SEL-251CD
DISTRIBUTION BUS RELAY

PHASE OVERCURRENT RELAY
WITH VOLTAGE AND DISTANCE CONTROL
NEGATIVE-SEQUENCE OVERCURRENT RELAY
GROUND OVERCURRENT RELAY
SELECTABLE SETTING GROUPS
CIRCUIT BREAKER MONITOR
SELOGIC® CONTROL EQUATIONS

INSTRUCTION MANUAL

SEL RELAY INSTRUCTION MANUAL ADDENDUM

ACB PHASE ROTATION OPTION

The SEL relay instruction manuals are written for standard ABC phase rotation applications. If your SEL relay is ordered with the ACB phase rotation option, references made in the instruction manual to voltage and current phase angle should be noted accordingly. The firmware identification number (FID) may be used to verify whether your relay was ordered with ABC or ACB rotation.

All current and voltage inputs are connected to the SEL relay rear panel as shown in the instruction manual.

SECTION 1: SEL-200 SERIES RELAY ADDENDUM

The SEL-200 series relays with 125 Vdc optical isolator inputs now have level-sensitive inputs. These inputs compare to the original SEL-200 series relays as follows:

ORIGINAL SEL-200 SERIES OPTICAL ISOLATOR LOGIC INPUT RATING

125 Vdc: 80 - 150 Vdc; 4 milliamps at nominal voltage

NEW SEL-200 SERIES OPTICAL ISOLATOR LOGIC INPUT RATING

125 Vdc: 100 - 150 Vdc; 6 milliamps at nominal voltage

The optical isolator input does not assert for applied voltages less than 75 Vdc. The firmware remains unchanged.

SEL RELAY INSTRUCTION MANUAL ADDENDUM

JUMPER INSTALLATION INSTRUCTIONS FOR ALL 200-SERIES RELAYS EXCEPT SEL-279 AND SEL-279H

The power available from these ports is limited and should be used only for SEL-RDs, SEL-DTAs, dc-powered modems, or other low-wattage devices approved by SEL.

The power is available on either Port 1 or Port 2R. Port 2F, located on the front of the relay, does NOT have power available.

To install jumpers for supplying power through the rear EIA RS-232-C ports on all SEL-200 series relays (except SEL-279 and SEL-279H Relays), perform the following steps:

1. Remove the relay top cover or withdraw the main circuit board.

2. Locate jumpers JMP12 (+5 Vdc), JMP13 (+12 Vdc) and JMP14 (-12 Vdc) near the AUX INPUT connector.

3. Remove and install the needed jumpers in the "on" position.

4. Replace the top cover or re-insert the main circuit board. (Ensure that the board is correctly seated and the cables to the power supply and input transformers are reconnected.)

SEL-200 SERIES (SHALLOW) RELAY HARDWARE ADDENDUM

The shallow SEL-200 series hardware brings a reduction in unit depth and weight. It compares to the original SEL-200 series relay hardware as follows:

ORIGINAL SEL-200 SERIES RELAY HARDWARE SPECIFICATIONS

3.47" x 19.00" x 11.66" (8.81 cm x 48.26 cm x 29.62 cm) (H x W x D)

16 pounds (7.3 kg)

SEL-200 SERIES (SHALLOW) RELAY HARDWARE SPECIFICATIONS

3.47" x 19.00" x 9.00" (8.81 cm x 48.26 cm x 22.86 cm) (H x W x D)

12 pounds (5.5 kg)

Depth (dimension D) is to the end of the rear panel terminal blocks.

This hardware is also equipped for low-level testing. The firmware remains unchanged.

All other specifications remain the same. The shallow SEL-200 series relay dimensions, panel cutout, and drill diagrams are on the following page.

17.25"
(438.2mm)

0.80"
(20.3mm)

8.20"
(208.3mm)
semi-flush
mounting

5.60"   flange is reversible
(142.2mm) for projection mounting

SEL-2XX

SCHWEITZER ENGINEERING LABORATORIES
PULLMAN WASHINGTON USA

3.47"
(88.1mm)

19.00"
(482.6mm)

17.63"
(447.7mm)

3.00"(76.2mm)
1.75"(44.4mm)
optional

3.60"
(91.4mm)

18.31"
(465.1mm)

7/32" (5.5mm) dia.
for #10 or 5mm screw
(4 places)

DWG. 1097-I01
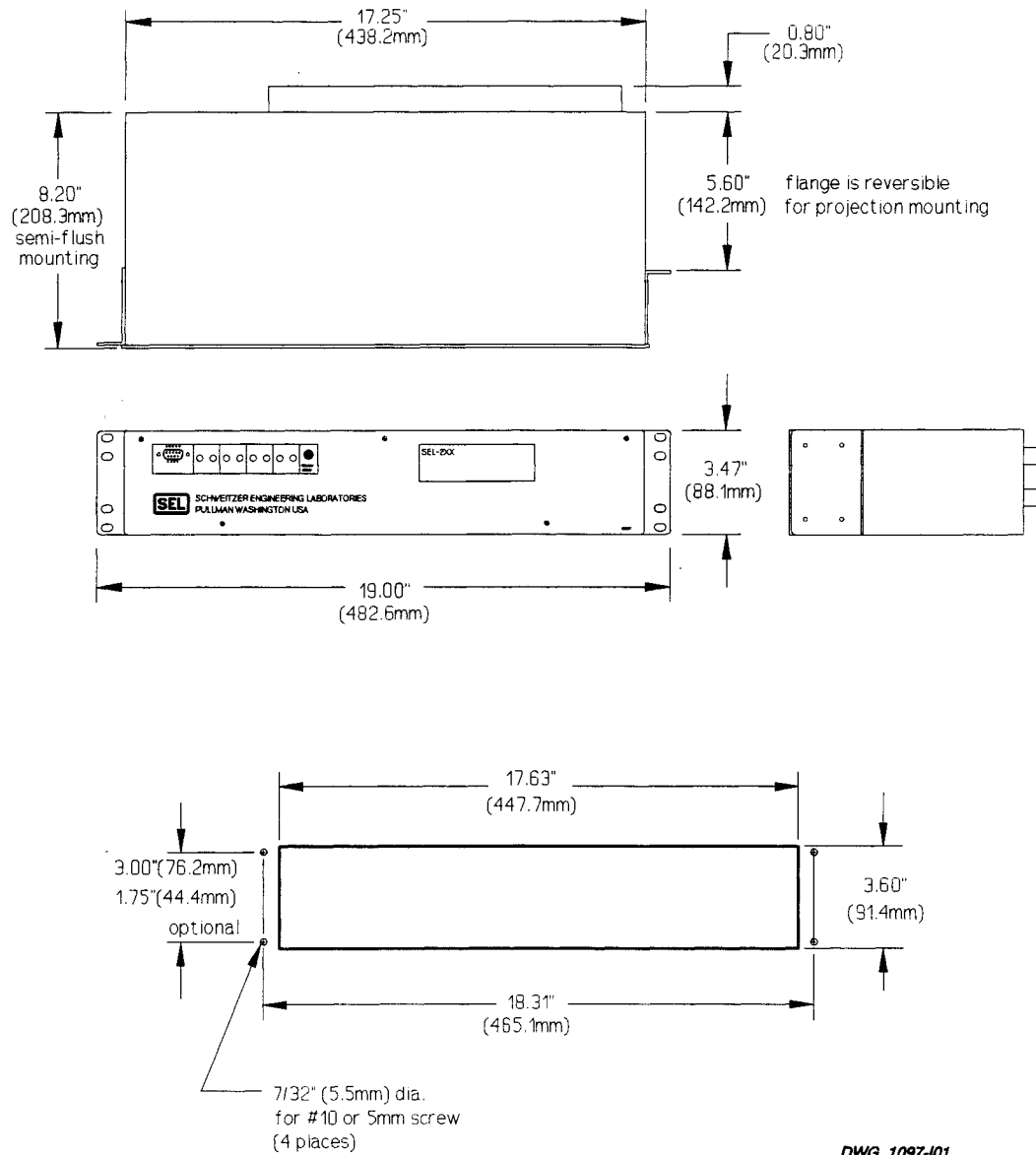
SEL-200 Series (Shallow) Relay Dimensions, Panel Cutout, and Drill Diagrams

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.
20020212	This revision includes the following changes: – Replaced Standard Product Warranty page with warranty statement on cover page. **Appendix A:** – Updated Firmware Version information.
970421	This revision includes the following changes: **Appendix A:** – Added New Firmware Versions.

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INTRODUCTION

GETTING STARTED

If you are not familiar with this relay, we suggest that you read this introduction, then perform the Initial Checkout Procedure in Section 7: MAINTENANCE & TESTING.

OVERVIEW

The SEL-251CD Relay is designed to protect distribution buses and backup distribution feeders for all fault types. It is intended for use on grounded systems with delta-connected voltage tranformers. The following list outlines protective features, performance, and versatility gained when applying the SEL-251CD Relay to your installations.

- Develop traditional and advanced schemes using flexible SELOGIC™ Control Equations
- Phase overcurrent elements have voltage and distance control for load security
- Negative-sequence elements reject load for more sensitive phase fault protection
- Ground/Residual overcurrent elements cover ground faults
- Choose fast or electromechanical reset characteristic for time-overcurrent elements
- Undervoltage logic detects high-side transformer fuse operations
- Six selectable setting groups cover all bus protection contingencies
- Circuit breaker monitor sums interrupted current in each pole to aid maintenance
- Selectively backup distribution feeder relays
- Eleven-cycle event report simplifies fault and system analysis
- Comprehensive voltage, current, power, unbalance, and demand metering
- Connects to SEL-RD Relay Display for easy information access

The SEL-251CD Relay improves every aspect of bus protection.

- Security: Phase distance supervision avoids load encroachment
- Reliability: Field-proven hardware; new backup concepts
- Sensitivity: Negative-sequence overcurrent elements for better phase fault coverage
- Flexibility: SELOGIC Control Equations handle virtually every conceivable scheme
- Capability: Brings transmission relay features to distribution applications
- Economy: Low price and unique features make the relay an exceptional value

GENERAL DESCRIPTION

The SEL-251CD Relay protects and monitors distribution busses and backs up distribution feeder relays. It offers important new and unique features, like user-programmable SELOGIC Control Equations, negative-sequence overcurrent elements, and selectable setting groups. The advanced relay design enhances security, reliability, sensitivity, and operation.

SELOGIC Control Equations: The Next Step in Programmable Relay Logic

In 1987, SEL invented Programmable Mask Logic. The SEL-251CD Relay offers SELOGIC Control Equations, the next step in user-programmability. SELOGIC Control Equations include ANDing, ORing, and inverting functions, timing, and programmable inputs and outputs. SELOGIC Control Equations add power and flexibility while simplifying programming.

Phase, Ground, and Negative-Sequence Overcurrent Protection

Phase and negative-sequence overcurrent elements detect phase faults. Negative-sequence overcurrent elements reject three-phase load to provide more sensitive coverage of phase-to-phase faults. Phase overcurrent elements are needed only for three-phase faults where negative-sequence quantities are not produced.

On heavily-loaded feeders, phase distance or undervoltage torque control of phase overcurrent elements adds security. Choose between three-phase and single-phase-pair phase distance or undervoltage torque control. When phase overcurrent elements are used only for three-phase faults, three-phase, phase distance or undervoltage torque control enhances security.

Ground/Residual overcurrent elements detect ground faults, and external inputs can torque control selected overcurrent elements.

There are two reset characteristic choices for the time-overcurrent elements. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates electromechanical induction disc elements where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current between zero and pickup.

Six Selectable Groups of Settings and Logic

The relay stores six setting groups. Select the active setting group by contact input or command. Use these setting groups to cover a wide range of distribution bus protection contingencies. Selectable setting groups make the SEL-251CD Relay ideal for applications requiring frequent setting changes.

Circuit Breaker Monitor Tracks Breaker Performance and Helps Maintenance Planning

Separate circuit breaker trip counters differentiate and tally relay-initiated trips and external trips. Running sums of interrupted current for relay and external trips indicate breaker wear on a pole-by-pole basis. Use these data to schedule breaker maintenance.

Trip failure logic provides alarm and breaker failure functions. A close failure alarm indicates circuit breaker closing circuit or mechanism problems. The trip circuit monitor detects abnormal open or short circuits in the circuit breaker tripping circuit or status input.

Analyze Operations Using Event Reports

Eleven-cycle event reports triggered by user selected conditions provide the current, voltage, and sequence-of-events information you need to understand relay and circuit breaker performance, as well as stress on the protected system for every fault.

Comprehensive Metering Supports Protection, Operation, and Demand Analysis

The relay measures phase and zero-sequence currents, phase-to-phase voltages, as well as MW and MVAR. Demand and peak demand values for current, MW, and MVAR are also available. Metering also supports protection, because you can inspect the quantities monitored by relay elements. Check for load encroachment and unbalance through instantaneous, demand, and peak-demand measurements.

Access SEL-251CD Relay Information Via the SEL-RD Relay Display

You can connect up to four SEL-251CD Relays to one SEL-RD Relay Display. Access relay target, meter, status, fault history, and circuit breaker information via the relay display. You can even change the active setting group via the display.

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GENERAL SPECIFICATIONS

Voltage Inputs
120 volt nominal phase-to-phase, three-phase, 3-wire connection
150 volt phase-to-phase saturation limit

Current Inputs
5 A nominal   110 A saturation limit
15 A continuous   500 A one second thermal rating

Output Contact Current Ratings
30 A make per IEEE C37.90
6 A carry continuously; MOV protection provided

Optical Isolator Logic Input Ratings
24 Vdc: 15 - 30 Vdc   125 Vdc: 80 - 150 Vdc
48 Vdc: 30 - 60 Vdc   250 Vdc: 150 - 300 Vdc
Current = 4 mA at nominal voltage

Power Supply
24/48 Volt: 20 - 60 Vdc; 125/250 Volt: 85 - 350 Vdc or 85 - 264 Vac
10 watts nominal, 14 watts max. (all output relays energized)

Communications
Two EIA RS-232-C serial communications ports; Port 2 of the SEL-251CD Relay has front and rear panel connectors.

Dimensions
3.47" x 19.00" x 9.00" (8.81 cm x 48.26 cm x 22.86 cm) (H x W x D)
Depth (D) is to the end of the rear panel terminal blocks

Time Code Input
Relay accepts demodulated IRIG-B time code input

Mounting
Available in horizontal and vertical mounting configurations

Dielectric Strength
V, I inputs: 2500 Vac for 10 seconds
Other: 3000 Vdc for 10 seconds (excludes EIA RS-232-C)

Operating Temperature
-40°F to 158°F (-40°C to 70°C)

Environment
IEC 68-2-30 Temperature/Humidity Cycle Test - six day (type tested)

Interference Tests
IEEE C37.90 SWC Test (type tested); IEC 255-6 Interference Test (type tested)
IEC 801-4 Electrical Fast Transient/Burst (type tested)

Impulse Tests
IEC 255-5 0.5 Joule, 5000 Volt Test (type tested)

RFI Tests
IEEE C37.90.2-199X (draft) Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

Vibration and Shock Test	IEC 255-21-1 & -2, Class 1 Test (type tested)
ESD Test	IEC 801-2 Electrostatic Discharge Test (type tested)
Unit Weight	12 pounds (5.5 kg), SEL-251CD Relay
Shipping Weight	20 pounds (9.1 kg), SEL-251CD Relay, including one instruction manual.
Burn-in Temperature	Each relay is burned in at 140°F (60°C) for 96 hours.
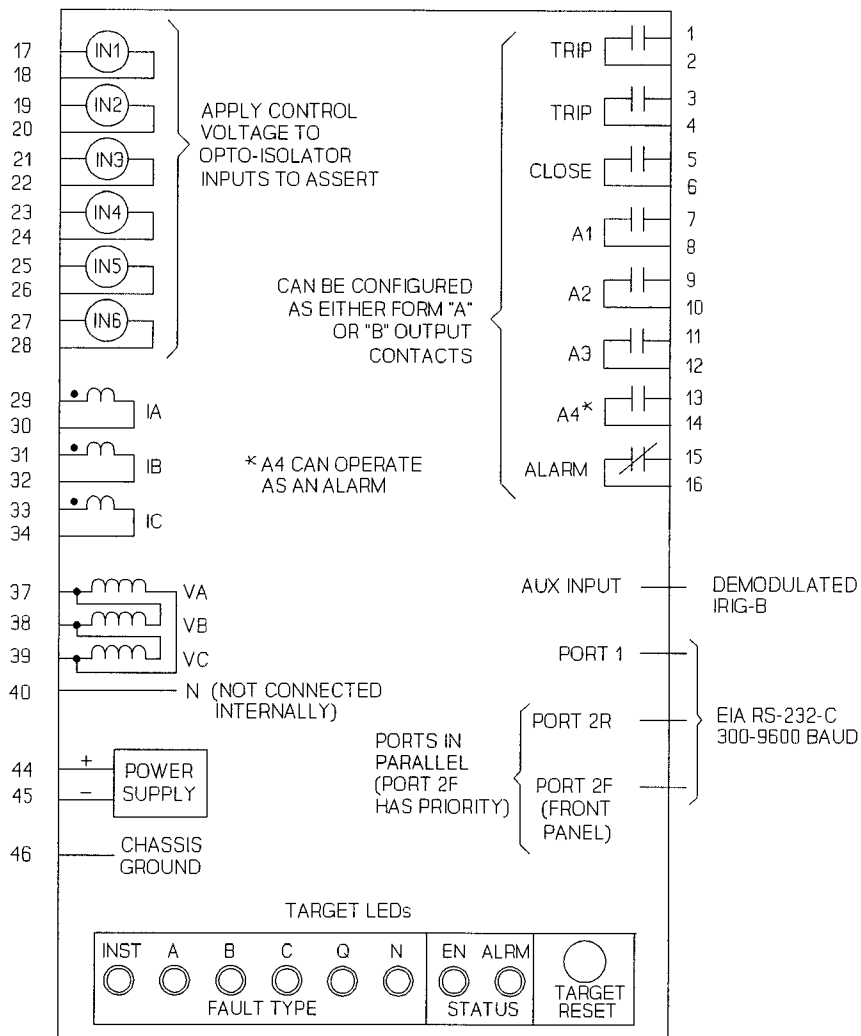
Figure 2.1: SEL-251CD Relay Inputs, Outputs, and Targets Diagram

FUNCTIONAL SPECIFICATIONS

Phase Overcurrent Elements for Phase and Three-Phase Faults - See Figures 2.14, 2.17, and 2.19

51T   Phase Time-Overcurrent Element
- Curve families: moderately inverse, inverse, very inverse, extremely inverse
- Time dial: 0.5 to 15.00 in 0.01 steps.
- Pickup (51P): 1 to 12 A ±2% of setting ±0.1 A secondary
- Time delay or one cycle reset time
- Timing: ±5% and ±1 cycle for currents between 2 and 20 multiples of pickup
- Internally and externally torque controllable

50LT   Phase Definite-Time Overcurrent Element
- Pickup (50L): 0.5 to 100 A ±2% of setting ±0.1 A secondary
- Time delay: 0 to 16,000 cycles in 1 cycle steps
- Internally and externally torque controllable

50MT   Phase Definite-Time Overcurrent Element
- Pickup (50M): 0.5 to 100 A ±2% of setting ±0.1 A secondary
- Time delay: 0 to 16,000 cycles in 1 cycle steps
- Internally and externally torque controllable

50H   Phase Instantaneous Overcurrent Element
- Pickup: 0.5 to 100 A ±2% of setting ±0.1 A secondary

50C   Phase Instantaneous Overcurrent Element
- Pickup: 0.5 to 100 A ±2% of setting ±0.1 A secondary
- Can be used to override voltage control through TCI setting choice

Negative-Sequence Overcurrent Elements for Phase-to-Phase Faults - See Figure 2.16

51QT   Negative-Sequence Time-Overcurrent Element
- Element measures 3 I_2 negative-sequence current
- Curve families: moderately inverse, inverse, very inverse, extremely inverse
- Time dial: 0.5 to 15.00 in 0.01 steps.
- Pickup (51QP): 1 to 12 A ±3% of setting ±0.18 A secondary
- Time delay or one cycle reset time
- Timing: ±5% and ±1 cycle for currents between 2 and 20 multiples of pickup
- Externally torque controllable

50QT   Negative-Sequence Definite-Time Overcurrent Element
- Element measures 3 I_2 negative-sequence current
- Pickup (50Q): 0.5 to 100 A ±3% of setting ±0.18 A secondary
- Time delay: 0 to 16,000 cycles in 1 cycle steps
- Externally torque controllable

Ground/Residual Overcurrent Elements for Ground Faults - See Figure 2.16

51NT   Ground/Residual Time-Overcurrent Element
- Curve families: moderately inverse, inverse, very inverse, extremely inverse
- Time dial: 0.5 to 15.00 in 0.01 steps
- Pickup (**51NP**): 0.25 to 12 A secondary
- Time delay or one cycle reset time
- Timing: ±5% and ±1 cycle for currents between 2 and 20 multiples of pickup
- Externally torque controllable

50NLT Ground/Residual Definite-Time Overcurrent Element
- Pickup (**50NL**): 0.5 to 100 A secondary (for $1 \leq 51NP \leq 12$ A secondary)
  - 0.25 to 50 A secondary (for $0.5 \leq 51NP < 1$ A secondary)
  - 0.125 to 25 A secondary (for $0.25 \leq 51NP < 0.5$ A secondary)
- Time delay: 0 to 16,000 cycles in 1 cycle steps
- Externally torque controllable

50NH   Ground/Residual Instantaneous Overcurrent Element
- Pickup: same range as **50NLT**
- Externally torque controllable

Accuracy
- Residual element pickup accuracy is dependent upon the 51NP setting. Pickup accuracy of the 51NP, 50NL, and 50NH elements is shown below in the given 51NP setting range.

1.0	$\leq 51NP \leq$	12.0 A sec	Pickup ±2% ±0.100 A sec
0.5	$\leq 51NP <$	1.0 A sec	Pickup ±2% ±0.050 A sec
0.25	$\leq 51NP <$	0.5 A sec	Pickup ±2% ±0.025 A sec

Phase Distance Torque Control Elements for Load Security (21P) - See Figure 2.19

- 21AB, 21BC, 21CA Phase-to-Phase Distance Elements
- Setting Range: 1 to 64 ohms, secondary; 0° to 90° maximum torque angle
- User selects either three-phase or phase-to-phase distance element
- Single zone, self-polarized mho
- Control can be overridden by **50C** element through TCI setting choice

Voltage Element for Healthy/Low Voltage Indication or Internal Control (27) - See Figure 2.17

- 27AB, 27BC, 27CA Phase-to-Phase Voltage Elements
- Setting Range: 0 to 140 V line-to-line secondary ±5%, ±1 V
- Two setting limits: 27H and 27L (high and low, respectively)
- 27 element asserts only if voltage is between 27H and 27L
- User selects either three-phase or phase-to-phase voltage condition
- Implement undervoltage load shedding scheme
- Internally torque control selected phase overcurrent elements
- Detect high-side transformer fuse operations

Time Delayed 52A or 52B Functions Handle Inrush

The time delay pickup and time delay dropout settings (52APU and 52ADO, respectively) are provided to generate the **52AT** and **52BT** functions. The **52AT** and **52BT** bits can be used to supervise overcurrent elements for inrush conditions.
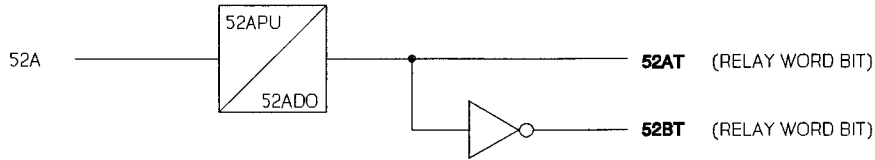
Figure 2.2: Time Delayed 52A and 52B Functions

Trip Failure Timer Detects Breaker Failure or Slow Trip - See Figure 2.21

A relay trip starts a trip failure timer. If the trip condition lasts longer than the TFT setting, the **TF** bit in the Relay Word asserts. The **TF** bit deasserts 60 cycles after the trip condition drops out. The **TF** bit can be assigned to an output contact to alarm for slow trips or to provide breaker failure tripping. It can also be used to trigger an event report.

Close Failure Timer Detects Failure to Close or Slow Close - See Figure 2.22

A close failure timer monitors the length of time the CLOSE output contact remains asserted. If CLOSE output contact assertion exceeds the CFT time setting, the close attempt is unsuccessful. The relay opens the CLOSE output contact and the **CF** bit in the Relay Word asserts. The **CF** bit asserts for 60 cycles. Use the **CF** bit to alarm for close failures or slow-close conditions and to trigger event reports.

Trip Circuit Monitor Alarm Checks Trip Circuit and Verifies Circuit Breaker Status Input

You can assign one of the six programmable inputs to the trip circuit monitor (TCM) logic.
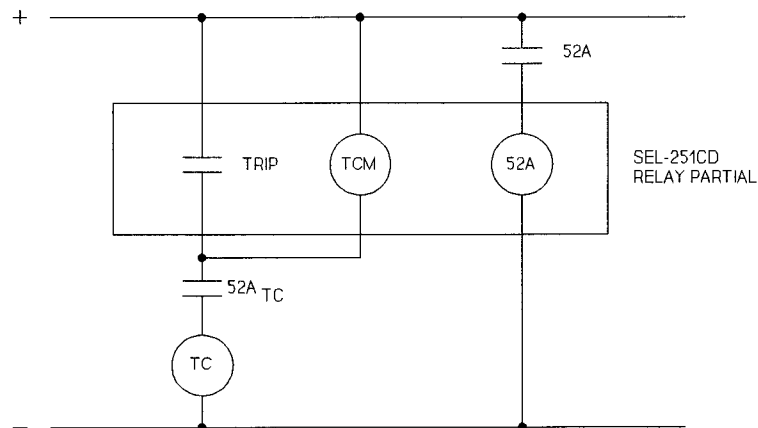
Figure 2.3: Trip Circuit Monitor (TCM) DC Voltage Connections

When the circuit breaker is closed (consequently 52A$_{TC}$ is closed) and the TRIP output contact is not asserted, the TCM input allows a few milliamperes of current through the trip coil. The voltage drop is across the TCM input because the input has a much higher impedance than the trip coil.

Trip circuit monitor logic ensures that the 52A and TCM inputs agree. When the circuit breaker is closed, inputs 52A and TCM are energized; 52A and 52A$_{TC}$ contacts are closed. When the circuit breaker is open, inputs 52A and TCM are de-energized; 52A and 52A$_{TC}$ contacts are open. If the two inputs disagree for 60 cycles, the trip circuit monitor alarm (**TCMA**) bit asserts in the Relay Word. The **TCMA** bit deasserts 60 cycles after the TCMA condition ends.

Table 2.1: Trip Circuit Monitor Alarm (TCMA) Truth Table

TCM input	52A	TCMA Relay Word bit	Notes
0	0	0	
0	1	1	(a)
1	0	1	(b)
1	1	0	

(a) Abnormal open circuit in TCM input/lower trip circuit path
   or a short circuit exists across the TCM input (e.g., TRIP output is asserted)
   or 52A contact short circuited or "stuck closed".

(b) 52A$_{TC}$ short circuited or "stuck closed"
   or there is an abnormal open circuit in the 52A input circuit path.
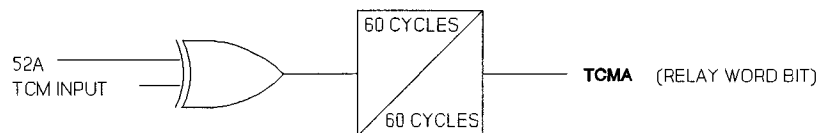
Figure 2.4: Trip Circuit Monitor Alarm (TCMA) Logic

Besides alarming for an abnormal open circuit in the trip circuit, the **TCMA** bit provides 52A input verification. It effectively compares the circuit breaker status input to $52A_{TC}$.

The **TCMA** bit can be used to alarm, cancel reclosing, or trigger event reports.

In Figure 2.3, a 52A contact is connected to relay input 52A. You can connect a 52B contact instead. Wire a 52B contact to a relay input !52A to perform the 52A function (see SEL-251CD Relay SELOGIC™ Control Equations).

SEL-251CD RELAY SELOGIC CONTROL EQUATIONS

SELOGIC Control Equations put relay logic in the hands of the relay applications engineer. Assign the inputs to suit your application, logically combine selected relay elements for various control functions, use non-dedicated timers for special applications, and assign output relays to your logic functions.

Programming SELOGIC Control Equations consist of assigning functions to the programmable inputs, designing the internal logic you need, expressing that logic in terms of the relay elements and internal logic variables, and defining the output functions. The SET command controls all SELOGIC Control Equations programming (See Section 3: COMMUNICATIONS). Section 5: APPLICATIONS gives several examples of implementing protection schemes with SELOGIC Control Equations. Sample SELOGIC Control Equations are given in Example Event Report 2 in Section 4: EVENT REPORTING.

Figure 2.5 shows how Relay Word rows R5 and R6 in Table 2.2 and the output functions are derived.

Assign Inputs to the Functions You Need

Program the six isolated inputs (IN1 through IN6) to the functions your application requires. Choose from the following functions:

			Default Logic States
SS1	Setting Group Selection Input 1	(assign to IN1 only)	0
SS2	Setting Group Selection Input 2	(assign to IN2 only)	0
SS3	Setting Group Selection Input 3	(assign to IN3 only)	0
TCP	External Torque Control (Phase and Negative-Sequence Elements)		1
!TCP	(inverted sense of TCP)		0
TCG	External Torque Control (Residual Overcurrent Elements)		1
!TCG	(inverted sense of TCG)		0
52A	Circuit Breaker Status		N/A
!52A	(inverted sense of 52A)		N/A
DC	Direct Close	(requires circuit breaker status)	0
TCM	Trip Circuit Monitor	(requires circuit breaker status)	N/A
ET	External Trigger of Event Report		0
DT	Direct Trip		0
(blank)	Unassigned input		

Inputs IN5 and IN6 also appear directly in the Relay Word for use in the programmable logic. Inputs IN1, IN2, and IN3 can be assigned to functions other than just SS1, SS2, and SS3, respectively.

Assert an input by applying control voltage to the corresponding rear panel input terminals. Control voltage polarity is not important. When a function is not assigned to an input, the relay uses the respective default logic state shown above.

RELAY WORD ROWS | RELAY WORD ELEMENTS(BITS)

R1	51P	50L	50M	51QP	50Q	51NP	50NL	50NH
R2	51T	50LT	50MT	51QT	50QT	51NT	50NLT	50H
R3	21P	50C	27		52AT	52BT	IN6	IN5
R4	PDEM	QDEM	NDEM	TF	CF	TCMA	ST	TRIP

ANY BITS IN R1, R2 AND R3 → OR → S → TS PU/DO → ST

R5
ANY BITS IN R1 AND R2 → OR → A
B, C AND D SIMILAR
ANY BITS IN R3 AND R4 → OR → E
F, G AND H SIMILAR

R6 (FIRST PART)
ANY BITS IN R1, R2 R3 AND R4 → OR → J
ANY BITS IN R1, R2 R3 AND R4 → OR → K → TK PU/DO → KT
ANY BITS IN R1, R2 R3 AND R4 → OR → L → !L

R6 (LAST PART)
ANY BITS A THROUGH !L → AND → V
W, X AND Y SIMILAR
ANY BITS A THROUGH !L → AND → Z → TZ PU/DO → ZT

ANY BITS IN R1, R2 R4 AND R6 → OR → TR
ER SIMILAR
ANY BITS IN R1, R2 R3 AND R4 → OR → A1
A2 SIMILAR
ANY BITS IN R1, R3 R4 AND R6 → OR → A3
ANY BITS IN R2, R3 R4 AND R6 → OR → A4

close TRIP output contacts = TR+...
trigger event report = ER+...
close A1 output contact = A1
⋮
close A4 output contact = A4

Figure 2.5: SEL-251CD Relay SELOGIC Control Equations Block Diagram

Select Combinations of Relay Elements You Need for Tripping and Other Purposes

The 48-bit Relay Word contains relay elements, intermediate logic results, and programmable logic variables.

Table 2.2: SEL-251CD Relay Word

R1	51P	50L	50M	51QP	50Q	51NP	50NL	50NH
R2	51T	50LT	50MT	51QT	50QT	51NT	50NLT	50H
R3	21P	50C	27		52AT	52BT	IN6	IN5
R4	PDEM	QDEM	NDEM	TF	CF	TCMA	ST	TRIP
R5	A	B	C	D	E	F	G	H
R6	J	KT	!L	V	W	X	Y	ZT

! indicates NOT

51P	Phase time-overcurrent element pickup
50L	Phase definite-time overcurrent element pickup
50M	Phase definite-time overcurrent element pickup
51QP	Negative-sequence time-overcurrent element pickup
50Q	Negative-sequence definite-time overcurrent element pickup
51NP	Ground/Residual time-overcurrent element pickup
50NL	Ground/Residual definite-time overcurrent element pickup
50NH	Ground/Residual instantaneous overcurrent element
51T	Phase time-overcurrent element
50LT	Phase definite-time overcurrent element
50MT	Phase definite-time overcurrent element
51QT	Negative-sequence time-overcurrent element
50QT	Negative-sequence definite-time overcurrent element
51NT	Ground/Residual time-overcurrent element
50NLT	Ground/Residual definite-time overcurrent element
50H	Phase instantaneous overcurrent element
21P	Single zone, self-polarized mho phase distance element for internal torque control
50C	Phase instantaneous overcurrent element (can override control by **21P** or **27**)
27	Phase undervoltage element for internal torque control and blown-fuse detection
52AT	Time delayed 52A
52BT	Inverse of **52AT**
IN6	Input IN6 bit; asserts for control voltage applied to input IN6
IN5	Input IN5 bit; asserts for control voltage applied to input IN5
PDEM	Phase demand current threshold exceeded
QDEM	Negative-sequence demand current threshold exceeded
NDEM	Ground/Residual demand current threshold exceeded
TF	Trip failure condition
CF	Close failure condition
TCMA	Trip circuit monitor alarm: asserts for abnormal open or short circuit in the circuit breaker tripping circuit or circuit breaker status input (52A)
ST	Output from timer TS, driven by any OR-combination of elements in R1 through R3 assigned to setting S
TRIP	Follows state of the TRIP output contacts

| A B C D | Select any OR-combination of elements in R1 and R2 |
| E F G H | Select any OR-combination of elements in R3 and R4 |

J	Select any OR-combination of elements in R1 through R4
KT	Output from timer TK, driven by any selected OR-combination of elements in R1 through R4 assigned to setting K
!L	Output from an inverter, driven by any selected OR-combination of elements in R1 through R4 assigned to setting L
V W X Y	Select any AND-combination of elements A through !L
ZT	Output from timer TZ, driven by any selected AND-combination of elements A through !L assigned to setting Z

Time Delayed Variables ST, KT, and ZT

Relay Word variables **ST**, **KT**, and **ZT** are outputs from time delay pickup/dropout timers TS, TK and TZ, respectively. TS and TK are driven by any OR-combination of Relay Word elements in R1...R3 and R1...R4, respectively. Any AND-combination of Relay Word elements **A** through **!L** may drive timer TZ.
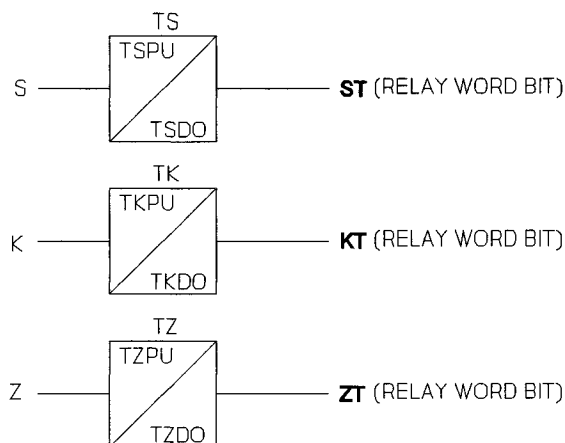
Figure 2.6: Relay Word Bit Realizations

Use !L for Inversion

Variable L is any OR-combination of elements in R1 through R4. The inverse of L (!L) is in the Relay Word. Also, output contacts A1 through A4 and the ALARM can be factory-configured as either "a" or "b" contacts for an additional inversion.
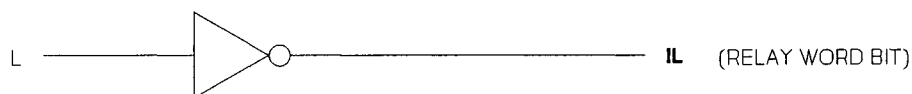
Figure 2.7: Relay Word Bit Realization

Programming Output Contacts

Write output equations to define tripping and other control functions.

TRIP: Select any OR-combination of elements in R1, R2, R4, and R6 via the TR(1246) variable. Direct Trip input and OPEN command also assert TRIP. See Figure 2.21 for information about TRIP output contact operation.

A1, A2: Select any OR-combination of elements in R1, R2, R3, and R4.

A3: Select any OR-combination of elements in R1, R3, R4, and R6.

A4: Select any OR-combination of elements in R2, R3, R4, and R6. Optionally, A4 can operate as an ALARM by placement of jumper JMP3 (the jumper has positions A4 and ALARM).

The CLOSE and ALARM functions have dedicated outputs:

CLOSE: Asserts by DC input, or CLOSE command (see Figure 2.22 for an illustration of CLOSE output contact operations).

ALARM: The ALARM output closes for the following conditions:
- Three unsuccessful Level 1 access attempts: 1 second pulse
- Any Level 2 attempt: 1 second pulse
- Self-test failures: permanent contact closure or 1 second pulse depending on which test fails (see Table 2.5)
- The ALARM output closes momentarily when relay settings, setting groups, or passwords are changed. It also closes when a date is entered, if the year stored in EEPROM differs from the year entered (see DATE command).

All output relay contacts may be configured as "a" or "b" contacts with soldered wire jumpers JMP4 through JMP11 (each jumper has positions A and B). All relay contacts are rated for circuit breaker tripping duty.

Viewing Logic Equations

Use the SHOWSET command to print all relay settings including the SELOGIC Control Equations configuration. You can inspect settings in the sample event report in Section 4: EVENT REPORTING.

SELOGIC Control Equations Settings in Each Setting Group

When you switch groups, you switch logic settings as well as relay element settings. You can program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, and cogeneration on/off.

TARGETS

Read targeting information locally by inspecting the LEDs or remotely with the TARGET command and event reports. The TARGET command can access other information as well (see Section 3: COMMUNICATIONS).

The INST target indicates that no overcurrent condition in Relay Word row R1 has been asserted longer than the ITT (instantaneous target time) timer setting before TRIP asserts. This gives you control over what qualifies as a close-in fault.

The phase current indicators (A, B, C) show which phases exceed the 51P pickup setting at the time of trip.

The negative-sequence and residual current indicators (Q, N) similarly show if these currents exceed the respective 51QP and 51NP pickup settings at the time of trip.

The last two indicators (EN, ALRM) show the state of the relay (enabled/normal operation or system alarm).

```
┌─────────────────────────────────────┬──────────────┐
│ INST   A    B    C    Q    N         │ EN   ALRM    │
│  ◯    ◯    ◯    ◯    ◯    ◯          │  ◯    ◯      │
│              FAULT TYPE              │   STATUS     │
└─────────────────────────────────────┴──────────────┘
```
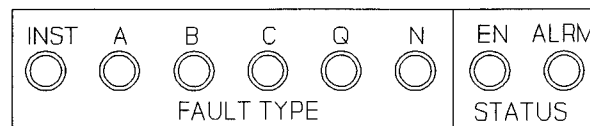
Figure 2.8: SEL-251CD Relay Front Panel Target LEDs

The FAULT TYPE LEDs latch and remain lit until the TRIP output deasserts and one of the following occurs:

- Next trip occurs
- Operator presses front panel TARGET RESET button
- Operator executes TARGET R command

When a new TRIP occurs, the FAULT TYPE LEDs clear, then display and latch the FAULT TYPE targets for the new TRIP condition.

When an operator presses the TARGET RESET button, all eight LEDs illuminate for a one-second lamp test and to indicate that the relay is operational.

SELECTABLE SETTING GROUPS

The relay accepts six groups of relay and logic settings.

Program relay elements and logic with the SET command. To program Group 1 settings and logic, use SET 1 and provide the requested information. The COPY command makes it easy to copy settings and logic from one group to another (e.g., **COPY 1 4** copies Group 1 to Group 4). Afterward, you can edit Group 4 settings and logic with the SET command.

The relay determines which group of settings and logic to use by monitoring the setting group selection inputs (SS1, SS2, and SS3). To use inputs, program one or more of the setting selection inputs SS1, SS2, and SS3 to the respective inputs IN1, IN2, and IN3. You can also use the GROUP command to specify a setting group.

	Table 2.3: Setting Group Selection Input Truth Table		
SS3	SS2	SS1	
0	0	0	GROUP Command Selection
0	0	1	Group 1
0	1	0	Group 2
0	1	1	Group 3
1	0	0	Group 4
1	0	1	Group 5
1	1	0	Group 6
1	1	1	GROUP Command Selection

If SS1, SS2, or SS3 is not assigned to an input, it defaults to 0. If no inputs are assigned as setting group selection inputs the GROUP command entry controls group selection. With only SS1 assigned, GROUP command selection determines settings to use if the input assigned to SS1 is not asserted. If the input is asserted, setting Group 1 is used.

For example, to switch between Group 1 and Group 5, program input IN1 to SS1 and use the GROUP command to select Group 5. With IN1 asserted, the relay uses Group 1. With IN1 deasserted, it uses Group 5.

When the status of any assigned setting group selection input changes, the relay waits a settable time period (TGR) for inputs to stabilize before changing the active setting group. Thus, if a setting group selection input status changes and reverts to its previous state before TGR expires, the relay does not change the active setting group. The TGR setting is one of several global settings and is entered with the SET G command.

Active setting group changes (via setting group selection inputs or GROUP command) disable the relay for less than 0.5 seconds to allow loading of new active settings. The ALARM output contacts close during this time and all timers and relay elements reset.

The DEMR setting allows you to specify whether or not demand values for current, MW, and MVAR are reset when the active setting group changes. The relay resets demand values as it would for METER RD execution. The following example illustrates a situation when you should reset demand values.

You might want to change the active setting group for distribution feeder switching where significant load is removed from the feeder. If the new active setting group has lower demand current thresholds (PDEM, QDEM, and NDEM settings) than the previous active setting group, the corresponding **PDEM, QDEM, and NDEM** demand ammeter threshold bits could assert. This is because the respective demand ammeters have not yet adjusted to the lower loading level, as dictated by the relatively long demand ammeter time constant (setting DATC = 5-60 minutes). If **PDEM, QDEM, and NDEM** are assigned to programmable output contacts (A1 - A4), a false alarm would result. To overcome this problem, set DEMR = Y. With this setting, the relay resets demand values to zero when the active setting group changes.

The DEMR setting is entered with the SET G command. See Section 3: COMMUNICATIONS for more details on the SET, COPY, GROUP, and METER RD commands.

CIRCUIT BREAKER MONITOR

The SEL-251CD Relay detects every circuit breaker trip operation. It designates each trip as one caused by the relay or an external device and maintains a running count of each.

The relay also maintains a running sum of the interrupted current in each circuit breaker pole for relay and external trips. Running sums for relay trips use the current present one cycle after the trip output contacts assert. Running sums for external trips use the currents present when the circuit breaker status input (52A or !52A) indicates that the circuit breaker has opened.

You can access the circuit breaker operation data using the BREAKER commands. See Section 3: COMMUNICATIONS for more details on these commands.

METERING

The SEL-251CD Relay provides complete voltage and current metering. It also determines real and reactive power values, demand values, peak demand values, and zero-sequence current.

You can access and reset metering data using different METER commands. See Section 3: COMMUNICATIONS for more information.

SERIAL INTERFACES

Port 1 and Port 2 are EIA RS-232-C serial data interfaces.

Port 1 is located on the rear panel and is generally used for remote communications via a modem or the SEL-PRTU.

Port 2 has connectors on both the front and rear panels, designated Port 2F and Port 2R, respectively. Port 2F has priority over Port 2R. These ports are generally used for local communications. Port 2R is typically connected to a printer, SEL-RD, or SEL-DTA. Port 2F is typically used for temporary communications via a portable terminal.

When a device is plugged into Port 2F, the relay automatically begins addressing Port 2F and discontinues communication with Port 2R. When a device unplugged from Port 2F, the relay automatically resumes communication with the device connected to Port 2R.

The baud rate of each port is set by jumpers near the front of the main board. You can access these jumpers by removing either the top cover or front panel. Available baud rates are 300, 600, 1200, 2400, 4800, or 9600.

The serial data format is:

Eight data bits
Two stop bits (-E2 model) or one stop bit (-E1 model)
No parity

This format may not be changed. The serial communications protocol and port pin definitions appear in Section 3: COMMUNICATIONS.

SELF-TESTS

The relay runs a variety of self-tests. Some tests have warning and failure states, others only have failure states. The relay generates a status report after any change in self-test status.

The relay closes the ALARM contacts after any self-test fails. When it detects certain failures, the relay disables the breaker control functions and places its output driver port in an input mode. No outputs may be asserted when the instrument is in this configuration. The relay runs all self-tests on power up and before enabling new settings. During normal operation, it performs self-tests at least every few minutes.

Offset

The relay measures the offset voltage of each analog input channel and compares the value against fixed limits. It issues a warning when offset is greater than 50 millivolts in any channel and declares a failure when offset exceeds 75 millivolts. The offset levels of all channels appear in the STATUS command format.

Power Supply

Power supply voltages are limit-checked. The table below summarizes voltage limits.

Table 2.4: Power Supply Self-Test Limits		
Supply	Warning Thresholds	Failure Thresholds
+5 V	+5.3 V +4.7 V	+5.4 V +4.6 V
+15 V	+15.8 V +14.2 V	+16.2 V +13.8 V
-15 V	-15.8 V -14.2 V	-16.2 V -13.8 V

The relay transmits a STATUS message for any self-test failure or warning. A +5 volt supply failure de-energizes all output relays and blocks their operation. A ±15 volt supply failure disables protective relay functions while control functions remain intact. The ALARM relay remains closed after a power supply failure.

Random-Access Memory

The relay checks random-access memory (RAM) to ensure that each byte can be written to and read from. There is no warning state for this test. If the relay detects a problem, it transmits a STATUS message with the socket designation of the affected RAM IC. A RAM failure disables protective and control functions and closes the ALARM output relay contacts.

Read-Only Memory

The relay checks read-only memory (ROM) by computing a checksum. If the computed value does not agree with the stored value, the relay declares a ROM failure. It transmits a STATUS message with the socket designation of the affected ROM IC. A ROM failure disables protective and control functions and closes the ALARM output relay contacts.

Analog-to-Digital Converter

The analog-to-digital converter (ADC) changes voltage signals derived from power system voltages and currents into numbers for processing by the microcomputer. The ADC test verifies converter function by checking conversion time. The test fails if conversion time is excessive or a conversion starts and never finishes. There is no warning state for this test. While an ADC failure disables protective functions, control functions remain intact. The relay transmits a STATUS message and closes the ALARM relay contacts.

Master Offset

The master offset (MOF) test checks offset in the multiplexer/analog to digital converter circuit. A grounded input is selected and sampled for dc offset. The warning threshold is 50 mV; failure threshold is 75 mV. A failure pulses the ALARM contact closed for one second. The relay transmits a STATUS message for both warning and failure conditions.

Settings

The relay stores two images of the system settings in nonvolatile memory. The test compares them when the relay is initially set and periodically thereafter. If the images disagree, the setting test fails and the relay disables all protective and control functions. It transmits the STATUS message to indicate a failed test. The ALARM relay remains closed after a setting failure.

Table 2.5 shows relay actions for any self-test condition: warning (W) or failure (F).

Table 2.5: Self-Test Summary

Self-Test	Limits	Status Message	Protection Disabled	Control Disabled	Alarm Output
RAM	----	F	YES	YES	permanent contact assertion
ROM	----	F	YES	YES	permanent contact assertion
SETTINGS	----	F	YES	YES	permanent contact assertion
A/D	----	F	YES	NO	permanent contact assertion
+5 V	±0.3 V	W	NO	NO	no ALARM contact assertion
	±0.4 V	F	YES	YES	permanent contact assertion
±15 V	±0.8 V	W	NO	NO	no ALARM contact assertion
	±1.2 V	F	YES	NO	permanent contact assertion
CHANNEL OFFSETS	50 mV	W	NO	NO	no ALARM contact assertion
	75 mV	F	NO	NO	one second contact pulse
MASTER OFFSET	50 mV	W	NO	NO	no ALARM contact assertion
	75 mV	F	NO	NO	one second contact pulse

IRIG-B INPUT DESCRIPTION

The port labeled J201/AUX INPUT receives demodulated IRIG-B time code input. The IRIG-B input circuit is a 56 ohm resistor in series with an optocoupler input diode. The input diode has a forward drop of about 1.5 volts. Driver circuits should put approximately 10 mA through the diode when "on."

The IRIG-B serial data format consists of a one second frame containing 100 pulses and divided into fields. The relay decodes second, minute, hour, month, and day fields and sets the relay clock accordingly.

When IRIG-B data acquisition is activated either manually (with the IRIG command) or automatically, the relay reads two consecutive frames. It updates the older frame by one second and compares the frames. If they do not agree, the relay considers the data erroneous and discards it.

The relay reads the time code automatically about once every five minutes. It stops IRIG-B data acquisition ten minutes before midnight on New Year's Eve so the relay clock can implement the year change without interference from the IRIG-B clock.

SIGNAL PROCESSING

The relay low-pass filters all analog input channels to remove high frequency components. Next it samples each channel four times per power system cycle. After low-pass filtering, the relay digitally filters each sample with the CAL digital filter method. The CAL filter eliminates dc offset and reduces the decaying exponential offset that may be present on the input signal following a fault.

The digital filter has the properties of a double differentiator smoother and requires only addition and subtraction of data samples. Let the latest four samples of one channel be X1, X2, X3, and X4. Then the digital filter is defined:

$$P = X1 - X2 - X3 + X4.$$

This filter eliminates dc offsets. When all samples are set to the same value, the filter output is zero. It also eliminates ramps, which you may verify by setting the samples equal to 1, 2, 3, and 4. Again, the output is zero.

Every quarter-cycle, the relay computes a new value of P for each input. The current value of P combines with the previous value (renamed Q) to form a Cartesian coordinate pair. This pair represents the input signal as a phasor (P, Q). The relay processes these phasor representations of the input signals.

TORQUE CONTROL

Elements in Relay Word row R1 may be torque controlled. Elements derived from row R1 elements are torque controlled if the row R1 element is torque controlled. For example, if row R1 elements **51P** and **50NL** are torque controlled, row R2 elements **51T** and **50NLT** are also torque controlled. **51P** and **50NL** are the pickups for **51T** and **50NLT**, respectively. See Figures 2.14, 2.15, and 2.16 for more information.

Phase overcurrent elements can be externally and internally torque controlled. Negative-sequence and ground/residual overcurrent elements can only be externally torque controlled.

External Torque Control

The ETC(1) setting selects overcurrent elements to be externally torque controlled. Only overcurrent elements in Relay Word row R1 can be selected. As an example:

ETC = **51P, 50Q, 50NL**   **51P, 50Q, 50NL**, and consequently **51T, 50QT**, and **50NLT** are selected for external torque control

TCP   External Torque Control (Phase and Negative-Sequence Overcurrent Elements)

TCG   External Torque Control (Ground/Residual Overcurrent Elements)

TCP and TCG are assigned to programmable inputs. The inverted sense of TCP or TCG is available, too (!TCP or !TCG, respectively).

If input IN3 = TCP, the phase and negative-sequence overcurrent elements selected in the ETC(1) setting (**51P** and **50Q** and consequently **51T** and **50QT** in this example) are enabled for operation when input IN3 is energized. If input IN3 = !TCP, the phase and negative-sequence overcurrent elements selected in the ETC(1) setting are enabled for operation when input IN3 is de-energized.

If neither TCP or !TCP is assigned to an input, the phase and negative-sequence overcurrent elements selected in the ETC(1) setting are not externally torque controlled. The selected phase and negative-sequence overcurrent elements are always enabled with respect to external torque control.

If input IN4 = TCG, the ground/residual overcurrent elements selected in the ETC(1) setting (**50NL** and consequently **50NLT** in this example) are enabled for operation when input IN4 is energized. If input IN4 = !TCG, the ground/residual overcurrent elements selected in the ETC(1) setting are enabled for operation when input IN4 is de-energized.

If neither TCG nor !TCG is assigned to an input, the ground/residual overcurrent elements selected in the ETC(1) setting are not externally torque controlled. The selected ground/residual overcurrent elements are always enabled with respect to external torque control.

Internal Torque Control

The ITC(1) setting selects phase overcurrent elements to be internally torque controlled. Only phase overcurrent elements in Relay Word row R1 can be selected. As an example:

ITC = **51P, 50M**   **51P, 50M**, and consequently **51T** and **50MT** are selected for internal torque control

The TCI setting selects the elements which perform internal torque control:

Table 2.6: TCI Settings

Element choices for TCI			setting TCI =
21P	50C	27	
0	0	0	0
0	0	1	V
0	1	0	I
0	1	1	3
1	0	0	Z
1	0	1	5
1	1	0	6
1	1	1	7

TCI setting examples:

If you set TCI equal to V, the **27** element torque controls phase overcurrent elements selected in the ITC(1) setting (**51P** and **50M** and consequently **51T** and **50MT** in this example). If **27** asserts, the selected phase overcurrent elements are enabled with respect to internal torque control.

If you set TCI equal to 3, the phase overcurrent elements selected in the ITC(1) setting (**51P** and **50M** and consequently **51T** and **50MT** in this example) are torque controlled by "**27** + **50C**". If either **27** or **50C** assert, the selected phase overcurrent elements are enabled with respect to internal torque control.

If you set TCI equal to 0, the phase overcurrent elements selected in the ITC(1) setting (**51P** and **50M** and consequently **51T** and **50MT** in this example) are not internally torque controlled. The phase overcurrent elements are always enabled with respect to internal torque control.

Transformer Blown-Fuse Detection

Delta-wye connected distribution transformer banks are frequently protected by fuses connected in the bank high side, as shown in Figure 2.9. When one high-side fuse blows, unbalanced voltages are applied to the transformer bank and its connected load.

The SEL-251CD Relay includes logic that detects high-fuse operations by measuring the low-side voltages. The logic also rejects operations of low-side Voltage Transformer (VT) fuses.
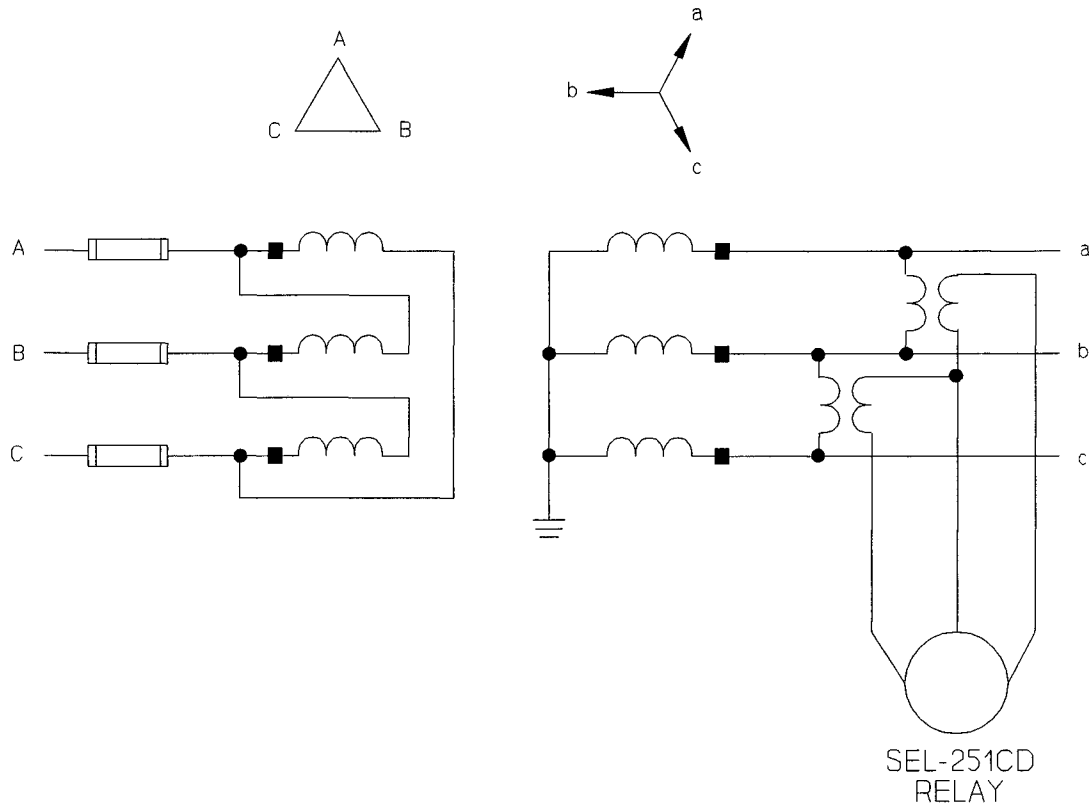
Figure 2.9: Distribution Transformer Bank Protected by High-Side Fuses

What Happens When a High-Side Fuse Blows?

When a transformer high-side fuse operates, the low-side phase-to-phase voltage magnitudes drop. One phase-to-phase voltage magnitude goes to zero, and the remaining two drop to 0.87 per unit of nominal voltage. If two high-side fuses operate, the low-side phase-to-phase voltages all go to zero.

If a VT secondary fuse blows while the transformer bank is otherwise operating normally, two of the phase-to-phase voltages presented to the relay drop to 0.58 per unit of nominal. If two VT secondary fuses operate, one phase-to-phase voltage measured by the relay goes to zero while the other two drop to 0.58 per unit.

With these facts in mind, the logic described below is easy to understand.

How Does the SEL-251CD Relay Detect Transformer Fuse Operations?

When the relay setting 27C=4, the 27 phase-to-phase undervoltage logic detects high-side fuse operations. To use the relay undervoltage logic in this application, make the following relay setting calculations:

$$27L = 0.40 \cdot Vnom$$
$$27H = 0.72 \cdot Vnom$$
$$27C = 4$$

where:

Vnom = Nominal Phase-to-Phase Voltage, V secondary

The setting option, 27C = 4, enables the following logic for the **27** Relay Word bit:

27 = (Any phase-to-phase voltage less that 0.4 pu) * (Any phase-to-phase voltage greater than 0.72 pu)

27 = (27LAB + 27LBC + 27LCA) * (!27HAB + !27HBC + !27HCA)

If a transformer fuse operates, one phase-to-phase voltage goes to zero (satisfying the left portion of the equation above) and the remaining phase-to-phase voltages stay above 0.72 per unit (satisfying the right portion of the equation). If a VT fuse operates, the phase-to-phase voltages drop below the 0.72 per unit threshold and the **27** equation is not satisfied.

Use the Detection Logic to Trip or Indicate

Since certain faults may also present these voltages to the SEL-251CD Relay, you may wish to use a nondedicated SELOGIC Control Equation timer, such as the **ST** timer to provide some coordinated time delay on pickup of the condition.

Set the SELOGIC Control Equation, S(123) = **27**. Use the time-delayed pickup timer, TSPU = 300 to 600 cycles to provide a 5- to 10-second time delay. You can use the **ST** bit, which includes the time-delayed pickup, in any of the SELOGIC Control Equations for tripping or programmable output contact operation.

DEMAND AMMETERS

The SEL-251CD Relay provides demand ammeters for phase, negative-sequence, and zero-sequence (ground/residual) currents. Peak demands are saved. The demand ammeters behave much like low-pass filters, responding to gradual trends. The demand ammeter time constant is used for all three demand ammeters. The time constant is settable from 5 to 60 minutes.

Figure 2.20 shows the phase, negative-sequence, and ground/residual demand ammeters from top to bottom. Let's concentrate on the bottom diagram (ground/residual demand ammeter) to understand demand ammeter functions in general.

Present ground/residual current (IR) is the input into the ground/residual demand ammeter and ground/residual demand current (ND(t)) is the output. If the ground/residual demand current is ND(0) at t=0 and the ground/residual current (IR) is constant, at t=DATC the ground/residual demand current will be:

$$ND(DATC) = 0.9(IR - ND(0)) + ND(0) = 0.9IR + 0.1ND(0)$$

If the ground/residual demand current was reset at t=0 (ND(0) = 0), at t=DATC the ground/residual demand current would be:

$$ND(DATC) = 0.9(IR)$$

For all demand ammeters in general, if demand current is reset at t=0 and a constant input current is applied, the demand current output will be 90% of the constant input current value at t=DATC.

Settable demand ammeter thresholds are available for all three demand ammeters in units of amps secondary. The thresholds are PDEM, QDEM, and NDEM for the phase, negative-sequence, and ground/residual demand ammeters, respectively.

If demand currents exceed a threshold, the respective Relay Word bit **PDEM**, **QDEM**, or **NDEM** is asserted. These Relay Word bits can alarm for phase overload and negative-sequence or residual current unbalance and can warn of impending overcurrent relay pickup and timing to trip due to such overload and unbalance conditions.

EVENT REPORT

The event report displays current and voltage quantities in primary units. The relay encodes relay element states, outputs, and inputs using a simple process, making the report compact and easy to interpret. Use the EVENT command to access the eleven cycle event reports. Use the HISTORY command to list summary event reports. See Section 3: COMMUNICATIONS for more information on these commands.

Event Report Triggering

Set the variable ER(1246) to any OR-combination of elements in Relay Word rows R1, R2, R4, and R6 to trigger an event report for any desired combination of conditions the relay can detect. Event reports also trigger for:

- Any TRIP output
- Assertion of an input assigned to the ET function
- TRIGGER command execution

See Section 4: EVENT REPORTING for more information on event reports.

TIME-OVERCURRENT ELEMENT CURVE-TIMING AND TIME DELAY RESET EQUATIONS

The following time-overcurrent equations are applicable to the phase, negative-sequence, and ground/residual time-overcurrent elements.

There are two reset characteristic choices for the phase, negative-sequence, and ground/residual time-overcurrent elements via the 51RS, 51QRS, and 51NRS settings, respectively. One choice resets the elements if current drops below pickup for at least one cycle. The other choice (time delay reset) emulates electromechanical induction disc elements, where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current between zero and pickup. The time delay reset equations $(t_r = ...)$ are given below.

t_M = curve operating time in seconds
t_r = reset time in seconds (for time delay reset)
TD = time dial setting
M = multiples of pickup. For curve operating time (t_M), $M > 1$.
        For reset time (t_r), $M \le 1$.

Curve 1: Moderately Inverse - see Figure 2.10

$$t_M = TD \left[0.157 + \frac{0.668}{M-1} \right] \qquad t_r = \frac{TD}{0.949 - 0.936M}$$

Curve 2: Inverse - see Figure 2.11

$$t_M = TD \left[0.180 + \frac{5.95}{M^2-1} \right] \qquad t_r = \frac{TD}{0.172 - 0.168M}$$

Curve 3: Very Inverse - see Figure 2.12

$$t_M = TD \left[0.0963 + \frac{3.88}{M^2-1} \right] \qquad t_r = \frac{TD}{0.246 - 0.240M}$$

Curve 4: Extremely Inverse - see Figure 2.13

$$t_M = TD \left[0.0352 + \frac{5.67}{M^2-1} \right] \qquad t_r = \frac{TD}{0.194 - 0.192M}$$
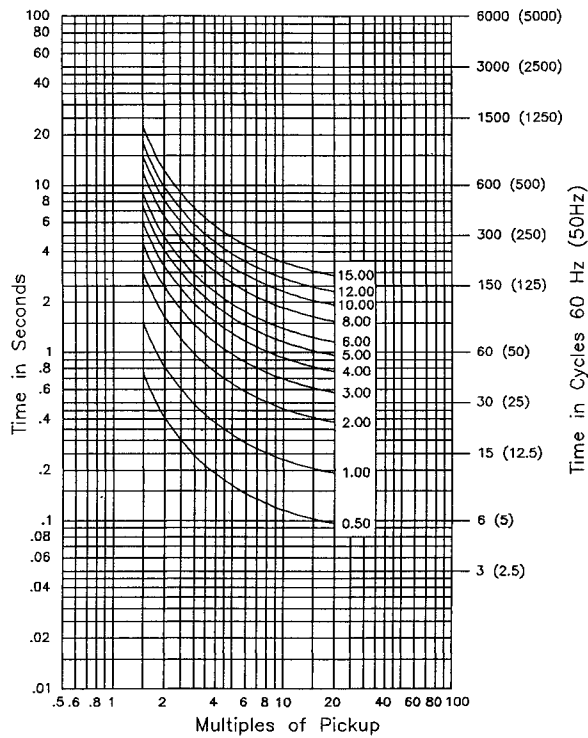
Figure 2.10: Moderately Inverse Curves
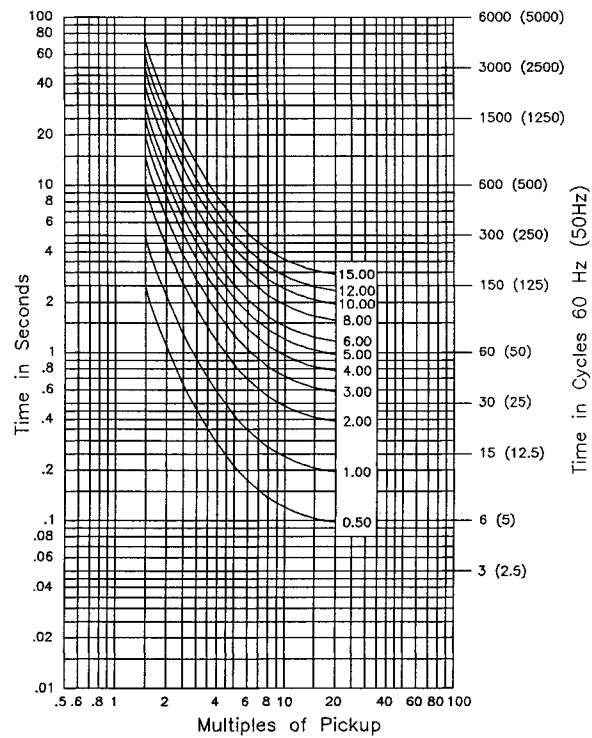
Figure 2.11: Inverse Curves
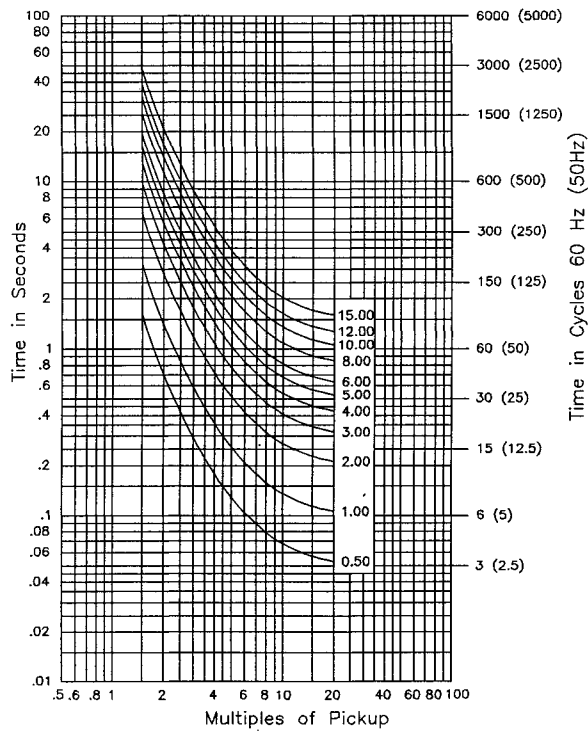
Figure 2.12: Very Inverse Curves
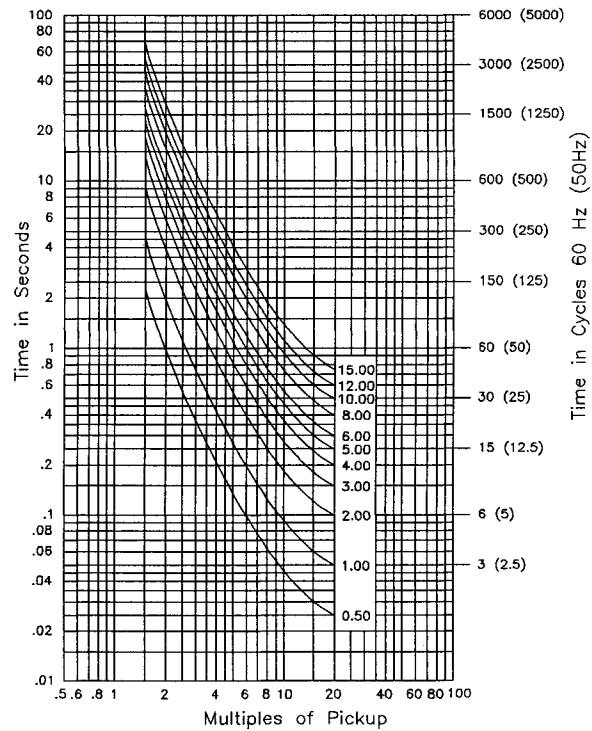
Figure 2.13: Extremely Inverse Curves
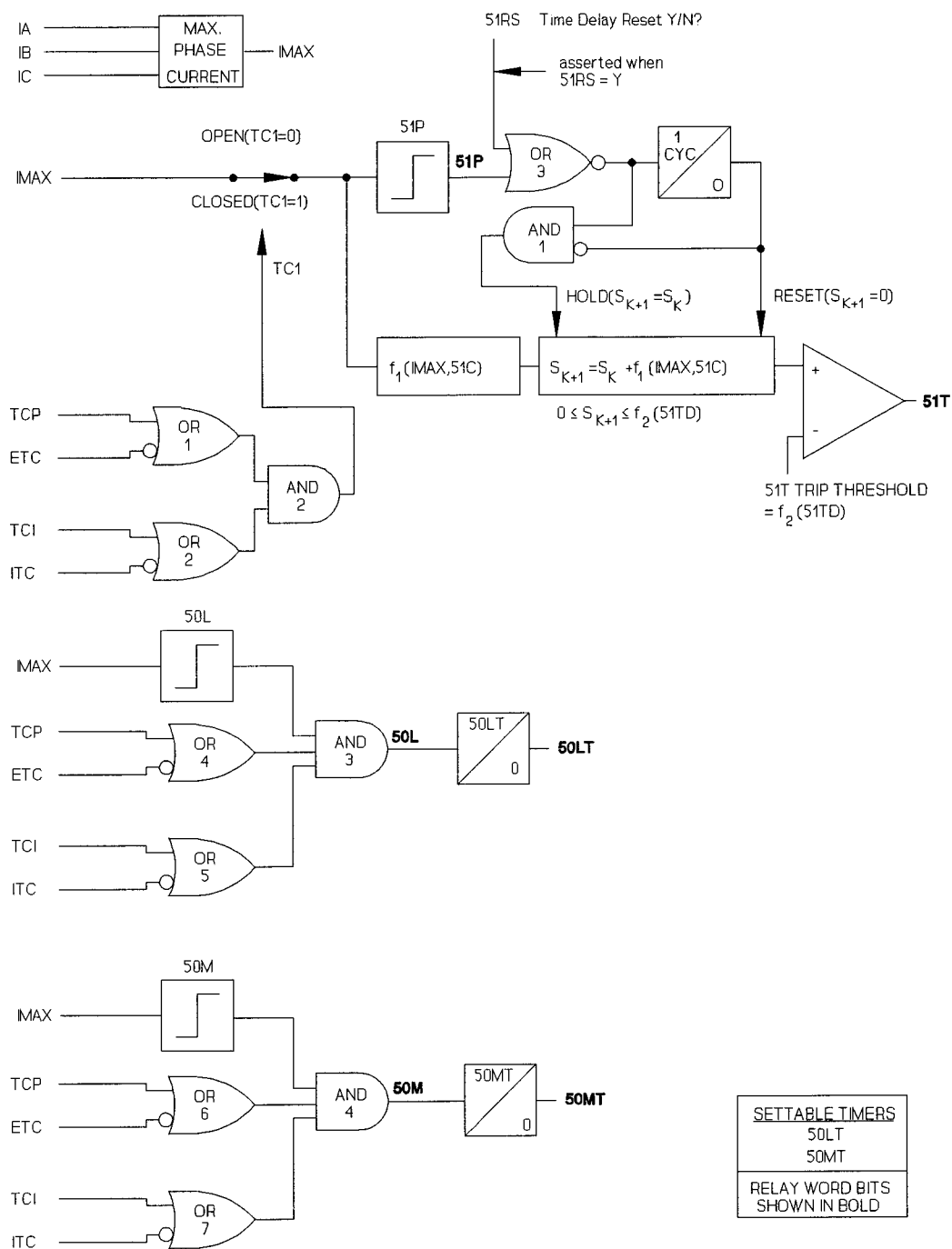
Figure 2.14: SEL-251CD Phase Overcurrent Logic Diagrams
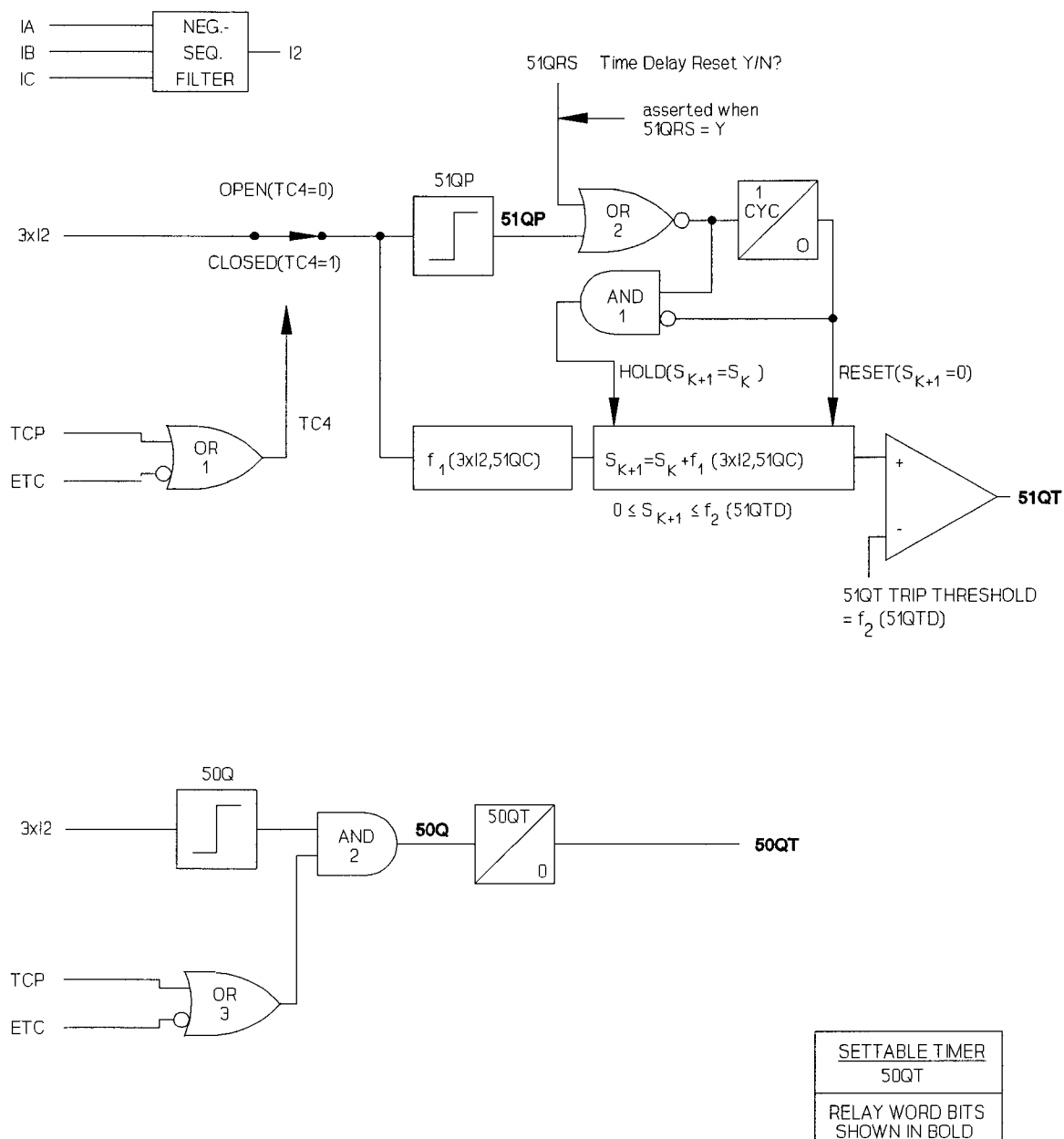
Figure 2.15 SEL-251CD Negative-Sequence Overcurrent Logic Diagrams
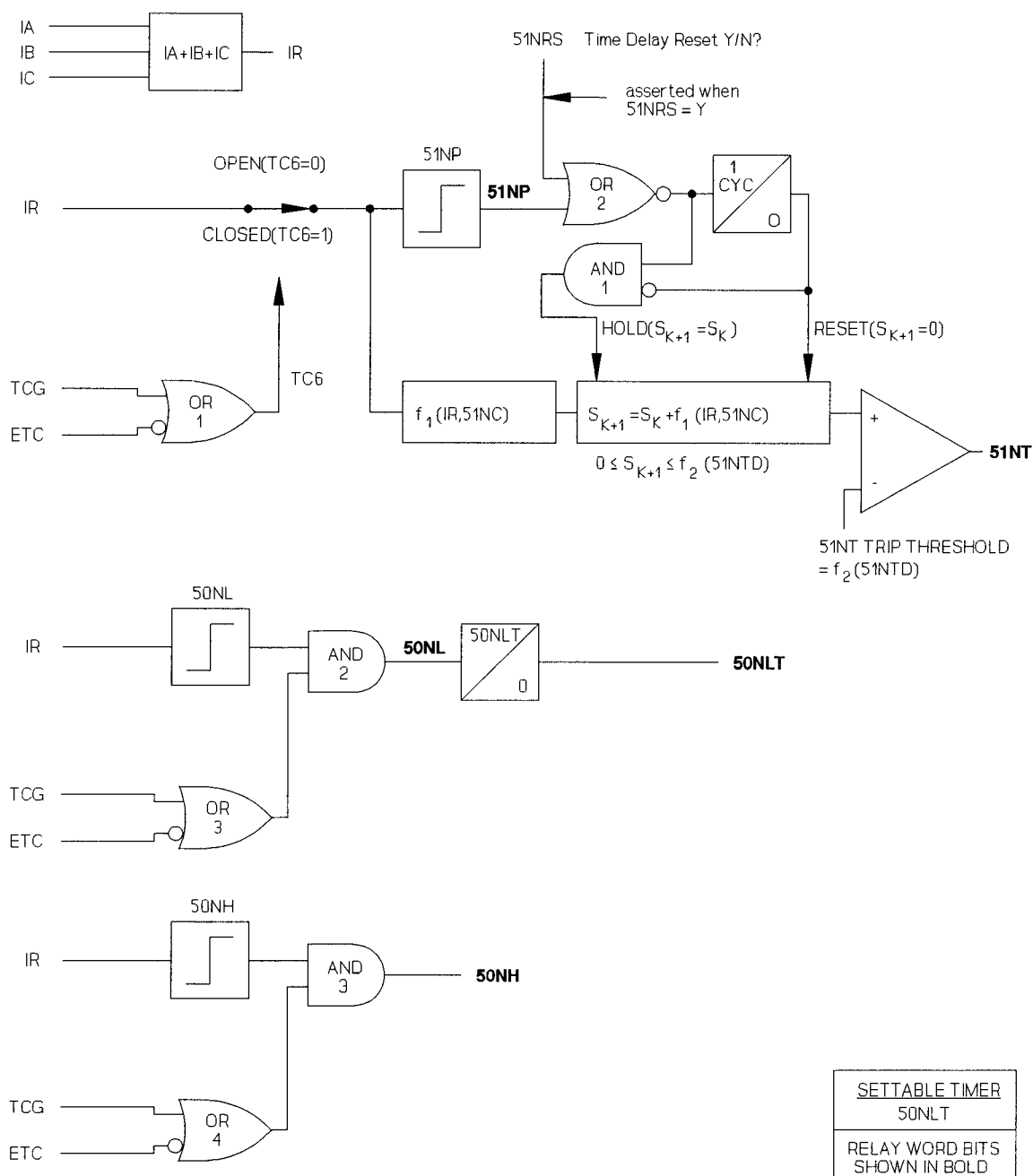
Figure 2.16: SEL-251CD Ground/Residual Overcurrent Logic Diagrams
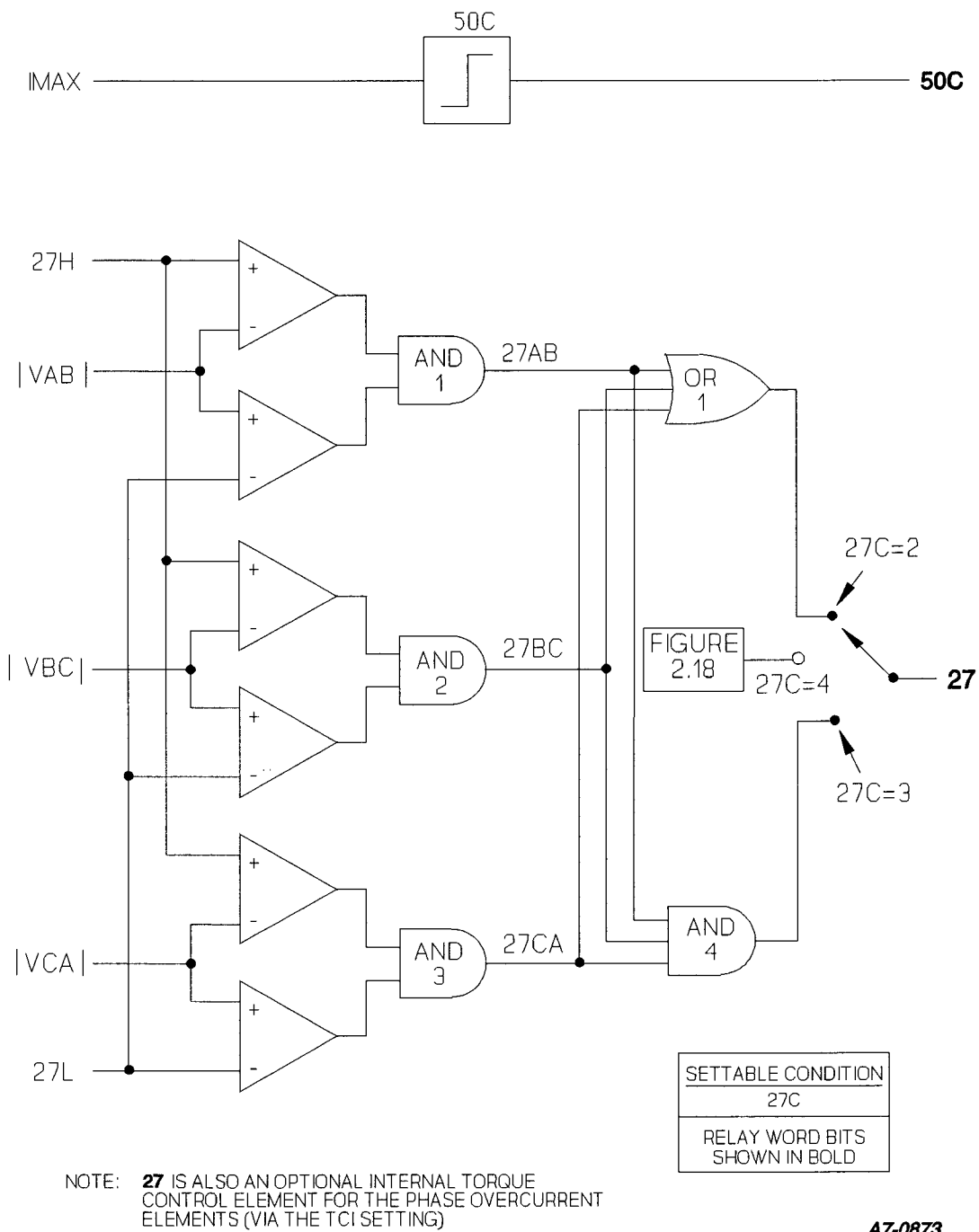
Figure 2.17: SEL-251CD Overcurrent and Undervoltage Elements

A7-0873

Figure 2.18: SEL-251CD Transformer Blown-Fuse Detection Logic

50H

IMAX ————————[50H]———————— **50H**

PHASE-TO-PHASE
SELF-POLARIZED
MHO DISTANCE
ELEMENTS

21AB ———————— OR 1

21BC ————————

21CA ———————— AND 1

21PC=2

21PC=3

21P
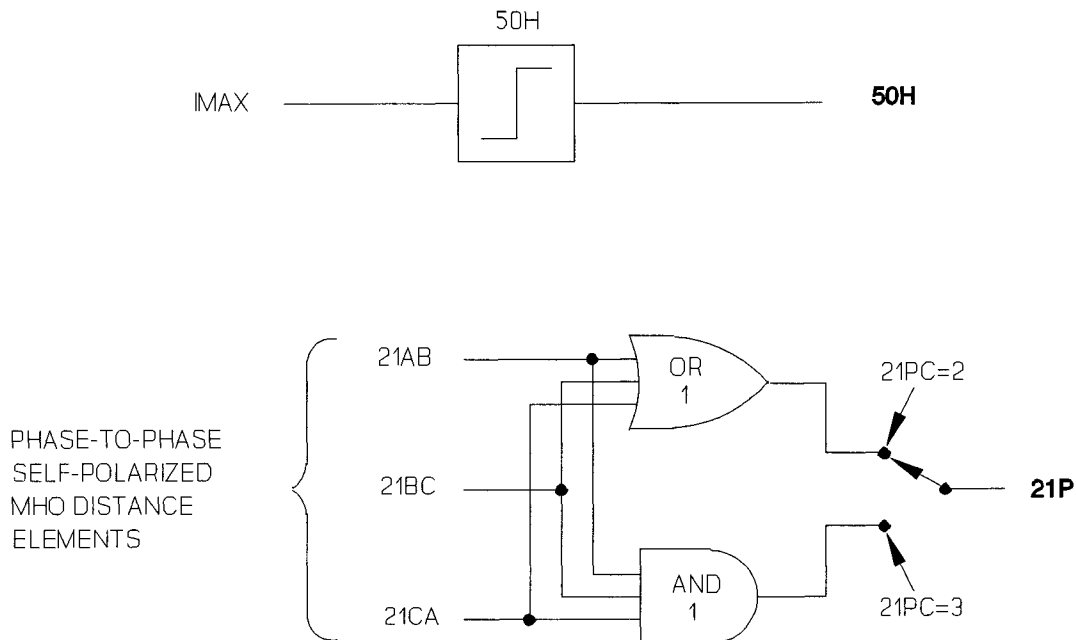
NOTE: 21P IS ALSO AN OPTIONAL INTERNAL
TORQUE CONTROL ELEMENT FOR THE PHASE
OVERCURRENT ELEMENTS (VIA THE TCI SETTING)

| SETTABLE CONDITION |
| 21PC |
| RELAY WORD BITS SHOWN IN BOLD |

Figure 2.19: SEL-251CD Overcurrent and Distance Elements
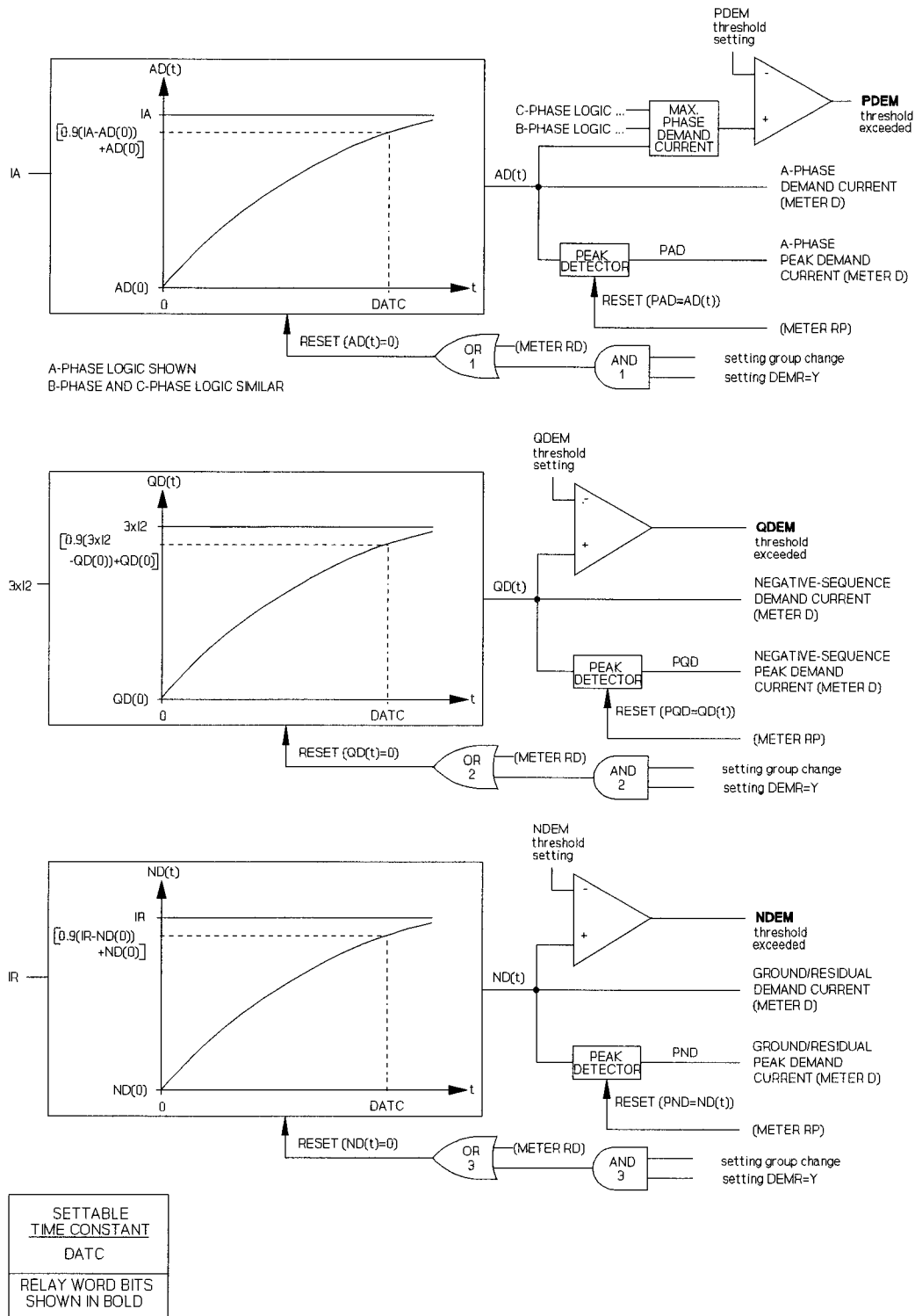
Figure 2.20: SEL-251CD Demand Ammeters
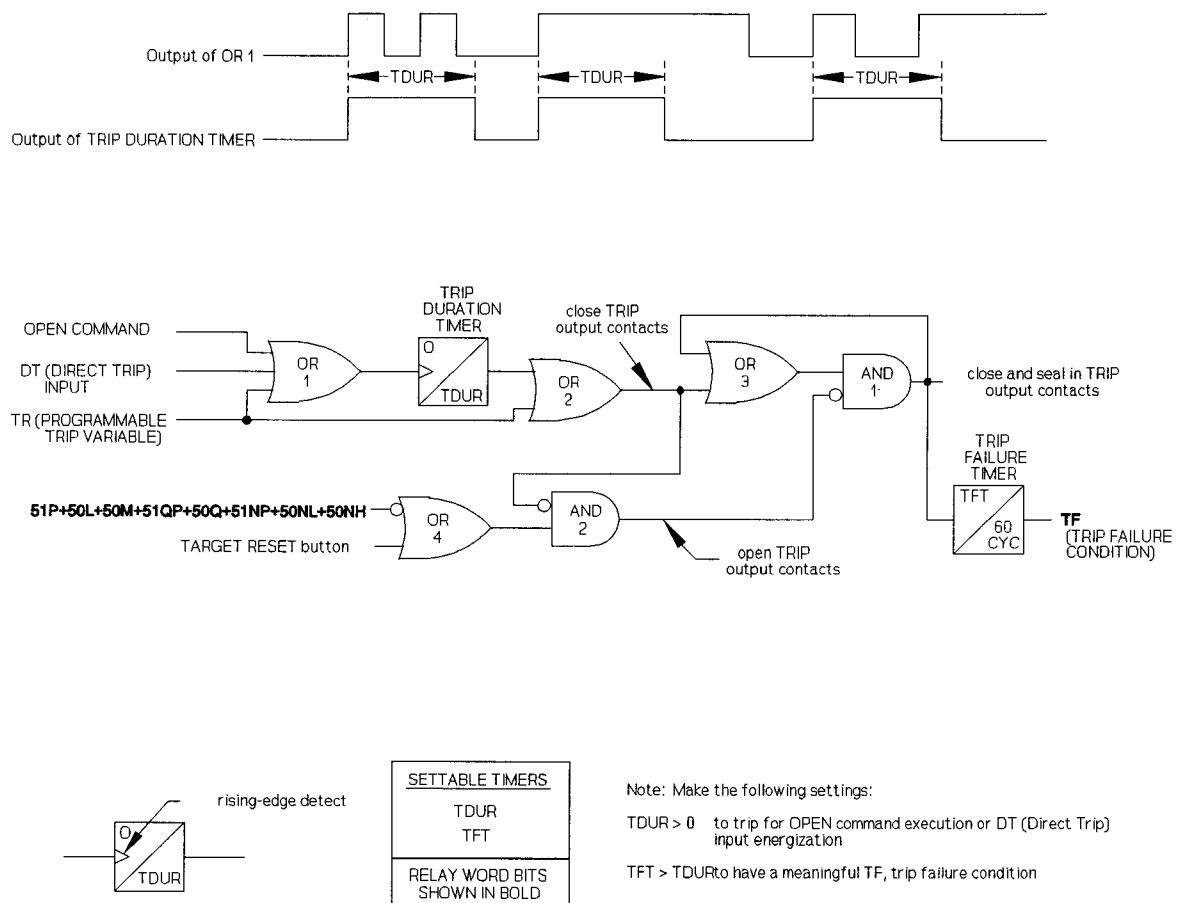
Figure 2.21: SEL-251CD Programmable Trip Logic Diagram

Figure 2.22: SEL-251CD Close Logic Diagram

COMMUNICATIONS
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FIGURES

COMMUNICATIONS

INTRODUCTION

The relay is set and operated via serial communications interfaces connected to a computer terminal and/or modem or the SEL-PRTU. Communications serves these purposes:

1. The relay responds to commands spanning all functions, e.g., setting, metering, and control operations.

2. The relay generates an event record for assertions of the TRIP output, for an event triggering command, or for pickup of any relay element that triggers an event record.

3. The relay transmits messages in response to changes in system status, e.g., self-test warning.

It is impossible to disable any relaying or control functions via communications, unless a user enters erroneous or improper settings or logic with the SET or GROUP commands.

Note: In this manual, commands to type appear in bold/upper case: **OTTER**. Keys to press appear in bold/upper case/brackets: **<ENTER>**.

Relay output appears boxed and in the following format:

```
Example 21.6 kV distribution bus       Date: 05/01/93 Time: 01:01:01
```

SERIAL PORT CONNECTIONS AND CONFIGURATIONS

Port 1 and Port 2 are EIA RS-232-C serial data interfaces.

Port 1 is located on the rear panel and is generally used for remote communications via a modem or the SEL-PRTU.

Port 2 has connectors on both the front and rear panels, designated Port 2F and Port 2R, respectively. Port 2F has priority over Port 2R. These ports are generally used for local communications. Port 2R is typically connected to a printer, SEL-RD, or SEL-DTA. Port 2F is typically used for temporary communications via a portable terminal.

When a device is plugged into Port 2F, the relay automatically begins addressing Port 2F and discontinues communication with Port 2R. When a device unplugged from Port 2F, the relay automatically resumes communication with the device connected to Port 2R.

The baud rate of each port is set by jumpers near the front of the main board. You can access these jumpers by removing either the top cover or front panel. Available baud rates are 300, 600, 1200, 2400, 4800, or 9600.

Caution: Do not select two baud rates for the same port as this can damage the relay baud rate generator. The relay is shipped with Port 1 set to 300 baud and Port 2F/2R set to 2400 baud.

The serial data format is:

Eight data bits
Two stop bits (-E2 model) or one stop bit (-E1 model)
No parity

This format may not be changed.

Figure 3.1 shows the pin number convention for the EIA RS-232-C data ports.

(female chassis connector, as viewed from outside panel)
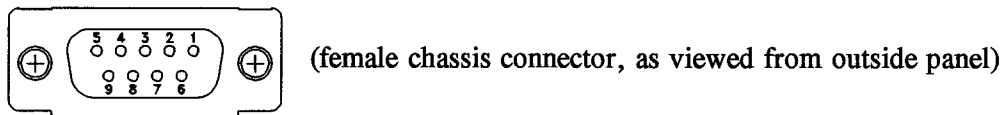
Figure 3.1: 9-Pin Connector Pin Number Convention

Table 3.1 lists port pin assignments and signal definitions.

Table 3.1: SEL-251CD Relay Serial Port Connector Pin Assignments

Pin	Port 1, Port 2R	Port 2F	Description
1	+5 Vdc	N/C	+5 Vdc available if JMP12 installed
2	RXD	RXD	Receive data input.
3	TXD	TXD	Transmit data output.
4	+12 Vdc	N/C	+12 Vdc available if JMP13 installed
5	GND	GND	
6	-12 Vdc	N/C	-12 Vdc available if JMP14 installed
7	RTS	RTS	The relay asserts this line under normal conditions. When its received-data buffer is full, the line is deasserted, and asserts again when the buffer has sufficient room to receive more data. Connected devices should monitor RTS (usually with their CTS input) and stop transmission whenever the line deasserts. If transmission continues, data may be lost.
8	CTS	CTS	The relay monitors CTS, and transmits characters only if CTS is asserted.
9	GND	GND	Ground for ground wires and shields

COMMUNICATIONS PROTOCOL

Communications protocol consists of hardware and software features. Hardware protocol includes the control line functions described above. The following software protocol is designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

   <command> <CR>   or   <command> <CRLF>

   Thus, a command transmitted to the relay should consist of the command followed by either a carriage return or a carriage return and line feed. You may truncate commands to the first three characters. Thus, **EVENT 1 <ENTER>** would become **EVE 1 <ENTER>**. Upper and lower case characters may be used without distinction, except in passwords.

Note: The ENTER key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the ENTER key after commands, which should send the proper ASCII code to the relay.

2. The relay transmits all messages in the following format:

<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>

.

.

<LAST MESSAGE LINE><CRLF><PROMPT><ETX>

Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

3. The relay indicates the volume of data in its received data buffer through an XON/XOFF protocol.

The relay transmits XON (ASCII hex 11) and asserts the RTS output when the buffer drops below 25% full.

The relay transmits XOFF (ASCII hex 13) when the buffer is over 75% full. The relay deasserts the RTS output when the buffer is approximately 95% full. Automatic transmission sources should monitor for the XOFF character so they do not overwrite the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and may resume when the relay sends XON.

4. You can use an XON/XOFF procedure to control the relay during data transmission. When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to its buffer. Messages will be accepted after the relay receives XON.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

5. Control characters can be sent from most keyboards with the following keystrokes:

XON:	<CTRL>Q	(hold down the Control key and press Q)
XOFF:	<CTRL>S	(hold down the Control key and press S)
CAN:	<CTRL>X	(hold down the Control key and press X)

6. The relay input buffer is limited to 128 characters. If the buffer is over 75% full, the relay will send an XOFF to the terminal to terminate transmission. This should be avoided, as the relay may never send an XON if there are no termination characters (carriage returns) within the buffered text.

COMMAND CHARACTERISTICS

The relay responds to commands sent to either serial communications interface. A two level password system provides security against unauthorized access.

When the power is first turned on, the relay is in Access Level 0 and honors only the ACCESS command. It responds "Invalid command" or "Invalid access level" to any other entry.

You may enter Access Level 1 with the ACCESS command and first password. The Level 1 password is factory-set to OTTER and may be changed with the PASSWORD command in Access Level 2. Most commands may be used in Access Level 1.

Critical commands such as SET operate only in Access Level 2. You may enter Access Level 2 with the 2ACCESS command and second password. The Level 2 password is factory-set to TAIL and may be changed with the PASSWORD command.

Startup

Immediately after power is applied, the relay transmits the following message to the port(s) designated automatic:

```
Example 21.6 kV distribution bus        Date: 05/01/93  Time: 01:01:01

SEL-251CD
=
```

The ALARM relay should pull in.

The = represents the Access Level 0 prompt.

The relays are shipped with Port 2 designated automatic; you may use the SET command to change this designation (see SET command, AUTO setting). This allows you to select Port 1, Port 2, or both ports to transmit automatic responses from the relay.

To enter Level 1, type the following on a terminal connected to Port 2:

```
=ACCESS <ENTER>
```

The response is:

```
Password: ? @@@@@@
```

Enter the Level 1 password **OTTER** and press **<ENTER>**. The response is:

```
Example 21.6 kV distribution bus      Date: 05/01/93  Time: 01:01:44

Level 1
=>
```

The Access Level 1 prompt is =>. Now you can execute any Level 1 command.

Use a similar procedure to enter Access Level 2:

Type **2ACCESS <ENTER>**. The relay pulses the ALARM relay contact closed for approximately one second in response to your access attempt. Enter the password **TAIL** when prompted. After you enter the second password, the relay opens access to Level 2, as indicated by the following message and Level 2 prompt (=>>):

```
=>2ACCESS <ENTER>
Password:   TAIL <ENTER>


Example 21.6 kV distribution bus      Date: 05/01/93  Time: 01:03:32

Level 2
=>>
```

You can enter any command at this prompt.

Command Format

Commands consist of three or more characters; only the first three characters of any command are required. You may use upper or lower case characters without distinction, except in passwords.

You must separate arguments from the command by spaces, commas, semicolons, colons, or slashes.

You can enter commands any time after the terminal displays an appropriate prompt.

In this manual, commands to type appear in bold/upper case: **OTTER**. Keys to press appear in bold/upper case/brackets: **<ENTER>**. Some commands have optional parameters; these appear after the command in bold/lower case.

COMMAND DESCRIPTIONS

Access Level 0 Command

ACCESS

ACCESS allows you to enter Access Level 1. The password is required unless you install jumper JMP103. The first password is set to OTTER at the factory; use the Level 2 command PASSWORD to change passwords.

The following display indicates successful access:

```
=ACCESS <ENTER>
Password:  OTTER <ENTER>


Example 21.6 kV distribution bus      Date: 05/01/93  Time: 14:03:57

Level 1
=>
```

The = > prompt indicates Access Level 1.

If you enter incorrect passwords during three consecutive attempts, the relay pulses the ALARM contact closed for one second. This feature can alert personnel to an unauthorized access attempt if the ALARM contact is connected to a monitoring system.

Access Level 1 Commands

2ACCESS

2ACCESS allows you to enter Access Level 2. The password is required unless you install jumper JMP103. The second password is set to TAIL at the factory; use the Level 2 command PASSWORD to change passwords.

The following display indicates successful access:

```
=>2ACCESS <ENTER>
Password:   TAIL <ENTER>


Example 21.6 kV distribution bus      Date: 05/01/93 Time: 14:12:01

Level 2
=>>
```

You may use any command from the = > > prompt. The relay pulses the ALARM output
contact closed for one second after any Level 2 access attempt (unless an alarm condition
exists). If access is denied, the ALARM output contact pulses again.

BREAKER

BREAKER displays running sums of circuit breaker trips for relay and external trips and
interrupted current in each circuit breaker pole for relay and external trips.

Relay trips are determined by coinciding change in circuit breaker auxiliary contact input
status (52A drops out or 52B asserts) and relay TRIP output contact assertion. Consideration
should be given to the TDUR (trip duration) timer setting so TRIP output contact assertion
always encompasses the status change of the circuit breaker auxiliary contact for a relay
initiated trip.

External trips are determined by coinciding change in circuit breaker auxiliary contact input
status (52A drops out or 52B asserts) and the absence of relay TRIP output contact assertion.

For trips, the relay measures interrupted current in each pole one cycle after the rising edge
of TRIP contact assertion.

For external trips, the relay measures interrupted current in each pole when the status of the
circuit breaker auxiliary contact input changes (52A drops out or 52B asserts). Remember to
consider the time delay between the change of circuit breaker auxiliary contact status and the
opening of circuit breaker main contacts. If circuit breaker auxiliary contact operation lags
too far behind circuit breaker main contact operation, current may already be interrupted
when the circuit breaker auxiliary contact changes status. Thus, no interrupted current would
be measured.

BREAKER also displays the date and time when circuit breaker trip counters and interrupted
current sums were last reset (set to zero). Cumulative currents appear in kA (kiloamperes).

```
=>BREAKER <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93 Time: 09:09:58

Rly Trips=15      From: 1/1/91    11:01:31
IA=42.65     IB=37.91     IC=34.20        KA

Ext Trips=2      From: 1/1/91    11:01:31
IA=0.65      IB=0.67      IC=0.62        KA

=>
```

If power to the relay is interrupted, the accumulated circuit breaker information is lost.

If the 52A or !52 function is not assigned to an input, circuit breaker trips and interrupted currents cannot be accumulated.

BREAKER R

BREAKER R resets (sets to zero) the circuit breaker trip counters and interrupted current sums. The relay also stores reset date and time.

```
=>BREAKER R <ENTER>
Reset Trip Counters and Current Sums:
Are you sure (Y/N) ? Y <ENTER>


Example 21.6 kV distribution bus      Date: 05/01/93 Time: 09:10:30

Rly Trips=0      From: 4/2/91    09:10:30
IA=0.00      IB=0.00      IC=0.00        KA

Ext Trips=0      From: 4/2/91    09:10:30
IA=0.00      IB=0.00      IC=0.00        KA

=>
```

DATE mm/dd/yy

DATE displays the date stored by the internal calendar/clock. To set the date, type **DATE mm/dd/yy <ENTER>**.

To set the date to May 1, 1993, enter:

```
=>DATE 5/1/93 <ENTER>
5/1/93
=>
```

The relay sets the date, pulses the ALARM relay closed as it stores the year in EEPROM (if the year input differs from the year stored), and displays the new date.

EVENT n

EVENT displays an event report. Type **EVENT n <ENTER>** to display an event report for the nth event. The parameter n ranges from 1 for the newest event through 12 for the oldest event stored in relay memory. If n is not specified, the default value is 1 and the relay displays the newest event report.

You can control transmissions from the relay with the following keystrokes:

- **<CTRL>S**   Pause transmission
- **<CTRL>Q**   Continue transmission
- **<CTRL>X**   Terminate transmission

The following incidents clear the event buffers:

- Control power interruption
- Changing any relay setting via the SET commands
- Changing any relay setting group via the COPY command

Switching setting groups does not clear the buffers.

All event data are lost when event buffers are cleared. If an event buffer is empty when you request an event, the relay returns an error message:

```
=>EVENT 12 <ENTER>
Invalid event
=>
```

Section 4: EVENT REPORTING explains the generation and analysis of event reports.

HISTORY

HISTORY displays the date, time, event type, maximum phase current, enabled setting group, and fault type targets for each of the last twelve events. The full eleven-cycle event reports also include this information (**EVENT n** to display).

```
=>HISTORY <ENTER>


Example 21.6 kV distribution bus          Date: 05/01/93    Time: 14:03:34

#   DATE        TIME        EVENT   CURR   GROUP   TARGETS
1   5/21/91   05:02:48.625   ER     8955     1     INSTBQN
2   3/17/91   08:07:40.129   TRIG   1412     2
3
4
5
6
7
8
9
10
11
12

=>
```

Note that only four events have occurred since the relay was set or powered on.

The time is saved to the nearest quarter-cycle (4.17 ms) and referenced to the 16th row of data in the report. All reports trigger at row 16. If a long fault triggers two event reports, you can still determine its duration. Simply calculate the time difference between the first report generated at fault inception and the second report generated at the TRIP.

The EVENT column provides an abbreviated indication of the event type.

The following incidents trigger an event report:

- TRIP output contact assertion
- ER (Event Report trigger) programmable variable assertion
- Input assigned to ET (External Trigger) function assertion
- TRIGGER command execution

The event report triggering condition appears in the EVENT column. These conditions are:

TR   : programmable TRipping variable
DT   : Direct Trip input
OPEN : OPEN command
ER   : programmable Event Report trigger variable
ET   : External Trigger input
TRIG : TRIGGER command

If two or more event report triggering conditions happen to coincide, the relay uses the previous hierarchy to display the event report triggering condition in the EVENT column.

The CURR column shows maximum phase current magnitude measured when the event report was triggered (primary amperes).

The GROUP column has the number of the setting group active at the time the report was triggered.

The TARGETS column lists the FAULT TYPE front panel targets illuminated at event report initiation.

If the event buffers are cleared, the event summaries listed by the HISTORY command are lost (see EVENT in this section).

IRIG

IRIG directs the relay to read the demodulated IRIG-B time code input (J201) on the rear panel.

If the relay reads the time code successfully, it updates the internal clock/calendar time and date to the time code reading, and the relay transmits a message with relay ID string, date, and time.

```
=>IRIG <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93  Time: 01:45:40

=>
```

If no IRIG-B signal is present or the code cannot be read successfully, the relay sends the error message "IRIGB DATA ERROR."

Note: Normally, it is not necessary to synchronize using this command because the relay automatically synchronizes every few minutes. The command is provided to speed testing.

METER n

METER displays **present** values of the following:

IA: A-phase current (primary amps)
 B: B-phase current (primary amps)
 C: C-phase current (primary amps)
 R: ground/residual current (primary amps)

3I2: 3 x negative-sequence current (primary amps)
P: Three-phase real power (MW)
Q: Three-phase reactive power (MVAR)

VAB: AB phase-to-phase voltage (primary volts)
VBC: BC phase-to-phase voltage (primary volts)
VCA: CA phase-to-phase voltage (primary volts)

```
=>METER <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93 Time: 09:12:49


MET IA=356    B=364     C=361     R=6
    3I2=5     P=12.910    Q=1.130

VAB=20827  VBC=20839  VCA=20836

=>
```

P is positive when three-phase real power flows out from the bus and into the line. If P is negative, three-phase real power flows in the opposite direction. Q is positive when three-phase reactive power flows from the bus and into the line (net load on the line has a lagging power factor). If Q is negative, three-phase reactive power flows in the opposite direction (net load on the line has a leading power factor). If $Q = 0$, no net reactive power is flowing past the relay (net load on the line has a unity power factor).

The optional parameter n selects the number of times the relay displays meter data. To display a series of eight meter readings, type **METER 8 <ENTER>**.

METER D

METER D displays **demand** and **peak demand** values of the following:

IA: A-phase current (primary amps)
B: B-phase current (primary amps)
C: C-phase current (primary amps)
R: Ground/residual current (primary amps)

3I2: 3 x negative-sequence current (primary amps)
  P: Three-phase real power (MW)
  Q: Three-phase reactive power (MVAR)

The demand ammeter time constant setting (DATC) is also used in determining I, P, and Q demand values.

```
=>METER D <ENTER>

Example 21.6 kV distribution bus       Date: 05/01/93 Time: 09:13:33


DEM IA=347     B=349     C=349     R=4
    3I2=3      P=12.897    Q=0.997

PK  IA=412     B=410     C=414     R=15
    3I2=13     P=14.701    Q=1.280

=>
```

If control power to the relay is interrupted, the demand and peak demand values reset to zero.

METER RD

METER RD resets **demand** values to zero.

```
=>METER RD <ENTER>
Reset Demand Meter: Are you sure (Y/N) ? Y <ENTER>

Example 21.6 kV distribution bus       Date: 05/01/93 Time: 09:14:15


DEM IA=0       B=0       C=0       R=0
    3I2=0      P=0.000     Q=0.000

PK  IA=412     B=410     C=414     R=15
    3I2=13     P=14.701    Q=1.280

=>
```

The demand values automatically reset if an active setting group change is made with global setting DEMR=Y (see SET G p in this section).

METER RP

METER RP resets **peak demand** values to their respective demand values.

```
=>METER RP <ENTER>
Reset Peak Demand: Are you sure (Y/N) ? Y <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93  Time: 10:31:26


DEM IA=341    B=345    C=348    R=5
    3I2=4     P=12.875   Q=0.757

PK  IA=341    B=345    C=348    R=5
    3I2=4     P=12.875   Q=0.757

=>
```

QUIT

QUIT returns control to Access Level 0 from Level 1 or 2 and resets targets to the Relay Targets (TAR 0). The command displays the relay I.D., date, and time of QUIT command execution.

Use this command when you finish communicating with the relay to prevent unauthorized access. Control returns to Access Level 0 automatically after a settable interval of no activity (see the TIME1 and TIME2 settings of the SET command).

```
=>QUIT <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93  Time: 01:45:40

=
```

SHOWSET n

SHOWSET n displays the relay and logic settings for setting Group n (n = 1, 2, 3, 4, 5, or 6). You cannot enter or modify settings with this command. The SET command description provides complete information about changing settings and logic. To display the active setting group, execute SHOWSET without the parameter n.

The display also includes the global settings (settings common to all groups).

The SHOWSET output pauses twice, as shown in the following example. Press < ENTER >
to continue viewing the next section of settings.

```
=>SHOWSET 1 <ENTER>
Settings for group 1

Example 21.6 kV distribution bus
CTR  =500.00  PTR  =180.00
DATC =15      PDEM =12.00    QDEM =12.00   NDEM =0.34
ZP   =25      MTA  =73.00    21PC =2
50C  =100.00  27L  =0.00     27H  =0.00    27C  =2        TCI  =Z
50Q  =100.00  50QT =0
51QP =1.50    51QTD=15.00    51QC =3       51QRS=N
50NL =50.00   50NLT=0        50NH =50.00
51NP =0.50    51NTD=3.50     51NC =3       51NRS=N
50L  =21.99   50LT =12       50H  =100.00
51P  =2.80    51TD =7.50     51C  =3       51RS =N
50M  =100.00  50MT =0
52APU=0       52ADO=0        TSPU =0       TSDO =0
TKPU =0       TKDO =0        TZPU =0       TZDO =0

PRESS RETURN ? <ENTER>

SELogic Equations

S(123)  =
A(12)   =
B(12)   =51NT
C(12)   =
D(12)   =
E(34)   =
F(34)   =IN6
G(34)   =
H(34)   =
J(1234) =
K(1234) =
L(1234) =
A1(1234)=TF
A2(1234)=NDEM

PRESS RETURN ? <ENTER>

V(56)   =B*F
W(56)   =
X(56)   =
Y(56)   =
Z(56)   =
A3(1346)=
A4(2346)=
TR(1246)=51T+50LT+V
ER(1246)=51P+51NP+TF
ETC(1)  =
ITC(1)  =51P

Global settings
DEMR =Y       CFT  =60       TDUR =4       TFT  =30      TGR  =180
ITT  =5       TIME1=15       TIME2=0       AUTO =2       RINGS=3
IN1  =SS1     IN2  =DT       IN3  =        IN4  =
IN5  =52A     IN6  =

=>
```

STATUS

STATUS allows inspection of self-test status. The relay automatically executes the STATUS
command whenever a self-test enters a warning or failure state. If this occurs, the relay

transmits a STATUS report from the port(s) designated automatic (see SET command, AUTO setting).

The STATUS report format appears below:

```
=>STATUS <ENTER>

Example 21.6 kV distribution bus      Date: 05/01/93 Time: 01:08:44

SELF TESTS

W=Warn F=Fail
        IR    IA    IB    IC    VAB   VBC   VCA

OS      0     0     0     0     2     0     2
PS      5.11        15.15       -14.91
RAM     ROM   A/D   MOF   SET
OK      OK    OK    OK    OK

=>
```

The OS row indicates measured dc offset voltages in millivolts for the seven analog channels. An out-of-tolerance offset is indicated by a W (warning) or F (failure) following the displayed offset value.

The PS row indicates power supply voltages in volts for the three power supply outputs.

If a RAM or ROM test fails, the IC socket number of the defective part replaces OK.

The A/D self-test checks analog-to-digital conversion time.

The MOF test checks dc offset in the MUX-PGA-A/D circuit.

The SET self-test calculates a checksum of the settings stored in nonvolatile memory and compares it to the checksum calculated when the settings were last changed.

Section 2: SPECIFICATIONS provides full definitions of the self-tests, warning and failure limits, and warning and failure results.

TARGET n k

TARGET selects the information to be displayed on the target LEDs and to be communicated by this command.

When relay power is first turned on, the LED display indicates the functions marked on the front panel.

Using the TARGET command, you may select any one of the following nine sets of data to display on the LEDs.

Table 3.2: Target LED Assignments

LED:	1	2	3	4	5	6	7	8	
n									
0	INST	A	B	C	Q	N	EN	ALRM	Front Panel Targets
1	51P	50L	50M	51QP	50Q	51NP	50NL	50NH	Relay Word row R1
2	51T	50LT	50MT	51QT	50QT	51NT	50NLT	50H	Relay Word row R2
3	21P	50C	27		52AT	52BT	IN6	IN5	Relay Word row R3
4	PDEM	QDEM	NDEM	TF	CF	TCMA	ST	TRIP	Relay Word row R4
5	A	B	C	D	E	F	G	H	Relay Word row R5
6	J	KT	!L	V	W	X	Y	ZT	Relay Word row R6
7			IN6	IN5	IN4	IN3	IN2	IN1	Inputs
8		TRIP	CLOSE	A1	A2	A3	A4	ALRM	Output Contacts

These selections are useful in testing, checking contact states, and reading targets remotely. "1" indicates an asserted element; "0" indicates a deasserted element.

The optional command parameter k selects the number of times the relay displays target data for parameter n. The example below shows a series of ten target readings for Relay Word row R3. Target headings repeat every eight rows. You cannot use parameter k without parameter n.

```
=>TARGET 3 10 <ENTER>


21P  50C  27       52AT 52BT IN6  IN5
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1

21P  50C  27       52AT 52BT IN6  IN5
0    0    0    0   1    0    1    1
0    0    0    0   1    0    1    1

=>
```

When you are finished, type **TAR 0 <ENTER>** to return to the functions marked on the front panel so field personnel do not misinterpret displayed data.

When a serial port times out (see TIME1, TIME2 settings) and an automatic message is sent to that port, the relay automatically clears the targets and displays the TAR 0 data.

Press the front panel TARGET RESET button to clear the TAR 0 data and illuminate all target LEDs for a one second lamp test.

If you place the relay in service with a target level other than Level 0, it automatically returns to target Level 0 when an automatic message transmits to a timed out port. While this feature prevents confusion among station operators and readers, it can be inconvenient if the relay tester requires targets to remain on another level. Targets remain in the specified level if you assign the AUTO setting to a port with zero timeout or set both TIME1 and TIME2 to zero. This halts automatic message transmission to a port which may be timed out.

TARGET R

You can reset front panel targets to TAR 0 and clear them remotely or locally with the TARGET R command. Type **TARGET R <ENTER>** to reset and clear the targets as shown in the following example.

```
=>TARGET R <ENTER>
Targets reset

 INST A    B    C    Q    N    EN   ALRM
 0     0    0    0    0    0    1    0

=>
```

TIME hh:mm:ss

TIME displays the internal clock. To set the clock, type **TIME** and the desired setting, then press **<ENTER>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes. To set the clock to 23:30:00, enter:

```
=>TIME  23:30:00 <ENTER>
23:30:00
=>
```

A quartz crystal oscillator provides the time base for the internal clock. You can set the clock automatically through the relay time code input with a source of demodulated IRIG-B time code.

TRIGGER

TRIGGER generates an event record. After command entry, the relay responds "Triggered" and displays a record summary.

```
=>TRIGGER <ENTER>
Triggered

=>

Example 21.6 kV distribution bus  Date: 05/01/93 Time: 10:45:20.000

Event    : TRIG                                   Targets:
Currents (A pri), ABCQN:           347    354    355      5       6

=>
```

Use TRIGGER to inspect input voltages. For example, when the relay is first installed, execute the TRIGGER command, draw the phasors (Section 4: EVENT REPORTING explains how to do this), and check for the proper polarity and phase sequence of the inputs.

Access Level 2 Commands

While all commands are available from Access Level 2, the commands below are available only from Access Level 2. Remember, the relay pulses the ALARM contacts closed for one second after any Level 2 access attempt.

CLOSE

The CLOSE command asserts the CLOSE output relay when jumper JMP104 is installed on the main board, the circuit breaker status input (52A or !52A) indicates an open circuit breaker, and the TRIP outputs are not asserted. The CLOSE output relay then remains closed until the circuit breaker status input indicates that the circuit breaker has closed or until the close failure timer (CFT) expires.

To close the circuit breaker with this command, type **CLOSE <ENTER>**. The relay responds with the message: "Close BREAKER (Y/N) ?" **Y <ENTER>** yields a second prompting string: "Are you sure (Y/N) ?" Type **Y <ENTER>** to assert the CLOSE output relay if the TRIP output and 52A input are not asserted. The relay transmits the message "Breaker CLOSED" when the breaker closes or if it is already closed (as determined by 52A input state). Typing **N <ENTER>** after either of the above messages aborts the closing operation with the message "Aborted."

```
=>>CLOSE <ENTER>
Close BREAKER (Y/N) ? Y <ENTER>
Are you sure (Y/N) ? Y <ENTER>
Breaker CLOSED
=>>
```

After CLOSE command execution, if the response is "Breaker OPEN" instead of "Breaker CLOSED," the circuit breaker status input (52A or !52A) did not indicate circuit breaker closure.

COPY m n

COPY m n copies settings and logic from setting Group m to Group n (m and n equal any combination of 1, 2, 3, 4, 5, or 6).

Usually, there are only a few setting or logic differences between groups. If you enter one setting group with the SET command, you can copy it to other groups with the COPY command. Use SET to modify copied setting groups.

COPY command execution clears the event report buffer. If n is the active setting group, the ALARM output contact closes momentarily.

```
=>>COPY 4 6
Are you sure (Y/N) ? Y <ENTER>

Please wait...
Settings copied

=>
```

GROUP n

GROUP n designates the Group Variable. This variable specifies which setting group to use when no Setting Group Selection inputs are assigned or all assigned inputs are deasserted (n = 1, 2, 3, 4, 5, or 6). You can execute this command at any time, but the setting group changes only when no Setting Group Selection inputs are assigned or all assigned inputs are deasserted. Otherwise, the current setting group remains active; the Group Variable becomes the Active Group only when no Setting Group Selection inputs are assigned or all assigned inputs are deasserted.

GROUP n command execution does not clear the event report buffer. However, any time the active setting group is changed, the relay pulses ALARM output contacts.

If global setting DEMR=Y and the active setting group is changed, the demand values are reset (see SET G p in this section).

```
=>>GROUP 3 <ENTER>
Change Group Variable:
Are you sure (Y/N) ? Y <ENTER>


=>>
Active Group = 1
Group Variable = 3

=>
```

The above response to **GROUP 3** command execution indicates that only Setting Group Selection input SS1 is energized (see Table 2.3) because the active group did not change to Group 3, but remained Group 1.

If you do not designate a setting group, the relay displays present group information:

```
=>>GROUP <ENTER>

Active Group = 1
Group Variable = 3

=>
```

OPEN

The OPEN command closes the TRIP output contacts when jumper JMP104 is installed on the main board. TRIP output contacts remain closed for at least the duration of TDUR (you must enter a TDUR setting) starting with the rising edge of the trip output. The TRIP outputs drop out only if none of the overcurrent element pickups in Relay Word row R1 are picked up or if you push the TARGET RESET button on the front panel.

To open the power circuit breaker by command, type **OPEN <ENTER>**. The prompt "Open BREAKER (Y/N) ?" is transmitted. Answering **Y <ENTER>** yields a second prompt: "Are you sure (Y/N) ?" Answering **Y <ENTER>** again closes the TRIP output relay as described above.

```
=>>OPEN <ENTER>
Open BREAKER (Y/N) ? Y<ENTER>
Are you sure (Y/N) ? Y<ENTER>
Breaker OPEN
=>>

Example 21.6 kV distribution bus  Date: 05/01/93 Time: 10:45:20.000

Event   : TRIG                                 Targets:
Currents (A pri), ABCQN:        347     354    355      5       6

=>>
```

After OPEN command execution, if the relay responds "Breaker CLOSED" instead of "Breaker OPEN," the circuit breaker status input (52A or !52A) did not indicate circuit breaker opening.

PASSWORD (1 or 2) password

PASSWORD allows you to inspect or change existing passwords. To inspect passwords, type **PASSWORD <ENTER>** as the following example shows:

```
=>>PASSWORD <ENTER>
1: OTTER
2: TAIL
=>>
```

To change the password for Access Level 1 to BIKE enter the following:

```
=>>PASSWORD 1 BIKE <ENTER>
Set
=>>
```

The relay sets the password, pulses the ALARM relay closed, and transmits the response "Set."

After entering new passwords, type **PASSWORD <ENTER>** to inspect them. Make sure they are what you intended and record the new passwords.

Passwords can be any length up to six numbers, letters, or any other printable characters except delimiters (space, comma, semicolon, colon, slash). Upper and lower case letters are treated as different characters. Examples of valid, distinct passwords include:

OTTER   otter   Ot3456   +TAIL+   !@#$%^   123456   12345.   12345

If the passwords are lost or you wish to operate the relay without password protection, install JMP103 on the main board. With no password protection, you may gain access without knowing the passwords and view or change current passwords and settings.

SET n p

SET n allows entry of relay settings and logic for setting Group n. At the setting procedure prompts (?), enter new data or press <ENTER> to retain existing settings. You can jump to a specific setting by entering the setting name as parameter p. If p is a SELOGIC™ Control Equations element, you need not include the parenthetical [e.g., just K, not K(1234)]. If you do not specify a setting, the procedure initiates at the first setting, Relay ID.

The relay prompts you for each group setting and checks the new setting against established limits. If a setting falls within its setting range, the relay prompts you for the next group setting. If a setting is outside its established limits, an "Out of range" or "Invalid" error

message results. You have another chance to enter the setting. If you want to retain the old setting, press <ENTER> and proceed to the next group setting.

The logic variable expressions should contain the name of each Relay Word bit (e.g. **51P**) and the correct delimiter "+" for OR logic, "*" for AND logic, and "," for the ETC(1) and ITC(1) torque control logic variables. Enter the logic expression with no spaces between the Relay Word bits and the delimiters. Some examples:

A(12) = **51P+51QP+51NP**	OR logic variable A takes bits from Relay Word rows 1 and 2 and uses the + delimiter.
V(56) = **A*F*KT**	AND logic variable V takes bits from Relay Word rows 5 and 6 and uses the * delimiter.
ITC(1) = **50L,50H**	The **50L** and **50H** phase overcurrent elements from Relay Word row 1 are selected for internal torque control. The respective time delayed elements they control (**50LT** and **50HT**) are also internally torque controlled through this setting.

Note that AND logic variables **V, W, X, Y,** and **ZT** cannot select other AND variables from Relay Word rows 5 and 6. They can only select the OR logic variables **A, B, C, D, E, F, H, J, KT,** and **!L** from Relay Word rows 5 and 6. This prevents recursive logic such as:

V(56) = **V*W**   (this setting is not possible)

If no function is desired for a logic variable, type **NA** <ENTER>.

To fully utilize the relay's resources, self-tests are delayed when any of the following elements are picked up:

51P, 50H, 51QP, 50Q, 51NP, 50NL, 50NH
51T, 51QT, 50QT, 51NT, and 50NLT

Therefore, you should be careful to set the relay so that under normal conditions none of these elements are picked up.

When you finish entering setting changes, you need not scroll through the remaining settings. Type **END** <ENTER> after your last change to display the new settings and enable prompt. Do not use the END statement at the Relay ID setting; use <CTRL>X to abort the SET procedure from this point.

After you enter all data, the relay displays new group and global settings and prompts for approval to enable new group settings. Answer **Y** <ENTER> to approve the new settings; the relay enables them and clears the event buffer. If the active group is the same as the one you are setting, the ALARM output pulses closed.

A list of relay settings follow. Setting ranges and explanations have been added.

= > >SET 1 <ENTER>

SET clears events. CTRL-X cancels.
SEL-251CD-R400 Group Settings
Group = 1
Active group = 1
Enter data, or **<ENTER>** for no change

				Range
ID	: Example 21.6 kV distribution bus		?	39 characters
CTR	: . . . . = 500.00		?	0.001-10000
	Current transformer ratio			
PTR	: . . . . = 180.00		?	0.001-10000
	Potential transformer ratio			
DATC	: Dem, 5 - 60 min . . . . = 15		?	
	Demand ammeter time constant			
PDEM	: Ph Dem Thr, A sec . . . . = 12.00		?	1.00-12.00
	Phase demand ammeter threshold for **PDEM**			
QDEM	: 3I2 Dem Thr, A sec . . . . = 12.00		?	0.25-12.00
	Negative-sequence demand ammeter threshold for **QDEM**			
NDEM	: IR Dem Thr, A sec . . . . = 0.34		?	0.25-12.00
	Ground/residual demand ammeter threshold for **NDEM**			
ZP	: Reach, sec ohms . . . . = 25		?	1-64
	Reach for single-zone, self-polarized mho distance element **21P**			
MTA	: Max Torq Angle . . . . = 73.00		?	0-90 deg.
	Maximum torque angle for mho distance element **21P**			
21PC	: 2 or 3 Ph Mho . . . . = 2		?	
	Phase-to-phase (2) or three-phase (3) operation for mho distance element **21P** (see Figure 2.17)			
50C	: A sec . . . . = 100.00		?	0.50-100.00
	Pickup for phase instantaneous overcurrent element **50C**			
27L	: V l-l sec . . . . = 0.00		?	0-140
	Low-set limit for undervoltage element **27**			
27H	: V l-l sec . . . . = 0.00		?	0-140
	High-set limit for undervoltage element **27**			

27C   : 2, 3 Ph or 4 = HS Blown Fuse . . . . . = 2   ?
        Select whether **27** is a phase-to-phase or three phase-to-phase element, or select 4
        to enable blown-fuse detection

TCI   : 0, V, I, 3, Z, 5, 6, or 7 . . . . = Z   ?
        Internal torque control conditions
        See Table 2.6 for setting definitions

50Q   : A sec . . . . = 100.00   ?   0.50-100.00
        Pickup for negative-sequence definite-time overcurrent element **50QT**
        The element responds to 3*I2

50QT   : Dly, cyc . . . . = 0   ?   0-16000
        Time delay for negative-sequence definite-time overcurrent element **50QT**

51QP   : A sec . . . . = 1.50   ?   1.00-12.00
        Pickup for negative-sequence time-overcurrent element **51QT**
        The element responds to 3*I2

51QTD   : Time Dial . . . . = 15.00   ?   0.50-15.00
        Time dial for negative-sequence time-overcurrent element **51QT**

51QC   : Curve 1,2,3 or 4 . . . . = 3   ?
        Curve for negative-sequence time-overcurrent element **51QT**
        1=moderately inverse, 2=inverse, 3=very inverse, 4=extremely inverse

51QRS   : Dly Reset Y/N? . . . . = N   ?
        Time delay reset for negative-sequence time-overcurrent element **51QT**?
        (If N, **51QT** resets 1 cycle after **51QP** drops out)

50NL   : A sec . . . . = 50.00   ?   0.125-100.00
        Pickup for ground/residual definite-time overcurrent element **50NLT**
        Setting range dependent on 51NP setting.

50NLT   : Dly, cyc . . . . = 0   ?   0-16000
        Time delay for ground/residual definite-time overcurrent element **50NLT**

50NH   : A sec . . . . = 50.00   ?   0.125-100.00
        Pickup for ground/residual instantaneous overcurrent element **50NH**
        Setting range dependent on 51NP setting.

51NP   : A sec . . . . = 0.50   ?   0.25-12.00
        Pickup for ground/residual time-overcurrent element **51NT**

51NTD   : Time Dial . . . . = 3.50   ?   0.50-15.00
        Time dial for ground/residual time-overcurrent element **51NT**

51NC   : Curve 1,2,3 or 4 . . . . = 3   ?
        Curve for ground/residual time-overcurrent element **51NT**

1=moderately inverse, 2=inverse, 3=very inverse, 4=extremely inverse

51NRS : Dly Reset Y/N? . . . . = N   ?
       Time delay reset for ground/residual time-overcurrent element **51NT?**
       (If N, **51NT** resets 1 cycle after **51NP** drops out)

50L   : A sec . . . . = 21.99   ?   0.50-100.00
       Pickup for phase definite-time overcurrent element **50LT**

50LT   : Dly, cyc . . . . = 12   ?   0-16000
       Time delay for phase definite-time overcurrent element **50LT**

50H   : A sec . . . . = 100.00 ?   0.50-100.00
       Pickup for phase instantaneous overcurrent element **50H**

51P   : A sec . . . . = 2.80   ?   1.00-12.00
       Pickup for phase time-overcurrent element **51T**

51TD   : Time Dial . . . . = 7.50   ?   0.50-15.00
       Time dial for phase time-overcurrent element **51T**

51C   : Curve 1,2,3 or 4 . . . . = 3   ?
       Curve for phase time-overcurrent element **51T**
       1=moderately inverse, 2=inverse, 3=very inverse, 4=extremely inverse

51RS   : Dly Reset Y/N? . . . . = N   ?
       Time delay reset for phase time-overcurrent element **51NT?**
       (If N, **51T** resets 1 cycle after **51P** drops out)

50M   : A sec . . . . = 100.00 ?   0.50-100.00
       Pickup for phase definite-time overcurrent element **50MT**

50MT   : Dly, cyc . . . . = 0   ?   0-16000
       Time delay for phase definite-time overcurrent element **50MT**

52APU : 52A PU, cyc . . . . = 0   ?   0-16000
       Time delay pickup for **52AT**

52ADO : 52A DO, cyc . . . . = 0   ?   0-16000
       Time delay dropout for **52AT**

TSPU   : Tmr PU, cyc . . . . = 0   ?   0-16000
       Timer TS time delay pickup (timer TS output is Relay Word bit **ST**)

TSDO   : Tmr DO, cyc . . . . = 0   ?   0-16000
       Timer TS time delay dropout (timer TS output is Relay Word bit **ST**)

TKPU   : . . . . = 0   ?   0-16000

TKDO : . . . . = 0   ?   0-16000
      Timer TK time delay dropout (timer TK output is Relay Word bit **KT**)

TZPU : . . . . = 0   ?   0-16000
      Timer TZ time delay pickup (timer TZ output is Relay Word bit **ZT**)

TZDO : . . . . = 0   ?   0-16000
      Timer TZ time delay dropout (timer TZ output is Relay Word bit **ZT**)

Set remaining settings equal to combinations of elements in the Relay Word via SELOGIC Control Equations. You can clear logic settings by entering NA.

The following settings S(123) through A2(1234) can be set to equal any OR-combination of elements in the Relay Word rows indicated in parentheses.

S(123)   = ?   Input into timer TS (TS output is Relay Word bit **ST**)

Settings A(12) through J(1234) are for Relay Word bits **A** through **J**, respectively.

A(12)   = ?
B(12)   = 51NT ?
C(12)   = ?
D(12)   = ?
E(34)   = ?
F(34)   = IN6 ?
G(34)   = ?
H(34)   = ?
J(1234)   = ?

K(1234)   = ?   Input into timer TK (TK output is Relay Word bit **KT**)
L(1234)   = ?   Input into an inverter (output is Relay Word bit **!L**)
A1(1234)   = TF ?   A1 output contact setting
A2(1234)   = NDEM ?   A2 output contact setting

The following settings V(56) through Z(56) can be set to equal any AND-combination of Relay Word bits **A** through **!L**, which are in Relay Word row R5 and the first three bits of row R6.

V(56)   = B*F ?
W(56)   = ?
X(56)   = ?
Y(56)   = ?
Z(56)   = ?   Input into timer TZ (TZ output is Relay Word bit **ZT**)

The following settings A3(1346) through SEQ(1) can be set to equal any OR-combination of elements in the Relay Word rows indicated in parentheses.

```
A3(1346)  = ?                    A3 output contact setting
A4(2346)  = ?                    A4 output contact setting
TR(1246)  = 51T+50LT+V ?         Programmable tripping conditions
ER(1246)  = 51P+51NP+TF ?        Programmable event report trigger conditions
```

Note: SELogic Control Equations cannot exceed 90 characters per equation (including + or * characters). Exceeding this limit may overflow the relay input buffer and cause it to XOFF the terminal from which you are entering settings (see Communications Protocol in this section).

The following settings specify overcurrent elements in Relay Word row R1 to be torque controlled (e.g., ETC(1) = **51P,50NL**).

```
ETC(1)    = ?                    Externally torque controlled elements
ITC(1)    = 51P                  Internally torque controlled phase overcurrent elements
                                 (choose from 51P, 50L, and 50M only)
```

Refer to the functional description and be sure the group settings you choose result in relay performance appropriate to your application.

SET G p

SET G allows entry of global settings which are used with all setting groups. At the setting procedure prompts, enter new data or press <ENTER> for no change. You can jump to a specific global setting by entering the setting name as parameter p. If you do not specify a setting, the procedure starts at the first global setting DEMR.

The relay prompts you for each global setting and checks entries against established limits as it does during group setting entry (see SET n p in this section). For the programmable contact inputs IN1 to IN6, if no function is desired, type **NA** <ENTER>. Type **END** <ENTER> after the last setting change. The relay displays the new global settings and the active group settings. Answer **Y** <ENTER> to enable the new global settings. The relay will pulse the ALARM output as the new global settings are stored in memory.

Following is a list of global settings with setting ranges and explanations.

=>>**SET G** <ENTER>

SET clears events. CTRL-X cancels.
SEL-151-R400 Global Settings
Enter data, or <ENTER> for no change

<div align="right"><u>Range</u></div>

```
DEMR  : Dem Reset Grp Chg Y/N? . . . . . . . . = Y      ?
        Reset the demand values when an active setting group change is made.
```

CFT   : Cl Fail Time, cyc . . . . = 60   ?   0-16000
          Close failure time. If CFT = 0, CLOSE output contact deasserts
          if breaker closes per circuit breaker status input (52A or !52A)
          or TRIP output contacts assert.

TDUR   : Trip Dur, cyc . . . . = 4   ?   0-63
          Trip duration time

TFT   : Trip Fail Time, cyc . . . . = 30   ?   "
          Trip failure time

TGR   : Grp Chg Dly, cyc . . . . = 180   ?   0-16000
          Setting Group Selection inputs (SS1, SS2, SS3) have to stabilize for
          time TGR before the relay changes setting groups.

ITT   : Inst Tar Time, cyc . . . . = 5   ?   0-63
          INST front panel target illuminates if TRIP occurs less than ITT time
          after any Relay Word row R1 overcurrent element picks up

TIME1   : Port 1 Timeout, min . . . . = 15   ?   0-30
          (=0, no timeout)

TIME2   : Port 2 Timeout, min . . . . = 0   ?   "
          (=0, no timeout)

AUTO   : Autoport 1,2 or 3 . . . . = 2   ?
          1 = Port 1, 2 = Port 2, and 3 = both
          Port to receive automatic messages

RINGS : Rings 1-30 . . . . = 3   ?
          Number of rings after which modem on Port 1 answers

Inputs IN1 through IN6 can be assigned to one of the following functions:

     SS1   Setting Group Selection Input 1 (assign to IN1 only)
     SS2   Setting Group Selection Input 2 (assign to IN2 only)
     SS3   Setting Group Selection Input 3 (assign to IN3 only)

     TCP   External Torque Control (Phase and Negative-Sequence Elements)
     !TCP   (inverted sense of TCP)

     TCG   External Torque Control (Residual Overcurrent Elements)
     !TCG   (inverted sense of TCG)

     52A   Circuit Breaker Status
     !52A   (inverted sense of 52A)

     DC   Direct Close   (requires circuit breaker status)
     TCM   Trip Circuit Monitor   (requires circuit breaker status)

ET   External Trigger of Event Report
DT   Direct Trip
(blank)   Unassigned Input

Type **NA** <**ENTER**> to clear settings.

IN1   = SS1   ?
IN2   = DT   ?
IN3   =   ?
IN4   =   ?
IN5   = 52A   ?
IN6   =   ?

Refer to the functional description and be sure the global settings you choose result in relay performance appropriate to your application.

The AUTO setting selects Port 1, Port 2, or both serial ports for automatically transmitted messages. If relay Port 2 is connected to an SEL-RD or SEL-PRTU, the AUTO setting must direct automatic messages to that port. The following table shows the effect of each possible setting:

AUTO SETTING	AUTOMATIC MESSAGE DESTINATION PORT
1	1
2	2
3	1 and 2

Event summaries and self-test warning and failure reports are automatically transmitted from port(s) designated automatic regardless of access level if the designated port is not timed out. Enter zero as the timeout setting of the appropriate port if automatic transmissions will be monitored by a dedicated channel or printed on a dedicated printer.

SEL-251CD RELAY COMMAND SUMMARY

Access Level 0

ACCESS   Answer password prompt (if password protection is enabled) to enter Access Level 1. Third unsuccessful attempt pulses ALARM contacts closed for one second.

Access Level 1

2ACCESS   Answer password prompt (if password protection is enabled) to enter Access Level 2. This command always pulses the ALARM contacts closed for one second.

BREAKER   Displays running sum of circuit breaker trips for relay and external trips (circuit breaker trip counters). Also displays running sum of interrupted current in each circuit breaker pole for relay and external trips.

BREAKER R   Resets circuit breaker trip counters and interrupted current sums to zero for both relay and external trips. Relay stores reset date and time.

DATE m/d/y   Sets or displays date. DAT 5/1/93 sets date to May 1, 1993. IRIG-B time code input overrides existing month and day settings. DATE pulses ALARM contacts when year entered differs from year stored. To display the date only, enter DATE.

EVENT n   Shows event record. EVE or EVE 1 shows newest event; EVE 12 shows oldest (n=1, 2, 3,...,11, or 12).

HISTORY   Shows DATE, TIME, EVENT, LOCAT (location), SHOT, TARGETS, and CURR (maximum fault current) for the last twelve events.

IRIG   Forces immediate attempt to synchronize internal relay clock to time code input.

METER n   Displays present phase, residual, and negative-sequence current values; present real and reactive power values; present line-to-line voltage values. Optional n displays METER data n times.

METER D   Displays demand and peak demand values of phase, residual, and negative-sequence current values and real and reactive power values.

METER RD   Resets demand values.

METER RP   Resets peak demand values.

QUIT   Returns control to Access Level 0; returns target display to Relay Targets.

SHOWSET n   Displays settings of setting Group n without affecting them (n = 1, 2, 3, 4, 5, or 6).

STATUS   Shows self-test status.

TARGET n k   Shows data and sets target LEDs as follows (n = 0, 1, 2, . . . 7, or 8):

TAR 0: Front Panel Targets	TAR 1: Relay Word row R1
TAR 2: Relay Word row R2	TAR 3: Relay Word row R3
TAR 4: Relay Word row R4	TAR 5: Relay Word row R5
TAR 6: Relay Word row R6	TAR 7: Input States
TAR 8: Output Contact States	Optional k displays target data k times.

Access Level 1 (Continued)

TARGET R   Clears targets and returns to TAR 0

TIME h/m/s   Sets or displays time. TIM 13/32/00 sets clock to 1:32:00 PM. IRIG-B synchronization overrides this setting. To display the time only, enter TIME.

TRIGGER   Triggers and saves an event record (event type is EXT).

Access Level 2

CLOSE   Closes circuit breaker, if allowed by jumper setting.

COPY m n   Copies setting Group m to setting Group n (m and n equal any combination of 1, 2, 3, 4, 5, or 6). Clears buffers. If n is the active setting group, the ALARM output contacts pulse closed.

GROUP n   Designates the active setting group when no Setting Group Selection Inputs are assigned to inputs or all Setting Group Selection Inputs assigned to inputs are deasserted (n = 1, 2, 3, 4, 5, or 6). The ALARM output contacts pulse closed when the active group changes. GROUP n command execution does not clear the event buffer.

OPEN   Opens circuit breaker, if allowed by jumper setting.

PASSWORD   Shows or sets passwords. ALARM contacts pulse closed after password entry. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.

SET n p   Initiates setting procedure for setting Group n (n = 1, 2, 3, 4, 5, or 6). Option p directs the relay to begin the setting procedure for setting Group n at setting p (e.g., if p = 51P, the setting procedure starts at setting 51P, bypassing all settings before 51P). If no optional p is entered, the setting procedure starts at the beginning.

                       The relay clears event buffers when new settings are stored. If n is the active setting group, the ALARM output contact pulses closed.

SET G p   Initiates setting procedure for the global setting group. Option p directs the relay to begin the setting procedure for the global setting group at setting p (e.g., if p = TDUR, the setting procedure starts at setting TDUR, bypassing all settings before TDUR). If optional p is not used, the setting procedure starts at the beginning.

                       The SET G command pulses ALARM contacts closed and clears event buffers when new settings are stored.

This product is covered by U.S. Patent No. 5,041,737 and U.S. Patent(s) Pending.

EVENT REPORTING
TABLE OF CONTENTS

TABLES

EVENT REPORTING

EVENT REPORT GENERATION

The relay generates a summary and long event report in response to the actions listed in Table 4.1. The summary event report allows a quick review of the information necessary to determine fault type and location. The long event report displays eleven cycles of information for analyzing system and scheme performance.

Table 4.1: Event Report Triggering Actions

- Programmable event report triggering variable (ER) assertion
- TRIGGER command execution
- ET (External Trigger) input assertion
- TRIP output contact assertion

The relay generates a second summary and long event report for the same fault if the trip occurs after the end of the first report.

Relay elements which trigger event reports must drop out for at least four cycles before they can initiate another event report. This helps to eliminate multiple records for boundary faults.

Triggering is recorded to the nearest quarter-cycle and referenced to the 16th row of data in the report. All reports trigger at row 16. This system allows you to determine the total duration of a long fault which triggers two event reports. Simply calculate the time difference between the report generated at fault inception by ER (the programmable event report triggering variable) and the report generated by the TRIP.

SUMMARY EVENT REPORT

The summary report is automatically transmitted from port(s) designated AUTOMATIC regardless of access level, as long as the designated port has not timed out. If automatic transmissions are monitored by a dedicated channel or printed on a dedicated printer, enter zero for the timeout setting of the appropriate port.

Due to the length of the full report, it is not automatically transmitted. You can display the full report with the EVENT command.

The summary event report includes:

- Relay terminal identifier
- Date and time
- Event type
- FAULT TYPE front panel targets
- Currents (phase, 3 x negative-sequence, and residual) measured near the middle of the fault or when the event report was triggered if no fault occurred.

The following shows an example summary event report.

```
Example 21.6 kV distribution bus    Date: 5/1/93 Time: 01:36:50.070

Event   : ER                                        Targets: INSTAQN
Currents (A pri), ABCQN:          2798    213   211   2741   2742

=>
```

See HISTORY in Section 3: COMMUNICATIONS for more information. The relay clears the event report and history buffer for the following conditions:

- Loss of control power
- Entry of new setting via SET or SET G command
- COPY command execution

LONG EVENT REPORT

The long event report contains 44 quarter-cycles of prefault, fault, and post fault voltage and current information. For each quarter-cycle of information, the relay also records the states of all fault measuring elements, outputs, and inputs. The report also includes settings active during the event. This information is useful in reviewing fault inception and duration, relay element response, fault evolution, and breaker reaction time.

The last twelve event records are stored in volatile memory. You can review the stored summary reports quickly with the HISTORY command; use the EVENT command to display the long form of each event report.

INTERPRETING VOLTAGE AND CURRENT DATA

The relay determines voltage and current data in the event report using the following steps. The process uses secondary quantities presented to the rear panel of the relay.

1. Two pole, low pass filters with cutoff frequencies of approximately 85 Hz filter input analog signals.

2. The relay samples filtered analog signals four times per power system cycle and converts them to numerical values.

3. A digital filter processes the sampled data and removes dc and ramp components. The unit sample response of this filter is:

$$1, -1, -1, 1$$

The filter has the property of a double differentiator smoother.

4. The digital filter processes the latest four samples every quarter-cycle. Successive filter outputs arrive every 90°. With respect to the present value of the filter output, the previous value was taken one quarter-cycle earlier and appears to be leading the present value by 90°.

Filter output values can be used to represent the signals as phasors:

The previous value of the output is the Y-component.
The present value of the output is the X-component.

The following example illustrates why the older data is the leading component of the phasor.

Consider a sinewave having zero-phase shift with respect to t = 0 and a peak amplitude of 1. Now consider two samples, one taken at t = 0, the other taken 90° later. They have values 0 and 1, respectively. By the above rules, the phasor components are (X,Y) = (1,0).

Now consider a cosine function. Its samples taken at t = 0 and t+90° are 1 and 0; its phasor representation is (0,1). The phasor (0,1) leads the phasor (1,0) by 90°. This coincides with a 90° lead of the cosine function over the sine function.

To construct a phasor diagram of voltages and currents, select a pair of adjacent rows from an area of interest in the event report. On Cartesian coordinates, plot the lower row (newer data) as the X-components and the upper row (older data) as the Y-components. Rotate the completed diagram to any angle of reference. The magnitude of any phasor equals the square root of the sum of its squares.

Note that moving forward one quarter-cycle rotates all phasors 90°. You can verify this by plotting the phasor diagram with rows 1 and 2, then rows 2 and 3 of an event report. Example Event Report 1 shows conversion of the rectangular format voltages and currents displayed in the event report to polar format (see Example Event Reports).

RELAY ELEMENT, OUTPUT CONTACT, AND INPUT DATA

Relay elements, inputs, and output contact states appear in the right-hand columns of the event report. The following information lists symbols corresponding to asserted combinations of elements ("1" indicates element/output contact assertion or input energization).

Event Report Column	Elements			Symbol
P	Phase overcurrent			
51	51P	51T		
	0	0		.
	0	1		1
	1	0		p
	1	1		T
50L	50L	50LT		
	0	0		.
	0	1		(not possible)
	1	0		p
	1	1		T
50M	50M	50MT		
	0	0		.
	0	1		(not possible)
	1	0		p
	1	1		T
TCI	Internal torque control			
	21P	50C	27	
	0	0	0	0
	0	0	1	V
	0	1	0	I
	0	1	1	3
	1	0	0	Z
	1	0	1	5
	1	1	0	6
	1	1	1	7
50H	50H			
	0			.
	1			p
Q	Negative-sequence overcurrent			
51	51QP	51QT		
	0	0		.
	0	1		1
	1	0		p
	1	1		T

Event Report Column	Elements			Symbol
50	50Q	50QT		
	0	0		.
	0	1		(not possible)
	1	0		p
	1	1		T
N	Ground/residual overcurrent			
51	51NP	51NT		
	0	0		.
	0	1		1
	1	0		p
	1	1		T
50L	50NL	50NLT		
	0	0		.
	0	1		(not possible)
	1	0		p
	1	1		T
50H	50NH			
	0			.
	1			p
I	Demand current thresholds			
DEM	PDEM	QDEM	NDEM	
	0	0	0	.
	0	0	1	N
	0	1	0	Q
	0	1	1	3
	1	0	0	P
	1	0	1	5
	1	1	0	6
	1	1	1	7

Left table

Event Report Column	Elements			Symbol
BKR	Circuit breaker alarms			
	TF	CF	TCMA	
	0	0	0	.
	0	0	1	M
	0	1	0	C
	0	1	1	3
	1	0	0	T
	1	0	1	5
	1	1	0	6
	1	1	1	7
Out	Output contacts			
T&C	TRIP	CLOSE		
	0	0		.
	0	1		C
	1	0		T
	1	1		(not possible)
1&2	A1	A2		
	0	0		.
	0	1		2
	1	0		1
	1	1		B (Both)

Right table

Event Report Column	Elements		Symbol
3&4	A3	A4	
	0	0	.
	0	1	4
	1	0	3
	1	1	B (Both)
ALR	Alarm		
	0		.
	1		A
In	Inputs		
1&2	IN2	IN1	
	0	0	.
	0	1	1
	1	0	2
	1	1	B (Both)
3&4	IN4	IN3	
	0	0	.
	0	1	3
	1	0	4
	1	1	B (Both)
5&6	IN6	IN5	
	0	0	.
	0	1	5
	1	0	6
	1	1	B (Both)

EXAMPLE EVENT REPORTS

Externally Triggered Event Report

Recall from Section 3: COMMUNICATIONS that the relay records an eleven-cycle event report when you issue the TRIGGER command. This command does not affect the protective functions of the relay. The event type listing "TRIG" signifies an event triggered on command. Use the TRIGGER command to generate an event report for plotting voltage and current phasors during normal load conditions prior to releasing the relay for service.

Example Event Report 1 shows the first cycle of an event report triggered under normal operating conditions for a 21.6 kV distribution bus. The report was generated with the TRIGGER command. In this excerpt, you can immediately see that load currents are balanced by the lack of significant current in the residual current column IR. Also, note that the line breaker is closed, as signified by a "B" in the column labeled In: 5 & 6 (IN5 = 52A).

Event report data for the voltages and currents appears in rectangular format. You can easily convert these rectangular values to polar format as described in Interpreting Voltage and Current Data. Section 6: INSTALLATION includes a blank voltage and current polarity check form for plotting voltage and current phasors. A direction and polarity check form completed using the first two rows of data from the event report appears on the following page for the phase currents.

Using the voltage and current phasor diagrams on the bottom of the SEL Direction and Polarity Check Form, note that the current phase rotation is ABC in the counterclockwise direction. This phase rotation must match that of your system.

Fault Triggered Event Report

Example Event Report 2 shows all eleven cycles of a fault triggered event report. The first three cycles show prefault conditions. The event report was triggered when the **51P** element picked up on a BC fault. **51P** is set to trigger event reports via the programmable event report trigger variable ER(1246). **51P** is not set to initiate tripping. Tripping is initiated if **51T** times out. **51T** is set to initiate tripping via the programmable tripping variable TR(1246). Comments to the right of the event report and settings explain additional details.

Example Event Report 1

```
Example 21.6 kV distribution bus          Date: 8/1/93    Time: 01:07:35.862

FID=SEL-251CD-R400-V656np0eqd-D930719-E2

            Currents                Voltages      P    Q   N   I  Out  In
            (A pri)                 (V pri)
                                                555T5 55 555 D B T13A 135
   IR   IA    IB    IC    VAB    VBC    VCA     100C0 10 100 E K &&&L &&&
                                                 LMIH    LH M R C24R 246

   -1  310  -171  -141  17251   2632 -19883     .... .. ... . . .... 1.B ┐── One cycle of data
    3   16   262  -276 -12999  21439  -8440     .... .. ... . . .... 1.B │
    1 -310   171   141 -17251  -2632  19883     .... .. ... . . .... 1.B │
   -3  -16  -262   276  12999 -21439   8440     .... .. ... . . .... 1.B ┘


Event  : TRIG                           Targets:    ─────────────── Event Summary
Currents: (ABCQN; amps, primary)   310    313   310    3
```

SEL DIRECTION AND POLARITY CHECK FORM

STATION ___21.6 KV DISTRIBUTION BUS___ DATE: _08_/_01_/_93_ TESTED BY _____

SWITCH NO. _____ EQUIPMENT ___SEL-251CD RELAY_____

INSTALLATION _____ ROUTINE __X__ OTHER _____

LOAD CONDITIONS:

STATION READINGS: _____ MW (OUT)(IN) _____ MVAR (OUT)(IN) _____ VOLTS _____ AMPS

SEL READINGS: _____ MW (+)(-) _____ MVAR (+)(-)

AS SEEN ON SCREEN	Ia	Ib	Ic	Va	Vb	Vc	
COMPANY NOTATION	I( )	I( )	I( )	V( )	V( )	V( )	
1st LINE CHOSEN (Y COMPONENT)	310	-171	-141				
2nd LINE CHOSEN (X COMPONENT)	16	262	-276				
CALCULATED MAGNITUDE $\sqrt{X^2 + Y^2}$	310	313	310				ROW 1
ANGLE IN DEGREES ARCTAN Y/X	87	-33	-153				
VALUE OF Va DEGREES TO SUBTRACT TO OBTAIN Va DEGREES = 0	-87	-87	-87				
@ Va DEGREES = 0, ANGLE USED TO DRAW PHASOR DIAGRAM	0	-120	-240				ROW 2

USE THE VALUES IN ROWS 1 AND 2 ABOVE TO DRAW PHASOR DIAGRAMS BELOW
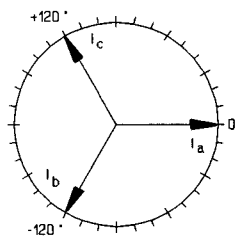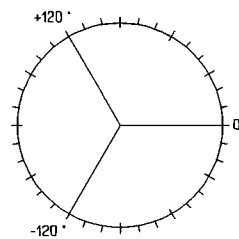
CURRENTS   VOLTAGES

Example 21.6 kV distribution bus   Date: 8/1/93   Time: 17:12:51.175 ├── Time-tag corresponds to the 16th quarter-cycle of this event report.

FID=SEL-251CD-R400-V656np0eqd-D930719-E2

	Currents A pri			Voltages V pri			P	Q	N	I	Out	In
							555T5 100CO LMIH	55 10	555 100 LH	D E M	B K R	T13A &&&L C24R
IR	IA	IB	IC	VAB	VBC	VCA						135 &&& 246
-0	-580	1540	-980	-16516	19641	-3125	.....	..	...	.	.	.... 1.5
-0	-1440	240	1230	-13219	-7798	21017	.....	..	...	.	.	.... 1.5
5	580	-1540	990	16524	-19634	3110	.....	..	...	.	.	.... 1.5
-5	1440	-240	-1230	13212	7805	-21017	.....	..	...	.	.	.... 1.5
-5	-580	1540	-990	-16539	19635	-3096	.....	..	...	.	.	.... 1.5
5	-1440	240	1240	-13198	-7826	21024	.....	..	...	.	.	.... 1.5
5	580	-1540	980	16538	-19620	3082	.....	..	...	.	.	.... 1.5
-5	1440	-240	-1240	13198	7826	-21024	.....	..	...	.	.	.... 1.5
-5	-580	1540	-980	-16538	19620	-3082	.....	..	...	.	.	.... 1.5
5	-1440	240	1240	-13198	-7826	21024	.....	..	...	.	.	.... 1.5
-0	580	-1550	980	16553	-19628	3075	.....	..	...	.	.	.... 1.5
-0	1450	-230	-1240	13183	7848	-21031	.....	..	...	.	.	.... 1.5
-0	-590	1670	-1090	-16337	19152	-2815	.....	..	...	.	.	.... 1.5
-0	-1450	660	800	-13313	-7567	20880	.....	p.	...	.	.	.... 1.5
5	590	-2120	1540	15675	-17813	2138	.....	p.	...	.	.	.... 1.5
-5	1440	-1390	-80	13767	6660	-20427	p..Z.	p.	...	.	.	.... 1.5
-5	-580	2500	-1920	-15171	16791	-1620	p..Z.	p.	...	.	.	.... 1.5
10	-1440	1710	-230	-14098	-5990	20088	p..Z.	p.	...	.	.	.... 1.5
-0	580	-2540	1960	15084	-16596	1512	p..Z.	p.	...	.	.	.... 1.5
-10	1440	-1740	270	14119	5925	-20044	p..Z.	p.	...	.	.	.... 1.5
-0	-580	2540	-1960	-15070	16553	-1483	p..Z.	p.	...	.	.	.... 1.5
5	-1440	1740	-290	-14126	-5918	20044	p..Z.	p.	...	.	.	.... 1.5
5	580	-2540	1970	15077	-16546	1469	p..Z.	p.	...	.	.	.... 1.5
-5	1450	-1740	290	14126	5918	-20044	p..Z.	p.	...	.	.	.... 1.5
-10	-590	2540	-1970	-15091	16553	-1462	p..Z.	p.	...	.	.	.... 1.5
15	-1450	1750	-280	-14112	-5925	20037	p..Z.	p.	...	.	.	.... 1.5
5	590	-2550	1960	15106	-16560	1454	p..Z.	p.	...	.	.	.... 1.5
-15	1450	-1750	280	14098	5940	-20038	p..Z.	p.	...	.	.	.... 1.5
-0	-590	2550	-1970	-15106	16553	-1447	p..Z.	p.	...	.	.	.... 1.5
5	-1450	1740	-270	-14098	-5947	20045	p..Z.	p.	...	.	.	.... 1.5
5	590	-2540	1970	15106	-16546	1440	p..Z.	p.	...	.	.	.... 1.5
-5	1450	-1740	270	14097	5955	-20052	p..Z.	p.	...	.	.	.... 1.5
-5	-590	2540	-1970	-15120	16546	-1426	p..Z.	p.	...	.	.	.... 1.5
5	-1450	1740	-280	-14076	-5969	20045	p..Z.	p.	...	.	.	.... 1.5
5	590	-2540	1980	15127	-16546	1419	p..Z.	p.	...	.	.	.... 1.5
-5	1440	-1740	280	14062	5983	-20045	p..Z.	p.	...	.	.	.... 1.5
-5	-580	2540	-1980	-15134	16538	-1404	p..Z.	p.	...	.	.	.... 1.5
5	-1440	1740	-270	-14062	-5990	20052	p..Z.	p.	...	.	.	.... 1.5
5	580	-2540	1970	15142	-16531	1389	p..Z.	p.	...	.	.	.... 1.5
-5	1450	-1740	270	14062	5990	-20052	p..Z.	p.	...	.	.	.... 1.5
-5	-590	2550	-1970	-15149	16538	-1389	p..Z.	p.	...	.	.	.... 1.5
10	-1450	1730	-270	-14055	-5997	20052	p..Z.	p.	...	.	.	.... 1.5
-0	590	-2550	1970	15156	-16538	1382	p..Z.	p.	...	.	.	.... 1.5
-10	1450	-1730	270	14040	6012	-20052	p..Z.	p.	...	.	.	.... 1.5

Annotations (right column):

— One cycle of data

Prefault bus load current is above the pickup of the 51T element (51P). 51P is torque controlled by 21P.

Input 1 (1) is energized
Input 2 is not energized
Input 3 and 4 are not energized
Input 5 (5) is energized
Input 6 is not energized

Distance element 21P picks up for a feeder BC fault (Z). 51P is then enabled and picks up (p) and initiates this event report.

Phase time-overcurrent element 51T is timing to trip in a backup mode for the relay protecting the faulted feeder.

Event   : ER   Targets: ─────────────── ── Event Summary
Currents (A pri), ABCQN: 1565   3092   1989   3154   15 ──────────┘

```
Settings for group 1 ─────────────────────────── Group 1 is enabled because IN1=SS1 and is energized.
                                                   SS2 = SS3 = 0 by default because they are not assigned
Example 21.6 kV distribution bus                   to inputs.
CTR  =500.00  PTR  =180.00
DATC =15      PDEM =12.00   QDEM =12.00   NDEM =0.34
ZP   =25      MTA  =73.00   21PC =2
50C  =99.99   27L  =0.00    27H  =0.00    27C  =2    TCI  =Z ──── Internal torque control of designated phase
50Q  =99.99   50QT =0                                             overcurrent elements is provided by the
51QP =1.50    51QTD=15.00   51QC =3       51QRS=N                 distance element 21P (TCI = Z).
50NL =50.00   50NLT=0       50NH =50.00
51NP =0.50    51NTD=3.50    51NC =3       51NRS=N
50L  =21.99   50LT =12      50H  =99.99
51P  =2.80    51TD =7.50    51C  =3       51RS =N
50M  =99.99   50MT =0
52APU=0       52ADO=0       TSPU =0       TSDO =0
TKPU =0       TKDO =0       TZPU =0       TZDO =0

SELogic Equations

S(123)  =
A(12)   =
B(12)   =51NT
C(12)   =
D(12)   =
E(34)   =
F(34)   =IN6 ─────────────────────────── Input IN6 functions as a permissive trip input for the 51NT
G(34)   =
H(34)   =
J(1234) =
K(1234) =
L(1234) =
A1(1234)=TF
A2(1234)=NDEM
V(56)   =B*F
W(56)   =
X(56)   =
Y(56)   =
Z(56)   =
A3(1346)=
A4(2346)=
TR(1246)=51T+50LT+V ─────────────────── Programmable tripping conditions
ER(1246)=51P+51NP+TF ────────────────── Programmable event report trigger conditions
ETC(1)  =
ITC(1)  =51P ─────────────────────────── 51P and consequently 51T are designated for torque control by the distance
                                          element 21P.
Global settings
DEMR =Y       CFT  =60      TDUR =4       TFT  =30      TGR  =180
ITT  =5       TIME1=15      TIME2=0       AUTO =2       RINGS=3
IN1  =SS1     IN2  =DT      IN3  =        IN4  =
IN5  =52A     IN6  = ──────────────────────────────────── Input IN6 is used as a permissive trip
                                                           input in the above logic.
```

FIRMWARE IDENTIFICATION

The SEL-251CD Relay provides a means of interpreting Firmware Identification Data (FID). The FID string is included near the top of each long event report. The string format is as follows:

$$\text{FID} = \text{[PN] - R[RN] - V[VS] - D[RD] - E[ER]}$$

Where:

[PN] = Product Name (e.g., SEL-251CD)

[RN] = Revision Number (e.g., 401)

[VS] = Version Specifications (e.g., 656np0eqde)

[RD] = Release Date (e.g., YYMMDD = 931014)

[ER] = Version Specification: EEPROM

For the SEL-251CD Relay family, version specifications are interpreted as follows:

$$\text{V[VS]} = \text{V[ABCDEFGHIJ]}$$

Option	Specifier	Specifier Meaning	Option Description
A	6	60 Hz	Power System Frequency
B	5	5 A	Nominal Amps per Phase
C	6	120 V	Nominal Volts Phase-Phase
D	n	none	Fault Locator type
E	p	positive	Phase-Sequence of Power System
F	0	none	Recloser
G	e	enable and alarm	Target LEDs
H	q	standard	Neg.-Seq. OC Elements
I	d	delta	Voltage Connection
J	e, b	extended, extended w/fast operate	Fast Meter Command

EEPROM version specifications are interpreted as follows:

$$\text{E[ER]} = \text{E[Z]}$$

Option	Specifier	Specifier Meaning	Option Description
Z	1, 2	1 stop bit, 2 stop bits	Communications Protocol Stop Bits

Please contact Schweitzer Engineering Laboratories, Inc. for information concerning available versions of the SEL-251CD Relay. Version specifications provided above are not intended for ordering purposes but to aid in identification of the software installed in a relay.

APPLICATIONS
TABLE OF CONTENTS

TABLES

FIGURES

APPLICATIONS

This section is included as a tool for applying the SEL-251CD Relay. The information does not represent suggested settings or standards. Please refer to Section 2: SPECIFICATIONS and Section 3: COMMUNICATIONS and be sure the settings you choose result in relay performance appropriate to your application.

BLOCKING SCHEMES FOR COLD LOAD INRUSH

Overcurrent elements with low pickup and low time delay settings can operate unintentionally on cold load inrush. These overcurrent elements need to be blocked from initiating tripping for a time period after circuit breaker closure if the potential for cold load inrush current exists.

Two overcurrent element blocking scheme implementations are possible. One scheme uses the **50C** Relay Word bit; the other uses the **52AT** Relay Word bit.

Blocking Scheme for Cold Load Inrush Using the 50C Bit

50C is a phase instantaneous overcurrent element that is not used in the reclosing relay reset inhibit function. Thus it can be set below load levels for a blocking scheme for cold load inrush. **50C** can assert with the presence of load current or deassert in its absence. With this setting, **50C** indicates whether the circuit breaker is closed or open. This scheme is not 52A dependent. To block an overcurrent element for cold load inrush for a time period after circuit breaker closure, supervise the element with a time delayed pickup **50C** condition.

If **50C** is used in this blocking scheme, it cannot be used in the internal torque control settings. The **50C** pickup setting would be too low.

Using SELOGIC™ Control Equations:

$$S(123) \quad = 50C$$
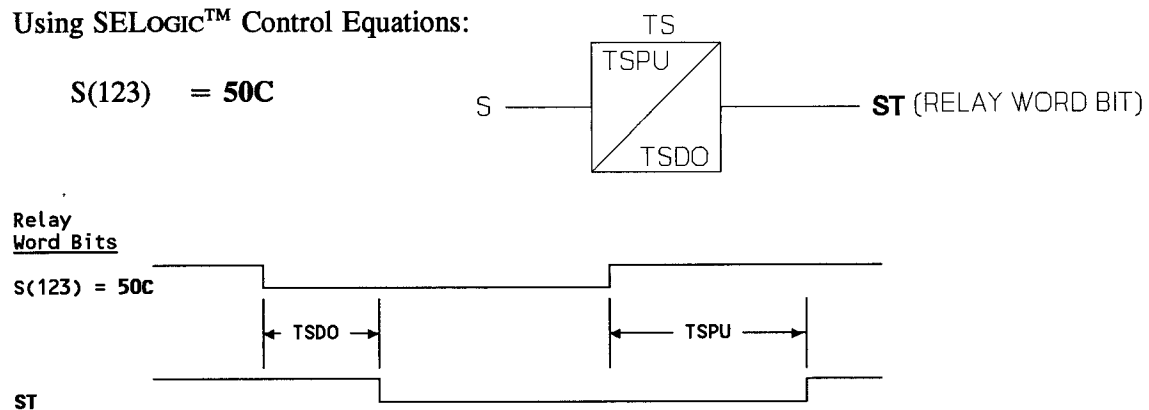
Figure 5.1: 50C Delayed by TSPU Time

If **50L** is supervised by **ST**, **50L** continues to be disabled for time period TSPU after the circuit breaker closes and load is picked up. Set TSPU slightly greater than the potential cold load inrush time.

Continuing with SELOGIC Control Equations:

B(12)	= **50L**	
E(34)	= **ST**	(time delayed **50C**)
V(56)	= **B*E**	
TR(1246)	= **V+**...	(TR is the programmable trip condition)

effectively, TR(1246) = **50L*ST+**...

close TRIP output contacts = TR + ...

If setting 50C is greater than minimum load levels, **50L** is disabled from initiating tripping during minimum load times. If a fault occurred during minimum load times, **50L** would be delayed from operating for the fault for TSPU time.

Blocking Scheme for Cold Load Inrush Using the 52AT Bit

The 52APU and 52ADO settings affect Relay Word bits **52AT** and **52BT** as follows:
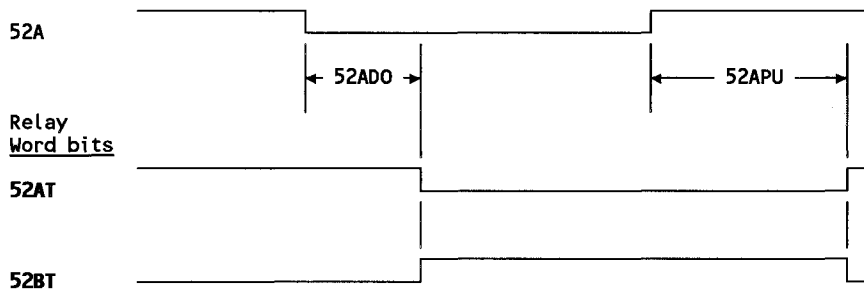
Figure 5.2: Effect of 52APU and 52ADO Settings on Relay Word Bits 52AT and 52BT

Note that **52BT** is the inverse of **52AT**. This discussion involves only **52AT**.

If **52AT** supervises **50L**, **50L** continues to be disabled for 52APU time after circuit breaker closure. Set 52APU slightly greater than the potential cold load inrush time.

Using SELogic Control Equations:

```
B(12)     = 50L
E(34)     = 52AT
V(56)     = B*E
TR(1246) = V+...          (TR is the programmable trip condition)
```

effectively, TR(1246) = **50L*52AT+...**

close TRIP output contacts = TR + ...

DISABLE GROUND/RESIDUAL OVERCURRENT ELEMENTS

Ground relays are often temporarily disabled during distribution circuit paralleling operations. This is done to avoid ground relay trips resulting from residual current unbalance. This unbalance results from line switches not closing or opening all phases in unison when making or breaking parallel, respectively. Ground/residual overcurrent elements in the SEL-251CD Relay can be disabled by inputs functioning as permissive trip, block trip, or torque control inputs. You can apply the principles in the following examples to other elements.

Disable Ground/Residual Overcurrent Elements with Permissive Trip Input

When a permissive trip input is energized, selected overcurrent elements are enabled for tripping. When a permissive trip input is de-energized, selected overcurrent elements are disabled for tripping.

Inputs IN5 and IN6 are available in the Relay Word and can be effectively used as permissive trip inputs.

Using SELogic Control Equations:

```
A(12)     = 51NT          (ground/residual time-overcurrent element)
F(34)     = IN5           (input IN5 to function as a permissive trip input)
V(56)     = A*F
TR(1246) = V+...          (TR is the programmable trip condition)
```

effectively, TR(1246) = **51NT*IN5+...**

close TRIP output contacts = TR + ...

Disable Ground/Residual Overcurrent Elements with Block Trip Input

When a block trip input is energized, selected overcurrent elements are disabled for tripping. When a block trip input is de-energized, selected overcurrent elements are enabled for tripping. This function is the opposite of a permissive trip input.

Inputs IN5 and IN6 are available in the Relay Word and can be effectively used as block trip inputs.

Using SELOGIC Control Equations:

A(12)	= 51NT	(ground/residual time-overcurrent element)
L(1234)	= IN5	(input IN5 to function as a block trip input)
V(56)	= A*!L	(!L=NOT(L) = NOT(IN5))
TR(1246)	= V+...	(TR is the programmable trip condition)

effectively, TR(1246) = 51NT*NOT(IN5)+...

close TRIP output contacts = TR + ...

If the control wiring into input IN5 is accidently open circuited (IN5 is de-energized; IN5=0), elements supervised by IN5 are still enabled, enhancing dependability.

Disable Ground/Residual Overcurrent Elements with Torque Control Input

When a torque control input is energized, selected overcurrent elements are enabled for operation.

When a torque control input is de-energized, selected overcurrent elements are disabled from operation. In such a state, selected instantaneous overcurrent elements do not pick up if current exceeds their pickup settings. Selected definite-time overcurrent and time-overcurrent elements do not start timing when current exceeds pickup settings.

For example, assign input IN4 to function as the ground/residual overcurrent element torque control input. Using the SET G command (global settings):

IN4	= TCG	(external torque control input for ground/residual elements)

Then externally torque control the ground/residual time-overcurrent element **51NT**.

Using SELOGIC Control Equations:

TR(1246)	= 51NT+...	(TR is the programmable trip condition)
ETC(1)	= 51NP	(choose elements to be externally torque controlled)

close TRIP output contacts = TR + ...

Setting ETC(1) lists overcurrent pickups to be externally torque controlled. Element **51NP** is the pickup for **51NT**. If **51NP** is torque controlled, **51NT** is also torque controlled. This is how the relay achieves torque controlling for time-overcurrent and definite-time overcurrent elements via pickups.

In this example, energizing input IN4 enables the **51NT** element; de-energizing input IN4 disables the **51NT** element.

If IN4 = !TCG, the opposite sense is on the input. De-energizing input IN4 enables the **51NT** element; energizing input IN4 disables the **51NT** element.

Implementation of this scheme using the external torque control function is much more efficient than the previous two examples. You can use the SELOGIC Control Equations variables saved to implement other schemes as needed.

MINIMUM RESPONSE TIME FOR TIME-OVERCURRENT ELEMENTS

For time-overcurrent element coordination problems at higher fault current levels, you can incorporate a minimum response time into the time-overcurrent element. Such a time-overcurrent element cannot operate until a set minimum time passes. A ground/residual time-overcurrent element example appears below.

To implement this scheme, set **51NT** and **50NLT** with the same magnitude pickup setting (51NP = 50NL). Set the 50NLT setting with the desired minimum response time.

Using SELOGIC Control Equations:

A(12)	= **51NT**	(ground/residual time-overcurrent element)
B(12)	= **50NLT**	(ground residual definite-time overcurrent element)
V(56)	= **A*B**	
TR(1246)	= **V+**...	(TR is the programmable trip condition)

effectively, TR(1246) = **51NT*50NLT+**...

close TRIP output contacts = TR + ...
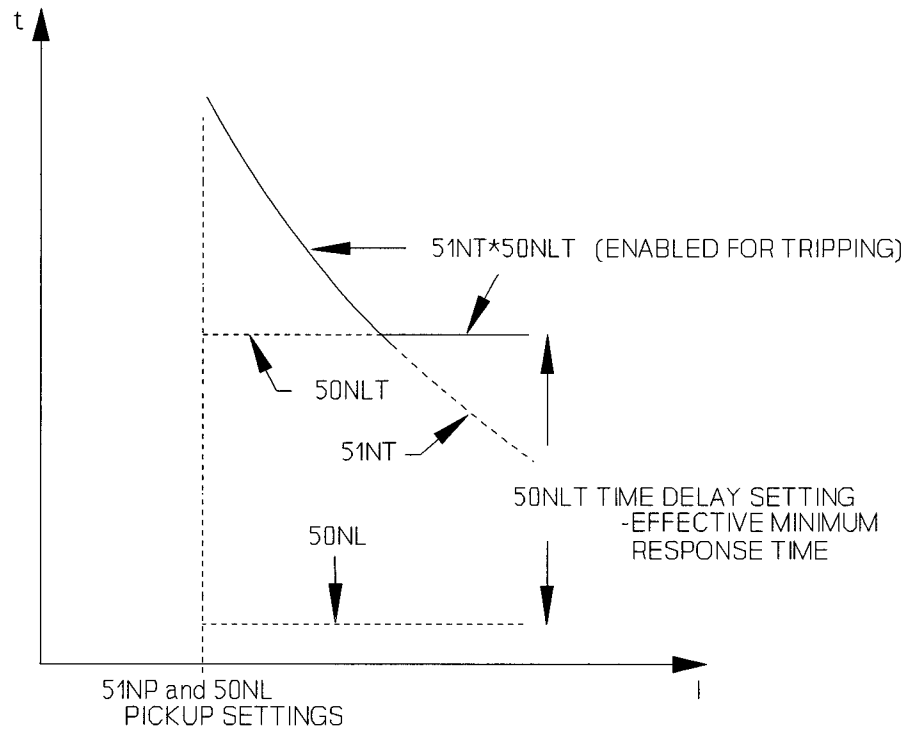
Figure 5.3: Minimum Response Time Using Ground/Residual Elements

NEGATIVE-SEQUENCE ELEMENTS PROTECT FOR PHASE FAULTS

Table 5.1 shows different system conditions and the currents generated by each.

Table 5.1: System Conditions and Currents Generated			
System Condition	Phase Current (I_P)	Negative-sequence Current (I_2)	Zero-sequence Current (I_0)
LG Fault	X	X	X
LLG Fault	X	X	X
LL Fault	X	X	
3-Phase Fault	X		
Balanced Load	X		

In traditional distribution feeder protection, residually connected ground overcurrent relays operate on $3xI_0$ current and cover LG and LLG faults. Phase overcurrent relays operate on I_P current and cover LL faults and three-phase faults. Phase overcurrent relays are sensitive to load current; their pickup settings must exceed load current levels.

Negative-sequence overcurrent relay elements in the SEL-251CD Relay respond to $3xI_2$ current. These elements can be set to cover LL faults more sensitively than phase overcurrent elements. This is because negative-sequence overcurrent elements do not respond to balanced load current. For an LL fault (current magnitudes only):

$$I_2 = (\sqrt{3}/3) \times I_P$$

$$3xI_2 = \sqrt{3} \times I_P$$

$$= 1.73 \times I_P$$

Thus, a negative-sequence overcurrent element has the same sensitivity for LL faults as a phase overcurrent element if negative-sequence overcurrent element pickup value is a factor of 1.73 times the phase overcurrent element pickup value.

The following negative-sequence overcurrent elements (with respective settings) are available in the SEL-251CD Relay:

51QP Negative-sequence time-overcurrent element pickup
51QT Negative-sequence time-overcurrent element
  Settings: 51QP pickup (secondary amps)
         51QTD time dial
         51QC curve
         51QRS time delay or one cycle delay reset

The 51QRS setting activates time delay reset. During the setting procedure, the relay sends the message: "Dly Reset Y/N?" If you press **Y** **<ENTER>**, the negative-sequence time-overcurrent element emulates an induction disc, rotating back to reset after the $3xI_2$ current drops below 51QP (time delay reset). If you press **N** **<ENTER>**, the negative-sequence time-overcurrent element resets completely when the $3xI_2$ current drops below 51QP for one cycle (one cycle delay reset).

The other negative-sequence overcurrent elements and settings are:

50Q Negative-sequence definite-time overcurrent element pickup
50QT Negative-sequence definite-time overcurrent element
  Settings: 50Q pickup (secondary amps)
         50QT time delay

The SEL-251CD Relay phase and ground overcurrent elements have similar element types and settings.

If you coordinate the negative-sequence time-overcurrent element (**51QT**) with the phase time-overcurrent element of a line recloser, settings can be as sensitive as the line recloser phase time-overcurrent element pickup for LL faults. This is possible because **51QT** does not respond to balanced load. The relay requires proper coordination time between **51QT** and the line recloser phase time-overcurrent element.

If you coordinate **51QT** with a phase time-overcurrent element for LL faults, it should have no coordination problems with ground time-overcurrent elements. Ground time-overcurrent elements usually have pickup values one-third or one-fourth the magnitude of phase time-overcurrent relay pickups in their respective protection zones. Ground time-overcurrent relays also have shorter time dials than phase time-overcurrent relays in their respective protection zones. For an LG fault, **51QT** sees the same current magnitude as a ground time-overcurrent relay:

$$I_2 = I_0, \text{ for a LG fault}$$

$$3 \times I_2 = 3 \times I_0$$

Negative-Sequence Overcurrent Elements and Delta-Wye Transformers

Phase-to-ground and phase-to-phase faults on the secondary side of delta-wye transformers can generate negative-sequence currents on the primary system. This should be considered when entering negative-sequence element settings, especially if the delta-wye transformer bank is a large kVA transformer (small impedance). Ground/residual elements are not affected by such phase-to-ground faults because the delta winding does not allow zero-sequence generation in the primary system. See Figures 5.4 and 5.5.

Summary of Figure 5.4

In general, for a phase-to-ground fault on the secondary side of a delta-wye transformer, the following primary current relationship is true:

$$I_P = 1.73 \times I_2$$

$$1.73 \times I_P = 3 \times I_2$$

Thus, for this case, the negative-sequence overcurrent elements have the same sensitivity as a primary phase overcurrent element (e.g., the fuses for the delta-wye transformer) if the negative-sequence overcurrent element pickup value is a factor of 1.73 times the primary phase overcurrent element pickup value.

Summary of Figure 5.5

In general, for a phase-to-phase fault on the secondary side of a delta-wye transformer, the following primary current relationship is true:

$$I_p = 2 \times I_2$$
$$1.5 \times I_p = 3 \times I_2$$

Thus, for this case, the negative-sequence overcurrent elements have the same sensitivity as a primary phase overcurrent element (e.g., the fuses for the delta-wye transformer) if the negative-sequence overcurrent element pickup value is a factor of 1.5 times the primary phase overcurrent element pickup value.
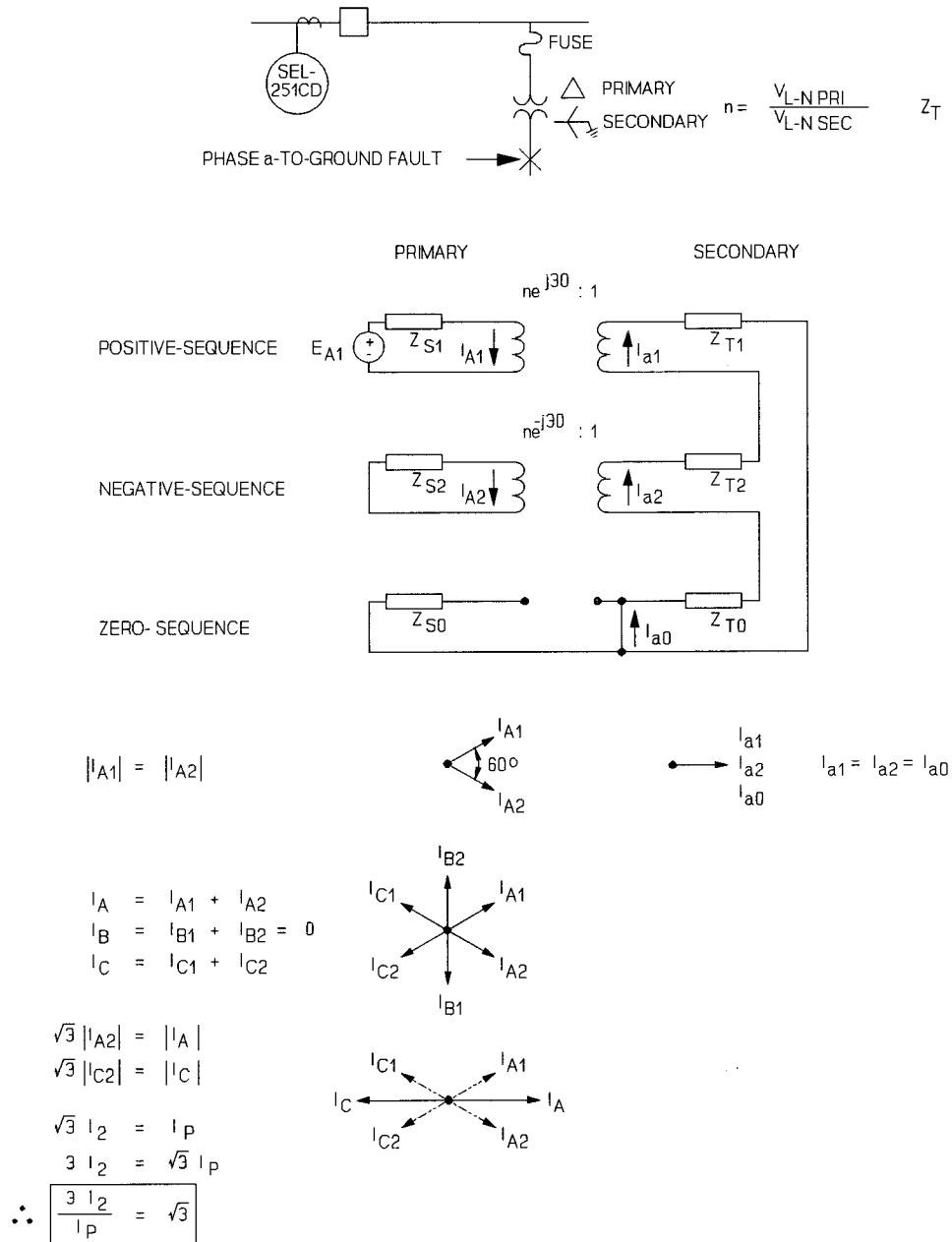
Figure 5.4: Phase-To-Ground Fault on Delta-Wye Transformer Secondary

Figure 5.5: Phase-To-Phase Fault on Delta-Wye Transformer Secondary

UNDERFREQUENCY LOAD SHEDDING INPUT

Relay Word inputs IN5 and IN6 can be used as time-qualified underfrequency load shedding inputs. The output of an underfrequency relay is wired into IN5 or IN6.

Using SELOGIC Control Equations:

$$K(1234) = \textbf{IN5}$$
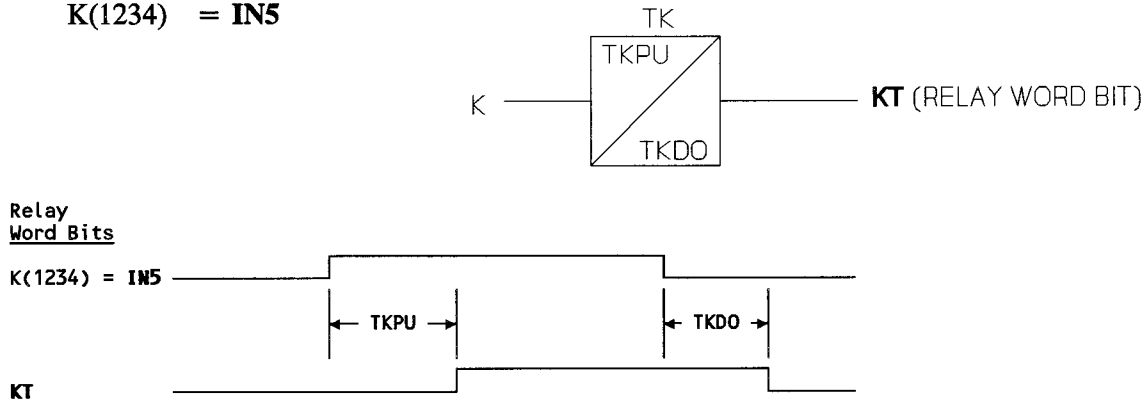
Figure 5.6: Input IN5 Qualified by Time TKPU

Time TKPU qualifies the underfrequency input condition.

Continuing with SELOGIC Control Equations:

$$TR(1246) = \textbf{KT} + ... \qquad \text{(TR is the programmable trip condition)}$$

close TRIP output contacts = TR + ...

Relays on different feeders can have different TKPU time delay pickup settings so certain feeders are tripped before others during a system underfrequency condition.

UNDERVOLTAGE LOAD SHEDDING

An undervoltage load shedding condition is possible by time qualifying the **27** Relay Word bit.

Using SELOGIC Control Equations:

K(1234)   = 27

```
          TK
        ┌──────┐
        │TKPU ╱│
  K ────┤    ╱ ├──────── KT (RELAY WORD BIT)
        │  ╱   │
        │╱ TKDO│
        └──────┘
```

Relay
Word Bits

K(1234) = 27 ─────────┌──────────────┐──────────────

                      │◄─ TKPU ─►│   │◄ TKDO ►│

KT   ─────────────────┌──────────┐──────────
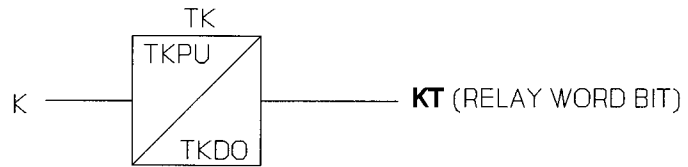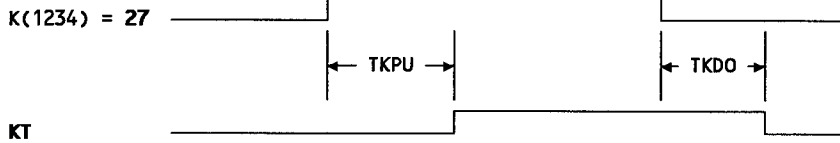
Figure 5.7: Element 27 Qualified by Time TKPU

The TKPU time qualifies the undervoltage condition.

Continuing with SELOGIC Control Equations:

TR(1246) = KT+...   (TR is the programmable trip condition)

close TRIP output contacts = TR + ...

A system undervoltage condition is a three-phase phenomenon, so the **27** element should be set three-phase sensitive (setting 27C = 3). Set high- and low-set limits for **27** (27H and 27L), according to system conditions.

BREAKER FAILURE

Use the **TF** bit in the Relay Word to create a breaker failure scheme.

Using SELOGIC Control Equations:

A1(1234) = TF

Output contact A1 operates as a breaker failure output. Breaker failure applications need the following setting relationship.

TFT (Trip Failure Time) > TDUR (Trip Duration Time)

Breaker Failure Implementation Notes

The "close TRIP output contacts" condition drives the trip failure timer. This condition ends if all trip conditions vanish and all overcurrent element pickups in Relay Word row R1 drop out. For more information, see Figure 2.22.

Even if a circuit breaker trips successfully and all overcurrent element pickups in Relay Word row R1 drop out, a trip condition can still be present.

For example, TR(1246) = **KT**+..., from the previous underfrequency or undervoltage load-shedding applications.

close TRIP output contacts = TR(1246) +...

In this example, a false breaker failure operation can occur if **KT** remains asserted long enough for the trip failure timer to expire. This problem can be overcome if trip condition **KT** is qualified by the presence of load current or limited in duration.

Qualify Trip Condition with Presence of Load Current

Phase instantaneous overcurrent element **50C** is not used in the reclosing relay reset inhibit function and can be set below load levels. **50C** can assert with the presence of load current or deassert in its absence. With this low setting **50C** can indicate whether the circuit breaker is closed or open. There is no 52A dependence.

Using SELOGIC Control Equations to qualify **KT**:

A(12)	= **50C**	
K(1234)	= **IN5** or **27**	(underfrequency or undervoltage application)
V(56)	= **A*KT**	
TR(1246)	= **V**+...	(TR is the programmable trip condition)

close TRIP output contacts = TR + ...

Limit Trip Condition Time Duration

Limiting the **KT** trip condition duration to a time shorter than TFT prevents false breaker failure operation.

Using SELOGIC Control Equations to effectively limit the duration of **KT**:

S(123)	= **IN5** or **27**	(underfrequency or undervoltage application)
L(1234)	= **ST**	
K(1234)	= **IN5** or **27**	(underfrequency or undervoltage application)
V(56)	= **KT*!L**	(!L limits the duration of **KT**)
TR(1246)	= **V**+...	(TR is the programmable trip condition)

close TRIP output contacts = TR + ...

S(123) and K(1234)
= IN5 or 27

KT

L = ST

!L = NOT(ST)

V(56) = KT*!L

TFT > (TSPU - TKPU)
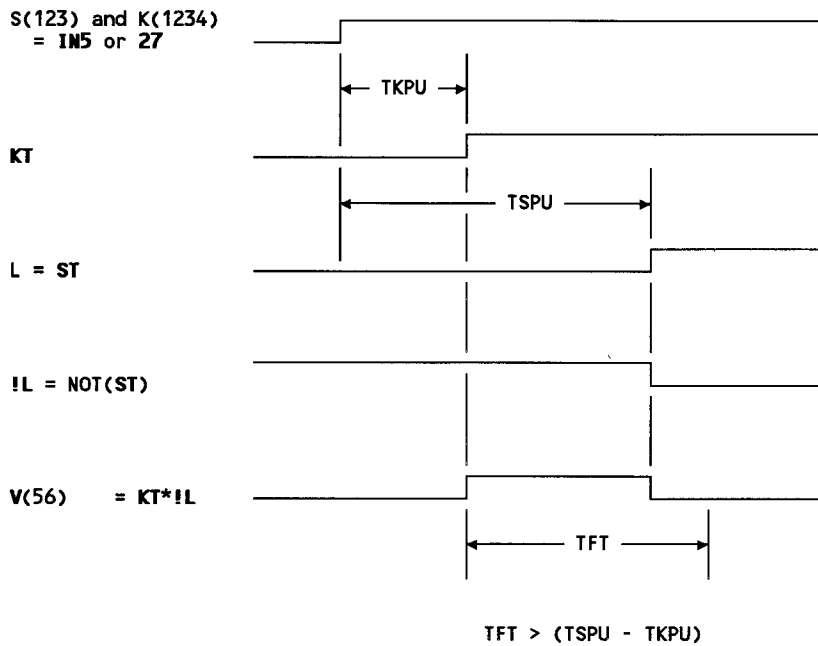
Figure 5.8: Underfrequency or Undervoltage Trip Condition Time Duration Limit

RESIDUAL CURRENT UNBALANCE ALARM

The **NDEM** bit asserts when current exceeds ground/residual demand threshold setting NDEM.

Using SELOGIC Control Equations:

A2(1234) = **NDEM**

Output contact A2 asserts for residual current unbalance. It can also warn of impending ground/residual overcurrent relay pickup due to residual current unbalance.

All demand ammeters use the same time constant (DATC settable from 5 to 60 minutes).

EXTRA ALARM OUTPUT CONTACT

The A4 output contact can function as an extra ALARM output contact, depending on the placement of jumper JMP3. With jumper JMP3 in the A4 position, the A4 output contact operates per setting A4(2346). With jumper JMP3 in the ALARM position, the A4 output contact operates with the ALARM output contact.

All the output contacts can be configured as "a" or "b" contacts with soldered wire jumpers JMP4 through JMP11 (each jumper has positions A and B). ALARM output contacts are usually "b" contacts, so soldered wire jumper JMP5 (for A4 output contact) should be in the B position for the A4 output contact to operate as an extra ALARM output contact.

This extra alarm contact can be used to notify backup protective relays of the primary relay failure condition so that protection adjustments can be made. It can also be used for local annunciation, SCADA input, trip supervision, etc.

BACKUP FEEDER RELAYS WITH A BUS RELAY

Use one SEL-251CD Relay to backup the SEL-251D Relays installed on individual feeders. The feeder relay ALARM contact can supervise a trip from the bus relay because backup is required only when the feeder relay fails. Because of this supervision, the bus relay TRIP output contacts can be set to operate simultaneously with feeder relay TRIP output contacts, both attempting to trip the feeder circuit breaker.

Time delayed trips from the feeder relays (for feeder circuit breaker failures) and the bus relay can trip the bus breaker. These time delayed trips are possible using the trip failure logic available in the SEL-251D and SEL-251CD Relays.

Using SELOGIC Control Equations (for SEL-251D and SEL-251CD Relays):

$$A1(1234) = \textbf{TF}$$

The TFT (trip failure time) settings provide the time delay for the A1 output contacts.

With the SEL-251D Relay ALARM output contact supervising the SEL-251CD Relay TRIP, the SEL-251D Relay A4 output contact can function as an extra ALARM output contact by the placement of jumper JMP3 in the ALARM position. The A4 output contact is made a "b" contact by soldering wire jumper JMP5 in the B position. This output contact can alarm a local annunciator or SCADA RTU for feeder relay failure.
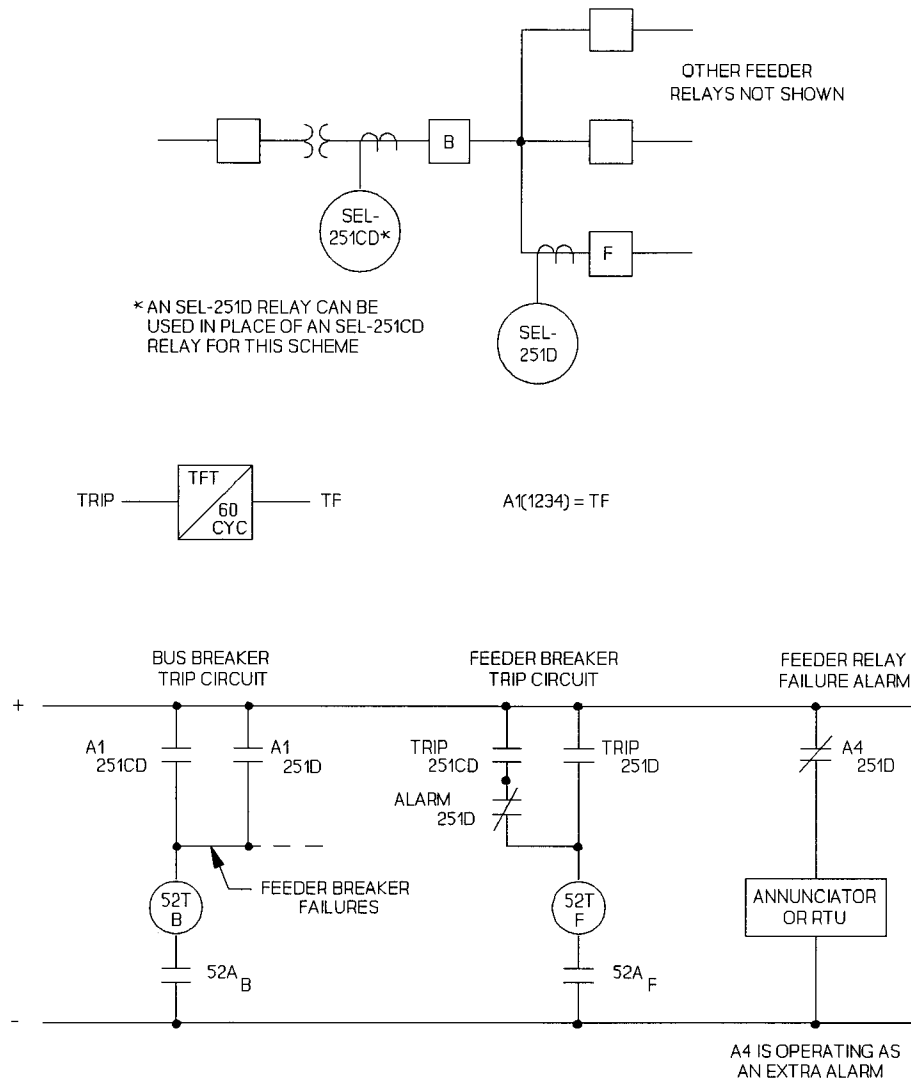
Figure 5.9: Distribution Feeder Relay Backup Scheme

BUS RELAY SETTING CHANGES

Bus relays back up feeder relays. If feeder relay protection settings are changed, bus relay settings may also need to be changed for coordination purposes. Save bus relay setting groups for different feeder relay backup scenarios.

Bus sections can be paralleled for bus breaker maintenance or other emergencies. Program bus relay setting groups for normal or parallel bus operation.

CLOCK-DRIVEN SETTING GROUP SELECTION

Consider seasonal, weekend/weekday, and daily system changes. Develop optimum settings for various times, and use clock contacts to select appropriate settings.

DEMAND-DRIVEN SETTING GROUP SELECTION

Trigger a change to less sensitive settings when demand (phase, negative-sequence or ground/ residual) encroaches on relay settings, thus avoiding nuisance trips. Set an alarm so problems can be investigated.

INSTALLATION
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INSTALLATION

Mounting

The relay is designed for mounting by its front vertical flanges in a 19" vertical relay rack. It may also be mounted semi-flush in a switchboard panel. Use four #10 screws for mounting. This section includes front and rear panel drawings.

Frame Ground Connection

Terminal 46 on the rear panel must be connected to frame ground for safety and performance. These terminals connect directly to the chassis ground of the instrument.

Power Connections

Terminals 44 and 45 on the rear panel must be connected to a source of control voltage. Control power passes through these terminals to the fuse(s) and a toggle switch, if installed. The power continues through a surge filter and connects to the switching power supply. The control power circuitry is isolated from the frame ground.

Secondary Circuits

The relay presents a very low burden to the secondary potential and current circuits. It requires three currents from the power system current transformer secondaries.

The four-wire wye potential from potential transformer secondaries is optional. It is used for fault locating, voltage and MW/MVAR metering, and undervoltage torque control.

Control Circuits

The control inputs are dry. For example, to assert the IN5 input, you must apply control voltage to the IN5 input terminals. Each input is individually isolated, and a terminal pair is brought out for each input. There are no internal connections between control inputs.

Control outputs are dry relay contacts rated for tripping duty. A metal-oxide varistor protects each contact.

Communications Circuits

Connections to the two EIA RS-232-C serial communications ports are made via the two 9-pin connectors labeled Port 1 and Port 2R on the rear panel and Port 2F on the front panel. Pins 5 and 9 connect directly to frame (chassis) ground. See Table 3.1 for pin assignment.

Warning: Do not rely upon pins 5 and 9 for safety grounding, since their current-carrying capacity is less than control-power short circuit current and protection levels.

The communications circuits are protected by low-energy, low-voltage MOVs and passive RC filters. You can minimize communications-circuit difficulties by keeping the length of the EIA RS-232-C cables as short as possible. Lengths of twelve feet or less are recommended, and the cable length should never exceed 100 feet. Use shielded communications cable for lengths greater than ten feet. Modems are required for communications over long distances.

Route the communications cables well away from the secondary and control circuits. Do not bundle the communications wiring with secondary or control circuit wiring. If these wires are bundled, switching spikes and surges can cause noise in the communications wiring. This noise may exceed the communications logic thresholds and introduce errors. The IRIG-B clock cable should also be routed away from the control wiring and secondary circuits.

Jumper Selection

Jumpers JMP103, JMP104, and JMP6 are on the front edge of the main board. They are easily accessed by removing the top cover or front panel. Jumpers JMP3 and soldered wire jumpers JMP4 through JMP11 are toward the back of the main board and are accessed by removing the top cover.

EIA RS-232-C Jumpers

J6 provides EIA RS-232-C baud rate selection. Available baud rates are 300, 600, 1200, 2400, 4800, and 9600. To select a baud rate for a particular port, place the jumper so it connects a pin labeled with the desired port to a pin labeled with the desired baud rate.

Caution: Do not select two baud rates for the same port. This can damage the baud rate generator.

Password Protection Jumper

Put JMP103 in place to disable password protection. This feature is useful if passwords are not required or when passwords are forgotten.

OPEN/CLOSE Command Enable Jumper

With jumper JMP104 in place, the OPEN and CLOSE commands are enabled. If you remove jumper JMP104, OPEN and CLOSE command execution results in the message: "Aborted."

A4 Output Contact Jumper

With jumper JMP3 in the A4 position, the A4 output contact operates per setting A4(2346). With jumper JMP3 in the ALARM position, the A4 output contact operates with the ALARM output contact.

Output Contact Soldered Wire Jumpers

All the output contacts can be configured as "a" or "b" contacts with soldered wire jumpers JMP4 through JMP11 (each jumper has positions A and B). The output contact/soldered wire jumper correspondence is as follows:

Output Contact	Jumper
TRIP (terminals 1,2)	JMP11
TRIP (terminals 3,4)	JMP10
CLOSE	JMP9
A1	JMP8
A2	JMP7
A3	JMP6
A4	JMP5
ALARM	JMP4

Communication Port External Power Jumpers

DC power is available from Port 1 and Port 2R to power external devices. Jumpers must be selected to route dc power to the rear panel connectors. The internal jumpers are near Port 1 and are labeled as follows: JMP12 = +5 V; JMP13= +12 V; JMP14 = -12 V. Use caution to ensure the dc current requirement of the external equipment does not exceed the relay power supply specifications. Only route dc power to the rear ports if required for your application.

EIA RS-232-C And IRIG-B Installation

The following information contains specific details regarding communications port pinouts.

A pin definition of the 9-pin port connectors and cabling information for the EIA RS-232-C ports appears in Figure 6.1. The following cable listings show several types of EIA RS-232-C cables. These and other cables are available from SEL. Cable configuration sheets are also available at no charge for a large number of devices. Contact the factory for more information.

 (female chassis connector, as viewed from outside panel)
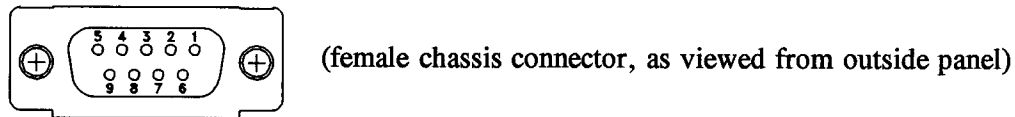
Figure 6.1: 9-Pin Connector Pin Number Convention

EIA RS-232-C Cables

```
SEL-251CD                      9-Pin *DTE DEVICE

GND   5 ——————————— 5   GND
TXD   3 ——————————— 2   RXD
RXD   2 ——————————— 3   TXD        (SEL  CABLE  234)
RTS   7 ┐
        ] Jumper
CTS   8 ┘
                        ┌ 1   DCD
                        ├ 4   DTR
              Jumper ├ 6   DSR
                        └ 8   CTS
                          9   RI
```

```
SEL-251CD                      **DCE DEVICE

GND   5 ——————————— 7   GND
TXD   3 ——————————— 2   RXD
RTS   7 ——————————— 20  DTR        (SEL  CABLE  222)
RXD   2 ——————————— 3   TXD
CTS   8 ——————————— 8   CD
GND   9 ——————————— 1   GND
```

```
RTU                            SEL-251CD

GND   1 ——————————— 5   GND
TXD   2 ——————————— 2   RXD
RXD   4 ——————————— 3   TXD        (SEL  CABLE  231)
CTS   5 ——————————— 7   RTS
+12   7 ——————————— 8   CTS
GND   9 ——————————— 9   GND
```
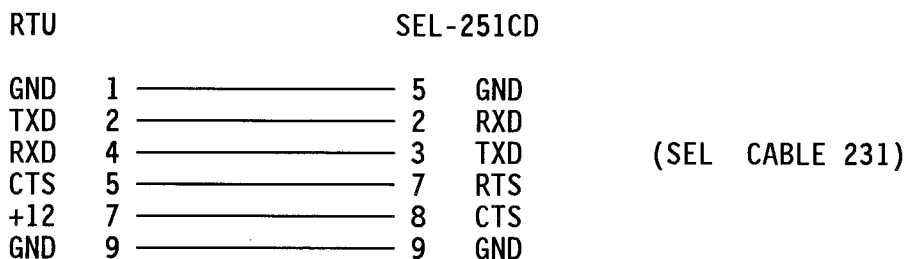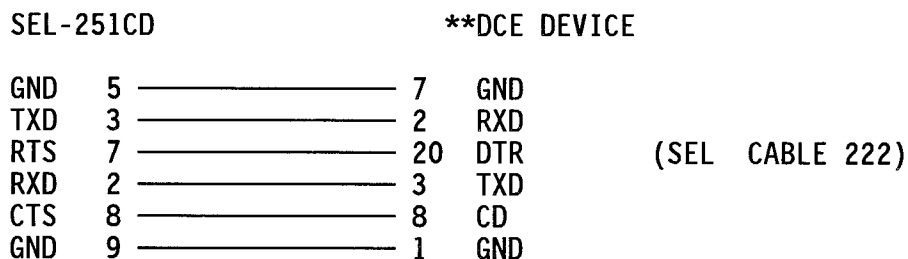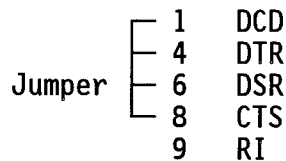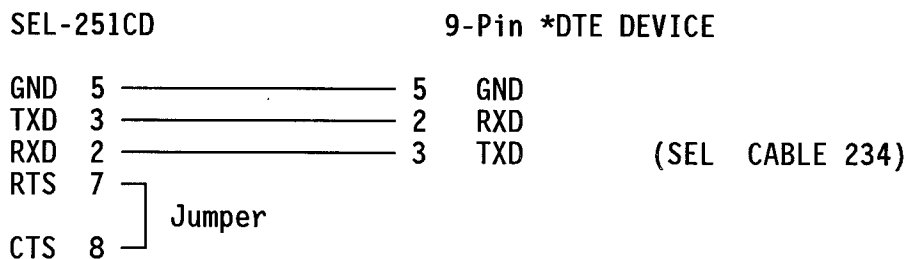
* DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)
** DCE = Data Communication Equipment (Modem, etc.)

IRIG-B Input Description

The port labeled J201/AUX INPUT receives demodulated IRIG-B input. Pin definitions appear in Table 6.1.

Table 6.1: IRIG-B Pin Definitions

Pin	Name	Description
1	+5	*
2	IRIGIN HI	Positive IRIG-B input.
3	IRIGIN LOW	Negative IRIG-B input.
4	+12	*
6	-12	*
5, 9	GND	Ground for ground wires and shields.

* Consult the factory before using these power supply outputs

The actual IRIG-B input circuit is a 56 ohm resistor in series with an optocoupler input diode. The input diode has a forward drop of about 1.5 volts. Driver circuits should put approximately 10 mA through the diode when "on."

The IRIG-B serial data format consists of a one second frame containing 100 pulses and divided into fields. The relay decodes the second, minute, hour, and day fields and sets the internal relay clock accordingly.

When IRIG-B data acquisition is activated either manually (with the IRIG command) or automatically, two consecutive frames are taken. The older frame is updated by one second and the two frames are compared. If they do not agree, the relay considers the data erroneous and discards it.

The relay reads the time code automatically about once every five minutes. The relay stops IRIG-B data acquisition ten minutes before midnight on New Year's Eve so the relay clock may implement the year change without interference from the IRIG-B clock. Ten minutes later, the relay restarts IRIG-B data acquisition.

INSTALLATION CHECKOUT

You may follow the suggestions below or combine them with your normal practice. Never implement recommendations prohibited by the rules of your normal practice. The checkout procedure recommends various settings for ease of testing. These settings may not be applicable to an in-service installation.

The following equipment is required for initial checkout:

- Portable terminal or computer with interconnecting cable (connect to Port 2F)
- Control power to the relay power connections
- Source of three-phase voltages and at least one current source
- Ohmmeter or contact opening/closing device

1. Apply control power and make sure the terminal displays the startup message. If not, set AUTO = 2 with the SET G command in Access Level 2. Check the settings with the ACCESS and SHOWSET commands. Use the TIME command to set the clock.

2. Apply three-phase voltages. Execute the METER command and make sure the readings are accurate. If they are not, be sure the correct PT ratio was entered. Remember that displayed values are in primary line-to-line volts.

3. Use the TRIGGER command to generate an event record. Type **EVENT 1 <ENTER>** and examine the event record. Refer to the top row of data as the "Y" components and the next row as the "X" components. Using the SEL Direction and Polarity Check Form at the end of this section, plot the three voltage phasors to ensure that they are 120° apart, of reasonable magnitudes, and rotating in the positive-sequence direction. The zero-sequence voltage Y and X components (times a factor of three) are the totals of the three Y components and the three X components. These sums should be near zero if balanced three-phase potentials are present.

4. Use the TARGET command to check all inputs (IN1-IN6). Type **TAR 7 <ENTER>** and the front panel target LEDs display input states. Corresponding targets and inputs appear below:

INST A	B	C	Q	N	EN	ALRM	Front Panel Targets
	IN6	IN5	IN4	IN3	IN2	IN1	Inputs

   An LED illuminates when a corresponding input is energized with nominal control voltage. Apply nominal control voltage to each input and make sure the corresponding LED illuminates. When the test is complete, type **TAR R <ENTER>** to reset and clear the front panel target LEDs.

5. Proceed to Access Level 2 with the 2ACCESS command and second password. Be sure the ALARM relay contacts close and open when the relay executes the 2ACCESS command. The ALARM pulse will not be detectable if the ALARM contacts are closed due to an alarm condition.

6. Test the TRIP output contacts by executing the OPEN command (The OPEN/CLOSE command enable jumper JMP104 must be in place). The TRIP output contacts remain asserted for at least the length of the TDUR (trip duration) setting and will not deassert until all overcurrent elements in Relay Word row R1 drop out or you press the front panel TARGET RESET button.

7. Test the CLOSE output contact by executing the CLOSE command (the OPEN/CLOSE command enable jumper JMP104 must be in place). CLOSE output contact operation requires that a 52A or !52A function be assigned to an input (for example, IN6=52A). With IN6 de-energized (circuit breaker open), execute the CLOSE command.

   The CLOSE contacts remain asserted for as long as the CFT (close failure time) setting unless the TRIP output contact is asserted or IN6 is energized (circuit breaker apparently closed). If CFT = 0, CLOSE remains asserted indefinitely unless TRIP is asserted or IN6 is energized (circuit breaker closed).

8. Test the programmable output contacts A1, A2, A3, and A4. Using the SET command, set these contacts to assert when input IN5 is energized. IN5 is in Relay Word row R3 and accessible by A1, A2, A3, and A4 output contact settings:

   A1(1234) = IN5
   A2(1234) = IN5
   A3(1346) = IN5
   A4(2346) = IN5

   After entering the previous settings, apply nominal control voltage to input IN5 and observe A1, A2, A3, and A4 output contact assertion.

9. Use the STATUS command to inspect the self-test status. You may wish to save the reading as part of an as-left record.

When local checkout is complete, check communications with the instrument via a remote interface (if used). Make sure the automatic port is properly assigned and that desired timeout intervals are selected for each port. Also, be sure to record password settings.

Figure 6.2: SEL-251CD Relay Horizontal Front and Rear Panel Drawings

17.25"
(438.2mm)

0.80"
(20.3mm)

8.20"
(208.3mm)
semi-flush
mounting

5.60"   flange is reversible
(142.2mm)   for projection mounting

SEL-2XX

SCHWEITZER ENGINEERING LABORATORIES
PULLMAN WASHINGTON USA

3.47"
(88.1mm)

19.00"
(482.6mm)

17.63"
(447.7mm)

3.00"(76.2mm)
1.75"(44.4mm)
optional

3.60"
(91.4mm)

18.31"
(465.1mm)

7/32" (5.5mm) dia.
for #10 or 5mm screw
(4 places)

DWG. 1097-I01

**Figure 6.3:   SEL-200 Series (Shallow) Relay Dimensions, Panel Cutout, and Drill
Diagrams**
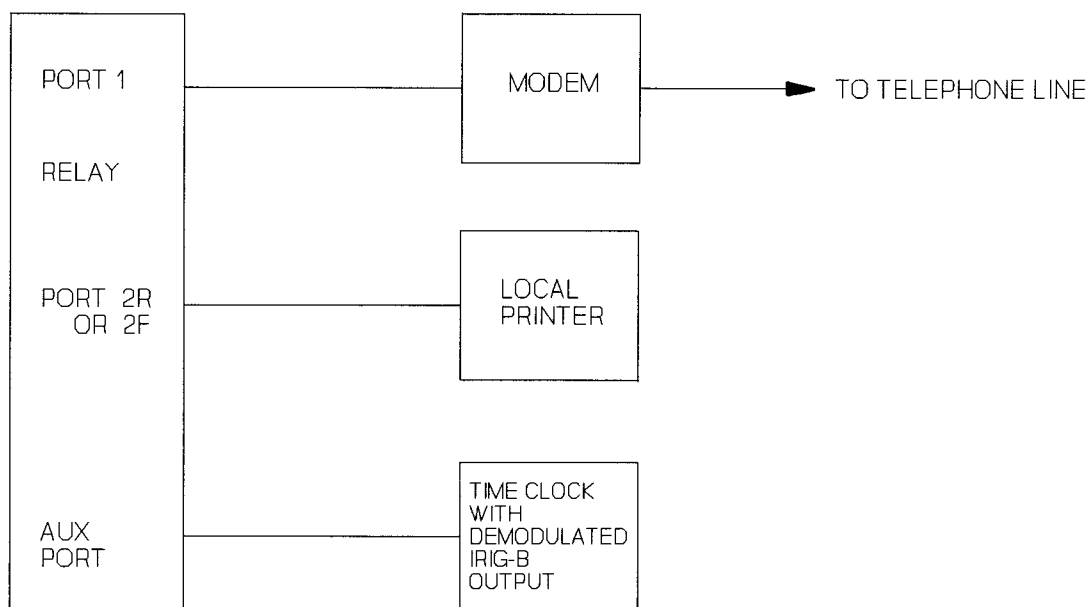
Figure 6.4: Communications and Clock Connections - One Unit at One Location
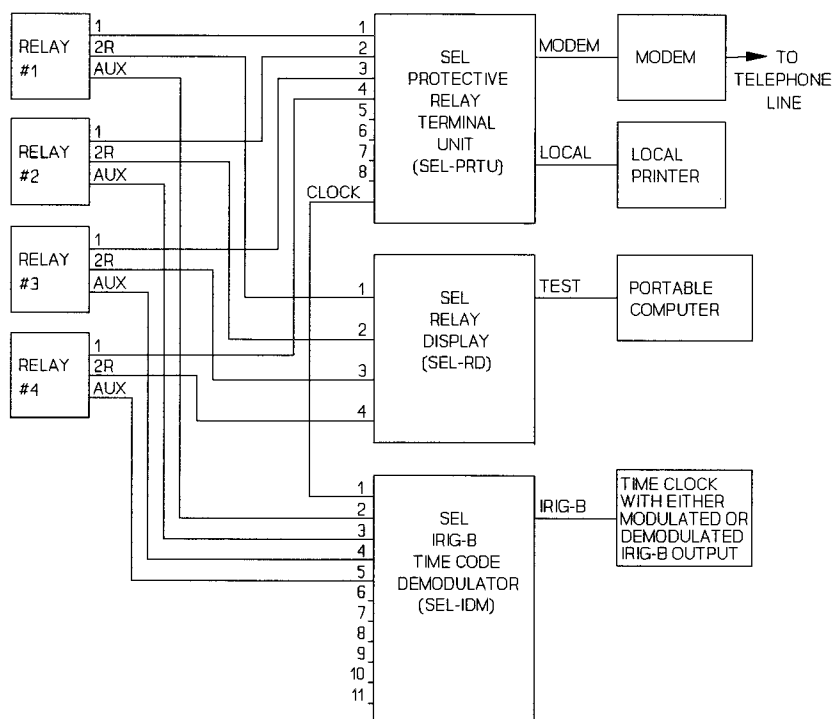
Figure 6.5: **Remote Communications, Local Display, and Clock Connections - Multiple Relay Units at One Location**
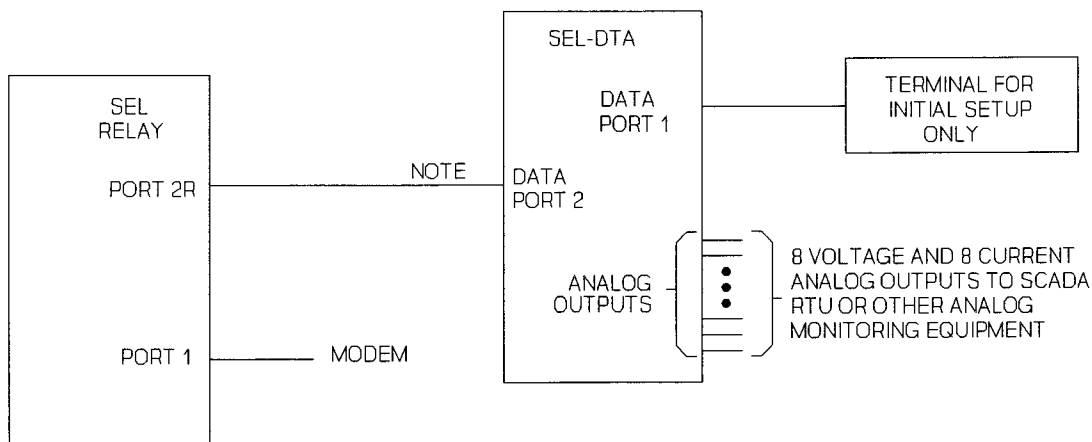
Figure 6.6: SEL Relay Communications Diagram for Connection to the SEL-DTA
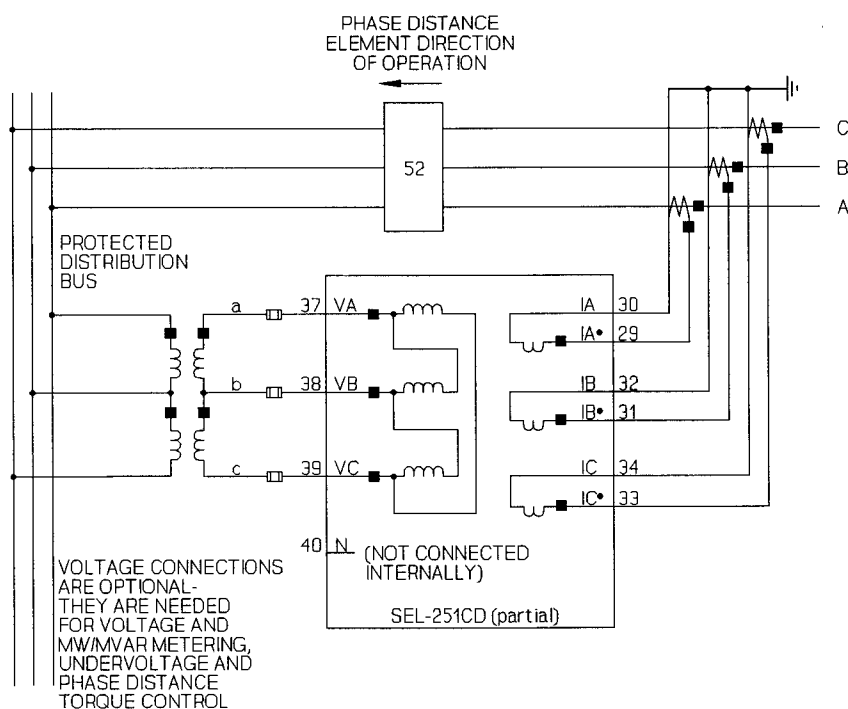
Figure 6.7: SEL-251CD Relay Typical AC External Current and Voltage Connections

The following diagram shows the DC external connections:

Terminal connections (top row, + OR -): 17, 19, 21, 23, 25, 27, 1, 3, 5, 7, 9, 11, 13, 15, 44

IN1, IN2, IN3, IN4, IN5, IN6 — TRIP 1, TRIP 2, CLOSE — A1, A2, A3, A4, ALARM — PS

Terminal connections (bottom row, - OR +): 18, 20, 22, 24, 26, 28, 2, 4, 6, 8, 10, 12, 14, 16, 46, 45

OPTIONAL CONNECTIONS

52T1 — 52a
52T2 — 52a
52C — 52b
— 52a

OPTIONAL CONNECTIONS

ANNUNCIATOR OR RTU

Note: CLOSE output contact operation requires a 52A or !52A function be assigned to an input (IN6=52A in this example).

Figure 6.8: SEL-251CD Relay Typical DC External Connections

SEL DIRECTION AND POLARITY CHECK FORM

STATION _____ DATE: ___/___/___ TESTED BY _____

SWITCH NO. _____ EQUIPMENT _____

INSTALLATION _____ ROUTINE _____ OTHER _____

LOAD CONDITIONS:

STATION READINGS: _____ MW (OUT)(IN) _____ MVAR (OUT)(IN) _____ VOLTS _____ AMPS

SEL READINGS: _____ MW (+)(-) _____ MVAR (+)(-)

AS SEEN ON SCREEN	Ia	Ib	Ic	Va	Vb	Vc	
COMPANY NOTATION	I( )	I( )	I( )	V( )	V( )	V( )	
1st LINE CHOSEN (Y COMPONENT)							
2nd LINE CHOSEN (X COMPONENT)							
CALCULATED MAGNITUDE $\sqrt{X^2 + Y^2}$							R O W 1
ANGLE IN DEGREES ARCTAN Y/X							
VALUE OF Va DEGREES TO SUBTRACT TO OBTAIN Va DEGREES = 0							
@ Va DEGREES = 0, ANGLE USED TO DRAW PHASOR DIAGRAM							R O W 2

USE THE VALUES IN ROWS 1 AND 2 ABOVE TO DRAW PHASOR DIAGRAMS BELOW

CURRENTS   VOLTAGES

SEL DIRECTION AND POLARITY CHECK FORM

STATION _____ DATE: ___/___/___ TESTED BY _____

SWITCH NO. _____ EQUIPMENT _____

INSTALLATION _____ ROUTINE _____ OTHER _____

LOAD CONDITIONS:

STATION READINGS: _____ MW (OUT)(IN)   _____ MVAR (OUT)(IN)   _____ VOLTS _____ AMPS

SEL READINGS: _____ MW (+)(-)   _____ MVAR (+)(-)

AS SEEN ON SCREEN	Ia	Ib	Ic	Va	Vb	Vc	
COMPANY NOTATION	I( )	I( )	I( )	V( )	V( )	V( )	
1st LINE CHOSEN (Y COMPONENT)							
2nd LINE CHOSEN (X COMPONENT)							
CALCULATED MAGNITUDE $\sqrt{X^2 + Y^2}$							R O W 1
ANGLE IN DEGREES ARCTAN Y/X							
VALUE OF Va DEGREES TO SUBTRACT TO OBTAIN Va DEGREES = 0							
@ Va DEGREES = 0, ANGLE USED TO DRAW PHASOR DIAGRAM							R O W 2

USE THE VALUES IN ROWS 1 AND 2 ABOVE TO DRAW PHASOR DIAGRAMS BELOW

CURRENTS

VOLTAGES

MAINTENANCE & TESTING
TABLE OF CONTENTS

TABLES

FIGURES

MAINTENANCE & TESTING

TEST PROCEDURES

Test Aids Provided by the Relay

The following features assist you during relay testing and calibration.

METER
Command

The METER command shows the voltages and currents presented to the relay in primary values. The relay calculates megawatts (MW) and megavars (MVAR) from these voltages and currents. These quantities are useful for comparing relay calibration against other meters of known accuracy.

When testing the relay, first verify relay calibration. Consider all tests invalid if you determine that the relay is out of calibration. Each relay is calibrated at the factory prior to shipment and should not require further adjustment. If calibration is necessary, refer to Calibration in this section.

TARGET
Command

The relay allows you to reassign front panel targets to indicate elements and intermediate logic results in the Relay Word as well as input and output contact status. Use the TARGET command to reassign the front panel LEDs. Once target LEDs are reassigned from the default targets, the front panel targets are no longer latching. This means the targets follow the pickup and dropout condition in much the same manner as an output contact. See Section 3: COMMUNICATIONS for more information about the TARGET command.

By employing the target LEDs for testing, you need not change the relay settings for testing purposes.

Event
Reporting

The relay generates an eleven-cycle event report in response to a trip condition or other user selected conditions. Each event report contains voltage and current information, relay element states, and input/output contact information in quarter-cycle resolution. If you question the relay response or your test method, use the event report for assistance.

Each event report is date and time tagged relative to the sixteenth quarter-cycle of the event report. Each report is triggered upon assertion of designated relay elements and/or contact inputs and outputs. If the time-out of a protective element results in TRIP output contact closure, the trip generates a second event report. Thus, the relay generates two event reports: the first when the designated instantaneous element asserts, the second when the TRIP output contact closes. Where time delayed pickup (TDPU) timers are concerned, use the event report time tag to determine

the validity of a TDPU timer setting. Simply subtract the latest event report time tag from the previous event report time tag. Section 2: SPECIFICATIONS has further details concerning event report generation.

SELOGIC™ Control Equations	SELOGIC Control Equations allow you to isolate individual relay elements. See the SET n p command description in Section 3: COMMUNICATIONS for more information.

Low-Level Test Interface (patent pending)

The SEL-251CD Relay has 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 7.1 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 20 volts peak-peak to the low-level test interface. Figure 7.1 shows the signal scaling factors.

You can test the input module two different ways:

- Measure the outputs from the input module with an accurate voltmeter, and compare the readings to accurate instruments in the relay input circuits, or

- replace the ribbon cable, execute the METER command, and compare the relay readings to accurate instruments in the relay input circuits.

```
           LOW-LEVEL  TEST  INTERFACE
 REMOVE  RIBBON  CABLE    GND GND N/C VCA VBC VAB  IC   IB   IA  N/C
     FOR  TESTING          O   O   O   O   O   O   O   O   O   ■
                           O   O   O   O   O   O   O   O   O   O
                          GND GND GND GND GND GND GND GND GND GND

 INPUT  MODULE  OUTPUT (J2) : 100 mV AT NOMINAL CURRENT (1 A OR 5 A)
                              1144 mV AT NOMINAL VOLTAGE (115 V_LL)
 PROCESSING  MODULE  INPUT (J8) : 20 V p-p MAXIMUM
   PATENTS  PENDING                      SEL-251D, 251CD   157-0067
```
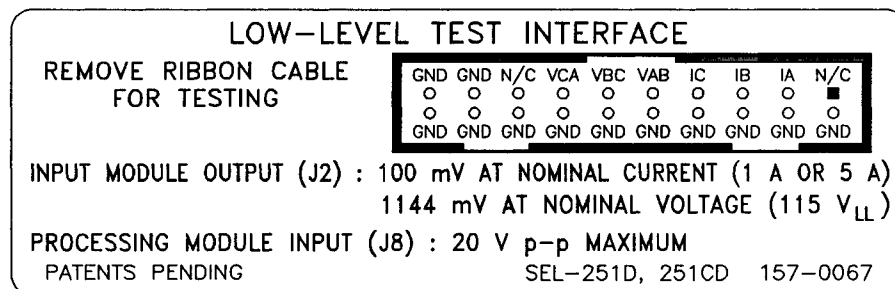
Figure 7.1: Low-Level Test Interface

Test Methods

There are two means of determining the pickup and dropout of relay elements: target lamp illumination and output contact closure.

Testing Via Target LED Illumination

During testing you can use target lamp illumination to determine relay element status. Using the TARGET command, set the front panel targets to display the element under test. For example, the overcurrent element pickups appear in Relay Word row 1. When you type the command **TARGET 1 < ENTER >**, the LEDs display the status of the elements in Relay Word row 1. Thus, with Target 1 displayed, if the phase time-overcurrent element pickup **(51P)** asserts, the left most LED illuminates. Using LED illumination as an indicator, you can measure the element operating characteristics.

When the TARGET command sets target LED output to a level other than 0 (Relay Targets), the front panel target markings no longer correspond to illuminated LEDs and the LEDs do not latch.

If you place the relay in service with a target level other than Level 0, it automatically returns to level 0 when an automatic message transmits to a timed out port. While this feature prevents confusion among station operators and readers, it can be inconvenient if the relay tester does not want targets to revert to level 0.

To simplify testing using targets, set the relay AUTO setting equal to the port which you intend to use. Also, set that port TIME setting equal to zero. This prevents automatic message transmission to a port which may be timed out. Remember to reset these settings and the target level before returning the relay to service following tests.

Testing Via Output Contact Assertion

To test using this method, set one programmable output contact to assert when the element under test picks up. With the SET n p command, set an output contact equal to the element under test.

For an "a" contact, when the condition asserts, the output contact closes; when the condition deasserts, the output contact opens.

For a "b" contact, when the condition asserts, the output contact opens. When the condition deasserts, the output contact closes. Programmable contacts can be specified at the factory as "a" or "b." Using contact operation as an indicator, you can measure element operating characteristics, stop timers, etc.

Tests in this section use the output contact method and assume an "a" output contact.

Using a Breaker Simulator

Because much of the relay logic depends on whether the breaker is open (52A deenergized) or closed (52A energized), it is important to use a breaker simulator. The following logic depends on the state of the 52A contact input:

- Close Function Logic
- Trip Circuit Monitor Logic
- 52AT and 52BT Functions
- Circuit Breaker Monitor Logic

We recommend testing the SEL-251CD Relay with a latching relay to simulate line breaker auxiliary contact action. This ensures proper assertion and deassertion of the 52A input contact on the back panel.

INITIAL CHECKOUT

The initial checkout procedure should familiarize you with the relay and ensure that all functions are operational. Study Functional Specification and Description in Section 2: SPECIFICATIONS, Command Descriptions in Section 3: COMMUNICATIONS, and Section 4: EVENT REPORTING for a complete understanding of the relay capabilities.

Equipment Required

The following equipment is necessary for initial checkout.

1. Terminal with EIA RS-232-C serial interface
2. Interconnecting cable between terminal and relay
3. Source of control power
4. Source of three-phase voltages and currents
5. Ohmmeter or contact opening/closing sensing device

Checkout Procedure

In the procedure below, you will use several relay commands. Section 3: COMMUNICATIONS provides a full explanation of all commands. The following information should allow you to complete the checkout without referring to the detailed descriptions.

Note: In this manual, commands to type appear in bold/upper case: **OTTER**. Keys to press appear in bold/upper case/brackets: **<ENTER>**.

Relay output appears in the following format:

```
+------------------------------------------------------------------------------+
| Example 21.6 kV distribution bus      Date: 05/01/93  Time: 01:01:01         |
|                                                                              |
+------------------------------------------------------------------------------+
```

■ **Step 1**

Purpose: Be sure you received the relay in satisfactory condition.

Method: Inspect the instrument for physical damage such as dents or rattles.

■ **Step 2**

Purpose: Verify the requirements for the relay logic inputs, control power voltage level, and voltage and current inputs.

Method: Refer to the information sticker on the rear panel of the relay. Figure 7.2 provides an example. Please read the information on this sticker before applying power to the relay or starting tests. Be sure your dc supply is correctly adjusted for the control and logic input requirements.
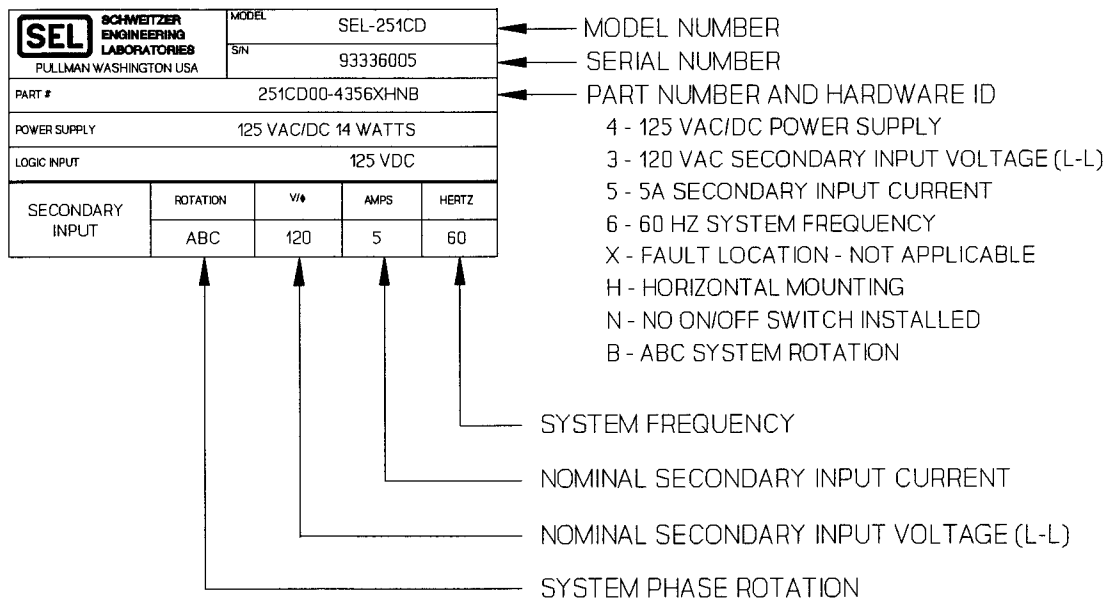
Figure 7.2: **Relay Part Number and Hardware Identification Sticker**

■ **Step 3**

Purpose: Verify the communications interface setup.

Method: Connect a computer terminal to Port 2F on the relay front panel. The terminal should be configured to 2400 baud, eight data bits, two stop bits, and no parity. The relay is shipped from the factory with Port 2 set to 2400 baud and Port 1 set to 300 baud. Section 3: COMMUNICATIONS provides additional details on port configuration. Baud rate selection is described under Jumper Selection in Section 6: INSTALLATION. Figure 7.3 shows the typical communication interface setup for testing purposes.
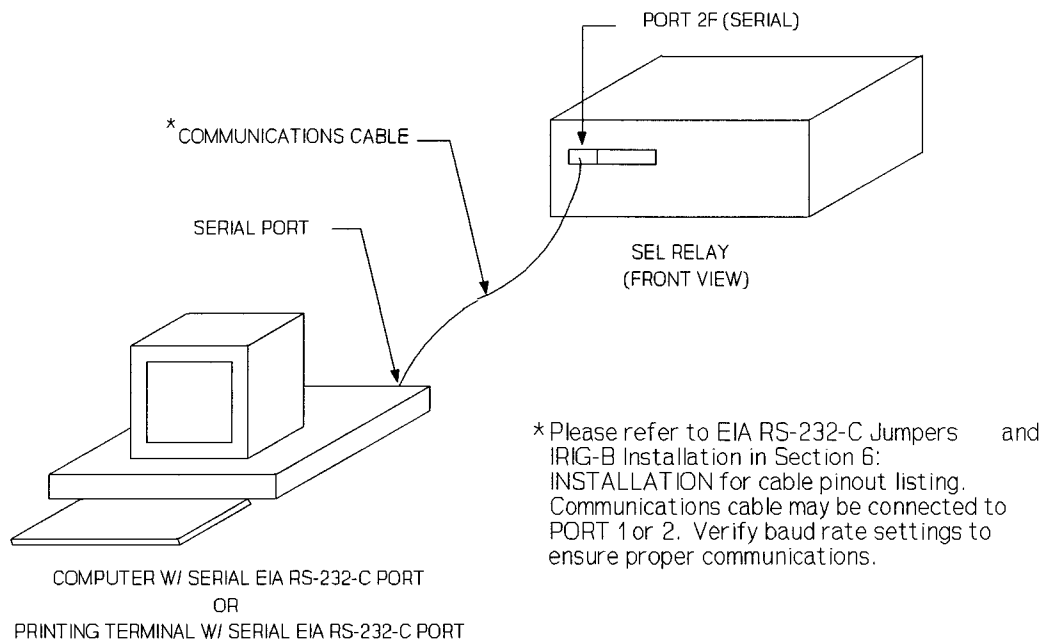
Figure 7.3: Communications Interface Setup

■ **Step 4**

Purpose: Establish control power connections.

Method: Connect a frame ground to terminal 46 on the rear panel and connect rated control power to terminals 44 and 45. Polarity is unimportant. Relays supplied with 125 or 250 V power supplies may be powered from a 115 V ac wall receptacle for testing. In the final installation, we recommend that the relay receive control power from the station dc battery to avoid losing events stored in volatile memory if station service is lost.

■ **Step 5**

Purpose: Apply control voltage to the relay and start Access Level 0 communications.

Method: Turn on the relay power. All front panel targets should illuminate when you press the TARGET RESET button. If not, be sure that power is present and check the fuse or fuses. The following message should appear on the terminal:

```
Example 21.6 kV distribution bus          Date: 5/1/93      Time: 01:01:01

SEL-251CD
=
```

The ALARM relay should pull in, holding its "b" contacts (terminals 15,16) open. If the relay pulls in but no message is received, check the terminal configuration. If neither occurs, turn off the power and refer to Trouble-shooting later in this section.

The = prompt indicates that communications with the relay are at Access Level 0, the first of three levels. The only command accepted at this level is ACCESS, which opens communications on Access Level 1.

Note: If you are using a battery simulator, be sure the simulator voltage level is stabilized before turning the relay on.

■ **Step 6**

Purpose: Establish Access Level 1 communications.

Method: Type **ACCESS** and press **<ENTER>**. At the prompt, enter the Access Level 1 password **OTTER** and press **<ENTER>**. The => prompt should appear, indicating that you have established communications at Access Level 1.

■ **Step 7**

Purpose: Verify relay self-test status.

Method: Type **STATUS** and press **<ENTER>**. The following display should appear on the terminal:

```
+------------------------------------------------------------------------+
| Example 21.6 kV distribution bus        Date: 5/1/93    Time: 01:04:56  |
|                                                                        |
| SELF-TESTS                                                             |
|                                                                        |
| W=Warn    F=Fail                                                       |
|                                                                        |
|          IR    IA    IB    IC    VAB   VBC   VCA                       |
| OS       0     0     0     0     0     0     0                         |
| PS       5.08       14.92       -14.99                                 |
| RAM      ROM   A/D   MOF   SET                                         |
| OK       OK    OK    OK    OK                                          |
|                                                                        |
| =>                                                                     |
|                                                                        |
+------------------------------------------------------------------------+
```

■ **Step 8**

Purpose: View the demonstration settings entered before shipment.

Method: The relay is shipped with demonstration settings; type **SHOWSET 1**
          <ENTER> to view them. The terminal should display the following:

```
=>SHOWSET 1 <ENTER>
Settings for group 1

Example 21.6 kV distribution bus
CTR  =500.00  PTR  =180.00
DATC =15      PDEM =12.00   QDEM =12.00   NDEM =0.34
ZP   =25      MTA  =73.00   21PC =2
50C  =99.99   27L  =0.00    27H  =0.00    27C  =2       TCI  =Z
50Q  =99.99   50QT =0
51QP =1.50    51QTD=15.00   51QC =3       51QRS=N
50NL =50.00   50NLT=0       50NH =50.00
51NP =0.50    51NTD=3.50    51NC =3       51NRS=N
50L  =21.99   50LT =12      50H  =99.99
51P  =2.80    51TD =7.50    51C  =3       51RS =N
50M  =99.99   50MT =0
52APU=0       52ADO=0       TSPU =0       TSDO =0
TKPU =0       TKDO =0       TZPU =0       TZDO =0

PRESS RETURN ? <ENTER>
SELogic Equations

S(123)  =
A(12)   =
B(12)   =51NT
C(12)   =
D(12)   =
E(34)   =
F(34)   =IN6
G(34)   =
H(34)   =
J(1234) =
K(1234) =
L(1234) =
A1(1234)=TF
A2(1234)=NDEM

PRESS RETURN ? <ENTER>

V(56)   =B*F
W(56)   =
X(56)   =
Y(56)   =
Z(56)   =
A3(1346)=
A4(2346)=
TR(1246)=51T+50LT+V
ER(1246)=51P+51NP+TF
ETC(1)  =
ITC(1)  =51P

Global settings
DEMR =Y       CFT  =60      TDUR =4       TFT  =30      TGR  =180
ITT  =5       TIME1=15      TIME2=0       AUTO =2       RINGS=3
IN1  =SS1     IN2  =DT      IN3  =        IN4  =
IN5  =52A     IN6  =

=>
```

The SET command descriptions in Section 3: COMMUNICATIONS include a complete explanation of the settings.

■ **Step 9**

Purpose: Connect voltage and current sources to the relay.

Method: Turn power off and connect the sources of voltage and current to the rear panel terminals of the relay as shown in Figure 7.4. Apply 69 V per phase (i.e., VA = 69) in positive-sequence rotation.

Set the A-phase current source to 2 A, at the same angle as the A-phase voltage. Set the B-phase current source to 2 A, at the same angle as the B-phase voltage. Set the C-phase current source to 2 A, at the same angle as the C-phase voltage.
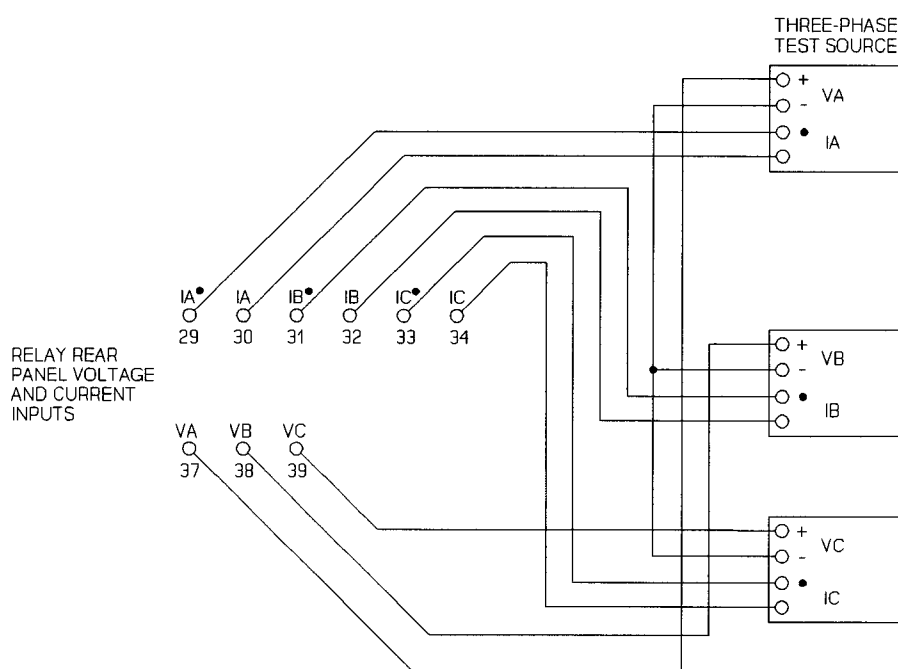
Figure 7.4: Three-Phase Voltage and Current Source Test Connections

■ **Step 10**

Purpose: Verify correct voltage and current connections and levels.

Method: Use the METER command to measure the voltages and currents applied in Step 9. With applied voltages of 69 V per phase and a potential transformer ratio of 180:1, the displayed line-to-line voltages should be 21600 V. With applied currents of 2.0 A per phase and a current transformer ratio of 500, the displayed line-to-neutral currents should be 1000 amperes. All line-to-line quantities should be balanced, differing from the line-to-neutral measurements by a factor of 1.73. Real power P should be approximately 37.26 MW; reactive power Q should be approximately 0 MVAR.

```
r------------------------------------------------------------------------------¬
|  =>METER <ENTER>                                                             |
|                                                                              |
|  Example 21.6 kV distribution bus                 Date: 5/1/93    Time: 09:12:49 |
|                                                                              |
|  MET IA=1000    B=1011    C=1006    R=6                                       |
|      3I2=5       P=37.260   Q=0.054                                           |
|                                                                              |
|  VAB=21501  VBC=21512  VCA=21513                                             |
|                                                                              |
|  =>                                                                          |
|                                                                              |
L------------------------------------------------------------------------------┘
```

If you inadvertently switched a pair of voltages or currents, the MW reading should be incorrect. It is important to remember this when commissioning the relay using system voltages and currents.

■ **Step 11**

Purpose: Establish Access Level 2 communications.

Method: Type **2ACCESS** and press **<ENTER>**. At the prompt, enter the Access Level 2 password **TAIL** and press **<ENTER>**. The = > > prompt should appear, indicating that you have established communications at Access Level 2.

This checkout procedure demonstrates only a few relay features. For a complete understanding of relay capabilities, study Functional Description in Section 2: SPECIFICATIONS, the command descriptions in Section 3: COMMUNICATIONS, and Section 4: EVENT REPORTING. For more test procedures, see the Full Functional Test portion of this section.

FULL FUNCTIONAL TEST

This procedure allows you to test the protective and control functions of the relay more fully than the initial checkout procedure does.

Equipment Required

The following equipment is necessary to complete a full functional test:

1. Communications terminal with EIA RS-232-C serial interface
2. Data cable to connect terminal and relay
3. Source of relay control power
4. Source of synchronized three-phase voltages and at least two currents
5. Ohmmeter or contact opening/closing sensing device
6. Timer with contact inputs for start and stop

What Should Be Tested

A full functional test includes the initial checkout procedure and the additional steps described below. In general, these tests assure that the relay settings match your application rather than checking relay performance. For commissioning purposes, your company policy may require you to perform the full functional test. For maintenance purposes, a quick test of selected fault types and elements should suffice.

SETTING TEST

Purpose: Ensure that the relay accepts settings.

Method: 1. Gain Level 2 Access (see ACCESS and 2ACCESS commands in Section 3: COMMUNICATIONS).

2. Change one setting in setting Group 1. For example, change the ground/residual time-overcurrent element pickup from 0.5 A secondary to 0.9 A secondary.

Type **SET 1 51NP** and press **<ENTER>**.

Following the 51NP prompt, type **0.9** and press **<ENTER>**.

3. To complete the setting procedure, type **END** and press **<ENTER>**. Type **Y <ENTER>** at the prompt: "OK (Y or N) ?" The relay computes internal settings and compares them against fixed limits. If all settings are within acceptable ranges, the ALARM contact closes momentarily as the new settings are enabled unless an alarm condition already exists (e.g., self-test failure).

4. Use the SHOWSET command to inspect settings. Make sure your change was accepted.

Type **SHOWSET 1** and press **<ENTER>**.

5. Use SET and SHOWSET again to restore the initial values and check the settings.

OVERCURRENT ELEMENT PICKUP TESTS

Purpose: Verify the pickup thresholds of the following overcurrent elements:

51P	Phase time-overcurrent element pickup
50L	Phase definite-time overcurrent element pickup
50M	Phase instantaneous overcurrent element pickup
51QP	Negative-sequence time-overcurrent element pickup

50Q	Negative-sequence definite-time overcurrent element pickup
51NP	Ground/Residual time-overcurrent element pickup
50NL	Ground/Residual definite-time overcurrent element pickup
50NH	Ground/Residual instantaneous overcurrent element

Method: 1. Using the SET command, set the desired programmable output (A1-A4) to follow the appropriate overcurrent element. Select one of the overcurrent elements from the first row of the Relay Word listed above.

2. Disable all external and internal torque control on the overcurrent elements. Using the SET command, enter NA for the ETC(1) and ITC(1) settings. These settings specify the overcurrent elements in Relay Word row R1 you want externally and internally torque controlled (none in this case).

3. Apply current to one phase and observe the pickup and dropout of each element. Record the results.

Note: With current applied to only one phase (e.g., $I_A = 6$ A, $I_B = I_C = 0$), the following sequence currents result:

$$I_0 = \tfrac{1}{3}[I_A + I_B + I_C]$$
$$= \tfrac{1}{3}[6 \text{ A } \angle 0° + 0 \text{ A } \angle 0° + 0 \text{ A } \angle 0°]$$
$$= 2 \text{ A } \angle 0°$$

$$I_2 = \tfrac{1}{3}[I_A + a^2(I_B) + a(I_C)]$$

Where: $a \equiv 1 \angle 120°$ and $a^2 \equiv 1 \angle 240°$

$$I_2 = \tfrac{1}{3}[6 \text{ A } \angle 0° + 0 \text{ A } \angle(0° + 240°) + 0 \text{ A } \angle(0+120°)]$$
$$= \tfrac{1}{3}[6 \text{ A } \angle 0° + 0 \text{ A } \angle\text{-}120° + 0 \text{ A } \angle 120°]$$
$$= 2 \text{ A } \angle 0°$$

The negative-sequence and ground/residual overcurrent elements respond to $3xI_2$ and $3xI_0$ currents, respectively. Thus, for this test all overcurrent elements see 6 A.

You can also test the following elements in Relay Word row R2 and R3 using the above method (bypass step 2 because **50H** and **50C** cannot be torque controlled).

50H	Phase instantaneous overcurrent element
50C	Phase instantaneous overcurrent element (**50C** overrides internal torque control element **27**)

DEFINITE-TIME OVERCURRENT ELEMENT TIMING TESTS

Purpose: Verify operating times for the following definite-time overcurrent elements.

50LT	Phase definite-time overcurrent element
50MT	Phase definite-time overcurrent element
50QT	Negative-sequence definite-time overcurrent element
50NLT	Ground/Residual definite-time overcurrent element

Method:
1. Disable all external and internal torque control on the definite-time overcurrent element pickups in Relay Word row R1. The above definite-time overcurrent elements are derived from their respective pickups in Relay Word row R1. If one of these pickups in Relay Word row R1 is torque controlled, the respective definite-time overcurrent element it drives in Relay Word row R2 is also torque controlled.

   Using the SET command, enter **NA** for the ETC(1) and ITC(1) settings. These settings specify the overcurrent elements in Relay Word row R1 you want externally and internally torque controlled, respectively (none in this case).

2. Set a programmable output (A1-A4) to follow a definite-time overcurrent element pickup (e.g., **50NL**). Use the assertion of this output (open to close) to start an external timer.

3. Set another programmable output to follow definite-time overcurrent element timeout via Relay Word bit 50NLT (**50NL** drives **50NLT**). Use the assertion of this output to stop the external timer.

4. Apply current to one phase over the 50NL pickup setting. The time shown on the timer should match the 50NLT time delay setting.

   Note: With current applied to only one phase (e.g., $I_A = 6$ A, $I_B = I_C = 0$), the following sequence currents result:

   $$I_0 = \tfrac{1}{3} [I_A + I_B + I_C]$$
   $$= \tfrac{1}{3} [6 \text{ A } \angle 0° + 0 \text{ A } \angle 0° + 0 \text{ A } \angle 0°]$$
   $$= 2 \text{ A } \angle 0°$$

   $$I_2 = \tfrac{1}{3} [I_A + a^2(I_B) + a(I_C)]$$

Where: $a \equiv 1 \angle 120°$ and $a^2 \equiv 1 \angle 240°$

$$I_2 = \tfrac{1}{3}[6 \text{ A} \angle 0° + 0 \text{ A} \angle (0° + 240°) + 0 \text{ A} \angle (0+120°)]$$
$$= \tfrac{1}{3}[6 \text{ A} \angle 0° + 0 \text{ A} \angle \text{-}120° + 0 \text{ A} \angle 120°]$$
$$= 2 \text{ A} \angle 0°$$

The negative-sequence and ground/residual overcurrent elements respond to $3xI_2$ and $3xI_0$ currents, respectively. Thus, for this test all overcurrent elements see 6 A.

5. Repeat these tests for the phase- and negative-sequence definite-time overcurrent elements (**50LT, 50MT,** and **50QT**).

TIME-OVERCURRENT ELEMENT TIMING TESTS

Purpose: Verify the operating times of the following time-overcurrent elements.

51T   Phase time-overcurrent element
51QT   Negative-sequence time-overcurrent element
51NT   Ground/Residual time-overcurrent element

Method: 1. Disable all external and internal torque control on the time-overcurrent element pickups in Relay Word row R1. The above time-overcurrent elements are derived from their respective pickups in Relay Word row R1. If a time-overcurrent element pickup in row R1 is torque controlled, the respective time-overcurrent element it drives in Relay Word row R2 is also torque controlled.

Using the SET command, enter **NA** for the ETC(1) and ITC(1) settings. These settings specify the overcurrent elements in Relay Word row R1 you want externally and internally torque controlled, respectively (none in this case).

2. Set a programmable output (A1-A4) to follow a time-overcurrent element pickup (e.g., **51NP**). Use the assertion of this output (open to close) to start an external timer.

3. Set another programmable output to follow time-overcurrent element timeout via the **51NT** bit in the Relay Word (**51NP** drives **51NT**). Use the assertion of this output to stop the external timer.

4. Calculate the expected operating time of **51NT** using the appropriate equation for the curve number (see Time-Overcurrent Curve-Timing and Time Delay Reset Equations in Section 2: SPECIFICATIONS). This is dictated by the 51NC setting. TD is the 51NTD time dial setting. M is the multiple of

pickup current to be applied to the relay. Using example relay settings and a current multiple of pickup equal to three, the equation for the very inverse curve (51NC = 3) is:

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

Where
$$M = \text{Multiples of Pickup} = 3$$
$$TD = \text{Time Dial} = 4$$

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

For example, if the relay measures 3.45 amperes of residual current, the 51NT bit in the Relay Word asserts 2.33 seconds after 51NP assertion (51NP = 1.15 A; 3x1.15 = 3.45). Table 7.1 shows current quantities for the previous example.

Table 7.1: Current Quantities for 51NT Timing Test Example

IA	IB	IC	
3.45	0.00	0.00	Amperes
0.0°	0.0°	0.0°	Degrees

5. Apply a multiple of pickup current to one phase. Record the **51NT** element operating time and compare it to the calculated time.

Note: With current applied to only one phase (e.g., $I_A = 3.45$ A, $I_B = I_C = 0$), the following sequence currents result:

$$I_0 = \tfrac{1}{3} [I_A + I_B + I_C]$$
$$= \tfrac{1}{3} [3.45 \text{ A} \angle 0° + 0 \text{ A} \angle 0° + 0 \text{ A} \angle 0°]$$
$$= 1.15 \text{ A} \angle 0°$$

$$I_2 = \tfrac{1}{3} [I_A + a^2(I_B) + a(I_C)]$$

Where: $a = 1 \angle 120°$ and $a^2 = 1 \angle 240°$

$$I_2 = \tfrac{1}{3} [3.45 \text{ A} \angle 0° + 0 \text{ A} \angle (0° + 240°)$$
$$+ 0 \text{ A} \angle (0+120°)]$$
$$= \tfrac{1}{3} [3.45 \text{ A} \angle 0° + 0 \text{ A} \angle -120° + 0 \text{ A} \angle 120°]$$
$$= 1.15 \text{ A} \angle 0°$$

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The negative-sequence and ground/residual overcurrent elements respond to $3xI_2$ and $3xI_0$ currents, respectively. Thus, for this test all overcurrent elements see 3.45 A.

6. Optional: You may want to repeat this test with various multiples of pickup current (e.g., M = 3, 5, and 7) and various time dial settings (e.g., TD = 1, 5, and 10) for each of the four curve indexes.

7. Repeat these tests for the phase- and negative-sequence time-overcurrent elements (**51T** and **51QT**).

DEMAND AMMETER TIMING TESTS

Purpose: Verify the operating time of the following demand ammeter thresholds.

     PDEM   Phase demand current threshold exceeded
     QDEM   Negative-sequence demand current threshold exceeded
     NDEM   Residual demand current threshold exceeded

Method: 1. Using the SET command, set a programmable output contact (A1-A4) to follow one of the demand ammeter threshold alarms from Relay Word row R4 (e.g., **NDEM**). Also, set the respective demand threshold to some secondary current value level and DATC (Demand Ammeter Time Constant) to a value from 5 to 60 minutes (e.g., NDEM = 4.50 and DATC = 15).

2. Using the METER RD command, reset demand ammeters to zero.

3. Note the time and apply a constant current to one phase. The current should be a factor of 10/9 = 1.11 times greater than the NDEM setting (constant current = 1.11 x 4.50 A = 5.00 A). See Demand Ammeter in Section 2: SPECIFICATIONS for background on the 1.11 factor.

    Note: With current applied to only one phase (e.g., $I_A = 5$ A, $I_B = I_C = 0$), the following sequence currents result:

$$I_0 = \tfrac{1}{3}[I_A + I_B + I_C]$$
$$= \tfrac{1}{3}[5\ A\ \angle 0° + 0\ A\ \angle 0° + 0\ A\ \angle 0°]$$
$$= 1.67\ A\ \angle 0°$$

$$I_2 = \tfrac{1}{3}[I_A + a^2(I_B) + a(I_C)]$$

Where: $a \equiv 1 \angle 120°$ and $a^2 \equiv 1 \angle 240°$

$$I_2 = \tfrac{1}{3} [5 \text{ A } \angle 0° + 0 \text{ A } \angle (0° + 240°) + 0 \text{ A } \angle (0+120°)]$$
$$= \tfrac{1}{3} [5 \text{ A } \angle 0° + 0 \text{ A } \angle -120° + 0 \text{ A } \angle 120°]$$
$$= 1.67 \text{ A } \angle 0°$$

The negative-sequence and residual demand threshold elements respond to $3xI_2$ and $3xI_0$ currents, respectively. Thus, for this test all demand threshold elements see 5 A.

4. If the current remains constant at 5.00 A, the programmable output contact assigned to the **NDEM** element asserts 15 minutes after you apply current when DATC = 15.

5. Repeat these tests for the phase- and negative-sequence demand threshold alarms (**PDEM** and **QDEM**).

CLOSE FAILURE TIMER TEST

Purpose: Verify the operating time of the close failure timer.

Method: 1. Using the SET n command (n is the active setting group), enter the following example setting:

.
.
.

| A4(2346) | = **CF** | close failure condition |

.
.
.

2. Using the SET G command (G signifies the global setting group: settings common to all groups), enter these settings:

.
.
.

| CFT | = 120 | close failure time (cycles) |

.
.
.

| IN4 | = DC | direct close |
| IN5 | = 52A | circuit breaker auxiliary |

The choice of inputs IN4 and IN5 is for demonstration purposes only.

Connect the CLOSE output contact to an external timer so the timer starts upon CLOSE output contact assertion. The close failure timer in the relay also starts at CLOSE output contact assertion.

The CLOSE output contact remains asserted until the close failure timer expires or the circuit breaker auxiliary contact input to the relay (IN5 = 52A) is energized (circuit breaker successfully closed). In this test, no circuit breaker simulator is connected to either the IN5 input (IN5 = 52A) or the CLOSE output contact. IN5 remains de-energized and the relay considers that the circuit breaker is open.

Connect the A4 output contact to the same external timer to stop the timer when the A4 output contact asserts. A4 contact assertion indicates that the relay failed to close the circuit breaker within the time allotted by the CFT setting; CFT = 120 cycles; A4 = **CF**, close failure condition.

Assert the relay CLOSE output contact using the CLOSE Command or by energizing the IN4 input (IN4 = DC) function. The external and close failure timers start. Input IN5 must remain de-energized (IN5 = 52A).

When the close failure timer expires, close failure condition **CF** asserts for 60 cycles and the A4 output contact asserts (A4 = **CF**). A4 output contact assertion stops the external timer. The CLOSE output contact deasserts when the **CF** bit asserts and the A4 output contact deasserts 60 cycles after asserting. Compare the external timer reading to the close failure time setting (in this example CFT = 120 cycles).

TRIP FAILURE TIMER TEST

Purpose: Verify the operating time of the trip failure timer.

Method: 1. Using the SET n command (n is the active setting group), program an element (e.g., **50L**, phase overcurrent pickup) for tripping via the programmable tripping variable TR:

close TRIP output contacts = TR + ...

50L should not be internally or externally torque controlled (via ITC and ETC). Enter the following example settings:

```
                .
                .
                .

   50L       = 4.00            amps secondary

                .
                .
                .

   A4(2346)  = TF              trip failure condition
   TR(1246)  = 50L

                .
                .
                .

   ETC(1)    = NA
   ITC(1)    = NA
```

The setting entry NA (not applicable) leaves the designated variable blank [e.g., ETC=].

2. Using the SET G command (G signifies the global setting group - settings common to all setting groups), enter the example settings:

```
                .
                .
                .

   TDUR      = 5              trip duration time (cycles)
   TFT       = 30             trip failure time (cycles)

                .
                .
                .
```

Connect a TRIP output contact to an external timer so that TRIP output contact assertion starts the external timer. The trip failure timer in the relay also starts when the TRIP output contact asserts.

The TRIP output contact remains asserted until the trip duration timer (TDUR) expires and all programmable trip conditions (TR) go away. Additionally, all overcurrent element pickups have to drop out or TARGET RESET must be pushed to unlatch the TRIP output contact.

Connect the A4 output contact to the same external timer so that it stops timing when A4 asserts. This indicates that the relay has failed to trip the circuit breaker and interrupt the fault current within the time allotted by the TFT setting (TFT = 30 cycles; A4 = **TF**, trip failure condition).

Apply 5 A of current to one phase of the relay. The TRIP output contacts will immediately assert (5 A > **50L** = 4.00 A). The external and trip failure timers start immediately.

When the trip failure timer expires, trip failure condition bit **TF** and the A4 output contact assert (A4 = **TF**). A4 output contact assertion stops the external timer. Compare the external timer reading to the trip failure time setting (TFT = 30 cycles in this example). The **TF** bit deasserts 60 cycles after you turn the current off.

PHASE-PHASE MHO ELEMENT TESTS

Purpose: Determine the pickup of the single-zone, self polarized mho distance element, **21P**, at three points on the mho characteristic: MTA, MTA +45° and MTA -45°.

Method: 1. Use the SET command to program a single output relay (A1-A4) to follow the distance element, **21P**. Make the following settings:

CTR = 500 (CT ratio)
PTR = 180 (PT ratio)
ZP = 25 (Reach for **21P**, secondary ohms)
MTA = 73 (Max. torque angle for **21P**, degrees)
21PC = 2 (Phase-to-phase operation for **21P**)

The following example outlines the test procedure for the phase-phase distance element.

2. Connect the sources of voltage and current to the relay rear panel terminals (see Figure 7.5a or Figure 7.5b). Note that two current sources are employed in Figure 7.5a, while only one current source is used in Figure 7.5b.

The single current source method yields the same results as the two current source method. Single current source method also assures that the phase angle of the two involved currents is always 180° apart.

These steps connect a single current source to the relay for a BC phase-phase fault test.

a. Connect B current source dotted output to dotted relay IB input (Terminal 31).

b. Jumper undotted relay IB and IC current inputs together (Terminals 32 and 34 respectively).

c. Connect dotted relay IC current input to common current source return of current Source B (Terminal 33 to source common current return).
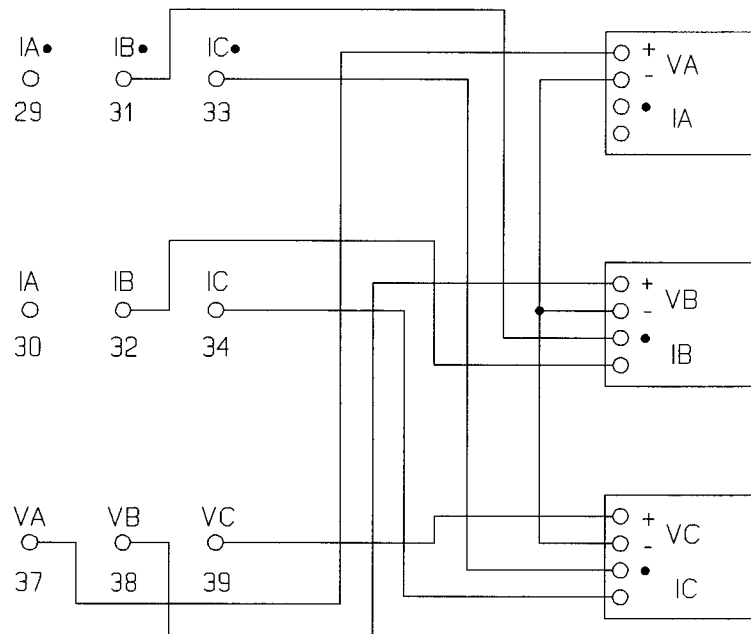
Figure 7.5a: Three-Phase Voltage and Two-Phase Current Source Test Connections for Phase-Phase Mho Test
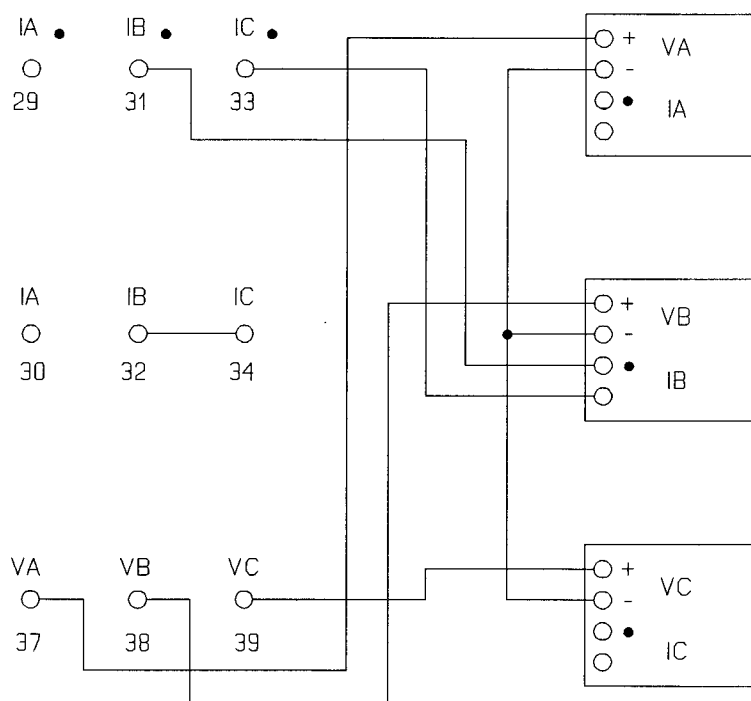
Figure 7.5b: Three-Phase Voltage and One-Phase Current Source Test Connections for Phase-Phase Mho Test

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3. Determine the voltages and currents required to simulate a phase-phase fault at the boundary of the desired relay reach (using ONEBUS or similar method). Currents and voltages required to test the phase-phase mho element reach of the example settings appear in Table 7.2:

Table 7.2: Phase-Phase Mho Test Voltages and Currents, BC Fault

VA	VB	VC	IA	IB	IC	
67.00	57.24	57.24	0.00	1.86	1.86	Volts/Amps
0.0°	-125.8°	125.8°	0.0°	-163°	17°	Degrees

4. Adjust the test set voltages and currents to the values in Table 7.2. Do not turn on the currents at this point.

5. Turn on the voltage sources VA, VB, and VC.

6. Apply current to the relay and ramp the current source magnitudes together until the monitored output contact toggles, indicating pickup. Record the pickup current threshold and compare it to the calculated threshold.

To calculate the phase-phase element reach, first calculate the resultant test voltage (VBC) and current (IBC).

<u>BC Fault</u>

$VB = 57.24\ V\ \angle -125.8°$
$VC = 57.24\ V\ \angle 125.8°$
$VBC = VB - VC = 92.85\ V\ \angle -90°$

$IB = 1.86\ A\ \angle -163°$
$IC = 1.86\ A\ \angle 17°$
$IBC = IB - IC = 3.71\ A\ \angle -163°$

Distance element reach, in secondary ohms, along the MTA,

$$Z_{sec} = \frac{VBC}{IBC} = \frac{92.85\ V\ \angle -90°}{3.71\ A\ \angle -163°} = 25.0\Omega\ \angle 73°\ \text{secondary}$$

In primary ohms,

Distance element reach, in primary ohms, along the MTA,

$$Z_{pri} = (25.0\Omega\ \angle 73°)\left(\frac{PTR}{CTR}\right) = 9.0\Omega\ \angle 73°\ \text{primary}$$

Where PTR = 180 and CTR = 500.

7. Find two other convenient test points. Consider a square inscribed in a mho circle with one diagonal being the diameter along the MTA. The two corners of that square on the other diagonal are reached by increasing the current by a factor of 1.414 at angles of ±45° from the angle obtained using the ONEBUS program.

For our phase-phase example, the required voltages remain unchanged. The current magnitudes are (1.86)(1.414) = 2.63 amperes at the angles listed as follows:

Table 7.3: Phase-Phase Mho Test Quantities at MTA ±45°

	Angle IB	Angle IC
MTA +45°	-118°	62°
MTA -45°	152°	-28°

8. Test the relay at the two additional current phase angle settings (MTA +45°, MTA -45°). Record the results.

INPUT CIRCUITS TEST

Purpose: Verify that logic inputs assert when you apply control voltage across respective terminal pairs.

Method: 1. Set the target LEDs to display the contact inputs by typing **TAR 7** **<ENTER>**. The front panel LEDs should now follow contact inputs.

2. Apply control voltage to each input and make sure the corresponding target LED turns on. Energizing the DT and ET inputs should trigger an event report. Table 7.4 lists contact inputs and terminal numbers.

Table 7.4: Contact Inputs and Terminal Numbers

IN1	17, 18
IN2	19, 20
IN3	21, 22
IN4	23, 24
IN5	25, 26
IN6	27, 28

SERIAL PORTS TEST

Purpose: Verify operation of serial Port 1.

Method: The initial checkout procedure assumes you connected a terminal to Port 2F on the relay front panel. Set the baud rate of Port 1 to match that of Port 2 and switch your terminal from Port 2F to Port 1. Be sure you can communicate through this port.

IRIG-B TIME CODE INPUT TEST

Purpose: Verify operation of the IRIG-B clock input port.

Method: 1. Connect a source of demodulated IRIG-B time code to the relay Auxiliary Port in series with a resistor to monitor the current. Adjust the source to obtain an "ON" current of about 10 mA.

2. Execute the IRIG command. Make sure the relay clock displays the correct date and time.

Note: A recording of the IRIG-B signal passed through a simple demodulator provides a convenient, inexpensive test of the IRIG-B port. Please contact the factory for further details.

POWER SUPPLY VOLTAGES TEST

Purpose: Verify that correct output voltages are presented to Port 1, Port 2R, and the auxiliary port. These voltages are required by external devices including a dc powered modem or the SEL-DTA and SEL-RD units.

Method: 1. Execute the STATUS command and inspect the voltage readings for the +5 and ±15 volt supplies.

2. At the Auxiliary Port, use a voltmeter to read the +5 and ±12 volt outputs. The 12 volt outputs are derived from the 15 volt supplies using three-terminal regulators. The following pins are the read points:

Pin 5:	Ground	
Pin 9:	Ground	
Pin 1:	+5 Vdc	if JMP12 installed
Pin 4:	+12 Vdc	if JMP13 installed
Pin 6:	-12 Vdc	if JMP14 installed
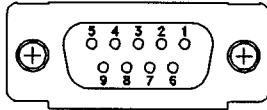
(female chassis connector, as viewed from outside panel)

Figure 7.6: 9-Pin Connector Pin Number Convention

3.   Compare the +5 volt readings from the status report and voltmeter. The voltage difference should be less than 50 mV, and both readings should be within 0.15 volts of five volts.

The 12 volt supplies should be within 0.5 volts of their nominal values.

RELAY CALIBRATION

The SEL-251CD Relay is factory calibrated to a very high degree of accuracy. If you suspect that the relay is out of calibration, please contact the factory. We can provide instructions for returning the relay for factory recalibration.

TROUBLESHOOTING

Inspection Procedure

Complete the following procedure before disturbing the system. After you finish the inspection, proceed to the Troubleshooting Table.

1.   Measure and record control power voltage at terminals 44 and 45.

2.   Check to see that the power is on, but do not turn system off if it is on.

3.   Measure and record the voltage at all control inputs.

4.   Measure and record the state of all output relays.

5.   Inspect the cabling to the serial communications ports and be sure a communications device is connected to at least one communications port.

Troubleshooting Table

All Front Panel LEDs Dark

1. Power is off.

2. Blown power supply fuse.

3. Input power not present.

4. Self-test failure.

5. Target command improperly set.

Note: For 1, 2, 3, and 4 the ALARM relay contacts should be closed.

System Does Not Respond to Commands

1. Communications device not connected to system.

2. Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.

3. System is processing event record. Wait several seconds.

4. System is attempting to transmit information, but cannot due to handshake line conflict. Check communications cabling.

5. System is in the XOFF state, halting communications. Type <CTRL>Q to put system in XON state.

Tripping Output Relay Remains Closed Following Fault

1. Contact inputs improperly wired.

2. Output relay contacts burned closed.

No Prompting Message Issued to Terminal upon Power-Up

1. Terminal not connected to system.

2. Wrong baud rate.

3. Terminal improperly connected to system.

4. Other port designated AUTO in the relay settings.

5. Port timeout interval set to a value other than zero.

6. Board failure.

System Does Not Respond to Faults

1. Relay improperly set. Review your settings with the SHOWSET command.

2. Improper test settings.

3. PT or CT input cable wiring error.

4. Analog input cable between transformer-termination and main board loose or defective.

5. Check self-test status with STATUS command.

6. Check input voltages and currents with METER command and TRIGGER and EVENT sequence.

Terminal Displays Meaningless Characters

1. Baud rate set incorrectly. Check terminal configuration. See Section 3: COMMUNI-CATIONS.

Self-Test Failure: +5 Volts

1. Power supply +5 V output out of tolerance. See STATUS command.

2. A/D converter failure.

Self-Test Failure: +15 Volts

1. Power supply +15 V output out of tolerance. See STATUS command.

2. A/D converter failure.

Self-Test Failure: -15 Volts

1. Power supply -15 V output out of tolerance. See STATUS command.

2. A/D converter failure.

Self-Test Failure: Offset

1. Offset drift. Adjust offsets.

2. A/D converter drift.

Self-Test Failure: ROM Checksum

1. EPROM failure. Replace EPROM(s).

Self-Test Failure: RAM

1. Static RAM IC failure. Replace RAM(s).

Self-Test Failure: A/D Converter

1. A/D converter failure.

2. RAM error not detected by RAM test.

Alarm Contact Closed

1. Power is off.

2. Blown power supply fuse.

3. Power supply failure.

4. Improper EPROMs or EPROM failure.

5. Board failure.

FIRMWARE UPGRADE INSTRUCTIONS

SEL may occasionally offer firmware upgrades to improve the performance of your relay. These instructions explain how to remove the relay drawout assembly to install new firmware.

The modifications require that you power down the relay, remove the relay front panel, pull out the drawout unit, exchange several integrated circuit chips, and reassemble the relay. If you do not wish to perform the modifications yourself, we can assist you. Simply return the relay and integrated circuit chips to us. We will install the new chips and return the unit to you within a few days.

Upgrade Instructions

1. If the relay is in service, disable its control functions. Turn off control power to the relay. Disconnect all communication cables from the rear panel of the relay.

2. Remove the relay front panel by unscrewing the five front panel screws. With the front panel removed, you can see the aluminum drawout chassis. The main board is attached to the top of the drawout chassis. The power supply and transformer assembly are attached to the bottom of the relay chassis.

3. Disconnect the power supply and transformer secondary cables from the underside of the drawout assembly.

   Caution: This procedure requires that you handle electrostatic discharge sensitive components. If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

4. Remove the drawout assembly by pulling the spacers on the bottom of the drawout chassis. You should be able to remove the assembly with your fingers. Because steps 5 and 6 involve handling electrostatic discharge (ESD) sensitive devices and assemblies, perform these steps at an ESD safe work station. This will help prevent possible damage by electrostatic discharge.

5. Note the orientation of the ICs to be replaced. Use a small screwdriver to pry the indicated ICs free from their sockets. Be careful not to bend the IC pins or damage adjacent components.

6. Carefully place the new ICs in the appropriate sockets. Check the orientation of the ICs. Be sure that each IC is in its corresponding socket. Look for IC pins that bent under or did not enter a socket hole.

7. Slide the drawout assembly into the relay chassis. Using your fingers, push the assembly in until the front of the assembly is flush with the front of the relay chassis. Reconnect the power supply and transformer secondary cables to the receivers on the underside of the drawout assembly. Replace the relay front panel.

8. With breaker control disabled, turn relay power on and enter your settings. Execute the STATUS, METER, and TRIGGER commands to ensure that all functions are operational. Set and record your Access Level 1 and 2 passwords and the date and time. The relay is now ready to resume protective functions.

FACTORY ASSISTANCE

If you have any questions regarding the performance, application, or repair of this or any other SEL product, do not hesitate to contact the factory. Our staff is always happy to assist you.

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

APPENDICES
TABLE OF CONTENTS

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.	Description of Firmware
SEL-251CD-3-R602 SEL-251CD-R602 SEL-251CD-3-R406 SEL-251CD-R411	This firmware differs from previous versions as follows: – Initialized analog gain on unused channel. 251CD-3 60 Hz 5 A ACB rotation extended Fast Meter Fast Operate 251CD 60 Hz 5 A ACB rotation extended Fast Meter 251CD 60 Hz 5 A extended Fast Meter Fast Operate 251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-3-R601 SEL-251CD-R601 SEL-251CD-3-R405 SEL-251CD-R410	This firmware differs from previous versions as follows: – INST target is now independent of phase targets. 251CD-3 60 Hz 5 A ACB rotation extended Fast Meter Fast Operate 251CD 60 Hz 5 A ACB rotation extended Fast Meter 251CD 60 Hz 5 A extended Fast Meter Fast Operate 251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-3-R600 SEL-251CD-R600	Created two new versions: 251CD-3 60 Hz 5 A ACB rotation extended Fast Meter Fast Operate 251CD 60 Hz 5 A ACB rotation extended Fast Meter
SEL-251CD-3-R404 SEL-251CD-R409	This firmware differs from previous versions as follows: – Debounce all control inputs. – Enhance SEL-2020 compatibility. 251CD 60 Hz 5 A extended Fast Meter Fast Operate 251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-3-R403 SEL-251CD-R408	This firmware differs from previous versions as follows: – Changed the RINGS setting prompt to "RINGS 1 - 30." – Added FOP Fast Operate enable input assignment (applies to SEL-251CD-3 only). 251CD 60 Hz 5 A extended Fast Meter Fast Operate 251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-3-R402 SEL-251CD-R407	This firmware differs from previous versions as follows: – Added high-side blow-fuse logic with new 27C setting option. – Improved operation of Fast Meter. – Improved Fast Operate (applies to SEL-251CD-3 only). 251CD 60 Hz 5 A extended Fast Meter Fast Operate 251CD 60 Hz 5 A extended Fast Meter

Firmware Part/Revision No.	Description of Firmware
SEL-251CD-3-R400	251CD-3 60 Hz 5 A extended Fast Meter Fast Operate
SEL-251CD-R405	251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-R404	251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-R403	251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-R402	251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-R401	251CD 60 Hz 5 A extended Fast Meter
SEL-251CD-R400	251CD 60 Hz 5 A includes extended Fast Meter

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

FID=**SEL-251CD-R401**-656np0eqd-D931014-E2

For a detailed explanation of the Firmware Identification Number (FID) refer to *Section 4: Event Reporting*.
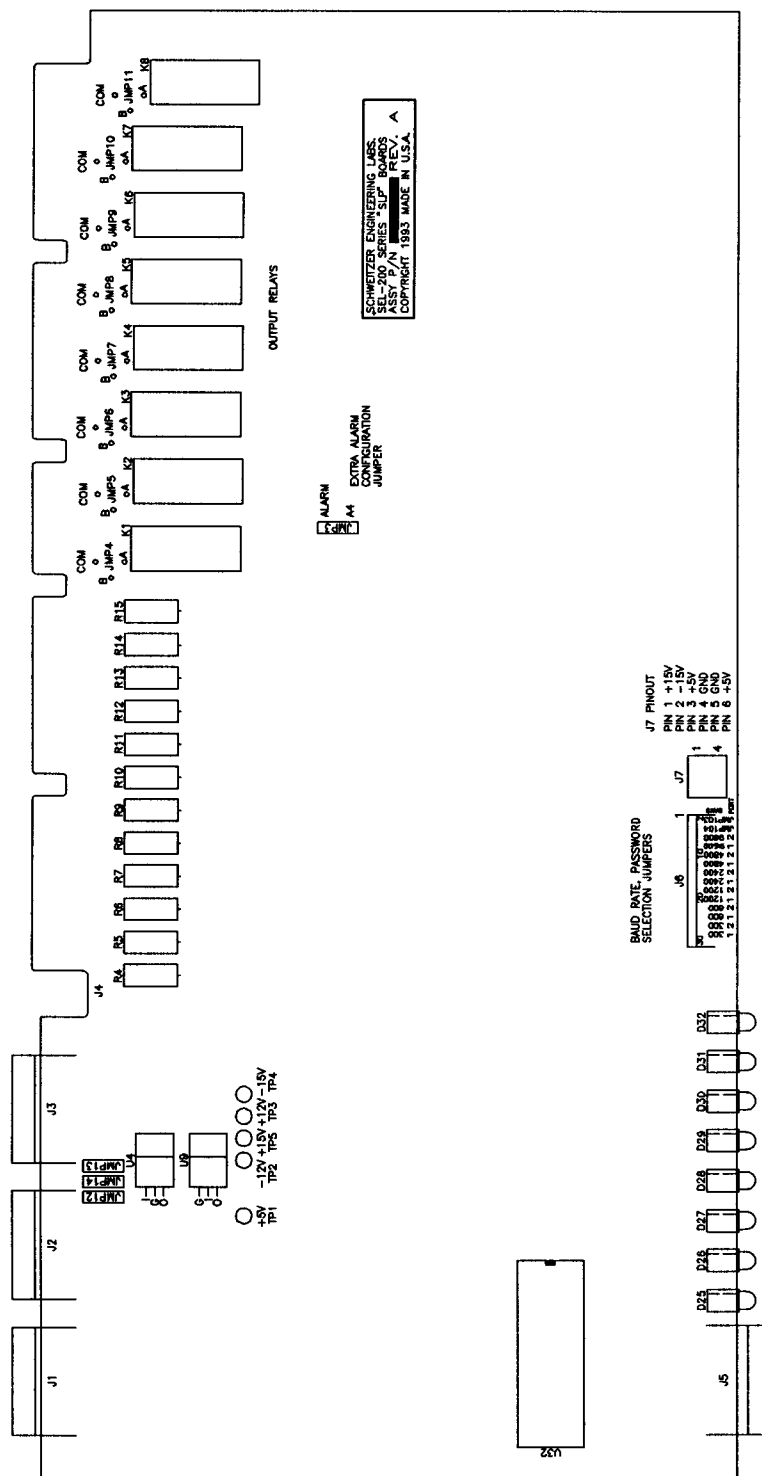
SEL-200 Series (Shallow) Main Board Troubleshooting Test Points and Jumper Locations

APPENDIX C - ONEBUS: PROGRAM TO COMPUTE TEST SET SETTINGS FOR TESTING DISTANCE RELAYS

The BASIC program in this note determines voltages and currents which would appear on distance relay terminals for ground and phase faults on a radial system with source impedance at the same angle as line impedance. It is useful in determining test voltage and current settings for SEL distance relays and fault locating equipment.

The program was initially designed to run on a TRS-80 Model 100 briefcase computer but may be installed on virtually any personal computer or laptop.

The program first prompts you for the positive- and zero-sequence impedances of the transmission line. Enter the data in secondary ohms for the entire length of the protected line.

Next, you may enter fault resistance, which is used in the ground-fault computations.

Enter source impedance as a per-unit value with a base of the previously-entered transmission line data. For example, if the radial system has a source impedance of about ten percent of the entered line impedance, enter 0.1 for the per-unit distance from the source to the bus.

Specify the distance from the bus to the fault as a fraction of the total line length. To obtain the voltages and currents for a fault one-half the way down the line from the bus, enter 0.5 for the distance from the bus to the fault.

After you enter this data, the program begins computations. The display then shows voltages and currents for both an AG and BC fault. These data can be entered into any active test source.

The bottom line of the display offers you a choice of entering new impedance data (I), changing the distance from the source to the bus (B), specifying a new fault location (F), or quitting (Q).

```
1      REM SCHWEITZER ENGINEERING LABORATORIES, INC.
2      REM 2350 NE Hopkins Court
3      REM Pullman, WA  99163-5603
4      REM
10     REM COMPUTE DOBLE SETTINGS FOR A ONE-BUS SYSTEM
20     REM HOMOGENEOUS SYSTEM
30     REM SOURCE VOLTS= 67 L-N
40     REM
50     REM ENTER IMPEDANCES FOR 100% OF LINE
60     INPUT "ENTER Z1: R,X";R1,S1
70     INPUT "ENTER Z0: R,X";R0,S0
75     INPUT "ENTER RF FOR GND FLTS";RF
80     REM
90     REM ENTER BUS LOC. FROM SOURCE
100    INPUT "DIST SOURCE TO BUS (PU OF LINE)";S
120    INPUT "DIST BUS TO FAULT (PU OF LINE)";F
130    REM
140    REM  PHASE A TO GROUND
150    REM COMPUTE POS SEQ CURRENT
160    X = R0+2*R1: Y = S0+2*S1
170    R3 = R1-R0:   S3 = S1-S0
180    AR=1/(S+F):  AI=0
190    BR=X      :  BI=Y
195    BR=BR+3*RF/(S+F)
200    GOSUB 2000
210    I = RR   :   J = RI
220    IA = 3*67*I:  JA=3*67*J
225    IB=0:JB=0:IC=0:JC=0
230    AR=X:AI=Y:BR=I:BI=J
232    GOSUB 1000
234    UA=67*(1-S*RR):VA=67*(-S*RI)
240    AR=R3     :AI=S3
250    BR=I      :BI=J
260    GOSUB 1000
270    TR=S*RR     :TS=S*RI
280    UB=67*(-0.5+TR)
290    VB=67*(-SQR(3)/2+TS)
300    UC=67*(-0.5+TR)
310    VC=67*(SQR(3)/2+TS)
315    FF$="A-G"
320    GOSUB 4041
500    REM  B-C FAULT
510    AR=1: AI=0
520    BR=2*R1*(S+F):BI=2*S1*(S+F)
530    GOSUB 2000
540    I=RR:J=RI
550    IA=0:JA=0
560    AR=I:AI=J:BR=0:BI=-67*SQR(3)
570    GOSUB 1000
580    IB=RR:JB=RI:IC=-IB:JC=-JB
590    UA=67:VA=0
600    AR=I:AI=J:BR=S*R1:BI=S*S1
610    GOSUB 1000
620    AR=RR:AI=RI:BR=0:BI=SQR(3)
630    GOSUB 1000

635    TR=RR:TS=RI
640    UB=67*(-0.5+TR)
650    VB=67*(-SQR(3)/2+TS)
660    UC=67*(-0.5-TR)
670    VC=67*(0.5*SQR(3)-TS)
675    FF$="B-C"
680    GOSUB 4041
900    INPUT "IMP BUS FAULT OR QUIT (I,B,F,Q)";A$
910    IF A$ = "I" THEN GOTO 50
920    IF A$ = "B" THEN GOTO  75
930    IF A$ = "F" THEN GOTO 120 ELSE GOTO 999
999    END
1000   REM MULT SUBROUTINE
1010   REM AR,AI * BR,BI = RR,RI
1020   RR=AR*BR-AI*BI
1030   RI=AI*BR+AR*BI
1040   RETURN
2000   REM DIVISION SUBROUTINE
2010   REM AR,AI / BR,BI = RR,RI
2020   D = BR*BR + BI*BI
2030   RR = AR*BR + AI*BI
2040   RR = RR/D
2050   RI = BR*AI - AR*BI
2060   RI = RI/D
2070   RETURN
3000   REM RECT TO POLAR CONV
3010   REM AR,AI, TO RH, TH
3020   PI = 3.14159265358
3030   IF (AR=0 AND AI=0) THEN    RH=0: TH=0: RETURN
3040   IF (AR=0 AND AI>0) THEN    RH=AI: TH=90:RETURN
3050   IF (AR=0 AND AI<0) THEN RH=-AI: TH=-90: RETURN
3060   IF (AR>0) THEN TH=(180/PI)*ATN(AI/AR)
3070   IF (AR<0) THEN TH=(180/PI)*ATN(AI/AR)+180
3080   IF TH>180 THEN TH = TH-360
3090   RH=SQR(AR*AR+AI*AI)
3100   RETURN
4041   AR=UA:AI=VA:GOSUB 3000
4042   UA=RH:VA=TH
4043   AR=UB:AI=VB:GOSUB 3000
4044   UB=RH:VB=TH-VA
4045   AR=UC:AI=VC:GOSUB 3000
4046   UC=RH:VC=TH-VA
4047   AR=IA:AI=JA:GOSUB 3000
4048   IA=RH:JA=TH-VA
4049   AR=IB:AI=JB:GOSUB 3000
4050   IB=RH:JB=TH-VA
4055   AR=IC:AI=JC:GOSUB 3000
4060   IC=RH:JC=TH-VA
4061   VA=0
4100   PRINT " VA    VB    VC    IA    IB    IC"
4130   PRINT USING"##.# ";UA;UB;UC;IA;IB;IC,
4132   PRINT FF$
4140   PRINT USING"#### ";VA;VB;VC;JA;JB;JC
4150   RETURN
```

SEL-251CD RELAY COMMAND SUMMARY

Access Level 0

ACCESS | Answer password prompt (if password protection is enabled) to enter Access Level 1. Third unsuccessful attempt pulses ALARM contacts closed for one second.

Access Level 1

2ACCESS | Answer password prompt (if password protection is enabled) to enter Access Level 2. This command always pulses the ALARM contacts closed for one second.

BREAKER | Displays running sum of circuit breaker trips for relay and external trips (circuit breaker trip counters). Also displays running sum of interrupted current in each circuit breaker pole for relay and external trips.

BREAKER R | Resets circuit breaker trip counters and interrupted current sums to zero for both relay and external trips. Relay stores reset date and time.

DATE m/d/y | Sets or displays date. DAT 5/1/93 sets date to May 1, 1993. IRIG-B time code input overrides existing month and day settings. DATE pulses ALARM contacts when year entered differs from year stored. To display the date only, enter DATE.

EVENT n | Shows event record. EVE or EVE 1 shows newest event; EVE 12 shows oldest (n=1, 2, 3,...,11, or 12).

HISTORY | Shows DATE, TIME, EVENT, LOCAT (location), SHOT, TARGETS, and CURR (maximum fault current) for the last twelve events.

IRIG | Forces immediate attempt to synchronize internal relay clock to time code input.

METER n | Displays present phase, residual, and negative-sequence current values; present real and reactive power values; present line-to-line voltage values. Optional n displays METER data n times.

METER D | Displays demand and peak demand values of phase, residual, and negative-sequence current values and real and reactive power values.

METER RD | Resets demand values.

METER RP | Resets peak demand values.

QUIT | Returns control to Access Level 0; returns target display to Relay Targets.

SHOWSET n | Displays settings of setting Group n without affecting them (n = 1, 2, 3, 4, 5, or 6).

STATUS | Shows self-test status.

TARGET n k | Shows data and sets target LEDs as follows (n = 0, 1, 2, . . . 7, or 8):

TAR 0: Front Panel Targets	TAR 1: Relay Word row R1
TAR 2: Relay Word row R2	TAR 3: Relay Word row R3
TAR 4: Relay Word row R4	TAR 5: Relay Word row R5
TAR 6: Relay Word row R6	TAR 7: Input States
TAR 8: Output Contact States	Optional k displays target data k times.

TARGET R   Clears targets and returns to TAR 0

TIME h/m/s   Sets or displays time. TIM 13/32/00 sets clock to 1:32:00 PM. IRIG-B synchronization overrides this setting. To display the time only, enter TIME.

TRIGGER   Triggers and saves an event record (event type is EXT).

Access Level 2

CLOSE   Closes circuit breaker, if allowed by jumper setting.

COPY m n   Copies setting Group m to setting Group n (m and n equal any combination of 1, 2, 3, 4, 5, or 6). Clears buffers. If n is the active setting group, the ALARM output contacts pulse closed.

GROUP n   Designates the active setting group when no Setting Group Selection Inputs are assigned to inputs or all Setting Group Selection Inputs assigned to inputs are deasserted (n = 1, 2, 3, 4, 5, or 6). The ALARM output contacts pulse closed when the active group changes. GROUP n command execution does not clear the event buffer.

OPEN   Opens circuit breaker, if allowed by jumper setting.

PASSWORD   Shows or sets passwords. ALARM contacts pulse closed after password entry. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.

SET n p   Initiates setting procedure for setting Group n (n = 1, 2, 3, 4, 5, or 6). Option p directs the relay to begin the setting procedure for setting Group n at setting p (e.g., if p = 51P, the setting procedure starts at setting 51P, bypassing all settings before 51P). If no optional p is entered, the setting procedure starts at the beginning.

                The relay clears event buffers when new settings are stored. If n is the active setting group, the ALARM output contact pulses closed.

SET G p   Initiates setting procedure for the global setting group. Option p directs the relay to begin the setting procedure for the global setting group at setting p (e.g., if p = TDUR, the setting procedure starts at setting TDUR, bypassing all settings before TDUR). If optional p is not used, the setting procedure starts at the beginning.

                The SET G command pulses ALARM contacts closed and clears event buffers when new settings are stored.

SEL-251CD RELAY COMMAND SUMMARY

Access Level 0

ACCESS   Answer password prompt (if password protection is enabled) to enter Access Level 1. Third unsuccessful attempt pulses ALARM contacts closed for one second.

Access Level 1

2ACCESS   Answer password prompt (if password protection is enabled) to enter Access Level 2. This command always pulses the ALARM contacts closed for one second.

BREAKER   Displays running sum of circuit breaker trips for relay and external trips (circuit breaker trip counters). Also displays running sum of interrupted current in each circuit breaker pole for relay and external trips.

BREAKER R   Resets circuit breaker trip counters and interrupted current sums to zero for both relay and external trips. Relay stores reset date and time.

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EVENT n   Shows event record. EVE or EVE 1 shows newest event; EVE 12 shows oldest (n=1, 2, 3,...,11, or 12).

HISTORY   Shows DATE, TIME, EVENT, LOCAT (location), SHOT, TARGETS, and CURR (maximum fault current) for the last twelve events.

IRIG   Forces immediate attempt to synchronize internal relay clock to time code input.

METER n   Displays present phase, residual, and negative-sequence current values; present real and reactive power values; present line-to-line voltage values. Optional n displays METER data n times.

METER D   Displays demand and peak demand values of phase, residual, and negative-sequence current values and real and reactive power values.

METER RD   Resets demand values.

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SHOWSET n   Displays settings of setting Group n without affecting them (n = 1, 2, 3, 4, 5, or 6).

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TAR 0: Front Panel Targets	TAR 1: Relay Word row R1
TAR 2: Relay Word row R2	TAR 3: Relay Word row R3
TAR 4: Relay Word row R4	TAR 5: Relay Word row R5
TAR 6: Relay Word row R6	TAR 7: Input States
TAR 8: Output Contact States	Optional k displays target data k times.

Access Level 1 (Continued)

TARGET R   Clears targets and returns to TAR 0

TIME h/m/s   Sets or displays time. TIM 13/32/00 sets clock to 1:32:00 PM. IRIG-B synchronization
                  overrides this setting. To display the time only, enter TIME.

TRIGGER   Triggers and saves an event record (event type is EXT).

Access Level 2

CLOSE   Closes circuit breaker, if allowed by jumper setting.

COPY m n   Copies setting Group m to setting Group n (m and n equal any combination of 1, 2, 3, 4, 5,
                  or 6). Clears buffers. If n is the active setting group, the ALARM output contacts pulse closed.

GROUP n   Designates the active setting group when no Setting Group Selection Inputs are assigned to inputs
                  or all Setting Group Selection Inputs assigned to inputs are deasserted (n = 1, 2, 3, 4, 5, or 6).
                  The ALARM output contacts pulse closed when the active group changes. GROUP n command
                  execution does not clear the event buffer.

OPEN   Opens circuit breaker, if allowed by jumper setting.

PASSWORD   Shows or sets passwords. ALARM contacts pulse closed after password entry. PAS 1 OTTER
                  sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.

SET n p   Initiates setting procedure for setting Group n (n = 1, 2, 3, 4, 5, or 6). Option p directs the
                  relay to begin the setting procedure for setting Group n at setting p (e.g., if p = 51P, the setting
                  procedure starts at setting 51P, bypassing all settings before 51P). If no optional p is entered,
                  the setting procedure starts at the beginning.

                  The relay clears event buffers when new settings are stored. If n is the active setting group, the
                  ALARM output contact pulses closed.

SET G p   Initiates setting procedure for the global setting group. Option p directs the relay to begin the
                  setting procedure for the global setting group at setting p (e.g., if p = TDUR, the setting
                  procedure starts at setting TDUR, bypassing all settings before TDUR). If optional p is not
                  used, the setting procedure starts at the beginning.

                  The SET G command pulses ALARM contacts closed and clears event buffers when new
                  settings are stored.

This product is covered by U.S. Patent No. 5,041,737 and U.S. Patent(s) Pending.