SEL-501/SEL-501-1

Dual Universal Overcurrent Relay

Instruction Manual

20250131

SEL SCHWEITZER ENGINEERING LABORATORIES

PM501-01

Table of Contents

Appendix G: Modbus RTU Communications Protocol

Appendix H: PC Software

Appendix I: Cybersecurity Features

This page intentionally left blank

List of Tables

List of Figures

This page intentionally left blank

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 Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	**⚠ATTENTION** Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION 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.

General Information

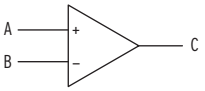
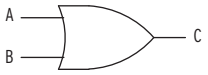
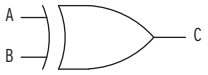
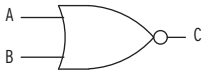
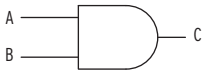
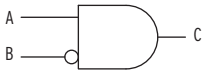
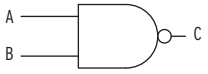
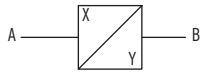
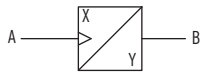
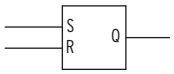
Typographic Conventions

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

Example	Description
STATUS	Commands, command options, and command variables typed at a command line interface on a PC.
n **SUM *n***	Variables determined based on an application (in bold if part of a command).
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC software dialog boxes and menu selections. The > character indicates submenus.
ENABLE	Relay front- or rear-panel labels and pushbutttons.

Logic Diagrams

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

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

Trademarks

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

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

acSELerator Architect®	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

This page intentionally left blank

SECTION 1

Introduction

Overview

The SEL-501 provides two complete and independent groups of protection functions in one compact unit. The SEL-501-1 is identical to the SEL-501 with the exception of the additional SY/MAX protocol (SY/MAX protocol is described in *Appendix F: SY/MAX Protocol* and the SEL-501-1 does not have CT Saturation Protection. The unit contains Relay X and Relay Y, each having two output contacts, one optoisolated input, and three-phase current inputs. Each relay provides overcurrent, motor, or breaker failure protection. You select the application and settings for each relay independently.

The dual-relay hardware 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 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*.

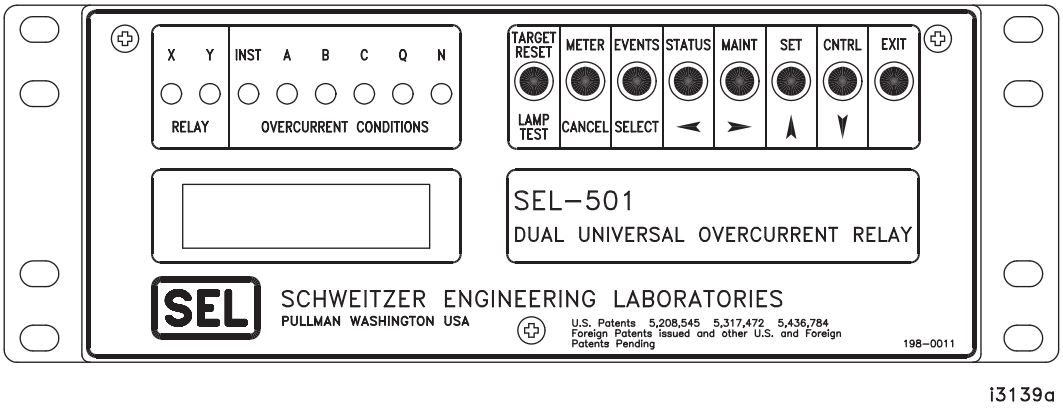


Figure 1.1 Front Panel Without Front Serial Port

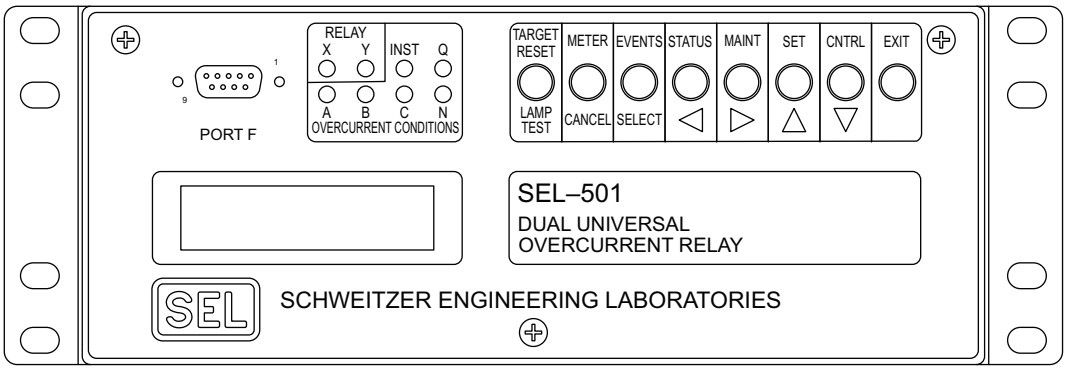


Figure 1.2 Front Panel With Front Serial Port

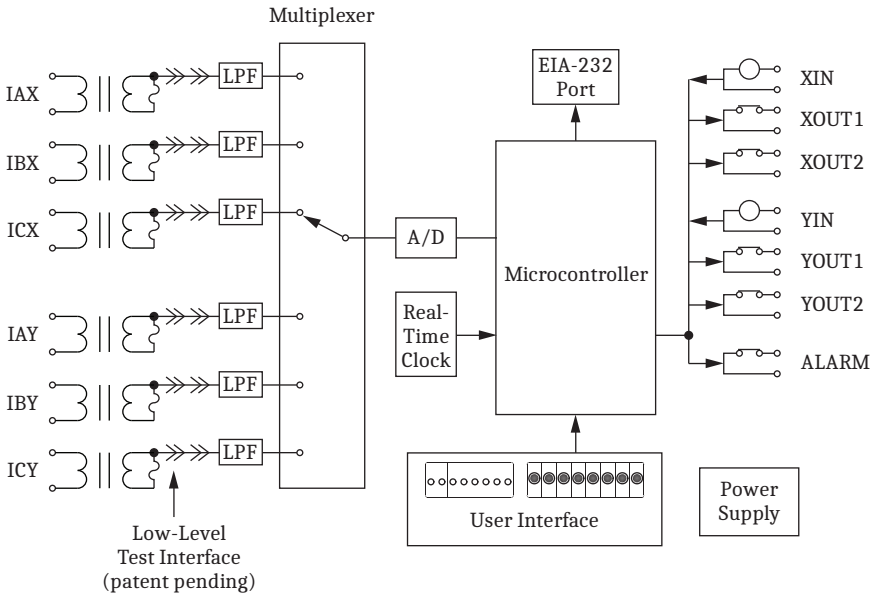


Figure 1.3 Dual-Relay Hardware Block Diagram

SEL-501 Dual-Relay Applications

Table 1.1 Example SEL-501 Dual-Relay Applications (Sheet 1 of 2)

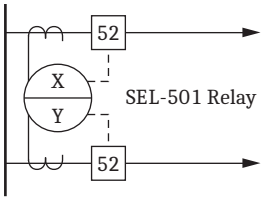
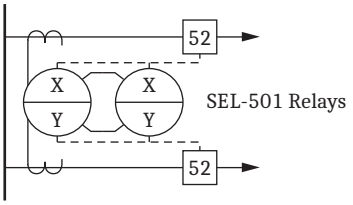
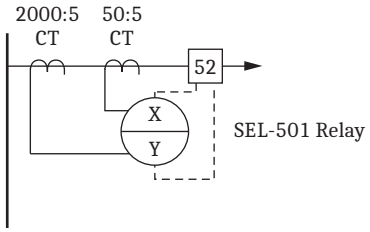
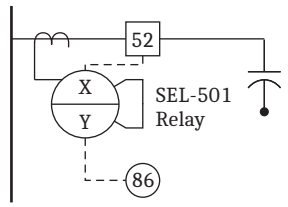
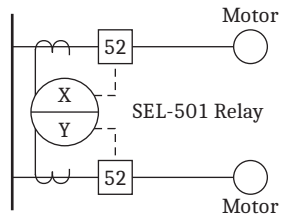
Protect Two Feeders		➤ Complete overcurrent and simple breaker failure protection for two feeders. ➤ Settable time-delay on trip output contact provides simple breaker failure protection. ➤ Low cost, compact protection.
Two Relays + Two Feeders = Full Redundancy		➤ Ideal for two-high switchgear. ➤ Front-panel control eliminates the need for manual control switches. ➤ Includes negative-sequence overcurrent protection for sensitive, fast phase-to-phase fault coverage.

Table 1.1 Example SEL-501 Dual-Relay Applications (Sheet 2 of 2)

Cover a Wide Range of Fault Currents		➤ 2000:5 CT covers faults as high as 32,000 amperes (5 A Model). ➤ 50:5 CT meters load accurately, and covers faults as low as 5 amperes primary (5 A Model).
Capacitor, Reactor, and Breaker Failure Protection		➤ Protects capacitors, reactors, and bus sections. ➤ Provides breaker failure protection
Protect Two Motors		➤ Complete protection for two motors. ➤ Ideal for compact motor control centers. ➤ Stop and start motors from relay front panel.

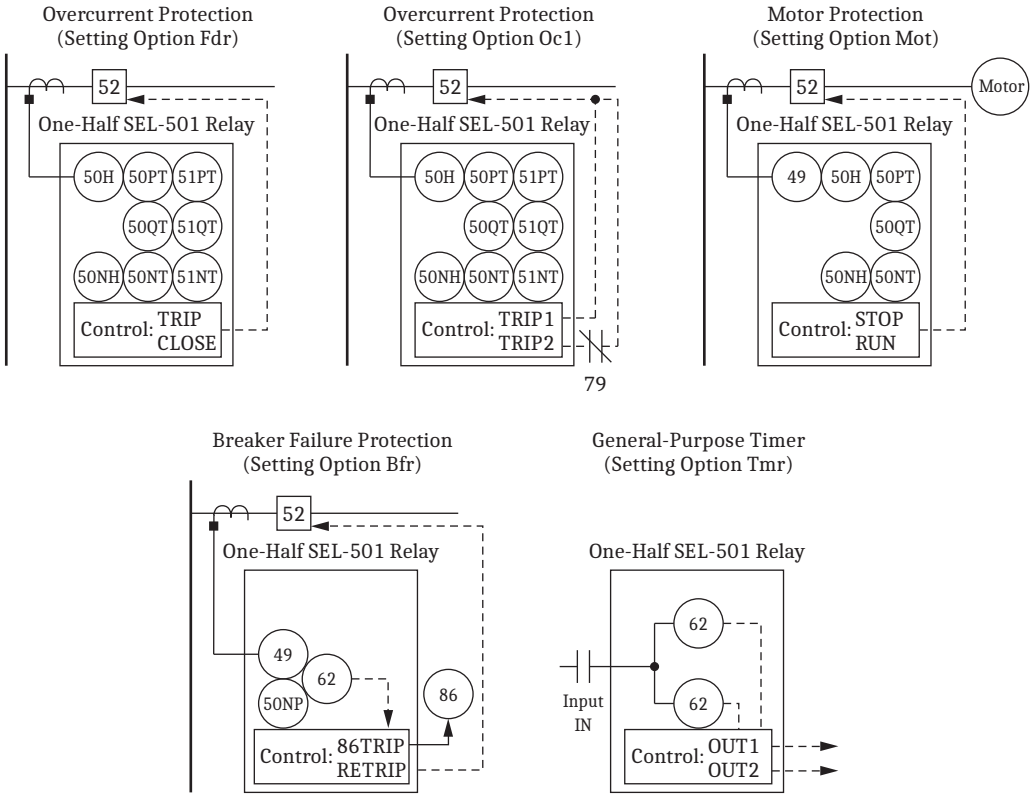


Figure 1.4 Relay Application Single-Line Diagrams

CT Saturation Protection in the SEL-501 (Not Included in the SEL-501-1)

The SEL-501 phase instantaneous overcurrent elements normally operate 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 U.S. 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[IEC 255-11]: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 Block 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
Update Rate:	1/8 cycle

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; Breaking and Cyclic Capacity per IEC 60255-23 [IEC 255-23]:1994.

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.

Jumper-Selectable (Conventional Terminal Blocks Option)
The conventional terminal block model is equipped with jumper-selectable inputs. 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	150–330 Vdc

Level-Sensitive (Conventional Terminal Blocks Option)
Both inputs can be individually user-configured to operate on any of the following nominal voltages:

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

Level-Sensitive (Plug-In Connectors Option)
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. Note that the 24 Vdc option is not available as "level-sensitive."

24 Vdc: on for	15–30 Vdc
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 192000; only available in SEL-501) SY/MAX (only available in SEL-501-1)

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 Test

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 inputs.

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

SECTION 2

Mounting and Connections

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

Relay Mounting

Rack Mount

The single SEL-501 is roughly half the size of a standard 19-inch rack (see *Figure 2.1*, *Figure 2.2*, and *Figure 2.3*). To mount the relay in a standard 19-inch rack, use another SEL-500 series relay in a package (P/N 9101) or use the Rack-Mount Bracket (P/N 9100). See *Figure 2.4* and *Figure 2.6*. 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 66.1 mm (2.60 in). 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 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 66.1 mm (2.60 in) 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.

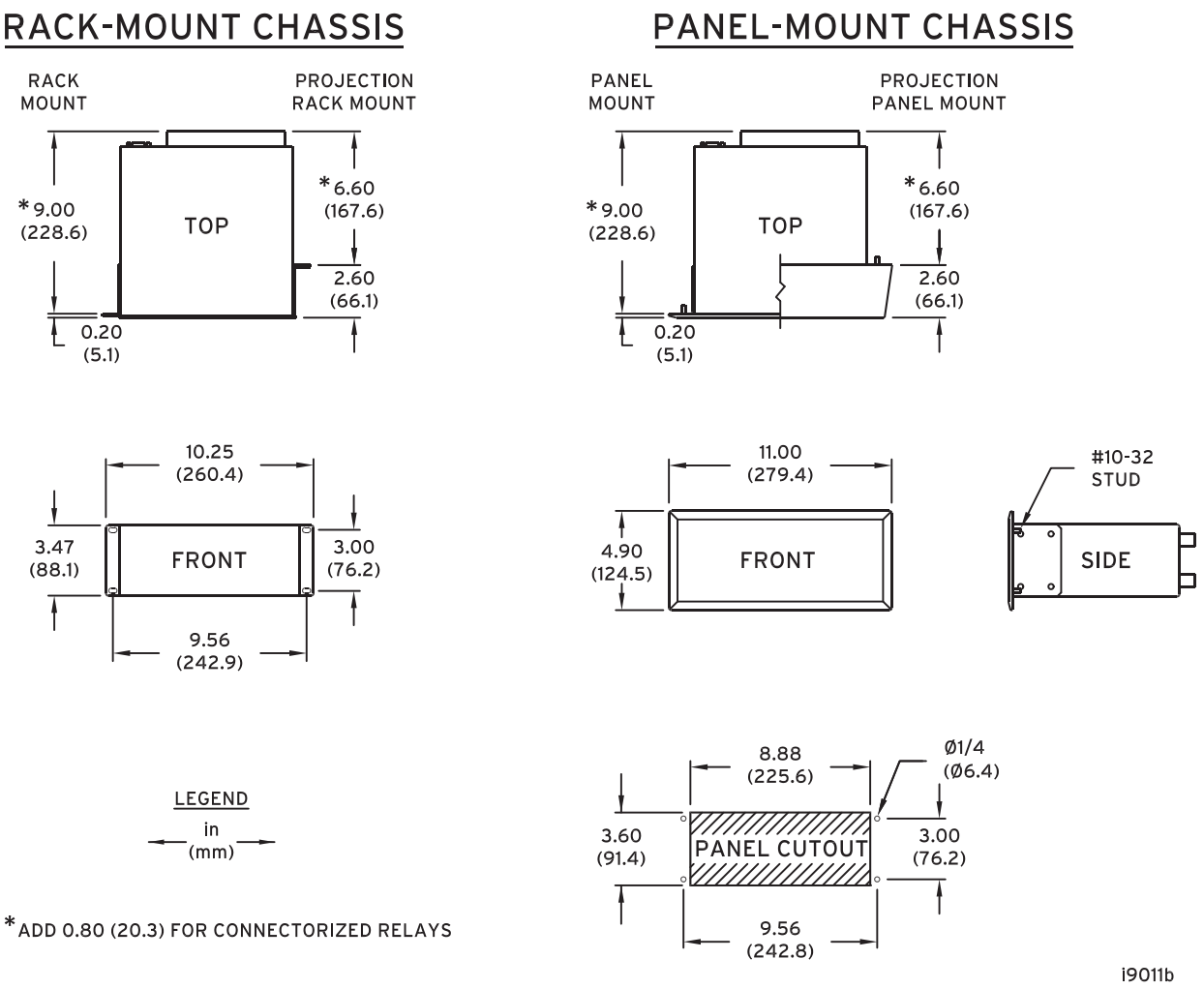


Figure 2.1 SEL-501 Dimensions and Drill Plan for Single Rack-Mount Relay

RACK-MOUNT CHASSIS

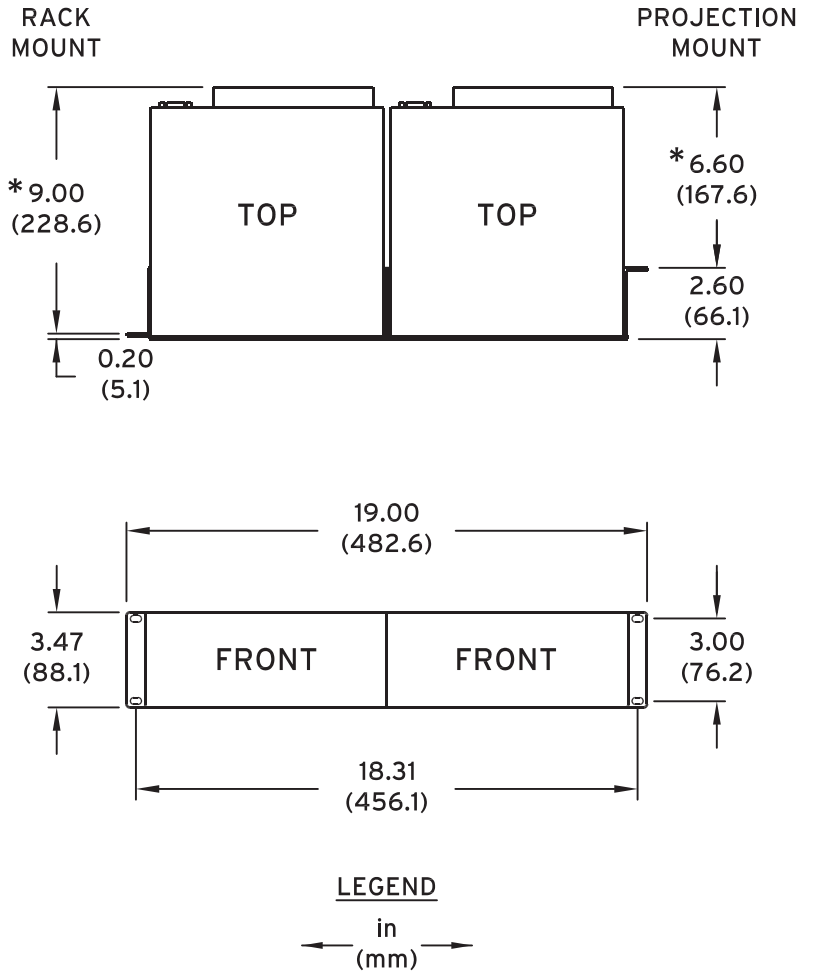


Figure 2.2 Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relays Together Using Mounting Block (SEL P/N 9101)

RACK-MOUNT CHASSIS

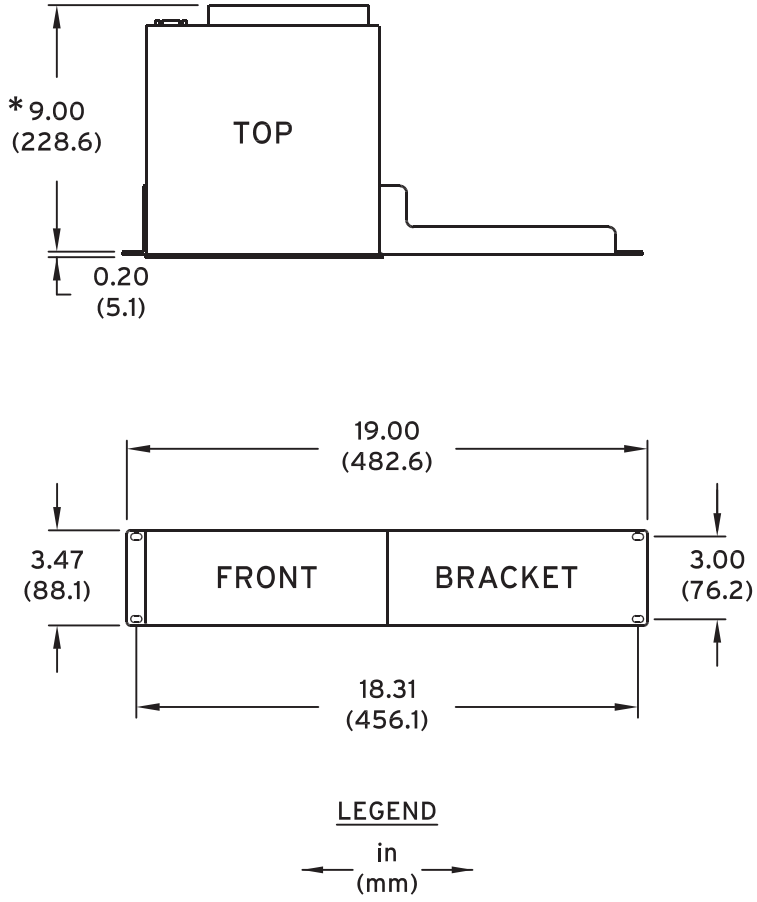


Figure 2.3 Relay Dimensions and Drill Plan for Mounting an SEL-501 With Rack Mount Bracket 9100 (Bracket on Right Side Front View)

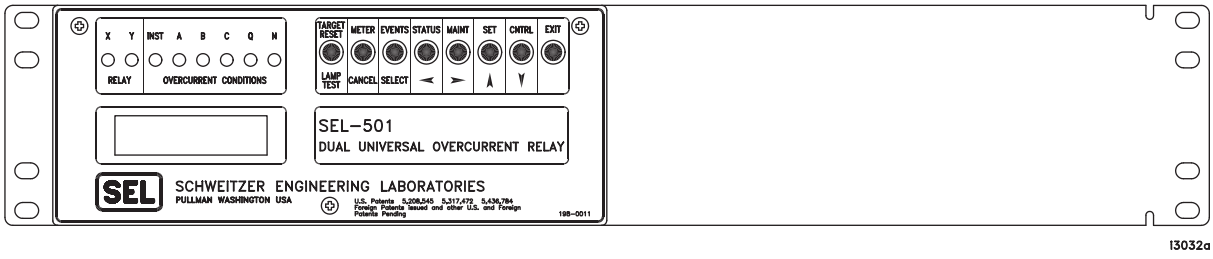


Figure 2.4 SEL-501 Without Front Serial Port Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

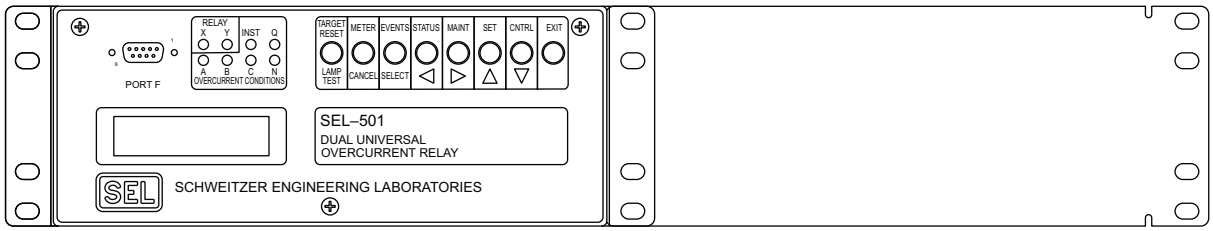


Figure 2.5 SEL-501 With Front Serial Port Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

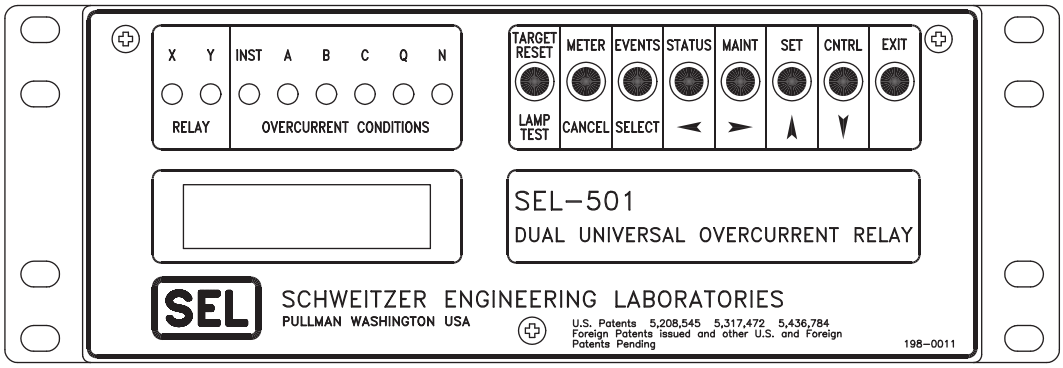


Figure 2.6 SEL-501 Front Panel Without Front Serial Port, Rack-Mount Version (Half-Rack Width)

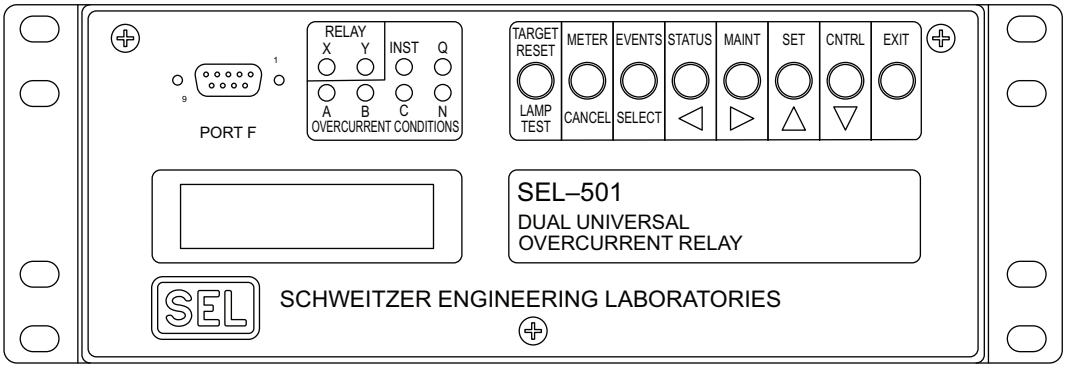


Figure 2.7 SEL-501 Front Panel With Front Serial Port, Rack-Mount Version (Half-Rack Width)

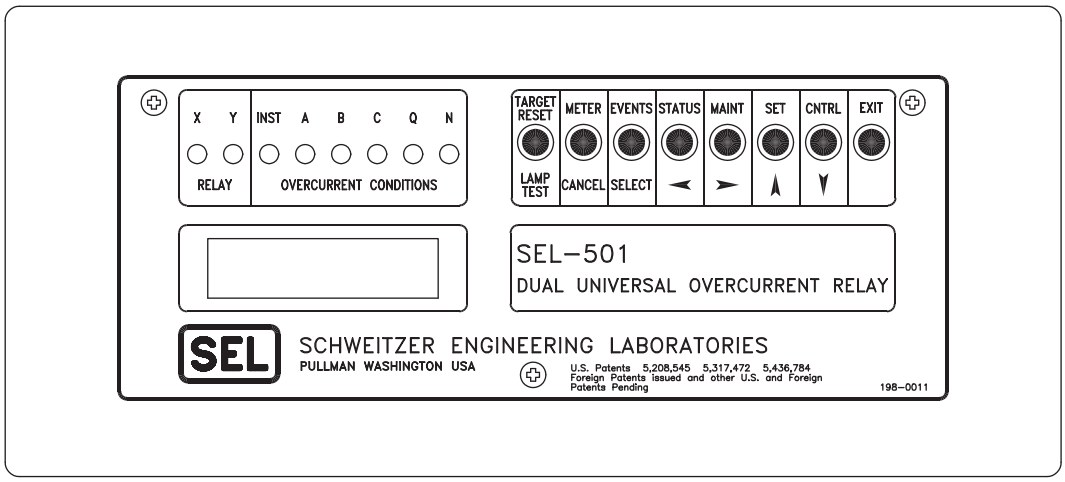


Figure 2.8 SEL-501 Front Panel Without Front Serial Port, Panel-Mount Version

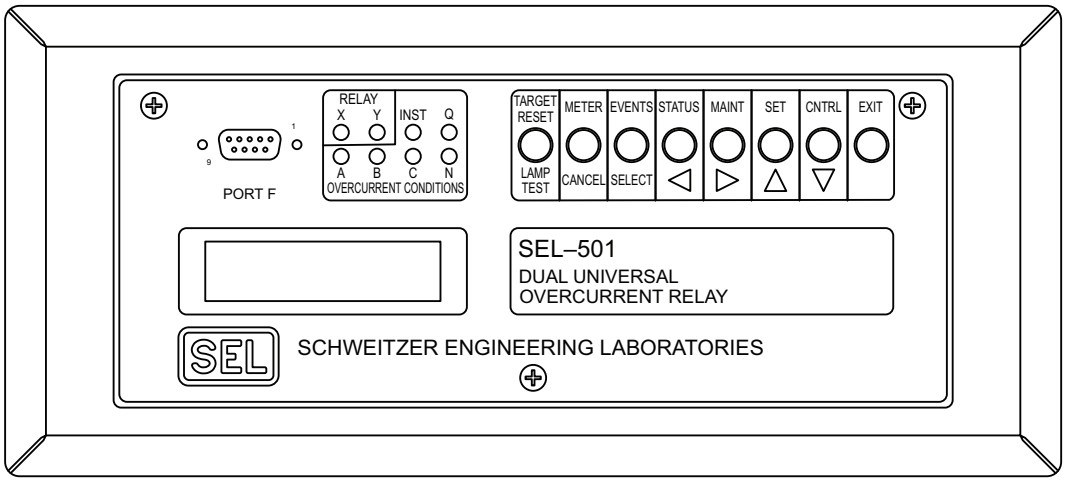


Figure 2.9 SEL-501 Front Panel With Front Serial Port, Panel-Mount Version

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 ensure that they conform to our standards for protective relay applications.

Terminal Block

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

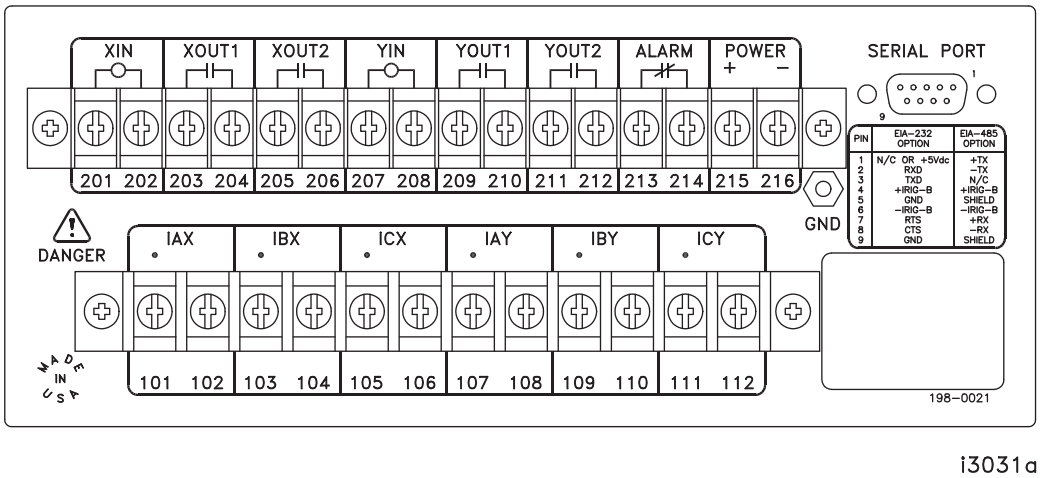


Figure 2.10 SEL-501 Rear Panel for Relay Without Front Serial Port (Conventional Terminal Blocks Option)

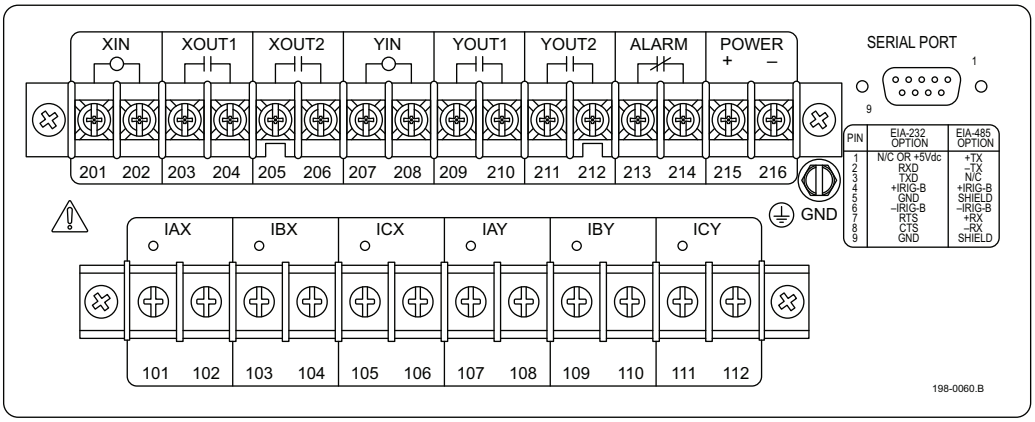


Figure 2.11 SEL-501 Rear Panel for Relay With Front Serial Port (Conventional Terminal Blocks Option)

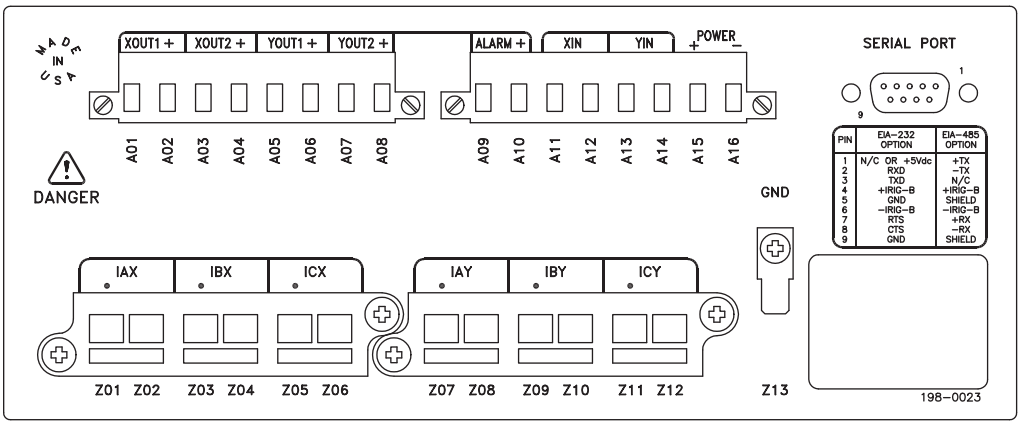
Output contacts **XOUT1**, **XOUT2**, **YOUT1**, **YOUT2**, and **ALARM** are not polarity-dependent.

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



i3034a

Figure 2.12 SEL-501 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

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

IMPORTANT: Improvements in Connectorized SEL-501/SEL-501-1 relays (plug-in connectors) result in part number changes.

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/SEL-501-1 relays with this improved connector have a new part number (partial part numbers shown):

OLD	NEW
0501xJ	0501xW

The respective wiring harness part numbers for these old and new Connectorized SEL-501/SEL-501-1 relays are (partial part numbers shown):

OLD	NEW
WA0501xJ	WA0501xW

The other connectors on the Connectorized SEL-501/SEL-501-1 rear panel (power input, output contacts, etc.) are the same for the old or new models. Only the current transformer shorting connectors have changed.

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

AC/DC Connection Diagrams

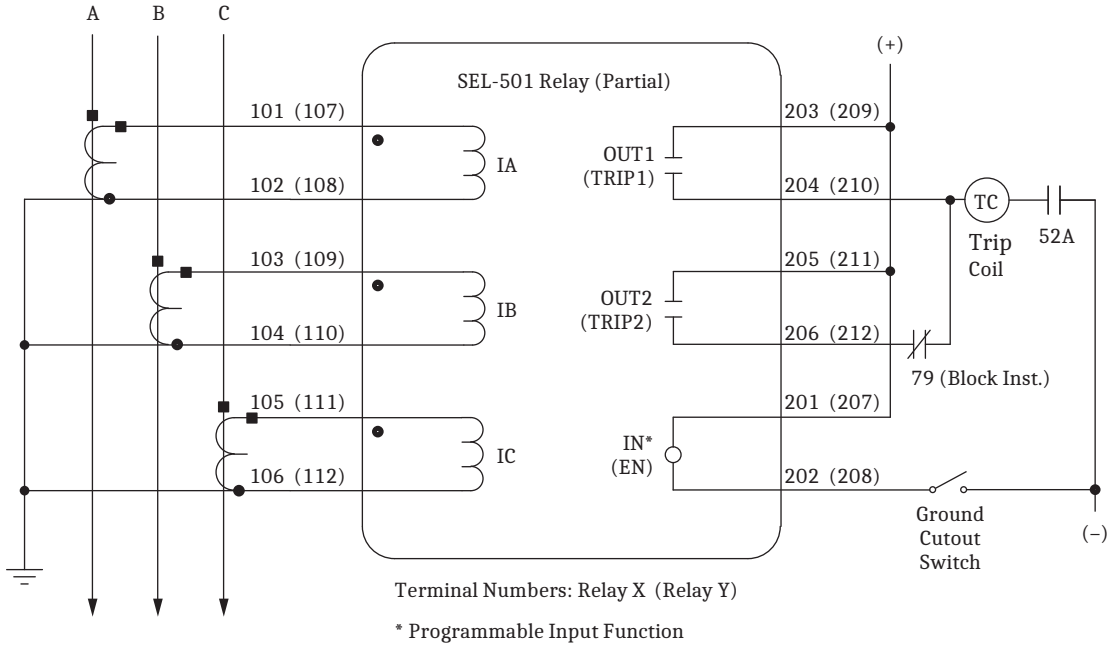


Figure 2.13 AC/DC Connections for Overcurrent Protection Applications (Feeder Application With External Reclosing Relay Shown; Setting APP = OC1)

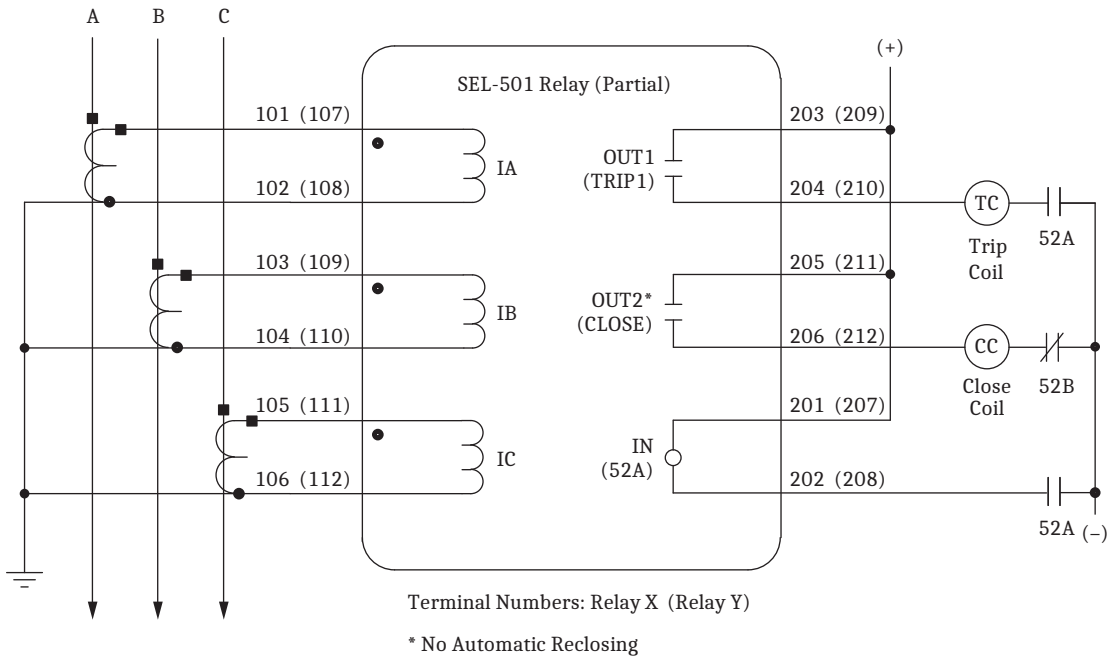


Figure 2.14 AC/DC Connections for Overcurrent or Motor Protection Applications (Setting APP = FDR or APP = MTR)

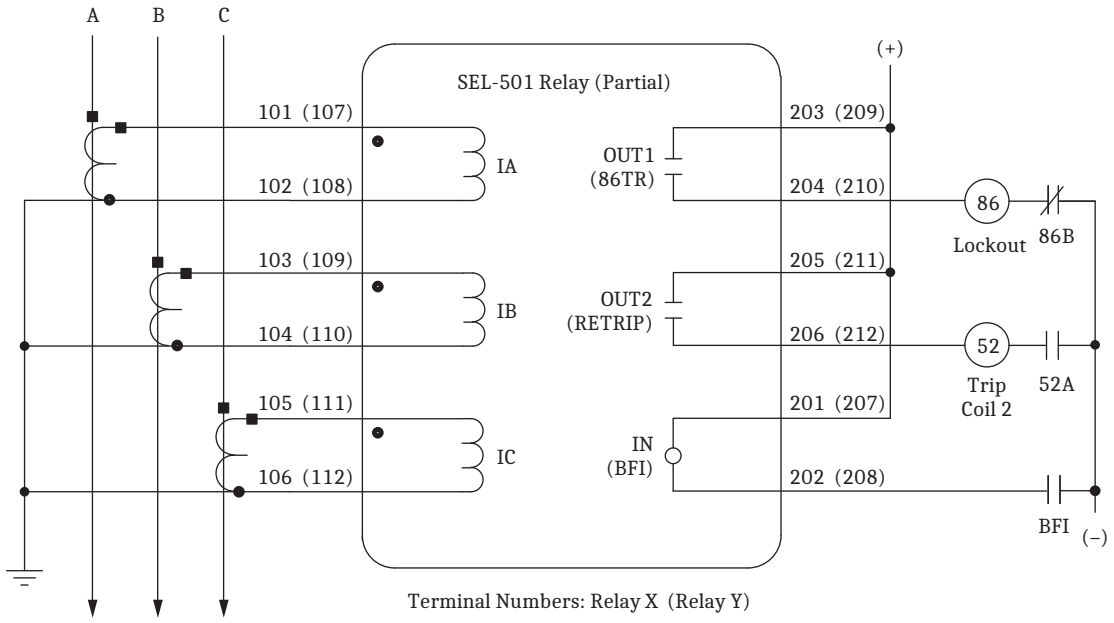


Figure 2.15 AC/DC Connections for Breaker Failure Protection Applications (Setting APP = BFR)

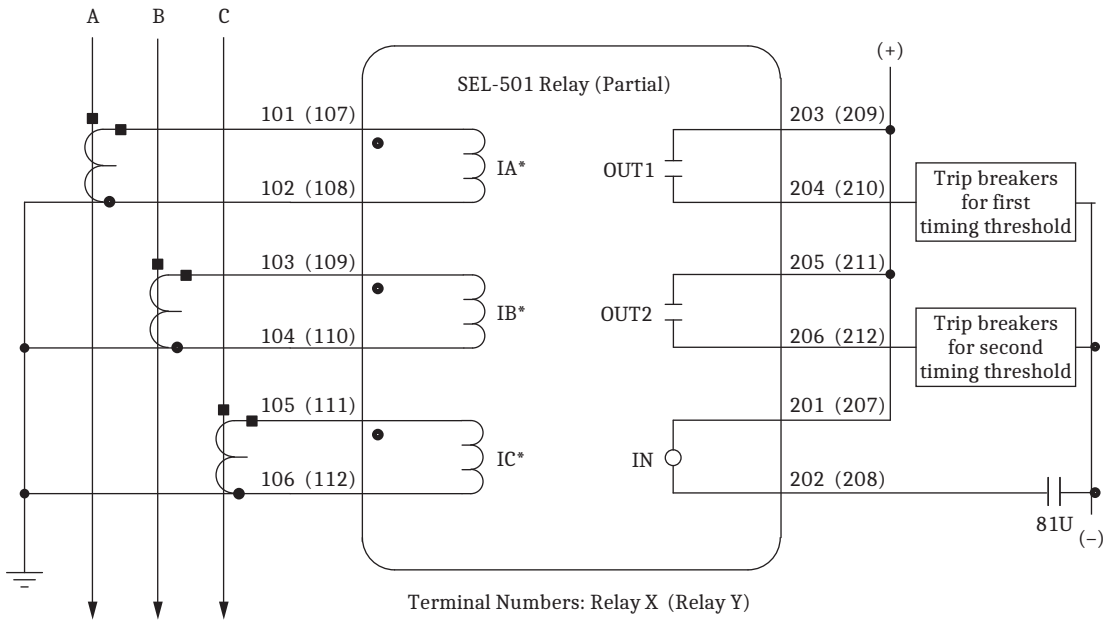


Figure 2.16 AC/DC Connections for General-Purpose Timer Applications (Underfrequency Load-Shedding Timing Application Shown; Setting APP = TMR)

Circuit Board Jumpers and Battery

Control Voltage Jumpers (Conventional Terminal Blocks Option Only)

⚠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.

The SEL-501/SEL-501-1 relays equipped with conventional terminal blocks can be ordered with either jumper-selectable voltage optoisolated inputs or level-sensitive optoisolated inputs. Level-sensitive inputs are not jumper-selectable. See *Specifications on page 1.5* for ratings.

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

To change the control input voltage range using 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 draw out 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 2.17*.

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.

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.

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)

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.

Refer to *Figure 2.17*. 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.

In *Figure 2.17*, 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 **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 **JMP24** (right-most jumper) in place to enable the output contact control commands (**OPEN**, **CLOSE**, **STOP**, **RUN**, **86TRIP**, **RETRIP**, **1OUT**, and **2OUT**). Any breaker control command is ignored while the jumper is removed.

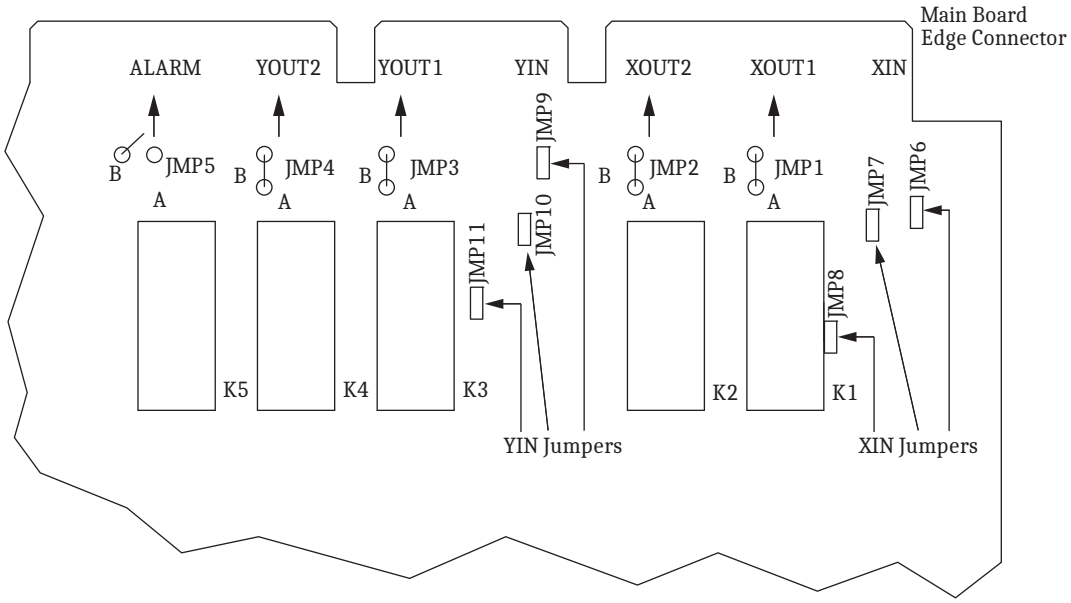


Figure 2.17 Input and Output Jumper Locations (Conventional Terminal Blocks With Jumper-Selectable Control Input Voltage Option Only)

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 2.18*. 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**.

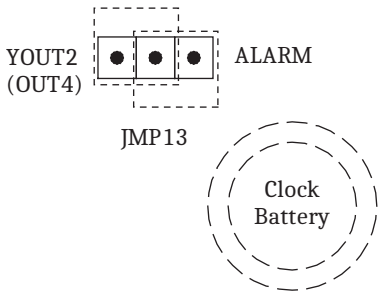


Figure 2.18 Output Contact OUT4 Control Jumper Location

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 battery keeps the clock (date and time) going if the external dc source is lost or removed. The battery is a 3 V lithium coin cell. At room temperature (25°C) the battery will nominally operate (discharge) for 10 years at rated load.

⚠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.

The battery experiences a low self-discharge rate when the SEL-501 is powered from an external dc source. If the dc source is lost or disconnected, the battery discharges to keep the clock going. Thus, battery life can extend well beyond the nominal 10 years because the battery rarely has to discharge (unless it is disconnected for extended periods of time or kept in storage). 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 (see *Section 7: Operation*).

⚠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 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.

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 again (see *Section 7: Operation*).

SECTION 3

Overcurrent Protection

Introduction

Set Relay X or Relay Y for overcurrent protection applications by changing the relay APP setting to FDR or OC1. Make this setting through use of the front-panel or serial port **SET** command. You can set either or both Relay X and Relay Y for overcurrent protection applications.

Both the FDR and OC1 overcurrent protection options use the same overcurrent elements. Apply these options to provide overcurrent protection for:

- Feeders
- Buses
- Transformers
- Other Apparatus

Overcurrent Protection Option Differences and Applications

The basic differences between the FDR and OC1 overcurrent protection options are input and output contact functions. The OC1 overcurrent protection option has all the settings of the FDR overcurrent protection option, plus additional settings for the unique features of the OC1 option (indicated with an asterisk [*] in *Table 3.1*).

APP = FDR

Input and Output Contact Functions

- Input IN operates as the 52A breaker status input
- Output contact OUT1 operates as the TRIP output contact
- Output contact OUT2 operates as the CLOSE output contact (automatic reclosing is not available)

If an overcurrent element pickup is not set to Off, it is enabled to operate the TRIP output contact.

Applications for APP = FDR

Use APP = FDR for most any overcurrent protection application and especially for applications requiring the relay to close the circuit breaker. The relay can close the breaker upon command via the front panel or serial communication port.

APP = OC1

Input Functions

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

Input IN provides true control, not supervision. If input IN 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. 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

Output Contact Functions

- Output contact OUT1 operates as the TRIP1 output contact
- Output contact OUT2 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 APP = OC1

Use APP = OC1 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 2.12*.
  - 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, 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 SEL-501 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 two- to three-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 (two- to three-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 firmware revisions prior to SEL-501 R900 V Z001001 D20021002 (see *Appendix A: Firmware and Manual Versions*). If you apply the SEL-501 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 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 = the maximum fault current in per unit of CT rating
Z_b = the CT burden in per unit of standard burden
X/R = 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} = the maximum primary fault current for line-to-line fault
CT_{RATING} = the CT primary rating in amperes
Z_B = the total CT secondary burden in ohms
X/R = the ANSI voltage classification of CTs

An SEL-501 phase instantaneous overcurrent element is to be set at 80 amperes. 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 (the SEL-501 has a negligible burden):

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

Example 3.1 Maximum Fault Current With an 80 A Instantaneous Setting

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

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

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 ampere instantaneous setting, what is the minimum CT rating that can be used when the maximum fault current is 40000 amperes, 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 Previous 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 burden	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 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 for the FDR and OC1 overcurrent protection options are shown in *Table 3.1*. The settings unique to the OC1 option are indicated with an asterisk (*).

Table 3.1 Overcurrent Relay Settings (Sheet 1 of 3)

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
ID	Relay Identifier	13 characters
APP	Relay Application	FDR, OC1
CTR	CT Ratio (CTR: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 sec (5 A Model) 0.1–16 A sec (1 A Model) 0.01 A steps
50PD	Phase Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
*50PTT	Assign 50PT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both

Table 3.1 Overcurrent Relay Settings (Sheet 2 of 3)

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
*50PTC	50PT controlled by input IN	Y, N
50H	Phase Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
*50HT	Assign 50H to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*50HC	50H controlled by input IN	Y, N
50QP	Negative-Sequence Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.01 A steps
50QD	Negative-Sequence Definite-Time Overcurrent Delay	1.5–16,000 cycles (0.25 steps)
*50QTT	Assign 50QT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*50QTC	50QT controlled by input IN	Y, N
50NP	Ground Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.01 A steps
50ND	Ground Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
*50NTT	Assign 50NT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*50NTC	50NT controlled by input IN	Y, N
50NH	Ground Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
*50NHT	Assign 50NH to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*50NHC	50NH controlled by input IN	Y, N
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 51PT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*51PTC	51PT controlled by input IN	Y, N
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
51QRS	Negative-Sequence Time-Overcurrent EM Reset	Y, N

Table 3.1 Overcurrent Relay Settings (Sheet 3 of 3)

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
*51QTT	Assign 51QT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*51QTC	51QT controlled by input IN	Y, N
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 51NT to trip output contacts	N = none, 1 = TRIP1, 2 = TRIP2, B = both
*51NTC	51NT controlled by input IN	Y, N
*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

Overcurrent Relay Trip Logic

APP = FDR

For an overcurrent trip or **OPEN** command execution, the TRIP output contact remains closed for a minimum of four cycles. After four cycles, the TRIP contact opens when all tripping elements have dropped out, and:

- All phase currents are less than one-tenth nominal current, or
- You press the front-panel **TARGET RESET** button, or
- You execute the **TARGET R** command from the serial port.

APP = OC1

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

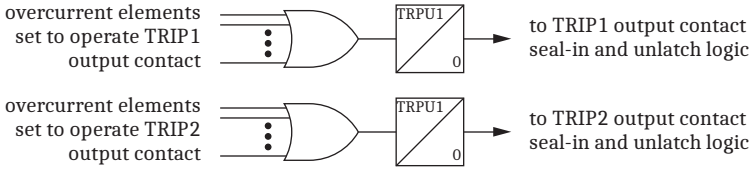


Figure 3.1 Time-Delay Pickup Timers for TRIP1 and TRIP2 Output Contacts

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 Close Logic (APP = FDR Only)

When you execute the **CLOSE** command from the front panel or serial port, the relay closes the appropriate CLOSE output if:

- The TRIP output is not closed and
- The 52A input is not asserted, indicating the breaker is open.

The CLOSE output remains closed until any of the following occurs:

- The 52A input asserts, indicating the breaker has closed, or
- The relay 60-cycle maximum close timer expires, or
- The relay trips.

No automatic reclosing is available.

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
- Relay X or Relay Y is disabled: its APP setting is Off
- 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 is illuminated, the tripping targets associated with that relay are displayed on the remaining LEDs.

The SEL-501 selects tripping targets, using the elements picked up when the relay trips.

If APP = OC1, the targets update anytime either trip output contact (TRIP1 or TRIP2) asserts.

Table 3.2 Overcurrent 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 = 3 • I_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% ±0.100 A sec	Time Delay Accuracy: ±0.25 cyc
1 A Model:	±5% ±0.020 A sec	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 U2 U3 U4	U.S. Moderately Inverse U.S. Inverse U.S. Very Inverse U.S. Extremely Inverse
	51PC, 51QC, or 51NC setting	Time-Curve Shape
	C1 C2 C3 C4	IEC Class A (Standard Inverse) IEC Class B (Very Inverse) IEC Class C (Extremely Inverse) IEC Long Time Inverse
Time-Dial Setting Ranges:	0.5–15, 0.01 Steps; U.S. Curves 0.05–1.0, 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.

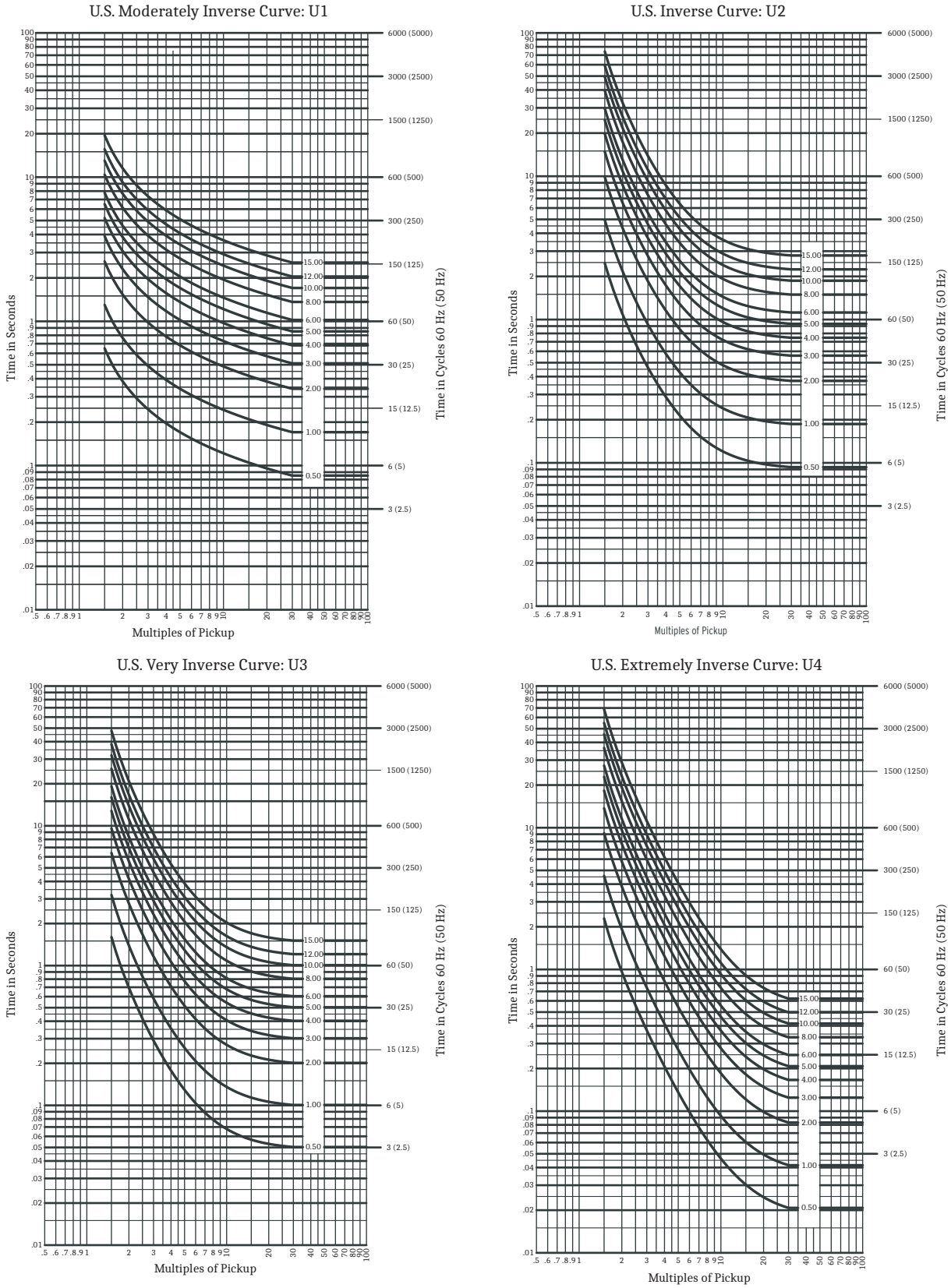
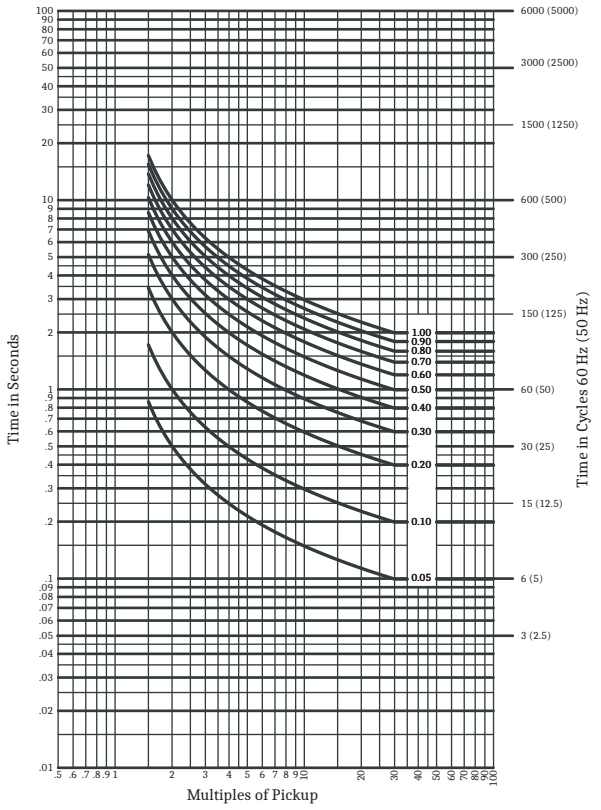
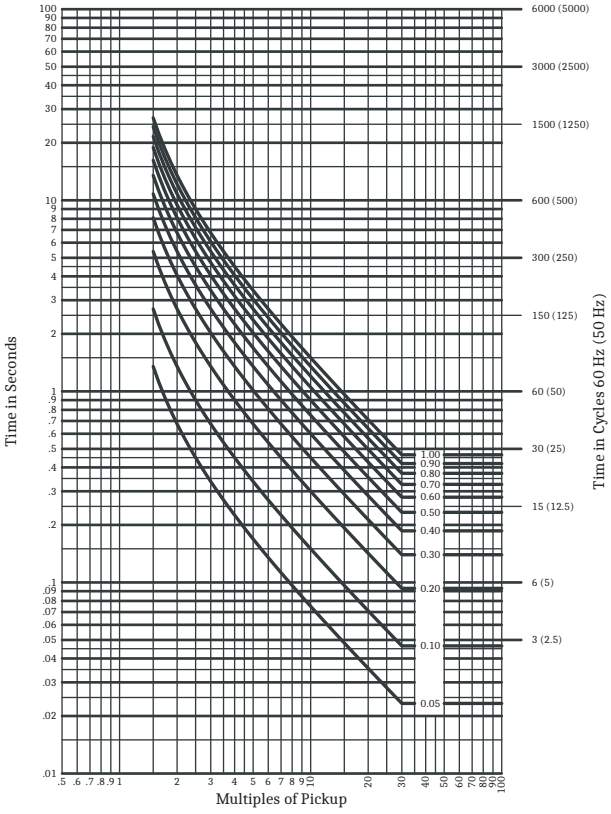


Figure 3.2 U.S. Time Curves U1, U2, U3, and U4

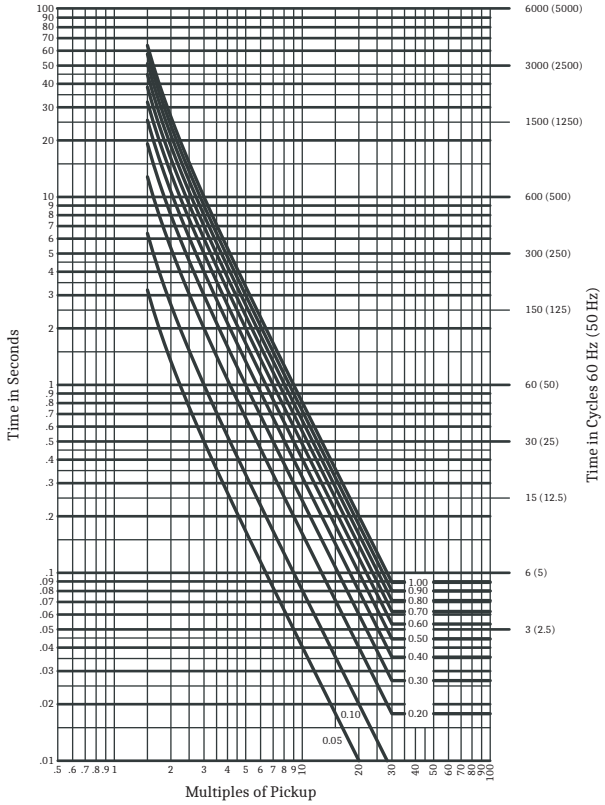
IEC Class A Curve (Standard Inverse): C1



IEC Class B Curve (Very Inverse): C2



IEC Class C Curve (Extremely Inverse): C3



IEC Long-Time Inverse Curve: C4

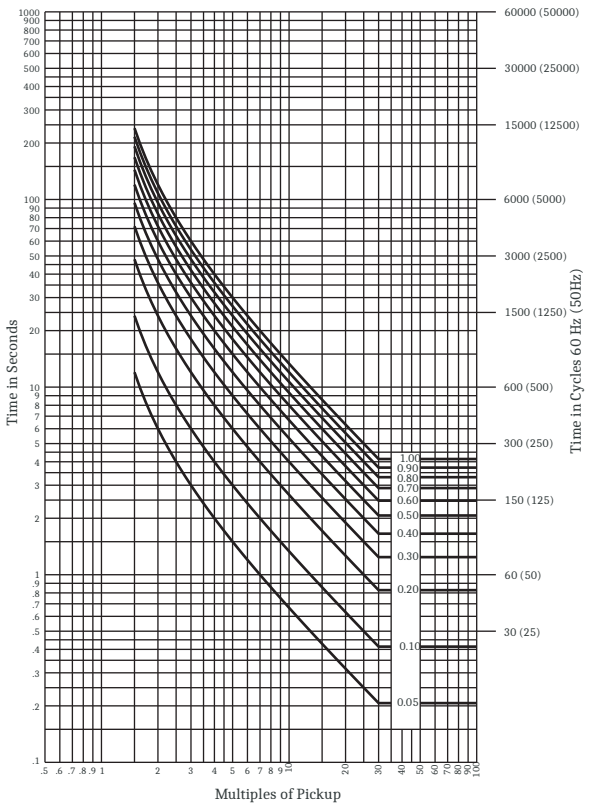


Figure 3.3 IEC Time Curves C1, C2, C3, and C4

SEL-501/SEL-501-1 Relay OC1 Settings Sheets

Relay Settings for General-Overcurrent Protection Application: OC1 (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 :=** _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	**APP :=** **OC1**
Current Transformer Ratio (CTR:1); (1–6000)	**CTR :=** _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	**DATC :=** _____
Programmable Input Function (EN, BLK, ET) (EN = Enable, BLK = Block, ET = External Trigger)	**IN :=** _____

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50PP :=** _____
Phase Definite-Time Overcurrent Delay (0–16,000 cycles in 0.25-cycle steps)	**50PD :=** _____
Assign 50PT to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP1, 2 = TRIP2, B = both)	**50PTT :=** _____
50PT controlled by input IN (Y, N)	**50PTC :=** _____
Phase Instantaneous Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50H :=** _____
Assign 50H to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP1, 2 = TRIP2, B = both)	**50HT :=** _____
50H controlled by input IN (Y, N)	**50HC :=** _____

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50QP :=** _____
Negative-Sequence Definite-Time Overcurrent Delay (1.5–16,000 cycles in 0.25-cycle steps)	**50QD :=** _____
Assign 50QT to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP1, 2 = TRIP2, B = both)	**50QTT :=** _____
50QT controlled by input IN (Y, N)	**50QTC :=** _____

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [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 (Y, N) **50NTC :=** _____

Ground Instantaneous Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [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 (Y, N) **50NHC :=** _____

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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 (Y, N) **51PTC :=** _____

Negative-Sequence Time-Overcurrent Element

Negative-Sequence Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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 (Y, N) **51QTC :=** _____

Ground Time-Overcurrent Element

Ground Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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) **51NTT :=** _____
(N = none, 1 = TRIP1, 2 = TRIP2, B = both)

51NT controlled by input IN (Y, N) **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 :=** _____

Protocol Setting (SET P 1) Rear Panel

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

Protocol Settings:

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = SYMAX for the Square D PowerLogic SY/MAX protocol (SEL-501-1 only).

Set PROTOCOL = MOD for Modbus RTU protocol (not available with SEL-501-1).

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

Refer to *Appendix F: SY/MAX Protocol* for details on the SY/MAX protocol.

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are the 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 the 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.

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	**SPEED :=** _____
AddressX (1–99)	**ADDRESSX :=** _____
AddressY (1–99)	**ADDRESSY :=** _____
Data Bits (7, 8)	**DATA_BITS :=** _____

Parity (None [N], Even [E], Odd [O]) **PARITY :=** _____

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

Protocol = MOD

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

Communications Settings

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

Protocol Settings:

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 the 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 the 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.

SEL-501/SEL-501-1 Relay FDR Settings Sheets

Relay Settings for Feeder-Overcurrent Protection Application: FDR (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 :=** _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	**APP :=** **FDR**
Current Transformer Ratio (CTR:1); (1–6000)	**CTR :=** _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	**DATC :=** _____

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50PP :=** _____
Phase Definite-Time Overcurrent Delay (0–16,000 cycles in 0.25-cycle steps)	**50PD :=** _____
Phase Instantaneous Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50H :=** _____

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50QP :=** _____
Negative-Sequence Definite-Time Overcurrent Delay (1.5–16,000 cycles in 0.25-cycle steps)	**50QD :=** _____

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50NP :=** _____
Ground Definite-Time Overcurrent Delay (0–16,000 cycles in 0.25-cycle steps)	**50ND :=** _____
Ground Instantaneous Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50NH :=** _____

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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 :=** _____

Negative-Sequence Time-Overcurrent Element

Negative-Sequence Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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 :=** _____

Ground Time-Overcurrent Element

Ground Time-Overcurrent Pickup—step size 0.1 A (Off, 0.5–16 A sec [5 A Model], 0.1–3.2 A sec [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 :=** _____

Protocol Setting (SET P 1) Rear Panel

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

Protocol Settings:

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = SYMAX for the Square D PowerLogic SY/MAX protocol (SEL-501-1 only).

Set PROTOCOL = MOD for Modbus RTU protocol (not available with SEL-501-1).

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

Refer to *Appendix F: SY/MAX Protocol* for details on the SY/MAX protocol.

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are the 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 the 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.

Protocol = SYMAX

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

Communications Settings

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

AddressX (1–99) **ADDRESSX :=** _____

AddressY (1–99) **ADDRESSY :=** _____

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

Parity (None [N], Even [E], Odd [O]) **PARITY :=** _____

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

Protocol = MOD

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

Communications Settings

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

Protocol Settings:

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 the 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 the 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

Motor Protection

Introduction

Set Relay X or Relay Y for motor protection applications by changing the relay APP setting to MOT. Make this setting through use of the front-panel or serial port **SET** command. You can set either or both Relay X and Relay Y for motor protection applications.

Motor Thermal Element Design, Application, and Setting

Figure 4.1 shows the starting current of an induction motor with the thermal and overcurrent protection characteristics of the SEL-501 motor application. In the motor application, definite-time and instantaneous overcurrent elements provide protection for faults in the motor leads and internal faults. A definite-time delay setting of about 6 cycles allows the overcurrent element pickup setting to be 1.2 to 1.5 times locked rotor current. This setting is high enough to avoid tripping on the initial X_d" inrush current (shown magnified). Set the instantaneous overcurrent element at twice the locked rotor current for fast clearing of high fault currents.

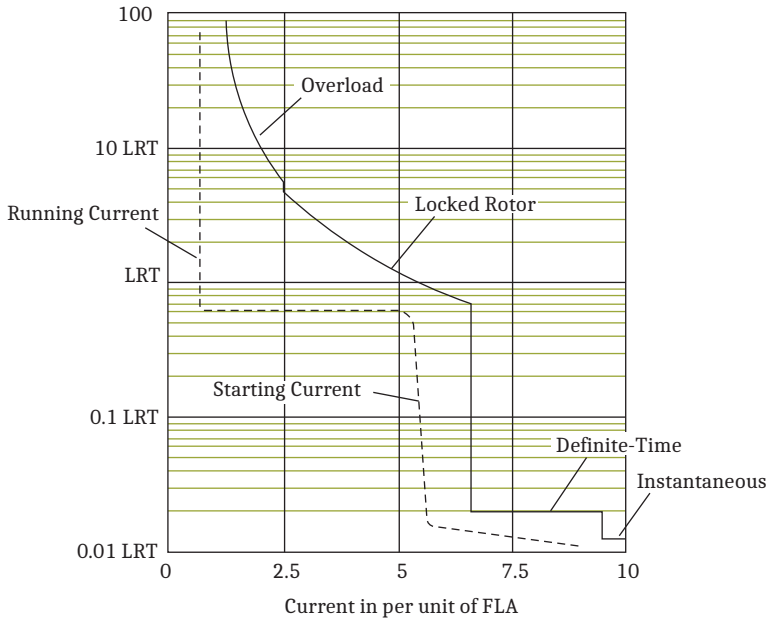


Figure 4.1 Motor Characteristics Plotted With Motor Starting Current

A time-overcurrent element and a separate negative-sequence overcurrent element could be applied to provide locked rotor and unbalance protection. However, neither of these elements account for thermal history or track excursions of motor temperature resulting from load or negative-sequence current heating.

The SEL-501 uses an element that accounts for the I^2r heating effect of both positive- and negative-sequence current. The element is a thermal model, defined by motor nameplate data, that estimates motor temperature. The temperature is then compared to thermal limit trip and alarm thresholds. The relay trips to prevent overheating for the abnormal conditions of overload, locked rotor starting, too frequent or prolonged starts, and unbalanced current.

Defining the Thermal Model

The I^2r heat source and two trip thresholds can be discerned from a motor characteristic of torque, current, and rotor resistance versus slip shown in *Figure 4.2*. The plot shows the characteristic of the induction motor to draw excessively high current until the peak torque develops near full speed. The skin effect of the slip frequency current flowing in the rotor bars causes the rotor resistance to exhibit a high locked rotor value labeled R_1. R_1 decreases to a low running value at rated slip, labeled R_0.

Using a typical starting current of six times the rated current and a locked rotor resistance R_1 of three times value of R_0, one can estimate I^2r heating at 6^2 x 3 or 108 times normal. Consequently, an extreme temperature must be tolerated for a limited time to start the motor.

Where an emergency I^2t threshold is specified by the locked rotor limit during a start, a threshold for the normal running condition is specified by the service factor. Therefore, the thermal model requires a trip threshold when starting indicated by the locked rotor thermal limit and a trip threshold when running indicated by the service factor.

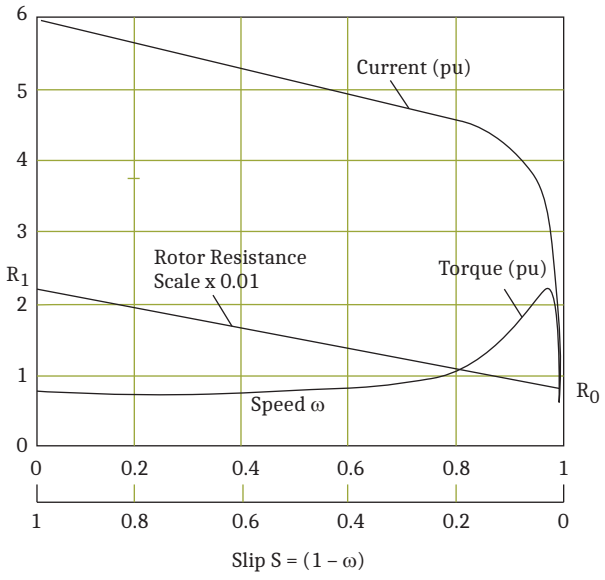


Figure 4.2 Current, Torque, and Rotor Resistance of an Induction Motor Versus Speed

The slip dependent heating effect of positive- and negative-sequence currents is derived as follows. The rotor resistance plotted in *Figure 4.1* is calculated through use of a linear function of current, torque, and slip in *Equation 4.1*:

$$R_r = \frac{Q_M}{I^2} S$$

Equation 4.1

where:

R_r = rotor resistance
Q_M = motor torque
S = slip
I = current

The positive-sequence rotor resistance R_{r+} is a function of the slip S:

$$R_{r+} = (R_1 - R_0)S + R_0$$

Equation 4.2

The negative-sequence rotor resistance R_{r-} is obtained when S is replaced with the negative-sequence slip (2 – S):

$$R_{r-} = (R_1 - R_0)(2 - S) + R_0$$

Equation 4.3

Factors expressing the relative heating effect of positive- and negative-sequence current are obtained by dividing *Equation 4.2* and *Equation 4.3* by the running resistance R_0. Consequently, for the locked rotor case, and where R_1 is typically three times R_0, the heating effect for both positive- and negative-sequence current is three times that caused by the normal running current.

$$\left.\frac{R_{r+}}{R_0}\right|_{S=1} = \left.\frac{R_{r-}}{R_0}\right|_{S=1} = \frac{R_1}{R_0} = 3$$

Equation 4.4

For the running case, the positive-sequence heating factor returns to one, and the negative-sequence heating factor increases to 5:

$$\left.\frac{R_{r+}}{R_0}\right|_{S=0} = 1 \qquad \left.\frac{R_{r-}}{R_0}\right|_{S=0} = 2 \qquad \left(\frac{R_1}{R_0}\right) - 1 = 5$$

Equation 4.5

These factors are the coefficients of the positive- and negative-sequence currents of the heat source in the thermal models.

States of the Thermal Model

Because of its torque characteristic, the motor must operate in either a high current starting state or be driven to a low current running state by the peak torque occurring at about 2.5 per unit current. The thermal model protects the motor in either state by using the trip threshold and heating factors indicated by the current magnitude. The two states of the thermal model are shown in *Figure 4.3*.

The thermal model is actually a difference equation executed by the microprocessor. However, it can be represented by the electrical analog circuit shown in *Figure 4.3*. In this analogy, the heat source is represented by a current generator, the temperature is represented by voltage, and thermal resistance and capacitance are represented by electrical resistance and capacitance. The parameters of the thermal model are defined:

R_1 = Locked rotor electrical resistance (per unit ohms)
R_0 = Running rotor electrical resistance also rated slip (per unit ohms)
I_L = locked rotor current in per unit of full load current
Ta = locked rotor time with motor initially at ambient
To = locked rotor time with motor initially at operating temperature

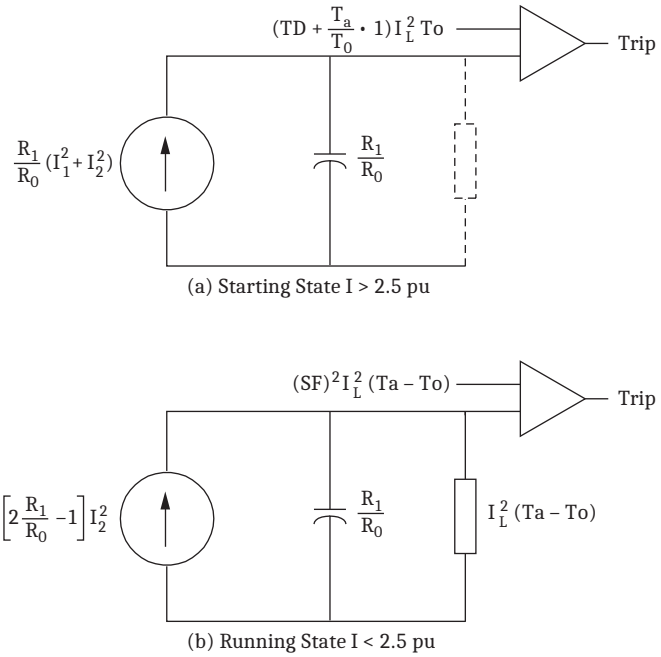


Figure 4.3 States of the Thermal Model

The starting state is shown in *Figure 4.3a* and is declared whenever the current exceeds 2.5 per unit of the rated full load current. The starting state thermal model uses the threshold and heating factors derived for the locked rotor case. Thermal resistance is not shown because the start calculation assumes adiabatic heating.

The running state, shown in *Figure 4.3b*, is declared when the current falls below 2.5 per unit current. It uses the heating factors derived for the running condition. In this state, the trip threshold "cools" exponentially from the locked rotor threshold to the appropriate threshold for the running condition through use of the motor thermal time constant. This emulates the motor temperature that also cools to the steady-state running condition.

In the model, the thermal limit $I_L^2T_a$ represents the locked rotor hot spot limit temperature. $I_L^2(T_a - T_o)$ represents the operating temperature with full load current. The locked rotor time T_a is not usually specified, but this time can be calculated by assuming a hot spot temperature of six times the operating temperature in the following relation:

$$\frac{I_L^2 T_a}{I_L^2 (T_a - T_o)} = 6 \therefore \frac{T_a}{T_o} = 1.2$$

Equation 4.6

There are two reasons for using the rotor model in the running state. The first is that, despite a difference in thresholds, it is an industry practice to publish the overload and locked rotor thermal limits as one continuous curve as illustrated in *Figure 4.1*. The second is that the rotor model accounts for the heating of both the positive- and the negative-sequence current. As a final refinement, assigning standard values of 3 and 1.2 to the ratios R_1/R_0 and T_a/T_o, respectively, allows the model parameters to be determined from these fundamental settings:

FLA	Rated full load motor current in secondary amperes
LRA	Rated locked rotor current in secondary amperes
LRT	Thermal limit time at rated locked rotor current
TD	Time Dial to trip temperature in per unit of LRT
49A	Thermal alarm level, in per unit of rated thermal trip
SF	Motor rated service factor

You can set the thermal time-dial, TD, from 0.1 to 1.5 per unit of rated locked rotor time. Setting TD to 1.0 protects the motor to the full locked rotor thermal level. A TD setting of 0.9 provides a 10 percent safety margin.

If you set the Alarm Latch setting, ALML, to Y, the relay closes and latches the ALARM contact if the thermal element output is greater than 49A times the trip level. After the motor cools, reset the alarm by pressing the front-panel **TARGET RESET** pushbutton, or by executing the serial port **TARGET R** command. When ALML is N, the ALARM contact resets when the thermal element output drops below the thermal alarm level. Setting ALML to D disables the thermal alarm function and hides the 49A setting.

Overcurrent Element Application and Setting

Settings for the phase, negative-sequence, and ground overcurrent elements are:

50PP	Phase definite-time overcurrent element pickup setting
50PD	Phase definite-time overcurrent element time delay setting
50H	Phase instantaneous overcurrent element pickup setting
50QP	Negative-sequence definite-time overcurrent element pickup setting
50QD	Negative-sequence definite-time overcurrent element time delay setting
50NP	Residual definite-time overcurrent element pickup setting
50ND	Residual definite-time overcurrent element time delay setting
50NH	Residual instantaneous overcurrent element pickup setting

Set the phase definite-time element pickup from 1.2 to 1.5 times the locked rotor current setting, LRA. Use a six-cycle time delay to override the subtransient component of the motor starting current. Set the 50H instantaneous element at least twice the locked rotor current.

Set the negative-sequence definite-time element pickup as low as one-tenth of nominal amperes with a delay of 240 cycles to override transient unbalance in the three-phase current during the motor start.

You can set the residual definite-time element pickup as low as one-tenth of nominal amperes, with a 10 to 25-cycle time delay. This delay allows the element to override false residual current that can result from CT saturation resulting from dc offset during motor starting. Set the residual instantaneous element, 50NH, from 5 to 10 times the motor full load current.

To prevent an overcurrent element from tripping, set the element pickup to OFF.

Load-Jam, Load-Loss, and Starts Limit Protection

The Load-Jam and Load-Loss features protect the motor drive and use the following settings:

ELJ	Enable Load-Jam Trip (Y/N)
LJA	Load-Jam Amps pickup
LJD	Load-Jam Trip Delay
ELL	Enable Load-Loss Trip (Y/N)
LLA	Load-Loss Amps
LLD	Load-Loss Trip Delay

Load-jam protection trips the protected motor if load or system conditions cause the motor to stall. Enable load-jam protection by setting ELJ to Y. Set LJA less than locked rotor current and greater than maximum expected load current. Set LJD longer than LRT to ride through the motor start.

The Load-Loss function protects for drive decoupling. Enable load-loss protection by setting ELL to Y. Set the load-loss current level, LLA, less than minimum load and set the load-loss delay, LLD to ride through momentary load dips.

The Starts-per-Hour Limit (STL) function counts the times the protected motor starts in any 60-minute period.

To enable STL tripping, set STL between 1 and 5. The number should be the motor nameplate rated maximum number of starts per hour. To disable STL tripping, set STL to N.

The STL function stores data in volatile memory. If the relay is de-energized, it loses information about any starts that occurred before loss of dc power.

Table 4.1 Motor Relay Settings (Sheet 1 of 2)

Setting	Setting Prompt (APP = Mot)	Setting Range
ID	Relay Identifier	13 characters
APP	Relay Application	MOT
CTR	CT Ratio (CTR:1)	1–6000
DATC	Demand Ammeter Time-Constant	Off, 5–60 minutes
TRL	Latch Motor Trips	Y, N

Table 4.1 Motor Relay Settings (Sheet 2 of 2)

Setting	Setting Prompt (APP = Mot)	Setting Range
ALML	Latch Motor Thermal Alarms	Y, N, D
FLA	Motor Full Load Amps	1–25 A sec (5 A Model) 0.2–5 A sec (1 A Model)
LRA	Motor Locked-Rotor Amps	9–80 A sec (5 A Model) 1.8–16 A sec (1 A Model) (3– 9 times FLA)
LRT	Motor Locked-Rotor Time	1–30 seconds
TD	Rotor Thermal Time-Dial (per unit of LRT)	0.1–1.5
49A	Thermal Alarm Level (per unit of rated trip)	0.1–1.0
SF	Motor Service Factor (per unit)	1.0–1.5
50PP	Phase Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
50PD	Phase Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
50H	Phase Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
50QP	Negative-Sequence Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
50QD	Negative-Sequence Definite-Time Overcurrent Delay	1.5–16,000 cycles (0.25 steps)
50NP	Residual Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
50ND	Residual Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
50NH	Residual Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
ELJ	Enable Load-Jam Tripping	Y, N
LJA	Load-Jam Amps	0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
LJD	Load-Jam Delay	0–2000 cycles (1 cyc steps)
ELL	Enable Load-Loss Tripping	Y, N
LLA	Load-Loss Amps	0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
LLD	Load-Loss Delay	5–2000 cycles (1 cyc steps)
STL	Starts/Hour Limit	1–5 starts, N disables

Motor Trip Logic

The motor protection function is equipped with Trip Latching. When Trip Latching is disabled (TRL = N), the trip output remains closed for a minimum of four cycles. After four cycles, the trip contacts open when all tripping elements have dropped out, and:

- All phase currents are less than one-tenth nominal current, or
- You press the front-panel **TARGET RESET** pushbutton, or
- You execute the **TARGET R** command from the serial port.

When Trip Latching is enabled (TRL = Y), the trip output remains closed until all tripping elements have dropped out and you:

- Press the front-panel **TARGET RESET** pushbutton, or
- Execute the **TARGET R** command from the serial port.

The Trip Latching function is useful if you require that the protected equipment be inspected before being placed back in service following a relay operation.

Motor Close Logic

When you execute the **RUN** command from the relay front panel or serial port, the relay closes the appropriate CLOSE output if:

- The TRIP output is not closed and
- The 52A input is not asserted, indicating the breaker/contactor is open.

The CLOSE output remains closed until:

- The 52A input asserts, indicating the breaker/contactor has closed, or
- The relay 60-cycle maximum close timer expires, or
- The relay trips, whichever occurs first.

Motor Relay Targets

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

- Target is blinking to indicate a trip
- Relay X or Relay Y is disabled: its APP setting is OFF
- Power is removed from the SEL-501
- SEL-501 self-test failure has been detected

When either relay trips, the X or Y LED blinks to indicate which relay tripped. While the blinking LED is illuminated, the tripping targets associated with that relay are also displayed on the remaining LEDs.

The relay selects tripping targets, using the elements picked up when the relay trips.

Table 4.2 Motor 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 50PP setting or trip resulted from thermal element operation
B	B-phase current is greater than 50PP setting or trip resulted from thermal element operation
C	C-phase current is greater than 50PP setting or trip resulted from thermal element operation
Q	50QP element is picked up
N	50NP element is picked up

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

Element Specifications

	Instantaneous Elements	Definite-Time Elements
Phase (Ia, Ib, and Ic)	50H	50PT
Negative-Sequence (IQ = 3 • I2)		50QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT
Pickup Ranges (A secondary):		
5 A Model:	0.5–80 A, 0.1 steps	0.5–80 A, 0.1 steps
1 A Model:	0.1–16 A, 0.1 steps	0.1–16 A, 0.1 steps
Pickup Accuracy:		
5 A Model:	±5% ±0.100 A	±5% ±0.025 A
1 A Model:	±5% ±0.020 A	±5% ±0.005 A
Definite-Time Delay:		0–16,000 cyc
Time Delay Accuracy:		±0.25 cyc
Locked Rotor Clearing Time Maximum Error: ±5% of TD • LRT ±10 cycles		

Figure 4.4 shows a plot of the motor thermal element time to trip plotted versus applied current in multiples of full load current.

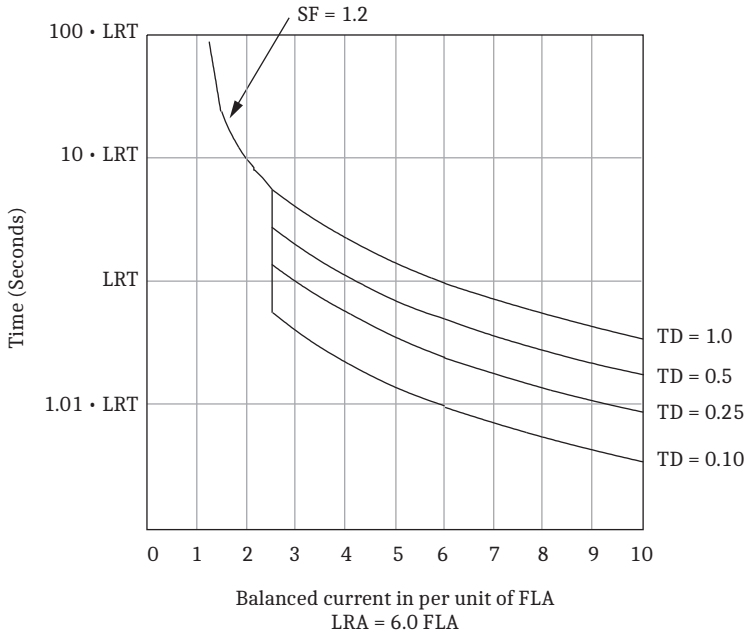


Figure 4.4 Thermal Model Operating Time Curves

The motor thermal model trip time is described by two equations and the motor relay settings.

For:

$$SF < \frac{|I_1|}{FLA} < 2.5$$

$$t_p = 0.6 \bullet \left(\frac{LRA}{FLA}\right)^2 \bullet LRT \bullet \ln\left[\frac{\frac{I_1^2 + 5 \bullet I_2^2}{(SF \bullet FLA)^2}}{\frac{I_1^2 + 5 \bullet I_2^2}{(SF \bullet FLA)^2} - 1}\right] \text{ seconds}$$

For:

$$\frac{|I_1|}{FLA} \geq 2.5$$

$$t_p = \frac{TD \bullet LRA^2 \bullet LRT}{(I_1^2 + I_2^2)} \text{ seconds}$$

where:

FLA, LRA, LRT,
SF, and TD = Relay settings

I_1 = Positive-sequence current

I_2 = Negative-sequence current (zero under balanced current conditions)

t_p = Time to trip from fully reset condition

SEL-501/SEL-501-1 Relay MOT Settings Sheets

Relay Settings for Motor Protection Application: MOT (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 :=** _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	**APP := MOT**
Current Transformer Ratio (CTR:1); (1–6000)	**CTR :=** _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	**DATC :=** _____

Latch Trips/Alarms

Latch Motor Trips (Y, N)	**TRL :=** _____
Latch Motor Thermal Alarms (Y, N, D)	**ALML :=** _____

Motor Parameters

Motor Full Load Amperes (1–25 A sec [5 A Model], 0.2–5 A sec [1 A Model])	**FLA :=** _____
Motor Locked-Rotor Amperes (9–80 A sec [5 A Model],1.8–16 A sec [1 A Model]); (3–9 times FLA)	**LRA :=** _____
Motor Locked-Rotor Time (1–30 seconds)	**LRT :=** _____
Rotor Thermal Time-Dial (per unit of LRT); (0.1–1.5)	**TD :=** _____
Thermal Alarm Level (per unit of rated trip); (0.1–1)	**49A :=** _____
Motor Service Factor (per unit); (1.0–1.5)	**SF :=** _____

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50PP :=** _____
Phase Definite-Time Overcurrent Delay (0–16,000 cycles in 0.25-cycle steps)	**50PD :=** _____
Phase Instantaneous Overcurrent Pickup—step size 0.1 A (Off, 0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model])	**50H :=** _____

Negative-Sequence Definite-Time Overcurrent Element

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

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

Residual Definite-Time/Instantaneous Overcurrent Elements

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

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

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

Load-Jam/Load-Loss Elements

Enable Load-Jam Tripping (Y, N) **ELJ :=** _____

Load-Jam Amperes (0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model]) **LJA :=** _____

Load-Jam Delay (0–2000 cycles); (1 cycle steps) **LJD :=** _____

Enable Load-Loss Tripping (Y, N) **ELL :=** _____

Load-Loss Amperes (0.5–80 A sec [5 A Model], 0.1–16 A sec [1 A Model]) **LLA :=** _____

Load-Loss Delay (5–2000 cycles); (1 cycle steps) **LLD :=** _____

Starts/Hour Limit (1–5 starts, N disables) **STL :=** _____

Protocol Setting (SET P 1) Rear Panel

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

Protocol Settings

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = SYMAX for the Square D PowerLogic SY/MAX protocol (SEL-501-1 only).

Set PROTOCOL = MOD for Modbus RTU protocol (not available with SEL-501-1).

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

Refer to *Appendix F: SY/MAX Protocol* for details on the SY/MAX protocol.

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are the 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 the 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.

Protocol = SYMAX

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

Communications Settings

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

AddressX (1–99) **ADDRESSX :=** _____

AddressY (1–99) **ADDRESSY :=** _____

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

Parity (None [N], Even [E], Odd [O]) **PARITY :=** _____

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

Protocol = MOD

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

Communications Settings

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

Protocol Settings

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 the 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 the 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.

This page intentionally left blank

SECTION 5

Breaker Failure Protection

Introduction

Set Relay X or Relay Y for breaker failure protection applications by changing the relay APP setting to BFR. Make this setting through use of the front-panel or serial port **SET** command. You can set either or both Relay X and Relay Y for breaker failure protection applications.

86 Trip Logic

Figure 5.1 shows the logic diagram for the breaker failure protection. Setting EBFIL gives the option to latch (seal-in) the breaker failure initiate (BFI) condition (see *Table 5.1*).

The breaker failure timer, 62FC, starts when the BFI input asserts and either the 50PP or 50NP overcurrent elements picks up. If either the 50PP or 50NP overcurrent element remains asserted for 62FC cycles, the relay closes the 86TR output. If both overcurrent elements drop out before the 62FC timer expires, the logic resets and the relay does not close the 86TR output.

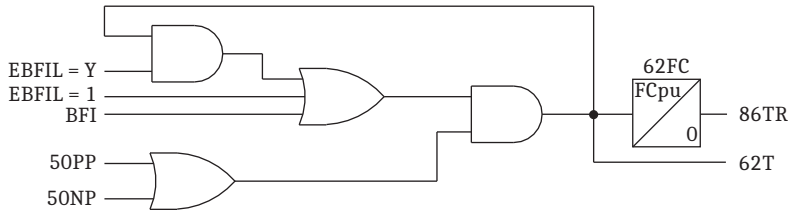


Figure 5.1 Breaker Failure Logic

The 86TR trip output remains closed for a minimum of four cycles. After four cycles, the trip contacts open when one of the following occurs:

- All phase currents are less than one-tenth nominal current
- You press the front-panel **TARGET RESET** pushbutton
- You execute the **TARGET R** command from the serial port

Figure 5.2 shows the timing of the breaker failure protection for both normal and failed breaker operations. When the breaker operates normally, current is interrupted and the overcurrent elements reset before the 62FC timer expires. Because the 62FC timer did not expire, the relay did not close the 86TR output contact. If the breaker fails to clear the fault, the overcurrent elements remain picked up, the 62FC timer expires, and the relay closes the 86TR output.

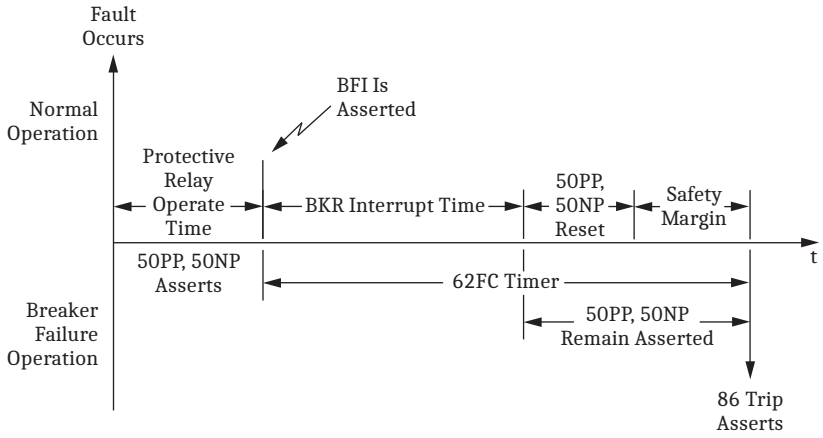


Figure 5.2 Breaker Failure Timing

Set the 50PP and 50NP overcurrent elements to detect all faults that the protected breaker is required to interrupt. You can set the 50PP element below load, if required.

Select the 62FC timer setting based upon the following factors:

- Maximum permissible fault duration
- Protective relay operating time
- Protected breaker operating time
- 50PP and 50NP element maximum reset time (*Overcurrent Element Specifications on page 5.4*)
- Operating times of electrically adjacent breakers
- Desired breaker failure operating safety margin

If an auxiliary interposing relay is used between the protective relay trip output and the BFI input, you must account for the operating time of the auxiliary relay as well. The BFI input must be asserted for two consecutive quarter-cycles for the relay to acknowledge the assertion.

Retrip Logic

Figure 5.3 shows the logic used to retrip the protected breaker. Enable this function by setting the ERTR setting to Y. When enabled, the 62RT timer starts when an external trip asserts the BFI input. If the BFI input remains asserted for 62RT time, the relay closes the RETRIP output.

With ERTR = N, the RETRIP output (OUT2) is reconfigured to follow the 86TR output.

The RETRIP output remains closed a minimum of 4 cycles, then opens when any of the following occurs:

- Voltage is removed from the BFI input, or
- The relay 60 cycle maximum retrip timer expires, or
- You press the **TARGET RESET** pushbutton or execute the **TARGET R** command.

If the RETRIP output is closed for 60 cycles, the retrip function is disabled until the next rising edge of the BFI input.

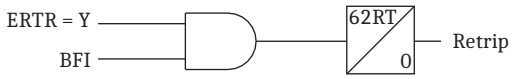


Figure 5.3 Retrip Logic

Select a 62RT time delay less than the difference between the 62FC setting and normal breaker operation time. If the 62RT delay is too long, the breaker may not have time to fully open on the retrip signal before the breaker failure 62FC timer expires. Setting 62RT for a time delay between 2 and 6 cycles is typical. This time delay allows you to distinguish between the initial trip from the protective relays and the retrip from the breaker failure relay.

Table 5.1 Breaker Failure Relay Settings

Setting	Setting Prompt (APP = Bfr)	Setting Range
ID	Relay Identifier	13 characters
APP	Relay Application	Bfr
CTR	CT Ratio (CTR:1)	1–6000
DATC	Demand Ammeter Time-Constant	Off, 5–60 minutes
50PP	Phase Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
50NP	Residual Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model) 0.1 A steps
FC	62FC Breaker Failure Delay	0.00–63.75 cycles (0.25 cycle steps)
ERTR	Enable Retripping	Y, N
62RT	Retrip Delay	0.00–63.75 cycles (0.25 cycle steps)
EBFIL	Enable Breaker Failure Initiate Latch	Y, N, 1

Breaker Failure Relay Targets

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

- Target is blinking to indicate a trip
- Relay X or Relay Y is disabled: its APP setting is OFF
- Power is removed from the SEL-501
- SEL-501 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 is illuminated, the tripping targets associated with that relay are displayed on the remaining LEDs.

The relay selects tripping targets, using the elements picked up when the relay trips.

Table 5.2 Breaker Failure Relay Tripping Targets (Sheet 1 of 2)

Tripping Target	Illuminates if:
INST	Not used in breaker failure applications
A	A-phase current is greater than 50PP
B	B-phase current is greater than 50PP

Table 5.2 Breaker Failure Relay Tripping Targets (Sheet 2 of 2)

Tripping Target	Illuminates if:
C	C-phase current is greater than 50PP
Q	Not used in breaker failure applications
N	50NP element is picked up

Clear the targets by pressing the front-panel **TARGET RESET** pushbutton or by executing the serial port **TARGET R** command. If you press the **TARGET RESET** pushbutton and the targets do not clear, the condition that caused the relay to trip is still present.

Overcurrent Element Specifications

Overcurrent Elements

Phase (Ia, Ib, or Ic)	50PP
Residual (IR = Ia + Ib + Ic)	50NP
Pickup Ranges (A secondary):	0.5–80 A (5 A Model), 0.1 steps
	0.1–16 A (1 A Model), 0.1 steps
Pickup Accuracy:	±5% ±0.100 A secondary (5 A Model)
	±5% ±0.020 A secondary (1 A Model)
Pickup Time (Typ/Max):	0.5/1.0 cyc
Reset Time (Typ/Max):	0.75/1.0 cyc

Overcurrent Element Pickup and Reset Speed Curves

Figure 5.4 and *Figure 5.5* show the pickup and reset times for the 50P breaker failure overcurrent element. Tests were run at each multiple of the pickup setting. The diagrams show the maximum, mean, and minimum operate and reset time at each multiple. These times do not include output contact closure time, thus they are accurate for determining element operating times for use with the SEL-501 internal breaker failure logic. The 50N breaker failure overcurrent element operate and reset times are comparable.

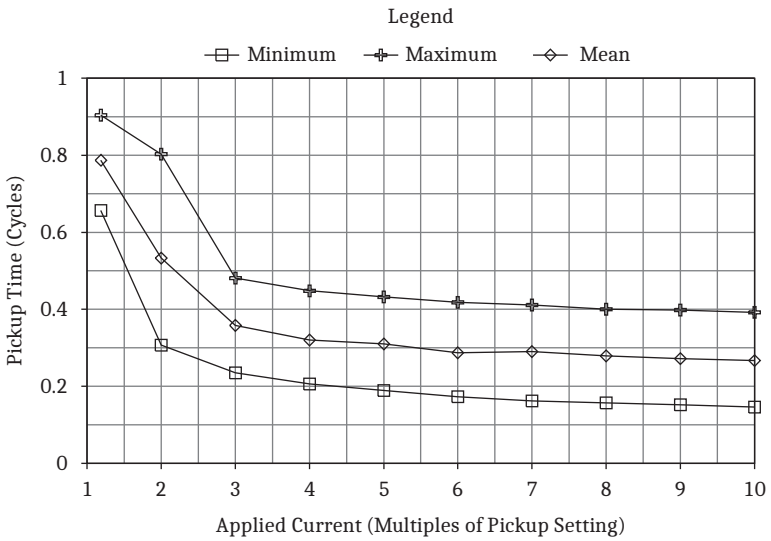


Figure 5.4 BFR 50P Pickup Time Curve

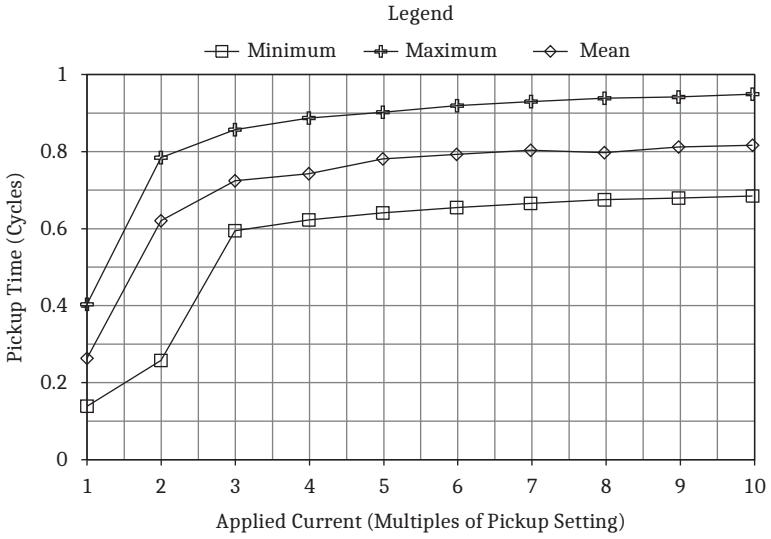


Figure 5.5 BFR 50P Reset Time Curve

This page intentionally left blank

SEL-501/SEL-501-1 Relay BFR Settings Sheets

Relay Settings for Motor Protection Application: BFR (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 :=** _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	**APP := BFR**
Current Transformer Ratio (CTR:1); (1–6000)	**CTR :=** _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	**DATC :=** _____

Phase Definite-Time/Instantaneous Overcurrent Elements

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

BFR Delay/Retripping/ BFI Latch

62FC Breaker Failure Delay (0.00–63.75 cycles)	**FC :=** _____
Enable Retripping (Y, N)	**ERTR :=** _____
Retrip Delay (0.00–63.75 cycles)	**62RT :=** _____
Enable Breaker Failure Initiate Latch (Y, N, 1)	**EBFIL :=** _____

Protocol Setting (SET P 1) Rear Panel

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

Protocol Settings:

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = SYMAX for the Square D PowerLogic SY/MAX protocol (SEL-501-1 only).

Set PROTOCOL = MOD for Modbus RTU protocol (not available with SEL-501-1).

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

Refer to *Appendix F: SY/MAX Protocol* for details on the SY/MAX protocol.

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are the 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 the 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.

Protocol = SYMAX

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

Communications Settings

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

AddressX (1–99) **ADDRESSX :=** _____

AddressY (1–99) **ADDRESSY :=** _____

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

Parity (None [N], Even [E], Odd [O]) **PARITY :=** _____

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

Protocol = MOD

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

Communications Settings

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

Protocol Settings:

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 the 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 the 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.

This page intentionally left blank

SECTION 6

General-Purpose Timer

Introduction

Set Relay X or Relay Y for timing applications by changing the relay APP setting to TMR. Make this setting through use of the front-panel or serial port **SET** command. You can set either or both Relay X and Relay Y for timing applications. The timers can be used for time-qualifying external trips or conditions:

- Underfrequency relay trips
- Overcurrent relay trips
- Hot or dead voltage conditions

Many other applications are possible.

Timer Logic and Settings

Input IN drives Timer 1 and Timer 2 (see *Figure 6.1*). If input IN remains asserted continuously for TDPU1 or TDPU2 pickup time, Timer 1 or Timer 2 times out and the respective output contact OUT1 or OUT2 asserts.

If input IN then deasserts, output contact OUT1 or OUT2 remains asserted until the TDDO1 or TDDO2 dropout time expires and the respective output contact OUT1 or OUT2 then deasserts.

1OUT or **2OUT** command execution from the front panel or serial port asserts the OUT1 or OUT2 output contact for 30 cycles. These command executions are not subject to Timer 1 or Timer 2, respectively.

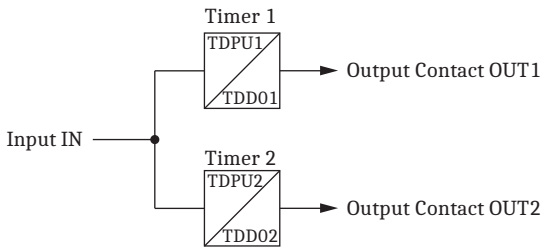


Figure 6.1 Input-Driven Timers Routed to Output Contacts OUT1 and OUT2

The timers are completely independent of the relay current inputs. The current inputs can still be connected for metering purposes and display in the event reports.

Table 6.1 Timer Settings

Setting	Setting Definition (APP = Tmr)	Setting Range
ID	Relay Identifier	13 characters
APP	Relay Application	Tmr
CTR	CT Ratio (CTR:1)	1–6000
DATC	Demand Ammeter Time Constant	Off, 5–60 minutes
TDPU1	Timer 1 Pickup Delay	0–16,000 cycles (0.25-cycle steps)
TDDO1	Timer 1 Dropout Delay	0–16,000 cycles (0.25-cycle steps)
TDPU2	Timer 2 Pickup Delay	0–16,000 cycles (0.25-cycle steps)
TDDO2	Timer 2 Dropout Delay	0–16,000 cycles (0.25-cycle steps)

Timer Targets

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

- Relay X or Relay Y is disabled: its APP setting is OFF
- Power is removed from relay
- A relay self-test failure has been detected

The OVERCURRENT CONDITIONS front-panel targets are not operational when APP = TMR.

SEL-501/SEL-501-1 Relay TMR Settings Sheets

Relay Settings for Motor Protection Application: TMR (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 :=** _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	**APP := TMR**
Current Transformer Ratio (CTR:1); (1–6000)	**CTR :=** _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	**DATC :=** _____

Timer Pickup/Dropout Delays

Timer 1 Pickup Delay (0–16,000 cycles)	**TDPU1 :=** _____
Timer 1 Dropout Delay (0–16,000 cycles)	**TDDO1 :=** _____
Timer 2 Pickup Delay (0–16,000 cycles)	**TDPU2 :=** _____
Timer 2 Dropout Delay (0–16,000 cycles)	**TDDO2 :=** _____

Protocol Setting (SET P 1) Rear Panel

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

Protocol Settings:

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = SYMAX for the Square D PowerLogic SY/MAX protocol (SEL-501-1 only).

Set PROTOCOL = MOD for Modbus RTU protocol (not available with SEL-501-1).

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

Refer to *Appendix F: SY/MAX Protocol* for details on the SY/MAX protocol.

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are the 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 the 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.

Protocol = SYMAX

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

Communications Settings

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

AddressX (1–99) **ADDRESSX :=** _____

AddressY (1–99) **ADDRESSY :=** _____

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

Parity (None [N], Even [E], Odd [O]) **PARITY :=** _____

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

Protocol = MOD

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

Communications Settings

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

Protocol Settings:

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 the 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 the 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.

This page intentionally left blank

SECTION 7

Operation

Front-Panel Operation

Overview

Use *Figure 7.1* and *Table 7.6* as guides to the operation of the SEL-501 front panel.

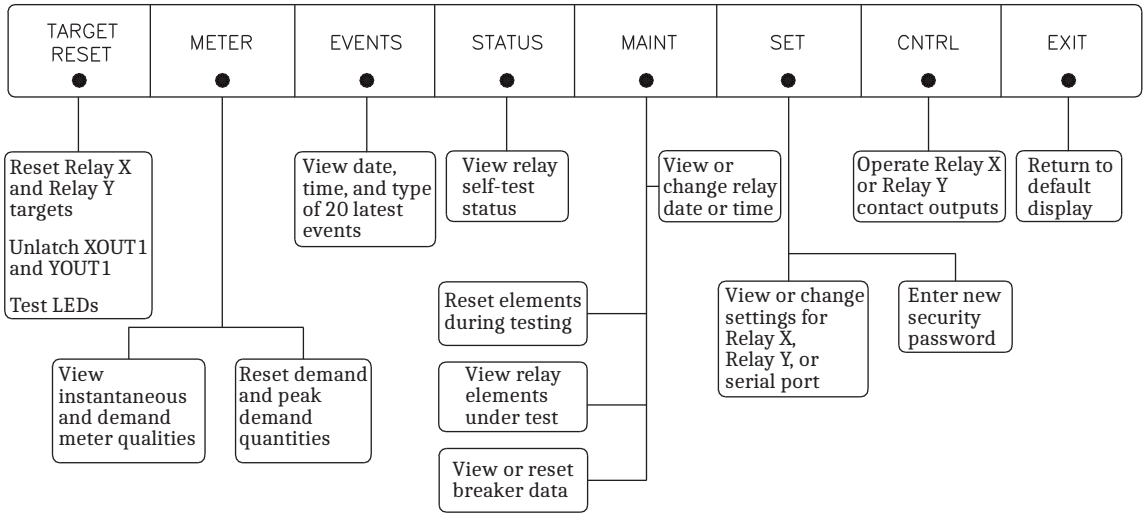


Figure 7.1 Front-Panel Function Drawing

Front-Panel Command Execution

Execute a front-panel command by pressing the desired control button. Use the left- and right-arrow pushbuttons 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 7.6 and *Table 7.7* 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 **JMP22** is removed, you must enter the Access Level 2 password before executing Access Level 2 commands. See *Circuit Board Jumpers and Battery on page 2.11* for jumper details.

The Access Level 2 password (passcode) is a 6 character or less combination of alphanumerics. The default Level 2 password is shown in *Table 7.4*. To enter the password from the front panel, use the left- and right-arrow pushbuttons to underline each character in turn. Use the up- and down-arrow pushbuttons 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. When either relay is set in a motor protection application, the present state of the thermal model is also displayed.

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

- Relay X or Relay Y triggers an event report
- A motor protection thermal element enters the alarm state
- An SEL-501 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 pushbutton.

Setting Changes Via the Front Panel

Press the front-panel **SET** pushbutton. Use the left- or right-arrow pushbuttons to underline X or Y, then press the **SELECT** pushbutton to indicate the relay you want 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 pushbuttons to scroll through the settings. When the relay displays a setting you want 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** pushbutton provides help-screen information when viewing or changing settings.

Relay Identifier Setting

To change the Relay Identifier setting, use the left- and right-arrow pushbuttons to underline the letter you want to change. Use the up- and down-arrow pushbuttons 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 pushbuttons to underline the number you want to change. Use the up- and down-arrow pushbuttons to scroll through the numbers. To change a pickup setting from a number to Off,

press the left- or right-arrow pushbutton 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 pushbutton once. Press **SELECT** when the setting is correct.

Enable, Disable Settings

Use the left- or right-arrow pushbutton 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 pushbuttons 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 and SEL-501-1 relays are 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 and SEL-501-1 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)
- Square D SY/MAX Protocol (SYMAX)—available only in the SEL-501-1
- Modbus RTU (MOD)—available only in the SEL-501

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 communications channel. For further details, refer to *Appendix D: Distributed Port Switch Protocol*.

Square D SY/MAX protocol is available in SEL-501-1 relays. For details, refer to *Appendix F: SY/MAX Protocol*.

Modbus RTU protocol is available only in SEL-501 relays. For details, refer to *Appendix G: Modbus RTU Communications Protocol*.

Serial port settings for each protocol are listed in *Table 7.1*.

Table 7.1 Communications Settings

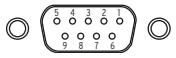
Field Description	Screen Name	Range	Default
PROTOCOL = SEL			
Port Protocol	PROTOCOL	SEL, LMD, SYMAX, MOD	SEL
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	DATA_BITS	7, 8	8
Parity	PARITY	N, E, O (N = None, E = Even, O = Odd)	N
Stop Bits	STOP	1, 2	1
Timeout	TIMEOUT	0–30 minutes	5
Automatic Message Output	AUTO	Y or N	Y
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, SYMAX, 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 = SYMAX (available in SEL-501-1 only)			
Port Protocol	PROTOCOL	SEL, LMD, SYMAX, MOD	SYMAX
ADDRESSX	ADDRESSX	1–99	2
ADDRESSY	ADDRESSY	1–99	3
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
PROTOCOL = MOD (Modbus protocol available in SEL-501 only)			
Port Protocol	PROTOCOL	SEL, LMD, SYMAX, MOD	MOD
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Parity	PARITY	N, E, O (N = None, E = Even, O = Odd)	N
Stop Bits	STOP	1, 2	1
Modbus Slave ID	SLAVEID	1–247	1

The SEL-501/SEL-501-1 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 7.2* and *Table 7.2*. The cable diagram shows two types of serial communication cables. These and other cables are available from SEL. Contact the factory for more information.



Female chassis connector, as viewed from outside panel

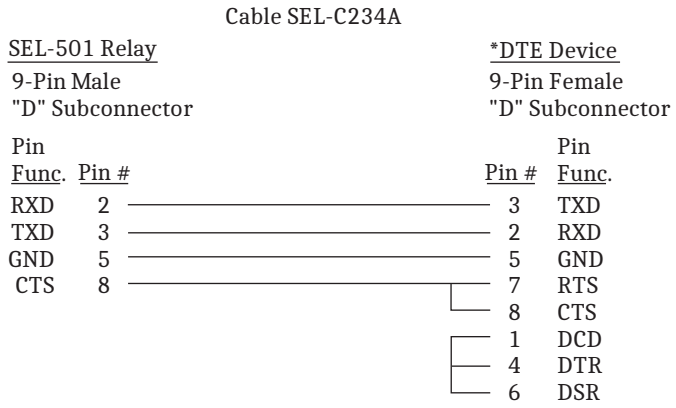
Figure 7.2 DB-9 Connector

Table 7.2 P1 DB-9 Connector Pinout Options

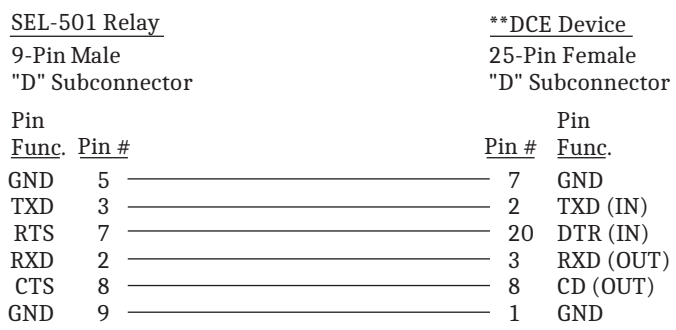
DB-9 Pin	EIA-232	EIA-485
1	N/C or +5 Vdc[a]	TX+
2	RXD	TX–
3	TXD	N/C
4	IRIG+	IRIG+
5	SHIELD	ISO_GND
6	IRIG-	IRIG–
7	RTS	RX+
8	CTS	RX–
9	DGND	DGND

[a] See Circuit Board Jumpers and Battery on page 2.11.

Serial Communication Cables for Use With the SEL-501



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



** DCE = Data Communications Equipment (Modem, etc.)

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 7.3*.

Table 7.3 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.
Thermal Alarm	The relay sends a thermal report each time a motor protection thermal element exceeds its alarm threshold.
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

⚠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.

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 jumper is one of two located between the front-panel LEDs and the control push-buttons. The serial port access levels are described in *Table 7.4*.

Table 7.4 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 7.6*.
2	=>>	501	Allows access to all commands including **PAS**, **SET**, and breaker control commands.
C	==>	332	Restricted access level, should be used under direction of SEL only.

The Access Level 1 and 2 passwords are factory-set to 501. You can change the passwords, using the Access Level 2 **PAS** command. The Access Level C password is factory-set to 332. You can change this password, using the Access Level C **PAS** command. 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-Iwg a501b

Setting Changes Via the Serial Port

To set the relay through 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 7.5*.

Table 7.5 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 settings.
<Ctrl+X>	Aborts editing session without saving changes.

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

When 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 7.6 Command Cross-Reference Table (Sheet 1 of 2)

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	**IRIG**	–	Force immediate attempt to synchronize interval clock to time code input.

Table 7.6 Command Cross-Reference Table (Sheet 2 of 2)

Access Level	Serial Port Command	Front-Panel Operations	Command Description
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	**TEMP *n***	**MAINT** > *n* > Temp	View thermal data. (*n* = X, Y)
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.
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	**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** > Pass	View or change password. (*l* = 1, 2, C; *###* = new password)
2	**RESET *n***	**MAINT** > *n* > EL	Reset thermal or 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 7.7 Access Level 2 Breaker Control Commands

Application[a]	Serial Port Command	Front-Panel Command	Closes Output
Fdr	**CLOSE *n*** **OPEN *n***	**CNTRL** > *n* > Close **CNTRL** > *n* > Open	*n*OUT2 (*n* = X, Y) *n*OUT1 (*n* = X, Y)
Mot	**RUN *n*** **STOP *n***	**CNTRL** > *n* > Run **CNTRL** > *n* > Stop	*n*OUT2 (*n* = X, Y) *n*OUT1 (*n* = X, Y)
Bfr	**RETRIP *n***[b] **86TR *n***[c]	**CNTRL** > *n* > Retrip[b] **CNTRL** > *n* > 86TR[c]	*n*OUT2 (*n* = X, Y) *n*OUT1 (*n* = X, Y)
Oc1	**1OUT *n*** **2OUT *n***	**CNTRL** > *n* > 1OUT **CNTRL** > *n* > 2OUT	*n*OUT1 (*n* = X, Y) *n*OUT2 (*n* = X, Y)
Tmr	**1OUT *n*** **2OUT *n***	**CNTRL** > *n* > 1OUT **CNTRL** > *n* > 2OUT	*n*OUT1 (*n* = X, Y) *n*OUT2 (*n* = X, Y)

[a] If APP = OFF, all commands are unavailable.

[b] If ERTR = N, this command is not available. The message Command invalid when ERTR=N is displayed.

[c] If ERTR = N, this command closes both outputs.

Selected Command Details

BREAKER Command

NOTE: In Breaker Failure protection applications, the external trip counter counts each time the BFI input is asserted. The internal trip counter does not count.

NOTE: In Overcurrent (APP = Fdr) and Motor protection applications, the external trip counter counts operations of the 52A input. The internal trip counter counts relay trips.

NOTE: In Overcurrent (APP = Oc1) protection applications, the internal trip counter counts relay trips for the first trip output contact to assert. The external trip counter does not count.

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 operations (Internal Trips) and as a result of other operations (External Trips).

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** pushbutton. Use the left- or right-arrow pushbuttons to underline X or Y, then press the **SELECT** pushbutton to indicate the relay data you want 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, use the up- and down-arrow pushbuttons to move through the data.

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.

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** pushbutton to inspect the most recent results of the relay self-tests. *Figure 7.3* 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-R100-V65X1XX-D930805


SELF TESTS


W=Warn    F=Fail


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


        +5V_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 7.3 Sample STATUS Report

Table 7.7 describes the STATUS report.

Table 7.8 Self-Test Status Report Description

Parameter	Description
OS: IAX–ICY, MOF	DC offset 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** command allows you to view the present condition of any relay control input or contact output, and selected relay elements.

To review TARGET data through use of the front panel, press the **MAINT** pushbutton. Use the left- or right-arrow pushbuttons to underline X or Y, then press the **SELECT** pushbutton to indicate the relay data you want to review. Underline and select the TAR command, then use the up- and down-arrow pushbuttons 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 7.14*). Target 2, 3, and 4 show different elements, depending upon the application of the selected relay.

Table 7.9 Overcurrent Protection Application Target Command Table (APP = Fdr or APP = Oc1)

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	*	*	*	*	*

Table 7.10 Feeder Protection Application 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
51NP	Residual Time-Overcurrent Pickup
50PP	Definite-Time Phase Overcurrent Pickup
*	Future Use
50QP	Definite-Time Negative-Sequence Overcurrent Pickup

Table 7.10 Feeder Protection Application Target Definitions (Sheet 2 of 2)

Element	Definition
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

[a] 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.

Table 7.11 Motor Protection Application Target Command Table (APP = Mot)

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	49	*	STL	50PT	50H	50QT	50NT	50NH
Target 3	49A	50L	50ST	50PP	LLOSS	50QP	50NP	LJAM

Table 7.12 Motor Protection Application 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
49	Thermal Trip Level Exceeded
*	Future Use
STL	Starts-per-Hour Limit Exceeded
50PT	Definite-Time Phase Overcurrent Trip
50H	Instantaneous Phase Overcurrent Trip
50QT	Definite-Time Negative-Sequence Overcurrent Trip
50NT	Definite-Time Residual Overcurrent Trip
50NH	Instantaneous Residual Overcurrent Trip
Element	Definition
49A	Thermal Alarm Level Exceeded

Table 7.12 Motor Protection Application Target Definitions (Sheet 2 of 2)

Element	Definition
50L	Motor Live Overcurrent Pickup (0.1 per unit FLA)
50ST	Start Current Detected (2.5 per unit FLA)
50PP	Definite-Time Phase Overcurrent Pickup
LLOSS	Motor Load-Loss Detected
50QP	Definite-Time Negative-Sequence Overcurrent Pickup
50NP	Definite-Time Residual Overcurrent Pickup
LJAM	Motor Load-Jam Detected

Table 7.13 Breaker Failure Protection Application Target Command Table (APP = Bfr)

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	86TR	RTRP	62T	50PP	*	*	50NP	*

Table 7.14 Breaker Failure Relay Target Definitions

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
86TR	Breaker Failure Trip
RTRP	Breaker Retrip
62T	Breaker Failure 62FC timer running
50PP	Phase Overcurrent Pickup
*	Future Use
50NP	Residual Overcurrent Pickup

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

TEMP Command

The relay **TEMP** command shows the present state of the motor thermal element. The thermal model output is shown in percent of rated trip level. This command also causes the relay to display the magnitudes of the positive- and negative-sequence currents and the number of starts detected in the past hour.

Relay Alarm Conditions

The relay asserts the ALARM output when dc power is removed, at any diagnostic test failure, or if a motor protection thermal element exceeds its alarm level. 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 7.15*.

Table 7.15 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

SECTION 8

Event Reporting

Introduction

The SEL-501 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 below. 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. Use the serial port **EVENT** command to review full-length event reports.

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 an overcurrent, motor, or breaker failure trip
- Relay X or Relay Y issues a breaker close or a breaker failure retrip
- Pickup of a definite-time or time-overcurrent element
- Thermal alarm
- Breaker failure initiate
- Motor start
- External trigger input assertion
- Timer time-out

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 in the SEL-501 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 8 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 on page 8.7* (for more information on the cosine filter and bipolar peak detector, see *CT Saturation Protection in the SEL-501 (Not Included in the SEL-501-1) on page 1.4*.

The Event Report Summary in the SEL-501-1 shows the fault current magnitude calculated by the cosine filter and displays that result.

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 sixteenth cycle, filters the data, processes these data every eighth or quarter 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 are 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 one sixteenth-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.

Table 8.1 EVENT Command

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, rms. 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. The specific information contained in each column depends upon the Relay X and Relay Y application settings.

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

Table 8.2 Element/Input Columns: Overcurrent Application (APP = FDR) (Sheet 1 of 2)

Column	Symbol	Definition
All	.	Element not picked up
51P	p	Phase time-overcurrent element 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	Neg-seq definite-time overcurrent element picked up
	T	Neg-seq 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
52A	*	Circuit breaker is closed

Table 8.2 Element/Input Columns: Overcurrent Application (APP = FDR) (Sheet 2 of 2)

Column	Symbol	Definition
OUT	1 2	TRIP output is closed CLOSE output is closed
ALRM	*	SEL-501 ALARM output is indicating an alarm state

Table 8.3 Element/Input Columns: Overcurrent Application (APP = OC1)

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

Table 8.4 Element/Input Columns: Motor Application (APP = MOT) (Sheet 1 of 2)

Column	Symbol	Definition
All	.	Element not picked up
49	a T	Temperature estimate exceeds alarm level Thermal element trip
50S	S	Motor Start Detected
50P	p T H	Phase definite-time overcurrent element picked up Phase definite-time overcurrent element trip Phase instantaneous overcurrent element trip
50Q	q T	Neg-seq definite-time overcurrent element picked up Neg-seq definite-time overcurrent element trip
50N	n T H	Residual definite-time overcurrent element picked up Residual definite-time overcurrent element trip Residual instantaneous overcurrent element trip
LD	L J	Load-Loss trip Load-Jam trip
52A	*	Circuit breaker is closed

Table 8.4 Element/Input Columns: Motor Application (APP = MOT) (Sheet 2 of 2)

Column	Symbol	Definition
OUT	1 2	TRIP output is closed CLOSE output is closed
ALRM	*	SEL-501 ALARM output is indicating an alarm state

Table 8.5 Element/Input Columns: Breaker Failure Application (APP = BFR)

Column	Symbol	Definition
All	.	All indications deasserted
50P	P	Phase overcurrent element picked up
50N	N	Residual overcurrent element picked up
62	t B	Breaker failure 62FC timer running Breaker failure timer expired
BFI	*	Breaker failure initiate input asserted
OUT	1 2 b	86TR output is closed RETRIP output is closed Both outputs are closed
ALRM	*	SEL-501 ALARM output is indicating an alarm state

Table 8.6 Element/Input Columns: Timer Application (APP = TMR)

Column	Symbol	Definition
All	.	Element not picked up
IN	*	Input asserted
OUT	1 2 b	OUT1 output is closed (Timer 1 timed out) OUT2 output is closed (Timer 2 timed out) Both outputs are closed
ALRM	*	SEL-501 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 8.7*.

Table 8.7 Event Type (Sheet 1 of 2)

Event	Event Triggered By:
TRIG	**TRIGGER** command
FAULT	Overcurrent element operation
OPEN	**OPEN** command (APP = FDR)
CLOSE	**CLOSE** command (APP = FDR)
RUN	Motor **RUN** command

Table 8.7 Event Type (Sheet 2 of 2)

Event	Event Triggered By:
START	Motor start detected
STOP	Motor **STOP** command
THERM	Motor thermal element operation
STL	Motor Starts-per-Hour Limit operation
LJAM	Motor load-jam
LLOSS	Motor load-loss
BFI	Breaker failure initiate
RETRIP	Breaker failure **RETRIP** operation or command
86TR	Breaker failure operation or 86TR command
EXT	Input IN = ET (External Trigger) assertion (APP = OC1)
TIMER1	Timer 1 timeout
TIMER2	Timer 2 timeout
1OUT	**1OUT** command (APP = OC1 or APP = TMR)
2OUT	**2OUT** command (APP = OC1 or APP = TMR)

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 in response to a simulated phase-to-phase fault, cleared by the Relay X negative-sequence time overcurrent element, 51QT.

```
FEEDER 1                                  Date: 06/11/94   Time:
   06:41:40.913                                                          Time-tag corresponds to the 8th
                                                                            quarter-cycle of this event
BFR 1


FID=SEL-501-R106-V65X1XXpa-D940525

                                                        Relay X    Relay Y  A
         Relay X                     Relay Y           555555  5O    5 5  BO L
         Amps Pri                    Amps Pri          111000  2U    0 06 FU R
  IRX    IAX    IBX    ICX     IRY    IAY    IBY    ICY  PQNPQN  AT    P N2 IT M

    -2    392    224   -618      -0    393    228   -621 ......  *.    P .. .. .
     0   -491    586    -94       2   -495    585    -88 ......  *.    P .. .. .
     1   -389   -230    620      -4   -389   -235    621 ......  *.    P .. .. .      One cycle of data
    -2    493   -583     88      -2    494   -585     89 ......  *.    P .. .. .

    -2    386    234   -622       2    386    240   -623 ......  *.    P .. .. .      Relay Y 50PP element is picked
     4   -495    582    -84      -0   -499    585    -86 ......  *.    P .. .. .
    -2   -382   -239    620       3   -380   -243    626 ......  *.    P .. .. .
    -8    496  -1141    637      -6    500  -1693   1186>pq....  *.    P .. .. .      Relay X 51PT and 51QT time-
                                                                            overcurrent elements pick up for
                                                                            BC fault, triggering this
                                                                            report. Breaker is closed.
     8    380   -450     78       8    381  -1172    799 pq....  *.    P .. .. .
     6   -501   2738  -2231       7   -505   3788  -3276 pq....  *.    P .. .. .
   -13   -377   1244   -880     -10   -376   1358   -992 pq....  *.    P .. .. .
    -8    502  -3783   3273     -13    503  -3795   3279 pq....  *.    P .. .. .
                          .
[Four cycles of data]     .
                          .
     5    341  -1126    790      10    342  -1123    791 pq....  *.    P .. .. .
     2   -526   3858  -3330       8   -526   3873  -3338 pq....  *.    P .. .. .
    -5   -339   1105   -770     -11   -341   1094   -764 pq....  *.    P .. .. .
    -3    528  -3863   3333      -8    529  -3878   3340 pq....  *.    P .. .. .

     5    337  -1077    745       6    334  -1058    730 pT....  *1    P .. .. .      Relay X 51QT element times out,
                                                                            causing a trip.
     4   -531   3872  -3337       4   -532   3883  -3347 pT....  *1    P .. .. .
    -6   -333   1049   -722     -10   -332   1038   -716 pT....  *1    P .. .. .
    -6    533  -3881   3343     -11    535  -3900   3354 pT....  *1    P .t *. .      Breaker Failure Initiate input is
                                                                            asserted, starting breaker
                                                                            failure timer.
     6    329  -1025    702       7    326  -1006    687 pT....  *1    P .t *. .
     4   -535   3887  -3348       5   -534   3897  -3358 pT....  *1    P .t *. .
    -6   -325    998   -678     -10   -324    975   -660 pT....  *1    P .t *. .
    -5    535  -3892   3352      -8    540  -3908   3360 pT....  *1    P .t *. .
                          .
[Two cycles of data]      .
                          .
```

Figure 8.1 Example Event Report

```
    -2    178   -449    268    -10     44     21    -74 pT....  *1    P .t *. .
    -1   -180   1122   -943      1      0      0      1 pT....  *1    . .. *. .
     3    -24      7     20     -5     -2     -2     -2 pT....  .1    . .. *. .
     0      0      0      0      0      0      0      0 ......  ..    . .. *. .

     0      0      0      0     -2     -2      0      0 ......  ..    . .. *. .
    -1     -1      0      0     -2     -2      0      0 ......  ..    . .. *. .
    -2     -1     -1      0      1      0      0      1 ......  ..    . .. .. .
     0      0      0      0     -2     -2     -2      1 ......  ..    . .. .. .

     2      1      0      0      1      1      0      0 ......  ..    . .. .. .
    -1      0     -1      0      0      0      0      0 ......  ..    . .. .. .
    -2     -1     -1      0      0      0      0      0 ......  ..    . .. .. .
     0      0      0      0      0      0      0      0 ......  ..    . .. .. .

Event: FAULT X            Targets:X B C Q          Duration:   11.00
Relay X Currents (A Pri), ABCQN:     626   1165    888    242      2
Relay Y Currents (A Pri), ABCQN:     628   1710 pk 1341   481      2

Relay X Settings:
ID    = FEEDER 1
APP   = FDR     CTR   = 120     DATC  = 15
50PP  = 15.5    50PD  = 20.00   50H   = 40.0
50QP  = 10.8    50QD  = 18.00
50NP  = 4.3     50ND  = 15.00   50NH  = 18.0
51PP  = 7.50    51PC  = U4      51PTD = 3.20
51PRS = N
51QP  = 5.00    51QC  = U4      51QTD = 1.10
51QRS = N
51NP  = 2.25    51NC  = U4      51NTD = 2.00
51NRS = N

Relay Y Settings:
ID    = BFR 1
APP   = BFR     CTR   = 120     DATC  = 15
50PP  = 4.0     50NP  = 2.0     FC    = 10.50
ERTR  = N
```

Breaker operates, clearing fault.

Event Summary

Relay X set for overcurrent protection

Relay Y set for breaker failure protection

Figure 8.1 Example Event Report (Continued)

SECTION 9

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 7: Operation*.

Low-Level Test Interface

⚠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.

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

Figure 9.1 shows the interface connections. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

You can test the relay processing module through use of 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 9.1* 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.

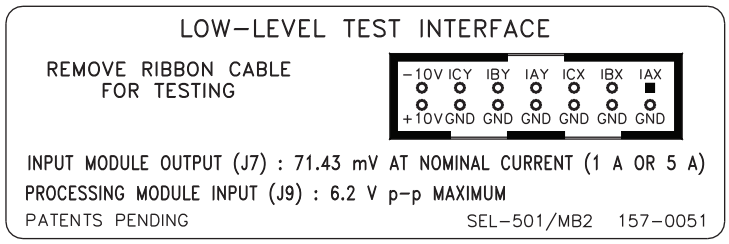


Figure 9.1 Low-Level Test Interface

Test Methods

Test the pickup and dropout of relay elements through use of 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, 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 7.10* 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 feeder relay 50H and 51PP phase overcurrent elements and the residual and negative-sequence overcurrent elements 50NP, 50NH, 51NP, 50QP, and 51QP. Relay X, set for feeder protection applications, 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 now displays the state of several Relay X overcurrent elements on the front-panel LED and LCD, as shown in the following table.

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 can be applied to test the feeder relay 51PT and 51QT time-overcurrent elements. Relay X, set for feeder protection applications, 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. Using 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 in *Time-Overcurrent Element Operate/Reset Curve Equations on page 3.11*. TD is the time-dial setting, 51NTD, and M is the applied multiple of pickup current.

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.

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):

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

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

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*.

Thermal Element: 49

NOTE: Relay X, set for motor protection applications, is used in this example. The example is also applicable to Relay Y, when set with APP = Mot.

Step 1. Execute the **SHOW** command and verify the relay settings for the thermal model. Settings of interest are: FLA, LRA, LRT, and TD.

Step 2. Using the **SET X** command, set 50PP, 50H, 50QP, 50NP, and 50NH to Off. Set ELJ and ELL to N. The Off and N settings disable these elements, leaving only the 49 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 three current sources to the phase current inputs of Relay X.

Step 4. Calculate the expected operating time of the 49 element. Use the element settings and the operating time equation shown below.

$$tp = TD \bullet \left(\frac{LRT}{(I/LRA)^2}\right)$$

where:

tp = expected operating time

I = applied three-phase test current magnitude (greater than 2.5 • FLA)

For example, if TD = 0.95, LRT = 12, and LRA = 25, we can use the equation to calculate the expected operating time for I = 25 A:

tp = 11.4 seconds

NOTE: The thermal element cools based upon the calculated thermal time constant of the motor and may take some time to cool fully. If the element is not cool when you run a second test, the time to trip will be lower than expected. To reset an element before running additional tests, use the **RESET** command from the relay serial port, or the **EL** command, under **MAINT**, from the relay front panel.

Step 5. Set the current sources to deliver (I) amperes, balanced phase angles, and turn them on. The timer should start. When the thermal element reaches the trip temperature, Relay X should trip, stopping the timer. The time recorded should be approximately equal to the time calculated in *Step 4*. Use the **TEMP** command to review the temperatures calculated.

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 9.1*):

- 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 9.1 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	Measures the +5 volt power supply every 0.2 seconds.
	Failure	+4.70 V +5.50 V	Yes	Latched	

Table 9.1 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
±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.
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 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 micro-processor 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.
+5 V PS Under-/ Overvoltage	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 on page 9.6*.

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 the relay off.

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.
3. Relay X and Relay Y APP settings OFF.

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 communication 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 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

This page intentionally left blank

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.

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

NOTE: The SEL-501-1 is not available with firmware version R950.

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-**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-**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 SEL-501 Firmware Revision History (Sheet 1 of 3)

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

Table A.1 SEL-501 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-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-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.	991129
SEL-501-R525-D991129	60 Hz, 5 A, ABC Rotation		
SEL-501-R575-D991129	60 Hz, 5 A, ACB Rotation		
SEL-501-R625-D991129	50 Hz, 5 A, ABC Rotation		
SEL-501-R725-D991129	60 Hz, 1 A, ABC Rotation		
SEL-501-R775-D991129	60 Hz, 1 A, ACB Rotation		
SEL-501-R825-D991129	50 Hz, 1 A, ABC Rotation		
Does not support PROTO = MOD			
SEL-501-R507-D991129	60 Hz, 5 A, ABC Rotation		
SEL-501-R554-D991129	60 Hz, 5 A, ACB Rotation		
SEL-501-R604-D991129	50 Hz, 5 A, ABC Rotation		
SEL-501-R704-D991129	60 Hz, 1 A, ABC Rotation		
SEL-501-R751-D991129	60 Hz, 1 A, ACB Rotation		
SEL-501-R804-D991129	50 Hz, 1 A, ABC Rotation		
SEL-501-R750-D980715	60 Hz, 1 A, ACB Rotation	➤ Added new configuration.	980715
SEL-501-R506-D970417	60 Hz, 5 A, ABC Rotation	➤ Software improvements.	970414
SEL-501-R553-D970417	60 Hz, 5 A, ACB Rotation		
SEL-501-R603-D970417	50 Hz, 5 A, ABC Rotation		
SEL-501-R703-D970417	60 Hz, 1 A, ABC Rotation		
SEL-501-R803-D970417	50 Hz, 1 A, ABC Rotation		
SEL-501-R505	60 Hz, 5 A, ABC Rotation	➤ Decreased power-up initialization time.	[a]
SEL-501-R552	60 Hz, 5 A, ACB Rotation		
SEL-501-R602	50 Hz, 5 A, ABC Rotation		
SEL-501-R702	60 Hz, 1 A, ABC Rotation		
SEL-501-R802	50 Hz, 1 A, ABC Rotation		
SEL-501-R504	60 Hz, 5 A, ABC Rotation	➤ Corrected front-panel targeting problem. Front-panel targets are illuminated if relay trips by 50H or 50NH.	[a]
SEL-501-R551	60 Hz, 5 A, ACB Rotation		
SEL-501-R601	50 Hz, 5 A, ABC Rotation		
SEL-501-R701	60 Hz, 1 A, ABC Rotation		
SEL-501-R801	50 Hz, 1 A, ABC Rotation		
SEL-501-R550	60 Hz, 5 A, ACB Rotation	➤ Hardware implemented to support RTS_CTS serial port setting (Serial number 96192039 and above).	[a]
SEL-501-R600	50 Hz, 5 A, ABC Rotation		
SEL-501-R700	60 Hz, 1 A, ABC Rotation		
SEL-501-R800	50 Hz, 1 A, ABC Rotation		
SEL-501-R503	60 Hz, 5 A, ABC Rotation	➤ Hardware implemented to support RTS_CTS serial port setting (Serial number 96192039 and above). ➤ Made Fast Meter and Fast Operate independent of ASCII commands.	[a]
SEL-501-R502	60 Hz, 5 A, ABC Rotation	➤ Add IRIG, Fast Meter, Fast Operate, LMD, and BFR logic modifications.	[a]

Table A.1 SEL-501 Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number		Summary of Revisions	Date Code
SEL-501-R501	60 Hz, 5 A, ABC Rotation	➤ Passwords changed to allow up to 6 alphanumeric characters.	[a]
SEL-501-R500	60 Hz, 5 A, ABC Rotation	➤ Added serial port settings: ➢ DATA_BITS ➢ STOP ➢ RTS_CTS: Not supported by hardware. Hardware to support RTS_CTS implemented with firmware releases R503, R550, R600, R700, and R800 (Serial number 96192039 and above).	[a]

[a] Information about changes to earlier versions of the SEL-501-0-1 Instruction Manual is not available.

Table A.2 SEL-501-1 Firmware Revision History

Firmware Identification (FID) Number		Summary of Revisions	Date Code
SEL-501-1-R503-970417	60 Hz, 5 A, ABC Rotation	➤ Software improvements.	[a]
SEL-501-1-R502	60 Hz, 5 A, ABC Rotation	➤ Added new firmware version containing Square D SY/MAX Protocol.	[a]

[a] Information about changes to earlier versions of the SEL-501-0-1 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.3 Instruction Manual Revision History (Sheet 1 of 7)

Date Code	Summary of Revisions
20250131	Preface ➤ Updated *General Safety Marks*. Section 2 ➤ Updated *Clock Battery*. Appendix I ➤ Updated *Product Function*, *Secure Operation Recommendations*, *Alarm Contact*, and *Malware Protection Features*.
20230907	Appendix A ➤ Updated *Determining the Firmware Version*. ➤ Revised R950 FID. Appendix I ➤ 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*. Section 2 ➤ Updated *Figure 2.15: AC/DC Connections for Breaker Failure Protection Applications (Setting APP = BFR)*.

Table A.3 Instruction Manual Revision History (Sheet 2 of 7)

Date Code	Summary of Revisions
	SEL-501/SEL-501-1 Relay MOT Settings Sheets ➤ Updated *Load-Jam/Load-Loss Elements*. Section 9 ➤ Updated *Table 9.1: Relay Self-Tests*. Appendix F ➤ Updated title. Appendix G ➤ Updated title. Appendix I ➤ Added new appendix.
20220630	Appendix A ➤ Added cybersecurity information to *Revision History*. ➤ Updated *Table A.1: SEL-501 Firmware Revision History* for R950, R902, R901, and R900.
20220113	Appendix B ➤ Updated *Firmware (EPROM) Upgrade Instructions*.
20211203	Section 1 ➤ Updated compliance information in *Specifications*.
20210406	Section 1 ➤ Added *Figure 1.2: SEL-501 Relay Front Panel With Front Serial Port.* Section 2 ➤ Added *Figure 2.5: SEL-501 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 Relay Front Panel With Front Serial Port, Rack-Mount Version (Half-Rack Width).* ➤ Added *Figure 2.9: SEL-501 Relay Front Panel With Front Serial Port, Panel-Mount Version.* ➤ Added *Figure 2.11: SEL-501 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/SEL-501-1 Relay OC1 Settings Sheets ➤ Updated *Protocol Setting (SET P 1) Rear Panel.* ➤ Added *Protocol Setting (SET P F) Front Panel.* SEL-501/SEL-501-1 Relay FDR Settings Sheets ➤ Updated *Protocol Setting (SET P 1) Rear Panel.* ➤ Added *Protocol Setting (SET P F) Front Panel.* SEL-501/SEL-501-1 Relay MOT Settings Sheets ➤ Updated *Protocol Setting (SET P 1) Rear Panel.* ➤ Added *Protocol Setting (SET P F) Front Panel.* SEL-501/SEL-501-1 Relay BFR Settings Sheets ➤ Updated *Protocol Setting (SET P 1) Rear Panel.* ➤ Added *Protocol Setting (SET P F) Front Panel.* SEL-501/SEL-501-1 Relay TMR 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.

Table A.3 Instruction Manual Revision History (Sheet 3 of 7)

Date Code	Summary of Revisions
	Appendix B ➤ Updated entire appendix for firmware version R950.
20191107	**Section 1** ➤ Updated *Specifications*.
20190809	**Appendix H** ➤ Added *Appendix H: PC Software*.
20170802	**Section 1** ➤ Updated compliance information in *General Specifications*.
20151105	**Section 1** ➤ Updated compliance information in *General Specifications*.
20150126	**Preface** ➤ Added *Safety Information*. **Section 1** ➤ Updated compliance information and tightening torque values in *General Specifications*.
20111101	**Appendix A** ➤ Updated for firmware version R902.
20100730	**Section 1** ➤ Updated *General Specifications*. **Section 2** ➤ Updated *EIA-232 Serial Communications Port Voltage Jumper (EIA-232 Option Only)*. **Section 3** ➤ Updated timing accuracy information in *Overcurrent Elements Specifications*. **Section 7** ➤ Added CAL level information. ➤ Added note regarding 50QT element in *Feeder Protection Application Target Definitions*.
20071025	**Section 1** ➤ Add 110 Vdc option to Optoisolated Input Ratings information in *General Specifications*.
20050725	**Section 1** ➤ Changed one-second thermal rating from 250 A to 500 A. **Section 2** ➤ Updated *Figure 2.13: Input and Output Jumper Locations (Conventional Terminal Blocks Option Only)*. ➤ Updated *Figure 2.14: Output Contact YOUT2 Control Jumper Location*. ➤ Updated *Table 2.2: Required Position of Jumper JMP13 for Desired Output Contact YOUT2*. **Section 8** ➤ Corrected command **EVENT R *n*** to **EVENT *n* R**. **Appendix B** ➤ Updated *Firmware Upgrade Instructions*. **Appendix G** ➤ Corrected errors in *Table G.18: Modbus Map*.
20050120	**Appendix G** ➤ Corrected Modbus Map under location 00B8 in *Table G.18: Modbus Map*.
20031008	**Section 1** ➤ Modified *CT Saturation Protection in the SEL-501 (Not Included in the SEL-501-1)* information. **Section 8** ➤ Modified text in *Event Summary*.

Table A.3 Instruction Manual Revision History (Sheet 4 of 7)

Date Code	Summary of Revisions
	Appendix A ➤ Updated for firmware version R901.
20021025	Section 1 ➤ Modified Optoisolated Input Ratings information in *General Specifications*. Section 2 ➤ Modified text in *Control Voltage Jumpers (Conventional Terminal Blocks Option Only)*.
20021002	Manual Change Information ➤ Combined with *Appendix A*. ➤ Removed from manual. Preface ➤ Added standard conventions. Section 1 ➤ Added *CT Saturation Protection in SEL-501* subsection. ➤ Added Level-Sensitive (Conventional Terminal Blocks Option) information to *General Specifications*. Section 2 ➤ Added *Relay Mounting* instructions. ➤ Replaced the following figures with new hardware drawings and/or changed their location and caption: ➢ *Figure 2.1: SEL-501 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 Relay with Rack Mount Bracket 9100 (bracket on right side in front view)* ➢ *Figure 2.4: SEL-501 Relay Fitted with Mounting Bracket (SEL P/N 9100) for Mounting in a 19-Inch Rack* ➤ Removed *Figure 2.5: SEL-501 Relay Fitted with Mounting Bracket (SEL P/N 9102) for Mounting in 19-Inch Rack Including Cutout to Fit an FT-1 Test Switch*. ➤ Inserted the following new figures: ➢ *Figure 2.5: Relay Front Panel, Rack-Mount Version (Half Rack Width)* ➢ *Figure 2.6: Relay Front Panel, Panel-Mount Version* ➤ Renumbered *Figure 2.6* and *Figure 2.7* to be *Figure 2.7* and *Figure 2.8*. ➤ Updated *Rear Panel Connections* subsection. ➤ Removed Convention Terminal Blocks Option in *Figure 2.6* and Plug-In Connectors Option in *Figure 2.7* headings. ➤ Added *Connectorized* subsection. ➤ Modified *Figure 2.8* (now *Figure 2.9*) through *Figure 2.11* (now *Figure 2.12*) (all AC/DC Connections drawings). Section 3 ➤ Updated figure references. ➤ Added CT Sizing subsection. ➤ Added step size information. ➤ Added Transient Overreach information to *Overcurrent Element Specifications*. 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, and Stored event report information. Section 8 ➤ Added **EVENT R** to the *Command Cross-Reference* table. Appendix A ➤ Updated for firmware version R900. ➤ Incorporated Manual Change Information.

Table A.3 Instruction Manual Revision History (Sheet 5 of 7)

Date Code	Summary of Revisions
	Appendix E ➤ Corrected "Length" 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 4** ➤ Replaced "inverse-time" with "time-overcurrent." **Section 8** ➤ Replaced "inverse-time" with "time-overcurrent."
20010518	➤ Added Caution, Danger, and Warning information to the back of the cover page of the manual. ➤ Updated passcode wording with password throughout the manual. **Section 1** ➤ Added Tightening Torque information to *General Specifications*. ➤ Updated *Power Supply* specification. **Section 2** ➤ Added caution note to the *Clock Battery* subsection. **Section 3** ➤ Updated 1OUT command execution information. **Section 7** ➤ Added **1OUT *n*** and **2OUT *n*** command information to *Table 7.5: Command Cross-Reference Table*. ➤ Added Target 0 and Target 1 information to *Table 7.8: Overcurrent Protection Application Target Command Table*. **Appendix A** ➤ Added clarification to *RTS_CTS Serial Port Setting*.
000131	**Section 3** ➤ Reissued entire section to correct pagination. **Appendix G** ➤ Made revisions and corrections.
991129	**Section 1** ➤ Made minor corrections. **Section 2** ➤ Updated relay panel cutout and drill guides. ➤ Added new *Figure 2.2*, *Figure 2.4*, and *Figure 2.5*. ➤ Updated *Figure 2.7* to document new current shorting connectors for Connectorized models. ➤ Added sections *EIA-232 Serial Communications Port Voltage Jumper* and *Output Contact YOUT2 Control Jumper*. **Section 3** ➤ Revised *OC1 Settings Sheets* and *FDR Settings Sheets*. **Section 4** ➤ Revised *MOT Settings Sheets*. **Section 5** ➤ Revised *BFR Settings Sheets*. **Section 6** ➤ Revised *TMR Settings Sheets*.

Table A.3 Instruction Manual Revision History (Sheet 6 of 7)

Date Code	Summary of Revisions
	Section 7 ➤ Revised *Table 7.1* and associated text preceding the table. ➤ Updated *Table 7.2*. **Section 9** ➤ Added relay self-test section. **Appendix B** ➤ Added *Appendix B: Firmware Upgrade Instructions*. Incremented letter of all subsequent appendices. **Appendix E** ➤ Added *Appendix E: Configuration, Fast Meter, and Fast Operate Commands*. Incremented letter of all subsequent appendices. **Appendix G** ➤ Added *Appendix G: Modbus RTU Communications Protocol*.
981101	**Section 2** ➤ Updated relay panel cutout and drill guides. ➤ Updated *Figure 2.4* to document new current shorting connectors for Connectorized models. **Section 3** ➤ Added *OC1 Settings Sheets* and *FDR Settings Sheets*. **Section 4** ➤ Added *MOT Settings Sheets*. **Section 5** ➤ Added *BFR Settings Sheets*. **Section 6** ➤ Added *TMR Settings Sheets*.
980715	**Appendix A** ➤ Updated for firmware version R750.
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** ➤ Removed note to show availability of 250 V "Level-Sensitive" inputs.
970725	**Section 1** ➤ Removed Specifications Addendum and incorporated specifications into *Section 1*. ➤ 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 255-22-3-1989 ➢ IEC 255-22-4-1992 ➢ IEC 695-2-2-1991 ➢ UL 508 Listing ➤ Added 24-volt power supply rating to *Output Contacts*, *Optoisolated Input Ratings*, and *Power Supply Ratings*. **Section 7** ➤ Corrected *Serial Communication Cables for Use with the SEL-501 Relay* cable information.
970424	➤ Added *Specifications Addendum*.

Table A.3 Instruction Manual Revision History (Sheet 7 of 7)

Date Code	Summary of Revisions
970414	Section 2 ➤ Clarified *Password and Breaker Control Command Jumpers*. Section 9 ➤ Modified LCD contrast adjustment steps in *Troubleshooting Procedure*.
970204	➤ Initial version.

This page intentionally left blank

APPENDIX B

Firmware (EPROM) Upgrade Instructions

The hardware of the SEL-501 relays that shipped with firmware versions R902 or earlier differs from the hardware of the SEL-501 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, please contact SEL for assistance.

Technical Support

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

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

This page intentionally left blank

APPENDIX C

Electronic-Level Input Option

The SEL relay instruction manuals address standard current (1 or 5 A) inputs. If you ordered your SEL relay with an electronic-level input option, references in the instruction manual to Current Inputs should be noted accordingly. Because the input circuits are designed to accept electronic levels, do not subject them to Dielectric Strength, Interference, or Impulse Tests. Stickers on the rear of the relay indicate which inputs should only be connected to low-level electronic sources. We recommend that you use twisted-shielded-pair (TSP) cable between the source and relay and that you ground the shield at one end of the cable.

Because the SEL-501 is set in secondary quantities and nonconventional sensor outputs are in primary quantities, you must scale the relay settings through use of the CTR (Current Transformer Ratio). The CTR is determined by dividing your 1 per-unit primary current by 5 A. Use the CTR to determine the settings in secondary quantities.

Example: CTR = 2000/5 = 400

Maximum Continuous Rating

Input: 15 $V_{peak} \approx 10.6\ V_{rms}$

Relay Test System (RTS)

The SEL RTS Relay Test System is designed to bypass the internal CTs and PTs (or low-level input module) of a relay so that it can provide low-level signals directly to the relay processing module. You can use the SEL RTS to test the low-level input module of a relay at the terminal screws by modifying Scale Factors in the SELTEST Configuration Window. To determine the current channel ratio, divide 5 A by the secondary 1 PU input.

Example: (5 A)/(200 mV) = 25

This page intentionally left blank

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 or 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. This delay accommodates transmitters with a slow rise time.

Operation

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 timeup period, this command 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.

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

This page intentionally left blank

APPENDIX E

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.

SEL Application Guide AG95-10, *Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. *Message Lists* and *Message Definitions* provide a description of the messages provided in the SEL-501.

Message Lists

Table E.1 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
A5E3	Fast Operate Breaker Control

Table E.2 ASCII Configuration Message List

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

Message Definitions

A5C0 Relay Definition Block

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

Table E.3 A5C0 Relay Definition 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:

Table E.4 A5C1 Fast Meter Configuration Block (Sheet 1 of 3)

Data	Description
A5C1	Fast Meter command
6A	Length
01	One status flag byte
00	Scale factors in Fast Meter message
02	Two scale factors

Table E.4 A5C1 Fast Meter Configuration Block (Sheet 2 of 3)

Data	Description
06	# of analog input channels
04	# of samples per channel
09	# 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	
XX	Line Configuration: 00—ABC, 01—ACB
03	Currents only
FFFF	No skew adjustment
FFFF	
FFFF	No compensation
00	Channel index IAX
01	IBX
02	ICX
FF	
FF	

Table E.4 A5C1 Fast Meter Configuration Block (Sheet 3 of 3)

Data	Description
FF	
XX	Line configuration: 00—ABC, 01—ACB
03	Currents only
FFFF	No skew adjustment
FFFF	
FFFF	No compensation
03	Channel index IAY
04	IBY
05	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:

Table E.5 A5D1 Fast Meter Data 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:

Table E.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Message Block (Sheet 1 of 3)

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
76	Length
00	No status flag byte

Table E.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Message Block (Sheet 2 of 3)

Data	Description
00	Scale factors in Fast Meter message
00	No scale factors
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	

Table E.6 A5C2/A5C3 Demand/Peak Demand Fast Meter Configuration Message Block (Sheet 3 of 3)

Data	Description
0000	
334932590000	Analog channel name (3I2Y)
02	
FF	
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:

Table E.7 A5D2/A5D3 Demand/Peak Demand Fast Meter Message Block

A5D2 or A5D3	Command
56	Length
1-byte	Reserved
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 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:

Table E.8 A5CE Fast Operate Configuration Block (Sheet 1 of 2)

Data	Description
A5CE	Command
0E	Length
02	Support 2 circuit breakers
0000	Support 0 remote bits set/clear commands
0000	No support for remote bit pulse commands
31	Operate code, close 1OUTX

Table E.8 A5CE Fast Operate Configuration Block (Sheet 2 of 2)

Data	Description
11	Operate code, close 2OUTX
32	Operate code, close 1OUTY
12	Operate code, close 2OUTY
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E3 Fast Operate Breaker Control

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

Table E.9 A5E3 Fast Operate Breaker Control Message

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

The relay performs the specified breaker operation if the breaker jumper (**JMP24**) is in place on the SEL-501 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 below.

```
<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>
```

where:

<STX> = the STX character (02)

<ETX> = the ETX character (03)

yyyy = 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 DNA message is:

```
<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>
```

where:

<STX> = the STX character (02).

<ETX> = the ETX character (03).

“xxx” = an element name in ASCII (the relay prepends an X to the Relay X names and a Y to the Relay Y names.

“yyyy” = the 4-byte ASCII hex representation of the checksum for the line.

“*” = 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:

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

where:

“yyyy” = the 4-byte ASCII representation of the checksum.

“*” = an unused bit location.

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

APPENDIX F

SY/MAX Protocol

Overview

The SEL-501-1 supports the Square D PowerLogic SY/MAX protocol. The SY/MAX protocol is a client/server protocol. The SEL-501-1 always appears as an end device and operates in a server mode with a designated host computer. In this mode, SEL-501-1 relays will only respond when spoken to via a valid message. The SEL-501-1 cannot and will not originate messages. The host computer can be any one of the following:

- Square D PowerLogic Network Interface Module (PNIM)
- IBM PC or compatible with a SY/LINK interface card
- IBM PC or compatible with an EIA-232 interface
- IBM PC or compatible with an EIA-485 interface

The SEL-501-1 understands and responds to a subset of the allowable SY/MAX opcodes (see *Command Set on page F.6* for details). By using these opcodes correctly, all SEL-501-1 operations can be accomplished, except reading and changing settings, and TEMP data can be accessed. *Table F.3* lists the SEL-501-1 register map.

The SEL-501-1 contains two relays: Relay X and Relay Y. You need to set a unique server address for Relay X and Relay Y, respectively. The SY/MAX client views the SEL-501-1 as two individual devices, each with a unique SY/MAX server address.

This document briefly describes the SY/MAX protocol relevant to SEL-501-1 implementation. For further details, reference Square D Bulletin #30598-712-01, and R3086.31-05.

In this appendix, hexadecimal numbers are indicated with a preceding "0x." Decimal numbers are not specially indicated. In protocol examples, hexadecimal numbers are used exclusively, without special indication.

Settings

From the SEL-501-1 front panel, go into port settings. Set the protocol to "SYMAX". The SEL-501-1 will prompt for server addresses for Relay X and Relay Y. With the server address setting, you provide the server device addresses for SY/MAX protocol access to data from the desired relays. The range of valid addresses is 1–99. Then set your communication parameters: band rate, data bits, parity, and stop bits.

Hardware Connections and RTS Line Usage

You have the option to buy an SEL-501-1 with an EIA-232 or EIA-485 port. An EIA-485 connection is the most common connection between an SEL-501-1 and Square D SY/LINK card. An EIA-232 connection can be used to connect an SEL-501-1 and an IBM PC or compatible directly. See *Section 7: Operation* for more information on the serial port connection.

NIM and PNIM Protocols

The SY/MAX protocol includes two similar protocols. One is NIM and another is PNIM. The NIM and PNIM protocols are slightly different in several respects:

- The NIM and PNIM protocols have different message headers.
- The PNIM protocol is a no-acknowledgment protocol. The types of messages between the client and server devices are command messages and reply messages.
- The NIM protocol uses acknowledgment between the client and the server devices. After the relay receives a complete message from a client device, it sends out an ACK to the client within 6 character transmission frames (at 9600 baud, a character transmission frame is approximately 1 ms). After the relay sends out a reply message to the client, it waits for acknowledgment from the client. If the relay receives a NAK, it resends the message just sent. If the relay receives an ACK or no reply at all, it is ready to receive the next message.
- The PNIM protocol uses a CRC-16 error checking versus a simple checksum in the NIM protocol.
- The PNIM protocol uses 0xFF as a pad character, and the NIM protocol uses 0xFE as a pad character.

The SEL-501-1 performs an automatic configuration to the protocol of the host device, NIM or PNIM, so that the user does not have to be concerned which type of protocol (NIM or PNIM) is being used.

Message Framing

All SY/MAX data requests consist of a start of header code, header information, start of data code, opcode, opcode related data, end of data code, and checksum or CRC. For the SEL-501-1 to respond, the address must match one of those established in the settings, and the checksum or CRC must be valid.

NIM Protocol

The frame format for NIM protocol requests is:

2 bytes	Start of header (DLE and SOH).
1 byte	ODD/EVEN—0x11 or 0x12, flip between messages. The SEL-501-1 does not use this for message validation.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.

2 bytes	Start of data (DLE and STX).
1 byte	Command opcode (see complete list in *Command Set on page F.6*).
1 byte	Transnum—the number of successful transmissions. Used for information flow control purposes.
n bytes	Opcode related data.
2 bytes	End of data (DLE and ETX).
1 byte	Checksum for message.

Upon receipt of a complete message, the SEL-501-1 will send a 2-byte ACK (DLE ODD/EVEN) within 6 character transmission frames.

For successful operations, the response message will have the following format:

2 bytes	Start of header (DLE and SOH).
1 byte	ODD/EVEN—0x11 or 0x12, flip between messages. This will match request message.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Reply opcode (see complete list in *Command Set on page F.6*).
1 byte	Transnum—the number of successful transmissions. Used for information flow control purposes. This will match request message.
n bytes	Opcode related data.
2 bytes	End of data (DLE and ETX).
1 byte	Checksum for message.

For error responses, the message format will be as follows:

2 bytes	Start of header (DLE and SOH).
1 byte	ODD/EVEN—0x11 or 0x12, flip between messages. This will match request message.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Error reply opcode (0xA2) for non-priority; reply opcode for priority.
1 or 2 bytes	Transnum (1 byte)—the number of successful transmissions (for non-priority error reply only). This will match request message. Status register address (2 bytes)—the address of the status register (for priority error reply only); will match request message.
1 or 2 bytes	Error code: 1 byte for non-priority error reply, 2 bytes for priority error reply only (high-byte will be 0x40 and low-byte will be error code).
2 bytes	End of data (DLE and ETX).
1 byte	Checksum for message.

PNIM Protocol

The frame format for PNIM protocol requests is:

2 bytes	Start of header (DLE and SOH).
1 byte	Destination Address: ultimate address in binary.
1 byte	Transnum—the number of successful transmissions.
1 byte	ID—The ID number is used to prevent cross-talk from occurring when two or more radio-link systems are operating within range of each other. The SEL-501-1 uses it only to distinguish NIM and PNIM protocols.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Command opcode (see complete list in *Command Set on page F.6*).
1 byte	Transnum—the number of successful transmissions. Used for information flow control purposes.
n bytes	Opcode related data.
2 bytes	End of data (DLE and ETX).
2 bytes	CRC-16 for message.

For PNIM protocol, no acknowledgment is sent.

For successful operations, the response message will have the following format:

NOTE: In NIM and PNIM protocols, the opcode related data are identical for identical commands. If a character value 0x10 occurs within the opcode related data, the character is repeated to distinguish it from normal instances of the DLE character.

2 bytes	Start of header (DLE and SOH).
1 byte	Destination address; this will match request message.
1 byte	Transnum—the number of successful transmissions.
1 byte	ID—The ID number is used to prevent cross-talk from occurring when two or more radio-link systems are operating within range of each other. The SEL-501-1 ignores this ID number. This will match request message.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Reply opcode (see complete list in *Command Set on page F.6*).
1 byte	Transnum—the number of successful transmissions. Used for information flow control purposes.
n bytes	Opcode related data.
2 bytes	End of data (DLE and ETX).
2 bytes	CRC-16 for message.

For error responses, the message format will be as follows:

NOTE: Multibyte data items are sent MSB first.

2 bytes	Start of header (DLE and SOH).
1 byte	Destination address.
1 byte	Transnum—the number of successful transmissions.

1 byte	ID—The ID number is used to prevent cross-talk from occurring when two or more radio-link systems are operating within range of each other. The SEL-501-1 ignores this ID number. This will match request message.
4–16 bytes	Route—This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Error reply opcode (0xA2) for non-priority; reply opcode for priority messages.
1 or 2 bytes	Transnum (1 byte)—the number of successful transmissions (for non-priority error reply only). Status register address (2 bytes) copied from request message (for priority error reply only).
1 or 2 bytes	Error code: 1 byte for non-priority error reply, 2 bytes for priority error reply (upper byte is 0x40 and lower byte is error code).
2 bytes	End of data (DLE and ETX).
2 bytes	CRC-16 for message.

Route Conversion

A Route field consists of the network route numbers that must handle the message transfer between its source and its final destination. There can be a maximum of eight route numbers in any one packet. The first one is the sender, and the last one is the receiver. A route number is an eight bit number that is transmitted as two ASCII hex characters. The transmission rules are as follows:

- Convert the route number into 2-digit hex number
- For each hex digit, convert it to an ASCII hex character by one of the following methods:
  - Adding 0x30 if the digit is less than 10
  - Adding 0x37 if the digit is greater than 9

For example, *Table F.1* displays the transition for route numbers 100, 14, and 81.

Table F.1 Route Conversion

Route Number	100	14	81
Hex	0x64	0x0E	0x51
ASCII Hex	0x36 0x34	0x30 0x45	0x35 0x31

Register Address Conversion

The register address in a message packet is a protocol representation of an address of a general register from an application. The addresses in *Table F.3* are general register addresses. If PA is the protocol register address, and GA is the general register address, you can get GA from PA by performing the following calculation:

$$GA = (PA/2) + 1$$

Conversely, you can get PA from GA using:

$$PA = 2\ (GA–1)$$

For example, if the protocol register address in the message packet is 0xC6, the user would read general register 100 (0x64); i.e., the protocol register address 0xC6 in a message packet will be converted to a general register address 100. The register addresses in *Table F.3* are general register address LA.

Error Handling

The SEL-501-1 can detect and handle a number of errors. Framing errors (messages did not have a complete frame or correct server address) and checksum or CRC mismatches will prevent an SEL-501-1 response to the message. The SEL-501-1 treats a non-existent register as a read-only register that has a content of 0x8000. If a legitimate message is received, but cannot be processed, the SEL-501-1 will respond with an error response, as indicated in *Message Framing on page F.2*. The following is a list of possible error codes:

01 - SYMAX_BADOPCODE	The received opcode is not supported.
16 - SYMAX _ COUNTOOLARGE	The register count in the received non-priority packet is too long.
19 - SYMAX_PRICOUNTTOOLARGE	The register count in the received priority packet is too long.
41 - SYMAX_BADREGWRITE	Some portion of the registers that the SEL-501-1 tried to write is read-only registers.

Command Set

The SEL-501-1 recognizes and processes a subset of the SY/MAX commands. They are as follows.

Table F.2 SEL-501 SY/MAX Commands

Command Type	Command Opcode	Reply Opcode
Non-Priority Register Read	0x00	0x86
Non-Priority Multiple Register Read	0x04	0x8A
Priority Register Read	0x20	0x90
Non-Priority Register Write	0x02	0x80
Priority Register Write	0x1E	0x92
Search Rung	0x0E	0x82
Read User Memory	0x14	0x88

The SEL-501-1 commands can be divided into three classes:

- View information (such as **METER**)
- Change information (such as **DATE hh:mm:ss**)
- Command the relay (such as **CLOSE**)

The first class corresponds to the read opcodes. The second and third classes correspond to the write opcodes.

Register Count

In the following opcode definitions, the register count in a message packet is zero based; the maximum value is 127 (i.e., 128 registers).

For example, a value of 3 implies a count of 4.

Register Read (Opcode 0x00 and 0x20)

An SEL-501-1 functions the same for Non-Priority Register Read and Priority Register Read opcodes. One register or an adjacent group of registers can be read at once. The start register tells the relay where to begin reading. The number of registers tells the relay how many registers should be read. The maximum number of registers that can be read at one time is 100. If a register address is not available in the relay, the SEL-501-1 will return a 0x8000 for the register data value of the register. See *Table F.3* for all the available register addresses.

Assume that the relay has a device address 2. The client station has a device address 101, and the contents of registers 100, 101, 102 are 20, 30, and 40 respectively. Here are the examples to read registers 100–102.

NIM Non-Priority Read

Request message:

Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	00
Transnum:	04
Start register address:	00 C6
Register count:	00 02
End of data:	10 03
Checksum:	---

Successful reply message:

Start of header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	86
Transnum:	04
Start register:	00 C6
Data (register 100):	00 14
Data (register 101):	00 1E
Data (register 102):	00 28
End of data:	10 03
Checksum:	---

NIM Priority Read

Request message:

Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	20
Status register address:	00 00
Destination register address:	00 00
Source register address:	00 C6
Register count:	00 02
End of data:	10 03
Checksum:	---

Successful reply message:

Start of header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	90
Status register address:	00 00
Status register data:	00 00
Destination register address:	00 00
Data (register 100):	00 14
Data (register 101):	00 1E
Data (register 102):	00 28
End of data:	10 03
Checksum:	---

The status register address and the destination register address are not used by the SEL-501-1; they are merely copied to the response message. The status register data for a successful message will always be 0x0000.

PNIM Non-Priority Register Read

Request message:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	36 35 30 32
Start of data:	10 02
Opcode:	00
Transnum:	00
Start register address:	00 C6
Register count:	00 02
End of data:	10 03
CRC:	--- ---

Successful reply message:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	86
Transnum:	00
Start register address:	00 C6
Data (register 100):	00 14
Data (register 101):	00 1E
Data (register 102):	00 28
End of data:	10 02
CRC:	------

PNIM Priority Register Read

The SEL-501-1 supports PNIM priority register reads; although these reads are not generally used.

Multiple Register Read (Opcode 0x04)

The Multiple Register Read opcodes allow an SEL-501 to read a non-adjacent group of registers at once. All the register addresses are indicated in the command. The maximum number of register addresses that can be listed in one command is 100. If a register address is not available in the relay, the SEL-501-1 will return a 0x8000 for the register data in that register. See *Table F.3* for all the available register addresses.

Assume that the relay has a device address 2, the client station has a device address 101, and the contents of register 100, 103, and 106 are 20, 30, and 40, respectively.

NIM Multiple Read

Request message:

Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	04
Transnum:	00
Register address:	00 C6
Register address:	00 CC
Register address:	00 D2
End of data:	10 03
Checksum:	---

Successful reply message:

Start of header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	8A
Transnum:	00
Data (register 100):	00 14
Data (register 103):	00 1E
Data (register 106):	00 28
End of data:	10 03
Checksum:	---

PNIM Multiple Read

Request message:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	36 35 30 32
Start of data:	10 02
Opcode:	04
Transnum:	00
Register address:	00 C6
Register address:	00 CC
Register address:	00 D2
End of data:	10 03
CRC:	--- ---

Successful reply message:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	8A
Transnum:	00
Data (register 100):	00 14
Data (register 103):	00 1E
Data (register 106):	00 28
End of data:	10 03
CRC:	--- ---

Register Write (Opcode 0x02 and 0x1E)

An SEL-501-1 functions the same for Non-Priority Register Write and Priority Register Write opcodes. One register or an adjacent group of registers can be written at once. The start register tells the relay where to begin writing. The data following the start register tells the relay what should be written. The maximum number of registers that can be written at one time is 8. If a register in the relay cannot be written, the SEL-501-1 will ignore the write command. See *Table F.3* for all the available register addresses.

A register has 16 bits. The Bit Mask field in a write message packet allows the user to write bit by bit. When the write is performed, the only alterable bits in the register(s) are the bits set in the mask. The rest of the bits in the register(s) are not affected by the operation. The SEL-501-1 ignores the bit mask field because it does not perform bit writes.

The write command can be used to change the contents of registers (such as date/time) or initiate relay operations (such as stop a motor).

Assume that the relay has a device address 2, the client station has a device address 101, and the user wants to write 20, 30, and 40 to register 2130, 2131, and 2132, respectively. Here are the examples to write registers 2130–2132.

NIM Non-Priority Write

Request message:	
Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	02
Transnum:	00
Start register address:	10 10 A2
Data (register 2130):	00 14
Data (register 2131):	00 1E
Data (register 2132):	00 28
Bit Mask:	FF FF
End of data:	10 03
Checksum:	---
Successful reply message:	
Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Reply Opcode:	80
Transnum:	00
End of data:	10 03
Checksum:	---

NIM Priority Write

Request message:

Start of header:	10 01
Odd-Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	1E
Status register address:	00 00
Start register address:	10 10 A2
Data (register 2130):	00 14
Data (register 2131):	00 1E
Data (register 2132):	00 28
End of data:	10 03
Checksum:	---

Successful reply message:

Start of header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	92
Status register address:	00 00
Status register data:	00 00
End of data:	10 03
Checksum:	---

The status register address is not used by the SEL-501-1; it is merely copied to the response message. The status register data in a successful response will always be 0x0000.

PNIM Non-Priority Write

Request message:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	36 35 30 32
Start of data:	10 02
Opcode:	02
Transnum:	00
Start register address:	10 10 A2
Data (register 2130):	00 14
Data (register 2131):	00 1E
Data (register 2132):	00 28
Bit mask:	FF FF
End of data:	10 03
CRC:	--- ---

Successful reply:

Start of header:	10 01
Destination address:	02
Transnum:	00
ID:	00
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	80
Transnum:	00
End of data:	10 03
CRC:	--- ---

PNIM Priority Write

The SEL-501-1 supports PNIM priority writes, although these writes are not generally used.

Search Rung (Opcode 0x0E)

For Opcode Search Rung, the SEL-501-1 will return four bytes of data (0x7f, 0xff, 0x9f, 0x3e) to satisfy the requirements for PLC programming equipment.

Assume that the relay has a device address 2. The client station has a device address 101. Here is a NIM example for Search Rung:

Request message:

Start of header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	0E
Transnum:	00
Rung Number:	00 03
End of data:	10 03
Checksum:	---

Successful reply message:

Start of header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	82
Transnum:	00
Rung Number:	00 03
Rung Data:	7F FF 9F 3E
End of data:	10 03
Checksum:	---

The rung number is not used by the SEL-501-1; it is merely repeated in the response message.

Read User Memory (Opcode 0x14)

For Opcode Read User memory, the SEL-501-1 will return all zeros for the memory locations requested. The byte count is zero-based, like the register counts.

Assume that the relay has a device address 2. The client station has a device address 101. And we read the user memory 1000, 1001, and 1002. Here is a NIM example:

Request message:

Start header:	10 01
Odd/Even:	11
Route:	36 35 30 32
Start of data:	10 02
Opcode:	14
Transnum:	00
Start memory address:	00 07 CE
Byte count:	02
End of data:	10 03
Checksum:	---

Successfully reply message:

Start header:	10 01
Odd/Even:	11
Route:	30 32 36 35
Start of data:	10 02
Reply Opcode:	88
Transnum:	00
Start memory address:	00 07 CE
Memory data:	00 00 00
End of data:	10 03
Checksum:	---

Register Map

Table F.3 lists the SEL-501-1 registers.

Table F.3 SY/MAX Protocol Register Map (Sheet 1 of 17)

Reg. #	Description	Units	Range
Breaker			
100(R)	Number of internal trips	none	0 to 32,767
101(R)	Internal IA	100 A	0 to 32,767
102(R)	Internal IB	100 A	0 to 32,767
103(R)	Internal IC	100 A	0 to 32,767
104(R)	Number of external trips	none	0 to 32,767
105(R)	External IA	100 A	0 to 32,767
106(R)	External IB	100 A	0 to 32,767
107(R)	External IC	100 A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 2 of 17)

Reg. #	Description	Units	Range
108(W)	Reset breaker	none	
Clear the Short Event Report			
150(R)	Number of events	none	0 to 20
151(W)	Clear events	none	
Acknowledge the Short Event Report			
160(R)	The oldest unacknowledged short event report packet	none	See Event Acknowledgment
161(W)	Acknowledge the oldest unacknowledged short event report packet	none	See Event Acknowledgment
Short Event Report (Total = 20 Event Reports)			
200(R)	Event Number	none	0 or 1
201–203(R)	Event 1 Compressed Date/Time	month, day, yr, hr, min, s	See time format
204(R)	Event 1 Compressed Date/Time	ms	See time format
205–211(R)	Event 1 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
212(R)	Event 1 system frequency	Hz/10	0.0 to 1000.0
213(R)	Event 1 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
214(R)	Event 1 type	none	See Event Type
215(R)	Event 1 Target	none	See Target Format
216(R)	Event 1 duration	cyc/100	0.00 to 15.00 cyc.
217(R)	Event 1 fault current IAX	A	0 to 32,767
218(R)	Event 1 fault current IBX	A	0 to 32,767
219(R)	Event 1 fault current ICX	A	0 to 32,767
220(R)	Event 1 fault current IQX	A	0 to 32,767
221(R)	Event 1 fault current INX	A	0 to 32,767
222(R)	Event 1 fault current IAY	A	0 to 32,767
223(R)	Event 1 fault current IBY	A	0 to 32,767
224(R)	Event 1 fault current ICY	A	0 to 32,767
225(R)	Event 1 fault current IQY	A	0 to 32,767
226(R)	Event 1 fault current INY	A	0 to 32,767
227(R)	Acknowledgment for Event 1	0—unack, 1—ack	0 to 1
228(R)	Event Number	none	0 or 2
229–231(R)	Event 2 Compressed Date/Time	month, day, yr, hr, min, s	See time format
232(R)	Event 2 Compressed Date/Time	ms	See time format
233–239(R)	Event 2 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
240(R)	Event 2 system frequency	Hz/10	0 to 1000

Table F.3 SY/MAX Protocol Register Map (Sheet 3 of 17)

Reg. #	Description	Units	Range
241(R)	Event 2 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
242(R)	Event 2 type	none	See Event Type
243(R)	Event 2 Target	none	See Target Format
244(R)	Event 2 duration	cyc/100	0.00 to 15.00 cyc.
245(R)	Event 2 fault current IAX	A	0 to 32,767
246(R)	Event 2 fault current IBX	A	0 to 32,767
247(R)	Event 2 fault current ICX	A	0 to 32,767
248(R)	Event 2 fault current IQX	A	0 to 32,767
249(R)	Event 2 fault current INX	A	0 to 32,767
250(R)	Event 2 fault current IAY	A	0 to 32,767
251(R)	Event 2 fault current IBY	A	0 to 32,767
252(R)	Event 2 fault current ICY	A	0 to 32,767
253(R)	Event 2 fault current IQY	A	0 to 32,767
254(R)	Event 2 fault current INY	A	0 to 32,767
255(R)	Acknowledgment for Event 2	0—unack, 1—ack	0 to 1
256(R)	Event Number	none	0 or 3
257–259(R)	Event 3 Compressed Date/Time	month, day, yr, hr, min, s	See time format
260	Event 3 Compressed Date/Time	ms	See time format
261–267(R)	Event 3 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
268(R)	Event 3 system frequency	Hz/10	0 to 1000
269(R)	Event 3 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
270(R)	Event 3 type	none	See Event Type
271(R)	Event 3 Target	none	See Target Format
272(R)	Event 3 duration	cyc/100	0.00 to 15.00 cyc.
273(R)	Event 3 fault current IAX	A	0 to 32,767
274(R)	Event 3 fault current IBX	A	0 to 32,767
275(R)	Event 3 fault current ICX	A	0 to 32,767
276(R)	Event 3 fault current IQX	A	0 to 32,767
277(R)	Event 3 fault current INX	A	0 to 32,767
278(R)	Event 3 fault current IAY	A	0 to 32,767
279(R)	Event 3 fault current IBY	A	0 to 32,767
280(R)	Event 3 fault current ICY	A	0 to 32,767
281(R)	Event 3 fault current IQY	A	0 to 32,767
282(R)	Event 3 fault current INY	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 4 of 17)

Reg. #	Description	Units	Range
283(R)	Acknowledgment for Event 3	0—unack, 1—ack	0 to 1
284(R)	Event Number	none	0 or 4
285–287(R)	Event 4 Compressed Date/Time	month, day, yr, hr, min, s	See time format
288(R)	Event 4 Compressed Date/Time	ms	See time format
289–295(R)	Event 4 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
296(R)	Event 4 system frequency	Hz/10	0 to 1000
297(R)	Event 4 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
298(R)	Event 4 type	none	See Event Type
299(R)	Event 4 Target	none	See Target Format
300(R)	Event 4 duration	cyc/100	0.00 to 15.00 cyc.
301(R)	Event 4 fault current IAX	A	0 to 32,767
302(R)	Event 4 fault current IBX	A	0 to 32,767
303(R)	Event 4 fault current ICX	A	0 to 32,767
304(R)	Event 4 fault current IQX	A	0 to 32,767
305(R)	Event 4 fault current INX	A	0 to 32,767
306(R)	Event 4 fault current IAY	A	0 to 32,767
307(R)	Event 4 fault current IBY	A	0 to 32,767
308(R)	Event 4 fault current ICY	A	0 to 32,767
309(R)	Event 4 fault current IQY	A	0 to 32,767
310(R)	Event 4 fault current INY	A	0 to 32,767
311(R)	Acknowledgment for Event 4	0—unack, 1—ack	0 to 1
312(R)	Event Number	none	0 or 5
313–315(R)	Event 5 Compressed Date/Time	month, day, yr, hr, min, s	See time format
316(R)	Event 5 Compressed Date/Time	ms	See time format
317–323(R)	Event 5 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
324(R)	Event 5 system frequency	Hz/10	0 to 1000
325(R)	Event 5 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
326(R)	Event 5 type	none	See Event Type
327(R)	Event 5 Target	none	See Target Format
328(R)	Event 5 duration	cyc/100	0.00 to 15.00 cyc.
329(R)	Event 5 fault current IAX	A	0 to 32,767
330(R)	Event 5 fault current IBX	A	0 to 32,767
331(R)	Event 5 fault current ICX	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 5 of 17)

Reg. #	Description	Units	Range
332(R)	Event 5 fault current IQX	A	0 to 32,767
333(R)	Event 5 fault current INX	A	0 to 32,767
334(R)	Event 5 fault current IAY	A	0 to 32,767
335(R)	Event 5 fault current IBY	A	0 to 32,767
336(R)	Event 5 fault current ICY	A	0 to 32,767
337(R)	Event 5 fault current IQY	A	0 to 32,767
338(R)	Event 5 fault current INY	A	0 to 32,767
339(R)	Acknowledgment for Event 5	0—unack, 1—ack	0 to 1
340(R)	Event Number	none	0 or 6
341–343(R)	Event 6 Compressed Date/Time	month, day, yr, hr, min, s	See time format
344(R)	Event 6 Compressed Date/Time	ms	See time format
345–351(R)	Event 6 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
352(R)	Event 6 system frequency	Hz/10	0 to 1000
353(R)	Event 6 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
354(R)	Event 6 type	none	See Event Type
355(R)	Event 6 Target	none	See Target Format
356(R)	Event 6 duration	cyc/100	0.00 to 15.00 cyc.
357(R)	Event 6 fault current IAX	A	0 to 32,767
358(R)	Event 6 fault current IBX	A	0 to 32,767
359(R)	Event 6 fault current ICX	A	0 to 32,767
360(R)	Event 6 fault current IQX	A	0 to 32,767
361(R)	Event 6 fault current INX	A	0 to 32,767
362(R)	Event 6 fault current IAY	A	0 to 32,767
363(R)	Event 6 fault current IBY	A	0 to 32,767
364(R)	Event 6 fault current ICY	A	0 to 32,767
365(R)	Event 6 fault current IQY	A	0 to 32,767
366(R)	Event 6 fault current INY	A	0 to 32,767
367(R	Acknowledgment for Event 6	0—unack, 1—ack	0 to 1
368(R)	Event Number	none	0 or 7
369–371(R)	Event 7 Compressed Date/Time	month, day, yr, hr, min, s	See time format
372(R)	Event 7 Compressed Date/Time	ms	See time format
373–379(R)	Event 7 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
380(R)	Event 7 system frequency	Hz/10	0 to 1000

Table F.3 SY/MAX Protocol Register Map (Sheet 6 of 17)

Reg. #	Description	Units	Range
381(R)	Event 7 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
382(R)	Event 7 type	none	See Event Type
383(R)	Event 7 Target	none	See Target Format
384(R)	Event 7 duration	cyc/100	0.00 to 15.00 cyc.
385(R)	Event 7 fault current IAX	A	0 to 32,767
386(R)	Event 7 fault current IBX	A	0 to 32,767
387(R)	Event 7 fault current ICX	A	0 to 32,767
388(R)	Event 7 fault current IQX	A	0 to 32,767
389(R)	Event 7 fault current INX	A	0 to 32,767
390(R)	Event 7 fault current IAY	A	0 to 32,767
391(R)	Event 7 fault current IBY	A	0 to 32,767
392(R)	Event 7 fault current ICY	A	0 to 32,767
393(R)	Event 7 fault current IQY	A	0 to 32,767
394(R)	Event 7 fault current INY	A	0 to 32,767
395(R)	Acknowledgment for Event 7	0—unack, 1—ack	0 to 1
396(R)	Event Number	none	0 or 8
397–399(R)	Event 8 Compressed Date/Time	month, day, yr, hr, min, s	See time format
400(R)	Event 8 Compressed Date/Time	ms	See time format
401–407(R)	Event 8 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
408(R)	Event 8 system frequency	Hz/10	0 to 1000
409(R)	Event 8 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
410(R)	Event 8 type	none	See Event Type
411(R)	Event 8 Target	none	See Target Format
412(R)	Event 8 duration	cyc/100	0.00 to 15.00 cyc.
413(R)	Event 8 fault current IAX	A	0 to 32,767
414(R)	Event 8 fault current IBX	A	0 to 32,767
415(R)	Event 8 fault current ICX	A	0 to 32,767
416(R)	Event 8 fault current IQX	A	0 to 32,767
417(R)	Event 8 fault current INX	A	0 to 32,767
418(R)	Event 8 fault current IAY	A	0 to 32,767
419(R)	Event 8 fault current IBY	A	0 to 32,767
420(R)	Event 8 fault current ICY	A	0 to 32,767
421(R)	Event 8 fault current IQY	A	0 to 32,767
422(R)	Event 8 fault current INY	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 7 of 17)

Reg. #	Description	Units	Range
423(R)	Acknowledgment for Event 8	0—unack, 1—ack	0 to 1
424(R)	Event Number	none	0 or 9
425–427(R)	Event 9 Compressed Date/Time	month, day, yr, hr, min, s	See time format
428(R)	Event 9 Compressed Date/Time	ms.	See time format
429–435(R)	Event 9 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
436(R)	Event 9 system frequency	Hz/10	0 to 1000
437(R)	Event 9 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
438(R)	Event 9 type	none	See Event Type
439(R)	Event 9 Target	none	See Target Format
440(R)	Event 9 duration	cyc/100	0.00 to 15.00 cyc.
441(R)	Event 9 fault current IAX	A	0 to 32,767
442(R)	Event 9 fault current IBX	A	0 to 32,767
443(R)	Event 9 fault current ICX	A	0 to 32,767
444(R)	Event 9 fault current IQX	A	0 to 32,767
445(R)	Event 9 fault current INX	A	0 to 32,767
446(R	Event 9 fault current IAY	A	0 to 32,767
447(R)	Event 9 fault current IBY	A	0 to 32,767
448(R)	Event 9 fault current ICY	A	0 to 32,767
449(R)	Event 9 fault current IQY	A	0 to 32,767
450(R)	Event 9 fault current INY	A	0 to 32,767
451(R)	Acknowledgment for Event 9	0—unack, 1—ack	0 to 1
452(R)	Event Number	none	0 or 10
453–455(R)	Event 10 Compressed Date/Time	month, day, yr, hr, min, s	See time format
456(R)	Event 10 Compressed Date/Time	ms	See time format
457–463(R)	Event 10 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
464(R)	Event 10 system frequency	Hz/10	0 to 1000
465(R)	Event 10 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
466(R)	Event 10 type	none	See Event Type
467(R)	Event 10 Target	none	See Target Format
468(R)	Event 10 duration	cyc/100	0.00 to 15.00 cyc.
469(R)	Event 10 fault current IAX	A	0 to 32,767
470(R)	Event 10 fault current IBX	A	0 to 32,767
471(R)	Event 10 fault current ICX	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 8 of 17)

Reg. #	Description	Units	Range
472(R)	Event 10 fault current IQX	A	0 to 32,767
473(R)	Event 10 fault current INX	A	0 to 32,767
474(R)	Event 10 fault current IAY	A	0 to 32,767
475(R)	Event 10 fault current IBY	A	0 to 32,767
476(R)	Event 10 fault current ICY	A	0 to 32,767
477(R)	Event 10 fault current IQY	A	0 to 32,767
478(R)	Event 10 fault current INY	A	0 to 32,767
479(R)	Acknowledgment for Event 10	0—unack, 1—ack	0 to 1
480(R)	Event Number	none	0 or 11
481–483(R)	Event 11 Compressed Date/Time	month, day, yr, hr, min, s	See time format
484(R)	Event 11 Compressed Date/Time	ms	See time format
485–491(R)	Event 11 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
492(R)	Event 11 system frequency	Hz/10	0 to 1000
493(R)	Event 11 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
494(R)	Event 11 type	none	See Event Type
495(R)	Event 11 Target	none	See Target Format
496(R)	Event 11 duration	cyc/100	0.00 to 15.00 cyc.
497(R)	Event 11 fault current IAX	A	0 to 32,767
498(R)	Event 11 fault current IBX	A	0 to 32,767
499(R)	Event 11 fault current ICX	A	0 to 32,767
500(R)	Event 11 fault current IQX	A	0 to 32,767
501(R)	Event 11 fault current INX	A	0 to 32,767
502(R)	Event 11 fault current IAY	A	0 to 32,767
503(R)	Event 11 fault current IBY	A	0 to 32,767
504(R)	Event 11 fault current ICY	A	0 to 32,767
505(R)	Event 11 fault current IQY	A	0 to 32,767
506(R)	Event 11 fault current INY	A	0 to 32,767
507(R)	Acknowledgment for Event 11	0—unack, 1—ack	0 to 1
508(R)	Event Number	none	0 or 12
509–511(R)	Event 12 Compressed Date/Time	month, day, yr, hr, min, s	See time format
512(R)	Event 12 Compressed Date/Time	ms	See time format
513–519(R)	Event 12 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
520(R)	Event 12 system frequency	Hz/10	0 to 1000

Table F.3 SY/MAX Protocol Register Map (Sheet 9 of 17)

Reg. #	Description	Units	Range
521(R)	Event 12 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
522(R)	Event 12 type	none	See Event Type
523(R)	Event 12 Target	none	See Target Format
524(R)	Event 12 duration	cyc/100	0.00 to 15.00 cyc.
525(R)	Event 12 fault current IAX	A	0 to 32,767
526(R)	Event 12 fault current IBX	A	0 to 32,767
527(R)	Event 12 fault current ICX	A	0 to 32,767
528(R)	Event 12 fault current IQX	A	0 to 32,767
529(R)	Event 12 fault current INX	A	0 to 32,767
530(R)	Event 12 fault current IAY	A	0 to 32,767
531(R)	Event 12 fault current IBY	A	0 to 32,767
532(R)	Event 12 fault current ICY	A	0 to 32,767
533(R)	Event 12 fault current IQY	A	0 to 32,767
534(R)	Event 12 fault current INY	A	0 to 32,767
535(R)	Acknowledgment for Event 12	0—unack, 1—ack	0 to 1
536(R)	Event Number	none	0 or 13
537–539(R)	Event 13 Compressed Date/Time	month, day, yr, hr, min, s	See time format
540(R)	Event 13 Compressed Date/Time	ms	See time format
541–547(R)	Event 13 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
548(R)	Event 13 system frequency	Hz/10	0 to 1000
549(R)	Event 13 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
550(R)	Event 13 type	none	See Event Type
551(R)	Event 13 Target	none	See Target Format
552(R)	Event 13 duration	cyc/100	0.00 to 15.00 cyc.
553(R)	Event 13 fault current IAX	A	0 to 32,767
554(R)	Event 13 fault current IBX	A	0 to 32,767
555(R)	Event 13 fault current ICX	A	0 to 32,767
556(R)	Event 13 fault current IQX	A	0 to 32,767
557(R)	Event 13 fault current INX	A	0 to 32,767
558(R)	Event 13 fault current IAY	A	0 to 32,767
559(R)	Event 13 fault current IBY	A	0 to 32,767
560(R)	Event 13 fault current ICY	A	0 to 32,767
561(R)	Event 13 fault current IQY	A	0 to 32,767
562(R)	Event 13 fault current INY	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 10 of 17)

Reg. #	Description	Units	Range
563(R)	Acknowledgment for Event 13	0—unack, 1—ack	0 to 1
564(R)	Event Number	none	0 or 14
565–567(R)	Event 14 Compressed Date/Time	month, day, yr, hr, min, s	See time format
568(R)	Event 14 Compressed Date/Time	ms	See time format
569–575(R)	Event 14 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
576(R)	Event 14 system frequency	Hz/10	0 to 1000
577(R)	Event 14 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
578(R)	Event 14 type	none	See Event Type
579(R)	Event 14 Target	none	See Target Format
580(R)	Event 14 duration	cyc/100	0.00 to 15.00 cyc.
581(R)	Event 14 fault current IAX	A	0 to 32,767
582(R)	Event 14 fault current IBX	A	0 to 32,767
583(R)	Event 14 fault current ICX	A	0 to 32,767
584(R)	Event 14 fault current IQX	A	0 to 32,767
585(R)	Event 14 fault current INX	A	0 to 32,767
586(R)	Event 14 fault current IAY	A	0 to 32,767
587(R)	Event 14 fault current IBY	A	0 to 32,767
588(R)	Event 14 fault current ICY	A	0 to 32,767
589(R)	Event 14 fault current IQY	A	0 to 32,767
590(R)	Event 14 fault current INY	A	0 to 32,767
591(R)	Acknowledgment for Event 14	0—unack, 1—ack	0 to 1
592(R)	Event Number	none	0 or 15
593–595(R)	Event 15 Compressed Date/Time	month, day, yr, hr, min, s	See time format
596(R)	Event 15 Compressed Date/Time	ms	See time format
597–603(R)	Event 15 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
604(R)	Event 15 system frequency	Hz/10	0 to 1000
605(R)	Event 15 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
606(R)	Event 15 type	none	See Event Type
607(R)	Event 15 Target	none	See Target Format
608(R)	Event 15 duration	cyc/100	0.00 to 15.00 cyc.
609(R)	Event 15 fault current IAX	A	0 to 32,767
610(R)	Event 15 fault current IBX	A	0 to 32,767
611(R)	Event 15 fault current ICX	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 11 of 17)

Reg. #	Description	Units	Range
612(R)	Event 15 fault current IQX	A	0 to 32,767
613(R)	Event 15 fault current INX	A	0 to 32,767
614(R)	Event 15 fault current IAY	A	0 to 32,767
615(R)	Event 15 fault current IBY	A	0 to 32,767
616(R)	Event 15 fault current ICY	A	0 to 32,767
617(R)	Event 15 fault current IQY	A	0 to 32,767
618(R)	Event 15 fault current INY	A	0 to 32,767
619(R)	Acknowledgment for Event 15	0—unack, 1—ack	0 to 1
620(R)	Event Number	none	0 or 16
621–623(R)	Event 16 Compressed Date/Time	month, day, yr, hr, min, s	See time format
624(R)	Event 16 Compressed Date/Time	ms	See time format
625–631(R)	Event 16 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
632(R)	Event 16 system frequency	Hz/10	0 to 1000
633(R)	Event 16 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
634(R)	Event 16 type	none	See Event Type
635(R)	Event 16 Target	none	See Target Format
636(R)	Event 16 duration	cyc/100	0.00 to 15.00 cyc.
637(R)	Event 16 fault current IAX	A	0 to 32,767
638(R)	Event 16 fault current IBX	A	0 to 32,767
639(R)	Event 16 fault current ICX	A	0 to 32,767
640(R)	Event 16 fault current IQX	A	0 to 32,767
641(R)	Event 16 fault current INX	A	0 to 32,767
642(R)	Event 16 fault current IAY	A	0 to 32,767
643(R)	Event 16 fault current IBY	A	0 to 32,767
644(R)	Event 16 fault current ICY	A	0 to 32,767
645(R)	Event 16 fault current IQY	A	0 to 32,767
646(R)	Event 16 fault current INY	A	0 to 32,767
647(R)	Acknowledgment for Event 16	0—unack, 1—ack	0 to 1
648(R)	Event Number	none	0 or 17
649–651(R)	Event 17 Compressed Date/Time	month, day, yr, hr, min, s	See time format
652(R)	Event 17 Compressed Date/Time	ms	See time format
653–659(R)	Event 17 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
660(R)	Event 17 system frequency	Hz/10	0 to 1000

Table F.3 SY/MAX Protocol Register Map (Sheet 12 of 17)

Reg. #	Description	Units	Range
661(R)	Event 17 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
662(R)	Event 17 type	none	See Event Type
663(R)	Event 17 Target	none	See Target Format
664(R)	Event 17 duration	cyc/100	0.00 to 15.00 cyc.
665(R)	Event 17 fault current IAX	A	0 to 32,767
666(R)	Event 17 fault current IBX	A	0 to 32,767
667(R)	Event 17 fault current ICX	A	0 to 32,767
668(R)	Event 17 fault current IQX	A	0 to 32,767
669(R)	Event 17 fault current INX	A	0 to 32,767
670(R)	Event 17 fault current IAY	A	0 to 32,767
671(R)	Event 17 fault current IBY	A	0 to 32,767
672(R)	Event 17 fault current ICY	A	0 to 32,767
673(R)	Event 17 fault current IQY	A	0 to 32,767
674(R)	Event 17 fault current INY	A	0 to 32,767
675(R)	Acknowledgment for Event 17	0—unack, 1—ack	0 to 1
676(R)	Event Number	none	0 or 18
677–679(R)	Event 18 Compressed Date/Time	month, day, yr, hr, min, s	See time format
680(R)	Event 18 Compressed Date/Time	ms	See time format
681–687(R)	Event 18 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
688(R)	Event 18 system frequency	Hz/10	0 to 1000
689(R)	Event 18 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
690(R)	Event 18 type	none	See Event Type
691(R)	Event 18 Target	none	See Target Format
692(R)	Event 18 duration	cyc/100	0.00 to 15.00 cyc.
693(R)	Event 18 fault current IAX	A	0 to 32,767
694(R)	Event 18 fault current IBX	A	0 to 32,767
695(R)	Event 18 fault current ICX	A	0 to 32,767
696(R)	Event 18 fault current IQX	A	0 to 32,767
697(R)	Event 18 fault current INX	A	0 to 32,767
698(R)	Event 18 fault current IAY	A	0 to 32,767
699(R)	Event 18 fault current IBY	A	0 to 32,767
700(R)	Event 18 fault current ICY	A	0 to 32,767
701(R)	Event 18 fault current IQY	A	0 to 32,767
702(R)	Event 18 fault current INY	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 13 of 17)

Reg. #	Description	Units	Range
703(R)	Acknowledgment for Event 18	0—unack, 1—ack	0 to 1
704(R)	Event Number	none	0 or 19
705–707(R)	Event 19 Compressed Date/Time	month, day, yr, hr, min, s	See time format
708(R)	Event 19 Compressed Date/Time	ms	See time format
709–715(R)	Event 19 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
716(R)	Event 19 system frequency	Hz/10	0 to 1000
717(R)	Event 19 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
718(R)	Event 19 type	none	See Event Type
719(R)	Event 19 Target	none	See Target Format
720(R)	Event 19 duration	cyc/100	0.00 to 15.00 cyc.
721(R)	Event 19 fault current IAX	A	0 to 32,767
722(R)	Event 19 fault current IBX	A	0 to 32,767
723(R)	Event 19 fault current ICX	A	0 to 32,767
724(R)	Event 19 fault current IQX	A	0 to 32,767
725(R)	Event 19 fault current INX	A	0 to 32,767
726(R)	Event 19 fault current IAY	A	0 to 32,767
727(R)	Event 19 fault current IBY	A	0 to 32,767
728(R)	Event 19 fault current ICY	A	0 to 32,767
729(R)	Event 19 fault current IQY	A	0 to 32,767
730(R)	Event 19 fault current INY	A	0 to 32,767
731(R)	Acknowledgment for Event 19	0—unack, 1—ack	0 to 1
732(R)	Event Number	none	0 or 20
733–735(R)	Event 20 Compressed Date/Time	month, day, yr, hr, min, s	See time format
736(R)	Event 20 Compressed Date/Time	ms	See time format
737–743(R)	Event 20 Expanded Date/Time	ms, s, min, hr, day, month, yr	See time format
744(R)	Event 20 system frequency	Hz/10	0 to 1000
745(R)	Event 20 setting changed 0—settings have not been changed 1—Relay X settings have been changed 2—Relay Y settings have been changed 3—both Relay X and Y settings have been changed	none	0 to 3
746(R)	Event 20 type	none	See Event Type
747(R)	Event 20 Target	none	See Target Format
748(R)	Event 20 duration	cyc/100	0.00 to 15.00 cyc.
749(R)	Event 20 fault current IAX	A	0 to 32,767
750(R)	Event 20 fault current IBX	A	0 to 32,767
751(R)	Event 20 fault current ICX	A	0 to 32,767

Table F.3 SY/MAX Protocol Register Map (Sheet 14 of 17)

Reg. #	Description	Units	Range
752(R)	Event 20 fault current IQX	A	0 to 32,767
753(R)	Event 20 fault current INX	A	0 to 32,767
754(R)	Event 20 fault current IAY	A	0 to 32,767
755(R)	Event 20 fault current IBY	A	0 to 32,767
756(R)	Event 20 fault current ICY	A	0 to 32,767
757(R)	Event 20 fault current IQY	A	0 to 32,767
758(R)	Event 20 fault current INY	A	0 to 32,767
759(R)	Acknowledgment for Event 20	0—unack, 1—ack	0 to 1
Scale Factor			
2020(R/W)	Scale Group A: Ammeter/Phase –2 = scale by 0.01 –1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	–2 to 1
2021(R/W)	Scale Group B: Ammeter Neutral –2 = scale by 0.01 –1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	–2 to 1
2022(R/W)	Scale Group C: Ammeter Ground –2 = scale by 0.01 –1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	–2 to 1
Instantaneous Meter			
1003(R)	Current, A-phase	Amperes scale factor A	0 to 32,767
1004(R)	Current, B-phase	Amperes scale factor A	0 to 32,767
1005(R)	Current, C-phase	Amperes scale factor A	0 to 32,767
1006(R)	Current, 3I2	Amperes scale factor B	0 to 32,767
1007(R)	Current, IR	Amperes scale factor C	0 to 32,767
1008–1010(R)	Compressed Date/Time recorded at the time of getting the meter data	month, day, yr, hr, min, s	See time format
1011(R)	Compressed Date/Time recorded at the time of getting the meter data	ms	See time format
1012–1018(R)	Expanded Date/Time recorded at the time of getting the meter data	ms, s, min, hr, day, month, yr	See time format
Demand Meter			
1700(R)	Demand Current, A-phase	Amperes scale factor A	0 to 32,767
1701(R)	Demand Current, B-phase	Amperes scale factor A	0 to 32,767
1702(R)	Demand Current, C-phase	Amperes scale factor A	0 to 32,767
1703(R)	Demand Current, 3I2	Amperes scale factor B	0 to 32,767
1704(R)	Demand Current, IR	Amperes scale factor C	0 to 32,767
1705–1707(R)	Compressed Date/Time recorded at the time of getting the meter D data	month, day, yr, hr, min, s	See time format

Table F.3 SY/MAX Protocol Register Map (Sheet 15 of 17)

Reg. #	Description	Units	Range
1708(R)	Compressed Date/Time recorded at the time of getting the meter D data	ms	See time format
1709–1715(R)	Expanded Date/Time recorded at the time of getting the meter D data	ms, s, min, hr, day, month, yr	See time format
1716(W)	Reset Demand Meter	none	
Peak Demand Meter			
1800(R)	Peak Demand Current, A-phase	Amperes scale factor A	0 to 32,767
1801(R)	Peak Demand Current, B-phase	Amperes scale factor A	0 to 32,767
1802(R)	Peak Demand Current, C-phase	Amperes scale factor A	0 to 32,767
1803(R)	Peak Demand Current, 3I2	Amperes scale factor B	0 to 32,767
1804(R)	Peak Demand Current, IR	Amperes scale factor C	0 to 32,767
1805–1807(R)	Compressed Date/Time recorded at the time of getting the meter P data	month, day, yr, hr, min, s	See time format
1808(R)	Compressed Date/Time recorded at the time of getting the meter P data	ms	See time format
1809–1815(R)	Expanded Date/Time recorded at the time of getting the meter P data	ms, s, min, hr, day, month, yr	See time format
1816(W)	Reset Peak Demand Meter	none	
Relay Status			
1900(R) 1901(R)	(IA) channel IA, the dc offset channel IA status message: 0—normal 1—warn 2—fail	mV	0 to 9000
1902(R) 1903(R)	(IB) channel IB, the dc offset channel IB status message: 0—normal 1—warn 2—fail	mV	0 to 9000
1904(R) 1905(R)	(IC) channel IC, the dc offset channel IC status message: 0—normal 1—warn 2—fail	mV	0 to 9000
1906(R)	(MOF), the dc offset in the A/D circuit when a grounded input is selected.	mV	0 to 9000
1907(R)	MOF status message: 0—normal 1—warn 2—fail		
1908(R)	(+5v_ps) power supply the power supply value	V/100	0.00 to 500.00
1909(R)	+5v_ps power supply status message: 0—normal 1—warn 2—fail		
1910(R)	(+5_REG) power supply the power supply value	V/100	0.00 to 500.00

Table F.3 SY/MAX Protocol Register Map (Sheet 16 of 17)

Reg. #	Description	Units	Range
1911(R)	+5_REG power supply status message: 0—normal 1—warn 2—fail		
1912(R)	(–5_REG) power supply the power supply value	V/100	0.00 to –500.00
1913(R)	–5_REG power supply status message: 0—normal 1—warn 2—fail		
1914(R)	(+10_ps) power supply the power supply value	V/100	0.00 to 500.00
1915(R)	+10_ps power supply status message: 0—normal 1—warn 2—fail		
1916(R)	(–10_ps) power supply the power supply value	V/100	0.00 to 500.00
1917(R)	–10_ps power supply status message: 0—normal 1—warn 2—fail		
1918(R)	(VBAT) power supply the power supply value	V/100	0.00 to 500.00
1919(R)	VBAT power supply status message: 0—normal 1—warn 2—fail		
1920(R)	(TEMP) Temperature in degrees centigrade	°C/100	0.00 to 100.00
1921(R)	temperature status message: 0—normal 1—warn 2—fail		
1922(R)	(RAM) RAM status 0—OK 2—fail	none	
1923(R)	(ROM) ROM status 0—OK 2—fail	none	
1924(R)	(CR_RAM) CR_RAM status 0—OK 2—fail	none	
1925(R)	(EEPROM) EEPROM status 0—OK 2—fail	none	
1926(R)	(SETTING) Setting status 0—OK 1—Relay setting is not OK 2—Calibration Setting is not OK	none	

Table F.3 SY/MAX Protocol Register Map (Sheet 17 of 17)

Reg. #	Description	Units	Range
1927(R)	(ENABLE) Enable status 0—relay enabled 1—relay disabled	none	
Target			
2040(R)	Target 0	none	see target format
2041(R)	Target 1	none	see target format
2042(R)	Target 2	none	see target format
2043(R)	Target 3	none	see target format
2044(R)	Target 4	none	see target format
2045(W)	Reset Target	none	
Trigger			
2050(W)	Trigger a relay event report	none	
SY/MAX Status Byte			
2060(R)	Status byte	none	see status byte
2061(W)	SY/MAX status acknowledgment	none	
Relay Command			
2071(W)	Execute 86tr	none	
2073(W)	Execute retrip	none	
2075(W)	Execute run	none	
2077(W)	Execute stop	none	
2079(W)	Execute close	none	
2081(W)	Execute open	none	
2083(W)	Execute open1	none	
2085(W)	Execute open2	none	
2087(W)	Execute TIMER1	none	
2089(W)	Execute TIMER2	none	
Reset X/Y			
2100(W)	Reset X/Y	none	
Time/Date			
2130–2132(R/W)	Compressed current date/time	month, day, yr, hr, min, s	See time format
2133(R/W)	Compressed current date/time	ms	See time format
2134–2140(R/W)	Expanded current date/time	ms, s, min, hr, day, month, yr	See time format

Date/Time Format

Within *Table F.3*, two date/time formats are used.

Compressed Date/Time

Four registers are used for the compressed date/time format.

- Register 1, Month (MSB) = 1 to 12, Day (LSB) = 1 to 31,
- Register 2 Year (MSB) = 0 to 199, Hour (LSB) = 0 to 23,

- Register 3, Minutes (MSB) = 0 to 59, Second (LSB) = 0 to 59,
- Register 4, Millisecond = 0 to 999.

The year is zero based on the year 1900 in anticipation of the 21st century, (e.g., 1989 would be represented as 89 and 2009 would be represented as 109).

Expanded Date/Time

Seven registers are used for the expanded date/time format.

- Register 1, millisecond, 0 to 999,
- Register 2, second, 0 to 59,
- Register 3, minute, 0 to 59,
- Register 4, hours, 0 to 23
- Register 5, day, 1 to 31
- Register 6, month 1 to 12
- Register 7, year 1900 to 2099

Target Format

When a target byte is reported, it consists of a set of 8 targets, where each bit of the byte represents a target. If the target is on, this bit is 1; otherwise, this bit is 0. Within the short event data, the reported target byte is the front-panel targets, which correspond to the Target 0 data available in the target data. The following table shows how Targets 0 and 1 map. Interpretation of Targets 2, 3, and 4 depends on the application setting of the relay. See the tables in *Section 7: Operation*, to determine target meanings.

Bit Number	7	6	5	4	3	2	1	0
Target 0	X	Y	INST	A	B	C	Q	N
Target 1	*	XIN	YIN	ALARM	XOUT1	XOUT2	YOUT1	YOUT2

For example:

Target	Target Byte in Binary	Target Byte in Hex
Y AB	01011000	0x58
X INST ABC	10111100	0xBC

Event Type

Table F.4 shows the event types and associated encoding.

Table F.4 Event Types and Encoding (Sheet 1 of 2)

Event Type	Encoding	Event Type	Encoding
TRIGGER	0x0	STOP	0xA
FAULT	0x1	RETRIP	0xB
START	0x2	CLOSE	0xC
THERM	0x3	RUN	0xD
STL	0x4	EXT	0xE

Table F.4 Event Types and Encoding (Sheet 2 of 2)

Event Type	Encoding	Event Type	Encoding
LJAM	0x5	TIMER1	0xF
LLOSS	0x6	TIMER2	0x10
BFI	0x7	OUT1	0x11
86TR	0x8	OUT2	0x12
OPEN	0x9	TRIP	0x40

If the Y relay triggered the event, the MSB will be 1. Otherwise, the MSB is 0.

For example:

Event Type	Numerical Representation
86TR X	0x08
OUT2 Y	0x92

Event Acknowledgment

The short event report includes event number, event type, and event target, system frequency, setting changed, event date/time and event acknowledgment. The event acknowledgment indicates if the short event report has been acknowledged by the client device yet. The acknowledgment procedure follows:

The client device asks for the oldest unacknowledged short event report packet. After this short event report is sent, if an event acknowledgment is received, the acknowledgment for this short event should be set to 1. If all the short event reports are acknowledged, the oldest unacknowledged short event report packet will return 0.

When you read the oldest unacknowledged short event report packet (address 160), the SEL-501-1 will return a 28-register packet. This packet is organized like all other short event report packets, starting with an event number and going through the acknowledgment flag.

Write-Only Registers

There are many registers to which you write to trigger various relay operations. The data you write to these registers does not matter; it is the act of writing that triggers the operation.

SY/MAX Status Byte

One status register is used to indicate the relay turning on and event trigger, self-test failure, and setting change conditions. Each condition occupies a bit in the status byte. When the condition is true, the corresponding bit will be set. The relay turning on and setting changed bits will be cleared by sending a status acknowledgment message. The other bits will be cleared when the condition is no longer true.

0—turn on	Set when relay is turned on, cleared by status acknowledgment message. Can also be cleared by Fast Meter status acknowledgment message.
1—event trigger	Set by triggering event report, cleared by acknowledging all events.
2—self-test warning	Set if self-test warning condition exists, clear if no diagnostic warnings exist.
3—self-test failure	Set if self-test failure condition exists, clear if no diagnostic failures exist.
4—setting change	Set if settings were changed or when the relay turns on, cleared by the status acknowledgment message. Can also be cleared by Fast Meter status acknowledgment message.

This page intentionally left blank

APPENDIX G

Modbus RTU Communications Protocol

Introduction

This appendix describes Modbus RTU communications features supported by the rear-panel serial communications port of the SEL-501. Complete specifications for the Modbus protocol are available from the Modicon website at www.modicon.com.

Use the serial port settings to enable Modbus protocol. 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 Modbus communication allows a Modbus client device to do the following:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-501 output contacts.
- Read the SEL-501 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 G.1*.

Table G.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 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 are described in *Table G.2*.

The cyclical redundancy check (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 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 supports the Modbus function codes shown in *Table G.2*.

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

Table G.3 SEL-501 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 is in the wrong state for the requested function.
06	Busy	The SEL-501 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 G.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 calculates a 2-byte CRC value, 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, 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 can read the status of as many as 2000 bits per query. Note the relay input addresses start at 0 (e.g., Coil 1 is located at address zero). The relay returns 8 bits per byte, most significant bit first, with zeros padded into incomplete bytes.

Table G.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 8, 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 in the following table.

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 G.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 0. The relay returns 8 bits per byte, most significant bit first, with zeros padded into incomplete bytes.

Table G.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 8, the relay adds one more byte to maintain the balance of bits, padded by zeros to make an even byte.

Input numbers are defined as follows:

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 in the following table.

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 G.18*. You can 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 5-digit addressing, add 40001 to the standard database address.

Table G.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 as follows:

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 G.18*. You can read a maximum of 125 registers at once with this function code.

Table G.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 in the following table.

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 G.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 offers the commands listed in *Table G.9* that you can execute through use of function code 05h. The command coils are self-resetting.

Table G.9 SEL-501 Command Coils

Coil	Field
1	OUT1X
2	OUT2X
3	OUT1Y
4	OUT2Y
5	ALARM

The relay response to the errors in the query are shown in the following table.

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil) number	Illegal Data Address (02h)	Invalid Address
Illegal bit state requested	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 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 6-digit addressing, add 400001 to the standard database addresses.

Table G.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 in the following table.

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 uses this function to allow a Modbus client to read the present status of the relay and protected circuit.

Table G.11 07h Read Exception Status Command (Sheet 1 of 2)

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 OUT 2 Status
Bit 3	Relay X OUT1 Status
Bit 4	Alarm Output status

Table G.11 07h Read Exception Status Command (Sheet 2 of 2)

Bytes	Field
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 in the following table.

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

08h Loopback Diagnostic Command

The SEL-501 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 G.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 byte	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 in the following table.

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 6-digit addressing, simply add 400001 to the standard database addresses.

Table G.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	Number of Registers to Write
1 byte	Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the server will have the following format:	
1 byte	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 in the following table.

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 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 G.14 64h Scattered Register Read Command

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
1 byte	Subfunction Code (04h)[a]
1 byte	Transmission Number
2 bytes	Address of First Register
2 bytes	Address of Second Register
• • •	• • •
2 bytes	Address of nth 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 responses to errors in the query are shown in the following table.

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 Modbus Register Map (*Table G.18*) includes two 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 G.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 G.15 SEL-501 Modbus Command Region

Address	Field
00C0h	Command Code
00C1h	Parameter 1

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

Table G.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 0000 0000 0000 0010 0000 0000 0000 0100 0000 0000 0000 1000 0000 0000 0001 0000 0000 0000 0010 0000 0000 0000 0100 0000 0000 0000 1000 0000 0000 0001 0000 0000 0000 0010 0000 0000	Breaker Monitor X Breaker Monitor Y Demand Metering X Demand Metering Y Peak Metering X Peak Metering Y History Buffer Communication Counters Alarm Occurrence (latched) Registers Alarm counters	06h, 10h

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

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).
- If **RESET** commands are issued while the relay application is set at BFR or TMR, the relay will return error code 04 (device error).

Reading Event Data Using Modbus

The Modbus Register Map (*Table G.18*) provides a feature that allows you to download complete event data via Modbus. The SEL-501 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 8: Event Reporting* for a more detailed description. If the user selects an event number for which no data are available, the inapplicable code will be returned.

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

Step 1. Write the event number you want to download at address 00E3h.

Step 2. Write the channel number you want to download at address 00E4h.

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

Table G.17 Assign Event Report Channel Using Address 00E4h

Set 00E4h	To Read Data 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 7: Operation to obtain the contents of each relay element status row. Relay Element Status Row 0, which represents targets, is displayed at 00DE, 00A0, and 00A1 in the Modbus Map.

Reading History Data Using Modbus

The Modbus Register Map (*Table G.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 5* of the Modbus Map for a list of event types.

To download the history data 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 G.18*).

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

Table G.18 Modbus Map (Sheet 1 of 17)

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					

Table G.18 Modbus Map (Sheet 2 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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
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 supply status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0040	+5_REG power supply value[b]	V	0	600	1	0.01

Table G.18 Modbus Map (Sheet 3 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0041	+5_REG power supply status message[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 status message[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 message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0046	–10_ps power supply value[c]	V	–1500	0	1	0.01
0047	–10_ps power supply status message[b] 0 = OK 1 = Warn 2 = Fail	–	–	–	–	–
0048	VBAT power supply value[b]	V	0	500	1	0.01
0049	VBAT power supply status message[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	–	–	–	–	–
004E	CR_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					

Table G.18 Modbus Map (Sheet 4 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Thermal Data (Relay X; see Note 2)						
0060	Thermal loading in % of rated trip level[b]	%	0	65535	1	1
0061	Positive-sequence current in % of full load amps[b]	%	0	65535	1	1
0062	Negative-sequence current in % of full load amps[b]	%	0	65535	1	1
0063	Positive-sequence current in primary amps[b]	A	0	65535	1	1
0064	Negative-sequence current in primary amps[b]	A	0	65535	1	1
0065	Number of starts in last one hour[b]	–	0	65535	1	1
Demand Meter (Relay X)						
0066	Demand current Phase Ax[b]	A	0	65535	1	1
0067	Demand current Phase Bx[b]	A	0	65535	1	1
0068	Demand current Phase Cx[b]	A	0	65535	1	1
0069	Demand current 3I2x[b]	A	0	65535	1	1
006A	Demand residual current Irx[b]	A	0	65535	1	1
Peak Demand Meter (Relay X)						
006B	Peak demand current Phase Ax[b]	A	0	65535	1	1
006C	Peak demand current Phase Bx[b]	A	0	65535	1	1
006D	Peak demand current Phase Cx[b]	A	0	65535	1	1
006E	Peak demand current 3I2x[b]	A	0	65535	1	1
006F	Peak residual current Irx[b]	A	0	65535	1	1
Instantaneous Metering (Relay X)						
0070	Inst. current Phase Ax[b]	A	0	65535	1	1
0071	Inst. current Phase Bx[b]	A	0	65535	1	1
0072	Inst. current Phase Cx[b]	A	0	65535	1	1
0073	Inst. current 3I2x[b]	A	0	65535	1	1
0074	Inst. residual current Irx[b]	A	0	65535	1	1
Thermal Data (Relay Y; see Note 2)						
0075	Thermal loading in % of rated trip level[b]	%	0	65535	1	1
0076	Positive-sequence current in % of full load amps[b]	%	0	65535	1	1
0077	Negative-sequence current in % of full load amps[b]	%	0	65535	1	1
0078	Positive-sequence current in primary amps[b]	A	0	65535	1	1
0079	Negative-sequence current in primary amps[b]	A	0	65535	1	1
007A	Number of starts in last one hour[b]	–	0	65535	1	1
Demand Meter (Relay Y)						
007B	Demand current Phase Ay[b]	A	0	65535	1	1
007C	Demand current Phase By[b]	A	0	65535	1	1
007D	Demand current Phase Cy[b]	A	0	65535	1	1

Table G.18 Modbus Map (Sheet 5 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
007E	Demand current 3I2y[b]	A	0	65535	1	1
007F	Demand residual current Iry[b]	A	0	65535	1	1
Peak Demand Meter (Relay Y)						
0080	Peak demand current Phase Ay[b]	A	0	65535	1	1
0081	Peak demand current Phase By[b]	A	0	65535	1	1
0082	Peak demand current Phase Cy[b]	A	0	65535	1	1
0083	Peak demand current 3I2y[b]	A	0	65535	1	1
0084	Peak demand residual current Iry[b]	A	0	65535	1	1
Instantaneous Metering (Relay Y)						
0085	Inst. current Phase Ay[b]	A	0	65535	1	1
0086	Inst. current Phase By[b]	A	0	65535	1	1
0087	Inst. current Phase Cy[b]	A	0	65535	1	1
0088	Inst. current 3I2x[b]	A	0	65535	1	1
0089	Inst. residual current Iry[b]	A	0	65535	1	1
Breaker Monitor (Relay X; see Note 3)						
008A	Number of internal trips[b]	–	0	65535	1	1
008B	Internal IA[b]	kA	0	65535	1	0.1
008C	Internal IB[b]	kA	0	65535	1	0.1
008D	Internal IC[b]	kA	0	65535	1	0.1
008E	Number of external trips[b]	–	0	65535	1	1
008F	External IA[b]	kA	0	65535	1	0.1
0090	External IB[b]	kA	0	65535	1	0.1
0091	External IC[b]	kA	0	65535	1	0.1
Breaker Monitor (Relay Y)						
0092	Number of internal trips[b]	–	0	65535	1	1
0093	Internal IA[b]	kA	0	65535	1	0.1
0094	Internal IB[b]	kA	0	65535	1	0.1
0095	Internal IC[b]	kA	0	65535	1	0.1
0096	Number of external trips[b]	–	0	65535	1	1
0097	External IA[b]	kA	0	65535	1	0.1
0098	External IB[b]	kA	0	65535	1	0.1
0099	External IC[b]	kA	0	65535	1	0.1
Expanded Relay Time and Date						
009A (RW) (see *Note 4*)	Time[b]	ss	0	59	1	1
009B (RW)	[b]	mm	0	59	1	1
009C (RW)	[b]	hh	0	23	1	1
009D (RW)	Date[b]	dd	1	31	1	1
009E (RW)	[b]	mm	1	12	1	1
009F (RW)	[b]	yyyy	1992	2999	1	1

Table G.18 Modbus Map (Sheet 6 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Targets						
00A0	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 = Neg.-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50 Bit 12 = Phase A 51/50 Bit 13 = Inst. Bit 14–15 = 0					
00A1	Targets Y 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 = Neg.-Sequence Bit 13 = Residual 51N/50N Bit 14–15 = 0					
00A2–00AF	Reserved					
00B0	Application Code Relay X[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR					
Relay Word (X)						
00B1	Row 2 (relay element status) APP = FDR or OC1 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					

Table G.18 Modbus Map (Sheet 7 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	APP = MOT 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 = STL Bit 14 = 0 Bit 15 = 49 APP = BFR 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 = 0 Bit 11 = 0 Bit 12 = 50PP Bit 13 = 62T Bit 14 = RTRP Bit 15 = 86TR APP = TMR or OFF Bit 0–15 = 0					
00B2	Row 3 (relay element status) APP = FDR or OC1 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 G.18 Modbus Map (Sheet 8 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	APP = MOT 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 = LJAM Bit 9 = 50NP Bit 10 = 50QP Bit 11 = LLOSS Bit 12 = 50PP Bit 13 = 51ST Bit 14 = 50L Bit 15 = 49A APP = BFR, TMR or OFF Bits 0–15 = 0					
00B3	Row 4 (relay element status) APP = FDR or OC1 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 = 0 Bit 10 = 0 Bit 11 = 0 Bit 12 = 0 Bit 13 = 51NR Bit 14 = 51QR Bit 15 = 51PR APP = MOT, BFR, TMR, or OFF Bit 0–15 = 0					
Relay Word (Y)						
00B4	Application code Relay Y[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR					
00B5	Row 2 APP = FDR or OC1 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					

Table G.18 Modbus Map (Sheet 9 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	APP = MOT 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 = STL Bit 14 = 0 Bit 15 = 49 APP = BFR 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 = 0 Bit 11 = 0 Bit 12 = 50PP Bit 13 = 62T Bit 14 = RTRP Bit 15 = 86TR APP = TMR or OFF Bit 0–15 = 0					
00B6	Row 3 APP = FDR or OC1 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 = 51NT Bit 14 = 51QP Bit 15 = 51PP					

Table G.18 Modbus Map (Sheet 10 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	APP = MOT 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 = LJAM Bit 9 = 50NP Bit 10 = 50QP Bit 11 = LLOSS Bit 12 = 50PP Bit 13 = 51ST Bit 14 = 51L Bit 15 = 49A APP = BFR, TMR, or OFF Bit 0–15 = 0					
00B7	Row 4 APP = FDR or OC1 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 = 0 Bit 10 = 0 Bit 11 = 0 Bit 12 = 0 Bit 13 = 51NR Bit 14 = 51QR Bit 15 = 51PR APP = MOT, BFR, TMR, or OFF Bit 0–15 = 0					
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 = YOUT2 Bit 9 = YOUT1 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 8*)	Command Code		1	11		
00C1 (W)	Parameter 1					
00C2–00CF	Reserved					

Table G.18 Modbus Map (Sheet 11 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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	[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 5*				
00DB						
00DC						
00DD						
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 Bit 1 = 0 Bit 2 = 0 Bit 3 = 0 Bit 4 = 0 Bit 5 = 0 Bit 6 = 0 Bit 7 = 0 Bit 8 = Residual 51N/50N Bit 9 = Neg.-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50 Bit 12 = Phase A 51/50 Bit 13 = Inst. Bit 14 = Relay Y Bit 15 = Relay X					
00DF	Reserved					
Event Reporting (see Note 7)						
00E0	Relay X Application[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR	–	–	–	–	–

Table G.18 Modbus Map (Sheet 12 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00E1	Relay Y Application[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR	–	–	–	–	–
00E2	Number event records[b]	–	1	5	1	1
00E3 (RW)	Event selection[b]	–	1	5	1	1
00E4 (RW)	Channel selection[b]	–	1	8	1	1
00E5	1/4 cycle[c]		–32767	32767	1	1
00E6	1/2 cycle[c]		–32767	32767	1	1
00E7	3/4 cycle[c]		–32767	32767	1	1
00E8	1 cycle[c]		–32767	32767	1	1
00E9	1 1/4 cycle[c]		–32767	32767	1	1
00EA	1 1/2 cycle[c]		–32767	32767	1	1
00EB	1 3/4 cycle[c]		–32767	32767	1	1
00EC	2 cycle[c]		–32767	32767	1	1
00ED	2 1/4 cycle[c]		–32767	32767	1	1
00EE	2 1/2 cycle[c]		–32767	32767	1	1
00EF	2 3/4 cycle[c]		–32767	32767	1	1
00F0	3 cycle[c]		–32767	32767	1	1
00F1	3 1/4 cycle[c]		–32767	32767	1	1
00F2	3 1/2 cycle[c]		–32767	32767	1	1
00F3	3 3/4 cycle[c]		–32767	32767	1	1
00F4	4 cycle[c]		–32767	32767	1	1
00F5	4 1/4 cycle[c]		–32767	32767	1	1
00F6	4 1/2 cycle[c]		–32767	32767	1	1
00F7	4 3/4 cycle[c]		–32767	32767	1	1
00F8	5 cycle[c]		–32767	32767	1	1
00F9	5 1/4 cycle[c]		–32767	32767	1	1
00FA	5 1/2 cycle[c]		–32767	32767	1	1
00FB	5 3/4 cycle[c]		–32767	32767	1	1
00FC	6 cycle[c]		–32767	32767	1	1
00FD	6 1/4 cycle[c]		–32767	32767	1	1
00FE	6 1/2 cycle[c]		–32767	32767	1	1
00FF	6 3/4 cycle[c]		–32767	32767	1	1
0100	7 cycle[c]		–32767	32767	1	1
0101	7 1/4 cycle[c]		–32767	32767	1	1
0102	7 1/2 cycle[c]		–32767	32767	1	1

Table G.18 Modbus Map (Sheet 13 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0103	7 3/4 cycle[c]		–32767	32767	1	1
0104	8 cycle[c]		–32767	32767	1	1
0105	8 1/4 cycle[c]		–32767	32767	1	1
0106	8 1/2 cycle[c]		–32767	32767	1	1
0107	8 3/4 cycle[c]		–32767	32767	1	1
0108	9 cycle[c]		–32767	32767	1	1
0109	9 1/4 cycle[c]		–32767	32767	1	1
010A	9 1/2 cycle[c]		–32767	32767	1	1
010B	9 3/4 cycle[c]		–32767	32767	1	1
010C	10 cycle[c]		–32767	32767	1	1
010D	10 1/4 cycle[c]		–32767	32767	1	1
010E	10 1/2 cycle[c]		–32767	32767	1	1
010F	10 3/4 cycle[c]		–32767	32767	1	1
0110	11 cycle[c]		–32767	32767	1	1
0111	11 1/4 cycle[c]		–32767	32767	1	1
0112	11 1/2 cycle[c]		–32767	32767	1	1
0113	11 3/4 cycle[c]		–32767	32767	1	1
0114	12 cycle[c]		–32767	32767	1	1
0115	12 1/4 cycle[c]		–32767	32767	1	1
0116	12 1/2 cycle[c]		–32767	32767	1	1
0117	12 3/4 cycle[c]		–32767	32767	1	1
0118	13 cycle[c]		–32767	32767	1	1
0119	13 1/4 cycle[c]		–32767	32767	1	1
011A	13 1/2 cycle[c]		–32767	32767	1	1
011B	13 3/4 cycle[c]		–32767	32767	1	1
011C	14 cycle[c]		–32767	32767	1	1
011D	14 1/4 cycle[c]		–32767	32767	1	1
011E	14 1/2 cycle[c]		–32767	32767	1	1
011F	14 3/4 cycle[c]		–32767	32767	1	1
0120	15 cycle[c]		–32767	32767	1	1
Relay Y						
0121	1/4 cycle[c]		–32767	32767	1	1
0122	1/2 cycle[c]		–32767	32767	1	1
0123	3/4 cycle[c]		–32767	32767	1	1
0124	1 cycle[c]		–32767	32767	1	1
0125	1 1/4 cycle[c]		–32767	32767	1	1
0126	1 1/2 cycle[c]		–32767	32767	1	1
0127	1 3/4 cycle[c]		–32767	32767	1	1
0128	2 cycle[c]		–32767	32767	1	1
0129	2 1/4 cycle[c]		–32767	32767	1	1

Table G.18 Modbus Map (Sheet 14 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
012A	2 1/2 cycle[c]		–32767	32767	1	1
012B	2 3/4 cycle[c]		–32767	32767	1	1
012C	3 cycle[c]		–32767	32767	1	1
012D	3 1/4 cycle[c]		–32767	32767	1	1
012E	3 1/2 cycle[c]		–32767	32767	1	1
012F	3 3/4 cycle[c]		–32767	32767	1	1
0130	4 cycle[c]		–32767	32767	1	1
0131	4 1/4 cycle[c]		–32767	32767	1	1
0132	4 1/2 cycle[c]		–32767	32767	1	1
0133	4 3/4 cycle[c]		–32767	32767	1	1
0134	5 cycle[c]		–32767	32767	1	1
0135	5 1/4 cycle[c]		–32767	32767	1	1
0136	5 1/2 cycle[c]		–32767	32767	1	1
0137	5 3/4 cycle[c]		–32767	32767	1	1
0138	6 cycle[c]		–32767	32767	1	1
0139	6 1/4 cycle[c]		–32767	32767	1	1
013A	6 1/2 cycle[c]		–32767	32767	1	1
013B	6 3/4 cycle[c]		–32767	32767	1	1
013C	7 cycle[c]		–32767	32767	1	1
013D	7 1/4 cycle[c]		–32767	32767	1	1
013E	7 1/2 cycle[c]		–32767	32767	1	1
013F	7 3/4 cycle[c]		–32767	32767	1	1
0140	8 cycle[c]		–32767	32767	1	1
0141	8 1/4 cycle[c]		–32767	32767	1	1
0142	8 1/2 cycle[c]		–32767	32767	1	1
0143	8 3/4 cycle[c]		–32767	32767	1	1
0144	9 cycle[c]		–32767	32767	1	1
0145	9 1/4 cycle[c]		–32767	32767	1	1
0146	9 1/2 cycle[c]		–32767	32767	1	1
0147	9 3/4 cycle[c]		–32767	32767	1	1
0148	10 cycle[c]		–32767	32767	1	1
0149	10 1/4 cycle[c]		–32767	32767	1	1
014A	10 1/2 cycle[c]		–32767	32767	1	1
014B	10 3/4 cycle[c]		–32767	32767	1	1
014C	11 cycle[c]		–32767	32767	1	1
014D	11 1/4 cycle[c]		–32767	32767	1	1
014E	11 1/2 cycle[c]		–32767	32767	1	1
014F	11 3/4 cycle[c]		–32767	32767	1	1
0150	12 cycle[c]		–32767	32767	1	1
0151	12 1/4 cycle[c]		–32767	32767	1	1

Table G.18 Modbus Map (Sheet 15 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0152	12 1/2 cycle[c]		–32767	32767	1	1
0153	12 3/4 cycle[c]		–32767	32767	1	1
0154	13 cycle[c]		–32767	32767	1	1
0155	13 1/4 cycle[c]		–32767	32767	1	1
0156	13 1/2 cycle[c]		–32767	32767	1	1
0157	13 3/4 cycle[c]		–32767	32767	1	1
0158	14 cycle[c]		–32767	32767	1	1
0159	14 1/4 cycle[c]		–32767	32767	1	1
015A	14 1/2 cycle[c]		–32767	32767	1	1
015B	14 3/4 cycle[c]		–32767	32767	1	1
015C	15 cycle[c]		–32767	32767	1	1
Summary Data						
015D	Event type[a]	ASCII string				
015E		See *Note 5*				
015F						
0160						
Date and Time						
0161						
0162	Event time[b]	ms	0	999	1	1
0163	[b]	ss	0	59	1	1
0164	[b]	mm	0	59	1	1
0165	[b]	hh	0	23	1	1
0166	Event date[b]	dd	1	31	1	1
0167	[b]	mm	1	12	1	1
0168	[b]	yyyy	1992	2999	1	1
0169	Duration extent[b] Null = actual fault is equal to the duration listed "+" = fault is probably greater than the duration listed (see *Note 6*)	ASCII string	Null	+	–	–
016A	Duration[b]	Cycles	0	65535	1	0.01
016B	X-Current IA[b]	A	0	65535	1	1
016C	X-Current IB[b]	A	0	65535	1	1
016D	X-Current IC[b]	A	0	65535	1	1
016E	X-Current IQ[b]	A	0	65535	1	1
016F	X-Current IN[b]	A	0	65535	1	1
0170	Y-Current IA[b]	A	0	65535	1	1
0171	Y-Current IB[b]	A	0	65535	1	1
0172	Y-Current IC[b]	A	0	65535	1	1
0173	Y-Current IQ[b]	A	0	65535	1	1
0174	Y-Current IN[b]	A	0	65535	1	1

Table G.18 Modbus Map (Sheet 16 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0175	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 Bit 1 = 0 Bit 2 = 0 Bit 3 = 0 Bit 4 = 0 Bit 5 = 0 Bit 6 = 0 Bit 7 = 0 Bit 8 = Residual 51N/50N Bit 9 = Neg.-Sequence Bit 10 = Phase C 51/50 Bit 11 = Phase B 51/50Phase A 51/50 Bit 12 = Bit 13 = Inst. Bit 14 = Relay Y Bit 15 = Relay X					
0176–017F	Reserved					
Alarm Indications						
0180	Current State of Alarm Indicators 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 Bit 1–7 = 0 Bit 8 = 49X Current State Bit 9 = 49Y Current State Bit 10 = 0 Bit 11 = 0 Bit 12 = 0 Bit 13 = 0 Bit 14 = 0 Bit 15 = 0 If APP is set to FDR, OC1, BFR, or TMR, Bits 0–15 = 0					
0181	Latched State of Alarm Indicators Bit 0 = 1 if bits 8 or 9 are set to 1 Bit 0 = 0 if bits 8 and 9 are set to 0 Bit 1–7 = 0 Bit 8 = 49X Latched State Bit 9 = 49Y Latched State Bit 10 = 0 Bit 11 = 0 Bit 12 = 0 Bit 13 = 0 Bit 14 = 0 Bit 15 = 0 If APP is set to FDR, OC1, BFR, or TMR, Bits 0–15 = 0					

Table G.18 Modbus Map (Sheet 17 of 17)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Alarm Counters						
0182	49AX Alarm[b]	–	0	32767	1	1
0183	49AY Alarm[b]	–	0	32767	1	1
Maximum Current Limit						
0184	Relay X[d]	A	–32767	32767	1	1
0185	Relay X[e]	Exponent	–4	4		
0186	Relay Y[d]	Amperes	–32767	32767	1	1
0187	Relay Y[e]	Exponent	–4	4		
0188–018F	Reserved					
Communication Counter						
0190	Number of messages received[b]	–	0	65535	1	1
0191	Number of messages sent to other devices[b]	–	0	65535	1	1
0192	Invalid address[b]	–	0	65535	1	1
0193	Bad CRC[b]	–	0	65535	1	1
0194	UART error[b]	–	0	65535	1	1
0195	Illegal function code/Op code[b]	–	0	65535	1	1
0196	Illegal register[b]	–	0	65535	1	1
0197	Illegal write[b]	–	0	65535	1	1
0198	Bad packet format[b]	–	0	65535	1	1
0199	Bad packet length[b]	–	0	65535	1	1
019A	Reserved					
019B	Reserved					
|	Reserved					
|	Reserved					
1FFB	Device tag #[b]	15041	–	–	–	–
1FFC	Feature set ID[b]	0				
1FFD	Reserved					
|	Reserved					
FFFF	Reserved					

[a] Two 8-bit characters per register.
[b] 16-bit unsigned value.
[c] 16-bit signed value.
[d] Two 16-bit registers needed to accomplish the Signed Integer Dynamic Fixed Point data format. Final value read = (R1 • 10R2).
[e] R1 is the content of register 0184h (0186h). R2, which is stored in 0185h (0187h), determines the decimal point position for the final value.

Note 1. Reserved addresses return 8000h.

Note 2. Thermal data are not applicable (–) if application code is not equal to MOT.

Note 3. For application FDR and MOT, both internal and external trips are applicable.

For application OC1, external trips are not applicable.

For application BFR, internal trips are not applicable.

For application TMR, neither internal nor external trips are applicable.

Note 4. Registers (RW) are read-write registers.

Registers (W) are write-only registers.

All other registers are read-only.

Note 5. Event Types

TRIG	LLOSS
FAULT	BFI
OPEN	RETRIP
CLOSE	86TR
RUN	EXT
START	TIMER1
STOP	TIMER2
THERM	1OUT
STL	2OUT
LJAM	

Note 6. 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 7. The Modbus map (*Table G.18*) provides a feature that allows you to download complete event data via Modbus.

The SEL-501 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 nonvolatile memory are lost upon loss of voltage to the relay.

The event report extraction will be through 8 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	|
Ch 7	|
Ch 8	|

Similarly, for Relay Y, there would be 8 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 8. Refer to *Table G.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 H

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 H.1*.

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

Table H.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 does not support the freeform logic described in the QuickSet instruction manual.

This page intentionally left blank

APPENDIX I

Cybersecurity Features

Introduction and Security Environment

Product Function

The SEL-501 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 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 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 has one or two serial ports for local or remote access. Restrict communications to the SEL-501 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-**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-**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.

Commissioning and Decommissioning

Commissioning

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

Secure Operation Recommendations

The SEL-501 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 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 I.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 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 models have an Ethernet interface.

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

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

Firmware Upgrade Interface

The SEL-501 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 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 does not support centrally managed accounts.

Local Accounts (or Access Levels)

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

Table I.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.

For firmware revision R501 or later, 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.

For firmware revision R500 or earlier, passwords may include three numbers. Valid numbers consist of 0–9. Valid passcodes are numbers ranging from 000 to 999.

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 does not support X.509 certificates.

Physical Access Controls

The SEL-501 has no physical access controls.

Logging Features

Security Events

When you log in to the SEL-501 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 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 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 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 operates the ALARM output contact if three consecutive incorrect password attempts are made at any access level.

Backup and Restore

The SEL-501 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 to a PC that has the latest version of QuickSet installed. Once communications are established, read the settings from the SEL-501 and save them as a .rdb file. You can open settings files with the .rdb extension and send them back to the SEL-501 relays with the same part number and firmware configuration.

Malware Protection Features

The SEL-501 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 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.

Update Verification

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

Contact SEL

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

Email: security@selinc.com

Phone: +1 (509) 332-1890

This page intentionally left blank