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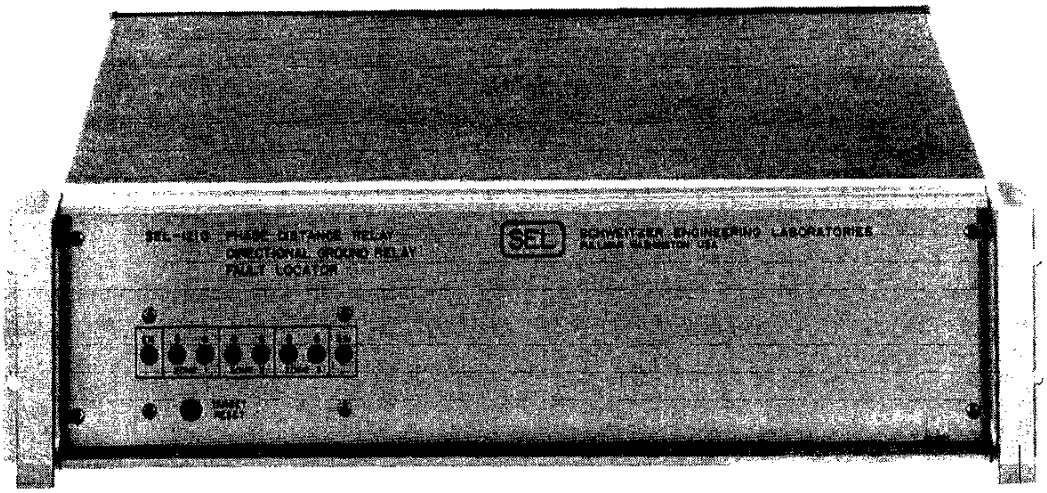
Making Electric Power Safer, More Reliable, and More Economical



SEL-121G PHASE DISTANCE RELAY
GROUND DIRECTIONAL OVERCURRENT RELAY
FAULT LOCATOR

Also Available in LOW-PROFILE Package

DATA SHEET

- 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 a variety of system conditions
- Switch-onto-fault logic permits instantaneous tripping for reclosing or line pickup
- Out-of-step blocking of selected zones for power swings
- Programmable three-shot reclosing
- 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 relay

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MODEL VARIATIONS

SEL offers several optional configurations of the SEL-121G relay for a wide range of applications. This introduction includes a short description of each model variation. All SEL-121G relays may have any output except TRIP configured as either an "a" or "b" contact when shipped from the factory. With the exception of the TRIP contacts, all contacts can be changed in the field at a later date.

SEL-121G Relay

This data sheet details the basic SEL-121G relay. For the SEL-121G relay, front panel targets are cumulative, indicating all picked up zones instead of only one zone element picked up at the time of trip.

SEL-121G-3 Relay

SEL-121G-3 front panel LEDs are "trip only targets." Thus, target LEDs indicate only the zone element picked up when the TRIP output contacts assert and show only the most recent fault (basic SEL-121G relay LEDs display cumulative targets).

SEL-121G-4 Relay

The Zone 4 three-phase element diameter is two times that of the Zone 3 three-phase mho element. The Zone 4 three-phase element diameter in all other SEL-121G relays is 1.5 times the diameter of the Zone 3 three-phase element. SEL-121G-4 relay LED targeting is identical to that of the SEL-121G-3 relay.

SEL-121G-5 Relay

The SEL-121G-5 relay is intended for application in Directional Comparison Blocking (DCB) schemes. Zone 1 phase and ground timers of the basic SEL-121G relay have been removed to provide two settable timers for the Zone 2 phase and ground elements. BT input assertion in the SEL-121G-5 relay does not generate an event report as it would in the basic SEL-121G relay. This eliminates event reports caused by carrier channel noise. The block trip input (BT) incorporates a one-quarter-cycle block trip input signal extension to provide added security for out-of-section faults. Zone 3 pickup extension logic is included to serve as block trip transmit extension. The logic output is indicated by the Z3X bit in the Relay Word (Z3X replaces 52AT in the SEL-121G Relay Word). Nondirectional instantaneous residual overcurrent element 50N3 is available in the Relay Word for high speed nondirectional carrier start function (50N3 replaces ALRM in the SEL-121G Relay Word). Logic for carrier stop over carrier start preference is also available for use with nondirectional overcurrent or offset mho element carrier start functions. The logic output is indicated by the STOP bit in the Relay Word (STOP replaces DF in the SEL-121G Relay Word). Front panel LEDs are "trip only targets." Thus, target LEDs indicate only the zone element picked up when the TRIP output contacts assert and show only the most recent fault (basic SEL-121G relay LEDs display cumulative targets).

SEL-121G-8 Relay

The SEL-121G-8 relay has several differences from the basic model. A Level 2 access attempt does not pulse the ALARM contacts as in the SEL-121G relay. Instead, the ALARM contacts pulse for one second after three unsuccessful Level 1 or 2 access attempts. DATE, TIME, TRIGGER, and IRIG command execution requires Level 2 access. TARGET command execution from Level 1 only displays targets. TARGET command execution from Level 2 displays targets and allows the operator to change front panel LED assignments. Front panel targeting is the same as that of the SEL-121G-3 relay. Aside from the differences listed here, the SEL-121G-8 relay is identical to the SEL-121G-5 relay.

SEL-121G-9 Relay

The SEL-121G-9 relay is identical to the SEL-121G-5 relay except for permissive trip input (PT) assertion, which does not generate an event report. This feature eliminates unwanted event reports for noise bursts on the permissive trip communication channel.

GENERAL DESCRIPTION

The SEL-121G relay simultaneously provides high-speed and time delayed protection for transmission, subtransmission, and distribution lines. A 32-bit Relay Word combines mho distance elements, overcurrent elements, directional element, timers, and data and control bits. You can program the logic through bit combinations to control tripping, communication channel keying, reclose initiation and cancellation, and four general programmable outputs.

Because of its many relay elements, large setting ranges, programmability, and low cost, the relay meets the requirements of a broad spectrum of applications. Flexible yet simple programmability provides access to relay elements (before and after time delays) and logic results. Relay features include four zones of three-phase elements, three zones of phase-to-phase elements, three zones of ground elements, time delayed backup for Zones 2 and 3 phase and ground elements, time-overcurrent element, out-of-step blocking, three shot reclosing with programmable initiate and reclose conditions, and loss-of-potential logic.

Without requiring an external initiating contact input, the relay provides time-stepped protection in parallel with communication-aided protection. The relay supports:

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

Analog inputs from current and voltage transformers are delivered to the protective relaying elements and saved for additional features such as metering and fault locating.

Relay elements process the analog data. Some intermediate logic is performed, such as overcurrent supervision of the mho elements, directional supervision of the residual overcurrent elements, and grouping of certain elements into zones.

The relay generates an eleven-cycle event report starting with information captured four cycles before fault detection through seven cycles afterward. Each report resembles a sequence-of-events report; each includes the following information every quarter-cycle for eleven cycles:

- Voltages (VA, VB, and VC)
- Currents (IA, IB, IC, IR (residual), and IP (current polarizing input))
- Fault type and involved phases
- Fault location
- Secondary ohms to the fault location
- Maximum phase current measured near the middle of the fault
- Date and time of the event
- Relay element status
- External inputs (breaker status, block trip, etc.)
- Relay contact outputs

The relay stores the latest twelve event reports, allowing retrieval and examination after the event. A user can retrieve any or all records remotely or locally through either of the two serial communications ports.

The metering function permits interrogation of the relay to obtain power system voltage, current, real power, and reactive power readings. The function also includes per-phase measurements of voltage and current. Metering is very valuable for unmanned or remote substations.

The CLOSE, A1, A2, A3, A4, and ALARM outputs may be specified as "a" or "b" type contacts. TRIP outputs are always an "a" type contact.

The relay is compatible with the SEL-PRTU protective relay terminal unit, the SEL-DTA Display/Transducer Adapter, and the SEL-PROFILE Transmission Line Fault Analysis Program.

GENERAL SPECIFICATIONS

Voltage Inputs	115 volt nominal phase-to-phase, three-phase four-wire connection
Current Inputs	5 amps per phase nominal 15 amps per phase continuous; 500 amps for one second thermal rating
Output Contact Current Ratings	30 amp make per IEEE C37.90 para 6.7.2 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 EIA RS-232-C)
Operating Temp.	-40°F to 158°F (-40°C to 70°C)
Environment	IEC 68-2-30 Temperature/Humidity Cycle Test - six day (type tested)
nterference 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 (14.5 kg), including two manuals.
Burn-in	140°F (60°C) for 100 hours.

FUNCTIONAL SPECIFICATIONS

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

- Independent timers for Zones 1, 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 Quantities)

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° in 0.01° increments.

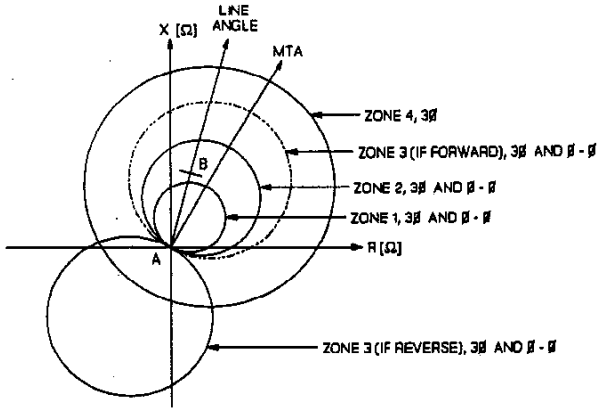


Figure 1: Phase-Phase and Three-Phase Mho Element Characteristics

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 1 timer (Z1DP) range: (0 - 60 cycles in quarter-cycle steps)
Zone 2 timer (Z2DP) range: (0 - 2000 cycles in quarter-cycle steps)
Zone 3 timer (Z3DP) range: (0 - 2000 cycles in quarter-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-121G 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

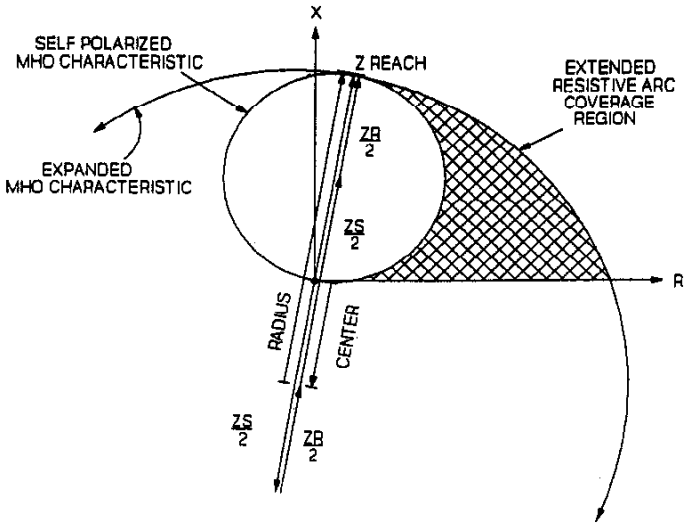


Figure 2: Expanded Phase-Phase Mho Characteristics

Three-Phase Elements:

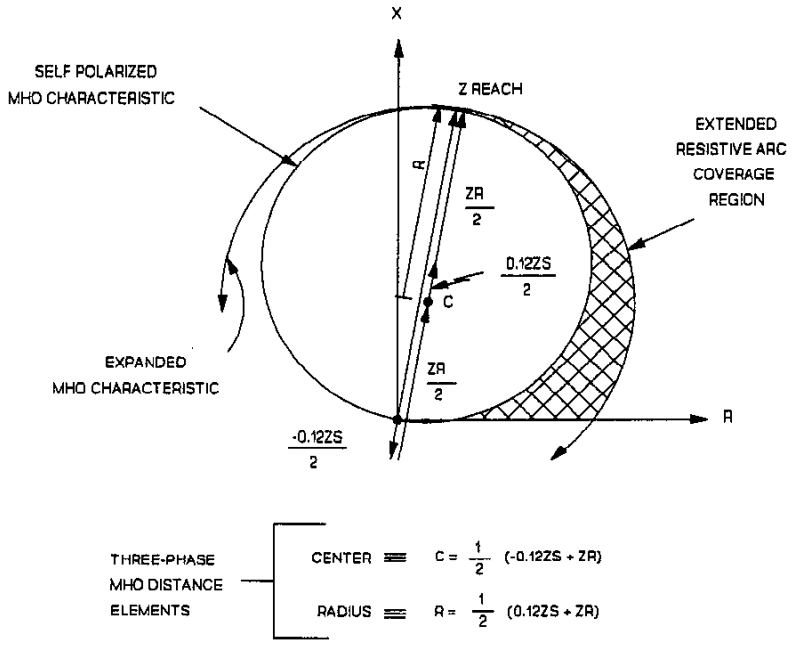


Figure 3: Expanded Three-Phase Mho Characteristics

Residual Overcurrent Protection for Ground Faults

- Time-overcurrent element
  - Four curve families (moderate, inverse, very inverse, and extremely inverse)
  - Nondirectional or forward reaching as enabled in relay settings
- Three residual overcurrent elements
  - Independent long timers for Zones 1, 2, and 3 elements (time-step backup protection)
  - Zone 3 reversible with a simple setting
- Choice of three polarization techniques for directional control
  - Nondirectional if no polarization method is selected

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, $\pm$0.05 A $\pm$2% of setting.
- Timing: $\pm$4% and $\pm$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 $\geq$ 3.15 A.
- Transient overreach: 5% of set pickup.
- May be directionally controlled (32Q, 32V, and 32I enables).

Residual Overcurrent Element Timers

- Zone 1 timer (Z1DG) range: (0 - 60 cycles in quarter-cycle steps)
- Zone 2 timer (Z2DG) range: (0 - 2000 cycles in quarter-cycle steps)
- Zone 3 timer (Z3DG) range: (0 - 2000 cycles in quarter-cycle steps)

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: 32V and 32I sensitivities depend on the pickup setting of the residual time-overcurrent element 51NP. 51NP is the pickup setting of the 51N element in secondary amps.

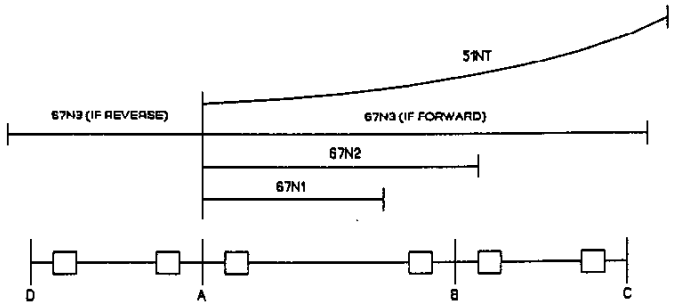


Figure 4: Residual Overcurrent Zones of Protection

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 ±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 ±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.

Out-of-Step Blocking

- Zone 4 three-phase mho (4ABC) pickup starts out-of-step blocking timer (OSBT)
- Settable out-of-step blocking timer (OSBT)
- Selected three-phase distance elements are blocked for two seconds after OSBT expires

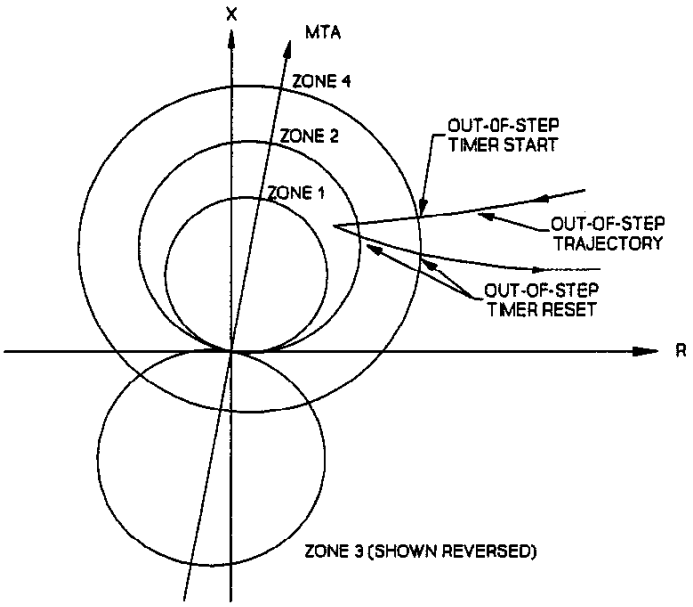


Figure 5: Out-of-Step Blocking Characteristics

Reclosing

- Three separate shots of reclosing with settable open interval timers
- Selectable reclose initiate and cancel conditions
- Settable reclose reset timer

Loss-of-Potential (LOP) Detection

- Detects blown secondary potential fuse(s) condition
- Enabled or disabled with a simple setting
- When enabled, an LOP condition blocks all mho distance elements
- LOP detection may be selected to close an output relay for alarming purposes

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, ±0.1 A ±2% of setting
  Transient overreach: 5% of set pickup

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

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

Switch-onto-Fault Protection

- User selected elements enabled to trip for 52BT time after the line breaker closes
- Functions independently from communications channel equipment

IRIG-B Input

The relay accepts demodulated IRIG-B from an external clock source to set the internal clock automatically.

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 these logic inputs by applying control voltage to the corresponding rear panel input terminals.

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	(permissive tripping with PT input asserted)
	+ 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 + 50NL))
+ TARGET RESET button pushed]
* (minimum trip duration timer expired)

Close contact = (DC + CLOSE COMMAND) * NOT (52A) * NOT (TRIP)
Open CLOSE contact = NOT (CLOSE) + 79RS (reclose cycle reset timer expired)

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 LEDs corresponding to the elements asserted at the time of trip. The target LEDs latch. The target LEDs illuminated during the last trip remain lit until one of the following occurs:

- Operator presses front panel TARGET RESET button
- Operator executes the TARGET R command

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.

The TARGET command allows you to display and examine the state of the relay inputs, outputs, and the elements of the Relay Word locally and remotely.

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.

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 configured as either "a" or "b." The TRIP output contact is always "a."

RELAY WORD

The Relay Word consists of four eight bit rows containing relay elements, intermediate logic results, logic inputs, and relay outputs. Each bit has two states: logical 1 when the element is asserted, logical 0 when the element is deasserted.

Table 2: Relay Word

1ABC	2ABC	3ABC	4ABC	LOP	50H	50M	50L
51NT	67N1	67N2	67N3	51NP	Z1P	Z2P	Z3P
Z2PT	Z3PT	OSB	3P50	50MF	RC	RI	DF
ALRM	TRIP	TC	DT	52BT	52AT	Z2GT	Z3GT

Table 3: Relay Word Bit Summary

1ABC	-	Zone 1 three-phase instantaneous element (includes Z1DP delay)(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 (includes Z1DG delay)(set by 50N1P)[1]
67N2	-	Residual instantaneous-overcurrent (set by 50N2P)[1]
67N3	-	Residual instantaneous-overcurrent (set by 50N3P)[1]
51NP	-	Residual time-overcurrent pickup
Z1P	-	Zone 1 phase-phase element (includes Z1DP delay)(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)
OSB	-	Out-of-step block
3P50	-	Three-phase fault current supervision
50MF	-	Asserts a settable delay after LOP and 50M pickup (delay set by 50MFD)
RC	-	Reclose cancel
RI	-	Reclose initiate
DF	-	Direction forward for ground faults
ALRM	-	System alarm
TRIP	-	Trip condition
TC	-	Trip (OPEN) Command
DT	-	Direct Trip (or other user defined external purposes)
52BT	-	Inverted time delayed 52A follower (delay set by 52BT setting)
52AT	-	Time-delayed 52A follower (delay set by 52BT setting)
Z2GT	-	Zone 2 timeout-ground (set by Z2DG)
Z3GT	-	Zone 3 timeout-ground (set by Z3DG)

[1] The 50N elements are made directional by enabling any of the directional control methods, i.e., 32QE = Y, or either 32VE = Y or 32IE = Y.

EVENT REPORTING

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.

FAULT LOCATION

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

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 exhaustive self tests which ensure reliable operation. If a test fails, the relay enters a warning or failure state, closes the ALARM output relay, and issues a status report to the port designated automatic. The duration of ALARM output contact closure depends on which self test warns or fails.

Self tests check the following items:

- Analog Channel Offset (IP, IR, IA, IB, IC, VA, VB, and VC)
- +5 V Power Supply
- ±15 V Power Supplies
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- A/D Conversion Time
- Master Offset
- Settings

CONNECTIONS

Figure 6 shows typical ac connections for an SEL-121G relay. Figure 7 shows typical dc connections for one terminal in a time-step distance scheme.

Figure 8 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, Z1N 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. TC and DT allow you to trip the relay by command or input assertion.

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.

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.

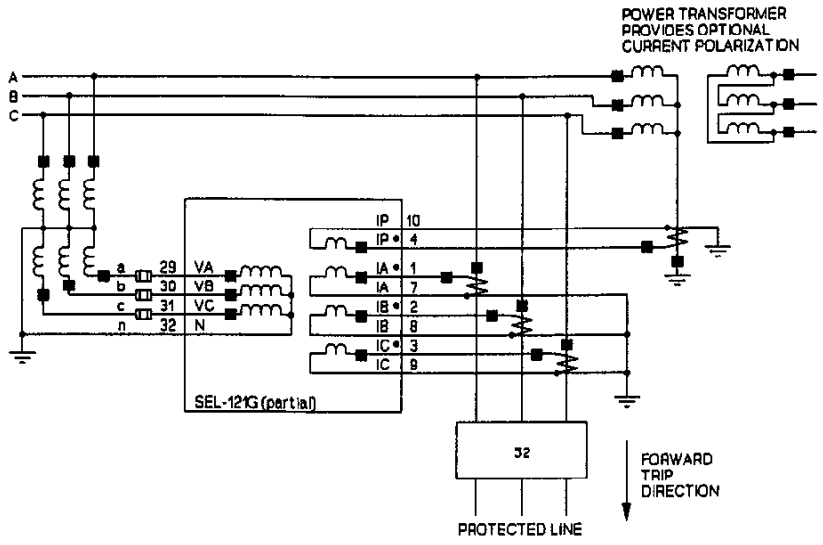


Figure 6: SEL-121G Relay Typical Ac Current and Voltage Connections

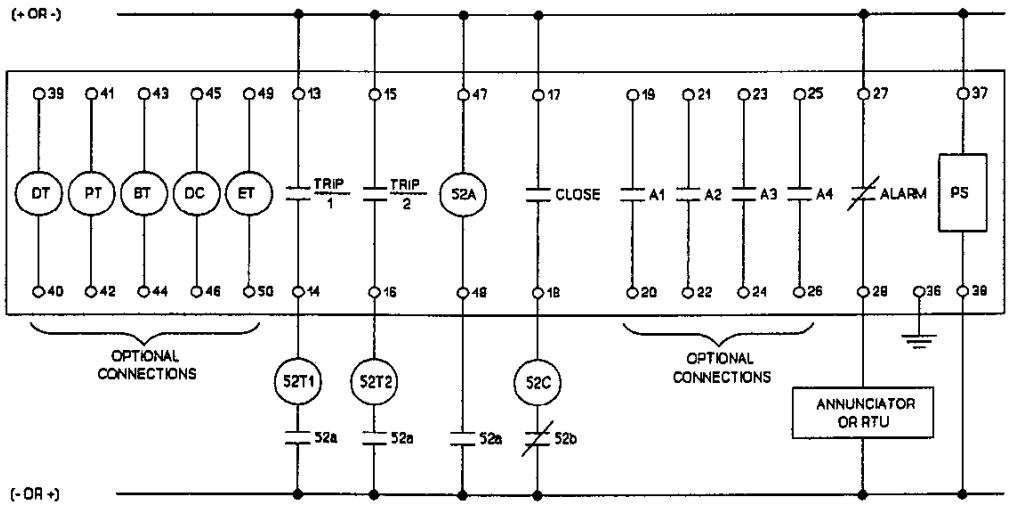


Figure 7: SEL-121G Relay Typical Dc Connections

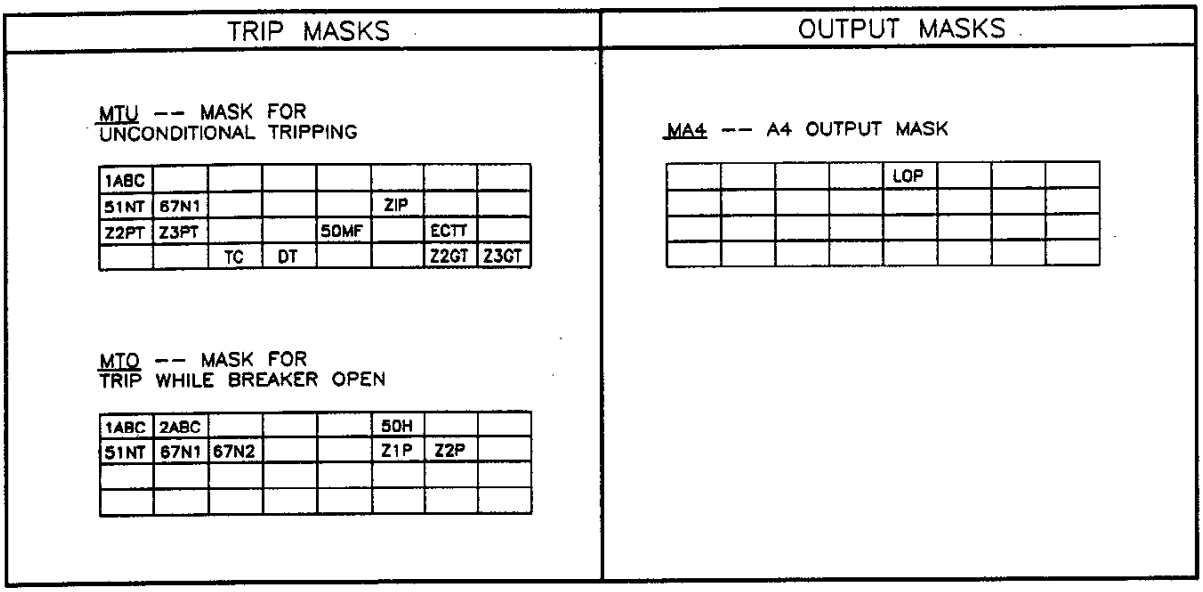


Figure 8: Programmable Logic Mask Settings for Scheme in Figure 7

RELAY ELEMENT OPERATING TIME CURVES

Figure 9 shows operating times for the 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 over-current 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.

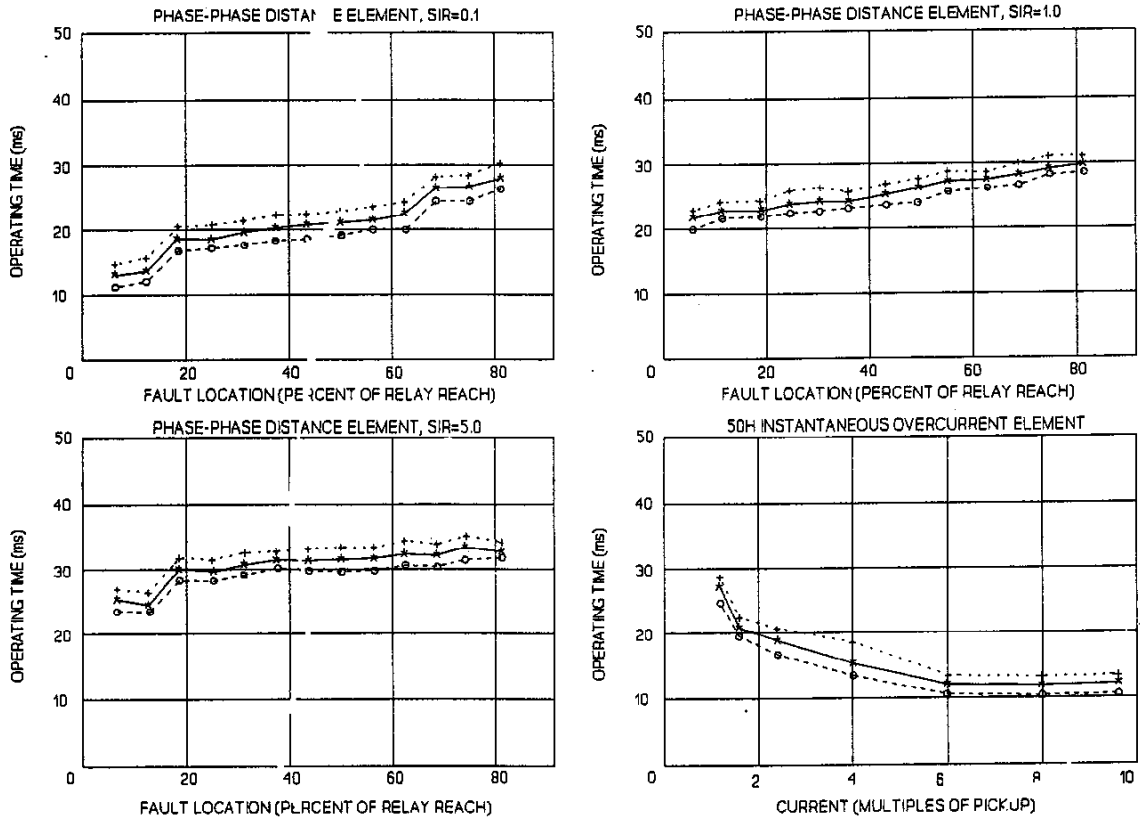
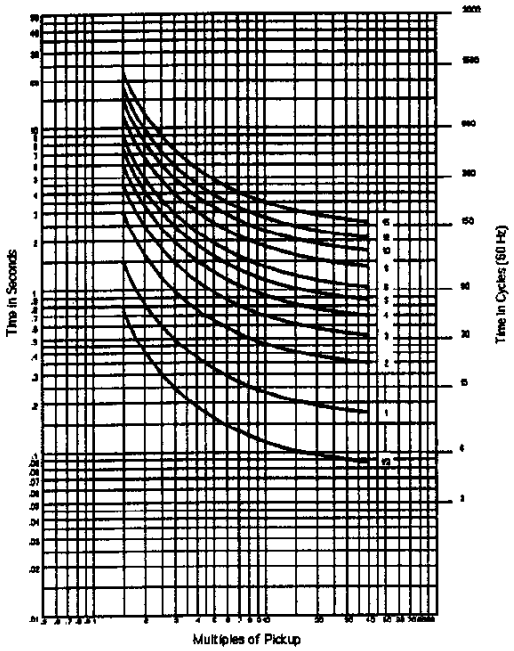
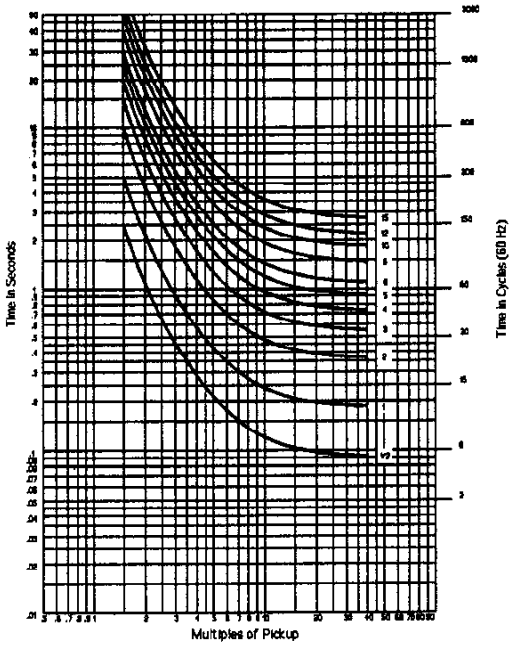


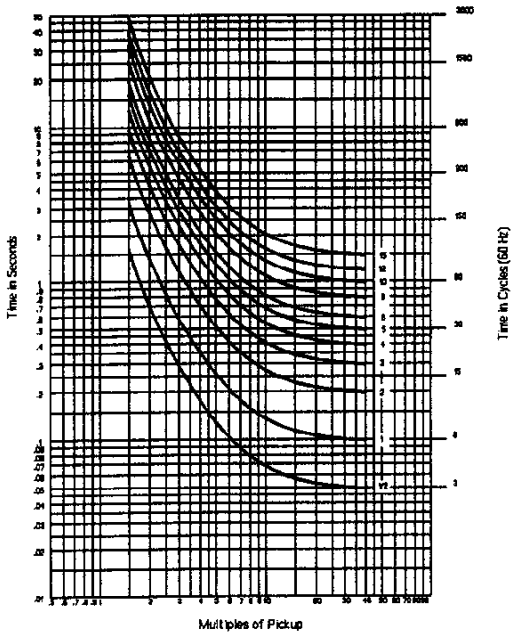
Figure 9: Phase Distance Speed Curves and Phase Overcurrent Speed Curve



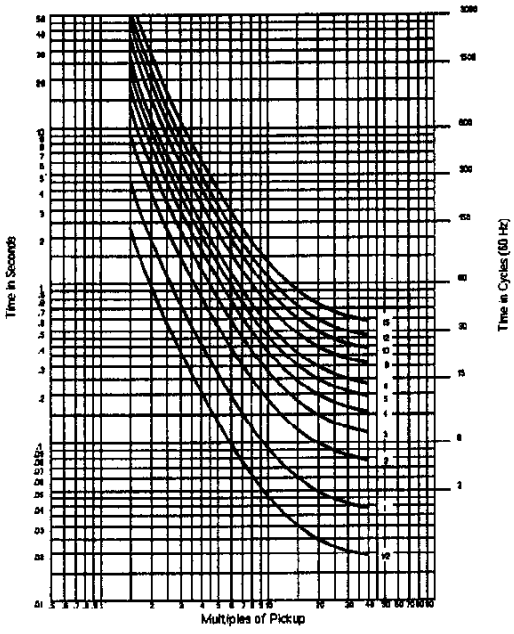
Residual Time-Overcurrent Element Moderately Inverse Time Characteristic



Residual Time-Overcurrent Element Inverse Time Characteristic

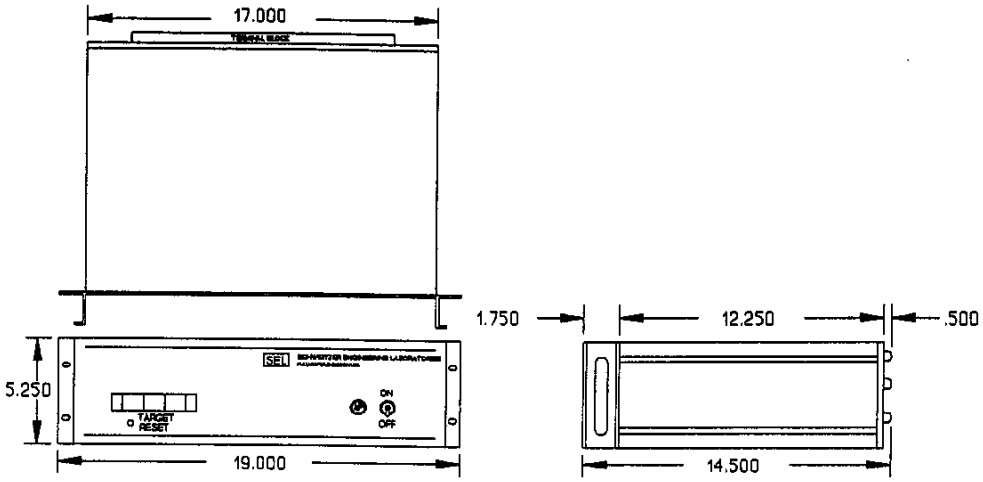


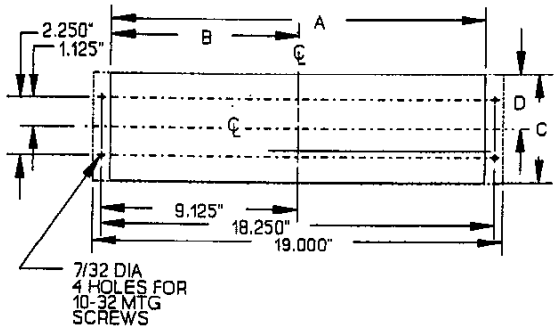
Residual Time-Overcurrent Element Very Inverse Time Characteristic



Residual Time-Overcurrent Element Extremely Inverse Time Characteristic

Figure 10: 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 11: Relay Dimensions, Panel Cutout, and Drill Diagrams

SAMPLE COMMAND DISPLAYS

Meter

```
=>METER <ENTER>

Example 230 kV Line                Date: 3/1/92      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: 3/1/92      Time: 01:08:44

SELF TESTS

W=Warn F=Fail
      IP   IR   IA   IB   IC   VA   VB   VC
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
```

History

```
=>HISTORY <ENTER>

Example 230 kV Line                Date: 3/1/92      Time: 07:38:12

#   DATE         TIME         TYPE  DIST   DUR   CURR

1  1/01/91   07:36:52.150  1AG   74.93  5.00  1070.1
2  1/01/91   07:36:18.400  1BC   74.53  4.75  1567.2
3  1/01/91   07:35:42.970  2BC   84.68  4.25  1411.8
4  1/01/91   07:35:23.783  EXT
5  1/01/91   07:35:07.958  TRIP
6
7
8
9
10
11
12
```

SET COMMAND EXAMPLE

```
=>>SET

SET clears events. <CTRL>X cancels.
Enter data, or <ENTER> for no change

ID   : Example 230 kV Line              ?
R1   : (Ohms pri)..... = 8.56          ?
X1   : ..... = 77.77                   ?
R0   : ..... = 35.12                   ?
X0   : ..... = 236.96                  ? 248.57 <- operator changes X0
LL   : Line Length (mi)..... = 100.00  ?        <- could type END here

CTR  : ..... = 200.00                  ?
PTR  : ..... = 2000.00                 ?
MTA  : Max Torque Angle (deg) = 83.72  ?
LOCAT: Locate faults (Y/N)... = Y      ?

79OI1: Open Int 1 (cyc)..... = 40.00   ?
79OI2: ..... = 60.00                   ?
79OI3: ..... = 80.00                   ?
79RS : Reset Int..... = 240.00         ?

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

Z1DP : Dly-Phase (cyc)..... = 0.00     ?
Z2DP : ..... = 20.00                   ?
Z3DP : ..... = 60.00                   ?

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                  ?

Z1DG : Dly-Gnd (cyc)..... = 0.00       ?
Z2DG : ..... = 30.00                   ?
Z3DG : ..... = 60.00                   ?
TDUR : ..... = 9.00                    ?

52BT : Dly (cyc)..... = 20.00          ?
ZONE3: Dir (F=fwd or R=rvs).. = R      ?
32QE : Enable (Y/N)..... = Y           ?
32VE : ..... = N                       ?
32IE : ..... = N                       ?

OSB1 : (Y/N)..... = Y                  ?
OSB2 : ..... = Y                       ?
OSB3 : ..... = Y                       ?
OSBT : Dly (cyc)..... = 30.00          ?
LOPE : Loss-of-Pot (Y/N)..... = Y      ?

TIME1: PORT 1 timeout (min).. = 5      ?
TIME2: ..... = 0                       ?
AUTO : Autoport (1,2,3)..... = 2       ?
RINGS: (1-30)..... = 7                 ?

New settings for: Example 230 kV Line

R1   =8.56    X1   =77.77    R0   =35.12   X0   =248.57  LL   =100.00
CTR  =200.00  PTR  =2000.00  MTA  =83.72   LOCAT=Y
79OI1=40.00   79OI2=60.00    79OI3=80.00   79RS =240.00
Z1%  =80.00   Z2%  =120.00   Z3%  =120.00
Z1DP =0.00    Z2DP =20.00    Z3DP =60.00
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
Z1DG =0.00    Z2DG =30.00    Z3DG =60.00   TDUR =9.00
52BT =20.00   ZONE3=R        32QE =Y       32VE =N       32IE =N
OSB1 =Y       OSB2 =Y        OSB3 =Y       OSBT =30.00   LOPE =Y
TIME =5       TIME2=0        AUTO =2       RINGS=7

OK (Y/N) ? Y
Please wait...
Enabled

Example 230 kV Line                  Date: 3/1/92        Time: 09:10:48

=>>
```

Sample Event Report 1
For Internal Zone 2 B-C Phase Fault

Example 230 kV Line Date: 3/1/92 Time: 01:58:37.820

Note: Time corresponds to Zone 2 element pickup

FID=SEL-121G-R403-V656mpac11sy52-D910322

	Currents (amps)				Voltages (kV)			Relays 52265L 011710 P3PNNP	Outputs TCAAAAA PL1234L	Inputs DP8D5E TTTC2T A	
IPOL	IR	IA	IB	IC	VA	VB	VC				
0	4	-47	-50	98	-37.4	-91.2	129.4	.....	.....	....*.	One cycle of data
0	4	85	-85	3	127.9	-95.8	-31.8	.....	.....	....*.	
0	-4	47	47	-98	37.4	91.2	-129.4	.....	.....	....*.	
0	-4	-85	85	-3	-127.9	95.8	31.8	.....	.....	....*.	
0	4	-47	-47	98	-37.4	-91.2	129.4	.....	.....	....*.	
0	4	85	-88	3	127.9	-95.7	-31.8	.....	.....	....*.	
0	-4	50	50	-98	37.4	91.2	-129.4	.....	.....	....*.	
0	-4	-88	88	0	-127.9	95.8	31.8	.....	.....	....*.	
0	4	-50	-50	94	-37.3	-91.3	129.5	.....	.....	....*.	
0	4	88	-85	0	127.8	-95.8	-32.0	.....	.....	....*.	
0	-4	47	50	-98	37.3	91.2	-129.4	.....	.....	....*.	
0	-18	-85	346	-277	-127.9	91.3	36.4	L.....	.....	....*.	
0	-11	-47	25	9	-37.2	-83.6	121.6	L.....	.....	....*.	Relay declares fault in forward direction. DF bit set in logic mask MA2.
0	58	85	-941	909	127.9	-88.1	-39.3	M.....	.....	....*.	
0	35	47	-157	148	37.2	73.7	-111.5	M.....	...*..	....*.	
0	-88	-85	1312	-1312	-127.9	89.2	38.0	M.2...	...*..	....*.	Zone 2 phase-phase element pickup.
0	-44	-47	223	-223	-37.2	-71.0	108.7	M.2...	...*..	....*.	
0	93	85	-1359	1365	127.9	-89.3	-37.9	M.2...	...*..	....*.	
0	44	47	-233	233	37.2	70.6	-108.3	M.2...	...*..	....*.	
0	-93	-85	1365	-1372	-127.9	89.3	37.9	M.2...	...*..	....*.	
0	-44	-47	233	-233	-37.2	-70.6	108.3	M.2...	...*..	....*.	
0	93	85	-1365	1372	127.9	-89.3	-37.9	M.2...	...*..	....*.	
0	44	47	-233	233	37.1	70.7	-108.3	M.2...	...*..	....*.	
0	-93	-85	1365	-1372	-127.9	89.3	37.9	M.2...	...*..	....*.	
0	-44	-47	233	-233	-37.1	-70.7	108.2	M.2...	...*..	....*.	
0	93	85	-1365	1372	127.9	-89.3	-37.9	M.2...	...*..	....*.	
0	44	47	-233	233	37.1	70.7	-108.3	M.2...	...*..	....*.	
0	-93	-85	1365	-1372	-127.9	89.3	38.0	M.2...	...*..	....*.	
0	-44	-47	233	-233	-37.1	-70.7	108.3	M.2...	...*..	....*.	
0	93	85	-1365	1372	127.9	-89.3	-38.1	M.2...	...*..	....*.	
0	44	47	-233	233	37.1	70.7	-108.3	M.2...	...*..	....*.	
0	-93	-85	1365	-1372	-127.9	89.3	38.1	M.2...	...*..	....*.	
0	-46	-47	233	-230	-37.1	-70.7	108.3	M.2...	...*..	....*.	
0	95	85	-1365	1369	127.9	-89.3	-38.1	M.2...	...*..	....*.	
0	46	47	-233	230	37.1	70.7	-108.3	M.2...	...*..	....*.	
0	-95	-85	1365	-1369	-127.9	89.3	38.1	M.2...	...*..	....*.	
0	-44	-47	233	-233	-37.1	-70.7	108.3	M.2...	...*..	....*.	
0	93	85	-1365	1372	127.9	-89.2	-38.1	M.2...	...*..	....*.	
0	44	47	-233	233	37.1	70.8	-108.3	M.2...	...*..	....*.	
0	-93	-85	1365	-1372	-127.9	89.2	38.2	M.2...	...*..	....*.	
0	-44	-47	233	-233	-37.0	-70.8	108.2	M.2...	...*..	....*.	
0	93	85	-1365	1372	127.9	-89.2	-38.2	M.2...	...*..	....*.	
0	44	50	-233	233	37.0	70.8	-108.2	M.2...	...*..	....*.	
0	-93	-88	1365	-1372	-127.9	89.2	38.2	M.2...	...*..	....*.	

Event : 2BC Location : 85.76 mi 6.71 ohms sec
Duration: 7.25 Flt Current: 1391.3

```
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
79OI1=40.00     79OI2=60.00     79OI3=80.00     79RS =240.00
Z1%  =80.00     Z2%  =120.00    Z3%  =120.00
Z1DP =0.00      Z2DP =20.00     Z3DP =60.00
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
Z1DG =0.00      Z2DG =30.00     Z3DG =60.00     TDUR =9.00
52BT =20.00     ZONE3=R         32QE =Y         32VE =N         32IE =N
OSB1 =Y         OSB2 =Y         OSB3 =Y         OSBT =30.00     LOPE =Y
TIME1=5         TIME2=0         AUTO =2         RINGS=7
```

Logic settings:

MTU	MPT	MTB	MTO	MA1	MA2	MA3	MA4	MRI	MRC
80	00	00	D4	20	00	00	08	00	E4
C4	00	00	66	11	00	00	00	44	80
C8	00	00	00	00	01	20	00	00	C8
33	00	00	00	00	00	00	00	00	33

Sample Event Report 2
For Internal Zone 2 B-C Phase Fault

Example 230 kV Line Date: 3/1/92 Time: 01:58:38.154

Note: Time corresponds to Zone 2 phase delay when compared with previous event report time.

FID=SEL-121G-R403-V656mpac11sy52-D910322

Currents (amps)					Voltages (kV)			Relays Outputs Inputs		
IPOL	IR	IA	IB	IC	VA	VB	VC	52265L 011710 P3PNNP	TCAAAAA PL1234L	DPBD5E TTTC2T A
0	-44	-47	227	-227	-36.6	-71.0	108.2	M.2...	...*...	....*.
0	93	85	-1372	1372	128.0	-88.9	-38.5	M.2...	...*...	....*.
0	44	47	-227	227	36.6	71.1	-108.1	M.2...	...*...	....*.
0	-93	-85	1372	-1372	-128.1	88.8	38.6	M.2...	...*...	....*.
0	-44	-47	223	-227	-36.4	-71.1	108.0	M.2...	...*...	....*.
0	93	85	-1369	1372	128.0	-88.8	-38.6	M.2...	...*...	....*.
0	44	47	-223	227	36.4	71.1	-108.0	M.2...	...*...	....*.
0	-93	-85	1369	-1375	-128.0	88.8	38.6	M.2...	...*...	....*.
0	-44	-47	227	-223	-36.4	-71.1	108.0	M.2...	...*...	....*.
0	93	85	-1372	1375	128.1	-88.8	-38.6	M.2...	...*...	....*.
0	44	47	-223	223	36.4	71.1	-108.0	M.2...	...*...	....*.
0	-93	-85	1369	-1375	-128.1	88.8	38.6	M.2...	...*...	....*.
0	-44	-47	223	-223	-36.4	-71.1	108.0	M.2...	...*...	....*.
0	93	85	-1369	1375	128.2	-88.8	-38.6	M.2...	...*...	....*.
0	44	47	-227	223	36.3	71.1	-108.0	M.2...	...*...	....*.
0	-93	-85	1372	-1375	-128.1	88.8	38.6	M.2...	*..*...	....*.
0	-44	-47	223	-223	-36.3	-71.1	108.1	M.2...	*..*...	....*.
0	93	85	-1369	1375	128.1	-88.8	-38.6	M.2...	*..*...	....*.
0	44	47	-223	223	36.3	71.1	-108.1	M.2...	*..*...	....*.
0	-93	-85	1369	-1375	-128.1	88.9	38.7	M.2...	*..*...	....*.
0	-44	-47	227	-223	-36.3	-71.2	108.0	M.2...	*..*...	....*.
0	93	85	-1372	1375	128.1	-88.8	-38.8	M.2...	*..*...	....*.
0	44	47	-227	220	36.3	71.3	-107.9	M.2...	*..*...	....*.
0	-93	-85	1372	-1372	-128.2	88.7	38.7	M.2...	*..*...	....*.
0	-44	-47	223	-220	-36.2	-71.2	108.0	M.2...	*..*...	....*.
0	91	85	-1369	1372	128.2	-88.8	-38.8	M.2...	*..*...	....*.
0	46	47	-223	223	36.2	71.4	-108.1	M.2...	*..*...	....*.
0	-77	-72	1076	-1082	-128.2	93.1	34.5	M.2...	*..*...	....*.
0	-31	-31	173	-170	-36.2	-79.0	115.8	M.2...	*..*...	....*.
0	38	31	-444	444	128.2	-96.3	-31.5	L.....	*..*...	....*.
0	9	13	-66	66	36.2	89.0	-126.0	L.....	*..*...	....*.
0	-7	-3	53	-53	-128.2	95.0	33.0	.....	*..*...	....*.
0	-2	-6	9	-9	-36.2	-91.7	128.7	.....	*..*...	.....
0	2	3	-3	6	128.2	-94.9	-33.1	.....	*.....	.....
0	0	3	-3	0	36.2	92.1	-129.0	.....	*.....	.....
0	0	-3	-3	0	-128.3	94.8	33.1	.....	*.....	.....
0	0	0	0	0	-36.1	-92.2	129.2	.....	*.....	.....
0	0	0	6	0	128.3	-94.8	-33.2	.....	*.....	.....
0	0	-3	0	0	36.1	92.2	-129.2	.....	*.....	.....
0	0	3	-6	0	-128.2	94.8	33.2	.....	*.....	.....
0	0	3	0	0	-36.0	-92.3	129.1	.....	*.....	.....
0	0	-3	6	0	128.2	-94.8	-33.2	.....	*.....	.....
0	0	0	-3	0	36.0	92.3	-129.1	.....	*.....	.....
0	0	0	-3	0	-128.2	94.8	33.2	.....	*.....	.....

Trip contact closes when Zone 2 phase delay times out.

Breaker opening indicated by deassertion of 52A input and dropout of 50L current element.

Event : 2BCT Location : 85.52 mi 6.69 ohms sec
Duration: 7.25 Flt Current: 1392.9

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		
79OI1=40.00	79OI2=60.00	79OI3=80.00	79RS =240.00		
Z1% =80.00	Z2% =120.00	Z3% =120.00			
Z1DP =0.00	Z2DP =20.00	Z3DP =60.00			
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			
Z1DG =0.00	Z2DG =30.00	Z3DG =60.00	TDUR =9.00		
52BT =20.00	ZONE3=R	32OE =Y	32VE =N	32IE =N	
OSB1 =Y	OSB2 =Y	OSB3 =Y	OSBT =30.00	LOPE =Y	
TIME1=5	TIME2=0	AUTO =2	RINGS=7		

Logic settings:

MTU	MPT	MTB	MTO	MA1	MA2	MA3	MA4	MRI	MRC
80	00	00	D4	20	00	00	08	00	E4
C4	00	00	66	11	00	00	00	44	80
C8	00	00	00	00	01	20	00	00	C8
33	00	00	00	00	00	00	00	00	33

EXPLANATION OF EVENT REPORT

```
Example 230 kV Line                          Date: 3/1/92       Time: 01:58:38.154

FID=SEL-121G-R403-V656mpac11sy52-D910322

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

     0      44      47    -223     223    36.4    71.1 -108.0              M.2... ...*... ....*.
     0     -93     -85    1369   -1375 -128.1    88.8    38.6              M.2... ...*... ....*.

     0     -44     -47     223    -223  -36.4   -71.1   108.0              M.2... ...*... ....*.
     0      93      85   -1369    1375  128.2   -88.8   -38.6              M.2... ...*... ....*.
     0      44      47    -227     223    36.3    71.1 -108.0              M.2... ...*... ....*.
     0     -93     -85    1372   -1375 -128.1    88.8    38.6              M.2... ...*... ....*.

Event    : 2BCT   Location   : 85.52 mi  6.69   ohms sec
Duration: 7.25   Flt Current: 1392.9

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
79OI1=40.00     79OI2=60.00     79OI3=80.00     79RS =240.00
Z1%  =80.00     Z2%  =120.00    Z3%  =120.00
Z1DP =0.00      Z2DP =20.00     Z3DP =60.00
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
Z1DG =0.00      Z2DG =30.00     Z3DG =60.00     TDUR =9.00
52BT =20.00     ZONE3=R         32QE =Y         32VE =N      32IE =N
OSB1 =Y         OSB2 =Y         OSB3 =Y         OSBT =30.00  LOPE =Y
TIME1=5         TIME2=0         AUTO =2         RINGS=7
```

Currents and voltages are in primary Amps and kV. Rows are a quarter-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, IAY = -497, IAX = -1277. Therefore, IA = 1370 amps. RMS primary, at an angle of ATAN(-497/-1277) = -159°, with respect to the sampling clock.

<FID>	Row 2 shows the Firmware Identification Data. This line varies according to version.
<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=PCB 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=Zone 3, 4=Zone 4, 5=51N H=50H, "?" = indeterminate zone T is one of AG,BG,CG = single-phase, 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
<Flt Current>	Max phase current (primary amps) taken near middle of fault
R1,X1,R0,X0	Primary series impedance settings for transmission line
LL	Line length corresponding to specified line impedances
CTR, PTR	Current and potential transformer ratios (XTR:1)
LOCAT	Enable or disable fault locator (Y/N)
79OI1,2,3,RS	Three-shot recloser Open and Reset intervals
Z1%,Z2%,Z3%	Reaches of 3- and 2-phase mhos, percent of line length (LL)
Z1DP,2,3	Zones 1, 2, and 3 timer settings for 3- and 2-phase faults
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
Z1DG,2,3	Zone timers for ground faults
52BT	52B delay setting (for switch-onto-fault coordination)
ZONE3	Directional orientation of ALL Zone 3 elements (Fwd/Rvs)
32QE,VE,IE	Ground fault directionality from (V2,I2), or (V0/IP,IO)
OSB1,2,3,T	Out-of-Step Blocking enables and delay for 3-phase mhos
LOPE	Enable for Loss-of-Potential supervision (Y/N)
TIME1,2	Communications port timeout intervals (automatic log-off)
AUTO	Port assignment for automatic message transmissions
RINGS	Number of rings to wait before modem answers telephone
<Logic settings>	See LOGIC command for a description of mask settings

SEL-121G 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 2/3/91 sets date to Feb. 3, 1991. 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, MRI, and MRC. 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. TDUR=0 also disables the OPEN command.

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 TDUR initiates setting procedure at TDUR setting. SET initiates setting procedure at beginning. Command pulses ALARM contacts closed and clears event buffers when new settings are stored.

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Rev. 3