automation counter Output 30	369
ACN30R	Automation counter Reset 30	373
ACN31Q	Automation counter Output 31	369
ACN31R	Automation counter Reset 31	373
ACN32Q	Automation counter Output 32	369
ACN32R	Automation counter Reset 32	373
ACT01Q	Automation conditioning timer Output 01	484
ACT02Q	Automation conditioning timer Output 02	484
ACT03Q	Automation conditioning timer Output 03	484
ACT04Q	Automation conditioning timer Output 04	484
ACT05Q	Automation conditioning timer Output 05	484
ACT06Q	Automation conditioning timer Output 06	484
ACT07Q	Automation conditioning timer Output 07	484
ACT08Q	Automation conditioning timer Output 08	484

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 20 of 79)

Name	Bit Description	Row
ACT09Q	Automation conditioning timer Output 09	485
ACT10Q	Automation conditioning timer Output 10	485
ACT11Q	Automation conditioning timer Output 11	485
ACT12Q	Automation conditioning timer Output 12	485
ACT13Q	Automation conditioning timer Output 13	485
ACT14Q	Automation conditioning timer Output 14	485
ACT15Q	Automation conditioning timer Output 15	485
ACT16Q	Automation conditioning timer Output 16	485
ACT17Q	Automation conditioning timer Output 17	486
ACT18Q	Automation conditioning timer Output 18	486
ACT19Q	Automation conditioning timer Output 19	486
ACT20Q	Automation conditioning timer Output 20	486
ACT21Q	Automation conditioning timer Output 21	486
ACT22Q	Automation conditioning timer Output 22	486
ACT23Q	Automation conditioning timer Output 23	486
ACT24Q	Automation conditioning timer Output 24	486
ACT25Q	Automation conditioning timer Output 25	487
ACT26Q	Automation conditioning timer Output 26	487
ACT27Q	Automation conditioning timer Output 27	487
ACT28Q	Automation conditioning timer Output 28	487
ACT29Q	Automation conditioning timer Output 29	487
ACT30Q	Automation conditioning timer Output 30	487
ACT31Q	Automation conditioning timer Output 31	487
ACT32Q	Automation conditioning timer Output 32	487
ACTRP1	Coupler 1 accelerated trip SELOGIC control equation	176
ACTRP2	Coupler 2 accelerated trip SELOGIC control equation	177
ACTRP3	Coupler 3 accelerated trip SELOGIC control equation	178
ACTRP4	Coupler 4 accelerated trip SELOGIC control equation	179
ACTRPT1	Coupler 1 accelerated trip timed out	176
ACTRPT2	Coupler 2 accelerated trip timed out	177
ACTRPT3	Coupler 3 accelerated trip timed out	178
ACTRPT4	Coupler 4 accelerated trip timed out	179
AFRTEXA	Automation SELOGIC control equation first execution automation	375
AFRTEXP	Automation SELOGIC control equation first execution protection	375
ALT01	Automation Latch 1	354
ALT02	Automation Latch 2	354
ALT03	Automation Latch 3	354
ALT04	Automation Latch 4	354
ALT05	Automation Latch 5	354
ALT06	Automation Latch 6	354
ALT07	Automation Latch 7	354

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 21 of 79)

Name	Bit Description	Row
ALT08	Automation Latch 8	354
ALT09	Automation Latch 9	355
ALT10	Automation Latch 10	355
ALT11	Automation Latch 11	355
ALT12	Automation Latch 12	355
ALT13	Automation Latch 13	355
ALT14	Automation Latch 14	355
ALT15	Automation Latch 15	355
ALT16	Automation Latch 16	355
ALT17	Automation Latch 17	356
ALT18	Automation Latch 18	356
ALT19	Automation Latch 19	356
ALT20	Automation Latch 20	356
ALT21	Automation Latch 21	356
ALT22	Automation Latch 22	356
ALT23	Automation Latch 23	356
ALT24	Automation Latch 24	356
ALT25	Automation Latch 25	357
ALT26	Automation Latch 26	357
ALT27	Automation Latch 27	357
ALT28	Automation Latch 28	357
ALT29	Automation Latch 29	357
ALT30	Automation Latch 30	357
ALT31	Automation Latch 31	357
ALT32	Automation Latch 32	357
ANOKA	Channel A MIRRORED BITS analog transfer OK	404
ANOKB	Channel B MIRRORED BITS analog transfer OK	405
AST01Q	Automation sequencing timer Output 1	358
AST01R	Automation sequencing timer Reset 1	362
AST02Q	Automation sequencing timer Output 2	358
AST02R	Automation sequencing timer Reset 2	362
AST03Q	Automation sequencing timer Output 3	358
AST03R	Automation sequencing timer Reset 3	362
AST04Q	Automation sequencing timer Output 4	358
AST04R	Automation sequencing timer Reset 4	362
AST05Q	Automation sequencing timer Output 5	358
AST05R	Automation sequencing timer Reset 5	362
AST06Q	Automation sequencing timer Output 6	358
AST06R	Automation sequencing timer Reset 6	362
AST07Q	Automation sequencing timer Output 7	358
AST07R	Automation sequencing timer Reset 7	362

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 22 of 79)

Name	Bit Description	Row
AST08Q	Automation sequencing timer Output 8	358
AST08R	Automation sequencing timer Reset 8	362
AST09Q	Automation sequencing timer Output 9	359
AST09R	Automation sequencing timer Reset 9	363
AST10Q	Automation sequencing timer Output 10	359
AST10R	Automation sequencing timer Reset 10	363
AST11Q	Automation sequencing timer Output 11	359
AST11R	Automation sequencing timer Reset 11	363
AST12Q	Automation sequencing timer Output 12	359
AST12R	Automation sequencing timer Reset 12	363
AST13Q	Automation sequencing timer Output 13	359
AST13R	Automation sequencing timer Reset 13	363
AST14Q	Automation sequencing timer Output 14	359
AST14R	Automation sequencing timer Reset 14	363
AST15Q	Automation sequencing timer Output 15	359
AST15R	Automation sequencing timer Reset 15	363
AST16Q	Automation sequencing timer Output 16	359
AST16R	Automation sequencing timer Reset 16	363
AST17Q	Automation sequencing timer Output 17	360
AST17R	Automation sequencing timer Reset 17	364
AST18Q	Automation sequencing timer Output 18	360
AST18R	Automation sequencing timer Reset 18	364
AST19Q	Automation sequencing timer Output 19	360
AST19R	Automation sequencing timer Reset 19	364
AST20Q	Automation sequencing timer Output 20	360
AST20R	Automation sequencing timer Reset 20	364
AST21Q	Automation sequencing timer Output 21	360
AST21R	Automation sequencing timer Reset 21	364
AST22Q	Automation sequencing timer Output 22	360
AST22R	Automation sequencing timer Reset 22	364
AST23Q	Automation sequencing timer Output 23	360
AST23R	Automation sequencing timer Reset 23	364
AST24Q	Automation sequencing timer Output 24	360
AST24R	Automation sequencing timer Reset 24	364
AST25Q	Automation sequencing timer Output 25	361
AST25R	Automation sequencing timer Reset 25	365
AST26Q	Automation sequencing timer Output 26	361
AST26R	Automation sequencing timer Reset 26	365
AST27Q	Automation sequencing timer Output 27	361
AST27R	Automation sequencing timer Reset 27	365
AST28Q	Automation sequencing timer Output 28	361

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 23 of 79)

Name	Bit Description	Row
AST28R	Automation sequencing timer Reset 28	365
AST29Q	Automation sequencing timer Output 29	361
AST29R	Automation sequencing timer Reset 29	365
AST30Q	Automation sequencing timer Output 30	361
AST30R	Automation sequencing timer Reset 30	365
AST31Q	Automation sequencing timer Output 31	361
AST31R	Automation sequencing timer Reset 31	365
AST32Q	Automation sequencing timer Output 32	361
AST32R	Automation sequencing timer Reset 32	365
ASV001	Automation SELOGIC control equation Variable 1	322
ASV002	Automation SELOGIC control equation Variable 2	322
ASV003	Automation SELOGIC control equation Variable 3	322
ASV004	Automation SELOGIC control equation Variable 4	322
ASV005	Automation SELOGIC control equation Variable 5	322
ASV006	Automation SELOGIC control equation Variable 6	322
ASV007	Automation SELOGIC control equation Variable 7	322
ASV008	Automation SELOGIC control equation Variable 8	322
ASV009	Automation SELOGIC control equation Variable 9	323
ASV010	Automation SELOGIC control equation Variable 10	323
ASV011	Automation SELOGIC control equation Variable 11	323
ASV012	Automation SELOGIC control equation Variable 12	323
ASV013	Automation SELOGIC control equation Variable 13	323
ASV014	Automation SELOGIC control equation Variable 14	323
ASV015	Automation SELOGIC control equation Variable 15	323
ASV016	Automation SELOGIC control equation Variable 16	323
ASV017	Automation SELOGIC control equation Variable 17	324
ASV018	Automation SELOGIC control equation Variable 18	324
ASV019	Automation SELOGIC control equation Variable 19	324
ASV020	Automation SELOGIC control equation Variable 20	324
ASV021	Automation SELOGIC control equation Variable 21	324
ASV022	Automation SELOGIC control equation Variable 22	324
ASV023	Automation SELOGIC control equation Variable 23	324
ASV024	Automation SELOGIC control equation Variable 24	324
ASV025	Automation SELOGIC control equation Variable 25	325
ASV026	Automation SELOGIC control equation Variable 26	325
ASV027	Automation SELOGIC control equation Variable 27	325
ASV028	Automation SELOGIC control equation Variable 28	325
ASV029	Automation SELOGIC control equation Variable 29	325
ASV030	Automation SELOGIC control equation Variable 30	325
ASV031	Automation SELOGIC control equation Variable 31	325
ASV032	Automation SELOGIC control equation Variable 32	325

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 24 of 79)

Name	Bit Description	Row
ASV033	Automation SELOGIC control equation Variable 33	326
ASV034	Automation SELOGIC control equation Variable 34	326
ASV035	Automation SELOGIC control equation Variable 35	326
ASV036	Automation SELOGIC control equation Variable 36	326
ASV037	Automation SELOGIC control equation Variable 37	326
ASV038	Automation SELOGIC control equation Variable 38	326
ASV039	Automation SELOGIC control equation Variable 39	326
ASV040	Automation SELOGIC control equation Variable 40	326
ASV041	Automation SELOGIC control equation Variable 41	327
ASV042	Automation SELOGIC control equation Variable 42	327
ASV043	Automation SELOGIC control equation Variable 43	327
ASV044	Automation SELOGIC control equation Variable 44	327
ASV045	Automation SELOGIC control equation Variable 45	327
ASV046	Automation SELOGIC control equation Variable 46	327
ASV047	Automation SELOGIC control equation Variable 47	327
ASV048	Automation SELOGIC control equation Variable 48	327
ASV049	Automation SELOGIC control equation Variable 49	328
ASV050	Automation SELOGIC control equation Variable 50	328
ASV051	Automation SELOGIC control equation Variable 51	328
ASV052	Automation SELOGIC control equation Variable 52	328
ASV053	Automation SELOGIC control equation Variable 53	328
ASV054	Automation SELOGIC control equation Variable 54	328
ASV055	Automation SELOGIC control equation Variable 55	328
ASV056	Automation SELOGIC control equation Variable 56	328
ASV057	Automation SELOGIC control equation Variable 57	329
ASV058	Automation SELOGIC control equation Variable 58	329
ASV059	Automation SELOGIC control equation Variable 59	329
ASV060	Automation SELOGIC control equation Variable 60	329
ASV061	Automation SELOGIC control equation Variable 61	329
ASV062	Automation SELOGIC control equation Variable 62	329
ASV063	Automation SELOGIC control equation Variable 63	329
ASV064	Automation SELOGIC control equation Variable 64	329
ASV065	Automation SELOGIC control equation Variable 65	330
ASV066	Automation SELOGIC control equation Variable 66	330
ASV067	Automation SELOGIC control equation Variable 67	330
ASV068	Automation SELOGIC control equation Variable 68	330
ASV069	Automation SELOGIC control equation Variable 69	330
ASV070	Automation SELOGIC control equation Variable 70	330
ASV071	Automation SELOGIC control equation Variable 71	330
ASV072	Automation SELOGIC control equation Variable 72	330
ASV073	Automation SELOGIC control equation Variable 73	331

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 25 of 79)

Name	Bit Description	Row
ASV074	Automation SELOGIC control equation Variable 74	331
ASV075	Automation SELOGIC control equation Variable 75	331
ASV076	Automation SELOGIC control equation Variable 76	331
ASV077	Automation SELOGIC control equation Variable 77	331
ASV078	Automation SELOGIC control equation Variable 78	331
ASV079	Automation SELOGIC control equation Variable 79	331
ASV080	Automation SELOGIC control equation Variable 80	331
ASV081	Automation SELOGIC control equation Variable 81	332
ASV082	Automation SELOGIC control equation Variable 82	332
ASV083	Automation SELOGIC control equation Variable 83	332
ASV084	Automation SELOGIC control equation Variable 84	332
ASV085	Automation SELOGIC control equation Variable 85	332
ASV086	Automation SELOGIC control equation Variable 86	332
ASV087	Automation SELOGIC control equation Variable 87	332
ASV088	Automation SELOGIC control equation Variable 88	332
ASV089	Automation SELOGIC control equation Variable 89	333
ASV090	Automation SELOGIC control equation Variable 90	333
ASV091	Automation SELOGIC control equation Variable 91	333
ASV092	Automation SELOGIC control equation Variable 92	333
ASV093	Automation SELOGIC control equation Variable 93	333
ASV094	Automation SELOGIC control equation Variable 94	333
ASV095	Automation SELOGIC control equation Variable 95	333
ASV096	Automation SELOGIC control equation Variable 96	333
ASV097	Automation SELOGIC control equation Variable 097	334
ASV098	Automation SELOGIC control equation Variable 098	334
ASV099	Automation SELOGIC control equation Variable 099	334
ASV100	Automation SELOGIC control equation Variable 100	334
ASV101	Automation SELOGIC control equation Variable 101	334
ASV102	Automation SELOGIC control equation Variable 102	334
ASV103	Automation SELOGIC control equation Variable 103	334
ASV104	Automation SELOGIC control equation Variable 104	334
ASV105	Automation SELOGIC control equation Variable 105	335
ASV106	Automation SELOGIC control equation Variable 106	335
ASV107	Automation SELOGIC control equation Variable 107	335
ASV108	Automation SELOGIC control equation Variable 108	335
ASV109	Automation SELOGIC control equation Variable 109	335
ASV110	Automation SELOGIC control equation Variable 110	335
ASV111	Automation SELOGIC control equation Variable 111	335
ASV112	Automation SELOGIC control equation Variable 112	335
ASV113	Automation SELOGIC control equation Variable 113	336
ASV114	Automation SELOGIC control equation Variable 114	336

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 26 of 79)

Name	Bit Description	Row
ASV115	Automation SELOGIC control equation Variable 115	336
ASV116	Automation SELOGIC control equation Variable 116	336
ASV117	Automation SELOGIC control equation Variable 117	336
ASV118	Automation SELOGIC control equation Variable 118	336
ASV119	Automation SELOGIC control equation Variable 119	336
ASV120	Automation SELOGIC control equation Variable 120	336
ASV121	Automation SELOGIC control equation Variable 121	337
ASV122	Automation SELOGIC control equation Variable 122	337
ASV123	Automation SELOGIC control equation Variable 123	337
ASV124	Automation SELOGIC control equation Variable 124	337
ASV125	Automation SELOGIC control equation Variable 125	337
ASV126	Automation SELOGIC control equation Variable 126	337
ASV127	Automation SELOGIC control equation Variable 127	337
ASV128	Automation SELOGIC control equation Variable 128	337
ASV129	Automation SELOGIC control equation Variable 129	338
ASV130	Automation SELOGIC control equation Variable 130	338
ASV131	Automation SELOGIC control equation Variable 131	338
ASV132	Automation SELOGIC control equation Variable 132	338
ASV133	Automation SELOGIC control equation Variable 133	338
ASV134	Automation SELOGIC control equation Variable 134	338
ASV135	Automation SELOGIC control equation Variable 135	338
ASV136	Automation SELOGIC control equation Variable 136	338
ASV137	Automation SELOGIC control equation Variable 137	339
ASV138	Automation SELOGIC control equation Variable 138	339
ASV139	Automation SELOGIC control equation Variable 139	339
ASV140	Automation SELOGIC control equation Variable 140	339
ASV141	Automation SELOGIC control equation Variable 141	339
ASV142	Automation SELOGIC control equation Variable 142	339
ASV143	Automation SELOGIC control equation Variable 143	339
ASV144	Automation SELOGIC control equation Variable 144	339
ASV145	Automation SELOGIC control equation Variable 145	340
ASV146	Automation SELOGIC control equation Variable 146	340
ASV147	Automation SELOGIC control equation Variable 147	340
ASV148	Automation SELOGIC control equation Variable 148	340
ASV149	Automation SELOGIC control equation Variable 149	340
ASV150	Automation SELOGIC control equation Variable 150	340
ASV151	Automation SELOGIC control equation Variable 151	340
ASV152	Automation SELOGIC control equation Variable 152	340
ASV153	Automation SELOGIC control equation Variable 153	341
ASV154	Automation SELOGIC control equation Variable 154	341
ASV155	Automation SELOGIC control equation Variable 155	341

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 27 of 79)

Name	Bit Description	Row
ASV156	Automation SELOGIC control equation Variable 156	341
ASV157	Automation SELOGIC control equation Variable 157	341
ASV158	Automation SELOGIC control equation Variable 158	341
ASV159	Automation SELOGIC control equation Variable 159	341
ASV160	Automation SELOGIC control equation Variable 160	341
ASV161	Automation SELOGIC control equation Variable 161	342
ASV162	Automation SELOGIC control equation Variable 162	342
ASV163	Automation SELOGIC control equation Variable 163	342
ASV164	Automation SELOGIC control equation Variable 164	342
ASV165	Automation SELOGIC control equation Variable 165	342
ASV166	Automation SELOGIC control equation Variable 166	342
ASV167	Automation SELOGIC control equation Variable 167	342
ASV168	Automation SELOGIC control equation Variable 168	342
ASV169	Automation SELOGIC control equation Variable 169	343
ASV170	Automation SELOGIC control equation Variable 170	343
ASV171	Automation SELOGIC control equation Variable 171	343
ASV172	Automation SELOGIC control equation Variable 172	343
ASV173	Automation SELOGIC control equation Variable 173	343
ASV174	Automation SELOGIC control equation Variable 174	343
ASV175	Automation SELOGIC control equation Variable 175	343
ASV176	Automation SELOGIC control equation Variable 176	343
ASV177	Automation SELOGIC control equation Variable 177	344
ASV178	Automation SELOGIC control equation Variable 178	344
ASV179	Automation SELOGIC control equation Variable 179	344
ASV180	Automation SELOGIC control equation Variable 180	344
ASV181	Automation SELOGIC control equation Variable 181	344
ASV182	Automation SELOGIC control equation Variable 182	344
ASV183	Automation SELOGIC control equation Variable 183	344
ASV184	Automation SELOGIC control equation Variable 184	344
ASV185	Automation SELOGIC control equation Variable 185	345
ASV186	Automation SELOGIC control equation Variable 186	345
ASV187	Automation SELOGIC control equation Variable 187	345
ASV188	Automation SELOGIC control equation Variable 188	345
ASV189	Automation SELOGIC control equation Variable 189	345
ASV190	Automation SELOGIC control equation Variable 190	345
ASV191	Automation SELOGIC control equation Variable 191	345
ASV192	Automation SELOGIC control equation Variable 192	345
ASV193	Automation SELOGIC control equation Variable 193	346
ASV194	Automation SELOGIC control equation Variable 194	346
ASV195	Automation SELOGIC control equation Variable 195	346
ASV196	Automation SELOGIC control equation Variable 196	346

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 28 of 79)

Name	Bit Description	Row
ASV197	Automation SELOGIC control equation Variable 197	346
ASV198	Automation SELOGIC control equation Variable 198	346
ASV199	Automation SELOGIC control equation Variable 199	346
ASV200	Automation SELOGIC control equation Variable 200	346
ASV201	Automation SELOGIC control equation Variable 201	347
ASV202	Automation SELOGIC control equation Variable 202	347
ASV203	Automation SELOGIC control equation Variable 203	347
ASV204	Automation SELOGIC control equation Variable 204	347
ASV205	Automation SELOGIC control equation Variable 205	347
ASV206	Automation SELOGIC control equation Variable 206	347
ASV207	Automation SELOGIC control equation Variable 207	347
ASV208	Automation SELOGIC control equation Variable 208	347
ASV209	Automation SELOGIC control equation Variable 209	348
ASV210	Automation SELOGIC control equation Variable 210	348
ASV211	Automation SELOGIC control equation Variable 211	348
ASV212	Automation SELOGIC control equation Variable 212	348
ASV213	Automation SELOGIC control equation Variable 213	348
ASV214	Automation SELOGIC control equation Variable 214	348
ASV215	Automation SELOGIC control equation Variable 215	348
ASV216	Automation SELOGIC control equation Variable 216	348
ASV217	Automation SELOGIC control equation Variable 217	349
ASV218	Automation SELOGIC control equation Variable 218	349
ASV219	Automation SELOGIC control equation Variable 219	349
ASV220	Automation SELOGIC control equation Variable 220	349
ASV221	Automation SELOGIC control equation Variable 221	349
ASV222	Automation SELOGIC control equation Variable 222	349
ASV223	Automation SELOGIC control equation Variable 223	349
ASV224	Automation SELOGIC control equation Variable 224	349
ASV225	Automation SELOGIC control equation Variable 225	350
ASV226	Automation SELOGIC control equation Variable 226	350
ASV227	Automation SELOGIC control equation Variable 227	350
ASV228	Automation SELOGIC control equation Variable 228	350
ASV229	Automation SELOGIC control equation Variable 229	350
ASV230	Automation SELOGIC control equation Variable 230	350
ASV231	Automation SELOGIC control equation Variable 231	350
ASV232	Automation SELOGIC control equation Variable 232	350
ASV233	Automation SELOGIC control equation Variable 233	351
ASV234	Automation SELOGIC control equation Variable 234	351
ASV235	Automation SELOGIC control equation Variable 235	351
ASV236	Automation SELOGIC control equation Variable 236	351
ASV237	Automation SELOGIC control equation Variable 237	351

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 29 of 79)

Name	Bit Description	Row
ASV238	Automation SELOGIC control equation Variable 238	351
ASV239	Automation SELOGIC control equation Variable 239	351
ASV240	Automation SELOGIC control equation Variable 240	351
ASV241	Automation SELOGIC control equation Variable 241	352
ASV242	Automation SELOGIC control equation Variable 242	352
ASV243	Automation SELOGIC control equation Variable 243	352
ASV244	Automation SELOGIC control equation Variable 244	352
ASV245	Automation SELOGIC control equation Variable 245	352
ASV246	Automation SELOGIC control equation Variable 246	352
ASV247	Automation SELOGIC control equation Variable 247	352
ASV248	Automation SELOGIC control equation Variable 248	352
ASV249	Automation SELOGIC control equation Variable 249	353
ASV250	Automation SELOGIC control equation Variable 250	353
ASV251	Automation SELOGIC control equation Variable 251	353
ASV252	Automation SELOGIC control equation Variable 252	353
ASV253	Automation SELOGIC control equation Variable 253	353
ASV254	Automation SELOGIC control equation Variable 254	353
ASV255	Automation SELOGIC control equation Variable 255	353
ASV256	Automation SELOGIC control equation Variable 256	353
ATBFI01	Circuit Breaker 1 alternate breaker failure initiate SELOGIC control equation	183
ATBFI02	Circuit Breaker 2 alternate breaker failure initiate SELOGIC control equation	184
ATBFI03	Circuit Breaker 3 alternate breaker failure initiate SELOGIC control equation	185
ATBFI04	Circuit Breaker 4 alternate breaker failure initiate SELOGIC control equation	186
ATBFI05	Circuit Breaker 5 alternate breaker failure initiate SELOGIC control equation	187
ATBFI06	Circuit Breaker 6 alternate breaker failure initiate SELOGIC control equation	188
ATBFI07	Circuit Breaker 7 alternate breaker failure initiate SELOGIC control equation	189
ATBFI08	Circuit Breaker 8 alternate breaker failure initiate SELOGIC control equation	190
ATBFI09	Circuit Breaker 9 alternate breaker failure initiate SELOGIC control equation	191
ATBFI10	Circuit Breaker 10 alternate breaker failure initiate SELOGIC control equation	192
ATBFI11	Circuit Breaker 11 alternate breaker failure initiate SELOGIC control equation	193
ATBFI12	Circuit Breaker 12 alternate breaker failure initiate SELOGIC control equation	194
ATBFI13	Circuit Breaker 13 alternate breaker failure initiate SELOGIC control equation	195
ATBFI14	Circuit Breaker 14 alternate breaker failure initiate SELOGIC control equation	196
ATBFI15	Circuit Breaker 15 alternate breaker failure initiate SELOGIC control equation	197
ATBFI16	Circuit Breaker 16 alternate breaker failure initiate SELOGIC control equation	198
ATBFI17	Circuit Breaker 17 alternate breaker failure initiate SELOGIC control equation	199
ATBFI18	Circuit Breaker 18 alternate breaker failure initiate SELOGIC control equation	200
ATBFI19	Circuit Breaker 19 alternate breaker failure initiate SELOGIC control equation	201
ATBFI20	Circuit Breaker 20 alternate breaker failure initiate SELOGIC control equation	202
ATBFI21	Circuit Breaker 21 alternate breaker failure initiate SELOGIC control equation	203
AUNRLBL	Automation SELOGIC control equation unresolved label	375

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 30 of 79)

Name	Bit Description	Row
BADPASS	Pulsed when user enters three successive bad passwords	376
BFI01	Circuit Breaker 1 breaker failure initiate SELOGIC control equation	183
BFI02	Circuit Breaker 2 breaker failure initiate SELOGIC control equation	184
BFI03	Circuit Breaker 3 breaker failure initiate SELOGIC control equation	185
BFI04	Circuit Breaker 4 breaker failure initiate SELOGIC control equation	186
BFI05	Circuit Breaker 5 breaker failure initiate SELOGIC control equation	187
BFI06	Circuit Breaker 6 breaker failure initiate SELOGIC control equation	188
BFI07	Circuit Breaker 7 breaker failure initiate SELOGIC control equation	189
BFI08	Circuit Breaker 8 breaker failure initiate SELOGIC control equation	190
BFI09	Circuit Breaker 9 breaker failure initiate SELOGIC control equation	191
BFI10	Circuit Breaker 10 breaker failure initiate SELOGIC control equation	192
BFI11	Circuit Breaker 11 breaker failure initiate SELOGIC control equation	193
BFI12	Circuit Breaker 12 breaker failure initiate SELOGIC control equation	194
BFI13	Circuit Breaker 13 breaker failure initiate SELOGIC control equation	195
BFI14	Circuit Breaker 14 breaker failure initiate SELOGIC control equation	196
BFI15	Circuit Breaker 15 breaker failure initiate SELOGIC control equation	197
BFI16	Circuit Breaker 16 breaker failure initiate SELOGIC control equation	198
BFI17	Circuit Breaker 17 breaker failure initiate SELOGIC control equation	199
BFI18	Circuit Breaker 18 breaker failure initiate SELOGIC control equation	200
BFI19	Circuit Breaker 19 breaker failure initiate SELOGIC control equation	201
BFI20	Circuit Breaker 20 breaker failure initiate SELOGIC control equation	202
BFI21	Circuit Breaker 21 breaker failure initiate SELOGIC control equation	203
BFIT01	Circuit Breaker 1 breaker failure timed out	183
BFIT02	Circuit Breaker 2 breaker failure timed out	184
BFIT03	Circuit Breaker 3 breaker failure timed out	185
BFIT04	Circuit Breaker 4 breaker failure timed out	186
BFIT05	Circuit Breaker 5 breaker failure timed out	187
BFIT06	Circuit Breaker 6 breaker failure timed out	188
BFIT07	Circuit Breaker 7 breaker failure timed out	189
BFIT08	Circuit Breaker 8 breaker failure timed out	190
BFIT09	Circuit Breaker 9 breaker failure timed out	191
BFIT10	Circuit Breaker 10 breaker failure timed out	192
BFIT11	Circuit Breaker 11 breaker failure timed out	193
BFIT12	Circuit Breaker 12 breaker failure timed out	194
BFIT13	Circuit Breaker 13 breaker failure timed out	195
BFIT14	Circuit Breaker 14 breaker failure timed out	196
BFIT15	Circuit Breaker 15 breaker failure timed out	197
BFIT16	Circuit Breaker 16 breaker failure timed out	198
BFIT17	Circuit Breaker 17 breaker failure timed out	199
BFIT18	Circuit Breaker 18 breaker failure timed out	200
BFIT19	Circuit Breaker 19 breaker failure timed out	201

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 31 of 79)

Name	Bit Description	Row
BFIT20	Circuit Breaker 20 breaker failure timed out	202
BFIT21	Circuit Breaker 21 breaker failure timed out	203
BFZ1	Zone 1 breaker failure	240
BFZ2	Zone 2 breaker failure	240
BFZ3	Zone 3 breaker failure	240
BFZ4	Zone 4 breaker failure	240
BFZ5	Zone 5 breaker failure	240
BFZ6	Zone 6 breaker failure	240
BLKLPTS	Block low-priority source from updating relay time	379
BNC_BNP	Bad jitter on BNC port and the IRIG-B signal is lost afterwards	472
BNC_OK	IRIG-B signal from BNC port is available and has sufficient quality	472
BNC_RST	Disqualify BNC IRIG-B time source	472
BNC_SET	Qualify BNC IRIG-B time source	472
BNC_TIM	A valid IRIG-B time source is detected on BNC port	473
BNCSYNC	Synchronized to a high-quality BNC IRIG source	474
BRKENAB	Asserts to indicate breaker control enable jumper is installed	377
BZ1BZ2R	A connection exists between BZ1 and BZ2 and a coupler is removed	136
BZ1BZ2V	A connection exists between BZ1 and BZ2	128
BZ1BZ3R	A connection exists between BZ1 and BZ3 and a coupler is removed	136
BZ1BZ3V	A connection exists between BZ1 and BZ3	128
BZ1BZ4R	A connection exists between BZ1 and BZ4 and a coupler is removed	136
BZ1BZ4V	A connection exists between BZ1 and BZ4	128
BZ1BZ5R	A connection exists between BZ1 and BZ5 and a coupler is removed	136
BZ1BZ5V	A connection exists between BZ1 and BZ5	128
BZ1BZ6R	A connection exists between BZ1 and BZ6 and a coupler is removed	136
BZ1BZ6V	A connection exists between BZ1 and BZ6	128
BZ2BZ3R	A connection exists between BZ2 and BZ3 and a coupler is removed	137
BZ2BZ3V	A connection exists between BZ2 and BZ3	129
BZ2BZ4R	A connection exists between BZ2 and BZ4 and a coupler is removed	137
BZ2BZ4V	A connection exists between BZ2 and BZ4	129
BZ2BZ5R	A connection exists between BZ2 and BZ5 and a coupler is removed	137
BZ2BZ5V	A connection exists between BZ2 and BZ5	129
BZ2BZ6R	A connection exists between BZ2 and BZ6 and a coupler is removed	137
BZ2BZ6V	A connection exists between BZ2 and BZ6	129
BZ3BZ4R	A connection exists between BZ3 and BZ4 and a coupler is removed	138
BZ3BZ4V	A connection exists between BZ3 and BZ4	130
BZ3BZ5R	A connection exists between BZ3 and BZ5 and a coupler is removed	138
BZ3BZ5V	A connection exists between BZ3 and BZ5	130
BZ3BZ6R	A connection exists between BZ3 and BZ6 and a coupler is removed	138
BZ3BZ6V	A connection exists between BZ3 and BZ6	130
BZ4BZ5R	A connection exists between BZ4 and BZ5 and a coupler is removed	139

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 32 of 79)

Name	Bit Description	Row
BZ4BZ5V	A connection exists between BZ4 and BZ5	131
BZ4BZ6R	A connection exists between BZ4 and BZ6 and a coupler is removed	139
BZ4BZ6V	A connection exists between BZ4 and BZ6	131
BZ5BZ6R	A connection exists between BZ5 and BZ6 and a coupler is removed	140
BZ5BZ6V	A connection exists between BZ5 and BZ6	132
CB52A1	Coupler 1 status SELOGIC control equation	176
CB52A2	Coupler 2 status SELOGIC control equation	177
CB52A3	Coupler 3 status SELOGIC control equation	178
CB52A4	Coupler 4 status SELOGIC control equation	179
CB52T1	Coupler 1 status timed out	176
CB52T2	Coupler 2 status timed out	177
CB52T3	Coupler 3 status timed out	178
CB52T4	Coupler 4 status timed out	179
CBADA	Channel A MIRRORED BITS unavailability	404
CBADB	Channel B MIRRORED BITS unavailability	405
CBCLS1	Coupler 1 close command SELOGIC control equation	176
CBCLS2	Coupler 2 close command SELOGIC control equation	177
CBCLS3	Coupler 3 close command SELOGIC control equation	178
CBCLS4	Coupler 4 close command SELOGIC control equation	179
CBCLST1	Coupler 1 close command timed out	176
CBCLST2	Coupler 2 close command timed out	177
CBCLST3	Coupler 3 close command timed out	178
CBCLST4	Coupler 4 close command timed out	179
CHSG	Asserted during settings group change	255
CON1	Zone 1 in high-security mode	159
CON2	Zone 2 in high-security mode	161
CON3	Zone 3 in high-security mode	163
CON4	Zone 4 in high-security mode	165
CON5	Zone 5 in high-security mode	167
CON6	Zone 6 in high-security mode	169
CONCZ1	Check Zone 1 in high-security mode	450
CONCZ2	Check Zone 2 in high-security mode	452
CONCZ3	Check Zone 3 in high-security mode	454
CSL1	Coupler 1 security logic picked up	176
CSL2	Coupler 2 security logic picked up	177
CSL3	Coupler 3 security logic picked up	178
CSL4	Coupler 4 security logic picked up	179
CZ11R	Include Bus Coupler 1 in Check Zone 1	407
CZ12R	Include Bus Coupler 2 in Check Zone 1	407
CZ13R	Include Bus Coupler 3 in Check Zone 1	407
CZ14R	Include Bus Coupler 4 in Check Zone 1	407

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 33 of 79)

Name	Bit Description	Row
CZ1S	Check Zone 1 supervision asserted	446
CZ21R	Include Bus Coupler 1 in Check Zone 2	407
CZ22R	Include Bus Coupler 2 in Check Zone 2	407
CZ23R	Include Bus Coupler 3 in Check Zone 2	407
CZ24R	Include Bus Coupler 4 in Check Zone 2	407
CZ2S	Check Zone 2 supervision asserted	446
CZ31R	Include Bus Coupler 1 in Check Zone 3	443
CZ32R	Include Bus Coupler 2 in Check Zone 3	443
CZ33R	Include Bus Coupler 3 in Check Zone 3	443
CZ34R	Include Bus Coupler 4 in Check Zone 3	443
CZ3S	Check Zone 3 supervision asserted	446
CZONE1	Check Zone 1 is active	445
CZONE2	Check Zone 2 is active	445
CZONE3	Check Zone 3 is active	445
DC1F	DC monitor fail alarm	227
DC1G	DC monitor ground fault alarm	227
DC1R	DC monitor alarm for ac ripple	227
DC1W	DC monitor warning alarm	227
DE1F	Zone 1 forward directional element picked up	172
DE2F	Zone 2 forward directional element picked up	172
DE3F	Zone 3 forward directional element picked up	172
DE4F	Zone 4 forward directional element picked up	172
DE5F	Zone 5 forward directional element picked up	172
DE6F	Zone 6 forward directional element picked up	172
DECZ1F	Check Zone 1 forward directional element picked up	456
DECZ2F	Check Zone 2 forward directional element picked up	456
DECZ3F	Check Zone 3 forward directional element picked up	456
DOKA	Channel A MIRRORED BITS communications normal status	404
DOKB	Channel B MIRRORED BITS communications normal status	405
DOP1	Zone 1 incremental operating current picked up	159
DOP2	Zone 2 incremental operating current picked up	161
DOP3	Zone 3 incremental operating current picked up	163
DOP4	Zone 4 incremental operating current picked up	165
DOP5	Zone 5 incremental operating current picked up	167
DOP6	Zone 6 incremental operating current picked up	169
DOPCZ1	Check Zone 1 incremental operating current picked up	450
DOPCZ2	Check Zone 2 incremental operating current picked up	452
DOPCZ3	Check Zone 3 incremental operating current picked up	454
DRT1	Zone 1 incremental restraint current picked up	159
DRT2	Zone 2 incremental restraint current picked up	161
DRT3	Zone 3 incremental restraint current picked up	163

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 34 of 79)

Name	Bit Description	Row
DRT4	Zone 4 incremental restraint current picked up	165
DRT5	Zone 5 incremental restraint current picked up	167
DRT6	Zone 6 incremental restraint current picked up	169
DRTCZ1	Check Zone 1 incremental restraint current picked up	450
DRTCZ2	Check Zone 2 incremental restraint current picked up	452
DRTCZ3	Check Zone 3 incremental restraint current picked up	454
DST	Daylight-saving time	470
DSTP	IRIG-B daylight-saving time pending	470
DUMMY	0	471
E2AC	Enable Levels 1–2 access (SELOGIC control equation)	377
EACC	Enable Level 1 access (SELOGIC control equation)	377
EN	Relay enabled	0
ER	Event report trigger equation (SELOGIC control equation)	241
EVELOCK	Event summary lock period	241
EXT1	Zone 1 external fault declaration	159
EXT2	Zone 2 external fault declaration	161
EXT3	Zone 3 external fault declaration	163
EXT4	Zone 4 external fault declaration	165
EXT5	Zone 5 external fault declaration	167
EXT6	Zone 6 external fault declaration	169
EXTCZ1	Check Zone 1 external fault declaration	450
EXTCZ2	Check Zone 2 external fault declaration	452
EXTCZ3	Check Zone 3 external fault declaration	454
FAULT	Busbar fault in any zone	171
FAULT1	Zone 1 fault detector picked up	159
FAULT2	Zone 2 fault detector picked up	161
FAULT3	Zone 3 fault detector picked up	163
FAULT4	Zone 4 fault detector picked up	165
FAULT5	Zone 5 fault detector picked up	167
FAULT6	Zone 6 fault detector picked up	169
FBF01	Circuit Breaker 1 failure	183
FBF02	Circuit Breaker 2 failure	184
FBF03	Circuit Breaker 3 failure	185
FBF04	Circuit Breaker 4 failure	186
FBF05	Circuit Breaker 5 failure	187
FBF06	Circuit Breaker 6 failure	188
FBF07	Circuit Breaker 7 failure	189
FBF08	Circuit Breaker 8 failure	190
FBF09	Circuit Breaker 9 failure	191
FBF10	Circuit Breaker 10 failure	192
FBF11	Circuit Breaker 11 failure	193

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 35 of 79)

Name	Bit Description	Row
FBF12	Circuit Breaker 12 failure	194
FBF13	Circuit Breaker 13 failure	195
FBF14	Circuit Breaker 14 failure	196
FBF15	Circuit Breaker 15 failure	197
FBF16	Circuit Breaker 16 failure	198
FBF17	Circuit Breaker 17 failure	199
FBF18	Circuit Breaker 18 failure	200
FBF19	Circuit Breaker 19 failure	201
FBF20	Circuit Breaker 20 failure	202
FBF21	Circuit Breaker 21 failure	203
FDIF1	Zone 1 filtered restrained differential element picked up	160
FDIF2	Zone 2 filtered restrained differential element picked up	162
FDIF3	Zone 3 filtered restrained differential element picked up	164
FDIF4	Zone 4 filtered restrained differential element picked up	166
FDIF5	Zone 5 filtered restrained differential element picked up	168
FDIF6	Zone 6 filtered restrained differential element picked up	170
FDIFCZ1	Check Zone 1 filtered restrained differential element picked up	451
FDIFCZ2	Check Zone 2 filtered restrained differential element picked up	453
FDIFCZ3	Check Zone 3 filtered restrained differential element picked up	455
FLTCZ1	Check Zone 1 fault detector picked up	450
FLTCZ2	Check Zone 2 fault detector picked up	452
FLTCZ3	Check Zone 3 fault detector picked up	454
FSERP1	Fast SER enabled for Serial Port 1	444
FSERP2	Fast SER enabled for Serial Port 2	444
FSERP3	Fast SER enabled for Serial Port 3	444
FSERP5	Fast SER enabled for Serial Port 5	444
FSERPF	Fast SER enabled for Serial Port F	444
GFAULT1	Zone 1 fast fault detection	160
GFAULT2	Zone 2 fast fault detection	162
GFAULT3	Zone 3 fast fault detection	164
GFAULT4	Zone 4 fast fault detection	166
GFAULT5	Zone 5 fast fault detection	168
GFAULT6	Zone 6 fast fault detection	170
GFLTCZ1	Check Zone 1 fast fault detection	451
GFLTCZ2	Check Zone 2 fast fault detection	453
GFLTCZ3	Check Zone 3 fast fault detection	455
GRPSW	Pulsed when settings group changes	376
HALARM	Relay diagnostic failure or warning	376
HALARMA	Relay warning periodic alarm	376
HALARML	Latching relay failure alarm	376
HALARMP	Relay warning alarm pulse	376

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 36 of 79)

Name	Bit Description	Row
I01BZ1V	Terminal I01 connected to BZ1	56
I01BZ2V	Terminal I01 connected to BZ2	60
I01BZ3V	Terminal I01 connected to BZ3	64
I01BZ4V	Terminal I01 connected to BZ4	68
I01BZ5V	Terminal I01 connected to BZ5	72
I01BZ6V	Terminal I01 connected to BZ6	76
I02BZ1V	Terminal I02 connected to BZ1	56
I02BZ2V	Terminal I02 connected to BZ2	60
I02BZ3V	Terminal I02 connected to BZ3	64
I02BZ4V	Terminal I02 connected to BZ4	68
I02BZ5V	Terminal I02 connected to BZ5	72
I02BZ6V	Terminal I02 connected to BZ6	76
I03BZ1V	Terminal I03 connected to BZ1	56
I03BZ2V	Terminal I03 connected to BZ2	60
I03BZ3V	Terminal I03 connected to BZ3	64
I03BZ4V	Terminal I03 connected to BZ4	68
I03BZ5V	Terminal I03 connected to BZ5	72
I03BZ6V	Terminal I03 connected to BZ6	76
I04BZ1V	Terminal I04 connected to BZ1	56
I04BZ2V	Terminal I04 connected to BZ2	60
I04BZ3V	Terminal I04 connected to BZ3	64
I04BZ4V	Terminal I04 connected to BZ4	68
I04BZ5V	Terminal I04 connected to BZ5	72
I04BZ6V	Terminal I04 connected to BZ6	76
I05BZ1V	Terminal I05 connected to BZ1	56
I05BZ2V	Terminal I05 connected to BZ2	60
I05BZ3V	Terminal I05 connected to BZ3	64
I05BZ4V	Terminal I05 connected to BZ4	68
I05BZ5V	Terminal I05 connected to BZ5	72
I05BZ6V	Terminal I05 connected to BZ6	76
I06BZ1V	Terminal I06 connected to BZ1	56
I06BZ2V	Terminal I06 connected to BZ2	60
I06BZ3V	Terminal I06 connected to BZ3	64
I06BZ4V	Terminal I06 connected to BZ4	68
I06BZ5V	Terminal I06 connected to BZ5	72
I06BZ6V	Terminal I06 connected to BZ6	76
I07BZ1V	Terminal I07 connected to BZ1	56
I07BZ2V	Terminal I07 connected to BZ2	60
I07BZ3V	Terminal I07 connected to BZ3	64
I07BZ4V	Terminal I07 connected to BZ4	68
I07BZ5V	Terminal I07 connected to BZ5	72

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 37 of 79)

Name	Bit Description	Row
I07BZ6V	Terminal I07 connected to BZ6	76
I08BZ1V	Terminal I08 connected to BZ1	56
I08BZ2V	Terminal I08 connected to BZ2	60
I08BZ3V	Terminal I08 connected to BZ3	64
I08BZ4V	Terminal I08 connected to BZ4	68
I08BZ5V	Terminal I08 connected to BZ5	72
I08BZ6V	Terminal I08 connected to BZ6	76
I09BZ1V	Terminal I09 connected to BZ1	57
I09BZ2V	Terminal I09 connected to BZ2	61
I09BZ3V	Terminal I09 connected to BZ3	65
I09BZ4V	Terminal I09 connected to BZ4	69
I09BZ5V	Terminal I09 connected to BZ5	73
I09BZ6V	Terminal I09 connected to BZ6	77
I10BZ1V	Terminal I10 connected to BZ1	57
I10BZ2V	Terminal I10 connected to BZ2	61
I10BZ3V	Terminal I10 connected to BZ3	65
I10BZ4V	Terminal I10 connected to BZ4	69
I10BZ5V	Terminal I10 connected to BZ5	73
I10BZ6V	Terminal I10 connected to BZ6	77
I11BZ1V	Terminal I11 connected to BZ1	57
I11BZ2V	Terminal I11 connected to BZ2	61
I11BZ3V	Terminal I11 connected to BZ3	65
I11BZ4V	Terminal I11 connected to BZ4	69
I11BZ5V	Terminal I11 connected to BZ5	73
I11BZ6V	Terminal I11 connected to BZ6	77
I12BZ1V	Terminal I12 connected to BZ1	57
I12BZ2V	Terminal I12 connected to BZ2	61
I12BZ3V	Terminal I12 connected to BZ3	65
I12BZ4V	Terminal I12 connected to BZ4	69
I12BZ5V	Terminal I12 connected to BZ5	73
I12BZ6V	Terminal I12 connected to BZ6	77
I13BZ1V	Terminal I13 connected to BZ1	57
I13BZ2V	Terminal I13 connected to BZ2	61
I13BZ3V	Terminal I13 connected to BZ3	65
I13BZ4V	Terminal I13 connected to BZ4	69
I13BZ5V	Terminal I13 connected to BZ5	73
I13BZ6V	Terminal I13 connected to BZ6	77
I14BZ1V	Terminal I14 connected to BZ1	57
I14BZ2V	Terminal I14 connected to BZ2	61
I14BZ3V	Terminal I14 connected to BZ3	65
I14BZ4V	Terminal I14 connected to BZ4	69

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 38 of 79)

Name	Bit Description	Row
I14BZ5V	Terminal I14 connected to BZ5	73
I14BZ6V	Terminal I14 connected to BZ6	77
I15BZ1V	Terminal I15 connected to BZ1	57
I15BZ2V	Terminal I15 connected to BZ2	61
I15BZ3V	Terminal I15 connected to BZ3	65
I15BZ4V	Terminal I15 connected to BZ4	69
I15BZ5V	Terminal I15 connected to BZ5	73
I15BZ6V	Terminal I15 connected to BZ6	77
I16BZ1V	Terminal I16 connected to BZ1	57
I16BZ2V	Terminal I16 connected to BZ2	61
I16BZ3V	Terminal I16 connected to BZ3	65
I16BZ4V	Terminal I16 connected to BZ4	69
I16BZ5V	Terminal I16 connected to BZ5	73
I16BZ6V	Terminal I16 connected to BZ6	77
I17BZ1V	Terminal I17 connected to BZ1	58
I17BZ2V	Terminal I17 connected to BZ2	62
I17BZ3V	Terminal I17 connected to BZ3	66
I17BZ4V	Terminal I17 connected to BZ4	70
I17BZ5V	Terminal I17 connected to BZ5	74
I17BZ6V	Terminal I17 connected to BZ6	78
I18BZ1V	Terminal I18 connected to BZ1	58
I18BZ2V	Terminal I18 connected to BZ2	62
I18BZ3V	Terminal I18 connected to BZ3	66
I18BZ4V	Terminal I18 connected to BZ4	70
I18BZ5V	Terminal I18 connected to BZ5	74
I18BZ6V	Terminal I18 connected to BZ6	78
I19BZ1V	Terminal I19 connected to BZ1	58
I19BZ2V	Terminal I19 connected to BZ2	62
I19BZ3V	Terminal I19 connected to BZ3	66
I19BZ4V	Terminal I19 connected to BZ4	70
I19BZ5V	Terminal I19 connected to BZ5	74
I19BZ6V	Terminal I19 connected to BZ6	78
I20BZ1V	Terminal I20 connected to BZ1	58
I20BZ2V	Terminal I20 connected to BZ2	62
I20BZ3V	Terminal I20 connected to BZ3	66
I20BZ4V	Terminal I20 connected to BZ4	70
I20BZ5V	Terminal I20 connected to BZ5	74
I20BZ6V	Terminal I20 connected to BZ6	78
I21BZ1V	Terminal I21 connected to BZ1	58
I21BZ2V	Terminal I21 connected to BZ2	62
I21BZ3V	Terminal I21 connected to BZ3	66

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 39 of 79)

Name	Bit Description	Row
I21BZ4V	Terminal I21 connected to BZ4	70
I21BZ5V	Terminal I21 connected to BZ5	74
I21BZ6V	Terminal I21 connected to BZ6	78
IFAULT1	Zone 1 fault detection	160
IFAULT2	Zone 2 fault detection	162
IFAULT3	Zone 3 fault detection	164
IFAULT4	Zone 4 fault detection	166
IFAULT5	Zone 5 fault detection	168
IFAULT6	Zone 6 fault detection	170
IFLTCZ1	Check Zone 1 fault detection	451
IFLTCZ2	Check Zone 2 fault detection	453
IFLTCZ3	Check Zone 3 fault detection	455
IN101	Main board Input 01	272
IN102	Main board Input 02	272
IN103	Main board Input 03	272
IN104	Main board Input 04	272
IN105	Main board Input 05	272
IN106	Main board Input 06	272
IN107	Main board Input 07	272
IN201	Optional I/O Board 1 Input 01	276
IN202	Optional I/O Board 1 Input 02	276
IN203	Optional I/O Board 1 Input 03	276
IN204	Optional I/O Board 1 Input 04	276
IN205	Optional I/O Board 1 Input 05	276
IN206	Optional I/O Board 1 Input 06	276
IN207	Optional I/O Board 1 Input 07	276
IN208	Optional I/O Board 1 Input 08	276
IN209	Optional I/O Board 1 Input 09	277
IN210	Optional I/O Board 1 Input 10	277
IN211	Optional I/O Board 1 Input 11	277
IN212	Optional I/O Board 1 Input 12	277
IN213	Optional I/O Board 1 Input 13	277
IN214	Optional I/O Board 1 Input 14	277
IN215	Optional I/O Board 1 Input 15	277
IN216	Optional I/O Board 1 Input 16	277
IN217	Optional I/O Board 1 Input 17	278
IN218	Optional I/O Board 1 Input 18	278
IN219	Optional I/O Board 1 Input 19	278
IN220	Optional I/O Board 1 Input 20	278
IN221	Optional I/O Board 1 Input 21	278
IN222	Optional I/O Board 1 Input 22	278

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 40 of 79)

Name	Bit Description	Row
IN223	Optional I/O Board 1 Input 23	278
IN224	Optional I/O Board 1 Input 24	278
IN301	Optional I/O Board 2 Input 01	280
IN302	Optional I/O Board 2 Input 02	280
IN303	Optional I/O Board 2 Input 03	280
IN304	Optional I/O Board 2 Input 04	280
IN305	Optional I/O Board 2 Input 05	280
IN306	Optional I/O Board 2 Input 06	280
IN307	Optional I/O Board 2 Input 07	280
IN308	Optional I/O Board 2 Input 08	280
IN309	Optional I/O Board 2 Input 09	281
IN310	Optional I/O Board 2 Input 10	281
IN311	Optional I/O Board 2 Input 11	281
IN312	Optional I/O Board 2 Input 12	281
IN313	Optional I/O Board 2 Input 13	281
IN314	Optional I/O Board 2 Input 14	281
IN315	Optional I/O Board 2 Input 15	281
IN316	Optional I/O Board 2 Input 16	281
IN317	Optional I/O Board 2 Input 17	282
IN318	Optional I/O Board 2 Input 18	282
IN319	Optional I/O Board 2 Input 19	282
IN320	Optional I/O Board 2 Input 20	282
IN321	Optional I/O Board 2 Input 21	282
IN322	Optional I/O Board 2 Input 22	282
IN323	Optional I/O Board 2 Input 23	282
IN324	Optional I/O Board 2 Input 24	282
IN401	Optional I/O Board 3 Input 01	284
IN402	Optional I/O Board 3 Input 02	284
IN403	Optional I/O Board 3 Input 03	284
IN404	Optional I/O Board 3 Input 04	284
IN405	Optional I/O Board 3 Input 05	284
IN406	Optional I/O Board 3 Input 06	284
IN407	Optional I/O Board 3 Input 07	284
IN408	Optional I/O Board 3 Input 08	284
IN409	Optional I/O Board 3 Input 09	285
IN410	Optional I/O Board 3 Input 10	285
IN411	Optional I/O Board 3 Input 11	285
IN412	Optional I/O Board 3 Input 12	285
IN413	Optional I/O Board 3 Input 13	285
IN414	Optional I/O Board 3 Input 14	285
IN415	Optional I/O Board 3 Input 15	285

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 41 of 79)

Name	Bit Description	Row
IN416	Optional I/O Board 3 Input 16	285
IN417	Optional I/O Board 3 Input 17	286
IN418	Optional I/O Board 3 Input 18	286
IN419	Optional I/O Board 3 Input 19	286
IN420	Optional I/O Board 3 Input 20	286
IN421	Optional I/O Board 3 Input 21	286
IN422	Optional I/O Board 3 Input 22	286
IN423	Optional I/O Board 3 Input 23	286
IN424	Optional I/O Board 3 Input 24	286
IN501	Optional I/O Board 4 Input 01	288
IN502	Optional I/O Board 4 Input 02	288
IN503	Optional I/O Board 4 Input 03	288
IN504	Optional I/O Board 4 Input 04	288
IN505	Optional I/O Board 4 Input 05	288
IN506	Optional I/O Board 4 Input 06	288
IN507	Optional I/O Board 4 Input 07	288
IN508	Optional I/O Board 4 Input 08	288
IN509	Optional I/O Board 4 Input 09	289
IN510	Optional I/O Board 4 Input 10	289
IN511	Optional I/O Board 4 Input 11	289
IN512	Optional I/O Board 4 Input 12	289
IN513	Optional I/O Board 4 Input 13	289
IN514	Optional I/O Board 4 Input 14	289
IN515	Optional I/O Board 4 Input 15	289
IN516	Optional I/O Board 4 Input 16	289
IN517	Optional I/O Board 4 Input 17	290
IN518	Optional I/O Board 4 Input 18	290
IN519	Optional I/O Board 4 Input 19	290
IN520	Optional I/O Board 4 Input 20	290
IN521	Optional I/O Board 4 Input 21	290
IN522	Optional I/O Board 4 Input 22	290
IN523	Optional I/O Board 4 Input 23	290
IN524	Optional I/O Board 4 Input 24	290
IO300OK	Communications status of Interface Board 300 when installed or commissioned	475
IO400OK	Communications status of Interface Board 400 when installed or commissioned	475
IO500OK	Communications status of Interface Board 400 when installed or commissioned	475
LB_DP01	Local Bit 01 status display (SELOGIC control equation)	461
LB_DP02	Local Bit 02 status display (SELOGIC control equation)	461
LB_DP03	Local Bit 03 status display (SELOGIC control equation)	461
LB_DP04	Local Bit 04 status display (SELOGIC control equation)	461
LB_DP05	Local Bit 05 status display (SELOGIC control equation)	461

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 42 of 79)

Name	Bit Description	Row
LB_DP06	Local Bit 06 status display (SELOGIC control equation)	461
LB_DP07	Local Bit 07 status display (SELOGIC control equation)	461
LB_DP08	Local Bit 08 status display (SELOGIC control equation)	461
LB_DP09	Local Bit 09 status display (SELOGIC control equation)	462
LB_DP10	Local Bit 10 status display (SELOGIC control equation)	462
LB_DP11	Local Bit 11 status display (SELOGIC control equation)	462
LB_DP12	Local Bit 12 status display (SELOGIC control equation)	462
LB_DP13	Local Bit 13 status display (SELOGIC control equation)	462
LB_DP14	Local Bit 14 status display (SELOGIC control equation)	462
LB_DP15	Local Bit 15 status display (SELOGIC control equation)	462
LB_DP16	Local Bit 16 status display (SELOGIC control equation)	462
LB_DP17	Local Bit 17 status display (SELOGIC control equation)	463
LB_DP18	Local Bit 18 status display (SELOGIC control equation)	463
LB_DP19	Local Bit 19 status display (SELOGIC control equation)	463
LB_DP20	Local Bit 20 status display (SELOGIC control equation)	463
LB_DP21	Local Bit 21 status display (SELOGIC control equation)	463
LB_DP22	Local Bit 22 status display (SELOGIC control equation)	463
LB_DP23	Local Bit 23 status display (SELOGIC control equation)	463
LB_DP24	Local Bit 24 status display (SELOGIC control equation)	463
LB_DP25	Local Bit 25 status display (SELOGIC control equation)	464
LB_DP26	Local Bit 26 status display (SELOGIC control equation)	464
LB_DP27	Local Bit 27 status display (SELOGIC control equation)	464
LB_DP28	Local Bit 28 status display (SELOGIC control equation)	464
LB_DP29	Local Bit 29 status display (SELOGIC control equation)	464
LB_DP30	Local Bit 30 status display (SELOGIC control equation)	464
LB_DP31	Local Bit 31 status display (SELOGIC control equation)	464
LB_DP32	Local Bit 32 status display (SELOGIC control equation)	464
LB_DP33	Local Bit 33 status display (SELOGIC control equation)	496
LB_DP34	Local Bit 34 status display (SELOGIC control equation)	496
LB_DP35	Local Bit 35 status display (SELOGIC control equation)	496
LB_DP36	Local Bit 36 status display (SELOGIC control equation)	496
LB_DP37	Local Bit 37 status display (SELOGIC control equation)	496
LB_DP38	Local Bit 38 status display (SELOGIC control equation)	496
LB_DP39	Local Bit 39 status display (SELOGIC control equation)	496
LB_DP40	Local Bit 40 status display (SELOGIC control equation)	496
LB_DP41	Local Bit 41 status display (SELOGIC control equation)	497
LB_DP42	Local Bit 42 status display (SELOGIC control equation)	497
LB_DP43	Local Bit 43 status display (SELOGIC control equation)	497
LB_DP44	Local Bit 44 status display (SELOGIC control equation)	497
LB_DP45	Local Bit 45 status display (SELOGIC control equation)	497
LB_DP46	Local Bit 46 status display (SELOGIC control equation)	497

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 43 of 79)

Name	Bit Description	Row
LB_DP47	Local Bit 47 status display (SELOGIC control equation)	497
LB_DP48	Local Bit 48 status display (SELOGIC control equation)	497
LB_DP49	Local Bit 49 status display (SELOGIC control equation)	498
LB_DP50	Local Bit 50 status display (SELOGIC control equation)	498
LB_DP51	Local Bit 51 status display (SELOGIC control equation)	498
LB_DP52	Local Bit 52 status display (SELOGIC control equation)	498
LB_DP53	Local Bit 53 status display (SELOGIC control equation)	498
LB_DP54	Local Bit 54 status display (SELOGIC control equation)	498
LB_DP55	Local Bit 55 status display (SELOGIC control equation)	498
LB_DP56	Local Bit 56 status display (SELOGIC control equation)	498
LB_DP57	Local Bit 57 status display (SELOGIC control equation)	498
LB_DP58	Local Bit 58 status display (SELOGIC control equation)	499
LB_DP59	Local Bit 59 status display (SELOGIC control equation)	499
LB_DP60	Local Bit 60 status display (SELOGIC control equation)	499
LB_DP61	Local Bit 61 status display (SELOGIC control equation)	499
LB_DP62	Local Bit 62 status display (SELOGIC control equation)	499
LB_DP63	Local Bit 63 status display (SELOGIC control equation)	499
LB_DP64	Local Bit 64 status display (SELOGIC control equation)	499
LB_SP01	Local Bit 01 supervision (SELOGIC control equation)	457
LB_SP02	Local Bit 02 supervision (SELOGIC control equation)	457
LB_SP03	Local Bit 03 supervision (SELOGIC control equation)	457
LB_SP04	Local Bit 04 supervision (SELOGIC control equation)	457
LB_SP05	Local Bit 05 supervision (SELOGIC control equation)	457
LB_SP06	Local Bit 06 supervision (SELOGIC control equation)	457
LB_SP07	Local Bit 07 supervision (SELOGIC control equation)	457
LB_SP08	Local Bit 08 supervision (SELOGIC control equation)	457
LB_SP09	Local Bit 09 supervision (SELOGIC control equation)	458
LB_SP10	Local Bit 10 supervision (SELOGIC control equation)	458
LB_SP11	Local Bit 11 supervision (SELOGIC control equation)	458
LB_SP12	Local Bit 12 supervision (SELOGIC control equation)	458
LB_SP13	Local Bit 13 supervision (SELOGIC control equation)	458
LB_SP14	Local Bit 14 supervision (SELOGIC control equation)	458
LB_SP15	Local Bit 15 supervision (SELOGIC control equation)	458
LB_SP16	Local Bit 16 supervision (SELOGIC control equation)	458
LB_SP17	Local Bit 17 supervision (SELOGIC control equation)	459
LB_SP18	Local Bit 18 supervision (SELOGIC control equation)	459
LB_SP19	Local Bit 19 supervision (SELOGIC control equation)	459
LB_SP20	Local Bit 20 supervision (SELOGIC control equation)	459
LB_SP21	Local Bit 21 supervision (SELOGIC control equation)	459
LB_SP22	Local Bit 22 supervision (SELOGIC control equation)	459
LB_SP23	Local Bit 23 supervision (SELOGIC control equation)	459

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 44 of 79)

Name	Bit Description	Row
LB_SP24	Local Bit 24 supervision (SELOGIC control equation)	459
LB_SP25	Local Bit 25 supervision (SELOGIC control equation)	460
LB_SP26	Local Bit 26 supervision (SELOGIC control equation)	460
LB_SP27	Local Bit 27 supervision (SELOGIC control equation)	460
LB_SP28	Local Bit 28 supervision (SELOGIC control equation)	460
LB_SP29	Local Bit 29 supervision (SELOGIC control equation)	460
LB_SP30	Local Bit 30 supervision (SELOGIC control equation)	460
LB_SP31	Local Bit 31 supervision (SELOGIC control equation)	460
LB_SP32	Local Bit 32 supervision (SELOGIC control equation)	460
LB_SP33	Local Bit 33 supervision (SELOGIC control equation)	492
LB_SP34	Local Bit 34 supervision (SELOGIC control equation)	492
LB_SP35	Local Bit 35 supervision (SELOGIC control equation)	492
LB_SP36	Local Bit 36 supervision (SELOGIC control equation)	492
LB_SP37	Local Bit 37 supervision (SELOGIC control equation)	492
LB_SP38	Local Bit 38 supervision (SELOGIC control equation)	492
LB_SP39	Local Bit 39 supervision (SELOGIC control equation)	492
LB_SP40	Local Bit 40 supervision (SELOGIC control equation)	492
LB_SP41	Local Bit 41 supervision (SELOGIC control equation)	493
LB_SP42	Local Bit 42 supervision (SELOGIC control equation)	493
LB_SP43	Local Bit 43 supervision (SELOGIC control equation)	493
LB_SP44	Local Bit 44 supervision (SELOGIC control equation)	493
LB_SP45	Local Bit 45 supervision (SELOGIC control equation)	493
LB_SP46	Local Bit 46 supervision (SELOGIC control equation)	493
LB_SP47	Local Bit 47 supervision (SELOGIC control equation)	493
LB_SP48	Local Bit 48 supervision (SELOGIC control equation)	493
LB_SP49	Local Bit 49 supervision (SELOGIC control equation)	494
LB_SP50	Local Bit 50 supervision (SELOGIC control equation)	494
LB_SP51	Local Bit 51 supervision (SELOGIC control equation)	494
LB_SP52	Local Bit 52 supervision (SELOGIC control equation)	494
LB_SP53	Local Bit 53 supervision (SELOGIC control equation)	494
LB_SP54	Local Bit 54 supervision (SELOGIC control equation)	494
LB_SP55	Local Bit 55 supervision (SELOGIC control equation)	494
LB_SP56	Local Bit 56 supervision (SELOGIC control equation)	494
LB_SP57	Local Bit 57 supervision (SELOGIC control equation)	495
LB_SP58	Local Bit 58 supervision (SELOGIC control equation)	495
LB_SP59	Local Bit 59 supervision (SELOGIC control equation)	495
LB_SP60	Local Bit 60 supervision (SELOGIC control equation)	495
LB_SP61	Local Bit 61 supervision (SELOGIC control equation)	495
LB_SP62	Local Bit 62 supervision (SELOGIC control equation)	495
LB_SP63	Local Bit 63 supervision (SELOGIC control equation)	495
LB_SP64	Local Bit 64 supervision (SELOGIC control equation)	495

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 45 of 79)

Name	Bit Description	Row
LB01	Local Bit 01	256
LB02	Local Bit 02	256
LB03	Local Bit 03	256
LB04	Local Bit 04	256
LB05	Local Bit 05	256
LB06	Local Bit 06	256
LB07	Local Bit 07	256
LB08	Local Bit 08	256
LB09	Local Bit 09	257
LB10	Local Bit 10	257
LB11	Local Bit 11	257
LB12	Local Bit 12	257
LB13	Local Bit 13	257
LB14	Local Bit 14	257
LB15	Local Bit 15	257
LB16	Local Bit 16	257
LB17	Local Bit 17	258
LB18	Local Bit 18	258
LB19	Local Bit 19	258
LB20	Local Bit 20	258
LB21	Local Bit 21	258
LB22	Local Bit 22	258
LB23	Local Bit 23	258
LB24	Local Bit 24	258
LB25	Local Bit 25	259
LB26	Local Bit 26	259
LB27	Local Bit 27	259
LB28	Local Bit 28	259
LB29	Local Bit 29	259
LB30	Local Bit 30	259
LB31	Local Bit 31	259
LB32	Local Bit 32	259
LB33	Local Bit 33	488
LB34	Local Bit 34	488
LB35	Local Bit 35	488
LB36	Local Bit 36	488
LB37	Local Bit 37	488
LB38	Local Bit 38	488
LB39	Local Bit 39	488
LB40	Local Bit 40	488
LB41	Local Bit 41	489

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 46 of 79)

Name	Bit Description	Row
LB42	Local Bit 42	489
LB43	Local Bit 43	489
LB44	Local Bit 44	489
LB45	Local Bit 45	489
LB46	Local Bit 46	489
LB47	Local Bit 47	489
LB48	Local Bit 48	489
LB49	Local Bit 49	490
LB50	Local Bit 50	490
LB51	Local Bit 51	490
LB52	Local Bit 52	490
LB53	Local Bit 53	490
LB54	Local Bit 54	490
LB55	Local Bit 55	490
LB56	Local Bit 56	490
LB57	Local Bit 57	491
LB58	Local Bit 58	491
LB59	Local Bit 59	491
LB60	Local Bit 60	491
LB61	Local Bit 61	491
LB62	Local Bit 62	491
LB63	Local Bit 63	491
LB64	Local Bit 64	491
LBOKA	Channel A MIRRORED BITS normal status (loopback)	404
LBOKB	Channel B MIRRORED BITS normal status (loopback mode)	405
LINK5A	Link status of Port 5A connection	441
LINK5B	Link status of Port 5B connection	441
LINK5C	Link status of Port 5C connection	441
LINK5D	Link status of Port 5D connection	441
LNKFAIL	Link status of the active port	441
LOC	Control authority at local (bay) level	480
LOCSTA	Control authority at station level	480
LPHDSIM	61850 Logical Node for Physical Device Simulation	406
LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added.	470
LPSECP	Leap second pending	470
MATHERR	SELOGIC control equation math error	374
MLTLEV	Multi-level control authority	480
OC01	Circuit Breaker 01 open command	249
OC02	Circuit Breaker 02 open command	249
OC03	Circuit Breaker 03 open command	249

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 47 of 79)

Name	Bit Description	Row
OC04	Circuit Breaker 04 open command	249
OC05	Circuit Breaker 05 open command	249
OC06	Circuit Breaker 06 open command	249
OC07	Circuit Breaker 07 open command	249
OC08	Circuit Breaker 08 open command	249
OC09	Circuit Breaker 09 open command	250
OC10	Circuit Breaker 10 open command	250
OC11	Circuit Breaker 11 open command	250
OC12	Circuit Breaker 12 open command	250
OC13	Circuit Breaker 13 open command	250
OC14	Circuit Breaker 14 open command	250
OC15	Circuit Breaker 15 open command	250
OC16	Circuit Breaker 16 open command	250
OC17	Circuit Breaker 17 open command	251
OC18	Circuit Breaker 18 open command	251
OC19	Circuit Breaker 19 open command	251
OC20	Circuit Breaker 20 open command	251
OC21	Circuit Breaker 21 open command	251
OCTZ1	Zone 1 open CT detection	155
OCTZ2	Zone 2 open CT detection	155
OCTZ3	Zone 3 open CT detection	155
OCTZ4	Zone 4 open CT detection	155
OCTZ5	Zone 5 open CT detection	155
OCTZ6	Zone 6 open CT detection	155
OPH01	Terminal 01 open phase detected	4
OPH02	Terminal 02 open phase detected	4
OPH03	Terminal 03 open phase detected	4
OPH04	Terminal 04 open phase detected	4
OPH05	Terminal 05 open phase detected	4
OPH06	Terminal 06 open phase detected	4
OPH07	Terminal 07 open phase detected	4
OPH08	Terminal 08 open phase detected	4
OPH09	Terminal 09 open phase detected	5
OPH10	Terminal 10 open phase detected	5
OPH11	Terminal 11 open phase detected	5
OPH12	Terminal 12 open phase detected	5
OPH13	Terminal 13 open phase detected	5
OPH14	Terminal 14 open phase detected	5
OPH15	Terminal 15 open phase detected	5
OPH16	Terminal 16 open phase detected	5
OPH17	Terminal 17 open phase detected	6

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 48 of 79)

Name	Bit Description	Row
OPH18	Terminal 18 open phase detected	6
OPH19	Terminal 19 open phase detected	6
OPH20	Terminal 20 open phase detected	6
OPH21	Terminal 21 open phase detected	6
OUT101	Main board Output 1	384
OUT102	Main board Output 2	384
OUT103	Main board Output 3	384
OUT104	Main board Output 4	384
OUT105	Main board Output 5	384
OUT106	Main board Output 6	384
OUT107	Main board Output 7	384
OUT108	Main board Output 8	384
OUT201	Optional I/O Board 1 Output 1	388
OUT202	Optional I/O Board 1 Output 2	388
OUT203	Optional I/O Board 1 Output 3	388
OUT204	Optional I/O Board 1 Output 4	388
OUT205	Optional I/O Board 1 Output 5	388
OUT206	Optional I/O Board 1 Output 6	388
OUT207	Optional I/O Board 1 Output 7	388
OUT208	Optional I/O Board 1 Output 8	388
OUT209	Optional I/O Board 1 Output 9	389
OUT210	Optional I/O Board 1 Output 10	389
OUT211	Optional I/O Board 1 Output 11	389
OUT212	Optional I/O Board 1 Output 12	389
OUT213	Optional I/O Board 1 Output 13	389
OUT214	Optional I/O Board 1 Output 14	389
OUT215	Optional I/O Board 1 Output 15	389
OUT216	Optional I/O Board 1 Output 16	389
OUT301	Optional I/O Board 2 Output 1	390
OUT302	Optional I/O Board 2 Output 2	390
OUT303	Optional I/O Board 2 Output 3	390
OUT304	Optional I/O Board 2 Output 4	390
OUT305	Optional I/O Board 2 Output 5	390
OUT306	Optional I/O Board 2 Output 6	390
OUT307	Optional I/O Board 2 Output 7	390
OUT308	Optional I/O Board 2 Output 8	390
OUT309	Optional I/O Board 2 Output 9	391
OUT310	Optional I/O Board 2 Output 10	391
OUT311	Optional I/O Board 2 Output 11	391
OUT312	Optional I/O Board 2 Output 12	391
OUT313	Optional I/O Board 2 Output 13	391

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 49 of 79)

Name	Bit Description	Row
OUT314	Optional I/O Board 2 Output 14	391
OUT315	Optional I/O Board 2 Output 15	391
OUT316	Optional I/O Board 2 Output 16	391
OUT401	Optional I/O Board 3 Output 1	392
OUT402	Optional I/O Board 3 Output 2	392
OUT403	Optional I/O Board 3 Output 3	392
OUT404	Optional I/O Board 3 Output 4	392
OUT405	Optional I/O Board 3 Output 5	392
OUT406	Optional I/O Board 3 Output 6	392
OUT407	Optional I/O Board 3 Output 7	392
OUT408	Optional I/O Board 3 Output 8	392
OUT409	Optional I/O Board 3 Output 9	393
OUT410	Optional I/O Board 3 Output 10	393
OUT411	Optional I/O Board 3 Output 11	393
OUT412	Optional I/O Board 3 Output 12	393
OUT413	Optional I/O Board 3 Output 13	393
OUT414	Optional I/O Board 3 Output 14	393
OUT415	Optional I/O Board 3 Output 15	393
OUT416	Optional I/O Board 3 Output 16	393
OUT501	Optional I/O Board 4 Output 1	394
OUT502	Optional I/O Board 4 Output 2	394
OUT503	Optional I/O Board 4 Output 3	394
OUT504	Optional I/O Board 4 Output 4	394
OUT505	Optional I/O Board 4 Output 5	394
OUT506	Optional I/O Board 4 Output 6	394
OUT507	Optional I/O Board 4 Output 7	394
OUT508	Optional I/O Board 4 Output 8	394
OUT509	Optional I/O Board 4 Output 9	395
OUT510	Optional I/O Board 4 Output 10	395
OUT511	Optional I/O Board 4 Output 11	395
OUT512	Optional I/O Board 4 Output 12	395
OUT513	Optional I/O Board 4 Output 13	395
OUT514	Optional I/O Board 4 Output 14	395
OUT515	Optional I/O Board 4 Output 15	395
OUT516	Optional I/O Board 4 Output 16	395
P5ABSW	Port 5A or 5B has just become active	473
P5ASEL	Port 5A active/inactive	442
P5BSEL	Port 5B active/inactive	442
P5CSEL	Port 5C active/inactive	442
P5DSEL	Port 5D active/inactive	442
P87R1	Zone 1 instantaneous differential element picked up	159

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 50 of 79)

Name	Bit Description	Row
P87R2	Zone 2 instantaneous differential element picked up	161
P87R3	Zone 3 instantaneous differential element picked up	163
P87R4	Zone 4 instantaneous differential element picked up	165
P87R5	Zone 5 instantaneous differential element picked up	167
P87R6	Zone 6 instantaneous differential element picked up	169
P87RCZ1	Check Zone 1 instantaneous differential element picked up	450
P87RCZ2	Check Zone 2 instantaneous differential element picked up	452
P87RCZ3	Check Zone 3 instantaneous differential element picked up	454
PASSDIS	Asserts to indicate password disable jumper is installed	377
PB1	Pushbutton 1	382
PB1_LED	Pushbutton 1 LED	398
PB1_PUL	Pushbutton 1 pulse input	396
PB10	Pushbutton 10	383
PB10LED	Pushbutton 10 LED	399
PB10PUL	Pushbutton 10 pulse input	397
PB11	Pushbutton 11	383
PB11LED	Pushbutton 11 LED	399
PB11PUL	Pushbutton 11 pulse input	397
PB12	Pushbutton 12	383
PB12LED	Pushbutton 12 LED	399
PB12PUL	Pushbutton 12 pulse input	397
PB2	Pushbutton 2	382
PB2_LED	Pushbutton 2 LED	398
PB2_PUL	Pushbutton 2 pulse input	396
PB3	Pushbutton 3	382
PB3_LED	Pushbutton 3 LED	398
PB3_PUL	Pushbutton 3 pulse input	396
PB4	Pushbutton 4	382
PB4_LED	Pushbutton 4 LED	398
PB4_PUL	Pushbutton 4 pulse input	396
PB5	Pushbutton 5	382
PB5_LED	Pushbutton 5 LED	398
PB5_PUL	Pushbutton 5 pulse input	396
PB6	Pushbutton 6	382
PB6_LED	Pushbutton 6 LED	398
PB6_PUL	Pushbutton 6 pulse input	396
PB7	Pushbutton 7	382
PB7_LED	Pushbutton 7 LED	398
PB7_PUL	Pushbutton 7 pulse input	396
PB8	Pushbutton 8	382
PB8_LED	Pushbutton 8 LED	398

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 51 of 79)

Name	Bit Description	Row
PB8_PUL	Pushbutton 8 pulse input	396
PB9	Pushbutton 9	383
PB9_LED	Pushbutton 9 LED	399
PB9_PUL	Pushbutton 9 pulse input	397
PCN01Q	Protection counter Output 01	314
PCN01R	Protection counter Reset 01	318
PCN02Q	Protection counter Output 02	314
PCN02R	Protection counter Reset 02	318
PCN03Q	Protection counter Output 03	314
PCN03R	Protection counter Reset 03	318
PCN04Q	Protection counter Output 04	314
PCN04R	Protection counter Reset 04	318
PCN05Q	Protection counter Output 05	314
PCN05R	Protection counter Reset 05	318
PCN06Q	Protection counter Output 06	314
PCN06R	Protection counter Reset 06	318
PCN07Q	Protection counter Output 07	314
PCN07R	Protection counter Reset 07	318
PCN08Q	Protection counter Output 08	314
PCN08R	Protection counter Reset 08	318
PCN09Q	Protection counter Output 09	315
PCN09R	Protection counter Reset 09	319
PCN10Q	Protection counter Output 10	315
PCN10R	Protection counter Reset 10	319
PCN11Q	Protection counter Output 11	315
PCN11R	Protection counter Reset 11	319
PCN12Q	Protection counter Output 12	315
PCN12R	Protection counter Reset 12	319
PCN13Q	Protection counter Output 13	315
PCN13R	Protection counter Reset 13	319
PCN14Q	Protection counter Output 14	315
PCN14R	Protection counter Reset 14	319
PCN15Q	Protection counter Output 15	315
PCN15R	Protection counter Reset 15	319
PCN16Q	Protection counter Output 16	315
PCN16R	Protection counter Reset 16	319
PCN17Q	Protection counter Output 17	316
PCN17R	Protection counter Reset 17	320
PCN18Q	Protection counter Output 18	316
PCN18R	Protection counter Reset 18	320
PCN19Q	Protection counter Output 19	316

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 52 of 79)

Name	Bit Description	Row
PCN19R	Protection counter Reset 19	320
PCN20Q	Protection counter Output 20	316
PCN20R	Protection counter Reset 20	320
PCN21Q	Protection counter Output 21	316
PCN21R	Protection counter Reset 21	320
PCN22Q	Protection counter Output 22	316
PCN22R	Protection counter Reset 22	320
PCN23Q	Protection counter Output 23	316
PCN23R	Protection counter Reset 23	320
PCN24Q	Protection counter Output 24	316
PCN24R	Protection counter Reset 24	320
PCN25Q	Protection counter Output 25	317
PCN25R	Protection counter Reset 25	321
PCN26Q	Protection counter Output 26	317
PCN26R	Protection counter Reset 26	321
PCN27Q	Protection counter Output 27	317
PCN27R	Protection counter Reset 27	321
PCN28Q	Protection counter Output 28	317
PCN28R	Protection counter Reset 28	321
PCN29Q	Protection counter Output 29	317
PCN29R	Protection counter Reset 29	321
PCN30Q	Protection counter Output 30	317
PCN30R	Protection counter Reset 30	321
PCN31Q	Protection counter Output 31	317
PCN31R	Protection counter Reset 31	321
PCN32Q	Protection counter Output 32	317
PCN32R	Protection counter Reset 32	321
PCT01Q	Protection conditioning timer Output 01	304
PCT02Q	Protection conditioning timer Output 02	304
PCT03Q	Protection conditioning timer Output 03	304
PCT04Q	Protection conditioning timer Output 04	304
PCT05Q	Protection conditioning timer Output 05	304
PCT06Q	Protection conditioning timer Output 06	304
PCT07Q	Protection conditioning timer Output 07	304
PCT08Q	Protection conditioning timer Output 08	304
PCT09Q	Protection conditioning timer Output 09	305
PCT10Q	Protection conditioning timer Output 10	305
PCT11Q	Protection conditioning timer Output 11	305
PCT12Q	Protection conditioning timer Output 12	305
PCT13Q	Protection conditioning timer Output 13	305
PCT14Q	Protection conditioning timer Output 14	305

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 53 of 79)

Name	Bit Description	Row
PCT15Q	Protection conditioning timer Output 15	305
PCT16Q	Protection conditioning timer Output 16	305
PFRTEX	Protection SELOGIC control equation first execution	374
PLT01	Protection Latch 01	300
PLT02	Protection Latch 02	300
PLT03	Protection Latch 03	300
PLT04	Protection Latch 04	300
PLT05	Protection Latch 05	300
PLT06	Protection Latch 06	300
PLT07	Protection Latch 07	300
PLT08	Protection Latch 08	300
PLT09	Protection Latch 09	301
PLT10	Protection Latch 10	301
PLT11	Protection Latch 11	301
PLT12	Protection Latch 12	301
PLT13	Protection Latch 13	301
PLT14	Protection Latch 14	301
PLT15	Protection Latch 15	301
PLT16	Protection Latch 16	301
PLT17	Protection Latch 17	302
PLT18	Protection Latch 18	302
PLT19	Protection Latch 19	302
PLT20	Protection Latch 20	302
PLT21	Protection Latch 21	302
PLT22	Protection Latch 22	302
PLT23	Protection Latch 23	302
PLT24	Protection Latch 24	302
PLT25	Protection Latch 25	303
PLT26	Protection Latch 26	303
PLT27	Protection Latch 27	303
PLT28	Protection Latch 28	303
PLT29	Protection Latch 29	303
PLT30	Protection Latch 30	303
PLT31	Protection Latch 31	303
PLT32	Protection Latch 32	303
PST01Q	Protection sequencing timer Output 01	306
PST01R	Protection sequencing timer Reset 01	310
PST02Q	Protection sequencing timer Output 02	306
PST02R	Protection sequencing timer Reset 02	310
PST03Q	Protection sequencing timer Output 03	306
PST03R	Protection sequencing timer Reset 03	310

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 54 of 79)

Name	Bit Description	Row
PST04Q	Protection sequencing timer Output 04	306
PST04R	Protection sequencing timer Reset 04	310
PST05Q	Protection sequencing timer Output 05	306
PST05R	Protection sequencing timer Reset 05	310
PST06Q	Protection sequencing timer Output 06	306
PST06R	Protection sequencing timer Reset 06	310
PST07Q	Protection sequencing timer Output 07	306
PST07R	Protection sequencing timer Reset 07	310
PST08Q	Protection sequencing timer Output 08	306
PST08R	Protection sequencing timer Reset 08	310
PST09Q	Protection sequencing timer Output 09	307
PST09R	Protection sequencing timer Reset 09	311
PST10Q	Protection sequencing timer Output 10	307
PST10R	Protection sequencing timer Reset 10	311
PST11Q	Protection sequencing timer Output 11	307
PST11R	Protection sequencing timer Reset 11	311
PST12Q	Protection sequencing timer Output 12	307
PST12R	Protection sequencing timer Reset 12	311
PST13Q	Protection sequencing timer Output 13	307
PST13R	Protection sequencing timer Reset 13	311
PST14Q	Protection sequencing timer Output 14	307
PST14R	Protection sequencing timer Reset 14	311
PST15Q	Protection sequencing timer Output 15	307
PST15R	Protection sequencing timer Reset 15	311
PST16Q	Protection sequencing timer Output 16	307
PST16R	Protection sequencing timer Reset 16	311
PST17Q	Protection sequencing timer Output 17	308
PST17R	Protection sequencing timer Reset 17	312
PST18Q	Protection sequencing timer Output 18	308
PST18R	Protection sequencing timer Reset 18	312
PST19Q	Protection sequencing timer Output 19	308
PST19R	Protection sequencing timer Reset 19	312
PST20Q	Protection sequencing timer Output 20	308
PST20R	Protection sequencing timer Reset 20	312
PST21Q	Protection sequencing timer Output 21	308
PST21R	Protection sequencing timer Reset 21	312
PST22Q	Protection sequencing timer Output 22	308
PST22R	Protection sequencing timer Reset 22	312
PST23Q	Protection sequencing timer Output 23	308
PST23R	Protection sequencing timer Reset 23	312
PST24Q	Protection sequencing timer Output 24	308

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 55 of 79)

Name	Bit Description	Row
PST24R	Protection sequencing timer Reset 24	312
PST25Q	Protection sequencing timer Output 25	309
PST25R	Protection sequencing timer Reset 25	313
PST26Q	Protection sequencing timer Output 26	309
PST26R	Protection sequencing timer Reset 26	313
PST27Q	Protection sequencing timer Output 27	309
PST27R	Protection sequencing timer Reset 27	313
PST28Q	Protection sequencing timer Output 28	309
PST28R	Protection sequencing timer Reset 28	313
PST29Q	Protection sequencing timer Output 29	309
PST29R	Protection sequencing timer Reset 29	313
PST30Q	Protection sequencing timer Output 30	309
PST30R	Protection sequencing timer Reset 30	313
PST31Q	Protection sequencing timer Output 31	309
PST31R	Protection sequencing timer Reset 31	313
PST32Q	Protection sequencing timer Output 32	309
PST32R	Protection sequencing timer Reset 32	313
PSV01	Protection SELOGIC control equation Variable 01	292
PSV02	Protection SELOGIC control equation Variable 02	292
PSV03	Protection SELOGIC control equation Variable 03	292
PSV04	Protection SELOGIC control equation Variable 04	292
PSV05	Protection SELOGIC control equation Variable 05	292
PSV06	Protection SELOGIC control equation Variable 06	292
PSV07	Protection SELOGIC control equation Variable 07	292
PSV08	Protection SELOGIC control equation Variable 08	292
PSV09	Protection SELOGIC control equation Variable 09	293
PSV10	Protection SELOGIC control equation Variable 10	293
PSV11	Protection SELOGIC control equation Variable 11	293
PSV12	Protection SELOGIC control equation Variable 12	293
PSV13	Protection SELOGIC control equation Variable 13	293
PSV14	Protection SELOGIC control equation Variable 14	293
PSV15	Protection SELOGIC control equation Variable 15	293
PSV16	Protection SELOGIC control equation Variable 16	293
PSV17	Protection SELOGIC control equation Variable 17	294
PSV18	Protection SELOGIC control equation Variable 18	294
PSV19	Protection SELOGIC control equation Variable 19	294
PSV20	Protection SELOGIC control equation Variable 20	294
PSV21	Protection SELOGIC control equation Variable 21	294
PSV22	Protection SELOGIC control equation Variable 22	294
PSV23	Protection SELOGIC control equation Variable 23	294
PSV24	Protection SELOGIC control equation Variable 24	294

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 56 of 79)

Name	Bit Description	Row
PSV25	Protection SELOGIC control equation Variable 25	295
PSV26	Protection SELOGIC control equation Variable 26	295
PSV27	Protection SELOGIC control equation Variable 27	295
PSV28	Protection SELOGIC control equation Variable 28	295
PSV29	Protection SELOGIC control equation Variable 29	295
PSV30	Protection SELOGIC control equation Variable 30	295
PSV31	Protection SELOGIC control equation Variable 31	295
PSV32	Protection SELOGIC control equation Variable 32	295
PSV33	Protection SELOGIC control equation Variable 33	296
PSV34	Protection SELOGIC control equation Variable 34	296
PSV35	Protection SELOGIC control equation Variable 35	296
PSV36	Protection SELOGIC control equation Variable 36	296
PSV37	Protection SELOGIC control equation Variable 37	296
PSV38	Protection SELOGIC control equation Variable 38	296
PSV39	Protection SELOGIC control equation Variable 39	296
PSV40	Protection SELOGIC control equation Variable 40	296
PSV41	Protection SELOGIC control equation Variable 41	297
PSV42	Protection SELOGIC control equation Variable 42	297
PSV43	Protection SELOGIC control equation Variable 43	297
PSV44	Protection SELOGIC control equation Variable 44	297
PSV45	Protection SELOGIC control equation Variable 45	297
PSV46	Protection SELOGIC control equation Variable 46	297
PSV47	Protection SELOGIC control equation Variable 47	297
PSV48	Protection SELOGIC control equation Variable 48	297
PSV49	Protection SELOGIC control equation Variable 49	298
PSV50	Protection SELOGIC control equation Variable 50	298
PSV51	Protection SELOGIC control equation Variable 51	298
PSV52	Protection SELOGIC control equation Variable 52	298
PSV53	Protection SELOGIC control equation Variable 53	298
PSV54	Protection SELOGIC control equation Variable 54	298
PSV55	Protection SELOGIC control equation Variable 55	298
PSV56	Protection SELOGIC control equation Variable 56	298
PSV57	Protection SELOGIC control equation Variable 57	299
PSV58	Protection SELOGIC control equation Variable 58	299
PSV59	Protection SELOGIC control equation Variable 59	299
PSV60	Protection SELOGIC control equation Variable 60	299
PSV61	Protection SELOGIC control equation Variable 61	299
PSV62	Protection SELOGIC control equation Variable 62	299
PSV63	Protection SELOGIC control equation Variable 63	299
PSV64	Protection SELOGIC control equation Variable 64	299
PTP_BNP	Bad jitter on PTP signals and the PTP signal is lost afterwards	474

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 57 of 79)

Name	Bit Description	Row
PTP_OK	PTP is available and has sufficient quality	473
PTP_RST	Disqualify PTP time source	473
PTP_SET	Qualify PTP time source	473
PTP_TIM	A valid PTP time source is detected	473
PTPSYNC	Synchronized to a high-quality PTP source	474
PUNRLBL	Protection SELOGIC control equation unresolved label	374
RB01	Remote Bit 01	271
RB02	Remote Bit 02	271
RB03	Remote Bit 03	271
RB04	Remote Bit 04	271
RB05	Remote Bit 05	271
RB06	Remote Bit 06	271
RB07	Remote Bit 07	271
RB08	Remote Bit 08	271
RB09	Remote Bit 09	270
RB10	Remote Bit 10	270
RB11	Remote Bit 11	270
RB12	Remote Bit 12	270
RB13	Remote Bit 13	270
RB14	Remote Bit 14	270
RB15	Remote Bit 15	270
RB16	Remote Bit 16	270
RB17	Remote Bit 17	269
RB18	Remote Bit 18	269
RB19	Remote Bit 19	269
RB20	Remote Bit 20	269
RB21	Remote Bit 21	269
RB22	Remote Bit 22	269
RB23	Remote Bit 23	269
RB24	Remote Bit 24	269
RB25	Remote Bit 25	268
RB26	Remote Bit 26	268
RB27	Remote Bit 27	268
RB28	Remote Bit 28	268
RB29	Remote Bit 29	268
RB30	Remote Bit 30	268
RB31	Remote Bit 31	268
RB32	Remote Bit 32	268
RB33	Remote Bit 33	267
RB34	Remote Bit 34	267
RB35	Remote Bit 35	267

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 58 of 79)

Name	Bit Description	Row
RB36	Remote Bit 36	267
RB37	Remote Bit 37	267
RB38	Remote Bit 38	267
RB39	Remote Bit 39	267
RB40	Remote Bit 40	267
RB41	Remote Bit 41	266
RB42	Remote Bit 42	266
RB43	Remote Bit 43	266
RB44	Remote Bit 44	266
RB45	Remote Bit 45	266
RB46	Remote Bit 46	266
RB47	Remote Bit 47	266
RB48	Remote Bit 48	266
RB49	Remote Bit 49	265
RB50	Remote Bit 50	265
RB51	Remote Bit 51	265
RB52	Remote Bit 52	265
RB53	Remote Bit 53	265
RB54	Remote Bit 54	265
RB55	Remote Bit 55	265
RB56	Remote Bit 56	265
RB57	Remote Bit 57	264
RB58	Remote Bit 58	264
RB59	Remote Bit 59	264
RB60	Remote Bit 60	264
RB61	Remote Bit 61	264
RB62	Remote Bit 62	264
RB63	Remote Bit 63	264
RB64	Remote Bit 64	264
RB65	Remote Bit 65	263
RB66	Remote Bit 66	263
RB67	Remote Bit 67	263
RB68	Remote Bit 68	263
RB69	Remote Bit 69	263
RB70	Remote Bit 70	263
RB71	Remote Bit 71	263
RB72	Remote Bit 72	263
RB73	Remote Bit 73	262
RB74	Remote Bit 74	262
RB75	Remote Bit 75	262
RB76	Remote Bit 76	262

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 59 of 79)

Name	Bit Description	Row
RB77	Remote Bit 77	262
RB78	Remote Bit 78	262
RB79	Remote Bit 79	262
RB80	Remote Bit 80	262
RB81	Remote Bit 81	261
RB82	Remote Bit 82	261
RB83	Remote Bit 83	261
RB84	Remote Bit 84	261
RB85	Remote Bit 85	261
RB86	Remote Bit 86	261
RB87	Remote Bit 87	261
RB88	Remote Bit 88	261
RB89	Remote Bit 89	260
RB90	Remote Bit 90	260
RB91	Remote Bit 91	260
RB92	Remote Bit 92	260
RB93	Remote Bit 93	260
RB94	Remote Bit 94	260
RB95	Remote Bit 95	260
RB96	Remote Bit 96	260
RBADA	Channel A MIRRORED BITS outage too long	404
RBADB	Channel B MIRRORED BITS outage too long	405
RDIF1	Zone 1 unfiltered restrained differential element picked up	160
RDIF2	Zone 2 unfiltered restrained differential element picked up	162
RDIF3	Zone 3 unfiltered restrained differential element picked up	164
RDIF4	Zone 4 unfiltered restrained differential element picked up	166
RDIF5	Zone 5 unfiltered restrained differential element picked up	168
RDIF6	Zone 6 unfiltered restrained differential element picked up	170
RDIFCZ1	Check Zone 1 unfiltered restrained differential element picked up	451
RDIFCZ2	Check Zone 2 unfiltered restrained differential element picked up	453
RDIFCZ3	Check Zone 3 unfiltered restrained differential element picked up	455
RMB1A	Channel A receive MIRRORED BIT 1	400
RMB1B	Channel B receive MIRRORED BIT 1	402
RMB2A	Channel A receive MIRRORED BIT 2	400
RMB2B	Channel B receive MIRRORED BIT 2	402
RMB3A	Channel A receive MIRRORED BIT 3	400
RMB3B	Channel B receive MIRRORED BIT 3	402
RMB4A	Channel A receive MIRRORED BIT 4	400
RMB4B	Channel B receive MIRRORED BIT 4	402
RMB5A	Channel A receive MIRRORED BIT 5	400
RMB5B	Channel B receive MIRRORED BIT 5	402

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 60 of 79)

Name	Bit Description	Row
RMB6A	Channel A receive MIRRORED BIT 6	400
RMB6B	Channel B receive MIRRORED BIT 6	402
RMB7A	Channel A receive MIRRORED BIT 7	400
RMB7B	Channel B receive MIRRORED BIT 7	402
RMB8A	Channel A receive MIRRORED BIT 8	400
RMB8B	Channel B receive MIRRORED BIT 8	402
ROCTZ1	Zone 1 open CT logic reset	154
ROCTZ2	Zone 2 open CT logic reset	154
ROCTZ3	Zone 3 open CT logic reset	154
ROCTZ4	Zone 4 open CT logic reset	154
ROCTZ5	Zone 5 open CT logic reset	154
ROCTZ6	Zone 6 open CT logic reset	154
ROKA	Channel A MIRRORED BITS normal status (non-loopback)	404
ROKB	Channel B MIRRORED BITS normal status (non-loopback mode)	405
RST_BAT	Reset battery monitoring	440
RST_HAL	Reset HALARMA	440
RSTDNPE	Reset DNP fault summary data	440
RSTOCT1	Zone 1 open CT detection reset	156
RSTOCT2	Zone 2 open CT detection reset	156
RSTOCT3	Zone 3 open CT detection reset	156
RSTOCT4	Zone 4 open CT detection reset	156
RSTOCT5	Zone 5 open CT detection reset	156
RSTOCT6	Zone 6 open CT detection reset	156
RSTTRGT	Target reset (SELOGIC control equation)	440
RT01	Circuit Breaker 1 retrip	183
RT02	Circuit Breaker 2 retrip	184
RT03	Circuit Breaker 3 retrip	185
RT04	Circuit Breaker 4 retrip	186
RT05	Circuit Breaker 5 retrip	187
RT06	Circuit Breaker 6 retrip	188
RT07	Circuit Breaker 7 retrip	189
RT08	Circuit Breaker 8 retrip	190
RT09	Circuit Breaker 9 retrip	191
RT10	Circuit Breaker 10 retrip	192
RT11	Circuit Breaker 11 retrip	193
RT12	Circuit Breaker 12 retrip	194
RT13	Circuit Breaker 13 retrip	195
RT14	Circuit Breaker 14 retrip	196
RT15	Circuit Breaker 15 retrip	197
RT16	Circuit Breaker 16 retrip	198
RT17	Circuit Breaker 17 retrip	199

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 61 of 79)

Name	Bit Description	Row
RT18	Circuit Breaker 18 retrip	200
RT19	Circuit Breaker 19 retrip	201
RT20	Circuit Breaker 20 retrip	202
RT21	Circuit Breaker 21 retrip	203
RZSWOAL	Reset zone switching operation alarm	152
SALARM	Non-diagnostic alarm pulse	376
SBFTR	Any circuit breaker failure trip	239
SBFTR01	Circuit Breaker 01 breaker failure trip	236
SBFTR02	Circuit Breaker 02 breaker failure trip	236
SBFTR03	Circuit Breaker 03 breaker failure trip	236
SBFTR04	Circuit Breaker 04 breaker failure trip	236
SBFTR05	Circuit Breaker 05 breaker failure trip	236
SBFTR06	Circuit Breaker 06 breaker failure trip	236
SBFTR07	Circuit Breaker 07 breaker failure trip	236
SBFTR08	Circuit Breaker 08 breaker failure trip	236
SBFTR09	Circuit Breaker 09 breaker failure trip	237
SBFTR10	Circuit Breaker 10 breaker failure trip	237
SBFTR11	Circuit Breaker 11 breaker failure trip	237
SBFTR12	Circuit Breaker 12 breaker failure trip	237
SBFTR13	Circuit Breaker 13 breaker failure trip	237
SBFTR14	Circuit Breaker 14 breaker failure trip	237
SBFTR15	Circuit Breaker 15 breaker failure trip	237
SBFTR16	Circuit Breaker 16 breaker failure trip	237
SBFTR17	Circuit Breaker 17 breaker failure trip	238
SBFTR18	Circuit Breaker 18 breaker failure trip	238
SBFTR19	Circuit Breaker 19 breaker failure trip	238
SBFTR20	Circuit Breaker 20 breaker failure trip	238
SBFTR21	Circuit Breaker 21 breaker failure trip	238
SC850BM	SELOGIC control for IEC 61850 blocked mode	476
SC850LS	SELOGIC control for control authority at station level	480
SC850SM	SELOGIC control for IEC 61850 simulation mode	476
SC850TM	SELOGIC control for IEC 61850 test mode	476
SER_BNP	Bad jitter on serial port and the IRIG-B signal is lost afterwards	473
SER_OK	IRIG-B signal from serial port 1 is available and has sufficient quality	472
SER_RST	Disqualify serial IRIG-B time source	472
SER_SET	Qualify serial IRIG-B time source	472
SER_TIM	A valid IRIG-B time source is detected on serial port	473
SERSYNC	Synchronized to a high-quality serial IRIG source	474
SETCHG	Pulsed when settings change	376
SG1	Settings Group 1 active	255
SG2	Settings Group 2 active	255

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 62 of 79)

Name	Bit Description	Row
SG3	Settings Group 3 active	255
SG4	Settings Group 4 active	255
SG5	Settings Group 5 active	255
SG6	Settings Group 6 active	255
SPEN	Signal Profiling enabled	467
TBNC	The active relay time source is BNC IRIG	378
TESTDB	Communications card database test bit	406
TESTDB2	DNP test bit	406
TESTFM	Fast meter test bit	406
TESTPUL	Pulse test bit	406
TGLOBAL	Relay calendar clock and ADC sampling synchronized to a high-priority Global time source	379
TIRIG	Assert while time is based on IRIG for both mark and value	378
TLED_1	Front-panel target LED 1	1
TLED_10	Front-panel target LED 10	2
TLED_11	Front-panel target LED 11	2
TLED_12	Front-panel target LED 12	2
TLED_13	Front-panel target LED 13	2
TLED_14	Front-panel target LED 14	2
TLED_15	Front-panel target LED 15	2
TLED_16	Front-panel target LED 16	2
TLED_17	Front-panel target LED 17	3
TLED_18	Front-panel target LED 18	3
TLED_19	Front-panel target LED 19	3
TLED_2	Front-panel target LED 2	1
TLED_20	Front-panel target LED 20	3
TLED_21	Front-panel target LED 21	3
TLED_22	Front-panel target LED 22	3
TLED_23	Front-panel target LED 23	3
TLED_24	Front-panel target LED 24	3
TLED_3	Front-panel target LED 3	1
TLED_4	Front-panel target LED 4	1
TLED_5	Front-panel target LED 5	1
TLED_6	Front-panel target LED 6	1
TLED_7	Front-panel target LED 7	1
TLED_8	Front-panel target LED 8	1
TLED_9	Front-panel target LED 9	2
TLOCAL	Relay calendar clock and ADC sampling synchronized to a high-priority local time source	379
TMB1A	Channel A transmit MIRRORED BIT 1	401
TMB1B	Channel B transmit MIRRORED BIT 1	403
TMB2A	Channel A transmit MIRRORED BIT 2	401
TMB2B	Channel B transmit MIRRORED BIT 2	403

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 63 of 79)

Name	Bit Description	Row
TMB3A	Channel A transmit MIRRORED BIT 3	401
TMB3B	Channel B transmit MIRRORED BIT 3	403
TMB4A	Channel A transmit MIRRORED BIT 4	401
TMB4B	Channel B transmit MIRRORED BIT 4	403
TMB5A	Channel A transmit MIRRORED BIT 5	401
TMB5B	Channel B transmit MIRRORED BIT 5	403
TMB6A	Channel A transmit MIRRORED BIT 6	401
TMB6B	Channel B transmit MIRRORED BIT 6	403
TMB7A	Channel A transmit MIRRORED BIT 7	401
TMB7B	Channel B transmit MIRRORED BIT 7	403
TMB8A	Channel A transmit MIRRORED BIT 8	401
TMB8B	Channel B transmit MIRRORED BIT 8	403
TOS01	Terminal 01 out of service	180
TOS02	Terminal 02 out of service	180
TOS03	Terminal 03 out of service	180
TOS04	Terminal 04 out of service	180
TOS05	Terminal 05 out of service	180
TOS06	Terminal 06 out of service	180
TOS07	Terminal 07 out of service	180
TOS08	Terminal 08 out of service	180
TOS09	Terminal 09 out of service	181
TOS10	Terminal 10 out of service	181
TOS11	Terminal 11 out of service	181
TOS12	Terminal 12 out of service	181
TOS13	Terminal 13 out of service	181
TOS14	Terminal 14 out of service	181
TOS15	Terminal 15 out of service	181
TOS16	Terminal 16 out of service	181
TOS17	Terminal 17 out of service	182
TOS18	Terminal 18 out of service	182
TOS19	Terminal 19 out of service	182
TOS20	Terminal 20 out of service	182
TOS21	Terminal 21 out of service	182
TPLLEXT	Update PLL using external signal	379
TPTP	The active relay time source is PTP	378
TQUAL1	Time quality, binary, add 1 when asserted	470
TQUAL2	Time quality, binary, add 2 when asserted	470
TQUAL4	Time quality, binary, add 4 when asserted	470
TQUAL8	Time quality, binary, add 8 when asserted	470
TRGTR	Reset all active target Relay Words	466
TRIP	Any terminal trip output	245

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 64 of 79)

Name	Bit Description	Row
TRIP01	Terminal 01 trip output	242
TRIP02	Terminal 02 trip output	242
TRIP03	Terminal 03 trip output	242
TRIP04	Terminal 04 trip output	242
TRIP05	Terminal 05 trip output	242
TRIP06	Terminal 06 trip output	242
TRIP07	Terminal 07 trip output	242
TRIP08	Terminal 08 trip output	242
TRIP09	Terminal 09 trip output	243
TRIP10	Terminal 10 trip output	243
TRIP11	Terminal 11 trip output	243
TRIP12	Terminal 12 trip output	243
TRIP13	Terminal 13 trip output	243
TRIP14	Terminal 14 trip output	243
TRIP15	Terminal 15 trip output	243
TRIP16	Terminal 16 trip output	243
TRIP17	Terminal 17 trip output	244
TRIP18	Terminal 18 trip output	244
TRIP19	Terminal 19 trip output	244
TRIP20	Terminal 20 trip output	244
TRIP21	Terminal 21 trip output	244
TRIPLED	Trip LED	0
TSER	The active relay time source is serial IRIG	378
TSNTPB	Asserts if time was synchronized with backup NTP server before SNTP time-out period expired	379
TSNTPP	Asserts if time was synchronized with primary NTP server before SNTP time-out period expired	379
TSOK	Assert if current time-source accuracy is sufficient for synchronized phasor measurements	378
TSSW	High-priority time source switching	379
TSYNC	Assert when ADC sampling is synchronized to a valid high-priority time source	379
TSYNCA	Assert while the time mark from time source or fixed internal source is not synchronized	378
TUPDH	Assert if update source is high-priority time source	378
TUTC1	IRIG-B offset hours from UTC time, binary, add 1 if asserted	469
TUTC2	IRIG-B offset hours from UTC time, binary, add 2 if asserted	469
TUTC4	IRIG-B offset hours from UTC time, binary, add 4 if asserted	469
TUTC8	IRIG-B offset hours from UTC time, binary, add 8 if asserted	469
TUTCH	IRIG-B offset half-hour from UTC time, binary, add 0.5 if asserted	469
TUTCS	IRIG-B offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted, add otherwise	469
ULTR01	Terminal 01 unlatch trip	246
ULTR02	Terminal 02 unlatch trip	246
ULTR03	Terminal 03 unlatch trip	246
ULTR04	Terminal 04 unlatch trip	246
ULTR05	Terminal 05 unlatch trip	246

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 65 of 79)

Name	Bit Description	Row
ULTR06	Terminal 06 unlatch trip	246
ULTR07	Terminal 07 unlatch trip	246
ULTR08	Terminal 08 unlatch trip	246
ULTR09	Terminal 09 unlatch trip	247
ULTR10	Terminal 10 unlatch trip	247
ULTR11	Terminal 11 unlatch trip	247
ULTR12	Terminal 12 unlatch trip	247
ULTR13	Terminal 13 unlatch trip	247
ULTR14	Terminal 14 unlatch trip	247
ULTR15	Terminal 15 unlatch trip	247
ULTR16	Terminal 16 unlatch trip	247
ULTR17	Terminal 17 unlatch trip	248
ULTR18	Terminal 18 unlatch trip	248
ULTR19	Terminal 19 unlatch trip	248
ULTR20	Terminal 20 unlatch trip	248
ULTR21	Terminal 21 unlatch trip	248
UPD_BLK	Block updating internal clock period and master time	472
UPD_EN	Enable updating internal clock with selected external time source	378
VB001	Virtual Bit 001	439
VB002	Virtual Bit 002	439
VB003	Virtual Bit 003	439
VB004	Virtual Bit 004	439
VB005	Virtual Bit 005	439
VB006	Virtual Bit 006	439
VB007	Virtual Bit 007	439
VB008	Virtual Bit 008	439
VB009	Virtual Bit 009	438
VB010	Virtual Bit 010	438
VB011	Virtual Bit 011	438
VB012	Virtual Bit 012	438
VB013	Virtual Bit 013	438
VB014	Virtual Bit 014	438
VB015	Virtual Bit 015	438
VB016	Virtual Bit 016	438
VB017	Virtual Bit 017	437
VB018	Virtual Bit 018	437
VB019	Virtual Bit 019	437
VB020	Virtual Bit 020	437
VB021	Virtual Bit 021	437
VB022	Virtual Bit 022	437
VB023	Virtual Bit 023	437

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 66 of 79)

Name	Bit Description	Row
VB024	Virtual Bit 024	437
VB025	Virtual Bit 025	436
VB026	Virtual Bit 026	436
VB027	Virtual Bit 027	436
VB028	Virtual Bit 028	436
VB029	Virtual Bit 029	436
VB030	Virtual Bit 030	436
VB031	Virtual Bit 031	436
VB032	Virtual Bit 032	436
VB033	Virtual Bit 033	435
VB034	Virtual Bit 034	435
VB035	Virtual Bit 035	435
VB036	Virtual Bit 036	435
VB037	Virtual Bit 037	435
VB038	Virtual Bit 038	435
VB039	Virtual Bit 039	435
VB040	Virtual Bit 040	435
VB041	Virtual Bit 041	434
VB042	Virtual Bit 042	434
VB043	Virtual Bit 043	434
VB044	Virtual Bit 044	434
VB045	Virtual Bit 045	434
VB046	Virtual Bit 046	434
VB047	Virtual Bit 047	434
VB048	Virtual Bit 048	434
VB049	Virtual Bit 049	433
VB050	Virtual Bit 050	433
VB051	Virtual Bit 051	433
VB052	Virtual Bit 052	433
VB053	Virtual Bit 053	433
VB054	Virtual Bit 054	433
VB055	Virtual Bit 055	433
VB056	Virtual Bit 056	433
VB057	Virtual Bit 057	432
VB058	Virtual Bit 058	432
VB059	Virtual Bit 059	432
VB060	Virtual Bit 060	432
VB061	Virtual Bit 061	432
VB062	Virtual Bit 062	432
VB063	Virtual Bit 063	432
VB064	Virtual Bit 064	432

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 67 of 79)

Name	Bit Description	Row
VB065	Virtual Bit 065	431
VB066	Virtual Bit 066	431
VB067	Virtual Bit 067	431
VB068	Virtual Bit 068	431
VB069	Virtual Bit 069	431
VB070	Virtual Bit 070	431
VB071	Virtual Bit 071	431
VB072	Virtual Bit 072	431
VB073	Virtual Bit 073	430
VB074	Virtual Bit 074	430
VB075	Virtual Bit 075	430
VB076	Virtual Bit 076	430
VB077	Virtual Bit 077	430
VB078	Virtual Bit 078	430
VB079	Virtual Bit 079	430
VB080	Virtual Bit 080	430
VB081	Virtual Bit 081	429
VB082	Virtual Bit 082	429
VB083	Virtual Bit 083	429
VB084	Virtual Bit 084	429
VB085	Virtual Bit 085	429
VB086	Virtual Bit 086	429
VB087	Virtual Bit 087	429
VB088	Virtual Bit 088	429
VB089	Virtual Bit 089	428
VB090	Virtual Bit 090	428
VB091	Virtual Bit 091	428
VB092	Virtual Bit 092	428
VB093	Virtual Bit 093	428
VB094	Virtual Bit 094	428
VB095	Virtual Bit 095	428
VB096	Virtual Bit 096	428
VB097	Virtual Bit 097	427
VB098	Virtual Bit 098	427
VB099	Virtual Bit 099	427
VB100	Virtual Bit 100	427
VB101	Virtual Bit 101	427
VB102	Virtual Bit 102	427
VB103	Virtual Bit 103	427
VB104	Virtual Bit 104	427
VB105	Virtual Bit 105	426

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 68 of 79)

Name	Bit Description	Row
VB106	Virtual Bit 106	426
VB107	Virtual Bit 107	426
VB108	Virtual Bit 108	426
VB109	Virtual Bit 109	426
VB110	Virtual Bit 110	426
VB111	Virtual Bit 111	426
VB112	Virtual Bit 112	426
VB113	Virtual Bit 113	425
VB114	Virtual Bit 114	425
VB115	Virtual Bit 115	425
VB116	Virtual Bit 116	425
VB117	Virtual Bit 117	425
VB118	Virtual Bit 118	425
VB119	Virtual Bit 119	425
VB120	Virtual Bit 120	425
VB121	Virtual Bit 121	424
VB122	Virtual Bit 122	424
VB123	Virtual Bit 123	424
VB124	Virtual Bit 124	424
VB125	Virtual Bit 125	424
VB126	Virtual Bit 126	424
VB127	Virtual Bit 127	424
VB128	Virtual Bit 128	424
VB129	Virtual Bit 129	423
VB130	Virtual Bit 130	423
VB131	Virtual Bit 131	423
VB132	Virtual Bit 132	423
VB133	Virtual Bit 133	423
VB134	Virtual Bit 134	423
VB135	Virtual Bit 135	423
VB136	Virtual Bit 136	423
VB137	Virtual Bit 137	422
VB138	Virtual Bit 138	422
VB139	Virtual Bit 139	422
VB140	Virtual Bit 140	422
VB141	Virtual Bit 141	422
VB142	Virtual Bit 142	422
VB143	Virtual Bit 143	422
VB144	Virtual Bit 144	422
VB145	Virtual Bit 145	421
VB146	Virtual Bit 146	421

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 69 of 79)

Name	Bit Description	Row
VB147	Virtual Bit 147	421
VB148	Virtual Bit 148	421
VB149	Virtual Bit 149	421
VB150	Virtual Bit 150	421
VB151	Virtual Bit 151	421
VB152	Virtual Bit 152	421
VB153	Virtual Bit 153	420
VB154	Virtual Bit 154	420
VB155	Virtual Bit 155	420
VB156	Virtual Bit 156	420
VB157	Virtual Bit 157	420
VB158	Virtual Bit 158	420
VB159	Virtual Bit 159	420
VB160	Virtual Bit 160	420
VB161	Virtual Bit 161	419
VB162	Virtual Bit 162	419
VB163	Virtual Bit 163	419
VB164	Virtual Bit 164	419
VB165	Virtual Bit 165	419
VB166	Virtual Bit 166	419
VB167	Virtual Bit 167	419
VB168	Virtual Bit 168	419
VB169	Virtual Bit 169	418
VB170	Virtual Bit 170	418
VB171	Virtual Bit 171	418
VB172	Virtual Bit 172	418
VB173	Virtual Bit 173	418
VB174	Virtual Bit 174	418
VB175	Virtual Bit 175	418
VB176	Virtual Bit 176	418
VB177	Virtual Bit 177	417
VB178	Virtual Bit 178	417
VB179	Virtual Bit 179	417
VB180	Virtual Bit 180	417
VB181	Virtual Bit 181	417
VB182	Virtual Bit 182	417
VB183	Virtual Bit 183	417
VB184	Virtual Bit 184	417
VB185	Virtual Bit 185	416
VB186	Virtual Bit 186	416
VB187	Virtual Bit 187	416

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 70 of 79)

Name	Bit Description	Row
VB188	Virtual Bit 188	416
VB189	Virtual Bit 189	416
VB190	Virtual Bit 190	416
VB191	Virtual Bit 191	416
VB192	Virtual Bit 192	416
VB193	Virtual Bit 193	415
VB194	Virtual Bit 194	415
VB195	Virtual Bit 195	415
VB196	Virtual Bit 196	415
VB197	Virtual Bit 197	415
VB198	Virtual Bit 198	415
VB199	Virtual Bit 199	415
VB200	Virtual Bit 200	415
VB201	Virtual Bit 201	414
VB202	Virtual Bit 202	414
VB203	Virtual Bit 203	414
VB204	Virtual Bit 204	414
VB205	Virtual Bit 205	414
VB206	Virtual Bit 206	414
VB207	Virtual Bit 207	414
VB208	Virtual Bit 208	414
VB209	Virtual Bit 209	413
VB210	Virtual Bit 210	413
VB211	Virtual Bit 211	413
VB212	Virtual Bit 212	413
VB213	Virtual Bit 213	413
VB214	Virtual Bit 214	413
VB215	Virtual Bit 215	413
VB216	Virtual Bit 216	413
VB217	Virtual Bit 217	412
VB218	Virtual Bit 218	412
VB219	Virtual Bit 219	412
VB220	Virtual Bit 220	412
VB221	Virtual Bit 221	412
VB222	Virtual Bit 222	412
VB223	Virtual Bit 223	412
VB224	Virtual Bit 224	412
VB225	Virtual Bit 225	411
VB226	Virtual Bit 226	411
VB227	Virtual Bit 227	411
VB228	Virtual Bit 228	411

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 71 of 79)

Name	Bit Description	Row
VB229	Virtual Bit 229	411
VB230	Virtual Bit 230	411
VB231	Virtual Bit 231	411
VB232	Virtual Bit 232	411
VB233	Virtual Bit 233	410
VB234	Virtual Bit 234	410
VB235	Virtual Bit 235	410
VB236	Virtual Bit 236	410
VB237	Virtual Bit 237	410
VB238	Virtual Bit 238	410
VB239	Virtual Bit 239	410
VB240	Virtual Bit 240	410
VB241	Virtual Bit 241	409
VB242	Virtual Bit 242	409
VB243	Virtual Bit 243	409
VB244	Virtual Bit 244	409
VB245	Virtual Bit 245	409
VB246	Virtual Bit 246	409
VB247	Virtual Bit 247	409
VB248	Virtual Bit 248	409
VB249	Virtual Bit 249	408
VB250	Virtual Bit 250	408
VB251	Virtual Bit 251	408
VB252	Virtual Bit 252	408
VB253	Virtual Bit 253	408
VB254	Virtual Bit 254	408
VB255	Virtual Bit 255	408
VB256	Virtual Bit 256	408
XBF01	Circuit Breaker 1 external breaker failure input (SELOGIC control equation)	183
XBF02	Circuit Breaker 2 external breaker failure input (SELOGIC control equation)	184
XBF03	Circuit Breaker 3 external breaker failure input (SELOGIC control equation)	185
XBF04	Circuit Breaker 4 external breaker failure input (SELOGIC control equation)	186
XBF05	Circuit Breaker 5 external breaker failure input (SELOGIC control equation)	187
XBF06	Circuit Breaker 6 external breaker failure input (SELOGIC control equation)	188
XBF07	Circuit Breaker 7 external breaker failure input (SELOGIC control equation)	189
XBF08	Circuit Breaker 8 external breaker failure input (SELOGIC control equation)	190
XBF09	Circuit Breaker 9 external breaker failure input (SELOGIC control equation)	191
XBF10	Circuit Breaker 10 external breaker failure input (SELOGIC control equation)	192
XBF11	Circuit Breaker 11 external breaker failure input (SELOGIC control equation)	193
XBF12	Circuit Breaker 12 external breaker failure input (SELOGIC control equation)	194
XBF13	Circuit Breaker 13 external breaker failure input (SELOGIC control equation)	195

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 72 of 79)

Name	Bit Description	Row
XBF14	Circuit Breaker 14 external breaker failure input (SELOGIC control equation)	196
XBF15	Circuit Breaker 15 external breaker failure input (SELOGIC control equation)	197
XBF16	Circuit Breaker 16 external breaker failure input (SELOGIC control equation)	198
XBF17	Circuit Breaker 17 external breaker failure input (SELOGIC control equation)	199
XBF18	Circuit Breaker 18 external breaker failure input (SELOGIC control equation)	200
XBF19	Circuit Breaker 19 external breaker failure input (SELOGIC control equation)	201
XBF20	Circuit Breaker 20 external breaker failure input (SELOGIC control equation)	202
XBF21	Circuit Breaker 21 external breaker failure input (SELOGIC control equation)	203
YEAR1	IRIG-B year information, binary-coded-decimal, add 1 if asserted	468
YEAR10	IRIG-B year information, binary-coded-decimal, add 10 if asserted	468
YEAR2	IRIG-B year information, binary-coded-decimal, add 2 if asserted	468
YEAR20	IRIG-B year information, binary-coded-decimal, add 20 if asserted	468
YEAR4	IRIG-B year information, binary-coded-decimal, add 4 if asserted	468
YEAR40	IRIG-B year information, binary-coded-decimal, add 40 if asserted	468
YEAR8	IRIG-B year information, binary-coded-decimal, add 8 if asserted	468
YEAR80	IRIG-B year information, binary-coded-decimal, add 80 if asserted	468
Z1BZ1	Bus-Zone 1 is part of Protective Zone 1	144
Z1BZ2	Bus-Zone 2 is part of Protective Zone 1	144
Z1BZ3	Bus-Zone 3 is part of Protective Zone 1	144
Z1BZ4	Bus-Zone 4 is part of Protective Zone 1	144
Z1BZ5	Bus-Zone 5 is part of Protective Zone 1	144
Z1BZ6	Bus-Zone 6 is part of Protective Zone 1	144
Z1S	Zone 1 supervision asserted	153
Z2BZ2	Bus-Zone 2 is part of Protective Zone 2	145
Z2BZ3	Bus-Zone 3 is part of Protective Zone 2	145
Z2BZ4	Bus-Zone 4 is part of Protective Zone 2	145
Z2BZ5	Bus-Zone 5 is part of Protective Zone 2	145
Z2BZ6	Bus-Zone 6 is part of Protective Zone 2	145
Z2S	Zone 2 supervision asserted	153
Z3BZ3	Bus-Zone 3 is part of Protective Zone 3	146
Z3BZ4	Bus-Zone 4 is part of Protective Zone 3	146
Z3BZ5	Bus-Zone 5 is part of Protective Zone 3	146
Z3BZ6	Bus-Zone 6 is part of Protective Zone 3	146
Z3S	Zone 3 supervision asserted	153
Z4BZ4	Bus-Zone 4 is part of Protective Zone 4	147
Z4BZ5	Bus-Zone 5 is part of Protective Zone 4	147
Z4BZ6	Bus-Zone 6 is part of Protective Zone 4	147
Z4S	Zone 4 supervision asserted	153
Z5BZ5	Bus-Zone 5 is part of Protective Zone 5	148
Z5BZ6	Bus-Zone 6 is part of Protective Zone 5	148
Z5S	Zone 5 supervision asserted	153

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 73 of 79)

Name	Bit Description	Row
Z6BZ6	Bus-Zone 6 is part of Protective Zone 6	149
Z6S	Zone 6 supervision asserted	153
ZN1I01	Terminal 01 connected to Zone 1	80
ZN1I01T	Terminal 01 connected to Zone 1 and will be tripped	104
ZN1I02	Terminal 02 connected to Zone 1	80
ZN1I02T	Terminal 02 connected to Zone 1 and will be tripped	104
ZN1I03	Terminal 03 connected to Zone 1	80
ZN1I03T	Terminal 03 connected to Zone 1 and will be tripped	104
ZN1I04	Terminal 04 connected to Zone 1	80
ZN1I04T	Terminal 04 connected to Zone 1 and will be tripped	104
ZN1I05	Terminal 05 connected to Zone 1	80
ZN1I05T	Terminal 05 connected to Zone 1 and will be tripped	104
ZN1I06	Terminal 06 connected to Zone 1	80
ZN1I06T	Terminal 06 connected to Zone 1 and will be tripped	104
ZN1I07	Terminal 07 connected to Zone 1	80
ZN1I07T	Terminal 07 connected to Zone 1 and will be tripped	104
ZN1I08	Terminal 08 connected to Zone 1	80
ZN1I08T	Terminal 08 connected to Zone 1 and will be tripped	104
ZN1I09	Terminal 09 connected to Zone 1	81
ZN1I09T	Terminal 09 connected to Zone 1 and will be tripped	105
ZN1I10	Terminal 10 connected to Zone 1	81
ZN1I10T	Terminal 10 connected to Zone 1 and will be tripped	105
ZN1I11	Terminal 11 connected to Zone 1	81
ZN1I11T	Terminal 11 connected to Zone 1 and will be tripped	105
ZN1I12	Terminal 12 connected to Zone 1	81
ZN1I12T	Terminal 12 connected to Zone 1 and will be tripped	105
ZN1I13	Terminal 13 connected to Zone 1	81
ZN1I13T	Terminal 13 connected to Zone 1 and will be tripped	105
ZN1I14	Terminal 14 connected to Zone 1	81
ZN1I14T	Terminal 14 connected to Zone 1 and will be tripped	105
ZN1I15	Terminal 15 connected to Zone 1	81
ZN1I15T	Terminal 15 connected to Zone 1 and will be tripped	105
ZN1I16	Terminal 16 connected to Zone 1	81
ZN1I16T	Terminal 16 connected to Zone 1 and will be tripped	105
ZN1I17	Terminal 17 connected to Zone 1	82
ZN1I17T	Terminal 17 connected to Zone 1 and will be tripped	106
ZN1I18	Terminal 18 connected to Zone 1	82
ZN1I18T	Terminal 18 connected to Zone 1 and will be tripped	106
ZN1I19	Terminal 19 connected to Zone 1	82
ZN1I19T	Terminal 19 connected to Zone 1 and will be tripped	106
ZN1I20	Terminal 20 connected to Zone 1	82

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 74 of 79)

Name	Bit Description	Row
ZN1I20T	Terminal 20 connected to Zone 1 and will be tripped	106
ZN1I21	Terminal 21 connected to Zone 1	82
ZN1I21T	Terminal 21 connected to Zone 1 and will be tripped	106
ZN2I01	Terminal 01 connected to Zone 2	84
ZN2I01T	Terminal 01 connected to Zone 2 and will be tripped	108
ZN2I02	Terminal 02 connected to Zone 2	84
ZN2I02T	Terminal 02 connected to Zone 2 and will be tripped	108
ZN2I03	Terminal 03 connected to Zone 2	84
ZN2I03T	Terminal 03 connected to Zone 2 and will be tripped	108
ZN2I04	Terminal 04 connected to Zone 2	84
ZN2I04T	Terminal 04 connected to Zone 2 and will be tripped	108
ZN2I05	Terminal 05 connected to Zone 2	84
ZN2I05T	Terminal 05 connected to Zone 2 and will be tripped	108
ZN2I06	Terminal 06 connected to Zone 2	84
ZN2I06T	Terminal 06 connected to Zone 2 and will be tripped	108
ZN2I07	Terminal 07 connected to Zone 2	84
ZN2I07T	Terminal 07 connected to Zone 2 and will be tripped	108
ZN2I08	Terminal 08 connected to Zone 2	84
ZN2I08T	Terminal 08 connected to Zone 2 and will be tripped	108
ZN2I09	Terminal 09 connected to Zone 2	85
ZN2I09T	Terminal 09 connected to Zone 2 and will be tripped	109
ZN2I10	Terminal 10 connected to Zone 2	85
ZN2I10T	Terminal 10 connected to Zone 2 and will be tripped	109
ZN2I11	Terminal 11 connected to Zone 2	85
ZN2I11T	Terminal 11 connected to Zone 2 and will be tripped	109
ZN2I12	Terminal 12 connected to Zone 2	85
ZN2I12T	Terminal 12 connected to Zone 2 and will be tripped	109
ZN2I13	Terminal 13 connected to Zone 2	85
ZN2I13T	Terminal 13 connected to Zone 2 and will be tripped	109
ZN2I14	Terminal 14 connected to Zone 2	85
ZN2I14T	Terminal 14 connected to Zone 2 and will be tripped	109
ZN2I15	Terminal 15 connected to Zone 2	85
ZN2I15T	Terminal 15 connected to Zone 2 and will be tripped	109
ZN2I16	Terminal 16 connected to Zone 2	85
ZN2I16T	Terminal 16 connected to Zone 2 and will be tripped	109
ZN2I17	Terminal 17 connected to Zone 2	86
ZN2I17T	Terminal 17 connected to Zone 2 and will be tripped	110
ZN2I18	Terminal 18 connected to Zone 2	86
ZN2I18T	Terminal 18 connected to Zone 2 and will be tripped	110
ZN2I19	Terminal 19 connected to Zone 2	86
ZN2I19T	Terminal 19 connected to Zone 2 and will be tripped	110

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 75 of 79)

Name	Bit Description	Row
ZN2I20	Terminal 20 connected to Zone 2	86
ZN2I20T	Terminal 20 connected to Zone 2 and will be tripped	110
ZN2I21	Terminal 21 connected to Zone 2	86
ZN2I21T	Terminal 21 connected to Zone 2 and will be tripped	110
ZN3I01	Terminal 01 connected to Zone 3	88
ZN3I01T	Terminal 01 connected to Zone 3 and will be tripped	112
ZN3I02	Terminal 02 connected to Zone 3	88
ZN3I02T	Terminal 02 connected to Zone 3 and will be tripped	112
ZN3I03	Terminal 03 connected to Zone 3	88
ZN3I03T	Terminal 03 connected to Zone 3 and will be tripped	112
ZN3I04	Terminal 04 connected to Zone 3	88
ZN3I04T	Terminal 04 connected to Zone 3 and will be tripped	112
ZN3I05	Terminal 05 connected to Zone 3	88
ZN3I05T	Terminal 05 connected to Zone 3 and will be tripped	112
ZN3I06	Terminal 06 connected to Zone 3	88
ZN3I06T	Terminal 06 connected to Zone 3 and will be tripped	112
ZN3I07	Terminal 07 connected to Zone 3	88
ZN3I07T	Terminal 07 connected to Zone 3 and will be tripped	112
ZN3I08	Terminal 08 connected to Zone 3	88
ZN3I08T	Terminal 08 connected to Zone 3 and will be tripped	112
ZN3I09	Terminal 09 connected to Zone 3	89
ZN3I09T	Terminal 09 connected to Zone 3 and will be tripped	113
ZN3I10	Terminal 10 connected to Zone 3	89
ZN3I10T	Terminal 10 connected to Zone 3 and will be tripped	113
ZN3I11	Terminal 11 connected to Zone 3	89
ZN3I11T	Terminal 11 connected to Zone 3 and will be tripped	113
ZN3I12	Terminal 12 connected to Zone 3	89
ZN3I12T	Terminal 12 connected to Zone 3 and will be tripped	113
ZN3I13	Terminal 13 connected to Zone 3	89
ZN3I13T	Terminal 13 connected to Zone 3 and will be tripped	113
ZN3I14	Terminal 14 connected to Zone 3	89
ZN3I14T	Terminal 14 connected to Zone 3 and will be tripped	113
ZN3I15	Terminal 15 connected to Zone 3	89
ZN3I15T	Terminal 15 connected to Zone 3 and will be tripped	113
ZN3I16	Terminal 16 connected to Zone 3	89
ZN3I16T	Terminal 16 connected to Zone 3 and will be tripped	113
ZN3I17	Terminal 17 connected to Zone 3	90
ZN3I17T	Terminal 17 connected to Zone 3 and will be tripped	114
ZN3I18	Terminal 18 connected to Zone 3	90
ZN3I18T	Terminal 18 connected to Zone 3 and will be tripped	114
ZN3I19	Terminal 19 connected to Zone 3	90

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 76 of 79)

Name	Bit Description	Row
ZN3I19T	Terminal 19 connected to Zone 3 and will be tripped	114
ZN3I20	Terminal 20 connected to Zone 3	90
ZN3I20T	Terminal 20 connected to Zone 3 and will be tripped	114
ZN3I21	Terminal 21 connected to Zone 3	90
ZN3I21T	Terminal 21 connected to Zone 3 and will be tripped	114
ZN4I01	Terminal 01 connected to Zone 4	92
ZN4I01T	Terminal 01 connected to Zone 4 and will be tripped	116
ZN4I02	Terminal 02 connected to Zone 4	92
ZN4I02T	Terminal 02 connected to Zone 4 and will be tripped	116
ZN4I03	Terminal 03 connected to Zone 4	92
ZN4I03T	Terminal 03 connected to Zone 4 and will be tripped	116
ZN4I04	Terminal 04 connected to Zone 4	92
ZN4I04T	Terminal 04 connected to Zone 4 and will be tripped	116
ZN4I05	Terminal 05 connected to Zone 4	92
ZN4I05T	Terminal 05 connected to Zone 4 and will be tripped	116
ZN4I06	Terminal 06 connected to Zone 4	92
ZN4I06T	Terminal 06 connected to Zone 4 and will be tripped	116
ZN4I07	Terminal 07 connected to Zone 4	92
ZN4I07T	Terminal 07 connected to Zone 4 and will be tripped	116
ZN4I08	Terminal 08 connected to Zone 4	92
ZN4I08T	Terminal 08 connected to Zone 4 and will be tripped	116
ZN4I09	Terminal 09 connected to Zone 4	93
ZN4I09T	Terminal 09 connected to Zone 4 and will be tripped	117
ZN4I10	Terminal 10 connected to Zone 4	93
ZN4I10T	Terminal 10 connected to Zone 4 and will be tripped	117
ZN4I11	Terminal 11 connected to Zone 4	93
ZN4I11T	Terminal 11 connected to Zone 4 and will be tripped	117
ZN4I12	Terminal 12 connected to Zone 4	93
ZN4I12T	Terminal 12 connected to Zone 4 and will be tripped	117
ZN4I13	Terminal 13 connected to Zone 4	93
ZN4I13T	Terminal 13 connected to Zone 4 and will be tripped	117
ZN4I14	Terminal 14 connected to Zone 4	93
ZN4I14T	Terminal 14 connected to Zone 4 and will be tripped	117
ZN4I15	Terminal 15 connected to Zone 4	93
ZN4I15T	Terminal 15 connected to Zone 4 and will be tripped	117
ZN4I16	Terminal 16 connected to Zone 4	93
ZN4I16T	Terminal 16 connected to Zone 4 and will be tripped	117
ZN4I17	Terminal 17 connected to Zone 4	94
ZN4I17T	Terminal 17 connected to Zone 4 and will be tripped	118
ZN4I18	Terminal 18 connected to Zone 4	94
ZN4I18T	Terminal 18 connected to Zone 4 and will be tripped	118

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 77 of 79)

Name	Bit Description	Row
ZN4I19	Terminal 19 connected to Zone 4	94
ZN4I19T	Terminal 19 connected to Zone 4 and will be tripped	118
ZN4I20	Terminal 20 connected to Zone 4	94
ZN4I20T	Terminal 20 connected to Zone 4 and will be tripped	118
ZN4I21	Terminal 21 connected to Zone 4	94
ZN4I21T	Terminal 21 connected to Zone 4 and will be tripped	118
ZN5I01	Terminal 01 connected to Zone 5	96
ZN5I01T	Terminal 01 connected to Zone 5 and will be tripped	120
ZN5I02	Terminal 02 connected to Zone 5	96
ZN5I02T	Terminal 02 connected to Zone 5 and will be tripped	120
ZN5I03	Terminal 03 connected to Zone 5	96
ZN5I03T	Terminal 03 connected to Zone 5 and will be tripped	120
ZN5I04	Terminal 04 connected to Zone 5	96
ZN5I04T	Terminal 04 connected to Zone 5 and will be tripped	120
ZN5I05	Terminal 05 connected to Zone 5	96
ZN5I05T	Terminal 05 connected to Zone 5 and will be tripped	120
ZN5I06	Terminal 06 connected to Zone 5	96
ZN5I06T	Terminal 06 connected to Zone 5 and will be tripped	120
ZN5I07	Terminal 07 connected to Zone 5	96
ZN5I07T	Terminal 07 connected to Zone 5 and will be tripped	120
ZN5I08	Terminal 08 connected to Zone 5	96
ZN5I08T	Terminal 08 connected to Zone 5 and will be tripped	120
ZN5I09	Terminal 09 connected to Zone 5	97
ZN5I09T	Terminal 09 connected to Zone 5 and will be tripped	121
ZN5I10	Terminal 10 connected to Zone 5	97
ZN5I10T	Terminal 10 connected to Zone 5 and will be tripped	121
ZN5I11	Terminal 11 connected to Zone 5	97
ZN5I11T	Terminal 11 connected to Zone 5 and will be tripped	121
ZN5I12	Terminal 12 connected to Zone 5	97
ZN5I12T	Terminal 12 connected to Zone 5 and will be tripped	121
ZN5I13	Terminal 13 connected to Zone 5	97
ZN5I13T	Terminal 13 connected to Zone 5 and will be tripped	121
ZN5I14	Terminal 14 connected to Zone 5	97
ZN5I14T	Terminal 14 connected to Zone 5 and will be tripped	121
ZN5I15	Terminal 15 connected to Zone 5	97
ZN5I15T	Terminal 15 connected to Zone 5 and will be tripped	121
ZN5I16	Terminal 16 connected to Zone 5	97
ZN5I16T	Terminal 16 connected to Zone 5 and will be tripped	121
ZN5I17	Terminal 17 connected to Zone 5	98
ZN5I17T	Terminal 17 connected to Zone 5 and will be tripped	122
ZN5I18	Terminal 18 connected to Zone 5	98

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 78 of 79)

Name	Bit Description	Row
ZN5I18T	Terminal 18 connected to Zone 5 and will be tripped	122
ZN5I19	Terminal 19 connected to Zone 5	98
ZN5I19T	Terminal 19 connected to Zone 5 and will be tripped	122
ZN5I20	Terminal 20 connected to Zone 5	98
ZN5I20T	Terminal 20 connected to Zone 5 and will be tripped	122
ZN5I21	Terminal 21 connected to Zone 5	98
ZN5I21T	Terminal 21 connected to Zone 5 and will be tripped	122
ZN6I01	Terminal 01 connected to Zone 6	100
ZN6I01T	Terminal 01 connected to Zone 6 and will be tripped	124
ZN6I02	Terminal 02 connected to Zone 6	100
ZN6I02T	Terminal 02 connected to Zone 6 and will be tripped	124
ZN6I03	Terminal 03 connected to Zone 6	100
ZN6I03T	Terminal 03 connected to Zone 6 and will be tripped	124
ZN6I04	Terminal 04 connected to Zone 6	100
ZN6I04T	Terminal 04 connected to Zone 6 and will be tripped	124
ZN6I05	Terminal 05 connected to Zone 6	100
ZN6I05T	Terminal 05 connected to Zone 6 and will be tripped	124
ZN6I06	Terminal 06 connected to Zone 6	100
ZN6I06T	Terminal 06 connected to Zone 6 and will be tripped	124
ZN6I07	Terminal 07 connected to Zone 6	100
ZN6I07T	Terminal 07 connected to Zone 6 and will be tripped	124
ZN6I08	Terminal 08 connected to Zone 6	100
ZN6I08T	Terminal 08 connected to Zone 6 and will be tripped	124
ZN6I09	Terminal 09 connected to Zone 6	101
ZN6I09T	Terminal 09 connected to Zone 6 and will be tripped	125
ZN6I10	Terminal 10 connected to Zone 6	101
ZN6I10T	Terminal 10 connected to Zone 6 and will be tripped	125
ZN6I11	Terminal 11 connected to Zone 6	101
ZN6I11T	Terminal 11 connected to Zone 6 and will be tripped	125
ZN6I12	Terminal 12 connected to Zone 6	101
ZN6I12T	Terminal 12 connected to Zone 6 and will be tripped	125
ZN6I13	Terminal 13 connected to Zone 6	101
ZN6I13T	Terminal 13 connected to Zone 6 and will be tripped	125
ZN6I14	Terminal 14 connected to Zone 6	101
ZN6I14T	Terminal 14 connected to Zone 6 and will be tripped	125
ZN6I15	Terminal 15 connected to Zone 6	101
ZN6I15T	Terminal 15 connected to Zone 6 and will be tripped	125
ZN6I16	Terminal 16 connected to Zone 6	101
ZN6I16T	Terminal 16 connected to Zone 6 and will be tripped	125
ZN6I17	Terminal 17 connected to Zone 6	102
ZN6I17T	Terminal 17 connected to Zone 6 and will be tripped	126

Table 11.1 Alphabetic List of Relay Word Bits (Sheet 79 of 79)

Name	Bit Description	Row
ZN6I18	Terminal 18 connected to Zone 6	102
ZN6I18T	Terminal 18 connected to Zone 6 and will be tripped	126
ZN6I19	Terminal 19 connected to Zone 6	102
ZN6I19T	Terminal 19 connected to Zone 6 and will be tripped	126
ZN6I20	Terminal 20 connected to Zone 6	102
ZN6I20T	Terminal 20 connected to Zone 6 and will be tripped	126
ZN6I21	Terminal 21 connected to Zone 6	102
ZN6I21T	Terminal 21 connected to Zone 6 and will be tripped	126
ZONE1	Differential Zone 1 is active	150
ZONE2	Differential Zone 2 is active	150
ZONE3	Differential Zone 3 is active	150
ZONE4	Differential Zone 4 is active	150
ZONE5	Differential Zone 5 is active	150
ZONE6	Differential Zone 6 is active	150
ZSWO	Zone switching operation	152
ZSWOAL	Zone switching operation alarm	152
ZSWOIP	Zone switching operation in progress	152
ZSWOP	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in any zone	151
ZSWOP1	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 1	151
ZSWOP2	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 2	151
ZSWOP3	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 3	151
ZSWOP4	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 4	151
ZSWOP5	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 5	151
ZSWOP6	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 6	151

Row List

Table 11.2 Row List of Relay Word Bits (Sheet 1 of 100)

Row	Name	Bit Description
Enable and Target LEDs		
0	EN	Relay enabled
0	TRIPLED	Trip LED
0	*	Reserved
0	*	Reserved
0	*	Reserved
0	*	Reserved
0	*	Reserved
0	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 2 of 100)

Row	Name	Bit Description
Target LEDs		
1	TLED_1	Front-panel target LED 1
1	TLED_2	Front-panel target LED 2
1	TLED_3	Front-panel target LED 3
1	TLED_4	Front-panel target LED 4
1	TLED_5	Front-panel target LED 5
1	TLED_6	Front-panel target LED 6
1	TLED_7	Front-panel target LED 7
1	TLED_8	Front-panel target LED 8
2	TLED_9	Front-panel target LED 9
2	TLED_10	Front-panel target LED 10
2	TLED_11	Front-panel target LED 11
2	TLED_12	Front-panel target LED 12
2	TLED_13	Front-panel target LED 13
2	TLED_14	Front-panel target LED 14
2	TLED_15	Front-panel target LED 15
2	TLED_16	Front-panel target LED 16
3	TLED_17	Front-panel target LED 17
3	TLED_18	Front-panel target LED 18
3	TLED_19	Front-panel target LED 19
3	TLED_20	Front-panel target LED 20
3	TLED_21	Front-panel target LED 21
3	TLED_22	Front-panel target LED 22
3	TLED_23	Front-panel target LED 23
3	TLED_24	Front-panel target LED 24
Open-Phase Detectors		
4	OPH08	Terminal 08 open phase detected
4	OPH07	Terminal 07 open phase detected
4	OPH06	Terminal 06 open phase detected
4	OPH05	Terminal 05 open phase detected
4	OPH04	Terminal 04 open phase detected
4	OPH03	Terminal 03 open phase detected
4	OPH02	Terminal 02 open phase detected
4	OPH01	Terminal 01 open phase detected
5	OPH16	Terminal 16 open phase detected
5	OPH15	Terminal 15 open phase detected
5	OPH14	Terminal 14 open phase detected
5	OPH13	Terminal 13 open phase detected
5	OPH12	Terminal 12 open phase detected
5	OPH11	Terminal 11 open phase detected
5	OPH10	Terminal 10 open phase detected

Table 11.2 Row List of Relay Word Bits (Sheet 3 of 100)

Row	Name	Bit Description
5	OPH09	Terminal 09 open phase detected
6	*	Reserved
6	*	Reserved
6	*	Reserved
6	OPH21	Terminal 21 open phase detected
6	OPH20	Terminal 20 open phase detected
6	OPH19	Terminal 19 open phase detected
6	OPH18	Terminal 18 open phase detected
6	OPH17	Terminal 17 open phase detected
52 Status		
7	52AL03	Circuit Breaker 03 alarm
7	52A03	Circuit Breaker 03 status
7	52CL02	Circuit Breaker 02 closed
7	52AL02	Circuit Breaker 02 alarm
7	52A02	Circuit Breaker 02 status
7	52CL01	Circuit Breaker 01 closed
7	52AL01	Circuit Breaker 01 alarm
7	52A01	Circuit Breaker 01 status
8	52A06	Circuit Breaker 06 status
8	52CL05	Circuit Breaker 05 closed
8	52AL05	Circuit Breaker 05 alarm
8	52A05	Circuit Breaker 05 status
8	52CL04	Circuit Breaker 04 closed
8	52AL04	Circuit Breaker 04 alarm
8	52A04	Circuit Breaker 04 status
8	52CL03	Circuit Breaker 03 closed
9	52CL08	Circuit Breaker 08 closed
9	52AL08	Circuit Breaker 08 alarm
9	52A08	Circuit Breaker 08 status
9	52CL07	Circuit Breaker 07 closed
9	52AL07	Circuit Breaker 07 alarm
9	52A07	Circuit Breaker 07 status
9	52CL06	Circuit Breaker 06 closed
9	52AL06	Circuit Breaker 06 alarm
10	52AL11	Circuit Breaker 11 alarm
10	52A11	Circuit Breaker 11 status
10	52CL10	Circuit Breaker 10 closed
10	52AL10	Circuit Breaker 10 alarm
10	52A10	Circuit Breaker 10 status
10	52CL09	Circuit Breaker 09 closed
10	52AL09	Circuit Breaker 09 alarm

Table 11.2 Row List of Relay Word Bits (Sheet 4 of 100)

Row	Name	Bit Description
10	52A09	Circuit Breaker 09 status
11	52A14	Circuit Breaker 14 status
11	52CL13	Circuit Breaker 13 closed
11	52AL13	Circuit Breaker 13 alarm
11	52A13	Circuit Breaker 13 status
11	52CL12	Circuit Breaker 12 closed
11	52AL12	Circuit Breaker 12 alarm
11	52A12	Circuit Breaker 12 status
11	52CL11	Circuit Breaker 11 closed
12	52CL16	Circuit Breaker 16 closed
12	52AL16	Circuit Breaker 16 alarm
12	52A16	Circuit Breaker 16 status
12	52CL15	Circuit Breaker 15 closed
12	52AL15	Circuit Breaker 15 alarm
12	52A15	Circuit Breaker 15 status
12	52CL14	Circuit Breaker 14 closed
12	52AL14	Circuit Breaker 14 alarm
13	52AL19	Circuit Breaker 19 alarm
13	52A19	Circuit Breaker 19 status
13	52CL18	Circuit Breaker 18 closed
13	52AL18	Circuit Breaker 18 alarm
13	52A18	Circuit Breaker 18 status
13	52CL17	Circuit Breaker 17 closed
13	52AL17	Circuit Breaker 17 alarm
13	52A17	Circuit Breaker 17 status
14	52AL	Any circuit breaker alarm
14	52CL21	Circuit Breaker 21 closed
14	52AL21	Circuit Breaker 21 alarm
14	52A21	Circuit Breaker 21 status
14	52CL20	Circuit Breaker 20 closed
14	52AL20	Circuit Breaker 20 alarm
14	52A20	Circuit Breaker 20 status
14	52CL19	Circuit Breaker 19 closed
15	*	Reserved
15	*	Reserved
15	*	Reserved
15	*	Reserved
15	*	Reserved
15	*	Reserved
15	*	Reserved
15	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 5 of 100)

Row	Name	Bit Description
16	*	Reserved
16	*	Reserved
16	*	Reserved
16	*	Reserved
16	*	Reserved
16	*	Reserved
16	*	Reserved
16	*	Reserved
89 Disconnect Status		
17	89CL02	Disconnect 02 closed
17	89B02	Disconnect 02 B auxiliary contact closed
17	89A02	Disconnect 02 A auxiliary contact closed
17	89AL01	Disconnect 01 auxiliary contact discrepancy alarm
17	89OIP01	Disconnect 01 operation in progress
17	89CL01	Disconnect 01 closed
17	89B01	Disconnect 01 B auxiliary contact closed
17	89A01	Disconnect 01 A auxiliary contact closed
18	89A04	Disconnect 04 A auxiliary contact closed
18	89AL03	Disconnect 03 auxiliary contact discrepancy alarm
18	89OIP03	Disconnect 03 operation in progress
18	89CL03	Disconnect 03 closed
18	89B03	Disconnect 03 B auxiliary contact closed
18	89A03	Disconnect 03 A auxiliary contact closed
18	89AL02	Disconnect 02 auxiliary contact discrepancy alarm
18	89OIP02	Disconnect 02 operation in progress
19	89OIP05	Disconnect 05 operation in progress
19	89CL05	Disconnect 05 closed
19	89B05	Disconnect 05 B auxiliary contact closed
19	89A05	Disconnect 05 A auxiliary contact closed
19	89AL04	Disconnect 04 auxiliary contact discrepancy alarm
19	89OIP04	Disconnect 04 operation in progress
19	89CL04	Disconnect 04 closed
19	89B04	Disconnect 04 B auxiliary contact closed
20	89B07	Disconnect 07 B auxiliary contact closed
20	89A07	Disconnect 07 A auxiliary contact closed
20	89AL06	Disconnect 06 auxiliary contact discrepancy alarm
20	89OIP06	Disconnect 06 operation in progress
20	89CL06	Disconnect 06 closed
20	89B06	Disconnect 06 B auxiliary contact closed
20	89A06	Disconnect 06 A auxiliary contact closed
20	89AL05	Disconnect 05 auxiliary contact discrepancy alarm

Table 11.2 Row List of Relay Word Bits (Sheet 6 of 100)

Row	Name	Bit Description
21	89AL08	Disconnect 08 auxiliary contact discrepancy alarm
21	89OIP08	Disconnect 08 operation in progress
21	89CL08	Disconnect 08 closed
21	89B08	Disconnect 08 B auxiliary contact closed
21	89A08	Disconnect 08 A auxiliary contact closed
21	89AL07	Disconnect 07 auxiliary contact discrepancy alarm
21	89OIP07	Disconnect 07 operation in progress
21	89CL07	Disconnect 07 closed
22	89CL10	Disconnect 10 closed
22	89B10	Disconnect 10 B auxiliary contact closed
22	89A10	Disconnect 10 A auxiliary contact closed
22	89AL09	Disconnect 09 auxiliary contact discrepancy alarm
22	89OIP09	Disconnect 09 operation in progress
22	89CL09	Disconnect 09 closed
22	89B09	Disconnect 09 B auxiliary contact closed
22	89A09	Disconnect 09 A auxiliary contact closed
23	89A12	Disconnect 12 A auxiliary contact closed
23	89AL11	Disconnect 11 auxiliary contact discrepancy alarm
23	89OIP11	Disconnect 11 operation in progress
23	89CL11	Disconnect 11 closed
23	89B11	Disconnect 11 B auxiliary contact closed
23	89A11	Disconnect 11 A auxiliary contact closed
23	89AL10	Disconnect 10 auxiliary contact discrepancy alarm
23	89OIP10	Disconnect 10 operation in progress
24	89OIP13	Disconnect 13 operation in progress
24	89CL13	Disconnect 13 closed
24	89B13	Disconnect 13 B auxiliary contact closed
24	89A13	Disconnect 13 A auxiliary contact closed
24	89AL12	Disconnect 12 auxiliary contact discrepancy alarm
24	89OIP12	Disconnect 12 operation in progress
24	89CL12	Disconnect 12 closed
24	89B12	Disconnect 12 B auxiliary contact closed
25	89B15	Disconnect 15 B auxiliary contact closed
25	89A15	Disconnect 15 A auxiliary contact closed
25	89AL14	Disconnect 14 auxiliary contact discrepancy alarm
25	89OIP14	Disconnect 14 operation in progress
25	89CL14	Disconnect 14 closed
25	89B14	Disconnect 14 B auxiliary contact closed
25	89A14	Disconnect 14 A auxiliary contact closed
25	89AL13	Disconnect 13 auxiliary contact discrepancy alarm
26	89AL16	Disconnect 16 auxiliary contact discrepancy alarm

Table 11.2 Row List of Relay Word Bits (Sheet 7 of 100)

Row	Name	Bit Description
26	89OIP16	Disconnect 16 operation in progress
26	89CL16	Disconnect 16 closed
26	89B16	Disconnect 16 B auxiliary contact closed
26	89A16	Disconnect 16 A auxiliary contact closed
26	89AL15	Disconnect 15 auxiliary contact discrepancy alarm
26	89OIP15	Disconnect 15 operation in progress
26	89CL15	Disconnect 15 closed
27	89CL18	Disconnect 18 closed
27	89B18	Disconnect 18 B auxiliary contact closed
27	89A18	Disconnect 18 A auxiliary contact closed
27	89AL17	Disconnect 17 auxiliary contact discrepancy alarm
27	89OIP17	Disconnect 17 operation in progress
27	89CL17	Disconnect 17 closed
27	89B17	Disconnect 17 B auxiliary contact closed
27	89A17	Disconnect 17 A auxiliary contact closed
28	89A20	Disconnect 20 A auxiliary contact closed
28	89AL19	Disconnect 19 auxiliary contact discrepancy alarm
28	89OIP19	Disconnect 19 operation in progress
28	89CL19	Disconnect 19 closed
28	89B19	Disconnect 19 B auxiliary contact closed
28	89A19	Disconnect 19 A auxiliary contact closed
28	89AL18	Disconnect 18 auxiliary contact discrepancy alarm
28	89OIP18	Disconnect 18 operation in progress
29	89OIP21	Disconnect 21 operation in progress
29	89CL21	Disconnect 21 closed
29	89B21	Disconnect 21 B auxiliary contact closed
29	89A21	Disconnect 21 A auxiliary contact closed
29	89AL20	Disconnect 20 auxiliary contact discrepancy alarm
29	89OIP20	Disconnect 20 operation in progress
29	89CL20	Disconnect 20 closed
29	89B20	Disconnect 20 B auxiliary contact closed
30	89B23	Disconnect 23 B auxiliary contact closed
30	89A23	Disconnect 23 A auxiliary contact closed
30	89AL22	Disconnect 22 auxiliary contact discrepancy alarm
30	89OIP22	Disconnect 22 operation in progress
30	89CL22	Disconnect 22 closed
30	89B22	Disconnect 22 B auxiliary contact closed
30	89A22	Disconnect 22 A auxiliary contact closed
30	89AL21	Disconnect 21 auxiliary contact discrepancy alarm
31	89AL24	Disconnect 24 auxiliary contact discrepancy alarm
31	89OIP24	Disconnect 24 operation in progress

Table 11.2 Row List of Relay Word Bits (Sheet 8 of 100)

Row	Name	Bit Description
31	89CL24	Disconnect 24 closed
31	89B24	Disconnect 24 B auxiliary contact closed
31	89A24	Disconnect 24 A auxiliary contact closed
31	89AL23	Disconnect 23 auxiliary contact discrepancy alarm
31	89OIP23	Disconnect 23 operation in progress
31	89CL23	Disconnect 23 closed
32	89CL26	Disconnect 26 closed
32	89B26	Disconnect 26 B auxiliary contact closed
32	89A26	Disconnect 26 A auxiliary contact closed
32	89AL25	Disconnect 25 auxiliary contact discrepancy alarm
32	89OIP25	Disconnect 25 operation in progress
32	89CL25	Disconnect 25 closed
32	89B25	Disconnect 25 B auxiliary contact closed
32	89A25	Disconnect 25 A auxiliary contact closed
33	89A28	Disconnect 28 A auxiliary contact closed
33	89AL27	Disconnect 27 auxiliary contact discrepancy alarm
33	89OIP27	Disconnect 27 operation in progress
33	89CL27	Disconnect 27 closed
33	89B27	Disconnect 27 B auxiliary contact closed
33	89A27	Disconnect 27 A auxiliary contact closed
33	89AL26	Disconnect 26 auxiliary contact discrepancy alarm
33	89OIP26	Disconnect 26 operation in progress
34	89OIP29	Disconnect 29 operation in progress
34	89CL29	Disconnect 29 closed
34	89B29	Disconnect 29 B auxiliary contact closed
34	89A29	Disconnect 29 A auxiliary contact closed
34	89AL28	Disconnect 28 auxiliary contact discrepancy alarm
34	89OIP28	Disconnect 28 operation in progress
34	89CL28	Disconnect 28 closed
34	89B28	Disconnect 28 B auxiliary contact closed
35	89B31	Disconnect 31 B auxiliary contact closed
35	89A31	Disconnect 31 A auxiliary contact closed
35	89AL30	Disconnect 30 auxiliary contact discrepancy alarm
35	89OIP30	Disconnect 30 operation in progress
35	89CL30	Disconnect 30 closed
35	89B30	Disconnect 30 B auxiliary contact closed
35	89A30	Disconnect 30 A auxiliary contact closed
35	89AL29	Disconnect 29 auxiliary contact discrepancy alarm
36	89AL32	Disconnect 32 auxiliary contact discrepancy alarm
36	89OIP32	Disconnect 32 operation in progress
36	89CL32	Disconnect 32 closed

Table 11.2 Row List of Relay Word Bits (Sheet 9 of 100)

Row	Name	Bit Description
36	89B32	Disconnect 32 B auxiliary contact closed
36	89A32	Disconnect 32 A auxiliary contact closed
36	89AL31	Disconnect 31 auxiliary contact discrepancy alarm
36	89OIP31	Disconnect 31 operation in progress
36	89CL31	Disconnect 31 closed
37	89CL34	Disconnect 34 closed
37	89B34	Disconnect 34 B auxiliary contact closed
37	89A34	Disconnect 34 A auxiliary contact closed
37	89AL33	Disconnect 33 auxiliary contact discrepancy alarm
37	89OIP33	Disconnect 33 operation in progress
37	89CL33	Disconnect 33 closed
37	89B33	Disconnect 33 B auxiliary contact closed
37	89A33	Disconnect 33 A auxiliary contact closed
38	89A36	Disconnect 36 A auxiliary contact closed
38	89AL35	Disconnect 35 auxiliary contact discrepancy alarm
38	89OIP35	Disconnect 35 operation in progress
38	89CL35	Disconnect 35 closed
38	89B35	Disconnect 35 B auxiliary contact closed
38	89A35	Disconnect 35 A auxiliary contact closed
38	89AL34	Disconnect 34 auxiliary contact discrepancy alarm
38	89OIP34	Disconnect 34 operation in progress
39	89OIP37	Disconnect 37 operation in progress
39	89CL37	Disconnect 37 closed
39	89B37	Disconnect 37 B auxiliary contact closed
39	89A37	Disconnect 37 A auxiliary contact closed
39	89AL36	Disconnect 36 auxiliary contact discrepancy alarm
39	89OIP36	Disconnect 36 operation in progress
39	89CL36	Disconnect 36 closed
39	89B36	Disconnect 36 B auxiliary contact closed
40	89B39	Disconnect 39 B auxiliary contact closed
40	89A39	Disconnect 39 A auxiliary contact closed
40	89AL38	Disconnect 38 auxiliary contact discrepancy alarm
40	89OIP38	Disconnect 38 operation in progress
40	89CL38	Disconnect 38 closed
40	89B38	Disconnect 38 B auxiliary contact closed
40	89A38	Disconnect 38 A auxiliary contact closed
40	89AL37	Disconnect 37 auxiliary contact discrepancy alarm
41	89AL40	Disconnect 40 auxiliary contact discrepancy alarm
41	89OIP40	Disconnect 40 operation in progress
41	89CL40	Disconnect 40 closed
41	89B40	Disconnect 40 B auxiliary contact closed

Table 11.2 Row List of Relay Word Bits (Sheet 10 of 100)

Row	Name	Bit Description
41	89A40	Disconnect 40 A auxiliary contact closed
41	89AL39	Disconnect 39 auxiliary contact discrepancy alarm
41	89OIP39	Disconnect 39 operation in progress
41	89CL39	Disconnect 39 closed
42	89CL42	Disconnect 42 closed
42	89B42	Disconnect 42 B auxiliary contact closed
42	89A42	Disconnect 42 A auxiliary contact closed
42	89AL41	Disconnect 41 auxiliary contact discrepancy alarm
42	89OIP41	Disconnect 41 operation in progress
42	89CL41	Disconnect 41 closed
42	89B41	Disconnect 41 B auxiliary contact closed
42	89A41	Disconnect 41 A auxiliary contact closed
43	89A44	Disconnect 44 A auxiliary contact closed
43	89AL43	Disconnect 43 auxiliary contact discrepancy alarm
43	89OIP43	Disconnect 43 operation in progress
43	89CL43	Disconnect 43 closed
43	89B43	Disconnect 43 B auxiliary contact closed
43	89A43	Disconnect 43 A auxiliary contact closed
43	89AL42	Disconnect 42 auxiliary contact discrepancy alarm
43	89OIP42	Disconnect 42 operation in progress
44	89OIP45	Disconnect 45 operation in progress
44	89CL45	Disconnect 45 closed
44	89B45	Disconnect 45 B auxiliary contact closed
44	89A45	Disconnect 45 A auxiliary contact closed
44	89AL44	Disconnect 44 auxiliary contact discrepancy alarm
44	89OIP44	Disconnect 44 operation in progress
44	89CL44	Disconnect 44 closed
44	89B44	Disconnect 44 B auxiliary contact closed
45	89B47	Disconnect 47 B auxiliary contact closed
45	89A47	Disconnect 47 A auxiliary contact closed
45	89AL46	Disconnect 46 auxiliary contact discrepancy alarm
45	89OIP46	Disconnect 46 operation in progress
45	89CL46	Disconnect 46 closed
45	89B46	Disconnect 46 B auxiliary contact closed
45	89A46	Disconnect 46 A auxiliary contact closed
45	89AL45	Disconnect 45 auxiliary contact discrepancy alarm
46	89AL48	Disconnect 48 auxiliary contact discrepancy alarm
46	89OIP48	Disconnect 48 operation in progress
46	89CL48	Disconnect 48 closed
46	89B48	Disconnect 48 B auxiliary contact closed
46	89A48	Disconnect 48 A auxiliary contact closed

Table 11.2 Row List of Relay Word Bits (Sheet 11 of 100)

Row	Name	Bit Description
46	89AL47	Disconnect 47 auxiliary contact discrepancy alarm
46	89OIP47	Disconnect 47 operation in progress
46	89CL47	Disconnect 47 closed
47	89CL50	Disconnect 50 closed
47	89B50	Disconnect 50 B auxiliary contact closed
47	89A50	Disconnect 50 A auxiliary contact closed
47	89AL49	Disconnect 49 auxiliary contact discrepancy alarm
47	89OIP49	Disconnect 49 operation in progress
47	89CL49	Disconnect 49 closed
47	89B49	Disconnect 49 B auxiliary contact closed
47	89A49	Disconnect 49 A auxiliary contact closed
48	89A52	Disconnect 52 A auxiliary contact closed
48	89AL51	Disconnect 51 auxiliary contact discrepancy alarm
48	89OIP51	Disconnect 51 operation in progress
48	89CL51	Disconnect 51 closed
48	89B51	Disconnect 51 B auxiliary contact closed
48	89A51	Disconnect 51 A auxiliary contact closed
48	89AL50	Disconnect 50 auxiliary contact discrepancy alarm
48	89OIP50	Disconnect 50 operation in progress
49	89OIP53	Disconnect 53 operation in progress
49	89CL53	Disconnect 53 closed
49	89B53	Disconnect 53 B auxiliary contact closed
49	89A53	Disconnect 53 A auxiliary contact closed
49	89AL52	Disconnect 52 auxiliary contact discrepancy alarm
49	89OIP52	Disconnect 52 operation in progress
49	89CL52	Disconnect 52 closed
49	89B52	Disconnect 52 B auxiliary contact closed
50	89B55	Disconnect 55 B auxiliary contact closed
50	89A55	Disconnect 55 A auxiliary contact closed
50	89AL54	Disconnect 54 auxiliary contact discrepancy alarm
50	89OIP54	Disconnect 54 operation in progress
50	89CL54	Disconnect 54 closed
50	89B54	Disconnect 54 B auxiliary contact closed
50	89A54	Disconnect 54 A auxiliary contact closed
50	89AL53	Disconnect 53 auxiliary contact discrepancy alarm
51	89AL56	Disconnect 56 auxiliary contact discrepancy alarm
51	89OIP56	Disconnect 56 operation in progress
51	89CL56	Disconnect 56 closed
51	89B56	Disconnect 56 B auxiliary contact closed
51	89A56	Disconnect 56 A auxiliary contact closed
51	89AL55	Disconnect 55 auxiliary contact discrepancy alarm

Table 11.2 Row List of Relay Word Bits (Sheet 12 of 100)

Row	Name	Bit Description
51	89OIP55	Disconnect 55 operation in progress
51	89CL55	Disconnect 55 closed
52	89CL58	Disconnect 58 closed
52	89B58	Disconnect 58 B auxiliary contact closed
52	89A58	Disconnect 58 A auxiliary contact closed
52	89AL57	Disconnect 57 auxiliary contact discrepancy alarm
52	89OIP57	Disconnect 57 operation in progress
52	89CL57	Disconnect 57 closed
52	89B57	Disconnect 57 B auxiliary contact closed
52	89A57	Disconnect 57 A auxiliary contact closed
53	89A60	Disconnect 60 A auxiliary contact closed
53	89AL59	Disconnect 59 auxiliary contact discrepancy alarm
53	89OIP59	Disconnect 59 operation in progress
53	89CL59	Disconnect 59 closed
53	89B59	Disconnect 59 B auxiliary contact closed
53	89A59	Disconnect 59 A auxiliary contact closed
53	89AL58	Disconnect 58 auxiliary contact discrepancy alarm
53	89OIP58	Disconnect 58 operation in progress
54	*	Reserved
54	*	Reserved
54	*	Reserved
54	*	Reserved
54	89AL60	Disconnect 60 auxiliary contact discrepancy alarm
54	89OIP60	Disconnect 60 operation in progress
54	89CL60	Disconnect 60 closed
54	89B60	Disconnect 60 B auxiliary contact closed
55	*	Reserved
55	*	Reserved
55	*	Reserved
55	*	Reserved
55	*	Reserved
55	*	Reserved
55	89OIP	Any Disconnect operation in progress
55	89AL	Any Disconnect auxiliary contact discrepancy alarm
Terminal-to-Bus-Zone Connection		
56	I08BZ1V	Terminal I08 connected to BZ1
56	I07BZ1V	Terminal I07 connected to BZ1
56	I06BZ1V	Terminal I06 connected to BZ1
56	I05BZ1V	Terminal I05 connected to BZ1
56	I04BZ1V	Terminal I04 connected to BZ1
56	I03BZ1V	Terminal I03 connected to BZ1

Table 11.2 Row List of Relay Word Bits (Sheet 13 of 100)

Row	Name	Bit Description
56	I02BZ1V	Terminal I02 connected to BZ1
56	I01BZ1V	Terminal I01 connected to BZ1
57	I16BZ1V	Terminal I16 connected to BZ1
57	I15BZ1V	Terminal I15 connected to BZ1
57	I14BZ1V	Terminal I14 connected to BZ1
57	I13BZ1V	Terminal I13 connected to BZ1
57	I12BZ1V	Terminal I12 connected to BZ1
57	I11BZ1V	Terminal I11 connected to BZ1
57	I10BZ1V	Terminal I10 connected to BZ1
57	I09BZ1V	Terminal I09 connected to BZ1
58	*	Reserved
58	*	Reserved
58	*	Reserved
58	I21BZ1V	Terminal I21 connected to BZ1
58	I20BZ1V	Terminal I20 connected to BZ1
58	I19BZ1V	Terminal I19 connected to BZ1
58	I18BZ1V	Terminal I18 connected to BZ1
58	I17BZ1V	Terminal I17 connected to BZ1
59	*	Reserved
59	*	Reserved
59	*	Reserved
59	*	Reserved
59	*	Reserved
59	*	Reserved
59	*	Reserved
59	*	Reserved
60	I08BZ2V	Terminal I08 connected to BZ2
60	I07BZ2V	Terminal I07 connected to BZ2
60	I06BZ2V	Terminal I06 connected to BZ2
60	I05BZ2V	Terminal I05 connected to BZ2
60	I04BZ2V	Terminal I04 connected to BZ2
60	I03BZ2V	Terminal I03 connected to BZ2
60	I02BZ2V	Terminal I02 connected to BZ2
60	I01BZ2V	Terminal I01 connected to BZ2
61	I16BZ2V	Terminal I16 connected to BZ2
61	I15BZ2V	Terminal I15 connected to BZ2
61	I14BZ2V	Terminal I14 connected to BZ2
61	I13BZ2V	Terminal I13 connected to BZ2
61	I12BZ2V	Terminal I12 connected to BZ2
61	I11BZ2V	Terminal I11 connected to BZ2
61	I10BZ2V	Terminal I10 connected to BZ2

Table 11.2 Row List of Relay Word Bits (Sheet 14 of 100)

Row	Name	Bit Description
61	I09BZ2V	Terminal I09 connected to BZ2
62	*	Reserved
62	*	Reserved
62	*	Reserved
62	I21BZ2V	Terminal I21 connected to BZ2
62	I20BZ2V	Terminal I20 connected to BZ2
62	I19BZ2V	Terminal I19 connected to BZ2
62	I18BZ2V	Terminal I18 connected to BZ2
62	I17BZ2V	Terminal I17 connected to BZ2
63	*	Reserved
63	*	Reserved
63	*	Reserved
63	*	Reserved
63	*	Reserved
63	*	Reserved
63	*	Reserved
63	*	Reserved
64	I08BZ3V	Terminal I08 connected to BZ3
64	I07BZ3V	Terminal I07 connected to BZ3
64	I06BZ3V	Terminal I06 connected to BZ3
64	I05BZ3V	Terminal I05 connected to BZ3
64	I04BZ3V	Terminal I04 connected to BZ3
64	I03BZ3V	Terminal I03 connected to BZ3
64	I02BZ3V	Terminal I02 connected to BZ3
64	I01BZ3V	Terminal I01 connected to BZ3
65	I16BZ3V	Terminal I16 connected to BZ3
65	I15BZ3V	Terminal I15 connected to BZ3
65	I14BZ3V	Terminal I14 connected to BZ3
65	I13BZ3V	Terminal I13 connected to BZ3
65	I12BZ3V	Terminal I12 connected to BZ3
65	I11BZ3V	Terminal I11 connected to BZ3
65	I10BZ3V	Terminal I10 connected to BZ3
65	I09BZ3V	Terminal I09 connected to BZ3
66	*	Reserved
66	*	Reserved
66	*	Reserved
66	I21BZ3V	Terminal I21 connected to BZ3
66	I20BZ3V	Terminal I20 connected to BZ3
66	I19BZ3V	Terminal I19 connected to BZ3
66	I18BZ3V	Terminal I18 connected to BZ3
66	I17BZ3V	Terminal I17 connected to BZ3

Table 11.2 Row List of Relay Word Bits (Sheet 15 of 100)

Row	Name	Bit Description
67	*	Reserved
67	*	Reserved
67	*	Reserved
67	*	Reserved
67	*	Reserved
67	*	Reserved
67	*	Reserved
67	*	Reserved
68	I08BZ4V	Terminal I08 connected to BZ4
68	I07BZ4V	Terminal I07 connected to BZ4
68	I06BZ4V	Terminal I06 connected to BZ4
68	I05BZ4V	Terminal I05 connected to BZ4
68	I04BZ4V	Terminal I04 connected to BZ4
68	I03BZ4V	Terminal I03 connected to BZ4
68	I02BZ4V	Terminal I02 connected to BZ4
68	I01BZ4V	Terminal I01 connected to BZ4
69	I16BZ4V	Terminal I16 connected to BZ4
69	I15BZ4V	Terminal I15 connected to BZ4
69	I14BZ4V	Terminal I14 connected to BZ4
69	I13BZ4V	Terminal I13 connected to BZ4
69	I12BZ4V	Terminal I12 connected to BZ4
69	I11BZ4V	Terminal I11 connected to BZ4
69	I10BZ4V	Terminal I10 connected to BZ4
69	I09BZ4V	Terminal I09 connected to BZ4
70	*	Reserved
70	*	Reserved
70	*	Reserved
70	I21BZ4V	Terminal I21 connected to BZ4
70	I20BZ4V	Terminal I20 connected to BZ4
70	I19BZ4V	Terminal I19 connected to BZ4
70	I18BZ4V	Terminal I18 connected to BZ4
70	I17BZ4V	Terminal I17 connected to BZ4
71	*	Reserved
71	*	Reserved
71	*	Reserved
71	*	Reserved
71	*	Reserved
71	*	Reserved
71	*	Reserved
71	*	Reserved
72	I08BZ5V	Terminal I08 connected to BZ5

Table 11.2 Row List of Relay Word Bits (Sheet 16 of 100)

Row	Name	Bit Description
72	I07BZ5V	Terminal I07 connected to BZ5
72	I06BZ5V	Terminal I06 connected to BZ5
72	I05BZ5V	Terminal I05 connected to BZ5
72	I04BZ5V	Terminal I04 connected to BZ5
72	I03BZ5V	Terminal I03 connected to BZ5
72	I02BZ5V	Terminal I02 connected to BZ5
72	I01BZ5V	Terminal I01 connected to BZ5
73	I16BZ5V	Terminal I16 connected to BZ5
73	I15BZ5V	Terminal I15 connected to BZ5
73	I14BZ5V	Terminal I14 connected to BZ5
73	I13BZ5V	Terminal I13 connected to BZ5
73	I12BZ5V	Terminal I12 connected to BZ5
73	I11BZ5V	Terminal I11 connected to BZ5
73	I10BZ5V	Terminal I10 connected to BZ5
73	I09BZ5V	Terminal I09 connected to BZ5
74	*	Reserved
74	*	Reserved
74	*	Reserved
74	I21BZ5V	Terminal I21 connected to BZ5
74	I20BZ5V	Terminal I20 connected to BZ5
74	I19BZ5V	Terminal I19 connected to BZ5
74	I18BZ5V	Terminal I18 connected to BZ5
74	I17BZ5V	Terminal I17 connected to BZ5
75	*	Reserved
75	*	Reserved
75	*	Reserved
75	*	Reserved
75	*	Reserved
75	*	Reserved
75	*	Reserved
75	*	Reserved
76	I08BZ6V	Terminal I08 connected to BZ6
76	I07BZ6V	Terminal I07 connected to BZ6
76	I06BZ6V	Terminal I06 connected to BZ6
76	I05BZ6V	Terminal I05 connected to BZ6
76	I04BZ6V	Terminal I04 connected to BZ6
76	I03BZ6V	Terminal I03 connected to BZ6
76	I02BZ6V	Terminal I02 connected to BZ6
76	I01BZ6V	Terminal I01 connected to BZ6
77	I16BZ6V	Terminal I16 connected to BZ6
77	I15BZ6V	Terminal I15 connected to BZ6

Table 11.2 Row List of Relay Word Bits (Sheet 17 of 100)

Row	Name	Bit Description
77	I14BZ6V	Terminal I14 connected to BZ6
77	I13BZ6V	Terminal I13 connected to BZ6
77	I12BZ6V	Terminal I12 connected to BZ6
77	I11BZ6V	Terminal I11 connected to BZ6
77	I10BZ6V	Terminal I10 connected to BZ6
77	I09BZ6V	Terminal I09 connected to BZ6
78	*	Reserved
78	*	Reserved
78	*	Reserved
78	I21BZ6V	Terminal I21 connected to BZ6
78	I20BZ6V	Terminal I20 connected to BZ6
78	I19BZ6V	Terminal I19 connected to BZ6
78	I18BZ6V	Terminal I18 connected to BZ6
78	I17BZ6V	Terminal I17 connected to BZ6
79	*	Reserved
79	*	Reserved
79	*	Reserved
79	*	Reserved
79	*	Reserved
79	*	Reserved
79	*	Reserved
79	*	Reserved
80	ZN1I08	Terminal 08 connected to Zone 1
80	ZN1I07	Terminal 07 connected to Zone 1
80	ZN1I06	Terminal 06 connected to Zone 1
80	ZN1I05	Terminal 05 connected to Zone 1
80	ZN1I04	Terminal 04 connected to Zone 1
80	ZN1I03	Terminal 03 connected to Zone 1
80	ZN1I02	Terminal 02 connected to Zone 1
80	ZN1I01	Terminal 01 connected to Zone 1
81	ZN1I16	Terminal 16 connected to Zone 1
81	ZN1I15	Terminal 15 connected to Zone 1
81	ZN1I14	Terminal 14 connected to Zone 1
81	ZN1I13	Terminal 13 connected to Zone 1
81	ZN1I12	Terminal 12 connected to Zone 1
81	ZN1I11	Terminal 11 connected to Zone 1
81	ZN1I10	Terminal 10 connected to Zone 1
81	ZN1I09	Terminal 09 connected to Zone 1
82	*	Reserved
82	*	Reserved
82	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 18 of 100)

Row	Name	Bit Description
82	ZN1I21	Terminal 21 connected to Zone 1
82	ZN1I20	Terminal 20 connected to Zone 1
82	ZN1I19	Terminal 19 connected to Zone 1
82	ZN1I18	Terminal 18 connected to Zone 1
82	ZN1I17	Terminal 17 connected to Zone 1
83	*	Reserved
83	*	Reserved
83	*	Reserved
83	*	Reserved
83	*	Reserved
83	*	Reserved
83	*	Reserved
83	*	Reserved
84	ZN2I08	Terminal 08 connected to Zone 2
84	ZN2I07	Terminal 07 connected to Zone 2
84	ZN2I06	Terminal 06 connected to Zone 2
84	ZN2I05	Terminal 05 connected to Zone 2
84	ZN2I04	Terminal 04 connected to Zone 2
84	ZN2I03	Terminal 03 connected to Zone 2
84	ZN2I02	Terminal 02 connected to Zone 2
84	ZN2I01	Terminal 01 connected to Zone 2
85	ZN2I16	Terminal 16 connected to Zone 2
85	ZN2I15	Terminal 15 connected to Zone 2
85	ZN2I14	Terminal 14 connected to Zone 2
85	ZN2I13	Terminal 13 connected to Zone 2
85	ZN2I12	Terminal 12 connected to Zone 2
85	ZN2I11	Terminal 11 connected to Zone 2
85	ZN2I10	Terminal 10 connected to Zone 2
85	ZN2I09	Terminal 09 connected to Zone 2
86	*	Reserved
86	*	Reserved
86	*	Reserved
86	ZN2I21	Terminal 21 connected to Zone 2
86	ZN2I20	Terminal 20 connected to Zone 2
86	ZN2I19	Terminal 19 connected to Zone 2
86	ZN2I18	Terminal 18 connected to Zone 2
86	ZN2I17	Terminal 17 connected to Zone 2
87	*	Reserved
87	*	Reserved
87	*	Reserved
87	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 19 of 100)

Row	Name	Bit Description
87	*	Reserved
87	*	Reserved
87	*	Reserved
87	*	Reserved
88	ZN3I08	Terminal 08 connected to Zone 3
88	ZN3I07	Terminal 07 connected to Zone 3
88	ZN3I06	Terminal 06 connected to Zone 3
88	ZN3I05	Terminal 05 connected to Zone 3
88	ZN3I04	Terminal 04 connected to Zone 3
88	ZN3I03	Terminal 03 connected to Zone 3
88	ZN3I02	Terminal 02 connected to Zone 3
88	ZN3I01	Terminal 01 connected to Zone 3
89	ZN3I16	Terminal 16 connected to Zone 3
89	ZN3I15	Terminal 15 connected to Zone 3
89	ZN3I14	Terminal 14 connected to Zone 3
89	ZN3I13	Terminal 13 connected to Zone 3
89	ZN3I12	Terminal 12 connected to Zone 3
89	ZN3I11	Terminal 11 connected to Zone 3
89	ZN3I10	Terminal 10 connected to Zone 3
89	ZN3I09	Terminal 09 connected to Zone 3
90	*	Reserved
90	*	Reserved
90	*	Reserved
90	ZN3I21	Terminal 21 connected to Zone 3
90	ZN3I20	Terminal 20 connected to Zone 3
90	ZN3I19	Terminal 19 connected to Zone 3
90	ZN3I18	Terminal 18 connected to Zone 3
90	ZN3I17	Terminal 17 connected to Zone 3
91	*	Reserved
91	*	Reserved
91	*	Reserved
91	*	Reserved
91	*	Reserved
91	*	Reserved
91	*	Reserved
91	*	Reserved
92	ZN4I08	Terminal 08 connected to Zone 4
92	ZN4I07	Terminal 07 connected to Zone 4
92	ZN4I06	Terminal 06 connected to Zone 4
92	ZN4I05	Terminal 05 connected to Zone 4
92	ZN4I04	Terminal 04 connected to Zone 4

Table 11.2 Row List of Relay Word Bits (Sheet 20 of 100)

Row	Name	Bit Description
92	ZN4I03	Terminal 03 connected to Zone 4
92	ZN4I02	Terminal 02 connected to Zone 4
92	ZN4I01	Terminal 01 connected to Zone 4
93	ZN4I16	Terminal 16 connected to Zone 4
93	ZN4I15	Terminal 15 connected to Zone 4
93	ZN4I14	Terminal 14 connected to Zone 4
93	ZN4I13	Terminal 13 connected to Zone 4
93	ZN4I12	Terminal 12 connected to Zone 4
93	ZN4I11	Terminal 11 connected to Zone 4
93	ZN4I10	Terminal 10 connected to Zone 4
93	ZN4I09	Terminal 09 connected to Zone 4
94	*	Reserved
94	*	Reserved
94	*	Reserved
94	ZN4I21	Terminal 21 connected to Zone 4
94	ZN4I20	Terminal 20 connected to Zone 4
94	ZN4I19	Terminal 19 connected to Zone 4
94	ZN4I18	Terminal 18 connected to Zone 4
94	ZN4I17	Terminal 17 connected to Zone 4
95	*	Reserved
95	*	Reserved
95	*	Reserved
95	*	Reserved
95	*	Reserved
95	*	Reserved
95	*	Reserved
95	*	Reserved
96	ZN5I08	Terminal 08 connected to Zone 5
96	ZN5I07	Terminal 07 connected to Zone 5
96	ZN5I06	Terminal 06 connected to Zone 5
96	ZN5I05	Terminal 05 connected to Zone 5
96	ZN5I04	Terminal 04 connected to Zone 5
96	ZN5I03	Terminal 03 connected to Zone 5
96	ZN5I02	Terminal 02 connected to Zone 5
96	ZN5I01	Terminal 01 connected to Zone 5
97	ZN5I16	Terminal 16 connected to Zone 5
97	ZN5I15	Terminal 15 connected to Zone 5
97	ZN5I14	Terminal 14 connected to Zone 5
97	ZN5I13	Terminal 13 connected to Zone 5
97	ZN5I12	Terminal 12 connected to Zone 5
97	ZN5I11	Terminal 11 connected to Zone 5

Table 11.2 Row List of Relay Word Bits (Sheet 21 of 100)

Row	Name	Bit Description
97	ZN5I10	Terminal 10 connected to Zone 5
97	ZN5I09	Terminal 09 connected to Zone 5
98	*	Reserved
98	*	Reserved
98	*	Reserved
98	ZN5I21	Terminal 21 connected to Zone 5
98	ZN5I20	Terminal 20 connected to Zone 5
98	ZN5I19	Terminal 19 connected to Zone 5
98	ZN5I18	Terminal 18 connected to Zone 5
98	ZN5I17	Terminal 17 connected to Zone 5
99	*	Reserved
99	*	Reserved
99	*	Reserved
99	*	Reserved
99	*	Reserved
99	*	Reserved
99	*	Reserved
99	*	Reserved
100	ZN6I08	Terminal 08 connected to Zone 6
100	ZN6I07	Terminal 07 connected to Zone 6
100	ZN6I06	Terminal 06 connected to Zone 6
100	ZN6I05	Terminal 05 connected to Zone 6
100	ZN6I04	Terminal 04 connected to Zone 6
100	ZN6I03	Terminal 03 connected to Zone 6
100	ZN6I02	Terminal 02 connected to Zone 6
100	ZN6I01	Terminal 01 connected to Zone 6
101	ZN6I16	Terminal 16 connected to Zone 6
101	ZN6I15	Terminal 15 connected to Zone 6
101	ZN6I14	Terminal 14 connected to Zone 6
101	ZN6I13	Terminal 13 connected to Zone 6
101	ZN6I12	Terminal 12 connected to Zone 6
101	ZN6I11	Terminal 11 connected to Zone 6
101	ZN6I10	Terminal 10 connected to Zone 6
101	ZN6I09	Terminal 09 connected to Zone 6
102	*	Reserved
102	*	Reserved
102	*	Reserved
102	ZN6I21	Terminal 21 connected to Zone 6
102	ZN6I20	Terminal 20 connected to Zone 6
102	ZN6I19	Terminal 19 connected to Zone 6
102	ZN6I18	Terminal 18 connected to Zone 6

Table 11.2 Row List of Relay Word Bits (Sheet 22 of 100)

Row	Name	Bit Description
102	ZN6I17	Terminal 17 connected to Zone 6
103	*	Reserved
103	*	Reserved
103	*	Reserved
103	*	Reserved
103	*	Reserved
103	*	Reserved
103	*	Reserved
103	*	Reserved
104	ZN1I08T	Terminal 08 connected to Zone 1 and will be tripped
104	ZN1I07T	Terminal 07 connected to Zone 1 and will be tripped
104	ZN1I06T	Terminal 06 connected to Zone 1 and will be tripped
104	ZN1I05T	Terminal 05 connected to Zone 1 and will be tripped
104	ZN1I04T	Terminal 04 connected to Zone 1 and will be tripped
104	ZN1I03T	Terminal 03 connected to Zone 1 and will be tripped
104	ZN1I02T	Terminal 02 connected to Zone 1 and will be tripped
104	ZN1I01T	Terminal 01 connected to Zone 1 and will be tripped
105	ZN1I16T	Terminal 16 connected to Zone 1 and will be tripped
105	ZN1I15T	Terminal 15 connected to Zone 1 and will be tripped
105	ZN1I14T	Terminal 14 connected to Zone 1 and will be tripped
105	ZN1I13T	Terminal 13 connected to Zone 1 and will be tripped
105	ZN1I12T	Terminal 12 connected to Zone 1 and will be tripped
105	ZN1I11T	Terminal 11 connected to Zone 1 and will be tripped
105	ZN1I10T	Terminal 10 connected to Zone 1 and will be tripped
105	ZN1I09T	Terminal 09 connected to Zone 1 and will be tripped
106	*	Reserved
106	*	Reserved
106	*	Reserved
106	ZN1I21T	Terminal 21 connected to Zone 1 and will be tripped
106	ZN1I20T	Terminal 20 connected to Zone 1 and will be tripped
106	ZN1I19T	Terminal 19 connected to Zone 1 and will be tripped
106	ZN1I18T	Terminal 18 connected to Zone 1 and will be tripped
106	ZN1I17T	Terminal 17 connected to Zone 1 and will be tripped
107	*	Reserved
107	*	Reserved
107	*	Reserved
107	*	Reserved
107	*	Reserved
107	*	Reserved
107	*	Reserved
107	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 23 of 100)

Row	Name	Bit Description
108	ZN2I08T	Terminal 08 connected to Zone 2 and will be tripped
108	ZN2I07T	Terminal 07 connected to Zone 2 and will be tripped
108	ZN2I06T	Terminal 06 connected to Zone 2 and will be tripped
108	ZN2I05T	Terminal 05 connected to Zone 2 and will be tripped
108	ZN2I04T	Terminal 04 connected to Zone 2 and will be tripped
108	ZN2I03T	Terminal 03 connected to Zone 2 and will be tripped
108	ZN2I02T	Terminal 02 connected to Zone 2 and will be tripped
108	ZN2I01T	Terminal 01 connected to Zone 2 and will be tripped
109	ZN2I16T	Terminal 16 connected to Zone 2 and will be tripped
109	ZN2I15T	Terminal 15 connected to Zone 2 and will be tripped
109	ZN2I14T	Terminal 14 connected to Zone 2 and will be tripped
109	ZN2I13T	Terminal 13 connected to Zone 2 and will be tripped
109	ZN2I12T	Terminal 12 connected to Zone 2 and will be tripped
109	ZN2I11T	Terminal 11 connected to Zone 2 and will be tripped
109	ZN2I10T	Terminal 10 connected to Zone 2 and will be tripped
109	ZN2I09T	Terminal 09 connected to Zone 2 and will be tripped
110	*	Reserved
110	*	Reserved
110	*	Reserved
110	ZN2I21T	Terminal 21 connected to Zone 2 and will be tripped
110	ZN2I20T	Terminal 20 connected to Zone 2 and will be tripped
110	ZN2I19T	Terminal 19 connected to Zone 2 and will be tripped
110	ZN2I18T	Terminal 18 connected to Zone 2 and will be tripped
110	ZN2I17T	Terminal 17 connected to Zone 2 and will be tripped
111	*	Reserved
111	*	Reserved
111	*	Reserved
111	*	Reserved
111	*	Reserved
111	*	Reserved
111	*	Reserved
111	*	Reserved
112	ZN3I08T	Terminal 08 connected to Zone 3 and will be tripped
112	ZN3I07T	Terminal 07 connected to Zone 3 and will be tripped
112	ZN3I06T	Terminal 06 connected to Zone 3 and will be tripped
112	ZN3I05T	Terminal 05 connected to Zone 3 and will be tripped
112	ZN3I04T	Terminal 04 connected to Zone 3 and will be tripped
112	ZN3I03T	Terminal 03 connected to Zone 3 and will be tripped
112	ZN3I02T	Terminal 02 connected to Zone 3 and will be tripped
112	ZN3I01T	Terminal 01 connected to Zone 3 and will be tripped
113	ZN3I16T	Terminal 16 connected to Zone 3 and will be tripped

Table 11.2 Row List of Relay Word Bits (Sheet 24 of 100)

Row	Name	Bit Description
113	ZN3I15T	Terminal 15 connected to Zone 3 and will be tripped
113	ZN3I14T	Terminal 14 connected to Zone 3 and will be tripped
113	ZN3I13T	Terminal 13 connected to Zone 3 and will be tripped
113	ZN3I12T	Terminal 12 connected to Zone 3 and will be tripped
113	ZN3I11T	Terminal 11 connected to Zone 3 and will be tripped
113	ZN3I10T	Terminal 10 connected to Zone 3 and will be tripped
113	ZN3I09T	Terminal 09 connected to Zone 3 and will be tripped
114	*	Reserved
114	*	Reserved
114	*	Reserved
114	ZN3I21T	Terminal 21 connected to Zone 3 and will be tripped
114	ZN3I20T	Terminal 20 connected to Zone 3 and will be tripped
114	ZN3I19T	Terminal 19 connected to Zone 3 and will be tripped
114	ZN3I18T	Terminal 18 connected to Zone 3 and will be tripped
114	ZN3I17T	Terminal 17 connected to Zone 3 and will be tripped
115	*	Reserved
115	*	Reserved
115	*	Reserved
115	*	Reserved
115	*	Reserved
115	*	Reserved
115	*	Reserved
115	*	Reserved
116	ZN4I08T	Terminal 08 connected to Zone 4 and will be tripped
116	ZN4I07T	Terminal 07 connected to Zone 4 and will be tripped
116	ZN4I06T	Terminal 06 connected to Zone 4 and will be tripped
116	ZN4I05T	Terminal 05 connected to Zone 4 and will be tripped
116	ZN4I04T	Terminal 04 connected to Zone 4 and will be tripped
116	ZN4I03T	Terminal 03 connected to Zone 4 and will be tripped
116	ZN4I02T	Terminal 02 connected to Zone 4 and will be tripped
116	ZN4I01T	Terminal 01 connected to Zone 4 and will be tripped
117	ZN4I16T	Terminal 16 connected to Zone 4 and will be tripped
117	ZN4I15T	Terminal 15 connected to Zone 4 and will be tripped
117	ZN4I14T	Terminal 14 connected to Zone 4 and will be tripped
117	ZN4I13T	Terminal 13 connected to Zone 4 and will be tripped
117	ZN4I12T	Terminal 12 connected to Zone 4 and will be tripped
117	ZN4I11T	Terminal 11 connected to Zone 4 and will be tripped
117	ZN4I10T	Terminal 10 connected to Zone 4 and will be tripped
117	ZN4I09T	Terminal 09 connected to Zone 4 and will be tripped
118	*	Reserved
118	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 25 of 100)

Row	Name	Bit Description
118	*	Reserved
118	ZN4I21T	Terminal 21 connected to Zone 4 and will be tripped
118	ZN4I20T	Terminal 20 connected to Zone 4 and will be tripped
118	ZN4I19T	Terminal 19 connected to Zone 4 and will be tripped
118	ZN4I18T	Terminal 18 connected to Zone 4 and will be tripped
118	ZN4I17T	Terminal 17 connected to Zone 4 and will be tripped
119	*	Reserved
119	*	Reserved
119	*	Reserved
119	*	Reserved
119	*	Reserved
119	*	Reserved
119	*	Reserved
119	*	Reserved
120	ZN5I08T	Terminal 08 connected to Zone 5 and will be tripped
120	ZN5I07T	Terminal 07 connected to Zone 5 and will be tripped
120	ZN5I06T	Terminal 06 connected to Zone 5 and will be tripped
120	ZN5I05T	Terminal 05 connected to Zone 5 and will be tripped
120	ZN5I04T	Terminal 04 connected to Zone 5 and will be tripped
120	ZN5I03T	Terminal 03 connected to Zone 5 and will be tripped
120	ZN5I02T	Terminal 02 connected to Zone 5 and will be tripped
120	ZN5I01T	Terminal 01 connected to Zone 5 and will be tripped
121	ZN5I16T	Terminal 16 connected to Zone 5 and will be tripped
121	ZN5I15T	Terminal 15 connected to Zone 5 and will be tripped
121	ZN5I14T	Terminal 14 connected to Zone 5 and will be tripped
121	ZN5I13T	Terminal 13 connected to Zone 5 and will be tripped
121	ZN5I12T	Terminal 12 connected to Zone 5 and will be tripped
121	ZN5I11T	Terminal 11 connected to Zone 5 and will be tripped
121	ZN5I10T	Terminal 10 connected to Zone 5 and will be tripped
121	ZN5I09T	Terminal 09 connected to Zone 5 and will be tripped
122	*	Reserved
122	*	Reserved
122	*	Reserved
122	ZN5I21T	Terminal 21 connected to Zone 5 and will be tripped
122	ZN5I20T	Terminal 20 connected to Zone 5 and will be tripped
122	ZN5I19T	Terminal 19 connected to Zone 5 and will be tripped
122	ZN5I18T	Terminal 18 connected to Zone 5 and will be tripped
122	ZN5I17T	Terminal 17 connected to Zone 5 and will be tripped
123	*	Reserved
123	*	Reserved
123	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 26 of 100)

Row	Name	Bit Description
123	*	Reserved
123	*	Reserved
123	*	Reserved
123	*	Reserved
123	*	Reserved
124	ZN6I08T	Terminal 08 connected to Zone 6 and will be tripped
124	ZN6I07T	Terminal 07 connected to Zone 6 and will be tripped
124	ZN6I06T	Terminal 06 connected to Zone 6 and will be tripped
124	ZN6I05T	Terminal 05 connected to Zone 6 and will be tripped
124	ZN6I04T	Terminal 04 connected to Zone 6 and will be tripped
124	ZN6I03T	Terminal 03 connected to Zone 6 and will be tripped
124	ZN6I02T	Terminal 02 connected to Zone 6 and will be tripped
124	ZN6I01T	Terminal 01 connected to Zone 6 and will be tripped
125	ZN6I16T	Terminal 16 connected to Zone 6 and will be tripped
125	ZN6I15T	Terminal 15 connected to Zone 6 and will be tripped
125	ZN6I14T	Terminal 14 connected to Zone 6 and will be tripped
125	ZN6I13T	Terminal 13 connected to Zone 6 and will be tripped
125	ZN6I12T	Terminal 12 connected to Zone 6 and will be tripped
125	ZN6I11T	Terminal 11 connected to Zone 6 and will be tripped
125	ZN6I10T	Terminal 10 connected to Zone 6 and will be tripped
125	ZN6I09T	Terminal 09 connected to Zone 6 and will be tripped
126	*	Reserved
126	*	Reserved
126	*	Reserved
126	ZN6I21T	Terminal 21 connected to Zone 6 and will be tripped
126	ZN6I20T	Terminal 20 connected to Zone 6 and will be tripped
126	ZN6I19T	Terminal 19 connected to Zone 6 and will be tripped
126	ZN6I18T	Terminal 18 connected to Zone 6 and will be tripped
126	ZN6I17T	Terminal 17 connected to Zone 6 and will be tripped
127	*	Reserved
127	*	Reserved
127	*	Reserved
127	*	Reserved
127	*	Reserved
127	*	Reserved
127	*	Reserved
127	*	Reserved
Bus-Zone-to-Bus-Zone Connection		
128	*	Reserved
128	*	Reserved
128	BZ1BZ6V	A connection exists between BZ1 and BZ6

Table 11.2 Row List of Relay Word Bits (Sheet 27 of 100)

Row	Name	Bit Description
128	BZ1BZ5V	A connection exists between BZ1 and BZ5
128	BZ1BZ4V	A connection exists between BZ1 and BZ4
128	BZ1BZ3V	A connection exists between BZ1 and BZ3
128	BZ1BZ2V	A connection exists between BZ1 and BZ2
128	*	Reserved
129	*	Reserved
129	*	Reserved
129	BZ2BZ6V	A connection exists between BZ2 and BZ6
129	BZ2BZ5V	A connection exists between BZ2 and BZ5
129	BZ2BZ4V	A connection exists between BZ2 and BZ4
129	BZ2BZ3V	A connection exists between BZ2 and BZ3
129	*	Reserved
129	*	Reserved
130	*	Reserved
130	*	Reserved
130	BZ3BZ6V	A connection exists between BZ3 and BZ6
130	BZ3BZ5V	A connection exists between BZ3 and BZ5
130	BZ3BZ4V	A connection exists between BZ3 and BZ4
130	*	Reserved
130	*	Reserved
130	*	Reserved
131	*	Reserved
131	*	Reserved
131	BZ4BZ6V	A connection exists between BZ4 and BZ6
131	BZ4BZ5V	A connection exists between BZ4 and BZ5
131	*	Reserved
131	*	Reserved
131	*	Reserved
131	*	Reserved
132	*	Reserved
132	*	Reserved
132	BZ5BZ6V	A connection exists between BZ5 and BZ6
132	*	Reserved
132	*	Reserved
132	*	Reserved
132	*	Reserved
132	*	Reserved
133	*	Reserved
133	*	Reserved
133	*	Reserved
133	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 28 of 100)

Row	Name	Bit Description
133	*	Reserved
133	*	Reserved
133	*	Reserved
133	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
134	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
135	*	Reserved
136	*	Reserved
136	*	Reserved
136	BZ1BZ6R	A connection exists between BZ1 and BZ6 and a coupler is removed
136	BZ1BZ5R	A connection exists between BZ1 and BZ5 and a coupler is removed
136	BZ1BZ4R	A connection exists between BZ1 and BZ4 and a coupler is removed
136	BZ1BZ3R	A connection exists between BZ1 and BZ3 and a coupler is removed
136	BZ1BZ2R	A connection exists between BZ1 and BZ2 and a coupler is removed
136	*	Reserved
137	*	Reserved
137	*	Reserved
137	BZ2BZ6R	A connection exists between BZ2 and BZ6 and a coupler is removed
137	BZ2BZ5R	A connection exists between BZ2 and BZ5 and a coupler is removed
137	BZ2BZ4R	A connection exists between BZ2and BZ4 and a coupler is removed
137	BZ2BZ3R	A connection exists between BZ2 and BZ3 and a coupler is removed
137	*	Reserved
137	*	Reserved
138	*	Reserved
138	*	Reserved
138	BZ3BZ6R	A connection exists between BZ3 and BZ6 and a coupler is removed
138	BZ3BZ5R	A connection exists between BZ3 and BZ5 and a coupler is removed
138	BZ3BZ4R	A connection exists between BZ3 and BZ4 and a coupler is removed

Table 11.2 Row List of Relay Word Bits (Sheet 29 of 100)

Row	Name	Bit Description
138	*	Reserved
138	*	Reserved
138	*	Reserved
139	*	Reserved
139	*	Reserved
139	BZ4BZ6R	A connection exists between BZ4 and BZ6 and a coupler is removed
139	BZ4BZ5R	A connection exists between BZ4 and BZ5 and a coupler is removed
139	*	Reserved
139	*	Reserved
139	*	Reserved
139	*	Reserved
140	*	Reserved
140	*	Reserved
140	BZ5BZ6R	A connection exists between BZ5 and BZ6 and a coupler is removed
140	*	Reserved
140	*	Reserved
140	*	Reserved
140	*	Reserved
140	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
141	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
142	*	Reserved
143	*	Reserved
143	*	Reserved
143	*	Reserved
143	*	Reserved
143	*	Reserved
143	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 30 of 100)

Row	Name	Bit Description
143	*	Reserved
143	*	Reserved
144	*	Reserved
144	*	Reserved
144	Z1BZ6	Bus-Zone 6 is part of Protective Zone 1
144	Z1BZ5	Bus-Zone 5 is part of Protective Zone 1
144	Z1BZ4	Bus-Zone 4 is part of Protective Zone 1
144	Z1BZ3	Bus-Zone 3 is part of Protective Zone 1
144	Z1BZ2	Bus-Zone 2 is part of Protective Zone 1
144	Z1BZ1	Bus-Zone 1 is part of Protective Zone 1
145	*	Reserved
145	*	Reserved
145	Z2BZ6	Bus-Zone 6 is part of Protective Zone 2
145	Z2BZ5	Bus-Zone 5 is part of Protective Zone 2
145	Z2BZ4	Bus-Zone 4 is part of Protective Zone 2
145	Z2BZ3	Bus-Zone 3 is part of Protective Zone 2
145	Z2BZ2	Bus-Zone 2 is part of Protective Zone 2
145	*	Reserved
146	*	Reserved
146	*	Reserved
146	Z3BZ6	Bus-Zone 6 is part of Protective Zone 3
146	Z3BZ5	Bus-Zone 5 is part of Protective Zone 3
146	Z3BZ4	Bus-Zone 4 is part of Protective Zone 3
146	Z3BZ3	Bus-Zone 3 is part of Protective Zone 3
146	*	Reserved
146	*	Reserved
147	*	Reserved
147	*	Reserved
147	Z4BZ6	Bus-Zone 6 is part of Protective Zone 4
147	Z4BZ5	Bus-Zone 5 is part of Protective Zone 4
147	Z4BZ4	Bus-Zone 4 is part of Protective Zone 4
147	*	Reserved
147	*	Reserved
147	*	Reserved
148	*	Reserved
148	*	Reserved
148	Z5BZ6	Bus-Zone 6 is part of Protective Zone 5
148	Z5BZ5	Bus-Zone 5 is part of Protective Zone 5
148	*	Reserved
148	*	Reserved
148	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 31 of 100)

Row	Name	Bit Description
148	*	Reserved
149	*	Reserved
149	*	Reserved
149	Z6BZ6	Bus-Zone 6 is part of Protective Zone 6
149	*	Reserved
149	*	Reserved
149	*	Reserved
149	*	Reserved
149	*	Reserved
Zone Selection		
150	*	Reserved
150	*	Reserved
150	ZONE6	Differential Zone 6 is active
150	ZONE5	Differential Zone 5 is active
150	ZONE4	Differential Zone 4 is active
150	ZONE3	Differential Zone 3 is active
150	ZONE2	Differential Zone 2 is active
150	ZONE1	Differential Zone 1 is active
151	*	Reserved
151	ZSWOP	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in any zone
151	ZSWOP6	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 6
151	ZSWOP5	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 5
151	ZSWOP4	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 4
151	ZSWOP3	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 3
151	ZSWOP2	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 2
151	ZSWOP1	Change to either bus-zone-to-bus-zone or terminal-to-bus-zone conditions in Zone 1
152	*	Reserved
152	*	Reserved
152	*	Reserved
152	*	Reserved
152	ZSWOAL	Zone switching operation alarm
152	ZSWOIP	Zone switching operation in progress
152	ZSWO	Zone switching operation
152	RZSWOAL	Reset zone switching operation alarm
Zone Supervision		
153	*	Reserved
153	*	Reserved
153	Z6S	Zone 6 supervision asserted
153	Z5S	Zone 5 supervision asserted
153	Z4S	Zone 4 supervision asserted
153	Z3S	Zone 3 supervision asserted

Table 11.2 Row List of Relay Word Bits (Sheet 32 of 100)

Row	Name	Bit Description
153	Z2S	Zone 2 supervision asserted
153	Z1S	Zone 1 supervision asserted
Open CT Detector		
154	*	Reserved
154	*	Reserved
154	ROCTZ6	Zone 6 open CT logic reset
154	ROCTZ5	Zone 5 open CT logic reset
154	ROCTZ4	Zone 4 open CT logic reset
154	ROCTZ3	Zone 3 open CT logic reset
154	ROCTZ2	Zone 2 open CT logic reset
154	ROCTZ1	Zone 1 open CT logic reset
155	*	Reserved
155	*	Reserved
155	OCTZ6	Zone 6 open CT detection
155	OCTZ5	Zone 5 open CT detection
155	OCTZ4	Zone 4 open CT detection
155	OCTZ3	Zone 3 open CT detection
155	OCTZ2	Zone 2 open CT detection
155	OCTZ1	Zone 1 open CT detection
156	*	Reserved
156	*	Reserved
156	RSTOCT6	Zone 6 open CT detection reset
156	RSTOCT5	Zone 5 open CT detection reset
156	RSTOCT4	Zone 4 open CT detection reset
156	RSTOCT3	Zone 3 open CT detection reset
156	RSTOCT2	Zone 2 open CT detection reset
156	RSTOCT1	Zone 1 open CT detection reset
Sensitive Element (87S)		
157	*	Reserved
157	*	Reserved
157	87S6	Zone 6 sensitive differential element picked up
157	87S5	Zone 5 sensitive differential element picked up
157	87S4	Zone 4 sensitive differential element picked up
157	87S3	Zone 3 sensitive differential element picked up
157	87S2	Zone 2 sensitive differential element picked up
157	87S1	Zone 1 sensitive differential element picked up
158	*	Reserved
158	87ST	Any sensitive differential element timer timed out
158	87ST6	Zone 6 sensitive differential element timed out
158	87ST5	Zone 5 sensitive differential element timed out
158	87ST4	Zone 4 sensitive differential element timed out

Table 11.2 Row List of Relay Word Bits (Sheet 33 of 100)

Row	Name	Bit Description
158	87ST3	Zone 3 sensitive differential element timed out
158	87ST2	Zone 2 sensitive differential element timed out
158	87ST1	Zone 1 sensitive differential element timed out
Differential Elements		
159	87R1	Zone 1 restraint differential element picked up
159	P87R1	Zone 1 instantaneous differential element picked up
159	87O1	Zone 1 restraint differential operating current above O87P
159	FAULT1	Zone 1 fault detector picked up
159	CON1	Zone 1 in high-security mode
159	EXT1	Zone 1 external fault declaration
159	DOP1	Zone 1 incremental operating current picked up
159	DRT1	Zone 1 incremental restraint current picked up
160	*	Reserved
160	*	Reserved
160	*	Reserved
160	*	Reserved
160	FDIF1	Zone 1 filtered restrained differential element picked up
160	RDIF1	Zone 1 unfiltered restrained differential element picked up
160	IFAULT1	Zone 1 fault detection
160	GFAULT1	Zone 1 fast fault detection
161	87R2	Zone 2 restraint differential element picked up
161	P87R2	Zone 2 instantaneous differential element picked up
161	87O2	Zone 2 restraint differential operating current above O87P
161	FAULT2	Zone 2 fault detector picked up
161	CON2	Zone 2 in high-security mode
161	EXT2	Zone 2 external fault declaration
161	DOP2	Zone 2 incremental operating current picked up
161	DRT2	Zone 2 incremental restraint current picked up
162	*	Reserved
162	*	Reserved
162	*	Reserved
162	*	Reserved
162	FDIF2	Zone 2 filtered restrained differential element picked up
162	RDIF2	Zone 2 unfiltered restrained differential element picked up
162	IFAULT2	Zone 2 fault detection
162	GFAULT2	Zone 2 fast fault detection
163	87R3	Zone 3 restraint differential element picked up
163	P87R3	Zone 3 instantaneous differential element picked up
163	87O3	Zone 3 restraint differential operating current above O87P
163	FAULT3	Zone 3 fault detector picked up
163	CON3	Zone 3 in high-security mode

Table 11.2 Row List of Relay Word Bits (Sheet 34 of 100)

Row	Name	Bit Description
163	EXT3	Zone 3 external fault declaration
163	DOP3	Zone 3 incremental operating current picked up
163	DRT3	Zone 3 incremental restraint current picked up
164	*	Reserved
164	*	Reserved
164	*	Reserved
164	*	Reserved
164	FDIF3	Zone 3 filtered restrained differential element picked up
164	RDIF3	Zone 3 unfiltered restrained differential element picked up
164	IFAULT3	Zone 3 fault detection
164	GFAULT3	Zone 3 fast fault detection
165	87R4	Zone 4 restraint differential element picked up
165	P87R4	Zone 4 instantaneous differential element picked up
165	87O4	Zone 4 restraint differential operating current above O87P
165	FAULT4	Zone 4 fault detector picked up
165	CON4	Zone 4 in high-security mode
165	EXT4	Zone 4 external fault declaration
165	DOP4	Zone 4 incremental operating current picked up
165	DRT4	Zone 4 incremental restraint current picked up
166	*	Reserved
166	*	Reserved
166	*	Reserved
166	*	Reserved
166	FDIF4	Zone 4 filtered restrained differential element picked up
166	RDIF4	Zone 4 unfiltered restrained differential element picked up
166	IFAULT4	Zone 4 fault detection
166	GFAULT4	Zone 4 fast fault detection
167	87R5	Zone 5 restraint differential element picked up
167	P87R5	Zone 5 instantaneous differential element picked up
167	87O5	Zone 5 restraint differential operating current above O87P
167	FAULT5	Zone 5 fault detector picked up
167	CON5	Zone 5 in high-security mode
167	EXT5	Zone 5 external fault declaration
167	DOP5	Zone 5 incremental operating current picked up
167	DRT5	Zone 5 incremental restraint current picked up
168	*	Reserved
168	*	Reserved
168	*	Reserved
168	*	Reserved
168	FDIF5	Zone 5 filtered restrained differential element picked up
168	RDIF5	Zone 5 unfiltered restrained differential element picked up

Table 11.2 Row List of Relay Word Bits (Sheet 35 of 100)

Row	Name	Bit Description
168	IFAULT5	Zone 5 fault detection
168	GFAULT5	Zone 5 fast fault detection
169	87R6	Zone 6 restraint differential element picked up
169	P87R6	Zone 6 instantaneous differential element picked up
169	87O6	Zone 6 restraint differential operating current above O87P
169	FAULT6	Zone 6 fault detector picked up
169	CON6	Zone 6 in high-security mode
169	EXT6	Zone 6 external fault declaration
169	DOP6	Zone 6 incremental operating current picked up
169	DRT6	Zone 6 incremental restraint current picked up
170	*	Reserved
170	*	Reserved
170	*	Reserved
170	*	Reserved
170	FDIF6	Zone 6 filtered restrained differential element picked up
170	RDIF6	Zone 6 unfiltered restrained differential element picked up
170	IFAULT6	Zone 6 fault detection
170	GFAULT6	Zone 6 fast fault detection
171	*	Reserved
171	*	Reserved
171	*	Reserved
171	*	Reserved
171	*	Reserved
171	*	Reserved
171	*	Reserved
171	FAULT	Busbar fault in any zone
Directional Element (Diff Zone)		
172	*	Reserved
172	*	Reserved
172	DE6F	Zone 6 forward directional element picked up
172	DE5F	Zone 5 forward directional element picked up
172	DE4F	Zone 4 forward directional element picked up
172	DE3F	Zone 3 forward directional element picked up
172	DE2F	Zone 2 forward directional element picked up
172	DE1F	Zone 1 forward directional element picked up
173	50DS08	Terminal 08 directional element current threshold exceeded
173	50DS07	Terminal 07 directional element current threshold exceeded
173	50DS06	Terminal 06 directional element current threshold exceeded
173	50DS05	Terminal 05 directional element current threshold exceeded
173	50DS04	Terminal 04 directional element current threshold exceeded
173	50DS03	Terminal 03 directional element current threshold exceeded

Table 11.2 Row List of Relay Word Bits (Sheet 36 of 100)

Row	Name	Bit Description
173	50DS02	Terminal 02 directional element current threshold exceeded
173	50DS01	Terminal 01 directional element current threshold exceeded
174	50DS16	Terminal 16 directional element current threshold exceeded
174	50DS15	Terminal 15 directional element current threshold exceeded
174	50DS14	Terminal 14 directional element current threshold exceeded
174	50DS13	Terminal 13 directional element current threshold exceeded
174	50DS12	Terminal 12 directional element current threshold exceeded
174	50DS11	Terminal 11 directional element current threshold exceeded
174	50DS10	Terminal 10 directional element current threshold exceeded
174	50DS09	Terminal 09 directional element current threshold exceeded
175	*	Reserved
175	*	Reserved
175	*	Reserved
175	50DS21	Terminal 21 directional element current threshold exceeded
175	50DS20	Terminal 20 directional element current threshold exceeded
175	50DS19	Terminal 19 directional element current threshold exceeded
175	50DS18	Terminal 18 directional element current threshold exceeded
175	50DS17	Terminal 17 directional element current threshold exceeded
Coupler Security Logic		
176	*	Reserved
176	CSL1	Coupler 1 security logic picked up
176	ACTRPT1	Coupler 1 accelerated trip timed out
176	ACTRP1	Coupler 1 accelerated trip SELOGIC control equation
176	CBCLST1	Coupler 1 close command timed out
176	CBCLS1	Coupler 1 close command SELOGIC control equation
176	CB52T1	Coupler 1 status timed out
176	CB52A1	Coupler 1 status SELOGIC control equation
177	*	Reserved
177	CSL2	Coupler 2 security logic picked up
177	ACTRPT2	Coupler 2 accelerated trip timed out
177	ACTRP2	Coupler 2 accelerated trip SELOGIC control equation
177	CBCLST2	Coupler 2 close command timed out
177	CBCLS2	Coupler 2 close command SELOGIC control equation
177	CB52T2	Coupler 2 status timed out
177	CB52A2	Coupler 2 status SELOGIC control equation
178	*	Reserved
178	CSL3	Coupler 3 security logic picked up
178	ACTRPT3	Coupler 3 accelerated trip timed out
178	ACTRP3	Coupler 3 accelerated trip SELOGIC control equation
178	CBCLST3	Coupler 3 close command timed out
178	CBCLS3	Coupler 3 close command SELOGIC control equation

Table 11.2 Row List of Relay Word Bits (Sheet 37 of 100)

Row	Name	Bit Description
178	CB52T3	Coupler 3 status timed out
178	CB52A3	Coupler 3 status SELOGIC control equation
179	*	Reserved
179	CSL4	Coupler 4 security logic picked up
179	ACTRPT4	Coupler 4 accelerated trip timed out
179	ACTRP4	Coupler 4 accelerated trip SELOGIC control equation
179	CBCLST4	Coupler 4 close command timed out
179	CBCLS4	Coupler 4 close command SELOGIC control equation
179	CB52T4	Coupler 4 status timed out
179	CB52A4	Coupler 4 status SELOGIC control equation
Terminal Out of Service		
180	TOS08	Terminal 08 out of service
180	TOS07	Terminal 07 out of service
180	TOS06	Terminal 06 out of service
180	TOS05	Terminal 05 out of service
180	TOS04	Terminal 04 out of service
180	TOS03	Terminal 03 out of service
180	TOS02	Terminal 02 out of service
180	TOS01	Terminal 01 out of service
181	TOS16	Terminal 16 out of service
181	TOS15	Terminal 15 out of service
181	TOS14	Terminal 14 out of service
181	TOS13	Terminal 13 out of service
181	TOS12	Terminal 12 out of service
181	TOS11	Terminal 11 out of service
181	TOS10	Terminal 10 out of service
181	TOS09	Terminal 09 out of service
182	*	Reserved
182	*	Reserved
182	*	Reserved
182	TOS21	Terminal 21 out of service
182	TOS20	Terminal 20 out of service
182	TOS19	Terminal 19 out of service
182	TOS18	Terminal 18 out of service
182	TOS17	Terminal 17 out of service
Breaker Failure		
183	FBF01	Circuit Breaker 1 failure
183	XBF01	Circuit Breaker 1 external breaker failure input (SELOGIC control equation)
183	RT01	Circuit Breaker 1 retrip
183	ABFIT01	Circuit Breaker 1 alternate circuit breaker failure initiate
183	ATBFI01	Circuit Breaker 1 alternate breaker failure initiate SELOGIC control equation

Table 11.2 Row List of Relay Word Bits (Sheet 38 of 100)

Row	Name	Bit Description
183	BFIT01	Circuit Breaker 1 breaker failure timed out
183	BFI01	Circuit Breaker 1 breaker failure initiate SELOGIC control equation
183	50F01	Circuit Breaker 1 breaker failure current threshold exceeded
184	FBF02	Circuit Breaker 2 failure
184	XBF02	Circuit Breaker 2 external breaker failure input (SELOGIC control equation)
184	RT02	Circuit Breaker 2 retrip
184	ABFIT02	Circuit Breaker 2 alternate circuit breaker failure initiate
184	ATBFI02	Circuit Breaker 2 alternate breaker failure initiate SELOGIC control equation
184	BFIT02	Circuit Breaker 2 breaker failure timed out
184	BFI02	Circuit Breaker 2 breaker failure initiate SELOGIC control equation
184	50F02	Circuit Breaker 2 breaker failure current threshold exceeded
185	FBF03	Circuit Breaker 3 failure
185	XBF03	Circuit Breaker 3 external breaker failure input (SELOGIC control equation)
185	RT03	Circuit Breaker 3 retrip
185	ABFIT03	Circuit Breaker 3 alternate circuit breaker failure initiate
185	ATBFI03	Circuit Breaker 3 alternate breaker failure initiate SELOGIC control equation
185	BFIT03	Circuit Breaker 3 breaker failure timed out
185	BFI03	Circuit Breaker 3 breaker failure initiate SELOGIC control equation
185	50F03	Circuit Breaker 3 breaker failure current threshold exceeded
186	FBF04	Circuit Breaker 4 failure
186	XBF04	Circuit Breaker 4 external breaker failure input (SELOGIC control equation)
186	RT04	Circuit Breaker 4 retrip
186	ABFIT04	Circuit Breaker 4 alternate circuit breaker failure initiate
186	ATBFI04	Circuit Breaker 4 alternate breaker failure initiate SELOGIC control equation
186	BFIT04	Circuit Breaker 4 breaker failure timed out
186	BFI04	Circuit Breaker 4 breaker failure initiate SELOGIC control equation
186	50F04	Circuit Breaker 4 breaker failure current threshold exceeded
187	FBF05	Circuit Breaker 5 failure
187	XBF05	Circuit Breaker 5 external breaker failure input (SELOGIC control equation)
187	RT05	Circuit Breaker 5 retrip
187	ABFIT05	Circuit Breaker 5 alternate circuit breaker failure initiate
187	ATBFI05	Circuit Breaker 5 alternate breaker failure initiate SELOGIC control equation
187	BFIT05	Circuit Breaker 5 breaker failure timed out
187	BFI05	Circuit Breaker 5 breaker failure initiate SELOGIC control equation
187	50F05	Circuit Breaker 5 breaker failure current threshold exceeded
188	FBF06	Circuit Breaker 6 failure
188	XBF06	Circuit Breaker 6 external breaker failure input (SELOGIC control equation)
188	RT06	Circuit Breaker 6 retrip
188	ABFIT06	Circuit Breaker 6 alternate circuit breaker failure initiate
188	ATBFI06	Circuit Breaker 6 alternate breaker failure initiate SELOGIC control equation
188	BFIT06	Circuit Breaker 6 breaker failure timed out

Table 11.2 Row List of Relay Word Bits (Sheet 39 of 100)

Row	Name	Bit Description
188	BFI06	Circuit Breaker 6 breaker failure initiate SELOGIC control equation
188	50F06	Circuit Breaker 6 breaker failure current threshold exceeded
189	FBF07	Circuit Breaker 7 failure
189	XBF07	Circuit Breaker 7 external breaker failure input (SELOGIC control equation)
189	RT07	Circuit Breaker 7 retrip
189	ABFIT07	Circuit Breaker 7 alternate circuit breaker failure initiate
189	ATBFI07	Circuit Breaker 7 alternate breaker failure initiate SELOGIC control equation
189	BFIT07	Circuit Breaker 7 breaker failure timed out
189	BFI07	Circuit Breaker 7 breaker failure initiate SELOGIC control equation
189	50F07	Circuit Breaker 7 breaker failure current threshold exceeded
190	FBF08	Circuit Breaker 8 failure
190	XBF08	Circuit Breaker 8 external breaker failure input (SELOGIC control equation)
190	RT08	Circuit Breaker 8 retrip
190	ABFIT08	Circuit Breaker 8 alternate circuit breaker failure initiate
190	ATBFI08	Circuit Breaker 8 alternate breaker failure initiate SELOGIC control equation
190	BFIT08	Circuit Breaker 8 breaker failure timed out
190	BFI08	Circuit Breaker 8 breaker failure initiate SELOGIC control equation
190	50F08	Circuit Breaker 8 breaker failure current threshold exceeded
191	FBF09	Circuit Breaker 9 failure
191	XBF09	Circuit Breaker 9 external breaker failure input (SELOGIC control equation)
191	RT09	Circuit Breaker 9 retrip
191	ABFIT09	Circuit Breaker 9 alternate circuit breaker failure initiate
191	ATBFI09	Circuit Breaker 9 alternate breaker failure initiate SELOGIC control equation
191	BFIT09	Circuit Breaker 9 breaker failure timed out
191	BFI09	Circuit Breaker 9 breaker failure initiate SELOGIC control equation
191	50F09	Circuit Breaker 9 breaker failure current threshold exceeded
192	FBF10	Circuit Breaker 10 failure
192	XBF10	Circuit Breaker 10 external breaker failure input (SELOGIC control equation)
192	RT10	Circuit Breaker 10 retrip
192	ABFIT10	Circuit Breaker 10 alternate circuit breaker failure initiate
192	ATBFI10	Circuit Breaker 10 alternate breaker failure initiate SELOGIC control equation
192	BFIT10	Circuit Breaker 10 breaker failure timed out
192	BFI10	Circuit Breaker 10 breaker failure initiate SELOGIC control equation
192	50F10	Circuit Breaker 10 breaker failure current threshold exceeded
193	FBF11	Circuit Breaker 11 failure
193	XBF11	Circuit Breaker 11 external breaker failure input (SELOGIC control equation)
193	RT11	Circuit Breaker 11 retrip
193	ABFIT11	Circuit Breaker 11 alternate circuit breaker failure initiate
193	ATBFI11	Circuit Breaker 11 alternate breaker failure initiate SELOGIC control equation
193	BFIT11	Circuit Breaker 11 breaker failure timed out
193	BFI11	Circuit Breaker 11 breaker failure initiate SELOGIC control equation

Table 11.2 Row List of Relay Word Bits (Sheet 40 of 100)

Row	Name	Bit Description
193	50F11	Circuit Breaker 11 breaker failure current threshold exceeded
194	FBF12	Circuit Breaker 12 failure
194	XBF12	Circuit Breaker 12 external breaker failure input (SELOGIC control equation)
194	RT12	Circuit Breaker 12 retrip
194	ABFIT12	Circuit Breaker 12 alternate circuit breaker failure initiate
194	ATBFI12	Circuit Breaker 12 alternate breaker failure initiate SELOGIC control equation
194	BFIT12	Circuit Breaker 12 breaker failure timed out
194	BFI12	Circuit Breaker 12 breaker failure initiate SELOGIC control equation
194	50F12	Circuit Breaker 12 breaker failure current threshold exceeded
195	FBF13	Circuit Breaker 13 failure
195	XBF13	Circuit Breaker 13 external breaker failure input (SELOGIC control equation)
195	RT13	Circuit Breaker 13 retrip
195	ABFIT13	Circuit Breaker 13 alternate circuit breaker failure initiate
195	ATBFI13	Circuit Breaker 13 alternate breaker failure initiate SELOGIC control equation
195	BFIT13	Circuit Breaker 13 breaker failure timed out
195	BFI13	Circuit Breaker 13 breaker failure initiate SELOGIC control equation
195	50F13	Circuit Breaker 13 breaker failure current threshold exceeded
196	FBF14	Circuit Breaker 14 failure
196	XBF14	Circuit Breaker 14 external breaker failure input (SELOGIC control equation)
196	RT14	Circuit Breaker 14 retrip
196	ABFIT14	Circuit Breaker 14 alternate circuit breaker failure initiate
196	ATBFI14	Circuit Breaker 14 alternate breaker failure initiate SELOGIC control equation
196	BFIT14	Circuit Breaker 14 breaker failure timed out
196	BFI14	Circuit Breaker 14 breaker failure initiate SELOGIC control equation
196	50F14	Circuit Breaker 14 breaker failure current threshold exceeded
197	FBF15	Circuit Breaker 15 failure
197	XBF15	Circuit Breaker 15 external breaker failure input (SELOGIC control equation)
197	RT15	Circuit Breaker 15 retrip
197	ABFIT15	Circuit Breaker 15 alternate circuit breaker failure initiate
197	ATBFI15	Circuit Breaker 15 alternate breaker failure initiate SELOGIC control equation
197	BFIT15	Circuit Breaker 15 breaker failure timed out
197	BFI15	Circuit Breaker 15 breaker failure initiate SELOGIC control equation
197	50F15	Circuit Breaker 15 breaker failure current threshold exceeded
198	FBF16	Circuit Breaker 16 failure
198	XBF16	Circuit Breaker 16 external breaker failure input (SELOGIC control equation)
198	RT16	Circuit Breaker 16 retrip
198	ABFIT16	Circuit Breaker 16 alternate circuit breaker failure initiate
198	ATBFI16	Circuit Breaker 16 alternate breaker failure initiate SELOGIC control equation
198	BFIT16	Circuit Breaker 16 breaker failure timed out
198	BFI16	Circuit Breaker 16 breaker failure initiate SELOGIC control equation
198	50F16	Circuit Breaker 16 breaker failure current threshold exceeded

Table 11.2 Row List of Relay Word Bits (Sheet 41 of 100)

Row	Name	Bit Description
199	FBF17	Circuit Breaker 17 failure
199	XBF17	Circuit Breaker 17 external breaker failure input (SELOGIC control equation)
199	RT17	Circuit Breaker 17 retrip
199	ABFIT17	Circuit Breaker 17 alternate circuit breaker failure initiate
199	ATBFI17	Circuit Breaker 17 alternate breaker failure initiate SELOGIC control equation
199	BFIT17	Circuit Breaker 17 breaker failure timed out
199	BFI17	Circuit Breaker 17 breaker failure initiate SELOGIC control equation
199	50F17	Circuit Breaker 17 breaker failure current threshold exceeded
200	FBF18	Circuit Breaker 18 failure
200	XBF18	Circuit Breaker 18 external breaker failure input (SELOGIC control equation)
200	RT18	Circuit Breaker 18 retrip
200	ABFIT18	Circuit Breaker 18 alternate circuit breaker failure initiate
200	ATBFI18	Circuit Breaker 18 alternate breaker failure initiate SELOGIC control equation
200	BFIT18	Circuit Breaker 18 breaker failure timed out
200	BFI18	Circuit Breaker 18 breaker failure initiate SELOGIC control equation
200	50F18	Circuit Breaker 18 breaker failure current threshold exceeded
201	FBF19	Circuit Breaker 19 failure
201	XBF19	Circuit Breaker 19 external breaker failure input (SELOGIC control equation)
201	RT19	Circuit Breaker 19 retrip
201	ABFIT19	Circuit Breaker 19 alternate circuit breaker failure initiate
201	ATBFI19	Circuit Breaker 19 alternate breaker failure initiate SELOGIC control equation
201	BFIT19	Circuit Breaker 19 breaker failure timed out
201	BFI19	Circuit Breaker 19 breaker failure initiate SELOGIC control equation
201	50F19	Circuit Breaker 19 breaker failure current threshold exceeded
202	FBF20	Circuit Breaker 20 failure
202	XBF20	Circuit Breaker 20 external breaker failure input (SELOGIC control equation)
202	RT20	Circuit Breaker 20 retrip
202	ABFIT20	Circuit Breaker 20 alternate circuit breaker failure initiate
202	ATBFI20	Circuit Breaker 20 alternate breaker failure initiate SELOGIC control equation
202	BFIT20	Circuit Breaker 20 breaker failure timed out
202	BFI20	Circuit Breaker 20 breaker failure initiate SELOGIC control equation
202	50F20	Circuit Breaker 20 breaker failure current threshold exceeded
203	FBF21	Circuit Breaker 21 failure
203	XBF21	Circuit Breaker 21 external breaker failure input (SELOGIC control equation)
203	RT21	Circuit Breaker 21 retrip
203	ABFIT21	Circuit Breaker 21 alternate circuit breaker failure initiate
203	ATBFI21	Circuit Breaker 21 alternate breaker failure initiate SELOGIC control equation
203	BFIT21	Circuit Breaker 21 breaker failure timed out
203	BFI21	Circuit Breaker 21 breaker failure initiate SELOGIC control equation
203	50F21	Circuit Breaker 21 breaker failure current threshold exceeded
204	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 42 of 100)

Row	Name	Bit Description
204	*	Reserved
204	*	Reserved
204	*	Reserved
204	*	Reserved
204	*	Reserved
204	*	Reserved
204	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
205	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
206	*	Reserved
Overcurrent Elements		
207	50P04T	Terminal 04 definite-time overcurrent element timed out
207	50P04	Terminal 04 instantaneous overcurrent element
207	50P03T	Terminal 03 definite-time overcurrent element timed out
207	50P03	Terminal 03 instantaneous overcurrent element
207	50P02T	Terminal 02 definite-time overcurrent element timed out
207	50P02	Terminal 02 instantaneous overcurrent element
207	50P01T	Terminal 01 definite-time overcurrent element timed out
207	50P01	Terminal 01 instantaneous overcurrent element
208	50P08T	Terminal 08 definite-time overcurrent element timed out
208	50P08	Terminal 08 instantaneous overcurrent element
208	50P07T	Terminal 07 definite-time overcurrent element timed out
208	50P07	Terminal 07 instantaneous overcurrent element
208	50P06T	Terminal 06 definite-time overcurrent element timed out
208	50P06	Terminal 06 instantaneous overcurrent element
208	50P05T	Terminal 05 definite-time overcurrent element timed out
208	50P05	Terminal 05 instantaneous overcurrent element
209	50P12T	Terminal 12 definite-time overcurrent element timed out

Table 11.2 Row List of Relay Word Bits (Sheet 43 of 100)

Row	Name	Bit Description
209	50P12	Terminal 12 instantaneous overcurrent element
209	50P11T	Terminal 11 definite-time overcurrent element timed out
209	50P11	Terminal 11 instantaneous overcurrent element
209	50P10T	Terminal 10 definite-time overcurrent element timed out
209	50P10	Terminal 10 instantaneous overcurrent element
209	50P09T	Terminal 09 definite-time overcurrent element timed out
209	50P09	Terminal 09 instantaneous overcurrent element
210	50P16T	Terminal 16 definite-time overcurrent element timed out
210	50P16	Terminal 16 instantaneous overcurrent element
210	50P15T	Terminal 15 definite-time overcurrent element timed out
210	50P15	Terminal 15 instantaneous overcurrent element
210	50P14T	Terminal 14 definite-time overcurrent element timed out
210	50P14	Terminal 14 instantaneous overcurrent element
210	50P13T	Terminal 13 definite-time overcurrent element timed out
210	50P13	Terminal 13 instantaneous overcurrent element
211	50P20T	Terminal 20 definite-time overcurrent element timed out
211	50P20	Terminal 20 instantaneous overcurrent element
211	50P19T	Terminal 19 definite-time overcurrent element timed out
211	50P19	Terminal 19 instantaneous overcurrent element
211	50P18T	Terminal 18 definite-time overcurrent element timed out
211	50P18	Terminal 18 instantaneous overcurrent element
211	50P17T	Terminal 17 definite-time overcurrent element timed out
211	50P17	Terminal 17 instantaneous overcurrent element
212	*	Reserved
212	*	Reserved
212	*	Reserved
212	*	Reserved
212	*	Reserved
212	*	Reserved
212	50P21T	Terminal 21 definite-time overcurrent element timed out
212	50P21	Terminal 21 instantaneous overcurrent element
Inverse-Time Overcurrent Elements		
213	51S04	Inverse-time Element 04 picked up
213	51T04	Inverse-time Element 04 timed out
213	51S03	Inverse-time Element 03 picked up
213	51T03	Inverse-time Element 03 timed out
213	51S02	Inverse-time Element 02 picked up
213	51T02	Inverse-time Element 02 timed out
213	51S01	Inverse-time Element 01 picked up
213	51T01	Inverse-time Element 01 timed out
214	51S08	Inverse-time Element 08 picked up

Table 11.2 Row List of Relay Word Bits (Sheet 44 of 100)

Row	Name	Bit Description
214	51T08	Inverse-time Element 08 timed out
214	51S07	Inverse-time Element 07 picked up
214	51T07	Inverse-time Element 07 timed out
214	51S06	Inverse-time Element 06 picked up
214	51T06	Inverse-time Element 06 timed out
214	51S05	Inverse-time Element 05 picked up
214	51T05	Inverse-time Element 05 timed out
215	51S12	Inverse-time Element 12 picked up
215	51T12	Inverse-time Element 12 timed out
215	51S11	Inverse-time Element 11 picked up
215	51T11	Inverse-time Element 11 timed out
215	51S10	Inverse-time Element 10 picked up
215	51T10	Inverse-time Element 10 timed out
215	51S09	Inverse-time Element 09 picked up
215	51T09	Inverse-time Element 09 timed out
216	51S16	Inverse-time Element 16 picked up
216	51T16	Inverse-time Element 16 timed out
216	51S15	Inverse-time Element 15 picked up
216	51T15	Inverse-time Element 15 timed out
216	51S14	Inverse-time Element 14 picked up
216	51T14	Inverse-time Element 14 timed out
216	51S13	Inverse-time Element 13 picked up
216	51T13	Inverse-time Element 13 timed out
217	51S20	Inverse-time Element 20 picked up
217	51T20	Inverse-time Element 20 timed out
217	51S19	Inverse-time Element 19 picked up
217	51T19	Inverse-time Element 19 timed out
217	51S18	Inverse-time Element 18 picked up
217	51T18	Inverse-time Element 18 timed out
217	51S17	Inverse-time Element 17 picked up
217	51T17	Inverse-time Element 17 timed out
218	*	Reserved
218	*	Reserved
218	*	Reserved
218	*	Reserved
218	*	Reserved
218	*	Reserved
218	51S21	Inverse-time Element 21 picked up
218	51T21	Inverse-time Element 21 timed out
219	51MM04	Inverse-time Element 04 pickup setting outside of specified limits
219	51TM04	Inverse-time Element 04 time-dial setting outside of specified limits

Table 11.2 Row List of Relay Word Bits (Sheet 45 of 100)

Row	Name	Bit Description
219	51MM03	Inverse-time Element 03 pickup setting outside of specified limits
219	51TM03	Inverse-time Element 03 time-dial setting outside of specified limits
219	51MM02	Inverse-time Element 02 pickup setting outside of specified limits
219	51TM02	Inverse-time Element 02 time-dial setting outside of specified limits
219	51MM01	Inverse-time Element 01 pickup setting outside of specified limits
219	51TM01	Inverse-time Element 01 time-dial setting outside of specified limits
220	51MM08	Inverse-time Element 08 pickup setting outside of specified limits
220	51TM08	Inverse-time Element 08 time-dial setting outside of specified limits
220	51MM07	Inverse-time Element 07 pickup setting outside of specified limits
220	51TM07	Inverse-time Element 07 time-dial setting outside of specified limits
220	51MM06	Inverse-time Element 06 pickup setting outside of specified limits
220	51TM06	Inverse-time Element 06 time-dial setting outside of specified limits
220	51MM05	Inverse-time Element 05 pickup setting outside of specified limits
220	51TM05	Inverse-time Element 05 time-dial setting outside of specified limits
Under- and Overvoltage Elements		
221	271P1	Undervoltage Element 1, Level 1 asserted
221	271P1T	Undervoltage Element 1, Level 1 timed out
221	271P2	Undervoltage Element 1, Level 2 asserted
221	27TC1	Undervoltage Element 1, torque control
221	272P1	Undervoltage Element 2, Level 1 asserted
221	272P1T	Undervoltage Element 2, Level 1 timed out
221	272P2	Undervoltage Element 2, Level 2 asserted
221	27TC2	Undervoltage Element 2, torque control
222	273P1	Undervoltage Element 3, Level 1 asserted
222	273P1T	Undervoltage Element 3, Level 1 timed out
222	273P2	Undervoltage Element 3, Level 2 asserted
222	27TC3	Undervoltage Element 3, torque control
222	274P1	Undervoltage Element 4, Level 1 asserted
222	274P1T	Undervoltage Element 4, Level 1 timed out
222	274P2	Undervoltage Element 4, Level 2 asserted
222	27TC4	Undervoltage Element 4, torque control
223	275P1	Undervoltage Element 5, Level 1 asserted
223	275P1T	Undervoltage Element 5, Level 1 timed out
223	275P2	Undervoltage Element 5, Level 2 asserted
223	27TC5	Undervoltage Element 5, torque control
223	276P1	Undervoltage Element 6, Level 1 asserted
223	276P1T	Undervoltage Element 6, Level 1 timed out
223	276P2	Undervoltage Element 6, Level 2 asserted
223	27TC6	Undervoltage Element 6, torque control
224	591P1	Overvoltage Element 1, Level 1 asserted
224	591P1T	Overvoltage Element 1, Level 1 timed out

Table 11.2 Row List of Relay Word Bits (Sheet 46 of 100)

Row	Name	Bit Description
224	591P2	Overvoltage Element 1, Level 2 asserted
224	59TC1	Overvoltage Element 1, torque control
224	592P1	Overvoltage Element 2, Level 1 asserted
224	592P1T	Overvoltage Element 2, Level 1 timed out
224	592P2	Overvoltage Element 2, Level 2 asserted
224	59TC2	Overvoltage Element 2, torque control
225	593P1	Overvoltage Element 3, Level 1 asserted
225	593P1T	Overvoltage Element 3, Level 1 timed out
225	593P2	Overvoltage Element 3, Level 2 asserted
225	59TC3	Overvoltage Element 3, torque control
225	594P1	Overvoltage Element 4, Level 1 asserted
225	594P1T	Overvoltage Element 4, Level 1 timed out
225	594P2	Overvoltage Element 4, Level 2 asserted
225	59TC4	Overvoltage Element 4, torque control
226	595P1	Overvoltage Element 5, Level 1 asserted
226	595P1T	Overvoltage Element 5, Level 1 timed out
226	595P2	Overvoltage Element 5, Level 2 asserted
226	59TC5	Overvoltage Element 5, torque control
226	596P1	Overvoltage Element 6, Level 1 asserted
226	596P1T	Overvoltage Element 6, Level 1 timed out
226	596P2	Overvoltage Element 6, Level 2 asserted
226	59TC6	Overvoltage Element 6, torque control
Battery Monitor		
227	DC1F	DC monitor fail alarm
227	DC1W	DC monitor warning alarm
227	DC1G	DC monitor ground fault alarm
227	DC1R	DC monitor alarm for ac ripple
227	*	Reserved
227	*	Reserved
227	*	Reserved
227	*	Reserved
Bus-Zone Trip		
228	87BTR08	Terminal 08 bus-zone differential trip asserted
228	87BTR07	Terminal 07 bus-zone differential trip asserted
228	87BTR06	Terminal 06 bus-zone differential trip asserted
228	87BTR05	Terminal 05 bus-zone differential trip asserted
228	87BTR04	Terminal 04 bus-zone differential trip asserted
228	87BTR03	Terminal 03 bus-zone differential trip asserted
228	87BTR02	Terminal 02 bus-zone differential trip asserted
228	87BTR01	Terminal 01 bus-zone differential trip asserted
229	87BTR16	Terminal 16 bus-zone differential trip asserted

Table 11.2 Row List of Relay Word Bits (Sheet 47 of 100)

Row	Name	Bit Description
229	87BTR15	Terminal 15 bus-zone differential trip asserted
229	87BTR14	Terminal 14 bus-zone differential trip asserted
229	87BTR13	Terminal 13 bus-zone differential trip asserted
229	87BTR12	Terminal 12 bus-zone differential trip asserted
229	87BTR11	Terminal 11 bus-zone differential trip asserted
229	87BTR10	Terminal 10 bus-zone differential trip asserted
229	87BTR09	Terminal 09 bus-zone differential trip asserted
230	*	Reserved
230	*	Reserved
230	*	Any terminal bus-zone differential trip asserted
230	87BTR21	Terminal 21 bus-zone differential trip asserted
230	87BTR20	Terminal 20 bus-zone differential trip asserted
230	87BTR19	Terminal 19 bus-zone differential trip asserted
230	87BTR18	Terminal 18 bus-zone differential trip asserted
230	87BTR17	Terminal 17 bus-zone differential trip asserted
231	*	Reserved
231	*	Reserved
231	*	Reserved
231	*	Reserved
231	*	Reserved
231	*	Reserved
231	*	Reserved
231	87BTR	Any terminal bus-zone differential trip asserted
Inverse-Time Overcurrent Elements		
232	51MM12	Inverse-time Element 12 pickup setting outside of specified limits
232	51TM12	Inverse-time Element 12 time-dial setting outside of specified limits
232	51MM11	Inverse-time Element 11 pickup setting outside of specified limits
232	51TM11	Inverse-time Element 11 time-dial setting outside of specified limits
232	51MM10	Inverse-time Element 10 pickup setting outside of specified limits
232	51TM10	Inverse-time Element 10 time-dial setting outside of specified limits
232	51MM09	Inverse-time Element 09 pickup setting outside of specified limits
232	51TM09	Inverse-time Element 09 time-dial setting outside of specified limits
233	51MM16	Inverse-time Element 16 pickup setting outside of specified limits
233	51TM16	Inverse-time Element 16 time-dial setting outside of specified limits
233	51MM15	Inverse-time Element 15 pickup setting outside of specified limits
233	51TM15	Inverse-time Element 15 time-dial setting outside of specified limits
233	51MM14	Inverse-time Element 14 pickup setting outside of specified limits
233	51TM14	Inverse-time Element 14 time-dial setting outside of specified limits
233	51MM13	Inverse-time Element 13 pickup setting outside of specified limits
233	51TM13	Inverse-time Element 13 time-dial setting outside of specified limits
234	51MM20	Inverse-time Element 20 pickup setting outside of specified limits

Table 11.2 Row List of Relay Word Bits (Sheet 48 of 100)

Row	Name	Bit Description
234	51TM20	Inverse-time Element 20 time-dial setting outside of specified limits
234	51MM19	Inverse-time Element 19 pickup setting outside of specified limits
234	51TM19	Inverse-time Element 19 time-dial setting outside of specified limits
234	51MM18	Inverse-time Element 18 pickup setting outside of specified limits
234	51TM18	Inverse-time Element 18 time-dial setting outside of specified limits
234	51MM17	Inverse-time Element 17 pickup setting outside of specified limits
234	51TM17	Inverse-time Element 17 time-dial setting outside of specified limits
Bus-Zone Trip		
235	*	Reserved
235	*	Reserved
235	87Z6	Zone 6 differential element trip
235	87Z5	Zone 5 differential element trip
235	87Z4	Zone 4 differential element trip
235	87Z3	Zone 3 differential element trip
235	87Z2	Zone 2 differential element trip
235	87Z1	Zone 1 differential element trip
Breaker Failure Trip		
236	SBFTR08	Circuit Breaker 08 breaker failure trip
236	SBFTR07	Circuit Breaker 07 breaker failure trip
236	SBFTR06	Circuit Breaker 06 breaker failure trip
236	SBFTR05	Circuit Breaker 05 breaker failure trip
236	SBFTR04	Circuit Breaker 04 breaker failure trip
236	SBFTR03	Circuit Breaker 03 breaker failure trip
236	SBFTR02	Circuit Breaker 02 breaker failure trip
236	SBFTR01	Circuit Breaker 01 breaker failure trip
237	SBFTR16	Circuit Breaker 16 breaker failure trip
237	SBFTR15	Circuit Breaker 15 breaker failure trip
237	SBFTR14	Circuit Breaker 14 breaker failure trip
237	SBFTR13	Circuit Breaker 13 breaker failure trip
237	SBFTR12	Circuit Breaker 12 breaker failure trip
237	SBFTR11	Circuit Breaker 11 breaker failure trip
237	SBFTR10	Circuit Breaker 10 breaker failure trip
237	SBFTR09	Circuit Breaker 09 breaker failure trip
238	*	Reserved
238	*	Reserved
238	*	Reserved
238	SBFTR21	Circuit Breaker 21 breaker failure trip
238	SBFTR20	Circuit Breaker 20 breaker failure trip
238	SBFTR19	Circuit Breaker 19 breaker failure trip
238	SBFTR18	Circuit Breaker 18 breaker failure trip
238	SBFTR17	Circuit Breaker 17 breaker failure trip

Table 11.2 Row List of Relay Word Bits (Sheet 49 of 100)

Row	Name	Bit Description
239	*	Reserved
239	*	Reserved
239	*	Reserved
239	*	Reserved
239	*	Reserved
239	*	Reserved
239	*	Reserved
239	SBFTR	Any circuit breaker failure trip
240	*	Reserved
240	*	Reserved
240	BFZ6	Zone 6 breaker failure
240	BFZ5	Zone 5 breaker failure
240	BFZ4	Zone 4 breaker failure
240	BFZ3	Zone 3 breaker failure
240	BFZ2	Zone 2 breaker failure
240	BFZ1	Zone 1 breaker failure
Miscellaneous Logic Elements		
241	ER	Event report trigger equation (SELOGIC control equation)
241	EVELOCK	Event summary lock period
241	*	Reserved
241	*	Reserved
241	*	Reserved
241	*	Reserved
241	*	Reserved
241	*	Reserved
Trip and Unlatch		
242	TRIP08	Terminal 08 trip output
242	TRIP07	Terminal 07 trip output
242	TRIP06	Terminal 06 trip output
242	TRIP05	Terminal 05 trip output
242	TRIP04	Terminal 04 trip output
242	TRIP03	Terminal 03 trip output
242	TRIP02	Terminal 02 trip output
242	TRIP01	Terminal 01 trip output
243	TRIP16	Terminal 16 trip output
243	TRIP15	Terminal 15 trip output
243	TRIP14	Terminal 14 trip output
243	TRIP13	Terminal 13 trip output
243	TRIP12	Terminal 12 trip output
243	TRIP11	Terminal 11 trip output
243	TRIP10	Terminal 10 trip output

Table 11.2 Row List of Relay Word Bits (Sheet 50 of 100)

Row	Name	Bit Description
243	TRIP09	Terminal 09 trip output
244	*	Reserved
244	*	Reserved
244	*	Reserved
244	TRIP21	Terminal 21 trip output
244	TRIP20	Terminal 20 trip output
244	TRIP19	Terminal 19 trip output
244	TRIP18	Terminal 18 trip output
244	TRIP17	Terminal 17 trip output
245	*	Reserved
245	*	Reserved
245	*	Reserved
245	*	Reserved
245	*	Reserved
245	*	Reserved
245	*	Reserved
245	TRIP	Any terminal trip output
246	ULTR08	Terminal 08 unlatch trip
246	ULTR07	Terminal 07 unlatch trip
246	ULTR06	Terminal 06 unlatch trip
246	ULTR05	Terminal 05 unlatch trip
246	ULTR04	Terminal 04 unlatch trip
246	ULTR03	Terminal 03 unlatch trip
246	ULTR02	Terminal 02 unlatch trip
246	ULTR01	Terminal 01 unlatch trip
247	ULTR16	Terminal 16 unlatch trip
247	ULTR15	Terminal 15 unlatch trip
247	ULTR14	Terminal 14 unlatch trip
247	ULTR13	Terminal 13 unlatch trip
247	ULTR12	Terminal 12 unlatch trip
247	ULTR11	Terminal 11 unlatch trip
247	ULTR10	Terminal 10 unlatch trip
247	ULTR09	Terminal 09 unlatch trip
248	*	Reserved
248	*	Reserved
248	*	Reserved
248	ULTR21	Terminal 21 unlatch trip
248	ULTR20	Terminal 20 unlatch trip
248	ULTR19	Terminal 19 unlatch trip
248	ULTR18	Terminal 18 unlatch trip
248	ULTR17	Terminal 17 unlatch trip

Table 11.2 Row List of Relay Word Bits (Sheet 51 of 100)

Row	Name	Bit Description
Breaker Open Controls		
249	OC08	Circuit Breaker 08 open command
249	OC07	Circuit Breaker 07 open command
249	OC06	Circuit Breaker 06 open command
249	OC05	Circuit Breaker 05 open command
249	OC04	Circuit Breaker 04 open command
249	OC03	Circuit Breaker 03 open command
249	OC02	Circuit Breaker 02 open command
249	OC01	Circuit Breaker 01 open command
250	OC16	Circuit Breaker 16 open command
250	OC15	Circuit Breaker 15 open command
250	OC14	Circuit Breaker 14 open command
250	OC13	Circuit Breaker 13 open command
250	OC12	Circuit Breaker 12 open command
250	OC11	Circuit Breaker 11 open command
250	OC10	Circuit Breaker 10 open command
250	OC09	Circuit Breaker 09 open command
251	*	Reserved
251	*	Reserved
251	*	Reserved
251	OC21	Circuit Breaker 21 open command
251	OC20	Circuit Breaker 20 open command
251	OC19	Circuit Breaker 19 open command
251	OC18	Circuit Breaker 18 open command
251	OC17	Circuit Breaker 17 open command
Inverse-Time Overcurrent Elements		
252	*	Reserved
252	*	Reserved
252	*	Reserved
252	*	Reserved
252	*	Reserved
252	*	Reserved
252	51MM21	Inverse-time Element 21 pickup setting outside of specified limits
252	51TM21	Inverse-time Element 21 time-dial setting outside of specified limits
253	51R16	Inverse-time Element 16 reset
253	51R15	Inverse-time Element 15 reset
253	51R14	Inverse-time Element 14 reset
253	51R13	Inverse-time Element 13 reset
253	51R12	Inverse-time Element 12 reset
253	51R11	Inverse-time Element 11 reset
253	51R10	Inverse-time Element 10 reset

Table 11.2 Row List of Relay Word Bits (Sheet 52 of 100)

Row	Name	Bit Description
253	51R09	Inverse-time Element 09 reset
254	51R08	Inverse-time Element 08 reset
254	51R07	Inverse-time Element 07 reset
254	51R06	Inverse-time Element 06 reset
254	51R05	Inverse-time Element 05 reset
254	51R04	Inverse-time Element 04 reset
254	51R03	Inverse-time Element 03 reset
254	51R02	Inverse-time Element 02 reset
254	51R01	Inverse-time Element 01 reset
Setting Group Bits		
255	SG6	Settings Group 6 active
255	SG5	Settings Group 5 active
255	SG4	Settings Group 4 active
255	SG3	Settings Group 3 active
255	SG2	Settings Group 2 active
255	SG1	Settings Group 1 active
255	CHSG	Asserted during settings group change
255	*	Reserved
Local Bits		
256	LB08	Local Bit 08
256	LB07	Local Bit 07
256	LB06	Local Bit 06
256	LB05	Local Bit 05
256	LB04	Local Bit 04
256	LB03	Local Bit 03
256	LB02	Local Bit 02
256	LB01	Local Bit 01
257	LB16	Local Bit 16
257	LB15	Local Bit 15
257	LB14	Local Bit 14
257	LB13	Local Bit 13
257	LB12	Local Bit 12
257	LB11	Local Bit 11
257	LB10	Local Bit 10
257	LB09	Local Bit 09
258	LB24	Local Bit 24
258	LB23	Local Bit 23
258	LB22	Local Bit 22
258	LB21	Local Bit 21
258	LB20	Local Bit 20
258	LB19	Local Bit 19

Table 11.2 Row List of Relay Word Bits (Sheet 53 of 100)

Row	Name	Bit Description
258	LB18	Local Bit 18
258	LB17	Local Bit 17
259	LB32	Local Bit 32
259	LB31	Local Bit 31
259	LB30	Local Bit 30
259	LB29	Local Bit 29
259	LB28	Local Bit 28
259	LB27	Local Bit 27
259	LB26	Local Bit 26
259	LB25	Local Bit 25
Remote Bits		
260	RB89	Remote Bit 89
260	RB90	Remote Bit 90
260	RB91	Remote Bit 91
260	RB92	Remote Bit 92
260	RB93	Remote Bit 93
260	RB94	Remote Bit 94
260	RB95	Remote Bit 95
260	RB96	Remote Bit 96
261	RB81	Remote Bit 81
261	RB82	Remote Bit 82
261	RB83	Remote Bit 83
261	RB84	Remote Bit 84
261	RB85	Remote Bit 85
261	RB86	Remote Bit 86
261	RB87	Remote Bit 87
261	RB88	Remote Bit 88
262	RB73	Remote Bit 73
262	RB74	Remote Bit 74
262	RB75	Remote Bit 75
262	RB76	Remote Bit 76
262	RB77	Remote Bit 77
262	RB78	Remote Bit 78
262	RB79	Remote Bit 79
262	RB80	Remote Bit 80
263	RB65	Remote Bit 65
263	RB66	Remote Bit 66
263	RB67	Remote Bit 67
263	RB68	Remote Bit 68
263	RB69	Remote Bit 69
263	RB70	Remote Bit 70

Table 11.2 Row List of Relay Word Bits (Sheet 54 of 100)

Row	Name	Bit Description
263	RB71	Remote Bit 71
263	RB72	Remote Bit 72
264	RB57	Remote Bit 57
264	RB58	Remote Bit 58
264	RB59	Remote Bit 59
264	RB60	Remote Bit 60
264	RB61	Remote Bit 61
264	RB62	Remote Bit 62
264	RB63	Remote Bit 63
264	RB64	Remote Bit 64
265	RB49	Remote Bit 49
265	RB50	Remote Bit 50
265	RB51	Remote Bit 51
265	RB52	Remote Bit 52
265	RB53	Remote Bit 53
265	RB54	Remote Bit 54
265	RB55	Remote Bit 55
265	RB56	Remote Bit 56
266	RB41	Remote Bit 41
266	RB42	Remote Bit 42
266	RB43	Remote Bit 43
266	RB44	Remote Bit 44
266	RB45	Remote Bit 45
266	RB46	Remote Bit 46
266	RB47	Remote Bit 47
266	RB48	Remote Bit 48
267	RB33	Remote Bit 33
267	RB34	Remote Bit 34
267	RB35	Remote Bit 35
267	RB36	Remote Bit 36
267	RB37	Remote Bit 37
267	RB38	Remote Bit 38
267	RB39	Remote Bit 39
267	RB40	Remote Bit 40
268	RB25	Remote Bit 25
268	RB26	Remote Bit 26
268	RB27	Remote Bit 27
268	RB28	Remote Bit 28
268	RB29	Remote Bit 29
268	RB30	Remote Bit 30
268	RB31	Remote Bit 31

Table 11.2 Row List of Relay Word Bits (Sheet 55 of 100)

Row	Name	Bit Description
268	RB32	Remote Bit 32
269	RB17	Remote Bit 17
269	RB18	Remote Bit 18
269	RB19	Remote Bit 19
269	RB20	Remote Bit 20
269	RB21	Remote Bit 21
269	RB22	Remote Bit 22
269	RB23	Remote Bit 23
269	RB24	Remote Bit 24
270	RB09	Remote Bit 09
270	RB10	Remote Bit 10
270	RB11	Remote Bit 11
270	RB12	Remote Bit 12
270	RB13	Remote Bit 13
270	RB14	Remote Bit 14
270	RB15	Remote Bit 15
270	RB16	Remote Bit 16
271	RB01	Remote Bit 01
271	RB02	Remote Bit 02
271	RB03	Remote Bit 03
271	RB04	Remote Bit 04
271	RB05	Remote Bit 05
271	RB06	Remote Bit 06
271	RB07	Remote Bit 07
271	RB08	Remote Bit 08
Contact Inputs		
272	*	Reserved
272	IN107	Main board Input 07
272	IN106	Main board Input 06
272	IN105	Main board Input 05
272	IN104	Main board Input 04
272	IN103	Main board Input 03
272	IN102	Main board Input 02
272	IN101	Main board Input 01
273	*	Reserved
273	*	Reserved
273	*	Reserved
273	*	Reserved
273	*	Reserved
273	*	Reserved
273	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 56 of 100)

Row	Name	Bit Description
273	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
274	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
275	*	Reserved
276	IN208	Optional I/O Board 1 Input 08
276	IN207	Optional I/O Board 1 Input 07
276	IN206	Optional I/O Board 1 Input 06
276	IN205	Optional I/O Board 1 Input 05
276	IN204	Optional I/O Board 1 Input 04
276	IN203	Optional I/O Board 1 Input 03
276	IN202	Optional I/O Board 1 Input 02
276	IN201	Optional I/O Board 1 Input 01
277	IN216	Optional I/O Board 1 Input 16
277	IN215	Optional I/O Board 1 Input 15
277	IN214	Optional I/O Board 1 Input 14
277	IN213	Optional I/O Board 1 Input 13
277	IN212	Optional I/O Board 1 Input 12
277	IN211	Optional I/O Board 1 Input 11
277	IN210	Optional I/O Board 1 Input 10
277	IN209	Optional I/O Board 1 Input 09
278	IN224	Optional I/O Board 1 Input 24
278	IN223	Optional I/O Board 1 Input 23
278	IN222	Optional I/O Board 1 Input 22
278	IN221	Optional I/O Board 1 Input 21
278	IN220	Optional I/O Board 1 Input 20
278	IN219	Optional I/O Board 1 Input 19
278	IN218	Optional I/O Board 1 Input 18
278	IN217	Optional I/O Board 1 Input 17

Table 11.2 Row List of Relay Word Bits (Sheet 57 of 100)

Row	Name	Bit Description
279	*	Reserved
279	*	Reserved
279	*	Reserved
279	*	Reserved
279	*	Reserved
279	*	Reserved
279	*	Reserved
279	*	Reserved
280	IN308	Optional I/O Board 2 input 08
280	IN307	Optional I/O Board 2 input 07
280	IN306	Optional I/O Board 2 input 06
280	IN305	Optional I/O Board 2 input 05
280	IN304	Optional I/O Board 2 input 04
280	IN303	Optional I/O Board 2 input 03
280	IN302	Optional I/O Board 2 input 02
280	IN301	Optional I/O Board 2 input 01
281	IN316	Optional I/O Board 2 input 16
281	IN315	Optional I/O Board 2 input 15
281	IN314	Optional I/O Board 2 input 14
281	IN313	Optional I/O Board 2 input 13
281	IN312	Optional I/O Board 2 input 12
281	IN311	Optional I/O Board 2 input 11
281	IN310	Optional I/O Board 2 input 10
281	IN309	Optional I/O Board 2 input 09
282	IN324	Optional I/O Board 2 input 24
282	IN323	Optional I/O Board 2 input 23
282	IN322	Optional I/O Board 2 input 22
282	IN321	Optional I/O Board 2 input 21
282	IN320	Optional I/O Board 2 input 20
282	IN319	Optional I/O Board 2 input 19
282	IN318	Optional I/O Board 2 input 18
282	IN317	Optional I/O Board 2 input 17
283	*	Reserved
283	*	Reserved
283	*	Reserved
283	*	Reserved
283	*	Reserved
283	*	Reserved
283	*	Reserved
283	*	Reserved
284	IN408	Optional I/O Board 3 input 08

Table 11.2 Row List of Relay Word Bits (Sheet 58 of 100)

Row	Name	Bit Description
284	IN407	Optional I/O Board 3 input 07
284	IN406	Optional I/O Board 3 input 06
284	IN405	Optional I/O Board 3 input 05
284	IN404	Optional I/O Board 3 input 04
284	IN403	Optional I/O Board 3 input 03
284	IN402	Optional I/O Board 3 input 02
284	IN401	Optional I/O Board 3 input 01
285	IN416	Optional I/O Board 3 input 16
285	IN415	Optional I/O Board 3 input 15
285	IN414	Optional I/O Board 3 input 14
285	IN413	Optional I/O Board 3 input 13
285	IN412	Optional I/O Board 3 input 12
285	IN411	Optional I/O Board 3 input 11
285	IN410	Optional I/O Board 3 input 10
285	IN409	Optional I/O Board 3 input 09
286	IN424	Optional I/O Board 3 input 24
286	IN423	Optional I/O Board 3 input 23
286	IN422	Optional I/O Board 3 input 22
286	IN421	Optional I/O Board 3 input 21
286	IN420	Optional I/O Board 3 input 20
286	IN419	Optional I/O Board 3 input 19
286	IN418	Optional I/O Board 3 input 18
286	IN417	Optional I/O Board 3 input 17
287	*	Reserved
287	*	Reserved
287	*	Reserved
287	*	Reserved
287	*	Reserved
287	*	Reserved
287	*	Reserved
287	*	Reserved
288	IN508	Optional I/O Board 4 input 08
288	IN507	Optional I/O Board 4 input 07
288	IN506	Optional I/O Board 4 input 06
288	IN505	Optional I/O Board 4 input 05
288	IN504	Optional I/O Board 4 input 04
288	IN503	Optional I/O Board 4 input 03
288	IN502	Optional I/O Board 4 input 02
288	IN501	Optional I/O Board 4 input 01
289	IN516	Optional I/O Board 4 input 16
289	IN515	Optional I/O Board 4 input 15

Table 11.2 Row List of Relay Word Bits (Sheet 59 of 100)

Row	Name	Bit Description
289	IN514	Optional I/O Board 4 input 14
289	IN513	Optional I/O Board 4 input 13
289	IN512	Optional I/O Board 4 input 12
289	IN511	Optional I/O Board 4 input 11
289	IN510	Optional I/O Board 4 input 10
289	IN509	Optional I/O Board 4 input 09
290	IN524	Optional I/O Board 4 input 24
290	IN523	Optional I/O Board 4 input 23
290	IN522	Optional I/O Board 4 input 22
290	IN521	Optional I/O Board 4 input 21
290	IN520	Optional I/O Board 4 input 20
290	IN519	Optional I/O Board 4 input 19
290	IN518	Optional I/O Board 4 input 18
290	IN517	Optional I/O Board 4 input 17
291	*	Reserved
291	*	Reserved
291	*	Reserved
291	*	Reserved
291	*	Reserved
291	*	Reserved
291	*	Reserved
291	*	Reserved
Protection SELOGIC Variables		
292	PSV08	Protection SELOGIC control equation Variable 08
292	PSV07	Protection SELOGIC control equation Variable 07
292	PSV06	Protection SELOGIC control equation Variable 06
292	PSV05	Protection SELOGIC control equation Variable 05
292	PSV04	Protection SELOGIC control equation Variable 04
292	PSV03	Protection SELOGIC control equation Variable 03
292	PSV02	Protection SELOGIC control equation Variable 02
292	PSV01	Protection SELOGIC control equation Variable 01
293	PSV16	Protection SELOGIC control equation Variable 16
293	PSV15	Protection SELOGIC control equation Variable 15
293	PSV14	Protection SELOGIC control equation Variable 14
293	PSV13	Protection SELOGIC control equation Variable 13
293	PSV12	Protection SELOGIC control equation Variable 12
293	PSV11	Protection SELOGIC control equation Variable 11
293	PSV10	Protection SELOGIC control equation Variable 10
293	PSV09	Protection SELOGIC control equation Variable 09
294	PSV24	Protection SELOGIC control equation Variable 24
294	PSV23	Protection SELOGIC control equation Variable 23

Table 11.2 Row List of Relay Word Bits (Sheet 60 of 100)

Row	Name	Bit Description
294	PSV22	Protection SELOGIC control equation Variable 22
294	PSV21	Protection SELOGIC control equation Variable 21
294	PSV20	Protection SELOGIC control equation Variable 20
294	PSV19	Protection SELOGIC control equation Variable 19
294	PSV18	Protection SELOGIC control equation Variable 18
294	PSV17	Protection SELOGIC control equation Variable 17
295	PSV32	Protection SELOGIC control equation Variable 32
295	PSV31	Protection SELOGIC control equation Variable 31
295	PSV30	Protection SELOGIC control equation Variable 30
295	PSV29	Protection SELOGIC control equation Variable 29
295	PSV28	Protection SELOGIC control equation Variable 28
295	PSV27	Protection SELOGIC control equation Variable 27
295	PSV26	Protection SELOGIC control equation Variable 26
295	PSV25	Protection SELOGIC control equation Variable 25
296	PSV40	Protection SELOGIC control equation Variable 40
296	PSV39	Protection SELOGIC control equation Variable 39
296	PSV38	Protection SELOGIC control equation Variable 38
296	PSV37	Protection SELOGIC control equation Variable 37
296	PSV36	Protection SELOGIC control equation Variable 36
296	PSV35	Protection SELOGIC control equation Variable 35
296	PSV34	Protection SELOGIC control equation Variable 34
296	PSV33	Protection SELOGIC control equation Variable 33
297	PSV48	Protection SELOGIC control equation Variable 48
297	PSV47	Protection SELOGIC control equation Variable 47
297	PSV46	Protection SELOGIC control equation Variable 46
297	PSV45	Protection SELOGIC control equation Variable 45
297	PSV44	Protection SELOGIC control equation Variable 44
297	PSV43	Protection SELOGIC control equation Variable 43
297	PSV42	Protection SELOGIC control equation Variable 42
297	PSV41	Protection SELOGIC control equation Variable 41
298	PSV56	Protection SELOGIC control equation Variable 56
298	PSV55	Protection SELOGIC control equation Variable 55
298	PSV54	Protection SELOGIC control equation Variable 54
298	PSV53	Protection SELOGIC control equation Variable 53
298	PSV52	Protection SELOGIC control equation Variable 52
298	PSV51	Protection SELOGIC control equation Variable 51
298	PSV50	Protection SELOGIC control equation Variable 50
298	PSV49	Protection SELOGIC control equation Variable 49
299	PSV64	Protection SELOGIC control equation Variable 64
299	PSV63	Protection SELOGIC control equation Variable 63
299	PSV62	Protection SELOGIC control equation Variable 62

Table 11.2 Row List of Relay Word Bits (Sheet 61 of 100)

Row	Name	Bit Description
299	PSV61	Protection SELOGIC control equation Variable 61
299	PSV60	Protection SELOGIC control equation Variable 60
299	PSV59	Protection SELOGIC control equation Variable 59
299	PSV58	Protection SELOGIC control equation Variable 58
299	PSV57	Protection SELOGIC control equation Variable 57
Protection SELOGIC Latches		
300	PLT08	Protection Latch 08
300	PLT07	Protection Latch 07
300	PLT06	Protection Latch 06
300	PLT05	Protection Latch 05
300	PLT04	Protection Latch 04
300	PLT03	Protection Latch 03
300	PLT02	Protection Latch 02
300	PLT01	Protection Latch 01
301	PLT16	Protection Latch 16
301	PLT15	Protection Latch 15
301	PLT14	Protection Latch 14
301	PLT13	Protection Latch 13
301	PLT12	Protection Latch 12
301	PLT11	Protection Latch 11
301	PLT10	Protection Latch 10
301	PLT09	Protection Latch 09
302	PLT24	Protection Latch 24
302	PLT23	Protection Latch 23
302	PLT22	Protection Latch 22
302	PLT21	Protection Latch 21
302	PLT20	Protection Latch 20
302	PLT19	Protection Latch 19
302	PLT18	Protection Latch 18
302	PLT17	Protection Latch 17
303	PLT32	Protection Latch 32
303	PLT31	Protection Latch 31
303	PLT30	Protection Latch 30
303	PLT29	Protection Latch 29
303	PLT28	Protection Latch 28
303	PLT27	Protection Latch 27
303	PLT26	Protection Latch 26
303	PLT25	Protection Latch 25
Protection SELOGIC Conditioning Timers		
304	PCT08Q	Protection conditioning timer Output 08
304	PCT07Q	Protection conditioning timer Output 07

Table 11.2 Row List of Relay Word Bits (Sheet 62 of 100)

Row	Name	Bit Description
304	PCT06Q	Protection conditioning timer Output 06
304	PCT05Q	Protection conditioning timer Output 05
304	PCT04Q	Protection conditioning timer Output 04
304	PCT03Q	Protection conditioning timer Output 03
304	PCT02Q	Protection conditioning timer Output 02
304	PCT01Q	Protection conditioning timer Output 01
305	PCT16Q	Protection conditioning timer Output 16
305	PCT15Q	Protection conditioning timer Output 15
305	PCT14Q	Protection conditioning timer Output 14
305	PCT13Q	Protection conditioning timer Output 13
305	PCT12Q	Protection conditioning timer Output 12
305	PCT11Q	Protection conditioning timer Output 11
305	PCT10Q	Protection conditioning timer Output 10
305	PCT09Q	Protection conditioning timer Output 09
Protection SELogic Sequencing Timers		
306	PST08Q	Protection sequencing timer Output 08
306	PST07Q	Protection sequencing timer Output 07
306	PST06Q	Protection sequencing timer Output 06
306	PST05Q	Protection sequencing timer Output 05
306	PST04Q	Protection sequencing timer Output 04
306	PST03Q	Protection sequencing timer Output 03
306	PST02Q	Protection sequencing timer Output 02
306	PST01Q	Protection sequencing timer Output 01
307	PST16Q	Protection sequencing timer Output 16
307	PST15Q	Protection sequencing timer Output 15
307	PST14Q	Protection sequencing timer Output 14
307	PST13Q	Protection sequencing timer Output 13
307	PST12Q	Protection sequencing timer Output 12
307	PST11Q	Protection sequencing timer Output 11
307	PST10Q	Protection sequencing timer Output 10
307	PST09Q	Protection sequencing timer Output 09
308	PST24Q	Protection sequencing timer Output 24
308	PST23Q	Protection sequencing timer Output 23
308	PST22Q	Protection sequencing timer Output 22
308	PST21Q	Protection sequencing timer Output 21
308	PST20Q	Protection sequencing timer Output 20
308	PST19Q	Protection sequencing timer Output 19
308	PST18Q	Protection sequencing timer Output 18
308	PST17Q	Protection sequencing timer Output 17
309	PST32Q	Protection sequencing timer Output 32
309	PST31Q	Protection sequencing timer Output 31

Table 11.2 Row List of Relay Word Bits (Sheet 63 of 100)

Row	Name	Bit Description
309	PST30Q	Protection sequencing timer Output 30
309	PST29Q	Protection sequencing timer Output 29
309	PST28Q	Protection sequencing timer Output 28
309	PST27Q	Protection sequencing timer Output 27
309	PST26Q	Protection sequencing timer Output 26
309	PST25Q	Protection sequencing timer Output 25
310	PST08R	Protection sequencing timer Reset 08
310	PST07R	Protection sequencing timer Reset 07
310	PST06R	Protection sequencing timer Reset 06
310	PST05R	Protection sequencing timer Reset 05
310	PST04R	Protection sequencing timer Reset 04
310	PST03R	Protection sequencing timer Reset 03
310	PST02R	Protection sequencing timer Reset 02
310	PST01R	Protection sequencing timer Reset 01
311	PST16R	Protection sequencing timer Reset 16
311	PST15R	Protection sequencing timer Reset 15
311	PST14R	Protection sequencing timer Reset 14
311	PST13R	Protection sequencing timer Reset 13
311	PST12R	Protection sequencing timer Reset 12
311	PST11R	Protection sequencing timer Reset 11
311	PST10R	Protection sequencing timer Reset 10
311	PST09R	Protection sequencing timer Reset 09
312	PST24R	Protection sequencing timer Reset 24
312	PST23R	Protection sequencing timer Reset 23
312	PST22R	Protection sequencing timer Reset 22
312	PST21R	Protection sequencing timer Reset 21
312	PST20R	Protection sequencing timer Reset 20
312	PST19R	Protection sequencing timer Reset 19
312	PST18R	Protection sequencing timer Reset 18
312	PST17R	Protection sequencing timer Reset 17
313	PST32R	Protection sequencing timer Reset 32
313	PST31R	Protection sequencing timer Reset 31
313	PST30R	Protection sequencing timer Reset 30
313	PST29R	Protection sequencing timer Reset 29
313	PST28R	Protection sequencing timer Reset 28
313	PST27R	Protection sequencing timer Reset 27
313	PST26R	Protection sequencing timer Reset 26
313	PST25R	Protection sequencing timer Reset 25
Protection SELogic Counters		
314	PCN08Q	Protection counter Output 08
314	PCN07Q	Protection counter Output 07

Table 11.2 Row List of Relay Word Bits (Sheet 64 of 100)

Row	Name	Bit Description
314	PCN06Q	Protection counter Output 06
314	PCN05Q	Protection counter Output 05
314	PCN04Q	Protection counter Output 04
314	PCN03Q	Protection counter Output 03
314	PCN02Q	Protection counter Output 02
314	PCN01Q	Protection counter Output 01
315	PCN16Q	Protection counter Output 16
315	PCN15Q	Protection counter Output 15
315	PCN14Q	Protection counter Output 14
315	PCN13Q	Protection counter Output 13
315	PCN12Q	Protection counter Output 12
315	PCN11Q	Protection counter Output 11
315	PCN10Q	Protection counter Output 10
315	PCN09Q	Protection counter Output 09
316	PCN24Q	Protection counter Output 24
316	PCN23Q	Protection counter Output 23
316	PCN22Q	Protection counter Output 22
316	PCN21Q	Protection counter Output 21
316	PCN20Q	Protection counter Output 20
316	PCN19Q	Protection counter Output 19
316	PCN18Q	Protection counter Output 18
316	PCN17Q	Protection counter Output 17
317	PCN32Q	Protection counter Output 32
317	PCN31Q	Protection counter Output 31
317	PCN30Q	Protection counter Output 30
317	PCN29Q	Protection counter Output 29
317	PCN28Q	Protection counter Output 28
317	PCN27Q	Protection counter Output 27
317	PCN26Q	Protection counter Output 26
317	PCN25Q	Protection counter Output 25
318	PCN08R	Protection counter reset 08
318	PCN07R	Protection counter reset 07
318	PCN06R	Protection counter reset 06
318	PCN05R	Protection counter reset 05
318	PCN04R	Protection counter reset 04
318	PCN03R	Protection counter reset 03
318	PCN02R	Protection counter reset 02
318	PCN01R	Protection counter reset 01
319	PCN16R	Protection counter reset 16
319	PCN15R	Protection counter reset 15
319	PCN14R	Protection counter reset 14

Table 11.2 Row List of Relay Word Bits (Sheet 65 of 100)

Row	Name	Bit Description
319	PCN13R	Protection counter reset 13
319	PCN12R	Protection counter reset 12
319	PCN11R	Protection counter reset 11
319	PCN10R	Protection counter reset 10
319	PCN09R	Protection counter reset 09
320	PCN24R	Protection counter reset 24
320	PCN23R	Protection counter reset 23
320	PCN22R	Protection counter reset 22
320	PCN21R	Protection counter reset 21
320	PCN20R	Protection counter reset 20
320	PCN19R	Protection counter reset 19
320	PCN18R	Protection counter reset 18
320	PCN17R	Protection counter reset 17
321	PCN32R	Protection counter reset 32
321	PCN31R	Protection counter reset 31
321	PCN30R	Protection counter reset 30
321	PCN29R	Protection counter reset 29
321	PCN28R	Protection counter reset 28
321	PCN27R	Protection counter reset 27
321	PCN26R	Protection counter reset 26
321	PCN25R	Protection counter reset 25
Automation SELOGIC Variables		
322	ASV008	Automation SELOGIC control equation Variable 8
322	ASV007	Automation SELOGIC control equation Variable 7
322	ASV006	Automation SELOGIC control equation Variable 6
322	ASV005	Automation SELOGIC control equation Variable 5
322	ASV004	Automation SELOGIC control equation Variable 4
322	ASV003	Automation SELOGIC control equation Variable 3
322	ASV002	Automation SELOGIC control equation Variable 2
322	ASV001	Automation SELOGIC control equation Variable 1
323	ASV016	Automation SELOGIC control equation Variable 16
323	ASV015	Automation SELOGIC control equation Variable 15
323	ASV014	Automation SELOGIC control equation Variable 14
323	ASV013	Automation SELOGIC control equation Variable 13
323	ASV012	Automation SELOGIC control equation Variable 12
323	ASV011	Automation SELOGIC control equation Variable 11
323	ASV010	Automation SELOGIC control equation Variable 10
323	ASV009	Automation SELOGIC control equation Variable 09
324	ASV024	Automation SELOGIC control equation Variable 24
324	ASV023	Automation SELOGIC control equation Variable 23
324	ASV022	Automation SELOGIC control equation Variable 22

Table 11.2 Row List of Relay Word Bits (Sheet 66 of 100)

Row	Name	Bit Description
324	ASV021	Automation SELOGIC control equation Variable 21
324	ASV020	Automation SELOGIC control equation Variable 20
324	ASV019	Automation SELOGIC control equation Variable 19
324	ASV018	Automation SELOGIC control equation Variable 18
324	ASV017	Automation SELOGIC control equation Variable 17
325	ASV032	Automation SELOGIC control equation Variable 32
325	ASV031	Automation SELOGIC control equation Variable 31
325	ASV030	Automation SELOGIC control equation Variable 30
325	ASV029	Automation SELOGIC control equation Variable 29
325	ASV028	Automation SELOGIC control equation Variable 28
325	ASV027	Automation SELOGIC control equation Variable 27
325	ASV026	Automation SELOGIC control equation Variable 26
325	ASV025	Automation SELOGIC control equation Variable 25
326	ASV040	Automation SELOGIC control equation Variable 40
326	ASV039	Automation SELOGIC control equation Variable 39
326	ASV038	Automation SELOGIC control equation Variable 38
326	ASV037	Automation SELOGIC control equation Variable 37
326	ASV036	Automation SELOGIC control equation Variable 36
326	ASV035	Automation SELOGIC control equation Variable 35
326	ASV034	Automation SELOGIC control equation Variable 34
326	ASV033	Automation SELOGIC control equation Variable 33
327	ASV048	Automation SELOGIC control equation Variable 48
327	ASV047	Automation SELOGIC control equation Variable 47
327	ASV046	Automation SELOGIC control equation Variable 46
327	ASV045	Automation SELOGIC control equation Variable 45
327	ASV044	Automation SELOGIC control equation Variable 44
327	ASV043	Automation SELOGIC control equation Variable 43
327	ASV042	Automation SELOGIC control equation Variable 42
327	ASV041	Automation SELOGIC control equation Variable 41
328	ASV056	Automation SELOGIC control equation Variable 56
328	ASV055	Automation SELOGIC control equation Variable 55
328	ASV054	Automation SELOGIC control equation Variable 54
328	ASV053	Automation SELOGIC control equation Variable 53
328	ASV052	Automation SELOGIC control equation Variable 52
328	ASV051	Automation SELOGIC control equation Variable 51
328	ASV050	Automation SELOGIC control equation Variable 50
328	ASV049	Automation SELOGIC control equation Variable 49
329	ASV064	Automation SELOGIC control equation Variable 64
329	ASV063	Automation SELOGIC control equation Variable 63
329	ASV062	Automation SELOGIC control equation Variable 62
329	ASV061	Automation SELOGIC control equation Variable 61

Table 11.2 Row List of Relay Word Bits (Sheet 67 of 100)

Row	Name	Bit Description
329	ASV060	Automation SELOGIC control equation Variable 60
329	ASV059	Automation SELOGIC control equation Variable 59
329	ASV058	Automation SELOGIC control equation Variable 58
329	ASV057	Automation SELOGIC control equation Variable 57
330	ASV072	Automation SELOGIC control equation Variable 72
330	ASV071	Automation SELOGIC control equation Variable 71
330	ASV070	Automation SELOGIC control equation Variable 70
330	ASV069	Automation SELOGIC control equation Variable 69
330	ASV068	Automation SELOGIC control equation Variable 68
330	ASV067	Automation SELOGIC control equation Variable 67
330	ASV066	Automation SELOGIC control equation Variable 66
330	ASV065	Automation SELOGIC control equation Variable 65
331	ASV080	Automation SELOGIC control equation Variable 80
331	ASV079	Automation SELOGIC control equation Variable 79
331	ASV078	Automation SELOGIC control equation Variable 78
331	ASV077	Automation SELOGIC control equation Variable 77
331	ASV076	Automation SELOGIC control equation Variable 76
331	ASV075	Automation SELOGIC control equation Variable 75
331	ASV074	Automation SELOGIC control equation Variable 74
331	ASV073	Automation SELOGIC control equation Variable 73
332	ASV088	Automation SELOGIC control equation Variable 88
332	ASV087	Automation SELOGIC control equation Variable 87
332	ASV086	Automation SELOGIC control equation Variable 86
332	ASV085	Automation SELOGIC control equation Variable 85
332	ASV084	Automation SELOGIC control equation Variable 84
332	ASV083	Automation SELOGIC control equation Variable 83
332	ASV082	Automation SELOGIC control equation Variable 82
332	ASV081	Automation SELOGIC control equation Variable 81
333	ASV096	Automation SELOGIC control equation Variable 96
333	ASV095	Automation SELOGIC control equation Variable 95
333	ASV094	Automation SELOGIC control equation Variable 94
333	ASV093	Automation SELOGIC control equation Variable 93
333	ASV092	Automation SELOGIC control equation Variable 92
333	ASV091	Automation SELOGIC control equation Variable 91
333	ASV090	Automation SELOGIC control equation Variable 90
333	ASV089	Automation SELOGIC control equation Variable 89
334	ASV104	Automation SELOGIC control equation Variable 104
334	ASV103	Automation SELOGIC control equation Variable 103
334	ASV102	Automation SELOGIC control equation Variable 102
334	ASV101	Automation SELOGIC control equation Variable 101
334	ASV100	Automation SELOGIC control equation Variable 100

Table 11.2 Row List of Relay Word Bits (Sheet 68 of 100)

Row	Name	Bit Description
334	ASV099	Automation SELOGIC control equation Variable 099
334	ASV098	Automation SELOGIC control equation Variable 098
334	ASV097	Automation SELOGIC control equation Variable 097
335	ASV112	Automation SELOGIC control equation Variable 112
335	ASV111	Automation SELOGIC control equation Variable 111
335	ASV110	Automation SELOGIC control equation Variable 110
335	ASV109	Automation SELOGIC control equation Variable 109
335	ASV108	Automation SELOGIC control equation Variable 108
335	ASV107	Automation SELOGIC control equation Variable 107
335	ASV106	Automation SELOGIC control equation Variable 106
335	ASV105	Automation SELOGIC control equation Variable 105
336	ASV120	Automation SELOGIC control equation Variable 120
336	ASV119	Automation SELOGIC control equation Variable 119
336	ASV118	Automation SELOGIC control equation Variable 118
336	ASV117	Automation SELOGIC control equation Variable 117
336	ASV116	Automation SELOGIC control equation Variable 116
336	ASV115	Automation SELOGIC control equation Variable 115
336	ASV114	Automation SELOGIC control equation Variable 114
336	ASV113	Automation SELOGIC control equation Variable 113
337	ASV128	Automation SELOGIC control equation Variable 128
337	ASV127	Automation SELOGIC control equation Variable 127
337	ASV126	Automation SELOGIC control equation Variable 126
337	ASV125	Automation SELOGIC control equation Variable 125
337	ASV124	Automation SELOGIC control equation Variable 124
337	ASV123	Automation SELOGIC control equation Variable 123
337	ASV122	Automation SELOGIC control equation Variable 122
337	ASV121	Automation SELOGIC control equation Variable 121
338	ASV136	Automation SELOGIC control equation Variable 136
338	ASV135	Automation SELOGIC control equation Variable 135
338	ASV134	Automation SELOGIC control equation Variable 134
338	ASV133	Automation SELOGIC control equation Variable 133
338	ASV132	Automation SELOGIC control equation Variable 132
338	ASV131	Automation SELOGIC control equation Variable 131
338	ASV130	Automation SELOGIC control equation Variable 130
338	ASV129	Automation SELOGIC control equation Variable 129
339	ASV144	Automation SELOGIC control equation Variable 144
339	ASV143	Automation SELOGIC control equation Variable 143
339	ASV142	Automation SELOGIC control equation Variable 142
339	ASV141	Automation SELOGIC control equation Variable 141
339	ASV140	Automation SELOGIC control equation Variable 140
339	ASV139	Automation SELOGIC control equation Variable 139

Table 11.2 Row List of Relay Word Bits (Sheet 69 of 100)

Row	Name	Bit Description
339	ASV138	Automation SELOGIC control equation Variable 138
339	ASV137	Automation SELOGIC control equation Variable 137
340	ASV152	Automation SELOGIC control equation Variable 152
340	ASV151	Automation SELOGIC control equation Variable 151
340	ASV150	Automation SELOGIC control equation Variable 150
340	ASV149	Automation SELOGIC control equation Variable 149
340	ASV148	Automation SELOGIC control equation Variable 148
340	ASV147	Automation SELOGIC control equation Variable 147
340	ASV146	Automation SELOGIC control equation Variable 146
340	ASV145	Automation SELOGIC control equation Variable 145
341	ASV160	Automation SELOGIC control equation Variable 160
341	ASV159	Automation SELOGIC control equation Variable 159
341	ASV158	Automation SELOGIC control equation Variable 158
341	ASV157	Automation SELOGIC control equation Variable 157
341	ASV156	Automation SELOGIC control equation Variable 156
341	ASV155	Automation SELOGIC control equation Variable 155
341	ASV154	Automation SELOGIC control equation Variable 154
341	ASV153	Automation SELOGIC control equation Variable 153
342	ASV168	Automation SELOGIC control equation Variable 168
342	ASV167	Automation SELOGIC control equation Variable 167
342	ASV166	Automation SELOGIC control equation Variable 166
342	ASV165	Automation SELOGIC control equation Variable 165
342	ASV164	Automation SELOGIC control equation Variable 164
342	ASV163	Automation SELOGIC control equation Variable 163
342	ASV162	Automation SELOGIC control equation Variable 162
342	ASV161	Automation SELOGIC control equation Variable 161
343	ASV176	Automation SELOGIC control equation Variable 176
343	ASV175	Automation SELOGIC control equation Variable 175
343	ASV174	Automation SELOGIC control equation Variable 174
343	ASV173	Automation SELOGIC control equation Variable 173
343	ASV172	Automation SELOGIC control equation Variable 172
343	ASV171	Automation SELOGIC control equation Variable 171
343	ASV170	Automation SELOGIC control equation Variable 170
343	ASV169	Automation SELOGIC control equation Variable 169
344	ASV184	Automation SELOGIC control equation Variable 184
344	ASV183	Automation SELOGIC control equation Variable 183
344	ASV182	Automation SELOGIC control equation Variable 182
344	ASV181	Automation SELOGIC control equation Variable 181
344	ASV180	Automation SELOGIC control equation Variable 180
344	ASV179	Automation SELOGIC control equation Variable 179
344	ASV178	Automation SELOGIC control equation Variable 178

Table 11.2 Row List of Relay Word Bits (Sheet 70 of 100)

Row	Name	Bit Description
344	ASV177	Automation SELOGIC control equation Variable 177
345	ASV192	Automation SELOGIC control equation Variable 192
345	ASV191	Automation SELOGIC control equation Variable 191
345	ASV190	Automation SELOGIC control equation Variable 190
345	ASV189	Automation SELOGIC control equation Variable 189
345	ASV188	Automation SELOGIC control equation Variable 188
345	ASV187	Automation SELOGIC control equation Variable 187
345	ASV186	Automation SELOGIC control equation Variable 186
345	ASV185	Automation SELOGIC control equation Variable 185
346	ASV200	Automation SELOGIC control equation Variable 200
346	ASV199	Automation SELOGIC control equation Variable 199
346	ASV198	Automation SELOGIC control equation Variable 198
346	ASV197	Automation SELOGIC control equation Variable 197
346	ASV196	Automation SELOGIC control equation Variable 196
346	ASV195	Automation SELOGIC control equation Variable 195
346	ASV194	Automation SELOGIC control equation Variable 194
346	ASV193	Automation SELOGIC control equation Variable 193
347	ASV208	Automation SELOGIC control equation Variable 208
347	ASV207	Automation SELOGIC control equation Variable 207
347	ASV206	Automation SELOGIC control equation Variable 206
347	ASV205	Automation SELOGIC control equation Variable 205
347	ASV204	Automation SELOGIC control equation Variable 204
347	ASV203	Automation SELOGIC control equation Variable 203
347	ASV202	Automation SELOGIC control equation Variable 202
347	ASV201	Automation SELOGIC control equation Variable 201
348	ASV216	Automation SELOGIC control equation Variable 216
348	ASV215	Automation SELOGIC control equation Variable 215
348	ASV214	Automation SELOGIC control equation Variable 214
348	ASV213	Automation SELOGIC control equation Variable 213
348	ASV212	Automation SELOGIC control equation Variable 212
348	ASV211	Automation SELOGIC control equation Variable 211
348	ASV210	Automation SELOGIC control equation Variable 210
348	ASV209	Automation SELOGIC control equation Variable 209
349	ASV224	Automation SELOGIC control equation Variable 224
349	ASV223	Automation SELOGIC control equation Variable 223
349	ASV222	Automation SELOGIC control equation Variable 222
349	ASV221	Automation SELOGIC control equation Variable 221
349	ASV220	Automation SELOGIC control equation Variable 220
349	ASV219	Automation SELOGIC control equation Variable 219
349	ASV218	Automation SELOGIC control equation Variable 218
349	ASV217	Automation SELOGIC control equation Variable 217

Table 11.2 Row List of Relay Word Bits (Sheet 71 of 100)

Row	Name	Bit Description
350	ASV232	Automation SELOGIC control equation Variable 232
350	ASV231	Automation SELOGIC control equation Variable 231
350	ASV230	Automation SELOGIC control equation Variable 230
350	ASV229	Automation SELOGIC control equation Variable 229
350	ASV228	Automation SELOGIC control equation Variable 228
350	ASV227	Automation SELOGIC control equation Variable 227
350	ASV226	Automation SELOGIC control equation Variable 226
350	ASV225	Automation SELOGIC control equation Variable 225
351	ASV240	Automation SELOGIC control equation Variable 240
351	ASV239	Automation SELOGIC control equation Variable 239
351	ASV238	Automation SELOGIC control equation Variable 238
351	ASV237	Automation SELOGIC control equation Variable 237
351	ASV236	Automation SELOGIC control equation Variable 236
351	ASV235	Automation SELOGIC control equation Variable 235
351	ASV234	Automation SELOGIC control equation Variable 234
351	ASV233	Automation SELOGIC control equation Variable 233
352	ASV248	Automation SELOGIC control equation Variable 248
352	ASV247	Automation SELOGIC control equation Variable 247
352	ASV246	Automation SELOGIC control equation Variable 246
352	ASV245	Automation SELOGIC control equation Variable 245
352	ASV244	Automation SELOGIC control equation Variable 244
352	ASV243	Automation SELOGIC control equation Variable 243
352	ASV242	Automation SELOGIC control equation Variable 242
352	ASV241	Automation SELOGIC control equation Variable 241
353	ASV256	Automation SELOGIC control equation Variable 256
353	ASV255	Automation SELOGIC control equation Variable 255
353	ASV254	Automation SELOGIC control equation Variable 254
353	ASV253	Automation SELOGIC control equation Variable 253
353	ASV252	Automation SELOGIC control equation Variable 252
353	ASV251	Automation SELOGIC control equation Variable 251
353	ASV250	Automation SELOGIC control equation Variable 250
353	ASV249	Automation SELOGIC control equation Variable 249
Automation SELOGIC Latches		
354	ALT08	Automation Latch 8
354	ALT07	Automation Latch 7
354	ALT06	Automation Latch 6
354	ALT05	Automation Latch 5
354	ALT04	Automation Latch 4
354	ALT03	Automation Latch 3
354	ALT02	Automation Latch 2
354	ALT01	Automation Latch 1

Table 11.2 Row List of Relay Word Bits (Sheet 72 of 100)

Row	Name	Bit Description
355	ALT16	Automation Latch 16
355	ALT15	Automation Latch 15
355	ALT14	Automation Latch 14
355	ALT13	Automation Latch 13
355	ALT12	Automation Latch 12
355	ALT11	Automation Latch 11
355	ALT10	Automation Latch 10
355	ALT09	Automation Latch 9
356	ALT24	Automation Latch 24
356	ALT23	Automation Latch 23
356	ALT22	Automation Latch 22
356	ALT21	Automation Latch 21
356	ALT20	Automation Latch 20
356	ALT19	Automation Latch 19
356	ALT18	Automation Latch 18
356	ALT17	Automation Latch 17
357	ALT32	Automation Latch 32
357	ALT31	Automation Latch 31
357	ALT30	Automation Latch 30
357	ALT29	Automation Latch 29
357	ALT28	Automation Latch 28
357	ALT27	Automation Latch 27
357	ALT26	Automation Latch 26
357	ALT25	Automation Latch 25
Automation SELogic Sequencing Timers		
358	AST08Q	Automation sequencing timer Output 8
358	AST07Q	Automation sequencing timer Output 7
358	AST06Q	Automation sequencing timer Output 6
358	AST05Q	Automation sequencing timer Output 5
358	AST04Q	Automation sequencing timer Output 4
358	AST03Q	Automation sequencing timer Output 3
358	AST02Q	Automation sequencing timer Output 2
358	AST01Q	Automation sequencing timer Output 1
359	AST16Q	Automation sequencing timer Output 16
359	AST15Q	Automation sequencing timer Output 15
359	AST14Q	Automation sequencing timer Output 14
359	AST13Q	Automation sequencing timer Output 13
359	AST12Q	Automation sequencing timer Output 12
359	AST11Q	Automation sequencing timer Output 11
359	AST10Q	Automation sequencing timer Output 10
359	AST09Q	Automation sequencing timer Output 9

Table 11.2 Row List of Relay Word Bits (Sheet 73 of 100)

Row	Name	Bit Description
360	AST24Q	Automation sequencing timer Output 24
360	AST23Q	Automation sequencing timer Output 23
360	AST22Q	Automation sequencing timer Output 22
360	AST21Q	Automation sequencing timer Output 21
360	AST20Q	Automation sequencing timer Output 20
360	AST19Q	Automation sequencing timer Output 19
360	AST18Q	Automation sequencing timer Output 18
360	AST17Q	Automation sequencing timer Output 17
361	AST32Q	Automation sequencing timer Output 32
361	AST31Q	Automation sequencing timer Output 31
361	AST30Q	Automation sequencing timer Output 30
361	AST29Q	Automation sequencing timer Output 29
361	AST28Q	Automation sequencing timer Output 28
361	AST27Q	Automation sequencing timer Output 27
361	AST26Q	Automation sequencing timer Output 26
361	AST25Q	Automation sequencing timer Output 25
362	AST08R	Automation sequencing timer Reset 8
362	AST07R	Automation sequencing timer Reset 7
362	AST06R	Automation sequencing timer Reset 6
362	AST05R	Automation sequencing timer Reset 5
362	AST04R	Automation sequencing timer Reset 4
362	AST03R	Automation sequencing timer Reset 3
362	AST02R	Automation sequencing timer Reset 2
362	AST01R	Automation sequencing timer Reset 1
363	AST16R	Automation sequencing timer Reset 16
363	AST15R	Automation sequencing timer Reset 15
363	AST14R	Automation sequencing timer Reset 14
363	AST13R	Automation sequencing timer Reset 13
363	AST12R	Automation sequencing timer Reset 12
363	AST11R	Automation sequencing timer Reset 11
363	AST10R	Automation sequencing timer Reset 10
363	AST09R	Automation sequencing timer Reset 9
364	AST24R	Automation sequencing timer Reset 24
364	AST23R	Automation sequencing timer Reset 23
364	AST22R	Automation sequencing timer Reset 22
364	AST21R	Automation sequencing timer Reset 21
364	AST20R	Automation sequencing timer Reset 20
364	AST19R	Automation sequencing timer Reset 19
364	AST18R	Automation sequencing timer Reset 18
364	AST17R	Automation sequencing timer Reset 17
365	AST32R	Automation sequencing timer Reset 32

Table 11.2 Row List of Relay Word Bits (Sheet 74 of 100)

Row	Name	Bit Description
365	AST31R	Automation sequencing timer Reset 31
365	AST30R	Automation sequencing timer Reset 30
365	AST29R	Automation sequencing timer Reset 29
365	AST28R	Automation sequencing timer Reset 28
365	AST27R	Automation sequencing timer Reset 27
365	AST26R	Automation sequencing timer Reset 26
365	AST25R	Automation sequencing timer Reset 25
Automation SELogic Counters		
366	ACN08Q	Automation counter Output 8
366	ACN07Q	Automation counter Output 7
366	ACN06Q	Automation counter Output 6
366	ACN05Q	Automation counter Output 5
366	ACN04Q	Automation counter Output 4
366	ACN03Q	Automation counter Output 3
366	ACN02Q	Automation counter Output 2
366	ACN01Q	Automation counter Output 1
367	ACN16Q	Automation counter Output 16
367	ACN15Q	Automation counter Output 15
367	ACN14Q	Automation counter Output 14
367	ACN13Q	Automation counter Output 13
367	ACN12Q	Automation counter Output 12
367	ACN11Q	Automation counter Output 11
367	ACN10Q	Automation counter Output 10
367	ACN09Q	Automation counter Output 9
368	ACN24Q	Automation counter Output 24
368	ACN23Q	Automation counter Output 23
368	ACN22Q	Automation counter Output 22
368	ACN21Q	Automation counter Output 21
368	ACN20Q	Automation counter Output 20
368	ACN19Q	Automation counter Output 19
368	ACN18Q	Automation counter Output 18
368	ACN17Q	Automation counter Output 17
369	ACN32Q	Automation counter Output 32
369	ACN31Q	Automation counter Output 31
369	ACN30Q	Automation counter Output 30
369	ACN29Q	Automation counter Output 29
369	ACN28Q	Automation counter Output 28
369	ACN27Q	Automation counter Output 27
369	ACN26Q	Automation counter Output 26
369	ACN25Q	Automation counter Output 25
370	ACN08R	Automation counter Reset 8

Table 11.2 Row List of Relay Word Bits (Sheet 75 of 100)

Row	Name	Bit Description
370	ACN07R	Automation counter Reset 7
370	ACN06R	Automation counter Reset 6
370	ACN05R	Automation counter Reset 5
370	ACN04R	Automation counter Reset 4
370	ACN03R	Automation counter Reset 3
370	ACN02R	Automation counter Reset 2
370	ACN01R	Automation counter Reset 1
371	ACN16R	Automation counter Reset 16
371	ACN15R	Automation counter Reset 15
371	ACN14R	Automation counter Reset 14
371	ACN13R	Automation counter Reset 13
371	ACN12R	Automation counter Reset 12
371	ACN11R	Automation counter Reset 11
371	ACN10R	Automation counter Reset 10
371	ACN09R	Automation counter Reset 9
372	ACN24R	Automation counter Reset 24
372	ACN23R	Automation counter Reset 23
372	ACN22R	Automation counter Reset 22
372	ACN21R	Automation counter Reset 21
372	ACN20R	Automation counter Reset 20
372	ACN19R	Automation counter Reset 19
372	ACN18R	Automation counter Reset 18
372	ACN17R	Automation counter Reset 17
373	ACN32R	Automation counter Reset 32
373	ACN31R	Automation counter Reset 31
373	ACN30R	Automation counter Reset 30
373	ACN29R	Automation counter Reset 29
373	ACN28R	Automation counter Reset 28
373	ACN27R	Automation counter Reset 27
373	ACN26R	Automation counter Reset 26
373	ACN25R	Automation counter Reset 25
SELOGIC Error and Status Reporting		
374	PUNRLBL	Protection SELOGIC control equation unresolved label
374	PFRTEX	Protection SELOGIC control equation first execution
374	MATHERR	SELOGIC control equation math error
374	*	Reserved
374	*	Reserved
374	*	Reserved
374	*	Reserved
374	*	Reserved
375	AUNRLBL	Automation SELOGIC control equation unresolved label

Table 11.2 Row List of Relay Word Bits (Sheet 76 of 100)

Row	Name	Bit Description
375	AFRTEXP	Automation SELOGIC control equation first execution protection
375	AFRTEXA	Automation SELOGIC control equation first execution automation
375	*	Reserved
375	*	Reserved
375	*	Reserved
375	*	Reserved
375	*	Reserved
Alarms		
376	SALARM	Non-diagnostic alarm pulse
376	HALARM	Relay diagnostic failure or warning
376	BADPASS	Pulsed when user enters three successive bad passwords
376	HALARML	Latching relay failure alarm
376	HALARMP	Relay warning alarm pulse
376	HALARMA	Relay warning periodic alarm
376	SETCHG	Pulsed when settings change
376	GRPSW	Pulsed when settings group changes
377	ACCESS	A user is connected at Access Level B or higher
377	ACCESSP	Pulsed when higher level access achieved
377	EACC	Enable Level 1 access (SELOGIC control equation)
377	E2AC	Enable Levels 1–2 access (SELOGIC control equation)
377	*	
377	*	
377	*	
377	*	
377	PASSDIS	Asserts to indicate password disable jumper is installed
377	BRKENAB	Asserts to indicate breaker control enable jumper is installed
Time and Date Management		
378	TBNC	The active relay time source is BNC IRIG
378	TPTP	The active relay time source is PTP
378	TIRIG	Assert while time is based on IRIG for both mark and value
378	TUPDH	Assert if update source is high-priority time source
378	TSYNCA	Assert while the time mark from time source or fixed internal source is not synchronized
378	TSOK	Assert if current time-source accuracy is sufficient for synchronized phasor measurements
378	TSER	The active relay time source is serial IRIG
378	UPD_EN	Enable updating internal clock with selected external time source
379	TSYNC	Assert when ADC sampling is synchronized to a valid high-priority time source
379	BLKLPTS	Block low priority source from updating relay time
379	TLOCAL	Relay calendar clock and ADC sampling synchronized to a high-priority local time source
379	TPLLEXT	Update PLL using external signal
379	TSSW	High priority time source switching
379	TGLOBAL	Relay calendar clock and ADC sampling synchronized to a high-priority Global time source

Table 11.2 Row List of Relay Word Bits (Sheet 77 of 100)

Row	Name	Bit Description
379	TSNTPP	Asserts if time was synchronized with primary NTP server before SNTP time-out period expired
379	TSNTPB	Asserts if time was synchronized with backup NTP server before SNTP time-out period expired
380	*	Reserved
380	*	Reserved
380	*	Reserved
380	*	Reserved
380	*	Reserved
380	*	Reserved
380	*	Reserved
380	*	Reserved
Inverse-Time Overcurrent Elements		
381	*	Reserved
381	*	Reserved
381	*	Reserved
381	51R21	Inverse-time Element 21 reset
381	51R20	Inverse-time Element 20 reset
381	51R19	Inverse-time Element 19 reset
381	51R18	Inverse-time Element 18 reset
381	51R17	Inverse-time Element 17 reset
Pushbuttons		
382	PB1	Pushbutton 1
382	PB2	Pushbutton 2
382	PB3	Pushbutton 3
382	PB4	Pushbutton 4
382	PB5	Pushbutton 5
382	PB6	Pushbutton 6
382	PB7	Pushbutton 7
382	PB8	Pushbutton 8
383	PB9	Pushbutton 9
383	PB10	Pushbutton 10
383	PB11	Pushbutton 11
383	PB12	Pushbutton 12
383	*	Reserved
383	*	Reserved
383	*	Reserved
383	*	Reserved
Contact Outputs		
384	OUT108	Main board Output 8
384	OUT107	Main board Output 7
384	OUT106	Main board Output 6
384	OUT105	Main board Output 5

Table 11.2 Row List of Relay Word Bits (Sheet 78 of 100)

Row	Name	Bit Description
384	OUT104	Main board Output 4
384	OUT103	Main board Output 3
384	OUT102	Main board Output 2
384	OUT101	Main board Output 1
385	*	Reserved
385	*	Reserved
385	*	Reserved
385	*	Reserved
385	*	Reserved
385	*	Reserved
385	*	Reserved
385	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
386	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
387	*	Reserved
388	OUT208	Optional I/O Board 1 Output 8
388	OUT207	Optional I/O Board 1 Output 7
388	OUT206	Optional I/O Board 1 Output 6
388	OUT205	Optional I/O Board 1 Output 5
388	OUT204	Optional I/O Board 1 Output 4
388	OUT203	Optional I/O Board 1 Output 3
388	OUT202	Optional I/O Board 1 Output 2
388	OUT201	Optional I/O Board 1 Output 1
389	OUT216	Optional I/O Board 1 Output 16
389	OUT215	Optional I/O Board 1 Output 15
389	OUT214	Optional I/O Board 1 Output 14
389	OUT213	Optional I/O Board 1 Output 13
389	OUT212	Optional I/O Board 1 Output 12

Table 11.2 Row List of Relay Word Bits (Sheet 79 of 100)

Row	Name	Bit Description
389	OUT211	Optional I/O Board 1 Output 11
389	OUT210	Optional I/O Board 1 Output 10
389	OUT209	Optional I/O Board 1 Output 9
390	OUT308	Optional I/O Board 2 Output 8
390	OUT307	Optional I/O Board 2 Output 7
390	OUT306	Optional I/O Board 2 Output 6
390	OUT305	Optional I/O Board 2 Output 5
390	OUT304	Optional I/O Board 2 Output 4
390	OUT303	Optional I/O Board 2 Output 3
390	OUT302	Optional I/O Board 2 Output 2
390	OUT301	Optional I/O Board 2 Output 1
391	OUT316	Optional I/O Board 2 Output 16
391	OUT315	Optional I/O Board 2 Output 15
391	OUT314	Optional I/O Board 2 Output 14
391	OUT313	Optional I/O Board 2 Output 13
391	OUT312	Optional I/O Board 2 Output 12
391	OUT311	Optional I/O Board 2 Output 11
391	OUT310	Optional I/O Board 2 Output 10
391	OUT309	Optional I/O Board 2 Output 9
392	OUT408	Optional I/O Board 3 Output 8
392	OUT407	Optional I/O Board 3 Output 7
392	OUT406	Optional I/O Board 3 Output 6
392	OUT405	Optional I/O Board 3 Output 5
392	OUT404	Optional I/O Board 3 Output 4
392	OUT403	Optional I/O Board 3 Output 3
392	OUT402	Optional I/O Board 3 Output 2
392	OUT401	Optional I/O Board 3 Output 1
393	OUT416	Optional I/O Board 3 Output 16
393	OUT415	Optional I/O Board 3 Output 15
393	OUT414	Optional I/O Board 3 Output 14
393	OUT413	Optional I/O Board 3 Output 13
393	OUT412	Optional I/O Board 3 Output 12
393	OUT411	Optional I/O Board 3 Output 11
393	OUT410	Optional I/O Board 3 Output 10
393	OUT409	Optional I/O Board 3 Output 9
394	OUT508	Optional I/O Board 4 Output 8
394	OUT507	Optional I/O Board 4 Output 7
394	OUT506	Optional I/O Board 4 Output 6
394	OUT505	Optional I/O Board 4 Output 5
394	OUT504	Optional I/O Board 4 Output 4
394	OUT503	Optional I/O Board 4 Output 3

Table 11.2 Row List of Relay Word Bits (Sheet 80 of 100)

Row	Name	Bit Description
394	OUT502	Optional I/O Board 4 Output 2
394	OUT501	Optional I/O Board 4 Output 1
395	OUT516	Optional I/O Board 4 Output 16
395	OUT515	Optional I/O Board 4 Output 15
395	OUT514	Optional I/O Board 4 Output 14
395	OUT513	Optional I/O Board 4 Output 13
395	OUT512	Optional I/O Board 4 Output 12
395	OUT511	Optional I/O Board 4 Output 11
395	OUT510	Optional I/O Board 4 Output 10
395	OUT509	Optional I/O Board 4 Output 9
Pushbuttons Pulse Inputs		
396	PB1_PUL	Pushbutton 1 pulse input
396	PB2_PUL	Pushbutton 2 pulse input
396	PB3_PUL	Pushbutton 3 pulse input
396	PB4_PUL	Pushbutton 4 pulse input
396	PB5_PUL	Pushbutton 5 pulse input
396	PB6_PUL	Pushbutton 6 pulse input
396	PB7_PUL	Pushbutton 7 pulse input
396	PB8_PUL	Pushbutton 8 pulse input
397	PB9_PUL	Pushbutton 9 pulse input
397	PB10PUL	Pushbutton 10 pulse input
397	PB11PUL	Pushbutton 11 pulse input
397	PB12PUL	Pushbutton 12 pulse input
397	*	Reserved
397	*	Reserved
397	*	Reserved
397	*	Reserved
Pushbutton LED Bits		
398	PB1_LED	Pushbutton 1 LED
398	PB2_LED	Pushbutton 2 LED
398	PB3_LED	Pushbutton 3 LED
398	PB4_LED	Pushbutton 4 LED
398	PB5_LED	Pushbutton 5 LED
398	PB6_LED	Pushbutton 6 LED
398	PB7_LED	Pushbutton 7 LED
398	PB8_LED	Pushbutton 8 LED
399	PB9_LED	Pushbutton 9 LED
399	PB10LED	Pushbutton 10 LED
399	PB11LED	Pushbutton 11 LED
399	PB12LED	Pushbutton 12 LED
399	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 81 of 100)

Row	Name	Bit Description
399	*	Reserved
399	*	Reserved
399	*	Reserved
MIRRORED BITS		
400	RMB8A	Channel A receive MIRRORED BIT 8
400	RMB7A	Channel A receive MIRRORED BIT 7
400	RMB6A	Channel A receive MIRRORED BIT 6
400	RMB5A	Channel A receive MIRRORED BIT 5
400	RMB4A	Channel A receive MIRRORED BIT 4
400	RMB3A	Channel A receive MIRRORED BIT 3
400	RMB2A	Channel A receive MIRRORED BIT 2
400	RMB1A	Channel A receive MIRRORED BIT 1
401	TMB8A	Channel A transmit MIRRORED BIT 8
401	TMB7A	Channel A transmit MIRRORED BIT 7
401	TMB6A	Channel A transmit MIRRORED BIT 6
401	TMB5A	Channel A transmit MIRRORED BIT 5
401	TMB4A	Channel A transmit MIRRORED BIT 4
401	TMB3A	Channel A transmit MIRRORED BIT 3
401	TMB2A	Channel A transmit MIRRORED BIT 2
401	TMB1A	Channel A transmit MIRRORED BIT 1
402	RMB8B	Channel B receive MIRRORED BIT 8
402	RMB7B	Channel B receive MIRRORED BIT 7
402	RMB6B	Channel B receive MIRRORED BIT 6
402	RMB5B	Channel B receive MIRRORED BIT 5
402	RMB4B	Channel B receive MIRRORED BIT 4
402	RMB3B	Channel B receive MIRRORED BIT 3
402	RMB2B	Channel B receive MIRRORED BIT 2
402	RMB1B	Channel B receive MIRRORED BIT 1
403	TMB8B	Channel B transmit MIRRORED BIT 8
403	TMB7B	Channel B transmit MIRRORED BIT 7
403	TMB6B	Channel B transmit MIRRORED BIT 6
403	TMB5B	Channel B transmit MIRRORED BIT 5
403	TMB4B	Channel B transmit MIRRORED BIT 4
403	TMB3B	Channel B transmit MIRRORED BIT 3
403	TMB2B	Channel B transmit MIRRORED BIT 2
403	TMB1B	Channel B transmit MIRRORED BIT 1
404	ROKA	Channel A MIRRORED BITS normal status (non-loopback)
404	RBADA	Channel A MIRRORED BITS outage too long
404	CBADA	Channel A MIRRORED BITS unavailability
404	LBOKA	Channel A MIRRORED BITS normal status (loopback)
404	ANOKA	Channel A MIRRORED BITS analog transfer OK

Table 11.2 Row List of Relay Word Bits (Sheet 82 of 100)

Row	Name	Bit Description
404	DOKA	Channel A MIRRORED BITS communications normal status
404	*	Reserved
404	*	Reserved
405	ROKB	Channel B MIRRORED BITS normal status (non-loopback mode)
405	RBADB	Channel B MIRRORED BITS outage too long
405	CBADB	Channel B MIRRORED BITS unavailability
405	LBOKB	Channel B MIRRORED BITS normal status (loopback mode)
405	ANOKB	Channel B MIRRORED BITS analog transfer OK
405	DOKB	Channel B MIRRORED BITS communications normal status
405	*	Reserved
405	*	Reserved
Test Bits		
406	TESTDB2	DNP test bit
406	TESTDB	Communications card database test bit
406	TESTFM	Fast meter test bit
406	TESTPUL	Pulse test bit
406	LPHDSIM	IEC 61850 Logical Node for physical device simulation
406	*	Reserved
406	*	Reserved
406	*	Reserved
Advanced Check Zone Bits		
407	CZ24R	Include Bus Coupler 4 in Check Zone 2
407	CZ23R	Include Bus Coupler 3 in Check Zone 2
407	CZ22R	Include Bus Coupler 2 in Check Zone 2
407	CZ21R	Include Bus Coupler 1 in Check Zone 2
407	CZ14R	Include Bus Coupler 4 in Check Zone 1
407	CZ13R	Include Bus Coupler 3 in Check Zone 1
407	CZ12R	Include Bus Coupler 2 in Check Zone 1
407	CZ11R	Include Bus Coupler 1 in Check Zone 1
Virtual Bits		
408	VB249	Virtual Bit 249
408	VB250	Virtual Bit 250
408	VB251	Virtual Bit 251
408	VB252	Virtual Bit 252
408	VB253	Virtual Bit 253
408	VB254	Virtual Bit 254
408	VB255	Virtual Bit 255
408	VB256	Virtual Bit 256
409	VB241	Virtual Bit 241
409	VB242	Virtual Bit 242
409	VB243	Virtual Bit 243

Table 11.2 Row List of Relay Word Bits (Sheet 83 of 100)

Row	Name	Bit Description
409	VB244	Virtual Bit 244
409	VB245	Virtual Bit 245
409	VB246	Virtual Bit 246
409	VB247	Virtual Bit 247
409	VB248	Virtual Bit 248
410	VB233	Virtual Bit 233
410	VB234	Virtual Bit 234
410	VB235	Virtual Bit 235
410	VB236	Virtual Bit 236
410	VB237	Virtual Bit 237
410	VB238	Virtual Bit 238
410	VB239	Virtual Bit 239
410	VB240	Virtual Bit 240
411	VB225	Virtual Bit 225
411	VB226	Virtual Bit 226
411	VB227	Virtual Bit 227
411	VB228	Virtual Bit 228
411	VB229	Virtual Bit 229
411	VB230	Virtual Bit 230
411	VB231	Virtual Bit 231
411	VB232	Virtual Bit 232
412	VB217	Virtual Bit 217
412	VB218	Virtual Bit 218
412	VB219	Virtual Bit 219
412	VB220	Virtual Bit 220
412	VB221	Virtual Bit 221
412	VB222	Virtual Bit 222
412	VB223	Virtual Bit 223
412	VB224	Virtual Bit 224
413	VB209	Virtual Bit 209
413	VB210	Virtual Bit 210
413	VB211	Virtual Bit 211
413	VB212	Virtual Bit 212
413	VB213	Virtual Bit 213
413	VB214	Virtual Bit 214
413	VB215	Virtual Bit 215
413	VB216	Virtual Bit 216
414	VB201	Virtual Bit 201
414	VB202	Virtual Bit 202
414	VB203	Virtual Bit 203
414	VB204	Virtual Bit 204

Table 11.2 Row List of Relay Word Bits (Sheet 84 of 100)

Row	Name	Bit Description
414	VB205	Virtual Bit 205
414	VB206	Virtual Bit 206
414	VB207	Virtual Bit 207
414	VB208	Virtual Bit 208
415	VB193	Virtual Bit 193
415	VB194	Virtual Bit 194
415	VB195	Virtual Bit 195
415	VB196	Virtual Bit 196
415	VB197	Virtual Bit 197
415	VB198	Virtual Bit 198
415	VB199	Virtual Bit 199
415	VB200	Virtual Bit 200
416	VB185	Virtual Bit 185
416	VB186	Virtual Bit 186
416	VB187	Virtual Bit 187
416	VB188	Virtual Bit 188
416	VB189	Virtual Bit 189
416	VB190	Virtual Bit 190
416	VB191	Virtual Bit 191
416	VB192	Virtual Bit 192
417	VB177	Virtual Bit 177
417	VB178	Virtual Bit 178
417	VB179	Virtual Bit 179
417	VB180	Virtual Bit 180
417	VB181	Virtual Bit 181
417	VB182	Virtual Bit 182
417	VB183	Virtual Bit 183
417	VB184	Virtual Bit 184
418	VB169	Virtual Bit 169
418	VB170	Virtual Bit 170
418	VB171	Virtual Bit 171
418	VB172	Virtual Bit 172
418	VB173	Virtual Bit 173
418	VB174	Virtual Bit 174
418	VB175	Virtual Bit 175
418	VB176	Virtual Bit 176
419	VB161	Virtual Bit 161
419	VB162	Virtual Bit 162
419	VB163	Virtual Bit 163
419	VB164	Virtual Bit 164
419	VB165	Virtual Bit 165

Table 11.2 Row List of Relay Word Bits (Sheet 85 of 100)

Row	Name	Bit Description
419	VB166	Virtual Bit 166
419	VB167	Virtual Bit 167
419	VB168	Virtual Bit 168
420	VB153	Virtual Bit 153
420	VB154	Virtual Bit 154
420	VB155	Virtual Bit 155
420	VB156	Virtual Bit 156
420	VB157	Virtual Bit 157
420	VB158	Virtual Bit 158
420	VB159	Virtual Bit 159
420	VB160	Virtual Bit 160
421	VB145	Virtual Bit 145
421	VB146	Virtual Bit 146
421	VB147	Virtual Bit 147
421	VB148	Virtual Bit 148
421	VB149	Virtual Bit 149
421	VB150	Virtual Bit 150
421	VB151	Virtual Bit 151
421	VB152	Virtual Bit 152
422	VB137	Virtual Bit 137
422	VB138	Virtual Bit 138
422	VB139	Virtual Bit 139
422	VB140	Virtual Bit 140
422	VB141	Virtual Bit 141
422	VB142	Virtual Bit 142
422	VB143	Virtual Bit 143
422	VB144	Virtual Bit 144
423	VB129	Virtual Bit 129
423	VB130	Virtual Bit 130
423	VB131	Virtual Bit 131
423	VB132	Virtual Bit 132
423	VB133	Virtual Bit 133
423	VB134	Virtual Bit 134
423	VB135	Virtual Bit 135
423	VB136	Virtual Bit 136
424	VB121	Virtual Bit 121
424	VB122	Virtual Bit 122
424	VB123	Virtual Bit 123
424	VB124	Virtual Bit 124
424	VB125	Virtual Bit 125
424	VB126	Virtual Bit 126

Table 11.2 Row List of Relay Word Bits (Sheet 86 of 100)

Row	Name	Bit Description
424	VB127	Virtual Bit 127
424	VB128	Virtual Bit 128
425	VB113	Virtual Bit 113
425	VB114	Virtual Bit 114
425	VB115	Virtual Bit 115
425	VB116	Virtual Bit 116
425	VB117	Virtual Bit 117
425	VB118	Virtual Bit 118
425	VB119	Virtual Bit 119
425	VB120	Virtual Bit 120
426	VB105	Virtual Bit 105
426	VB106	Virtual Bit 106
426	VB107	Virtual Bit 107
426	VB108	Virtual Bit 108
426	VB109	Virtual Bit 109
426	VB110	Virtual Bit 110
426	VB111	Virtual Bit 111
426	VB112	Virtual Bit 112
427	VB097	Virtual Bit 097
427	VB098	Virtual Bit 098
427	VB099	Virtual Bit 099
427	VB100	Virtual Bit 100
427	VB101	Virtual Bit 101
427	VB102	Virtual Bit 102
427	VB103	Virtual Bit 103
427	VB104	Virtual Bit 104
428	VB089	Virtual Bit 089
428	VB090	Virtual Bit 090
428	VB091	Virtual Bit 091
428	VB092	Virtual Bit 092
428	VB093	Virtual Bit 093
428	VB094	Virtual Bit 094
428	VB095	Virtual Bit 095
428	VB096	Virtual Bit 096
429	VB081	Virtual Bit 081
429	VB082	Virtual Bit 082
429	VB083	Virtual Bit 083
429	VB084	Virtual Bit 084
429	VB085	Virtual Bit 085
429	VB086	Virtual Bit 086
429	VB087	Virtual Bit 087

Table 11.2 Row List of Relay Word Bits (Sheet 87 of 100)

Row	Name	Bit Description
429	VB088	Virtual Bit 088
430	VB073	Virtual Bit 073
430	VB074	Virtual Bit 074
430	VB075	Virtual Bit 075
430	VB076	Virtual Bit 076
430	VB077	Virtual Bit 077
430	VB078	Virtual Bit 078
430	VB079	Virtual Bit 079
430	VB080	Virtual Bit 080
431	VB065	Virtual Bit 065
431	VB066	Virtual Bit 066
431	VB067	Virtual Bit 067
431	VB068	Virtual Bit 068
431	VB069	Virtual Bit 069
431	VB070	Virtual Bit 070
431	VB071	Virtual Bit 071
431	VB072	Virtual Bit 072
432	VB057	Virtual Bit 057
432	VB058	Virtual Bit 058
432	VB059	Virtual Bit 059
432	VB060	Virtual Bit 060
432	VB061	Virtual Bit 061
432	VB062	Virtual Bit 062
432	VB063	Virtual Bit 063
432	VB064	Virtual Bit 064
433	VB049	Virtual Bit 049
433	VB050	Virtual Bit 050
433	VB051	Virtual Bit 051
433	VB052	Virtual Bit 052
433	VB053	Virtual Bit 053
433	VB054	Virtual Bit 054
433	VB055	Virtual Bit 055
433	VB056	Virtual Bit 056
434	VB041	Virtual Bit 041
434	VB042	Virtual Bit 042
434	VB043	Virtual Bit 043
434	VB044	Virtual Bit 044
434	VB045	Virtual Bit 045
434	VB046	Virtual Bit 046
434	VB047	Virtual Bit 047
434	VB048	Virtual Bit 048

Table 11.2 Row List of Relay Word Bits (Sheet 88 of 100)

Row	Name	Bit Description
435	VB033	Virtual Bit 033
435	VB034	Virtual Bit 034
435	VB035	Virtual Bit 035
435	VB036	Virtual Bit 036
435	VB037	Virtual Bit 037
435	VB038	Virtual Bit 038
435	VB039	Virtual Bit 039
435	VB040	Virtual Bit 040
436	VB025	Virtual Bit 025
436	VB026	Virtual Bit 026
436	VB027	Virtual Bit 027
436	VB028	Virtual Bit 028
436	VB029	Virtual Bit 029
436	VB030	Virtual Bit 030
436	VB031	Virtual Bit 031
436	VB032	Virtual Bit 032
437	VB017	Virtual Bit 017
437	VB018	Virtual Bit 018
437	VB019	Virtual Bit 019
437	VB020	Virtual Bit 020
437	VB021	Virtual Bit 021
437	VB022	Virtual Bit 022
437	VB023	Virtual Bit 023
437	VB024	Virtual Bit 024
438	VB009	Virtual Bit 009
438	VB010	Virtual Bit 010
438	VB011	Virtual Bit 011
438	VB012	Virtual Bit 012
438	VB013	Virtual Bit 013
438	VB014	Virtual Bit 014
438	VB015	Virtual Bit 015
438	VB016	Virtual Bit 016
439	VB001	Virtual Bit 001
439	VB002	Virtual Bit 002
439	VB003	Virtual Bit 003
439	VB004	Virtual Bit 004
439	VB005	Virtual Bit 005
439	VB006	Virtual Bit 006
439	VB007	Virtual Bit 007
439	VB008	Virtual Bit 008

Table 11.2 Row List of Relay Word Bits (Sheet 89 of 100)

Row	Name	Bit Description
Data Reset Bits		
440	RST_BAT	Reset battery monitoring
440	RSTTRGT	Target reset (SELOGIC control equation)
440	RSTDNPE	Reset DNP fault summary data
440	RST_HAL	Reset HALARMA
440	*	Reserved
440	*	Reserved
440	*	Reserved
440	*	Reserved
Ethernet Switch		
441	LINK5A	Link status of Port 5A connection
441	LINK5B	Link status of Port 5B connection
441	LINK5C	Link status of Port 5C connection
441	LINK5D	Link status of Port 5D connection
441	LNKFAIL	Link status of the active port
441	*	Reserved
441	*	Reserved
441	*	Reserved
442	P5ASEL	Port 5A active/inactive
442	P5BSEL	Port 5B active/inactive
442	P5CSEL	Port 5C active/inactive
442	P5DSEL	Port 5D active/inactive
442	*	Reserved
442	*	Reserved
442	*	Reserved
442	*	Reserved
Advanced Check Zone Bits		
443	*	Reserved
443	*	Reserved
443	*	Reserved
443	*	Reserved
443	CZ34R	Include Bus Coupler 4 in Check Zone 3
443	CZ33R	Include Bus Coupler 3 in Check Zone 3
443	CZ32R	Include Bus Coupler 2 in Check Zone 3
443	CZ31R	Include Bus Coupler 1 in Check Zone 3
Fast SER Enable Bits		
444	FSERP1	Fast SER enabled for Serial Port 1
444	FSERP2	Fast SER enabled for Serial Port 2
444	FSERP3	Fast SER enabled for Serial Port 3
444	FSERPF	Fast SER enabled for Serial Port F
444	FSERP5	Fast SER enabled for Serial Port 5

Table 11.2 Row List of Relay Word Bits (Sheet 90 of 100)

Row	Name	Bit Description
444	*	Reserved
444	*	Reserved
444	*	Reserved
Check Zone Activation		
445	*	Reserved
445	*	Reserved
445	*	Reserved
445	*	Reserved
445	*	Reserved
445	CZONE3	Check Zone 3 is active
445	CZONE2	Check Zone 2 is active
445	CZONE1	Check Zone 1 is active
Check Zone Supervision		
446	*	Reserved
446	*	Reserved
446	*	Reserved
446	*	Reserved
446	*	Reserved
446	CZ3S	Check Zone 3 supervision asserted
446	CZ2S	Check Zone 2 supervision asserted
446	CZ1S	Check Zone 1 supervision asserted
Check Zone Trip		
447	*	Reserved
447	*	Reserved
447	*	Reserved
447	*	Reserved
447	*	Reserved
447	87CZ3	Check Zone 3 differential element trip
447	87CZ2	Check Zone 2 differential element trip
447	87CZ1	Check Zone 1 differential element trip
Check Zone Elements		
448	*	Reserved
448	*	Reserved
448	*	Reserved
448	*	Reserved
448	*	Reserved
448	87SCZ3	Check Zone 3 sensitive differential element picked up
448	87SCZ2	Check Zone 2 sensitive differential element picked up
448	87SCZ1	Check Zone 1 sensitive differential element picked up
449	*	Reserved
449	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 91 of 100)

Row	Name	Bit Description
449	*	Reserved
449	*	Reserved
449	*	Reserved
449	87STCZ3	Check Zone 3 sensitive differential element timed out
449	87STCZ2	Check Zone 2 sensitive differential element timed out
449	87STCZ1	Check Zone 1 sensitive differential element timed out
450	87RCZ1	Check Zone 1 restraint differential element picked up
450	P87RCZ1	Check Zone 1 instantaneous differential element picked up
450	87OCZ1	Check Zone 1 restraint differential operating current above CZO87P
450	FLTCZ1	Check Zone 1 fault detector picked up
450	CONCZ1	Check Zone 1 in high-security mode
450	EXTCZ1	Check Zone 1 external fault declaration
450	DOPCZ1	Check Zone 1 incremental operating current picked up
450	DRTCZ1	Check Zone 1 incremental restraint current picked up
451	*	Reserved
451	*	Reserved
451	*	Reserved
451	*	Reserved
451	FDIFCZ1	Check Zone 1 filtered restrained differential element picked up
451	RDIFCZ1	Check Zone 1 unfiltered restrained differential element picked up
451	IFLTCZ1	Check Zone 1 fault detection
451	GFLTCZ1	Check Zone 1 fast fault detection
452	87RCZ2	Check Zone 2 restraint differential element picked up
452	P87RCZ2	Check Zone 2 instantaneous differential element picked up
452	87OCZ2	Check Zone 2 restraint differential operating current above CZO87P
452	FLTCZ2	Check Zone 2 fault detector picked up
452	CONCZ2	Check Zone 2 in high-security mode
452	EXTCZ2	Check Zone 2 external fault declaration
452	DOPCZ2	Check Zone 2 incremental operating current picked up
452	DRTCZ2	Check Zone 2 incremental restraint current picked up
453	*	Reserved
453	*	Reserved
453	*	Reserved
453	*	Reserved
453	FDIFCZ2	Check Zone 2 filtered restrained differential element picked up
453	RDIFCZ2	Check Zone 2 unfiltered restrained differential element picked up
453	IFLTCZ2	Check Zone 2 fault detection
453	GFLTCZ2	Check Zone 2 fast fault detection
454	87RCZ3	Check Zone 3 restraint differential element picked up
454	P87RCZ3	Check Zone 3 instantaneous differential element picked up
454	87OCZ3	Check Zone 3 restraint differential operating current above CZO87P

Table 11.2 Row List of Relay Word Bits (Sheet 92 of 100)

Row	Name	Bit Description
454	FLTCZ3	Check Zone 3 fault detector picked up
454	CONCZ3	Check Zone 3 in high-security mode
454	EXTCZ3	Check Zone 3 external fault declaration
454	DOPCZ3	Check Zone 3 incremental operating current picked up
454	DRTCZ3	Check Zone 3 incremental restraint current picked up
455	*	Reserved
455	*	Reserved
455	*	Reserved
455	*	Reserved
455	FDIFCZ3	Check Zone 3 filtered restrained differential element picked up
455	RDIFCZ3	Check Zone 3 unfiltered restrained differential element picked up
455	IFLTCZ3	Check Zone 3 fault detection
455	GFLTCZ3	Check Zone 3 fast fault detection
456	*	Reserved
456	*	Reserved
456	*	Reserved
456	*	Reserved
456	*	Reserved
456	DECZ3F	Check Zone 3 forward directional element picked up
456	DECZ2F	Check Zone 2 forward directional element picked up
456	DECZ1F	Check Zone 1 forward directional element picked up
Local Bit Supervision		
457	LB_SP08	Local Bit 08 supervision (SELOGIC control equation)
457	LB_SP07	Local Bit 07 supervision (SELOGIC control equation)
457	LB_SP06	Local Bit 06 supervision (SELOGIC control equation)
457	LB_SP05	Local Bit 05 supervision (SELOGIC control equation)
457	LB_SP04	Local Bit 04 supervision (SELOGIC control equation)
457	LB_SP03	Local Bit 03 supervision (SELOGIC control equation)
457	LB_SP02	Local Bit 02 supervision (SELOGIC control equation)
457	LB_SP01	Local Bit 01 supervision (SELOGIC control equation)
458	LB_SP16	Local Bit 16 supervision (SELOGIC control equation)
458	LB_SP15	Local Bit 15 supervision (SELOGIC control equation)
458	LB_SP14	Local Bit 14 supervision (SELOGIC control equation)
458	LB_SP13	Local Bit 13 supervision (SELOGIC control equation)
458	LB_SP12	Local Bit 12 supervision (SELOGIC control equation)
458	LB_SP11	Local Bit 11 supervision (SELOGIC control equation)
458	LB_SP10	Local Bit 10 supervision (SELOGIC control equation)
458	LB_SP09	Local Bit 09 supervision (SELOGIC control equation)
459	LB_SP24	Local Bit 24 supervision (SELOGIC control equation)
459	LB_SP23	Local Bit 23 supervision (SELOGIC control equation)
459	LB_SP22	Local Bit 22 supervision (SELOGIC control equation)

Table 11.2 Row List of Relay Word Bits (Sheet 93 of 100)

Row	Name	Bit Description
459	LB_SP21	Local Bit 21 supervision (SELOGIC control equation)
459	LB_SP20	Local Bit 20 supervision (SELOGIC control equation)
459	LB_SP19	Local Bit 19 supervision (SELOGIC control equation)
459	LB_SP18	Local Bit 18 supervision (SELOGIC control equation)
459	LB_SP17	Local Bit 17 supervision (SELOGIC control equation)
460	LB_SP32	Local Bit 32 supervision (SELOGIC control equation)
460	LB_SP31	Local Bit 31 supervision (SELOGIC control equation)
460	LB_SP30	Local Bit 30 supervision (SELOGIC control equation)
460	LB_SP29	Local Bit 29 supervision (SELOGIC control equation)
460	LB_SP28	Local Bit 28 supervision (SELOGIC control equation)
460	LB_SP27	Local Bit 27 supervision (SELOGIC control equation)
460	LB_SP26	Local Bit 26 supervision (SELOGIC control equation)
460	LB_SP25	Local Bit 25 supervision (SELOGIC control equation)
Local Bit Status		
461	LB_DP08	Local Bit 08 status display (SELOGIC control equation)
461	LB_DP07	Local Bit 07 status display (SELOGIC control equation)
461	LB_DP06	Local Bit 06 status display (SELOGIC control equation)
461	LB_DP05	Local Bit 05 status display (SELOGIC control equation)
461	LB_DP04	Local Bit 04 status display (SELOGIC control equation)
461	LB_DP03	Local Bit 03 status display (SELOGIC control equation)
461	LB_DP02	Local Bit 02 status display (SELOGIC control equation)
461	LB_DP01	Local Bit 01 status display (SELOGIC control equation)
462	LB_DP16	Local Bit 16 status display (SELOGIC control equation)
462	LB_DP15	Local Bit 15 status display (SELOGIC control equation)
462	LB_DP14	Local Bit 14 status display (SELOGIC control equation)
462	LB_DP13	Local Bit 13 status display (SELOGIC control equation)
462	LB_DP12	Local Bit 12 status display (SELOGIC control equation)
462	LB_DP11	Local Bit 11 status display (SELOGIC control equation)
462	LB_DP10	Local Bit 10 status display (SELOGIC control equation)
462	LB_DP09	Local Bit 09 status display (SELOGIC control equation)
463	LB_DP24	Local Bit 24 status display (SELOGIC control equation)
463	LB_DP23	Local Bit 23 status display (SELOGIC control equation)
463	LB_DP22	Local Bit 22 status display (SELOGIC control equation)
463	LB_DP21	Local Bit 21 status display (SELOGIC control equation)
463	LB_DP20	Local Bit 20 status display (SELOGIC control equation)
463	LB_DP19	Local Bit 19 status display (SELOGIC control equation)
463	LB_DP18	Local Bit 18 status display (SELOGIC control equation)
463	LB_DP17	Local Bit 17 status display (SELOGIC control equation)
464	LB_DP32	Local Bit 32 status display (SELOGIC control equation)
464	LB_DP31	Local Bit 31 status display (SELOGIC control equation)
464	LB_DP30	Local Bit 30 status display (SELOGIC control equation)

Table 11.2 Row List of Relay Word Bits (Sheet 94 of 100)

Row	Name	Bit Description
464	LB_DP29	Local Bit 29 status display (SELOGIC control equation)
464	LB_DP28	Local Bit 28 status display (SELOGIC control equation)
464	LB_DP27	Local Bit 27 status display (SELOGIC control equation)
464	LB_DP26	Local Bit 26 status display (SELOGIC control equation)
464	LB_DP25	Local Bit 25 status display (SELOGIC control equation)
465	*	Reserved
465	*	Reserved
465	*	Reserved
465	*	Reserved
465	*	Reserved
465	*	Reserved
465	*	Reserved
465	*	Reserved
Target Logic Bits		
466	TRGTR	Reset all active target Relay Words
466	*	Reserved
466	*	Reserved
466	*	Reserved
466	*	Reserved
466	*	Reserved
466	*	Reserved
466	*	Reserved
Signal Profiling		
467	SPEN	Signal profiling enabled
467	*	Reserved
467	*	Reserved
467	*	Reserved
467	*	Reserved
467	*	Reserved
467	*	Reserved
467	*	Reserved
IRIG-B Control Bits		
468	YEAR80	IRIG-B year information, binary-coded-decimal, add 80 if asserted
468	YEAR40	IRIG-B year information, binary-coded-decimal, add 40 if asserted
468	YEAR20	IRIG-B year information, binary-coded-decimal, add 20 if asserted
468	YEAR10	IRIG-B year information, binary-coded-decimal, add 10 if asserted
468	YEAR8	IRIG-B year information, binary-coded-decimal, add 8 if asserted
468	YEAR4	IRIG-B year information, binary-coded-decimal, add 4 if asserted
468	YEAR2	IRIG-B year information, binary-coded-decimal, add 2 if asserted
468	YEAR1	IRIG-B year information, binary-coded-decimal, add 1 if asserted
469	*	Reserved

Table 11.2 Row List of Relay Word Bits (Sheet 95 of 100)

Row	Name	Bit Description
469	*	Reserved
469	TUTCH	IRIG-B offset half-hour from UTC time, binary, add 0.5 if asserted
469	TUTC8	IRIG-B offset hours from UTC time, binary, add 8 if asserted
469	TUTC4	IRIG-B offset hours from UTC time, binary, add 4 if asserted
469	TUTC2	IRIG-B offset hours from UTC time, binary, add 2 if asserted
469	TUTC1	IRIG-B offset hours from UTC time, binary, add 1 if asserted
469	TUTCS	IRIG-B offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted, add otherwise
470	DST	Daylight-saving time
470	DSTP	IRIG-B daylight-saving time pending
470	LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added.
470	LPSECP	Leap second pending
470	TQUAL8	Time quality, binary, add 8 when asserted
470	TQUAL4	Time quality, binary, add 4 when asserted
470	TQUAL2	Time quality, binary, add 2 when asserted
470	TQUAL1	Time quality, binary, add 1 when asserted
471	DUMMY	0
471	*	Reserved
471	*	Reserved
471	*	Reserved
471	*	Reserved
471	*	Reserved
471	*	Reserved
471	*	Reserved
Time and Date Management		
472	SER_SET	Qualify serial IRIG-B time source
472	SER_RST	Disqualify serial IRIG-B time source
472	BNC_SET	Qualify BNC IRIG-B time source
472	BNC_RST	Disqualify BNC IRIG-B time source
472	BNC_OK	IRIG-B signal from BNC port is available and has sufficient quality
472	SER_OK	IRIG-B signal from Serial Port 1 is available and has sufficient quality
472	UPD_BLK	Block updating internal clock period and master time
472	BNC_BNP	Bad jitter on BNC port and the IRIG-B signal is lost afterwards
473	SER_BNP	Bad jitter on serial port and the IRIG-B signal is lost afterwards
473	BNC_TIM	A valid IRIG-B time source is detected on BNC port
473	SER_TIM	A valid IRIG-B time source is detected on serial port
473	PTP_TIM	A valid PTP time source is detected
473	PTP_SET	Qualify PTP time source
473	PTP_RST	Disqualify PTP time source
473	PTP_OK	PTP is available and has sufficient quality
473	P5ABSW	Port 5A or 5B has just become active

Table 11.2 Row List of Relay Word Bits (Sheet 96 of 100)

Row	Name	Bit Description
474	PTPSYNC	Synchronized to a high-quality PTP source
474	PTP_BNP	Bad jitter on PTP signals and the PTP signal is lost afterwards
474	SERSYNC	Synchronized to a high-quality serial IRIG source
474	BNCSYNC	Synchronized to a high-quality BNC IRIG source
474	*	Reserved
474	*	Reserved
474	*	Reserved
474	*	Reserved
Axion Status		
475	IO500OK	Communications are good with virtual interface board 500
475	IO400OK	Communications are good with virtual interface board 400
475	IO300OK	Communications are good with virtual interface board 300
475	*	Reserved
475	*	Reserved
475	*	Reserved
475	*	Reserved
475	*	Reserved
IEC 61850 Mode Control Bits		
476	SC850TM	SELOGIC control for IEC 61850 test mode
476	SC850BM	SELOGIC control for IEC 61850 blocked mode
476	SC850SM	SELOGIC control for IEC 61850 simulation mode
476	*	Reserved
476	*	Reserved
476	*	Reserved
476	*	Reserved
476	*	Reserved
IED Local Remote Bits		
480	LOC	Control authority at local (bay) level
480	SC850LS	SELOGIC control for control authority at station level
480	MLTLEV	Multi-level control authority
480	LOCSTA	Control authority at station level
480	*	Reserved
480	*	Reserved
480	*	Reserved
480	*	Reserved
Automation SELOGIC Conditioning Timers		
484	ACT08Q	Automation conditioning timer Output 08
484	ACT07Q	Automation conditioning timer Output 07
484	ACT06Q	Automation conditioning timer Output 06
484	ACT05Q	Automation conditioning timer Output 05
484	ACT04Q	Automation conditioning timer Output 04

Table 11.2 Row List of Relay Word Bits (Sheet 97 of 100)

Row	Name	Bit Description
484	ACT03Q	Automation conditioning timer Output 03
484	ACT02Q	Automation conditioning timer Output 02
484	ACT01Q	Automation conditioning timer Output 01
485	ACT16Q	Automation conditioning timer Output 16
485	ACT15Q	Automation conditioning timer Output 15
485	ACT14Q	Automation conditioning timer Output 14
485	ACT13Q	Automation conditioning timer Output 13
485	ACT12Q	Automation conditioning timer Output 12
485	ACT11Q	Automation conditioning timer Output 11
485	ACT10Q	Automation conditioning timer Output 10
485	ACT09Q	Automation conditioning timer Output 09
486	ACT24Q	Automation conditioning timer Output 24
486	ACT23Q	Automation conditioning timer Output 23
486	ACT22Q	Automation conditioning timer Output 22
486	ACT21Q	Automation conditioning timer Output 21
486	ACT20Q	Automation conditioning timer Output 20
486	ACT19Q	Automation conditioning timer Output 19
486	ACT18Q	Automation conditioning timer Output 18
486	ACT17Q	Automation conditioning timer Output 17
487	ACT32Q	Automation conditioning timer Output 32
487	ACT31Q	Automation conditioning timer Output 31
487	ACT30Q	Automation conditioning timer Output 30
487	ACT29Q	Automation conditioning timer Output 29
487	ACT28Q	Automation conditioning timer Output 28
487	ACT27Q	Automation conditioning timer Output 27
487	ACT26Q	Automation conditioning timer Output 26
487	ACT25Q	Automation conditioning timer Output 25
Local Bits 2		
488	LB40	Local Bit 40
488	LB39	Local Bit 39
488	LB38	Local Bit 38
488	LB37	Local Bit 37
488	LB36	Local Bit 36
488	LB35	Local Bit 35
488	LB34	Local Bit 34
488	LB33	Local Bit 33
489	LB48	Local Bit 48
489	LB47	Local Bit 47
489	LB46	Local Bit 46
489	LB45	Local Bit 45
489	LB44	Local Bit 44

Table 11.2 Row List of Relay Word Bits (Sheet 98 of 100)

Row	Name	Bit Description
489	LB43	Local Bit 43
489	LB42	Local Bit 42
489	LB41	Local Bit 41
490	LB56	Local Bit 56
490	LB55	Local Bit 55
490	LB54	Local Bit 54
490	LB53	Local Bit 53
490	LB52	Local Bit 52
490	LB51	Local Bit 51
490	LB50	Local Bit 50
490	LB49	Local Bit 49
491	LB64	Local Bit 64
491	LB63	Local Bit 63
491	LB62	Local Bit 62
491	LB61	Local Bit 61
491	LB60	Local Bit 60
491	LB59	Local Bit 59
491	LB58	Local Bit 58
491	LB57	Local Bit 57
Local Bit Supervision 2		
492	LB_SP40	Local Bit 40 supervision (SELOGIC control equation)
492	LB_SP39	Local Bit 39 supervision (SELOGIC control equation)
492	LB_SP38	Local Bit 38 supervision (SELOGIC control equation)
492	LB_SP37	Local Bit 37 supervision (SELOGIC control equation)
492	LB_SP36	Local Bit 36 supervision (SELOGIC control equation)
492	LB_SP35	Local Bit 35 supervision (SELOGIC control equation)
492	LB_SP34	Local Bit 34 supervision (SELOGIC control equation)
492	LB_SP33	Local Bit 33 supervision (SELOGIC control equation)
493	LB_SP48	Local Bit 48 supervision (SELOGIC control equation)
493	LB_SP46	Local Bit 46 supervision (SELOGIC control equation)
493	LB_SP45	Local Bit 45 supervision (SELOGIC control equation)
493	LB_SP44	Local Bit 44 supervision (SELOGIC control equation)
493	LB_SP43	Local Bit 43 supervision (SELOGIC control equation)
493	LB_SP42	Local Bit 42 supervision (SELOGIC control equation)
493	LB_SP41	Local Bit 41 supervision (SELOGIC control equation)
494	LB_SP56	Local Bit 56 supervision (SELOGIC control equation)
494	LB_SP55	Local Bit 55 supervision (SELOGIC control equation)
494	LB_SP54	Local Bit 54 supervision (SELOGIC control equation)
494	LB_SP53	Local Bit 53 supervision (SELOGIC control equation)
494	LB_SP52	Local Bit 52 supervision (SELOGIC control equation)
494	LB_SP51	Local Bit 51 supervision (SELOGIC control equation)

Table 11.2 Row List of Relay Word Bits (Sheet 99 of 100)

Row	Name	Bit Description
494	LB_SP50	Local Bit 50 supervision (SELOGIC control equation)
494	LB_SP49	Local Bit 49 supervision (SELOGIC control equation)
495	LB_SP64	Local Bit 64 supervision (SELOGIC control equation)
495	LB_SP63	Local Bit 63 supervision (SELOGIC control equation)
495	LB_SP62	Local Bit 62 supervision (SELOGIC control equation)
495	LB_SP61	Local Bit 61 supervision (SELOGIC control equation)
495	LB_SP60	Local Bit 60 supervision (SELOGIC control equation)
495	LB_SP59	Local Bit 59 supervision (SELOGIC control equation)
495	LB_SP58	Local Bit 58 supervision (SELOGIC control equation)
495	LB_SP57	Local Bit 57 supervision (SELOGIC control equation)
Local Bit Status 2		
496	LB_DP40	Local Bit 40 status display (SELOGIC control equation)
496	LB_DP39	Local Bit 39 status display (SELOGIC control equation)
496	LB_DP38	Local Bit 38 status display (SELOGIC control equation)
496	LB_DP37	Local Bit 37 status display (SELOGIC control equation)
496	LB_DP36	Local Bit 36 status display (SELOGIC control equation)
496	LB_DP35	Local Bit 35 status display (SELOGIC control equation)
496	LB_DP34	Local Bit 34 status display (SELOGIC control equation)
496	LB_DP33	Local Bit 33 status display (SELOGIC control equation)
497	LB_DP48	Local Bit 48 status display (SELOGIC control equation)
497	LB_DP47	Local Bit 47 status display (SELOGIC control equation)
497	LB_DP46	Local Bit 46 status display (SELOGIC control equation)
497	LB_DP45	Local Bit 45 status display (SELOGIC control equation)
497	LB_DP44	Local Bit 44 status display (SELOGIC control equation)
497	LB_DP43	Local Bit 43 status display (SELOGIC control equation)
497	LB_DP42	Local Bit 42 status display (SELOGIC control equation)
497	LB_DP41	Local Bit 41 status display (SELOGIC control equation)
498	LB_DP57	Local Bit 57 status display (SELOGIC control equation)
498	LB_DP56	Local Bit 56 status display (SELOGIC control equation)
498	LB_DP55	Local Bit 55 status display (SELOGIC control equation)
498	LB_DP54	Local Bit 54 status display (SELOGIC control equation)
498	LB_DP53	Local Bit 53 status display (SELOGIC control equation)
498	LB_DP52	Local Bit 52 status display (SELOGIC control equation)
498	LB_DP51	Local Bit 51 status display (SELOGIC control equation)
498	LB_DP50	Local Bit 50 status display (SELOGIC control equation)
498	LB_DP49	Local Bit 49 status display (SELOGIC control equation)
499	LB_DP64	Local Bit 64 status display (SELOGIC control equation)
499	LB_DP63	Local Bit 63 status display (SELOGIC control equation)
499	LB_DP62	Local Bit 62 status display (SELOGIC control equation)
499	LB_DP61	Local Bit 61 status display (SELOGIC control equation)
499	LB_DP60	Local Bit 60 status display (SELOGIC control equation)

Table 11.2 Row List of Relay Word Bits (Sheet 100 of 100)

Row	Name	Bit Description
499	LB_DP59	Local Bit 59 status display (SELOGIC control equation)
499	LB_DP58	Local Bit 58 status display (SELOGIC control equation)

SECTION 12

Analog Quantities

This section contains tables of the analog quantities available within the SEL-487B relay.

Use *Table 12.1* and *Table 12.2* as a reference for labels in this manual and as a resource for quantities you use in SELOGIC control equation relay settings. *Table 12.1* lists the analog quantities alphabetically, and *Table 12.2* groups the analog quantities by function.

Table 12.1 Analog Quantities Sorted Alphabetically (Sheet 1 of 3)

Label	Description	Units
3V0FII	Filtered instantaneous zero sequence voltage (imaginary)	Volts [V] (secondary)
3V0FIM	Filtered instantaneous zero sequence voltage (magnitude)	Volts [V] (secondary)
3V0FIR	Filtered instantaneous zero sequence voltage (real)	Volts [V] (secondary)
3V2FII	Filtered instantaneous negative sequence voltage (imaginary)	Volts [V] (secondary)
3V2FIM	Filtered instantaneous negative sequence voltage (magnitude)	Volts [V] (secondary)
3V2FIR	Filtered instantaneous negative sequence voltage (real)	Volts [V] (secondary)
51P01–51P21	51 element 01–21 pickup value	Amperes [A] (secondary)
51TD01–51TD21	51 element 01–21 time-dial setting	–
ACN01CV–ACN32CV	Automation SELOGIC counter current value	
ACN01PV–ACN32PV	Automation SELOGIC counter preset value	
ACT01DO–ACT32DO	Automation SELOGIC conditioning timer dropout time	seconds
ACT01PU–ACT32PU	Automation SELOGIC conditioning timer pickup time	seconds
ACTGRP	Active group setting	
AMV001–AMV256	Automation SELOGIC math variable	
AST01ET–AST32ET	Automation SELOGIC math sequencing timer elapsed time	seconds
AST01PT–AST32PT	Automation SELOGIC sequencing timer preset time	seconds
BNCDSJI	BNC port 100PPS data stream jitter	µs
BNCOTJF	Fast converging BNC port ON TIME marker jitter, coarse accuracy	µs
BNCOTJS	Slow converging BNC port ON TIME marker jitter, fine accuracy	µs
BNCTBTW	Time between BNC 100PPS pulses	µs
CUR_SRC	Current high-priority time source	
DC1	Station Battery 1 dc voltage	Volts [V]
DC1MAX	Maximum dc 1 voltage	Volts [V]
DC1MIN	Minimum dc 1 voltage	Volts [V]
DC1NE	Average negative-to-ground dc 1 voltage	Volts [V]
DC1PO	Average positive-to-ground dc 1 voltage	Volts [V]
DC1RI	AC ripple of dc 1 voltage	Volts [V]
DDOM	UTC Date, day of the month (1–31)	day

Table 12.1 Analog Quantities Sorted Alphabetically (Sheet 2 of 3)

Label	Description	Units
DDOW	UTC Date, day of the week (1-SU,.., 7-SA)	
DDOY	UTC Date, day of the year (1–366)	day
DLDOM	Local date, day of the month (1–31)	day
DLDOW	Local date, day of the week (1-SU,.., 7-SA)	
DLDOY	Local date, day of the year (1–366)	day
DLMON	Local date, month (1–12)	month
DLYEAR	Local date, year (2000–2200)	year
DMON	UTC date, month (1–12)	month
DYEAR	UTC date, year (2000–2200)	year
I01FA–I21FA	1-cycle average phase current (angle)	Degrees [°]
I01FIA–I21FIA	Filtered instantaneous phase current (angle)	Degrees [°]
I01FII–I21FII	Filtered instantaneous phase current (imaginary)	Amperes [A] (secondary)
I01FIM–I21FIM	Filtered instantaneous phase current (magnitude)	Amperes [A] (secondary)
I01FIR–I21FIR	Filtered instantaneous phase current (real)	Amperes [A] (secondary)
I01FM–I21FM	1-cycle average phase current (magnitude)	Amperes [A] (primary)
I850MOD	IEC 61850 mode/behavior status	N/A
IOPCZ1–IOPCZ3	Check Zone 1–3 operating current	per unit [pu]
IOPCZ1F–IOPCZ3F	1-cycle average Check Zone 1–3 operating current	per unit [pu]
IOP1–IOP6	Zone 1–6 operating current	per unit [pu]
IOP1F–IOP6F	1-cycle average Zone 1–6 operating current	per unit [pu]
IRTCZ1–IRTCZ3	Check Zone 1–3 Restraint current	per unit [pu]
IRTCZ1F–IRTCZ3F	1-cycle average Check Zone 1–3 restraint current	per unit [pu]
IRT1–IRT6	Zone 1–6 restraint current	per unit [pu]
IRT1F–IRT6F	1-cycle average Zone 1–6 restraint current	per unit [pu]
MB1A–MB7A	A Channel received MIRRORED BITS analog values	
MB1B–MB7B	B Channel received MIRRORED BITS analog values	
NEW_SRC	Selected high-priority time source	
PCN01CV–PCN32CV	Protection SELOGIC counter current value	
PCN01PV–PCN32PV	Protection SELOGIC counter preset value	
PCT01DO–PCT16DO	Protection SELOGIC conditioning timer dropout time	cycles
PCT01PU–PCT16PU	Protection SELOGIC conditioning timer pickup time	cycles
PMV01–PMV64	Protection SELOGIC math variable	
PST01ET–PST32ET	Protection SELOGIC sequencing timer elapsed time	cycles
PST01PT–PST32PT	Protection SELOGIC sequencing timer preset time	cycles
PTPDSJI	PTP 100PPS data stream jitter in µs	µs
PTPMCC	PTP master clock class enumerated value	N/A
PTPOFST	Raw clock offset between PTP master and relay time	ns
PTPOTJF	Fast converging PTP ON TIME marker jitter in µs, coarse accuracy	µs
PTPOTJS	Slow converging PTP ON TIME marker jitter in µs, fine accuracy	µs
PTPPORT	Active PTP port number	N/A
PTPSTEN	PTP port state enumerated value	

Table 12.1 Analog Quantities Sorted Alphabetically (Sheet 3 of 3)

Label	Description	Units
PTPTBTW	Time between PTP 100PPS pulses in µs	µs
RA001–RA256	Remote analogs	
RAO01–RAO64	Remote analog output	–
RLYTEMP	Relay temperature (temperature of the box)	°C (degrees Celsius)
SERDSJI	Serial port 100PPS data stream jitter	µs
SEROTJF	Fast converging serial port ON TIME marker jitter, coarse accuracy	µs
SEROTJS	Slow converging serial port ON TIME marker jitter, fine accuracy	µs
SERTBTW	Time between serial 100PPS pulses	µs
SQUAL	Synchronization accuracy of the selected high-priority time source	µs
THR	UTC time, hour (0–23)	hour
TLHR	Local time, hour (0–23)	hour
TLMIN	Local time, minute (0–59)	min
TLMSEC	Local time, milliseconds (0–999)	ms
TLNSEC	Local time, nanoseconds (0–999999)	ns
TLODMS	Local time of day in milliseconds (0–86400000)	ms
TLSEC	Local time, seconds (0–59)	seconds
TMIN	UTC time, minute (0–59)	minutes
TMSEC	UTC time, milliseconds (0–999)	ms
TNSEC	UTC time, nanoseconds (0–999999)	ns
TODMS	UTC time of day in milliseconds (0–86400000)	ms
TQUAL	Worst-case clock time error of the selected high-priority time source	seconds
TSEC	UTC time, seconds (0–59)	seconds
TUTC	Offset from local time to UTC time	hours
V1FII	Filtered instantaneous positive-sequence voltage (imaginary)	Volts [V] (secondary)
V1FIM	Filtered instantaneous positive-sequence voltage (magnitude)	Volts [V] (secondary)
V1FIR	Filtered instantaneous positive-sequence voltage (real)	Volts [V] (secondary)
V01FA–V03FA	1-cycle average phase voltage (angle)	Degrees [°]
V01FIA–V03FIA	Filtered instantaneous phase voltage (angle)	Degrees [°]
V01FII–F03FII	Filtered instantaneous phase voltage (imaginary)	Volts [V] (secondary)
V01FIM–V03FIM	Filtered instantaneous phase voltage (magnitude)	Volts [V] (secondary)
V01FIR–F03FIR	Filtered instantaneous phase voltage (real)	Volts [V] (secondary)
V01FM–V03FM	1-cycle average phase voltage (magnitude)	Kilovolts [kV] (primary)

Table 12.2 Analog Quantities Sorted by Function (Sheet 1 of 4)

Label	Description	Units
Current		
I*nn*FIM[a]	Phase-filtered instantaneous current magnitude	A (sec)
I*nn*FIA[a]	Phase-filtered instantaneous current angle	degrees
I*nn*FIR[a]	Phase-filtered instantaneous current (real)	A (sec)
I*nn*FII[a]	Phase-filtered instantaneous current (imaginary)	A (sec)
I*nn*FM[a]	Phase one-cycle average current magnitude	A (pri)

Table 12.2 Analog Quantities Sorted by Function (Sheet 2 of 4)

Label	Description	Units
I*nn*FA[a]	Phase one-cycle average current angle	degrees
IOP*k*[b]	Zone *k* operating current	pu
IOPCZ*p*[c]	Check Zone *p* operating current	pu
IRT*k*[b]	Zone *k* restraint current	pu
IRTCZ*p*[c]	Check Zone *p* restraint current	pu
IOP*k*F[b]	Zone *k* one-cycle average operating current	pu
IOPCZ*p*F[c]	Check Zone *p* one-cycle average operating current	pu
IRT*k*F[b]	Zone *k* one-cycle average restraint current	pu
IRTCZ*p*F[c]	Check Zone *p* one-cycle average restraint current	pu
Voltage		
V*mm*FIM[d]	Phase-filtered instantaneous voltage magnitude	V (sec)
V*mm*FIA[d]	Phase-filtered instantaneous voltage angle	degrees
V*mm*FIR[d]	Phase-filtered instantaneous voltage (real)	V (sec)
V*mm*FII[d]	Phase-filtered instantaneous voltage (imaginary)	V (sec)
V*mm*FM[d]	Phase one-cycle average voltage magnitude	kV (pri)
V*mm*FA[d]	Phase one-cycle average voltage angle	degrees
V1FIM	Positive-sequence filtered instantaneous voltage magnitude, V1	V (sec)
V1FIR	Positive-sequence filtered instantaneous voltage (real)	V (sec)
V1FII	Positive-sequence filtered instantaneous voltage (imaginary)	V (sec)
3V2FIM	Negative-sequence filtered instantaneous voltage magnitude, 3V2	V (sec)
3V2FIR	Negative-sequence filtered instantaneous voltage (real)	V (sec)
3V2FII	Negative-sequence filtered instantaneous voltage (imaginary)	V (sec)
3V0FIM	Zero-sequence filtered instantaneous voltage magnitude, 3V0	V (sec)
3V0FIR	Zero-sequence filtered instantaneous voltage (real)	V (sec)
3V0FII	Zero-sequence filtered instantaneous voltage (imaginary)	V (sec)
DC1	Filtered dc monitor voltage	V
DC1PO	Average positive-to-ground dc voltage	V
DC1NE	Average negative-to-ground dc voltage	V
DC1RI	AC ripple of dc voltage (peak-to-peak)	V
DC1MIN	Minimum dc voltage	V
DC1MAX	Maximum dc voltage	V
Database Structure		
RA001–RA256	Remote analogs from Ethernet card	N/A
Output Settings		
RAO001–RAO064	Remote analog output	N/A
Date and Time		
TODMS	UTC time of day in milliseconds (0–86399999)	ms
THR	UTC time, hour (0–23)	hours
TMIN	UTC time, minute (0–59)	minutes
TSEC	UTC time, seconds (0–59)	seconds
TMSEC	UTC time, milliseconds (0–999)	ms

Table 12.2 Analog Quantities Sorted by Function (Sheet 3 of 4)

Label	Description	Units
TNSEC	UTC time, nanoseconds (0–999999)	ns
DDOW	UTC date, day of the week (Encoded value: 1 = Sun, 2 = Mon, 3 = Tue, 4 = Wed, 5 = Thu, 6 = Fri, 7 = Sat)	n/a
DDOM	UTC date, day of the month (1–31)	day
DDOY	UTC date, day of the year (1–366)	day
DMON	UTC date, month (1–12)	month
DYEAR	UTC date, year (2000–2200)	year
TLODMS	Local time of Day in Milliseconds (0–86400000)	ms
TLHR	Local time, hour (0–23)	hr
TLMIN	Local time, minute (0–59)	min
TLSEC	Local time, seconds (0–59)	s
TLMSEC	Local time, milliseconds (0–999)	ms
TLNSEC	Local time, nanoseconds (0–999999)	ns
DLDOW	Local date, day of the week (1-SU,.., 7-SA)	n/a
DLDOM	Local date, day of the month (1–31)	day
DLDOY	Local date, day of the year (1–366)	day
DLMON	Local date, month (1–12)	month
DLYEAR	Local date, year (2000–2200)	year
High-Priority Time Analogs		
TUTC	Offset from local time to UTC time	hr
TQUAL	Worst-case clock time error of the selected high-priority time source	s
NEW_SRC	Selected high-priority time source	n/a
CUR_SRC	Current high-priority time source	n/a
SQUAL	Synchronization accuracy of the selected high-priority time source	µs
BNCDSJI	BNC port 100PPS data stream jitter	µs
BNCOTJS	Slow converging BNC port ON TIME marker jitter, fine accuracy	µs
BNCOTJF	Fast converging BNC port ON TIME marker jitter, coarse accuracy	µs
BNCTBTW	Time between BNC 100PPS pulses	µs
SERDSJI	Serial port 100PPS data stream jitter	µs
SEROTJS	Slow converging serial port ON TIME marker jitter, fine accuracy	µs
SEROTJF	Fast converging serial port ON TIME marker jitter, coarse accuracy	µs
SERTBTW	Time between serial 100PPS pulses	µs
MIRRORED BITS Communications		
MB1A–MB7A	MIRRORED BITS communications Channel A received analog values	n/a
MB1B–MB7B	MIRRORED BITS communications Channel B received analog values	n/a
SELOGIC and Automation Elements		
PMV01–PMV64	Protection SELOGIC control equation math variable	n/a
PCT01PU–PCT16PU	Protection conditioning timer pickup time	cycles
PCT01DO–PCT16DO	Protection conditioning timer dropout time	cycles
PST01ET–PST32ET	Protection sequencing timer elapsed time	cycles
PST01PT–PST32PT	Protection sequencing timer preset time	cycles

Table 12.2 Analog Quantities Sorted by Function (Sheet 4 of 4)

Label	Description	Units
PCN01CV–PCN32CV	Protection counter current value	n/a
PCN01PV–PCN32PV	Protection counter preset value	n/a
AMV001–AMV256	Automation SELOGIC control equation math variable	n/a
ACT01PU–ACT32PU	Automation conditioning timer pickup time	seconds
ACT01DO–ACT32DO	Automation conditioning timer dropout time	seconds
AST01ET–AST32ET	Automation sequencing timer elapsed time	seconds
AST01PT–AST32PT	Automation sequencing timer preset time	seconds
ACN01CV–ACN32CV	Automation counter current value	n/a
ACN01PV–ACN32PV	Automation counter preset value	n/a
Setting Group		
ACTGRP	Active group setting	n/a
51 Elements		
51P*mm*[d]	51 element *mm* pickup value	A (sec)
51TD*mm*[d]	51 element *mm* time-dial setting	n/a
Auxiliary Channels		
RLYTEMP	Relay temperature (temperature of the box)	°C (degrees Celsius)
IEEE 1588 PTP Status		
PTPDSJI	PTPDSJI PTP 100PPS data stream jitter in µs	µs
PTPMCC	PTP master clock class enumerated value	N/A
PTPOTJS	PTPOTJS Slow converging PTP ON TIME marker jitter in µs, fine accuracy	µs
PTPOTJF	PTPOTJF Fast converging PTP ON TIME marker jitter in µs, coarse accuracy	µs
PTPOFST	PTPOFST Raw clock offset between PTP master and relay time	ns
PTPPORT	Active PTP port number	N/A
PTPTBTW	PTPTBTW Time between PTP 100PPS pulses in µs	µs
PTPSTEN	PTPSTEN PTP Port State enumerated value	
IEC 61850 Mode/Behavior Status		
I850MOD	IEC 61850 mode/behavior status	N/A

[a] nn = 01–21.
[b] k = 1–6.
[c] p = 1–3.
[d] mm = 01–03.

APPENDIX A

Firmware, ICD File, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front-panel HMI. The status report displays the Firmware Identification (FID) number.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

NOTE: The SEL-487B-1 relay (firmware versions R3xx) is incompatible with the SEL-487B-0 and SEL-487B-2 relays (firmware versions R1xx and R4xx). Do not attempt to load firmware on incompatible hardware.

A standard release is identified by a change in the R-number of the device FID number.

Existing firmware:

FID=SEL-487B-**R302**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-487B-**R303**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID number.

Existing firmware:

FID=SEL-487B-R307-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-487B-R307-**V1**-Z001001-Dxxxxxxxx

The settings software driver for an associated firmware is identified by the Z-number of the device FID number.

FID=SEL-487B-R307-V0-**Z001**001-Dxxxxxxxx

The date code is after the D. For example, the following is firmware version number R302, date code November 7, 2011.

FID=SEL-487B-R302-V0-Z007005-**D20111107**

Similarly, the device SELBOOT firmware revision (BFID) will be reported as:

BFID=SLBT-4XX-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx

Revision History

Table A.1 lists the firmware versions, revision descriptions, and corresponding instruction manual date codes.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with "[Cybersecurity]". Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with "[Cybersecurity Enhancement]".

Table A.1 Firmware Revision History (Sheet 1 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-1-R319-V0-Z018007-D20250214	➤ Resolved an issue where the relay may not synchronize to a PTP time source when NETMODE = ISOLATEIP and PTPTR = LAYER2. This issue is only applicable if the relay receives PTP messages on the non-designated IP port. ➤ Resolved an issue where the relay could incorrectly indicate the time synchronization status when the relay is transitioning between two Grandmaster clock sources and the active clock source is no longer available. This does not apply when both clocks are globally time-synchronized. ➤ Resolved an issue in the previous firmware version, where PTP messages were not processed on one of the ports when NETMODE = PRP and PTPPRO = C37.238. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2.1. ➤ Added support for deadband configuration, including the dbRef, dbAngRef, zeroDbRef, and zeroDb attributes, according to IEC 61850-7-3 Edition 2.1. ➤ Added support for indexed buffered and unbuffered MMS reports. ➤ Added support to allow the sAddr attribute to replace the esel:datasrc attribute in ICD files to improve compatibility with third-party system configuration tools. ➤ Added support for the remote bit pulse configuration according to IEC 61850-7-3. ➤ Modified the firmware to update the settings group control block (SGCB) and the LTRK logical node's last activation time-stamp attribute for Group settings switches that were not initiated by MMS and for changes to the active Group settings. ➤ Improved support for IEC 61850 Edition 1 MMS clients. ➤ Modified the firmware to allow the relay to accept GOOSE data with invalid or questionable validity. ➤ Modified the firmware to allow the GOOSE quality attribute to map to a remote analog. Additionally, the processed quality indicator now can be mapped to a virtual bit. ➤ Modified the firmware to accept retransmitted GOOSE messages with the test flag set to TRUE when the relay transitions into Test Mode. ➤ Modified the firmware to provide the IEC 61850 library version (LIB61850ID) to the LPHD logical node. ➤ Modified the IEC 61850 hierarchical relationship for the XCBR.Loc and XSWI.Loc data objects to exclude their inheritance from LLN0.Loc and CSWI.Loc.	20250214

Table A.1 Firmware Revision History (Sheet 2 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Enhanced support for the IEC 61850 logical device hierarchy, which enables additional levels of inheritance. This includes support for the Loc and LocSta data objects. ➤ Resolved an issue where the relay would set the validity attribute to invalid in GOOSE messages when resuming publications from Off to On mode. This is only applicable when EOFFMTX = N and the relay receives a CID file while in Off mode.	
SEL-487B-1-R318-V1-Z018007-D20240509	Includes all the functions of SEL-487B-1-R318-V0-Z018007-D20231207 with the following addition: ➤ [Cybersecurity] Resolved an issue where a maliciously crafted web request sent to the relay from an unauthenticated user could cause a diagnostic restart. By design, three diagnostic restarts within 7 days cause the relay to disable. This issue can only be triggered when the Port 5 setting EHTTP is configured to Y.	20240509
SEL-487B-1-R318-V0-Z018007-D20231207	➤ Resolved an issue where the relay could become unresponsive after an Ethernet card hardware failure. ➤ Resolved a file transfer issue that could result in a loss of SEL Fast Message communications. ➤ Resolved a PTP issue where the TGLOBAL Relay Word bit could incorrectly assert during the transition from a local to global time source. ➤ Resolved an issue where IEC 61850 Simulation Mode is not retained following a relay power cycle. This is applicable when Simulation Mode is entered using IEC 61850 MMS. ➤ Resolved an issue where MMS time stamps do not match the SER time stamps for Relay Word bit state changes during a settings or IEC 61850 Mode/Behavior change. ➤ Resolved an issue where a change of an stSeld (status selector) attribute may not generate an MMS buffered or unbuffered report. ➤ Modified the default value of the settings ESERDEL, SRDLCNT, and SRDLTIM to Y, 10, and 0.5, respectively. ➤ Modified the default value of the setting ERDIG from S to A. ➤ Modified the synchronization status values reported in IEC 61850 LTMS.TmSyn.stVal to accurately reflect the definitions in IEC 61850-9-2. ➤ Modified the firmware to improve the IEC 61850 time accuracy value LTMS.TmAcc.stVal. ➤ Enhanced the SER to automatically include an entry when entering or exiting IEC 61850 Simulation Mode. ➤ Added support for MMS buffered and unbuffered report reservation. ➤ Modified the firmware to report zero for the Time Quality indicator code in the IEEE C37.111-2013 COMTRADE configuration file when the relay is connected to a PTP clock that is locked to a satellite-synchronized clock source.	20231207
SEL-487B-1-R317-V1-Z017007-D20230830	Includes all the functions of SEL-487B-1-R317-V0-Z017007-D20220523 with the following additions: ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable.	20230830

Table A.1 Firmware Revision History (Sheet 3 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication. ➤ Improved the performance of protection and automation latch bits during diagnostic restart. ➤ Resolved a rare issue that could prevent the relay from restarting after a diagnostic failure.	
SEL-487B-1-R317-V0-Z017007-D20220523	➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Added support for new communications Ethernet card. ➤ Added support for PTP Power Utility Automation profile (IEC/IEEE 61850-9-3). ➤ Modified the firmware to remove the 1 µs accuracy requirements to assert Relay Word Bit TLOCAL. ➤ Modified the firmware to allow for a seamless transition from TGLOBAL to TLOCAL. ➤ Added IEC 61850 and PTP settings to COMTRADE event reports. ➤ Resolved an issue where PTP time synchronization could be lost in PRP network applications. ➤ Modified the firmware to address SER time-stamping accuracy and IEC 61850 mode control change following a power cycle. ➤ Modified the firmware to address an issue where the Simulation mode status SimSt.stVal for the LGOS logical node does not transition from TRUE to FALSE for a change in the LPHD logical node Sim.stVal.	20220523
SEL-487B-1-R316-V3-Z016007-D20230830	Includes all the functions of SEL-487B-1-R316-V2-Z016007-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	20230830
SEL-487B-1-R316-V2-Z016007-D20220630	Includes all the functions of SEL-487B-1-R316-V1-Z016007-D20211203 with the following addition: ➤ Added support for new Ethernet communications card.	20220630

Table A.1 Firmware Revision History (Sheet 4 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-1-R316-V1-Z016007-D20211203	Includes all the functions of SEL-487B-1-R316-V0-Z016007-D20210514 with the following additions: ➤ Resolved an issue where an MMS client may report the relay as offline when multiple MMS clients are simultaneously accessing reports. ➤ Resolved an issue where an MMS client may not be able to retrieve file attributes associated with IEEE C37.111-2013 COMTRADE event files.	20211203
SEL-487B-1-R316-V0-Z016007-D20210514	➤ Added settings EACC, E2AC, and EPAC to support port access control using SELOGIC control equations. ➤ Added conditioning timers to Automation SELOGIC. ➤ Improved processing consistency of breaker control bits in Automation SELOGIC. ➤ Improved Automation SELOGIC timer accuracy. Automation SELOGIC timer accuracy is now within ± 1% or ± 1 s for values up to 1 month. ➤ Enhanced **STA A** and **CST** command responses to include high-accuracy PTP time status. ➤ Modified firmware by adding warm start (settings change, group switch) ride-through capability for control inputs. In this release, previously asserted control inputs do not change state during warm start. ➤ Resolved a rare issue where the SELBOOT checksum could be reported incorrectly in the **VER** command response. ➤ Reduced maximum relay automatic diagnostic restart response time. ➤ Enhanced the internal fault detection logic associated with the differential element. ➤ Increased the number of available display points to 192. ➤ Increased the number of available local bits to 64. ➤ Increased the number of available DNP binary output points to 160. ➤ Improved received GOOSE message processing speed for relay virtual bits mapped to GOOSE binary data. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. ➤ Enhanced IEC 61850 processing to indicate when the invalid quality attribute is set in received GOOSE messages. ➤ Added SELOGIC variable SC850SM to change the IEC 61850 simulation mode of the relay. ➤ Corrected an issue where the Mode, Beh, and Health quality.validity = good is not maintained when Mode = OFF. ➤ Added IEC 61850 simulation mode indication to the **STA** and **GOO** commands.	20210514
SEL-487B-1-R315-V4-Z015006-D20230830	Includes all the functions of SEL-487B-1-R315-V3-Z015006-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service.	20230830

Table A.1 Firmware Revision History (Sheet 5 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	
SEL-487B-1-R315-V3-Z015006-D20220630	Includes all the functions of SEL-487B-1-R315-V2-Z015006-D20210428 with the following addition: ➤ Added support for new Ethernet communications card.	20220630
SEL-487B-1-R315-V2-Z015006-D20210428	Includes all the functions of SEL-487B-1-R315-V1-Z015006-D20201009 with the following additions: ➤ Resolved an issue where uncommon and repetitive command line operations can cause a relay restart when the IEC 61850 GOOSE function is enabled. ➤ Enhanced the relay's logic to use both the BMCA algorithm and the network time inaccuracy check in power profile to choose the best Grandmaster clock on a PRP network.	20210428
SEL-487B-1-R315-V1-Z015006-D20201009	Includes all the functions of SEL-487B-1-R315-V0-Z015006-D20200229 with the following additions: ➤ Enhanced output contact behavior following a power cycle while the relay is in IEC 61850 "Blocked" or "Test/Blocked" operating mode. ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201009
SEL-487B-1-R315-V0-Z015006-D20200229 **NOTE:** This firmware release only supports .zds digitally signed firmware files. SELBOOT R300 or newer is required for this and all new firmware versions. See Appendix B: Firmware Upgrade Instructions in the SEL-400 Series Relays Instruction Manual for more information.	➤ Modified firmware to enable DNP and IEC 61850 breaker control only when the circuit breaker jumper is installed. ➤ Added the ability to remotely upgrade relay firmware over an Ethernet network. ➤ Improved relay response to three consecutive failed login attempts within a one-minute interval to pulse the BADPASS and SALARM Relay Word bits for all communication interfaces. ➤ Enhanced relay self-tests to detect current or voltage magnitudes that exceed the maximum analog-to-digital converter output and perform an automatic diagnostic restart. ➤ Enhanced FTP Network Security. ➤ Modified firmware to retain stored data after successful reads of SER.TXT, CSER.TXT, PRO.TXT, and CPRO.TXT over Ethernet connections. ➤ Modified firmware to support all printable ASCII characters in the password entry HMI screen. ➤ Modified firmware to interpret Group settings RTDI, OPDI, CZRTDI, and CZOPDI as peak values instead of rms. ➤ Modified firmware to increment the state number (stNum) in GOOSE messages for all changes in quality. ➤ Modified firmware to support default profile for Precision Time Protocol when NETMODE = PRP. ➤ Added support for new IEC 61850 control and settings common data classes. ➤ Enhanced wildcard parsing used in the YMODEM file-transfer operations. ➤ Improved reference angle selection for metering.	20200229

Table A.1 Firmware Revision History (Sheet 6 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-1-R314-V4-Z014006-D20230830	Includes all the functions of SEL-487B-1-R314-V3-Z014006-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	20230830
SEL-487B-1-R314-V3-Z014006-D20220630	Includes all the functions of SEL-487B-1-R314-V2-Z014006-D20201009 with the following addition: ➤ Added support for new Ethernet communications card.	20220630
SEL-487B-1-R314-V2-Z014006-D20201009	Includes all the functions of SEL-487B-1-R314-V1-Z014006-D20191210 with the following additions: ➤ Enhanced output contact behavior following a power cycle while the relay is in IEC 61850 "Blocked" or "Test/Blocked" operating mode. ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201009
SEL-487B-1-R314-V1-Z014006-D20191210	Includes all the functions of SEL-487B-1-R314-V0-Z014006-D20181115 with the following addition: ➤ Modified processing of pulsed Relay Word bits.	20191210
SEL-487B-1-R314-V0-Z014006-D20181115	➤ Added IEC 61850 standard operating modes, including TEST, TEST-BLOCKED, ON, ON-BLOCKED, and OFF. ➤ Modified Ethernet communications to automatically correct a loss of synchronization between the communications subsystem and the other relay subsystems. ➤ Modified the relay to prevent rare cases of a CID file reverting to the previous version of the file during a firmware upgrade. ➤ Improved the processing consistency of remote and local control bits with a one-processing interval pulse width. ➤ Improved error handling for the Ethernet interface. ➤ Modified the firmware to verify that Precision Time Protocol (PTP) is enabled (EPTP = Y) as an initial validity check for all PTP messages being received by the relay. ➤ Modified MMS file reads to allow mixed-case file names. ➤ Improved backward compatibility with certain MMS clients. ➤ Enhanced dc offset processing. ➤ Modified the firmware to prevent settings read/write issues when Port 5 is disabled and an IEC 61850 configuration file is loaded.	20181115

Table A.1 Firmware Revision History (Sheet 7 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Modified the firmware to address an issue in retransmitted TCP/IP frames with PRP trailer, which in previous firmware may have been discarded on reception. ➤ Added support for IEEE C37.111-2013 COMTRADE. ➤ Added the company name Global setting (CONAM). ➤ Added the open-phase detection setting (OPHDO) under advanced Global settings. ➤ Modified the VECTOR command (**VEC**) to show all Sequential Events Recorder (SER) entries.	
SEL-487B-1-R313-V3-Z013005-D20230830	Includes all the functions of SEL-487B-1-R313-V2-Z013005-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	20230830
SEL-487B-1-R313-V2-Z013005-D20220630	Includes all the functions of SEL-487B-1-R313-V1-Z013005-D20201009 with the following addition: ➤ Added support for new Ethernet communications card.	20220630
SEL-487B-1-R313-V1-Z013005-D20201009	Includes all the functions of SEL-487B-1-R313-V0-Z013005-D20180105 with the following addition: ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201009
SEL-487B-1-R313-V0-Z013005-D20180105	➤ Updated firmware ID (FID) to support ACSELERATOR QuickSet SEL-5030 Software with features added in release R312-V0.	20180105
SEL-487B-1-R312-V3-Z012005-D20230830	Includes all the functions of SEL-487B-1-R312-V2-Z012005-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens.	20230830

Table A.1 Firmware Revision History (Sheet 8 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ [Cybersecurity] Resolved a rare issue where continuous event report polling requests from a communication processor can cause the relay to disable. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	
SEL-487B-1-R312-V2-Z012005-D20220630	Includes all the functions of SEL-487B-1-R312-V1-Z012005-D20201009 with the following addition: ➤ Added support for new Ethernet communications card.	20220630
SEL-487B-1-R312-V1-Z012005-D20201009	Includes all the functions of SEL-487B-1-R312-V1-Z012005-D20201009 with the following addition: ➤ Resolved an extremely rare issue that could cause the relay to perform a diagnostic restart when configured for Parallel Redundancy Protocol (NETMODE = PRP) and the relay received abnormal Ethernet traffic.	20201009
SEL-487B-1-R312-V0-Z012005-D20171008 NOTE: ACSELERATOR QuickSet SEL-5030 Software does not include some of the added features, analog quantities, or Relay Word bits for this release.	➤ Added a new analog quantity, PTPMCC, to indicate the clock class of the PTP master. ➤ Enhanced memory read diagnostics. ➤ DNP3 data are now reported with a LOCAL_FORCED flag when they have been overridden through use of the TEST DB2 command. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2. ➤ Modified the relay response to an MMS identify request so that it will respond with the firmware ID (FID) string. ➤ Improved MMS file services performance with successive file transfers. ➤ Enhanced wild card parsing used in MMS file transfer operations. ➤ Modified the **ID** command to display a string that uniquely identifies the IEC 61850 firmware present in the relay. ➤ Modified firmware to replace non-printable characters with question marks in settings that are sent to the front panel of the HMI. ➤ Modified firmware to allow SNTPPIP to be set to 0.0.0.0 when ESNTP = BROADCAST. ➤ DNP3 data are now reported with an overridden flag when they have been overridden using the **TEST DB2** command. ➤ Modified firmware to allow all settings changes when the relay is disabled. ➤ The **ETH** command now shows both MAC addresses ➤ Modified firmware to indicate an enabled or disable transition of the IEC 61850 Buffer Report Control Block (BRCB) by sending an overflow flag on the next report sent after the transition. ➤ Modified firmware to avoid false GOOSE out of sequence errors while in PRP mode. ➤ Modified firmware to allow the relay to synchronize to an external time source more responsively. ➤ Modified firmware to display the history region correctly. ➤ IEC 61850 Product ICD File Datasets and Report Names changed to be consistent with other products. ➤ Increased the default MMS inactivity timeout from 2 to 15 minutes. ➤ Modified IEEE-1588 PTP power profile to be supported in Parallel Redundancy Protocol (PRP) mode.	20171008

Table A.1 Firmware Revision History (Sheet 9 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-1-R311-V4-Z012005-D20230830	Includes all the functions of SEL-487B-1-R311-V3-Z012005-D20220630 with the following additions: ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ [Cybersecurity] Improved web server security against session hijacking. ➤ [Cybersecurity] Improved web server security against intentionally large files causing denial of service. ➤ [Cybersecurity] Improved web server security against cross-site scripting and misuse of session tokens. ➤ Improved the firmware so that access levels defined by the MAXACC setting apply correctly for MMS setting file transfers. Previously, MMS file transfer access was controlled only by MMS authentication.	20230830
SEL-487B-1-R311-V3-Z012005-D20220630	Includes all the functions of SEL-487B-1-R311-V2-Z012005-D20171021 with the following addition: ➤ Added support for new Ethernet communications card.	20220630
SEL-487B-1-R311-V2-Z012005-D20171021	Includes all the functions of SEL-487B-1-R311-V1-Z012005-D20170809 with the following addition: ➤ Enhanced memory read diagnostics.	20171021
SEL-487B-1-R311-V1-Z012005-D20170809	Includes all the functions of SEL-487B-1-R311-V0-Z012005-D20170329 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170809
SEL-487B-1-R311-V0-Z012005-D20170329	➤ Added an event report digital setting, ERDIG, which can be set to S (some) or A (all) to allow the option for all Relay Word bits to be added to COMTRADE event reports. ➤ Improved Simple Network Time Protocol (SNTP) accuracy to ± 1 ms in an ideal network. ➤ Added time-domain link (TiDL) technology. ➤ Modified firmware to prevent delays in periodic MMS reports. ➤ Modified firmware to allow the MMS inactivity time-out to be turned off.	20170329
SEL-487B-1-R310-V2-Z011005-D20171021	Includes all the functions of SEL-487B-1-R310-V1-Z011005-D20170820 with the following addition: ➤ Enhanced memory read diagnostics.	20171021
SEL-487B-1-R310-V1-Z011005-D20170820	Includes all the functions of SEL-487B-1-R310-V0-Z011005-D20160718 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170820
SEL-487B-1-R310-V0-Z011005-D20160718	➤ Added support for IEEE 1588-2008 Precision Time Protocol (PTP) time synchronization. ➤ Added ordering option to select Ethernet Ports 5A/5B for PTP. ➤ Added EVEMOD*n* (where *n* = 1–6 for DNP LAN/WAN, or empty for DNP serial) setting to force the relay to start in single- or multiple-event mode. ➤ Enhanced front-panel operations to show settings warnings, in addition to settings errors already displayed, during settings changes. ➤ Modified DNP Object 0, Variation 242 to report the firmware V-number.	20160718

Table A.1 Firmware Revision History (Sheet 10 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Improved MIRRORED BITS performance under a high level of GOOSE traffic. ➤ Improved relay startup time. ➤ Modified Virtual Bits to reset upon a successful CID file download. ➤ Modified GOOSE subscription to update data after the messages transition from bad to good quality. ➤ Modified the handling of a leap year when the relay setting and clock disagree. ➤ Modified the **TEST DB2** functionality to override Relay Word bits that are in the Sequential Events Recorder (SER). ➤ Modified the **TEST DB2 OFF** command to disable the overridden remote analog output and digital values in IEC 61850 GOOSE messages.	
SEL-487B-1-R309-V3-Z010005-D20170820	Includes all the functions of SEL-487B-1-R309-V2-Z010005-D20160323 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170820
SEL-487B-1-R309-V2-Z010005-D20160323	Includes all the functions of SEL-487B-1-R309-V1-Z010005-D20151102 with the following addition: ➤ Modified firmware to initialize all instances of Check Zone settings when multiple settings groups are sent to the relay or following a group switch operation.	20160323
SEL-487B-1-R309-V1-Z010005-D20151102	➤ Improved firmware upgrade process to correctly initialize Check Zone settings within Zone Configuration settings group and the Breaker and Disconnect Inputs SELOGIC equations within Global settings group.	20151102
SEL-487B-1-R309-V0-Z010005-D20150421	➤ Added local time and date analog quantities. ➤ Added Isolated IP mode (NETMODE = ISOLATEIP) that permits IEC 61850 GOOSE messages on two ports, but restricts IP traffic to just one port. ➤ Added the option to change settings groups with IEC 61850. ➤ Changed Group and Global settings so they are now available via the front-panel HMI. ➤ Added pulsed remote bits in Automation SELOGIC. ➤ Added support for the stSeld attribute in IEC 61850 SBO controls. ➤ Added the LPHD.Sim logical node so the relay will accept GOOSE messages with the test flag asserted. ➤ Updated the profile and compressed profile commands (**PRO** and **CPRO**, respectively) to display the available analog signal profiling records regardless of the state of the signal profile enable (SPEN) setting. ➤ Enhanced the embedded HTTP server user interface to be consistent with other SEL relays. ➤ Enhanced the report time records to save the active UTC offset (UTCOFF) value with each report. Now, when the relay collects a report, it assigns the time stamp based on the UTC time and the UTCOFF value at the time the relay stores the report. ➤ Improved Port 5 functionality to disable auto-messages when the auto-messages setting is equal to no (AUTO=N). ➤ Changed the IEC 61850 Configured IED Description (CID) file to support non-Relay Word bit binary elements included in a GOOSE message. ➤ Modified the relay to support MMS file transfer service even if the relay contains an invalid CID file.	20150421

Table A.1 Firmware Revision History (Sheet 11 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Modified the firmware to prevent IP traffic from becoming unresponsive when the Parallel Redundancy Protocol (PRP) is enabled. ➤ Changed the Station ID label in the COMTRADE configuration (.cfg) file to prevent non-alphanumeric characters per the COMTRADE IEEE C37.111-1999 standard. ➤ Reset the port timeout on transmitted Telnet messages. ➤ Enhanced performance to ensure that the relay does not become unresponsive when MIRRORED BITS is used on the front port. In previous firmware, the relay could become unresponsive on rare occasions if the front port is set to MIRRORED BITS protocol. ➤ Modified the embedded HTTP server web access to always require a valid relay Access Level 1 (ACC) password. ➤ Clarified the message generated by the relay in response to an invalid CID file. ➤ Closed an outgoing UDP port that was reported as open by a port scanner when IEC 61850 was enabled. ➤ Removed the alias names from the compressed event report (CEV) and compressed ASCII summary (CSU) headers to match the compressed ASCII (CAS) header labels. Added new labels ILAB*nn* (*nn* = 01–21) and VLAB*mm* (*mm* = 01–03) to reference to the alias names. ➤ Modified firmware to correctly process the last row of Relay Word bits in the four samples per cycle event reports. ➤ Improved relay performance during certain incorrect memory reads. ➤ Modified firmware to correctly process the last row of Relay Word bits in the four samples per cycle compressed event reports. ➤ Changed the result of a SELOGIC equation math error from NAN (not a number) to the previously stored valid result.	
SEL-487B-1-R308-V0-Z010005-D20150421	**Note:** This firmware did not production release.	—
SEL-487B-1-R307-V1-Z009005-D20170820	Includes all the functions of SEL-487B-1-R307-V0-Z009005-D20131014 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170820
SEL-487B-1-R307-V0-Z009005-D20131014	➤ Improved the accuracy of GOOSE message data time stamps. ➤ Closed an outgoing UDP port that was reported as open by a port scanner when IEC 61850 was enabled. ➤ Added MMS file transfer. ➤ Included the DNP settings labels in DNP Maps 1–5. ➤ Added support for MMS authentication. ➤ Added Parallel Redundancy Protocol (PRP). ➤ Increased the number of binary outputs to 100 for DNP map. ➤ Increased the number of buffered and unbuffered reports to seven for MMS reporting. ➤ Increased the number of GOOSE message subscriptions to 128. ➤ Improved ability to select subscribed GOOSE message attributes for control of relay rejection or acceptance of incoming GOOSE messages. ➤ Implemented multiple updates to the DNP3 control point operations.	20131014

Table A.1 Firmware Revision History (Sheet 12 of 12)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-487B-1-R306-V0-Z007005-D20130606	➤ Corrected the calculation of SELOGIC Execution Capacity. ➤ Updated IRIG output to report local time instead of UTC time. ➤ Fixed an issue of rejected IP packets with VLAN ID tags.	20130606
SEL-487B-1-R305-V0-Z007005-D20121221	➤ Corrected an issue that causes Fast Message Meter data to be reported incorrectly. These data are made available in communications processors as METER2 data.	20121221
SEL-487B-1-R304-V0-Z007005-D20120828	Note: This firmware version was not production released. See R305, above, which also includes the enhancements in R304. ➤ Added Connectorized option.	20120828
SEL-487B-1-R303-V0-Z007005-D20120508	➤ Added DNP1-5 to **HELP SET** command. ➤ Added DNP to **HELP COPY** command. ➤ Improved relay diagnostic response. ➤ Fixed problem when maximum LER setting would be rejected upon subsequent **SET R** command to relay. ➤ Reduced DNP current cut off from 5.0% to 0.5% of nominal current. ➤ Enhanced performance to ensure the relay does not become unresponsive when connected to another relay through the serial port with automessaging enabled on both ports (AUTO=Y).	20120508
SEL-487B-1-R302-V0-Z007005-D20111107	➤ Initial version.	20111107

SELBOOT

NOTE: R2xx SELBOOT versions only support serial-port firmware upgrades with .s19 or .z19 firmware upgrade files. R3xx SELBOOT versions only support .zds digitally signed firmware upgrade files over a serial or Ethernet connection. If upgrading from R2xx SELBOOT to R3xx SELBOOT, load the .s19 file. Do not load a .zds file when using R2xx SELBOOT.

SELBOOT is a firmware package inside the relay that handles hardware initialization and provides the functions needed to support firmware upgrades. To determine the SELBOOT version, view the status report by using the serial port **STATUS** command or the front panel. The device will report the SELBOOT firmware identification (BFID) label as:

BFID=SLBT-4XX-Rxxx-Vx-Zxxxxxx-Dxxxxxxxx

Table A.2 lists the SELBOOT releases used with the SEL-487B and revision descriptions. The most recent SELBOOT revision is listed first.

Table A.2 SELBOOT Revision History

SELBOOT Firmware Identification (BFID)	Summary of Revisions
SLBT-4XX-R300-V0-Z001002-D20200229	➤ Modified SELBOOT to support digitally signed firmware.
SLBT-4XX-R209-V0-Z001002-D20150130	➤ Modified the firmware to prevent an issue that could cause the relay to become unresponsive.
SLBT-4XX-R208-V0-Z001002-D20120220	➤ Added support for a new main board variant.
SLBT-4XX-R207-V0-Z001002-D20110922	➤ First revision used with SEL-487B-1.

ICD File

To find the ICD revision number in your relay, view the configVersion by using the serial port ID command. The configVersion is the last item displayed in the information returned from the ID command.

configVersion = ICD-487B-1-R201-V0-Z307005-D20130828

The ICD revision number is after the R (e.g., 201) and the date code is after the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

NOTE: The Z-number representation is implemented with ClassFileVersion 002. Previous ClassFileVersions do not provide an informative Z-number.

The configVersion contains other useful information. The Z-number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 307). The second three digits represent the ICD ClassFileVersion (e.g., 005). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.3 list the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.3 ICD File Revision History (Sheet 1 of 2)

configVersion	Summary of Revisions	Minimum Relay Firmware	ClassFile Version	Manual Date Code
ICD-487B-R405-V0-Z319010-D20250214	➤ IEC 61850 Edition 2.1 Conformance ➤ Modified the LPHD logical node to include the IEC 61850 library version SelLibId.val. ➤ Added support for the cmdQual, onDur, offDur, and numPls pulse configuration attributes, according to IEC 61850-7-3. ➤ Added the LocKey data object support and changed the data source mapping for Loc and LocSta. ➤ Modified the ICD file to remove control blocks and default GOOSE and report data sets. ➤ Added GGIO logical nodes to support Automation SELOGIC Variables 129–256. ➤ Added support for the valImport and valKind attributes according to IEC 61850-6 for compatibility with third-party system configuration tools. ➤ Reduced the size of all GGIO lnTypes to a maximum of 32 indices. ➤ Modified logical nodes prefixes and instances.	R319	010	20250214
ICD-487B-R404-V0-Z318009-D20231207 **NOTE:** ClassFileVersions 007 and 008 did not production release.	➤ Updated IEC 61850 Edition 2 Conformance. ➤ Updated ClassFileVersion to 009. ➤ Added support for MMS buffered and unbuffered report reservation.	R318	009	20231207
ICD-487B-R403-V0-Z316006-D20210204	➤ Added PRBGGIO logical nodes to support pulsing remote bits. ➤ Corrected the IEC 61850 Data Object number extensions according to the Ed 2 number usage.	R316	006	20210514

Table A.3 ICD File Revision History (Sheet 2 of 2)

configVersion	Summary of Revisions	Minimum Relay Firmware	ClassFile Version	Manual Date Code
	➤ Added support for the IEC 61850 Functional Naming feature. ➤ Added the IEC 61850 LTRK logical node for service tracking. ➤ Added new LBGGIO logical nodes for local bits 33–64. ➤ Added FltTyp and FltCaus data attributes to the FLTRDRE logical node. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. Control messages need to include the orCat value associated with the active control authority.			
ICD-487B-R402-V0-Z315006-D20200229	➤ Added BFR*n*R8BRF protection logical nodes (where *n* = 1–21). ➤ Added ALMGGIO, ETHGGIO, and SGGGIO annunciator logical nodes. ➤ Added DCZBAT metering logical node. ➤ Moved IEC 61850 mode/behavior control from logical node LPHD to LLN0. ➤ Improved consistency in deadband units for the ICD file to use voltage in kV and power in MW. ➤ Added system logical nodes LGOS, LTIM, LTMS, and LCCH.	R315	006	20200229
ICD-487B-R401-V0-Z314006-D20181105	➤ Added the ability to control mode and behavior through an MMS write to the LPHD local node Mod.ctlVal attribute. ➤ Addressed nonfunctional settings link tab within ACSELERATOR Architect SEL-5032 Software by disabling "System setFileSupported" in the ICD file.	R314	006	20181115
ICD-487B-R400-V0-Z312006-D20170731	➤ IEC 61850 Edition 2 Conformance. ➤ Updated ClassFileVersion to 006. ➤ Increased the default MMS inactivity timeout value to 900 seconds. ➤ Updated data set and MMS report names.	R312	006	20171008
ICD-487B-R302-V0-Z311005-D20170318	➤ Added the ability to turn off the MMS inactivity timeout.	R311-V0	005	20170329
ICD-487B-R300-V0-Z308005-D20150325	➤ Added support for IEC 61850 group switch, Simulated Goose and stSeld.	R308	005	20150421
ICD-487B-R202-V0-Z307005-D20150324	➤ Conformance Enhancements.	R307	005	20150421
ICD-487B-R201-V0-Z307005-D20130828	➤ Added support for 128 incoming GOOSE subscriptions, MMS authentication, and user-configurable GOOSE filtering.	R307	005	20131014
ICD-487B-R103-V0-Z302004-D20130828	➤ Modified the dead band for voltages from 10000 to 10.	R302	004	20150421
ICD-487B-R102-V0-Z002001-D20110810	➤ SEL-487B-1 initial ICD file release.	R302	004	20111107

Instruction Manual

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

Table A.4 lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table A.4 Instruction Manual Revision History (Sheet 1 of 4)

Date Code	Summary of Revisions
20250214	General ➤ Removed references to product literature DVD and firmware CD. Section 1 ➤ Updated *Specifications*. Section 10 ➤ Updated *Table 10.8: SEL-487B DNP3 Reference Data Map*. Appendix A ➤ Updated for firmware version R319. ➤ Updated for ICD file version R405.
20240927	Section 1 ➤ Changed *Object Penetration* to *Ingress Protection* and updated contents in *Specifications*.
20240509	Appendix A ➤ [Cybersecurity] Updated for firmware version R318-V1.
20231207	Section 1 ➤ Updated *Figure 1.1: SEL-487B Relay Basic Functions in a Double-Bus Application*. ➤ Updated *Models and Options* and *Specifications*. Section 4 ➤ Updated *Figure 4.11: Factory-Default Operator Control Pushbuttons*. Section 5 ➤ Updated *Figure 5.23: U.S. Curves U1, U2, U3, and U4* and *Figure 5.28: Open-Phase Detection*. Section 12 ➤ Updated *Table 12.2: Analog Quantities Sorted by Function*. Appendix A ➤ Updated for firmware version R318. ➤ Updated note in *SELBOOT*. ➤ Updated for ICD file version R404. Appendix B ➤ Updated *Table B.5: Serial DNP Basic Binary Input Reference Mapping*.
20230830	Appendix A ➤ Updated for firmware versions R311-V4, R312-V3, R313-V3, R314-V4, R315-V4, R316-V3, R317-V1.
20220630	Appendix A ➤ Updated for firmware versions R311-V3, R312-V2, R313-V2, R314-V3, R315-V3, and R316-V2.
20220523	Section 1 ➤ Updated *Figure 1.1: SEL-487B Relay Basic Functions in a Double-Bus Application*. ➤ Updated *Models and Options, Applications,* and *Specifications*. Section 2 ➤ Updated *Relay Sizes, Time-Domain Link,* and *Secondary Circuits*. ➤ Added *Hybrid (High-Current Interrupting) Control Outputs*. ➤ Updated *High-Speed, High-Current Interrupting Control Outputs, TiDL (EtherCAT) Connections,* and *Commissioning*.

Table A.4 Instruction Manual Revision History (Sheet 2 of 4)

Date Code	Summary of Revisions
	Section 5 ➤ Clarified notes regarding TiDL (EtherCAT) operating times. ➤ Updated *Polarity, Terminal Configurations,* and *Bus Coupler (Tie Breaker) Configurations*. **Section 6** ➤ Updated *Bus-Zone Configurations*. **Section 7** ➤ Added *COMTRADE Relay Word Bit Behavior*. **Section 8** ➤ Updated *Table 8.5: Station DC Monitor* and *Table 8.44: Inverse-Time Overcurrent Elements*. **Section 11** ➤ Updated *Table 11.2: Row List of Relay Word Bits*. **Appendix A** ➤ Updated for firmware version R317-V0. **Command Summary** ➤ Updated descriptions for *CFG CTNOM i* and *CFG NFREQ f*.
20211203	**Appendix A** ➤ Updated for firmware version R316-V1. ➤ Updated Summary of Revisions for ICD file version R403 in *Table A.3: ICD File Revision History*.
20210708	**Section 1** ➤ Updated *Specifications*.
20210514	**Section 1** ➤ Updated *Table 1.2: SEL-487B Relay Characteristics*. ➤ Updated *Specifications*. **Section 2** ➤ Updated *High-Speed, High-Current Interrupting Control Outputs*. **Section 5** ➤ Updated *Internal Fault Detection Logic, Selectable Time-Overcurrent Elements (51), Coupler Security Logic* and *Circuit Breaker Status Logic*. **Section 6** ➤ 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 Bus Coupler*. ➤ Updated *Zone Configuration Group Settings* and *Protection Group Settings* in *Application 7: Double and Transfer Bus (Outboard CTs)*. **Section 8** ➤ Added *Table 8.17: Access Controls*. **Section 10** ➤ Updated *Table 10.4: SEL-487B Database Structure—TARGET Region*, *Table 10.12: Logical Device: PRO (Protection)*, and *Table 10.13: Logical Device: MET (Metering)*. ➤ Added *Table 10.14: FLTYPE—Fault Type* and *Table 10.15: FLTCAUS—Fault Cause*. **Section 11** ➤ Updated *Table 11.1: Alphabetic List of Relay Word Bits* and *Table 11.2: Row List of Relay Word Bits*. **Section 12** ➤ Updated *Table 12.1: Analog Quantities Sorted Alphabetically* and *Table 12.2: Analog Quantities Sorted by Function*. **Appendix A** ➤ Updated for firmware version R316-V0. ➤ Updated for ICD version R403.

Table A.4 Instruction Manual Revision History (Sheet 3 of 4)

Date Code	Summary of Revisions
20210428	Appendix A ➤ Updated for firmware versions R315-V2.
20201204	Preface ➤ Updated *SEL-400 Series Relays Instruction Manual* and *Safety Marks*.
20201009	Appendix A ➤ Updated for firmware versions R312-V1, R313-V1, R314-V2, and R315-V1.
20200617	Section 2 ➤ Updated *Jumpers* for new BREAKER jumper description. Appendix A ➤ Updated for firmware version R315-V0.
20200229	Section 1 ➤ Updated *Specifications*. Section 10 ➤ Updated *Table 10.12: Logical Device: PRO (Protection)*, *Table 10.13: Logical Device: MET (Metering)*, and *Table 10.14: Logical Device: CON (Remote Control)*. Section 11 ➤ Updated *Table 11.1: Alphabetic List of Relay Word Bits* and *Table 11.2: Row List of Relay Word Bits* for SC850TM and SC850BM. Section 12 ➤ Updated *Table 12.1: Analog Quantities Sorted Alphabetically* and *Table 12.2: Analog Quantities Sorted by Function* for I850MOD. Appendix A ➤ Updated for firmware version R315. ➤ Updated for ICD file version R402.
20191210	Appendix A ➤ Updated for firmware version R314-V1.
20181210	Appendix A ➤ Updated for firmware version R314-V0.
20181115	Section 8 ➤ Added *Table 8.18: Open-Phase Logic*. Appendix A ➤ Updated for firmware version R314-V0. ➤ Updated for ICD file version R401.
20180105	Appendix A ➤ Updated for firmware version R313.
20171021	Appendix A ➤ Updated for firmware versions R310-V2 and R311-V2.
20171008	Section 10 ➤ Updated *Table 10.12 Logical Device: PRO (Protection)* and *Table 10.13 Logical Device: MET (Metering)*. Section 12 ➤ Updated *Table 12.1: Analog Quantities Sorted Alphabetically* and *Table 12.2: Analog Quantities Sorted by Function* for PRPMCC and PTPPORT. Appendix A ➤ Updated for firmware version R312. ➤ Updated for ICD file version R400.
20170820	Appendix A ➤ Updated for firmware versions R307-V1, R309-V3, and R310-V1.

Table A.4 Instruction Manual Revision History (Sheet 4 of 4)

Date Code	Summary of Revisions
20170809	Appendix A ➤ Updated for firmware version R311-V1.
20170428	Cover ➤ Updated copyright information. Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.25: SEL-2243 Power Coupler*.
20170329	Section 1 ➤ Updated *Specifications*. Section 2 ➤ Removed *Figure 2.14: IRIG-B Terminating Resistors* and the *IRIG-B Jumper* section. ➤ Added *TiDL Connections*. Section 5 ➤ Updated *Selectable Time-Overcurrent Element (51)*. Section 6 ➤ Updated *Figure 6.15: Polarity Marks Above the Odd-Numbered CT Terminals at the Rear of the Relay*. Section 7 ➤ Updated *Table 7.12: Event Report Nonvolatile Storage Capability When ERDIG=S*. ➤ Added *Table 7.13: Event Report Nonvolatile Storage Capability When ERDIG=A*. Section 9 ➤ Added **CFG CTNOM** and **CFG NFREQ** to *Table 9.1: SEL-487E List of Commands*. Section 10 ➤ Updated *Table 10.15: Logical Device*. Section 11 ➤ Updated *Table 11.1: Alphabetic List of Relay Word Bits*. ➤ Updated *Table 11.2: Row List of Relay Word Bits*. Section 12 ➤ Updated *Table 12.2: Analog Quantities Sorted by Function*. Appendix A ➤ Updated for firmware version R311-V0. ➤ Updated for ICD file version R302. Command Summary ➤ Added **COM PTP**, **CFG CTNOM**, and **CFG NFREQ**.
20160718	➤ Initial version.

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APPENDIX B

Converting Settings From SEL-487B-0 to SEL-487B-1

Because of hardware changes and feature enhancements between the SEL-487B-0 and the SEL-487B-1 relays, the handling of a number of settings has changed. In particular, the replacement of the SEL-2702 Ethernet Processor with integrated Ethernet has significantly changed the handling of Ethernet-related settings. This appendix describes the key differences to aid users who need to convert their settings from an SEL-487B-0 to an SEL-487B-1.

Relay Word Bit Changes

Relay Word bits are used in SELOGIC control equations and many other settings. Some of these bits have different names or do not exist in the latest relay version. *Table B.1* lists these differences.

The SEL-487B-1 contains six pairs of under- and overvoltage elements. The input voltage for each pair is selectable using the 27O*n* and 59O*n* settings, where *n* = 1–6. Likewise, the input current for the time-overcurrent elements is selectable in the SEL-487B-1 using the 51O*qq* settings, where *qq* = 1–21.

Selections for these settings are listed in *Table B.1* to help match the 27, 59, and 51 Relay Word bits in the SEL-487B-1 to those in the SEL-487B-0.

Table B.1 Relay Word Bit Differences (Sheet 1 of 2)

SEL-487B-0 Relay Word Bit	Corresponding SEL-487B-1 Relay Word Bit	Comments
27P11	271P1	Assumes 27O1 = V01FIM
27P12	271P2	Assumes 27O1 = V01FIM
27P21	272P1	Assumes 27O2 = V02FIM
27P22	272P2	Assumes 27O2 = V02FIM
27P31	273P1	Assumes 27O3 = V03FIM
27P32	273P2	Assumes 27O3 = V03FIM
59P11	591P1	Assumes 59O1 = V01FIM
59P12	591P2	Assumes 59O1 = V01FIM
59P21	592P1	Assumes 59O2 = V02FIM
59P22	592P2	Assumes 59O2 = V02FIM
59P31	593P1	Assumes 59O3 = V03FIM
59P32	593P2	Assumes 59O3 = V03FIM
59PQ1	594P1	Assumes 59O4 = 3V2FIM
59PQ2	594P2	Assumes 59O4 = 3V2FIM

Table B.1 Relay Word Bit Differences (Sheet 2 of 2)

SEL-487B-0 Relay Word Bit	Corresponding SEL-487B-1 Relay Word Bit	Comments
59PN1	595P1	Assumes 59O5 = 3V0FIM
59PN2	595P2	Assumes 59O5 = 3V0FIM
51P01–51P18	51S01–51S18	Assumes 51O*xx*[a] = I*xx*FIM[a]
51P01T–5118T	51T01–51T18	Assumes 51O*xx*[a] = I*xx*FIM[a]
51P01R–51P18R	51R01–51R18	Assumes 51O*xx*[a] = I*xx*FIM[a]
CCALARM	--	No longer needed because of SEL-2702 removal.
CCOK	--	No longer needed because of SEL-2702 removal.
TESTDNP	TESTDB2	
CCIN001–CCIN128	VB001–VB128	
CCOUT01–CCOUT32	--	Any Relay Word bit may now be used for outgoing GOOSE.
CCSTA01–CCSTA32	--	No longer needed because of SEL-2702 removal. The previous bits provided communications card status information. New bits LINK5C, LINK5D, LNKFAIL, P5CSEL, and P5DSEL have no direct correspondence to the previous bits, but provide status information about Ethernet connectivity.

[a] xx = 01–18.

Group Settings

The SEL-487B-1 includes settings for selecting the voltage and current inputs for the 27, 59, and 51 elements. In *Table B.2*, these settings are chosen to match the fixed input quantities in the SEL-487B-0.

Table B.2 Group Settings Differences (Sheet 1 of 2)

SEL-487B-0 Setting	SEL-487B-1 Setting	Notes
--	27O1 = V01FIM	This setting selects the voltage input for the first undervoltage pair. This was fixed at V01FIM in the SEL-487B-0.
27P11P	27P1P1	
27P12P	27P1P2	
--	27O2 = V02FIM	This setting selects the voltage input for the second undervoltage pair. This was fixed at V02FIM in the SEL-487B-0.
27P21P	27P2P1	
27P22P	27P2P2	
--	27O3 = V03FIM	This setting selects the voltage input for the third undervoltage pair. This was fixed at V03FIM in the SEL-487B-0.
27P31P	27P3P1	
27P32P	27P3P2	
--	59O1 = V01FIM	This setting selects the voltage input for the first overvoltage pair. This was fixed at V01FIM in the SEL-487B-0.
59P11P	59P1P1	
59P12P	59P1P2	
--	59O2 = V02FIM	This setting selects the voltage input for the second overvoltage pair. This was fixed at V02FIM in the SEL-487B-0.
59P21P	59P2P1	

Table B.2 Group Settings Differences (Sheet 2 of 2)

SEL-487B-0 Setting	SEL-487B-1 Setting	Notes
59P22P	59P2P2	
--	59O3 = V03FIM	This setting selects the voltage input for the third overvoltage pair. This was fixed at V03FIM in the SEL-487B-0.
59P31P	59P3P1	
59P32P	59P3P2	
--	59O4 = 3V2FIM	This setting selects the voltage input for the fourth overvoltage pair. This was fixed at 3V2FIM in the SEL-487B-0.
59Q1P	59P4P1	
59Q2P	59P4P2	
--	59O5 = 3V0FIM	This setting selects the voltage input for the fifth overvoltage pair. This was fixed at 3V0FIM in the SEL-487B-0.
59N1P	59P5P1	
59N2P	59P5P2	
--	51O01 = I01FIM	
51O02 = I02FIM		
. . .		
51O18 = I18FIM		These are 18 of the 21 settings used to select the current inputs for the time-overcurrent elements in the SEL-487B-1. These were fixed to the respective current terminal in the SEL-487B-0 (i.e., 51P01P used the I01 terminal).
51P01P–51P18P	51P01–51P18	
51P01C–51P18C	51C01–51C18	
51P01TD–51P18TD	51TD01–51TD18	
51P01RS–51P18RS	51RS01–51RS18	
51P01TC–51P18TC	51TC01–51TC18	

Port Settings Changes

Serial Port Settings

Table B.3 highlights key differences in the serial port settings between the SEL-487B-0 and the SEL-487B-1.

Table B.3 Serial Port Settings Differences

SEL-487B-0 Settings	SEL-487B-1 Setting	Notes
--	DNPCL	This is a new setting. It needs to be set to Y to enable control operations on a DNP port. In the SEL-487B-0, control was always enabled.

Ethernet Port (Port 5) Settings

In the SEL-487B-0, Ethernet was supplied by the SEL-2702 Ethernet Processor. In the SEL-487B-1, Ethernet is native to the relay, with the interfaces provided by the E4 daughter card. This has a significant effect on the settings, as described in *Table B.4*.

Table B.4 Ethernet Port Settings Differences (Sheet 1 of 2)

SEL-487B-0 Settings	SEL-487B-1 Setting	Notes
IPADDR SUBNETM	IPADDR	This setting now operates using CIDR rules, which consolidates the old SUBNETM setting into the IPADDR setting.
FAILOVER	NETMODE	FAILOVER of N is equivalent to a NETMODE of FIXED. FAILOVER of Y is equivalent to a NETMODE of FAILOVER. NETMODE also has a SWITCHED option, which enables both ports.
NETPORT	NETPORT	The old setting had choices of A, B, and D, for ports A, B, and to disable. The SEL-487B-1 setting has choices of C and D for ports C and D.
NETASPD	NETCSPD	
NETBSPD	NETDSPD	
HOST*n*	--	This setting no longer exists.
IPADR*n*	--	This setting no longer exists.
T1RECV	ETELNET	
T1CBAN	TCBAN	
T1INIT	--	This setting no longer exists.
T1PNUM	TPORT	
T2CBAN	--	The T2CBAN, T2RECV, and T2PNUM settings have been eliminated. They existed for access to the SEL-2702 local interface, which no longer exists.
T2RECV	--	
T2PNUM	--	
ENDNP	EDNP	While ENDNP was a Y, N selection, the EDNP setting in the SEL-487B-1 provides a range, from 0 to 6, for the number of DNP sessions you can enable.
DNPPNUM	DNPPNUM	The range is slightly more restrictive in the SEL-487B-1 implementation. The lowest assignable port is 1025.
DNPMAP	--	This setting has been eliminated. Maps are now always custom.
RPADR01–RPADR06	REPADR1–REPADR6	
RPADR07–RPADR10	--	This setting no longer exists; the SEL-487B-1 supports 6 sessions instead of the prior 10.
DNIP01–DNPIP06	DNPIP1–DNPIP6	
DNPIP07–DNPIP10	--	This setting no longer exists; now supports six sessions instead of the prior 10.
DNPTR01–DNPTR06	DNPTR1–DNPTR6	
DNPTR07–DNPTR10	--	This setting no longer exists; now supports six sessions instead of the prior 10.
DNPUP01–DNPUP06	DNPUDP1–DNPUDP6	The range is slightly more restrictive in the SEL-487B-1 implementation. The lowest assignable port is 1025.
DNPUP07–DNPUP10	--	This setting no longer exists; now supports six sessions instead of the prior 10.
UNSL01–UNSL06	UNSOL1–UNSOL6	
UNSL07–UNSL10	--	This setting no longer exists; now supports six sessions instead of the prior 10.
PUNSL01–PUNSL06	PUNSOL1–PUNSOL6	
PUNSL07–PUNSL10	--	No longer exist; now support six sessions instead of the prior 10.
DNPMP01–DNPMP06	DNPMAP1–DNPMAP6	

Table B.4 Ethernet Port Settings Differences (Sheet 2 of 2)

SEL-487B-0 Settings	SEL-487B-1 Setting	Notes
DNPMP07–DNPMP10	--	No longer exist; now support six sessions instead of the prior 10.
DNPCL01–DNPCL06	DNPCL1–DNPCL6	
DNPCL07–DNPCL10	--	No longer exist; now support six sessions instead of the prior 10.
ECLASSA	CLASSA1–CLASSA6	Old setting allowed 0–3. SEL-487B-1 setting has OFF, 1–3. Old setting 0 is equivalent to new setting OFF.
ECLASSB	CLASSB1–CLASSB6	Old setting allowed 0–3. SEL-487B-1 setting has OFF, 1–3. Old setting 0 is equivalent to new setting OFF.
ECLASSC	CLASSC1–CLASSC6	Old setting allowed 0–3. SEL-487B-1 setting has OFF, 1–3. Old setting 0 is equivalent to new setting OFF.
DECPL	DECPLA1–DECPLA6	
	DECPLV1–DECPLV6	
	DECPLM1–DECPLM6	
ANADB	ANADBA1–ANADBA6	
	ANADBV1–ANADBV6	
	ANADBM1–ANADBM6	
16BIT	AIVAR1–AIVAR6	The old setting allowed the choice between 16-bit and 32-bit variations. The SEL-487B-1 settings allow the choice between any of the six valid analog input variations. The old setting of 16 is equivalent to 2, and 32 is equivalent to 1.
STIMEO	STIMEO1–STIMEO6	The SEL-487B-1 settings accept integers only.
DNPPAIR	--	This setting no longer exists. Selection of paired controls is now a function of configuring the map.
DNPINA	DNPINA1–DNPINA6	
NUMEVE	NUMEVE1–NUMEVE6	
ETIMEO	ETIMEO1–ETIMEO6	
URETRY	URETRY1–URETRY6	
UTIMEO	UTIMEO1–UTIMEO6	

DNP3 Mapping Changes

DNP3 Settings Classes

In the SEL-487B-0 implementations of DNP3, there was one map for serial DNP3 (SETTINGS\SET_D1.TXT) and five maps for Ethernet DNP3 (SETTINGS\CARD\SET_DNP*n*.TXT, where *n* = 1–5). Now in the SEL-487B-1, there are simply five maps (SETTINGS\SET_D*n*.TXT, where *n* = 1–5) that can be used for serial or Ethernet DNP3.

Serial DNP3 Map Value Changes

The SEL-487B-0 serial DNP3 map was based on numeric references for all data. The SEL-487B-1 DNP3 mapping uses labels. The following tables show the relationships between the old numeric references and the labels.

Binary Inputs (MAPSEL = B)

Table B.5 lists the valid numeric references used when MAPSEL = B in the SEL-487B-0 with the equivalent label in the SEL-487B-1. Note that the numeric reference ranges 0–799 and 800–1599 are equivalent, the only difference being whether SER quality time-tags are used. In the SEL-487B-1, SER quality time-tags are always used, if available. If a bit does not appear in the table, then there is no equivalent in the SEL-487B-1.

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 1 of 17)

Numeric Reference	Label Reference
6, 806	TRIPLED
7, 807	EN
8, 808	TLED_8
9, 809	TLED_7
10, 810	TLED_6
11, 811	TLED_5
12, 812	TLED_4
13, 813	TLED_3
14, 814	TLED_2
15, 815	TLED_1
16, 816	TLED_16
17, 817	TLED_15
18, 818	TLED_14
19, 819	TLED_13
20, 820	TLED_12
21, 821	TLED_11
22, 822	TLED_10
23, 823	TLED_9
24, 824	52A01
25, 825	52AL01
26, 826	52CL01
27, 827	52A02
28, 828	52AL02
29, 829	52CL02
30, 830	52A03
31, 831	52AL03
32, 832	52CL03
33, 833	52A04
34, 834	52AL04
35, 835	52CL04
36, 836	52A05
37, 837	52AL05
38, 838	52CL05
39, 839	52A06

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 2 of 17)

Numeric Reference	Label Reference
40, 840	ZONE1
41, 841	ZONE2
42, 842	ZONE3
43, 843	ZONE4
44, 844	ZONE5
45, 845	ZONE6
48, 848	RZSWOAL
49, 849	ZSWO
50, 850	ZSWOIP
51, 851	ZSWOAL
56, 856	87ST1
57, 857	87ST2
58, 858	87ST3
59, 859	87ST4
60, 860	87ST5
61, 861	87ST6
62, 862	87ST
64, 864	CB52A1
65, 865	CB52T1
66, 866	CBCLS1
67, 867	CBCLST1
68, 868	ACTRP1
69, 869	ACTRPT1
70, 870	CSL1
72, 872	CB52A2
73, 873	CB52T2
74, 874	CBCLS2
75, 875	CBCLST2
76, 876	ACTRP2
77, 877	ACTRPT2
78, 878	CSL2
80, 880	TOS01
81, 881	TOS02
82, 882	TOS03
83, 883	TOS04
84, 884	TOS05
85, 885	TOS06
86, 886	TOS07
87, 887	TOS08
88, 888	TOS09
89, 889	TOS10

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 3 of 17)

Numeric Reference	Label Reference
90, 890	TOS11
91, 891	TOS12
92, 892	TOS13
93, 893	TOS14
94, 894	TOS15
95, 895	TOS16
96, 896	TOS17
97, 897	TOS18
105, 905	CHSG
106, 906	SG1
107, 907	SG2
108, 908	SG3
109, 909	SG4
110, 910	SG5
111, 911	SG6
112, 912	RB32
113, 913	RB31
114, 914	RB30
115, 915	RB29
116, 916	RB28
117, 917	RB27
118, 918	RB26
119, 919	RB25
120, 920	RB24
121, 921	RB23
122, 922	RB22
123, 923	RB21
124, 924	RB20
125, 925	RB19
126, 926	RB18
127, 927	RB17
128, 928	RB16
129, 929	RB15
130, 930	RB14
131, 931	RB13
132, 932	RB12
133, 933	RB11
134, 934	RB10
135, 935	RB09
136, 936	RB08
137, 937	RB07

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 4 of 17)

Numeric Reference	Label Reference
138, 938	RB06
139, 939	RB05
140, 940	RB04
141, 941	RB03
142, 942	RB02
143, 943	RB01
144, 944	IN101
145, 945	IN102
146, 946	IN103
147, 947	IN104
148, 948	IN105
149, 949	1N106
150, 950	IN107
152, 952	IN201
153, 953	IN202
154, 954	IN203
155, 955	IN204
156, 956	IN205
157, 957	IN206
158, 958	IN207
159, 959	IN208
160, 960	IN209
161, 961	IN210
162, 962	IN211
163, 963	IN212
164, 964	IN213
165, 965	IN214
166, 966	IN215
167, 967	IN216
168, 968	IN217
169, 969	IN218
170, 970	IN219
171, 971	IN220
172, 972	IN221
173, 973	IN222
174, 974	IN223
175, 975	IN224
176, 976	IN301
177, 977	IN302
178, 978	IN303
179, 979	IN304

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 5 of 17)

Numeric Reference	Label Reference
180, 980	IN305
181, 981	IN306
182, 982	IN307
183, 983	IN308
184, 984	IN309
185, 985	IN310
186, 986	IN311
187, 987	IN312
188, 988	IN313
189, 989	IN314
190, 990	IN315
191, 991	IN316
192, 992	IN317
193, 993	IN318
194, 994	IN319
195, 995	IN320
196, 996	IN321
197, 997	IN322
198, 998	IN323
199, 999	IN324
200, 1000	IN401
201, 1001	IN402
202, 1002	IN403
203, 1003	IN404
204, 1004	IN405
205, 1005	IN406
206, 1006	IN407
207, 1007	IN408
208, 1008	IN409
209, 1009	IN410
210, 1010	IN411
211, 1011	IN412
212, 1012	IN413
213, 1013	IN414
214, 1014	IN415
215, 1015	IN416
216, 1016	IN417
217, 1017	IN418
218, 1018	IN419
219, 1019	IN420
220, 1020	IN421

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 6 of 17)

Numeric Reference	Label Reference
221, 1021	IN422
222, 1022	IN423
223, 1023	IN424
224, 1024	IN501
225, 1025	IN502
226, 1026	IN503
227, 1027	IN504
228, 1028	IN505
229, 1029	IN506
230, 1030	IN507
231, 1031	IN508
232, 1032	IN509
233, 1033	IN510
234, 1034	IN511
235, 1035	IN512
236, 1036	IN513
237, 1037	IN514
238, 1038	IN515
239, 1039	IN516
240, 1040	IN517
241, 1041	IN518
242, 1042	IN519
243, 1043	IN520
244, 1044	IN521
245, 1045	IN522
246, 1046	IN523
247, 1047	IN524
248, 1048	PSV01
249, 1049	PSV02
250, 1050	PSV03
251, 1051	PSV04
252, 1052	PSV05
253, 1053	PSV06
254, 1054	PSV07
255, 1055	PSV08
256, 1056	PSV09
257, 1057	PSV10
258, 1058	PSV11
259, 1059	PSV12
260, 1060	PSV13
261, 1061	PSV14

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 7 of 17)

Numeric Reference	Label Reference
262, 1062	PSV15
263, 1063	PSV16
264, 1064	PSV17
265, 1065	PSV18
266, 1066	PSV19
267, 1067	PSV20
268, 1068	PSV21
269, 1069	PSV22
270, 1070	PSV23
271, 1071	PSV24
272, 1072	PSV25
273, 1073	PSV26
274, 1074	PSV27
275, 1075	PSV28
276, 1076	PSV29
277, 1077	PSV30
278, 1078	PSV31
279, 1079	PSV32
280, 1080	PSV33
281, 1081	PSV34
282, 1082	PSV35
283, 1083	PSV36
284, 1084	PSV37
285, 1085	PSV38
286, 1086	PSV39
287, 1087	PSV40
288, 1088	PSV41
289, 1089	PSV42
290, 1090	PSV43
291, 1091	PSV44
292, 1092	PSV45
293, 1093	PSV46
294, 1094	PSV47
295, 1095	PSV48
296, 1096	PSV49
297, 1097	PSV50
298, 1098	PSV51
299, 1099	PSV52
300, 1100	PSV53
301, 1101	PSV54
302, 1102	PSV55

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 8 of 17)

Numeric Reference	Label Reference
303, 1103	PSV56
304, 1104	PSV57
305, 1105	PSV58
306, 1106	PSV59
307, 1107	PSV60
308, 1108	PSV61
309, 1109	PSV62
310, 1110	PSV63
311, 1111	PSV64
312, 1112	PLT01
313, 1113	PLT02
314, 1114	PLT03
315, 1115	PLT04
316, 1116	PLT05
317, 1117	PLT06
318, 1118	PLT07
319, 1119	PLT08
320, 1120	PLT09
321, 1121	PLT10
322, 1122	PLT11
323, 1123	PLT12
324, 1124	PLT13
325, 1125	PLT14
326, 1126	PLT15
327, 1127	PLT16
328, 1128	PCT01Q
329, 1129	PCT02Q
330, 1130	PCT03Q
331, 1131	PCT04Q
332, 1132	PCT05Q
333, 1133	PCT06Q
334, 1134	PCT07Q
335, 1135	PCT08Q
336, 1136	PCT09Q
337, 1137	PCT10Q
338, 1138	PCT11Q
339, 1139	PCT12Q
340, 1140	PCT13Q
341, 1141	PCT14Q
342, 1142	PCT15Q
343, 1143	PCT16Q

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 9 of 17)

Numeric Reference	Label Reference
344, 1144	PST01Q
345, 1145	PST02Q
346, 1146	PST03Q
347, 1147	PST04Q
348, 1148	PST05Q
349, 1149	PST06Q
350, 1150	PST07Q
351, 1151	PST08Q
352, 1152	PST09Q
353, 1153	PST10Q
354, 1154	PST11Q
355, 1155	PST12Q
356, 1156	PST13Q
357, 1157	PST14Q
358, 1158	PST15Q
359, 1159	PST16Q
360, 1160	PCN01Q
361, 1161	PCN02Q
362, 1162	PCN03Q
363, 1163	PCN04Q
364, 1164	PCN05Q
365, 1165	PCN06Q
366, 1166	PCN07Q
367, 1167	PCN08Q
368, 1168	PCN09Q
369, 1169	PCN10Q
370, 1170	PCN11Q
371, 1171	PCN12Q
372, 1172	PCN13Q
373, 1173	PCN14Q
374, 1174	PCN15Q
375, 1175	PCN16Q
376, 1176	ASV001
377, 1177	ASV002
378, 1178	ASV003
379, 1179	ASV004
380, 1180	ASV005
381, 1181	ASV006
382, 1182	ASV007
383, 1183	ASV008
384, 1184	ASV009

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 10 of 17)

Numeric Reference	Label Reference
385, 1185	ASV010
386, 1186	ASV011
387, 1187	ASV012
388, 1188	ASV013
389, 1189	ASV014
390, 1190	ASV015
391, 1191	ASV016
392, 1192	ASV017
393, 1193	ASV018
394, 1194	ASV019
395, 1195	ASV020
396, 1196	ASV021
397, 1197	ASV022
398, 1198	ASV023
399, 1199	ASV024
400, 1200	ASV025
401, 1201	ASV026
402, 1202	ASV027
403, 1203	ASV028
404, 1204	ASV029
405, 1205	ASV030
406, 1206	ASV031
407, 1207	ASV032
408, 1208	ASV033
409, 1209	ASV034
410, 1210	ASV035
411, 1211	ASV036
412, 1212	ASV037
413, 1213	ASV038
414, 1214	ASV039
415, 1215	ASV040
416, 1216	ASV041
417, 1217	ASV042
418, 1218	ASV043
419, 1219	ASV044
420, 1220	ASV045
421, 1221	ASV046
422, 1222	ASV047
423, 1223	ASV048
424, 1224	ASV049
425, 1225	ASV050

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 11 of 17)

Numeric Reference	Label Reference
426, 1226	ASV051
427, 1227	ASV052
428, 1228	ASV053
429, 1229	ASV054
430, 1230	ASV055
431, 1231	ASV056
432, 1232	ASV057
433, 1233	ASV058
434, 1234	ASV059
435, 1235	ASV060
436, 1236	ASV061
437, 1237	ASV062
438, 1238	ASV063
439, 1239	ASV064
440, 1240	ALT01
441, 1241	ALT02
442, 1242	ALT03
443, 1243	ALT04
444, 1244	ALT05
445, 1245	ALT06
446, 1246	ALT07
447, 1247	ALT08
448, 1248	ALT09
449, 1249	ALT10
450, 1250	ALT11
451, 1251	ALT12
452, 1252	ALT13
453, 1253	ALT14
454, 1254	ALT15
455, 1255	ALT16
456, 1256	AST01Q
457, 1257	AST02Q
458, 1258	AST03Q
459, 1259	AST04Q
460, 1260	AST05Q
461, 1261	AST06Q
462, 1262	AST07Q
463, 1263	AST08Q
464, 1264	AST09Q
465, 1265	AST10Q
466, 1266	AST11Q

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 12 of 17)

Numeric Reference	Label Reference
467, 1267	AST12Q
468, 1268	AST13Q
469, 1269	AST14Q
470, 1270	AST15Q
471, 1271	AST16Q
472, 1272	ACN01Q
473, 1273	ACN02Q
474, 1274	ACN03Q
475, 1275	ACN04Q
476, 1276	ACN05Q
477, 1277	ACN06Q
478, 1278	ACN07Q
479, 1279	ACN08Q
480, 1280	ACN09Q
481, 1281	ACN10Q
482, 1282	ACN11Q
483, 1283	ACN12Q
484, 1284	ACN13Q
485, 1285	ACN14Q
486, 1286	ACN15Q
487, 1287	ACN16Q
493, 1293	MATHERR
494, 1294	PFRTEX
495, 1295	PUNRLBL
501, 1301	AFRTEXA
502, 1302	AFRTEXP
503, 1303	AUNRLBL
508, 1308	CCALARM
509, 1309	BADPASS
510, 1310	HALARM
511, 1311	SALARM
516, 1316	TUPDH
517, 1317	TIRIG
520, 1320	OUT101
521, 1321	OUT102
522, 1322	OUT103
523, 1323	OUT104
524, 1324	OUT105
525, 1325	OUT106
526, 1326	OUT107
527, 1327	OUT108

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 13 of 17)

Numeric Reference	Label Reference
528, 1328	OUT201
529, 1329	OUT202
530, 1330	OUT203
531, 1331	OUT204
532, 1332	OUT205
533, 1333	OUT206
534, 1334	OUT207
535, 1335	OUT208
536, 1336	OUT301
537, 1337	OUT302
538, 1338	OUT303
539, 1339	OUT304
540, 1340	OUT305
541, 1341	OUT306
542, 1342	OUT307
543, 1343	OUT308
544, 1344	OUT401
545, 1345	OUT402
546, 1346	OUT403
547, 1347	OUT404
548, 1348	OUT405
549, 1349	OUT406
550, 1350	OUT407
551, 1351	OUT408
552, 1352	OUT501
553, 1353	OUT502
554, 1354	OUT503
555, 1355	OUT504
556, 1356	OUT505
557, 1357	OUT506
558, 1358	OUT507
559, 1359	OUT508
560, 1360	PB8_LED
561, 1361	PB7_LED
562, 1362	PB6_LED
563, 1363	PB5_LED
564, 1364	PB4_LED
565, 1365	PB3_LED
566, 1366	PB2_LED
567, 1367	PB1_LED
568, 1368	RMB1A

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 14 of 17)

Numeric Reference	Label Reference
569, 1369	RMB2A
570, 1370	RMB3A
571, 1371	RMB4A
572, 1372	RMB5A
573, 1373	RMB6A
574, 1374	RMB7A
575, 1375	RMB8A
576, 1376	TMB1A
577, 1377	TMB2A
578, 1378	TMB3A
579, 1379	TMB4A
580, 1380	TMB5A
581, 1381	TMB6A
582, 1382	TMB7A
583, 1383	TMB8A
584, 1384	RMB1B
585, 1385	RMB2B
586, 1386	RMB3B
587, 1387	RMB4B
588, 1388	RMB5B
589, 1389	RMB6B
590, 1390	RMB7B
591, 1391	RMB8B
592, 1392	TMB1B
593, 1393	TMB2B
594, 1394	TMB3B
595, 1395	TMB4B
596, 1396	TMB5B
597, 1397	TMB6B
598, 1398	TMB7B
599, 1399	TMB8B
602, 1402	DOKA
603, 1403	ANOKA
604, 1404	LBOKA
605, 1405	CBADA
606, 1406	RBADA
607, 1407	ROKA
610, 1410	DOKB
611, 1411	ANOKB
612, 1412	LBOKB
613, 1413	CBADB

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 15 of 17)

Numeric Reference	Label Reference
614, 1414	RBADB
615, 1415	ROKB
620, 1420	TESTPUL
621, 1421	TESTFM
622, 1422	TESTDB
623, 1423	TESTDB2
624, 1424	VB32
625, 1425	VB31
626, 1426	VB30
627, 1427	VB29
628, 1428	VB28
629, 1429	VB27
630, 1430	VB26
631, 1431	VB25
632, 1432	VB24
633, 1433	VB23
634, 1434	VB22
635, 1435	VB21
636, 1436	VB20
637, 1437	VB19
638, 1438	VB18
639, 1439	VB17
640, 1440	VB16
641, 1441	VB15
642, 1442	VB14
643, 1443	VB13
644, 1444	VB12
645, 1445	VB11
646, 1446	VB10
647, 1447	VB09
648, 1448	VB08
649, 1449	VB07
650, 1450	VB06
651, 1451	VB05
652, 1452	VB04
653, 1453	VB03
654, 1454	VB02
655, 1455	VB01
724, 1524	FSERPF
725, 1525	FSERP3
726, 1526	FSERP2

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 16 of 17)

Numeric Reference	Label Reference
727, 1527	FSERP1
728, 1528	CZONE1
736, 1536	87CZ1
744, 1544	87STCZ1
752, 1552	TLED_24
753, 1553	TLED_23
754, 1554	TLED_22
755, 1555	TLED_21
756, 1556	TLED_20
757, 1557	TLED_19
758, 1558	TLED_18
759, 1559	TLED_17
764, 1564	PB12LED
765, 1565	PB11LED
766, 1566	PB10LED
767, 1567	PB9_LED
1600	TLED_8
1601	TLED_7
1602	TLED_6
1603	TLED_5
1604	TLED_4
1605	TLED_3
1606	TLED_2
1607	TLED_1
1608	TLED_16
1609	TLED_15
1610	TLED_14
1611	TLED_13
1612	TLED_12
1613	TLED_11
1614	TLED_10
1615	TLED_9
1616	RLYDIS
1617	STFAIL
1618	STWARN
1619	UNRDEV
1620	STSET
1624	TLED_24
1625	TLED_23
1626	TLED_22
1627	TLED_21

Table B.5 Serial DNP Basic Binary Input Reference Mapping (Sheet 17 of 17)

Numeric Reference	Label Reference
1628	TLED_20
1629	TLED_19
1630	TLED_18
1631	TLED_17

Binary Inputs (MAPSEL = E)

Table B.6 lists the mapping for Binary Input points when MAPSEL = E on the SEL-487B-0.

Table B.6 Serial DNP Extended Map Binary Input Point Mapping

Numeric Reference	Label Reference	Notes
0	RLYDIS	
1	STFAIL	
2	STWARN	
3	UNRDEV	
4	STSET	
16–265	See below	
272 and above	See below	

References 16–265 do not have a good equivalent, because they were dependent on the SER settings.

References 266–271 are reserved so they have no equivalent mapping.

References 272 and above simply map to the SEL-487B-0 Relay Word, starting at bit 0. To find the label equivalent for these points, subtract 272 from the reference to get the bit number and then find the bit within *Section 11: Relay Word Bits*. You can then use that bit label in the SEL-487B-1 DNP3 map, except as noted in *Table B.1*.

Binary Outputs

Table B.7 Serial DNP3 Binary Outputs Point Mapping (Sheet 1 of 3)

Numeric Reference	Label Reference	Notes
0	RB01	
1	RB02	
2	RB03	
3	RB04	
4	RB05	
5	RB06	
6	RB07	
7	RB08	
8	RB09	
9	RB10	
10	RB11	

Table B.7 Serial DNP3 Binary Outputs Point Mapping (Sheet 2 of 3)

Numeric Reference	Label Reference	Notes
11	RB12	
12	RB13	
13	RB14	
14	RB15	
15	RB16	
16	OC1	
18	OC2	
20	OC3	
22	OC4	
24	RB01:RB02	
25	RB03:RB04	
26	RB05:RB06	
27	RB07:RB08	
28	RB09:RB10	
29	RB11:RB12	
30	RB13:RB14	
31	RB15:RB16	
32	OC1:0	Open “pair” for Circuit Breaker 1
33	OC2:0	Open “pair” for Circuit Breaker 2
34	OC3:0	Open “pair” for Circuit Breaker 3
35	OC4:0	Open “pair” for Circuit Breaker 4
40	RSTTRGT	
41	NXTEVE	
44	RB17	
45	RB18	
46	RB19	
47	RB20	
48	RB21	
49	RB22	
50	RB23	
51	RB24	
52	RB25	
53	RB26	
54	RB27	
55	RB28	
56	RB29	
57	RB30	
58	RB31	
59	RB32	
60	RB17:RB18	
61	RB19:RB20	

Table B.7 Serial DNP3 Binary Outputs Point Mapping (Sheet 3 of 3)

Numeric Reference	Label Reference	Notes
62	RB21:RB22	
63	RB23:RB24	
64	RB25:RB26	
65	RB27:RB28	
66	RB29:RB30	
67	RB31:RB32	
68	OC5	
70	OC6	
72	OC7	
74	OC8	
76	OC9	
78	OC10	
80	OC11	
82	OC12	
84	OC13	
86	OC14	
88	OC15	
90	OC16	
92	OC17	
94	OC18	
108	OC5:0	Open “pair” for Circuit Breaker 5
109	OC6:0	Open “pair” for Circuit Breaker 6
110	OC7:0	Open “pair” for Circuit Breaker 7
111	OC8:0	Open “pair” for Circuit Breaker 8
112	OC9:0	Open “pair” for Circuit Breaker 9
113	OC10:0	Open “pair” for Circuit Breaker 10
114	OC11:0	Open “pair” for Circuit Breaker 11
115	OC12:0	Open “pair” for Circuit Breaker 12
116	OC13:0	Open “pair” for Circuit Breaker 13
117	OC14:0	Open “pair” for Circuit Breaker 14
118	OC15:0	Open “pair” for Circuit Breaker 15
119	OC16:0	Open “pair” for Circuit Breaker 16
120	OC17:0	Open “pair” for Circuit Breaker 17
121	OC18:0	Open “pair” for Circuit Breaker 18

Counters

Table B.8 Serial DNP3 Counters Point Mapping

Numeric Reference	Label Reference
0	ACTGRP

Analog Inputs

Table B.9 Serial DNP3 Analog Inputs Point Mapping (Sheet 1 of 3)

Numeric Reference	Label Reference	Notes
0	I01FM	
1	I01FA	
2	I02FM	
3	I02FA	
4	I03FM	
5	I03FA	
6	I04FM	
7	I04FA	
8	I05FM	
9	I05FA	
10	I06FM	
11	I06FA	
12	I07FM	
13	I07FA	
14	I08FM	
15	I08FA	
16	I09FM	
17	I09FA	
18	I10FM	
19	I10FA	
20	I11FM	
21	I11FA	
22	I12FM	
23	I12FA	
24	I13FM	
25	I13FA	
26	I14FM	
27	I14FA	
28	I15FM	
29	I15FA	
30	I16FM	
31	I16FA	
32	I17FM	
33	I17FA	
34	I18FM	
35	I18FA	
48	V01FA	
49	V01FM	
50	V02FA	

Table B.9 Serial DNP3 Analog Inputs Point Mapping (Sheet 2 of 3)

Numeric Reference	Label Reference	Notes
51	V02FM	
52	V03FA	
53	V03FM	
60	IOP1	
61	IOP2	
62	IOP3	
63	IOP4	
64	IOP5	
65	IOP6	
68	IRT1	
69	IRT2	
70	IRT3	
71	IRT4	
72	IRT5	
73	IRT6	
76	IOPCZ1	
79	IRTCZ1	
100	VDC1	
176	FTYPE	
177	FTAR1	
178	FTAR2	
181	FGRP	
184	FIMEUH	UTC Time high byte
185	FTIMEUM	UTC Time middle byte
186	FTIMEUL	UTC Time low byte
196	AMV001	
197	AMV002	
198	AMV003	
199	AMV004	
200	AMV005	
201	AMV006	
202	AMV007	
203	AMV008	
204	AMV009	
205	AMV010	
206	AMV011	
207	AMV012	
208	AMV013	
209	AMV014	
210	AMV015	
211	AMV016	

Table B.9 Serial DNP3 Analog Inputs Point Mapping (Sheet 3 of 3)

Numeric Reference	Label Reference	Notes
212	AMV017	
213	AMV018	
214	AMV019	
215	AMV020	
216	AMV021	
217	AMV022	
218	AMV023	
219	AMV024	
220	AMV025	
221	AMV026	
222	AMV027	
223	AMV028	
224	AMV029	
225	AMV030	
226	AMV031	
227	AMV032	

Analog Outputs

Table B.10 Serial DNP Analog Output Point Mapping

Numeric Reference	Label Reference
0	ACTGRP

Ethernet DNP3 Map Value Changes

The SEL-487B-0 Ethernet DNP3 map was based on database references. The SEL-487B-1 DNP3 mapping uses direct data labels. The following sections describe how to get from this database mapping to the new direct data labels.

Binary Inputs

In the SEL-487B-0 mapping, any bit in the database could be referenced for use by DNP3 LAN/WAN. Now, only Relay Word bits and a few other special bits can be used. The SEL-487B-0 reference format looked like 1:addr:bit. If addr is 3004h or greater, but not greater than 4000h, then the bits can be associated with the SEL-487B-0 Relay Word. Address 3004h corresponds to Relay Word 0, 3005h to row 1, etc. The bits are simply references in the range 0–7 and match the bits within the Relay Word row. Thus the Relay Word bits can be mapped to labels by using the comparing the SEL-487B-0 Relay Word to the SEL-487B-1 Relay Word.

Table B.11 provides reference addresses and corresponding bit labels for the SEL-487B-0 Relay Word. Consult *Table B.1* for any Relay Word changes.

Binary Outputs

In the SEL-487B-0, indices 0–127 were used to map the CCIN bits. These were general-purpose, high-speed bits, but they are no longer available in the SEL-487B-1. The equivalent in the SEL-487B-1 is the VB bits. The end user will need to remap these to remote bits.

Table B.11 describes the mapping for the Binary Outputs.

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 1 of 8)

Numeric Reference (CPId)	Label Reference
0	VB001
1	VB002
2	VB003
3	VB004
4	VB005
5	VB006
6	VB007
7	VB008
8	VB009
9	VB010
10	VB011
11	VB012
12	VB013
13	VB014
14	VB015
15	VB016
16	VB017
17	VB018
18	VB019
19	VB020
20	VB021
21	VB022
22	VB023
23	VB024
24	VB025
25	VB026
26	VB027
27	VB028
28	VB029
29	VB030
30	VB031
31	VB032
32	VB033
33	VB034

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 2 of 8)

Numeric Reference (CPId)	Label Reference
34	VB035
35	VB036
36	VB037
37	VB038
38	VB039
39	VB040
40	VB041
41	VB042
42	VB043
43	VB044
44	VB045
45	VB046
46	VB047
47	VB048
48	VB049
49	VB050
50	VB051
51	VB052
52	VB053
53	VB054
54	VB055
55	VB056
56	VB057
57	VB058
58	VB059
59	VB060
60	VB061
61	VB062
62	VB063
63	VB064
64	VB065
65	VB066
66	VB067
67	VB068
68	VB069
69	VB070
70	VB071
71	VB072
72	VB073
73	VB074
74	VB075

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 3 of 8)

Numeric Reference (CPId)	Label Reference
75	VB076
76	VB077
77	VB078
78	VB079
79	VB080
80	VB081
81	VB082
82	VB083
83	VB084
84	VB085
85	VB086
86	VB087
87	VB088
88	VB089
89	VB090
90	VB091
91	VB092
92	VB093
93	VB094
94	VB095
95	VB096
96	VB097
97	VB098
98	VB099
99	VB100
100	VB101
101	VB102
102	VB103
103	VB104
104	VB105
105	VB106
106	VB107
107	VB108
108	VB109
109	VB110
110	VB111
111	VB112
112	VB113
113	VB114
114	VB115
115	VB116

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 4 of 8)

Numeric Reference (CPId)	Label Reference
116	VB117
117	VB118
118	VB119
119	VB120
120	VB121
121	VB122
122	VB123
123	VB124
124	VB125
125	VB126
126	VB127
127	VB128
128	RB01
129	RB02
130	RB03
131	RB04
132	RB05
133	RB06
134	RB07
135	RB08
136	RB09
137	RB10
138	RB11
139	RB12
140	RB13
141	RB14
142	RB15
143	RB16
144	RB17
145	RB18
146	RB19
147	RB20
148	RB21
149	RB22
150	RB23
151	RB24
152	RB25
153	RB26
154	RB27
155	RB28
156	RB29

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 5 of 8)

Numeric Reference (CPId)	Label Reference
157	RB30
158	RB31
159	RB32
160	RB33
161	RB34
162	RB35
163	RB36
164	RB37
165	RB38
166	RB39
167	RB40
168	RB41
169	RB42
170	RB43
171	RB44
172	RB45
173	RB46
174	RB47
175	RB48
176	RB49
177	RB50
178	RB51
179	RB52
180	RB53
181	RB54
182	RB55
183	RB56
184	RB57
185	RB58
186	RB59
187	RB60
188	RB61
189	RB62
190	RB63
191	RB64
192	RB65
193	RB66
194	RB67
195	RB68
196	RB69
197	RB70

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 6 of 8)

Numeric Reference (CPId)	Label Reference
198	RB71
199	RB72
200	RB73
201	RB74
202	RB75
203	RB76
204	RB77
205	RB78
206	RB79
207	RB80
208	RB81
209	RB82
210	RB83
211	RB84
212	RB85
213	RB86
214	RB87
215	RB88
216	RB89
217	RB90
218	RB91
219	RB92
220	RB93
221	RB94
222	RB95
223	RB96
224	RB01:RB02
225	RB03:RB04
226	RB05:RB06
227	RB07:RB08
228	RB09:RB10
229	RB11:RB12
230	RB13:RB14
231	RB15:RB16
232	RB17:RB18
233	RB19:RB20
234	RB21:RB22
235	RB23:RB24
236	RB25:RB26
237	RB27:RB28
238	RB29:RB30

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 7 of 8)

Numeric Reference (CPId)	Label Reference
239	RB31:RB32
240	RB33:RB34
241	RB35:RB36
242	RB37:RB38
243	RB39:RB40
244	RB41:RB42
245	RB43:RB44
246	RB45:RB46
247	RB47:RB48
248	RB49:RB50
249	RB51:RB52
250	RB53:RB54
251	RB55:RB56
252	RB57:RB58
253	RB59:RB60
254	RB61:RB62
255	RB63:RB64
256	RB65:RB66
257	RB67:RB68
258	RB69:RB70
259	RB71:RB72
260	RB73:RB74
261	RB75:RB76
262	RB77:RB78
263	RB79:RB80
264	RB81:RB82
265	RB83:RB84
266	RB85:RB86
267	RB87:RB88
268	RB89:RB90
269	RB91:RB92
270	RB93:RB94
271	RB95:RB96
272	OC1
273	OC2
274	OC3
275	OC4
276	OC5
277	OC6
278	OC7
279	OC8

Table B.11 Ethernet DNP Binary Output Point Mapping (Sheet 8 of 8)

Numeric Reference (CPId)	Label Reference
280	OC9
281	OC10
282	OC11
283	OC12
284	OC13
285	OC14
286	OC15
287	OC16
288	OC17
289	OC18

Counters

In the SEL-487B-0, counters were referenced as points in the database. There is no direct equivalent in the SEL-487B-1, so this will need to be analyzed to determine the appropriate counter mapping.

Analog Inputs

In the SEL-487B-0, analog inputs were referenced as points in the database with optional “treat as” qualifiers and with per-point class selection. There is no direct equivalent in the SEL-487B-1, so this will need to be analyzed to determine the appropriate analog input mapping.

Table B.12 provides reference addresses and corresponding labels for the SEL-487B-0 METER database region.

Table B.12 Meter Database Labels and Addresses (Sheet 1 of 3)

Address	Label Reference
1004h	FREQ
1006h	VDC
1008h	I01FIM
100ah	I01FIA
100ch	I02FIM
100eh	I02FIA
1010h	I03FIM
1012h	I03FIA
1014h	I04FIM
1016h	I04FIA
1018h	I05FIM
101ah	I05FIA
101ch	I06FIM
101eh	I06FIA
1020h	I07FIM

Table B.12 Meter Database Labels and Addresses (Sheet 2 of 3)

Address	Label Reference
1022h	I07FIA
1024h	I08FIM
1026h	I08FIA
1028h	I09FIM
102ah	I09FIA
102ch	I10FIM
102eh	I10FIA
1030h	I11FIM
1032h	I11FIA
1034h	I12FIM
1036h	I12FIA
1038h	I13FIM
103ah	I13FIA
103ch	I14FIM
103eh	I14FIA
1040h	I15FIM
1042h	I15FIA
1044h	I16FIM
1046h	I16FIA
1048h	I17FIM
104ah	I17FIA
104ch	I18FIM
104eh	I18FIA
1068h	V01FIM
106ah	V01FIA
106ch	V02FIM
106eh	V02FIA
1070h	V03FIM
1072h	V03FIA
1080h	IOP1
1082h	IOP2
1084h	IOP3
1086h	IOP4
1088h	IOP5
108ah	IOP6
108ch	IRT1
108eh	IRT2
1090h	IRT3
1092h	IRT4
1094h	IRT5
1096h	IRT6

Table B.12 Meter Database Labels and Addresses (Sheet 3 of 3)

Address	Label Reference
1098h	IOPCZ1
109ah	IRTCZ1

Analog Outputs

In the SEL-487B-0, analog outputs were referenced by index (0–255). These mapped to remote analogs (RA001–RA256). In the SEL-487B-1, these same remote analogs are available. So if Index 0 was referenced in the SEL-487B-0 DNP3 map, the SEL-487B-1 DNP3 reference is RA001. Similarly index 1 goes to RA002, etc.

IEC 61850 Object Changes

The SEL-487B-0 implementation of the IEC 61850 protocol suite differs slightly from the SEL-487B-1 implementation. *Table B.13* lists the main functional changes between the two.

Table B.13 IEC 61850 Functional Differences

Topic	SEL-487B-0	SEL-487B-1
ICD File Version	Version 002	Version 004
Incoming GOOSE	Mappable to CCIN001–CCIN128 (binary data)	VB001–VB256 (binary data) and RA001–RA128 (analog data)
Outgoing GOOSE	Relay Word Bits mapped to CCOUT001 (binary data)	N/A (Relay Word bits can be sent directly without intermediate mapping; Analog outputs RAO01–RAO64 also available)
SER Timestamps	SER-quality timestamps available only for LNs included in the SER dataset (not editable)	Any points in the SER list (SET R) will have SER-quality time stamps. Otherwise, accuracy is within 500 ms of relay time.
Controls	Direct operate with normal security only	Direct operate with enhanced security and select-before operate (SBO) with enhanced security is also available.

Default datasets may be used for MMS Reports or for GOOSE message transmission. *Table B.14* lists the default dataset changes in the new ICD file version. Note that the contents of any data set may be modified via ACSELERATOR Architect SEL-5032 Software.

Table B.14 Default Dataset Differences

Default Dataset	SEL-487B-0	SEL-487B-1
DSet06, DSet12	Includes CCIN001–CCIN016	Includes VB001–VB016 instead
DSet13	CCOUT01–COUT08 Status	VB001–VB008 Status
SER1	List of LNs that have SER-quality time stamps (informational only, not editable)	N/A (Any point in the SER list will have SER-quality time stamps)

Most of the Logical Nodes and Attributes remain the same between the two implementations. *Table B.15* lists the mapping changes in the new ICD file.

Table B.15 Logical Node and Mapping Differences (Sheet 1 of 4)

LD	487B-0		487B-1	
	Path	Mapping	Path (If Different)	Mapping
PRO	T87CZPTRC25Trgeneral	87CZ1	NA	NA
PRO	BKRCSWI1PosOper$ctlVal	1:CONTROL:BR01		OC01:NOOP
PRO	BKRCSWI2PosOper$ctlVal	1:CONTROL:BR02		OC02:NOOP
PRO	BKRCSWI3PosOper$ctlVal	1:CONTROL:BR03		OC03:NOOP
PRO	BKRCSWI4PosOper$ctlVal	1:CONTROL:BR04		OC04:NOOP
PRO	BKRCSWI5PosOper$ctlVal	1:CONTROL:BR05		OC05:NOOP
PRO	BKRCSWI6PosOper$ctlVal	1:CONTROL:BR06		OC06:NOOP
PRO	BKRCSWI7PosOper$ctlVal	1:CONTROL:BR07		OC07:NOOP
PRO	BKRCSWI8PosOper$ctlVal	1:CONTROL:BR08		OC08:NOOP
PRO	BKRCSWI9PosOper$ctlVal	1:CONTROL:BR09		OC09:NOOP
PRO	BKRCSWI10PosOper$ctlVal	1:CONTROL:BR010		OC10:NOOP
PRO	BKRCSWI11PosOper$ctlVal	1:CONTROL:BR11		OC11:NOOP
PRO	BKRCSWI12PosOper$ctlVal	1:CONTROL:BR12		OC12:NOOP
PRO	BKRCSWI13PosOper$ctlVal	1:CONTROL:BR13		OC13:NOOP
PRO	BKRCSWI14PosOper$ctlVal	1:CONTROL:BR14		OC14:NOOP
PRO	BKRCSWI15PosOper$ctlVal	1:CONTROL:BR15		OC15:NOOP
PRO	BKRCSWI16PosOper$ctlVal	1:CONTROL:BR16		OC16:NOOP
PRO	BKRCSWI17PosOper$ctlVal	1:CONTROL:BR17		OC17:NOOP
PRO	BKRCSWI18PosOper$ctlVal	1:CONTROL:BR18		OC18:NOOP
MET	METMMXN1$Amp01$Mag$f	1:METER:I01[0]		I01FM
MET	METMMXN1$Amp02$Mag$f	1:METER:I02[0]		I02FM
MET	METMMXN1$Amp03$Mag$f	1:METER:I03[0]		I03FM
MET	METMMXN1$Amp04$Mag$f	1:METER:I04[0]		I04FM
MET	METMMXN1$Amp05$Mag$f	1:METER:I05[0]		I05FM
MET	METMMXN1$Amp06$Mag$f	1:METER:I06[0]		I06FM
MET	METMMXN1$Amp07$Mag$f	1:METER:I07[0]		I07FM
MET	METMMXN1$Amp08$Mag$f	1:METER:I08[0]		I08FM
MET	METMMXN1$Amp09$Mag$f	1:METER:I09[0]		I09FM
MET	METMMXN1$Amp10$Mag$f	1:METER:I10[0]		I10FM
MET	METMMXN1$Amp11$Mag$f	1:METER:I11[0]		I11FM
MET	METMMXN1$Amp12$Mag$f	1:METER:I12[0]		I12FM
MET	METMMXN1$Amp13$Mag$f	1:METER:I13[0]		I13FM
MET	METMMXN1$Amp14$Mag$f	1:METER:I14[0]		I14FM
MET	METMMXN1$Amp15$Mag$f	1:METER:I15[0]		I15FM
MET	METMMXN1$Amp16$Mag$f	1:METER:I16[0]		I16FM
MET	METMMXN1$Amp17$Mag$f	1:METER:I17[0]		I17FM
MET	METMMXN1$Amp18$Mag$f	1:METER:I18[0]		I18FM
MET	METMMXN1$Vol01$Mag$f	1:METER:V01[0]		V01FM
MET	METMMXN1$Vol02$Mag$f	1:METER:V02[0]		V01FM
MET	METMMXN1$Vol03$Mag$f	1:METER:V03[0]		V01FM

Table B.15 Logical Node and Mapping Differences (Sheet 2 of 4)

LD	487B-0		487B-1	
	Path	Mapping	Path (If Different)	Mapping
MET	IOPMMXN2$Amp01$Mag$f	1:METER:IOP1		IOP1F
MET	IOPMMXN2$Amp02$Mag$f	1:METER:IOP2		IOP2F
MET	IOPMMXN2$Amp03$Mag$f	1:METER:IOP3		IOP3F
MET	IOPMMXN2$Amp04$Mag$f	1:METER:IOP4		IOP4F
MET	IOPMMXN2$Amp05$Mag$f	1:METER:IOP5		IOP5F
MET	IOPMMXN2$Amp06$Mag$f	1:METER:IOP6		IOP6F
MET	IOPMMXN2$Amp06$Mag$f	1:METER:IOPCZ1	NA	NA
MET	IRTMMXN3$Amp01$Mag$f	1:METER:IRT1		IRT1F
MET	IRTMMXN3$Amp02$Mag$f	1:METER:IRT2		IRT2F
MET	IRTMMXN3$Amp03$Mag$f	1:METER:IRT3		IRT3F
MET	IRTMMXN3$Amp04$Mag$f	1:METER:IRT4		IRT4F
MET	IRTMMXN3$Amp05$Mag$f	1:METER:IRT5		IRT5F
MET	IRTMMXN3$Amp06$Mag$f	1:METER:IRT6		IRT6F
MET	IRTMMXN3$Amp07$Mag$f	1:METER:IRTCZ1	NA	NA
CON	RBGGIO1$SPSCO09$Oper$ctlVal	1:CONTROL:RB09	RBGGIO2$SPSCO09$Oper$ctlVal	RB09
CON	RBGGIO1$SPSCO10$Oper$ctlVal	1:CONTROL:RB10	RBGGIO2$SPSCO10$Oper$ctlVal	RB10
CON	RBGGIO1$SPSCO11$Oper$ctlVal	1:CONTROL:RB11	RBGGIO2$SPSCO11$Oper$ctlVal	RB11
CON	RBGGIO1$SPSCO12$Oper$ctlVal	1:CONTROL:RB12	RBGGIO2$SPSCO12$Oper$ctlVal	RB12
CON	RBGGIO1$SPSCO13$Oper$ctlVal	1:CONTROL:RB13	RBGGIO2$SPSCO13$Oper$ctlVal	RB13
CON	RBGGIO1$SPSCO14$Oper$ctlVal	1:CONTROL:RB14	RBGGIO2$SPSCO14$Oper$ctlVal	RB14
CON	RBGGIO1$SPSCO15$Oper$ctlVal	1:CONTROL:RB15	RBGGIO2$SPSCO15$Oper$ctlVal	RB15
CON	RBGGIO1$SPSCO16$Oper$ctlVal	1:CONTROL:RB16	RBGGIO2$SPSCO16$Oper$ctlVal	RB16
CON	RBGGIO1$SPSCO17$Oper$ctlVal	1:CONTROL:RB17	RBGGIO3$SPSCO17$Oper$ctlVal	RB17
CON	RBGGIO1$SPSCO18$Oper$ctlVal	1:CONTROL:RB18	RBGGIO3$SPSCO18$Oper$ctlVal	RB18
CON	RBGGIO1$SPSCO19$Oper$ctlVal	1:CONTROL:RB19	RBGGIO3$SPSCO19$Oper$ctlVal	RB19
CON	RBGGIO1$SPSCO20$Oper$ctlVal	1:CONTROL:RB20	RBGGIO3$SPSCO20$Oper$ctlVal	RB20
CON	RBGGIO1$SPSCO21$Oper$ctlVal	1:CONTROL:RB21	RBGGIO3$SPSCO21$Oper$ctlVal	RB21
CON	RBGGIO1$SPSCO22$Oper$ctlVal	1:CONTROL:RB22	RBGGIO3$SPSCO22$Oper$ctlVal	RB22
CON	RBGGIO1$SPSCO23$Oper$ctlVal	1:CONTROL:RB23	RBGGIO3$SPSCO23$Oper$ctlVal	RB23
CON	RBGGIO1$SPSCO24$Oper$ctlVal	1:CONTROL:RB24	RBGGIO3$SPSCO24$Oper$ctlVal	RB24
CON	RBGGIO1$SPSCO25$Oper$ctlVal	1:CONTROL:RB25	RBGGIO4$SPSCO25$Oper$ctlVal	RB25
CON	RBGGIO1$SPSCO26$Oper$ctlVal	1:CONTROL:RB26	RBGGIO4$SPSCO26$Oper$ctlVal	RB26
CON	RBGGIO1$SPSCO27$Oper$ctlVal	1:CONTROL:RB27	RBGGIO4$SPSCO27$Oper$ctlVal	RB27
CON	RBGGIO1$SPSCO28$Oper$ctlVal	1:CONTROL:RB28	RBGGIO4$SPSCO28$Oper$ctlVal	RB28
CON	RBGGIO1$SPSCO29$Oper$ctlVal	1:CONTROL:RB29	RBGGIO4$SPSCO29$Oper$ctlVal	RB29
CON	RBGGIO1$SPSCO30$Oper$ctlVal	1:CONTROL:RB30	RBGGIO4$SPSCO30$Oper$ctlVal	RB30
CON	RBGGIO1$SPSCO31$Oper$ctlVal	1:CONTROL:RB31	RBGGIO4$SPSCO31$Oper$ctlVal	RB31
CON	RBGGIO1$SPSCO32$Oper$ctlVal	1:CONTROL:RB32	RBGGIO4$SPSCO32$Oper$ctlVal	RB32
CON	RBGGIO1$SPSCO33$Oper$ctlVal	1:CONTROL:RB33	RBGGIO5$SPSCO33$Oper$ctlVal	RB33
CON	RBGGIO1$SPSCO34$Oper$ctlVal	1:CONTROL:RB34	RBGGIO5$SPSCO34$Oper$ctlVal	RB34

Table B.15 Logical Node and Mapping Differences (Sheet 3 of 4)

LD	487B-0		487B-1	
	Path	Mapping	Path (If Different)	Mapping
CON	RBGGIO1$SPSCO35$Oper$ctlVal	1:CONTROL:RB35	RBGGIO5$SPSCO35$Oper$ctlVal	RB35
CON	RBGGIO1$SPSCO36$Oper$ctlVal	1:CONTROL:RB36	RBGGIO5$SPSCO36$Oper$ctlVal	RB36
CON	RBGGIO1$SPSCO37$Oper$ctlVal	1:CONTROL:RB37	RBGGIO5$SPSCO37$Oper$ctlVal	RB37
CON	RBGGIO1$SPSCO38$Oper$ctlVal	1:CONTROL:RB38	RBGGIO5$SPSCO38$Oper$ctlVal	RB38
CON	RBGGIO1$SPSCO39$Oper$ctlVal	1:CONTROL:RB39	RBGGIO5$SPSCO39$Oper$ctlVal	RB39
CON	RBGGIO1$SPSCO40$Oper$ctlVal	1:CONTROL:RB40	RBGGIO5$SPSCO40$Oper$ctlVal	RB40
CON	RBGGIO1$SPSCO41$Oper$ctlVal	1:CONTROL:RB41	RBGGIO6$SPSCO41$Oper$ctlVal	RB41
CON	RBGGIO1$SPSCO42$Oper$ctlVal	1:CONTROL:RB42	RBGGIO6$SPSCO42$Oper$ctlVal	RB42
CON	RBGGIO1$SPSCO43$Oper$ctlVal	1:CONTROL:RB43	RBGGIO6$SPSCO43$Oper$ctlVal	RB43
CON	RBGGIO1$SPSCO44$Oper$ctlVal	1:CONTROL:RB44	RBGGIO6$SPSCO44$Oper$ctlVal	RB44
CON	RBGGIO1$SPSCO45$Oper$ctlVal	1:CONTROL:RB45	RBGGIO6$SPSCO45$Oper$ctlVal	RB45
CON	RBGGIO1$SPSCO46$Oper$ctlVal	1:CONTROL:RB46	RBGGIO6$SPSCO46$Oper$ctlVal	RB46
CON	RBGGIO1$SPSCO47$Oper$ctlVal	1:CONTROL:RB47	RBGGIO6$SPSCO47$Oper$ctlVal	RB47
CON	RBGGIO1$SPSCO48$Oper$ctlVal	1:CONTROL:RB48	RBGGIO6$SPSCO48$Oper$ctlVal	RB48
ANN	TLEDGGIO7$Ind19$stVal	1:TARGET:TARGET: TLED_17	NA	NA
ANN	TLEDGGIO7$Ind20$stVal	1:TARGET:TARGET: TLED_18	NA	NA
ANN	TLEDGGIO7$Ind21$stVal	1:TARGET:TARGET: TLED_19	NA	NA
ANN	TLEDGGIO7$Ind22$stVal	1:TARGET:TARGET: TLED_20	NA	NA
ANN	TLEDGGIO7$Ind23$stVal	1:TARGET:TARGET: TLED_21	NA	NA
ANN	TLEDGGIO7$Ind24$stVal	1:TARGET:TARGET: TLED_22	NA	NA
ANN	TLEDGGIO7$Ind25$stVal	1:TARGET:TARGET: TLED_23	NA	NA
ANN	TLEDGGIO7$Ind26$stVal	1:TARGET:TARGET: TLED_24	NA	NA
ANN	PBLEDGGIO8$Ind09$stVal	1:TARGET:TARGET: PB9_LED	NA	NA
ANN	PBLEDGGIO8$Ind10$stVal	1:TARGET:TARGET: PB10LED	NA	NA
ANN	PBLEDGGIO8$Ind11$stVal	1:TARGET:TARGET: PB11LED	NA	NA
ANN	PBLEDGGIO8$Ind12$stVal	1:TARGET:TARGET: PB12LED	NA	NA
ANN	CCINGGIO19$Ind001$stVal– CCINGGIO19$Ind001$stVal	CCIN001–CCIN128	NA	NA
ANN	CCOUTGGIO20$Ind01$stVal– CCOUTGGIO20$Ind32$stVal	CCOUT01–CCOUT32	NA	NA
ANN	RMBAGGIO21$Ind01$stVal– RMBAGGIO21$Ind08$stVal	RMB1A–RMB8A	NA	NA

Table B.15 Logical Node and Mapping Differences (Sheet 4 of 4)

LD	487B-0		487B-1	
	Path	Mapping	Path (If Different)	Mapping
ANN	TMBAGGIO22$Ind01$stVal–TMBAGGIO22$Ind08$stVal	TMB1A–TMB8A	NA	NA
ANN	RMBBGGIO23$Ind01$stVal–RMBBGGIO23$Ind08$stVal	RMB1B–RMB8B	NA	NA
ANN	TMBBGGIO24$Ind01$stVal–TMBBGGIO24$Ind08$stVal	TMB1B–TMB8B	NA	NA
ANN	MBOKGGIO25$Ind01$stVal	1:TARGET:TARGET:ROKA	NA	NA
ANN	MBOKGGIO25$Ind02$stVal	1:TARGET:TARGET:RBADA	NA	NA
ANN	MBOKGGIO25$Ind03$stVal	1:TARGET:TARGET:CBADA	NA	NA
ANN	MBOKGGIO25$Ind04$stVal	1:TARGET:TARGET:LBOKA	NA	NA
ANN	MBOKGGIO25$Ind05$stVal	1:TARGET:TARGET:ANOKA	NA	NA
ANN	MBOKGGIO25$Ind06$stVal	1:TARGET:TARGET:DOKA	NA	NA
ANN	MBOKGGIO25$Ind07$stVal	1:TARGET:TARGET:ROKB	NA	NA
ANN	MBOKGGIO25$Ind08$stVal	1:TARGET:TARGET:RBADB	NA	NA
ANN	MBOKGGIO25$Ind09$stVal	1:TARGET:TARGET:CBADB	NA	NA
ANN	MBOKGGIO25$Ind10$stVal	1:TARGET:TARGET:LBOKB	NA	NA
ANN	MBOKGGIO25$Ind11$stVal	1:TARGET:TARGET:ANOKB	NA	NA
ANN	MBOKGGIO25$Ind12$stVal	1:TARGET:TARGET:DOKB	NA	NA

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SEL-487B-1 Relay Command Summary

Command[a, b]	Description
2ACCESS	Go to Access Level 2 (full control)
AACCESS	Go to Access Level A (automation configuration)
ACCESS	Go to Access Level 1 (monitor relay)
BACCESS	Go to Access Level B (monitor relay and control circuit breakers)
BNAME	ASCII names of Fast Meter status bits
CASCII	Generate the Compressed ASCII response configuration message
CEVENT	Display Compressed ASCII event report
CFG CTNOM *i*	For TiDL (EtherCAT) relays, configure the nominal CT input value *i* to 1 or 5
CFG NFREQ *f*	In TiDL (EtherCAT) relays, set the nominal frequency, *f* (50 or 60)
CHISTORY	Display Compressed ASCII history report
COM *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)
COM PTP	Display a report on PTP data sets and statistics
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)
CPR	Display Compressed ASCII signal profiling report
CSER	Display Compressed ASCII sequential events report
CSTATUS	Display Compressed ASCII relay status report
CSUMMARY	Display Compressed ASCII summary event report
DATE	Display and set the date
DNAME X	ASCII names of all relay digital points reported via Fast Meter
ETHERNET	Display Ethernet port (Port 5) configuration and status
EVENT	Display and acknowledge event reports
EXIT	Terminates a Telnet session
FILE	Transfer files between the relay and external software
GOOSE	Displays transmit and receive GOOSE messaging information
GROUP	Display the active group number or select the active group
HELP	List and describe available commands at each access level
HISTORY	View event summaries/histories; clear event summary 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
MAC	Display the MAC addresses
MAP 1	View the relay database organization
METER	Display metering data and internal relay operating variables
OACCESS	Go to Access Level O (output configuration)
OPEN *n*	Open the circuit breaker (*n* = 1–21)
PACCESS	Go to Access Level P (protection configuration)
PASSWORD *n*	Change relay password for Access Level *n*

Command[a, b]	Description
PING ***addr***	Sends an ICMP echo request message to the provided IP address to confirm connectivity
PORT ***p***	Connect to a remote relay via MIRRORED BITS virtual terminal for port number *p* (*p* = 1–3 and F)
PROFILE	Display signal profile records
PULSE OUT*nnn*	Pulse a relay control output (OUT*nnn* is a control output)
QUIT	Reduce access level to Access Level 0 (exit relay control)
SER	View Sequential Events Recorder report
SET	Set or modify relay settings
SHOW	Display relay settings
SNS	Display Sequential Events Recorder settings name strings (Fast SER)
STATUS	Report or clear relay status and SELOGIC control equation errors
SUMMARY	Display a summary event report
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 DB2	Test all communications protocols except Fast Message
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 Fast Message database
ZONE	Display the terminal and bus names associated with all active protective zones

[a] See Section 9: ASCII Command Reference.
[b] For help on a specific command, type **HELP [command] <Enter>** at an ASCII terminal communicating with the relay.

SEL-487B-1 Relay Command Summary

Command[a, b]	Description
2ACCESS	Go to Access Level 2 (full control)
AACCESS	Go to Access Level A (automation configuration)
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CONTROL *nn*	Set, clear, or pulse an internal remote bit (*nn* is the remote bit number from 01–96)
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CSER	Display Compressed ASCII sequential events report
CSTATUS	Display Compressed ASCII relay status report
CSUMMARY	Display Compressed ASCII summary event report
DATE	Display and set the date
DNAME X	ASCII names of all relay digital points reported via Fast Meter
ETHERNET	Display Ethernet port (Port 5) configuration and status
EVENT	Display and acknowledge event reports
EXIT	Terminates a Telnet session
FILE	Transfer files between the relay and external software
GOOSE	Displays transmit and receive GOOSE messaging information
GROUP	Display the active group number or select the active group
HELP	List and describe available commands at each access level
HISTORY	View event summaries/histories; clear event summary 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
MAC	Display the MAC addresses
MAP 1	View the relay database organization
METER	Display metering data and internal relay operating variables
OACCESS	Go to Access Level O (output configuration)
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PACCESS	Go to Access Level P (protection configuration)
PASSWORD *n*	Change relay password for Access Level *n*

Command[a, b]	Description
PING *addr*	Sends an ICMP echo request message to the provided IP address to confirm connectivity
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PULSE OUT*nnn*	Pulse a relay control output (OUT*nnn* is a control output)
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SER	View Sequential Events Recorder report
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TEST DB	Display or place values in the communications card database (useful for Ethernet protocol read tests)
TEST DB2	Test all communications protocols except Fast Message
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 Fast Message database
ZONE	Display the terminal and bus names associated with all active protective zones

[a] See Section 9: ASCII Command Reference.
[b] For help on a specific command, type **HELP [command] <Enter>** at an ASCII terminal communicating with the relay.