SEL-501
SEL-501-1

DUAL UNIVERSAL OVERCURRENT RELAY

INSTRUCTION MANUAL

SCHWEITZER ENGINEERING LABORATORIES
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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 revision includes the following changes: – 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 7:** – Added 1OUT n and 2OUT n command information to ***Table 7.5 Command Cross-Reference Table***. – Added Target 0 and Target 1 information to ***Table 7.8: Overcurrent Protection Application Target Command Table***. **Appendix A:** – Added clarification to RTS_CTS Serial Port Setting.

Revision Date	Summary of Revisions
000131	This manual differs from the previous revision as stated in the following summary: **Section 3:** – Reissued entire section to correct pagination. **Appendix** G: – Made revisions and corrections.
991129	This manual differs from the previous revision as stated in the following summary: **Section 1:** – Made minor corrections. **Section 2:** – Updated relay panel cutout and drill guides. – Added new Figure 2.2, Figure 2.4 and Figure 2.5. – Updated Figure 2.7 to document new current shorting connectors for Connectorized® models. – Added sections EIA-232 Serial Communications Port Voltage Jumper and Output Contact YOUT2 Control Jumper **Section 3:** – Revised OC1 and FDR Settings Sheets. **Section 4:** – Revised MOT Settings Sheets. **Section 5:** – Revised BFR Settings Sheets. **Section 6:** – Revised TMR Settings Sheets. **Section 7:** Revised Table 7.1 and associated text preceding the table. – Updated Table 7.2. **Section 9:** – Added relay Self-test section. **Appendix B:** – Added **Appendix B: Firmware Upgrade Instructions**. Incremented letter of all subsequent appendices. **Appendix E:** – Added **Appendix E: Configuration, *Fast Meter*, and *Fast Operate* Commands**. Incremented letter of all subsequent appendices.

Revision Date	Summary of Revisions
	Appendix G: – Added **Appendix G: Modbus™ RTU Communications Protocol.**
981101	This manual differs from the previous revision as stated in the following summary: **Section 2:** – Updated relay panel cutout and drill guides. – Updated Figure 2.4 to document new current shorting connectors for Connectorized™ models. **Section 3:** – Added OC1 and FDR Settings Sheets. **Section 4:** – Added MOT Settings Sheets. **Section 5:** – Added BFR Settings Sheets. **Section 6:** – Added TMR Settings Sheets.
980715	This manual differs from the previous revision as stated in the following summary: **Appendix A:** – Updated Appendix A: Firmware Versions.
980626	This manual differs from the previous revision as stated in the following summary: **Section 1:** – Pages 1-5 through 1-7, removed note to show availability of 250 V "Level-Sensitive" inputs. – Changed 250 Vdc dropout from 200 to 150 Vdc. **Section 2:** – Page 2-7, removed note to show availability of 250 V "Level Sensitive" inputs.

Revision Date	Summary of Revisions
970725	This manual differs from the previous revision as stated in the following summary: **Section 1:** – Removed Specifications Addendum and incorporated specifications into ***Section 1***. – Reformatted the existing type tests and 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 255-22-3 - 1989 IEC 255-22-4 - 1992 IEC 695-2-2 - 1991 UL 508 Listing – Added 24-volt power supply rating to Output Contacts, Optoisolated Input Ratings, and Power Supply Ratings. **Section 7:** – Corrected Serial Communication Cables for Use with the SEL-501 Relay cable information.
970424	This manual differs from the previous revision as stated in the following summary: – Add Specifications Addendum
970414	This manual differs from the previous revision as stated in the following summary: **Section 2:** – Password and Breaker Control Command Jumpers—Clarification. **Section 9:** – Troubleshooting Procedure—Modify LCD contrast adjustment steps.
970204	Initial Release

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SECTION 1: INTRODUCTION

INTRODUCTION

The SEL-501 Dual Universal Overcurrent Relay provides two complete and independent groups of protection functions in one compact unit. The SEL-501-1 Relay is identical to the SEL-501 Relay with the exception of the additional SY/MAX protocol (SY/MAX protocol is described in ***Appendix F***). The unit contains Relay X and Relay Y, each having two output contacts, one optoisolated input, and three-phase current inputs. Each relay provides overcurrent, motor, or breaker failure protection. You select the application and settings for each relay independently.

The dual relay hardware block diagram in Figure 1.2 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 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.

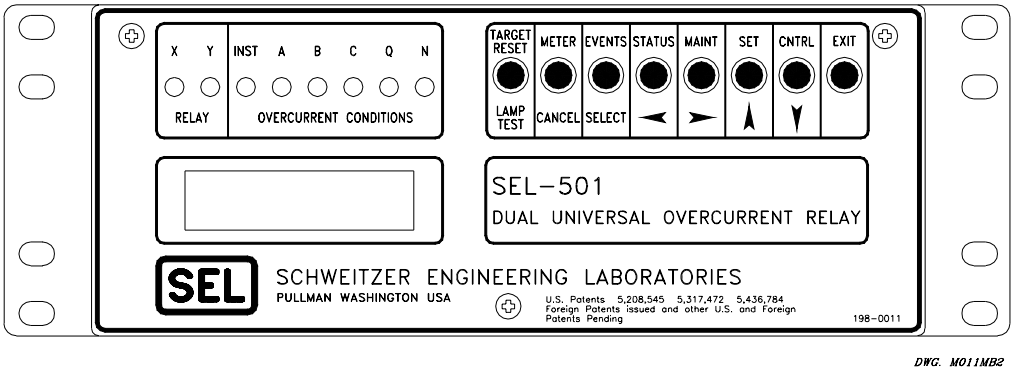


Figure 1.1: SEL-501 Relay Front Panel

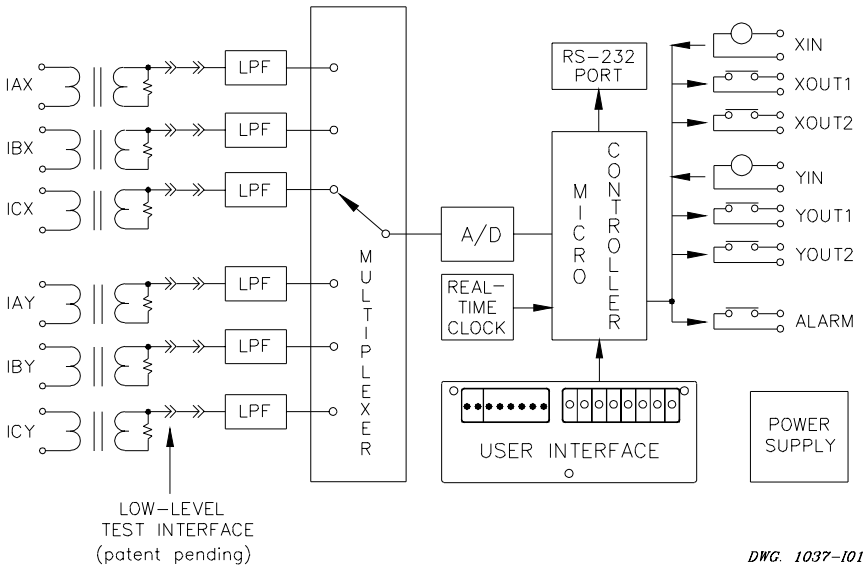
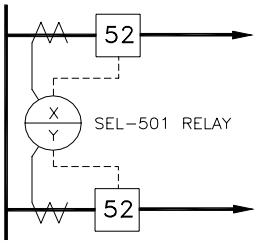


Figure 1.2: Dual Relay Hardware Block Diagram

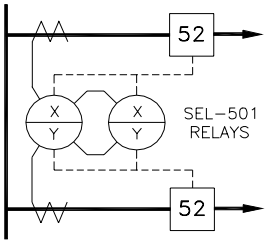
SEL-501 DUAL RELAY APPLICATIONS

Protect Two Feeders



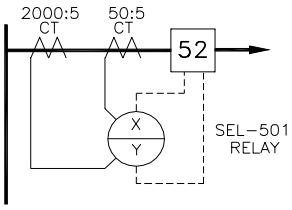
- Complete overcurrent and simple breaker failure protection for two feeders.
- Settable time-delay on trip output contact provides simple breaker failure protection.
- Low cost, compact protection.

Two Relays + Two Feeders = Full Redundancy



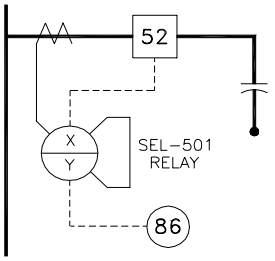
- Ideal for two-high switchgear.
- Front-panel control eliminate the need for manual control switches.
- Includes negative-sequence overcurrent protection for sensitive, fast phase-phase fault coverage.

Cover a Wide Range of Fault Currents



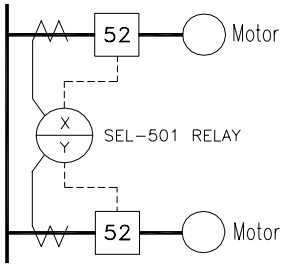
- 2000:5 CT covers fault up to 32,000 amps (5 A Model).
- 50:5 CT meters load accurately, and covers faults down to 5 amps primary (5 A Model).

Capacitor, Reactor, and Breaker Failure Protection



- Protects capacitors, reactors, and bus sections.
- Provides breaker failure protection

Protect Two Motors



- Complete protection for two motors.
- Ideal for compact motor control centers.
- Stop and start motors from relay front panel.

DWG. 1037–I05

Figure 1.3: Example SEL-501 Dual Relay Applications

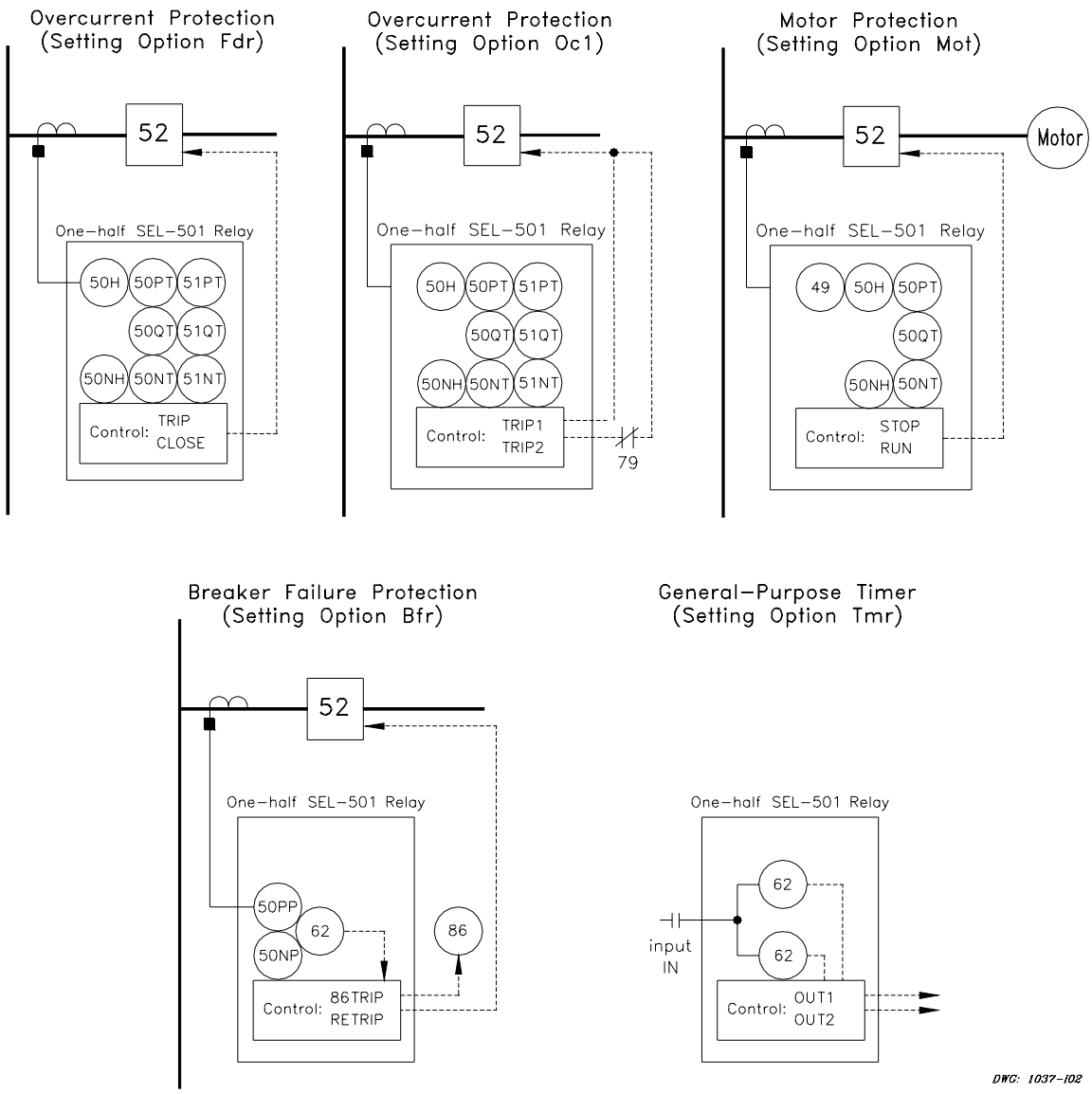


Figure 1.4: Relay Application Single-Line Diagrams

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; only available in SEL-501 Relay)
SY/MAX (only available in SEL-501-1 Relay)

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 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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FIGURES

SECTION 2: MOUNTING AND CONNECTIONS

RELAY MOUNTING

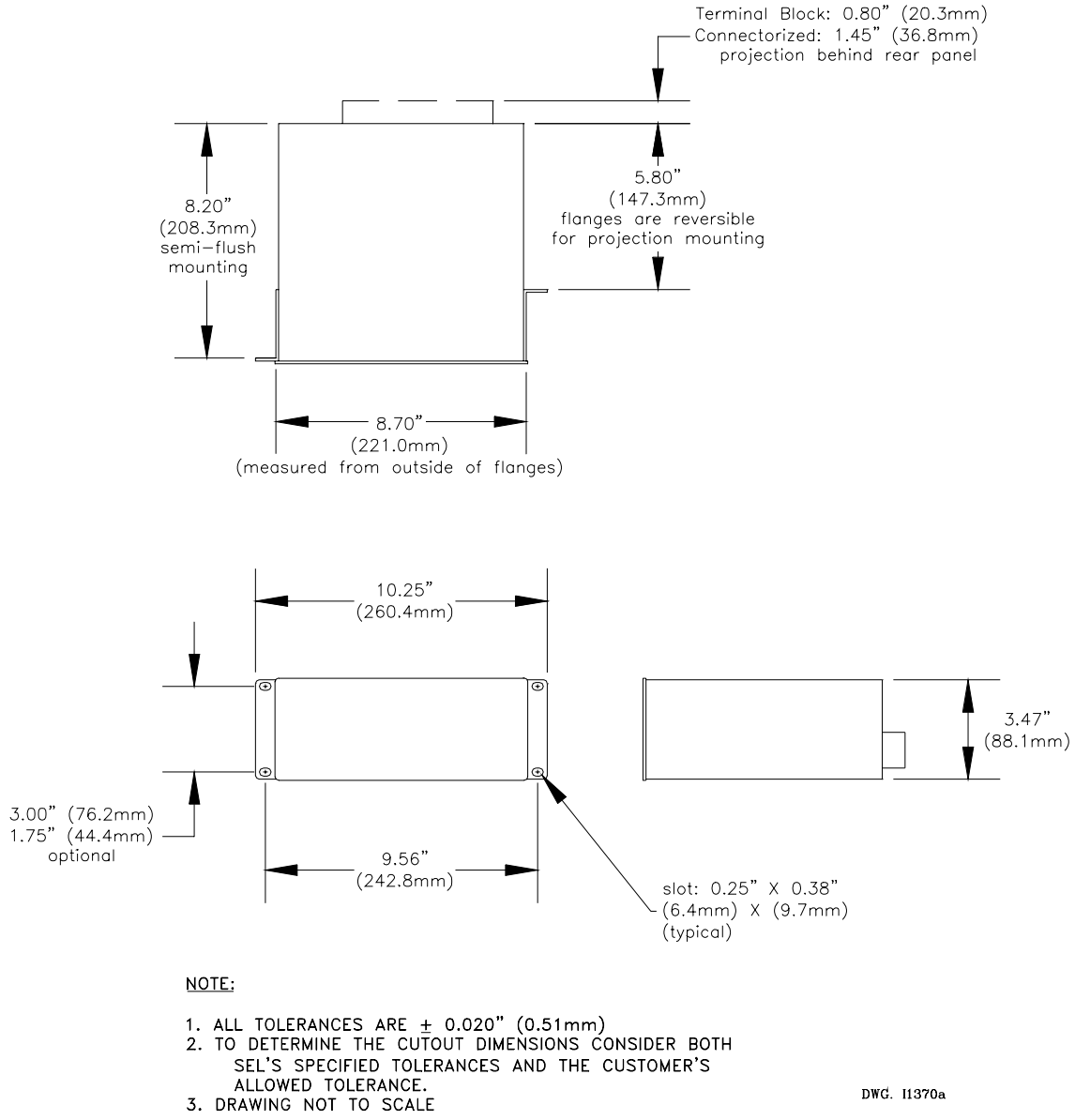
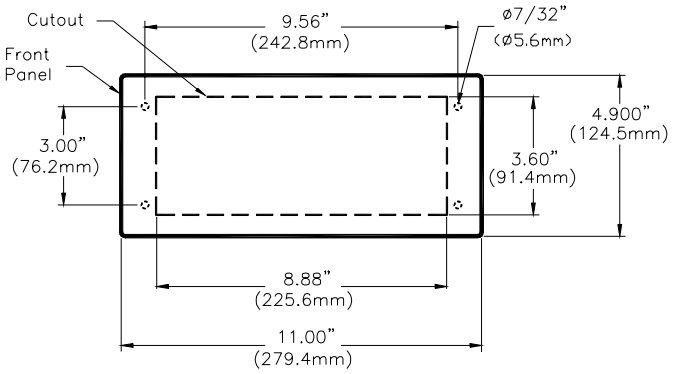


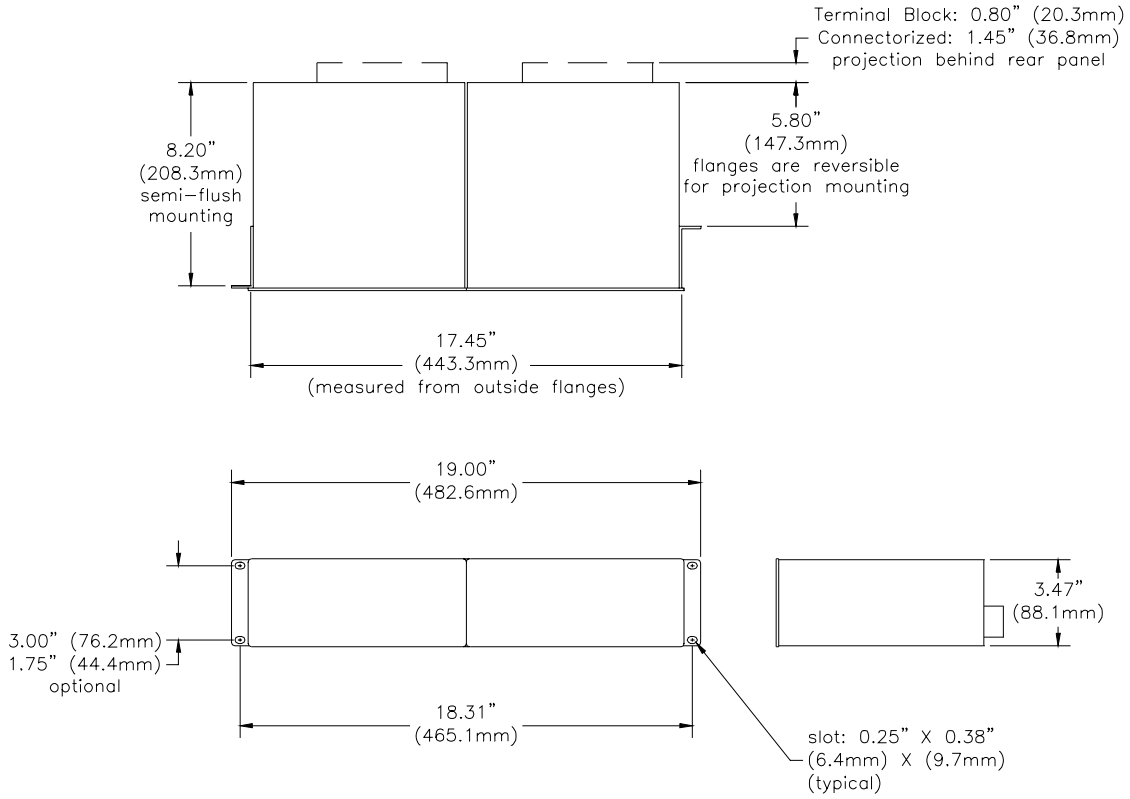
Figure 2.1: SEL-501 Relay Dimensions and Drill Plan for Single Rack-Mount Relay



NOTE:

1. ALL TOLERANCES ARE ± 0.020" (0.51mm)
2. TO DETERMINE THE CUTOUT DIMENSIONS CONSIDER BOTH SEL'S SPECIFIED TOLERANCES AND THE CUSTOMER'S ALLOWED TOLERANCE.
3. DRAWING NOT TO SCALE

Figure 2.2: Panel Cut-Out and Drill Plan for Single Panel-Mount Relay



NOTE:

1. ALL TOLERANCES ARE ± 0.020" (0.51mm)
2. TO DETERMINE THE CUTOUT DIMENSIONS CONSIDER BOTH SEL'S SPECIFIED TOLERANCES AND THE CUSTOMER'S ALLOWED TOLERANCE.
3. DRAWING NOT TO SCALE

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Figure 2.3: Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relays Together Using Mounting Block (SEL P/N 9101)

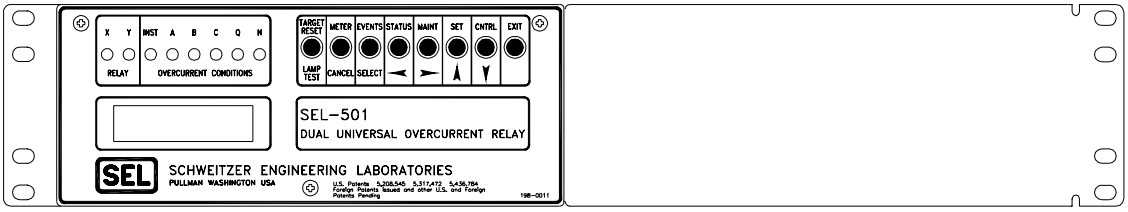

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Figure 2.4: SEL-501 Relay Fitted with Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

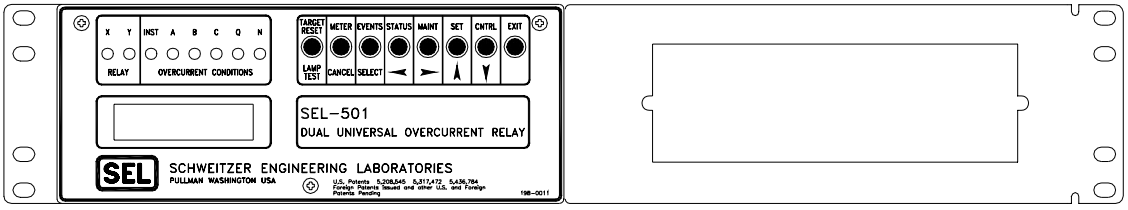

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Figure 2.5: SEL-501 Relay Fitted with Mounting Bracket (SEL P/N 9102) for Mounting in 19-Inch Rack Including Cutout to Fit an FT-1 Test Switch

TWO REAR-PANEL OPTIONS

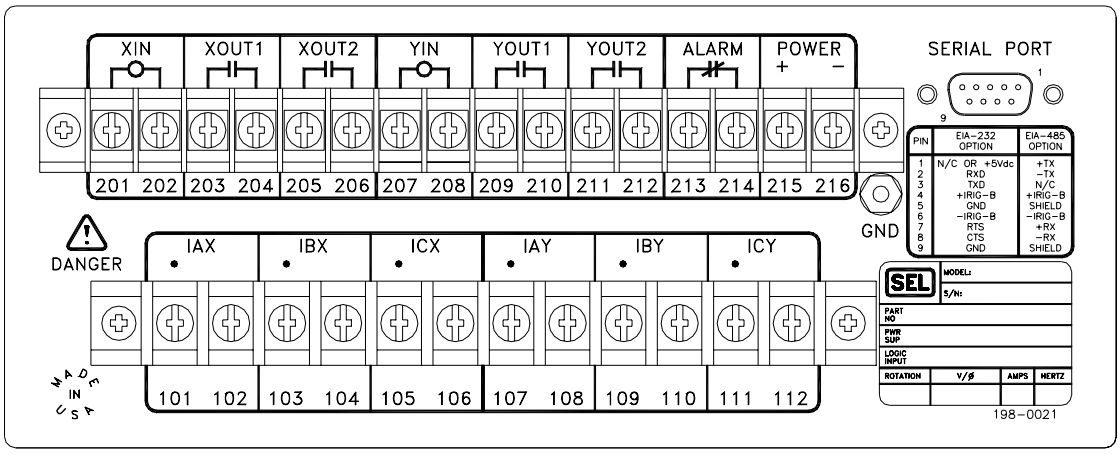

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Figure 2.6: SEL-501 Relay Rear Panel (Conventional Terminal Blocks Option)

Conventional Terminal Blocks Option in Figure 2.6

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.

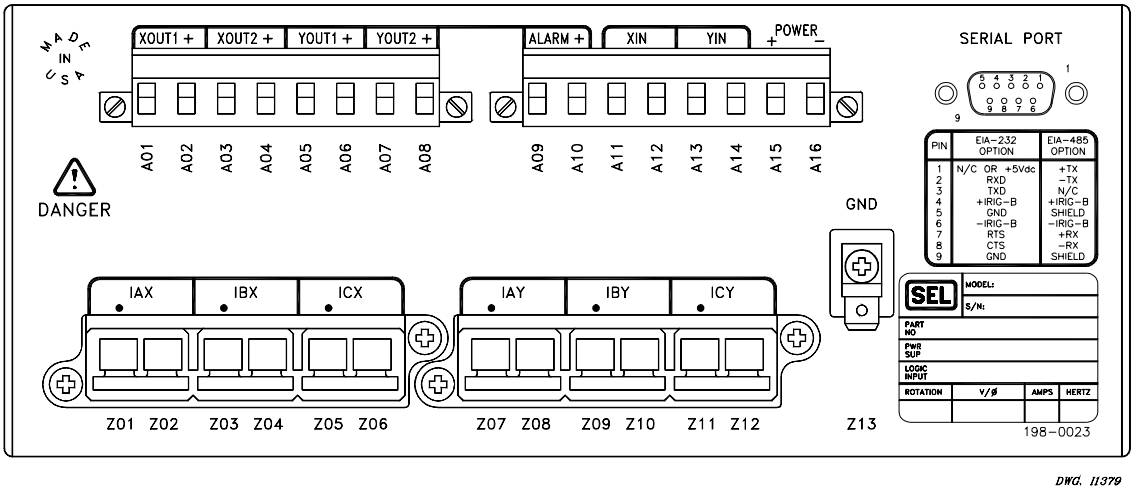

Figure 2.7: SEL-501 Relay Rear Panel (Plug-In Connectors Option)

Plug-In Connectors Option in Figure 2.7

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

OLD		NEW
0501xJ	→	0501xW

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

OLD		NEW
WA0501xJ	→	WA0501xW

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

Figure 2.7 shows the rear panel for new models 0501xW. Because all terminal labeling/numbering remains the same between the new and old relays, these figures can also be used as a reference for old model 0501xJ. Only the connectors and part numbers have changed.

SEL-501 RELAY AC/DC CONNECTION DIAGRAMS

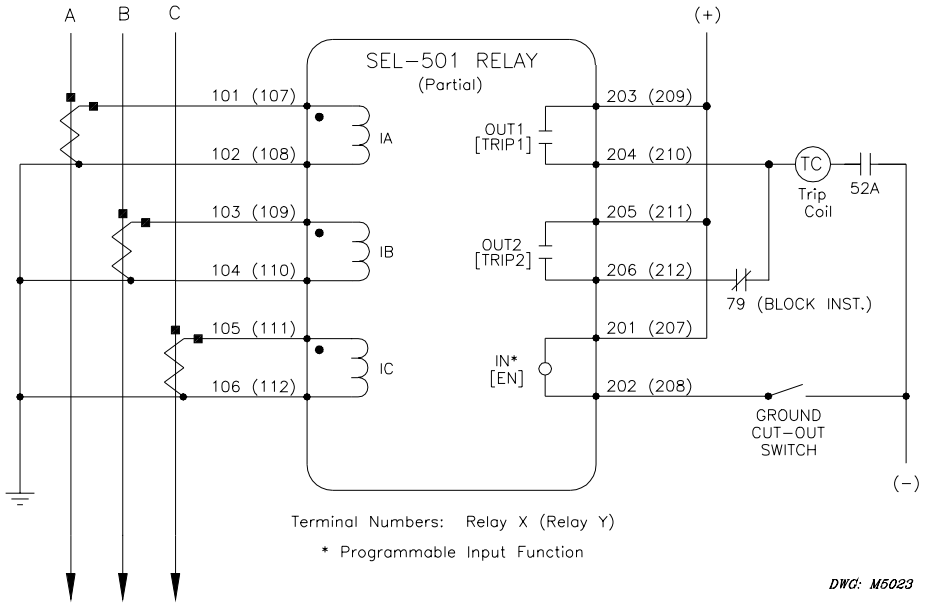

Figure 2.8: AC/DC Connections for Overcurrent Protection Applications
(Feeder application with external reclosing relay shown; setting APP = OC1)

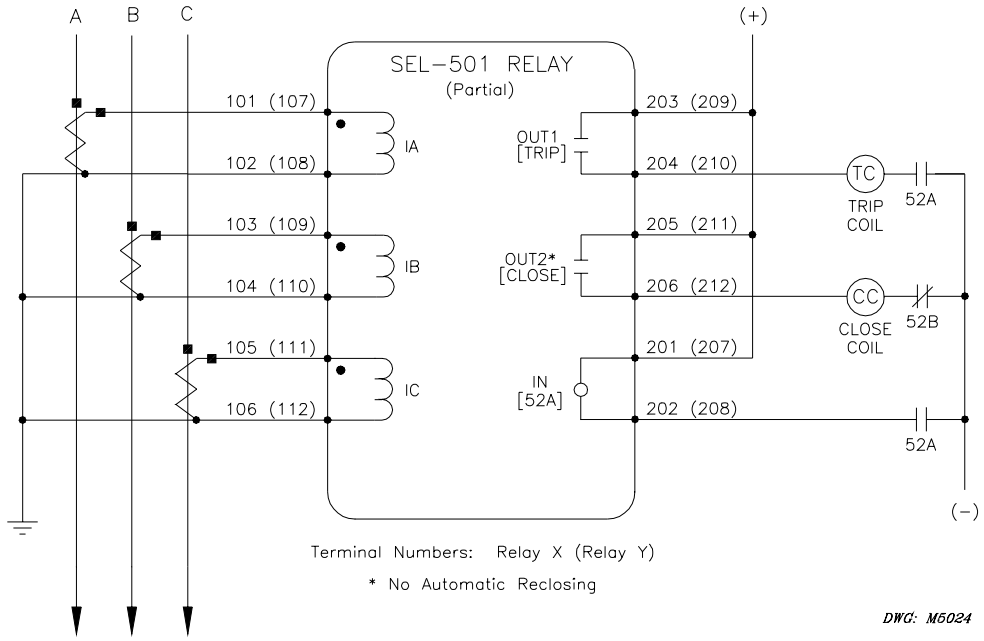

Figure 2.9: AC/DC Connections for Overcurrent or Motor Protection Applications
(setting APP = Fdr or APP = Mtr)

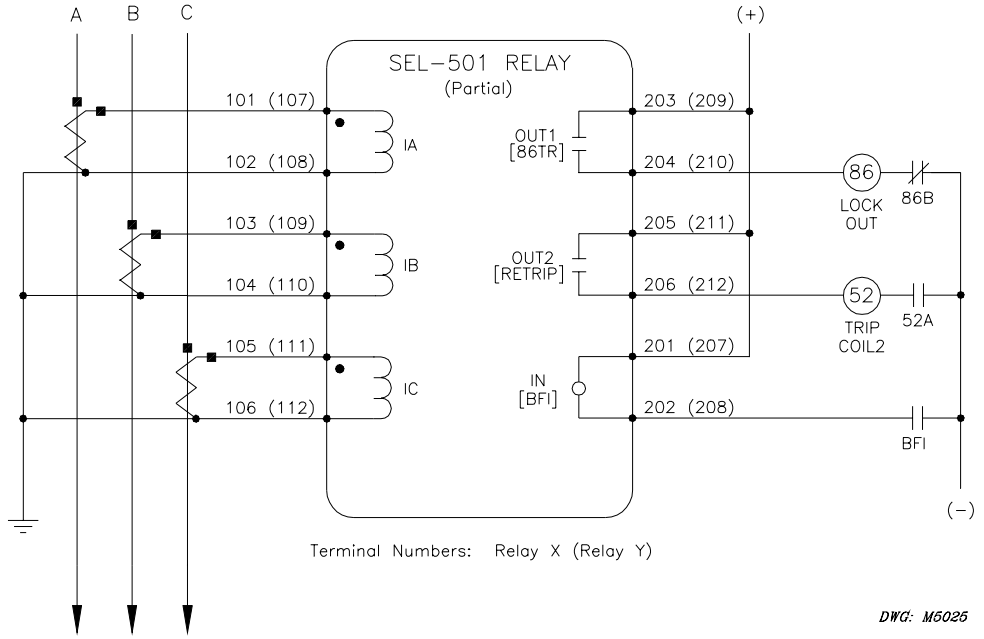

Figure 2.10: AC/DC Connections for Breaker Failure Protection Applications
(setting APP = Bfr)

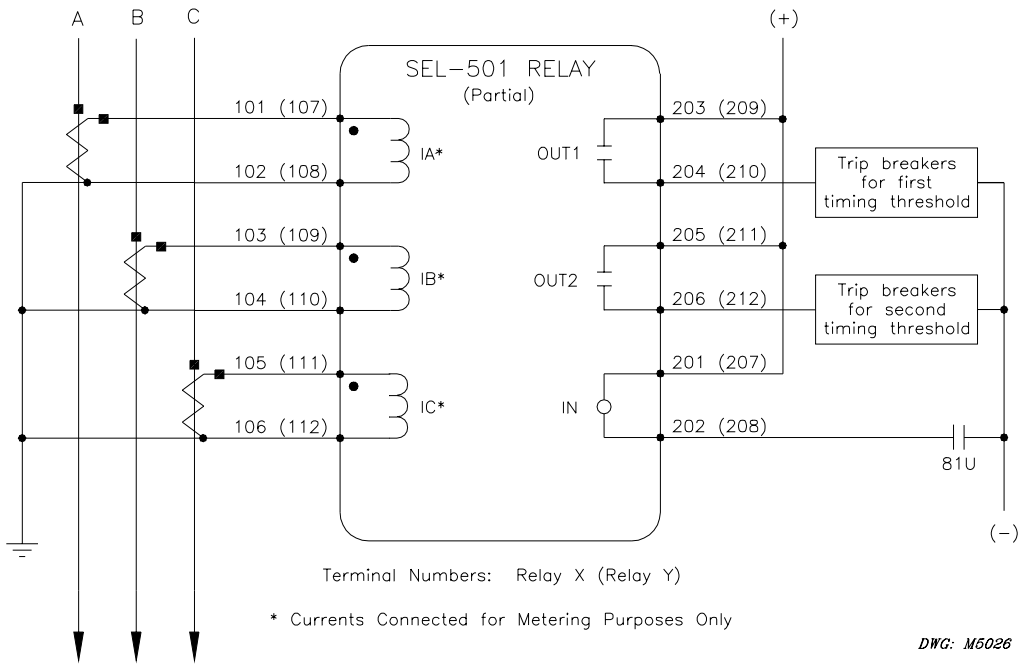

Figure 2.11: AC/DC Connections for General-Purpose Timer Applications
(Underfrequency load shedding timing application shown; setting APP = Tmr)

CIRCUIT BOARD JUMPERS AND BATTERY

Control Voltage Jumpers (Conventional Terminal Blocks Option Only)

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: Introduction*** 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 draw out 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 2.12.

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 2.12. 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 2.12, 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 JMP22 (left-most jumper) in place to disable serial port and front panel password protection. With the jumper removed, password security is enabled. Set the password with the PAS command.

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

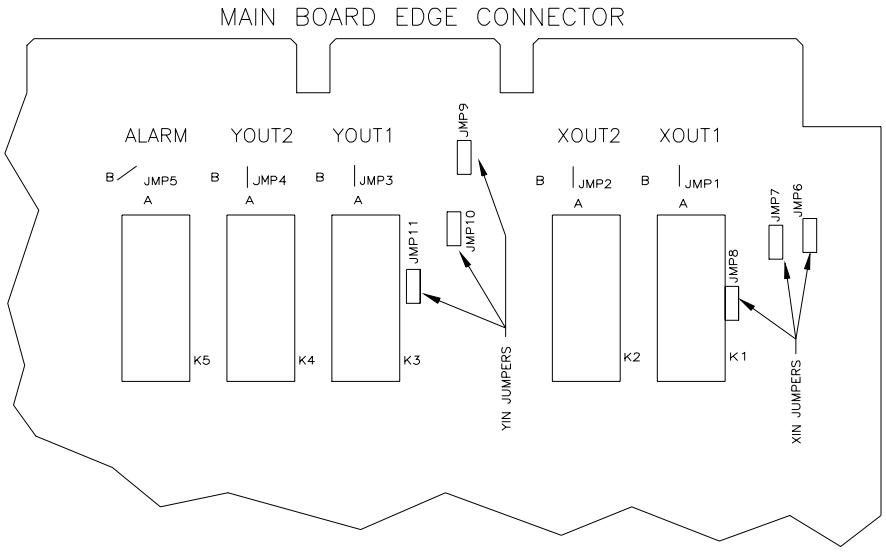

Figure 2.12: Input and Output Jumper Locations (Conventional Terminal Blocks Option Only)

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 7.2 in ***Section 7: Operations***.

Output Contact YOUT2 Control Jumper

Refer to Figure 2.13 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.

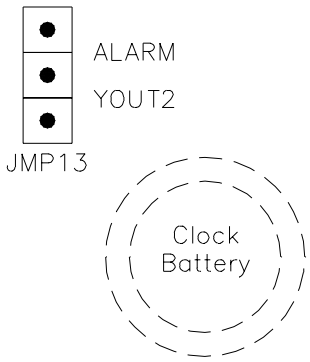

Figure 2.13: Output Contact YOUT2 Control Jumper Location

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 battery keeps the clock (date and time) going 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.

The battery experiences a low self-discharge rate when the SEL-501 Relay is powered from an external dc source. If the dc source is lost or disconnected, the battery discharges to keep the clock going. Thus, battery life can extend well beyond the nominal 10 years because the battery rarely has to discharge (unless it is disconnected for extended periods of time or kept in storage). The battery cannot be recharged.

If the battery voltage is out-of-tolerance, an automatic status message is sent to the serial port and the front panel display (see ***Section 7: Operation***).

CAUTION

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 reenergize the relay.
7. Set the date and time again (see ***Section 7: Operation***).

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TABLES

FIGURES

SECTION 3: OVERCURRENT PROTECTION

INTRODUCTION

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

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

- Feeders
- Busses
- Transformers
- Other Apparatus

OVERCURRENT PROTECTION OPTION DIFFERENCES AND APPLICATIONS

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

APP = FDR

Input and Output Contact Functions

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

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

Applications for APP = FDR

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

APP = OC1

Input Functions

Program input IN to function as one of the following:

- IN = EN (Enable)
  - Assert input IN to enable user-specified overcurrent elements.
  - Deassert input IN to disable the same user-specified overcurrent elements.

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

IN = EN or IN = BLK

Input IN provides true control, not supervision. If input IN disables an overcurrent element, the overcurrent element cannot time or assert, no matter what the current level. Settings specify which overcurrent elements are controlled by input IN. A printout of the relay settings gives a summary of the overcurrent elements controlled by input IN. Summary example:

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

IN = ET

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

IN: External Trigger

Output Contact Functions

- Output contact OUT1 operates as the TRIP1 output contact
- Output contact OUT2 operates as the TRIP2 output contact

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

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

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

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

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

Applications for APP = OC1

Use APP = OC1 for most any overcurrent protection application and especially for applications requiring:

- Overcurrent elements routed to different trip output contacts.
  - Refer to the example in Fibure 2.6, ***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 Fibure 3.1).
- Fast bus tripping (reverse interlocking) on a radial system. This replaces a more expensive bus differential scheme.
  - Apply the SEL-501 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 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 for the FDR and OC1 overcurrent protection options are shown in Table 3.1. The settings unique to the OC1 option are indicated with an asterisk (*).

Table 3.1: Overcurrent Relay Settings

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
ID	Relay Identifier	13 Characters
APP	Relay Application	FDR, OC1
CTR	CT Ratio (CTR:1)	1–6000
DATC	Demand Ammeter Time Constant	Off, 5–60 minutes
*IN	Programmable Input Function	EN = Enable BLK = Block ET = Ext. Trigger
50PP	Phase Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50PD	Phase Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
*50PTT	Assign 50PT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*50PTC	50PT controlled by input IN	Y, N
50H	Phase Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
*50HT	Assign 50H to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*50HC	50H controlled by input IN	Y, N
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 50QT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*50QTC	50QT controlled by input IN	Y, N
50NP	Ground Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50ND	Ground Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
*50NTT	Assign 50NT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*50NTC	50NT controlled by input IN	Y, N
50NH	Ground Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
*50NHT	Assign 50NH to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*50NHC	50NH controlled by input IN	Y, N
51PP	Phase Time-Overcurrent Pickup	Off, 0.5–16 A sec (5 A Model) 0.1–3.2 A sec (1 A Model)
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 51PT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*51PTC	51PT controlled by input IN	Y, N
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)

Setting	Setting Definitions (APP = FDR or OC1)	Setting Range
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 51QT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*51QTC	51QT controlled by input IN	Y, N
51NP	Ground Time-Overcurrent Pickup	Off, 0.5–16 A sec (5 A Model) 0.1–3.2 A sec (1 A Model)
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 51NT to trip output contacts	N = none, 1 = TRIP1 2 = TRIP2, B = both
*51NTC	51NT controlled by input IN	Y, N
*TRPU1	TRIP1 time-delay pickup	0–16,000 cycles (0.25 steps)
*TDUR1	minimum TRIP1 duration	0–16,000 cycles (0.25 steps)
*TRPU2	TRIP2 time-delay pickup	0–16,000 cycles (0.25 steps)
*TDUR2	minimum TRIP2 duration	0–16,000 cycles (0.25 steps)
*ELTCH	Enable phase current latch condition for trip output contacts	Y, N

OVERCURRENT RELAY TRIP LOGIC

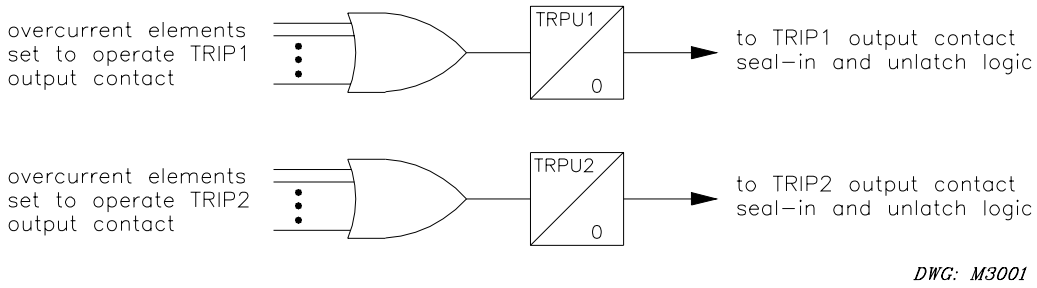
APP = FDR

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

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

APP = OC1

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



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

TRIP1 Output Contact

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

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

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

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

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

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

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

TRIP2 Output Contact

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

OVERCURRENT RELAY CLOSE LOGIC (APP = FDR ONLY)

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

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

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

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

No automatic reclosing is available.

OVERCURRENT RELAY TARGETS

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

- Target is blinking to indicate a trip
- Relay X or Relay Y is disabled: its APP setting is Off
- Power is removed from relay
- A relay self-test failure has been detected

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

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

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

Table 3.2: Overcurrent Relay Tripping Targets

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

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

OVERCURRENT ELEMENT SPECIFICATIONS

Eight Overcurrent Elements	Instantaneous Elements	Definite-Time Elements	Inverse-Time Elements
Phase (Ia, Ib, and Ic)	50H	50PT	51PT
Negative-Sequence (IQ = 3•I_2)		50QT	51QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT	51NT
Pickup Ranges (A secondary)			
5 A Model:	0.5–80 A	0.5–80 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% ±0.100 A sec	Time Delay Accuracy: ±0.25 cyc
1 A Model	±5% ±0.020 A sec	Time Delay Accuracy: ±0.25 cyc

Pickup Time (Typ/Max): 0.75/1.2 cyc

Time-Overcurrent Elements

Eight Curve Shapes:

51PC, 51QC, or 51NC setting	Time-Curve Shape
U1	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
0.05–1.0, 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

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

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

US Inverse Curve: U2

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

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

US Very Inverse Curve: U3

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

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

US Extremely Inverse Curve: U4

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

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

IEC Class A Curve: C1 (Standard Inverse)

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

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

IEC Class B Curve: C2 (Very Inverse)

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

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

IEC Class C Curve: C3 (Extremely Inverse)

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

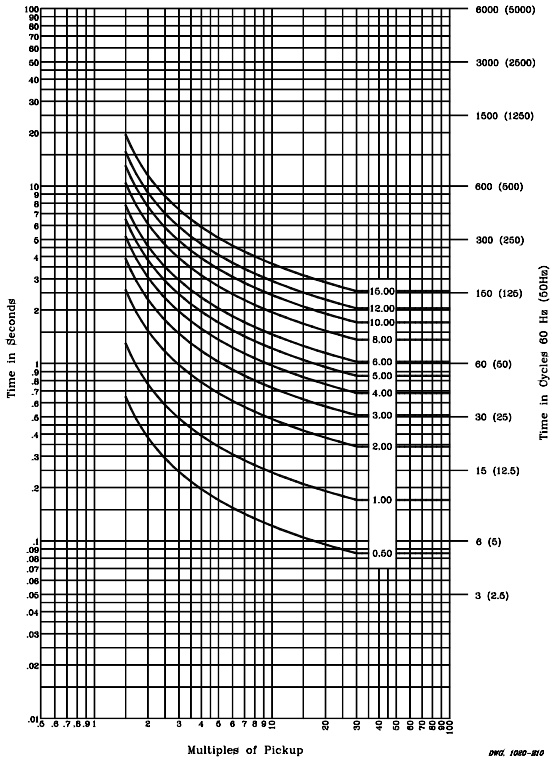
$$tr = TD \bullet \left[\frac{80.0}{1 - M^2} \right]$$

IEC Long Time Inverse: C4

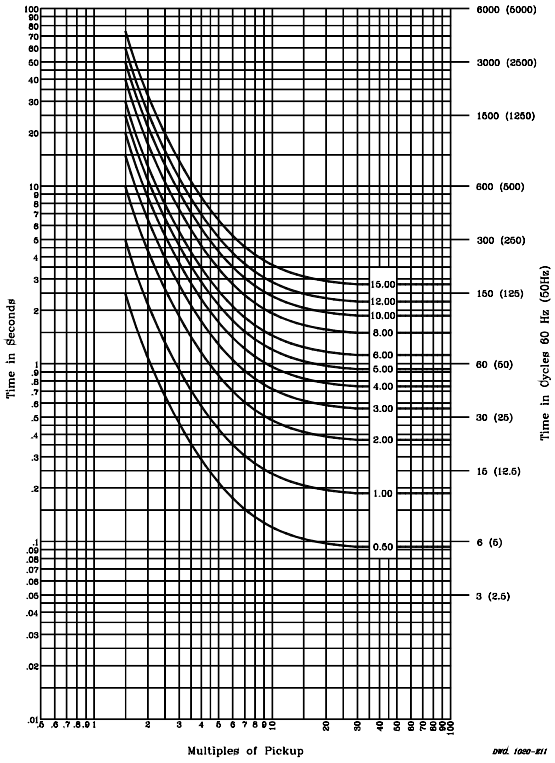
$$tp = TD \bullet \left[\frac{120.0}{M - 1} \right]$$

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

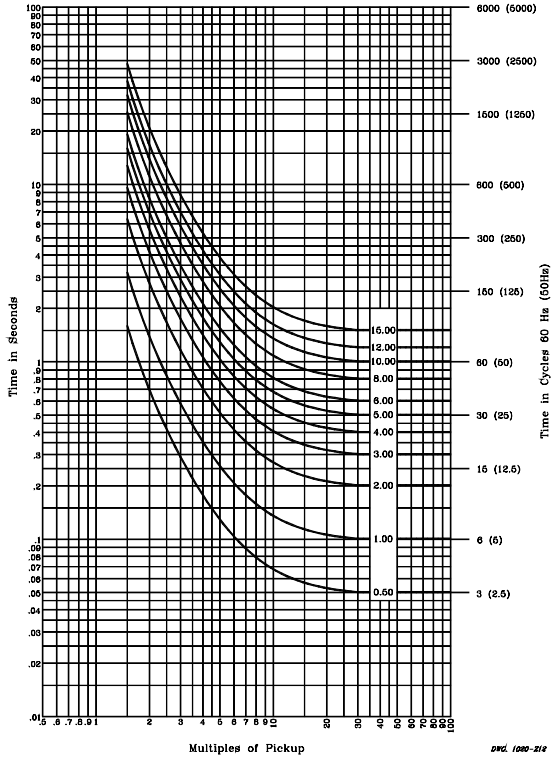
Full-sized time-current curve transparencies are available from the factory.



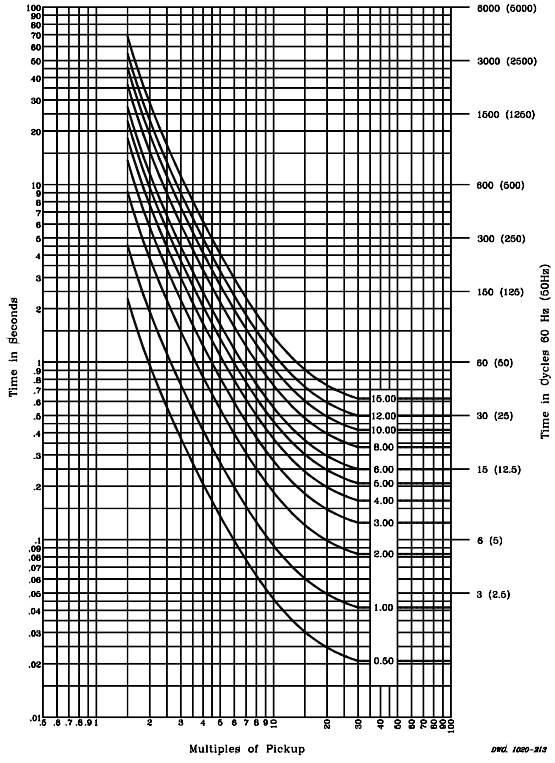
Fibure 3.2: Time Curve U1



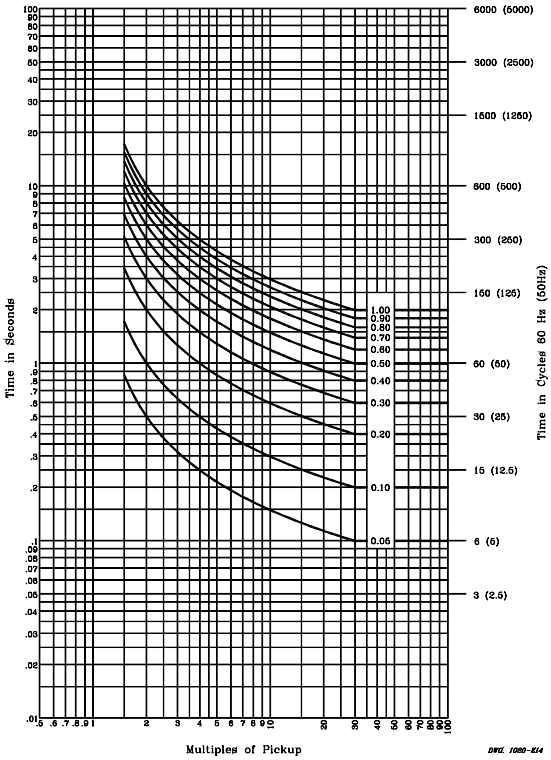
Fibure 3.3: Time Curve U2



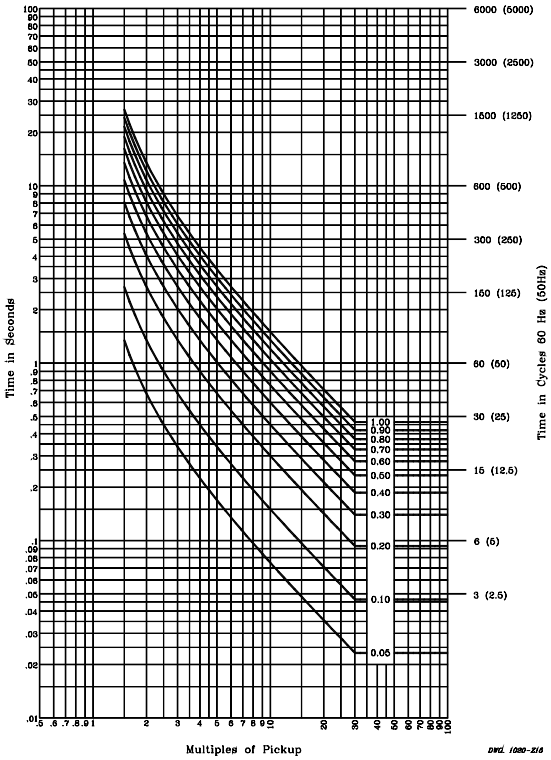
Fibure 3.4: Time Curve U3



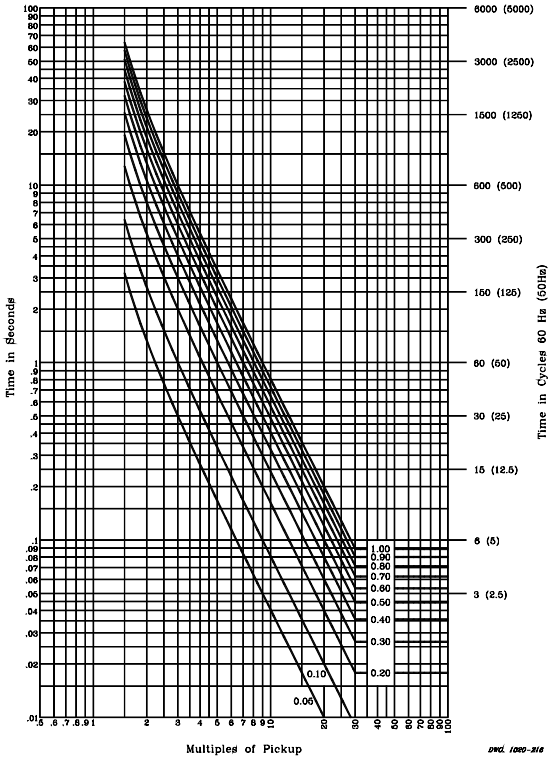
Fibure 3.5: Time Curve U4



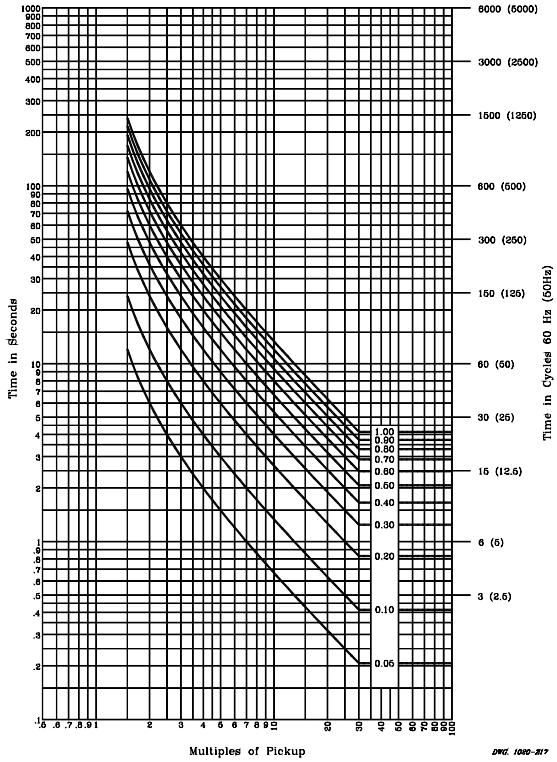
Fibure 3.6: Time Curve C1



Fibure 3.7: Time Curve C2



Fibure 3.8: Time Curve C3



Fibure 3.9: Time Curve C4

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR GENERAL-OVERCURRENT PROTECTION APPLICATION: "OC1"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

CHECKMARK TO INDICATE X SIDE RELAY _____ OR Y SIDE RELAY _____

General Data

Relay Identifier (13 characters)	ID = _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	APP = **OC1**
Current Transformer Ratio (CTR:1); (1–6000)	CTR = _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	DATC = _____
Programmable Input Function (EN, BLK, ET) {EN = Enable, BLK = Block, ET = External Trigger}	IN = _____

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup (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 = TRIP1, 2 = TRIP2, B = both}	50PTT = _____
50PT controlled by input IN (Y, N)	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 = TRIP1, 2 = TRIP2, B = both}	50HT = _____
50H controlled by input IN (Y, N)	50HC = _____

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup (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 = TRIP1, 2 = TRIP2, B = both}	50QTT = _____
50QT controlled by input IN (Y, N)	50QTC = _____

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup (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 = TRIP1, 2 = TRIP2, B = both}	50NTT = _____
50NT controlled by input IN (Y, N)	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 = TRIP1, 2 = TRIP2, B = both}	50NHT = _____
50NH controlled by input IN (Y, N)	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 = TRIP1, 2 = TRIP2, B = both}	51PTT = _____
51PT controlled by input IN (Y, N)	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 = TRIP1, 2 = TRIP2, B = both}	51QTT = _____
51QT controlled by input IN (Y, N)	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 = TRIP1, 2 = TRIP2, B = both}	51NTT = _____
51NT controlled by input IN (Y, N)	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 = _____

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "OC1"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

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

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

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

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

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

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

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

Protocol = SEL

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Other Port Settings (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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR GENERAL-OVERCURRENT PROTECTION APPLICATION: "OC1"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
AddressX (1–99)	ADDRESSX = _____
AddressY (1–99)	ADDRESSY = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Protocol = MOD

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1–247)	SLAVEID = _____

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "FDR"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

CHECKMARK TO INDICATE X SIDE RELAY _____ OR Y SIDE RELAY _____

General Data

Relay Identifier (13 characters) ID = _____

Relay Application (OFF, MOT, BFR, FDR, OC1, TMR) APP = **FDR**

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

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

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup
(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 = _____

Phase Instantaneous Overcurrent Pickup
(Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model}) 50H = _____

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup
(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 = _____

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 = _____

Ground Instantaneous Overcurrent Pickup
(Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model}) 50NH = _____

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup
(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 = _____

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 = _____

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 = _____

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "FDR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

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

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

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

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

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

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

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

Protocol = SEL

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Other Port Settings (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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "FDR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
AddressX (1–99)	ADDRESSX = _____
AddressY (1–99)	ADDRESSY = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Protocol = MOD

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1–247)	SLAVEID = _____

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 4: MOTOR PROTECTION

INTRODUCTION

Set Relay X or Relay Y for motor protection applications by changing the relay APP setting to Mot. Make this setting using the front panel or serial port SET command. You may set either or both Relay X and Relay Y for motor protection applications.

MOTOR THERMAL ELEMENT DESIGN, APPLICATION, AND SETTING

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

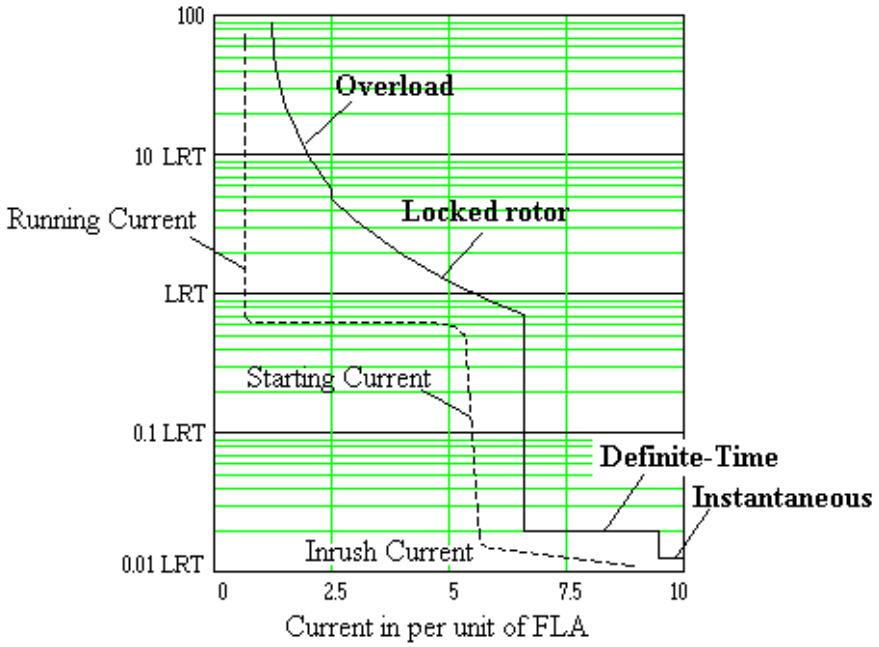


Figure 4.1: Motor Characteristics Plotted with Motor Starting Current

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

The SEL-501 Relay uses an element that accounts for the I^2r heating effect of both positive- and negative-sequence current. The element is a thermal model, defined by motor nameplate data, that estimates motor temperature. The temperature is then compared to thermal limit trip and

alarm thresholds. The relay trips to prevent overheating for the abnormal conditions of overload, locked rotor starting, too frequent or prolonged starts, and unbalanced current.

Defining the Thermal Model

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

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

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

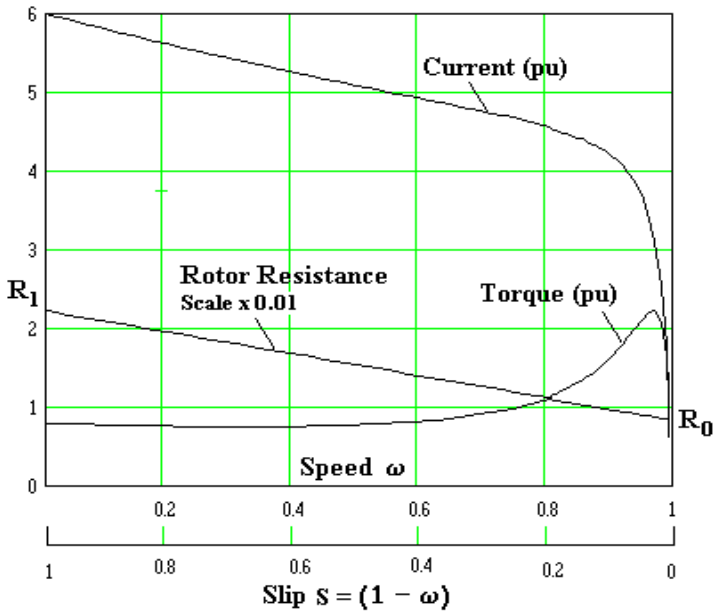


Figure 4.2: Current, Torque, and Rotor Resistance of an Induction Motor Versus Speed

The slip dependent heating effect of positive- and negative-sequence currents are derived as follows. The rotor resistance plotted in Figure 4.1 is calculated using a linear function of current, torque, and slip in the following equation:

$$R_r = \frac{Q_M}{I^2} S \qquad \text{Eq 1}$$

where: R_r = rotor resistance, Q_M = motor torque, S = slip, and I = current. The positive-sequence rotor resistance R_{r+} is a function of the slip S:

$$R_{r+} = (R_1 - R_0)S + R_0 \qquad \text{Eq 2}$$

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

$$R_{r-} = (R_1 - R_0)(2 - S) + R_0 \qquad \text{Eq 3}$$

Factors expressing the relative heating effect of positive- and negative-sequence current are obtained by dividing Eq 2 and 3 by the running resistance R_0. Consequently, for the locked rotor case, and where R_1 is typically three times R_0, the heating effect for both positive- and negative-sequence current is three times that caused by the normal running current.

$$\frac{R_{r+}}{R_0}\Big|_{S=1} = \frac{R_{r-}}{R_0}\Big|_{S=1} = \frac{R_1}{R_0} = 3 \qquad \text{Eq 4}$$

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

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

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

States of the Thermal Model

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

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

R1 = Locked rotor electrical resistance (per unit ohms)
R0 = Running rotor electrical resistance also rated slip (per unit ohms)
IL = locked rotor current in per unit of full load current
Ta = locked rotor time with motor initial at ambient
To = locked rotor time with motor initially at operating temperature

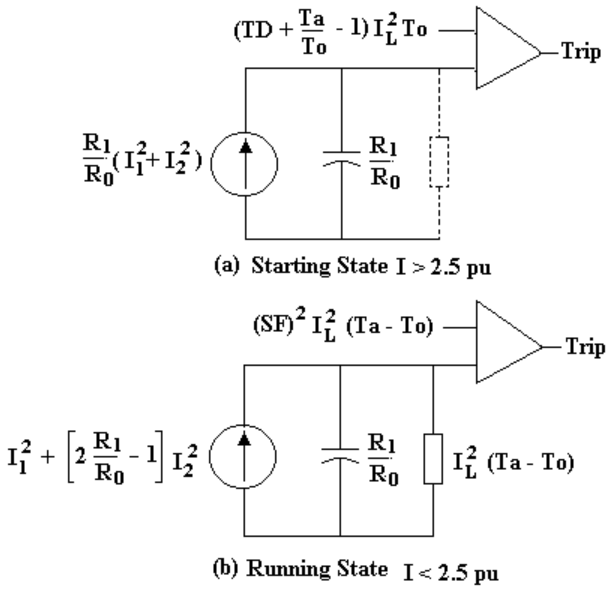


Figure 4.3: States of the Thermal Model

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

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

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

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

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

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

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

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

OVERCURRENT ELEMENT APPLICATION AND SETTING

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

50PP Phase definite-time overcurrent element pickup setting
50PD Phase definite-time overcurrent element time delay setting
50H Phase instantaneous overcurrent element pickup setting

50QP Negative-sequence definite-time overcurrent element pickup setting
50QD Negative-sequence definite-time overcurrent element time delay setting

50NP Residual definite-time overcurrent element pickup setting
50ND Residual definite-time overcurrent element time delay setting
50NH Residual instantaneous overcurrent element pickup setting

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

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

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

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

LOAD-JAM, LOAD-LOSS, AND STARTS LIMIT PROTECTION

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

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

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

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

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

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

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

Table 4.1: Motor Relay Settings

Setting	Setting Prompt (APP = Mot)	Setting Range
ID	Relay Identifier	13 Characters
APP	Relay Application	Mot
CTR	CT Ratio (CTR:1)	1–6000
DATC	Demand Ammeter Time-Constant	Off, 5–60 minutes
TRL	Latch Motor Trips	Y, N
ALML	Latch Motor Thermal Alarms	Y, N, D
FLA	Motor Full Load Amps	1–25 A sec (5 A Model) 0.2–5 A sec (1 A Model)
LRA	Motor Locked-Rotor Amps	9–80 A sec (5 A Model) 1.8–16 A sec (1 A Model) (3– 9 times FLA)
LRT	Motor Locked-Rotor Time	1–30 seconds
TD	Rotor Thermal Time-Dial (per unit of LRT)	0.1–1.5
49A	Thermal Alarm Level (per unit of rated trip)	0.1–1.0
SF	Motor Service Factor (per unit)	1.0–1.5

Setting	Setting Prompt (APP = Mot)	Setting Range
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)
50H	Phase Instantaneous 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 Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50QD	Negative-Sequence Definite-Time Overcurrent Delay	1.5–16,000 cycles (0.25 steps)
50NP	Residual Definite-Time Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
50ND	Residual Definite-Time Overcurrent Delay	0–16,000 cycles (0.25 steps)
50NH	Residual Instantaneous Overcurrent Pickup	Off, 0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
ELJ	Enable Load-Jam Tripping	Y, N
LJA	Load-Jam Amps	0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
LJD	Load-Jam Delay	0–2000 cycles (1 cyc steps)
ELL	Enable Load-Loss Tripping	Y, N
LLA	Load-Loss Amps	0.5–80 A sec (5 A Model) 0.1–16 A sec (1 A Model)
LLD	Load-Loss Delay	5–2000 cycles (1 cyc steps)
STL	Starts/Hour Limit	1–5 starts, N disables

MOTOR TRIP LOGIC

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

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

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

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

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

MOTOR CLOSE LOGIC

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

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

The CLOSE output remains closed until:

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

MOTOR RELAY TARGETS

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

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

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

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

Table 4.2: Motor Relay Tripping Targets

Tripping Target	Illuminates if:
INST	Trip occurs less than 3 cycles after pickup of the tripping element
A	A-phase current is greater than 50PP setting or trip was due to thermal element operation
B	B-phase current is greater than 50PP setting or trip was due to thermal element operation
C	C-phase current is greater than 50PP setting or trip was due to thermal element operation
Q	50QP element is picked up
N	50NP element is picked up

Clear the targets by pressing the front-panel TARGET RESET button or by entering 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.

ELEMENT SPECIFICATIONS

	Instantaneous Elements	Definite-Time Elements
Phase (Ia, Ib, and Ic)	50H	50PT
Negative-Sequence (IQ = 3•I_2)		50QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT
Pickup Ranges (A secondary):		
5 A Model:	0.5–80 A	0.5–80 A
1 A Model:	0.1–16 A	0.1–16 A
Pickup Accuracy:		
5 A Model:	±5% ±0.100 A	±5% ±0.025 A
1 A Model:	±5% ±0.020 A	±5% ±0.005 A
Definite Time Delay		0–16,000 cyc
Time Delay Accuracy:		±0.25 cyc

Locked Rotor Clearing Time Maximum Error: ±5% of TD•LRT ±10 cycles

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

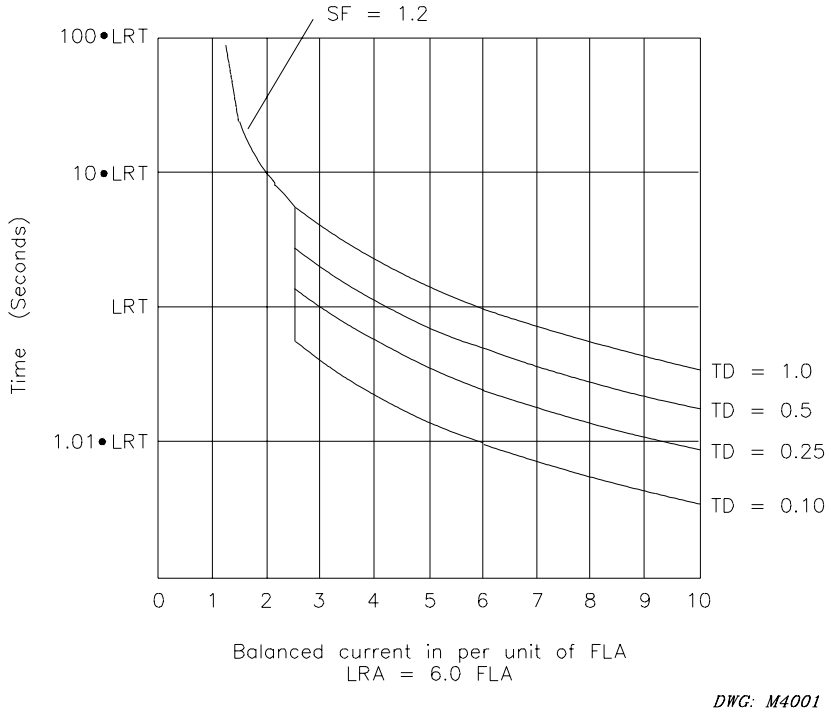


Figure 4.4: Thermal Model Operating Time Curves

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

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

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

For:

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

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

Where:

FLA, LRA, LRT, SF, and TD = Relay Settings
I_1 = positive-sequence current
I_2 = negative-sequence current (zero under balanced current conditions)
t_p = time to trip from fully reset condition

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR MOTOR PROTECTION APPLICATION: "MOT"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

CHECKMARK TO INDICATE X SIDE RELAY _____ OR Y SIDE RELAY _____

General Data

Relay Identifier (13 characters) ID = _____

Relay Application (OFF, MOT, BFR, FDR, OC1, TMR) APP = **MOT**

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

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

Latch Trips/Alarms

Latch Motor Trips (Y, N) TRL = _____

Latch Motor Thermal Alarms (Y, N, D) ALML = _____

Motor Parameters

Motor Full Load Amps
(1–25 A sec {5 A Model}, 0.2–5 A sec {1 A Model}) FLA = _____

Motor Locked-Rotor Amps
(9–80 A sec {5 A Model},1.8–16 A sec {1 A Model}); (3–9 times FLA) LRA = _____

Motor Locked-Rotor Time (1–30 seconds) LRT = _____

Rotor Thermal Time-Dial (per unit of LRT); (0.1–1.5) TD = _____

Thermal Alarm Level (per unit of rated trip); (0.1–1) 49A = _____

Motor Service Factor (per unit); (1.0–1.5) SF = _____

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup
(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 = _____

Phase Instantaneous Overcurrent Pickup
(Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model}) 50H = _____

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup
(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 = _____

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR MOTOR PROTECTION APPLICATION: "MOT"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

Residual Definite-Time/Instantaneous Overcurrent Elements

Residual Definite-Time Overcurrent Pickup (Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	50NP = _____
Residual Definite-Time Overcurrent Delay (0–16,000 cycles)	50ND = _____
Residual Instantaneous Overcurrent Pickup (Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	50NH = _____

Load Jam/Load Loss Elements

Enable Load-Jam Tripping (Y, N)	ELJ = _____
Load-Jam Amps (0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	LJA = _____
Load-Jam Delay (0–2000 cycles); (1 cycle steps)	LJD = _____
Enable Load-Loss Tripping (Y, N)	ELL = _____
Load-Loss Amps (0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	LLA = _____
Load-Loss Delay (5–2000 cycles); (1 cycle steps)	LJD = _____
Starts/Hour Limit (1–5 starts, N disables)	STL = _____

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "MOT"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

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

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

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

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

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

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

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

Protocol = SEL

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

Communications Settings

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

Data Bits (7, 8) DATA_BITS = _____

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

Stop Bits (1, 2) STOP = _____

Other Port Settings (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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR MOTOR PROTECTION APPLICATION: "MOT"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
AddressX (1–99)	ADDRESSX = _____
AddressY (1–99)	ADDRESSY = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Protocol = MOD

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1–247)	SLAVEID = _____

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TABLES

FIGURES

SECTION 5: BREAKER FAILURE PROTECTION

INTRODUCTION

Set Relay X or Relay Y for breaker failure protection applications by changing the relay APP setting to Bfr. Make this setting using the front panel or serial port SET command. You may set either or both Relay X and Relay Y for breaker failure protection applications.

86 TRIP LOGIC

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

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

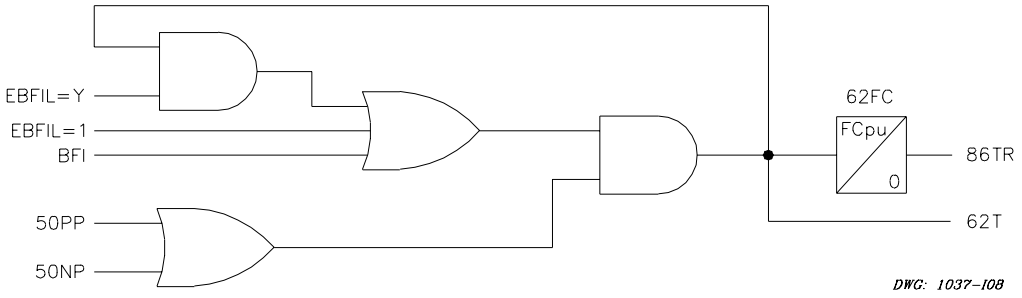

Figure 5.1: Breaker Failure Logic

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

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

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

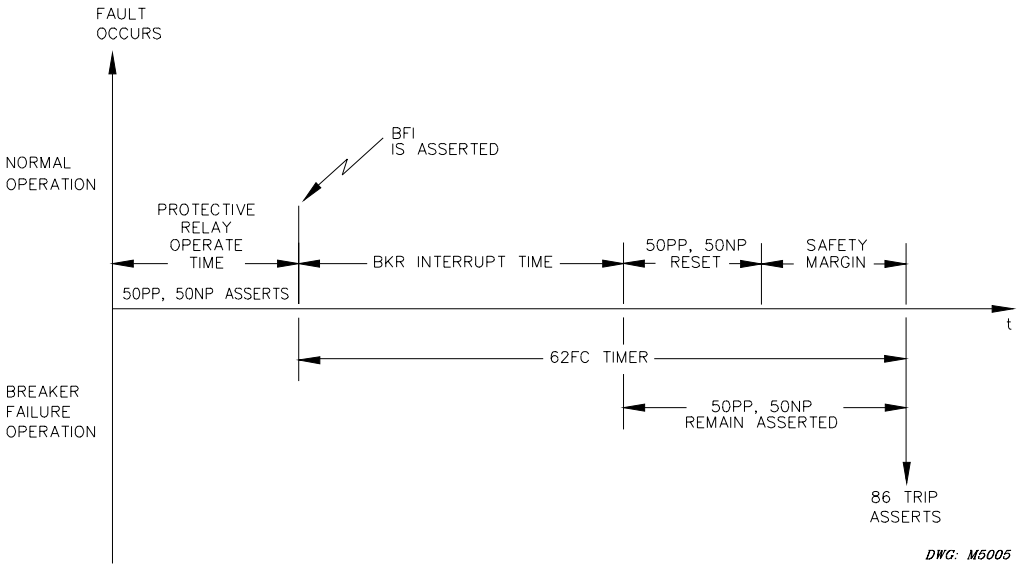

Figure 5.2: Breaker Failure Timing

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

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

- Maximum permissible fault duration
- Protective relay operating time
- Protected breaker operating time
- 50PP and 50NP element maximum reset time (pp 5-4, 5-5)
- Operating times of electrically adjacent breakers
- Desired breaker failure operating safety margin

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

RETRIP LOGIC

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

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

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

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

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

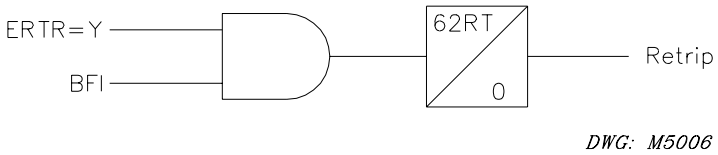

Figure 5.3: Retrip Logic

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

Table 5.1: Breaker Failure Relay Settings

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

BREAKER FAILURE RELAY TARGETS

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

- Target is blinking to indicate a trip
- Relay X or Relay Y is disabled: its APP setting is Off
- Power is removed from SEL-501 Relay
- SEL-501 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 relay selects tripping targets using the elements picked up when the relay trips.

Table 5.2: Breaker Failure Relay Tripping Targets

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

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

OVERCURRENT ELEMENT SPECIFICATIONS

Overcurrent Elements

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

OVERCURRENT ELEMENT PICKUP AND RESET SPEED CURVES

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

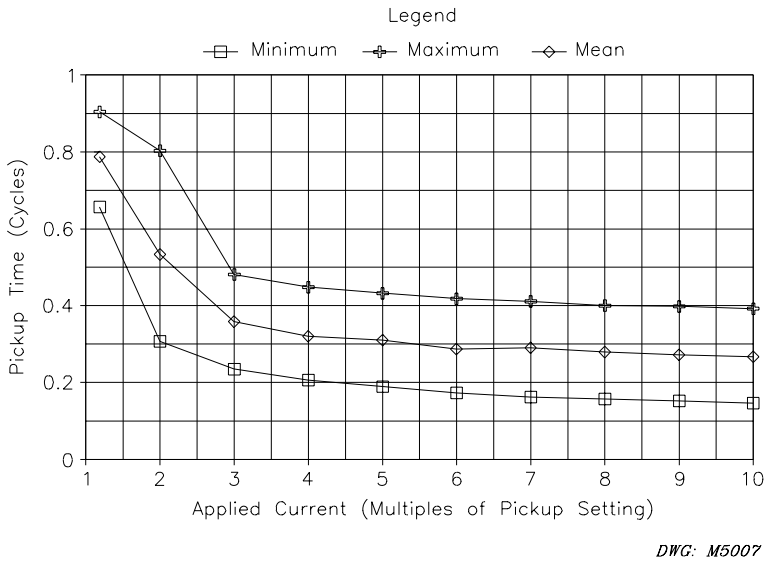

Figure 5.4: BFR 50P Pickup Time Curve

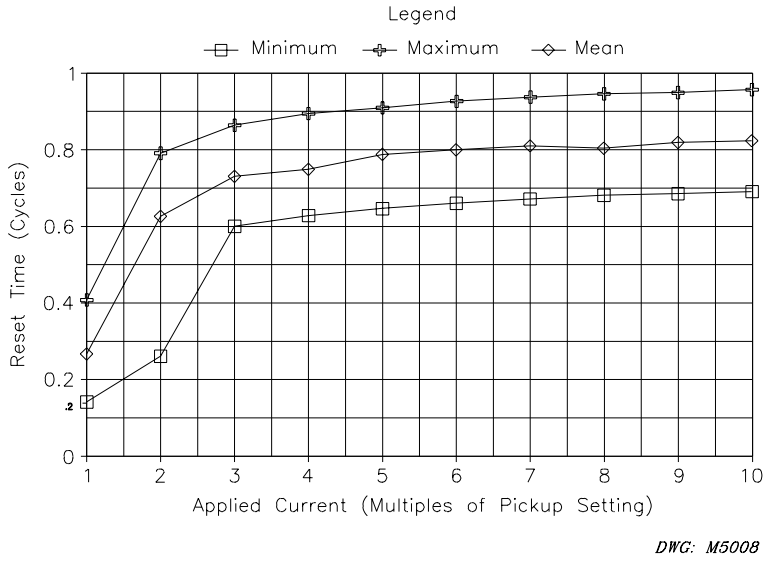

Figure 5.5: BFR 50P Reset Time Curve

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SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR BREAKER FAILURE PROTECTION APPLICATION: "BFR"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

CHECKMARK TO INDICATE X SIDE RELAY _____ OR Y SIDE RELAY _____

General Data

Relay Identifier (13 characters)	ID = _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	APP = **BFR**
Current Transformer Ratio (CTR:1); (1–6000)	CTR = _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	DATC = _____

Phase/Residual Overcurrent Elements

Phase Overcurrent Pickup (Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	50PP = _____
Residual Overcurrent Pickup (Off, 0.5–80 A sec {5 A Model}, 0.1–16 A sec {1 A Model})	50NP = _____

BFR Delay/Retripping/ BFI Latch

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

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "BFR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

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

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

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

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

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

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

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

Protocol = SEL

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Other Port Settings (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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR BREAKER FAILURE PROTECTION APPLICATION: "BFR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
AddressX (1–99)	ADDRESSX = _____
AddressY (1–99)	ADDRESSY = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Protocol = MOD

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1–247)	SLAVEID = _____

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SECTION 6: GENERAL-PURPOSE TIMER

INTRODUCTION

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

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

Many other applications are possible.

TIMER LOGIC AND SETTINGS

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

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

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

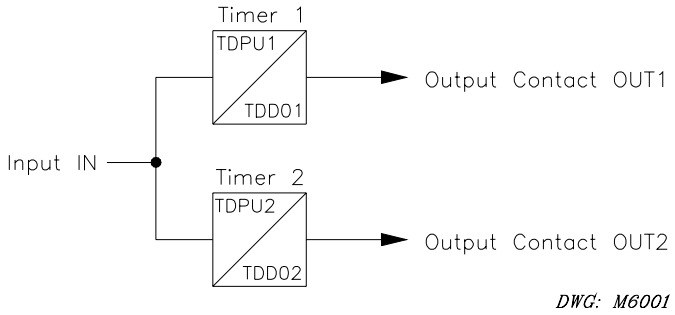

Figure 6.1: Input-Driven Timers Routed to Output Contacts OUT1 and OUT2

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

Table 6.1: Timer Settings

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

TIMER TARGETS

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

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

The OVERCURRENT CONDITIONS front-panel targets are not operational when App = Tmr.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR GENERAL PURPOSE TIMER APPLICATION: "TMR"
(SERIAL PORT COMMAND SET AND FRONT PANEL)

CHECKMARK TO INDICATE X SIDE RELAY _____ OR Y SIDE RELAY _____

General Data

Relay Identifier (13 characters)	ID = _____
Relay Application (OFF, MOT, BFR, FDR, OC1, TMR)	APP = **TMR**
Current Transformer Ratio (CTR:1); (1–6000)	CTR = _____
Demand Ammeter Time Constant (Off, 5–60 minutes)	DATC = _____

Timer Pickup/Dropout Delays

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

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "TMR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

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

Protocol Settings.

Set PROTOCOL = SEL for standard SEL ASCII protocol.

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

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

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

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

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

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

Protocol = SEL

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Other Port Settings (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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR FEEDER-OVERCURRENT PROTECTION APPLICATION: "TMR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

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.

SETTINGS SHEET
FOR THE SEL-501 RELAY

Date _____

RELAY SETTINGS FOR GENERAL PURPOSE TIMER APPLICATION: "TMR"
(SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = SYMAX

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
AddressX (1–99)	ADDRESSX = _____
AddressY (1–99)	ADDRESSY = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

Protocol = MOD

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

Communications Settings

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None[N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1–247)	SLAVEID = _____

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SECTION 7: 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 7.1 and Table 7.5 as guides to operation of the SEL-501 Relay front panel.

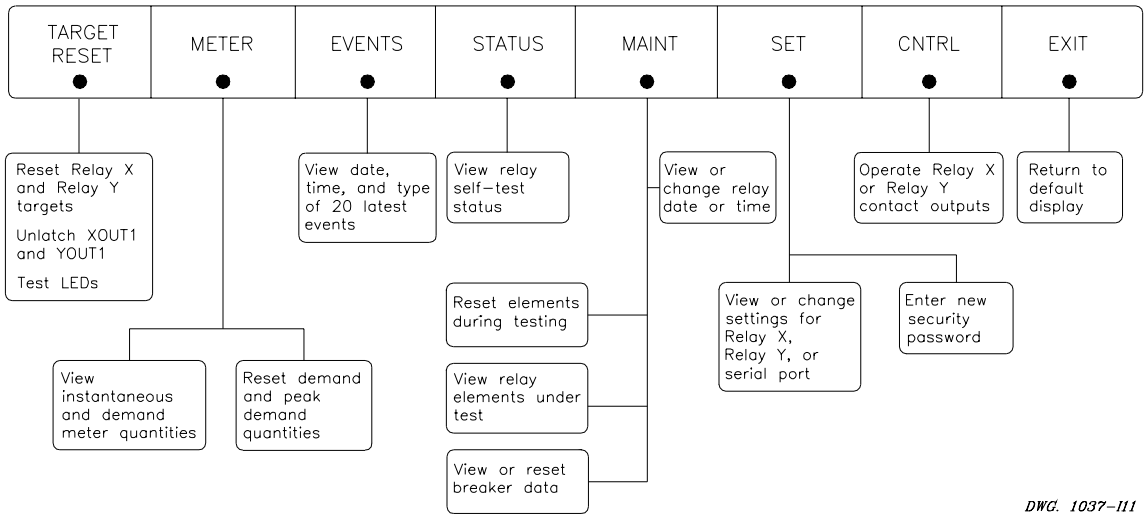


Figure 7.1: Front-Panel Function Drawing

Front-Panel Command Execution

Execute a front-panel command by pressing the desired control button. Use the Left- and Right-arrow 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 7.5 and Table 7.6 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 JMP22 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 (passcode) 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. When either relay is set in a motor protection application, the present state of the thermal model is also displayed.

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

- Relay X or Relay Y triggers an event report
- A motor protection thermal element enters the alarm state
- An SEL-501 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 and SEL-501-1 Relays are equipped with a single serial communications port. The communication can support the following protocols:

- Standard ASCII Communication (SEL)
- Distributed Port Switch Protocol (LMD)
- Square D SY/MAX Protocol (SYMAX)–available only in the SEL-501-1
- Modbus™ RTU (MOD)–available only in the SEL-501

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

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

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

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

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

Table 7.1: Communications Settings

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

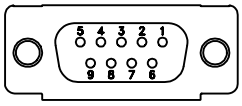
Field Description	Screen Name	Range	Default
PROTOCOL = SYMAX (available in SEL-501-1 only)			
Port Protocol	PROTOCOL	SEL, LMD, SYMAX, MOD	SYMAX
ADDRESSX	ADDRESSX	1–99	2
ADDRESSY	ADDRESSY	1–99	3
Baud Rate	SPEED	300, 1200, 2400, 4800, 9600, 19200, 38400	2400
Number Data Bits	DATA_BITS	7, 8	8
Parity	PARITY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

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



(female chassis connector, as viewed from outside panel)

P1 DB9 Connector Pinout Options

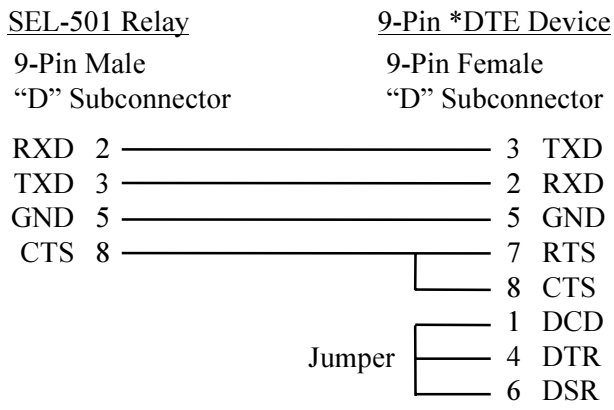
DB9 Pin	EIA-232	EIA-485
1	N/C or +5 Vdc*	TX+
2	RXD	TX-
3	TXD	N/C
4	IRIG+	IRIG+
5	SHIELD	ISO_GND
6	IRIG-	IRIG-
7	RTS	RX+
8	CTS	RX-
9	DGND	DGND

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

Figure 7.2: 9-Pin Connector Pin Number Convention

Serial Communication Cables for Use with the SEL-501 Relay

Cable C234A



Cable C222

SEL-501 Relay			**DCE Device
9-Pin Male			25-Pin Female
"D" Subconnector			"D" Subconnector
GND	5	——	7 GND
TXD	3	——	2 TXD (IN)
RTS	7	——	20 DTR (IN)
RXD	2	——	3 RXD (OUT)
CTS	8	——	8 CD (OUT)
GND	9	——	1 GND

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

Serial Port Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. The automatic messages are described in Table 7.2.

Table 7.2: 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.
Thermal Alarm	The relay sends a thermal report each time a motor protection thermal element exceeds its alarm threshold.
Self-Test Warning or Failure	The relay sends a status report each time a self-test warning or failure condition is detected.

Serial Port Password Security

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 jumper is one of two located between the front-panel LEDs and the control pushbuttons. The serial port access levels are described in Table 7.3.

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 7.3: 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 7.5.
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 using the Access Level 2 PAS command. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct strong passwords include:

Ot3579 A24.68 Ih2dcs 4u-Iwg a501b

Setting Changes via the Serial Port

To set the relay 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 7.4.

Table 7.4: 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 7.5: 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.
1	METER METER D METER P	<METER>, *n*, Display	View instantaneous, demand (D), and peak demand (P) currents.
1	METER RD *n* METER RP *n*	<METER>, *n*, Reset	Reset demand (RD) and peak demand (RP) values. (*n* = X, Y)
1	SHOW *n*	<SET>, *n*, Show	View relay settings (*n* = X, Y, Port).
1	STATUS	<STATUS>	View relay self-test status.
1	TARGET *n* #	<MAINT>, *n*, Tar	View relay element, input, output status. (*n* = X, Y; # = 0–4)
1	TARGET R	<TARGET RESET>	Reset tripping targets.
1	TEMP *n*	<MAINT>, *n*, Temp	View thermal data. (*n* = X, Y)
1	TIME TIME *hh:mm:ss*	<MAINT>, Time	View or change time.
1	TRIGGER	--	Trigger a relay event report.
1	QUIT	--	Move to Access Level 0.
2	BREAKER *n* R	**<MAINT>**, *n*, Breaker	Reset trip counters and trip current data. (*n* = X, Y)
2	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 thermal or 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 7.6: Access Level 2 Breaker Control Commands

Application[3]	Serial Port Command	Front-Panel Command	Closes Output
Fdr	CLOSE *n*	**<CNTRL>**, *n*, Close	*n*OUT2 (*n* = X, Y)
	OPEN *n*	**<CNTRL>**, *n*, Open	*n*OUT1 (*n* = X, Y)
Mot	RUN *n*	**<CNTRL>**, *n*, Run	*n*OUT2 (*n* = X, Y)
	STOP *n*	**<CNTRL>**, *n*, Stop	*n*OUT1 (*n* = X, Y)
Bfr	RETRIP *n*[1]	**<CNTRL>**, *n*, Retrip[1]	*n*OUT2 (*n* = X, Y)
	86TR *n*[2]	**<CNTRL>**, *n*, 86TR[2]	*n*OUT1 (*n* = X, Y)
Oc1	1OUT *n*	**<CNTRL>**, *n*, 1out	*n*OUT1 (*n* = X, Y)
	2OUT *n*	**<CNTRL>**, *n*, 2out	*n*OUT2 (*n* = X, Y)
Tmr	1OUT *n*	**<CNTRL>**, *n*, 1out	*n*OUT1 (*n* = X, Y)
	2OUT *n*	**<CNTRL>**, *n*, 2out	*n*OUT2 (*n* = X, Y)

Notes:

1. If ERTR=N, this command is not available. The message "Command invalid when ERTR=N" is displayed.
2. If ERTR=N, this command closes both outputs.
3. If APP=OFF, all commands are unavailable.

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

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

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

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

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.

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-R100-V65X1XX-D930805

SELF TESTS

W=Warn    F=Fail

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

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

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

Table 7.7 describes the STATUS report.

Table 7.7: 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). Target 2, 3, and 4 show different elements, depending upon the application of the selected relay.

Table 7.8: Overcurrent Protection Application Target Command Table (APP = Fdr or APP = Oc1)

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

Feeder Protection Application 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

Table 7.9: Motor Protection Application Target Command Table (APP = Mot)

LED	X	Y	INST	A	B	C	Q	N
Target 0	X	Y	INST	A	B	C	Q	N
Target 1	*	XIN	YIN	ALARM	XOUT1	XOUT2	YOUT1	YOUT2
Target 2	49	*	STL	50PT	50H	50QT	50NT	50NH
Target 3	49A	50L	50ST	50PP	LLOSS	50QP	50NP	LJAM

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

Element	Definition
49A	Thermal Alarm Level Exceeded
50L	Motor Live Overcurrent Pickup (0.1 per unit FLA)
50ST	Start Current Detected (2.5 per unit FLA)
50PP	Definite-Time Phase Overcurrent Pickup
LLOSS	Motor Load-Loss Detected
50QP	Definite-Time Negative-Sequence Overcurrent Pickup
50NP	Definite-Time Residual Overcurrent Pickup
LJAM	Motor Load-Jam Detected

Table 7.10: Breaker Failure Protection Application Target Command Table (APP = Bfr)

LED	X	Y	INST	A	B	C	Q	N
Target 0	X	Y	INST	A	B	C	Q	N
Target 1	*	XIN	YIN	ALARM	XOUT1	XOUT2	YOUT1	YOUT2
Target 2	86TR	RTRP	62T	50PP	*	*	50NP	*

Breaker Failure Relay Target Definitions

Element	Definition
X	X Relay
Y	Y Relay
INST	Instantaneous Trip
A	A-Phase Current
B	B-Phase Current
C	C-Phase Current
Q	Negative-Sequence Overcurrent
N	Residual Overcurrent
XIN	X Relay Optoisolated Input
YIN	Y Relay Optoisolated Input
ALARM	ALARM
XOUT1	X1 Output Contact
XOUT2	X2 Output Contact
YOUT1	Y1 Output Contact
YOUT2	Y2 Output Contact
86TR	Breaker Failure Trip
RTRP	Breaker Retrip
62T	Breaker Failure 62FC timer running
50PP	Phase Overcurrent Pickup
*	Future Use
50NP	Residual Overcurrent Pickup

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

TEMP Command

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

RELAY ALARM CONDITIONS

The relay asserts the ALARM output when dc power is removed, at any diagnostic test failure, or if a motor protection thermal element exceeds its alarm level. In addition to these, the ALARM output pulses with the commands and conditions shown in Table 7.11.

Table 7.11: Commands With Alarm Conditions

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

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SECTION 8: EVENT REPORTING

INTRODUCTION

The SEL-501 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 pickup, 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 an overcurrent, motor, or breaker failure trip
- Relay X or Relay Y issues a breaker close or a breaker failure retrip
- Pickup of a definite-time or inverse-time overcurrent element
- Thermal alarm
- Breaker failure initiate
- Motor start
- External trigger input assertion
- Timer time-out

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

EVENT SUMMARY

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

- Relay X and Relay Y identifier settings
- Date and time when the event was triggered
- Event type and duration
- Tripping targets for the relay that triggered the event
- Current magnitudes 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 nonvolatile 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. The specific information contained in each column depends upon the Relay X and Relay Y application settings. Each column shows a letter or symbol to indicate the condition of protection elements that quarter-cycle. Read the column labels vertically.

Element/Input Columns: Overcurrent Application (APP = FDR)

Column	Symbol	Definition
All	.	Element not picked up
51P	p	Phase time-overcurrent element picked up
	T	Phase time-overcurrent element trip
51Q	q	Negative-sequence time-overcurrent element picked up
	T	Negative-sequence time-overcurrent element trip
51N	n	Residual time-overcurrent element picked up
	T	Residual time-overcurrent element trip

50P	p	Phase definite-time overcurrent element picked up
	T	Phase definite-time overcurrent element trip
	H	Phase instantaneous overcurrent element trip
50Q	q	Neg-seq definite-time overcurrent element picked up
	T	Neg-seq definite-time overcurrent element trip
50N	n	Residual definite-time overcurrent element picked up
	T	Residual definite-time overcurrent element trip
	H	Residual instantaneous overcurrent element trip
52A	*	Circuit breaker is closed
OUT	1	TRIP output is closed
	2	CLOSE output is closed
ALRM	*	SEL-501 Relay ALARM Output is indicating an alarm state

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

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

Element/Input Columns: Motor Application (APP = MOT)

Column	Symbol	Definition
All	.	Element not picked up
49	a	Temperature estimate exceeds alarm level
	T	Thermal element trip
50S	S	Motor Start Detected

50P	p	Phase definite-time overcurrent element picked up
	T	Phase definite-time overcurrent element trip
	H	Phase instantaneous overcurrent element trip
50Q	q	Neg-seq definite-time overcurrent element picked up
	T	Neg-seq definite-time overcurrent element trip
50N	n	Residual definite-time overcurrent element picked up
	T	Residual definite-time overcurrent element trip
	H	Residual instantaneous overcurrent element trip
LD	L	Load-Loss trip
	J	Load-Jam trip
52A	*	Circuit breaker is closed
OUT	1	TRIP output is closed
	2	CLOSE output is closed
ALRM	*	SEL-501 Relay ALARM Output is indicating an alarm state

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

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

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

Column	Symbol	Definition
All	.	Element not picked up
IN	*	Input asserted
OUT	1	OUT1 output is closed (Timer 1 timed out)
	2	OUT2 output is closed (Timer 2 timed out)
	b	Both outputs are closed
ALRM	*	SEL-501 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 8.1.

Table 8.1: Event Types

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

Event Targets and Duration

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

Relay Settings

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

EXAMPLE EVENT REPORT

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

```
FEEDER 1                                    Date: 06/11/94   Time: 06:41:40.913
BFR 1

FID=SEL501-R106-V65X1XXpa-D940525
                                                          Relay X    Relay Y  A
          Relay X                      Relay Y            555555  50   5 5  BO L
          Amps Pri                     Amps Pri           111000  2U   0 06 FU R
  IRX    IAX    IBX    ICX     IRY    IAY    IBY    ICY  PQNPQN  AT   P N2 IT M

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

    -2    386    234   -622       2    386    240   -623 ......  *.   P .. .. .
     4   -495    582    -84      -0   -499    585    -86 ......  *.   P .. .. .
    -2   -382   -239    620       3   -380   -243    626 ......  *.   P .. .. .
    -8    496  -1141    637      -6    500  -1693   1186>pq....  *.   P .. .. .

     8    380   -450     78       8    381  -1172    799 pq....  *.   P .. .. .
     6   -501   2738  -2231       7   -505   3788  -3276 pq....  *.   P .. .. .
   -13   -377   1244   -880     -10   -376   1358   -992 pq....  *.   P .. .. .
    -8    502  -3783   3273     -13    503  -3795   3279 pq....  *.   P .. .. .
                  .
[Four cycles of data]  .
                  .
     5    341  -1126    790      10    342  -1123    791 pq....  *.   P .. .. .
     2   -526   3858  -3330       8   -526   3873  -3338 pq....  *.   P .. .. .
    -5   -339   1105   -770     -11   -341   1094   -764 pq....  *.   P .. .. .
    -3    528  -3863   3333      -8    529  -3878   3340 pq....  *.   P .. .. .

     5    337  -1077    745       6    334  -1058    730 pT....  *1   P .. .. .
     4   -531   3872  -3337       4   -532   3883  -3347 pT....  *1   P .. .. .
    -6   -333   1049   -722     -10   -332   1038   -716 pT....  *1   P .. .. .
    -6    533  -3881   3343     -11    535  -3900   3354 pT....  *1   P .t *. .

     6    329  -1025    702       7    326  -1006    687 pT....  *1   P .t *. .
     4   -535   3887  -3348       5   -534   3897  -3358 pT....  *1   P .t *. .
    -6   -325    998   -678     -10   -324    975   -660 pT....  *1   P .t *. .
    -5    535  -3892   3352      -8    540  -3908   3360 pT....  *1   P .t *. .
                  .
[Two cycles of data]   .
                  .
    -2    178   -449    268     -10     44     21    -74 pT....  *1   P .t *. .
    -1   -180   1122   -943       1      0      0      1 pT....  *1   . .. *. .
     3    -24      7     20      -5     -2     -2     -2 pT....  .1   . .. *. .
     0      0      0      0       0      0      0      0 ......  ..   . .. *. .

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

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

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

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

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

Time-tag corresponds to the 8th quarter-cycle of this event

One cycle of data

Relay Y 50PP element is picked up

Relay X 51PT and 51QT time-overcurrent elements pick up for BC fault, triggering this report. Breaker is closed.

Relay X 51QT element times out, causing a trip.

Breaker Failure Initiate input is asserted, starting breaker failure timer.

Breaker operates, clearing fault.

Event Summary

Relay X set for overcurrent protection

Relay Y set for breaker failure protection

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SECTION 9: TESTING

TESTING METHODS AND TOOLS

Test Features Provided by the Relay

The following features assist you during relay testing:

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

For more information on these features and commands, see ***Section 7: Operation***.

Low-Level Test Interface

The SEL-501 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 9.1 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 9.1 shows the signal scaling factors.

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.

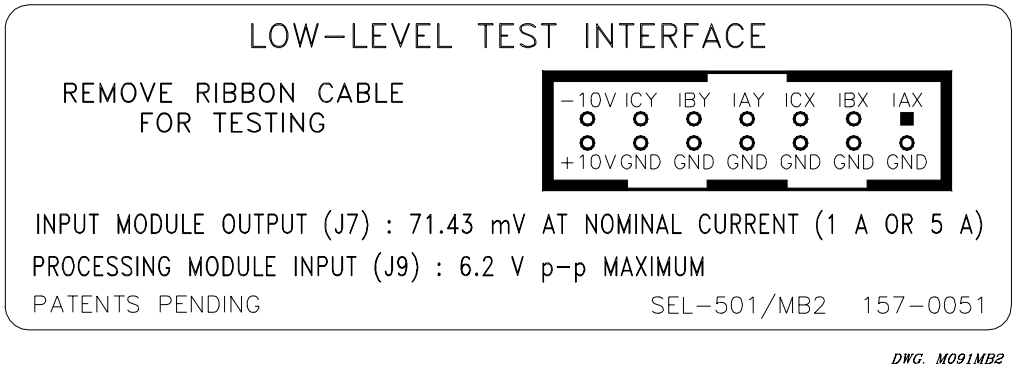

Figure 9.1: Low-Level Test Interface

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 7: 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 feeder relay 50H and 51PP phase overcurrent elements and the residual and negative-sequence overcurrent elements 50NP, 50NH, 51NP, 50QP, and 51QP. Relay X, set for feeder protection applications, is shown in this example.

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

Step 2. Execute the TARGET X 3 command. The SEL-501 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, set for feeder protection applications, is shown in this example.

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

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

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

Step 4. Calculate the expected operating time (tp) of the element. Use the element settings and the operating time equations shown on pages 3-11 and 3-12. TD is the time-dial setting, 51NTD, and M is the applied multiple of pickup current.

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

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

tp = 2.33 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.

Thermal Element: 49

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

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

Step 2. Using the SET X command, set 50PP, 50H, 50QP, 50NP, and 50NH to Off. Set ELJ and ELL to N. The Off and N settings disable these elements, leaving only the 49 element enabled to trip. Connect XOUT1 to an external timer. ConFigure the timer to start on application of current and stop on operation of the XOUT1 contact.

Step 3. Connect three current sources to the phase current inputs of Relay X.

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

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

Where: tp = expected operating time
I = applied three-phase test current magnitude (greater than 2.5•FLA)

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

tp = 11.4 seconds

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

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

RELAY SELF-TESTS

The relay runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see Table 9.1):

- Protection Disabled: The relay disables overcurrent elements and trip/close logic. All output contacts are 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 9.1: 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.

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
+5V PS Under/Over Voltage	Failure	+4.65 V +5.95 V	Yes	Latched	A circuit on the SEL-501 main board monitors the +5 V power supply. Upon detection of a failure, the circuit forces the microprocessor to reset.

RELAY TROUBLESHOOTING

Inspection Procedure

Complete the following procedure before disturbing the relay. After you finish the inspection, proceed to 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.
3. Relay X and Relay Y APP settings Off

Cannot See Characters on Relay LCD Screen

1. Relay is de-energized. Check to see if the ALARM contact is closed.
2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
   a. Remove the relay front panel by removing the three front-panel screws.
   b. Press any front-panel button. The relay should turn on the LCD 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 communication parameter incompatibility, including cabling error.
3. Relay serial port has received an XOFF, halting communications. Type **<CTRL>Q** to send relay an XON and restart communications.

Relay Does Not Respond to Faults

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

RELAY CALIBRATION

The SEL-501 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, Washington 99163-5603
Tel: (509) 332-1890
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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(APPLIES ONLY TO SEL-501-1 RELAY) F-1

APPENDIX G: MODBUS™ RTU COMMUNICATIONS PROTOCOL
(APPLIES ONLY TO SEL-501 RELAYS) G-1

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APPENDIX A: FIRMWARE VERSIONS IN THIS MANUAL

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 No.	SEL-501 Relay Version 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-R525-991129	60Hz, 5 Amp, ABC Rotation with Modbus
SEL-501-R575-991129	60Hz, 5 Amp, ACB Rotation with Modbus
SEL-501-R625-991129	50Hz, 5 Amp, ABC Rotation with Modbus
SEL-501-R725-991129	60Hz, 1 Amp, ABC Rotation with Modbus
SEL-501-R775-991129	60Hz, 1 Amp, ACB Rotation with Modbus
SEL-501-R825-991129	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-R507-991129	60Hz, 5 Amp, ABC Rotation without Modbus
SEL-501-R554-991129	60Hz, 5 Amp, ACB Rotation without Modbus
SEL-501-R604-991129	50Hz, 5 Amp, ABC Rotation without Modbus
SEL-501-R704-991129	60Hz, 1 Amp, ABC Rotation without Modbus
SEL-501-R751-991129	60Hz, 1 Amp, ACB Rotation without Modbus
SEL-501-R804-991129	50Hz, 1 Amp, ABC Rotation without Modbus
	This firmware differs from previous versions as follows: – Added new configuration
SEL-501-R750-980715	60 Hz, 1 Amp, ACB Rotation
	This firmware differs from previous versions as follows: – Software improvements
SEL-501-R506-970417	60Hz, 5 Amp, ABC Rotation
SEL-501-R553-970417	60Hz, 5 Amp, ACB Rotation
SEL-501-R603-970417	50Hz, 5 Amp, ABC Rotation
SEL-501-R707-970417	60Hz, 1 Amp, ABC Rotation
SEL-501-R803-970417	50Hz, 1 Amp, ABC Rotation

Firmware Part/Revision No.	SEL-501 Relay Version Description of Firmware
	This firmware differs from previous versions as follows: – Decreased power-up initialization time.
SEL-501-R505	60 Hz, 5 Amp, ABC Rotation
SEL-501-R552	60 Hz, 5 Amp, ACB Rotation
SEL-501-R602	50 Hz, 5 Amp, ABC Rotation
SEL-501-R702	60 Hz, 1 Amp, ABC Rotation
SEL-501-R802	50 Hz, 1 Amp, ABC 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-R504	60 Hz, 5 Amp, ABC Rotation
SEL-501-R551	60 Hz, 5 Amp, ACB Rotation
SEL-501-R601	50 Hz, 5 Amp, ABC Rotation
SEL-501-R701	60 Hz, 1 Amp, ABC Rotation
SEL-501-R801	50 Hz, 1 Amp, ABC Rotation
	This firmware differs from previous versions as follows: – Hardware implemented to support RTS_CTS serial port setting (Serial number 96192039 and above). – Added new firmware versions as follows:
SEL-501-R550	60 Hz, 5 Amp, ACB Rotation
SEL-501-R600	50 Hz, 5 Amp, ABC Rotation
SEL-501-R700	60 Hz, 1 Amp, ABC Rotation
SEL-501-R800	50 Hz, 1 Amp, ABC Rotation
	This firmware differs from previous versions as follows: – Hardware implemented to support RTS_CTS serial port setting (Serial number 96192039 and above). – Made *Fast Meter* and *Fast Operate* independent of ASCII commands.
SEL-501-R503	60 Hz, 5 Amp, ABC Rotation
	This firmware differs from previous versions as follows: – Add IRIG, *Fast Meter*, *Fast Operate*, LMD, and BFR logic modifications.
SEL-501-R502	60 Hz, 5 Amp, ABC Rotation
	This firmware differs from previous versions as follows: – Passwords changed to allow up to 6 alphanumeric characters.
SEL-501-R501	60 Hz, 5 Amp, ABC Rotation

Firmware Part/Revision No.	SEL-501 Relay Version Description of Firmware
	This firmware differs from previous versions as follows: – Added serial port settings: DATA_BITS STOP RTS_CTS Not supported by hardware. Hardware to support RTS_CTS implemented with firmware releases R503, R550, R600, R700, and R800 (Serial number 96192039 and above).
SEL-501-R500	60 Hz, 5 Amp, ABC 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-R525-**V65X1XXp2-D991129

Firmware Part/Revision No.	SEL-501-1 Relay Version Description of Firmware
	This firmware differs from previous versions as follows: – Software improvements
SEL-501-1-R503-970417	60 Hz, 5 Amp, ABC Rotation
	Added new firmware version containing Square D SY/MAX Protocol:
SEL-501-1-R502	60 Hz, 5 Amp, ABC 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-501-1-R500-**V65X1XXp2-D960205

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 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.

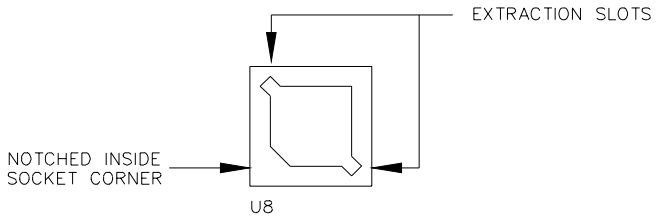

Figure B.1: EPROM Socket

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.

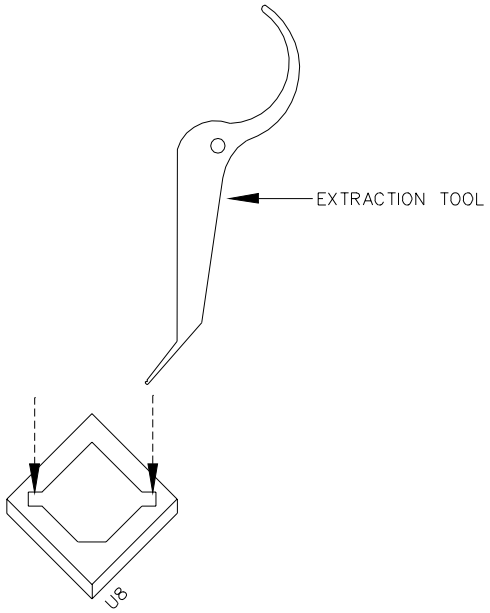

Figure B.2: Insertion of the Extraction Tool in the EPROM Socket

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

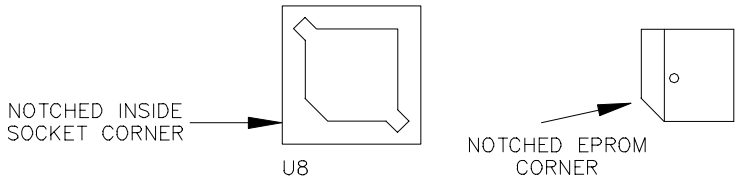

Figure B.3: Proper Orientation of the EPROM and EPROM Socket

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: ELECTRONIC-LEVEL INPUT OPTION

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

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

Example: CTR = 2000/5 = 400

MAXIMUM CONTINUOUS RATING

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

RELAY TEST SYSTEM (RTS)

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

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

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: 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 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
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 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
0000	Support 0 remote bits 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	Reserved
checksum	1-byte checksum of all preceding bytes

A5E3 *Fast Operate* Breaker Control

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

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

The relay performs the specified breaker operation if THE breaker jumper (JMP24) is in place on the SEL-501 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 F: SY/MAX PROTOCOL
(APPLIES ONLY TO SEL-501-1 RELAY)

OVERVIEW

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

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

The SEL-501-1 Relay understands and responds to a subset of the allowable SY/MAX opcodes (See ***Command Set*** subsection for details.). By using these opcodes correctly, all SEL-501-1 Relay operations can be accomplished, except reading and changing settings, and TEMP data access. Table F.2 lists the SEL-501-1 Relay register map.

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

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

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

SETTINGS

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

HARDWARE CONNECTIONS AND RTS LINE USAGE

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

NIM AND PNIM PROTOCOLS

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

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

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

MESSAGE FRAMING

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

NIM Protocol

The frame format for NIM protocol requests is:

2 bytes	Start of header (DLE and SOH).
1 byte	ODD/EVEN - 0x11 or 0x12, flip between messages. The SEL-501-1 Relay does not use this for message validation.
4–16 bytes	Route - This field handles the message transfer between its source and its final destination. Two ASCII hex characters represent a route number. There can be a maximum of 8 route numbers in any one packet.
2 bytes	Start of data (DLE and STX).
1 byte	Command opcode (see complete list in ***Command Set*** section).
1 byte	Transnum - the number of successful transmissions. Used for information flow control purposes.
n bytes	Opcode related data.
2 bytes	End of data (DLE and ETX).
1 byte	Checksum for message.

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

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

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

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

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

PNIM Protocol

The frame format for PNIM protocol requests is:

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

For PNIM protocol, no acknowledgment is sent.

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

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

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

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

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

Note: Multibyte data items are sent MSB first.

Route Conversion

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

- Convert the route number into 2-digit hex number.
- For each hex digit, convert it to an ASCII hex character by
  a) adding 0x30 if the digit is less than 10,
  b) adding 0x37 if the digit is greater than 9.

For example, the table below displays the transition for route numbers 100, 14 and 81.

Table F.1: Route Conversion

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

Register Address Conversion

The register address in a message packet is a protocol representation of an address of a general register from an application. The addresses in Table F.2 are general register addresses. If PA is the protocol register address, and GA is the general register address, you can get GA from PA by performing the following calculation:

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

Conversely, you can get PA from GA using:

$$PA = 2\ (GA\text{-}1).$$

For example, if the protocol register address in the message packet is 0xC6, the user would read general register 100 (0x64); i.e., the protocol register address 0xC6 in a message packet will be converted to a general register address 100. The register addresses in Table F.2 are general register address LA.

ERROR HANDLING

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

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

COMMAND SET

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

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

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

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

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

Register Count

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

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

Register Read (Opcode 0x00 and 0x20)

An SEL-501-1 Relay functions the same for Non-Priority Register Read and Priority Register Read opcodes. One register or an adjacent group of registers can be read at once. The start register tells the relay where to begin reading. The number of registers tells the relay how many registers should be read. The maximum number of registers that can be read at one time is 100. If a register address is not available in the relay, the SEL-501-1 Relay will return a 0x8000 for the register's data value. See Table F.2 for all the available register addresses.

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

NIM Non-Priority Read:

Request message:

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

Successful reply message:

Start of header	:	10 01
Odd/Even	:	11
Route	:	30 32 36 35
Start of data	:	10 02
Reply Opcode	:	86
Transnum	:	04
Start register	:	00 C6

Data (register 100)	:	00 14
Data (register 101)	:	00 1E
Data (register 102)	:	00 28
End of data	:	10 03
Checksum	:	---

NIM Priority Read:

Request message:

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

Successful reply message:

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

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

PNIM Non-Priority Register Read:

Request message:

Start of header	:	10 01
Destination address	:	02
Transnum	:	00
ID	:	00
Route	:	36 35 30 32
Start of data	:	10 02
Opcode	:	00

Transnum	:	00
Start register address	:	00 C6
Register count	:	00 02
End of data	:	10 03
CRC	:	--- ---

Successful reply message:

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

PNIM Priority Register Read:

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

Multiple Register Read (Opcode 0x04)

The Multiple Register Read opcodes allow an SEL-501 Relay to read a non-adjacent group of registers at once. All the register addresses are indicated in the command. The maximum number of register addresses that can be listed in one command is 100. If a register address is not available in the relay, the SEL-501-1 Relay will return a 0x8000 for the register's data. See Table F.2 for all the available register addresses.

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

NIM Multiple Read:

Request message:

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

Register address	:	00 CC
Register address	:	00 D2
End of data	:	10 03
Checksum	:	---

Successful reply message:

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

PNIM Multiple Read:

Request message:

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

Successful reply message:

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

Register Write (Opcode 0x02 and 0x1E)

An SEL-501-1 Relay functions the same for Non-Priority Register Write and Priority Register Write opcodes. One register or an adjacent group of registers can be written at once. The start register tells the relay where to begin writing. The data following the start register tells the relay what should be written. The maximum number of registers that can be written at one time is 8. If a register in the relay cannot be written, the SEL-501-1 Relay will ignore the write command. See Table F.2 for all the available register addresses.

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

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

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

NIM Non-Priority Write:

Request message:

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

Successful reply message:

Start of header	:	10 01
Odd/Even	:	11
Route	:	36 35 30 32
Start of data	:	10 02
Reply Opcode	:	80
Transnum	:	00
End of data	:	10 03
Checksum	:	---

NIM Priority Write:

Request message:

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

Successful reply message:

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

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

PNIM Non-Priority Write:

Request message:

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

Successful reply:

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

PNIM Priority Write:

The SEL-501-1 Relay supports PNIM priority writes; although they are not generally used.

Search Rung (Opcode 0x0E)

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

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

Request message:

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

Successful reply message:

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

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

Read User Memory (Opcode 0x14)

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

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

Request message:

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

Successfully reply message:

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

REGISTER MAP

The following table is a listing of SEL-501-1 Relay registers.

Table F.2: SY/MAX Protocol Register Map

Reg. #	Description	Units	Range
Breaker			
100(R)	Number of internal trips	none	0 to 32,767
101(R)	Internal IA	100 Amps	0 to 32,767
102(R)	Internal IB	100 Amps	0 to 32,767
103(R)	Internal IC	100 Amps	0 to 32,767
104(R)	Number of external trips	none	0 to 32,767
105(R)	External IA	100 Amps	0 to 32,767
106(R)	External IB	100 Amps	0 to 32,767
107(R)	External IC	100 Amps	0 to 32,767
108(W)	Reset breaker	none	
Clear the Short Event Report			
150(R)	Number of events	none	0 to 20
151(W)	Clear events	none	
Acknowledge the Short Event Report			
160(R)	The oldest unacknowledged short event report packet	none	See Event Acknowledgment
161(W)	Acknowledge the oldest unacknowledged short event report packet	none	See Event Acknowledgment
Short Event Report (Total = 20 Event Reports)			
200(R)	Event Number	none	0 or 1
201-203(R)	Event 1 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
204(R)	Event 1 Compressed Date/Time	ms.	See time format
205-211(R)	Event 1 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
212(R)	Event 1 system frequency	Hz/10	0.0 to 1000.0
213(R)	Event 1 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
214(R)	Event 1 type	none	See Event Type
215(R)	Event 1 Target	none	See Target Format
216(R)	Event 1 duration	cyc/100	0.00 to 15.00 cyc.
217(R)	Event 1 fault current IAX	Amp	0 to 32,767
218(R)	Event 1 fault current IBX	Amp	0 to 32,767
219(R)	Event 1 fault current ICX	Amp	0 to 32,767
220(R)	Event 1 fault current IQX	Amp	0 to 32,767
221(R)	Event 1 fault current INX	Amp	0 to 32,767
222(R)	Event 1 fault current IAY	Amp	0 to 32,767
223(R)	Event 1 fault current IBY	Amp	0 to 32,767
224(R)	Event 1 fault current ICY	Amp	0 to 32,767
225(R)	Event 1 fault current IQY	Amp	0 to 32,767
226(R)	Event 1 fault current INY	Amp	0 to 32,767
227(R)	Acknowledgment for event 1	0 - unack. 1 - ack	0 to 1
228(R)	Event Number	none	0 or 2
229-231(R)	Event 2 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
232(R)	Event 2 Compressed Date/Time	ms.	See time format
233-239(R)	Event 2 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
240(R)	Event 2 system frequency	Hz/10	0 to 1000
241(R)	Event 2 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
242(R)	Event 2 type	none	See Event Type
243(R)	Event 2 Target	none	See Target Format
244(R)	Event 2 duration	cyc/100	0.00 to 15.00 cyc.
245(R)	Event 2 fault current IAX	Amp	0 to 32,767
246(R)	Event 2 fault current IBX	Amp	0 to 32,767
247(R)	Event 2 fault current ICX	Amp	0 to 32,767
248(R)	Event 2 fault current IQX	Amp	0 to 32,767
249(R)	Event 2 fault current INX	Amp	0 to 32,767

Reg. #	Description	Units	Range
250(R)	Event 2 fault current IAY	Amp	0 to 32,767
251(R)	Event 2 fault current IBY	Amp	0 to 32,767
252(R)	Event 2 fault current ICY	Amp	0 to 32,767
253(R)	Event 2 fault current IQY	Amp	0 to 32,767
254(R)	Event 2 fault current INY	Amp	0 to 32,767
255(R)	Acknowledgment for event 2	0 - unack. 1 - ack	0 to 1
256(R)	Event Number	none	0 or 3
257-259(R)	Event 3 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
260	Event 3 Compressed Date/Time	ms.	See time format
261-267(R)	Event 3 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	see time format
268(R)	Event 3 system frequency	Hz/10	0 to 1000
269(R)	Event 3 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
270(R)	Event 3 type	none	See Event Type
271(R)	Event 3 Target	none	See Target Format
272(R)	Event 3 duration	cyc/100	0.00 to 15.00 cyc.
273(R)	Event 3 fault current IAX	Amp	0 to 32,767
274(R)	Event 3 fault current IBX	Amp	0 to 32,767
275(R)	Event 3 fault current ICX	Amp	0 to 32,767
276(R)	Event 3 fault current IQX	Amp	0 to 32,767
277(R)	Event 3 fault current INX	Amp	0 to 32,767
278(R)	Event 3 fault current IAY	Amp	0 to 32,767
279(R)	Event 3 fault current IBY	Amp	0 to 32,767
280(R)	Event 3 fault current ICY	Amp	0 to 32,767
281(R)	Event 3 fault current IQY	Amp	0 to 32,767
282(R)	Event 3 fault current INY	Amp	0 to 32,767
283(R)	Acknowledgment for event 3	0 - unack. 1 - ack	0 to 1
284(R)	Event Number	none	0 or 4
285-287(R)	Event 4 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
288(R)	Event 4 Compressed Date/Time	ms.	See time format
289-295(R)	Event 4 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
296(R)	Event 4 system frequency	Hz/10	0 to 1000
297(R)	Event 4 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
298(R)	Event 4 type	none	See Event Type
299(R)	Event 4 Target	none	See Target Format
300(R)	Event 4 duration	cyc/100	0.00 to 15.00 cyc.
301(R)	Event 4 fault current IAX	Amp	0 to 32,767
302(R)	Event 4 fault current IBX	Amp	0 to 32,767
303(R)	Event 4 fault current ICX	Amp	0 to 32,767
304(R)	Event 4 fault current IQX	Amp	0 to 32,767
305(R)	Event 4 fault current INX	Amp	0 to 32,767
306(R)	Event 4 fault current IAY	Amp	0 to 32,767
307(R)	Event 4 fault current IBY	Amp	0 to 32,767
308(R)	Event 4 fault current ICY	Amp	0 to 32,767
309(R)	Event 4 fault current IQY	Amp	0 to 32,767
310(R)	Event 4 fault current INY	Amp	0 to 32,767
311(R)	Acknowledgment for event 4	0 - unack. 1 - ack	0 to 1
312(R)	Event Number	none	0 or 5
313-315(R)	Event 5 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
316(R)	Event 5 Compressed Date/Time	ms.	See time format
317-323(R)	Event 5 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
324(R)	Event 5 system frequency	Hz/10	0 to 1000
325(R)	Event 5 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
326(R)	Event 5 type	none	See Event Type
327(R)	Event 5 Target	none	See Target Format
328(R)	Event 5 duration	cyc/100	0.00 to 15.00 cyc.
329(R)	Event 5 fault current IAX	Amp	0 to 32,767
330(R)	Event 5 fault current IBX	Amp	0 to 32,767
331(R)	Event 5 fault current ICX	Amp	0 to 32,767
332(R)	Event 5 fault current IQX	Amp	0 to 32,767
333(R)	Event 5 fault current INX	Amp	0 to 32,767

Reg. #	Description	Units	Range
334(R)	Event 5 fault current IAY	Amp	0 to 32,767
335(R)	Event 5 fault current IBY	Amp	0 to 32,767
336(R)	Event 5 fault current ICY	Amp	0 to 32,767
337(R)	Event 5 fault current IQY	Amp	0 to 32,767
338(R)	Event 5 fault current INY	Amp	0 to 32,767
339(R)	Acknowledgment for event 5	0 - unack. 1 - ack	0 to 1
340(R)	Event Number	none	0 or 6
341-343(R)	Event 6 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
344(R)	Event 6 Compressed Date/Time	ms.	See time format
345-351(R)	Event 6 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
352(R)	Event 6 system frequency	Hz/10	0 to 1000
353(R)	Event 6 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
354(R)	Event 6 type	none	See Event Type
355(R)	Event 6 Target	none	See Target Format
356(R)	Event 6 duration	cyc/100	0.00 to 15.00 cyc.
357(R)	Event 6 fault current IAX	Amp	0 to 32,767
358(R)	Event 6 fault current IBX	Amp	0 to 32,767
359(R)	Event 6 fault current ICX	Amp	0 to 32,767
360(R)	Event 6 fault current IQX	Amp	0 to 32,767
361(R)	Event 6 fault current INX	Amp	0 to 32,767
362(R)	Event 6 fault current IAY	Amp	0 to 32,767
363(R)	Event 6 fault current IBY	Amp	0 to 32,767
364(R)	Event 6 fault current ICY	Amp	0 to 32,767
365(R)	Event 6 fault current IQY	Amp	0 to 32,767
366(R)	Event 6 fault current INY	Amp	0 to 32,767
367(R	Acknowledgment for event 6	0 - unack. 1 - ack	0 to 1
368(R)	Event Number	none	0 or 7
369-371(R)	Event 7 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
372(R)	Event 7 Compressed Date/Time	ms.	See time format
373-379(R)	Event 7 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
380(R)	Event 7 system frequency	Hz/10	0 to 1000
381(R)	Event 7 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
382(R)	Event 7 type	none	See Event Type
383(R)	Event 7 Target	none	See Target Format
384(R)	Event 7 duration	cyc/100	0.00 to 15.00 cyc.
385(R)	Event 7 fault current IAX	Amp	0 to 32,767
386(R)	Event 7 fault current IBX	Amp	0 to 32,767
387(R)	Event 7 fault current ICX	Amp	0 to 32,767
388(R)	Event 7 fault current IQX	Amp	0 to 32,767
389(R)	Event 7 fault current INX	Amp	0 to 32,767
390(R)	Event 7 fault current IAY	Amp	0 to 32,767
391(R)	Event 7 fault current IBY	Amp	0 to 32,767
392(R)	Event 7 fault current ICY	Amp	0 to 32,767
393(R)	Event 7 fault current IQY	Amp	0 to 32,767
394(R)	Event 7 fault current INY	Amp	0 to 32,767
395(R)	Acknowledgment for event 7	0 - unack. 1 - ack	0 to 1
396(R)	Event Number	none	0 or 8
397-399(R)	Event 8 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
400(R)	Event 8 Compressed Date/Time	ms.	See time format
401-407(R)	Event 8 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
408(R)	Event 8 system frequency	Hz/10	0 to 1000
409(R)	Event 8 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
410(R)	Event 8 type	none	See Event Type
411(R)	Event 8 Target	none	See Target Format
412(R)	Event 8 duration	cyc/100	0.00 to 15.00 cyc.
413(R)	Event 8 fault current IAX	Amp	0 to 32,767
414(R)	Event 8 fault current IBX	Amp	0 to 32,767
415(R)	Event 8 fault current ICX	Amp	0 to 32,767
416(R)	Event 8 fault current IQX	Amp	0 to 32,767
417(R)	Event 8 fault current INX	Amp	0 to 32,767

Reg. #	Description	Units	Range
418(R)	Event 8 fault current IAY	Amp	0 to 32,767
419(R)	Event 8 fault current IBY	Amp	0 to 32,767
420(R)	Event 8 fault current ICY	Amp	0 to 32,767
421(R)	Event 8 fault current IQY	Amp	0 to 32,767
422(R)	Event 8 fault current INY	Amp	0 to 32,767
423(R)	Acknowledgment for event 8	0 - unack. 1 - ack	0 to 1
424(R)	Event Number	none	0 or 9
425-427(R)	Event 9 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
428(R)	Event 9 Compressed Date/Time	ms.	See time format
429-435(R)	Event 9 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
436(R)	Event 9 system frequency	Hz/10	0 to 1000
437(R)	Event 9 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
438(R)	Event 9 type	none	See Event Type
439(R)	Event 9 Target	none	See Target Format
440(R)	Event 9 duration	cyc/100	0.00 to 15.00 cyc.
441(R)	Event 9 fault current IAX	Amp	0 to 32,767
442(R)	Event 9 fault current IBX	Amp	0 to 32,767
443(R)	Event 9 fault current ICX	Amp	0 to 32,767
444(R)	Event 9 fault current IQX	Amp	0 to 32,767
445(R)	Event 9 fault current INX	Amp	0 to 32,767
446(R	Event 9 fault current IAY	Amp	0 to 32,767
447(R)	Event 9 fault current IBY	Amp	0 to 32,767
448(R)	Event 9 fault current ICY	Amp	0 to 32,767
449(R)	Event 9 fault current IQY	Amp	0 to 32,767
450(R)	Event 9 fault current INY	Amp	0 to 32,767
451(R)	Acknowledgment for event 9	0 - unack. 1 - ack	0 to 1
452(R)	Event Number	none	0 or 10
453-455(R)	Event 10 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
456(R)	Event 10 Compressed Date/Time	ms.	See time format
457-463(R)	Event 10 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
464(R)	Event 10 system frequency	Hz/10	0 to 1000
465(R)	Event 10 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
466(R)	Event 10 type	none	See Event Type
467(R)	Event 10 Target	none	See Target Format
468(R)	Event 10 duration	cyc/100	0.00 to 15.00 cyc.
469(R)	Event 10 fault current IAX	Amp	0 to 32,767
470(R)	Event 10 fault current IBX	Amp	0 to 32,767
471(R)	Event 10 fault current ICX	Amp	0 to 32,767
472(R)	Event 10 fault current IQX	Amp	0 to 32,767
473(R)	Event 10 fault current INX	Amp	0 to 32,767
474(R)	Event 10 fault current IAY	Amp	0 to 32,767
475(R)	Event 10 fault current IBY	Amp	0 to 32,767
476(R)	Event 10 fault current ICY	Amp	0 to 32,767
477(R)	Event 10 fault current IQY	Amp	0 to 32,767
478(R)	Event 10 fault current INY	Amp	0 to 32,767
479(R)	Acknowledgment for event 10	0 - unack. 1 - ack	0 to 1
480(R)	Event Number	none	0 or 11
481-483(R)	Event 11 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
484(R)	Event 11 Compressed Date/Time	ms.	See time format
485-491(R)	Event 11 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
492(R)	Event 11 system frequency	Hz/10	0 to 1000
493(R)	Event 11 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
494(R)	Event 11 type	none	See Event Type
495(R)	Event 11 Target	none	See Target Format
496(R)	Event 11 duration	cyc/100	0.00 to 15.00 cyc.
497(R)	Event 11 fault current IAX	Amp	0 to 32,767
498(R)	Event 11 fault current IBX	Amp	0 to 32,767

Reg. #	Description	Units	Range
499(R)	Event 11 fault current ICX	Amp	0 to 32,767
500(R)	Event 11 fault current IQX	Amp	0 to 32,767
501(R)	Event 11 fault current INX	Amp	0 to 32,767
502(R)	Event 11 fault current IAY	Amp	0 to 32,767
503(R)	Event 11 fault current IBY	Amp	0 to 32,767
504(R)	Event 11 fault current ICY	Amp	0 to 32,767
505(R)	Event 11 fault current IQY	Amp	0 to 32,767
506(R)	Event 11 fault current INY	Amp	0 to 32,767
507(R)	Acknowledgment for event 11	0 - unack. 1 - ack	0 to 1
508(R)	Event Number	none	0 or 12
509-511(R)	Event 12 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
512(R)	Event 12 Compressed Date/Time	ms.	See time format
513-519(R)	Event 12 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
520(R)	Event 12 system frequency	Hz/10	0 to 1000
521(R)	Event 12 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
522(R)	Event 12 type	none	See Event Type
523(R)	Event 12 Target	none	See Target Format
524(R)	Event 12 duration	cyc/100	0.00 to 15.00 cyc.
525(R)	Event 12 fault current IAX	Amp	0 to 32,767
526(R)	Event 12 fault current IBX	Amp	0 to 32,767
527(R)	Event 12 fault current ICX	Amp	0 to 32,767
528(R)	Event 12 fault current IQX	Amp	0 to 32,767
529(R)	Event 12 fault current INX	Amp	0 to 32,767
530(R)	Event 12 fault current IAY	Amp	0 to 32,767
531(R)	Event 12 fault current IBY	Amp	0 to 32,767
532(R)	Event 12 fault current ICY	Amp	0 to 32,767
533(R)	Event 12 fault current IQY	Amp	0 to 32,767
534(R)	Event 12 fault current INY	Amp	0 to 32,767
535(R)	Acknowledgment for event 12	0 - unack. 1 - ack	0 to 1
536(R)	Event Number	none	0 or 13
537-539(R)	Event 13 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
540(R)	Event 13 Compressed Date/Time	ms.	See time format
541-547(R)	Event 13 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
548(R)	Event 13 system frequency	Hz/10	0 to 1000
549(R)	Event 13 setting changed 0 - settings have not been changed 1 - relay X settings have been hanged 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
550(R)	Event 13 type	none	See Event Type
551(R)	Event 13 Target	none	See Target Format
552(R)	Event 13 duration	cyc/100	0.00 to 15.00 cyc.
553(R)	Event 13 fault current IAX	Amp	0 to 32,767
554(R)	Event 13 fault current IBX	Amp	0 to 32,767
555(R)	Event 13 fault current ICX	Amp	0 to 32,767
556(R)	Event 13 fault current IQX	Amp	0 to 32,767
557(R)	Event 13 fault current INX	Amp	0 to 32,767
558(R)	Event 13 fault current IAY	Amp	0 to 32,767
559(R)	Event 13 fault current IBY	Amp	0 to 32,767
560(R)	Event 13 fault current ICY	Amp	0 to 32,767
561(R)	Event 13 fault current IQY	Amp	0 to 32,767
562(R)	Event 13 fault current INY	Amp	0 to 32,767
563(R)	Acknowledgment for event 13	0 - unack. 1 - ack	0 to 1
564(R)	Event Number	none	0 or 14
565-567(R)	Event 14 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
568(R)	Event 14 Compressed Date/Time	ms.	See time format
569-575(R)	Event 14 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
576(R)	Event 14 system frequency	Hz/10	0 to 1000
577(R)	Event 14 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
578(R)	Event 14 type	none	See Event Type
579(R)	Event 14 Target	none	See Target Format
580(R)	Event 14 duration	cyc/100	0.00 to 15.00 cyc.

Reg. #	Description	Units	Range
581(R)	Event 14 fault current IAX	Amp	0 to 32,767
582(R)	Event 14 fault current IBX	Amp	0 to 32,767
583(R)	Event 14 fault current ICX	Amp	0 to 32,767
584(R)	Event 14 fault current IQX	Amp	0 to 32,767
585(R)	Event 14 fault current INX	Amp	0 to 32,767
586(R)	Event 14 fault current IAY	Amp	0 to 32,767
587(R)	Event 14 fault current IBY	Amp	0 to 32,767
588(R)	Event 14 fault current ICY	Amp	0 to 32,767
589(R)	Event 14 fault current IQY	Amp	0 to 32,767
590(R)	Event 14 fault current INY	Amp	0 to 32,767
591(R)	Acknowledgment for event 14	0 - unack. 1 - ack	0 to 1
592(R)	Event Number	none	0 or 15
593-595(R)	Event 15 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
596(R)	Event 15 Compressed Date/Time	ms.	See time format
597-603(R)	Event 15 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
604(R)	Event 15 system frequency	Hz/10	0 to 1000
605(R)	Event 15 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
606(R)	Event 15 type	none	See Event Type
607(R)	Event 15 Target	none	See Target Format
608(R)	Event 15 duration	cyc/100	0.00 to 15.00 cyc.
609(R)	Event 15 fault current IAX	Amp	0 to 32,767
610(R)	Event 15 fault current IBX	Amp	0 to 32,767
611(R)	Event 15 fault current ICX	Amp	0 to 32,767
612(R)	Event 15 fault current IQX	Amp	0 to 32,767
613(R)	Event 15 fault current INX	Amp	0 to 32,767
614(R)	Event 15 fault current IAY	Amp	0 to 32,767
615(R)	Event 15 fault current IBY	Amp	0 to 32,767
616(R)	Event 15 fault current ICY	Amp	0 to 32,767
617(R)	Event 15 fault current IQY	Amp	0 to 32,767
618(R)	Event 15 fault current INY	Amp	0 to 32,767
619(R)	Acknowledgment for event 15	0 - unack. 1 - ack	0 to 1
620(R)	Event Number	none	0 or 16
621-623(R)	Event 16 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
624(R)	Event 16 Compressed Date/Time	ms.	See time format
625-631(R)	Event 16 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
632(R)	Event 16 system frequency	Hz/10	0 to 1000
633(R)	Event 16 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
634(R)	Event 16 type	none	See Event Type
635(R)	Event 16 Target	none	See Target Format
636(R)	Event 16 duration	cyc/100	0.00 to 15.00 cyc.
637(R)	Event 16 fault current IAX	Amp	0 to 32,767
638(R)	Event 16 fault current IBX	Amp	0 to 32,767
639(R)	Event 16 fault current ICX	Amp	0 to 32,767
640(R)	Event 16 fault current IQX	Amp	0 to 32,767
641(R)	Event 16 fault current INX	Amp	0 to 32,767
642(R)	Event 16 fault current IAY	Amp	0 to 32,767
643(R)	Event 16 fault current IBY	Amp	0 to 32,767
644(R)	Event 16 fault current ICY	Amp	0 to 32,767
645(R)	Event 16 fault current IQY	Amp	0 to 32,767
646(R)	Event 16 fault current INY	Amp	0 to 32,767
647(R)	Acknowledgment for event 16	0 - unack. 1 - ack	0 to 1
648(R)	Event Number	none	0 or 17
649-651(R)	Event 17 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
652(R)	Event 17 Compressed Date/Time	ms.	See time format
653-659(R)	Event 17 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
660(R)	Event 17 system frequency	Hz/10	0 to 1000
661(R)	Event 17 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3

Reg. #	Description	Units	Range
662(R)	Event 17 type	none	See Event Type
663(R)	Event 17 Target	none	See Target Format
664(R)	Event 17 duration	cyc/100	0.00 to 15.00 cyc.
665(R)	Event 17 fault current IAX	Amp	0 to 32,767
666(R)	Event 17 fault current IBX	Amp	0 to 32,767
667(R)	Event 17 fault current ICX	Amp	0 to 32,767
668(R)	Event 17 fault current IQX	Amp	0 to 32,767
669(R)	Event 17 fault current INX	Amp	0 to 32,767
670(R)	Event 17 fault current IAY	Amp	0 to 32,767
671(R)	Event 17 fault current IBY	Amp	0 to 32,767
672(R)	Event 17 fault current ICY	Amp	0 to 32,767
673(R)	Event 17 fault current IQY	Amp	0 to 32,767
674(R)	Event 17 fault current INY	Amp	0 to 32,767
675(R)	Acknowledgment for event 17	0 - unack. 1 - ack	0 to 1
676(R)	Event Number	none	0 or 18
677-679(R)	Event 18 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
680(R)	Event 18 Compressed Date/Time	ms.	See time format
681-687(R)	Event 18 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
688(R)	Event 18 system frequency	Hz/10	0 to 1000
689(R)	Event 18 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
690(R)	Event 18 type	none	See Event Type
691(R)	Event 18 Target	none	See Target Format
692(R)	Event 18 duration	cyc/100	0.00 to 15.00 cyc.
693(R)	Event 18 fault current IAX	Amp	0 to 32,767
694(R)	Event 18 fault current IBX	Amp	0 to 32,767
695(R)	Event 18 fault current ICX	Amp	0 to 32,767
696(R)	Event 18 fault current IQX	Amp	0 to 32,767
697(R)	Event 18 fault current INX	Amp	0 to 32,767
698(R)	Event 18 fault current IAY	Amp	0 to 32,767
699(R)	Event 18 fault current IBY	Amp	0 to 32,767
700(R)	Event 18 fault current ICY	Amp	0 to 32,767
701(R)	Event 18 fault current IQY	Amp	0 to 32,767
702(R)	Event 18 fault current INY	Amp	0 to 32,767
703(R)	Acknowledgment for event 18	0 - unack. 1 - ack	0 to 1
704(R)	Event Number	none	0 or 19
705-707(R)	Event 19 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
708(R)	Event 19 Compressed Date/Time	ms.	See time format
709-715(R)	Event 19 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
716(R)	Event 19 system frequency	Hz/10	0 to 1000
717(R)	Event 19 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
718(R)	Event 19 type	none	See Event Type
719(R)	Event 19 Target	none	See Target Format
720(R)	Event 19 duration	cyc/100	0.00 to 15.00 cyc.
721(R)	Event 19 fault current IAX	Amp	0 to 32,767
722(R)	Event 19 fault current IBX	Amp	0 to 32,767
723(R)	Event 19 fault current ICX	Amp	0 to 32,767
724(R)	Event 19 fault current IQX	Amp	0 to 32,767
725(R)	Event 19 fault current INX	Amp	0 to 32,767
726(R)	Event 19 fault current IAY	Amp	0 to 32,767
727(R)	Event 19 fault current IBY	Amp	0 to 32,767
728(R)	Event 19 fault current ICY	Amp	0 to 32,767
729(R)	Event 19 fault current IQY	Amp	0 to 32,767
730(R)	Event 19 fault current INY	Amp	0 to 32,767
731(R)	Acknowledgment for event 19	0 - unack. 1 - ack	0 to 1
732(R)	Event Number	none	0 or 20
733-735(R)	Event 20 Compressed Date/Time	Month, Day, Yr., Hr., Min., Sec.	See time format
736(R)	Event 20 Compressed Date/Time	ms.	See time format
737-743(R)	Event 20 Expanded Date/Time	ms., Sec., Min., Hr., Day, Month, Yr.	See time format

Reg. #	Description	Units	Range
744(R)	Event 20 system frequency	Hz/10	0 to 1000
745(R)	Event 20 setting changed 0 - settings have not been changed 1 - relay X settings have been changed 2 - relay Y settings have been changed 3 - both relay X and Y settings have been changed	none	0 to 3
746(R)	Event 20 type	none	See Event Type
747(R)	Event 20 Target	none	See Target Format
748(R)	Event 20 duration	cyc/100	0.00 to 15.00 cyc.
749(R)	Event 20 fault current IAX	Amp	0 to 32,767
750(R)	Event 20 fault current IBX	Amp	0 to 32,767
751(R)	Event 20 fault current ICX	Amp	0 to 32,767
752(R)	Event 20 fault current IQX	Amp	0 to 32,767
753(R)	Event 20 fault current INX	Amp	0 to 32,767
754(R)	Event 20 fault current IAY	Amp	0 to 32,767
755(R)	Event 20 fault current IBY	Amp	0 to 32,767
756(R)	Event 20 fault current ICY	Amp	0 to 32,767
757(R)	Event 20 fault current IQY	Amp	0 to 32,767
758(R)	Event 20 fault current INY	Amp	0 to 32,767
759(R)	Acknowledgment for event 20	0 - unack. 1 - ack	0 to 1
Scale Factor			
2020(R/W)	Scale Group A: Ammeter/Phase -2 = scale by 0.01 -1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	-2 to 1
2021(R/W)	Scale Group B: Ammeter Neutral -2 = scale by 0.01 -1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	-2 to 1
2022(R/W)	Scale Group C: Ammeter Ground -2 = scale by 0.01 -1 = scale by 0.10 0 = scale by 1.00 (default) 1 = scale by 10.0	none	-2 to 1
Instantaneous Meter			
1003(R)	Current, Phase A	Amps scale factor A	0 to 32,767
1004(R)	Current, Phase B	Amps scale factor A	0 to 32,767
1005(R)	Current, Phase C	Amps scale factor A	0 to 32,767
1006(R)	Current, 3I2	Amps scale factor B	0 to 32,767
1007(R)	Current, IR	Amps scale factor C	0 to 32,767
1008-1010(R)	Compressed Date/Time recorded at the time of getting the meter data	Month, Day, Yr., Hr., Min., Sec.	See time format
1011(R)	Compressed Date/Time recorded at the time of getting the meter data	ms.	See time format
1012-1018(R)	Expanded Date/Time recorded at the time of getting the meter data	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
Demand Meter			
1700(R)	Demand Current, Phase A	Amps scale factor A	0 to 32,767
1701(R)	Demand Current, Phase B	Amps scale factor A	0 to 32,767
1702(R)	Demand Current, Phase C	Amps scale factor A	0 to 32,767
1703(R)	Demand Current, 3I2	Amps scale factor B	0 to 32,767
1704(R)	Demand Current, IR	Amps scale factor C	0 to 32,767
1705-1707(R)	Compressed Date/Time recorded at the time of getting the meter D data	Month, Day, Yr., Hr., Min., Sec.	See time format
1708(R)	Compressed Date/Time recorded at the time of getting the meter D data	ms.	See time format
1709-1715(R)	Expanded Date/Time recorded at the time of getting the meter D data	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
1716(W)	Reset Demand Meter	none	
Peak Demand Meter			
1800(R)	Peak Demand Current, Phase A	Amps scale factor A	0 to 32,767
1801(R)	Peak Demand Current, Phase B	Amps scale factor A	0 to 32,767
1802(R)	Peak Demand Current, Phase C	Amps scale factor A	0 to 32,767
1803(R)	Peak Demand Current, 3I2	Amps scale factor B	0 to 32,767
1804(R)	Peak Demand Current, IR	Amps scale factor C	0 to 32,767
1805-1807(R)	Compressed Date/Time recorded at the time of getting the meter P data	Month, Day, Yr., Hr., Min., Sec.	See time format
1808(R)	Compressed Date/Time recorded at the time of getting the meter P data	ms.	See time format
1809-1815(R)	Expanded Date/Time recorded at the time of getting the meter P data	ms., Sec., Min., Hr., Day, Month, Yr.	See time format
1816(W)	Reset Peak Demand Meter	none	

Reg. #	Description	Units	Range
Relay Status			
1900(R)	(IA) channel IA, the dc offset	mV	0 to 9000
1901(R)	channel IA status message: 0 - normal 1 - warn 2 - fail		
1902(R)	(IB) channel IB, the dc offset	mV	0 to 9000
1903(R)	channel IB status message: 0 - normal 1 - warn 2 - fail		
1904(R)	(IC) channel IC, the dc offset	mV	0 to 9000
1905(R)	channel IC status message: 0 - normal 1 - warn 2 - fail		
1906(R)	(MOF), the dc offset in the A/D circuit when a grounded input is selected.	mV	0 to 9000
1907(R)	MOF status message: 0 - normal 1 - warn 2 - fail		
1908(R)	(+5v_ps) power supply the power supply value	V/100	0.00 to 500.00
1909(R)	+5v_ps power supply status message: 0 - normal 1 - warn 2 - fail		
1910(R)	(+5_REG) power supply the power supply value	V/100	0.00 to 500.00
1911(R)	+5_REG power supply status message: 0 - normal 1 - warn 2 - fail		
1912(R)	(-5_REG) power supply the power supply value	V/100	0.00 to -500.00
1913(R)	-5_REG power supply status message: 0 - normal 1 - warn 2 - fail		
1914(R)	(+10_ps) power supply the power supply value	V/100	0.00 to 500.00
1915(R)	+10_ps power supply status message: 0 - normal 1 - warn 2 - fail		
1916(R)	(-10_ps) power supply the power supply value	V/100	0.00 to 500.00
1917(R)	-10_ps power supply status message: 0 - normal 1 - warn 2 - fail		
1918(R)	(VBAT) power supply the power supply value	V/100	0.00 to 500.00
1919(R)	VBAT power supply status message: 0 - normal 1 - warn 2 - fail		
1920(R)	(TEMP) Temperature in degrees centigrade	°C/100	0.00 to 100.00
1921(R)	temperature status message: 0 - normal 1 - warn 2 - fail		
1922(R)	(RAM) RAM status 0 - OK 2 - fail	none	
1923(R)	(ROM) ROM status 0 - OK 2 - fail	none	
1924(R)	(CR_RAM) CR_RAM status 0 - OK 2 - fail	none	
1925(R)	(EEPROM) EEPROM status 0 - OK 2 - fail	none	
1926(R)	(SETTING) Setting status 0 - OK 1 - Relay setting is not OK 2 - Calibration Setting is not OK	none	
1927(R)	(ENABLE) Enable status 0 - relay enabled 1 - relay disabled	none	

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

Date/Time Format

Within Table F.2, two date/time formats are used.

Compressed Date/Time:

Four registers are used for the compressed date/time format.
Register 1, Month (MSB) = 1 to 12, Day (LSB) = 1 to 31,
Register 2 Year (MSB) = 0 to 199, Hour (LSB) = 0 to 23,
Register 3, Minutes (MSB) = 0 to 59, Second (LSB) = 0 to 59,
Register 4, Millisecond = 0 to 999.
The year is zero based on the year 1900 in anticipation of the 21st century, (e.g., 1989 would be represented as 89 and 2009 would be represented as 109).

Expanded Date/Time:

Seven registers are used for the expanded date/time format.
Register 1, millisecond, 0 to 999,
Register 2, second, 0 to 59,
Register 3, minute, 0 to 59,
Register 4, hours, 0 to 23
Register 5, day, 1 to 31
Register 6, month 1 to 12
Register 7, year 1900 to 2099

Target Format

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

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

For example:

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

Event Type

The following list shows the event types and their encoding.

Event Type	Encoding	Event Type	Encoding
TRIGGER	0x0	STOP	0xA
FAULT	0x1	RETRIP	0xB
START	0x2	CLOSE	0xC
THERM	0x3	RUN	0xD
STL	0x4	EXT	0xE
LJAM	0x5	TIMER1	0xF
LLOSS	0x6	TIMER2	0x10
BFI	0x7	OUT1	0x11
86TR	0x8	OUT2	0x12
OPEN	0x9	TRIP	0x40

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

For example:

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

Event Acknowledgment

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

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

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

Write-Only Registers

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

SY/MAX Status Byte

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

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

APPENDIX G: MODBUS™ RTU COMMUNICATIONS PROTOCOL (APPLIES ONLY TO SEL-501 RELAYS)

INTRODUCTION

This appendix describes Modbus RTU communications features supported by the SEL-501 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 Relay Modbus communication allows a Modbus master device to:

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

Table G.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 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 Relay are described in Table G.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 Relay supports the Modbus function codes shown in Table G.2.

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

Table G.3: SEL-501 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.

Table G.3: SEL-501 Relay Modbus Exception Codes

Exception Code	Error Type	Description
03	Illegal Data Value	The received command contains a value that is out of range.
04	Device Error	The SEL-501 Relay is in the wrong state for the requested function.
06	Busy	The SEL-501 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 G.3 occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the requested data.

Cyclical Redundancy Check

The SEL-501 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 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 at 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 G.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

Table G.4: 01h Read Coil Status Commands

Bytes	Field
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 G.9 for coil number assignments.

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (coils). You 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 G.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 G.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 G.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 G.18. You may read a maximum of 125 registers at once with this function code.

Table G.7: 04h Read Holding Register Command

Bytes	Field
Requests from the 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 G.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 Relay offers the commands listed in Table G.9 that you can execute using function code 05h. The command coils are self-resetting.

Table G.9: SEL-501 Relay Command Coils

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

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

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

06h Preset Single Register Command

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

Table G.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 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 G.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 G.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 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 G.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 Relay Modbus Register Map (Table G.18) includes two 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 G.15. If function code 06h is used to write to a command code that has parameters, the parameters must be written before the command code.

Table G.15: SEL-501 Relay Modbus Command Region

Address	Field
00C0h	Command Code
00C1h	Parameter 1

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

Table G.16: Modbus Command Codes

Command Code	Function	Parameter Definition		Modbus Function Code
01	Pulse OUT1 X	No Parameter		06h, 10h
02	Pulse OUT2 X	No Parameter		06h, 10h
03	Pulse OUT1 Y	No Parameter		06h, 10h
04	Pulse OUT2 Y	No Parameter		06h, 10h
05	Pulse Alarm	No Parameter		06h, 10h
06	Reset Targets	No Parameter		06h, 10h
07	Reset Thermal X	No Parameter		06h, 10h
08	Reset Thermal Y	No Parameter		06h, 10h
09	Trigger	No Parameter		06h, 10h
10	Switch Protocol	0080h		06h, 10h
11[a]	Reset Data Regions	0000 0000 0000 0001	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	
		0000 0001 0000 0000	Alarm Occurrence (latched) Registers	
		0000 0010 0000 0000	Alarm counters	

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

Error Codes:

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

Reading Event Data Using Modbus

The Modbus Register Map (Table G.18) provides a feature that allows you to download complete event data via Modbus. The SEL-501 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 8: 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 00E3h.
2. Write the channel number you wish to download at address 00E4h.
3. Read the four-sample per cycle event data from the Modbus Map.

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

Set 00E4h	To Read Data From Channel
1	IR
2	IA
3	IB
4	IC
5	Relay Element Status Row 1[a]
6	Relay Element Status Row 2[a]
7	Relay Element Status Row 3[a]
8	Relay Element Status Row 4[a]

[a] 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, 00A0, and 00A1 in the Modbus Map.

Reading History Data Using Modbus

The Modbus Register Map (Table G.18) provides a feature that allows you to download complete history of the last 20 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, and the targets. Please refer to Note 5 of the Modbus Map for a list of event types.

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

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

Table G.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

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0033	Channel IBX status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
0034	Channel ICX offset value[c]	mV	–5000	5000	1	1
0035	Channel ICX status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
0036	Channel IAY offset value[c]	mV	–5000	5000	1	1
0037	Channel IAY status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
0038	Channel IBY offset value[c]	mV	–5000	5000	1	1
0039	Channel IBY status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
003A	Channel ICY offset value[c]	mV	–5000	5000	1	1
003B	Channel ICY status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
003C	(MOF) DC offset in A/D circuit when a grounded input is selected[c]	mV	–5000	5000	1	1
003D	MOF status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–

(*Continued*)

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

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

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0049	VBAT power supply status message[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
004A	TEMP in degrees Celsius[c]	°C	–100	100	1	1
004B	Temperature status[b] 0 = OK, 1 = Warn, 2 = Fail	–	–	–	–	–
004C	RAM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
004D	ROM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
004E	CR_RAM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
004F	EEPROM status[b] 0 = OK, 2 = Fail	–	–	–	–	–
0050	Setting status[b] 0 = OK, 1 = relay setting is not OK, 2 = calibration setting is not OK	–	–	–	–	–
0051	Enable status[b] 0 = relay enabled, 2 = relay disabled	–	–	–	–	–
0052–005F	Reserved					
Thermal Data (RelayX; see Note 2)						
0060	Thermal loading in % of rated trip level[b]	%	0	65535	1	1
0061	Positive-sequence current in % of full load amps[b]	%	0	65535	1	1

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0062	Negative-sequence current in % of full load amps[b]	%	0	65535	1	1
0063	Positive-sequence current in primary amps[b]	Amps	0	65535	1	1
0064	Negative-sequence current in primary amps[b]	Amps	0	65535	1	1
0065	Number of starts in last one hour[b]	–	0	65535	1	1
Demand Meter (Relay X)						
0066	Demand current phase Ax[b]	Amps	0	65535	1	1
0067	Demand current phase Bx[b]	Amps	0	65535	1	1
0068	Demand current phase Cx[b]	Amps	0	65535	1	1
0069	Demand current $3I_2x$[b]	Amps	0	65535	1	1
006A	Demand residual current Irx[b]	Amps	0	65535	1	1
Peak Demand Meter (Relay X)						
006B	Peak demand current phase Ax[b]	Amps	0	65535	1	1
006C	Peak demand current phase Bx[b]	Amps	0	65535	1	1
006D	Peak demand current phase Cx[b]	Amps	0	65535	1	1
006E	Peak demand current $3I_2x$[b]	Amps	0	65535	1	1
006F	Peak residual current Irx[b]	Amps	0	65535	1	1
Instantaneous Metering (Relay X)						
0070	Inst. current phase Ax[b]	Amps	0	65535	1	1

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0071	Inst. current phase Bx[b]	Amps	0	65535	1	1
0072	Inst. current phase Cx[b]	Amps	0	65535	1	1
0073	Inst. current $3I_2x$[b]	Amps	0	65535	1	1
0074	Inst. residual current Irx[b]	Amps	0	65535	1	1
Thermal Data (Relay Y; see Note 2)						
0075	Thermal loading in % of rated trip level[b]	%	0	65535	1	1
0076	Positive-sequence current in % of full load amps[b]	%	0	65535	1	1
0077	Negative-sequence current in % of full load amps[b]	%	0	65535	1	1
0078	Positive-sequence current in primary amps[b]	Amps	0	65535	1	1
0079	Negative-sequence current in primary amps[b]	Amps	0	65535	1	1
007A	Number of starts in last one hour[b]	–	0	65535	1	1
Demand Meter (Relay Y)						
007B	Demand current phase Ay[b]	Amps	0	65535	1	1
007C	Demand current phase By[b]	Amps	0	65535	1	1
007D	Demand current phase Cy[b]	Amps	0	65535	1	1
007E	Demand current $3I_2y$[b]	Amps	0	65535	1	1
007F	Demand residual current Iry[b]	Amps	0	65535	1	1

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Peak Demand Meter (Relay Y)						
0080	Peak demand current phase Ay[b]	Amps	0	65535	1	1
0081	Peak demand current phase By[b]	Amps	0	65535	1	1
0082	Peak demand current phase Cy[b]	Amps	0	65535	1	1
0083	Peak demand current $3I_2y$[b]	Amps	0	65535	1	1
0084	Peak demand residual current Iry[b]	Amps	0	65535	1	1
Instantaneous Metering (Relay Y)						
0085	Inst. current phase Ay[b]	Amps	0	65535	1	1
0086	Inst. current phase By[b]	Amps	0	65535	1	1
0087	Inst. current phase Cy[b]	Amps	0	65535	1	1
0088	Inst. current $3I_2x$[b]	Amps	0	65535	1	1
0089	Inst. residual current Iry[b]	Amps	0	65535	1	1
Breaker Monitor (Relay X; see Note 3)						
008A	Number of internal trips[b]	–	0	65535	1	1
008B	Internal IA[b]	KA	0	65535	1	0.1
008C	Internal IB[b]	KA	0	65535	1	0.1
008D	Internal IC[b]	KA	0	65535	1	0.1
008E	Number of external trips[b]	–	0	65535	1	1
008F	External IA[b]	KA	0	65535	1	0.1
0090	External IB[b]	KA	0	65535	1	0.1
0091	External IC[b]	KA	0	65535	1	0.1

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Breaker Monitor (Relay Y)						
0092	Number of internal trips[b]	–	0	65535	1	1
0093	Internal IA[b]	KA	0	65535	1	0.1
0094	Internal IB[b]	KA	0	65535	1	0.1
0095	Internal IC[b]	KA	0	65535	1	0.1
0096	Number of external trips[b]	–	0	65535	1	1
0097	External IA[b]	KA	0	65535	1	0.1
0098	External IB[b]	KA	0	65535	1	0.1
0099	External IC[b]	KA	0	65535	1	0.1
Expanded Relay Time and Date						
009A (RW) (see Note 4)	Time[b]	ss	0	59	1	1
009B (RW)	[b]	mm	0	59	1	1
009C (RW)	[b]	hh	0	23	1	1
009D (RW)	Date[b]	dd	1	31	1	1
009E (RW)	[b]	mm	1	12	1	1
009F (RW)	[b]	yyyy	1992	2999	1	1
Targets						
00A0	Targets X Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Inst.					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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					
00A1	Targets Y Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if any of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = Inst. Bit 9 = Phase A 51/50					
	Bit 10 = Phase B 51/50 Bit 11 = Phase C 51/50 Bit 12 = Neg.-Sequence Bit 13 = Residual 51N/50N					
	Bit 14–15 = 0					
00A2–00AF	Reserved					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Relay Word (X)						
00B0	Application Code Relay X[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR					
00B1	Row 2 (relay element status) APP = FDR or OC1 Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = 50NH Bit 9 = 50NT Bit 10 = 50QT Bit 11 = 50H Bit 12 = 50PT Bit 13 = 51NT Bit 14 = 51QT Bit 15 = 51PT APP = MOT Bit 0 = 1 if any of bits 8–15 are set to 1 Bit 0 = 0 if all of bits 8–15 are set to 0 Bits 1–7 = 0 Bit 8 = 50NH Bit 9 = 50NT					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 10 = 50QT					
	Bit 11 = 50H					
	Bit 12 = 50PT					
	Bit 13 = STL					
	Bit 14 = 0					
	Bit 15 = 49					
	APP = BFR					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 0					
	Bit 9 = 50NP					
	Bit 10 = 0					
	Bit 11 = 0					
	Bit 12 = 50PP					
	Bit 13 = 62T					
	Bit 14 = RTRP					
	Bit 15 = 86TR					
	APP = TMR or OFF					
	Bit 0–15 = 0					
00B2	Row 3 (relay element status)					
	APP = FDR or OC1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 0					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 9 = 50NP					
	Bit 10 = 50QP					
	Bit 11 = 0					
	Bit 12 = 50PP					
	Bit 13 = 51NP					
	Bit 14 = 51QP					
	Bit 15 = 51PP					
	APP = MOT					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = LJAM					
	Bit 9 = 50NP					
	Bit 10 = 50QP					
	Bit 11 = LLOSS					
	Bit 12 = 50PP					
	Bit 13 = 50ST					
	Bit 14 = 50L					
	Bit 15 =49A					
	APP = BFR, TMR or OFF					
	Bits 0–15 = 0					
00B3	Row 4 (relay element status)					
	APP = FDR or OC1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 8 = 0					
	Bit 9 = 0					
	Bit 10 = 0					
	Bit 11 = 0					
	Bit 12 = 0					
	Bit 13 = 51NR					
	Bit 14 = 51QR					
	Bit 15 = 51PR					
	APP = MOT, BFR, TMR, or OFF					
	Bit 0–15 = 0					
Relay Word (Y)						
00B4	Application code Relay Y[b]					
	0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR					
00B5	Row 2					
	APP = FDR or OC1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 50NH					
	Bit 9 = 50NT					
	Bit 10 = 50QT					
	Bit 11 = 50H					
	Bit 12 = 50PT					
	Bit 13 = 51NT					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 14 = 51QT					
	Bit 15 = 51PT					
	APP = MOT					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 50NH					
	Bit 9 = 50NT					
	Bit 10 = 50QT					
	Bit 11 = 50H					
	Bit 12 = 50PT					
	Bit 13 = STL					
	Bit 14 = 0					
	Bit 15 = 49					
	APP = BFR					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 0					
	Bit 9 = 50NP					
	Bit 10 = 0					
	Bit 11 = 0					
	Bit 12 = 50PP					
	Bit 13 = 62T					
	Bit 14 = RTRP					
	Bit 15 = 86TR					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	APP = TMR or OFF					
	Bit 0–15 = 0					
00B6	Row 3					
	APP = FDR or OC1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 0					
	Bit 9 = 50NP					
	Bit 10 = 50QP					
	Bit 11 = 0					
	Bit 12 = 50PP					
	Bit 13 = 51NP					
	Bit 14 = 51QP					
	Bit 15 = 51PP					
	APP = MOT					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = LJAM					
	Bit 9 = 50NP					
	Bit 10 = 50QP					
	Bit 11 = LLOSS					
	Bit 12 = 50PP					
	Bit 13 = 50ST					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 14 = 50L					
	Bit 15 = 49A					
	APP = BFR, TMR, or OFF					
	Bit 0–15 = 0					
00B7	Row 4					
	APP = FDR or OC1					
	Bit 0 = 1 if any of bits 8–15 are set to 1					
	Bit 0 = 0 if all of bits 8–15 are set to 0					
	Bits 1–7 = 0					
	Bit 8 = 0					
	Bit 9 = 0					
	Bit 10 = 0					
	Bit 11 = 0					
	Bit 12 = 0					
	Bit 13 = 51NR					
	Bit 14 = 51QR					
	Bit 15 = 51PR					
	APP = MOT, BFR, TMR, or OFF					
	Bit 0–15 = 0					
Status of Contacts						
00B8	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					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 10 = ALARM					
	Bit 11 = XOUT1					
	Bit 12 = XOUT2					
	Bit 13 = YOUT1					
	Bit 14 = YOUT2					
	Bit 15 = 0					
00B9–00BF	Reserved					
Commands						
00C0 (W) (see Note 8)	Command Code		1	11		
00C1 (W)	Parameter 1					
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	[b]	ss	0	59	1	1
00D4	[b]	mm	0	59	1	1
00D5	[b]	hh	0	23	1	1
00D6	Event Date[b]	dd	1	31	1	1
00D7	[b]	mm	1	12	1	1
00D8	[b]	yyyy	1992	2999	1	1
00D9	Event Type[a]	ASCII string				
00DA		see Note 5				
00DB						
00DC						

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00DD						
00DE	Targets					
	Bit 0 = 1 if any of bits 8-15 are set to 1					
	Bit 0 = 0 if all of bits 8-15 are set to 0					
	Bit 1 = 0					
	Bit 2 = 0					
	Bit 3 = 0					
	Bit 4 = 0					
	Bit 5 = 0					
	Bit 6 = 0					
	Bit 7 = 0					
	Bit 8 = 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 7)						
	Relay X					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00E0	Application[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR Relay Y	–	–	–	–	–
00E1	Application[b] 0 = OFF 1 = FDR 2 = OC1 3 = MOT 4 = BFR 5 = TMR	–	–	–	–	–
00E2	Number event records[b]	–	1	12	1	1
00E3 (RW)	Event selection[b]	–	1	12	1	1
00E4 (RW)	Channel selection[b]	–	1	8	1	1
00E5	1/4 cycle[c]		–32767	32767	1	1
00E6	1/2 cycle[c]		–32767	32767	1	1
00E7	3/4 cycle[c]		–32767	32767	1	1
00E8	1 cycle[c]		–32767	32767	1	1
00E9	1 1/4 cycle[c]		–32767	32767	1	1
00EA	1 1/2 cycle[c]		–32767	32767	1	1
00EB	1 3/4 cycle[c]		–32767	32767	1	1
00EC	2 cycle[c]		–32767	32767	1	1
00ED	2 1/4 cycle[c]		–32767	32767	1	1
00EE	2 1/2 cycle[c]		–32767	32767	1	1
00EF	2 3/4 cycle[c]		–32767	32767	1	1
00F0	3 cycle[c]		–32767	32767	1	1
00F1	3 1/4 cycle[c]		–32767	32767	1	1
00F2	3 1/2 cycle[c]		–32767	32767	1	1

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
00F3	3 3/4 cycle[c]		–32767	32767	1	1
00F4	4 cycle[c]		–32767	32767	1	1
00F5	4 1/4 cycle[c]		–32767	32767	1	1
00F6	4 1/2 cycle[c]		–32767	32767	1	1
00F7	4 3/4 cycle[c]		–32767	32767	1	1
00F8	5 cycle[c]		–32767	32767	1	1
00F9	5 1/4 cycle[c]		–32767	32767	1	1
00FA	5 1/2 cycle[c]		–32767	32767	1	1
00FB	5 3/4 cycle[c]		–32767	32767	1	1
00FC	6 cycle[c]		–32767	32767	1	1
00FD	6 1/4 cycle[c]		–32767	32767	1	1
00FE	6 1/2 cycle[c]		–32767	32767	1	1
00FF	6 3/4 cycle[c]		–32767	32767	1	1
0100	7 cycle[c]		–32767	32767	1	1
0101	7 1/4 cycle[c]		–32767	32767	1	1
0102	7 1/2 cycle[c]		–32767	32767	1	1
0103	7 3/4 cycle[c]		–32767	32767	1	1
0104	8 cycle[c]		–32767	32767	1	1
0105	8 1/4 cycle[c]		–32767	32767	1	1
0106	8 1/2 cycle[c]		–32767	32767	1	1
0107	8 3/4 cycle[c]		–32767	32767	1	1
0108	9 cycle[c]		–32767	32767	1	1
0109	9 1/4 cycle[c]		–32767	32767	1	1
010A	9 1/2 cycle[c]		–32767	32767	1	1
010B	9 3/4 cycle[c]		–32767	32767	1	1
010C	10 cycle[c]		–32767	32767	1	1
010D	10 1/4 cycle[c]		–32767	32767	1	1
010E	10 1/2 cycle[c]		–32767	32767	1	1

(*Continued*)

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

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

(*Continued*)

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

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

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
0146	9 1/2 cycle[c]		–32767	32767	1	1
0147	9 3/4 cycle[c]		–32767	32767	1	1
0148	10 cycle[c]		–32767	32767	1	1
0149	10 1/4 cycle[c]		–32767	32767	1	1
014A	10 1/2 cycle[c]		–32767	32767	1	1
014B	10 3/4 cycle[c]		–32767	32767	1	1
014C	11 cycle[c]		–32767	32767	1	1
014D	11 1/4 cycle[c]		–32767	32767	1	1
014E	11 1/2 cycle[c]		–32767	32767	1	1
014F	11 3/4 cycle[c]		–32767	32767	1	1
0150	12 cycle[c]		–32767	32767	1	1
0151	12 1/4 cycle[c]		–32767	32767	1	1
0152	12 1/2 cycle[c]		–32767	32767	1	1
0153	12 3/4 cycle[c]		–32767	32767	1	1
0154	13 cycle[c]		–32767	32767	1	1
0155	13 1/4 cycle[c]		–32767	32767	1	1
0156	13 1/2 cycle[c]		–32767	32767	1	1
0157	13 3/4 cycle[c]		–32767	32767	1	1
0158	14 cycle[c]		–32767	32767	1	1
0159	14 1/4 cycle[c]		–32767	32767	1	1
015A	14 1/2 cycle[c]		–32767	32767	1	1
015B	14 3/4 cycle[c]		–32767	32767	1	1
015C	15 cycle[c]		–32767	32767	1	1
Summary Data						
015D	Event type[a]	ASCII string				
015E		see Note 5				
015F						
0160						

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
Date and Time						
0161						
0162	Event time[b]	millisec	0	999	1	1
0163	[b]	ss	0	59	1	1
0164	[b]	mm	0	59	1	1
0165	[b]	hh	0	23	1	1
0166	Event date[b]	dd	1	31	1	1
0167	[b]	mm	1	12	1	1
0168	[b]	yyyy	1992	2999	1	1
0169	Duration extent[b] Null = actual fault is equal to the duration listed "+" = fault is probably greater than the duration listed (see Note 6)	ASCII string	Null	+	–	–
016A	Duration[b]	Cycles	0	65535	1	0.01
016B	X-Current IA[b]	Amps	0	65535	1	1
016C	X-Current IB[b]	Amps	0	65535	1	1
016D	X-Current IC[b]	Amps	0	65535	1	1
016E	X-Current IQ[b]	Amps	0	65535	1	1
016F	X-Current IN[b]	Amps	0	65535	1	1
0170	Y-Current IA[b]	Amps	0	65535	1	1
0171	Y-Current IB[b]	Amps	0	65535	1	1
0172	Y-Current IC[b]	Amps	0	65535	1	1
0173	Y-Current IQ[b]	Amps	0	65535	1	1
0174	Y-Current IN[b]	Amps	0	65535	1	1
0175	Targets Bit 0 = 1 if any of bits 8-15 are set to 1 Bit 0 = 0 if all of bits 8-15 are set to 0					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	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					
0176–017F	Reserved					
Alarm Indications						
0180	Current State of Alarm Indicators					
	Bit 0 = 1 if bits 8 or 9 are set to 1					
	Bit 0 = 0 if bits 8 and 9 are set to 0					
	Bit 1–7 = 0					
	Bit 8 = 49X Current State					
	Bit 9 = 49Y Current State					
	Bit 10 = 0					
	Bit 11 = 0					

(*Continued*)

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

Address (Hex)	Field	Units	Range			Scale Factor
			Low	High	Step	
	Bit 12 = 0					
	Bit 13 = 0					
	Bit 14 = 0					
	Bit 15 = 0					
	If APP is set to FDR, OC1, BFR, or TMR, Bits 0–15 = 0					
0181	Latched State of Alarm Indicators					
	Bit 0 = 1 if bits 8 or 9 are set to 1					
	Bit 0 = 0 if bits 8 and 9 are set to 0					
	Bit 1–7 = 0					
	Bit 8 = 49X Latched State					
	Bit 9 = 49Y Latched State					
	Bit 10 = 0					
	Bit 11 = 0					
	Bit 12 = 0					
	Bit 13 = 0					
	Bit 14 = 0					
	Bit 15 = 0					
	If APP is set to FDR, OC1, BFR, or TMR, Bits 0–15 = 0					
Alarm Counters						
0182	49AX Alarm[b]	–	0	32767	1	1
0183	49AY Alarm[b]	–	0	32767	1	1
Maximum Current Limit						
0184	Relay X[d]	Amps	–32767	32767	1	1
0185	Relay X[e]	Exponent	–4	4		

(*Continued*)

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

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

[a] Two 8-bit characters per register

[b] 16-bit unsigned value

[c] 16-bit signed value

[d] Two 16-bit registers needed to accomplish the Signed Integer Dynamic Fixed Point data format. Final value read = $(R1 \bullet 10^{R2})$

[e] R1 is the content of register 0184h (0186h). R2, which is stored in 0185h (0187h), determines the decimal point position for the final value.

NOTE 1: Reserved addresses return 8000h.

NOTE 2: Thermal Data is not applicable (–) if application code is not equal to MOT.

NOTE 3: For application FDR and MOT, both internal and external trips are applicable.
For application OC1, external trips are not applicable.
For application BFR, internal trips are not applicable.
For application TMR, neither internal nor external trips are applicable.

NOTE 4: Registers (RW) are read-write registers.
Registers (W) are write-only registers.
All other registers are read-only.

NOTE 5: Event Types

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

NOTE 6: If the elements are picked up at the beginning or end of the event report, the relay adds a "+" to the duration. This indicates that the actual duration of the fault is probably greater than the figure reported.

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

The SEL-501 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 8: Please refer to Table G.16 for a list of Command Codes.

General Comments

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

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