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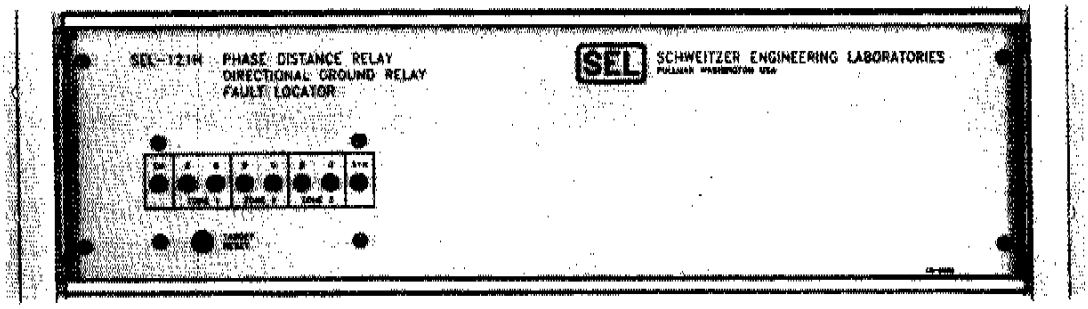


SEL-121H PHASE DISTANCE RELAY, DIRECTIONAL GROUND RELAY, FAULT LOCATOR

Also Available in LOW-PROFILE Package

DATA SHEET

- Use in permissive transfer trip and unblocking protection schemes
- Current reversal logic provides security for healthy parallel lines
- Weak-infeed logic permits rapid clearing of both line ends
- Open breaker echo logic reduces fault clearing time
- Three zones of phase distance protection provide complete line coverage
- Multiple residual overcurrent elements give sensitivity for high impedance ground faults
- Three ground directional polarization methods span variety of system conditions
- Switch-onto-fault logic permits instantaneous tripping for reclosing or line pickup
- Programmable Mask Logic provides application and testing flexibility
- Load compensating fault locator reduces line patrolling for improved system reliability
- Eleven-cycle event report simplifies fault and system analysis
- Serial communication ports allow local or remote interaction with the relay

2350 NE Hopkins Court • Pullman, WA USA 99163-5603 Tel: (509) 332-1890 Fax: (509) 332-7990

GENERAL DESCRIPTION

Use the SEL-121H Relay in Communication-Based Protection Schemes

The SEL-121H relay supports the following communication-based protection schemes:

- Permissive Overreaching Transfer Trip (POTT) schemes
- Permissive Underreaching Transfer Trip (PUTT) schemes
- Directional Comparison Unblocking (DCUB) schemes
- Direct Underreaching Transfer Trip (DUTT) schemes
- Direct Transfer Trip (DTT) schemes

Current Reversal Logic

In double-circuit applications, faults near one end of the line may result in sequential trip of the faulted line, which causes a current reversal in the healthy line. To preserve the security of the healthy line, the SEL-121H relay uses reverse Zone 3 elements and associated logic to block permissive tripping and keying for a short time following the current reversal.

Weak-Infeed Logic

Applying the SEL-121H relay on a weak-source terminal allows you to use the weak-infeed logic to echo the strong-source terminal permissive trip signal. The weak-infeed logic uses a combination of breaker status, reverse Zone 3 elements, and voltage elements to detect a forward fault. You can use the received permissive trip signal to trip the weak source terminal under certain conditions.

Open Breaker Echo Logic

With the local breaker open, the remote end typically clears faults near the local end in Zone 2 time. With the local breaker open and no reverse Zone 3 elements picked up, the SEL-121H relay can echo the permissive trip signal to the remote end and clear Zone 2 faults faster.

Three Zones of Phase Distance Protection

The relay has three zones of phase-phase mho distance elements with independent timers. Zone 3 elements are reversible. Four zones of three-phase mho distance elements with timers provide protection for three-phase faults. Three-phase elements are memory polarized from a four-cycle filter. Zone 4 provides sensitive switch-onto-fault protection; the Zone 4 element can alarm for load encroachment.

Multiple Residual Overcurrent Elements

The relay has three steps of instantaneous/definite-time directional ground overcurrent protection. Zone 3 is reversible. A ground inverse-time overcurrent element is available for sensitive ground fault detection. Four curve shapes are available and the time-dial is settable in small increments to simplify coordination with downstream protective devices.

Three Ground Directional Polarization Methods

The relay has sensitive negative-sequence, zero-sequence voltage, and zero-sequence current directional polarization elements to control the ground overcurrent elements. Zero-sequence elements may be used together to provide dual zero-sequence polarization.

Switch-Onto-Fault Logic

Select sensitive elements to trip for a settable time after the breaker closes. Zone 2 faults can be cleared with no time-delay on reclose. A high-set, non-directional phase overcurrent element can clear close-in, zero-voltage three-phase faults on line pickup.

Programmable Mask Logic

The SEL-121H relay also has programmable mask logic. Configure the TRIP and auxiliary outputs to operate when any of 32 protective elements and logic outputs pick up. Implement complete protective schemes using a minimum of wiring and panel space. Programmable contact closure simplifies testing by indicating pickup and dropout of elements under test.

Load Compensating Fault Locator

The relay has a fault locating algorithm which automatically compensates for prefault load flow and fault resistance. Accurate fault location reduces search and outage time; lower outage time means higher overall system reliability.

Eleven-Cycle Event Report

The relay generates an eleven-cycle event report after each fault, or upon command. The report provides four cycles of prefault data and seven cycles of fault data. The data includes voltages, currents, relay elements, and relay inputs and outputs. The report also shows the calculated fault location, time and date of event, and relay settings. This information simplifies post-fault analysis and improves understanding of protective scheme operation. The relay stores the last twelve event reports for local or remote retrieval. Reclosing sequences are stored intact and no information is lost when several events occur in a short time.

Serial Communication Ports

The relay is equipped with two serial communication ports to provide local or remote access to setting, metering, and fault analysis capability. Remote communications allow operators to retrieve fault information from a remote relay immediately, without leaving their stations.

A two-level password security scheme prevents unauthorized access to the relay. The first level allows examination of settings and power system data. Setting changes are made from the second level.

The relay requires no special communication software: you can use a dumb terminal, printing terminal, or computer with serial port and terminal emulation software.

GENERAL SPECIFICATIONS

Voltage Inputs	115 volt nominal phase-to-phase, three-phase four-wire connection 0.07 VA burden at 67 V line-to-neutral
Current Inputs	5 amps per phase nominal; 0.06 VA burden 15 amps per phase continuous; 500 amps for one second thermal rating
Output Contact Current Ratings	30 amp make per IEEE C37.90 para 6.6.2 6 amp carry continuously; MOV protection provided
Optical Isolator Logic Input Ratings	48 Vdc: 25 - 60 Vdc 125 Vdc: 60 - 200 Vdc 250 Vdc:200 - 280 Vdc
Time Code Input	Demodulated IRIG-B
Communications	Two EIA RS-232-C serial communications ports
Power Supply	48 Volt:30 - 60 Vdc; 12 watts 125/250 Volt:85 - 280 Vdc or 85 - 200 Vac; 12 watts
Dimensions	5¼" x 19" x 13" (13.3 cm x 48.2 cm x 33.0 cm) (H x W x D)
Mounting	Available in horizontal or vertical mounting configurations.
Dielectric Strength	V, I inputs: 2500 Vac for 10 seconds Other: 3000 Vdc for 10 seconds (excludes RS-232-C)
Operating Temp.	-4°F to 131°F (-20°C to +55°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)
Impulse Tests	IEC 255-5 0.5 joule 5000 volt test (type tested)
RFI Tests	Type-tested in field from a ¼-wave antenna driven by 20 watts at 150 MHz and 450 MHz randomly keyed on and off one meter from relay.
ESD Test	IEC 801-2 Electrostatic Discharge Test (type tested)
Weight	21 lbs (9.1 kg); shipping weight 32 lbs (14.1 kg), including two manuals.
Burn-in	140°F (60°C) for 100 hours.
Warranty	Four years from date of purchase.

FUNCTIONAL SPECIFICATIONS

Expanded Mho Characteristics for Phase-Phase and Three-Phase Faults

- Independent timers for Zone 2 and 3 distance elements
- Overcurrent elements supervise all distance elements
- Loss-of-potential logic can supervise all distance elements
- Zone 3 elements are reversible

Phase-Phase Distance Elements (secondary quantitics)

21P1: 0.125 to 64 ohms
21P2: 0.125 to 64 ohms
21P3: 0.125 to 64 ohms

Three-Phase Distance Elements (secondary quantities)

21ABC1: 0.125 to 64 ohms
21ABC2: 0.125 to 64 ohms
21ABC3: 0.125 to 64 ohms
21ABC4: offset mho with diameter 1.50 times Zone 3

Maximum Torque Angle (MTA)

Adjustable from 47 - 90 degrees in 0.01 degree increments.

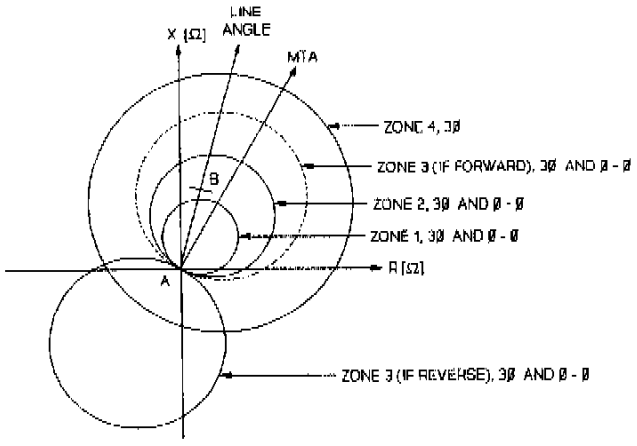


Figure 1: Phase-Phase and Three-Phase Mho Element Characteristics

Zone 2 and 3 settings are limited as follows:

For Zone 3 Forward: Zone 1 < Zone 2 < Zone 3
For Zone 3 Reverse: Zone 1 < Zone 2, Zone 1 < Zone 3

Accuracy

Steady-state Error:

- 5% of set reach ± 0.01 ohm at MTA for V > 5 V and I > 2 A.
- 10% of set reach ± 0.01 ohm at MTA for 1 < V < 5 V and 0.5 < I < 2 A.

Transient Overreach:

- 5% of set reach, plus steady-state error.

Operating Speed

See distance element operating time curves on page 19.

Distance Element Timers

Zone 2 timer (Z2DP) range: (0 - 2000 cycles in ¼ cycle steps)
Zone 3 timer (Z3DP) range: (0 - 2000 cycles in ¼ cycle steps)

Mho Element Expansion

The phase distance elements use the compensator distance principle, which expands the mho distance characteristics. The phase-phase elements are strongly polarized from the non-involved phase and do not require memory polarization. The three-phase elements use memory polarization to achieve expanded characteristics.

Figure 2 illustrates the expanded mho characteristics for phase-phase faults in front of the relay. Figure 3 illustrates the expanded mho characteristics for three-phase faults in front of the relay. In both figures, the amount of mho expansion depends on the relative strength of the source. To determine the amount of expansion mho characteristics experience, relay reach and positive-sequence source impedance must be known. Use the equations to plot the circle center and radius of the mho characteristics.

Figures 2 and 3 show an example for an SIR of two, and compare the SEL-121H relay expanded mho characteristic with theoretical self-polarized mho characteristics.

Phase-phase Elements:

$$\text{CENTER} = \tfrac{1}{2}(-ZS + ZR) \qquad \text{RADIUS} = \tfrac{1}{2}(ZS + ZR)$$

Where:

ZS = Positive-sequence source impedance
ZR = Relay reach in positive-sequence ohms

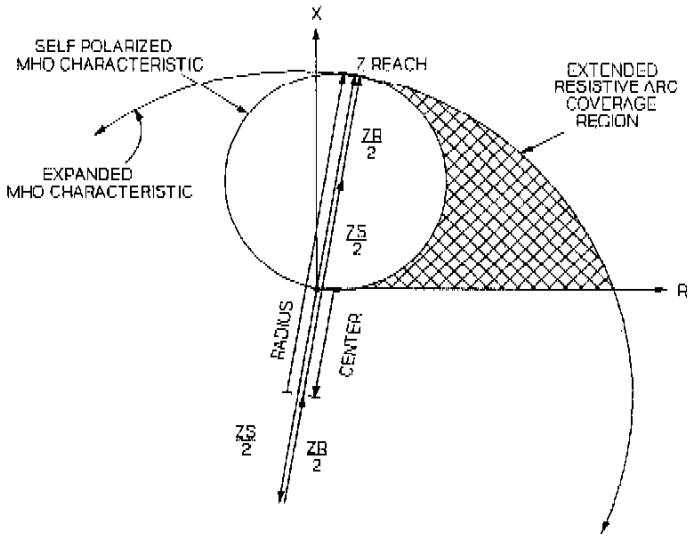


Figure 2: Expanded Phase-Phase Mho Characteristics

Three-Phase Elements:

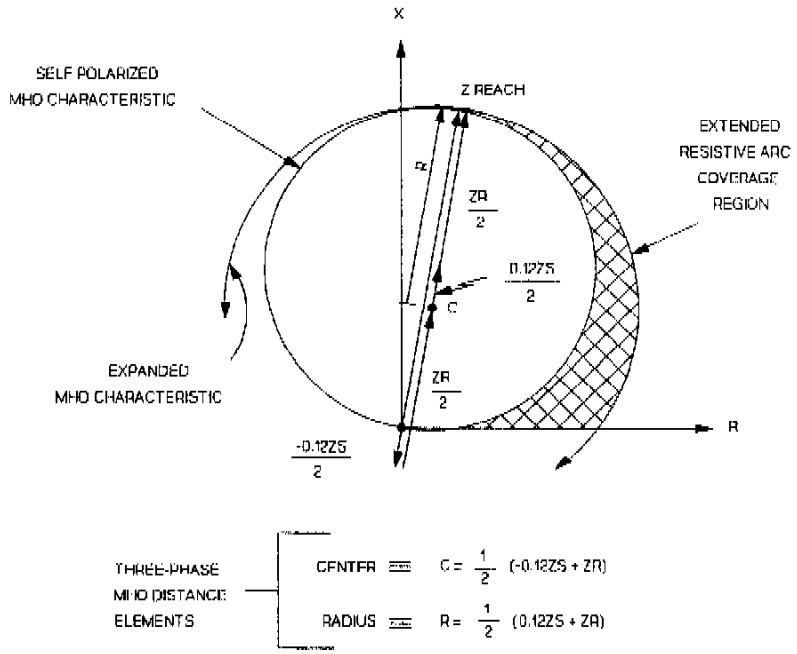


Figure 3: Expanded Three-Phase Mho Characteristics

Residual Overcurrent Protection for Ground Faults

51N Residual Time-overcurrent Element (secondary quantities)

- Selectable curve shape (four curve families)
  - Moderately Inverse (curve family 1)
  - Inverse (curve family 2)
  - Very Inverse (curve family 3)
  - Extremely Inverse (curve family 4)
- Time dial: 0.50 to 15.00 in 0.01 steps.
- Pickup: 0.25 to 6.3 A, ± 0.05 A ± 2% of setting.
- Timing: ±4% and ±1 cycle for residual current magnitude between 2 and 20 multiples of pickup.
- May be directionally controlled (51NTC setting).

50N1, 50N2, 50N3 Residual Overcurrent Elements (secondary quantities)

- Pickup: 0.25 A to 48 times 51N pickup for 51N pickup < 3.15 A.
  0.50 A to 48 times 51N pickup for 51N pickup ≥ 3.15 A.
- Transient overreach: 5% of set pickup.
- May be directionally controlled (32Q, 32V, and 32I enables).

Residual Overcurrent Element Timers

Zone 2 timer (Z2DG) range: (0 - 2000 cycles in ¼ cycle steps)
Zone 3 timer (Z3DG) range: (0 - 2000 cycles in ¼ cycle steps)

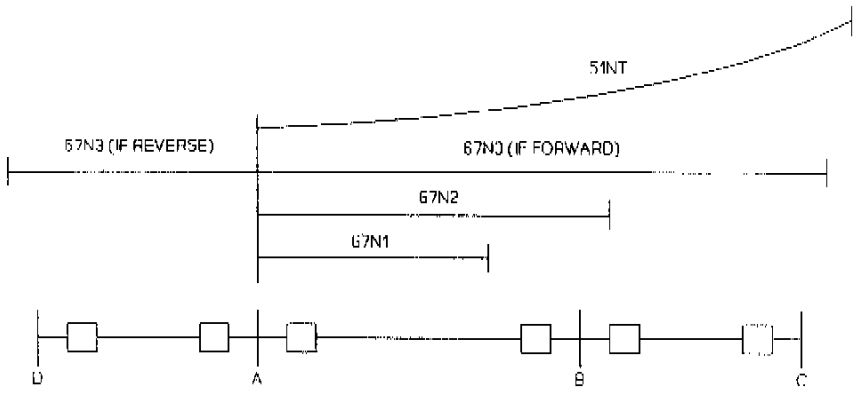


Figure 4: Residual Overcurrent Zones of Protection

Residual Overcurrent Directional Element Ranges and Sensitivities

Negative-sequence directional element

- The angle between the measured negative-sequence voltage and current adjusted by the MTA setting determines fault direction (I2 leads V2 $\pm 90°$ from MTA).

Zero-sequence directional element

Voltage polarization

- The angle between the measured zero-sequence voltage and residual current adjusted by the MTA setting determines fault direction (I0 leads V0 $\pm 90°$ from MTA).
- Does not require an external polarizing source.

Current polarization

- The relay measures the angle between the measured residual current and zero-sequence current from an external source to determine fault direction.

Table 1: Directional Element Sensitivities at Maximum Torque Angle (MTA)

Element	Negative-Sequence 32Q	Zero-Sequence 32D	
Sensitivity	0.10	(0.29)(51NP)	(0.44)(51NP)
Units	(V2)(I2)	(V0)(IR)	(IR)(IP)

Note: 51NP is the pickup setting of the 51N element in secondary amps.

Nondirectional Phase Overcurrent Elements

- 50AL, 50BL, 50CL (current detectors)
- 50AM, 50BM, 50CM (current detectors, used in loss-of-potential logic)

Pickup: 0.5 to 40 A, $\pm$ 0.1 A $\pm$ 2% of setting
Transient overreach: 5% of set pickup

- 50AH, 50BH, 50CH (high-set phase overcurrent elements)

Pickup: 0.5 to 80 A, $\pm$ 0.1 A $\pm$ 2% of setting
Transient overreach: 5% of set pickup

Loss-of-Potential (LOP) Detection

- Declares an LOP condition when zero-sequence voltage is detected in the absence of zero-sequence current (one or two potential fuses blown).
- Declares an LOP condition when positive sequence voltage drops below 14 volts secondary and phase current is below the 50M setting (three potential fuses blown).
- Clears LOP condition when balanced three-phase voltages return.
- When you set LOPE = Y, LOP blocks distance elements and causes directional elements to default forward.
- Use LOP condition to close programmable output contacts to alarm for a blown fuse condition.

Open Breaker Echo Keying

- Echoes the received permissive trip signal to the remote terminal when no reverse Zone 3 elements are picked up and the local line breaker is judged open by the 52A input.
- Received permissive trip signal must be present for a settable time before echoing is permitted.
- Echo duration is settable.

Weak-Infeed Conditional Logic

- Conditions a received permissive trip signal to allow tripping of a weak-infeed terminal if no reverse elements are asserted and the breaker is closed (Echo-Conversion-To-Trip).
- 27AB, 27BC, 27CA elements monitor the magnitudes of phase-to-phase voltages.
- 59N monitors the magnitude of the zero-sequence voltage.
- Voltage setting ranges:
  - 27PP elements: 0 - 260 V_{LL} secondary, ±5%, ±1 V
  - 59N elements : 0 - 150 V_{L-n} secondary, ±5%, ±1 V

Current Reversal Logic

- Reverse phase distance elements, reverse ground overcurrent elements, and breaker status supervise the current reversal logic.
- Settable current reversal timer (Z3RBT).
- Breaker status defeats current reversal logic (BZ3RB) for a settable time during a line test.

LOGIC INPUTS

The relay has six opto-isolator inputs to sense external conditions: received permissive trip and block trip signals, breaker status, direct close, direct trip, and external event report trigger. Assert an input by applying control voltage to the corresponding rear panel input terminals.

OUTPUT CONTACTS

The relay has seven output contacts: TRIP, CLOSE, ALARM, and four programmable outputs: A1, A2, A3, and A4. Any output contact except TRIP may be factory configured as either form a or form b.

RELAY WORD

The Relay Word consists of four eight-bit rows containing relay elements, intermediate logic results, logic inputs, and relay outputs. Each bit in the Relay Word is either a logical 1 or logical 0.

Table 2: Relay Word

1ABC	2ABC	3ABC	4ABC	LOP	50H	50M	50L
51NT	67N1	67N2	67N3	51NP	Z1P	Z2P	Z3P
Z2PT	Z3PT	Z3RB	KEY	50MF	PTEE	ECTT	DF
ALRM	TRIP	TC	DT	52BT	WFC	Z2GT	Z3GT

The Relay Word Bit Summary Table explains each bit in the Relay Word.

Table 3: Relay Word Bit Summary

1ABC	-	Zone 1 three-phase instantaneous element (set by Z1%)
2ABC	-	Zone 2 three-phase instantaneous element (set by Z2%)
3ABC	-	Zone 3 three-phase instantaneous element (set by Z3%)
4ABC	-	Zone 4 three-phase instantaneous element (equal to 1.5 x Z3%)
LOP	-	Loss-of-potential condition
50H	-	High-level overcurrent element (set by 50H)
50M	-	Medium-level overcurrent element (set by 50M)
50L	-	Phase fault current supervision (set by 50L)
51NT	-	Residual time-overcurrent trip (set by 51NP, 51NTD, and 51NC)
67N1	-	Residual instantaneous-overcurrent (set by 50N1P)
67N2	-	Residual instantaneous-overcurrent (set by 50N2P)
67N3	-	Residual instantaneous-overcurrent (set by 50N3P)
51NP	-	Residual time-overcurrent pickup
Z1P	-	Zone 1 phase-phase element (set by Z1%)
Z2P	-	Zone 2 phase-phase element (set by Z2%)
Z3P	-	Zone 3 phase-phase element (set by Z3%)
Z2PT	-	Zone 2 phase-phase or three-phase timeout (set by Z2DP)
Z3PT	-	Zone 3 phase-phase or three-phase timeout (set by Z3DP)
Z3RB	-	Zone 3 reverse block timer output (TDDO time set by Z3RBT)
KEY	-	Communication channel keying bit
50MF	-	Asserts a settable delay after LOP and 50M pickup (delay set by 50MFD)
PTEE	-	Permissive Trip Echo Enable (limited duration pulse set by echo timers, ETDPU and EDUR)
ECTT	-	Echo-Conversion-To-Trip
DF	-	Direction forward for ground faults
ALRM	-	System alarm
TRIP	-	Trip contact closure
TC	-	Trip (OPEN) Command
DT	-	Direct Trip (or other user defined external purposes)
52BT	-	Inverted time delayed 52a follower (delay set by 52BT setting)
WFC	-	Weak-infeed condition (set by 27PP and 59N)
Z2GT	-	Zone 2 timeout-ground (set by Z2DG)
Z3GT	-	Zone 3 timeout-ground (set by Z2DG)

PROGRAMMABLE OUTPUT LOGIC

The relay uses programmable logic masks to control the TRIP and programmable output relays. Logic masks are saved in nonvolatile memory with the other settings. They are set with the LOGIC command and retained through losses of control power.

To program each logic mask, select elements of the Relay Word. If any element in the Relay Word asserts and the same element is selected in a logic mask, the output contact associated with the logic mask closes.

The output equations follow:

Let R= Relay Word

MTU = mask for trip	(unconditional)
MPT = mask for trip	(permissive trip)
MTB = mask for trip	(with no blocking)
MTO = mask for trip	(with breaker open)

then:

TRIP = R * MTU	(unconditional tripping)
+ R * MPT * PT * NOT(Z3RB)	(permissive tripping with PT input asserted and no reverse block)
+ R * MTB * NOT (BT)	(tripping with BT input deasserted)
+ R * MTO * 52BT	(breaker open/just closed tripping)

Close TRIP contact = TRIP

Open TRIP contact = NOT (TRIP)
* [(NOT(50L) + NOT(50NL))
+ TARGET RESET button pushed]
* (trip duration timer expires)

Close CLOSE contact = (DC + CLOSE COMMAND) * NOT (52A) * NOT (TRIP)

Open CLOSE contact = NOT (CLOSE) + 63.75 cycle CLOSE reset timer

A1 = R * MA1
A2 = R * MA2
A3 = R * MA3
A4 = R * MA4

The "*" indicates a logical "and," while the "+" indicates a logical "or."

RELAY TARGETS

The relay normally displays the targets identified on the front panel. Under normal operating conditions, the enable (EN) target lamp is lit. If the relay trips, it illuminates the LED corresponding to the element asserted at the time of trip. The target LEDs latch. The target LEDs which illuminated during the last trip remain lit until 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 targets clear and the LEDs display the most recent tripping target.

When you press the TARGET RESET button, all eight indicators illuminate for a one-second lamp test. The relay targets clear and the Enable light (EN) illuminates to indicate that the relay is operational.

Use the TARGET command and display to examine the state of the relay inputs, outputs, and the elements of the Relay Word.

SERIAL INTERFACES

Connectors labeled PORT 1 and PORT 2 are EIA RS-232-C serial data interfaces. Generally, PORT 1 is used for remote communications via a modem, while PORT 2 is used for local communications via a terminal or SEL-PRTU protective relay terminal unit. PORT 2 may also be connected to the SEL-DTA, which serves as a local operator interface and transducer output.

Port baud rates are 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, no parity. Communications use XON/XOFF flow control.

EVENT REPORTING

The relay retains a data record for each of the last twelve events. The record includes fault location, input voltages and currents, relay elements, input contacts, and output contacts. The relay saves a report when any of the following occur:

- The relay trips
- Selected relay elements assert
- User executes the TRIGGER or OPEN commands
- DT (Direct Trip) or ET (External Trigger) input is asserted

Two sample event reports are included near the end of this data sheet.

FAULT LOCATION

The relay computes fault location from event report data stored for each fault or disturbance. The relay uses two fault locating methods: the Takagi method where sound prefault data are available, or simple reactance method when sound prefault data are not available. The Takagi fault locating algorithm compensates for prefault load current to improve fault locating accuracy under load and for high-resistance faults.

METERING

The meter function shows the line-neutral and line-line ac voltage and current values, megawatts (P to represent real power), and megavars (Q to represent reactive power) in primary values. You can display these values locally or remotely with the METER command.

SELF TESTING

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 self test warning or failure.

The relay closes the ALARM contact after any self test fails. When the relay detects certain failures, it disables the breaker control functions and places the output relay driver port in an

input mode. No outputs may be asserted when the relay is in this configuration. The relay runs all self tests at least every five minutes.

Table 4 shows a list of the self tests performed by the relay.

Table 4: Relay Self Tests

Test	Description
Offset	Measures dc offset of analog input channels.
Power Supply	Measures internal power supply voltages.
Random-Access Memory	Verifies RAM operation.
Read-Only Memory	Verifies ROM operation.
Analog-to-Digital Converter	Verifies A/D operation.
Master Offset	Measures dc offset of multiplexer channel.
Settings	Verifies checksum of setting group.

CONNECTIONS

Figure 5 shows typical ac connections for an SEL-121H relay. Figure 6 shows connections for one terminal in a typical permissive overreaching transfer trip (POTT) scheme. The receive contact (RX), is connected to the relay permissive trip (PT) input. When the KEY bit in the Relay Word asserts, the A1 output contact closes to assert the transmit input (TX) of the communication equipment.

The protection scheme uses unsupervised instantaneous Zone 1 elements and instantaneous Zone 2 elements supervised by the permissive trip (PT) input. Time-delayed Zone 2 and Zone 3 elements provide time-stepped backup protection in the event of a communication channel failure.

Figure 7 shows the tripping and output contact masks used to implement this protection scheme.

Mask for Unconditional Tripping (MTU) Selects Elements for Unqualified Tripping

The MTU mask contains the Zone 1 instantaneous elements 1ABC, Z1P, and 67N1. It also contains the residual time overcurrent element 51NT and the time-delayed Zone 2 and Zone 3 phase distance and ground overcurrent elements Z2PT, Z2GT, Z3PT, and Z3GT. The 50MF bit provides non-directional, time-delayed, phase overcurrent protection under loss-of-potential conditions. ECTT asserts to trip the relay under weak-infeed conditions when a permissive signal is received from the strong source terminal and the breaker is closed. TC and DT allow you to trip the relay by command or input assertion.

Mask for Permissive Tripping (MPT) Selects Elements for PT-Qualified Tripping

When the PT input is asserted and no reverse block condition is present, bits set in the MPT mask are enabled for tripping. The MPT mask normally contains the forward looking instantaneous Zone 2 elements.

Mask for Trip while Breaker Is Open (MTO) Selects Elements for Switch-Onto-Fault Tripping

Use the MTO mask to provide switch-onto-fault protection. Elements set in the MTO mask are enabled for tripping when the breaker is open and for a short time after it closes. The MTO mask elements are enabled when the 52BT bit is asserted. 52BT is an inverted, time-delayed follower of the 52a input signal.

Zone 1 and Zone 2 instantaneous phase distance and ground overcurrent elements provide fast tripping for faults in the reenergized section during a line pickup or test. The 50H element provides tripping for close-in bolted faults.

Program the A1 Output to Key-Permissive Signal via Mask MA1

The MA1 logic mask contains the KEY bit. This bit performs the permissive echo function. It also asserts to transmit permission to the remote terminal when forward reaching elements set in the MPT mask assert. The KEY bit is supervised by the reverse block logic.

Use the A4 Output to Indicate Loss-of-Potential (LOP) via Mask MA4

When a loss-of-potential condition occurs, the LOP bit asserts to close the A4 output contact. The A4 contact is connected to an annunciator which can alert the operator to the LOP condition.

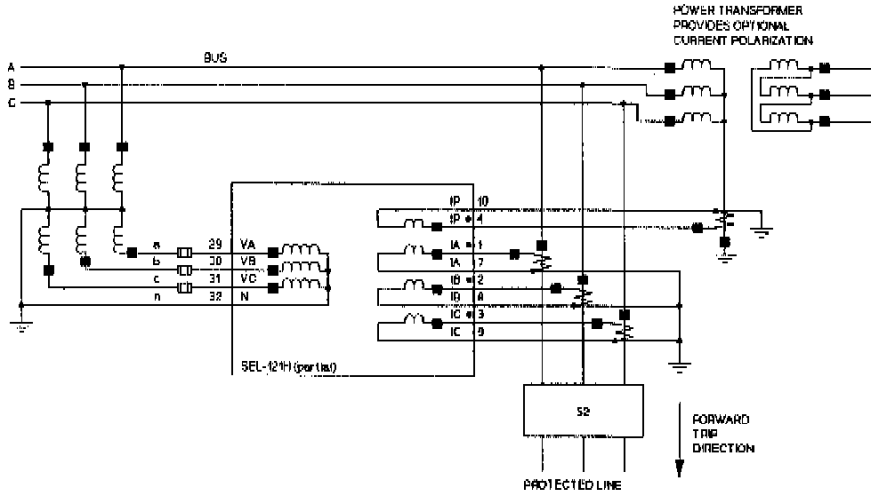


Figure 5: SEL-121H Relay Typical AC Current and Voltage Connections

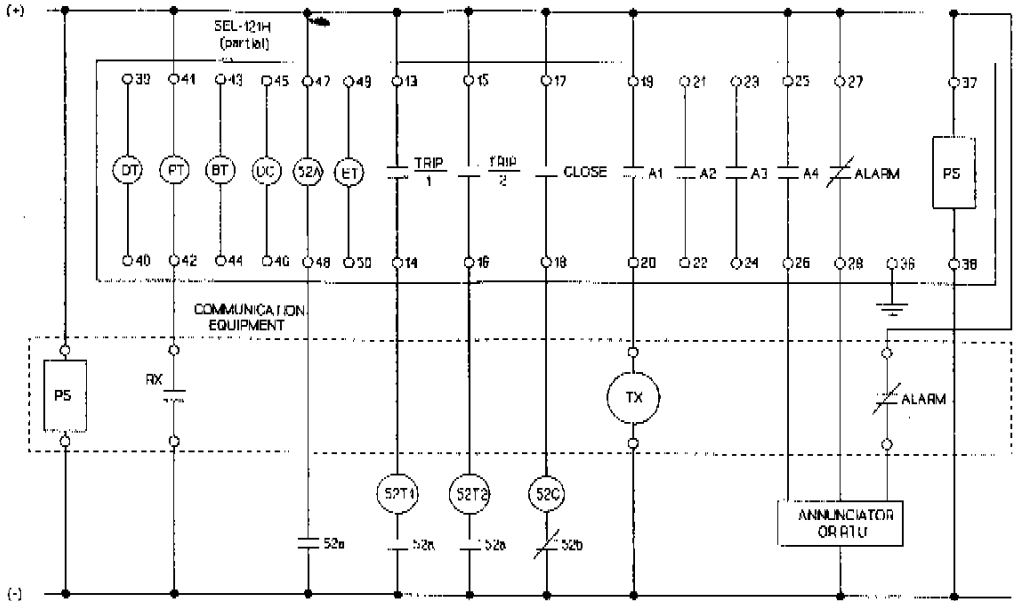


Figure 6: SEL-121H Relay Typical DC Connections to Communication Equipment

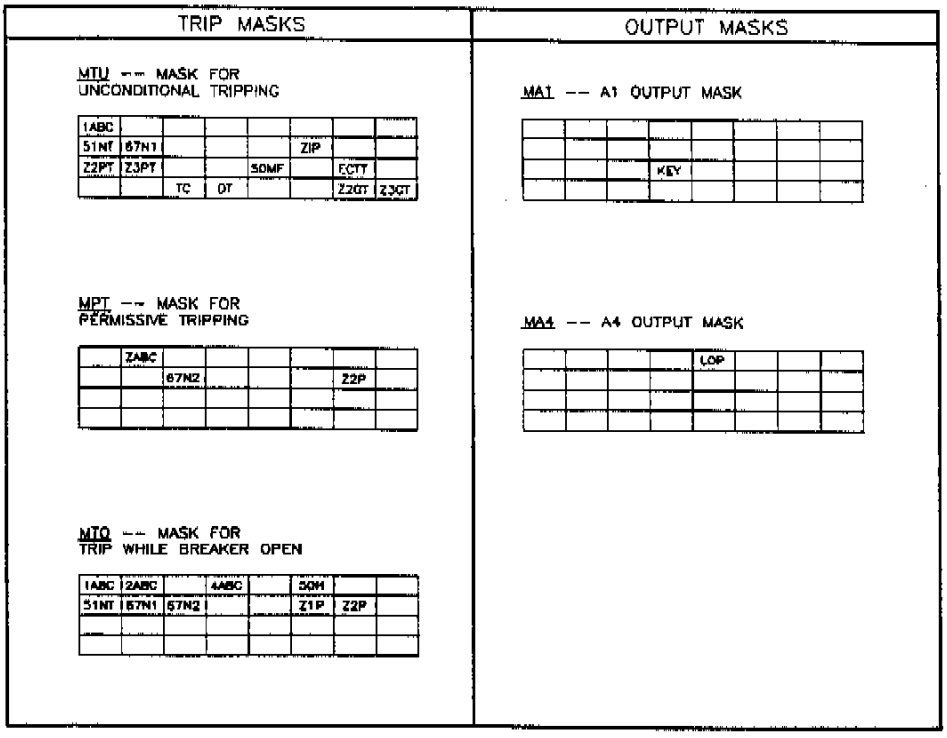


Figure 7: Programmable Logic Mask Settings for Scheme in Figure 6

RELAY ELEMENT OPERATING TIME CURVES

Figure 8 shows operating times for the SEL-121H relay phase-phase mho distance elements and the 50H instantaneous phase overcurrent element. At each reach percentage or current multiple, ten tests were run. The diagrams show maximum, average, and minimum operating times at each test point. Operating times include output contact closure time.

For the distance element test, a phase-phase fault was applied at a location representing a percentage of the Zone 1 relay reach setting. Tests were performed for source impedance ratios (SIR) of 0.1, 1.0, and 5.0. No prefault load current was included. System frequency is 60 Hz.

Balanced three-phase currents and no voltages were applied to the relay for the 50H overcurrent element tests. This test simulates a bolted 3ϕ fault in front of the relay location when line side PTs are employed. Test currents are shown as a multiple of the pickup setting. No prefault load current was included. System frequency is 60 Hz.

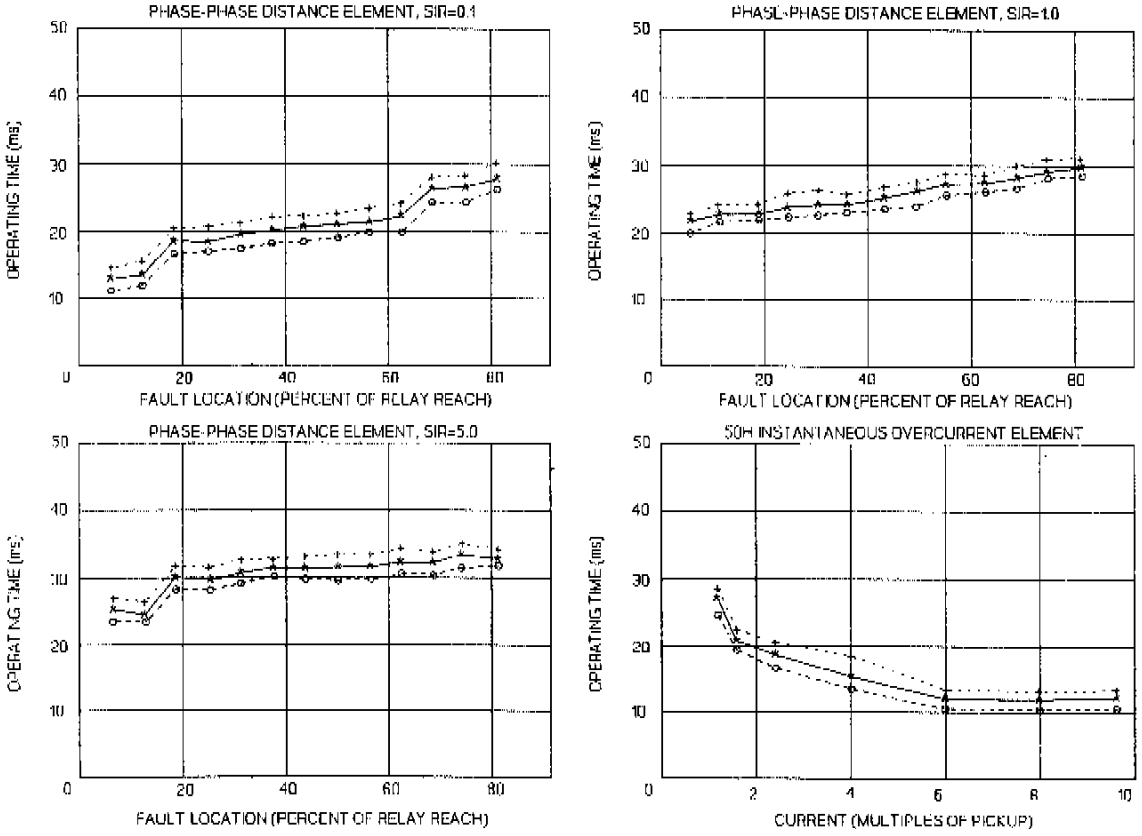
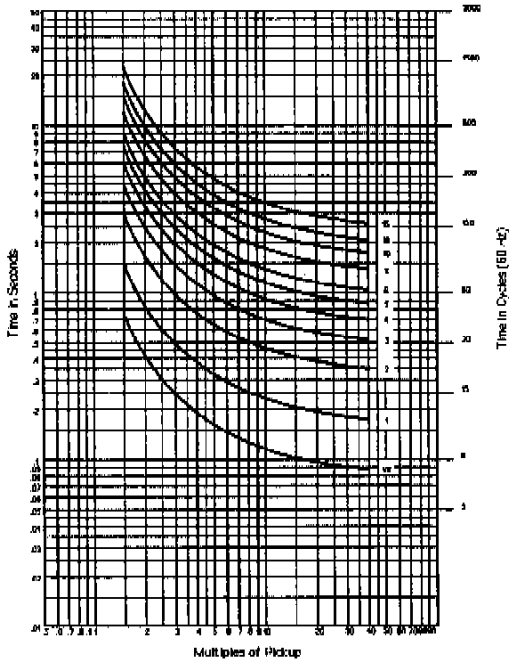
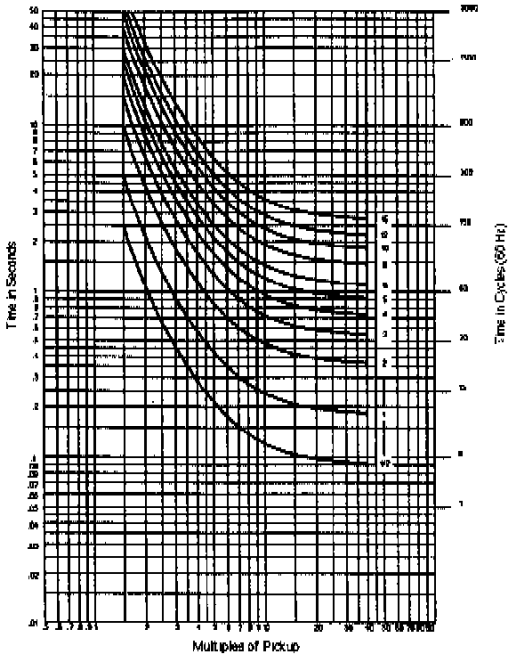


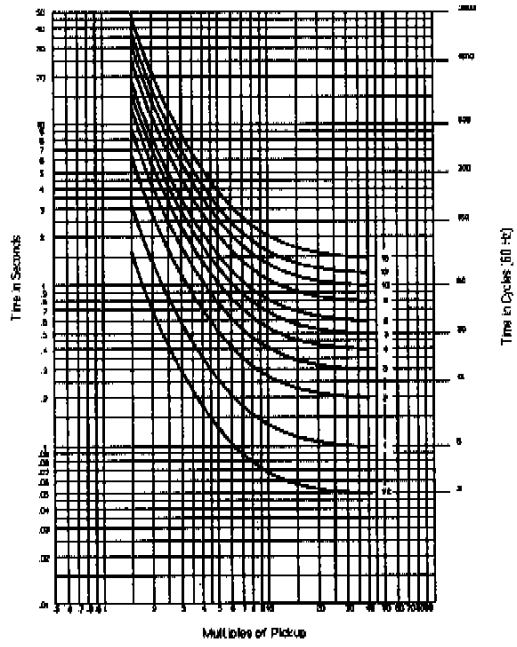
Figure 8: Phase Distance Speed Curves and Phase Overcurrent Speed Curve



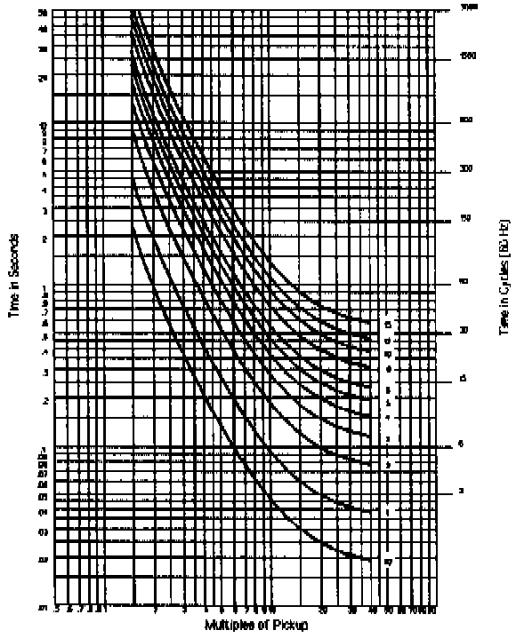
Residual Time-Overcurrent Element Moderately Inverse Time Characteristic



Residual Time-Overcurrent Element Inverse Time Characteristic

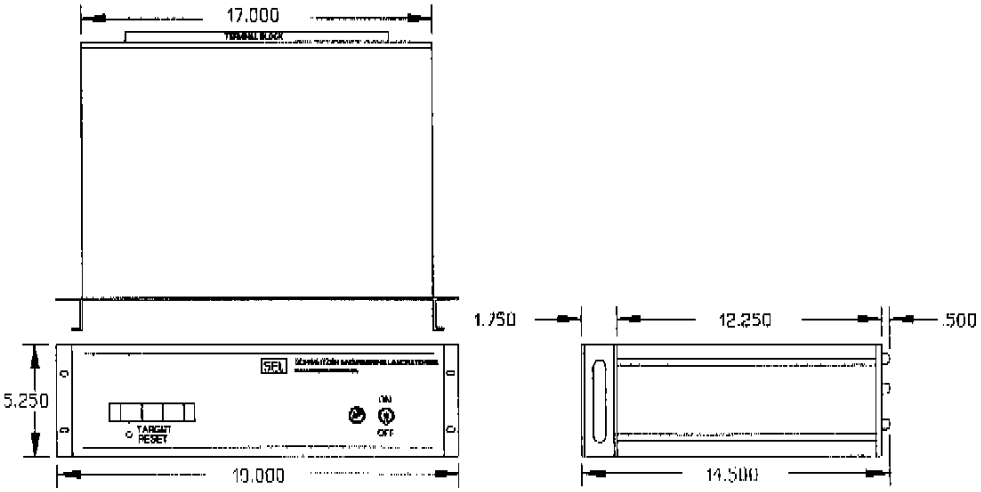


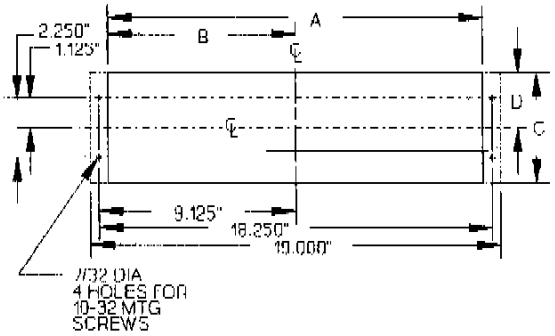
Residual Time-Overcurrent Element Very Inverse Time Characteristic



Residual Time-Overcurrent Element Extremely Inverse Time Characteristic

Figure 9: Residual Time-Overcurrent Curves





DIMENSION A:
CUT OUT: 17.250" - 17.875"
17.375" PREFERRED
DIMENSION B:
CUT OUT: 8.625" - 8.9375"
8.688" PREFERRED
DIMENSION C:
CUT OUT: 5.350" - 5.450"
DIMENSION D:
CUT OUT: 2.675" - 2.725"

NOTE: ALL INSTRUMENTS MAY BE MOUNTED HORIZONTALLY (AS SHOWN) OR VERTICALLY.

PANEL CUTOUT AND DRILL FOR SEMI-FLUSH MOUNTING OF 5.250 INCH HIGH CASE.

Figure 10: Relay Dimensions, Panel Cutout, and Drill Diagrams

SAMPLE COMMAND DISPLAYS

Meter

```
=>METER <ENTER>

Example 230 kV Line                Date: 10/8/90      Time: 07:56:36

              A       B       C      AB      BC      CA
I (A)       202     198     197     349     339     344
V (kV)    134.0   133.8   133.6   231.5   230.9   231.9

P (MW)    78.61
Q (MVAR)  13.85
```

Status

```
=>STATUS <ENTER>

Example 230 kV Line                Date: 10/8/90      Time: 01:08:44

SELF TESTS

W=Warn F=Fail
      IP   IR   IA   IB   IC   VA   VB   VC
OS    0    0    0    0    0    2    0    2
PS     5.11      15.15     -14.91
RAM     ROM     A/D     NOF     SET
OK      OK      OK      OK      OK
```

History

```
=>HISTORY <ENTER>

Example 230 kV Line                Date: 10/8/90      Time: 07:38:12

#   DATE         TIME          TYPE  DIST   DUR   CURR

1  8/31/90   07:36:52.150  1AG   74.93  5.00  1070.1
2  8/31/90   07:36:18.400  1BC   74.53  4.75  1567.2
3  8/31/90   07:35:42.970  2BC   84.68  4.25  1411.8
4  8/31/90   07:35:23.783  EXT
5  8/31/90   07:35:07.958  TRIP
6
7
8
9
10
11
12
```

Set

```
=>>SET<ENTER>

SET clears events. CTRL-X cancels.
Enter data, or RETURN for no change

ID    : Example 230 kV Line
 ?
R1    : (Ohms pri)..... = 8.56     ?
X1    : ..............  = 77.77    ?
R0    : ..............  = 35.12    ?
X0    : ..............  = 236.96   ?
LL    : Line Length (mi)..... = 100.00   ?

CTR   : ..............  = 200.00   ?
PTR   : ..............  = 2000.00  ?
MTA   : Max Torque Angle (deg) = 83.70    ?
LOCAT: Locate faults (Y/N)... = Y        ?

Z1%   : Reach (% line)........ =  80.00   ?
Z2%   : ..............  = 120.00   ?
Z3%   : ..............  = 120.00   ?

Z2DP  : Dly-Phase(cyc)........ = 20.00    ?
Z3DP  : Dly-Phase(cyc)........ = 60.00    ?
A1TP  : A1 Pickup Dly (cyc)... = 0.00     ?
A1TD  : A1 Dropout Dly (cyc).. = 0.00     ?

50L   : PU (Amps pri)......... = 275.00   ?
50M   : PU.....  ..............  = 500.00   ?
50MFD: Dly (cyc)..... = 20.00    ?
50H   : PU.....  ..............  = 3420.00  ?

51NP  : PU (Amps pri)......... = 230.00   ?
51NTD: Time Dial..... = 4.00     ?
51NC  : Curve (1,2,3,or4)..... = 3        ?
51NTC: Torque Ctrl (Y/N)..... = Y        ?

50N1P: PU (Amps pri)......... = 835.00   ?
50N2P: ..............  = 276.00   ?
50N3P: ..............  = 282.00   ?

Z2DG  : Dly-Gnd(cyc).......... = 30.00    ?
Z3DG  : Dly-Gnd(cyc).......... = 60.00    ?

TDUR  : Trip duration (cyc)... = 9.00     ?
52BT  : Dly (cyc)..... = 20.00    ?
ZONE3: Dir (F=fwd or R=rvs).. = R        ?
Z3RBT: Rev Block dly(cyc).... = 4.50     ?
BZ3RB: Block RB dly(cyc)..... = 1.50     ?

ETDPU: Echo dly(cyc)......... = 2.00     ?
EDUR  : Echo dur(cyc)......... = 3.50     ?
WFCE  : Enable (Y/N).......... = Y        ?
27PP  : PU (kV pri)..... = 160.00   ?
59N   : PU (kV pri)..... = 6.00     ?

32QE  : Enable (Y/N)..... = Y        ?
32VE  : ..............  = N        ?
32IE  : ..............  = N        ?
LOPE  : Loss of Pot (Y/N)..... = Y        ?

TIME1: Port 1 timeout (min).. = 5.00     ?
TIME2: ..............  = 0.00     ?
AUTO  : Auto port (1,2,3)..... = 2        ?
RINGS: (1-30)..... = 7.00     ?

New settings for: Example 230 kV Line

R1   =8.56     X1   =77.77    R0   =35.12    X0   =236.96   LL   =100.00
CTR  =200.00   PTR  =2000.00 MTA  =83.70    LOCAT=Y
Z1%  =100.00   Z2%  =120.00  Z3%  =120.00
Z2DP =20.00    Z3DP =120.00  A1TP =0.00     A1TD =0.00
50L  =275.00   50M  =500.00  50MFD=20.00    50H  =3420.00
51NP =230.00   51NTD=4.00    51NC =3        51NTC=Y
50N1P=835.00   50N2P=276.00  50N3P=282.00
Z2DG =30.00    Z3DG =60.00
TDUR =9.00     52BT =20.00   ZONE3=R        Z3RBT=4.50    BZ3RB=1.50
ETDPU=2.00     EDUR =3.50    WFCE =Y        27PP =160.00  59N  =6.00
32QE =Y        32VE =N       32IE =N        LOPE =Y
TIME1=5.00     TIME2=0.00    AUTO =2        RINGS=7.00

OK (Y/N) ? Y<ENTER>
Please wait...
Enabled

Example 230 kV Line                        Date: 1/1/90      Time: 01:03:32
```

SAMPLE EVENT REPORT FOR INTERNAL ZONE 2 FAULT

Example 230 kV Line Date: 9/18/90 Time:09:20:59.241

Date and time of event

FID=SEL-121H-R400-V656mptr1s-D900823

	Currents (amps)				Voltages (kV)			Relays Outputs Inputs		
IPOL	IR	IA	IB	IC	VA	VB	VC	52265L 011710 P3PNNP	TCAAAAA PL1234L	DPBD5E TTTC2T A
3	-2	-66	94	-31	-115.0	-0.9	116.5	.....	.....	....*
-3	0	-72	-19	94	67.6	-133.7	65.7	.....	.....	....*
-3	4	66	-91	31	115.0	1.0	-116.5	.....	.....	....*
6	0	72	16	-94	-67.6	133.6	-65.7	.....	.....	....*
-3	-4	-66	91	-31	-115.0	-1.0	116.5	.....	.....	....*
-3	2	-72	-16	94	67.6	-133.6	65.6	.....	.....	....*
3	2	66	-91	31	115.0	1.0	-116.5	.....	.....	....*
0	-2	72	16	-94	-67.6	133.7	-65.6	.....	.....	....*
0	-2	-66	91	-31	-115.0	-1.1	116.6	.....	.....	....*
0	2	-72	-16	94	67.8	-133.6	65.6	.....	.....	....*
0	2	66	-94	31	114.9	1.7	-117.2	.....	.....	....*
0	7	72	107	-173	-67.8	129.7	-61.6	.....	.....	....*
0	-13	-66	409	-356	-114.9	-0.1	115.5	L....	.....	....*
0	-38	-72	-481	513	67.8	-121.0	52.9	M....	.....	.*..*
3	49	66	-893	878	114.9	-5.5	-109.8	M....	.....	.*..*
-3	60	72	799	-809	-67.8	115.5	-47.4	M.2...	*.*....	.*..*
-3	-71	-66	1092	-1101	-114.8	9.4	105.9	M.2...	*.*....	.*..*
3	-64	-72	-840	849	67.8	-114.8	46.6	M.2...	*.*....	.*..*
0	73	66	-1120	1129	114.8	-9.9	-105.4	M.2...	*.*....	.*..*
0	64	72	846	-859	-67.8	114.7	-46.4	M.2...	*.*....	.*..*
0	-73	-66	1123	-1129	-114.8	9.9	105.3	M.2...	*.*....	.*..*
0	-64	-72	-846	859	67.8	-114.7	46.5	M.2...	*.*....	.*..*
0	73	66	-1123	1126	114.8	-10.4	-104.8	M.2...	*.*....	.*..*
0	53	60	735	-761	-67.8	118.5	-50.3	M.2...	*.*....	.*..*
0	-60	-53	790	-793	-114.9	8.9	106.4	M.2...	*.*....	.*....
0	-24	-31	-378	381	67.9	-127.2	59.1	M....	*.*....	.*....
0	27	25	-255	255	114.8	-3.2	-112.1	L....	*.*....	.*....
0	4	9	50	-50	-67.9	132.8	-64.6	.....	*.*....	.*....
0	-7	-6	31	-31	-114.8	-0.7	116.1	.....	*.*....	.*....
0	2	-3	-6	6	67.9	-133.5	65.3	.....	*.....	.*....
0	2	3	-3	6	114.8	1.2	-116.7	.....	*.....	.....
3	-2	0	-3	-3	-68.0	133.5	-65.3	.....	*.....	.....
-3	-2	0	0	0	-114.8	-1.3	116.7	.....	*.....	.....
-3	2	3	6	0	68.0	-133.6	65.3	.....	*.....	.....
3	2	-3	0	0	114.8	1.4	-116.7	.....	*.....	.....
0	-2	0	-3	0	-68.0	133.6	-65.4	.....	*.....	.....
0	-2	3	-3	0	-114.8	-1.4	116.7	.....	*.....	.....
0	2	-6	3	0	68.0	-133.6	65.3	.....	*.....	.....
0	2	0	3	0	114.8	1.4	-116.7	.....	*.....	.....
0	-2	6	-3	0	-68.0	133.6	-65.3	.....	*.....	.....
0	0	0	-3	0	-114.8	-1.4	116.7	.....	*.....	.....
0	0	-6	3	0	68.0	-133.6	65.3	.....	*.....	.....
0	0	0	3	0	114.7	1.4	-116.7	.....	*.....	.....
0	0	6	-6	0	-68.0	133.6	-65.3	.....	*.....	.....

One cycle of data

Permissive Trip (PT) input is received

TRIP output asserts and permissive output (A1) keys when Zone 2 phase distance element asserts

52A input dropout indicates that breaker is opening

Event : ZBC Location : 84.70 mi 6.63 ohms sec
Duration: 2.50 Flt Current: 1418.9

Fault Summary

```
R1   =8.56      X1   =77.77     RO   =35.12     XO   =236.96    LL   =100.00
CTR  =200.00    PTR  =2000.00   MTA  =83.72     LOCAT=Y
Z1%  =80.00     Z2%  =120.00    Z3%  =120.00
Z2DP =20.00     Z3DP =60.00     A1TP =0.00      A1TD =0.00
50L  =275.00    50N  =500.00    50MFD=20.00     50H  =3420.00
51NP =230.00    51NTD=4.00      51NC =3         51NTC=Y
50N1P=835.00    50N2P=276.00    50N3P=282.00
Z2DG =30.00     Z3DG =60.00
TDUR =9.00      52BT =20.00     ZONE3=R         Z3RBT=4.50     BZ3RB=1.50
ETDPU=2.00      EDUR =3.50      WFCE =Y         27PP =160.00   59N  =6.00
32QE =Y         32VE =N         32IE =N         LOPE =Y
TIME1=5.00      TIME2=0.00      AUTO =2         RINGS=7.00
```

Relay Settings

Logic settings:

Logic Mask Settings

MTU	MPT	MTB	MTD	MA1	MA2	MA3	MA4
80	40	00	D4	00	00	00	08
C4	22	00	E6	00	00	00	00
CA	00	00	00	10	00	00	00
33	00	00	00	00	00	00	00

EXPLANATION OF SAMPLE EVENT REPORT FOR INTERNAL ZONE 2 FAULT

```
Example 230 kV Line                          Date: 9/18/90     Time: 09:20:59.241

FID=SEL-121H-R400-V656mptr1s-D900823

                Currents                          Voltages          Relays Outputs Inputs
                (amps)                             (kV)
                                                                    52265L TCAAAAA DPBD5E
  IPOL     IR     IA     IB     IC      VA      VB      VC          011710 PL1234L TTTC2T
                                                                    P3PNNP               A

     0    -13    -66    409   -356  -114.9    -0.1   115.5  L..... ....... ....*.
     0    -38    -72   -481    513    67.8  -121.0    52.9  M..... ....... .*..*.
     3     49     66   -893    878   114.9    -5.5  -109.8  M..... ....... .*..*.
    -3     60     72    799   -809   -67.8   115.5   -47.4  M.2... *.*.... .*..*.

    -3    -71    -66   1092  -1101  -114.8     9.4   105.9  M.2... *.*.... .*..*.
     3    -64    -72   -840    849    67.8  -114.8    46.6  M.2... *.*.... .*..*.

Event    : 28C    Location   : 84.70  mi  6.63   ohms sec
Duration: 2.50    Flt Current: 1418.9

R1   =8.56     X1   =77.77    R0   =35.12    X0   =236.96   LL   =100.00
CTR  =200.00   PTR  =2000.00  MTA  =83.72    LOCAT=Y
Z1%  =80.00    Z2%  =120.00   Z3%  =120.00
Z2DP =20.00    Z3DP =60.00    A1TP =0.00     A1TD =0.00
50L  =275.00   50M  =500.00   50MFD=20.00    50H  =3420.00
51NP =230.00   51NTD=4.00     51NC =3        51NTC=Y
50N1P=835.00   50N2P=276.00   50N3P=282.00
Z2DG =30.00    Z3DG =60.00
TDUR =9.00     52BT =20.00    ZONE3=R        Z3RBT=4.50     BZ3RB=1.50
ETDPU=2.00     EDUR =3.50     WFCE =Y        27PP =160.00   59N  =6.00
32QE =Y        32VE =N        32IE =N        LOPE =Y
TIME1=5.00     TIME2=0.00     AUTO =2        RINGS=7.00
```

Currents and voltages are in primary amps and kV. Rows are ¼ cycle apart. Time runs down page. Obtain phasor RMS value and angle using any entry as Y-component and the entry immediately underneath as the X-component. For example, from bottom rows, IBY = 1092, IBX = -840. Therefore, IB = 1378 amps primary at an angle of ATAN (1092/-840) = 128°, with respect to the sampling clock.

<FID>	Firmware Identification Data
<Relays>	columns show states of internal relay elements ---> Designators 50P : phase overcurrent ..... : 50H, 50M, 50L ---> H,M,L 21З : 3-phase distance ..... : Z1, Z2, Z3, Z4 ---> 1,2,3,4 21P : 2-phase distance ..... : Z1, Z2, Z3 ---> 1,2,3 67N : inst ground overcurrent : 67N1, 67N2, 67N3 ---> 1,2,3 51N : ground time-overcurrent ---> P,T LOP : loss-of-potential logic ---> *
<Outputs>	columns show states of output contacts: ON = "*", OFF = "." TP=TRIP, CL=CLOSE, A1-A4=PROGRAMMABLE, AL=ALARM
<Inputs>	columns show states of input contacts: DT=DIRECT TRIP, PT=PERMISSIVE TRIP, BT=BLOCK TRIP, DC=DIRECT CLOSE, 52A=AUX A-CONTACT, ET=EXTERNAL TRIGGER (event report)
<Event>	Fault indications are "ZT" where Z indicates zone and T type Z is one of 1=Zone 1, 2=Zone 2, 3=Zone3, 4=Zone4, 5=51N, H=50H, "?" = indeterminate T is one of AG,BG,CG = single-phase to ground, AB,BC,CA = 2-phase, ABG,BCG,CAG = 2-phase to ground, ABC = 3-phase. Followed by a "T" if a TRIP triggered the report Other indications are TRIP = triggered by TRIP output and EXT = externally or otherwise triggered
<Location>	Distance to fault in miles. 999999 is indeterminate distance
<ohms sec>	Distance to fault in secondary ohms. 999999 is indeterminate
<Duration>	Fault duration determined from relay element(s) pickup time (cyc.)
<Flt Current>	Maximum phase current (primary amps) taken near middle of fault
R1,X1,R0,X0	Primary series impedance settings for transmission line (ohms)
LL	Line length corresponding to specified line impedances
CTR, PTR	Current and potential tranaformer ratios (XTR:1)
MTA,LOCAT	Maximum torque angle (degrees) and fault locator enable (Y/N)
Z1%,Z2%,Z3%	Reaches of 3- and 2-phase mhos, percent of positive sequence line impedances
Z2DP,Z3DP	Zones 2 and 3 timer settings for 3- and 2-phase faults (cyc.)
A1TP,A1TD	A1 programmable output pickup and dropout delays (cyc.)
50L,M,H,MFD	Overcurrent settings and coordinating delay for 50M & LOP Trip
51NP,TD, C,TC	GND time-overcurrent Pickup, Time-Dial, Curve, Torque Control
50N1P,2,3	Ground inst-overcurrent pickup settings Zones 1, 2, and 3
Z2DG, Z3DG	Zone 2 and 3 ground timer settings (cyc.)
TDUR,52BT	Trip output duration timer, 52B delay setting (for switch-onto-fault coordination) (cyc.)
ZONE3	Direction of all zone 3 elements (Fwd/Rvs)
Z3RBT,BZ3RB	Reverse block and block-the-reverse-block timer settings (cyc.)
ETDPU,EDUR	Echo Time Delay Pickup timer and Echo Duration timer (cyc.)
WFCE,27PP,59N	Weak Feed enable (Y/N), phase-phase voltage level detector (kV), and residual overvoltage level detector (kV).
32QE,VE,IE	Ground fault direction from (V2,I2) or (V0/IP,I0)
LOPE	Loss-of-potential enable (Y/N)
TIME1,2	Communications port timeout intervals (automatic log-off) (minutes)
AUTO	Port assignment for automatic message transmissions (1, 2, or 3)
RINGS	Number of rings to wait before modem answers telephone
<Logic settings>	See LOGIC command for a description of mask settings

SAMPLE EVENT REPORT FOR CURRENT REVERSAL AT BREAKER 1

```
Example 230 kV Line Breaker 1                Date: 9/18/90     Time: 09:33:50.620
FID=SEL-121N-R400-V656mptr1s-D900823
```

Date and time of event

	Currents (amps)				Voltages (kV)			Relays Outputs Inputs		
								52265L	TCAAAAA	DPBD5E
IPOL	IR	IA	IB	IC	VA	VB	VC	011710 P3PNNP	PL1234L	TTTC2T A
0	0	82	0	-88	-43.4	131.1	-87.6	.....	.....	....*.
0	0	-50	98	-50	-126.2	25.6	101.2	.....	.....	....*.
0	0	-82	-3	88	43.4	-131.2	87.6	.....	.....	....*.
3	0	50	-98	50	126.1	-25.5	-101.2	.....	.....	....*.
-3	-2	82	3	-88	-43.4	131.2	-87.6	.....	.....	....*.
-3	2	-50	94	-50	-126.1	25.5	101.2	.....	.....	....*.
3	2	-82	0	88	43.4	-131.2	87.6	.....	.....	....*.
0	-2	50	-94	50	126.2	-25.5	-101.2	.....	.....	....*.
0	0	82	0	-88	-43.5	131.1	-87.5	.....	.....	....*.
0	0	-47	94	-50	-126.2	25.5	101.2	.....	.....	....*.
0	0	-85	0	88	43.5	-131.1	87.5	.....	.....	....*.
0	0	47	-94	50	125.8	-25.5	-101.3	.....	.....	....*.
0	-102	-16	0	-85	-43.3	131.1	-87.5	.....	.....	....*.
0	22	-28	94	-53	-118.4	28.6	104.3	.....	.....	....*.
0	520	437	3	85	39.5	-132.6	86.1	L.....	.....	....*.
0	-246	-195	-98	53	106.6	-33.5	-109.2	L..3..	.....	.*..*.
0	-905	-821	-3	-88	-35.4	134.2	-84.5	M..3..	.....	.*..*.
0	473	422	98	-50	-101.6	35.5	111.4	M..3..	.....	.*..*.
0	980	897	0	88	34.9	-134.4	84.2	M..3..	.....	.*..*.
0	-500	-453	-94	50	100.9	-35.8	-111.7	M..3..	.....	.*..*.
0	-989	-903	0	-88	-34.9	134.5	-84.1	M..3..	.....	.*..*.
0	502	456	94	-50	-100.9	35.8	111.6	M..3..	.....	.*..*.
3	989	903	0	88	34.9	-134.5	84.1	M..3..	.....	.*..*.
-3	-502	-456	-94	50	100.9	-35.8	-111.6	M..3..	.....	.*..*.
-3	-823	-736	0	-88	-34.9	134.5	-84.1	M..3..	.....	.*..*.
3	469	422	94	-50	-100.9	35.8	111.7	M..3..	.....	.*..*.
0	142	50	0	88	34.9	-134.5	84.1	L..3..	.....	.*..*.
0	-113	-57	-94	50	100.9	-35.8	-111.7	.....	.....	.*..*.
0	484	573	0	-88	-35.0	134.5	-84.1	M.....	.....	.*..*.
0	-254	-311	94	-50	-100.9	35.8	111.7	M..2P.	.....	.*..*.
0	-608	-692	0	88	35.0	-134.5	84.1	M..2P.	.....	.*..*.
3	303	356	-94	50	100.7	-35.7	-111.9	M..2P.	.....	.*..*.
-3	624	708	0	-88	-35.0	134.4	-84.1	M..2P.	.....	.*..*.
-3	-310	-359	94	-50	-100.7	35.7	111.9	M..2P.	.....	.*..*.
3	-622	-711	0	88	35.0	-134.4	84.1	M..2P.	.....	.*..*.
0	310	359	-94	50	101.0	-35.7	-111.7	M..2P.	.....	.*..*.
0	546	636	0	-88	-35.1	134.5	-84.0	M..2P.	.....	.*..*.
0	-294	-343	94	-50	-108.6	32.5	108.7	M..2P.	.....	.*..*.
0	-248	-333	0	88	39.0	-133.1	85.4	L..2P.	.....	.*..*.
0	137	182	-94	50	120.3	-27.6	-103.8	L..2P.	.....	.*..*.
0	-27	60	0	-88	-43.2	131.5	-87.0	.....	.....	.*..*.
0	24	-19	94	-50	-125.3	25.4	101.7	.....	.....	.*..*.
0	80	-9	0	88	43.7	-131.3	87.2	.....	.....	.*..*.
0	-46	0	-94	50	126.0	-25.2	-101.5	.....	.....	....*.

52A input assertion indicates breaker is closed

Permissive Trip (PT) input is received

Reverse Zone 3 residual overcurrent element asserts and initiates current reversal logic

Reverse Zone 3 residual overcurrent element drops out

Forward Zone 2 residual overcurrent element asserts, but current reversal logic blocks tripping and keying

Forward residual overcurrent elements drop out

Permissive Trip (PT) input drops out

```
Event    : 3AG    Location    : -77.14 mi -6.04  ohms sec
Duration: 3.00    Flt Current: 1011.6

R1   =8.56     X1   =77.77    R0   =35.12    X0   =236.96   LL   =100.00
CTR  =200.00   PTR  =2000.00  MTA  =83.72    LOCAT=Y
Z1%  =80.00    Z2%  =120.00   Z3%  =120.00
Z2DP =20.00    Z3DP =60.00    A1TP =0.00     A1TD =0.00
50L  =275.00   50M  =500.00   50MFD=20.00    50H  =3420.00
51NP =230.00   51NTD=4.00     51NC =3        51NTC=Y
50N1P=835.00   50N2P=276.00   50N3P=282.00
Z2DG =30.00    Z3DG =60.00
TDUR =9.00     52BT =20.00    ZONE3=R        Z3RBT=4.50    BZ3RB=1.50
ETDPU=2.00     EDUR =3.50     WFCE =Y        27PP =160.00  59N  =6.00
32QE =Y        32VE =N        32IE =N        LOPE =Y
TIME1=5.00     TIME2=0.00     AUTO =2        RINGS=7.00

Logic settings:

MTU  MPT  MTB  MTO  MA1  MA2  MA3  MA4
80   40   00   D4   00   00   00   08
C4   22   00   E6   00   00   00   00
CA   00   00   00   10   00   00   00
33   00   00   00   00   00   00   00
```

EXPLANATION OF SAMPLE EVENT REPORT FOR CURRENT REVERSAL AT BREAKER 1

The previous event report illustrates relay security during an out-of-section fault resulting in current reversal. The report shows that no trip occurred at Breaker 1 following the current reversal because the current reversal logic blocked tripping by permissive trip logic. Also notice that the current reversal logic blocked the relay from keying the permissive trip signal when the Zone 2 elements asserted.

Referring to Figure 11, the relay at Breaker 1 initially sees the fault with a reverse Zone 3 67N3 ground overcurrent element. The relay at Breaker 3 trips instantaneously via its Zone 1 ground elements. The protection at Breaker 4 must wait to receive a permissive signal from the protection at Breaker 3, resulting in a short duration sequential clearance for the fault. Referring to Figure 12, after Breaker 3 opens, the fault current redistributes and the relay at Breaker 1 sees the fault as a forward Zone 2 ground fault.

The SEL-121H relay current reversal logic initiates with the assertion of any reverse Zone 3 element and drops out a settable time after the Zone 3 elements. This prevents the relay from tripping or keying via the permissive logic when the current reverses and Zone 2 elements pick up.

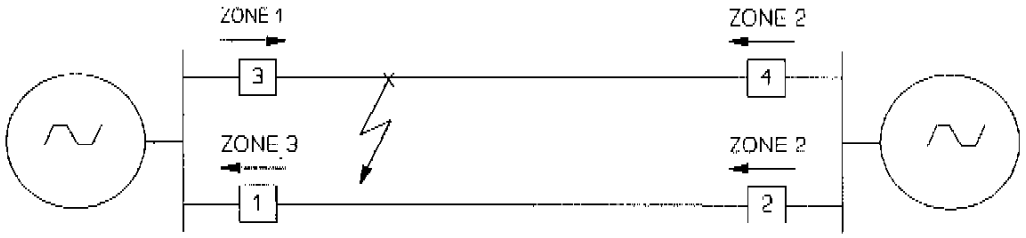


Figure 11: Fault Inception, All Sources In

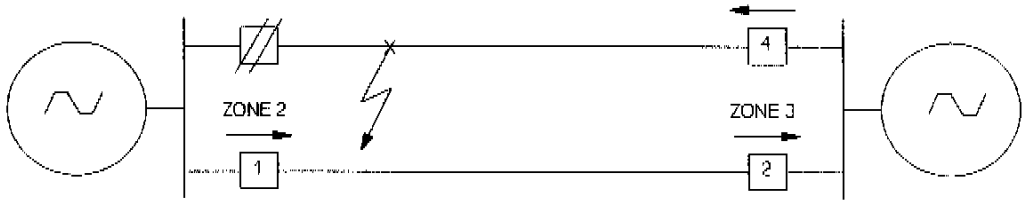


Figure 12: Faulted System with Breaker 1 Open

SEL-121H RELAY COMMAND SUMMARY

Access Level 0

ACCESS Answer password prompt (if password protection is enabled) to enter Access Level 1. Three unsuccessful attempts pulse 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.

DATE [m/d/y] Show or set date. DAT 2/3/90 sets date to Feb. 3, 1990. IRIG-B time code input overrides existing month and day settings. DATE pulses ALARM contacts when year entered differs from year stored.

EVENT Show event record. EVE 1 shows newest event; EVE 12 shows oldest.

HISTORY Show DATE, TIME, TYPE, DIST (distance), DUR (duration), and CURR (maximum fault current) for the last twelve events.

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

METER [N] Display primary phase-to-neutral and phase-to-phase voltages and currents and real and reactive power. Option N displays meter data N times.

QUIT Return control to Access Level 0; return target display to Relay Targets.

SHOWSET Display settings without affecting them.

STATUS Show self test status.

TARGET [N][K] Show data and set target LEDs as follows:

TAR 0: Relay Targets	TAR 1: Relay Word row #1
TAR 2: Relay Word row #2	TAR 3: Relay Word row #3
TAR 4: Relay Word row #4	TAR 5: Contact Input States
TAR 6: Contact Output States	TAR R: Clears Targets and returns to TAR 0

Option K displays target data K times.

TIME [h/m/s] Show or set time. TIM 13/32/00 sets clock to 1:32:00 PM. IRIG-B synchronization overrides this setting.

TRIGGER Trigger and save an event record (event type is EXT).

Access Level 2

CLOSE Close circuit breaker, if allowed by jumper setting.

LOGIC [N] Show or set logic masks MTU, MPT, MTB, MTO, MA1-MA4. Command pulses ALARM contacts closed for one second and clears event buffers when new settings are stored.

OPEN Open circuit breaker, if allowed by jumper setting.

PASSWORD Show or set passwords. Command pulses ALARM contacts closed momentarily after password entry. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.

SET [N] Initiate set procedure. Optional N directs relay to begin setting procedure at that setting. SET EDUR initiates setting procedure at EDUR setting. SET initiates setting procedure at beginning. Command pulses ALARM contacts closed and clears event buffers when new settings are stored.

SCHWEITZER ENGINEERING LABORATORIES, INC.
N.E. 2350 Hopkins Court
Pullman, WA 99163-5600
TEL: (509) 332-1890 FAX: (509) 332-7990