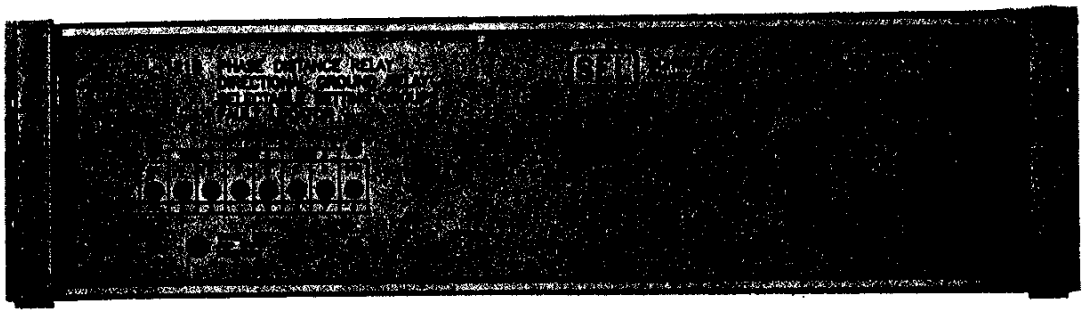
SCHWEITZER ENGINEERING LABORATORIES, INC.
Making Electric Power Safer, More Reliable, and More Economical

SEL-121B

PHASE DISTANCE RELAY
GROUND DIRECTIONAL OVERCURRENT RELAY
SELECTABLE SETTING GROUPS
FAULT LOCATOR

DATA SHEET

Also Available In LOW-PROFILE Package



- EIGHT SELECTABLE RELAY SETTING GROUPS
- THREE ZONES OF PHASE DISTANCE PROTECTION WITH TIMERS
- THREE RESIDUAL DEFINITE-TIME OVERCURRENT ZONES
- RESIDUAL INVERSE-TIME ELEMENT WITH SELECTABLE CURVES
- NEGATIVE- AND ZERO-SEQUENCE GROUND DIRECTIONAL ELEMENTS
- PROGRAMMABLE LOGIC FOR OUTPUTS AND TRIPPING
- FAULT LOCATING • EVENT REPORTING • METERING
- AUTOMATIC SELF-TESTING • RS232-C COMMUNICATIONS (TWO PORTS)
- HORIZONTAL AND VERTICAL MOUNTING CONFIGURATIONS AVAILABLE

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GENERAL DESCRIPTION

The SEL-121B PHASE DISTANCE RELAY AND GROUND DIRECTIONAL OVERCURRENT RELAY WITH SELECTABLE SETTING GROUPS AND FAULT LOCATOR provides high-speed and time-delayed protection for transmission and distribution lines. Its eight selectable relay setting groups makes it ideal for use on a bus-tie or line substitute breaker. It may be used on a double bus or main auxiliary bus arrangement. Any of the eight setting groups can be easily activated with either a manual selector switch or by command to accommodate eight different protection schemes.

The SEL-121B relay combines six mho elements, seven overcurrent elements, a directional element, timers, and some other data and control bits in a 24-bit Relay Word. Logic, programmable by the applications engineer, combines these bits to control tripping and four general programmable outputs.

With its many relay elements, programmability, and low cost, the SEL-121B relay meets the requirements of a broad spectrum of applications. The flexible yet simple programmability provides access to the relay elements (before and after time delays), and logic results, such as loss of potential, alarm, and trip.

The SEL-121B Relay Function Block Diagram illustrates the basic configuration of the protective capabilities.

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

The 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 SEL-121B relay generates an 11-cycle event report following each fault. Each report includes voltage and current information, and sequence-of-events information for relay elements, inputs, and outputs. It saves the twelve most recent event reports for later retrieval. Any or all of the records can be retrieved remotely or locally through the serial communication ports.

A metering function permits interrogation of the SEL-121B relay to obtain voltage, current, real power, and reactive power readings. The function also includes per-phase measurements of voltage and current.

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

The SEL-121B relay is compatible with the SEL-PRTU Protective Relay Terminal Unit, the SEL-DTA Display Transducer Adapter, and the SEL-PROFILE Fault Analysis Program.

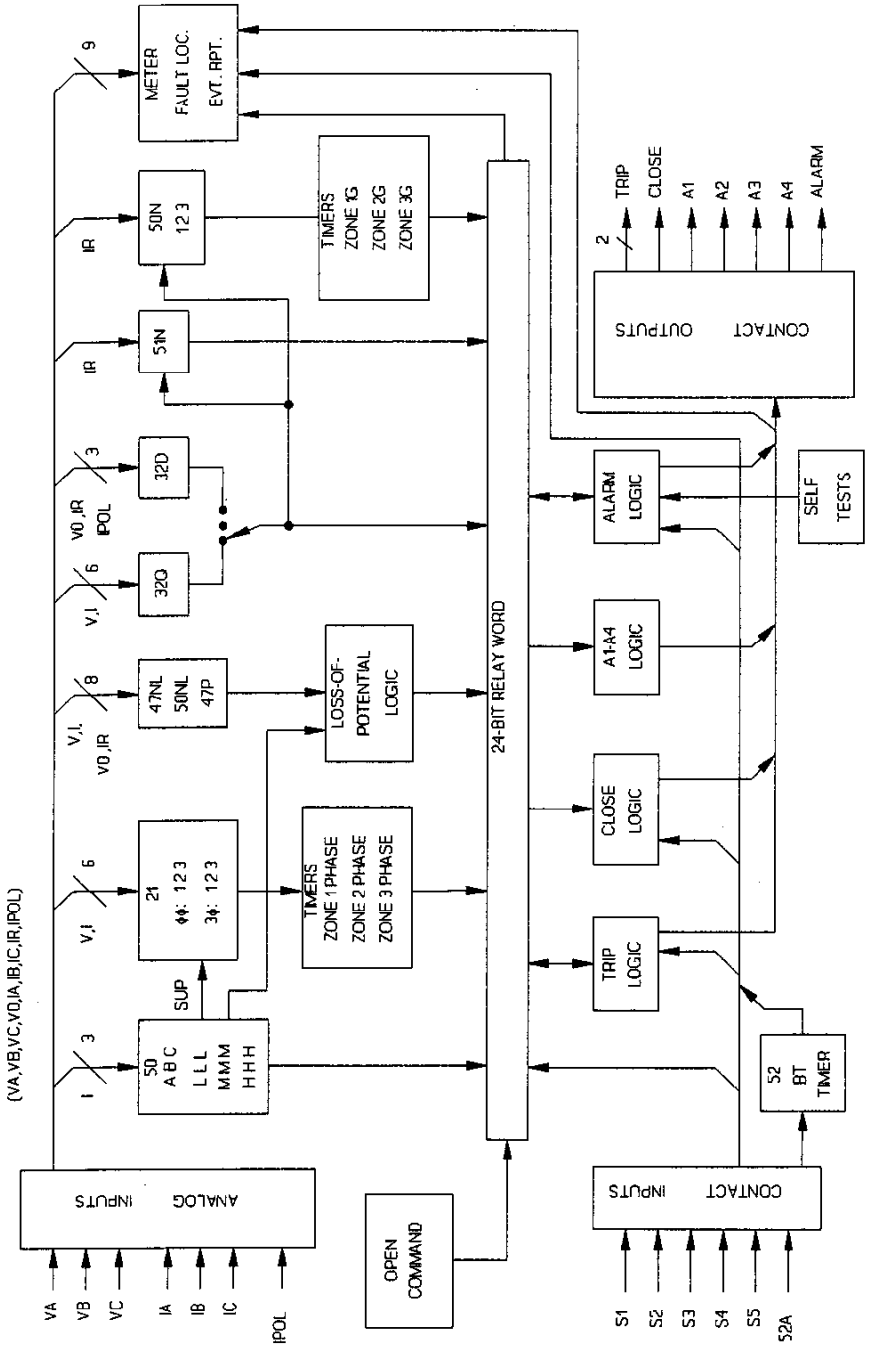


Figure 1: Relay Function Block Diagram

APPLICATIONS

Bus-tie or Line Substitute Breaker Schemes

The SEL-121B relay is ideal for bus-tie or line substitute breaker applications. The relay stores eight different line protection settings in its memory, each of which can be activated with either a manual selector switch or by command. This relay is suitable for use on a double or main/auxiliary bus arrangement to protect any of eight different line configurations attached to the bus.

A major cost-saving feature of the SEL-121B relay is its ability to reverse the current transformer polarity via the CTP setting in the setting procedure. This feature eliminates the need for a costly external current reversing switch.

The flexible SEL-121B relay also can be used concurrently with electromechanical relays in a bus-tie breaker or line substitute breaker scheme. These schemes may require the CT and PT ratios of the breaker to be changed to make certain all faults are within the range of the electromechanical relay. The SEL-121B relay CT and PT ratio settings may be easily set or changed in each of the eight setting groups to accommodate the values needed by the electromechanical relay.

Replacement of Outdated Protective Relays

The SEL-121B relay is ideal for replacement of obsolete electromechanical relays. Its compact size and simple field wiring make replacement especially convenient in crowded relay panels. Its event-reporting and fault-locating features economically provide valuable engineering and operating information, eliminating the need for event recorders and oscillographs in most applications. Its negligible instrument transformer burden makes the SEL-121B relay an attractive alternative for overburdened current and potential transformers.

Time-Step Relaying

The SEL-121B relay provides three zones of time-step protection, with separate timers for phase and ground faults in all three zones. In such applications, the SEL-121B relay is the only instrument needed for primary relaying. Its exhaustive self-testing and communications capabilities reduce dependence on local and remote backup schemes.

Dual-Primary Schemes: SEL-121B Relay / SEL-121F Relay

The protective functions of the SEL-121B relay and SEL-121F relay are complementary. Phase protection is compensator-distance in the SEL-121B relay and on a phase-pair basis in the SEL-121F relay. Ground fault protection is directional overcurrent in the SEL-121B relay and distance as well as directional overcurrent in the SEL-121F relay.

A dual-primary scheme consisting of an SEL-121B relay and an SEL-121F relay provides totally redundant protection at a price competitive with one set of electromechanical relays for a single scheme.

Backup Relaying

Where adequate high-speed primary protection already exists, the SEL-121B relay can be applied for back-up. Its programmability, eight selectable setting groups, and remote-access capabilities allow the relay settings to be adjusted remotely to meet virtually any contingency.

Its application also adds event reporting and fault locating.

Other Applications

The SEL-121B relay is also cost effective in these applications: fault locating, temporary installations (where frequent setting changes may be required), and remote control and monitoring.

SPECIFICATIONS

Relay Functions

Mho characteristics for phase-phase and three-phase faults
- Three phase-to-phase zones
- Three three-phase zones

Residual overcurrent protection for ground faults
- Three definite-time elements
- One inverse-time element with selectable curve shapes

Negative- and zero-sequence directional elements for ground faults. Zero-sequence element is dual polarized

Zone 3 mhos and definite time element may be reversed

High-set phase overcurrent elements

Medium-set phase overcurrent elements may be enabled on loss of potential.

Relay Elements

Phase Overcurrent Elements
- 50AL, 50BL, 50CL (phase fault detectors)
- 50AM, 50BM, 50CM (loss of potential scheme)
- 50AH, 50BH, 50CH (high-set elements)
  - Pickup: 0.5 to 40 A, ± 0.1 A ± 2% of setting
  - Transient overreach: 5% of set pickup

Distance Elements

Phase distance:
- 21P1: 0.125 to 32 ohms
- 21P2: 0.125 to 128 ohms
- 21P3: 0.125 to 128 ohms

Three-phase distance:
21ABC1: 0.125 to 32 ohms
21ABC2: 0.125 to 128 ohms
21ABC3: 0.125 to 128 ohms

Maximum torque angle: 47 - 90 degrees in one degree steps

Zone 2 and 3 settings are limited as follows:
For Zone 1 < 8 ohms: 1 - 16 times Zone 1
For Zone 1 > 8 ohms: 1 - 4 times Zone 1
Zone 2 may not be set greater than 4 times Zone 1 when Zone 3 is less than 4 times Zone 1

Operating time: 10 - 45 ms (25 ms typical), including output relay delay

Steady-state Error:
5% of set reach ± 0.01 ohm at angle of maximum torque for V > 5 V and I > 2 A
10% of set reach ± 0.01 ohm at angle of maximum torque for 5 > V > 1 V or 0.5 < I < 2 A

Transient Overreach:
5% of set reach, plus steady-state error

Positive-Sequence Voltage Memory polarization:
All mho elements are memory-polarized by an infinite-impulse response filter with a four-cycle time constant, yielding polarization for at least six cycles

Ground Overcurrent Elements

51N residual time overcurrent element:
Selectable curve shape (4 curves)
Pickup: 0.25 to 6.3 A, ± 0.05 A ± 3% of setting

50N1, 50N2, 50N3 residual overcurrent elements:
Pickup: 0.25 A to 48 times 51N pickup for 51N pickup < 3.15 A
0.5 A to 48 times 51N pickup for 51N pickup ≥ 3.15 A
Transient overreach: 5% of set pickup
Timers are provided for 50N1, 50N2, and 50N3

Ground Directional Elements

Negative-sequence directional element:
Angle: same as mho element setting
Sensitivity: refer to the table below

Zero-sequence directional element:
Voltage polarization:
Angle: same as mho element setting
Sensitivity: refer to the table below

Voltage Polarization Sensitivities for 32Q and 32V

*Z1 (ohms)	**32Q Sens. (VA)	***32V Sens. (VA)
0.125 - 0.5	0.04 / Z1	0.14 * 51N
0.5 - 2.0	0.14 * Z1	0.28 * 51N * Z1
2.0 - 8.0	0.04 * Z1	0.07 * 51N * Z1
8.0 - 32.0	0.01 * Z1	0.02 * 51N * Z1

* Z1 is the Zone 1 reach setting, in secondary ohms
** 32Q sensitivity is in units of (neg. seq. amps) * (neg. seq. volts)
*** 32V sensitivity is in units of (residual amps) * (Zero-sequence volts)

Current polarization:
Angle: Zero degrees
Sensitivity: (0.5 amps) * (51N pickup setting) in units of residual amps squared

Sequence-Component Elements

Zero-sequence overvoltage element (47NL)
Pickup: 14 volts V0
Zero-sequence overcurrent element (50NL)
Pickup: I0 = 0.083 amps for 51N pickup < 3.15 amps
I0 = (0.083 amps) * (51N pickup / 3.15 amps) for 51N pickup ≥ 3.15 amps
Positive-sequence overvoltage element (47P)
Pickup: 14 volts V1

Relay Settings

The eight selectable relay setting groups are set using the SET command followed by the group number (1-8). The setting groups are selected locally with a two-pole, multi-position switch or remotely using the GROUP command followed by the group number (1-8). A valid change in the active setting group requires two of the five setting group selector input contacts to be asserted. Each position of the switch asserts a different pair of input contacts which in turn invokes a different setting group. The combinations of input contact pairs corresponding to the different setting groups are shown in Table 1.

NOTE: Any combination of setting group selector input contacts other than those shown in Table 1 causes the alarm contacts to close and the previous setting group to stay active. This protects against an optoisolator burning out (only one input asserted), against loss of dc (no inputs asserted), and against the switch malfunctioning.

Table 1 - Setting groups invoked by input pairs

Setting Groups	Contact Inputs				
	S1	S2	S3	S4	S5
Setting #1	1	1	0	0	0
Setting #2	0	1	1	0	0
Setting #3	0	0	1	1	0
Setting #4	0	0	0	1	1
Setting #5	1	0	1	0	0
Setting #6	0	1	0	1	0
Setting #7	0	0	1	0	1
Setting #8	1	0	0	1	0
Remote	0	1	0	0	1

NOTE: The GROUP command only works when input contacts S2 and S5 are asserted.

Setting Group

A front panel indication of the selected setting group is displayed by pressing the TARGET RESET button. Initially all the LEDs illuminate for one second as a lamp test; then the LED corresponding to the setting group number illuminates for one second. Finally, the targets return to their normal state.

Movement of the setting group selector switch causes the LED corresponding to the switch location to illuminate. If the switch is left in a location, the LED corresponding to that location stays lit for about five seconds. At that time the active setting group is updated. If the selector switch is returned to the active setting group position before another setting group is activated, the LED illuminates for about one second, then the targets return to their normal state.

Fault Location

Fault location is computed from event reports stored following each fault. Algorithm compensates for prefault current to improve accuracy for high-resistance faults.

Fault Reporting

A data record is retained for each of the 12 most recent faults, which includes current, voltage, relay element, input contact, and output contact information. The report may also be triggered by

command. When tripping occurs after the end of the event report, a second report is triggered at tripping. Records are erased when the settings are changed or a new setting group is activated.

Self-Testing

Analog ac channel offset errors
Stall timer monitors processor
Power supply voltage checks
Setting checks
RAM, ROM, and A/D converter tests

Rated Input Voltage

115 volt nominal phase-to-phase, 3 phase 4 wire connection

Rated Input Current

5 amps per phase nominal
15 amps per phase continuous
500 amps for one second thermal rating

Output Contact Ratings

30 amp make per IEEE C37-90 para 6.6.2
6 amp carry continuously
MOV protection provided

Logic Input Ratings

48 Vdc: 30 - 60 Vdc
125 Vdc: 60 - 200 Vdc
250 Vdc: 200 - 280 Vdc
Current = 6 mA at nominal voltage

Power Supply

48 Volt: 20 - 60 Vdc; 12 watts
125 Volt: 85 - 200 Vac or Vdc; 12 watts
250 Volt: 85 - 280 Vdc or 85 - 200 Vac; 12 watts

Dielectric Strength

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

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 near a 1/4-wave antenna driven by 20 watts at 150 MHz and 450 MHz, randomly keyed on and off, at a distance of 1 meter from relay.

Dimensions	5 1/4" x 19" x 13". Mounts in EIA 19" rack, or panel cutout. Also available for vertical mounting.
Unit Weight	21 pounds
Shipping Weight	32 pounds, including two instruction manuals
Operating Temp.	-20 degrees C to +55 degrees C
Burn-in Temp.	Each SEL-121B relay is burned in at 60 degrees C for 100 hours.

LOGIC DESCRIPTION

The SEL-121B relay logic consists of relay elements, timers, and combinations of conditions. Many of these are recorded in the Relay Word, which forms the heart of the programmable mask logic of this relay. Elements and other quantities available in the Relay Word are indicated in boldface type in this section of the data sheet.

Relay Elements

Single-phase overcurrent relays	50AL 50BL 50CL	(Phase fault detectors)
Medium-set single phase OC relays	50AM 50BM 50CM	(Selectable for loss of pot)
High-set single phase OC relays	50AH 50BH 50CH	(Always available)
Zone 3 three-phase mho distance	21ABC3	(Reversible)
Zone 3 line-line mho distance	21P3	(Reversible)
Zone 2 three-phase mho distance	21ABC2	
Zone 2 line-line mho distance	21P2	
Zone 1 three-phase mho distance	21ABC1	(Includes delay if Z1DP not 0.00)
Zone 1 line-line mho distance	21P1	(Includes delay if Z1DP not 0.00)
Residual time-overcurrent pickup	**51NP**	Directional
Residual time-overcurrent trip	**51NT**	Directional
Residual overcurrent	50N1	Nondirectional (Includes delay if Z1DG not 0.00)
Residual inst-overcurrent	50N2	Nondirectional
Residual inst-overcurrent	50N3	Nondirectional
Negative-sequence directional	32Q	32QF=forward; 32QR=reverse
Zero-sequence dual pol directional	32D	32DF=forward; 32DR=reverse
Zero-sequence overvoltage	47NL	Used for loss-of-pot detection
Zero-sequence overcurrent	50NL	Used for loss-of-pot detection
Positive-sequence overvoltage	47P	Used for loss-of-pot detection

Contact Inputs

Setting group selector	S1
Setting group selector	S2
Setting group selector	S3
Setting group selector	S4
Setting group selector	S5
Circuit breaker monitor	52A

Contact Outputs

Circuit breaker trip	TRIP
Circuit breaker close	CLOSE
Programmable output 1	A1
Programmable output 2	A2
Programmable output 3	A3
Programmable output 4	A4
System alarm	ALARM

INTERMEDIATE LOGIC

The logic equations developed below represent combinations of the relay elements and other conditions. In the following equations, the "*" symbol indicates logical "and", and the "+" symbol indicates logical "or".

Loss-of-Potential Logic

Set **LOP** = [47NL * NOT(50NL)] + NOT(47P) * NOT(50M) (Zero sequence set condition includes a three-cycle pickup delay)

Clear **LOP** = NOT(47NL) * 47P

(The different set and clear conditions ensure that LOP stays latched during subsequent faults, but is cleared when balanced voltages return.)

Phase Overcurrent Conditions

50L	= 50AL + 50BL + 50CL	Phase fault current supervision
3P50	= 50AL * 50BL * 50CL	Three-phase fault current supervision
50M	= 50AM + 50BM + 50CM	Medium-level overcurrent condition
50MF	= 50M * [LOP + NOT(LOPE)] * (50MFD)	Asserts a settable delay after LOP and 50M overcurrent, or just 50M overcurrent if LOP is disabled
50H	= 50AH + 50BH + 50CH	High-level overcurrent condition

Distance Relay Logic

```
Z3ABC = 21ABC3 * 3P50 * NOT(LOP * LOPE)            (3ABC in Relay Word)
Z2ABC = 21ABC2 * 3P50 * NOT(LOP * LOPE)            (2ABC in Relay Word)
Z1ABC = 21ABC1 * 3P50 * NOT(LOP * LOPE) * Z1PTMR   (1ABC in Relay Word)

Z3P   = 21P3 * 50L * NOT(LOP * LOPE)
Z2P   = 21P2 * 50L * NOT(LOP * LOPE)
Z1P   = 21P1 * 50L * NOT(LOP * LOPE) * Z1PTMR      (Includes delay if Z1DP not
                                                   0.00)

Z3PT  = (Z3P + Z3ABC) * Z3PTMR                     Zone 3 timeout-phase
Z2PT  = (Z2P + Z2ABC) * Z2PTMR                     Zone 2 timeout-phase
```

Ground Overcurrent Conditions

```
DF    = [(32QF + [LOP * LOPE]) * 32QE] + [32DF * 32IE] +        Forward direction
        [(32DF + [LOP * LOPE]) * 32VE] + NOT(32QE + 32VE + 32IE)
DR    = 32QR * 32QE + 32DR * (32IE + 32VE)                      Reverse direction

D3    = DF   if Zone 3 is forward
D3    = DR   if Zone 3 is reverse

67N1  = 50N1 * DF * Z1GTMR                         (Includes delay if Z1DG not 0.00)
67N2  = 50N2 * DF
67N3  = 50N3 * D3                                  (Reversible)
```

NOTE: When directional elements are all disabled (32QE = 32VE = 32IE = N), the DF (directional forward) bit defaults forward. The Zone 3 ground element will not operate under this condition when Zone 3 is reversed.

```
Z3GT  = 67N3 * Z3GTMR                              Zone 3 timeout-ground
Z2GT  = 67N2 * Z2GTMR                              Zone 2 timeout-ground
```

RELAY WORD

Relay elements and intermediate logic results are represented in a 24-bit relay word, which is grouped into three 8-bit words. The user selects bits in this word to control outputs and tripping. The selected bits are stored in masks for each function. The user programs the bits in these masks with the LOGIC command.

Relay Word

1ABC	2ABC	3ABC	LOP	50H	50M	50MF	50L
51NT	67N1	67N2	67N3	51NP	Z1P	Z2P	Z3P
Z2PT	Z3PT	Z2GT	Z3GT	ALRM	TRIP	TC	DF

The Relay Word Bit Summary Table (below) explains the meaning of each bit in the relay word.

Relay Word Bit Summary Table

1ABC	Zone 1 three-phase element (set by Z1%)
2ABC	Zone 2 three-phase element (set by Z2%)
3ABC	Zone 3 three-phase element (set by Z3%)
LOP	Loss of potential condition
50H	High-level overcurrent element (set by 50H)
50M	Medium-level overcurrent element (set by 50M)
50MF	Asserts a settable delay after LOP and 50M pickup (delay set by 50MFD)
50L	Phase fault current supervision (set by 50L)
51NT	Residual time-overcurrent trip
67N1	Residual instantaneous-overcurrent (directional or nondirectional) (set by 50N1P)
67N2	Residual instantaneous-overcurrent (directional or nondirectional) (set by 50N2P)
67N3	Residual instantaneous-overcurrent (directional or nondirectional) (set by 50N3P)
51NP	Residual time-overcurrent pickup (set by 51NP, 51NTD, and 51NC)
Z1P	Zone 1 line-line element (set by Z1%)
Z2P	Zone 2 line-line element (set by Z2%)
Z3P	Zone 3 line-line element (set by Z3%)
Z2PT	Zone 2 phase fault, time delayed (set by Z2DP)
Z3PT	Zone 3 phase fault, time delayed (set by Z3DP)
Z2GT	Zone 2 ground fault, time delayed (set by Z2DG)
Z3GT	Zone 3 ground fault, time delayed (set by Z3DG)
ALRM	System alarm
TRIP	Circuit breaker trip
TC	Trip (open) command
DF	Direction forward

The Relay Word and programmable masks provide the user with great flexibility in applying the SEL-121B relay, without having to rewire panels or change jumpers on circuit boards.

OUTPUT EQUATIONS

The logic for controlling the TRIP, A1, A2, A3, and A4 output relays is programmable for flexibility and for testing. The logic is programmed for various conditions by setting masks which are applied to the general Relay Word.

The general forms for each of the output equations follow:

```
Let R    = Relay Word

  MTU    = mask for trip (unconditional)
  MTO    = mask for trip (with breaker open)

then:    TRIP  = R * MTU
             + R * MTO * 52BT

close TRIP contact   = TRIP
open TRIP contact    = NOT(TRIP) * [NOT(52A) + TARGET RESET button pushed] * (60 ms
                       minimum TRIP)

close CLOSE contact  = (CLOSE Command) * NOT(52A) * NOT(TRIP)
open CLOSE contact   = NOT(CLOSE)

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

The "*" symbol indicates logical "and", and the "+" indicates logical "or".

SETTING PROCEDURE

The SEL-121B relay stores eight independent relay setting groups. The SET command followed by a setting group number invokes the relay setting procedure for the group specified. For example, typing "SET 3 <CR>" activates the setting procedure for setting group three.

In the following example, setting group number three was chosen and only the X0 value was changed. It was changed from 259.40 to 248.57. Note that the new value of 248.57, along with all other settings, is presented at the end of the procedure before enabling. This provides a final inspection for typographical or other errors.

As a convenience, the operator could have typed END in response to the prompt for Line Length or any other setting except Relay ID, and gone directly to the final presentation of settings, without having to scroll through the rest of the prompts.

The operator could have also typed any setting descriptor as a SET command option, except for the ID setting. All settings prior to the specified setting are skipped when the command is executed in this manner. For example, typing "SET 3 Z3DP <CR>" will activate the setting procedure for setting group three and skip all settings prior to the Z3DP setting.

SET COMMAND PROCEDURE

```
=>>SET 3

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

ID  3: Example 230 kV Line
  ?
R1    : (Ohms pri)..... = 13.90    ?
X1    : ..............  = 79.96    ?
R0    : ..............  = 41.50    ?
X0    : ..............  = 259.40   ? 248.57 <- operator changes X0
LL    : Line Length (mi)...... = 100.00   ?        <- could type END here

CTP   : CT Polarity (N/I)..... = N         ?
CTR   : ..............  = 200.00   ?
PTR   : ..............  = 2000.00  ?
MTA   : Max Torque Angle (deg) = 80.80    ?
LOCAT: Locate faults (Y/N)... = Y         ?

Z1%   : Reach (% line)........ = 80.00    ?
Z2%   : ..............  = 120.00   ?
Z3%   : ..............  = 150.00   ?

Z1DP  : Dly-Phase (cyc)....... = 0.00     ?
Z2DP  : ..............  = 30.00    ?
Z3DP  : ..............  = 60.00    ?

50L   : PU (Amps pri)......... = 100.00   ?
50M   : PU.....................  = 200.00   ?
50MFD: Dly (cyc)..............  = 20.00    ?
50H   : PU.....................  = 3000.00  ?

51NP  : PU (Amps pri)......... = 100.00   ?
51NTD: Time Dial.............  = 3.00     ?
51NC  : Curve (1,2,3, or4).... = 2         ?

50N1P: PU (Amps pri)......... = 1000.00  ?
50N2P: ..............  = 700.00   ?
50N3P: ..............  = 600.00   ?

Z1DG  : Dly-Gnd (cyc)......... = 0.00     ?
Z2DG  : ..............  = 20.00    ?
Z3DG  : ..............  = 40.00    ?

52BT  : Dly (cyc)............. = 30.00    ?
ZONE3: Dir (F=fwd or R=rvs).. = F         ?
32QE  : Enable (Y/N).......... = N         ?
32VE  : ..............  = Y         ?
32IE  : ..............  = Y         ?

LOPE  : Loss of Pot (Y/N)..... = Y         ?
TIME1: Port 1 timeout (min).. = 5         ?
TIME2: ..............  = 0         ?
AUTO  : Auto port (1,2)....... = 2         ?
RINGS: (1-30)................. = 3         ?

New settings for group 3: Example 230 kV Line

R1   =13.90     X1   =79.96     R0   =41.50     X0   =248.57    LL   =100.00
CTP  = N        CTR  =200.00    PTR  =2000.00  MTA  =80.80     LOCAT=Y
Z1%  =80.00     Z2%  =120.00    Z3%  =150.00
Z1DP =0.00      Z2DP =30.00     Z3DP =60.00
50L  =100.00    50M  =200.00    50MFD=20.00    50H  =3000.00
51NP =100.00    51NTD=3.00      51NC =2
50N1P=1000.00   50N2P=700.00    50N3P=600.00
Z1DG =0.00      Z2DG =20.00     Z3DG =40.00
52BT =30.00     ZONE3=F         32QE =N        32VE =Y        32IE =Y
LOPE =Y         TIME1=5         TIME2=0        AUTO =2        RINGS=3


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

SAMPLE EVENT REPORT

3: Example 230 kV Line Date: 9/15/89 Time: 02:51:45.208

FID=SEL-121B-R400-V656mptr-D890914

	Currents (amps)				Voltages (kV)			Relays	Outputs	Inputs
IPOL	IR	IA	IB	IC	VA	VB	VC	52265L 011710 P3PNNP	TCAAAAA PL1234L	SSSSS5 123452 A
0	2	123	76	-201	93.0	37.0	-129.5	M.....	.....	**...*
0	0	-160	189	-28	-95.8	128.3	-31.5	M.....	.....	**...*
0	-2	-123	-76	198	-93.0	-37.0	129.5	M.....	.....	**...*
0	0	160	-189	25	95.8	-128.3	31.5	M.....	.....	**...*
0	2	123	76	-195	93.0	37.0	-129.5	M.....	.....	**...*
0	0	-160	189	-28	-95.8	128.3	-31.5	M.....	.....	**...*
0	-2	-123	-76	198	-93.0	-37.0	129.5	M.....	.....	**...*
0	0	160	-189	31	95.8	-128.3	31.5	M.....	.....	**...*
0	2	123	79	-201	93.0	37.0	-129.5	M.....	.....	**...*
0	0	-160	189	-31	-95.8	128.3	-31.5	M.....	.....	**...*
0	-2	-123	-82	201	-93.0	-37.0	129.5	M.....	.....	**...*
0	0	160	-189	28	95.8	-128.3	31.5	M.....	.....	**...*
0	2	123	79	-198	92.3	36.8	-129.7	M.....	.....	**...*
0	168	6	189	-28	-92.2	129.1	-30.7	M.....	.....	**...*
0	-202	-321	-76	198	-86.6	-34.0	132.6	M.....	.....	**...*
0	-470	-308	-189	28	81.5	-132.5	27.3	M...P.	.....	**...*
0	568	689	79	-198	79.7	30.0	-136.6	M...P.	.....	**...*
0	624	459	189	-28	-73.7	135.4	-24.2	M..2P.	...**.	**...*
0	-756	-878	-79	198	-77.4	-28.7	138.1	M..2P.	...**.	**...*
0	-647	-481	-192	28	72.8	-135.7	23.8	M..2P.	...**.	**...*
0	781	903	79	-198	76.9	28.5	-138.3	M..1P.	*.***.	**...*
0	649	485	189	-28	-72.6	135.8	-23.7	M..1P.	*.***.	**...*
0	-785	-906	-79	198	-76.9	-28.5	138.3	M..1P.	*.***.	**...*
0	-648	-485	-186	28	72.6	-135.8	23.7	M..1P.	*.***.	**...*
0	785	906	76	-198	76.9	28.5	-138.3	M..1P.	*.***.	**...*
0	648	485	189	-28	-72.6	135.8	-23.7	M..1P.	*.***.	**...*
0	-785	-906	-76	198	-76.9	-28.5	138.3	M..1P.	*.***.	**...*
0	-648	-485	-189	28	72.6	-135.8	23.8	M..1P.	*.***.	**...*
0	785	906	76	-201	77.6	28.6	-138.2	M..1P.	*.***.	**...*
0	480	340	151	-6	-76.1	135.0	-24.6	M..2P.	*..**.	**....
0	-585	-667	-60	148	-83.3	-31.4	135.1	M..2P.	*..**.	**....
0	-178	-113	-66	-9	86.8	-131.7	28.1	M..3P.	*...*.	**....
0	218	242	25	-53	90.3	35.5	-131.2	M...P.	*.....	**....
0	25	16	9	3	-94.6	128.7	-31.1	M...P.	*.....	**....
0	-29	-31	-3	6	-92.6	-36.9	129.7	.....	*.....	**....
0	-3	3	0	0	95.5	-128.3	31.4	.....	*.....	**....
0	5	3	0	0	93.0	37.0	-129.5	.....	.....	**....
0	0	-6	0	0	-95.8	128.3	-31.5	.....	.....	**....
0	-2	0	0	0	-93.0	-37.1	129.5	.....	.....	**....
0	0	6	0	0	95.8	-128.2	31.5	.....	.....	**....
0	2	-3	0	3	93.0	37.1	-129.5	.....	.....	**....
0	-1	-3	0	-3	-95.8	128.2	-31.5	.....	.....	**....
0	-1	3	0	-3	-93.0	-37.0	129.5	.....	.....	**....
0	2	3	0	3	95.8	-128.3	31.5	.....	.....	**....

Event : 1AG Location : 74.81 mi 6.07 ohms sec
Duration: 4.75 Flt Current: 1027.5

R1	=13.90	X1	=79.96	RO	=41.50	XO	=248.57	LL	=100.00		
CTP	=N	CTR	=200.00	PTR	=2000.00	MTA	=80.80	LOCAT	=Y		
Z1%	=80.00	Z2%	=120.00	Z3%	=150.00						
Z1DP	=0.00	Z2DP	=30.00	Z3DP	=60.00						
50L	=100.00	50M	=200.00	50MFD	=20.00	50H	=3000.00				
51NP	=100.00	51NTD	=3.00	51NC	=2						
50N1P	=1000.00	50N2P	=700.00	50N3P	=600.00						
Z1DG	=0.00	Z2DG	=20.00	Z3DG	=40.00						
52BT	=30.00	ZONE3	=F	32QE	=N	32VE	=Y	32IE	=Y		
LOPE	=Y	TIME1	=5	TIME2	=0	AUTO	=2	RINGS	=3		

Logic settings:

MTU	MTO	MA1	MA2	MA3	MA4
8A	EA	80	40	20	00
C4	F7	44	22	11	80
F2	F2	00	A0	50	00

EXPLANATION OF EVENT REPORT

```
3: Example 230 kV Line                          Date: 9/15/89     Time: 02:51:45.208

FID=SEL-1218-R400-V656mptr-D890914

                Currents                              Voltages                Relays Outputs Inputs
                (amps)                                 (kV)
                                                                                52265L TCAAAAA SSSSS5
   IPOL      IR      IA      IB      IC      VA      VB      VC                 011710 PL1234L 123452
                                                                                P3PNNP          A

      0    -202    -321     -76     198   -86.6   -34.0   132.6               M.....  .......  **...*
      0    -470    -308    -189      28    81.5  -132.5    27.3               M...P.  .......  **...*

      0     568     689      79    -198    79.7    30.0  -136.6               M...P.  .......  **...*
      0     624     459     189     -28   -73.7   135.4   -24.2               M..2P.  ...**..  **...*
      0    -756    -878     -79     198   -77.4   -28.7   138.1               M..2P.  ...**..  **...*
      0    -647    -481    -192      28    72.8  -135.7    23.8               M..2P.  ...**..  **...*

Event    : 1AG    Location   : 74.81  mi  6.07   ohms sec
Duration: 4.75    Flt Current: 1027.5

R1   =13.90     X1   =79.96     R0   =41.50     X0   =248.57    LL   =100.00
CTP  =N         CTR  =200.00    PTR  =2000.00   MTA  =80.80     LOCAT=Y
Z1%  =80.00     Z2%  =120.00    Z3%  =150.00
Z1DP =0.00      Z2DP =30.00     Z3DP =60.00
50L  =100.00    50M  =200.00    50MFD=20.00     50H  =3000.00
51NP =100.00    51NTD=3.00      51NC =2
50N1P=1000.00   50N2P=700.00   50N3P=600.00
Z1DG =0.00      Z2DG =20.00     Z3DG =40.00
52BT =30.00     ZONE3=F         32QE =N         32VE =Y         32IE =Y
LOPE =Y         TIME1=5         TIME2=0         AUTO =2         RINGS=3
```

Currents and voltages are in primary Amps and kV. Rows are 1/4 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 = -878, IAX = -481. Therefore, IA = 1,001 amps RMS primary, at an angle of ATAN(-878/-481) = -119 degrees, with respect to the sampling clock.

<Setting Grp>	The first digit in row 1 indicates the setting group selected. For this example, setting group number three is in use.
<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 ---> 1,2,3 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: ON = "*" , OFF = "." S1-S5=SETTING GROUP SELECTOR INPUT CONTACTS, 52A=PCB A-CONTACT
<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, 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 = triggered by TRIGGER command
<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
CTP	Polarity of current (normal or inverted)
CTR, PTR	Current and potential transformer ratios (XTR:1)
MTA	Maximum torque angle in degrees
LOCAT	Enable or disable fault locator (Y/N)
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	GND time-overcurrent Pickup, Time-Dial, Curve
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,I0)
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

SAMPLE COMMAND DISPLAYS

Sample History Command

```
=>>HISTORY

3: Example 230 kV Line                    Date: 8/28/89      Time: 09:03:40

#    DATE          TIME          TYPE  DIST   DUR   CURR

1   8/28/89   09:03:01.092  3AG   100.2  7.25  798
2   8/28/89   09:02:13.041  3AG   74.9   7.00  1016
3   8/28/89   09:00:39.962  1AG   25.3   7.25  2162
4   8/28/89   09:00:13.345  1BC   25.5   7.25  3167
5
6
7
8
9
10
11
12
```

Sample Meter Command

```
=>>METER

3: Example 230 kV Line                    Date: 8/28/89      Time: 09:27:05

            A       B       C       AB      BC      CA
I (A)     994     995     994     1723    1724    1724
V (kV)  134.4   134.3   134.2    233.1   232.8   232.9

P (MW)      401.12
Q (MVAR)      1.00
```

Sample Self-Test Status Report

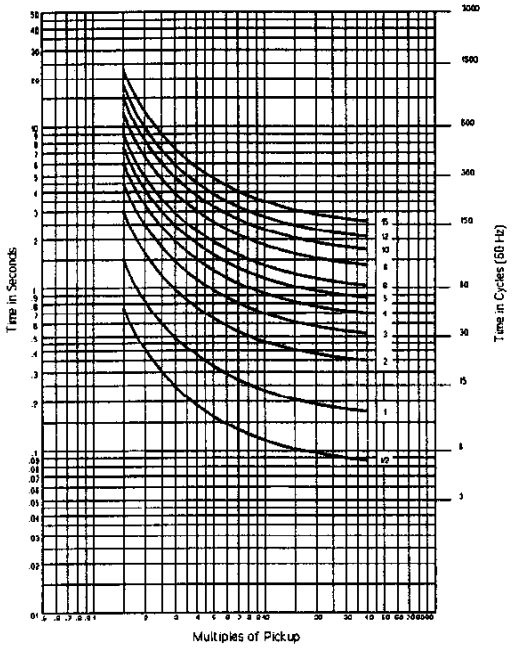
```
=>>STATUS

3: Example 230 kV Line                    Date: 8/28/89      Time: 09:32:56

SELF-TESTS

W=Warn   F=Fail
      IP   IR   IA   IB   IC   VA   VB   VC
OS    0    0    0    0    0    0    0    0
PS      4.99      15.14      -14.85
RAM    ROM    A/D      MOF     SET
OK     OK     OK       OK      OK
```

Targets Command

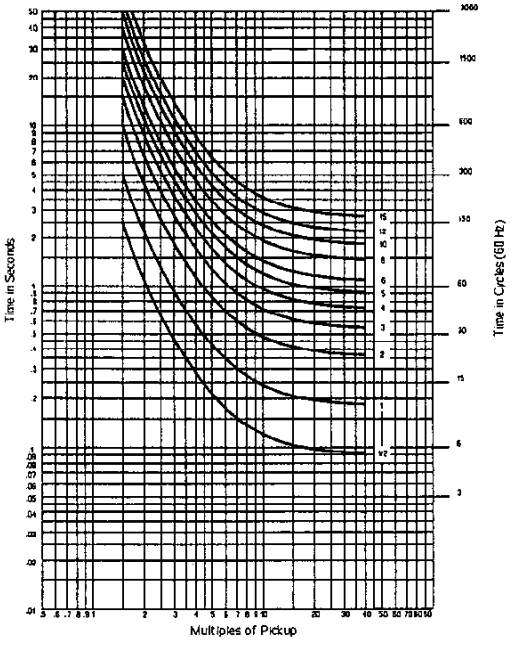
The eight-LED display on the front panel can be programmed to show relay targets (default), Relay Word bits, contact inputs, and contact outputs as shown below. This feature is especially useful for testing individual relay elements.

```
=>>TARGETS [N]
LED:  1      2      3      4      5      6      7      8
N
0     EN     PH1    G1     PH2    G2     PH3    G3     51N     RELAY TARGETS
1     1ABC   2ABC   3ABC   LOP    50H    50M    50MF   50L     RELAY WORD #1
2     51NT   67N1   67N2   67N3   51NP   Z1P    Z2P    Z3P     RELAY WORD #2
3     Z2PT   Z3PT   Z2GT   Z3GT   ALRM   TRIP   TC     DF      RELAY WORD #3
4                   S1     S2     S3     S4     S5     52A     CONTACT INPUTS
5            TRIP   CLOS   A1     A2     A3     A4     ALRM    CONTACT OUTPUTS
```

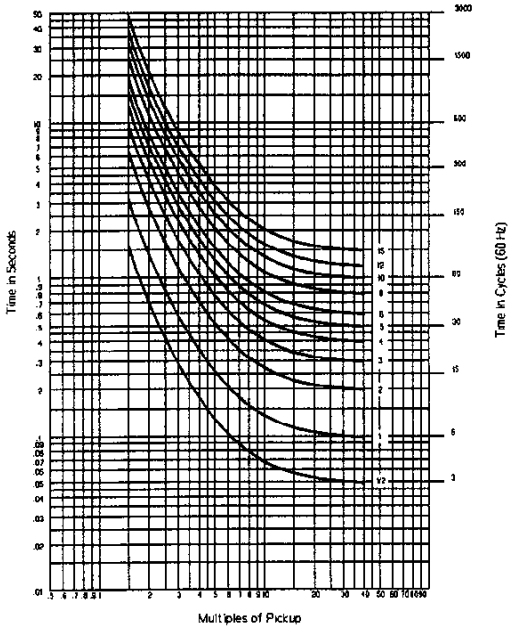
Use the TARGET command to reset and clear the front panel targets remotely or locally. Type "TARGET R <RETURN>" to reset and clear the targets.



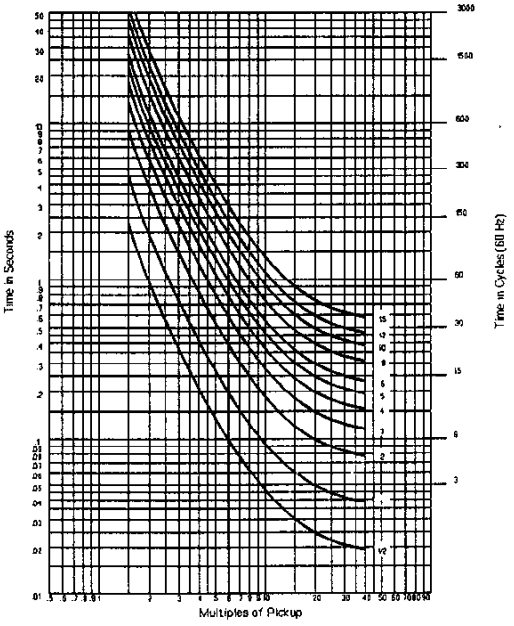
Residual Time-Overcurrent Element Moderately Inverse Time Characteristic



Residual Time-Overcurrent Element Inverse Time Characteristic



Residual Time-Overcurrent Element Very Inverse Time Characteristic



Residual Time-Overcurrent Element Extremely Inverse Time Characteristic

Figure 2: Residual Time-Overcurrent Curves

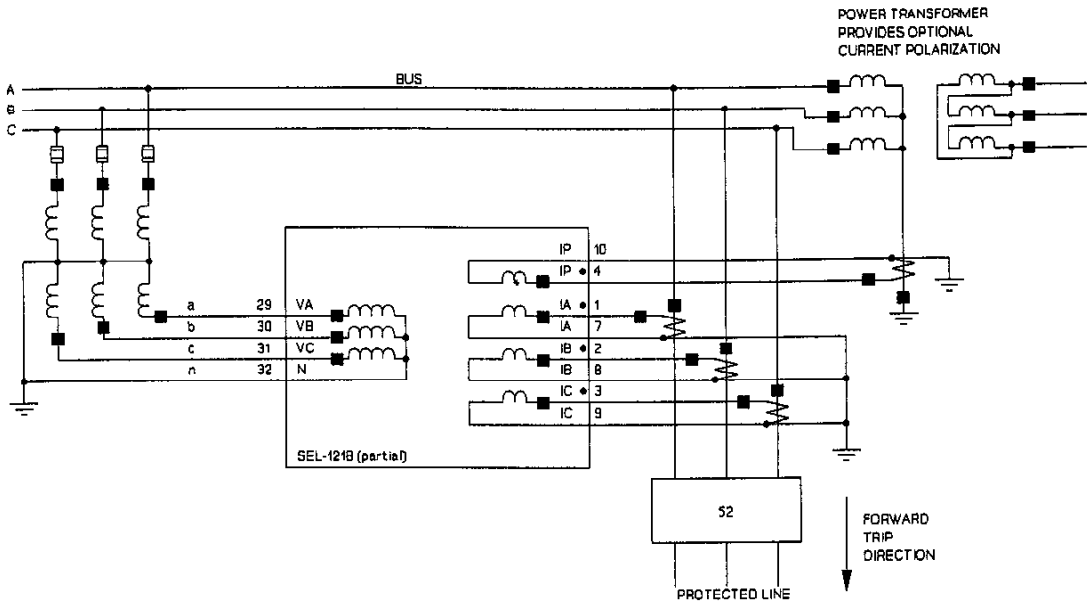


Figure 3: External AC Current and Voltage Connections

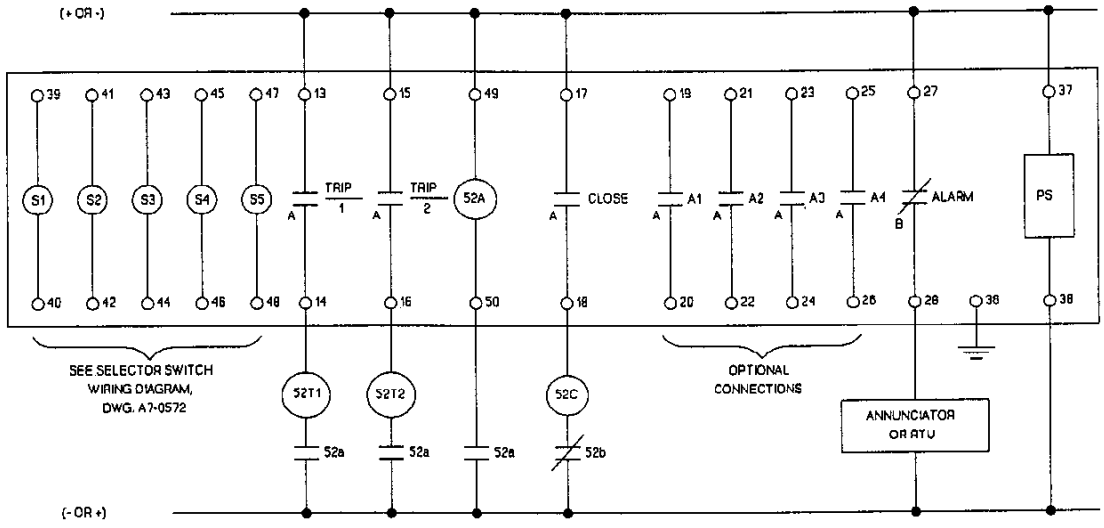


Figure 4: External DC Connection Diagram (Typical)

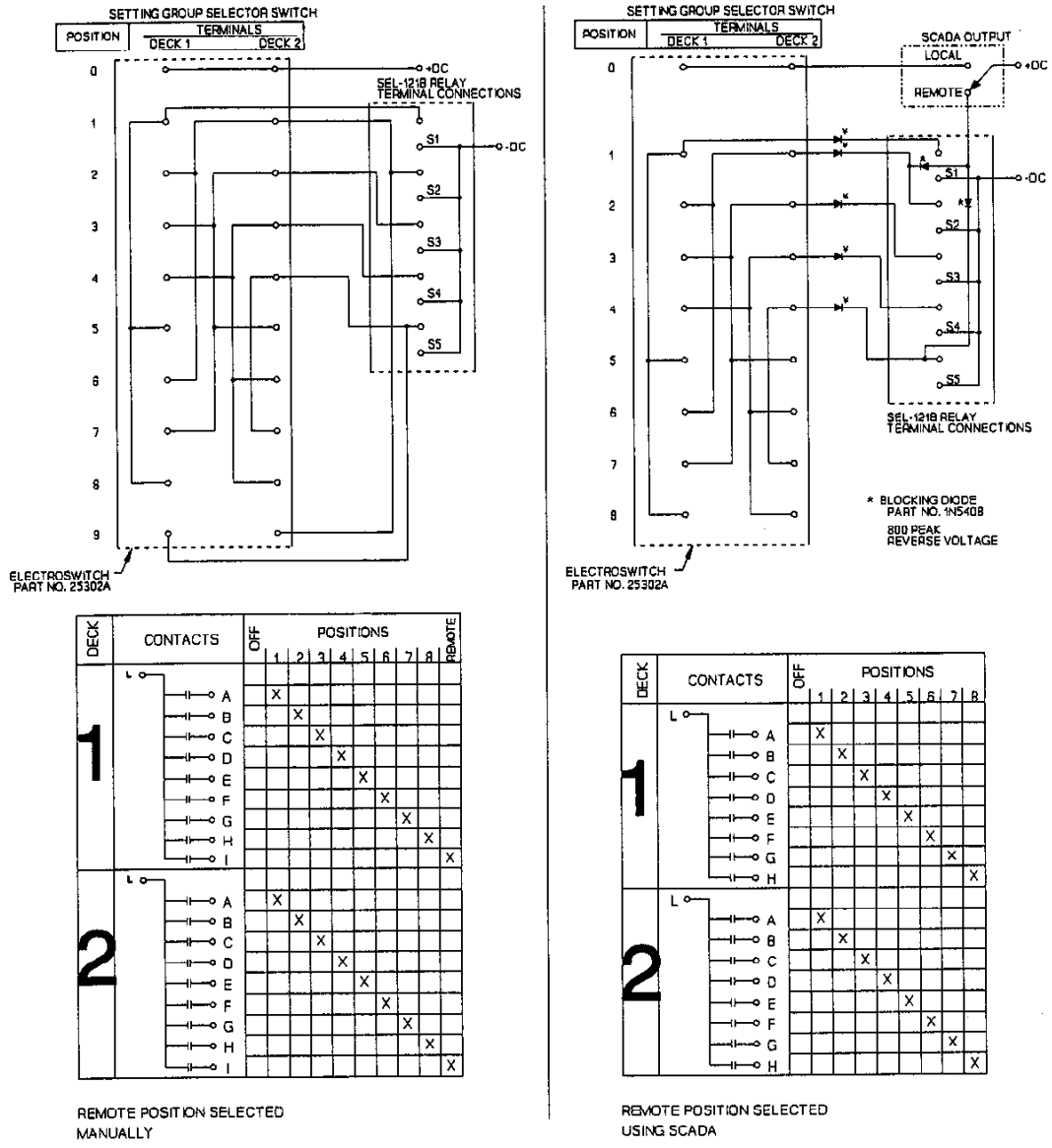


Figure 5: Selector Switch Wiring Diagram

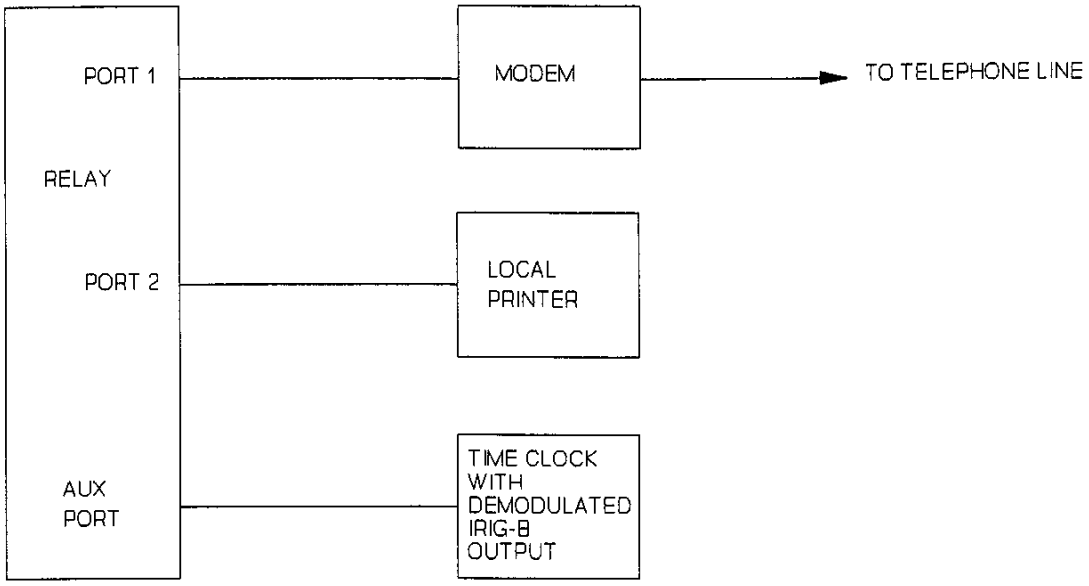


Figure 6: Communications and Clock Connections - One Unit at One Location

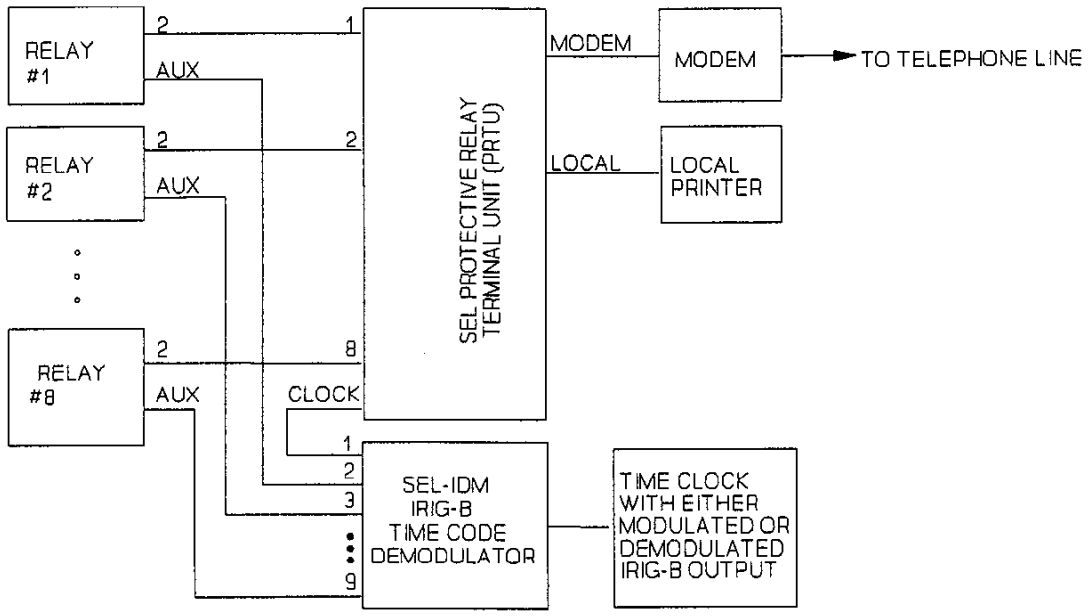


Figure 7: Communications and Clock Connections - Multiple Units at One Location

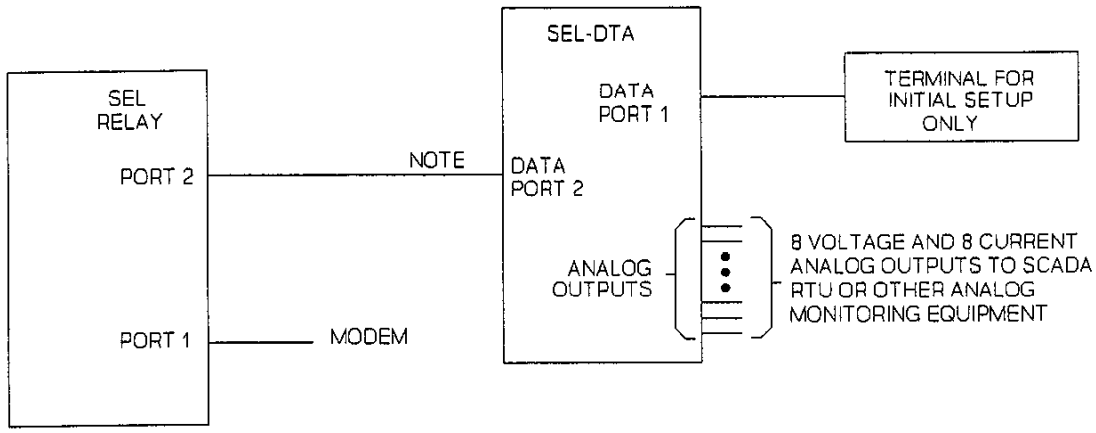


Figure 8: SEL Relay Communications Diagram for Connection to the SEL-DTA

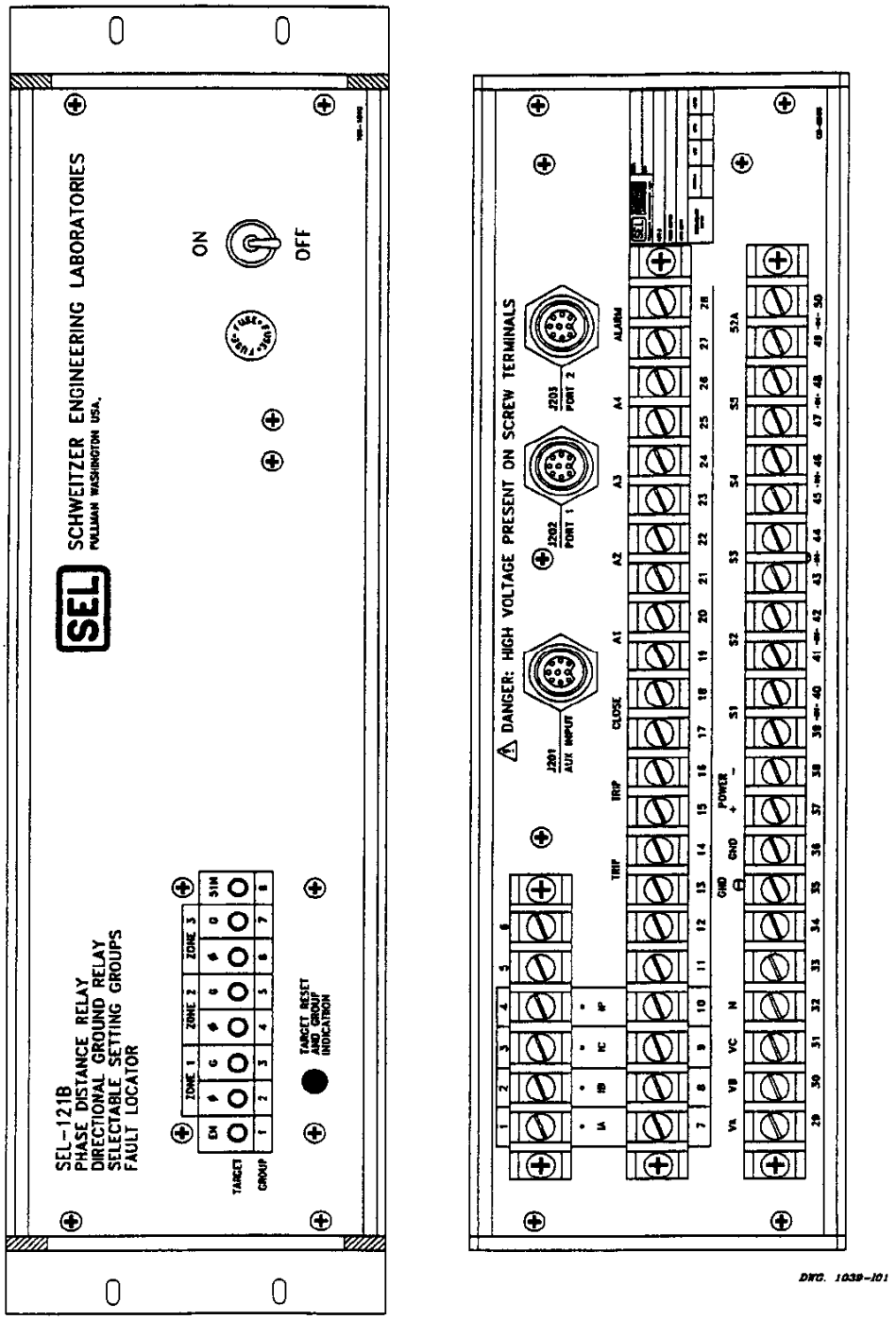


Figure 9: Horizontal Front and Rear Panel Drawings

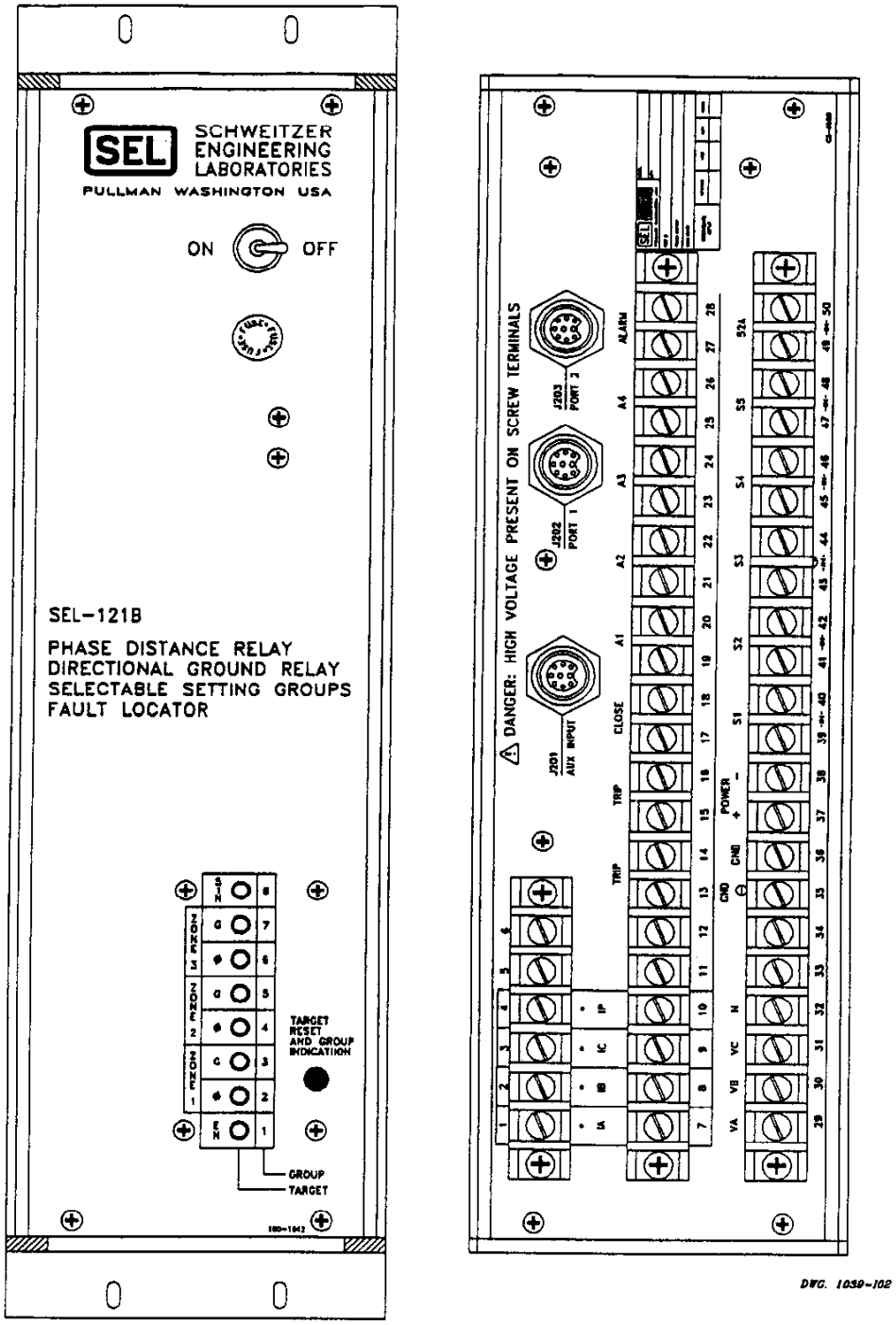


Figure 10: Vertical Front and Rear Panel Drawings

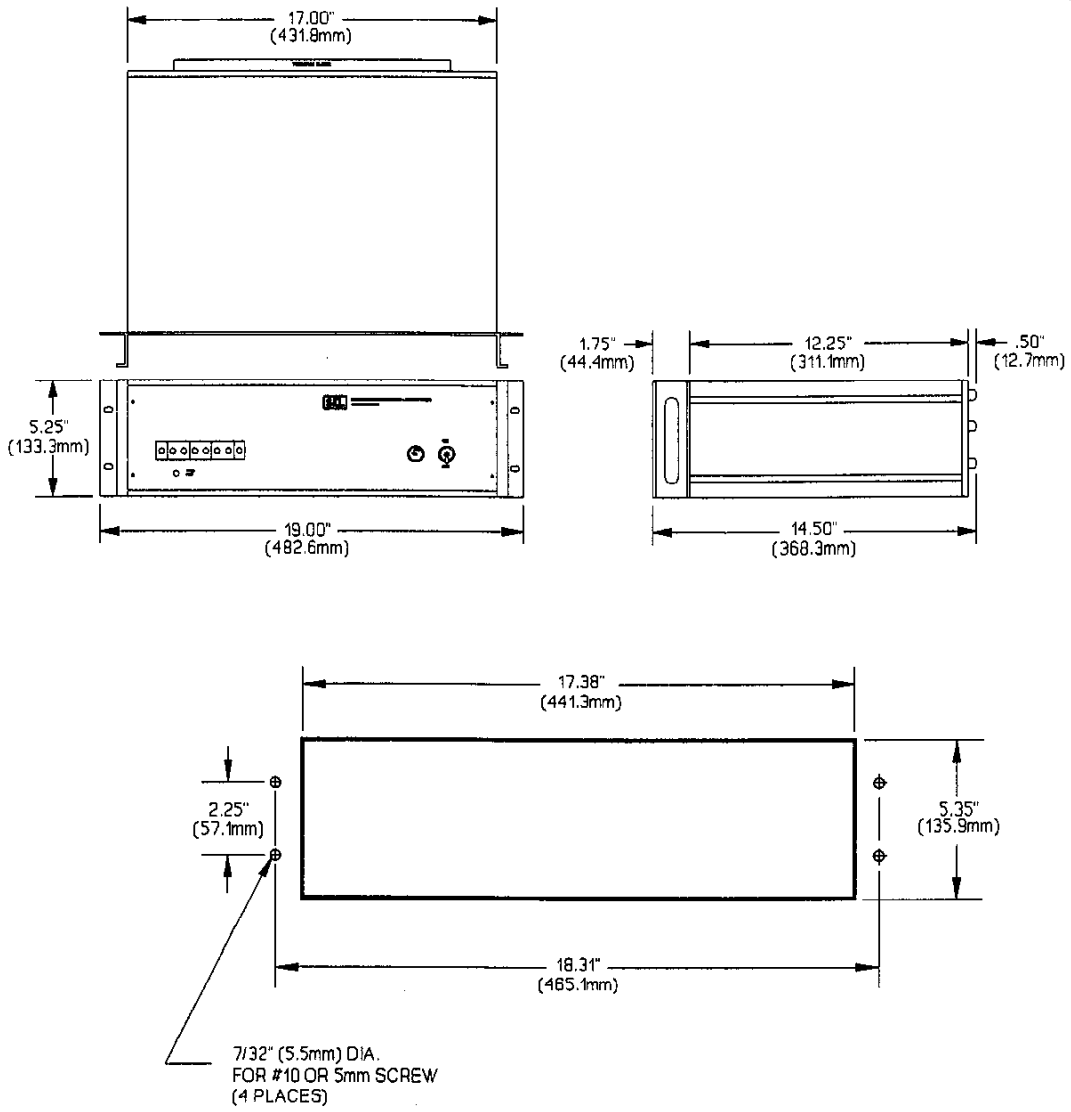


Figure 11: Relay Dimensions, Panel Cutout, and Drill Plan

SEL-121B DISTANCE RELAY/FAULT LOCATOR COMMAND SUMMARY

Level 0

ACCESS Answer password prompt (if password protection enabled) to gain access to Level 1. Three unsuccessful attempts pulses ALARM relay.

Level 1

2ACCESS Answer password prompt (if password protection enabled) to gain access to Level 2. This command always pulses the ALARM relay.

DATE Show or set date. DAT 2/3/89 sets date to Feb. 3, 1989. This setting is overridden when IRIG-B synchronization occurs. Pulses the ALARM relay when a different year is entered than the previously stored.

EVENT Show event record. EVE 1 shows long form of most recent event.

HISTORY Show DATE, TIME, EVENT TYPE, FAULT LOCATION, DURATION, and CURRENT for the 12 most recent faults.

IRIG Force immediate execution of time-code synchronization task.

METER Show primary current, voltage, real and reactive power. METER runs once. "METER N" runs N times.

QUIT Return to Access Level 0 and reset targets to target 0.

SHOWSET Show the relay and logic settings. This command does not affect the settings. "SHOWSET 4" displays the settings for setting group four. The logic settings are shown in hexadecimal format for each mask.

STATUS Show self-test status.

TARGETS Show data and set target lights as follows:
TAR 0: Relay Targets TAR 1: RELAY WORD #1
TAR 2: RELAY WORD #2 TAR 3: RELAY WORD #3
TAR 4: Contact Inputs TAR 5: Contact Outputs
TAR R: Clears targets and returns to TAR 0
Be sure to return to TAR 0 when done, so LEDs display fault targets.

TIME Show or set time. TIM 13/32/00 sets clock to 1:32:00 PM. This setting is overridden when IRIG-B synchronization occurs.

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

Level 2

CLOSE Close circuit breaker, if allowed by jumper setting.

COPY* Copy settings from one setting group to another.

GROUP* Change the active setting group. "GROUP N" activates setting group N (N = 1-8). This command only works when contact inputs S2 and S5 are asserted.

LOGIC* Show or set logic masks MTU, MTO, MA1-MA4.

OPEN Open circuit breaker, if allowed by jumper setting.

PASSWORD Show or set passwords. Pulses the ALARM relay momentarily when new passwords are set.
PAS 1 OTTER sets Level 1 password to OTTER.
PAS 2 TAIL sets Level 2 password to TAIL.

SET* Initiate setting procedure. "SET N" initiates the setting procedure for setting group N (N = 1-8).

Use the following to separate commands and their parameters: space, comma, semicolon, colon, slash.

* ALARM relay closes while new settings are being computed, and event data buffers are cleared.

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