SEL-501-2

DUAL OVERCURRENT RELAY

INSTRUCTION MANUAL

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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.

CAUTION: This procedure requires that you handle components sensitive to Electrostatic Discharge (ESD). If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

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 reenergize the relay with an IC reversed, do not place the relay in service using that IC, even if you correct the orientation.

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

WARNING: This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

ATTENTION: Le relais contient des pièces sensibles aux décharges électrostatiques (DES). Quand on travaille sur le relais avec le panneau avant ou du dessus enlevé, les surfaces de travail et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

ATTENTION: Cette procédure requiert que vous manipuliez des composants sensibles aux décharges électrostatiques (DES). Si vous n'êtes pas équipés pour travailler avec ce type de composants, nous vous recommandons de les retourner à SEL pour leur installation.

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.

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

AVERTISSEMENT: Cet équipement 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 accès non-autorisé à l'équipement pourrait être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

MANUAL CHANGE INFORMATION

The date code at the bottom of each page of this manual reflects the creation or revision date. Date codes are changed only on pages that have been revised and any following pages affected by the revisions (i.e., pagination). If significant revisions are made to a section, the date code on all pages of the section will be changed to reflect the revision date.

Each time revisions are made, both the main table of contents and the affected individual section table of contents are regenerated and the date code is changed to reflect the revision date.

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

Revision Date	Summary of Revisions
The ***Manual Change Information*** section has been created to begin a record of revisions to this manual. All changes will be recorded in this Summary of revisions table.	
20010518	This manual differs from previous revision as stated in the following summary: – Reissued Entire Manual. – Added Caution, Danger, and Warning information to the back of the cover page of the Manual. – Replaced Standard Product Warranty page with warranty statement on cover page. – Updated passcode wording with password throughout the manual. **Section 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 4:** – Added Target 0 and Target 1 information to ***Table 4.8: Target Command Table***. **Section 8:** – Added 1OUT n and 2OUT n command information to ***Command Cross-Reference Table***.
20000501	This manual differs from previous revision as stated in the following summary: **Section 1**, Modified Dimensions description in ***Specifications***. **Appendix A**, Adjusted date code in footer to reflect current date. **Appendix E**, Made technical adjustments.

Revision Date	Summary of Revisions
20000405	This manual differs from previous revision as stated in the following summary: Reissued **Appendix D** with correct footer information.
20000105	This manual differs from previous revision as stated in the following summary: **Section 1**, Added Protocols information to ***General Specifications*** section. **Section 2**, Fixed typographical errors. **Section 3**, Added Modbus® information to ***Settings Sheets***. **Section 4**, Modified ***Serial Port Operation*** section and **Table 4.1** to add information about Modbus. **Appendix A**, Added new firmware versions to reflect addition of Modbus. **Appendix D**, Added new appendix covering Distributed Port Switch Protocol. **Appendix E**, Added new appendix with information about Modbus.
991117	This manual differs from previous revision as stated in the following summary: Reissued entire manual. **Section 1**, Made minor corrections to ***General Specifications*** section. **Section 2**, Added Figure 2.3 and renumbered the following figures. Added ***EIA-232 Serial Communications Port Voltage Jumper*** and ***Output Contact YOUT2 Control Jumper*** subsections. **Section 4**, Updated Table 4.2. **Section 6**, Added ***Relay Self-Tests*** subsection. **Appendix,** Added new ***Appendix B*** and relettered following appendices.

Revision Date	Summary of Revisions
990528	This manual differs from previous revision as stated in the following summary: **Section 2**, Updated Figures 2.1 and 2.2. **Appendix A**, Updated to include new firmware version.
981101	This manual differs from previous revision as stated in the following summary: **Section 2,** Updated relay dimension and drill plans. Updated Figure 2.4 to document new current shorting connectors for Connectorized® models. **Section 3, Table 3.1**, Page 3-7 - Corrected Table 3.1 to document 51QC and 51QTD settings. Added relay settings sheets. **Appendix B**, Page B-7, Corrected Operate Code for ***A5E3 Fast Operate Breaker Control*** section.
980626	**Section 1, General Specifications**, Page 4 - Removed note to show availability of 250 V "Level-Sensitive" inputs. Changed 250 Vdc dropout from 200 to 150 Vdc **Section 2, Two Rear-Panel Options,** Page 4 - Added "10 A for L/R = 20 ms at 250 Vdc" **Section 2, Circuit Board Jumpers and Battery,** Page 6 - Removed note to show availability of 250 V "Level Sensitive" inputs. **Section 5, Event Summary Data**, Pages 3-4 - format change moved "Event Type" heading to next page.
980327	This manual differs from previous revision as stated in the following summary: **Section 3**, Pages 6-7 - Add Y option to control settings 50PTC, 50HC, 50QTC, 50NTC, 50NHC, 51PTC, 51QTC, 51NTC. **Appendix A** - Include date code of firmware part/revision number.
970828	This manual differs from previous revision as stated in the following summary: **Section 3,** Page 1 - Add remote bit to relay control functions. **Section 3,** Pages 6-7 - Add RB option to control settings 50PTC, 50HC, 50QTC, 50NTC, 50NHC, 51PTC, 51QTC, 51NTC. **Section 4,** Pages 8, 10 - Add CONTROL command. **Section 4,** Page 12 - Add RB, CNTR8, CNTR4, CNTR2, CNTR1 to Target Command Table. **Section 4,** Page 13 - Add Change of State Counters. **Section 5,** Page 3 - Add remote bit to event report IN column. **Appendix B:** Add New Appendix.

Revision Date	Summary of Revisions
970725	This manual differs from previous revision as stated in the following summary: **Specifications Addendum** - Removed Specifications Addendum and incorporated specifications into ***Section 1: General Specifications***. **Section 1, General Specifications,** Pages 3-7 - Extensively reformatted and added specifications from the ***Specifications Addendum***. **Section 1, General Specifications**, Pages 5-7 - Reformatted the existing type test standards for clarification and added the following to ***Type Tests and Standards***: IEC 68-2-1 - 1990 IEC 68-2-2 - 1974 IEC 255-11 - 1979 IEC 255-21-3 - 1993 IEC 255-22-2 - 1996 IEC 255-22-4 - 1992 IEC 695-2-2 - 1991 UL 508 Listing **Section 1, General Specifications,** Pages 3-4 - Added 24 volt power supply ratings to ***Output Contacts***, ***Optoisolated Input Ratings***, and ***Power Supply Ratings***.
970424	This manual differs from previous revision as stated in the following summary: Add Specifications Addendum.
970414	This manual differs from previous revision as stated in the following summary: Section 2, Page 7 - Password and Breaker Control Command Jumpers - Clarification. Section 6, Page 5 - Troubleshooting Procedure (from previous page) - Revise steps to adjust LCD contract.

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FIGURES

SECTION 1: INTRODUCTION

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

The Dual Relay Block Diagram in Figure 1.2 shows the relay hardware arrangement. A single microprocessor, data acquisition system, and power supply perform the functions required to protect two pieces of power system equipment. This design makes the SEL-501-2 Relay extremely economical in terms of initial cost, panel space requirements, communications, wiring, and testing. Some possible relay applications are shown in Figure 1.3. Single-line diagrams of the protection groups are shown in Figure 1.4.

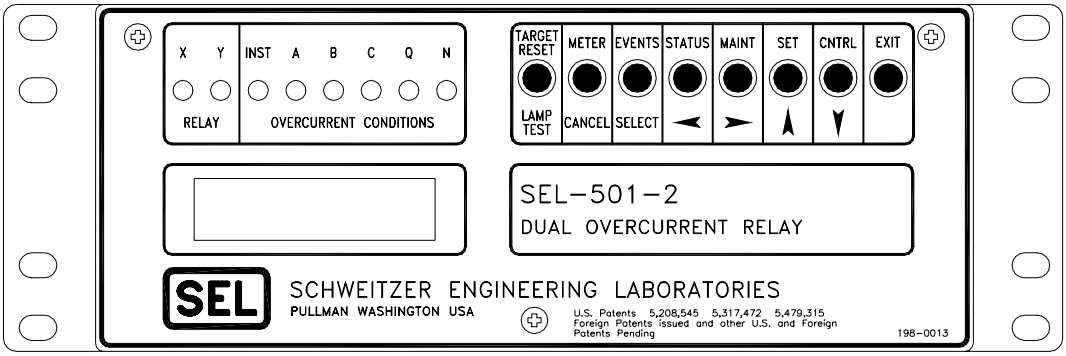


Figure 1.1: SEL-501-2 Relay Front Panel

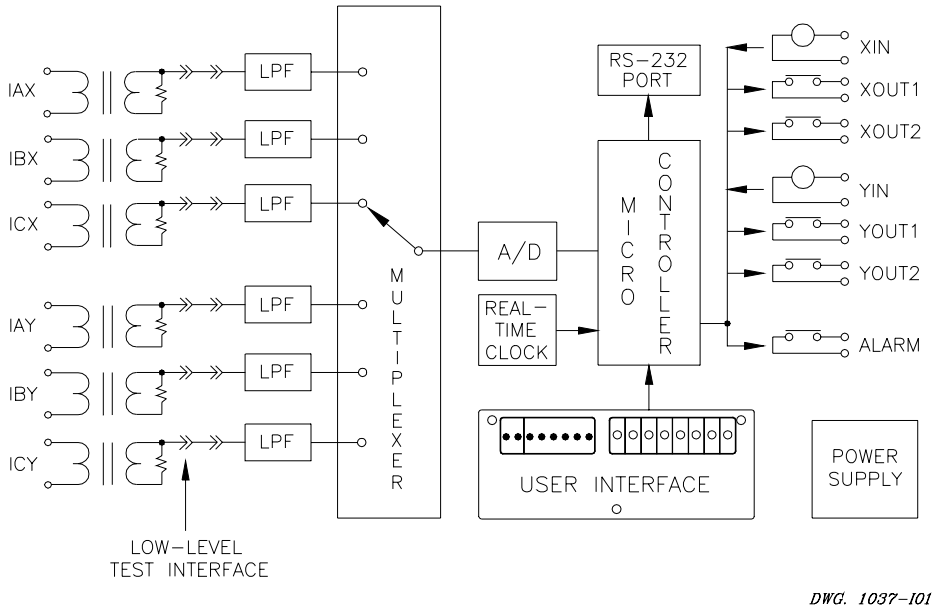
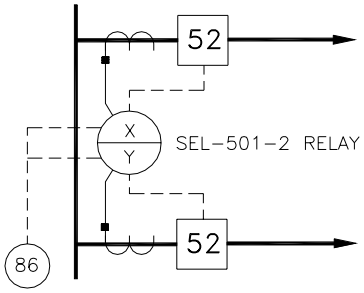


Figure 1.2: Dual Relay Hardware Block Diagram

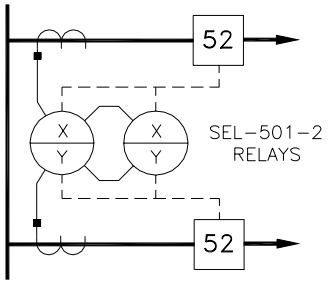
SEL-501-2 DUAL RELAY APPLICATIONS

Protect Two Feeders



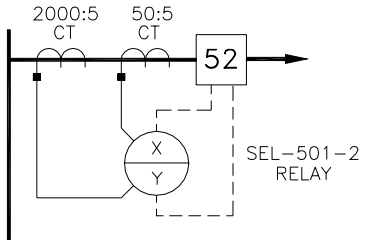
- Complete overcurrent and simple breaker failure protection for two feeders.
- Settable time-delay on trip output contact provides simple breaker failure protection.
- Low cost, compact protection.

Two Relays + Two Feeders = Full Redundancy



- Ideal for two-high switchgear.
- Front-panel controls eliminate the need for manual control switches.
- Includes negative-sequence overcurrent protection for sensitive, fast phase-to-phase fault coverage.

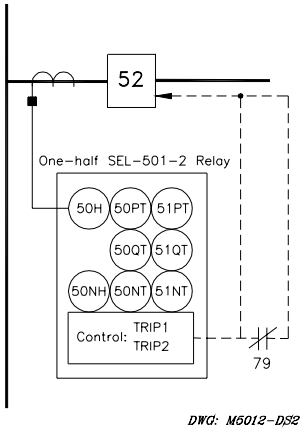
Cover a Wide Range of Fault Currents



- 2000:5 CT covers fault up to 32,000 amps (5 A Model).
- 50:5 CT meters load accurately, and covers faults down to 5 amps primary (5 A Model).

DWG: M5012ds5

Figure 1.3: Example SEL-501-2 Dual Relay Applications



DWG: M5012-DS2

Figure 1.4: Relay Application Single-Line Diagram

GENERAL SPECIFICATIONS

Tightening Torque

Terminal Block:
Minimum: 7-inch-pounds (0.8 Nm)
Maximum: 12-inch-pounds (1.4 Nm)

Connectorized®:
Minimum: 4.4-inch-pounds (0.5 Nm)
Maximum: 8.8-inch-pounds (1.0 Nm)

Terminal Connections

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

AC Current Inputs

5 A nominal: 15 A continuous; 250 A for 1 second; linear to 100 A symmetrical
Limiting Dynamic Value: 625 A for 1 cycle (sinusoidal waveform)
Burden: 0.16 VA @ 5 A, 1.15 VA @ 15 A

1 A nominal: 3 A continuous; 100 A for 1 second: linear to 20 A symmetrical
Limiting Dynamic Value: 250 A for 1 cycle (sinusoidal waveform)
Burden: 0.06 VA @ 1 A, 0.18 VA @ 3 A

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

Output Contacts

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

Standard (Conventional Terminal Blocks Option):

6 A continuous carry
30 A make per *IEEE C37.90 - 1989*
100 A for one second
270 Vac/360 Vdc MOV for differential surge protection
Pickup/dropout time: < 5 ms

Breaking Capacity (L/R = 40 ms):

24 V	0.75 A	10,000 operations
48 V	0.50 A	10,000 operations
125 V	0.30 A	10,000 operations
250 V	0.20 A	10,000 operations

Cyclic Capacity (L/R = 40 ms):

24 V	0.75 A	2.5 cycles per second
48 V	0.50 A	2.5 cycles per second
125 V	0.30 A	2.5 cycles per second
250 V	0.20 A	2.5 cycles per second

High Current Interrupting (Plug-in Connectors Option):

6 A continuous carry
30 A make per *IEEE C37.90 - 1989*
330 Vdc MOV for differential surge protection.
Pickup time: < 5 ms
Dropout time: < 8 ms (typical)

Breaking Capacity: 10 A	10,000 operations
24, 48, and 125 V	(L/R = 40 ms)
250 V	(L/R = 20 ms)
Cyclic Capacity: 10 A	4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation
24, 48, and 125 V	(L/R = 40 ms)
250 V	(L/R = 20 ms)

Note: Do not use high current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.

Optoisolated Input Ratings

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	150–300 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. Please 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
125 Vdc: on for	105–150 Vdc;	off below 75 Vdc
250 Vdc: on for	200–300 Vdc;	off below 150 Vdc

Power Supply Ratings	Rated:	125/250 Vdc or Vac
	Range:	85–350 Vdc or 85–264 Vac
	Interruption:	100 ms @ 250 Vdc
	Ripple:	100%
	Burden:	<5.5 W
	Rated:	48/125 Vdc or 125 Vac
	Range:	36–200 Vdc or 85–140 Vac
	Interruption:	100 ms @ 125 Vdc
	Ripple:	5%
	Burden:	<5.5 W
	Rated:	24 Vdc
	Range:	16–36 Vdc polarity dependent
	Interruption:	25 ms @ 36 Vdc
	Ripple:	5%
	Burden:	<5.5 W

Note: Interruption and Ripple per *IEC 60225-11: 1979*.

Serial Communications Rear-panel 9-pin sub-D connector; 300, 1200, 2400, 4800, 9600, 19200 and 38400 baud; settable baud rate and data bit protocols.

Protocols The serial port will support the following user selectable protocols.

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

Metering Functions Instantaneous and Demand Ammetering functions.
Measurement Accuracy: ±2%.

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 seconds.
Power supply, optoisolated inputs, and output contacts: 3000 Vdc for 10 seconds.

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

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

Operating Temp. –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 and Standards

The SEL-501-2 Relay complies with the rules governing CE marking.

IEEE C37.90 - 1989 IEEE Standards for Relay Systems Associated with Electrical Power Apparatus, Section 8: Dielectric Tests.
Severity Level: 2500 Vac on analog inputs; 3100 Vdc (3000 Vdc for Plug-In Connectors option) on contact inputs, contact outputs, and power supply.

IEEE C37.90.1 - 1989 IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems.
Severity Level: 3.0 kV oscillatory, 5.0 kV fast transient.

IEEE C37.90.2 - 1987 IEEE Trial-Use Standard, Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
Severity Level: 10 V/m

Exceptions:
5.5.2 (2) Performed with 200 frequency steps per octave
5.5.3 *Digital Equipment Modulation Test* not performed
5.5.4 Test signal turned off between frequency steps to simulate keying

IEC 60068-2-1 - 1990 Environmental testing, Part 2: Tests - Test Ad: Cold.
Severity Level: 16 hours at –40°C.

IEC 60068-2-2 - 1974 Environmental testing, Part 2: Tests - Test Bd: Dry heat.
Severity Level: 16 hours at +85°C.

IEC 60068-2-3 - 1969 Basic environmental testing procedures, Part 2: Tests - Test Ca: Damp heat, steady state.
Severity Level: 96 hours at +40°C, 93% RH.

IEC 60068-2-30 - 1980 Basic environmental testing procedures, Part 2: Tests, Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle).
Severity Level: 55°C, 6 cycles; Variant 1.

Exceptions:
6.3.3 Humidity not less than 94%

IEC 60255-5 - 1977 Electrical relays, Part 5: Insulation tests for electrical relays.
Section 6: Dielectric Tests.
Severity Level: Series C (2500 Vac on analog inputs; 3000 Vdc on power supply, contact inputs, and contact outputs).
Section 8: Impulse voltage test.
Severity Level: 0.5 Joule, 5000 volt.

IEC 60255-21-1 - 1988 Electrical relays - Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section 1: Vibration test (sinusoidal).
Severity Level: Class 2.

IEC 60255-21-2 - 1988 Electrical relays - Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section 2: Shock and bump tests.
Severity Level: Class 2.

IEC 60255-21-3 - 1993 Electrical relays - Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section 3: Seismic tests. (Conventional Terminal Block option only.)
Severity Level: Class 2.

IEC 60255-22-1 - 1988 Electrical disturbance tests for measuring relays and protection equipment, Section 1: 1 MHz burst disturbance tests.
Severity Level: 2.5 kV peak common mode, 2.5 kV peak differential mode.

IEC 60255-22-2 - 1996 Electrical disturbance tests for measuring relays and protection equipment, Section 2: Electrostatic Discharge tests.
Severity Level: 4.

IEC 60255-22-3 - 1989 Electrical disturbance tests for measuring relays and protection equipment, Section 3: Radiated electromagnetic field disturbance tests.
Severity Level: 10 V/m

Exceptions:
4.3.2.2 Frequency sweep approximated with 200 frequency steps per octave

IEC 60255-22-4 - 1992 Electrical disturbance tests for measuring relays and protection equipment, Section 4: Fast transient disturbance test.
Severity Level: 4 (4 kV on power supply, 2 kV on inputs and outputs).

IEC 60529 - 1989 Degrees of protection provided by enclosures.
Severity Level: IP3X.

IEC 60801-2 - 1991 Electromagnetic compatibility for industrial-process measurement and control equipment, Part 2: Electrostatic discharge requirements.
Severity Level: 4.

IEC 60801-3 - 1984 Electromagnetic compatibility for industrial-process measurement and control equipment, Part 3: Radiated electromagnetic field requirements.
Severity Level: 10 V/m

Exceptions:
9.1 Frequency sweep approximated with 200 frequency steps per octave

IEC 60801-4 - 1988 Electromagnetic compatibility for industrial-process measurement and control equipment, Part 4: Electrical fast transient/burst requirements.
Severity Level: 4 (4 kV on power supply, 2 kV on inputs and outputs).

UL 508 and CSA C22.2 No. 14-95 Industrial Control Equipment Standard for Safety.

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TABLES

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SECTION 2: MOUNTING AND CONNECTIONS

RELAY MOUNTING

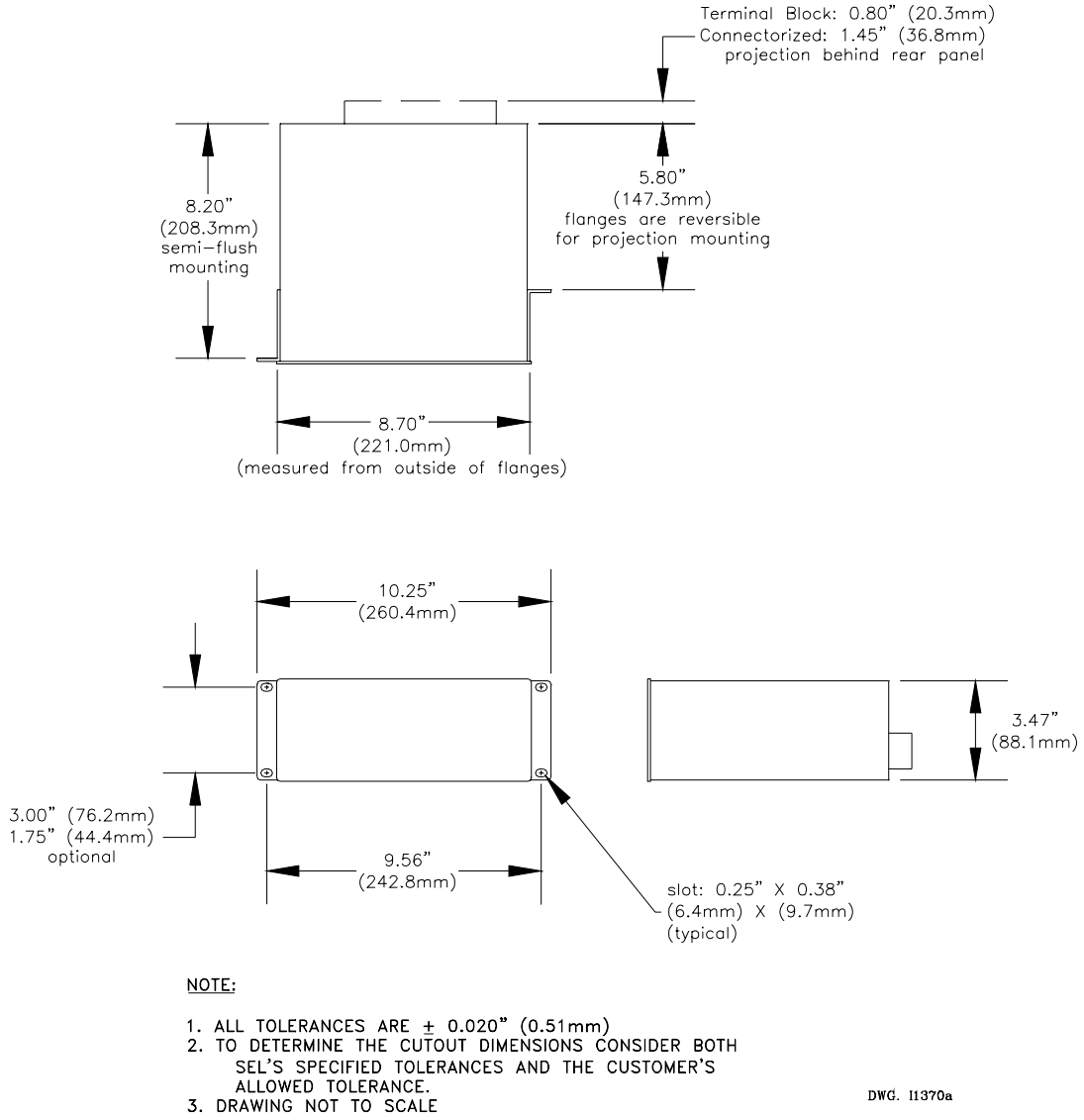

Figure 2.1: SEL-501 Relay Dimensions and Drill Plan for Single Rack-Mount Relay

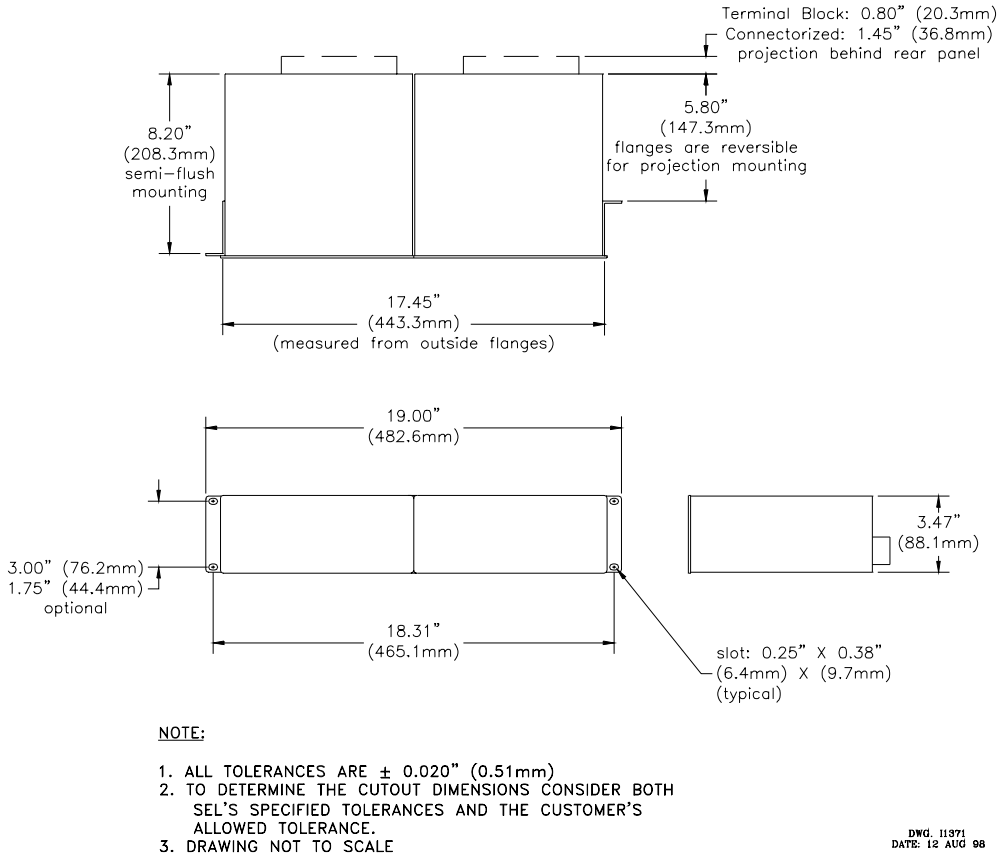

Figure 2.2: Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relay Together Using Mounting Block (SEL P/N 9101)

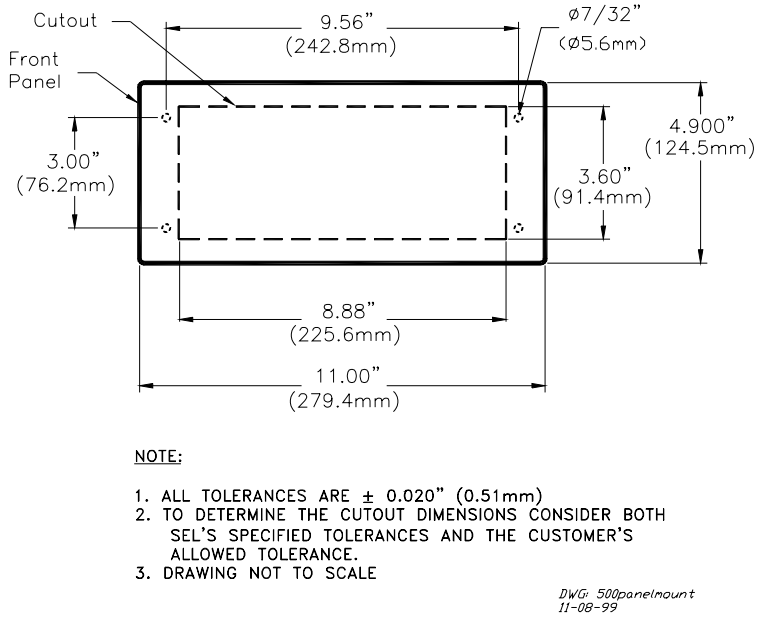

Figure 2.3: Panel Cutout and Drill Plan for Single Panel-Mount Relay

TWO REAR-PANEL OPTIONS

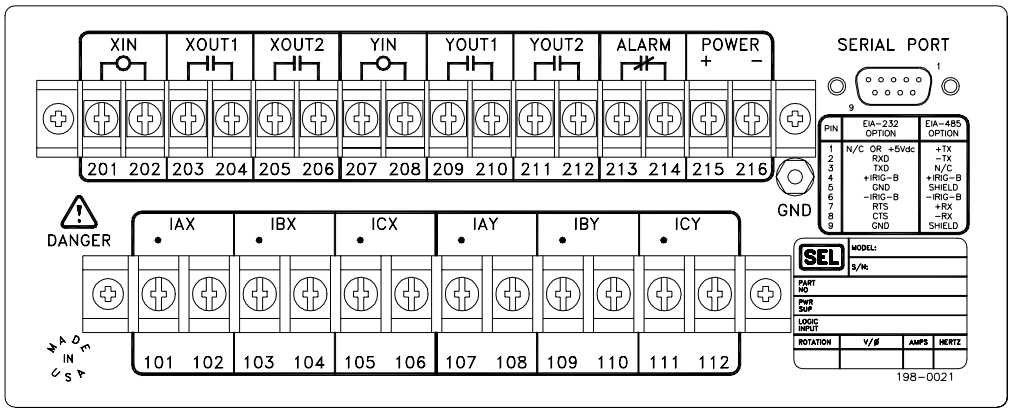

Figure 2.4: SEL-501 Relay Rear Panel (Conventional Terminal Blocks Option)

Conventional Terminal Blocks Option in Figure 2.4

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.

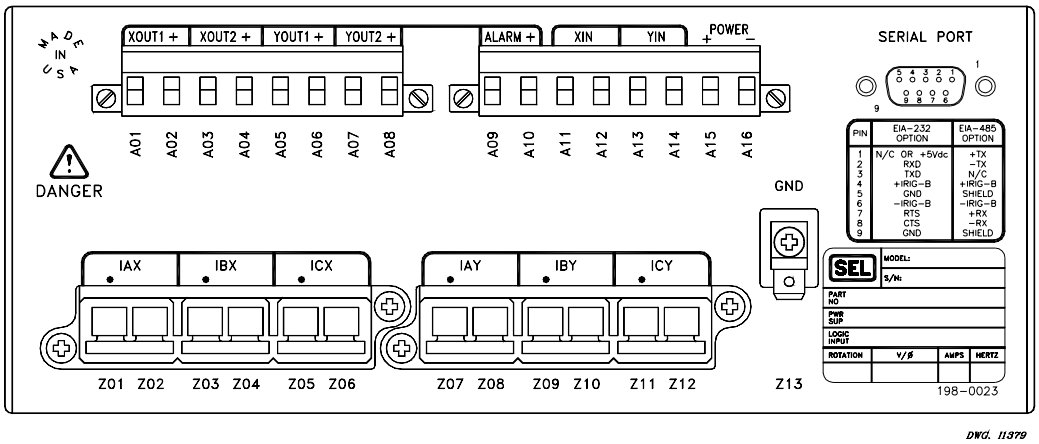

Figure 2.5: SEL-501 Relay Rear Panel (Plug-In Connectors Option)

Plug-In Connectors Option in Figure 2.5

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-501-2 Relays (Plug-In Connectors) Results 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-501-2 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-501-2 Relays are (partial part numbers shown):

Old		**New**
WA0501xJ	→	WA0501xW

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

Figure 2.5 shows the rear panel for new models 0501xW. Because all terminal/numbering remains the same between the new and old relays, these figures can also be used as a reference for old model 0501xJ. Only the connectors and part numbers have changed.

SEL-501-2 RELAY AC/DC CONNECTION DIAGRAMS

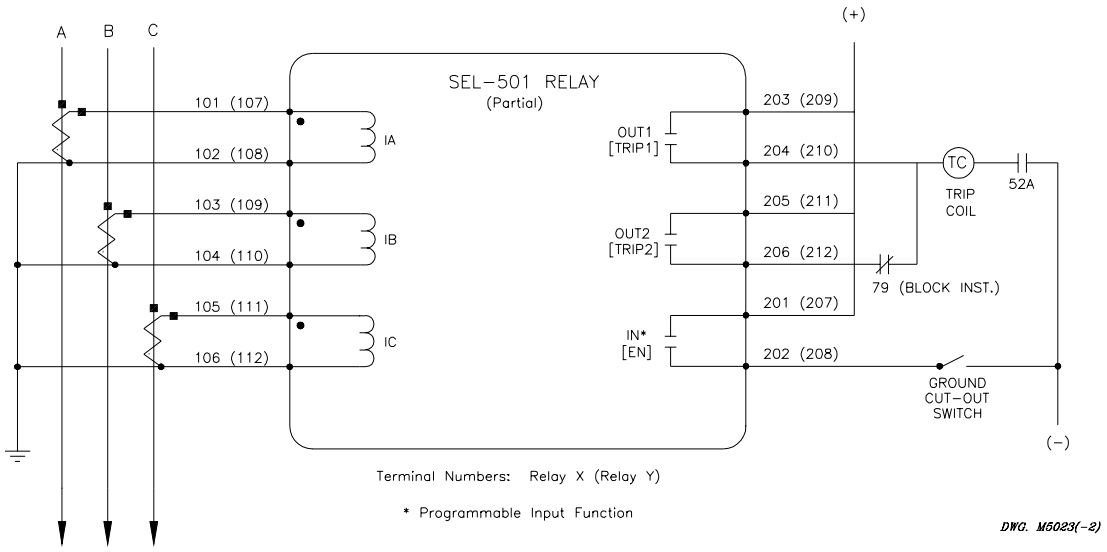

Figure 2.6: AC/DC Connections for Overcurrent Protection Applications
(Feeder protection application with external reclosing relay shown)

CIRCUIT BOARD JUMPERS AND BATTERY

Control Voltage Jumpers (Conventional Terminal Blocks Option Only)

Relays equipped with conventional terminal blocks have field-changeable jumpers that select the control voltage for the two digital inputs. The jumpers are factory-configured to the control voltage specified at time of ordering. The jumpers may be changed as outlined below.

Note: Relays equipped with plug-in connectors have fixed "level-sensitive" inputs that are factory-configured to the control voltage specified at time of ordering. These inputs are not field-changeable.

Refer to ***General Specifications*** in ***Section 1*** for details on operating voltage and current levels.

To change the control input voltage range using internal jumpers, take the following steps:

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

CAUTION

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

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

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 2.7.

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

6. Slide the drawout assembly into the relay chassis. Reconnect the analog signal ribbon cable. Replace the relay front panel and reenergize the relay.

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

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

Output Contact Jumpers (Conventional Terminal Blocks Option Only)

Refer to Figure 2.7. 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 deenergized 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 deenergized and open when the output contact coil is energized. These jumpers are soldered in place.

In Figure 2.7, 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.

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.

Password and Breaker Control Command Jumpers

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

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

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

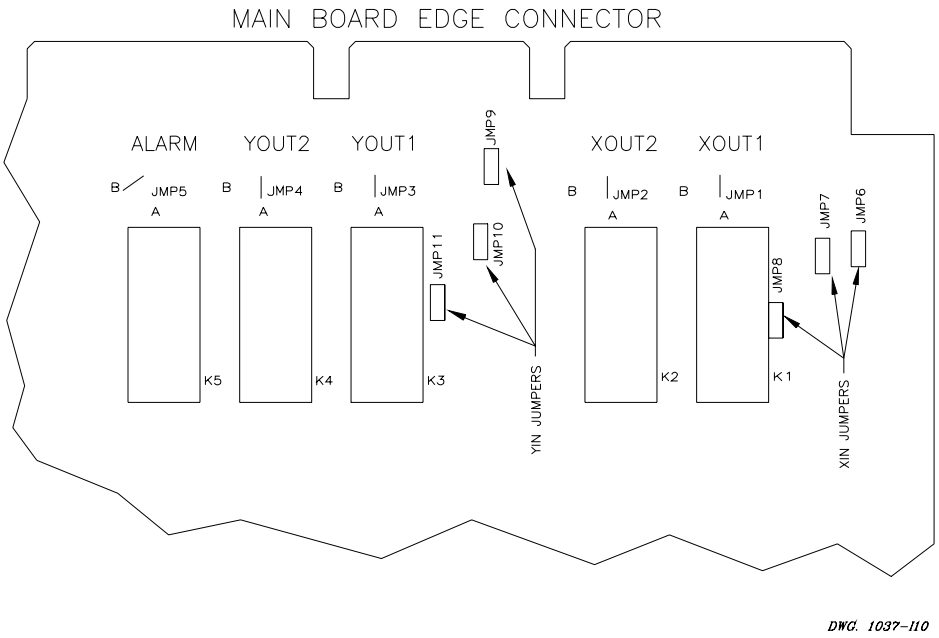

Figure 2.7: Input and Output Jumper Locations (Conventional Terminal Blocks Option Only)

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

Jumper JMP12 is toward the rear of the main board, near the rear-panel EIA-232 serial communications port. This jumper connects or disconnects +5 Vdc to pin 1 on the EIA-232 serial communications port. In a standard relay shipment, jumper JMP12 would be removed (out-of-place) so that the +5 Vdc is not connected to pin 1 on the EIA-232 serial communications port. See Figure 4.2 in ***Section 4: Operations***.

Output Contact YOUT2 Control Jumper

Refer to Figure 2.8 and Table 2.2. Main board jumper JMP13 controls the operation of output contact YOUT2. It provides the option of a second alarm output contact by changing the signal that drives output contact YOUT2.

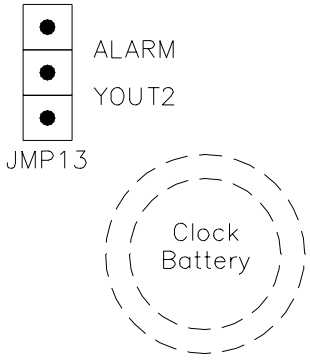

Figure 2.8: Output Contact YOUT2 Control Jumper Location

Table 2.2: Required Position of Jumper JMP13 for Desired Output Contact YOUT2 Operation

Position	Output Contact YOUT2 Operation
• ALARM ┃ • YOUT2	Regular output contact YOUT2 (operated by overcurrent elements selected for TRIP2 of Relay Y [output contact YOUT2 is deemed TRIP2 of Relay Y] or serial port command 2OUT Y). Jumper JMP13 comes in this position in a standard relay shipment.
┃ ALARM • ┃ YOUT2 •	Extra Alarm output contact (operated by alarm logic/circuitry). Over-current elements selected for TRIP2 of Relay Y [output contact YOUT2 is deemed TRIP2 of Relay Y] and serial port command 2OUT Y do not have any effect on output contact YOUT2 when jumper JMP13 is in this position.

If jumper JMP13 is in position ALARM and both output contacts YOUT2 and ALARM are the same output contact type (a or b), they will be in the same state (closed or open). If jumper JMP13 is in position ALARM and output contacts YOUT2 and ALARM are different output contact types (one is an "a" and one is a "b"), they will be in opposite states (one is closed and one is open).

Clock Battery

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

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

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

CAUTION

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

To change the battery, take the following steps:

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

CAUTION

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

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.

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

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

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.

7. Set the date and time.

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SECTION 3: OVERCURRENT PROTECTION

INTRODUCTION

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

Apply the relay to provide overcurrent protection for:

- Feeders
- Busses
- Transformers
- Other Apparatus

RELAY CONTROL FUNCTIONS

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

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

Relay Control by Input IN

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

Program input IN to function as one of the following:

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

IN = EN or IN = BLK

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

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

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

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

IN = ET

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

```
IN:  External Trigger
```

Relay Control by Remote Bit RB

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

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

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

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

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

Remote Bit Serial Port Commands

Set and clear remote bit RB with either the ASCII "CONTROL" command or the binary *Fast Operate* command. The ASCII CONTROL command provides a convenient means for setting and clearing the remote bit via a dumb terminal or other device not capable of binary communications. The *Fast Operate* command provides an efficient means to set and clear remote bits via devices capable of binary communication (e.g., the SEL-2020 Communications Processor). The CONTROL command is described in ***Section 4: Operation***. The *Fast Operate* command is described in Appendix B: Configuration, *Fast Meter*, and *Fast Operate* Commands.

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

To determine the state of a remote bit,

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

RELAY OUTPUT CONTACT FUNCTIONS

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

If an overcurrent element pickup is not set to "off," it is enabled to operate.

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

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

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

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

APPLICATIONS FOR THE SEL-501-2 RELAY

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

- Overcurrent elements routed to different trip output contacts.
  - Refer to the example in ***Figure 2.3***, ***Section 2: Mounting and Connections***.
  - 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 cut-out switch to disable the ground overcurrent elements for feeder paralleling operations.

- One output contact to provide primary tripping and the other output contact to provide simple breaker failure tripping.
  - Assign the same overcurrent elements to both output contacts.
  - Use the TRIP1 output contact for primary tripping.
  - Use the TRIP2 output contact for breaker failure tripping. Set a time-delay pickup on the TRIP2 output contact. The time delay should correspond to breaker failure time (see Figure 3.1).
- Fast bus tripping (reverse interlocking) on a radial system. This replaces a more expensive bus differential scheme.
  - Apply the relay for bus overcurrent protection.
  - Make setting IN = BLK (Block). Connect the high-set instantaneous overcurrent trip contacts of the downstream feeder relays into the bus relay input IN, in parallel.
  - Set the bus relay definite-time overcurrent elements to back up the feeder relay high-set instantaneous overcurrent elements. Set the bus relay definite-time delays for 2 to 3 cycles.
  - Set the bus relay definite-time overcurrent elements to be controlled by input IN. When IN is asserted, the bus relay definite-time overcurrent elements are disabled (blocked).
  - The 2 to 3 cycle delay on the bus relay definite-time overcurrent elements gives the feeder relay high-set instantaneous overcurrent trip contacts enough time to assert input IN. This disables (blocks) the bus relay definite-time overcurrent elements if the fault is on a feeder.

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

Many variations of the preceding application examples are possible.

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-phase and three-phase faults. Phase overcurrent relay pickup settings must exceed load current levels.

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

Setting Negative-Sequence Overcurrent Elements

Negative-sequence overcurrent elements in the SEL-501-2 Relay respond to $3I_2$ current. You can set these elements to detect phase-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 inverse-time elements) of a local equivalent phase overcurrent element that would coordinate with the downstream element. You may select a pickup setting that is below normal load current. Multiply the local equivalent phase overcurrent pickup setting by 1.73 to calculate the negative-sequence overcurrent element pickup setting. Use the time settings directly, with no conversion factor.

OVERCURRENT RELAY SETTINGS

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

Table 3.1: Relay Settings

Setting	Setting Definitions	Setting Range
ID	Relay Identifier	13 Characters
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)
50PD	Phase Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
50PTT	Assign Phase Definite-Time Overcurrent Element (50PT) to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
50PTC	50PT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
50H	Phase Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50HT	Assign Phase Instantaneous Overcurrent Element (50H) to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
50HC	50H controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
50QP	Neg-Seq Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50QD	Neg-Seq Definite-Time Overcurrent Delay	1.5–16,000 cycles (0.25 steps)
50QTT	Assign Neg-Seq Definite-Time Overcurrent Element (50QT) to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both

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

Setting	Setting Definitions	Setting Range
51NC	Ground Time-Overcurrent Operating Curve	U1–U4 (US Curves) C1–C4 (IEC Curves)
51NTD	Ground Time-Overcurrent Time-Dial	0.5–15 (US Curves) 0.05–1.0 (IEC Curves)
51NRS	Ground Time-Overcurrent EM Reset	Y, N
51NTT	Assign Ground Time-Overcururent Element (51NT) to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
51NTC	51NT controlled by input IN or remote bit	Control: N = none, Y = input, IN = input, RB = remote bit
TRPU1	TRIP1 time-delay pickup	0–16,000 cycles (0.25 steps)
TDUR1	minimum TRIP1 duration	0–16,000 cycles (0.25 steps)
TRPU2	TRIP2 time-delay pickup	0–16,000 cycles (0.25 steps)
TDUR2	minimum TRIP2 duration	0–16,000 cycles (0.25 steps)
ELTCH	Enable phase current latch condition for trip output contacts	Y, N

RELAY TRIP LOGIC

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

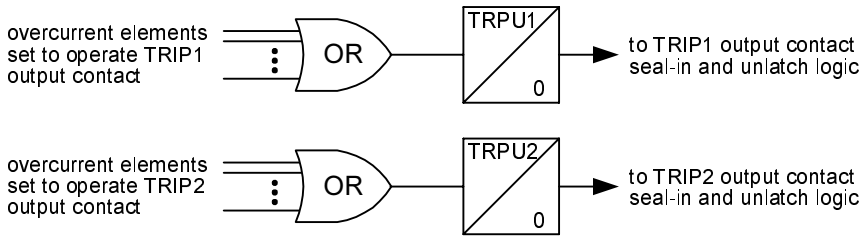


Figure 3.1: Time-Delay Pickup Timers for TRIP1 and TRIP2 Output Contacts

TRIP1 Output Contact

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

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

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

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

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

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

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

TRIP2 Output Contact

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

OVERCURRENT RELAY TARGETS

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

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

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

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

Table 3.2: Relay Tripping Targets

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

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

OVERCURRENT ELEMENT SPECIFICATIONS

Eight Overcurrent Elements	Instantaneous Elements	Definite-Time Elements	Inverse-Time Elements
Phase (Ia, Ib, and Ic)	50H	50PT	51PT
Negative-Sequence (IQ = 3I2)		50QT	51QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT	51NT
Pickup Ranges (A secondary)			
5 A Model:	0.5–80 A	0.5–80 A	0.5–16 A
1 A Model:	0.1–16 A	0.1–16 A	0.1–3.2 A
Definite Time Delay		0–16,000 cyc	

Instantaneous/Definite-Time Element Performance

Pickup Accuracy:			
5 A Model	±5% ±0.10 A sec	Time Delay Accuracy:	±0.25 cyc
1 A Model	±5% ±0.02 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	U.S. Moderately Inverse
U2	U.S. Inverse
U3	U.S. Very Inverse
U4	U.S. Extremely Inverse

51PC, 51QC, or 51NC setting	Time-Curve Shape
C1	IEC Class A (Standard Inverse)
C2	IEC Class B (Very Inverse)
C3	IEC Class C (Extremely Inverse)
C4	IEC Long Time Inverse

Time-Dial Setting Ranges: 0.5–15, 0.01 Step; US Curves
0.01–1.0, 0.01 Step; IEC Curves

Timing Accuracy: ±4% ±1.5 cycles for $2 \leq M \leq 30$;
Curves operate on definite-time for multiples above 30 or currents above 16 times nominal current.

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

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

US Moderately Inverse Curve: U1

$$tp = TD \cdot \left[0.0226 + \frac{0.0104}{M^{0.02} - 1} \right]$$

$$tr = TD \cdot \left[\frac{1.08}{1 - M^2} \right]$$

US Inverse Curve: U2

$$tp = TD \cdot \left[0.180 + \frac{5.95}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{5.95}{1 - M^2} \right]$$

US Very Inverse Curve: U3

$$tp = TD \cdot \left[0.0963 + \frac{3.88}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{3.88}{1 - M^2} \right]$$

US Extremely Inverse Curve: U4

$$tp = TD \cdot \left[0.0352 + \frac{5.67}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{5.67}{1 - M^2} \right]$$

IEC Class A Curve: C1 (Standard Inverse)

$$tp = TD \cdot \left[\frac{0.14}{M^{0.02} - 1} \right]$$

$$tr = TD \cdot \left[\frac{13.5}{1 - M^2} \right]$$

IEC Class B Curve: C2 (Very Inverse)

$$tp = TD \cdot \left[\frac{13.5}{M - 1} \right]$$

$$tr = TD \cdot \left[\frac{47.3}{1 - M^2} \right]$$

IEC Class C Curve: C3 (Extremely Inverse)

$$tp = TD \cdot \left[\frac{80.0}{M^2 - 1} \right]$$

$$tr = TD \cdot \left[\frac{80.0}{1 - M^2} \right]$$

IEC Long Time Inverse: C4

$$tp = TD \cdot \left[\frac{120.0}{M - 1} \right]$$

$$tr = TD \cdot \left[\frac{120.0}{1 - M} \right]$$

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

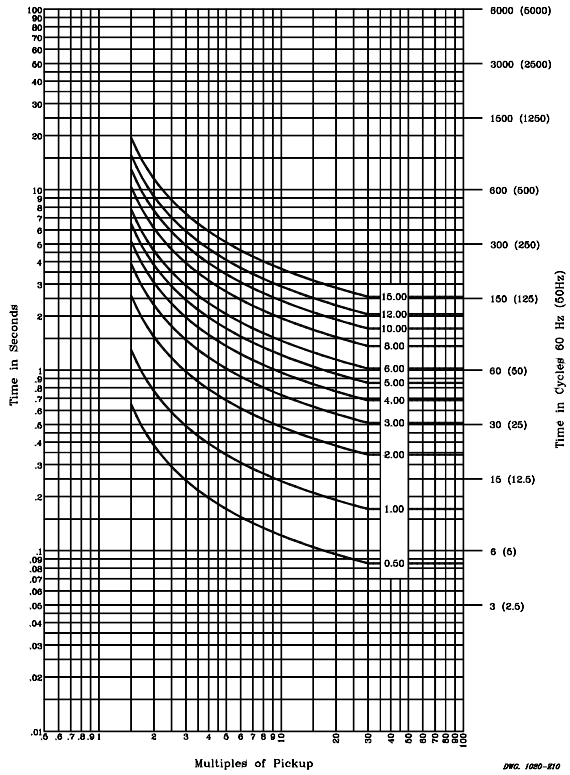


Figure 3.2: Time Curve U1

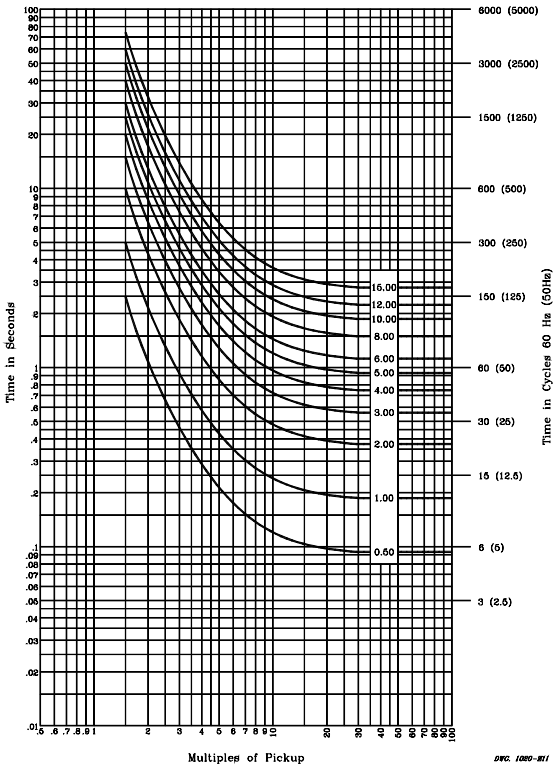


Figure 3.3: Time Curve U2

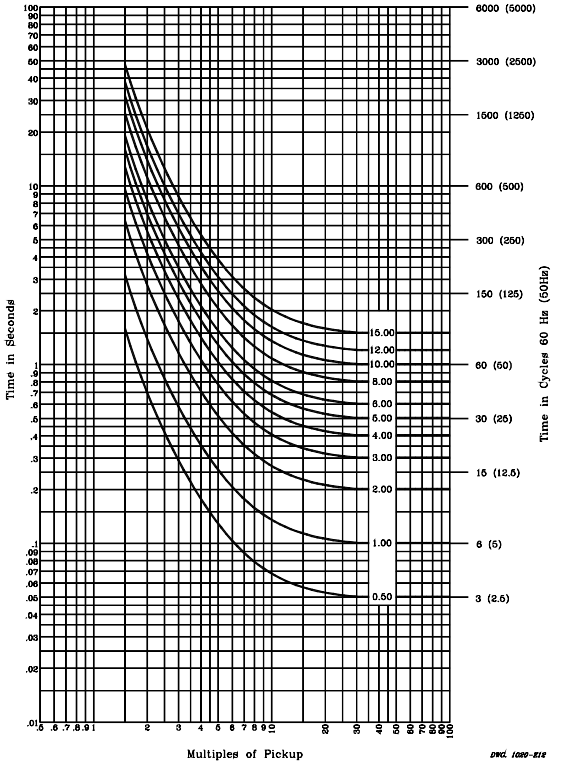


Figure 3.4: Time Curve U3

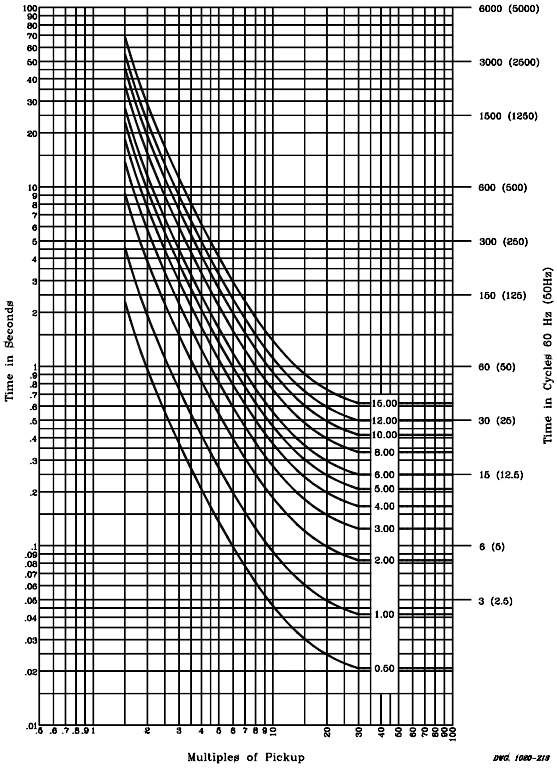


Figure 3.5: Time Curve U4

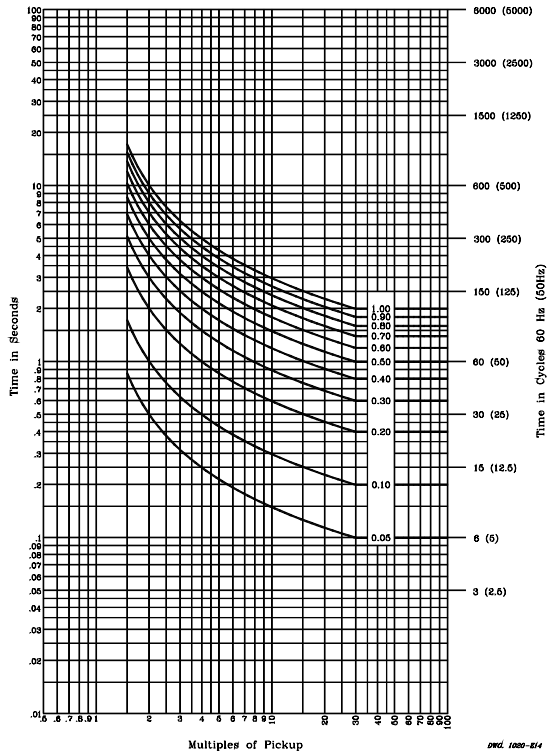


Figure 3.6: Time Curve C1

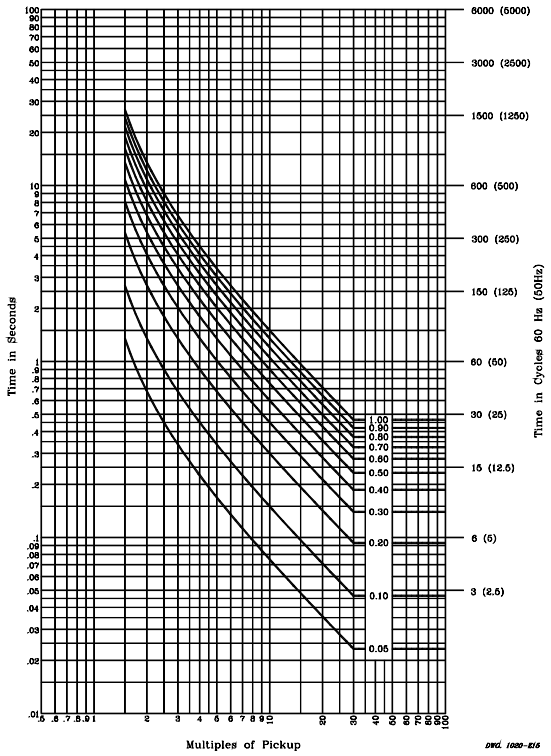


Figure 3.7: Time Curve C2

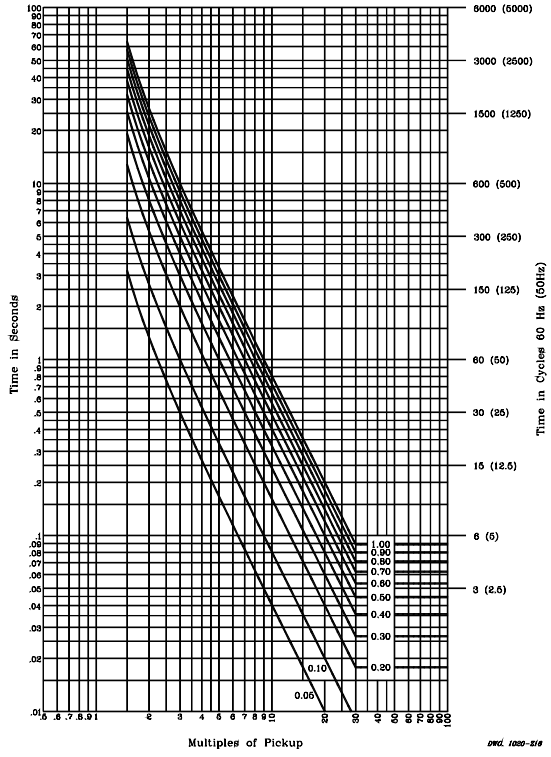


Figure 3.8: Time Curve C3

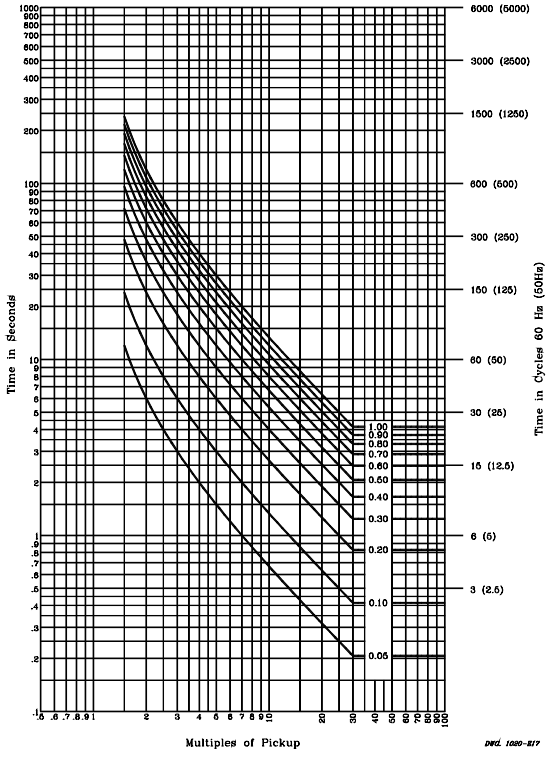


Figure 3.9: Time Curve C4

SETTINGS SHEET
FOR THE SEL-501-2 RELAY

Date _____

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

General Data

Relay Identifier (13 characters) ID =

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

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

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

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup
(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) 50PD = _____

Assign 50PT to trip output contacts (N, 1, 2, B)
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50PTT = _____

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

Phase Instantaneous Overcurrent Pickup
(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 = TRIP 1, 2 = TRIP2, B = both} 50HT = _____

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

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup
(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) 50QD = _____

Assign 50QT to trip output contacts (N, 1, 2, B)
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50QTT = _____

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

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup
(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) 50ND = _____

Assign 50NT to trip output contacts (N, 1, 2, B)
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50NTT = _____

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

Ground Instantaneous Overcurrent Pickup
(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 = TRIP 1, 2 = TRIP2, B = both} 50NHT = _____

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

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup
(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 {US Curves}, C1–C4 {IEC Curves}) 51PC = _____

Phase Time-Overcurrent Time-Dial
(0.5–15 {US 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 = TRIP 1, 2 = TRIP2, B = both} 51PTT = _____

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

Negative-Sequence Time-Overcurrent Element

Negative-Sequence Time-Overcurrent Pickup
(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 {US Curves}, C1–C4 {IEC Curves}) 51QC = _____

Negative-Sequence Time-Overcurrent Time-Dial
(0.50–15 {US 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 = TRIP 1, 2 = TRIP2, B = both} 51QTT = _____

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

Ground Time-Overcurrent Element

Ground Time-Overcurrent Pickup (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 {US Curves}, C1–C4 {IEC Curves})	51NC = _____
Ground Time-Overcurrent Time-Dial (0.50–15 {US Curves}, 0.05–1.0 {IEC Curves})	51NTD = _____
Ground Time-Overcurrent Electromechanical Reset (Y, N)	51NRS = _____
Assign 51NT to trip output contacts (N, 1, 2, B) {N = none, 1 = TRIP 1, 2 = TRIP2, B = both}	51NTT = _____
51NT controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	51NTC = _____

TRIP Output Contact Timers/Latch

TRIP1 time-delay pickup (0–16,000 cycles)	TRPU1 = _____
Minimum TRIP1 duration (0–16,000 cycles)	TDUR1 = _____
TRIP2 time-delay pickup (0–16,000 cycles)	TRPU2 = _____
Minimum TRIP2 duration (0–16,000 cycles)	TDUR2 = _____
Enable phase current latch condition for trip output contacts (Y, N)	ELTCH = _____

Protocol Setting (see below)

Protocol (SEL, LMD, MOD) PROTOCOL = _____

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

Set PROTOCOL = MOD for Modbus™ RTU protocol.

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

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

Protocol = SEL

If PROTOCOL is set to SEL, the following are 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 (see below)

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 (see below)

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 = 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 = _____

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 4: OPERATION

INTRODUCTION

In this manual, commands you type appear in bold/uppercase: **SHOW**. Keys or front-panel buttons you press appear in bold/uppercase/brackets: **<ENTER>**.

FRONT-PANEL OPERATION

Overview

Use Figure 4.1: Front-Panel Function Drawing, and Table 4.5: Command Cross-Reference Table as guides to operation of the SEL-501-2 Relay front panel.

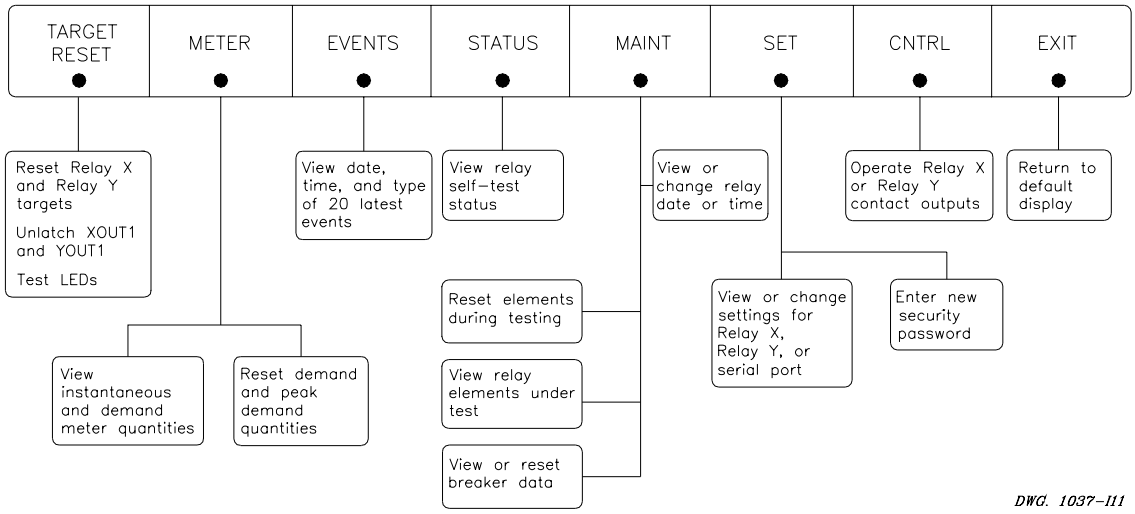


Figure 4.1: Front-Panel Function Drawing

Front-Panel Command Execution

Execute a front-panel command by pressing the desired control button. Use the Left- and Right-arrow buttons to underline the desired Relay (X or Y) or function, then press **<SELECT>**.

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

Table 4.5 and Table 4.6 contain complete lists of serial port and front-panel relay commands.

Front-Panel Password Security

The relay includes a password security function. When Main Board Jumper A (left jumper) is removed, you must enter the Access Level 2 password before executing Access Level 2 commands. See ***Section 2: Mounting and Connections*** for jumper details.

The Access Level 2 password is a 6-character or less combination of alphanumerics. The default Level 2 password is shown in the table under ***Serial Port Password Security*** later in this section. To enter the password from the front panel, use the Left- and Right-arrow buttons to underline each character in turn. Use the Up- and Down-arrow buttons to enter the correct character. Unused characters to the right of the password appear as spaces. Press **<SELECT>** when you have entered the correct character in each position of the password.

Default and Automatic Messages

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

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

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

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

Setting Changes via the Front Panel

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

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

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

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

The Target Reset button provides help-screen information when viewing or changing settings.

Relay Identifier Setting

To change the Relay Identifier setting, use the Left- and Right-arrow buttons to underline the letter you wish to change. Use the Up- and Down-arrow buttons to scroll through the characters available. Press **<SELECT>** when the setting is correct.

Pickup, Time-delay, and Numeric Settings

To change a numeric setting, use the Left- and Right-arrow buttons to underline the number you wish to change. Use the Up- and Down-arrow buttons to scroll through the numbers. To change a pickup setting from a number to 'Off,' press the Left- or Right-arrow button several times, until

the number field changes to 'Off.' To change a pickup setting from 'Off' back to a number, press the Left- or Right-arrow button once. Press **<SELECT>** when the setting is correct.

Enable, Disable Settings

Use the Left- or Right-arrow button to change an enable setting from 'Y' to 'N' or from 'N' to 'Y.' Press **<SELECT>** when the setting is correct.

Front-Panel Reset

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

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

SERIAL PORT OPERATION

Connections and Protocol

The SEL-501-2 Relay is equipped with a single serial communications port. The communication can support the following protocols:

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

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

Use a terminal emulation program with your personal computer to allow serial communications with the relay. Examples of PC-based terminal emulation programs include: ProComm Plus™, Relay Gold™, Microsoft Windows Terminal™, Smartcom™, and Crosstalk™.

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

SEL-501-2 Relays support Modbus RTU protocol. For details, please refer to ***Appendix E: Modbus® RTU Communications Protocol for PowerLogic® Compatible Devices***.

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

Table 4.1: Communications Settings

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

(Continued)

Table 4.1: Communications Settings *(Continued)*

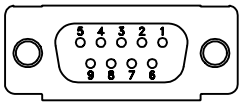
Field Description	Screen Name	Range	Default
PROTOCOL = MOD			
Port Protocol	PROTOCOL	SEL, LMD, MOD	MOD
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Parity	PARITY	N, E, O (N = None, E = Even, O = Odd)	N
Stop Bits	STOP	1, 2	1
Modbus Slave ID	SLAVEID	1–247	1

The SEL-501-2 Relay 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 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 may type either the full command, or simply the first three letters. For instance, to execute the EVENT command, it is only necessary to type EVE and press <ENTER>.

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



(female chassis connector, as viewed from outside panel)

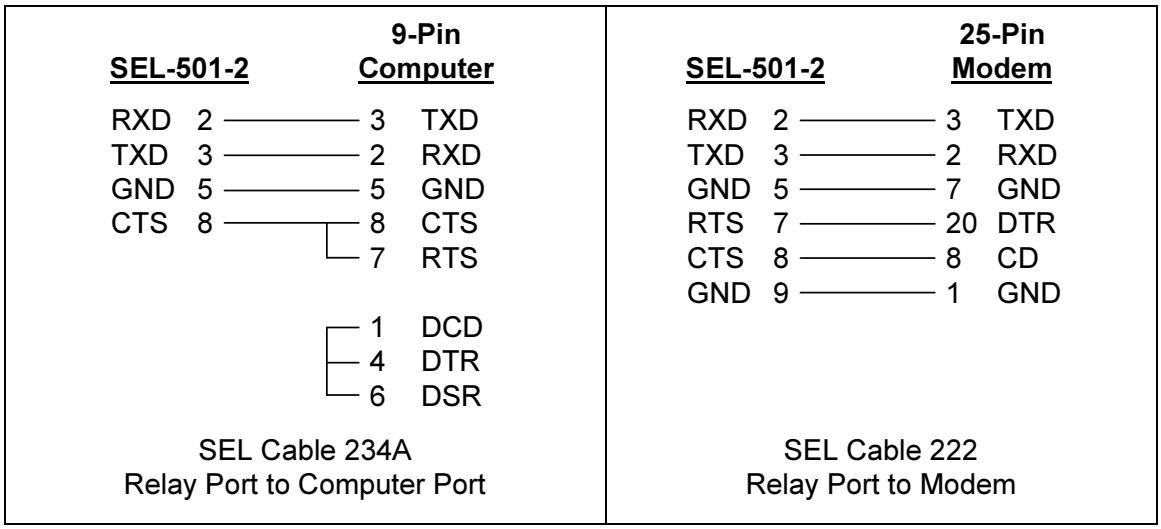
P1 DB9 Connector Pinout Options

DB9 Pin	EIA-232	EIA-485
1	N/C or +5 Vdc*	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

* See ***Circuit Board Jumpers and Battery*** in ***Section 2: Mounting and Connections***.

Figure 4.2: 9-Pin Connector Pin Number Convention

Serial Communication Cables for use with the SEL-501-2 Relay



Serial Port Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in Table 4.2.

Table 4.2: Serial Port Automatic Messages

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

Serial Port Password Security

The relay serial port includes a password security function. When Main Board jumper A (left jumper) is removed, the relay prompts you to enter passwords (passcodes) to enter Access Level 1 and Access Level 2. The serial port access levels are described in Table 4.3.

WARNING

This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Table 4.3: Serial Port Security Function

Access Level	Prompt	Default Password	Description
0	=		On power-up, the relay is in Access Level 0 and honors the ACCESS command.
1	=>	501	Allows access to those commands listed as Access Level 1 in Table 4.5.
2	=>>	501	Allows access to all commands including PAS, SET, and breaker control commands.

The Access Level 1 and 2 passwords are factory-set to 501. You may change the passwords to any other pair of 6-digit or less alphanumerics using the Access Level 2 PAS command. Valid characters are numbers, letters, dash, or period. Upper and lower case letters are treated as different characters. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

Ot3579 A24.68 Ih2dcs 4u-Iwg a501b

Setting Changes via the Serial Port

To set the relay using 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 wish to change.

When you execute the SET command, the relay presents a list of settings, one at a time. Enter a new setting, or press **<ENTER>** to accept the existing setting. The relay shows only the settings required for your application. Editing keystrokes are shown in Table 4.4.

Table 4.4: 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 4.5: Command Cross-Reference Table

Access Level	Serial Port Command	Front-Panel Operations	Command Description
0	ACCESS	--	Move to Access Level 1.
1	2ACCESS	--	Move to Access Level 2.
1	BREAKER	**<MAINT>**, *n*, Breaker	View trip counters and trip current data. (*n* = X, Y)
1	DATE DATE *mm/dd/yy*	**<MAINT>**, Date	View or change relay calendar date.
1	EVENT #	--	View event report. (# = 1–12)
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.

(*Continued*)

Table 4.5: Command Cross-Reference Table (*Continued*)

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	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	CON n	--	Control remote bit (n = X,Y)
2	1OUT n	**<CNTRL>**, *n*, 1OUT	Closes Output *n*OUT1 (*n* = X,Y)
2	2OUT n	**<CNTRL>**, *n*, 2OUT	Closes Output *n*OUT2 (*n* = X,Y)
2	PAS PAS *l* ######	**<SET>**, Pass	View or change password. (*l* = 1, 2; ###### = new password)
2	RESET *n*	**<MAINT>**, *n*, EL	Reset time-overcurrent elements. (*n* = X, Y)
2	SET X SET Y SET P	**<SET>**, X, Set **<SET>**, Y, Set **<SET>**, Port, Set	View or change relay or serial port protocol settings.

Table 4.6: Access Level 2 Breaker Control Commands

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

SELECTED COMMAND DETAILS

BREAKER Command

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

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

Breaker Command from the Front Panel

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

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

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

Breaker Command from the Serial Port

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

CONTROL Command

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

=>>CON X <ENTER>
CONTROL RBX: **SRB X <ENTER>**

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

STATUS Command

Self-test functions monitor the operation of several major relay subsystems. Execute the serial port STATUS command, or press the front-panel **<STATUS>** button to inspect the most recent results of the relay self-tests. An example of the STATUS report is shown below.

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

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

SELF TESTS

W=Warn    F=Fail

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

       +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
```

Table 4.7 describes the STATUS report.

Table 4.7: 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 function allows you to view the present condition of any relay control input or contact output, and selected relay elements.

To review TARGET data using the front panel, press the **<MAINT>** button. Use the Left- or Right-arrow buttons to underline X or Y, then press the **<SELECT>** button to indicate the relay whose data you wish to review. Underline and select the TAR command, then use the Up- and Down-arrow buttons to view the target data.

The relay reassigns the front-panel target LEDs to display the state of elements in the Target Row you select. The LEDs illuminate to show when an element is picked up, or when an input or output is asserted. The relay updates this information each quarter-cycle. In addition, the LCD display 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*** in ***Section 3: Overcurrent Protection***). Target 1 shows the state of the relay contact inputs and outputs (see ***Two Rear-Panel Options*** in ***Section 2: Mounting and Connections***, and ***Relay Alarm Conditions*** later in this section).

Table 4.8: Target Command Table

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

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

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

RELAY ALARM CONDITIONS

The relay asserts the ALARM output when dc power is removed, or if any diagnostic test fails. In addition to these, the ALARM output pulses with the commands and conditions shown in Table 4.9.

Table 4.9: Commands With Alarm Conditions

Command	Condition
2ACCESS	Entering Access Level 2 or Three wrong password attempts
ACCESS	Three wrong password attempts
PAS	Any password is changed
SET commands	The relay setting changes are accepted.

Change of State Counters

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

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

Each COS counter consists of 4 bits in the Relay Word: CNTR8, CNTR4, CNTR2, and CNTR1. CNTR1 is the least significant bit in the counter; CNTR8 is the most significant bit.

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INTRODUCTION

The SEL-501-2 Relay 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 twenty latest events and full length reports for the twelve latest events. Review the event summaries using the front-panel LCD display and the **<EVENTS>** pushbutton or the serial port HISTORY command. Review full length event reports using the serial port EVENT command.

EVENT TRIGGERING

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

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

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

EVENT SUMMARY

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

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

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 stores the twelve latest event reports. The two latest reports are stored in non-volatile memory and are saved through loss of dc power. The remaining ten events are stored in volatile memory. These reports are lost if the relay is shut off or loses dc power.

Each event report is 15 cycles long. The data are presented on a quarter-cycle basis, 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.

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°, apart in time.

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

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

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

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

Relay Column Headings

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

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

Element/Input Column Definitions:

Column	Symbol	Definition
All	.	Element not picked up
51P	p	Phase time-overcurrent 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	Negative-sequence definite-time overcurrent element picked up
	T	Negative-sequence definite-time overcurrent element trip

50N	n	Residual definite-time overcurrent element picked up
	T	Residual definite-time overcurrent element trip
	H	Residual instantaneous overcurrent element trip
IN	*	Programmable input asserted
	R	Remote bit asserted
	b	Both input and remote bit asserted
OUT	1	TRIP1 output is closed
	2	TRIP2 output is closed
	b	Both outputs are closed
ALRM	*	SEL-501-2 Relay ALARM Output is indicating an alarm state

Event Summary Data

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

Event Type

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

Table 5.1: Event Types

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

Event Targets and Duration

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

Relay Settings

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

EXAMPLE EVENT REPORT

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

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

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

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

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

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

picks
  1203    1291     206    -295      11     136     206    -332 p.n...  .. ......  .. .
   584     297     219      69     124    -188     265      48 p.n...  .. ......  .. .
 -2758   -2846    -207     294     -27    -152    -207     331 p.n..n  .. ......  .. .
  -215      73    -219     -69    -165     149    -265     -48 p.n..n  .. ......  .. .

  3110    3199     206    -295      32     157     206    -332 p.np.H  .b ......  .. .
   213     -75     219      69     164    -148     265      47 p.np.H  .b ......  .. .
 -3114   -3200    -207     294     -34    -157    -208     331 pqnp.H  .b ......  .. .
  -210      77    -219     -68    -164     149    -265     -47 pqnp.H  .b ......  .. .

[Four cycles of data]

  1910    1956     130    -176      21     147     208    -334 pqn.qn  .b ......  .. .
  -372    -458      27      58      37    -277     264      50 pqn.qn  .b ......  .. .
  -350    -352     -28      30      -7    -131    -209     332 ..n...  .b ......  .. .
     0       0       0       0       2     315    -264     -50 ..n...  .b ......  .. .

[Six cycles of data]

Event: FAULT X           Targets:X INST A N       Duration:    7.25
Relay X Currents (A Pri), ABCQN:     210    301    302     479    481
Relay Y Currents (A Pri), ABCQN:     298    336    334      40     42

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

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

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

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SECTION 6: TESTING

TESTING METHODS AND TOOLS

Test Features Provided by the Relay

The following features assist you during relay testing.

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

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

Low-Level Test Interface

The SEL-501-2 Relay has a low-level test interface between the calibrated input module and the separately calibrated processing module. You may 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 6.1 shows the interface connections. This drawing also appears on the inside of the relay front panel. Remove the ribbon cable between the two modules to access the outputs of the input module and the inputs to the processing module (relay main board).

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

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.

You can test the input module two different ways:

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

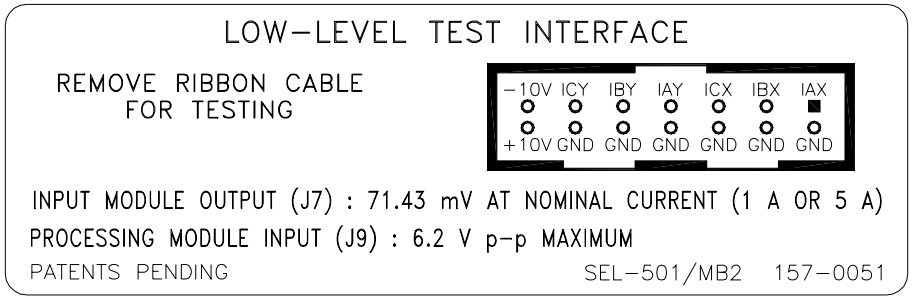

Figure 6.1: Low-Level Test Interface

Test Methods

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

Testing Via Front-Panel Indicators

Display the state of relay elements, inputs, and outputs 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 ***Section 4: Operation*** for further details.

Testing Via Output Contacts

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

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

TEST PROCEDURES

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

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

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

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

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

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

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

Residual Time-Overcurrent Element: 51NT

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

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

Step 2. 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 shown in the Time-Overcurrent Element Operate/Reset Curve Equations subsection in ***Section 3: Overcurrent Protection***. TD is the time-dial setting, 51NTD, and M is the applied multiple of pickup current.

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

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

tp = 2.33 seconds

Step 5. Set the current source to deliver M·51NP amps 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.

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.

RELAY SELF-TESTS

The relay runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see Table 6.1):

- Protection Disabled: The relay disables overcurrent elements and trip/close logic. All output contacts are deenergized. The EN front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its deenergized state. If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the relay is deenergized. If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the relay is deenergized. 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 display for failures.

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

Table 6.1: Relay Self-Tests

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
IA,IB,IC,IN 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	
±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	

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
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.					
Micro-processor Crystal	Failure		Yes	Latched	The relay monitors the micro-processor crystal. If the crystal fails, the relay displays "CLOCK STOPPED" on the LCD display. The test runs continuously.
Micro-processor	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The relay displays "VECTOR nn" on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.
+5V PS Under-/Over-Voltage	Failure	+4.65 V +5.95 V	Yes	Latched	A circuit on the 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 the Troubleshooting Procedure.

1. Measure and record the power supply voltage at the power input terminals.
2. Check to see that the power is on. Do not turn 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.

Cannot See Characters on Relay LCD Screen

1. Relay is deenergized. 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 back lighting.
   c) Locate the contrast adjust potentiometer directly adjacent to the EN LED.
   d) Use a small screwdriver to adjust the potentiometer.
   e) Replace the relay front panel.

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

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

Relay Does Not Respond to Faults

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

RELAY CALIBRATION

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

FACTORY ASSISTANCE

The employee-owners of Schweitzer Engineering Laboratories, Inc. are dedicated to making electric power safer, more reliable, and more economical.

We appreciate your interest in SEL products, and we are committed to making sure you are satisfied. If you have any questions, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603
Telephone: (509) 332-1890
Business FAX: (509) 332-7990

We provide prompt, courteous, and professional service.

We appreciate receiving any comments and suggestions about new products or product improvements that would help us make your job easier.

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APPENDIX A: FIRMWARE VERSIONS

This manual covers SEL relays that contain firmware bearing the following part numbers and revision numbers (most recent firmware listed at top):

Firmware Part/Revision Number	Description of Firmware
	This firmware differs from previous versions as follows: – Corrected password display – Fixed *Fast Meter* response issue – Added Modbus® communications protocol
SEL-501-2-R525-D000105 SEL-501-2-R575-D000105 SEL-501-2-R625-D000105 SEL-501-2-R725-D000105 SEL-501-2-R775-D000105 SEL-501-2-R825-D000105	60Hz, 5 Amp, ABC Rotation with Modbus 60Hz, 5 Amp, ACB Rotation with Modbus 50Hz, 5 Amp, ABC Rotation with Modbus 60Hz, 1 Amp, ABC Rotation with Modbus 60Hz, 1 Amp, ACB Rotation with Modbus 50Hz, 1 Amp, ABC Rotation with Modbus
	This firmware differs from previous versions as follows: – Corrected password display – Fixed *Fast Meter* response issue
SEL-501-2-R506-D000105 SEL-501-2-R556-D000105 SEL-501-2-R606-D000105 SEL-501-2-R706-D000105 SEL-501-2-R756-D000105 SEL-501-2-R806-D000105	60Hz, 5 Amp, ABC Rotation without Modbus 60Hz, 5 Amp, ACB Rotation without Modbus 50Hz, 5 Amp, ABC Rotation without Modbus 60Hz, 1 Amp, ABC Rotation without Modbus 60Hz, 1 Amp, ACB Rotation without Modbus 50Hz, 1 Amp, ABC Rotation without Modbus
	This firmware differs from previous versions as follows: – Created new firmware version for SEL-501-2
SEL-501-2-R755-D990525	60 Hz, 1 Amp, ACB Rotation
	This firmware differs from previous versions as follows: – Added Y option for input control of overcurrent elements.
SEL-501-2-R705-D980401 SEL-501-2-R505-D980401 SEL-501-2-R805-D980401 SEL-501-2-R605-D980401 SEL-501-2-R555-D980401	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation

Firmware Part/Revision Number	Description of Firmware
	This firmware differs from previous versions as follows: – Added remote bits to control overcurrent elements via serial port commands. Added CON and *Fast Operate* commands to set and clear remote bits. – Changed front panel LCD underscore character. – Added change of date counters for optoisolated inputs. – Added factory settings to redefine front-panel CNTRL command "1OUT" and "2OUT" labels.
SEL-501-2-R704 SEL-501-2-R504 SEL-501-2-R804 SEL-501-2-R604 SEL-501-2-R554	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation
	This firmware differs from previous versions as follows: -Corrected problem where relay would fail to respond to *Fast Meter* messages if a serial port timeout occurred during the *Fast Meter* message.
SEL-501-2-R703 SEL-501-2-R503 SEL-501-2-R803 SEL-501-2-R603 SEL-501-2-R553	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation
	This firmware differs from previous versions as follows: – Decreased power-up initialization time.
SEL-501-2-R702 SEL-501-2-R502 SEL-501-2-R802 SEL-501-2-R602 SEL-501-2-R552	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation
	This firmware differs from previous versions as follows: – Corrected front-panel targeting problem. Front-panel targets are illuminated if relay trips by 50H or 50NH.
SEL-501-2-R701 SEL-501-2-R501-2 SEL-501-2-R801 SEL-501-2-R601 SEL-501-2-R551	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation

Firmware Part/Revision Number	Description of Firmware
	Original Firmware Release.
SEL-501-2-R700 SEL-501-2-R500 SEL-501-2-R800 SEL-501-2-R600 SEL-501-2-R550	60 Hz, 1 Amp, ABC Rotation 60 Hz, 5 Amp, ABC Rotation 50 Hz, 1 Amp, ABC Rotation 50 Hz, 5 Amp, ABC Rotation 60 Hz, 5 Amp, ACB Rotation

To find the firmware revision number in your relay, obtain a status report (which identifies the firmware) using the STATUS command. This is an FID number with the Part/Revision number in bold:

FID=**SEL-501-2-R525**-V65X1XXp2-D000105

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

SEL provides EPROM firmware upgrades in an integrated circuit (IC). Upgrade EPROM firmware by replacing an IC component on the SEL-501-2 main board.

EPROM FIRMWARE UPGRADES

Installing new EPROM firmware requires that you power down the relay, remove its front panel, pull out the main circuit board, exchange an IC component, and reassemble the relay. If you do not wish to perform the installation yourself, SEL can assist you. Simply return the relay and IC to SEL. We will install the new IC and return the unit to you within a few days.

Required Equipment:

- Phillips screwdriver
- Personal computer
- Terminal emulation software (e.g., Windows Terminal)
- Serial communications cable (SEL-234A or equivalent)
- ESD workstation (grounding pad and wrist strap)
- AMP Extraction Tool 822154-1

Upgrade Instructions

CAUTION

This procedure requires that you handle components sensitive to Electrostatic Discharge (ESD). If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

Step 1. Connect a computer to the relay serial communications port, and enter Access Level 1. Execute the **SHO C** command, and record all displayed data for possible reentry after the EPROM upgrade.

Step 2. If the relay is in service, disable its breaker control functions. Turn off control power to the relay.

Step 3. Remove three front-panel screws with the Phillips screwdriver, and remove the relay front panel.

CAUTION

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

Step 4. Disconnect the analog signal ribbon cable from the underside of the relay main board and from the input module. Grasp the black knob on the front of the drawout assembly, and remove the assembly from the relay chassis. Because steps 5 and 6 involve handling devices and assemblies sensitive to ESD, perform these steps at an ESD-safe workstation. This will help prevent possible damage by ESD.

Locate the EPROM socket (reference designator U8) on the main board.

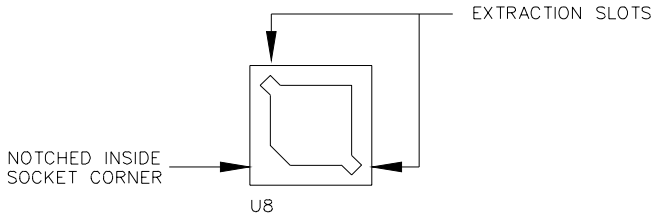


Figure B.1: EPROM Socket

Step 5. Insert AMP Extraction Tool 822154-1 into one of the extraction slots on the EPROM socket. With a slight downward pressure, rotate the extraction tool away from the EPROM socket until the EPROM starts to lift away from the socket. Do not lift the EPROM all the way out on the first attempt.

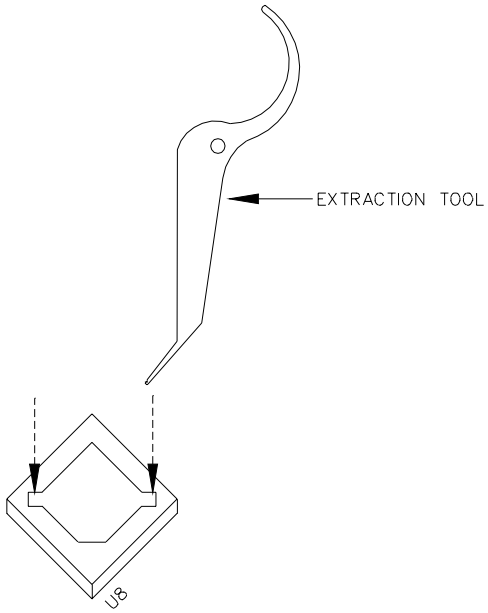


Figure B.2: Insertion of the Extraction Tool in the EPROM Socket

Reference: AMP Instruction Sheet 408-9695 (dated May 18, 1994, Rev. B).

Step 6. Remove the extraction tool from the slot, and insert it into the opposite extraction slot. With a slight downward pressure, rotate the extraction tool away from the EPROM socket until the other side of the EPROM starts to lift away from the EPROM socket.

Alternate between the two extraction slots, and gently lift out the EPROM from the socket.

Step 7. Carefully place the new EPROM in the socket, and apply even, firm pressure to fully engage it in the socket.

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 reenergize the relay with an IC reversed, do not place the relay in service using that IC, even if you correct the orientation.

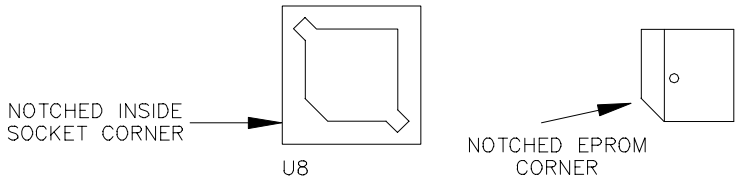


Figure B.3: Proper Orientation of the EPROM and EPROM Socket

Step 8. Slide the drawout assembly into the relay chassis. Reconnect the analog signal ribbon cable. Replace the relay front panel. Replace the rear-panel communications cable.

Step 9. With breaker control disabled, turn relay power on. If relay front panel displays an INVALID message (i.e., RLY SET INVALID), relay settings will need to be verified. Connect a computer or terminal set to 2400 baud, 8 data bits, and 1 stop bit to the relay serial communications port and enter Access Level 2. Execute the **SHOWSET X** and the **SHOWSET Y** commands.

If a setting named VALID is displayed, it will have a value of N. This signifies that default settings have been loaded. Execute the **SET X** command to enter the correct relay X settings for your application, and set VALID to Y. Note that when VALID is Y, the setting is no longer displayed. Execute the **SET Y** command to enter the correct relay Y settings for your application, and set VALID to Y.

Execute the **STATUS**, **METER**, and **TRIGGER** commands to ensure that all functions are operational. Set and record your Access Level 1 and Access Level 2 passwords and the date and time.

Step 10. With relay communications still established and at Access Level 2, execute the **SHO C** command, and review displayed data. If data is identical to previously recorded data of step 1, you may execute the **QUIT** command, and the relay is ready for your commissioning procedure. If, however, any channel gains are different, you must reenter the previously recorded values by executing the **SET C** command (similar to relay settings procedure). After this procedure is completed and changes have been saved, execute the **QUIT** command. The relay is now ready for your commissioning procedure.

APPENDIX C: CONFIGURATION, *FAST METER*, AND *FAST OPERATE* COMMANDS

INTRODUCTION

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

SEL Application Guide AG95-10, *Configuration and Fast Meter Messages*, is a comprehensive description of the SEL binary messages. Below is a description of the messages provided in the SEL-501-2 Relay.

MESSAGE LISTS

Binary Message List

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

ASCII Configuration Message List

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

MESSAGE DEFINITIONS

A5C0 Relay Definition Block

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

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

A5C1 *Fast Meter* Configuration Block

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

Data	Description
A5C1	*Fast Meter* command
6A	Length
01	One status flag byte
00	Scale factors in *Fast Meter* message
02	Two scale factors
06	# 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	
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:

Data	Description
A5D1	Command
4E	Length
1-byte	1 Status Byte
4-bytes	X CTR/Phase current scale factor
4-bytes	Y CTR/Phase current scale factor

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

A5C2/A5C3 Demand/Peak Demand *Fast Meter* Configuration Messages

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

Data	Description
A5C2 or A5C3	Command; Demand (A5C2) or Peak Demand (A5C3)
76	Length
00	No status flag byte
00	Scale factors in *Fast Meter* message
00	No scale factors
0A	Ten analog input channels
01	One sample per channel
00	Zero digital banks
00	No calculation
0004	Analog channel offset
FFFF	No time stamp
FFFF	No digital data
494158000000	Analog channel name (IAX)
02	Analog channel type (double precision float)
FF	Scale factor type (no scale factor)
0000	Scale factor offset in *Fast Meter* message
494258000000	Analog channel name (IBX)
02	
FF	
0000	
494358000000	Analog channel name (ICX)
02	
FF	
0000	
334932580000	Analog channel name (3I2X)
02	
FF	
0000	
495258000000	Analog channel name (IRX)
02	
FF	
0000	
494159000000	Analog channel name (IAY)
02	
FF	
0000	
494259000000	Analog channel name(IBY)
02	
FF	

0000	
494359000000	Analog channel name(ICY)
02	
FF	
0000	
334932590000	Analog channel name(3I2Y)
02	
FF	
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:

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-501-2 Status Byte contains one active bit, STSET (bit 4). The bit is set on power up and on settings changes.

A5CE *Fast Operate* Configuration Block

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

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

01	Operate code, clear remote bit RBY
21	Operate code, set remote bit RBY
41	Operate code, pulse remote bit RBY
00	Reserved
checksum	1-byte checksum of all preceding bytes

A5E0 *Fast Operate* Remote Bit Control

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

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

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

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

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

A5E3 *Fast Operate* Breaker Control

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

Data	Description
A5E3	Command
06	Length
1-byte	Operate code: 31 or 32 1OUTX or 1OUTY 11 or 12 2OUTX or 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 following conditions are true:

1. Conditions 1-5 defined in the A5E0 message are true.
2. The breaker jumper (JMP24) is in place on the SEL-501-2 Relay 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> is the STX character (02)
<ETX> is the ETX character (03)
yyyy is the 4-byte ASCII hex representation of the checksum for each line.

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

DNA Message

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

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

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

BNA Message

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

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

where: "yyyy" is the 4-byte ASCII representation of the checksum.
"*" indicates an unused bit location.

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

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 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 which 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, it automatically terminates the connection.
6. Enter the sequence CTRL-X QUIT <CR> 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.

APPENDIX E: MODBUS® RTU COMMUNICATIONS PROTOCOL

INTRODUCTION

This appendix describes Modbus RTU communications features supported by the SEL-501-2 Relay.

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

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

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

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

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

MODBUS RTU COMMUNICATIONS PROTOCOL

Modbus Queries

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

Table E.1: Modbus Query Fields

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

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

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

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

Modbus Responses

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

Supported Modbus Function Codes

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

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

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

Modbus Exception Responses

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

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

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

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

Cyclical Redundancy Check

The SEL-501-2 Relay 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 master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-501-2 Relay, the master 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 master sends queries.

01h Read Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils). You may read the status of up to 2000 bits per query. Note the relay input addresses start from 0 (e.g., Coil 1 is located at address zero). The relay returns 8 bits per byte, most significant bit first, with zeroes padded into incomplete bytes.

Table E.4: 01h Read Coil Status Commands

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave 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 zeroes to make an even byte.

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

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

Please refer to Table E.9 for coil number assignments.

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (coils). You may read the status of up to 2000 bits per query. Note the relay input addresses start at 0. The relay returns 8 bits per byte, most significant bit first, with zeroes padded into incomplete bytes.

Table E.5: 02h Read Input Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave 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 zeroes to make an even byte.

Input numbers are defined below:

Input Numbers	Description
1	Input X
2	Input Y

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

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

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

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register map shown in Table E.18. You may read a maximum of 125 registers at once with this function code. Most masters 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 E.6: 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

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

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

04h Read Input Registers Command

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

Table E.7: 04h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (n)
n bytes	Data
2 bytes	CRC-16

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

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

05h Force Single Coil Command

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

Table E.8: 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

The command response is identical to the command request.

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

Table E.9: SEL-501-2 Relay Command Coils

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

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

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

06h Preset Single Register Command

The SEL-501-2 Relay uses this function to allow a Modbus master 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 E.10: 06h Preset Single Register Command

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

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

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

07h Read Exception Status Command

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

Table E.11: 07h Read Exception Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (07h)
0 bytes	No Data Fields Are Sent
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave 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
Bit 5	Relay Y Input Status
Bit 6	Relay X Input Status
Bit 7	Relay Status

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

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

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

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

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

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

08h Loopback Diagnostic Command

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

Table E.12: 08h Loopback Diagnostic Command

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

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

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

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, up to 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 E.13: 10h Preset Multiple Registers Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

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

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

64h Scattered Register Read

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

Table E.14: 64h Scattered Register Read Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave 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 slave will have the following format:	
1 byte	Slave 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 nth Register
2 bytes	CRC-16

[a] Only subfunction 04h is supported.

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

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

Controlling Output Contacts

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

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

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

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

Table E.16: Modbus Command Codes

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

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

Remote Bits

Command Code 12 (0C hex)–Control Remote Bits:

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

Parameter 1 determines the bit operation.

Value	Operation
1	Set
2	Clear

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

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

Error Codes:

- If the relay is disabled while the commands are issued, the relay will return error code 04 (device error).
- If the TRIGGER command cannot be executed due to multiple events in progress, the relay will return error code 06 (device busy).

Reading Event Data Using Modbus

The Modbus Register Map (Table E.18) provides a feature that allows you to download complete event data via Modbus. The SEL-501-2 Relay stores the 12 latest 15 cycle full length event reports. The two latest reports are stored in nonvolatile memory while the remaining ten reports are stored in volatile memory. Please refer to ***Section 5: Event Reporting*** for more detailed description. If the user selects an event number for which no data is available, the not applicable 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:

1. Write the event number you wish to download at address 00E1h.
2. Write the channel number you wish to download at address 00E2h.
3. Read the four-sample per cycle event data from the Modbus Map.

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

Set 00E2h	To Read 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] Please 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, 0094, and 0095 in the Modbus Map.

Reading History Data Using Modbus

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

If the user selects an event number for which there is no data available, the not applicable code will be returned.

Table E.18: Modbus Map

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay ID						
0000–0016	FID[a]	ASCII String	–	–	–	–
0017–0019	Revision[a]	ASCII String	–	–	–	–
001A–0022	Relay X ID[a]	ASCII String	–	–	–	–
0023–002B	Relay Y ID[a]	ASCII String	–	–	–	–
002C	Reserved (see Note 1)					
002D	Device Tag #[b]	15041	–	–	–	–
002E	Feature Set ID[b]	0	–	–	–	–
002F	Reserved					
Relay Status						
0030	Channel IAX offset value[c]	mV	–5000	5000	1	1
0031	Channel IAX status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
0032	Channel IBX offset value[c]	mV	–5000	5000	1	1
0033	Channel IBX status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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

(*Continued*)

Table E.18: Modbus Map (*Continued*)

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

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
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	CD_RAM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
004F	EEPROM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
0050	Setting status[b] 0 = OK, 1 = relay setting is not OK, 2 = calibration setting is not OK	–	–	–	–	–
0051	Enable status[b] 0 = relay enabled, 2 = relay disabled	–	–	–	–	–
0052–005F	Reserved					
Demand Meter (Relay X)						
0060	Demand current phase Ax[b]	Amps	0	65535	1	1
0061	Demand current phase Bx[b]	Amps	0	65535	1	1
0062	Demand current phase Cx[b]	Amps	0	65535	1	1
0063	Demand current $3I_2x$[b]	Amps	0	65535	1	1
0064	Demand residual current Irx[b]	Amps	0	65535	1	1
Peak Demand Meter (Relay X)						
0065	Peak demand current phase Ax[b]	Amps	0	65535	1	1
0066	Peak demand current phase Bx[b]	Amps	0	65535	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0067	Peak demand current phase Cx[b]	Amps	0	65535	1	1
0068	Peak demand current $3I_2x$[b]	Amps	0	65535	1	1
0069	Peak residual current Irx[b]	Amps	0	65535	1	1
Instantaneous Metering (Relay X)						
006A	Inst. current phase Ax[b]	Amps	0	65535	1	1
006B	Inst. current phase Bx[b]	Amps	0	65535	1	1
006C	Inst. current phase Cx[b]	Amps	0	65535	1	1
006D	Inst. current $3I_2x$[b]	Amps	0	65535	1	1
006E	Inst. residual current Irx[b]	Amps	0	65535	1	1
Demand Meter (Relay Y)						
006F	Demand current phase Ay[b]	Amps	0	65535	1	1
0070	Demand current phase By[b]	Amps	0	65535	1	1
0071	Demand current phase Cy[b]	Amps	0	65535	1	1
0072	Demand current $3I_2y$[b]	Amps	0	65535	1	1
0073	Demand residual current Iry[b]	Amps	0	65535	1	1
Peak Demand Meter (Relay Y)						
0074	Peak demand current phase Ay[b]	Amps	0	65S535	1	1
0075	Peak demand current phase By[b]	Amps	0	65535	1	1
0076	Peak demand current phase Cy[b]	Amps	0	65535	1	1
0077	Peak demand current $3I_2y$[b]	Amps	0	65535	1	1
0078	Peak demand residual current Iry[b]	Amps	0	65535	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Instantaneous Metering (Relay Y)						
0079	Inst. current phase Ay[b]	Amps	0	65535	1	1
007A	Inst. current phase By[b]	Amps	0	65535	1	1
007B	Inst. current phase Cy[b]	Amps	0	65535	1	1
007C	Inst. current $3I_2x$[b]	Amps	0	65535	1	1
007D	Inst. residual current Iry[b]	Amps	0	65535	1	1
Breaker Monitor (Relay X; see Note 6)						
007E	Number of internal trips[b]	–	0	65535	1	1
007F	Internal IA[b]	KA	0	65535	1	0.1
0080	Internal IB[b]	KA	0	65535	1	0.1
0081	Internal IC[b]	KA	0	65535	1	0.1
0082	Number of external trips[b]	–	0	65535	1	1
0083	External IA[b]	KA	0	65535	1	0.1
0084	External IB[b]	KA	0	65535	1	0.1
0085	External IC[b]	KA	0	65535	1	0.1
Breaker Monitor (Relay Y)						
0086	Number of internal trips[b]	–	0	65535	1	1
0087	Internal IA[b]	KA	0	65535	1	0.1
0088	Internal IB[b]	KA	0	65535	1	0.1
0089	Internal IC[b]	KA	0	65535	1	0.1
008A	Number of external trips[b]	–	0	65535	1	1
008B	External IA[b]	KA	0	65535	1	0.1
008C	External IB[b]	KA	0	65535	1	0.1
008D	External IC[b]	KA	0	65535	1	0.1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Expanded Relay Time and Date						
008E (RW) (see Note 4)	Time[b]	ss	0	59	1	1
008F (RW)	[b]	mm	0	59	1	1
0090 (RW)	[b]	hh	0	23	1	1
0091 (RW)	Date[b]	dd	1	31	1	1
0092 (RW)	[b]	mm	1	12	1	1
0093 (RW)	[b]	yyyy	1992	2999	1	1
	Targets					
0094	Targets X					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = Inst.					
	Bit 9 = Phase 1 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 = 0					
	Bit 15 = 0					
0095	Targets Y					
	Bit 0 = 1 if any of bits 8–15 are set to 1					

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 0 = 0 if any 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					
0096–009F	Reserved					
Relay Word (X)						
00A0	Row 2 (relay element status)					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 50NH					
	Bit 9 = 50NT					
	Bit 10 = 50QT					
	Bit 11 = 50H					
	Bit 12 = 50PT					
	Bit 13 = 51NT					
	Bit 14 = 51QT					
	Bit 15 = 51PT					
00A1	Row 3 (relay element status)					
	Bit 0 = 1 if any of bits 8–15 are set to 1					

(*Continued*)

Table E.18: Modbus Map (*Continued*)

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

(*Continued*)

Table E.18: Modbus Map (*Continued*)

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

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 11 = XOUT1					
	Bit 12 = XOUT2					
	Bit 13 = YOUT1					
	Bit 14 = YOUT2					
	Bit 15 = 0					
00A7–00BF	Reserved					
Commands						
00C0 (W) (see Note 8)	Command Code		1	11		
00C1 (W)	Parameter 1					
00C2 (W)	Parameter 2					
00C2–00CF	Reserved					
History Records						
00D0	Number of History Records[b]		1	20	1	1
00D1 (RW)	History Selection[b]		1	20	1	1
00D2	Event Time[b]	millisec	0	999	1	1
00D3	Event Time[b]	ss	0	59	1	1
00D4	[b]	mm	0	59	1	1
00D5	[b]	hh	0	23	1	1
00D6	Event Date[b]	dd	1	31	1	1
00D7	[b]	mm	1	12	1	1
00D8	[b]	yyyy	1992	2999	1	1
00D9	Event Type[a]	ASCII string				
00DA		see Note 3				
00DB						
00DC						
00DD						
00DE	Targets					

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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 = 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 = Relay Y					
	Bit 15 = Relay X					
00DF	Reserved					
Event Reporting (see Note 5)						
00E0	Number event records[b]	–	1	12	1	1
00E1 (RW)	Event selection[b]	–	1	12	1	1
00E2 (RW)	Channel selection[b]	–	1	8	1	1
00E3	1/4 cycle[c]		–32767	32767	1	1
00E4	1/2 cycle[c]		–32767	32767	1	1
00E5	3/4 cycle[c]		–32767	32767	1	1
00E6	1 cycle[c]		–32767	32767	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00E7	1 1/4 cycle[c]		–32767	32767	1	1
00E8	1 1/2 cycle[c]		–32767	32767	1	1
00E9	1 3/4 cycle[c]		–32767	32767	1	1
00EA	2 cycle[c]		–32767	32767	1	1
00EB	2 1/4 cycle[c]		–32767	32767	1	1
00EC	2 1/2 cycle[c]		–32767	32767	1	1
00ED	2 3/4 cycle[c]		–32767	32767	1	1
00EE	3 cycle[c]		–32767	32767	1	1
00EF	3 1/4 cycle[c]		–32767	32767	1	1
00F0	3 1/2 cycle[c]		–32767	32767	1	1
00F1	3 3/4 cycle[c]		–32767	32767	1	1
00F2	4 cycle[c]		–32767	32767	1	1
00F3	4 1/4 cycle[c]		–32767	32767	1	1
00F4	4 1/2 cycle[c]		–32767	32767	1	1
00F5	4 3/4 cycle[c]		–32767	32767	1	1
00F6	5 cycle[c]		–32767	32767	1	1
00F7	5 1/4 cycle[c]		–32767	32767	1	1
00F8	5 1/2 cycle[c]		–32767	32767	1	1
00F9	5 3/4 cycle[c]		–32767	32767	1	1
00FA	6 cycle[c]		–32767	32767	1	1
00FB	6 1/4 cycle[c]		–32767	32767	1	1
00FC	6 1/2 cycle[c]		–32767	32767	1	1
00FD	6 3/4 cycle[c]		–32767	32767	1	1
00FE	7 cycle[c]		–32767	32767	1	1
00FF	7 1/4 cycle[c]		–32767	32767	1	1
0100	7 1/2 cycle[c]		–32767	32767	1	1
0101	7 3/4 cycle[c]		–32767	32767	1	1
0102	8 cycle[c]		–32767	32767	1	1
0103	8 1/4 cycle[c]		–32767	32767	1	1
0104	8 1/2 cycle[c]		–32767	32767	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

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

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0122	1 cycle[c]		–32767	32767	1	1
0123	1 1/4 cycle[c]		–32767	32767	1	1
0124	1 1/2 cycle[c]		–32767	32767	1	1
0125	1 3/4 cycle[c]		–32767	32767	1	1
0126	2 cycle[c]		–32767	32767	1	1
0127	2 1/4 cycle[c]		–32767	32767	1	1
0128	2 1/2 cycle[c]		–32767	32767	1	1
0129	2 3/4 cycle[c]		–32767	32767	1	1
012A	3 cycle[c]		–32767	32767	1	1
012B	3 1/4 cycle[c]		–32767	32767	1	1
012C	3 1/2 cycle[c]		–32767	32767	1	1
012D	3 3/4 cycle[c]		–32767	32767	1	1
012E	4 cycle[c]		–32767	32767	1	1
012F	4 1/4 cycle[c]		–32767	32767	1	1
0130	4 1/2 cycle[c]		–32767	32767	1	1
0131	4 3/4 cycle[c]		–32767	32767	1	1
0132	5 cycle[c]		–32767	32767	1	1
0133	5 1/4 cycle[c]		–32767	32767	1	1
0134	5 1/2 cycle[c]		–32767	32767	1	1
0135	5 3/4 cycle[c]		–32767	32767	1	1
0136	6 cycle[c]		–32767	32767	1	1
0137	6 1/4 cycle[c]		–32767	32767	1	1
0138	6 1/2 cycle[c]		–32767	32767	1	1
0139	6 3/4 cycle[c]		–32767	32767	1	1
013A	7 cycle[c]		–32767	32767	1	1
013B	7 1/4 cycle[c]		–32767	32767	1	1
013C	7 1/2 cycle[c]		–32767	32767	1	1
013D	7 3/4 cycle[c]		–32767	32767	1	1
013E	8 cycle[c]		–32767	32767	1	1
013F	8 1/4 cycle[c]		–32767	32767	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0140	8 1/2 cycle[c]		–32767	32767	1	1
0141	8 3/4 cycle[c]		–32767	32767	1	1
0142	9 cycle[c]		–32767	32767	1	1
0143	9 1/4 cycle[c]		–32767	32767	1	1
0144	9 1/2 cycle[c]		–32767	32767	1	1
0145	9 3/4 cycle[c]		–32767	32767	1	1
0146	10 cycle[c]		–32767	32767	1	1
0147	10 1/4 cycle[c]		–32767	32767	1	1
0148	10 1/2 cycle[c]		–32767	32767	1	1
0149	10 3/4 cycle[c]		–32767	32767	1	1
014A	11 cycle[c]		–32767	32767	1	1
014B	11 1/4 cycle[c]		–32767	32767	1	1
014C	11 1/2 cycle[c]		–32767	32767	1	1
014D	11 3/4 cycle[c]		–32767	32767	1	1
014E	12 cycle[c]		–32767	32767	1	1
014F	12 1/4 cycle[c]		–32767	32767	1	1
0150	12 1/2 cycle[c]		–32767	32767	1	1
0151	12 3/4 cycle[c]		–32767	32767	1	1
0152	13 cycle[c]		–32767	32767	1	1
0153	13 1/4 cycle[c]		–32767	32767	1	1
0154	13 1/2 cycle[c]		–32767	32767	1	1
0155	13 3/4 cycle[c]		–32767	32767	1	1
0156	14 cycle[c]		–32767	32767	1	1
0157	14 1/4 cycle[c]		–32767	32767	1	1
0158	14 1/2 cycle[c]		–32767	32767	1	1
0159	14 3/4 cycle[c]		–32767	32767	1	1
015A	15 cycle[c]		–32767	32767	1	1
Summary Data						
015B	Event type[a]	ASCII string				
015C		see Note 3				

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
015D						
015E						
Date and Time						
015F						
0160	Event time[b]	millisec	0	999	1	1
0161	Event time[b]	ss	0	59	1	1
0162	[b]	mm	0	59	1	1
0163	[b]	hh	0	23	1	1
0164	Event date[b]	dd	1	31	1	1
0165	[b]	mm	1	12	1	1
0166	[b]	yyyy	1992	2999	1	1
0167	Duration extent[b] Null = actual fault is equal to the duration listed "+" = fault is probably greater than the duration listed (see Note 4)	ASCII string	Null	+	–	–
0168	Duration[b]	Cycles	0	65535	1	0.01
0169	X-Current IA[b]	Amps	0	65535	1	1
016A	X-Current IB[b]	Amps	0	65535	1	1
016B	X-Current IC[b]	Amps	0	65535	1	1
016C	X-Current IQ[b]	Amps	0	65535	1	1
016D	X-Current IN[b]	Amps	0	65535	1	1
016E	Y-Current IA[b]	Amps	0	65535	1	1
016F	Y-Current IB[b]	Amps	0	65535	1	1
0170	Y-Current IC[b]	Amps	0	65535	1	1
0171	Y-Current IQ[b]	Amps	0	65535	1	1
0172	Y-Current IN[b]	Amps	0	65535	1	1
0173	Targets Bit 0 = 1 if any of bits 8-15 are set to 1 Bit 0 = 0 if all of bits 8-15 are set to 0 Bit 1 = 0					

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 2 = 0					
	Bit 3 = 0					
	Bit 4 = 0					
	Bit 5 = 0					
	Bit 6 = 0					
	Bit 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 = Relay Y					
	Bit 15 = Relay X					
0176–017F	Reserved					
Maximum Current Limit						
0174	Relay X[d]	Amps	–32767	32767	1	1
0175	Relay X[e]	Exponent	–4	4		
0176	Relay Y[d]	Amps	–32767	32767	1	1
0177	Relay Y[e]	Exponent	–4	4		
0178–017F	Reserved					
Communication Counter						
0180	Number of messages received[b]	–	0	65535	1	1
0181	Number of messages sent to other devices[b]	–	0	65535	1	1
0182	Invalid address[b]	–	0	65535	1	1
0183	Bad CRC[b]	–	0	65535	1	1
0184	UART error[b]	–	0	65535	1	1

(*Continued*)

Table E.18: Modbus Map (*Continued*)

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0185	Illegal function code/Op code[b]	–	0	65535	1	1
0186	Illegal register[b]	–	0	65535	1	1
0187	Illegal write[b]	–	0	65535	1	1
0188	Bad packet format[b]	–	0	65535	1	1
0189	Bad packet length[b]	–	0	65535	1	1
018A	Reserved					
018B	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 = $(R1 \bullet 10^{R2})$

[e] R1 is the content of register 0174h (0176h). R2, which is stored in 0175h (0177h), determines the decimal point position for the final value.

NOTE 1: Reserved addresses return 8000h.

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

NOTE 3: Event Types

TRIG 1OUT

FAULT 2OUT

EXT

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

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

The SEL-501-2 Relay stores the latest 12 event reports. The two latest reports are stored in nonvolatile memory and survive the loss of voltage to the relay. The remaining ten 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 6: External Trip is not applicable.

NOTE 7: Please refer to Table E.16 for a list of Command Codes.

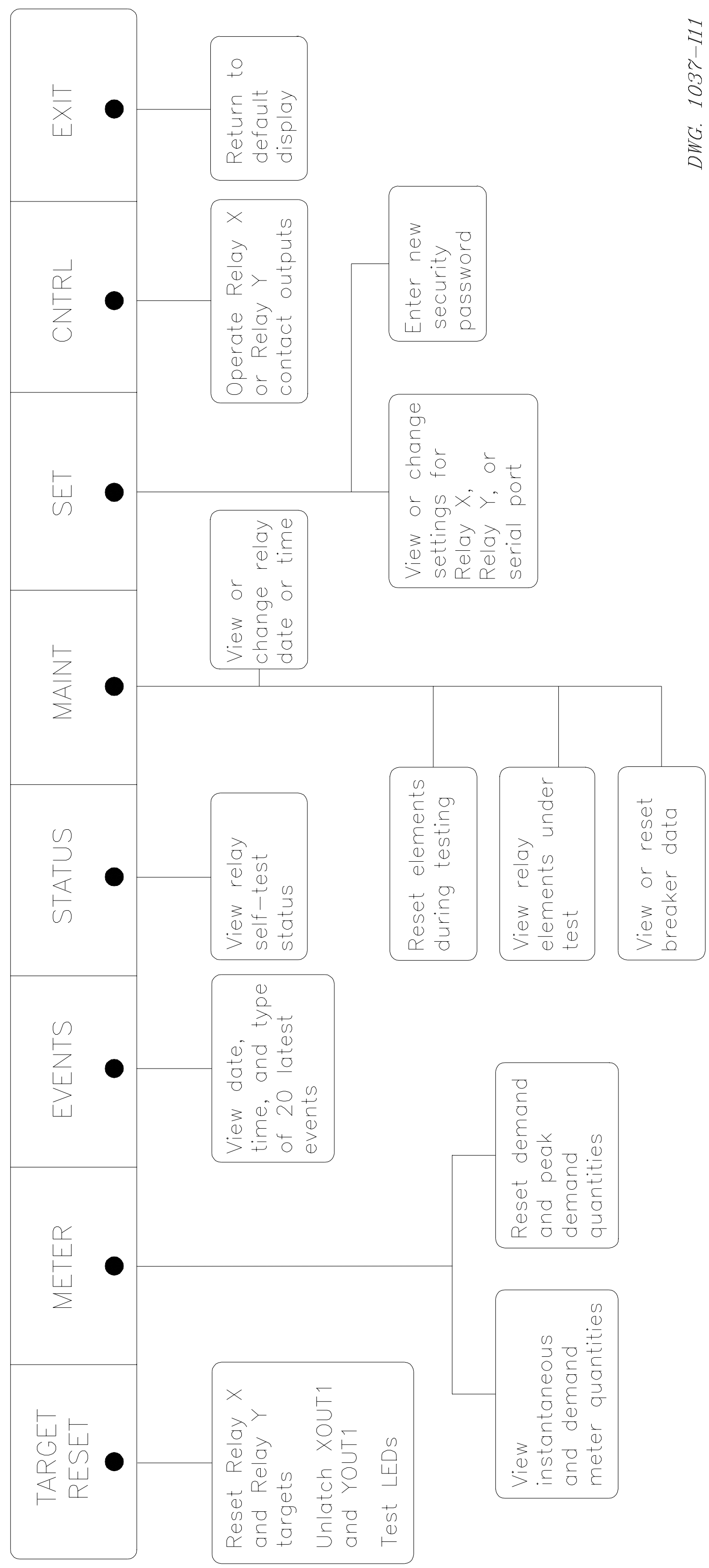
General Comments

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

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

COMMAND CROSS-REFERENCE TABLE

Access Level	Serial Port Command	Front-Panel Operations	Command Description
0	ACCESS	--	Move to Access Level 1.
1	2ACCESS	--	Move to Access Level 2.
1	BREAKER	<**MAINT**>, *n*, Breaker	View trip counters and trip current data. (*n* = X, Y)
1	DATE DATE *mm/dd/yy*	<**MAINT**>, Date	View or change relay calendar date.
1	EVENT #	--	View event report. (# = 1 - 12)
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.
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	OUT n		
1	SHOW *n*	<**SET**>, *n*, Show	View relay settings (*n* = X, Y, Port).
1	STATUS	<**STATUS**>	View relay self-test status.
1	TARGET *n* #	<**MAINT**>, *n*, Tar	View relay element, input, output status. (*n* = X, Y; # = 0 - 4)
1	TARGET R	<**TARGET RESET**>	Reset tripping targets.
1	TIME TIME *hh:mm:ss*	<**MAINT**>, Time	View or change time.
1	TRIGGER	--	Trigger a relay event report.
1	QUIT	--	Move to Access Level 0.
2	BREAKER *n* R	<**MAINT**>, *n*, Breaker	Reset trip counters and trip current data. (*n* = X, Y)
2	CON *n*	--	Control remote bit (*n* = X,Y)
2	1OUT n	<**CNTRL**>, *n*, 1OUT	Closes Output *n*OUT1 (*n* = X,Y)
2	2OUT n	<**CNTRL**>, *n*, 2OUT	Closes Output *n*OUT2 (*n* = X,Y)
2	PAS PAS *l* ######	<**SET**>, Pass	View or change password. (*l* = 1, 2; ###### = new password)
2	RESET *n*	<**MAINT**>, *n*, EL	Reset time-overcurrent elements. (*n* = X, Y)
2	SET X SET Y SET P	<**SET**>, X, Set <**SET**>, Y, Set <**SET**>, Port, Set	View or change relay or serial port protocol settings.



FRONT-PANEL FUNCTION DRAWING