SEL-501-2

Dual Overcurrent Relay

Instruction Manual

20250131

SCHWEITZER ENGINEERING LABORATORIES

Part Number: PM501-02

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Preface

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 Panasonic BR-2330A 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 Panasonic BR-2330A 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.
For use in Pollution Degree 2 environment.	Pour utilisation dans un environnement de Degré de Pollution 2.

Other Safety Marks

⚠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, blesser 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 is not 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 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.
⚠CAUTION The relay contains devices sensitive to electrostatic discharge (ESD). When working on the relay with front or top cover removed, work surfaces and personnel must be properly grounded or equipment damage may result.	**⚠ATTENTION** Le relais contient des pièces sensibles aux décharges électrostatiques (DES). Quand on travaille sur le relais avec le panneau avant ou du dessus enlevé, les surfaces de travail et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.
⚠CAUTION This procedure requires that you handle components sensitive to Electrostatic Discharge (ESD). If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.	**⚠ATTENTION** Cette procédure requiert que vous manipuliez des composants sensibles aux décharges électrostatiques (DES). Si vous n'êtes pas équipés pour travailler avec ce type de composants, nous vous recommandons de les retourner à SEL pour leur installation.
⚠CAUTION Verify proper orientation of any replaced Integrated Circuit(s) (ICs) before reassembling the relay. Energizing the relay with an IC reversed irrecoverably damages the IC. If you mistakenly re-energize the relay with an IC reversed, do not place the relay in service using that IC, even if you correct the orientation.	**⚠ATTENTION** Vérifier l'orientation d'un circuit intégré (CI) que vous remplacez avant de l' installer sur le relais. La mise sous-tension du relais avec un CI inversé endommagera de façon irréversible celui-ci. Si vous remettez le relais sous tension par mégarde, ne pas laisser le relais en service avec ce CI, même si l'orientation a été corrigée.

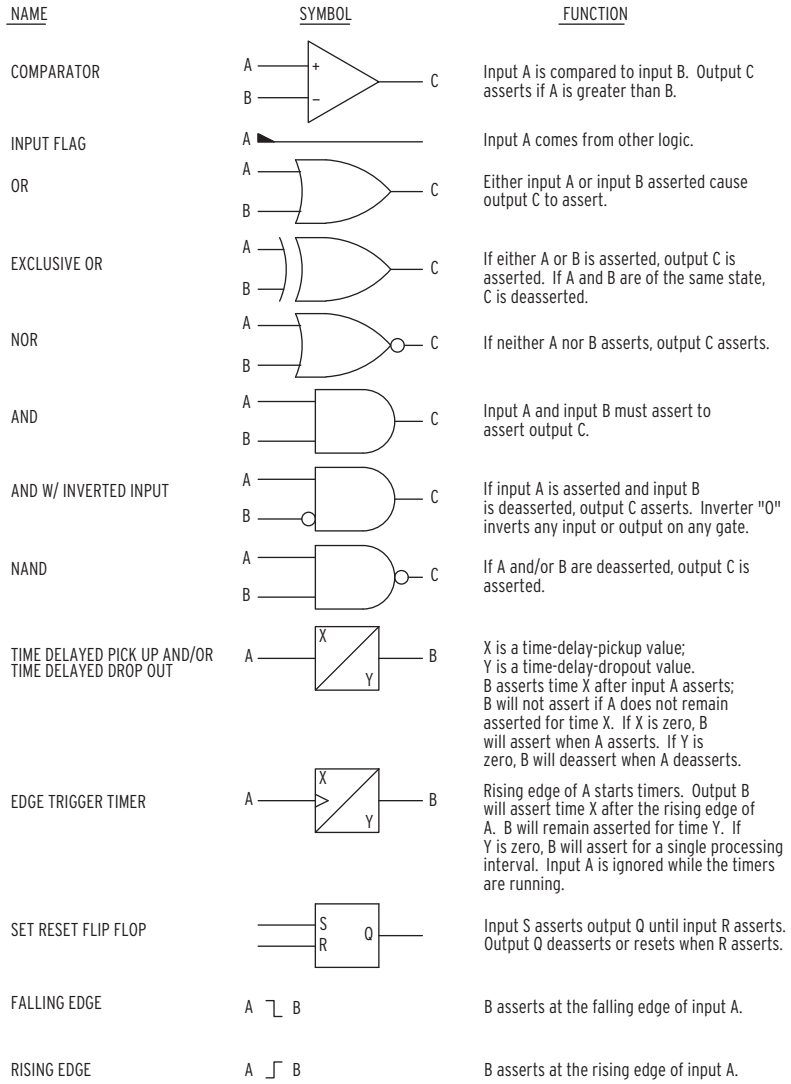
Typographic Conventions

This manual shows certain information with specific font and formatting attributes. The following table lists the typographic conventions used in this documentation.

Example	Description
STATUS	ASCII and Compressed ASCII commands.
TAR 23 <Enter>	Commands/input that you type.
CLOSE	Relay front-panel pushbuttons.
<Enter>	Single keystroke command.
<Ctrl+D>	Multiple keystroke command to bring up a control window or activate a control function.
RELAY ELEMENTS	Front-panel LCD menu items.

Logic Diagrams

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



Trademarks

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

ACSELERATOR Architect®	Compass®
ACSELERATOR QuickSet®	Connectorized®
ACSELERATOR TEAM®	SYNCHROWAVE®

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

SECTION 1

Introduction

The SEL-501-2 provides two complete and independent groups of protection functions in one compact unit. The unit contains Relay X and Relay Y, each having two output contacts, one optoisolator input, and three-phase current inputs. Each SEL-501-2 provides overcurrent protection. You select the settings for each relay independently. Unlike the SEL-501 Dual Universal Overcurrent Relay, Motor, and Breaker Failure protection functions are not available with the SEL-501-2.

The Dual Relay Block Diagram in *Figure 1.3* shows the relay hardware arrangement. A single microprocessor, data acquisition system, and power supply perform the functions required to protect two pieces of power system equipment. This design makes the SEL-501-2 extremely economical in terms of initial cost, panel space requirements, communications, wiring, and testing. Some possible relay applications are shown in *Table 1.1*. Single-line diagrams of the protection groups are shown in *Figure 1.4*.

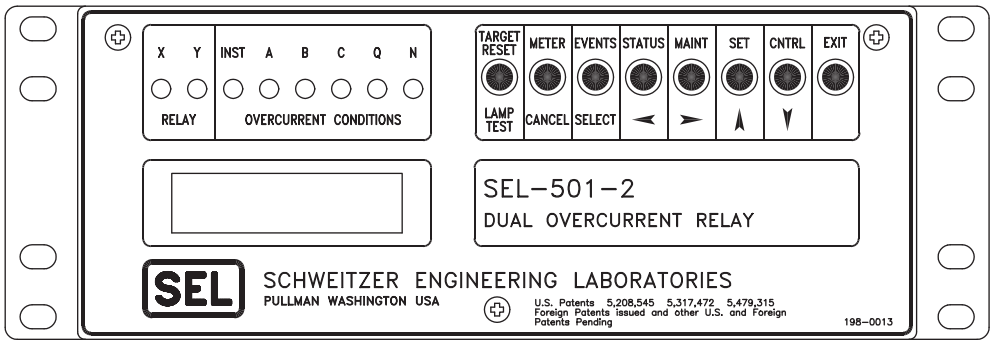


Figure 1.1 SEL-501-2 Front Panel Without Front Serial Port

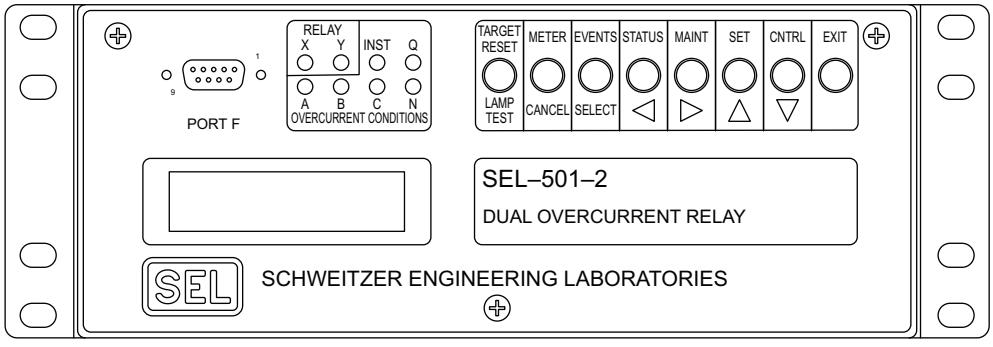


Figure 1.2 SEL-501-2 Front Panel With Front Serial Port

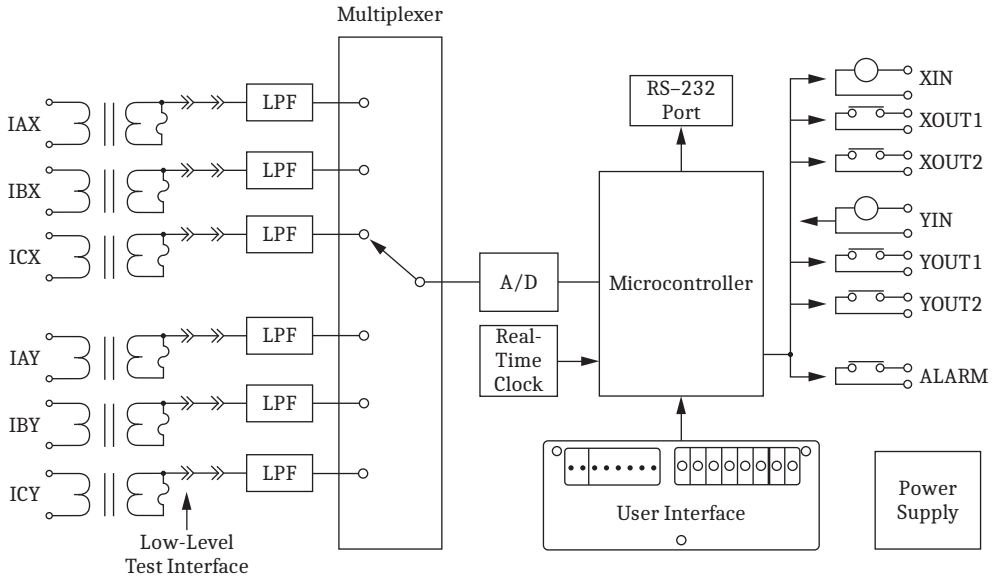
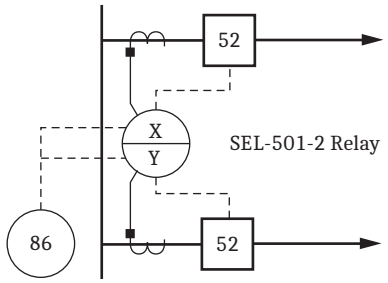
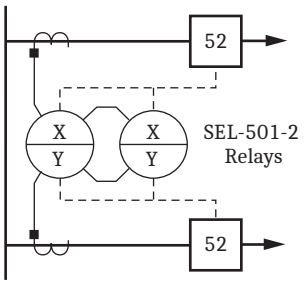
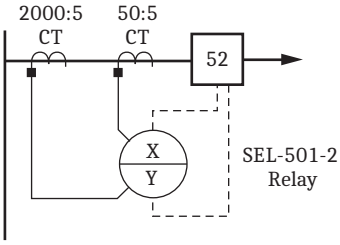


Figure 1.3 Dual-Relay Hardware Block Diagram

SEL-501-2 Dual-Relay Applications

Table 1.1 Example SEL-501-2 Dual-Relay Applications

Protect Two Feeders		➤ Complete overcurrent and simple breaker failure protection for two feeders. ➤ Settable time delay on trip output contact provides simple breaker failure protections. ➤ Low cost, compact protection.
Two Relays + Two Feeders = Full Redundancy		➤ Ideal for two-high switchgear. ➤ Front-panel controls eliminate the need for manual control switches. ➤ Includes negative-sequence overcurrent protection for sensitive, fast phase-to-phase fault coverage.
Cover a Wide Range of Fault Currents		➤ 2000:5 CT covers fault as high as 32,000 A (5 A Model). ➤ 50:5 CT meters load accurately, and covers faults as low as 5 A primary (5 A Model).

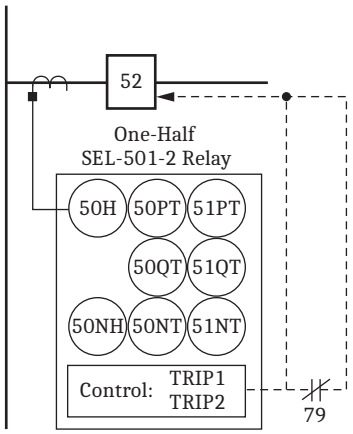


Figure 1.4 Relay Application Single-Line Diagram

CT Saturation Protection

The SEL–501-2 phase instantaneous overcurrent elements normally operate by using the output of a cosine filter algorithm. During heavy fault currents when the relay detects severe CT saturation, the overcurrent elements can operate on the adaptive current algorithm.

The adaptive current algorithm is only used for phase instantaneous overcurrent elements if and only if the corresponding pickup setting is greater than eight times the nominal phase current. For example, if 50H = 45 A (in a 5 A nominal phase current relay), then the 50H element operates on the adaptive current algorithm. However, if 50H = 35 A, then the 50H element operates on the output of a cosine filter algorithm. No other overcurrent elements use the adaptive current algorithm.

Based on the level of a "harmonic distortion index," the adaptive current is either the output of the cosine filter or the output of the bipolar peak detector. When the harmonic distortion index exceeds the fixed threshold that indicates severe CT saturation, the adaptive current is the output of the bipolar peak detector. When the harmonic distortion index is below the fixed threshold, the adaptive current is the output of the cosine filter.

The cosine filter provides excellent performance in removing dc offset and harmonics. However, the bipolar peak detector has the best performance in situations of severe CT saturation when the cosine filter magnitude estimation is significantly degraded. Combining the two filters provides an elegant solution for ensuring dependable phase instantaneous overcurrent element operation.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to US and Canadian safety standards (File E212775; NRGU, NRGU7)

CE Mark

UKCA Mark

RCM Mark

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

General

Terminal Connections

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

Tightening Torque

Terminal Block

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

Connectorized

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

AC Current Inputs

5 A Nominal:	15 A continuous, 500 A for 1 s, linear to 100 A symmetrical. 625 A for 1 cycle (sinusoidal waveform)
Burden:	0.16 VA at 5 A 1.15 VA at 15 A
1 A Nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical. 250 A for 1 cycle (sinusoidal waveform)
Burden:	0.06 VA at 1 A 0.18 VA at 3 A

Note: 60/50 Hz system frequency and ABC/ACB phase rotation are ordering options.

Power Supply

125/250 Vdc or Vac

Range:	85–350 Vdc or 85–264 Vac
Burden:	<5.5 W
Interruption:	100 ms at 250 Vdc
Ripple:	100%

48/125 Vdc or 125 Vac

Range:	36–200 Vdc or 85–140 Vac
Burden:	<5.5 W
Interruption:	100 ms at 125 Vdc
Ripple:	5%

24 Vdc

Range:	16–36 Vdc polarity-dependent
Burden:	<5.5 W
Interruption:	25 ms at 36 Vdc
Ripple:	5%

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

Output Contacts

The output type is dependent on the rear-panel terminal type. Output ratings were determined with IEC 60255-0-20:1974, using the simplified method of assessment.

Standard (Conventional Terminal Blocks Option)

Make:	30 A
Carry:	6 A continuous carry
1 s Rating:	100 A
MOV Protection:	270 Vac/360 Vdc
Pickup Time:	<5 ms
Dropout Time:	<5 ms

Breaking Capacity (10000 operations)

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

Cyclic Capacity (2.5 cycle/second)

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

High-Current Interrupting (Plug-In Connectors Option)

Make:	30 A
Carry:	6 A continuous carry
MOV Protection:	330 Vdc
Pickup Time:	<5 ms
Dropout Time:	<8 ms, typical

Breaking Capacity (10000 operations)

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

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

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

Note: Do not use high current interrupting output contacts to switch ac control signals. These outputs are polarity-dependent.
Note: Make per IEEE C37.90-1989.

Optoisolated Inputs

The input type is dependent on the rear-panel terminal type. "Level-sensitive" inputs differ from "standard" jumper-selectable inputs in that they are guaranteed to deassert below a certain voltage level and they are not user-settable. The inputs are not polarity-dependent. With nominal control voltage applied, each input draws approximately 4 mA of current.

Conventional Terminal Blocks Option

The conventional terminal block model is can be ordered with either jumper-selectable voltage optoisolated inputs or level-sensitive optoisolated inputs.

Jumper-Selectable Control Voltage:

Both inputs may be individually user-configured to operate on any of the following nominal voltages:

24 Vdc:	on for 15–30 Vdc
48 Vdc:	on for 30–60 Vdc
125 Vdc:	on for 80–150 Vdc
250 Vdc:	on for 150–300 Vdc

Level-Sensitive

Both inputs are factory-configured for a fixed voltage level that cannot be changed:

48 Vdc:	on for 38.4–60 Vdc; off below 28.8 Vdc
110 Vdc:	on for 88–132 Vdc; off below 66 Vdc
125 Vdc:	on for 105–150 Vdc; off below 75 Vdc
220 Vdc:	on for 176–264 Vdc; off below 132 Vdc
250 Vdc:	on for 200–300 Vdc; off below 150 Vdc

Plug-In Connectors Option

Standard (Non-Level-Sensitive):

24 Vdc:	on for 15–30 Vdc

Level-Sensitive:

The plug-in connectors model is equipped with fixed "level-sensitive" inputs. Both inputs are factory configured to the control voltage specified at time of ordering:

48 Vdc:	on for 38.4–60 Vdc; off below 28.8 Vdc
110 Vdc:	on for 88–132 Vdc; off below 66 Vdc
125 Vdc:	on for 105–150 Vdc; off below 75 Vdc
250 Vdc:	on for 200–300 Vdc; off below 150 Vdc

Serial Communications

Front and Rear Panel:	9-pin sub-D connector
Baud Rate:	300–38400 baud; settable baud rate and data bit protocol

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1.

Protocols

Serial Port Protocols:	ASCII Distributed Port Switch Protocol (LMD) Modbus RTU (baud rate limited to 19200)

Metering Functions

Instantaneous and Demand Ammetering Functions

Measurement Accuracy:	5 A Model: ±2% ±0.10 A 1 A Model: ±2% ±0.02 A

Breaker Monitor

Relay counts trip operations and accumulates interrupted current on a pole-by-pole basis.

Routine Dielectric Strength

Current Inputs:	2500 Vac for 10 s
Power Supply, Optoisolated Inputs, and Output Contacts:	3000 Vdc for 10 s

The following IEC 60255-5:1977 dielectric test is performed on all units with the CE mark:

2500 Vac for 10 seconds on analog inputs.
3100 Vdc for 10 seconds on power supply, optoisolated inputs, and contact outputs.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Dimensions

8.81 cm x 21.59 cm x 23.37 cm (3.47" x 8.5" x 9.2") (H x W x D)

Weight

2.6 kg (5 lb, 12 oz)

Type Tests

Electromagnetic Compatibility Emission (EMC)

Canada ICES-001 (A) / NMB-001 (A)

Environmental Tests

Cold:	IEC 60068-2-1:1990 [EN 60068-1-1:1993] Test Ad; 16 hr at –40°C
Damp Heat, Steady State:	IEC 60068-2-3:1969 Test Ca; 96 hours at +40°C, 93% RH
Damp Heat, Cyclic	IEC 60068-2-30:1980 Test Db; 25° to 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:1974 [EN 60068-2-2:1993] Test Bd: 16 hr at +85°C

Dielectric Strength and Impulse Tests

Dielectric:	IEC 60255-5:1977 IEEE C37.90-1989 2500 Vac on analogs, contact inputs, and contact outputs; 100 Vdc on power supply; 2200 Vdc on EIA-485 communications port
Impulse:	IEC 60255-5:1977 0.5 J, 5000 V

Electrostatic Discharge Test

ESD:	IEC 60255-22-2:1996 IEC 60801-2:1991 Level 4

RFI and Interference Tests

Fast Transient Burst:	IEC 60801-4:1988 Level 4 (4 kV on power supply, 2 kV on inputs and outputs)
Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 60801-2:1991 Level 4
Radiated EMI:	IEC 60255-22-3:1989, 10 V/m
Surge Withstand:	IEEE C37.90.1-1989 3.0 kV oscillatory; 5.0 kV fast transient

Vibration and Shock Tests

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

Object Penetration

Object Penetration:	IEC 60529:1989 IP3X

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SECTION 2

Mounting and Connections

Relay Mounting

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

Rack Mount

A single SEL-501-2 is roughly half the size of a standard 19-inch rack (see *Figure 2.1*, *Figure 2.7*, and *Figure 2.8*). To mount the relay in a standard 19-inch rack, use another SEL-501-2 in a package (P/N 9101) or use the Rack-Mount Bracket (P/N 9100). See *Figure 2.2*, *Figure 2.3*, and *Figure 2.4*. Secure the relays with four rack screws (two on each side) that you insert from the front of the relays through the holes on the relay mounting flanges.

Reverse the relay mounting flanges on the single or package versions to cause the relays to project 2.60 in (66.1 mm). This provides additional space at the rear of the relays for applications where the relays might otherwise be too deep to fit.

Panel Mount

We also offer the SEL-501-2 in a panel-mount version for a clean look. Panel-mount relays have sculpted front-panel molding that covers all installation holes. See *Figure 2.1* and *Figure 2.8*. Cut your panel and drill mounting holes according to the dimensions in *Figure 2.1*. Insert the relay into the cutout, aligning four relay mounting studs on the rear of the relay front panel with the drilled holes in your panel, and use nuts to secure the relay to your panel.

The projection panel-mount option covers all installation holes and maintains the sculpted look of the panel-mount option; the relay projects 2.60 in (66.1 mm) from the front of your panel. This ordering option increases space at the rear of the relay for applications where the relay would ordinarily be too deep to fit your cabinet.

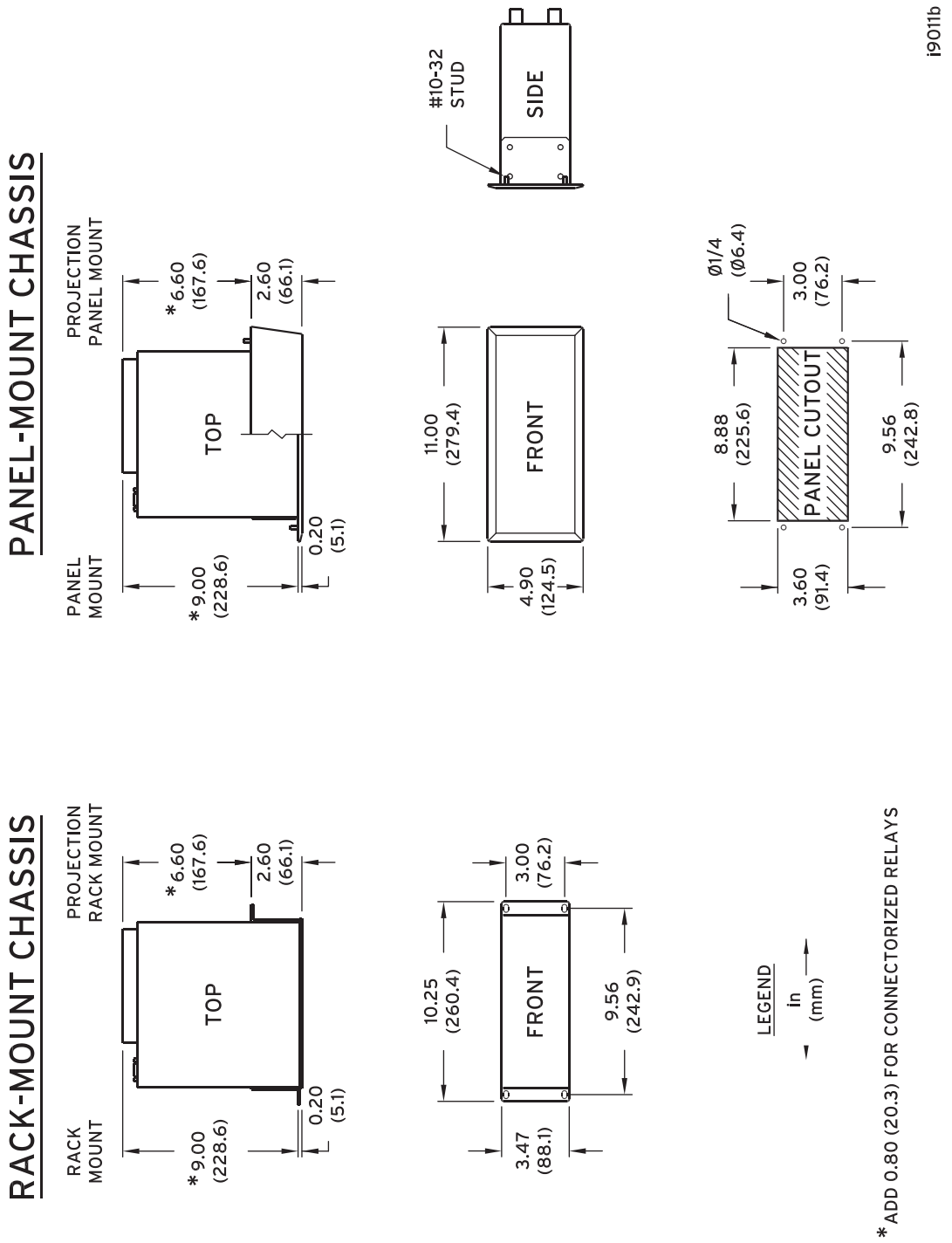
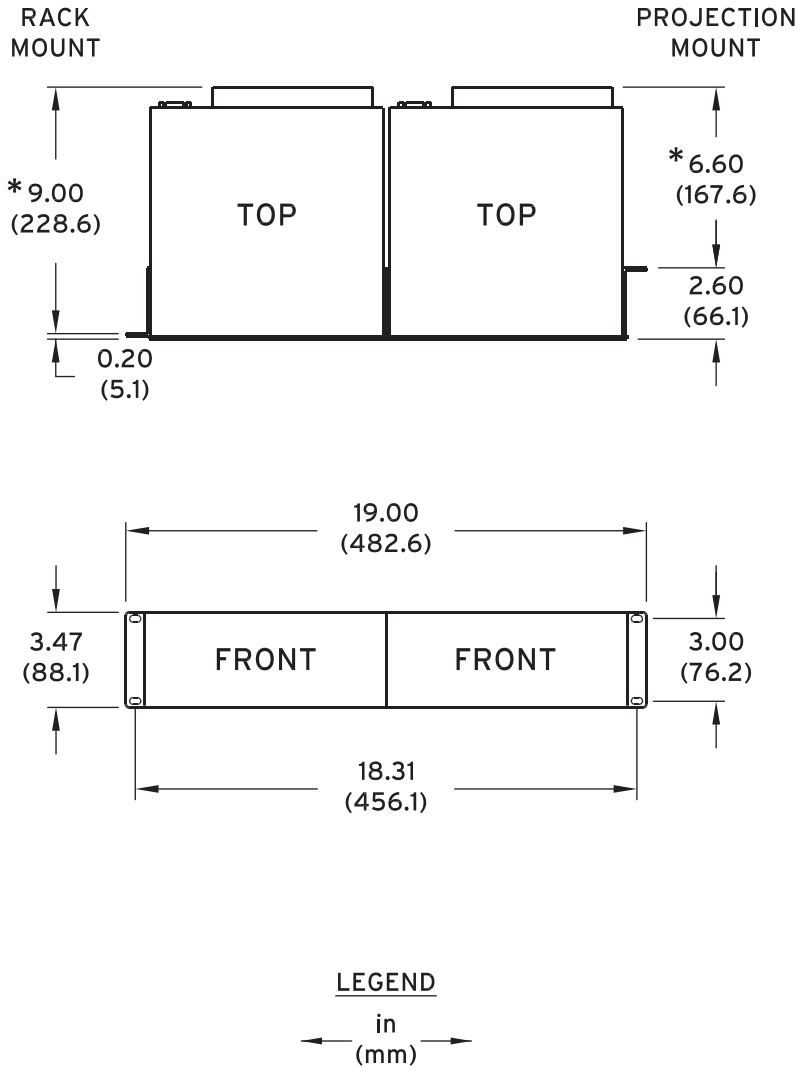


Figure 2.1 SEL-501-2 Dimensions and Drill Plan for Single Rack-Mount Relay

RACK-MOUNT CHASSIS



*ADD 0.80 (20.3) FOR CONNECTORIZED RELAYS

i9024b

Figure 2.2 Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relays Together Using Mounting Block (SEL P/N 9101)

RACK-MOUNT CHASSIS

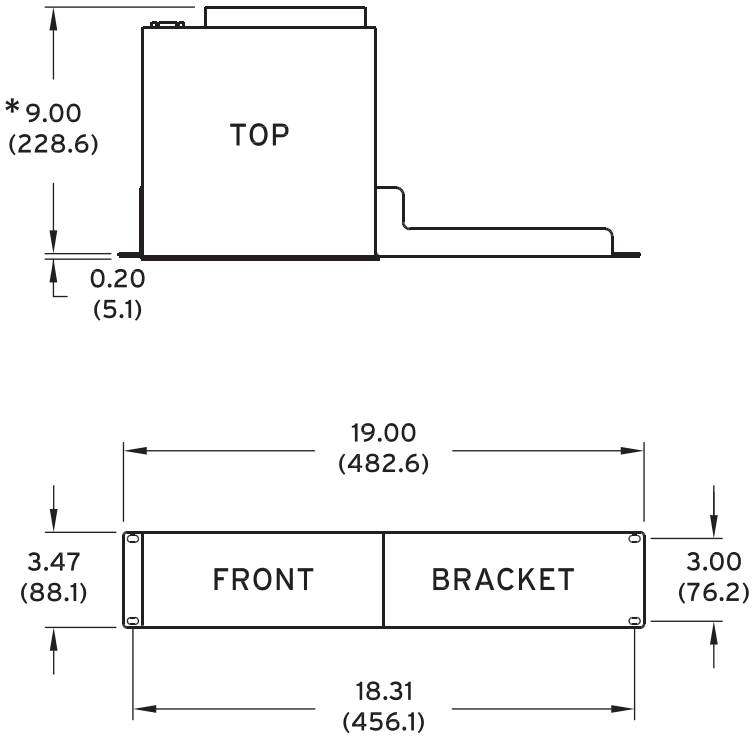


Figure 2.3 Relay Dimensions and Drill Plan for Mounting an SEL-501-2 With Rack-Mount Bracket 9100 (Bracket on Right Side in Front View)

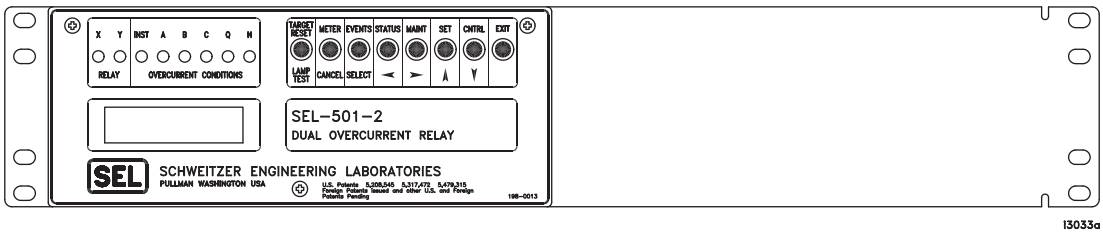


Figure 2.4 SEL-501-2 Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in a 19-Inch Rack (No Front Serial Port)

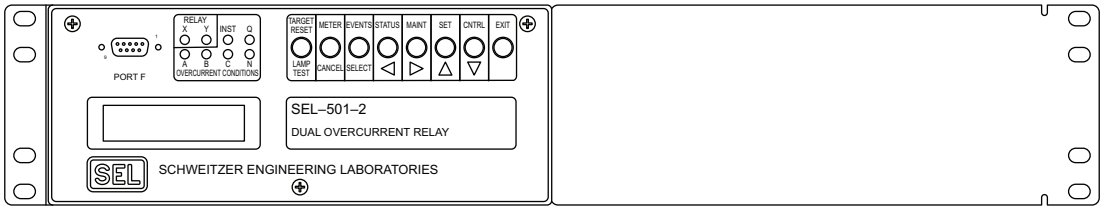


Figure 2.5 SEL-501-2 Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in a 19-Inch Rack (With Front Serial Port)

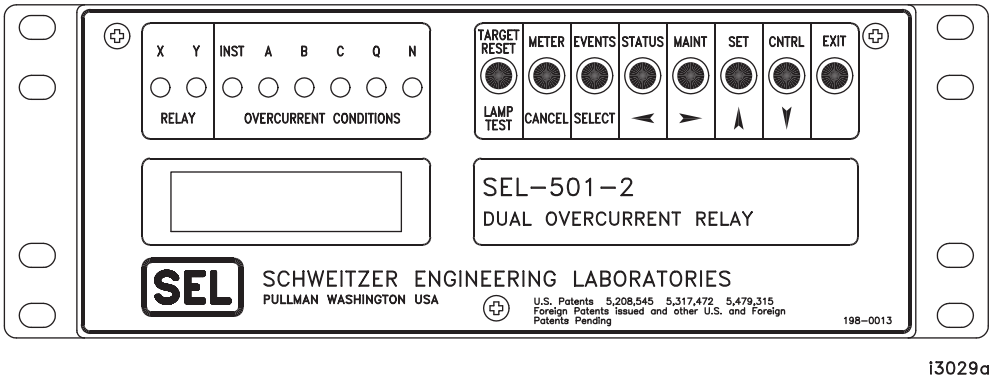


Figure 2.6 SEL-501-2 Front Panel, Rack-Mount Version (Half-Rack Width, No Front Serial Port)

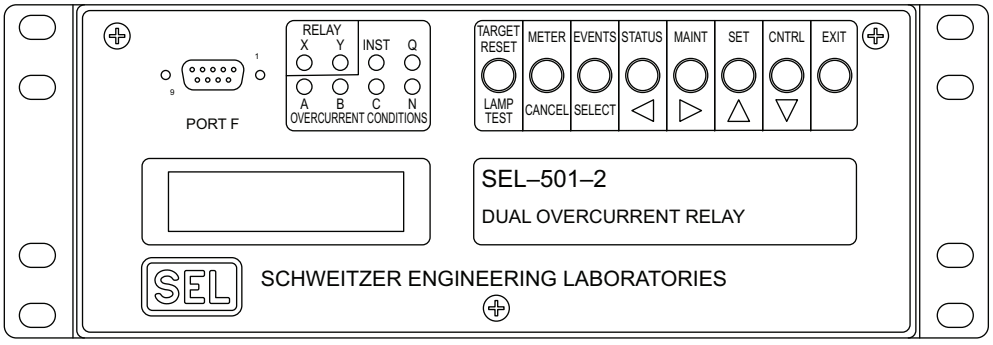


Figure 2.7 SEL-501-2 Front Panel, Rack-Mount Version (Half-Rack Width, With Front Serial Port)

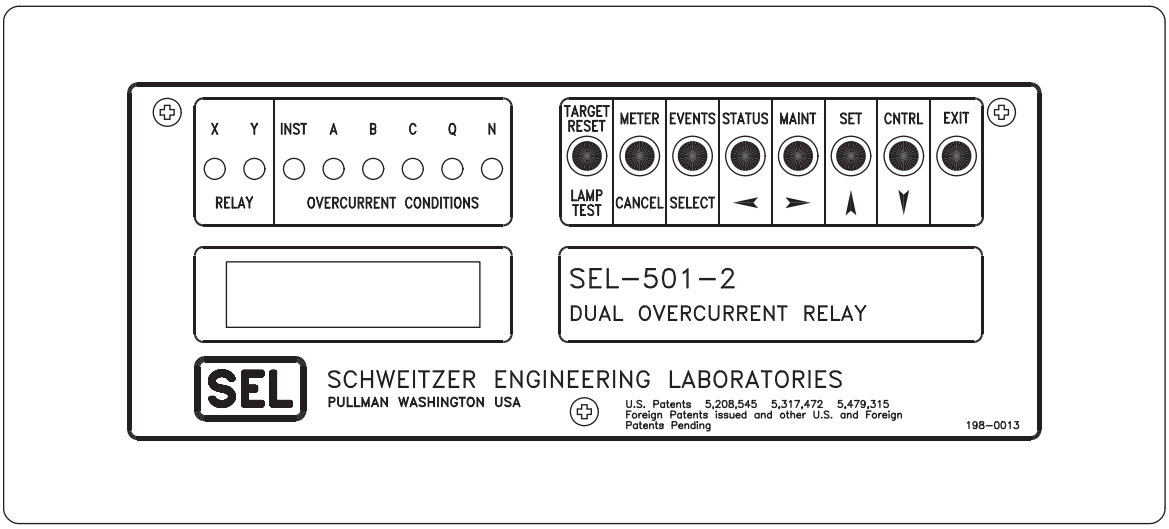


Figure 2.8 SEL-501-2 Front Panel, Panel-Mount Version, No Front Serial Port

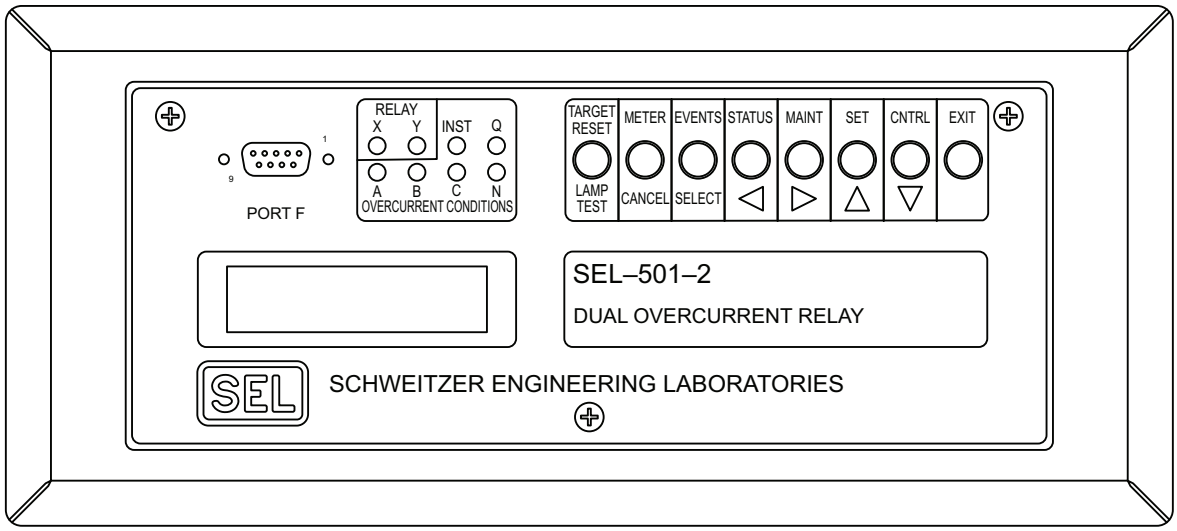


Figure 2.9 SEL-501-2 Front Panel, Panel-Mount Version, With Front Serial Port

Rear-Panel Connections

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

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

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

Terminal Block

Make terminal block connections with size #6-32 screws by using a Phillips or slotted screwdriver. You may request locking screws from the factory. Refer to *Figure 2.10* to make all terminal block connections.

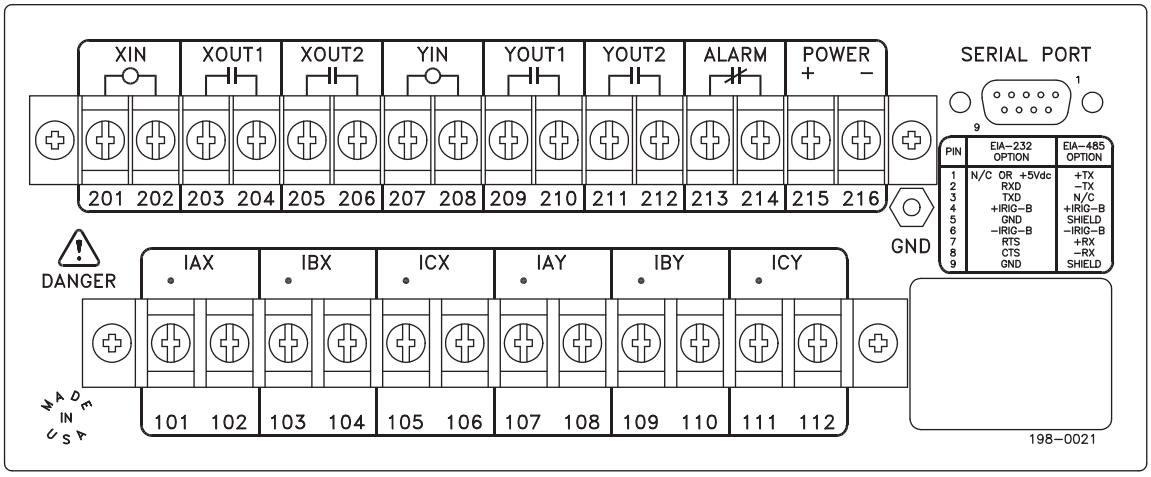


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Figure 2.10 SEL-501-2 Rear Panel From Relay Without Front Serial Port (Conventional Terminal Blocks Option)

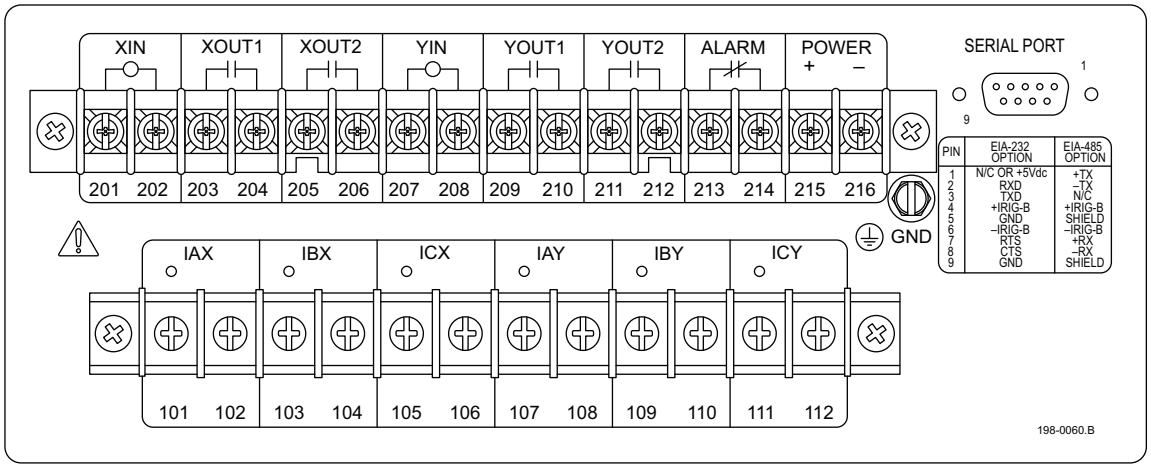

Figure 2.11 SEL-501-2 Rear Panel From Relay With Front Serial Port (Conventional Terminal Blocks Option)

Output contacts **XOUT1**, **XOUT2**, **YOUT1**, **YOUT2**, and **ALARM** are not polarity-dependent.

Optoisolated inputs **XIN** and **YIN** are not polarity-dependent.

All screws are size #6-32.

Connectorized

To use the Connectorized version of the SEL-501-2, ask your SEL sales or customer service representative for the appropriate model option table and order wiring harness kit WA05010W*x*X*y*A, where *x* designates wire size and *y* designates wire length. You can find the model option table (MOT) on the SEL website at selinc.com. Refer to *Figure 2.12* to make all Connectorized connections.

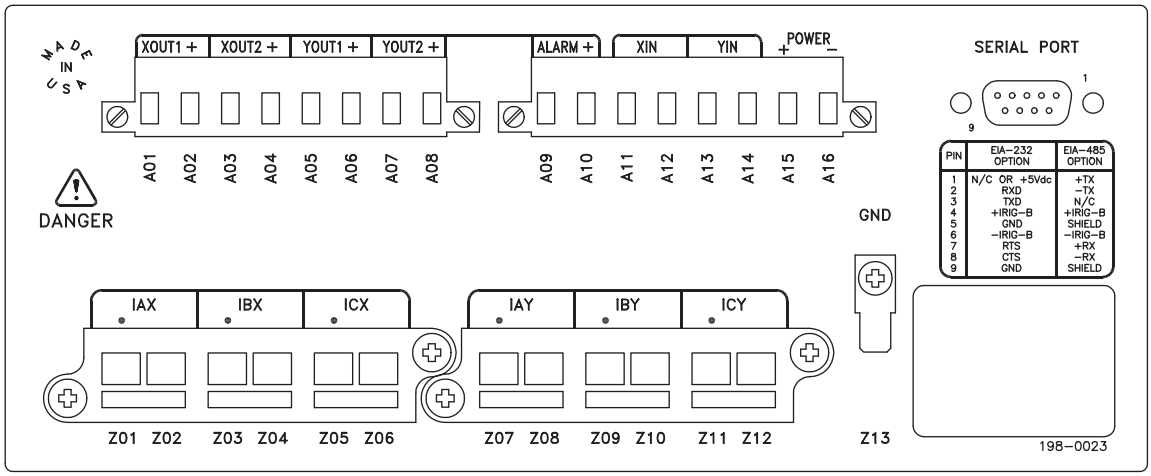

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Figure 2.12 SEL-501-2 Rear Panel (Plug-In Connectors Option)

Connector Terminals **A01**–**A16** accept wire size AWG 24 to 12 (install wires with a small slotted-tip screwdriver).

Output contacts **XOUT1**, **XOUT2**, **YOUT1**, **YOUT2**, and **ALARM** are polarity-dependent (note the "+" above Terminals **A02**, **A04**, **A06**, **A08**, and **A10**).

As an example, consider the connection of Terminals **A01** and **A02** (output contact **XOUT1**) in a circuit:

> Terminal **A02** (+) has to be at a higher voltage potential than Terminal **A01** in the circuit.

With the plug-in connectors, the output contacts are also interrupting-duty output contacts:

> 10 A for L/R = 40 ms at 125 Vdc
>
> 10 A for L/R = 20 ms at 250 Vdc

Optoisolated inputs **XIN** and **YIN** are not polarity-dependent.

Current input connector (Terminals **Z01**–**Z12**):

- Contains current transformer shorting mechanisms
- Accepts wire size AWG 16 to 10 (special tool required to attach wire to connector)
- Can be ordered prewired

IMPORTANT: Improvements in Connectorized SEL-501-2 relays (plug-in connectors) results in part number changes.

Ground connection (Terminal **Z13**): tab size 0.250 inch x 0.032 inch, screw size #6-32.

The current transformer shorting connectors for current channel inputs **IAX**, **IBX**, **ICX** and **IAY**, **IBY**, **ICY** have been made more robust. This improvement makes the new connector design incompatible with the old design. Thus, new Connectorized SEL-501-2 relays with this improved connector have a new part number (partial part numbers shown):

Old	New
0501*x*J	0501*x*X

The respective wiring harness part numbers for these old and new Connectorized SEL-501-2 relays are (partial part numbers shown):

Old	New
WA0501*x*J	WA0501*x*W

The other connectors on the Connectorized SEL-501-2 rear panel (power input, output contacts, etc.) are the same for these old and new models. Only the current transformer shorting connectors have changed.

Figure 2.12 shows the rear panel for new models 0501*x*W. Because all terminal/numbering remains the same between the new and old relays, these figures can also be used as a reference for old model 0501*x*J. Only the connectors and part numbers have changed.

AC/DC Connection Diagram

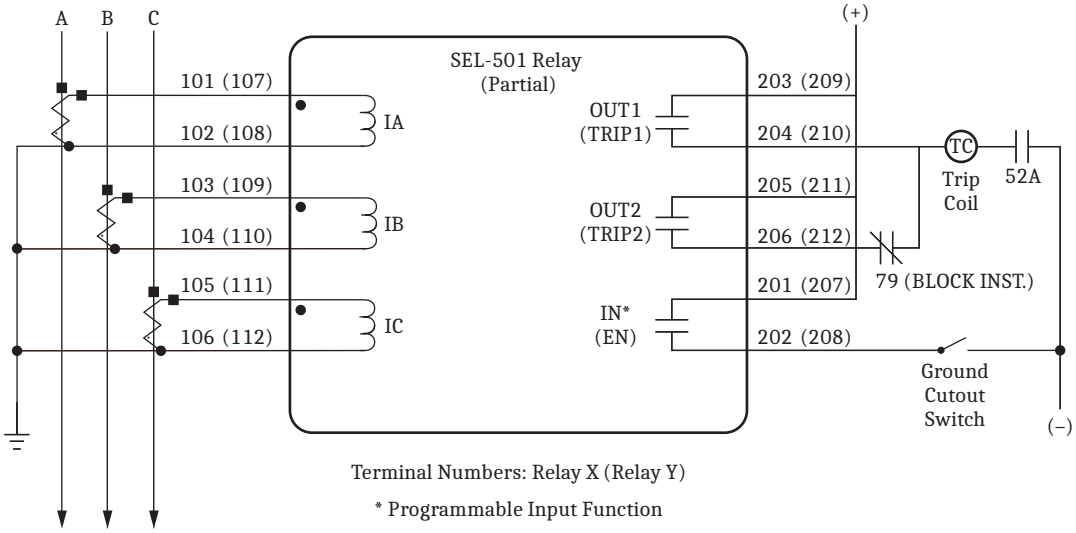

Figure 2.13 AC/DC Connections for Overcurrent Protection Applications (Feeder Protection Application With External Reclosing Relay Shown)

Circuit Board Jumpers and Battery

Control Voltage Jumpers (Conventional Terminal Blocks Option Only)

The SEL-501-2 relays equipped with conventional terminal blocks may be ordered with either jumper-selectable voltage optoisolated inputs or level-sensitive optoisolated inputs. Level-sensitive inputs are not jumper-selectable. See *Specifications* for ratings.

The jumper-selectable control voltage models are factory-configured to the control voltage specified at time of ordering. The jumpers may be changed as outlined below.

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

To change the control input voltage range through the use of internal jumpers, take the following steps:

Step 1. De-energize the relay.

Step 2. Remove three front-panel screws and remove the relay front panel.

Step 3. Disconnect the analog signal ribbon cable from the underside of the relay main board. Grasp the black knob on the front of the drawout assembly and pull the assembly from the relay chassis.

Step 4. Locate the control voltage jumpers near the rear edge of the relay main board. The jumpers are numbered **JMP6** through **JMP11**. Refer to *Figure 2.14*.

NOTE: For use with relays equipped with the jumper-selectable control input voltage option only. Not supported in the level-sensitive control input option. See product MOT for details.

Step 5. Install or remove jumpers according to *Table 2.1* to select the desired control voltage level.

Step 6. Slide the drawout assembly into the relay chassis. Reconnect the analog signal ribbon cable. Replace the relay front panel and re-energize the relay.

Table 2.1 Control Input Voltage Selection Jumper Positions (Conventional Terminal Blocks Option Only)

Control Voltage	XIN			YIN		
	JMP6	JMP7	JMP8	JMP9	JMP10	JMP11
250 Vdc	• •	• •	• •	• •	• •	• •
125 Vdc	•—•	• •	• •	•—•	• •	• •
48 Vdc	•—•	•—•	• •	•—•	•—•	• •
24 Vdc	•—•	•—•	•—•	•—•	•—•	•—•

Output Contact Jumpers (Conventional Terminal Blocks Option Only)

Refer to *Figure 2.14*. Jumpers **JMP1** through **JMP5** select the contact type for the output contacts. With a jumper in the A position, the corresponding output contact is an a type output contact. An a type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. With a jumper in the B position, the corresponding output contact is a b type output contact. A b type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized. These jumpers are soldered in place.

NOTE: For a relay with Plug-In Connectors Option, the contact types are fixed. There are no jumpers available to change the contact types. Output contacts **XOUT1**, **XOUT2**, **YOUT1**, and **YOUT2** are all a type contacts. The **ALARM** output contact is a b type contact.

In *Figure 2.14*, note that the **ALARM** output contact is a b contact and the other output contacts are all a contacts. This is how these jumpers are configured in a standard relay shipment.

Password and Breaker Control Command Jumpers

Password and Breaker Control Command jumpers are on the front edge of the relay main board between the front-panel LEDs and the control pushbuttons. Change them by removing the relay front panel.

Put jumper **JMP22** (left-most jumper) in place to disable serial port and front-panel password protection. With the jumper removed, password security is enabled. Set the password with the **PAS** command.

Put jumper **JMP24** (right-most jumper) in place to enable the output contact control commands (**1OUT** and **2OUT**). Any breaker control command is ignored while the jumper is removed.

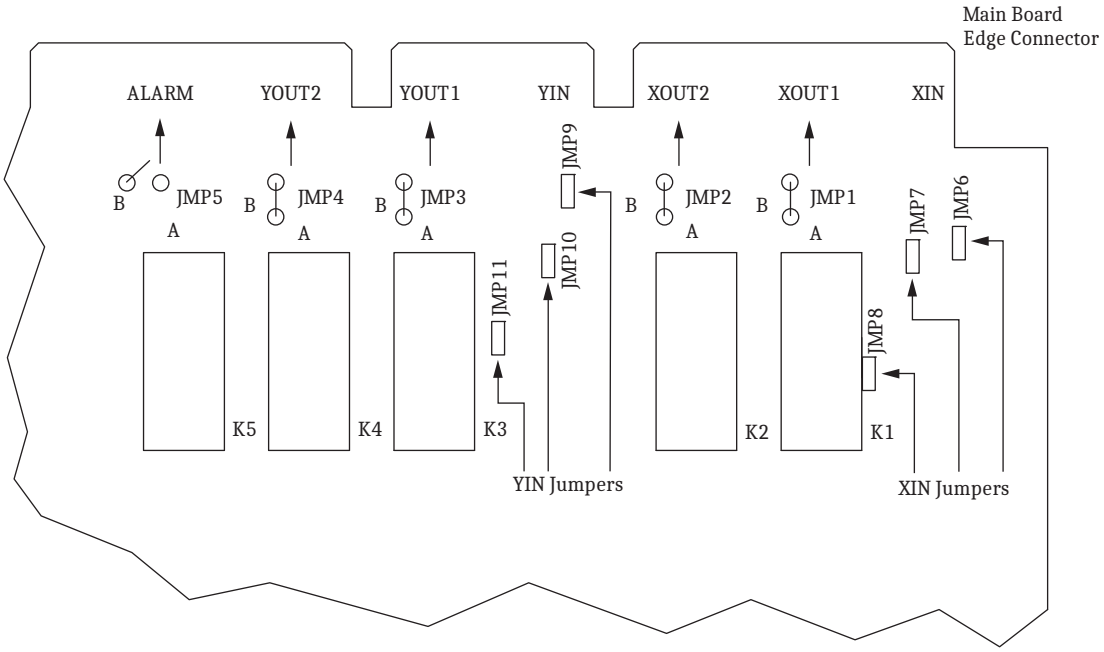

Figure 2.14 Input and Output Jumper Locations (Conventional Terminal Blocks With Jumper-Selectable Control Input Voltage Option Only)

EIA-232 Serial Communications Port Voltage Jumper (EIA-232 Option Only)

Jumper **JMP12** and jumper **JMP14** apply to the EIA-232 option only for Port 1 (rear port) and are at the rear of the main board, near the rear-panel EIA-232 serial communications port. Jumper **JMP12** connects or disconnects +5 Vdc to Pin 1 on the EIA-232 serial communications port. For successful port voltage output, you must also apply jumper **JMP14** (located near the rear communications port) to short Pin 5 and Pin 9 for the +5 Vdc ground return path. When jumper **JMP12** and jumper **JMP14** are in place, the rear communications port is no longer isolated. In a standard relay shipment, jumpers **JMP12** and **JMP14** are removed (out of place) so that the +5 Vdc is not connected on the EIA-232 serial communications port and the port is isolated from ground.

Output Contact YOUT2 Control Jumper

Refer to *Figure 2.15*. Main board jumper **JMP13** controls the operation of output contact **OUT4**. It provides the option of a second alarm output contact by changing the signal that drives output contact **OUT4**.

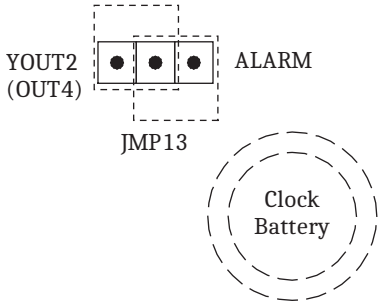

Figure 2.15 Output Contact OUT4 Control Jumper Location

Table 2.2 Required Position of Jumper JMP13 for Desired Output Contact OUT4 Operation

Position	Output Contact YOUT2 Operation
Jumper Left	Regular output contact **OUT4** (operated by Relay Word bit OUT4). Jumper **JMP13** comes in this position in a standard relay shipment.
Jumper Right	Extra Alarm output contact (operated by alarm logic/circuitry). Relay Word bit OUT4 does not have any effect on output contact **OUT4** when jumper **JMP13** is in this position.

If jumper **JMP13** is in position **ALARM** and both output contacts **OUT4** and **ALARM** are the same output contact type (a or b), these outputs will be in the same state (closed or open). If jumper **JMP13** is in position **ALARM** and output contacts **OUT4** and **ALARM** are different output contact types (one is an a and one is a b), these outputs will be in opposite states (one is closed and one is open).

Clock Battery

A lithium battery powers the relay clock if the external dc source is lost or removed. The battery is a 3 V lithium coin cell. At room temperature (25 degrees Celsius) the battery will nominally operate (discharge) for 10 years at rated load.

If the dc source is lost or disconnected, the battery discharges to power the clock. When the relay is powered from an external source, the battery only experiences a low self-discharge rate. Thus, battery life can extend well beyond the nominal 10 years because the battery rarely has to discharge after the relay is installed. The battery cannot be recharged.

If the battery voltage is out-of-tolerance, an automatic status message is sent to the serial port and the front-panel display.

To change the battery, take the following steps:

Step 1. De-energize the relay.

Step 2. Remove three front-panel screws and remove the relay front panel.

Step 3. Disconnect the analog signal ribbon cable from the underside of the relay main board. Grasp the black knob on the front of the drawout assembly and draw out the assembly from the relay chassis.

Step 4. Locate the battery on the right-hand side of the relay main board.

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Panasonic BR-2330A 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.

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

Step 5. Remove the battery from beneath the clip and install a new one. The positive side (+) of the battery faces up.

Step 6. Slide the drawout assembly into the relay chassis. Reconnect the analog signal ribbon cable. Replace the relay front panel and re-energize the relay.

Step 7. Set the date and time.

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SECTION 3

Overcurrent Protection

Introduction

Relay X and Relay Y provide overcurrent protection. Set the relay by using the front panel or serial port **SET** command.

Apply the relay to provide overcurrent protection for:

- Feeders
- Buses
- Transformers
- Other Apparatus

Relay Control Functions

Control SEL-501-2 overcurrent elements with either optoisolator input IN or serial port remote bit RB. Any given overcurrent element can be controlled by optoisolated input IN or remote bit RB, but not by both at the same time. Overcurrent elements do not have to be controlled. If an overcurrent element is not controlled by optoisolator input IN or remote bit RB, it is enabled all the time.

Input IN and remote bit RB provide true control, not supervision. If IN or RB disables an overcurrent element, the overcurrent element cannot time or assert, no matter what the current level. Settings specify which overcurrent elements are controlled by input IN or RB.

Relay Control by Input IN

To control overcurrent elements via optoisolator input IN, program the IN as either an enable or block, program individual overcurrent elements for IN control, and assert/deassert the IN optoisolator input.

Program input IN to function as one of the following:

- IN = EN (Enable)
  - *Assert* input IN to *enable* user-specified overcurrent elements.
  - *Deassert* input IN to *disable* the same user-specified overcurrent elements.
- IN = BLK (Block)
  - *Assert* input IN to *disable* (block) user-specified overcurrent elements.
  - *Deassert* input IN to *enable* the same user-specified overcurrent elements.
- IN = ET (External Trigger)
  - Assert input IN to trigger an event report.

IN = EN or IN = BLK

To program IN to enable overcurrent elements (e.g., 51N and 50NH), issue the following settings:

IN = EN	IN enables overcurrent elements
51NTC = IN	51N controlled by IN
50NHC = IN	50NH controlled by IN

To enable the 51N and 50NH elements, assert optoisolator input IN to a logical 1. Deassert optoisolator input IN to disable the elements. A printout of the relay settings gives a summary of the overcurrent elements controlled by input IN. Summary example:

```
IN: 51NT, 50NH
Input IN controls ground overcurrent elements 51NT and 50NH
```

IN = ET

No overcurrent elements are controlled by the input. The input summary appears as:

```
IN: External Trigger
```

Relay Control by Remote Bit RB

To control overcurrent elements via remote bit RB, program individual overcurrent elements for RB control, and assert/deassert the RB remote bit via serial port command.

To program RB to disable overcurrent elements (e.g., 51N and 50NH), issue the following settings:

51NTC = RB	51N controlled by RB
50NHC = RB	50NH controlled by RB

To disable the 51N and 50NH elements, set remote bit RB via serial port command. To enable the 51N and 50NH elements, clear remote bit RB via serial port command. A printout of the relay settings gives a summary of the overcurrent elements controlled by remote bit RB. Summary example:

```
RB: 51NT, 50NH
Remote bit RB controls ground overcurrent elements 51NT and 50NH
```

Remote Bit Serial Port Commands

Set and clear remote bit RB with either the **ASCII CONTROL** command or the binary **Fast Operate** command. The **ASCII CONTROL** command provides a convenient means for setting and clearing the remote bit via a dumb terminal or other device not capable of binary communications. The **Fast Operate** command provides an efficient means to set and clear remote bits via devices capable of binary communication (e.g., the SEL-2020 Communications Processor). The **CONTROL** command is described in *CONTROL Command on page 4.8*. The **Fast Operate** command is described in *Appendix B: Firmware (EPROM) Upgrade Instructions.*

The SEL-501-2 stores the remote bit state in nonvolatile memory; remote bit states are retained in the event of a loss of power to the relay.

To determine the state of a remote bit,

- Issue the **ASCII TAR X** or **TAR Y** command via the serial port,
- Issue the binary (A5D1) Fast Meter message request, or
- Press the relay front-panel **MAINT** pushbutton and select relay **X** or **Y** and then **TAR**.

Relay Output Contact Functions

- Output contact OUT 1 operates as the TRIP1 output contact
- Output contact OUT 2 operates as the TRIP2 output contact

If an overcurrent element pickup is *not* set to “off,” it is enabled to operate.

Any overcurrent element can operate one or the other of the trip output contacts, both, or neither. *Table 3.1* lists the settings that control tripping. A printout of the relay settings gives a summary of the overcurrent elements that operate the trip output contacts. Summary example:

TRIP1: 51PT, 51NT	Phase and ground time-overcurrent elements routed to TRIP1 output contact
TRIP2: 50H, 50NH	Phase and ground instantaneous overcurrent elements routed to TRIP2 output contact

Each trip output contact also includes settable time-delay pickup and minimum trip duration timers. See trip output contact time-delay pickup timers in *Figure 3.1*.

Overcurrent element operation can show up in the event reports without the element being set to operate any trip output contact. In this way, you can evaluate overcurrent element operation without setting the element to trip.

Applications for the SEL-501-2

Use this relay for most any overcurrent protection application and especially for applications requiring:

- Overcurrent elements routed to different trip output contacts.
  - Refer to the example in *Figure 2.3*.
  - Set the time-overcurrent elements to operate the TRIP1 output contact. Note this contact is not externally supervised.
  - Set the instantaneous overcurrent elements to operate the TRIP2 output contact. Supervise this output contact externally by using a reclosing relay block instantaneous contact (79). The reclosing relay blocks instantaneous tripping automatically after the first trip.
  - Additionally, set ground overcurrent elements to be controlled by input IN = EN (Enable). Open the external ground cutout switch to disable the ground overcurrent elements for feeder paralleling operations.
- One output contact to provide primary tripping and the other output contact to provide simple breaker failure tripping.
  - Assign the same overcurrent elements to both output contacts.
  - Use the TRIP1 output contact for primary tripping.
  - Use the TRIP2 output contact for breaker failure tripping. Set a time-delay pickup on the TRIP2 output contact. The time delay should correspond to breaker failure time (see *Figure 3.1*).
- Fast bus tripping (reverse interlocking) on a radial system. This replaces a more expensive bus differential scheme.
  - Apply the relay for bus overcurrent protection.
  - Make setting IN = BLK (Block). Connect the high-set instantaneous overcurrent trip contacts of the downstream feeder relays into the bus relay input IN, in parallel.
  - Set the bus relay definite-time overcurrent elements to back up the feeder relay high-set instantaneous overcurrent elements. Set the bus relay definite-time delays for 2 to 3 cycles.
  - Set the bus relay definite-time overcurrent elements to be controlled by input IN. When IN is asserted, the bus relay definite-time overcurrent elements are disabled (blocked).
  - The 2- to 3-cycle delay on the bus relay definite-time overcurrent elements gives the feeder relay high-set instantaneous overcurrent trip contacts enough time to assert input IN. This disables (blocks) the bus relay definite-time overcurrent elements if the fault is on a feeder.

    If the fault is on the bus, input IN is not asserted and definite-time overcurrent elements time out (2- to 3-cycle delay) and trip the bus. Bus tripping speeds approach those of a bus differential scheme, without the additional expense of extra current transformers required in the feeder switchgear for a bus differential scheme. Relay, wiring, and testing costs are also reduced.

Many variations of the preceding application examples are possible.

CT Sizing

Sizing a CT to avoid saturation for the maximum asymmetrical fault is ideal, but not always possible. This requires a CT ANSI voltage classification 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.

Use caution when selecting CTs for saturation conditions in the SEL-501-2 firmware revisions prior to SEL-501-2-R900-D20021002 (see *Appendix A: Firmware and Manual Versions*). If you apply the SEL-501-2 in high fault current situations, such as in power plant auxiliary buses with as much as 40000 A of line-to-line fault current, current transformers used with the SEL-501-2 should meet the following criterion:

$$262.5 \geq \left(\frac{X}{R} + 1\right) \bullet I_f \bullet Z_b$$

Equation 3.1

where:

I_f is the maximum fault current in per unit of CT rating
Z_b is the CT burden in per unit of standard burden
X/R is the X/R ratio of the primary fault circuit

This ensures a two-cycle trip of an instantaneous element set at 80 A. The following examples show how the criterion is used.

Example 3.1 Maximum Fault Current With an 80 A Instantaneous Setting

Maximum fault current in terms of primary CT and ANSI voltage rating, burden in ohms, and X/R ratio is:

$$I_{MAX} = \frac{262.5}{\left(1 + \frac{X}{R}\right)} \bullet \frac{ANSI}{100 \bullet Z_B} \bullet CT_{RATING}$$

Equation 3.2

Equation 3.2 is an actual-value equation derived from *Equation 3.1*.

where:

I_{MAX} is the maximum primary fault current for line-to-line fault
CT_{RATING} is the CT primary rating in amperes
Z_B is the total CT secondary burden in ohms
ANSI is the ANSI voltage classification of CTs

An SEL-501-2 phase instantaneous overcurrent element is to be set at 80 A. The relay will be used with a C400, 400:5 current transformer with a 0.50 Ω total burden. The X/R ratio is 20. Determine the maximum fault current for dependable operation.

The burden is primarily from the CT windings and external leads to the SEL-501-2 (the SEL-501-2 has a negligible burden):

300 ft full-circuit run of #10 AWG (1.0/1000-ft):	0.30
CT winding of 80 turns at 0.0025/turn:	0.20
Total burden:	0.50

Example 3.1 Maximum Fault Current With an 80 A Instantaneous Setting

$$I_{MAX} = \frac{262.5}{\left(1 + \frac{X}{R}\right)} \bullet \frac{ANSI}{100 \bullet Z_B} \bullet CT_{RATING}$$

$$= \frac{262.5}{(1 + 20)} \bullet \frac{400}{100 \bullet 0.50\Omega} \bullet 400 = 40000\,A$$

Example 3.2 Minimum CT Rating With an 80 A Instantaneous Setting

CT rating in terms of maximum fault current, X/R ratio, ANSI rating, and burden is:

$$CT_{RATING} = \frac{\left(1 + \frac{X}{R}\right)}{262.5} \bullet \frac{100}{ANSI} \bullet I_{MAX} \bullet Z_B$$

Equation 3.3

With an 80 A instantaneous setting, what is the minimum CT rating that can be used when the maximum fault current is 40000 A, X/R = 20, and the burden is 0.50 Ω?

$$CT_{RATING} = \frac{\left(1 + \frac{X}{R}\right)}{262.5} \bullet \frac{100}{ANSI} \bullet I_{MAX} \bullet Z_B$$

$$= \frac{(1 + 20)}{2625} \bullet \frac{100}{400} \bullet 40000 \bullet 0.50 = 400\ A$$

Example 3.3 Determine Whether the Following Application Meets the Above Criteria

CTs used:	400:5 A, class C400
Instantaneous element pickup setting:	80 A secondary
Maximum current for a line-to-line fault:	40000 A primary
X/R ratio:	20
Total CT secondary:	0.50 Ω

Apply *Equation 3.1* to verify if the CTs meet the required criteria.

$$\left(\frac{X}{R} + 1\right) \bullet I_f \bullet Z_b = (20 + 1) \bullet \frac{40000}{400} \bullet \frac{0.50\Omega}{4} = 262.5$$

The calculation shows that the 400:5 (class C400) CT meets the criteria in *Equation 3.1*.

Overcurrent Element Application and Setting

In traditional distribution feeder protection schemes, ground overcurrent relays operate on residual or ground current to detect phase-to-ground faults. Phase overcurrent relays operate on single-phase current to detect phase-to-phase and three-phase faults. Phase overcurrent relay pickup settings must exceed load current levels.

Set phase and ground instantaneous, definite-time, and time-overcurrent elements as you would any other nondirectional phase or ground overcurrent relay.

Setting Negative-Sequence Overcurrent Elements

Negative-sequence overcurrent elements in the SEL-501-2 respond to $3I_2$ current. You can set these elements to detect phase-to-phase faults more sensitively than phase overcurrent elements because $3I_2$ elements do not respond to balanced load current.

Coordinate a negative-sequence overcurrent element with a downstream overcurrent element by first identifying the settings of the downstream element that is the greatest phase coordination concern.

Next, determine the pickup and time settings (delay for definite-time elements; curve shape, pickup, and time-dial for time-overcurrent elements) of a local equivalent phase overcurrent element that would coordinate with the downstream element. You may select a pickup setting that is below normal load current. Multiply the local equivalent phase overcurrent pickup setting by 1.73 to calculate the negative-sequence overcurrent element pickup setting. Use the time settings directly, with no conversion factor.

Overcurrent Relay Settings

The overcurrent relay settings, definitions, and setting ranges are shown in *Table 3.1*

Table 3.1 Relay Settings (Sheet 1 of 3)

Setting	Setting Definitions	Setting Range
ID	Relay Identifier	13 characters
CTR	CT Ratio (CRTR:1)	1–6000
DATC	Demand Ammeter Time Constant	Off, 5–60 minutes
IN	Programmable Input Function	EN = Enable BLK = Block ET = Ext. Trigger
50PP	Phase Definite-Time Overcurrent pickup	Off, 0.5–80 A secondary (5 A model) 0.1–16 A secondary (1 A model) 0.1 A steps
50PD	Phase Definite-Time Overcurrent delay	0–16,000 cycles (0.25 steps)
50PTT	Assign Phase Definite-Time Overcurrent Element (50PT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
50PTC	50PT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit

Table 3.1 Relay Settings (Sheet 2 of 3)

Setting	Setting Definitions	Setting Range
50H	Phase Instantaneous Overcurrent Pickup	Off, 0.5–80 A secondary (5 A model) 0.1–16 A secondary (1 A model) 0.1 A steps
50HT	Assign Phase Instantaneous Overcurrent Element (50H) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
50HC	50H controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
50QP	Negative-Sequence Definite-Time Overcurrent Pickup	Off, 0.5–80 A secondary (5 A model) 0.1–16 A secondary (1 A model) 0.1 A steps
50QD	Negative-Sequence Definite-Time Overcurrent Delay	1.5–16,000 cycles (0.25 steps)
50QTT	Assign Negative-Sequence Definite-Time Overcurrent Element (50QT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
50QTC	50QT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
50NP	Ground Definite-Time Overcurrent Pickup	Off, 0.5–80 A secondary (5 A model) 0.1–16 A secondary (1 A model) 0.1 A steps
50ND	Ground Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
50NTT	Assign Ground Definite-Time Overcurrent Element (50NT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
50NTC	50NT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
50NH	Ground Instantaneous Overcurrent Pickup	Off, 0.5–80 A secondary (5 A model) 0.1–16 A secondary (1 A model) 0.1 A steps
50NHT	Assign Ground Instantaneous Overcurrent Element (50NH) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
50NHC	50NH controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
51PP	Phase Time-Overcurrent Pickup	Off, 0.5–16 A sec (5 A model) 0.1–3.2 A sec (1 A model) 0.01 A steps
51PC	Phase Time-Overcurrent Operating Curve	U1–U4 (U.S. Curves) C1–C4 (IEC Curves)
51PTD	Phase Time-Overcurrent Time-Dial	0.5 15 (U.S. Curves) 0.05–1.0 (IEC Curves) 0.01 steps
51PRS	Phase Time-Overcurrent EM Reset	Y, N
51PTT	Assign Phase Time-Overcurrent Element (51PT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
51PTC	51PT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
51QP	Negative-Sequence Time-Overcurrent Pickup	Off, 0.5–16 A sec (5 A Model) 0.1–3.2 A sec (1 A Model) 0.01 A steps
51QC	Negative-Sequence Time-Overcurrent Operating Curve	U1–U4 (U.S. Curves) C1–C4 (IEC Curves)
51QTD	Negative-Sequence Time-Overcurrent Time-Dial	0.5–15 (U.S. Curves) 0.05–1.0 (IEC Curves) 0.01 steps

Table 3.1 Relay Settings (Sheet 3 of 3)

Setting	Setting Definitions	Setting Range
51QRS	Negative-Sequence Time-Overcurrent EM Reset	Y, N
51QTT	Assign Negative-Sequence Time-Overcurrent Element (51QT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
51QTC	51QT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
51NP	Ground Time-Overcurrent Pickup	Off, 0.5–16 A sec (5 A Model) 0.1–3.2 A sec (1 A Model) 0.01 A steps
51NC	Ground Time-Overcurrent Operating Curve	U1–U4 (U.S. Curves), C1–C4 (IEC Curves)
51NTD	Ground Time-Overcurrent Time-Dial	0.5–15 (U.S. Curves) 0.05–1.0 (IEC Curves) 0.01 steps
51NRS	Ground Time-Overcurrent EM Reset	Y, N
51NTT	Assign Ground Time-Overcurrent Element (51NT) to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
51NTC	51NT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
TRPU1	TRIP1 time-delay pickup	0–16,000 cycles (0.25 steps)
TDUR1	Minimum TRIP1 duration	0–16,000 cycles (0.25 steps)
TRPU2	TRIP2 time-delay pickup	0–16,000 cycles (0.25 steps)
TDUR2	Minimum TRIP2 duration	0–16,000 cycles (0.25 steps)
ELTCH	Enable phase current latch condition for trip output contacts	Y, N

Relay Trip Logic

The TRIP1 and TRIP2 output contacts have time-delay pickup timers TRPU1 and TRPU2, respectively (see *Figure 3.1*).

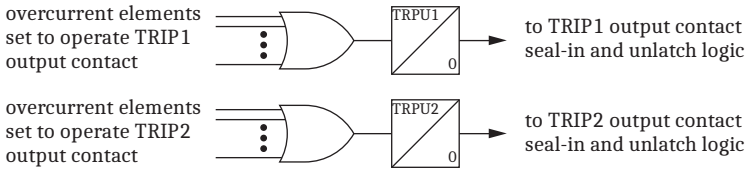

Figure 3.1 Time-Delay Pickup Timers for TRIP1 and TRIP2 Output Contacts

TRIP1 Output Contact

Settings specify overcurrent elements to operate the TRIP1 output contact. If one or more of these selected overcurrent elements remain asserted for TRPU1 time, the TRIP1 output contact asserts.

1OUT command execution from the front panel or serial port asserts the TRIP1 (OUT1) output contact provided that setting TDUR1 > 0 cycles. The TRIP1 (OUT1) output contact assertion is not subject to the TRPU1 time-delay pickup timer.

The TRIP1 output contact remains asserted for a minimum time equal to the TRIP1 duration setting, TDUR1. After the TDUR1 time period, the TRIP1 output contact unlatches when all tripping overcurrent elements have dropped out and:

- Setting ELTCH = N, or
- All phase currents are less than one-tenth nominal current (and setting ELTCH = Y), or
- You press the front-panel **TARGET RESET** button, or
- You execute the **TARGET R** command from the serial port.

If time-delay pickup setting TRPU1 = 0, there is no intentional delay on the TRIP1 output contact for overcurrent tripping.

If the minimum TRIP1 duration setting is set TDUR1 = 0:

- The TRIP1 output contact has no minimum assertion time.
- The **1OUT** command is not functional.

TRIP2 Output Contact

The TRIP2 output contact operates like the TRIP1 output contact, described above. TRIP2 includes independent TRPU2 and TDUR2 settings and **2OUT** command.

Overcurrent Relay Targets

The X and Y LEDs remain steadily illuminated unless one of the following is true:

- Target is blinking to indicate a trip
- Power is removed from relay
- A relay self-test failure has been detected.

When either relay trips, the associated X or Y LED blinks to indicate that a trip occurred. When the blinking LED illuminates, the tripping targets associated with that relay are displayed on the remaining LEDs.

The SEL-501-2 selects tripping targets by using the elements picked up when either trip output contact (TRIP1 or TRIP2) asserts.

Table 3.2 Relay Tripping Targets

Tripping Target	Illuminates if:
INST	Trip occurs less than 3 cycles after pickup of the tripping element
A	A-Phase current is greater than the 50PP, 51PP, or the 50H setting
B	B-Phase current is greater than the 50PP, 51PP, or the 50H setting
C	C-Phase current is greater than the 50PP, 51PP, or the 50H setting
Q	51QP or 50QP element is picked up
N	51NP, 50NP, or 50NH element is picked up

Clear the targets by pressing the front-panel **TARGET RESET** button or by executing the serial port **TARGET R** command. If you press the **TARGET RESET** button and the targets do not clear, the tripping condition is still present.

Overcurrent Element Specifications

Eight Overcurrent Elements	Instantaneous Elements	Definite-Time Elements	Time-Overcurrent Elements
Phase (Ia, Ib, and Ic)	50H	50PT	51PT
Negative-Sequence (IQ = $3I_2$)		50QT	51QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT	51NT
Pickup Ranges (A secondary)			
5 A Model:	0.5–80 A, 0.1 steps	0.5–80 A, 0.1 steps	0.5–16 A, 0.1 steps
1 A Model:	0.1–16 A, 0.1 steps	0.1–16 A, 0.1 steps	0.1–3.2 A, 0.1 steps
Definite-Time Delay		0–16,000 cyc	

Instantaneous/Definite-Time Element Performance		
Pickup Accuracy:		
5 A Model	±5% ±0.10 A secondary	Time-delay accuracy: ±0.25 cyc
1 A Model	±5% ±0.02 A secondary	Time-delay accuracy: ±0.25 cyc
Pickup Time (Typ/Max):	0.75/1.2 cyc	

Time-Overcurrent Elements		
Eight Curve Shapes:	51PC, 51QC, or 51NC Setting	Time-Curve Shape
	U1	U.S. Moderately Inverse
	U2	U.S. Inverse
	U3	U.S. Very Inverse
	U4	U.S. Extremely Inverse
	C1	IEC Class A (Standard Inverse)
	C2	IEC Class B (Very Inverse)
	C3	IEC Class C (Extremely Inverse)
	C4	IEC Long Time Inverse
Time-Dial Setting Ranges:	0.5–15, 0.01 Steps; U.S. Curves 0.01–1.0, 0.01 Steps; IEC Curves	
Timing Accuracy:	±4% ±2% (I_{NOM}/I_{SEC}) ±1.5 cycles for $2 \le M \le 30$; Curves operate on definite-time for multiples above 30 or currents above 16 times nominal current.	
Transient Overreach:	<5% of pickup	
Reset Characteristics (51PRS, 51QRS, 51NRS)	Y = Enable induction-disk reset emulation N = Reset element if current drops below pickup for 1 cycle	

Time-Overcurrent Element Operate/Reset Curve Equations

Table 3.3 U.S Time-Overcurrent Equations[a]

Curve Type	Operating Time	Reset Time
U1 (Moderately Inverse)	$tp = TD \bullet \left[0.0226 + \frac{0.0104}{M^{0.02} - 1}\right]$	$tr = TD \bullet \left[\frac{1.08}{1 - M^2}\right]$
U2 (Inverse)	$tp = TD \bullet \left[0.180 + \frac{5.95}{M^2 - 1}\right]$	$tr = TD \bullet \left[\frac{5.95}{1 - M^2}\right]$
U3 (Very Inverse)	$tp = TD \bullet \left[0.0963 + \frac{3.88}{M^2 - 1}\right]$	$tr = TD \bullet \left[\frac{3.88}{1 - M^2}\right]$
U4 (Extremely Inverse)	$tp = TD \bullet \left[0.0352 + \frac{5.67}{M^2 - 1}\right]$	$tr = TD \bullet \left[\frac{5.67}{1 - M^2}\right]$

[a] tp = operating time
tr = induction-disk emulation reset time
TD = 51 time-dial setting
M = applied multiples of pickup current

Table 3.4 IEC Time-Overcurrent Equations

Curve Type	Operating Time	Reset Time
C1 (Standard Inverse)	$tp = TD \bullet \left[\frac{0.14}{M^{0.02} - 1}\right]$	$tr = TD \bullet \left[\frac{13.5}{1 - M^2}\right]$
C2 (Very Inverse)	$tp = TD \bullet \left[\frac{13.5}{M - 1}\right]$	$tr = TD \bullet \left[\frac{47.3}{1 - M^2}\right]$
C3 (Extremely Inverse)	$tp = TD \bullet \left[\frac{80.0}{M^2 - 1}\right]$	$tr = TD \bullet \left[\frac{80.0}{1 - M^2}\right]$
C4 (Long Time Inverse)	$tp = TD \bullet \left[\frac{120.0}{M - 1}\right]$	$tr = TD \bullet \left[\frac{120.0}{1 - M}\right]$

Full-sized time-current curve transparencies are available from the factory.

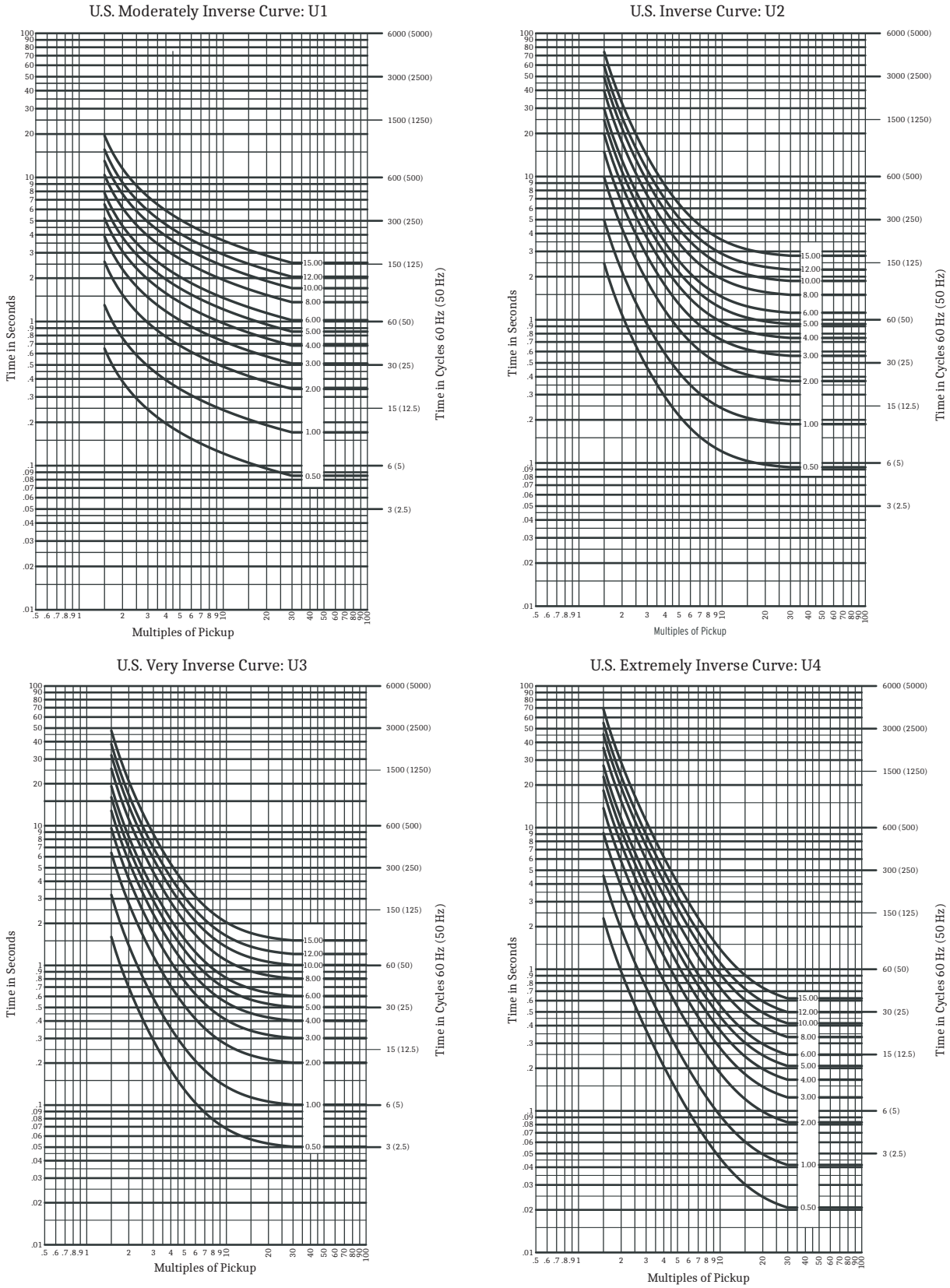

Figure 3.2 U.S. Time Curves U1, U2, U3, and U4

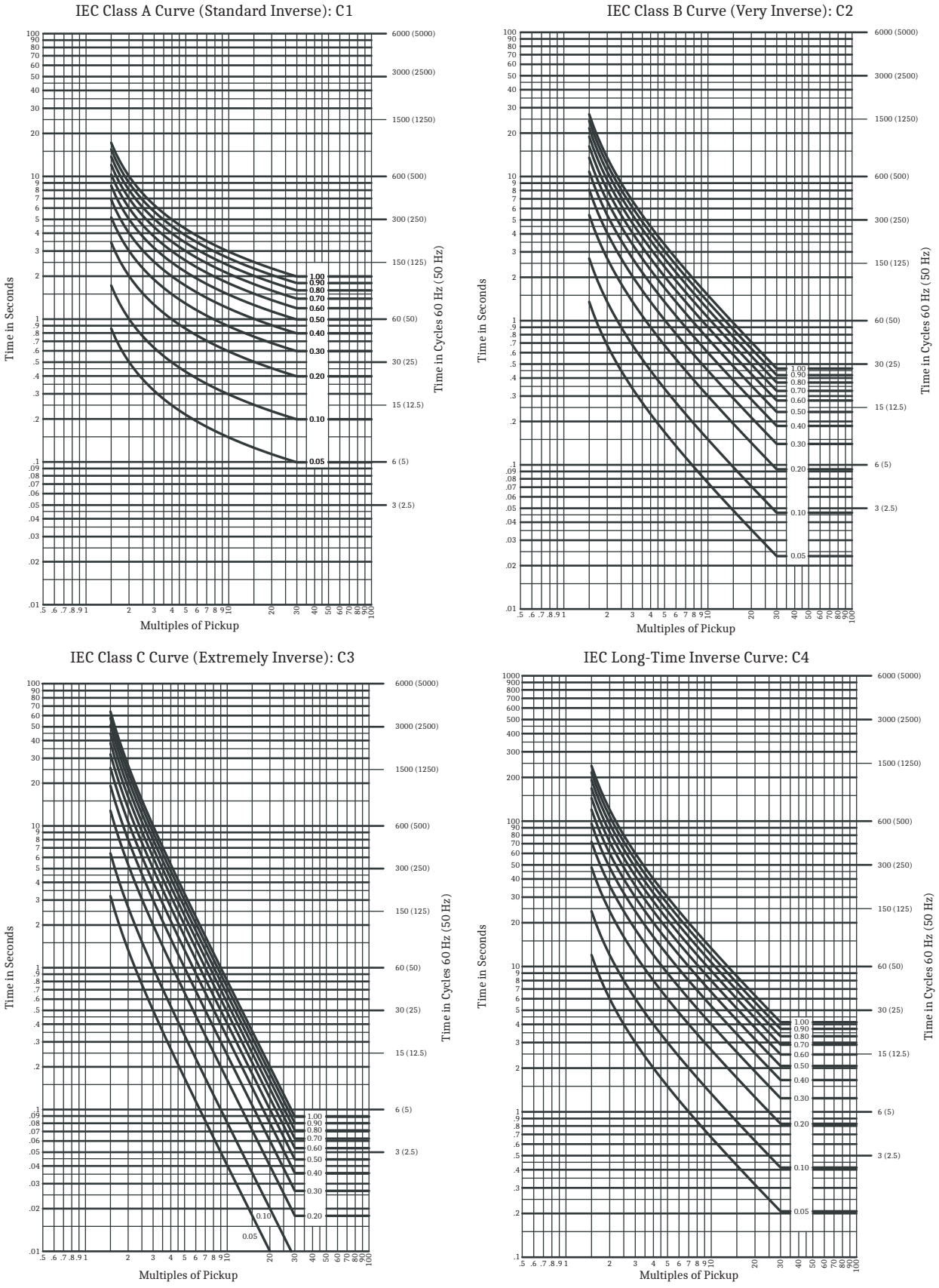

Figure 3.3 IEC Time Curves C1, C2, C3, and C4

SEL-501-2 Relay Settings Sheets

Serial Port Command SET and Front Panel)

Add a check mark to indicate X-side Relay ___ or Y-side Relay ___

General Data

Relay Identifier (13 characters) **ID :=** _____

Current Transformer Ratio (CTR:1); (1–6000) **CTR :=** _____

Demand Ammeter Time Constant (Off, 5–60 minutes) **DATC :=** _____

Programmable Input Function (EN, BLK, ET) **IN :=** _____
(EN = Enable, BLK = Block, ET = External Trigger)

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup—step size 0.1 A **50PP :=** _____
(Off, 0.5–80 A secondary [5 A model], 0.1–16 A secondary [1 A model])

Phase Definite-Time Overcurrent Delay **50PD :=** _____
(0–16,000 cycles in 0.25-cycle steps)

Assign 50PT to trip output contacts (N, 1, 2, B) **50PTT :=** _____
(N = none, 1 = TRIP1, 2 = TRIP2, B = both)

50PT controlled by input IN or remote bit (N, Y, IN, RB) **50PTC :=** _____
(N = none, Y = input, IN = input, RB = remote bit)

Phase Instantaneous Overcurrent Pickup—step size 0.1 A **50H :=** _____
(Off, 0.5–80 A secondary [5 A model], 0.1–16 A secondary [1 A model])

Assign 50H to trip output contacts (N, 1, 2, B) **50HT :=** _____
(N = none, 1 = TRIP 1, 2 = TRIP2, B = both)

50H controlled by input IN or remote bit (N, Y, IN, RB) **50HC :=** _____
(N = none, Y = input, IN = input, RB = remote bit)

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup—step size 0.1 A **50QP :=** _____
(Off, 0.5–80 A secondary [5 A model], 0.1–16 A secondary [1 A model])

Negative-Sequence Definite-Time Overcurrent Delay **50QD :=** _____
(1.5–16,000 cycles in 0.25-cycle steps)

Assign 50QT to trip output contacts (N, 1, 2, B) **50QTT :=** _____
(N = none, 1 = TRIP1, 2 = TRIP2, B = both)

50QT controlled by input IN or remote bit (N, Y, IN, RB) **50QTC :=** _____
(N = none, Y = input, IN = input, RB = remote bit)

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup—step size 0.1 A
(Off, 0.5–80 A secondary [5 A model], 0.1–16 A secondary [1 A model]) **50NP :=** _____

Ground Definite-Time Overcurrent Delay
(0–16,000 cycles in 0.25-cycle steps) **50ND :=** _____

Assign 50NT to trip output contacts (N, 1, 2, B)
(N = none, 1 = TRIP1, 2 = TRIP2, B = both) **50NTT :=** _____

50NT controlled by input IN or remote bit (N, Y, IN, RB)
(N = none, Y = input, IN = input, RB = remote bit) **50NTC :=** _____

Ground Instantaneous Overcurrent Pickup—step size 0.1 A
(Off, 0.5–80 A secondary [5 A model], 0.1–16 A secondary [1 A model]) **50NH :=** _____

Assign 50NH to trip output contacts (N, 1, 2, B)
(N = none, 1 = TRIP1, 2 = TRIP2, B = both) **50NHT :=** _____

50NH controlled by input IN or remote bit (N, Y, IN, RB)
(N = none, Y = input, IN = input, RB = remote bit) **50NHC :=** _____

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup—step size 0.1 A
(Off, 0.5–16 A secondary [5 A model], 0.1–3.2 A secondary [1 A model]) **51PP :=** _____

Phase Time-Overcurrent Operating Curve
(U1–U4 [U.S. curves], C1–C4 [IEC curves]) **51PC :=** _____

Phase Time-Overcurrent Time-Dial—step size 0.01
(0.5–15 [U.S. curves], 0.05–1.0 [IEC curves]) **51PTD :=** _____

Phase Time-Overcurrent EM Reset (Y, N) **51PRS :=** _____

Assign 51PT to trip output contacts (N, 1, 2, B)
(N = none, 1 = TRIP1, 2 = TRIP2, B = both) **51PTT :=** _____

51PT controlled by input IN or remote bit (N, Y, IN, RB)
(N = none, Y = input, IN = input, RB = remote bit) **51PTC :=** _____

Negative-Sequence Time-Overcurrent Element

Negative-Sequence Time-Overcurrent Pickup—step size 0.1 A
(Off, 0.5–16 A secondary [5 A model], 0.1–3.2 A secondary [1 A model]) **51QP :=** _____

Negative-Sequence Time-Overcurrent Operating Curve
(U1–U4 [U.S. Curves], C1–C4 [IEC Curves]) **51QC :=** _____

Negative-Sequence Time-Overcurrent Time-Dial—step size 0.01
(0.50–15 [U.S. Curves], 0.05–1.0 [IEC Curves]) **51QTD :=** _____

Negative-Sequence Time-Overcurrent Electromechanical Reset (Y, N) **51QRS :=** _____

Assign 51QT to trip output contacts (N, 1, 2, B)
(N = none, 1 = TRIP1, 2 = TRIP2, B = both) **51QTT :=** _____

51QT controlled by input IN or remote bit (N, Y, IN, RB)
(N = none, Y = input, IN = input, RB = remote bit) **51QTC :=** _____

Ground Time-Overcurrent Element

Ground Time-Overcurrent Pickup—step size 0.1 A
(Off, 0.5–16 A secondary [5 A model], 0.1–3.2 A secondary [1 A model]) **51NP :=** _____

Ground Time-Overcurrent Operating Curve
(U1–U4 [U.S. curves], C1–C4 [IEC curves]) **51NC :=** _____

Ground Time-Overcurrent Time-Dial—step size 0.01
(0.50–15 [U.S. curves], 0.05–1.0 [IEC curves]) **51NTD :=** _____

Ground Time-Overcurrent Electromechanical Reset (Y, N) **51NRS :=** _____

Assign 51NT to trip output contacts (N, 1, 2, B)
(N = none, 1 = TRIP1, 2 = TRIP2, B = both) **51NTT :=** _____

51NT controlled by input IN or remote bit (N, Y, IN, RB)
(N = none, Y = input, IN = input, RB = remote bit) **51NTC :=** _____

TRIP Output Contact Timers/Latch

TRIP1 time-delay pickup (0–16,000 cycles in 0.25-cycle steps) **TRPU1 :=** _____

Minimum TRIP1 duration (0–16,000 cycles in 0.25-cycle steps) **TDUR1 :=** _____

TRIP2 time-delay pickup (0–16,000 cycles in 0.25-cycle steps) **TRPU2 :=** _____

Minimum TRIP2 duration (0–16,000 cycles in 0.25-cycle steps) **TDUR2 :=** _____

Enable phase current latch condition for trip output contacts (Y, N) **ELTCH :=** _____

Serial Port Command SET P and Front Panel

Protocol Setting (SET P 1) Rear Panel

Protocol (SEL, LMD, MOD) **PROTOCOL :=** _____

Set PROTOCOL = SEL for standard SEL ASCII protocol.

Set PROTOCOL = LMD for SEL Distributed Port Switch Protocol (LMD).

Set PROTOCOL = MOD for Modbus RTU protocol.

Refer to *Appendix D: Distributed Port Switch Protocol* for details on the LMD protocol.

Refer to *Appendix E: Modbus RTU Communications Protocol*.

PROTOCOL = SEL

If PROTOCOL is set to SEL, the following are applicable fields that need to be entered by the user.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) **SPEED :=** _____

Data Bits (7, 8) **DATA_BITS :=** _____

Parity (none = N, even = E, odd = O) **PARITY :=** _____

Stop Bits (1, 2) **STOP :=** _____

Other Port Settings

Time-Out (0–30 minutes) **TIMEOUT :=** _____

Automatic Message Output (Y, N) **AUTO :=** _____

Enable RTS/CTS Hardware Handshaking (Y, N) **RTS_CTS :=** _____

Fast Operate Enable (Y, N) **FAST_OP :=** _____

Other Port Settings

Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set RTS_CTS = Y to enable hardware handshaking. With RTS_CTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTS_CTS is not applicable for EIA-485 serial port option or when PROTOCOL = LMD.

Set FAST_OP = Y to enable binary Fast Operate messages at the serial port. Set FAST_OP = N to block binary Fast Operate messages.

PROTOCOL = LMD

If PROTOCOL is set to LMD, the following are applicable fields that need to be entered by the user.

Communications Settings

LMD Prefix (@, #, $, %, &) **PREFIX :=** _____

LMD Address (1–99) **ADDRESS :=** _____

LMD Settling Time (0–30 seconds) **SETTLE_TIME :=** _____

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) **SPEED :=** _____

Data Bits (7, 8) **DATA_BITS :=** _____

Parity (none = N, even = E, odd = O) **PARITY :=** _____

Stop Bits (1, 2) **STOP :=** _____

Other Port Settings

Time-Out (0–30 minutes) **TIMEOUT :=** _____

Automatic Message Output (Y, N) **AUTO :=** _____

Enable RTS/CTS Hardware Handshaking (Y, N) **RTS_CTS :=** _____

Fast Operate Enable (Y, N) **FAST_OP :=** _____

Other Port Settings

Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set FAST_OP = Y to enable binary Fast Operate messages at the serial port. Set FAST_OP = N to block binary Fast Operate messages.

PROTOCOL = MOD

If PROTOCOL is set to MOD, the following are applicable fields that need to be entered by the user.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) **SPEED :=** _____

Parity (none = N, even = E, odd = O) **PARITY :=** _____

Stop Bits (1, 2) **STOP :=** _____

Modbus Slave ID (1–247) **SLAVEID :=** _____

Protocol Setting (SET P F) Front Panel

Protocol (SEL, LMD) **PROTOCOL :=** _____

Set PROTOCOL = SEL for standard SEL ASCII protocol.

Set PROTOCOL = LMD for SEL Distributed Port Switch Protocol (LMD).

Refer to *Appendix D: Distributed Port Switch Protocol* for details on the LMD protocol.

PROTOCOL = SEL

If PROTOCOL is set to SEL, the following are applicable fields that need to be entered by the user.

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400) **SPEED :=** _____

Data Bits (7, 8) **DATA_BITS :=** _____

Parity (none = N, even = E, odd = O) **PARITY :=** _____

Stop Bits (1, 2) **STOP :=** _____

Other Port Settings

Time-Out (0–30 minutes)	**TIMEOUT :=** _____
Automatic Message Output (Y, N)	**AUTO :=** _____
Enable RTS/CTS Hardware Handshaking (Y, N)	**RTS_CTS :=** _____
Fast Operate Enable (Y, N)	**FAST_OP :=** _____

Other Port Settings

Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set RTS_CTS = Y to enable hardware handshaking. With RTS_CTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTS_CTS is not applicable for EIA-485 serial port option or when PROTOCOL = LMD.

Set FAST_OP = Y to enable binary Fast Operate messages at the serial port. Set FAST_OP = N to block binary Fast Operate messages.

PROTOCOL = LMD

If PROTOCOL is set to LMD, the following are applicable fields that need to be entered by the user.

Communications Settings

LMD Prefix (@, #, $, %, &)	**PREFIX :=** _____
LMD Address (1–99)	**ADDRESS :=** _____
LMD Settling Time (0–30 seconds)	**SETTLE_TIME :=** _____
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	**SPEED :=** _____
Data Bits (7, 8)	**DATA_BITS :=** _____
Parity (none = N, even = E, odd = O)	**PARITY :=** _____
Stop Bits (1, 2)	**STOP :=** _____

Other Port Settings

Time-Out (0–30 minutes)	**TIMEOUT :=** _____
Automatic Message Output (Y, N)	**AUTO :=** _____
Fast Operate Enable (Y, N)	**FAST_OP :=** _____

Other Port Settings

Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set FAST_OP = Y to enable binary Fast Operate messages at the serial port. Set FAST_OP = N to block binary Fast Operate messages.

SECTION 4

Operation

Front-Panel Operation

Overview

Use *Figure 4.1* and *Table 4.6* as guides to operation of the SEL-501-2 front panel.

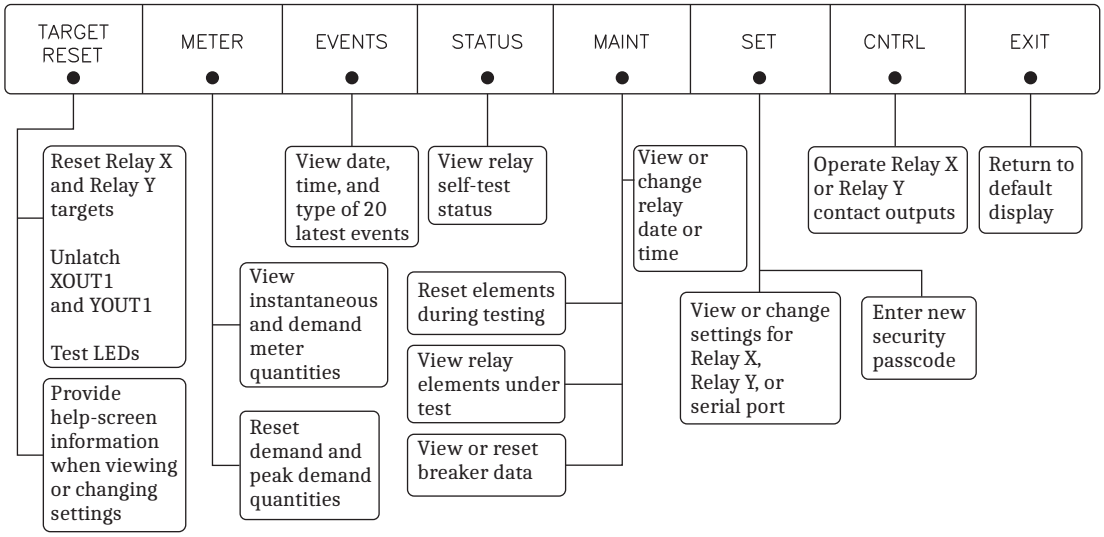

Figure 4.1 Front-Panel Function Drawing

Front-Panel Command Execution

Execute a front-panel command by pressing the desired control button. Use the left- and right-arrow buttons to underline the desired relay (X or Y) or function, then press **SELECT**.

Press **EXIT** to end a command and return to the default display. Press **CANCEL** to undo the last selection and return to the previous display.

Table 4.6 and *Table 4.7* contain complete lists of serial port and front-panel relay commands.

Front-Panel Password Security

The relay includes a password security function. When Main Board Jumper A (left jumper) is removed, you must enter the Access Level 2 password before executing Access Level 2 commands. See *Circuit Board Jumpers and Battery on page 2.10* for jumper details.

The Access Level 2 password is a six-character or less combination of alphanumerics. The default Level 2 password is shown in *Table 4.4*. To enter the password from the front panel, use the left- and right-arrow buttons to underline each character in turn. Use the up- and down-arrow buttons to enter the correct character. Unused characters to the right of the password appear as spaces. Press **SELECT** when you have entered the correct character in each position of the password.

Default and Automatic Messages

The front panel normally displays phase current magnitudes in primary amperes for Relay X and Relay Y.

The default display is cleared and new information shown for any of the following conditions:

- Relay X or Relay Y triggers an event report
- An SEL-501-2 self-test enters a warning or failure state.

The relay displays the automatic message until a new condition occurs or you press any front-panel button.

Setting Changes via the Front Panel

Press the front-panel **SET** button. Use the left- or right-arrow buttons to underline X or Y, then press the **SELECT** button to indicate the relay you wish to set. Next, underline and select the `SET` command.

The relay prompts you to enter the Access Level 2 password (passcode), if password security is enabled. When you have correctly entered the password, press **SELECT**. The relay displays the first setting, Relay Identifier.

Use the up- and down-arrow buttons to scroll through the settings. When the relay displays a setting you wish to change, press **SELECT** and follow the instructions for the type of setting you are changing.

When you have entered all the desired setting changes, press **EXIT**. The relay prompts you to save changes. To save the new settings, underline `Yes` and press **SELECT**. To reject the new settings, underline `No` and press **SELECT**.

The **TARGET RESET** button provides help-screen information when viewing or changing settings.

Relay Identifier Setting

To change the Relay Identifier setting, use the left- and right-arrow buttons to underline the letter you wish to change. Use the up- and down-arrow buttons to scroll through the characters available. Press **SELECT** when the setting is correct.

Pickup, Time-Delay, and Numeric Settings

To change a numeric setting, use the left- and right-arrow buttons to underline the number you wish to change. Use the up- and down-arrow buttons to scroll through the numbers. To change a pickup setting from a number to Off, press the left- or right-arrow button several times, until the number field changes to Off. To change a pickup setting from Off back to a number, press the left- or right-arrow button once. Press **SELECT** when the setting is correct.

Enable, Disable Settings

Use the left- or right-arrow button to change an enable setting from Y to N or from N to Y. Press **SELECT** when the setting is correct.

Front-Panel Reset

If you do not press any front-panel buttons in 5 minutes, the relay takes the following actions:

- The front-panel LCD resets to the default display.
- The LCD backlighting is turned off.
- Any routine being executed via a front-panel command is interrupted.
- The target LEDs display the tripping targets.

Serial Port Operation

Connections and Protocol

The SEL-501-2 is equipped with two serial communications ports. The front communications port supports the following protocols:

- Standard ASCII Communication (SEL)
- Distributed Port Switch Protocol (LMD)

NOTE: SEL-501-2 relays with firmware versions prior to firmware R950 only support a single rear serial port.

The rear communications port supports the following protocols:

- Standard ASCII Communication (SEL)
- Distributed Port Switch Protocol (LMD)
- Modbus RTU (MOD)

To run the standard communication program, connect the serial port to a PC serial port for local communications, or to a modem for remote communications.

Use a terminal emulation program with your personal computer to allow serial communications with the relay.

The LMD protocol, which is an extension of SEL ASCII communications, permits multiple SEL relays to share a common communication channel. For further details, refer to *Appendix D: Distributed Port Switch Protocol*.

The SEL-501-2 relays support Modbus RTU protocol. For details, refer to *Appendix E: Modbus RTU Communications Protocol* for PowerLogic compatible devices.

Serial port settings for each protocol are listed in *Table 4.1*.

Table 4.1 Communications Settings (Sheet 1 of 2)

Field Description	Screen Name	Range	Default
PROTOCOL = SEL			
Port Protocol	PROTOCOL	SEL, LMD, MOD	SEL
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	DATA_BITS	7, 8	8

Table 4.1 Communications Settings (Sheet 2 of 2)

Field Description	Screen Name	Range	Default
Parity	PARITY	N, E, O (N = none, E = even, O = odd)	N
Stop Bits	STOP	1, 2	1
Timeout	TIMEOUT	0–30 minutes	5
Automatic Message Output	AUTO	Y or N	Y
Enable RTS/CTS Handshaking	RTS/CTS	Y or N	N
Fast Operate Enable	FAST_OP	Y or N	N
PROTOCOL = LMD			
Port Protocol	PROTOCOL	SEL, LMD, MOD	LMD
LMD Prefix	PREFIX	@, #, $, %, &	@
LMD Address	ADDRESS	1–99	1
LMD Settling Time	SETTLE_TIME	0–30 seconds	0
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	DATA_BITS	7, 8	8
Parity	PARITY	N, E, O (N = none, E = even, O = odd)	N
Stop Bits	STOP	1, 2	1
Timeout	TIMEOUT	0–30 minutes	5
Automatic Message Output	AUTO	Y or N	Y
Fast Operate Enable	FAST_OP	Y or N	N
PROTOCOL = MOD			
Port Protocol	PROTOCOL	SEL, LMD, MOD	MOD
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Stop Bits	STOP	1, 2	1
Modbus Slave ID	SLAVEID	1–247	1

The SEL-501-2 can be ordered with either an EIA-232 or EIA-485 (4 wire) serial port.

To change the port settings, use the serial port **SET P F**, **SET P 1**, or front-panel **SET** port command.

The relay responds to the first three letters of commands executed from the serial port. When you type a command, you can type either the full command, or simply the first three letters. For instance, to execute the **EVENT** command, it is only necessary to type **EVE** and press **<Enter>**.

A drawing of the 9-pin port connector and cabling information for the serial port appears in *Figure 4.2*. The cable diagram shows two types of serial communication cables. These and other cables are available from SEL. Contact the factory for more information.

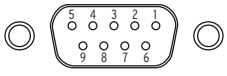

Figure 4.2 Female Chassis Connector, as Viewed From Outside Panel

Table 4.2 P1 DB-9 Connector Pinout Options

DB-9 Pin	EIA-232	EIA-485
1	N/C or +5 Vdc[a]	TX+
2	RXD	TX–
3	TXD	N/C
4	IRIG+	IRIG+
5	SHIELD	ISO_GND
6	IRIG–	IRIG–
7	RTS	RX+
8	CTS	RX–
9	DGND	DGND

[a] See Circuit Board Jumpers and Battery on page 2.10

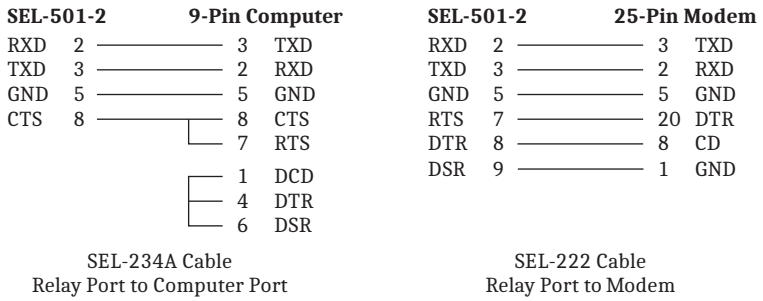

Figure 4.3 Serial Communication Cables for Use With the SEL-501-2

Serial Port Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in *Table 4.3*.

Table 4.3 Serial Port Automatic Messages

Condition	Description
Turn On	The relay sends a message containing the present date and time, Relay X and Relay Y identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered.
Self-Test Warning or Failure	The relay sends a status report each time a self-test warning or failure condition is detected.

Serial Port Password Security

The relay serial port includes a password security function. When Main Board Jumper **JMP22** (left jumper) is removed, the relay prompts you to enter passwords (passcodes) to enter Access Level 1, Access Level 2, and Access Level C. The serial port access levels are described in *Table 4.4*.

⚠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 is not responsible for any damage resulting from unauthorized access.

Table 4.4 Serial Port Security Function

Access Level	Prompt	Default Password	Description
0	=		When turned on, the relay is in Access Level 0 and honors the **ACCESS** command.
1	=>	501	Allows access to those commands listed as Access Level 1 in *Table 4.5*.
2	=>>	501	Allows access to all commands including **PAS**, **SET**, and breaker control commands.
C	==>	332	Restricted access level, should only be used under direction of SEL only.

The Access Level 1 and 2 passwords are factory-set to 501. You can change the passwords to any other pair of six-digit or less alphanumerics by using the Access Level 2 **PAS** command. The Access Level C password is factory-set to 332. You can change the password to any other six-digit or less alphanumeric by using the Access Level C **PAS** command. Valid characters are numbers, letters, dash, or period. Upper- and lowercase letters are treated as different characters. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

- Ot3579
- A24.68
- Ih2dcs
- 4u-lwg
- a501b

Setting Changes via the Serial Port

To set the relay through the use of serial port commands, first establish serial communications with the relay. Next, execute the **ACCESS** and **2ACCESS** commands to enter Access Level 2. Enter the command **SET X**, **SET Y**, or **SET P**. To change a specific setting, enter **SET *n s***, where *n* is X, Y, or P and *s* is the name of the setting you want to change.

When you execute the **SET** command, the relay presents a list of settings, one at a time. Enter a new setting, or press **<Enter>** to accept the existing setting. The relay shows only the settings required for your application. Editing keystrokes are shown in *Table 4.5*.

Table 4.5 Editing Keys for SET Command

Press Key(s)	Results
<Enter>	Retains setting and moves to the next.
^<Enter>	Move to previous setting.
END<Enter>	Exits editing session, then prompts you to save the setting.
<Ctrl+X>	Aborts editing session without saving changes.

The relay checks each entry to ensure that it is within the setting range. If it is not, an `Out of Range` message is generated, and the relay prompts for the setting again.

When settings are complete, the relay displays the new settings and prompts for approval to enable them. Answer **Y <Enter>** to enable the new settings. For about 1 second, while the active settings are updated, the relay is disabled and the ALARM output contacts close.

Table 4.6 Command Cross-Reference Table

Access Level	Serial Port Command	Front-Panel Operations	Command Description
0	**ACCESS**	--	Move to Access Level 1.
1	**2ACCESS**	--	Move to Access Level 2.
1	**BREAKER**	**MAINT** > *n* > Breaker	View trip counters and trip current data (*n* = X, Y).
1	**DATE** **DATE** ***mm/dd/yy***	**MAINT** > Date	View or change relay calendar date.
1	**EVENT** ***n***	--	View event report (*n* = 1–5).
1	**EVENT R** ***n***	--	View raw (unfiltered) event report (*n* = 1–5).
1	**HISTORY**	**EVENTS**	View latest event summaries.
1	**HISTORY C**	--	Clear event history.
1	**METER** **METER D** **METER P**	**METER** > *n* > Display	View instantaneous, demand (D), and peak demand (P) currents.
1	**METER RD** ***n*** **METER RP** ***n***	**METER** > *n* > Reset	Reset demand (RD) and peak demand (RP) values (*n* = X, Y).
1	**SHOW** ***n***	**SET** > *n* > Show	View relay settings (*n* = X, Y, Port).
1	**STATUS**	**STATUS**	View relay self-test status.
1	**TARGET** ***n*** **#**	**MAINT** > *n* > Tar	View relay element, input, output status (*n* = X, Y; # = 0–4).
1	**TARGET R**	**TARGET RESET**	Reset tripping targets.
1	**TIME** **TIME** ***hh:mm:ss***	**MAINT** > Time	View or change time.
1	**TRIGGER**	--	Trigger a relay event report.
1	**QUIT**	--	Move to Access Level 0.
1	**VER**	--	View relay configuration and firmware version.
2	**BREAKER** ***n*** **R**	**MAINT** > *n* > Breaker	Reset trip counters and trip current data (*n* = X, Y).
2	**CALIBRATION**	--	Move to Access Level C.
2	**CON** ***n***	--	Control remote bit (*n* = X, Y).
2	**1OUT** ***n***	**CNTRL** > *n* > **1OUT**	Closes Output *n*OUT1 (*n* = X, Y).
2	**2OUT** ***n***	**CNTRL** > *n* > **2OUT**	Closes Output *n*OUT2 (*n* = X, Y).
2	**PAS** **PAS** ***l*** **######**	**SET** > **PAS**	View or change password (*l* = 1, 2, C; ###### = new password). Entering DISABLE as the password disables the password requirement for the specified access level).
2	**RESET** ***n***	**MAINT** > *n* > **EL**	Reset time-overcurrent elements (*n* = X, Y).
2	**SET X** **SET Y** **SET P F** **SET P 1**	**SET** > X > Set **SET** > Y > Set **SET** > Port > Set	View or change relay or serial port protocol settings.

Table 4.7 Access Level 2 Breaker Control Commands

Serial Port Command	Front-Panel Command	Closes Output
1OUT *n*	CNTRL > *n* > 1OUT	*n*OUT1 (*n* = X, Y)
2OUT *n*	CNTRL > *n* > 2OUT	*n*OUT2 (*n* = X, Y)

Selected Command Details

BREAKER Command

The relay includes monitor functions for the breakers controlled by Relay X and Relay Y. The relay counts the number times each breaker trips as a result of SEL-501-2 operations (internal trips). The internal trip counter counts relay trips for the first trip output contact to assert.

Relay X and Relay Y breaker monitors also record running sums of the current interrupted by the breakers on a pole-by-pole basis. The relay reports this sum in primary kiloamperes, kA.

Breaker Command From the Front Panel

To view the breaker monitor data, press the front-panel **MAINT** button. Use the left- or right-arrow buttons to underline X or Y, then press the **SELECT** button to indicate the relay data you wish to review. Underline and select the **BREAKER** command, then underline and select `Display`.

The relay displays the number of internal and external trips recorded for Relay X or Relay Y. In addition, the display scrolls automatically through the interrupted kiloamperes pole-by-pole. Stop the scrolling by pressing **SELECT**, resume scrolling by pressing **SELECT** again. While scrolling is stopped, move through the data by using the up- and down-arrow buttons.

To reset the data, select `Reset` instead of `Display`. If password security is in effect, you must enter the password before resetting the breaker monitor data.

Breaker Command From the Serial Port

To view the breaker monitor data via the serial port, enter the command **BREAKER**. To reset Relay X or Relay Y breaker monitor data, enter the command **BREAKER** (**X** or **Y**) **R** from Access Level 2.

CONTROL Command

The **CON** command is a two-step command that allows you to control Relay Word bit RB. At the Access Level 2 prompt, type **CON**, a space, and the remote bit you wish to control (X or Y). The relay responds by repeating your command followed by a colon. At the colon, type the desired control command, a space, and the remote bit name. Control commands are **SRB** to set the remote bit and **CRB** to clear the remote bit. *Figure 4.4* shows the steps necessary to set remote bit for Relay X.

```
=>>CON X <Enter>
CONTROL RBX: SRB X <Enter>
```

Figure 4.4 CONTROL Command Example

To confirm the remote bit is set, issue the **TAR 4 X** serial port command.

STATUS Command

Self-test functions monitor the operation of several major relay subsystems. Execute the serial port **STATUS** command, or press the front-panel **STATUS** button to inspect the most recent results of the relay self-tests. *Figure 4.5* shows an example of the **STATUS** report.

```
RELAY X FDR                                    Date: 08/28/93   Time: 19:22:11.745
RELAY Y FDR

FID = SEL-501-2-R100-V65X1XXpa-D950426

SELF TESTS

W=Warn    F=Fail

       IAX       IBX       ICX       IAY       IBY       ICY       MOF
OS      2         2         2         3         2         2         0

       +5_PS    +5V_REG   -5V_REG   +10V_PS   -10V_PS   VBAT
PS      4.94      5.11     -4.96      10.12    -10.07    2.92

       TEMP      RAM       ROM      CR_RAM    EEPROM   SETTINGS
       23.4      OK        OK        OK        OK        OK
```

Figure 4.5 STATUS Command Example

Table 4.7 describes the **STATUS** report.

Table 4.8 Self-Test Status Report Description

Parameter	Description
OS: IAX–ICY, MOF	DC offsets voltages in millivolts for the analog channels (IAX, IBX, ICX, IAY, IBY, ICY) and master offset (MOF). W (Warning) or F (Failure) indicates an out-of-tolerance condition
PS: +5V_PS–VBAT	Power supply and voltage regulator output voltages. W (Warning) or F (Failure) indicates out-of-tolerance condition.
TEMP	Temperature inside the relay in degrees Celsius. W (Warning) or F (Failure) indicates out-of-tolerance condition.
RAM, ROM, CR_RAM	Memory functions. Status is either OK or FAIL.
EEPROM	Checksums of the settings in EEPROM are checked. If they agree with an initial checksum, OK is displayed. If not, FAIL is displayed.
SETTINGS	Settings self-test checks status of relay settings. RELAY or CAL is displayed if the test fails. Otherwise OK is displayed.

TARGET Command

The **TARGET** function allows you to view the present condition of any relay control input or contact output, and selected relay elements.

To review **TARGET** data through the use of the front panel, press the **MAINT** button. Use the left- or right-arrow buttons to underline X or Y, then press the **SELECT** button to indicate the relay data you want to review. Underline and select the TAR command, then use the up- and down-arrow buttons to view the target data.

The relay reassigns the front-panel target LEDs to display the state of elements in the Target Row you select. The LEDs illuminate to show when an element is picked up, or when an input or output is asserted. The relay updates this information each quarter-cycle. In addition, the LCD shows the names of the elements that are picked up, updated every two seconds.

Target 0 shows the tripping targets for the selected relay (see *Overcurrent Relay Targets on page 3.10*). Target 1 shows the state of the relay contact inputs and outputs (see *Rear-Panel Connections on page 2.6* and *Relay Alarm Conditions on page 4.11*).

Table 4.9 Target Command Table

LED	X	Y	INST	A	B	C	Q	N
Target 0	X	Y	INST	A	B	C	Q	N
Target 1	*	XIN	YIN	ALARM	XOUT1	XOUT2	YOUT1	YOUT2
Target 2	51PT	51QT	51NT	50PT	50H	50QT	50NT	50NH
Target 3	51PP	51QP	51NP	50PP	*	50QP	50NP	*
Target 4	51PR	51QR	51NR	RB	CNTR8	CNTR4	CNTR2	CNTR1

Table 4.10 Target Definitions (Sheet 1 of 2)

Element	Definition
X	X Relay
Y	Y Relay
INST	Instantaneous Trip
A	A-Phase Current
B	B-Phase Current
C	C-Phase Current
Q	Negative-Sequence Overcurrent
N	Residual Overcurrent
XIN	X Relay Optoisolated Input
YIN	Y Relay Optoisolated Input
ALARM	ALARM
XOUT1	X1 Output Contact
XOUT2	X2 Output Contact
YOUT1	Y1 Output Contact
YOUT2	Y2 Output Contact
51PT	Phase Time-Overcurrent Trip
51QT	Negative-Sequence Time-Overcurrent Trip
51NT	Residual Time-Overcurrent Trip
50PT	Definite-Time Phase Overcurrent Trip
50H	Instantaneous Phase Overcurrent Trip
50QT	Definite-Time Negative-Sequence Overcurrent Trip[a]
50NT	Definite-Time Residual Overcurrent Trip
50NH	Instantaneous Residual Overcurrent Trip
51PP	Phase Time-Overcurrent Pickup
51QP	Negative-Sequence Time-Overcurrent Pickup

Table 4.10 Target Definitions (Sheet 2 of 2)

Element	Definition
51NP	Definite-Time Phase Overcurrent Pickup
*	Future Use
50QP	Definite-Time Negative-Sequence Overcurrent Pickup
50NP	Definite-Time Residual Overcurrent Pickup
51PR	Phase Time-Overcurrent Element Reset
51QR	Negative-Sequence Time-Overcurrent Element Reset
51NR	Residual Time-Overcurrent Element Reset
RB	Remote Bit
CNTR8	Optoisolated Input Change-of-State Counter/8
CNTR4	Optoisolated Input Change-of-State Counter/4
CNTR2	Optoisolated Input Change-of-State Counter/2
CNTR1	Optoisolated Input Change-of-State Counter

[a] Note: 50QP is intentionally delayed by 1.5 cycles, and timer 50QD is shortened by 1.5 cycles. Thus the delay from 50QP to 50QT is 1.5 cycles shorter than setting 50QD.

To use the **TARGET** command from the relay serial port, type the command, followed by an X or Y, the desired target row and press **<Enter>**. For example, **TARGET X 2 <Enter>** changes the front-panel target indication to Relay X Target 2.

Relay Alarm Conditions

The relay asserts the ALARM output when dc power is removed, or if any diagnostic test fails. The relay pulses the ALARM output for five seconds for diagnostic test warnings. The relay pulses the ALARM output for one second for the commands and conditions shown in *Table 4.10*.

Table 4.11 Commands With Alarm Conditions

Command	Condition
CALIBRATION	Entering Access Level C or three wrong password attempts
2ACCESS	Entering Access Level 2 or three wrong password attempts
ACCESS	Three wrong password attempts
PAS	Any password (passcode) is changed
SET commands	The relay setting changes are accepted

Change-of-State Counters

The SEL-501-2 provides Change-of-State (COS) counters to monitor optoisolated inputs XIN and YIN. The COS counters increment each time an optoisolated input changes state. These counters are used in SCADA systems where the optoisolated state can change between SCADA scans. To determine if an input has changed state since the last scan, the SCADA system compares the value of the COS counter with the previous value.

The SEL-501-2 stores the COS counters in the Relay Word. To access the counters, use either the **ASCII TARGET** command or the binary Fast Meter command (A5D1). Refer to the **TARGET** Command description earlier in this section, or the A5D1 message description in *Appendix B: Firmware (EPROM) Upgrade Instructions*.

Each COS counter consists of four bits in the Relay Word: CNTR8, CNTR4, CNTR2, and CNTR1. CNTR1 is the least significant bit in the counter; CNTR8 is the most significant bit.

SECTION 5

Event Reporting

Introduction

The SEL-501-2 saves a 15-cycle report each time Relay X or Relay Y OUT1 or OUT2 output contact closes, or when any of several protection elements pick up, as described in the following sections. Each event report contains detailed current, relay element, input, and output data associated with the event. Use the information contained in the relay event reports to review relay operation during faults and tests.

The relay stores event summaries for the 20 latest events and full-length reports for the 5 latest events. Review the event summaries using the front-panel LCD and the **EVENTS** pushbutton or the serial port **HISTORY** command. Review full-length event reports using the serial port **EVENT** command.

Event Triggering

The relay generates an event report when any of the following occurs:

- You execute the serial port **TRIGGER** command
- Relay X or Relay Y issues a trip
- Pickup of a definite-time or time-overcurrent element
- External trigger input assertion

The relay generates a second report for a single fault if either relay trips after the end of the initial report. This allows the relay to record the inception and clearance of long faults.

Event Summary

Each time the relay generates an event report, it also generates an event summary. Event summaries contain the following information:

- Relay X and Relay Y identifier settings
- Date and time when the event was triggered
- Event type and duration
- Tripping targets for the relay that triggered the event
- Current magnitudes in amperes primary measured by Relay X and Relay Y at the trigger instant.

The Event Report Summary displays the phase current magnitude calculated by the cosine filter or bipolar peak detector (CT saturation condition). If the relay used the bipolar peak detector value at the trigger instant (when an instantaneous

pickup setting is greater than eight times nominal phase current and the harmonic distortion index is greater than a fixed threshold), the relay displays `pk` as shown in the Event Summary portion of the *Example 15-Cycle Event Report* (for more information on the cosine filter and bipolar peak detector see *CT Saturation Protection on page 1.3*).

If the relay is configured to transmit automatic messages, the event summary is sent from the serial port a few seconds after the event.

Event Reports

The relay acquires data every 1/16 cycle, filters the data, processes these data every 1/8 or 1/4 cycle, and provides you the option of displaying either a standard, cosine-filtered event report or a raw, unfiltered event report. Filtered event report row data is always the output of the cosine filter; the relay reports the bipolar peak detector output value only in the Event Summary if active at the trigger instant. The standard event report displays event data at four samples per cycle. The relay displays raw event reports at 16 samples per cycle.

The relay stores the five latest event reports. The latest report is stored in nonvolatile memory and is saved through loss of dc power. The remaining four events are stored in volatile memory. These reports are lost if the relay is shut off or loses dc power.

The standard event report is 15 cycles long. The raw event report is 16 cycles long. The data are presented on a quarter-cycle basis for the standard event report and on a 1/16-cycle basis for the raw event report, with time running down the report. The time recorded at the top of the report corresponds to the event report trigger instant. The trigger point in the event report is indicated by the ">" symbol adjacent to the ICY column.

Event Commands

The listing below shows the event commands and report formats.

Command	Format
EVENT *n*	Display 15-cycle filtered event report at 1/4-cycle resolution.
EVENT *n* R	Display 16-cycle raw (unfiltered) event report at 1/16-cycle resolution.

The *n* parameter refers to the event report number (*n* = 1 through 5), with *n* = 1 being the most recent event report and *n* = 5 being the oldest event report.

Relay Current Data

The first eight columns of event report data show the power system currents measured by Relay X and Relay Y. Each row shows the instantaneous samples of the current signals, after analog and digital filtering, scaled in primary amperes. The data in a single row correspond to a single point in time. The rows are a quarter cycle, or 90 degrees, apart in time.

Event report current values can be used to represent the signals as phasors:

- The previous value of the current is the Q-component.
- The present value of the current is the P-component.

To construct a phasor diagram of the currents, select two consecutive rows from an area of interest in the event report. On Cartesian coordinates, plot the lower row (P-component) on the X (horizontal) axis and the upper row (Q-component) on the Y (vertical) axis.

Use any two consecutive samples to calculate the magnitude and phase angle of the measured current. Calculate the magnitude of the current phasors by taking the square root of $P^2 + Q^2$. Calculate the phase angle of the signal by taking the arctangent of (Q/P).

Relay Column Headings

The columns adjacent to the current data contain information on the state of Relay X and Relay Y elements, inputs, and outputs each quarter-cycle during the event.

Each column shows a letter or symbol to indicate the condition of protection elements that quarter-cycle. Read the column labels vertically.

Element/Input Column Definitions

Column	Symbol	Definition
All	.	Element not picked up
51P	p	Phase time-overcurrent picked up
	T	Phase time-overcurrent element trip
51Q	q	Negative-sequence time-overcurrent element picked up
	T	Negative-sequence time-overcurrent element trip
51N	n	Residual time-overcurrent element picked up
	T	Residual time-overcurrent element trip
50P	p	Phase definite-time overcurrent element picked up
	T	Phase definite-time overcurrent element trip
	H	Phase instantaneous overcurrent element trip
50Q	q	Negative-sequence definite-time overcurrent element picked up
	T	Negative-sequence definite-time overcurrent element trip
50N	n	Residual definite-time overcurrent element picked up
	T	Residual definite-time overcurrent element trip
	H	Residual instantaneous overcurrent element trip
IN	*	Programmable input asserted
	R	Remote bit asserted
	b	Both input and remote bit asserted
OUT	1	TRIP1 output is closed
	2	TRIP2 output is closed
	b	Both outputs are closed
ALRM	*	SEL-501-2 ALARM output is indicating an alarm state

Event Summary Data

The event summary includes the event type, tripping targets, fault duration, and the magnitudes of phase, negative-sequence, and residual currents measured by each relay at the trigger instant.

Event Type

The event report event field shows the event type and which relay triggered the event. The possible types of events and their descriptions are shown in *Table 5.1*.

Table 5.1 Event Types

Event	Event Triggered By:
TRIG	**TRIGGER** command
FAULT	Overcurrent element operation
EXT	Input IN = ET (External Trigger) assertion
1OUT	**1OUT** command
2OUT	**2OUT** command

Event Targets and Duration

The Targets field shows the front-panel tripping targets for the relay that triggered the event report. The Duration field shows the number of cycles that fault-detecting elements were picked up during the event report. If elements are picked up at the beginning or end of the event report, the relay adds a "+" to the duration. This indicates that actual duration of the fault is probably greater than the figure reported.

Relay Settings

Relay X and Relay Y settings are shown with each event report unless the settings have changed since the report was triggered. The settings are included with each report. The event report shows a message (instead of the settings) if Relay X or Relay Y settings have been changed since the event was triggered.

Example 15-Cycle Event Report

The following event report was generated by an SEL-501-2 in response to a simulated phase-phase fault, cleared by the Relay X negative-sequence time overcurrent element, 51QT.

```
EXAMPLE FD                          Date: 06/02/95   Time: 16:04:50.541
EXAMPLE FD
```

Time-tag corresponds to the eighth quarter-cycle of this event

```
FID=SEL-501-2-R100-V65X1XXpa-D950426

                                        Relay X     Relay Y  A
        Relay X             Relay Y     555555   O 555555  O L
        Amps Pri            Amps Pri    111000  IU 111000 IU R
   IRX    IAX   IBX  ICX  IRY   IAY  IBY  ICY  PQNPQN  NT PQNPQN NT M

    -2     86   206 -294   -0   124  208 -332  ......  .. ...... .. .
    -0   -288   220   68   -3  -313  265   46  ......  .. ...... .. .
     0    -86  -206  292   -1  -125 -207  331  ......  .. ...... .. .
     0    288  -220  -67    2   313 -265  -46  ......  .. ...... .. .
```

One cycle of data

```
    -2     86   205 -293    1   126  206 -332  ......  .. ...... .. .
    -2   -288   220   66   -4  -314  265   46  ......  .. ...... .. .
     2    -87  -206  294   -2  -126 -207  331  ......  .. ...... .. .
  -480   -191  -220  -69  -42   270 -265  -47>..n...  .. ......  .. .
```

Relay X 51 element picks up, triggering this report

```
  1203   1291   206 -295   11   136  206 -332 p.n...  .. ......  .. .
   584    297   219   69  124  -188  265   48 p.n...  .. ......  .. .
 -2758  -2846  -207  294  -27  -152 -207  331 p.n..n  .. ......  .. .
  -215     73  -219  -69 -165   149 -265  -48 p.n..n  .. ......  .. .
  3110   3199   206 -295   32   157  206 -332 p.np.H  .b ......  .. .
   213    -75   219   69  164  -148  265   47 p.np.H  .b ......  .. .
 -3114  -3200  -207  294  -34  -157 -208  331 pqnp.H  .b ......  .. .
  -210     77  -219  -68 -164   149 -265  -47 pqnp.H  .b ......  .. .
```

Relay X 51P, 51N, 50P, and 50N elements are picked up. 50H element picks up, causing a trip. XOUT1 and XOUT2 both close.

```
[Four cycles of data]

  1910   1956   130 -176   21   147  208 -334 pqn.qn  .b ......  .. .
  -372   -458    27   58   37  -277  264   50 pqn.qn  .b ......  .. .
```

```
  -350   -352   -28   30   -7  -131 -209  332 ..n...  .b ......  .. .
     0      0     0    0    2   315 -264  -50 ..n...  .b ......  .. .
```

Breaker operates, clearing the fault

```
[Six cycles of data]
Event: FAULT X            Targets:X INST A N       Duration:    7.25
Relay X Currents (A Pri), ABCQN:     210 pk 301 pk 302 pk  479   481
Relay Y Currents (A Pri), ABCQN:     298    336    334      40    42
```

Event Summary

```
Relay X Settings:
ID    = EXAMPLE FD
CTR   = 120      DATC  = 5        IN    = ET
50PP  = 25.0     50PD  = 20.00    50PTT = B
50H   = 40.0     50HT  = B
50QP  = 15.0     50QD  = 20.00    50QTT = B
50NP  = 15.0     50ND  = 20.00    50NTT = B
50NH  = 25.0     50NHT = B
51PP  = 6.00     51PC  = U3       51PTD = 3.00
51PRS = Y        51PTT = B
51QP  = 6.00     51QC  = U3       51QTD = 3.00
51QRS = Y        51QTT = B
51NP  = 1.50     51NC  = U3       51NTD = 3.00
51NRS = Y        51NTT = B
TRPU1 = 0.00     TDUR1 = 6.00
TRPU2 = 0.00     TDUR2 = 6.00
ELTCH = Y
```

Relay X Settings

```
   IN: External Trigger
TRIP1: 51PT, 51QT, 51NT, 50PT, 50H, 50QT, 50NT, 50NH
TRIP2: 51PT, 51QT, 51NT, 50PT, 50H, 50QT, 50NT, 50NH
```

Input and output function summary, defined by relay settings

```
Relay Y Settings: [similar to Relay X settings, above]
```

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SECTION 6

Testing

Testing Methods and Tools

Test Features Provided by the Relay

The following features assist you during relay testing.

METER Command	The **METER** command shows the currents presented to the relay in primary values. Compare these quantities against other devices of known accuracy.
Event Reporting	The relay generates a 15-cycle event report in response to faults or disturbances. Each report contains current information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information.
TARGET Command	Use the **TARGET (X** or **Y) *n*** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test.

For more information on these features and commands, see *Section 4: Operation*.

Low-Level Test Interface

The SEL-501-2 has a low-level test interface between the calibrated input module and the separately calibrated processing module. You can test the relay in either of two ways: conventionally, by applying ac current signals to the relay inputs; or by applying low magnitude ac voltage signals to the low-level test interface. Access the test interface by removing the relay front panel.

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

Figure 6.1 shows the interface connections. This drawing also appears on the inside of the relay front panel. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

You can test the relay processing module by using signals from the SEL-RTS Low-Level Relay Test System. Never apply voltage signals greater than 6.2 volts peak-peak to the low-level test interface. *Figure 6.1* shows the signal scaling factors.

You can test the input module two different ways:

1. Measure the outputs from the input module with an accurate voltmeter, and compare the readings to accurate instruments in the relay input circuits, or
2. Replace the ribbon cable, press the front-panel **METER** button, and compare the relay readings to accurate instruments in the relay input circuits.

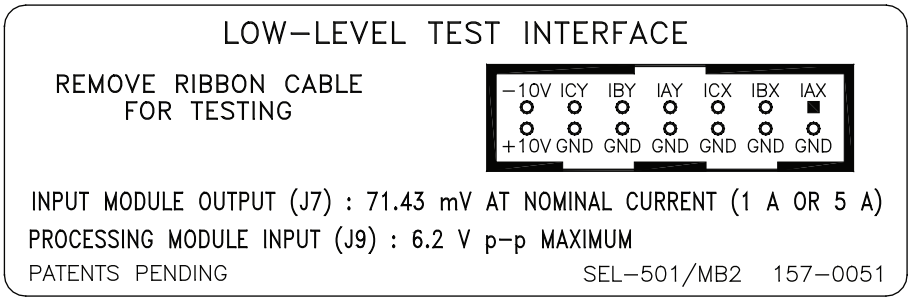

Figure 6.1 Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements by using one of two methods: front-panel LCD/LED indication and output contact closure.

Testing Via Front-Panel Indicators

Display the state of relay elements, inputs, and outputs by using the **TARGET** command via the front panel or serial port. Use this method to verify the pickup settings of protection elements.

Review the **TARGET** command description in *TARGET Command on page 4.9* for further details.

Testing Via Output Contacts

Relay X and Relay Y can be set to trip for operation of a single element for testing purposes. Make a record of the present relay settings. Set the pickup setting for the element under test. Set all other element pickup settings OFF.

Use this method to verify definite-time delays and delays associated with time-current elements. Do not forget to reenter the correct relay settings when you are ready to place the relay in service.

Test Procedures

Overcurrent Element Pickup Test: 50PP, 50H, 50QP, 50NP, 50NH, 51PP, 51QP, 51NP

NOTE: This example tests the 50PP phase overcurrent element. Use the same procedure to test the 50H and 51PP phase overcurrent elements and the residual and negative-sequence overcurrent elements 50NP, 50NH, 51NP, 50QP, and 51QP. Relay X is shown in this example.

Step 1. Execute the **SHOW** command via the relay front panel or serial port and verify the relay setting for the 50PP overcurrent element.

Step 2. Execute the **TARGET X 3** command. The SEL-501-2 now displays the state of several Relay X overcurrent elements on the front-panel LED and LCD, as shown in *Table 6.1*.

Table 6.1 Front-Panel LED and LCD

Target Label	X •	Y •	INST •	A •	B •	C •	Q •	N •
Indicates	51PP	51QP	51NP	50PP	*	50QP	50NP	*

Step 3. Connect a single current source to one phase current input of Relay X.

Step 4. Turn on the current test source and slowly increase the magnitude of current applied until the 50PP element asserts, causing the **A** (50PP) LED to illuminate. Note the magnitude of the current applied. It should equal the 50PP setting.

Residual Time-Overcurrent Element: 51NT

NOTE: The steps taken in the example test for the 51NT residual time-overcurrent element operating time may be applied to test the feeder relay 51PT and 51QT time-overcurrent elements. Relay X is shown in this example.

Step 1. Execute the **SHOW** command and verify the relay settings for the residual time-overcurrent element. Settings of interest are: 51NP, 51NC, 51NTD, and 51NRS.

Step 2. Through the use of the **SET X** command, set 50PP, 50H, 50QP, 50NP, 51PP, 50NH, and 51QP to Off. The Off setting disables these elements, leaving only the 51NT element enabled to trip. Connect XOUT1 to an external timer. Configure the timer to start on application of current and stop on operation of the XOUT1 contact.

Step 3. Connect a single current source to one phase current input of Relay X.

Step 4. Calculate the expected operating time (tp) of the element. Use the element settings and the operating time equations shown in *Time-Overcurrent Element Operate/Reset Curve Equations on page 3.12*. TD is the time-dial setting, 51NTD, and M is the applied multiple of pickup current.

For example, if 51NP = 2.2 A, 51NC = U3, and 51NTD = 4.0, we can use the equation below to calculate the expected operating time for M = 3 (applied current equals M • 51NP = 6.6 A):

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

$$tp = 2.33 \text{ seconds}$$

NOTE: If the time-overcurrent element induction-disk reset emulation is enabled (51NRS, 51PRS, or 51QRS = Y), the element under test may take some time to reset fully. If the element is not fully reset when you run a second test, the time to trip will be lower than expected. To reset an element before running additional tests, enter the **RESET** command from the relay serial port, or the **EL** command, under the **MAINT** pushbutton, from the relay front panel.

Step 5. Set the current source to deliver M • 51NP amperes and turn the current source on. The timer should start. When the time-overcurrent element times out, Relay X should trip, stopping the timer. The time recorded should be approximately equal to the time you calculated in *Step 4*.

Relay Self-Tests

The relay runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 6.2*):

- Protection Disabled: The relay disables overcurrent elements and trip/close logic. All output contacts are de-energized. The **EN** front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its de-energized state. If the ALARM output contact is a b contact (normally closed), it closes for an alarm condition or if the relay is de-energized. If the ALARM output contact is an a contact (normally open), it opens for an alarm condition or if the relay is de-energized. Alarm condition signaling can be 5-second pulses (Pulsed) or permanent (Latched).
- The relay generates automatic STATUS reports at the serial port for warnings and failures.
- The relay displays failure messages on the relay LCD for failures.

Use the serial port **STATUS** command or front-panel **STATUS** pushbutton to view relay self-test status.

Table 6.2 Relay Self-Tests (Sheet 1 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
IAX, IBX, ICX, IAY, IBY, ICY Offset	Warning	30 mV	No	Pulsed	Measures the dc offset at each of the current input channels every 0.2 seconds.
Master Offset	Warning	20 mV	No	Pulsed	Measures the dc offset at the A/D every 0.2 seconds
	Failure	30 mV	Yes	Latched	
+5V PS	Warning	+4.75 V +5.25 V	No	Pulsed	Measured the +5 volt power supply every 0.2 seconds.
	Failure	+4.70 V +5.50 V	Yes	Latched	
±5V REG	Warning	±4.65 V ±5.35 V	No	Pulsed	Measures the regulated 5-volt power supply every 0.2 seconds.
	Failure	±4.50 V ±5.50 V	Yes	Latched	
±10V PS	Warning	±9.00 V ±11.00 V	No	Pulsed	Measures the 10-volt power supply every 0.2 seconds.
	Failure	±8.00 V ±12.00 V	Yes	Latched	
VBAT	Warning	+2.25 V +5.00 V	No	Pulsed	Measures the Real-Time clock battery every 0.2 seconds.
	Failure	+2.10 V +6.00 V	No	Pulsed	
TEMP	Warning	–40 C +85 C	No		Measures the temperature at the A/D voltage reference every 0.2 seconds.
	Failure	–50 C +100 C	Yes	Latched	
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the relay program memory every 0.2 seconds.

Table 6.2 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
CR_RAM	Failure	checksum	Yes	Latched	Performs a checksum test on the active copy of the relay settings every 0.2 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the relay settings every 0.2 seconds.
The following self-tests are performed by dedicated circuitry in the microprocessor and the SEL-501-2 main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Microprocessor Crystal	Failure		Yes	Latched	The relay monitors the microprocessor crystal. If the crystal fails, the relay displays `CLOCK STOPPED` on the LCD. The test runs continuously.
Microprocessor	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The relay displays `VECTOR nn` on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.
+5V PS Under/ Over Voltage	Failure	+4.65 V +5.95 V	Yes	Latched	A circuit on the SEL-501 main board monitors the +5 V power supply. Upon detection of a failure, the circuit forces the microprocessor to reset.

Relay Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to *Troubleshooting Procedure*.

1. Measure and record the power supply voltage at the power input terminals.
2. Check to see that the power is on. Do not turn off the relay.
3. Measure and record the voltage at all control inputs.
4. Measure and record the state of all output relays.

Troubleshooting Procedure

All Front-Panel LEDs Dark

1. Input power not present or fuse is blown.
2. Self-test failure.

Cannot See Characters on Relay LCD Screen

1. Relay is de-energized. Check to see if the ALARM contact is closed.
2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
   a. Remove the relay front panel by removing the three front-panel screws.
   b. Press any front-panel button. The relay should turn on the LCD backlighting.

c. Locate the contrast adjust potentiometer directly adjacent to the **EN** LED.

d. Use a small screwdriver to adjust the potentiometer.

e. Replace the relay front panel.

Relay Does Not Respond to Commands From Device Connected to Serial Port

1. Communications device not connected to relay.
2. Relay or communications device at incorrect baud rate or other communications parameter incompatibility, including cabling error.
3. Relay serial port has received an **XOFF**, halting communications. Type **<Ctrl+Q>** to send relay an **XON** and restart communications.

Relay Does Not Respond to Faults

1. Relay improperly set.
2. Improper test source settings.
3. CT input wiring error.
4. Analog input cable between transformer secondary and main board loose or defective.
5. Failed relay self-test.

Relay Calibration

The SEL-501-2 is factory-calibrated. If you suspect that the relay is out of calibration, contact the factory.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

APPENDIX A

Firmware 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 **STATUS** pushbutton. The status report displays the Firmware Identification (FID) number.

The firmware revision number is after the R, and the date code is after the D. For firmware versions with the date code 20011002 through 20111101, the status report displays the FID number:

FID=SEL-501-2-**Rxxx-Vabxxcxdx-Dxxxxxxxx**

NOTE: The hardware of SEL-501-2 relays that shipped with firmware versions R902 and prior differs from the hardware of SEL-501-2 relays that have shipped with R950 firmware. Relays with firmware versions R902 and prior can not be upgraded to R950 firmware.

For firmware versions with the date code of 20210406, or later, the status report displays the following FID number:

FID=SEL-501-2-**Rxxx-Vabxxcxdx-Z001001-Dxxxxxxxx**

The version number follows the V as follows:

V[VS] = V[abxxcxdx]

Option	Specifier	Specifier Meaning	Option Description
a	5, 6	50 Hz, 60 Hz	Power System Frequency
b	1, 5	1 A, 5 A	Nominal Amperes per Phase
c	X, 2	No, Yes	Modbus
d	p, n	Positive, Negative	Phase-Sequence of Power System

Revision History

Table A.1 lists the firmware versions, revision descriptions, and corresponding instruction manual date codes. The most recent firmware version is listed first.

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 3)

Firmware Identification (FID) Number	Summary of Revisions	Date Code
Conventional Terminal Blocks SEL-501-2-R950-Z001001-D20210406	➤ Added support for front-panel serial port.	20210406
Conventional Terminal Blocks and Plug-in Connectors (Connectorized) SEL-501-2-R902-D20111101	➤ Enhanced Modbus to operate reliably at 19200 baud.	20111101

Table A.1 Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) Number		Summary of Revisions	Date Code
Conventional Terminal Blocks and Plug-in Connectors (Connectorized) SEL-501-2-R901-D20031008		➤ CT saturation protection was enhanced to improve security with low-set instantaneous values.	20031008
Conventional Terminal Blocks and Plug-in Connectors (Connectorized) SEL-501-2-R900-D20021002		➤ Added CT Saturation Protection ➤ Added Raw Event Report ➤ Made internal changes to support battery-backed clock hardware change.	20021002
Supports PROTO = MOD		➤ Corrected password display. ➤ Fixed Fast Meter response issue. ➤ Added Modbus communications protocol	20000105
SEL-501-2-R525-D000105	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R575-D000105	60 Hz, 5 A, ACB Rotation		
SEL-501-2-R625-D000105	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R725-D000105	60 Hz, 1 A, ABC Rotation		
SEL-501-2-R775-D000105	60 Hz, 1 A, ACB Rotation		
SEL-501-2-R825-D000105	50 Hz, 1 A, ABC Rotation		
Does not support PROTO = MOD			
SEL-501-2-R506-D000105	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R556-D000105	60 Hz, 5 A, ACB Rotation		
SEL-501-2-R606-D000105	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R706-D000105	60 Hz, 1 A, ABC Rotation		
SEL-501-2-R756-D000105	60 Hz, 1 A, ACB Rotation		
SEL-501-2-R806-D000105	50 Hz, 1 A, ABC Rotation		
SEL-501-2-R755-D990525	60 Hz, 1 A, ACB Rotation	➤ Created new firmware version for SEL-501-2.	990528
SEL-501-2-R705-D980401	60 Hz, 1 A, ABC Rotation	➤ Added Y option for input control of overcurrent elements	980327
SEL-501-2-R505-D980401	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R805-D980401	50 Hz, 1 A, ABC Rotation		
SEL-501-2-R605-D980401	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R555-D980401	60 Hz, 5 A, ACB Rotation		
SEL-501-2-R704	60 Hz, 1 A, ABC Rotation	➤ Added remote bits to control overcurrent elements via serial port commands. Added **CON** and **Fast Operate** commands to set and clear remote bits. ➤ Changed front-panel LCD underscore character. ➤ Added change of date counters for optoisolated inputs. ➤ Added factory settings to redefine front-panel **CNTRL** command "1OUT" and "2OUT" labels.	970828
SEL-501-2-R504	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R804	50 Hz, 1 A, ABC Rotation		
SEL-501-2-R604	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R554	60 Hz, 5 A, ACB Rotation		
SEL-501-2-R703	60 Hz, 1 A, ABC Rotation	➤ Corrected problem where relay would fail to respond to Fast Meter messages if a serial port timeout occurred during the Fast Meter message.	[a]
SEL-501-2-R503	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R803	50 Hz, 1 A, ABC Rotation		
SEL-501-2-R603	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R553	60 Hz, 5 A, ACB Rotation		
SEL-501-2-R702	60 Hz, 1 A, ABC Rotation	➤ Decreased power-up initialization time.	[a]
SEL-501-2-R502	60 Hz, 5 A, ABC Rotation		
SEL-501-2-R802	50 Hz, 1 A, ABC Rotation		
SEL-501-2-R602	50 Hz, 5 A, ABC Rotation		
SEL-501-2-R552	60 Hz, 5 A, ACB Rotation		

Table A.1 Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number		Summary of Revisions	Date Code
SEL-501-2-R701 SEL-501-2-R501 SEL-501-2-R801 SEL-501-2-R601 SEL-501-2-R551	60 Hz, 1 A, ABC Rotation 60 Hz, 5 A, ABC Rotation 50 Hz, 1 A, ABC Rotation 50 Hz, 5 A, ABC Rotation 60 Hz, 5 A, ACB Rotation	➤ Corrected front-panel targeting problem. Front-panel targets are illuminated if relay trips by 50H or 50NH.	[a]
SEL-501-2-R700 SEL-501-2-R500 SEL-501-2-R800 SEL-501-2-R600 SEL-501-2-R550	60 Hz, 1 A, ABC Rotation 60 Hz, 5 A, ABC Rotation 50 Hz, 1 A, ABC Rotation 50 Hz, 5 A, ABC Rotation 60 Hz, 5 A, ACB Rotation	➤ Original firmware release.	[a]

[a] Information about changes to earlier versions of the SEL-501-2 Instruction Manual is not available.

Instruction Manual

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

Table A.2 lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table A.2 Instruction Manual Revision History[a] (Sheet 1 of 6)

Date Code	Summary of Revisions
20250116	**Preface** ➤ Updated *General Safety Marks*. **Section 2** ➤ Updated *Clock Battery*. **Appendix G** ➤ Updated *Product Function*, *Secure Operation Recommendations*, *Ports and Services*, *Alarm Contact*, and *Malware Protection Features*.
20230907	**Appendix A** ➤ Updated *Determining the Firmware Version*. ➤ Revised R950 FID. **Appendix G** ➤ Updated *Version Information*.
20221103	**Section 1** ➤ Added UKCA Mark in *Specifications*.
20221013	**General** ➤ Updated communication protocol description terminology to replace slave with server and master with client. **Section 1** ➤ Updated *Metering Functions* and added *Time-Code Input* in *Specifications*. **Appendix G** ➤ Added new appendix.
20220630	**Appendix A** ➤ Added cybersecurity information to *Revision History*. ➤ Updated *Table A.1: Firmware Revision History* for R950, R902, R901, and R900.
20220113	**Appendix B** ➤ Updated *Firmware (EPROM) Upgrade Instructions*.

Table A.2 Instruction Manual Revision History[a] (Sheet 2 of 6)

Date Code	Summary of Revisions
20211203	Section 1 ➤ Updated compliance information in *Specifications*.
20210406	Section 1 ➤ Added *Figure 1.2: SEL-501-2 Relay Front Panel With Front Serial Port.* Section 2 ➤ Added *Figure 2.5: SEL-501-2 Relay With Front Serial Port Fitted With Mounting Bracket (SEL P/N 9100 for Mounting in 19-Inch Rack).* ➤ Added *Figure 2.7: SEL-501-2 Relay Front Panel With Front Serial Port, Rack-Mount Version (Half-Rack Width).* ➤ Added *Figure 2.9: SEL-501-2 Relay Front Panel With Front Serial Port, Panel-Mount Version.* ➤ Added *Figure 2.11: SEL-501-2 Relay Rear Panel For Relay With Front Serial Port (Conventional Terminal Blocks Option).* ➤ Updated *EIA-232 Serial Communications Port Voltage Jumper (EIA-232 Option Only).* ➤ Updated *Output Contact YOUT2 Control Jumper.* SEL-501-2 Relay Settings Sheets ➤ Updated *Protocol Setting (SET P 1) Rear Panel.* ➤ Added *Protocol Setting (SET P F) Front Panel.* Section 7 ➤ Updated *Connections and Protocol.* ➤ Updated description of **SET P** commands to include **SET P 1** and **SET P F**. Appendix A ➤ Updated for firmware version R950. Appendix B ➤ Updated entire appendix for firmware version R950.
20191107	Section 1 ➤ Updated *Specifications*.
20190809	Appendix F ➤ Added *Appendix F: PC Software*.
20170802	Section 1 ➤ Updated compliance information in *Specifications*.
20151105	Section 1 ➤ Updated compliance information in *Specifications.*
20150126	Preface ➤ Added *Safety Information.* Section 1 ➤ Updated compliance information and tightening torque values in *Specifications*.
20111101	Appendix A ➤ Updated for firmware version R902.
20100730	Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Circuit Board Jumpers and Battery*. Section 3 ➤ Updated timing accuracy information in *Overcurrent Elements Specifications*. Section 4 ➤ Added CAL level information. ➤ Added note regarding 50QT element in *Feeder Protection Application Target Definitions*.

Table A.2 Instruction Manual Revision History[a] (Sheet 3 of 6)

Date Code	Summary of Revisions
20071025	**Section 1** ➤ Added 110 Vdc option to *Optoisolated Inputs Ratings* information in *Specifications*.
20050725	**Section 1** ➤ Changed one-second thermal rating from 250 A to 500 A. **Section 2** ➤ Updated *Figure 2.10: Input and Output Jumper Locations (Conventional Terminal Blocks Option Only)*. ➤ Updated *Figure 2.11: Output Contact YOUT2 Control Jumper Location*. ➤ Updated *Table 2.2: Required Position of Jumper JMP13 for Desired Output Contact YOUT2*. **Section 5** ➤ Corrected command **EVENT R *n*** to **EVENT *n* R**. **Appendix B** ➤ Updated *Firmware Upgrade Instructions*. **Appendix E** ➤ Corrected errors in *Table E.18, Modbus Map*.
20050120	**Appendix G** ➤ Corrected Modbus Map under location 00B8 in *Table E.18*.
20031008	**Section 1** ➤ Modified text in *CT Saturation Protection*. **Section 5** ➤ Modified text in *Event Summary*. **Appendix A** ➤ Updated for firmware version R901.
20021025	**Section 1** ➤ Modified *Optoisolated Input Ratings* information in *Specifications*. **Section 2** ➤ Modified text in *Control Voltage Jumpers (Conventional Terminal Blocks Option Only)*.
20021002	**Section 1** ➤ Added information on *CT Saturation Protection*. ➤ Added *Level-Sensitive (Conventional Terminal Blocks Option)* to *General Specifications*. **Section 2** ➤ Inserted new text in *Relay Mounting*. ➤ Replaced the following figures with new hardware drawings: ➢ *Figure 2.1: SEL-501-2 Relay Dimensions and Drill Plan for Single Rack-Mount Relay*. ➢ *Figure 2.2: Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relays Together Using Mounting Block (SEL P/N 9101)*. ➢ *Figure 2.3: Relay Dimensions and Drill Plan for Mounting an SEL-501-2 Relay with Rack Mount Bracket 9100 (bracket on right side in front view)*. ➤ Inserted the following new figures: ➢ *Figure 2.4: SEL-501-2 Relay Fitted with Mounting Bracket (SEL P/N 9100) for Mounting in a 19-Inch Rack*. ➢ *Figure 2.5: SEL-501-2 Relay Front Panel, Rack-Mount Version (Half Rack Width)*. ➢ *Figure 2.6: SEL-501-2 Relay Front Panel, Panel-Mount Version.* ➤ Edited *Figure 2.6 (now 2.9): AC/DC Connections for Overcurrent Protection Applications.* **Section 3** ➤ Added *CT Sizing* information. ➤ Added step size information. ➤ Added transient overreach information to *Overcurrent Element Specifications.* ➤ Updated *Settings Sheets*.

Table A.2 Instruction Manual Revision History[a] (Sheet 4 of 6)

Date Code	Summary of Revisions
	Section 4 ➤ Added Raw Event Report Command. ➤ Updated alarm pulse time information. **Section 5** ➤ Updated *Event Summary* and *Event Reports* to include: *CT Saturation Protection,* Raw Event report information, Stored event report information. **Section 8** ➤ Added **EVENT R *n*** to the command Cross-Reference table. **Appendix A** ➤ Updated for firmware version R900. ➤ Incorporated *Manual Change Information*. **Appendix C** ➤ Removed reference to pulse remote bits in *Fast Operate* configuration block.
20020506	**Section 1** ➤ Updated Tightening Torque information in *General Specifications*. **Section 3** ➤ Added *Application Warning* for CT selection. ➤ Added pickup ranges and resolutions to *Overcurrent Element Specifications*. ➤ Replaced "inverse-time" with "time-overcurrent." **Section 5** ➤ Replaced "inverse-time" with "time-overcurrent."
20010518	➤ Added Caution, Danger, and Warning information to the back of the cover page of the Manual. ➤ Replaced *Standard Product Warranty* page with warranty statement on cover page. ➤ Updated passcode wording with password throughout the manual. **Section 2** ➤ Added caution note to the *Clock Battery* subsection. **Section 3** ➤ Updated 1OUT command execution information. **Section 4** ➤ Added Target 0 and Target 1 information to *Table 4.8: Target Command Table*. **Section 8** ➤ Added 1OUT n and 2OUT n command information to *Command Cross-Reference Table*.
20000501	**Section 1** ➤ Modified Dimensions description in *Specifications*. **Appendix E** ➤ Made technical adjustments.
20000405	**Appendix D** ➤ Reissued *Appendix D* with correct footer information.
20000105	**Section 1** ➤ Added Protocols information to *Specifications*. **Section 2** ➤ Fixed typographical errors. **Section 3** ➤ Added Modbus information to *Settings Sheets*. **Section 4** ➤ Modified *Serial Port Operation* section and *Table 4.1* to add information about Modbus.

Table A.2 Instruction Manual Revision History[a] (Sheet 5 of 6)

Date Code	Summary of Revisions
	Appendix A ➤ Updated for firmware version R506, R525, R556, R575, R606, R625, R706, R725, R756, R775, R806, and R825. **Appendix D** ➤ Added new appendix covering Distributed Port Switch Protocol. **Appendix E** ➤ Added new appendix with information about Modbus.
991117	Reissued entire manual. **Section 1** ➤ Made minor corrections to *General Specifications* section. **Section 2** ➤ Added *Figure 2.3* and renumbered the following figures. ➤ Added *EIA-232 Serial Communications Port Voltage Jumper* and *Output Contact YOUT2 Control Jumper* subsections. **Section 4** ➤ Updated *Table 4.2*. **Section 6** ➤ Added *Relay Self-Tests* subsection. **Appendix B** ➤ Added new *Appendix B* and relettered following appendices.
990528	**Section 2** ➤ Updated *Figure 2.1* and *Figure 2.2*. **Appendix A** ➤ Updated for firmware version R755.
981101	**Section 2** ➤ Updated relay dimension and drill plans. Updated *Figure 2.4* to document new current shorting connectors for Connectorized models. **Section 3** ➤ Corrected *Table 3.1* to document 51QC and 51QTD settings. Added relay settings sheets. **Appendix B** ➤ Corrected Operate Code for *A5E3 Fast Operate Breaker Control* section.
980626	**Section 1** ➤ Removed note to show availability of 250 V "Level-Sensitive" inputs. ➤ Changed 250 Vdc dropout from 200 to 150 Vdc. **Section 2** ➤ Added "10 A for L/R = 20 ms at 250 Vdc" to *Two Rear-Panel Options.* ➤ Removed note to show availability of 250 V "Level Sensitive" inputs from *Circuit Board Jumpers and Battery*. **Section 5** ➤ Moved "Event Type" heading to next page in *Event Summary Data*.
980327	**Section 3** ➤ Added Y option to control settings 50PTC, 50HC, 50QTC, 50NTC, 50NHC, 51PTC, 51QTC, 51NTC. **Appendix A** ➤ Updated for firmware version R705, R505, R805, R605, and R555.
970828	**Section 3** ➤ Added remote bit to relay control functions. **Section 3** ➤ Added RB option to control settings 50PTC, 50HC, 50QTC, 50NTC, 50NHC, 51PTC, 51QTC, 51NTC.

Table A.2 Instruction Manual Revision History[a] (Sheet 6 of 6)

Date Code	Summary of Revisions
	Section 4 ➤ Added **CONTROL** command. ➤ Added RB, CNTR8, CNTR4, CNTR2, CNTR1 to *Target Command Table*. ➤ Added *Change of State Counters*. **Section 5** ➤ Added remote bit to event report IN column. **Appendix B** ➤ Added new appendix.
970725	**Specifications Addendum** ➤ Removed Specifications Addendum and incorporated specifications into *Section 1: Specifications*. **Section 1** ➤ Extensively reformatted and added specifications from the *Specifications Addendum*. ➤ Reformatted the existing type test standards for clarification and added the following to *Type Tests and Standards*: IEC 68-2-1 - 1990 IEC 68-2-2 - 1974 IEC 255-11 - 1979 IEC 255-21-3 - 1993 IEC 255-22-2 - 1996 IEC 255-22-4 - 1992 IEC 695-2-2 - 1991 UL 508 Listing ➤ Added 24 volt power supply ratings to *Output Contacts*, *Optoisolated Input Ratings*, and *Power Supply Ratings*.
970424	➤ Added Specifications Addendum.
970414	**Section 2** ➤ Clarified *Password and Breaker Control Command Jumpers*. **Section 6** ➤ Revised steps to adjust LCD contract in *Troubleshooting Procedure*.

[a] Information about changes to earlier versions of the SEL-501-2 Instruction Manual is not available.

APPENDIX B

Firmware (EPROM) Upgrade Instructions

The hardware of the SEL-501-2 relays that shipped with firmware versions R902 or earlier differs from the hardware of the SEL-501-2 relays that shipped with R950 firmware. Relays with firmware versions R902 or earlier cannot be upgraded to R950 firmware. To upgrade firmware on relays with firmware versions R902 or earlier, contact SEL for assistance.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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APPENDIX C

Configuration, Fast Meter, and Fast Operate Commands

Introduction

SEL relays have two separate data streams that share the same serial port. The human data communications with the relay consist of ASCII character commands and reports that are intelligible to humans using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. The binary commands and ASCII commands can also be accessed by a device that does not interleave the data streams.

The SEL application guide, *Configuration and Fast Meter Messages* (AG95-10) is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-501-2.

Message Lists

Binary Message List

Request to Relay (hex)	Response From Relay
A5C0	Relay Definition Block
A5C1	Fast Meter Configuration Block
A5D1	Fast Meter Data Block
A5C2	Demand Fast Meter Configuration Block
A5D2	Demand Fast Meter Data Message
A5C3	Peak Demand Fast Meter Configuration Block
A5D3	Peak Demand Fast Meter Data Message
A5B9	Fast Meter Status Acknowledge
A5CE	Fast Operate Configuration Block
A5E0	Fast Operate Remote Bit Control
A5E3	Fast Operate Breaker Control

ASCII Configuration Message List

Request to Relay (ASCII)	Response from Relay
ID	ASCII Firmware ID String and Terminal ID Setting (TID)
DNA	ASCII Names of Relay Word bits
BNA	ASCII Names of bits in the A5B9 Status Byte

Message Definitions

A5C0 Relay Definition Block

In response to the A5C0 request, the relay sends the following block:

Data	Description
A5C0	Command
20	Length
02	Support two protocols, SEL and LMD
03	Support three Fast Meter messages
01	Support one status flag command
A5C1	Fast Meter configuration command
A5D1	Fast Meter command
A5C2	Demand Fast Meter configuration command
A5D2	Demand Fast Meter command
A5C3	Peak Demand Fast Meter configuration command
A5D3	Peak Demand Fast Meter command
0004	Settings change bit
444E410D0000	DNA command
0100	SEL protocol, Fast Operate
0101	LMD protocol, Fast Operate
00	Reserved
checksum	1-byte checksum of preceding bytes

A5C1 Fast Meter Configuration Block

In response to the A5C1 request, the relay sends the following block:

Data	Description
A5C1	Fast Meter command
6A	Length
01	One status flag byte
00	Scale factors in Fast Meter message
02	Two scale factors
06	Number of analog input channels

Data	Description
04	Number of samples per channel
09	Number of digital banks (4 for X, 4 for Y, 1 digital I/O)
02	Two calculation blocks
000C	Analog channel offset
003C	Time stamp offset
0044	Digital offset
494158000000	Analog channel name (IAX)
00	Analog channel type (integer)
01	Scale factor type (float)
0004	First scale factor offset in Fast Meter message
494258000000	Analog channel name (IBX)
00	
01	
0004	
494358000000	Analog channel name (ICX)
00	
01	
0004	
494159000000	Analog channel name (IAY)
00	
01	
0008	Second scale factor offset in Fast Meter message
494259000000	Analog channel name (IBY)
00	
01	
0008	
494359000000	Analog channel name (ICY)
00	
01	
0008	
494359000000	Analog channel name (ICY)
00	
01	
0008	
XX	Line Configuration: 00–ABC, 01–ACB
03	Currents only
FFFF	No skew adjustment
FFFF	
FFFF	No compensation
00	Channel index IAX
01	Channel index IBX
02	Channel index ICX

Data	Description
FF	
FF	
FF	
XX	Line configuration: 00–ABC, 01–ACB
03	Currents only
FFFF	No skew adjustment
FFFF	
FFFF	No compensation
03	Channel index IAY
04	Channel index IBY
05	Channel index ICY
FF	
FF	
FF	
00	Reserved for future use
checksum	Checksum (1 byte)

A5D1 Fast Meter Data Block

In response to the A5D1 request the relay sends the following block:

Data	Description
A5D1	Command
4E	Length
1-byte	1 Status Byte
4-bytes	X CTR/Phase current scale factor
4-bytes	Y CTR/Phase current scale factor
48-bytes	The first and third half-cycles of two cycles of data saved by the relay. The data are presented in quarter-cycle sets of integer data in the following order: IAX, IBX, ICX, IAY, IBY, ICY
8-bytes	Time stamp
9-bytes	Relay Word (4 bytes for X, 4 bytes for Y, 1 digital I/O)
checksum	1-byte checksum of all preceding bytes

A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Messages

In response to the A5C2 or A5C3 request, the relay sends the following block:

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
76	Length
00	No status flag byte
00	Scale factors in Fast Meter message
00	No scale factors

Data	Description
0A	Ten analog input channels
01	One sample per channel
00	Zero digital banks
00	No calculation
0004	Analog channel offset
FFFF	No time stamp
FFFF	No digital data
494158000000	Analog channel name (IAX)
02	Analog channel type (double precision float)
FF	Scale factor type (no scale factor)
0000	Scale factor offset in Fast Meter message
494258000000	Analog channel name (IBX)
02	
FF	
0000	
494358000000	Analog channel name (ICX)
02	
FF	
0000	
334932580000	Analog channel name (3I2X)
02	
FF	
0000	
495258000000	Analog channel name (IRX)
02	
FF	
0000	
494159000000	Analog channel name (IAY)
02	
FF	
0000	
494259000000	Analog channel name (IBY)
02	
FF	
0000	
494359000000	Analog channel name (ICY)
02	
FF	
0000	
334932590000	Analog channel name (3I2Y)
02	
FF	

Data	Description
0000	
495259000000	Analog channel name (IRY)
02	
FF	
0000	
00	Reserved for future use
checksum	Checksum (1 byte)

A5D2/A5D3 Demand/Peak Demand Fast Meter Message

In response to the A5D2 or A5D3 request, the relay sends the following block:

Data	Description
A5D2 or A5D3	Command
56	Length
80-bytes	Demand: IAX, IBX, ICX, 312X, IRX, IAY, IBY, ICY, 312Y, IRY in 8-byte IEEE FPS
1-byte	Reserved
1-byte	1-byte checksum of all preceding bytes

A5B9 Fast Meter Status Acknowledge Message

In response to the A5B9 request, the relay clears the Fast Meter (message A5D1) Status Byte. The SEL-501-2 Status Byte contains one active bit, STSET (Bit 4). The bit is set when the relay turns on and on settings changes.

A5CE Fast Operate Configuration Block

In response to the A5CE request, the relay sends the following block:

Data	Description
A5CE	Command
12	Length
02	Support 2 circuit breakers
0002	Support 2 remote bit set/clear commands
0000	No support for remote bit pulse commands
31	Operate code, close 1OUTX
11	Operate code, close 2OUTX
32	Operate code, close 1OUTY
12	Operate code, close 2OUTY
00	Operate code, clear remote bit RBX
20	Operate code, set remote bit RBX
01	Operate code, clear remote bit RBY
21	Operate code, set remote bit RBY

Data	Description
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 Fast Operate Remote Bit Control

The external device sends the following message to perform a remote bit operation:

Data	Description
A5E0	Command
06	Length
1-byte	Operate code: 00–01 clear remote bit RBX–RBY 20–21 set remote bit RBX–RBY
1-byte	Operate validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified remote bit operation if the following conditions are true:

1. The Operate code is valid.
2. The Operate validation = 4 • Operate code + 1.
3. The message checksum is valid.
4. The FASTOP port setting is set to Y.
5. The relay is enabled.

Remote bit set and clear operations are latched by the relay and stored in nonvolatile memory.

A5E3 Fast Operate Breaker Control

The external device sends the following message to perform a fast breaker open/close:

Data	Description
A5E3	Command
06	Length
1-byte	Operate code: 31 or 32 1OUTX or 1OUTY 11 or 12 2OUTX or 2 OUTY
1-byte	Operate Validation: 4 • Operate code + 1
checksum	1-byte checksum of preceding bytes

The relay performs the specified breaker operation if the following conditions are true:

1. Conditions 1–5 defined in the A5E0 message are true.
2. The breaker jumper (JMP24) is in place on the SEL-501-2 main board.

ID Message

In response to the **ID** command, the relay sends the firmware ID, Relay X and Y ID settings, and the Modbus device code, as described in *Figure C.1*.

```
<STX>"FID STRING ENCLOSED IN QUOTES","yyyy"<CR>
"RELAY X ID SETTING ENCLOSED IN QUOTES","yyyy"<CR>
"RELAY Y ID SETTING ENCLOSED IN QUOTES","yyyy"<CR>
"25", "yyyy"<CR>
<ETX>
```

Figure C.1 ID Message

where:

<STX> is the STX character (02)
<ETX> is the ETX character (03)
"yyyy" is the 4-byte ASCII hex representation of the checksum for each line.

The ID message is available from Access Level 1 and higher.

DNA Message

In response to the **DNA** command, the relay sends names of the Relay Word bits transmitted in the A5D1 message. The first name is associated with the MSB, the last name with the LSB. The SEL-501-2 DNA message is described in *Figure C.2*.

```
<STX>
"X","*","XINST","XA","XB","XC","XQ","XN","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"*","Y","YINST","YA","YB","YC","YQ","YN","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"xxx","xxx","xxx","xxx","xxx","xxx","xxx","xxx","yyyy"<CR>
"*","XIN","YIN","ALARM","XOUT1","XOUT2","YOUT1","YOUT2","yyyy"<CR>
<ETX>
```

Figure C.2 DNA Message

where:

<STX> is the STX character (02)
<ETX> is the ETX character (03)
"xxx" is an element name in ASCII (the relay prepends an X to the Relay X names and a Y to the Relay Y names).
"yyyy" is the 4-byte ASCII hex representation of the checksum for the line.
"*" indicates an unused bit location.

The **DNA** command is available from Access Level 1 and higher.

BNA Message

In response to the **BNA** command, the relay sends names of the bits transmitted in the Status Byte in the A5D1 message. The first name is the MSB, the last name is the LSB. The BNA message is described in *Figure C.3*.

```
<STX>"*","*","*","STSET","*","*","*","*","yyyy"<ETX>
```

Figure C.3 BNA Message

where:

"yyyy" is the 4-byte ASCII representation of the checksum.

"*" indicates an unused bit location.

The **BNA** command is available from Access Level 1 and higher.

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APPENDIX D

Distributed Port Switch Protocol

SEL Distributed Port Switch Protocol (LMD) permits multiple SEL relays to share a common communications channel. It is appropriate for low-cost, low-speed port switching applications where updating a real-time database is not a requirement.

Settings

Use the front-panel SET pushbutton, the serial port **SET P F**, or **SET P 1** command to activate the LMD protocol. Change the port PROTOCOL setting from the default SEL to LMD to reveal the following settings:

PREFIX	One character to precede the address. This should be a character that does not occur in the course of other communications with the relay. Valid choices are one of the following: @, #, $, %, &. The default is @
ADDRESS	Two character ASCII address. The range is 01 to 99. The default is 01
SETTLE_TIME	Time in seconds that transmission is delayed after the request to send (RTS line) asserts. The delay accommodates transmitters with a slow rise time.

Operation

NOTE: You can use the front-panel SET pushbutton to change the port settings to return to SEL protocol.

1. The relay ignores all input from this port until it detects the prefix character and the two-byte address.
2. Upon receipt of the prefix and address, the relay enables echo and message transmission.
3. Wait until you receive a prompt before entering commands to avoid losing echoed characters while the external transmitter is warming up.
4. Until the relay connection terminates, you can use the standard commands that are available when PROTOCOL is set to SEL.
5. The **QUIT** command terminates the connection. If no data are sent to the relay before the port time-up period, it automatically terminates the connection.
6. Enter the sequence **<Ctrl+X> <Quit> <Enter>** before entering the prefix character if all relays in the multidrop network do not have the same prefix setting.

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APPENDIX E

Modbus RTU Communications Protocol

Introduction

This appendix describes Modbus RTU communications features supported bythe rear-panel serial communications port of the SEL-501-2.

Complete specifications for the Modbus protocol are available from the Modicon website at www.modicon.com.

Enable Modbus protocol by using the serial port settings. When Modbus protocol is enabled, the relay switches the serial port to Modbus protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single client device and multiple server devices. The communication is half duplex; only one device transmits at a time. The client transmits a binary command that includes the address of the desired server device. All of the server devices receive the message, but only the server device with the matching address responds.

The SEL-501-2 Modbus communication allows a Modbus client device to:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-501-2 output contacts.
- Read the SEL-501-2 self-test status and learn the present condition of all relay protection elements.

Modbus RTU Communications Protocol

Modbus Queries

Modbus RTU client devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table E.1*.

Table E.1 Modbus Query Fields

Field	Number of Bytes
Server Device Address	1 byte
Function Code	1 byte
Data Region	0–251 bytes
Cyclical Redundancy Check (CRC)	2 bytes

The SEL-501-2 SLAVEID setting defines the server device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two server devices may have the same address.

Function codes supported by the SEL-501-2 are described in *Table E.2*.

The CRC detects errors in the received data. If an error is detected, the packet is discarded.

Modbus Responses

The server device sends a response message after it performs the action requested in the query. If the server device cannot execute the command for any reason, it sends an error response. Otherwise, the server device response is formatted similarly to the query including the server address, function code, data (if applicable), and a CRC value.

Supported Modbus Function Codes

The SEL-501-2 supports the Modbus function codes shown in *Table E.2*.

Table E.2 SEL-501-2 Modbus Function Codes

Codes	Description
01h	Read Coil Status
02h	Read Input Status
03h	Read Holding Registers
04h	Read Input Registers
05h	Force Single Coil
06h	Preset Single Register
07h	Read Exception Status
08h	Loopback Diagnostic Command
10h	Preset Multiple Registers
64h	Scattered Register Read

Modbus Exception Responses

The SEL-501-2 sends an exception code under the conditions described in *Table E.3*.

Table E.3 SEL-501-2 Modbus Exception Codes

Exception Code	Error Type	Description
01	Illegal Function Code	The received function code is either undefined or unsupported.
02	Illegal Data Address	The received command contains an unsupported address in the data field.
03	Illegal Data Value	The received command contains a value that is out of range.
04	Device Error	The SEL-501-2 is in the wrong state for the requested function.
06	Busy	The SEL-501-2 is unable to process the command at this time because of a busy resource.

In the event that any of the errors listed in *Table E.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the client that the data field contains an error code, instead of the requested data.

Cyclical Redundancy Check

The SEL-501-2 calculates a two-byte CRC value by using the device address, function code, and data fields. It appends this value to the end of every Modbus response. When the client device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-501-2, the client device uses the data received. If there is not a match, the check fails and the message is ignored. The devices use a similar process when the client sends queries.

01h Read Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils). You may read the status of as many as 2000 bits per query. Note the relay input addresses start at zero (e.g., Coil 1 is located at address zero). The relay returns eight bits per byte, most significant bit first, with zeros padded into incomplete bytes.

Table E.4 01h Read Coil Status Commands

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (01h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (01h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the relay calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the relay adds one more byte to maintain the balance of bits, padded by zeros to make an even byte.

The relay response to errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

Refer to *Table E.9* for coil number assignments.

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (coils). You can read the status of as many as 2000 bits per query. Note the relay input addresses start at zero. The relay returns eight bits per byte, most significant bit first, with zeros padded into incomplete bytes.

Table E.5 02h Read Input Status Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (02h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the relay calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the relay adds one more byte to maintain the balance of bits, padded by zeros to make an even byte.

Input numbers are defined below:

Input Numbers	Description
1	Input X
2	Input Y

Input addresses start at 0000 (i.e., Input 1 is located at Input Address 0000).

The relay response to errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register map shown in *Table E.18*. You may read a maximum of 125 registers at once with this function code. Most clients use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.6 03h Read Holding Register Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Registers Command

Use function code 04h to read from the Modbus Register map shown in *Table E.18*. You can read a maximum of 125 registers at once with this function code.

Table E.7 04h Read Holding Register Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil.

Table E.8 05h Force Single Coil Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16
The command response is identical to the command request	

The SEL-501-2 offers the commands listed in *Table E.9* that you can execute by using function code 05h. The output coils are self-resetting.

Table E.9 SEL-501-2 Command Coils

Coil	Field
1	OUT1X
2	OUT2X
3	RBX
4	OUT1Y
5	OUT2Y
6	RBY
7	ALARM

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal bit (coil) number	Illegal Data Address (02h)	Invalid Address
Illegal bit state desired	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-501-2 uses this function to allow a Modbus client to write directly to a database register. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

Table E.10 06h Preset Single Register Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

07h Read Exception Status Command

The SEL-501-2 uses this function to allow a Modbus client to read the present status of the relay and protected circuit.

Table E.11 07h Read Exception Status Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (07h)
0 bytes	No Data Fields Are Sent
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (07h)
1 byte	Status Byte
2 bytes	CRC-16
The status byte is sent most significant bit first, and consists of the following bits:	
Bit 0	Relay Y OUT2 Status
Bit 1	Relay Y OUT1 Status
Bit 2	Relay X OUT2 Status
Bit 3	Relay X OUT1 Status
Bit 4	Alarm Output Status
Bit 5	Relay Y Input Status
Bit 6	Relay X Input Status
Bit 7	Relay Status

If the bit is set to 1, the following are true:

- ➤ Output and Alarm contacts are asserted.
- ➤ Relay inputs are asserted.
- ➤ Relay is disabled.

If the bit is set to 0, the following are true:

- ➤ Output and Alarm contacts are deasserted.
- ➤ Relay inputs are deasserted.
- ➤ Relay is enabled.

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-501-2 uses this function to allow a Modbus client to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table E.12 08h Loopback Diagnostic Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 bytes	Server Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (Identical to data in client request)
2 bytes	CRC-16

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table E.13 10h Preset Multiple Registers Command

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Numbers of Registers to Write
2 bytes	Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 bytes	Server Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

64h Scattered Register Read

The SEL-501-2 uses this function to allow a Modbus client to read noncontiguous registers in a single request. A maximum of 100 registers can be read in a single query.

Table E.14 64h Scattered Register Read Command (Sheet 1 of 2)

Bytes	Field
Requests from the client must have the following format:	
1 byte	Server Address
1 byte	Function Code (64h)
1 byte	Query Data Length

Table E.14 64h Scattered Register Read Command (Sheet 2 of 2)

Bytes	Field
1 byte	Subfunction Code (04h)
1 byte	Transmission Number
2 bytes	Address of First Register
2 bytes	Address of Second Register
•	•
•	•
•	•
2 bytes	Address of *n*th Register
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	Server Address
1 byte	Function Code (64h)
1 byte	Response Data Length
1 byte	Subfunction Code (04h)[a]
1 byte	Transmission Number
2 bytes	Data from First Register
2 bytes	Data from Second Register
•	•
•	•
•	•
2 bytes	Data from *n*th Register
2 bytes	CRC-16

[a] Only subfunction 04h is supported.

The relay response to the errors in the query are shown below:

Error	Error Code Returned	Communication Counter Increments
Incorrect/Illegal query data length	Illegal Data Value (02h)	Bad Packet Format
Invalid subfunction code	Illegal Data Value (03h)	Illegal Function Code/Op Code
Illegal register address	Illegal Data Address (03h)	Invalid Address

Controlling Output Contacts

The SEL-501-2 Modbus Register Map (*Table E.18*) includes three fields that allow a Modbus client to control relay output contacts. Use Modbus functions codes 06h or 10h to write the appropriate command codes and parameters into the registers shown in *Table E.15*. If function code 06h is used to write to a command code that has parameters, the parameters must be written before the command code.

Table E.15 SEL-501-2 Modbus Command Region

Address	Field
00C0h	Command Code
00C1h	Parameter 1
00C2h	Parameter 2

Table E.16 defines the command codes, their function and associated parameters, and the Modbus function code used to initiate the related command code.

Table E.16 Modbus Command Codes

Command Code	Function	Parameter Definition	Modbus Function Code
01	Pulse OUT1 X	No Parameter	06h, 10h
02	Pulse OUT2 X	No Parameter	06h, 10h
03	Pulse OUT1 Y	No Parameter	06h, 10h
04	Pulse OUT2 Y	No Parameter	06h, 10h
05	Pulse Alarm	No Parameter	06h, 10h
06	Reset Targets	No Parameter	06h, 10h
07	Reset Thermal X	No Parameter	06h, 10h
08	Reset Thermal Y	No Parameter	06h, 10h
09	Trigger	No Parameter	06h, 10h
10	Switch Protocol	0080h	06h, 10h
11[a]	Reset Data Regions	0000 0000 0000 0001 Breaker Monitor X 0000 0000 0000 0010 Breaker Monitor Y 0000 0000 0000 0100 Demand Metering X 0000 0000 0000 1000 Demand Metering Y 0000 0000 0001 0000 Peak Metering X 0000 0000 0010 0000 Peak Metering Y 0000 0000 0100 0000 History Buffer 0000 0000 1000 0000 Communication Counters	06h, 10h

[a] Parameter of Command Code 11 is bit masked to allow you to manipulate several data regions simultaneously.

Remote Bits

Command Code 12 (0C hex)—Control Remote Bits

This code controls the remote bits. This command code has two parameters.

Parameter 1 determines the bit operation.

Value	Operation
1	Set
2	Clear

Parameter 2 determines which bit to control. It is bit masked for future expansion, but only one bit can be controlled at a time. The highest numbered bit will be controlled if more than one bit occurs in the parameter.

Bit Pattern	Remote Bit
0000 0000 0000 0001	RBX
0000 0000 0000 0010	RBY

Error Codes:

- If the relay is disabled while the commands are issued, the relay will return Error Code 04 (device error).
- If the **TRIGGER** command cannot be executed because of multiple events in progress, the relay will return Error Code 06 (device busy).

Reading Event Data Using Modbus

The Modbus Register Map (*Table E.18*) provides a feature that allows you to download complete event data via Modbus. The SEL-501-2 stores the five latest 15-cycle full-length event reports. The latest report is stored in nonvolatile memory while the remaining four reports are stored in volatile memory. Refer to *Section 5: Event Reporting* for more detailed description. If the user selects an event number for which no data are available, the not applicable code will be returned.

The event report will contain both analog and digital data. To download the analog event data by using Modbus, proceed as follows:

Step 1. Write the event number you wish to download at address 00E1h.

Step 2. Write the channel number you wish to download at address 00E2h.

Step 3. Read the four-sample per cycle event data from the Modbus Map.

Table E.17 Assign Event Report Channel Using Address 00E2h

Set 00E2h	To Read Date From Channel
1	IR
2	IA
3	IB
4	IC
5	Relay Element Status Row 1[a]
6	Relay Element Status Row 2[a]
7	Relay Element Status Row 3[a]
8	Relay Element Status Row 4[a]

[a] Refer to Section 4: Operation to obtain the contents of each relay element status row. Relay Element Status Row 0, which represents targets, is displayed at 00DE, 0094, and 0095 in the Modbus Map.

Reading History Data Using Modbus

The Modbus Register Map (*Table E.18*) provides a feature that allows you to download complete history of the last 20 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, and the targets. Refer to *Note 3* of the Modbus Map for a list of event types.

To download the history data by using Modbus, write the event number (1–20) to address 00D1h. Then read the history of the specific event number you requested from the Modbus Map (*Table E.18*).

If the user selects an event number for which there are no data available, the inapplicable code will be returned.

Table E.18 Modbus Map (Sheet 1 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay ID						
0000–0016	FID[a]	ASCII String	–	–	–	–
0017–0019	Revision[a]	ASCII String	–	–	–	–
001A–0022	Relay X ID[a]	ASCII String	–	–	–	–
0023–002B	Relay Y ID[a]	ASCII String	–	–	–	–
002C	Reserved (see *Note 1*)					
002D	Device Tag #[b]	15041	–	–	–	–
002E	Feature Set ID[b]	0	–	–	–	–
002F	Reserved					
Relay Status						
0030	Channel IAX offset value[c]	mV	–5000	5000	1	1
0031	Channel IAX status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0032	Channel IBX offset value[c]	mV	–5000	5000	1	1
0033	Channel IBX status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0034	Channel ICX offset value[c]	mV	–5000	5000	1	1
0035	Channel ICX status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0036	Channel IAY offset value[c]	mV	–5000	5000	1	1
0037	Channel IAY status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0038	Channel IBY offset value[c]	mV	–5000	5000	1	1
0039	Channel IBY status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003A	Channel ICY offset value[c]	mV	–5000	5000	1	1
003B	Channel ICY status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003C	(MOF) DC offset in A/D circuit when a grounded input is selected[c]	mV	–5000	5000	1	1

Table E.18 Modbus Map (Sheet 2 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
003D	MOF status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
003E	+5 V power supply voltage value[b]	V	0	600	1	0.01
003F	+5 V power[b] supply status message 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0040	+5_REG power[b] supply value	V	0	600	1	0.01
0041	+5_REG power supply value[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0042	–5_REG power supply value[c]	V	–600	0	1	0.01
0043	–5_REG power supply value[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0044	+10_ps power supply value[b]	V	0	1500	1	0.01
0045	+10_ps power supply status[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0046	–10_ps power supply value[c]	V	–1500	0	1	0.01
0047	–10_ps status[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0048	VBAT power supply value[b]	V	0	500	1	0.01
0049	VBAT power supply status[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
004A	TEMP in degrees Celsius[c]	°C	–100	100	1	1
004B	Temperature status[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
004C	RAM status[b] 0 = OK 2 = Fail	–	–	–	–	–
004D	ROM status[b] 0 = OK 2 = Fail	–	–	–	–	–

Table E.18 Modbus Map (Sheet 3 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
004E	CD_RAM status[b] 0 = OK 2 = Fail	–	–	–	–	–
004F	EEPROM status[b] 0 = OK 2 = Fail	–	–	–	–	–
0050	Setting status[b] 0 = OK 1 = relay setting is not OK 2 = calibration setting is not OK	–	–	–	–	–
0051	Enable status[b] 0 = relay enabled 2 = relay disabled	–	–	–	–	–
0052–005F	Reserved					
Demand Meter (Relay X)						
0060	Demand current Phase Ax[b]	A	0	65535	1	1
0061	Demand current Phase Bx[b]	A	0	65535	1	1
0662	Demand current Phase Cx[b]	A	0	65535	1	1
0063	Demand current $3I_2x$[b]	A	0	65535	1	1
0064	Demand residual current Irx[b]	A	0	65535	1	1
Peak Demand Meter (Relay X)						
0065	Peak demand current Phase Ax[b]	A	0	65535	1	1
0066	Peak demand current Phase Bx[b]	A	0	65535	1	1
0067	Peak demand current Phase Cx[b]	A	0	66535	1	1
0068	Peak demand current $3I_2x$[b]	A	0	65535	1	1
0069	Peak residual current Irx[b]	A	0	65535	1	1
Instantaneous Metering (Relay X)						
006A	Inst. current Phase Ax[b]	A	0	65535	1	1
006B	Inst. current Phase Bx[b]	A	0	65535	1	1
006C	Inst. current Phase Cx[b]	A	0	65535	1	1
006D	Inst. current Phase 3Ix[b]	A	0	65535	1	1
006E	Inst. residual current Irx[b]	A	0	65535	1	1
Demand Meter (Relay Y)						
006F	Demand current Phase Ay[b]	A	0	65535	1	1
0070	Demand current Phase By[b]	A	0	65535	1	1
0071	Demand current Phase Cy[b]	A	0	65535	1	1
0072	Demand current $3I_2y$[b]	A	0	65535	1	1
0073	Demand current Iry[b]	A	0	65535	1	1
Peak Demand Meter (Relay Y)						
0074	Peak demand current Phase Ay[b]	A	0	65535	1	1
0075	Peak demand current Phase By[b]	A	0	65535	1	1
0076	Peak demand current Phase Cy[b]	A	0	65535	1	1

Table E.18 Modbus Map (Sheet 4 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0077	Peak demand current $3I_2y$[b]	A	0	65535	1	1
0078	Peak demand residual current Iry[b]	A	0	65535	1	1
Instantaneous Metering (Relay Y)						
0079	Inst. current Phase Ay[b]	A	0	65535	1	1
007A	Inst. current Phase Ay[b]	A	0	65535	1	1
007B	Inst. current Phase By[b]	A	0	65535	1	1
007C	Inst. current $3I_2x$[b]	A	0	65535	1	1
007D	Inst. residual current Iry[b]	A	0	65535	1	1
Breaker Monitor (Relay X, see Note 6)						
007E	Number of internal trips[b]	–	0	65535	1	1
007F	Internal IA[b]	KA	0	65535	1	0.1
0080	Internal IB[b]	KA	0	65535	1	0.1
0081	Internal IC[b]	KA	0	65535	1	0.1
0082	Number of external trips[b]	–	0	65535	1	1
0083	External IA[b]	KA	0	65535	1	0.1
0084	External IB[b]	KA	0	65535	1	0.1
0085	External IC[b]	KA	0	65535	1	0.1
Breaker Monitor (Relay Y)						
0086	Number of internal trips[b]	–	0	65535	1	1
0087	Internal IA[b]	KA	0	65535	1	0.1
0088	Internal IA[b]	KA	0	65535	1	0.1
0089	Internal IC[b]	KA	0	65535	1	0.1
008A	Number of external trips[b]	–	0	65535	1	1
08B	External IA[b]	KA	0	65535	1	0.1
008C	External IB[b]	KA	0	65535	1	0.1
008D	External IC[b]	KA	0	65535	1	0.1
Expanded Relay Time and Date						
008E (RW) (see *Note 4*)	Time[b]	ss	0	59	1	1
008F (RW)	[b]	mm	0	59	1	1
0090 (RW)	[b]	hh	0	23	1	1
0091 (RW)	Date[b]	dd	1	31	1	1
0092 (RW)	[b]	mm	1	12	1	1
0093 (RW)	[b]	yyyy	1992	2999	1	1

Table E.18 Modbus Map (Sheet 5 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Targets						
0094	Targets X Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Residual 51N/50N Bit 9 = Negative-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50 Bit 12 = Phase A 51/50 Bit 13 = Instantaneous Bit 14–15 = 0					
0095	Targets Y Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if any of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Residual 51N/50N Bit 9 = Negative-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50 Bit 12 = Phase A 51/50 Bit 13 = Instantaneous Bit 14–15= 0					
0096–009F	Reserved					
Relay Word (X)						
00A0	Row 2 (relay element status) Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = 50NH Bit 9 = 50NT Bit 10 = 50QT Bit 11 = 50H Bit 12 = 50PT Bit 13 = 51NT Bit 14 = 51QT Bit 15 = 51PT					
00A1	Row 3 (relay element status) Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = 0 Bit 9 = 50NP Bit 10 = 50QP Bit 11 = 0 Bit 12 = 50PP Bit 13 = 51NP Bit 14 = 51QP Bit 15 = 51PP					

Table E.18 Modbus Map (Sheet 6 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00A2	Row 4 (relay element status) Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = CNTR1 Bit 9 = CNTR2 Bit 10 = CNTR4 Bit 11 = CNTR8 Bit 12 = RB Bit 13 = 51NR Bit 14 = 51QR Bit 15 = 51PR					
Relay Word (Y)						
00A3	Row 2 Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = 50NH Bit 9 = 50NT Bit 10 = 50QT Bit 11 = 50H Bit 12 = 50PT Bit 13 = 51NT Bit 14 = 51QT Bit 15 = 51PT					
00A4	Row 3 Bit 0 = 1 if any of bits 8–15 are set to 1					
00A5	Row 4 Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = CNTR1 Bit 9 = CNTR2 Bit 10 = CNTR4 Bit 11 = CNTR8 Bit 12 = RB Bit 13 = 51NR Bit 14 = 51QR Bit 15 = 51PR					

Table E.18 Modbus Map (Sheet 7 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Status of Contacts						
00A6	Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = YOUT1 Bit 9 = YOUT2 Bit 10 = XOUT2 Bit 11 = XOUT1 Bit 12 = ALARM Bit 13 = YIN Bit 14 = XIN Bit 15 = 0					
00A7–00BF	Reserved					
Commands						
00C0 (W) (see *Note 7*)	Command Code		1	11		
00C1 (W)	Parameter 1					
00C2 (W)	Parameter 2					
00C2–00CF	Reserved					
History Records						
00D0	Number of History Records[b]		1	20	1	1
00D1 (RW)	History Selection[b]		1	20	1	1
00D2	Event Time[b]	ms	0	999	1	1
00D3	Event Time[b]	ss	0	59	1	1
00D4	[b]	mm	0	59	1	1
00D5	[b]	hh	0	23	1	1
00D6	Event Date[b]	dd	1	31	1	1
00D7	[b]	mm	1	12	1	1
00D8	[b]	yyyy	1992	2999	1	1
00D9	Event Type[a]	ASCII string				
00DA		see *Note 3*				
00DB						
00DC						
00DD						

Table E.18 Modbus Map (Sheet 8 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00DE	Targets Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Inst. Bit 9 = Phase A 51/50 Bit 10 = Phase B 51/50 Bit 11 = Phase C 51/50 Bit 12 = Negative-Sequence Bit 13 = Residual 51N/50N Bit 14 = Relay Y Bit 15 = Relay X					
00DF	Reserved					
Event Reporting (see Note 5)						
00E0	Number event records[b]	–	1	5	1	1
00E1 (RW)	Event selection[b]	–	1	5	1	1
00E2 (RW)	Channel selection[b]	–	1	8	1	1
00E3	1/4 cycle[c]		–32767	32767	1	1
00E4	1/2 cycle[c]		–32767	32767	1	1
00E5	3/4 cycle[c]		–32767	32767	1	1
00E6	1 cycle[c]		–32767	32767	1	1
00E7	1 1/4 cycle[c]		–32767	32767	1	1
00E8	1 1/2 cycle[c]		–32767	32767	1	1
00E9	1 3/4 cycle[c]		–32767	32767	1	1
00EA	2 cycle[c]		–32767	32767	1	1
00EB	2 1/4 cycle[c]		–32767	32767	1	1
00EC	2 1/2 cycle[c]		–32767	32767	1	1
00ED	2 3/4 cycle[c]		–32767	32767	1	1
00EE	3 cycle[c]		–32767	32767	1	1
00EF	3 1/4 cycle[c]		–32767	32767	1	1
00F0	3 1/2 cycle[c]		–32767	32767	1	1
00F1	3 3/4 cycle[c]		–32767	32767	1	1
00F2	4 cycle[c]		–32767	32767	1	1
00F3	4 1/4 cycle[c]		–32767	32767	1	1
00F4	4 1/2 cycle[c]		–32767	32767	1	1
00F5	4 3/4 cycle[c]		–32767	32767	1	1
00F6	5 cycle[c]		–32767	32767	1	1
00F7	5 1/4 cycle[c]		–32767	32767	1	1
00F8	5 1/2 cycle[c]		–32767	32767	1	1
00F8	5 3/4 cycle[c]		–32767	32767	1	1
00FA	6 cycle[c]		–32767	32767	1	1
00FB	6 1/4 cycle[c]		–32767	32767	1	1

Table E.18 Modbus Map (Sheet 9 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00FC	6 1/2 cycle[c]		–32767	32767	1	1
00FD	6 3/4 cycle[c]		–32767	32767	1	1
00FE	7 cycle[c]		–32767	32767	1	1
00FF	7 1/4 cycle[c]		–32767	32767	1	1
0100	7 1/2 cycle[c]		–32767	32767	1	1
0101	7 3/4 cycle[c]		–32767	32767	1	1
0102	8 cycle[c]		–32767	32767	1	1
0103	8 1/4 cycle[c]		–32767	32767	1	1
0104	8 1/2 cycle[c]		–32767	32767	1	1
0105	8 3/4 cycle[c]		–32767	32767	1	1
0106	9 cycle[c]		–32767	32767	1	1
0107	9 1/4 cycle[c]		–32767	32767	1	1
0108	9 1/2 cycle[c]		–32767	32767	1	1
0109	9 3/4 cycle[c]		–32767	32767	1	1
010A	10 cycle[c]		–32767	32767	1	1
010B	10 1/4 cycle[c]		–32767	32767	1	1
010C	10 1/2 cycle[c]		–32767	32767	1	1
010D	10 3/4 cycle[c]		–32767	32767	1	1
010E	11 cycle[c]		–32767	32767	1	1
010F	11 1/4 cycle[c]		–32767	32767	1	1
0110	11 1/2 cycle[c]		–32767	32767	1	1
0111	11 3/4 cycle[c]		–32767	32767	1	1
0112	12 cycle[c]		–32767	32767	1	1
0113	12 1/4 cycle[c]		–32767	32767	1	1
0114	12 1/2 cycle[c]		–32767	32767	1	1
0115	12 3/4 cycle[c]		–32767	32767	1	1
0116	13 cycle[c]		–32767	32767	1	1
0117	13 1/4 cycle[c]		–32767	32767	1	1
0118	13 1/2 cycle[c]		–32767	32767	1	1
0119	13 3/4 cycle[c]		–32767	32767	1	1
011A	14 cycle[c]		–32767	32767	1	1
011B	14 1/4 cycle[c]		–32767	32767	1	1
011C	14 1/2 cycle[c]		–32767	32767	1	1
011D	14 3/4 cycle[c]		–32767	32767	1	1
011E	15 cycle[c]		–32767	32767	1	1
Relay Y						
011F	1/4 cycle[c]		–32767	32767	1	1
0120	1/2 cycle[c]		–32767	32767	1	1
0121	3/4 cycle[c]		–32767	32767	1	1
0122	1 cycle[c]		–32767	32767	1	1

Table E.18 Modbus Map (Sheet 10 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0123	1 1/4 cycle[c]		–32767	32767	1	1
0124	1 1/2 cycle[c]		–32767	32767	1	1
0125	1 3/4 cycle[c]		–32767	32767	1	1
0126	2 cycle[c]		–32767	32767	1	1
0127	2 1/4 cycle[c]		–32767	32767	1	1
0128	2 1/2 cycle[c]		–32767	32767	1	1
0129	2 3/4 cycle[c]		–32767	32767	1	1
012A	3 cycle[c]		–32767	32767	1	1
012B	3 1/4 cycle[c]		–32767	32767	1	1
012C	3 1/2 cycle[c]		–32767	32767	1	1
012D	3 3/4 cycle[c]		–32767	32767	1	1
012E	4 cycle[c]		–32767	32767	1	1
012F	4 1/4 cycle[c]		–32767	32767	1	1
0130	4 1/2 cycle[c]		–32767	32767	1	1
0131	4 3/4 cycle[c]		–32767	32767	1	1
0132	5 cycle[c]		–32767	32767	1	1
0133	5 1/4 cycle[c]		–32767	32767	1	1
0134	5 1/2 cycle[c]		–32767	32767	1	1
0135	5 3/4 cycle[c]		–32767	32767	1	1
0136	6 cycle[c]		–32767	32767	1	1
0137	6 1/4 cycle[c]		–32767	32767	1	1
0138	6 1/2 cycle[c]		–32767	32767	1	1
0139	6 3/4 cycle[c]		–32767	32767	1	1
013A	7 cycle[c]		–32767	32767	1	1
013B	7 1/4 cycle[c]		–32767	32767	1	1
013C	7 1/2 cycle[c]		–32767	32767	1	1
013D	7 3/4 cycle[c]		–32767	32767	1	1
013E	8 cycle[c]		–32767	32767	1	1
013F	8 1/4 cycle[c]		–32767	32767	1	1
0140	8 1/2 cycle[c]		–32767	32767	1	1
0141	8 3/4 cycle[c]		–32767	32767	1	1
0142	9 cycle[c]		–32767	32767	1	1
0143	9 1/4 cycle[c]		–32767	32767	1	1
0144	9 1/2 cycle[c]		–32767	32767	1	1
0145	9 3/4 cycle[c]		–32767	32767	1	1
0146	10 cycle[c]		–32767	32767	1	1
0147	10 1/4 cycle[c]		–32767	32767	1	1
0148	10 1/2 cycle[c]		–32767	32767	1	1
0149	10 3/4 cycle[c]		–32767	32767	1	1
014A	11 cycle[c]		–32767	32767	1	1

Table E.18 Modbus Map (Sheet 11 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
014B	11 1/4 cycle[c]		–32767	32767	1	1
014C	11 1/2 cycle[c]		–32767	32767	1	1
014D	11 3/4 cycle[c]		–32767	32767	1	1
014E	12 cycle[c]		–32767	32767	1	1
014F	12 1/4 cycle[c]		–32767	32767	1	1
0150	12 1/2 cycle[c]		–32767	32767	1	1
0151	12 3/4 cycle[c]		–32767	32767	1	1
0152	13 cycle[c]		–32767	32767	1	1
0153	13 1/4 cycle[c]		–32767	32767	1	1
0154	13 1/2 cycle[c]		–32767	32767	1	1
0155	13 3/4 cycle[c]		–32767	32767	1	1
0156	14 cycle[c]		–32767	32767	1	1
0157	14 1/4 cycle[c]		–32767	32767	1	1
0158	14 1/2 cycle[c]		–32767	32767	1	1
0159	14 3/4 cycle[c]		–32767	32767	1	1
015A	15 cycle[c]		–32767	32767	1	1
Summary Data						
015B	Event type[a]	ASCII string				
015C		See *Note 3*				
015D						
015E						
Date and Time						
015F						
0160	Event time[b]	ms	0	999	1	1
0161	Event time[b]	ss	0	59	1	1
0162	[b]	mm	0	59	1	1
0163	[b]	dd	1	31	1	1
0164	Event date[b]	dd	1	31	1	1
0165	[b]	mm	1	12	1	1
0166	[b]	yyyy	1992	2999	1	1
0167	Duration extent[b] Null = actual fault is equal to the duration listed "+" = fault is probably greater than the duration listed (see *Note 4*)	ASCII string	Null	+	–	–
0168	Duration[b]	Cycles	0	65535	1	0.01
0169	X-Current IA[b]	A	0	65535	1	1
016A	X-Current IB[b]	A	0	65535	1	1
016B	X-Current IC[b]	A	0	65535	1	1
016C	X-Current IQ[b]	A	0	65535	1	1
016D	X-Current IN[b]	A	0	65535	1	1
016E	Y-Current IA[b]	A	0	65535	1	1

Table E.18 Modbus Map (Sheet 12 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
016F	Y-Current IB[b]	A	0	65535	1	1
0170	Y-Current IC[b]	A	0	65535	1	1
0171	Y-Current IQ[b]	A	0	65535	1	1
0172	Y-Current IQ[b]	A	0	65535	1	1
0172	Y-Current IN[b]	A	0	65535	1	1
0173	Targets Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Residual 51N/50N Bit 9 = Negative-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50 Bit 12 = Phase A 51/50 Bit 13 = Instantaneous Bit 14 = Relay Y Bit 15 = Relay X					
0176–017F	Reserved					
Maximum Current Limit						
0174	Relay X[d]	A	–32767	32767	1	1
0175	Relay X[e]	Exponent	–4	4		
0176	Relay Y[d]	A	–32767	32767	1	1
0177	Relay Y[e]	Exponent	–4	4		
0178–017F	Reserved					
Communication Counters						
0180	Number of messages received[b]	–	0	65535	1	1
0181	Number of messages sent to other devices[b]	–	0	65535	1	1
0182	Invalid address[b]	–	0	65535	1	1
0183	Bad CRC[b]	–	0	65535	1	1
0184	UART error[b]	–	0	65535	1	1
0185	Illegal function code/Op code[b]	–	0	65535	1	1
0186	Illegal register[b]	–	0	65535	1	1
0187	Illegal write[b]	–	0	65535	1	1
0188	Back packet format[b]	–	0	65535	1	1
0189	Bad packet length[b]	–	0	65535	1	1
018A	Reserved					
018B–1FFA	Reserved					
1FFB	Device tag #[b]	15041	–	–	–	–

Table E.18 Modbus Map (Sheet 13 of 13)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
1FFC	Feature set ID[b]	0				
1FFD–FFFF	Reserved					

[a] Two 8-bit characters per register.
[b] 16-bit unsigned value.
[c] 16-bit signed value.
[d] Two 16-bit registers need to accomplish the Signed Integer Dynamic Fixed Point data format. Final value read = $(R1 \bullet 10^{R2})$.
[e] R1 is the content of register 0174h (0176h). R2, which is stored in 0175h (0177h), determines the decimal point position for the final value.

Note 1. Reserved addresses return 8000h.

Note 2. Registers (RW) are read-write registers. Registers (W) are write-only registers. All other registers are read-only.

Note 3. Event Types:

TRIG
1OUT
FAULT
2OUT
EXT

Note 4. If the elements are picked up at the beginning or end of the event report, the relay adds a "+" to the duration. This indicates that the actual duration of the fault is probably greater than the figure reported.

Note 5. The Modbus map (*Table E.18*) provides a feature that allows you to download complete event data via Modbus.

The SEL-501-2 stores the latest five event reports. The latest report is stored in nonvolatile memory and survives the loss of voltage to the relay. The remaining four event reports stored in volatile memory are lost upon loss of voltage to the relay.

The event report extraction will be through eight channels. These channels must be assigned as follows:

Ch 1	IRX
Ch 2	IAX
Ch 3	IBX
Ch 4	ICX
Ch 5	RELAY WORDS
Ch 6	RELAY WORDS
Ch 7	RELAY WORDS
Ch 8	RELAY WORDS

Similarly for Relay Y, there would be eight channels. The main intent of the event report extraction is as follows:

At each 1/4 cycle, four current values and four rows of Relay Words association with the applications should be retrievable.

Note 6. External Trip is not applicable.

Note 7. Refer to *Table E.16* for a list of Command Codes.

General Comments

All registers are 16 bits with bit locations ranging from 0 to 15.

Relay Words, targets, and alarm status are mapped in bit Positions 8–15 in the register. The 0 bit position of this register is set equal to 1 if any of the 1–15 positions are set to 1.

APPENDIX F

PC Software

Overview

NOTE: PC software is updated more frequently than relay firmware. As a result, the descriptions in this section may differ slightly from the software. Select **Help** in the PC software for information.

SEL provides many PC software solutions (applications) that support SEL devices. These software solutions are listed in *Table F.1*.

Visit selinc.com to obtain the latest versions of the software listed in *Table F.1*.

Table F.1 SEL Software Solutions

Product Name	Description
SEL Compass	This application provides an interface for web-based notification of product updates and automatic software updating.
ACSELERATOR QuickSet SEL-5030 Software	QuickSet is a powerful setting, event analysis, and measurement tool that aids in applying and using the relay. See *ACSELERATOR QuickSet SEL-5030 Software Instruction Manual* for information about the various QuickSet applications.[a]
ACSELERATOR Architect SEL-5032 Software	Use this application to design and commission SEL IEDs in IEC 61850 substations, create and map GOOSE messages, utilize predefined reports, create and edit data sets, and read in SCD, ICD, and CID files.
ACSELERATOR TEAM SEL-5045 Software	The TEAM system provides custom data collection and movement of a wide variety of device information. The system provides tools for device communication, automatic collection of data, and creation of reports, warnings, and alarms. See *ACSELERATOR Team SEL-5045 Software Instruction Manual* for information about the various TEAM applications.
SEL-5601-2 SYNCHROWAVE Event Software	Converts SEL Compressed ASCII and COMTRADE event report files to oscillography.
Cable Selector SEL-5801 Software	Selects the proper SEL cables for your application.

[a] The SEL-501-2 does not support the freeform logic described in the QuickSet instruction manual.

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APPENDIX G

Cybersecurity Features

Introduction and Security Environment

Product Function

The SEL-501-2 is a protective relay that has two serial communications ports. The serial ports allow you to access three password-protected access levels for the device that provide different capabilities. The communications protocols available on the SEL-501-2 allow the device to periodically communicate information like relay status or metering quantities to other devices such as a SCADA client. The available communications protocols also allow for local engineering access via a terminal connection.

Security Requirements

The SEL-501-2 is designed to be applied in secure environments like substation control houses, switchyards, or similar control facilities. Only permit authorized personnel physical or remote access to the relay. Depending on relay configuration, the SEL-501-2 has one or two serial ports for local or remote access. Restrict communications to the SEL-501-2 to trusted network segments that are isolated from the internet.

Version Information

Obtaining Version Information

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front-panel **STATUS** pushbutton. The status report displays the Firmware Identification (FID) number.

The firmware revision number is after the R, and the date code is after the D. For firmware versions with the date code 20011002 through 20111101, the status report displays the FID number:

FID=SEL-501-2-**Rxxx-Vabxxcxdx-Dxxxxxxxx**

For firmware versions with the date code of 20210406, or later, the status report displays the following FID number:

FID=SEL-501-2-**Rxxx-Vabxxcxdx-Z001001-Dxxxxxxxx**

The version number follows the V as follows:

V[VS] = V[abxxcxdx]

Option	Specifier	Specifier Meaning	Option Description
a	5, 6	50 Hz, 60 Hz	Power System Frequency
b	1, 5	1 A, 5 A	Nominal Amperes per Phase
c	X, 2	No, Yes	Modbus
d	p, n	Positive, Negative	Phase-Sequence of Power System

Appendix A: Firmware and Manual Versions includes the release notes for every firmware version. More firmware version information, including identification of the current version and identification of compatible SELBOOT versions, is available at selinc.com/products/firmware/.

Integrity Indicators

Contact SEL to verify the integrity indicators for the SEL-501-2.

Commissioning and Decommissioning

Commissioning

All serial ports of the SEL-501-2 are enabled by default and cannot be disabled.

Secure Operation Recommendations

The SEL-501-2 provides a physical ALARM output contact that you can use to monitor relay diagnostic failures or access to the relay. If a diagnostic self-test results in the relay disabling protection, the ALARM output contact asserts and provides an external indication of the relay failure. When you log in at Access Level 2 or C, the ALARM output contact pulses for 1 second. If access is denied, the ALARM contact pulses for 1 second.

Good operating practice is to always monitor the physical state of the ALARM output contact.

Decommissioning

It is often desirable to erase settings and data from a relay when it is removed from service. You can completely erase all the settings and data from the SEL-501-2 by using the following procedure:

Step 1. Log in at Access Level 2, and use the **CAL** command to log in to Access Level C.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

Once this procedure is complete, all settings, passwords, and other data are erased; and you can return the relay to inventory, redeploy it, or dispose of it.

Returning Protective Relays for Service

When returning protective relays to SEL for service, preserve the data stored in the relay because it is needed to diagnose many problems.

One option is to leave data in the relay but specify special handling to protect the data. The online return merchandise authorization (RMA) form contains an option for special BES Cyber Asset handling. Ensure that the RMA number generated during the return process appears on the exterior of the shipping container. The shipping method you choose should provide tracking information and delivery confirmation.

If your processes do not permit the relay to be shipped with the settings intact, the other option is to export settings and data from the relay, and then erase the data from the relay as described in *Decommissioning* on page G.2. You can send the data to SEL separately from the relay by coordinating with an SEL application engineer or customer service representative to use SEL's secure file transfer service (securefile.selinc.com). Include the RMA number for the associated product in the file name.

Prior to return shipping of your BES Cyber Asset, SEL follows NIST Special Publication 800-88 Revision 1 guidelines to ensure secure handling and destruction of all customer data before returning the unit. The returned unit will also be packaged by using tamper-evident tape or a similar device. The shipping service will provide tracking information and delivery confirmation.

External Interfaces

Ports and Services

The SEL-501-2 models have one or two serial ports, as described in the following paragraphs. All physical ports of the relay are enabled by default and cannot be disabled. No SEL-501-2 models have an Ethernet interface.

- The SEL-501-2 models with firmware revision R902 and earlier have one rear serial port. The serial port can be either EIA-232 or EIA-485 depending on the ordered option.
- The SEL-501-2 models with firmware revision R950 and later have one front-panel serial port and one rear serial port. The rear serial port can be either EIA-232 or EIA-485 depending on the ordered option. The front-panel serial port is always EIA-232.

The SEL-501-2 provides the following software communications protocols.

Protocol	Description
SEL ASCII Protocol	Designed for manual and automatic communications.
SEL Fast Meter Protocol (see *Appendix C: Configuration, Fast Meter, and Fast Operate Commands*)	Supports binary messages to transfer metering and control messages.
SEL Distributed Port Switch Protocol (see *Appendix D: Distributed Port Switch Protocol*)	Permits multiple SEL relays to share a common communications channel.
Modbus RTU Communications Protocol (see *Appendix E: Modbus RTU Communications Protocol*)	Permits multiple IEDs to share a common communications channel.

Firmware Upgrade Interface

The SEL-501-2 firmware upgrade interface includes a firmware loader program called SELBOOT. To upgrade firmware, use the SELBOOT program to download an SEL-supplied firmware file from a PC to the relay through one of the serial ports. Refer to *Appendix B: Firmware (EPROM) Upgrade Instructions* for more information.

Access Controls

Privilege Levels

The SEL-501-2 has four access levels. Three access levels require separate passwords that allow administrators to restrict access to users authorized for the capabilities those levels provide.

Centrally Managed Accounts

The SEL-501-2 does not support centrally managed accounts.

Local Accounts (or Access Levels)

The SEL-501-2 supports the following four access levels. These access levels cannot be edited.

- **Access Level 0**: The lowest access level that provides limited read-only functions for unauthenticated users.
- **Access Level 1**: Allows you to look at more information such as settings and metering but still read-only.
- **Access Level 2**: Allows you to change relay settings.
- **Access Level C**: Restricted access level for specific maintenance functions, some of which should be used under direction of SEL only.

Passwords

The SEL-501-2 ships with default passwords in place for each access level that you should change at installation. *Table G.1* lists the factory-default passwords for Access Levels 1, 2, and C.

Table G.1 Access Levels and Passwords

Access Level	Factory-Default Password
1	501
2	501
C[a]	332

[a] Use Access Level C only under the direction of SEL

Change the default passwords at installation. Failure to set non-default passwords for all access levels may allow unauthorized access. SEL is not responsible for any damage resulting from unauthorized access.

Passwords may include as many as six characters. Valid characters consist of A–Z, a–z, 0–9, "-", and ".". Upper- and lowercase letters are treated as different characters.

If the passwords are lost or you want to operate the relay without password protection, put the main board password jumper (**JMP22**) in place (password jumper = ON). Refer to *Circuit Board Jumpers and Battery* on page 2.11 for password jumper information.

X.509 Certificates

The SEL-501-2 does not support X.509 certificates.

Physical Access Controls

The SEL-501-2 has no physical access controls.

Logging Features

Security Events

When you log in to the SEL-501-2 at Access Level 2, the ALARM Relay Word bit asserts to logical 1 for 1 second and the ALARM output contact coil is de-energized for 1 second.

The ALARM Relay Word bit can be mapped for SCADA monitoring. The ALARM output contact can be physically monitored to provide a notification of when Access Level 2 is reached.

Internal Log Storage

The SEL-501-2 does not provide security logs to notify users of the storage capacity of the relay or indications that the storage capacity is full. The SEL-501-2 self-manages its memory storage capacity for each of the event recording features by overwriting older entries first when storage is full.

The relay generates (triggers) standard 15-cycle event reports by using fixed and programmable conditions. These reports show information for 15 continuous cycles. The relay stores event summaries for the 20 latest events and full-length reports for the 5 latest events. The most recent event report is stored in nonvolatile memory. If more reports are triggered, the latest event report overwrites the oldest event report.

Syslog

The SEL-501-2 does not support Syslog functionality.

Alarm Contact

When the relay is operational, the ALARM output contact coil is energized. The alarm logic and circuitry keep the ALARM output contact coil energized. Depending on the ALARM output contact type (a or b) the ALARM output contact closes or opens. An a type output contact is open when the output contact coil is de-energized and closed when the output contact coil is energized. A b type output contact is closed when the output contact coil is de-energized and open when the output contact coil is energized.

The ALARM Relay Word bit deasserts to logical 0 when the relay is operational. When you enter Access Level 2, the ALARM Relay Word bit asserts to logical 1 for 1 second (and the ALARM output contact coil is de-energized for 1 second).

The SEL-501-2 operates the ALARM output contact if three consecutive incorrect password attempts are made at any access level.

Backup and Restore

The SEL-501-2 supports the backup and restoration of settings. The Read and Send functions are available in the ACSELERATOR QuickSet SEL-5030 Software. Connect the SEL-501-2 to a PC that has the latest version of QuickSet installed. Once communications are established, read the settings from the SEL-501-2 and save them as a .rdb file. You can open settings files with the .rdb extension and send them back to the SEL-501-2 relays with the same part number and firmware configuration.

Malware Protection Features

The SEL-501-2 is an embedded product that includes the following features to protect against malware:

- **Use of an embedded environment that allows neither installation nor execution of new programs.** SEL embedded devices cannot load or run new programs. These devices also run memory integrity checks to ensure that the running program has not been altered.
- **Verification of software stored in permanent memory.** When the device starts, it performs a detailed checksum of the contents of permanent memory and verifies the checksum value to verify integrity.
- **Firmware hashes.** SEL provides firmware hashes as a tool to verify the integrity of SEL-501-2 firmware files prior to installation. Visit selinc.com/products/firmware to perform firmware file hash verification.

For questions or concerns about the malware protection features of a specific firmware revision, contact SEL.

Product Updates

The most recent instruction manual release is available on selinc.com for download. *Appendix A: Firmware and Manual Versions* contains the latest product updates.

The *Appendix A: Firmware and Manual Versions* entries for firmware versions released after March 1, 2022, adds the [Cybersecurity] tag to each firmware change that is related to a security vulnerability and [Cybersecurity Enhancement] to other cybersecurity improvements.

Obtain information regarding security vulnerabilities at selinc.com/security_vulnerabilities/.

Obtaining Updates

Contact your local SEL customer service representative for firmware updates for the SEL-501-2.

Update Verification

Contact SEL to verify the integrity indicators for the SEL-501-2.

Contact SEL

For further questions or concerns about SEL product security, contact SEL.

Email: security@selinc.com

Phone: +1 (509) 332-1890

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SEL-501-2 Relay Command Summary

Access Level	Serial Port Command	Front-Panel Operations	Command Description
0	**ACCESS**	--	Move to Access Level 1.
1	**2ACCESS**	--	Move to Access Level 2.
1	**BREAKER**	**MAINT** > *n* > Breaker	View trip counters and trip current data (*n* = X, Y).
1	**DATE** **DATE** *mm/dd/yy*	**MAINT** > Date	View or change relay calendar date.
1	**EVENT** *n*	--	View event report (*n* = 1–5).
1	**EVENT R** *n*	--	View raw (unfiltered) event report (*n* = 1–5).
1	**HISTORY**	**EVENTS**	View latest event summaries.
1	**HISTORY C**	--	Clear event history.
1	**METER** **METER D** **METER P**	**METER** > *n* > Display	View instantaneous, demand (D), and peak demand (P) currents.
1	**METER RD** *n* **METER RP** *n*	**METER** > *n* > Reset	Reset demand (RD) and peak demand (RP) values (*n* = X, Y).
1	**SHOW** *n*	**SET** > *n* > Show	View relay settings (*n* = X, Y, Port).
1	**STATUS**	**STATUS**	View relay self-test status.
1	**TARGET** *n* **#**	**MAINT** > *n* > Tar	View relay element, input, output, status (*n* = X, Y, # = 0–4).
1	**TARGET R**	**TARGET RESET**	Reset tripping elements.
1	**TIME** **TIME** *hh*:*mm*:*ss*	**MAINT** > Time	View or change time.
1	**TRIGGER**	--	Trigger a relay event report.
1	**QUIT**	--	Move to Access Level 0.
1	**VER**	--	View relay configuration and firmware version.
2	**BREAKER** *n* **R**	**MAINT** > *n* > Breaker	Reset trip counters and trip current data (*n* = X, Y).
2	**CALIBRATION**	--	Move to Access Level C.
2	**CON** ***n***	--	Control remote bit (*n* = X, Y).
2	**1OUT** *n*	**CNTRL** > *n* > 1OUT	Closes Output *n*OUT1 (*n* = X, Y).
2	**2OUT** *n*	**CNTRL** > *n* > 2OUT	Closes Output *n*OUT2 (*n* = X, Y).
2	**PAS** **PAS** *l* **######**	**SET** > **PAS**	View or change password (*l* = 1, 2, C, ###### = new password. Entering DISABLE as the password disables the password requirement for the specified access level).
2	**RESET** *n*	**MAINT** > *n* > EL	Reset time-overcurrent elements (*n* = X, Y).
2	**SET X** **SET Y** **SET P F** **SET P 1**	**SET** > X > Set **SET** > Y > Set **SET** > Port > Set	View or change relay or serial port protocol settings.

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SEL-501-2 Relay Command Summary

Access Level	Serial Port Command	Front-Panel Operations	Command Description
0	**ACCESS**	--	Move to Access Level 1.
1	**2ACCESS**	--	Move to Access Level 2.
1	**BREAKER**	**MAINT** > *n* > Breaker	View trip counters and trip current data (*n* = X, Y).
1	**DATE** **DATE** *mm/dd/yy*	**MAINT** > Date	View or change relay calendar date.
1	**EVENT** *n*	--	View event report (*n* = 1–5).
1	**EVENT R** *n*	--	View raw (unfiltered) event report (*n* = 1–5).
1	**HISTORY**	**EVENTS**	View latest event summaries.
1	**HISTORY C**	--	Clear event history.
1	**METER** **METER D** **METER P**	**METER** > *n* > Display	View instantaneous, demand (D), and peak demand (P) currents.
1	**METER RD** *n* **METER RP** *n*	**METER** > *n* > Reset	Reset demand (RD) and peak demand (RP) values (*n* = X, Y).
1	**SHOW** *n*	**SET** > *n* > Show	View relay settings (*n* = X, Y, Port).
1	**STATUS**	**STATUS**	View relay self-test status.
1	**TARGET** *n* **#**	**MAINT** > *n* > Tar	View relay element, input, output, status (*n* = X, Y, # = 0–4).
1	**TARGET R**	**TARGET RESET**	Reset tripping elements.
1	**TIME** **TIME** *hh*:*mm*:*ss*	**MAINT** > Time	View or change time.
1	**TRIGGER**	--	Trigger a relay event report.
1	**QUIT**	--	Move to Access Level 0.
1	**VER**	--	View relay configuration and firmware version.
2	**BREAKER** *n* **R**	**MAINT** > *n* > Breaker	Reset trip counters and trip current data (*n* = X, Y).
2	**CALIBRATION**	--	Move to Access Level C.
2	**CON** ***n***	--	Control remote bit (*n* = X, Y).
2	**1OUT** *n*	**CNTRL** > *n* > 1OUT	Closes Output *n*OUT1 (*n* = X, Y).
2	**2OUT** *n*	**CNTRL** > *n* > 2OUT	Closes Output *n*OUT2 (*n* = X, Y).
2	**PAS** **PAS** *l* **######**	**SET** > **PAS**	View or change password (*l* = 1, 2, C, ###### = new password. Entering DISABLE as the password disables the password requirement for the specified access level).
2	**RESET** *n*	**MAINT** > *n* > EL	Reset time-overcurrent elements (*n* = X, Y).
2	**SET X** **SET Y** **SET P F** **SET P 1**	**SET** > X > Set **SET** > Y > Set **SET** > Port > Set	View or change relay or serial port protocol settings.

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