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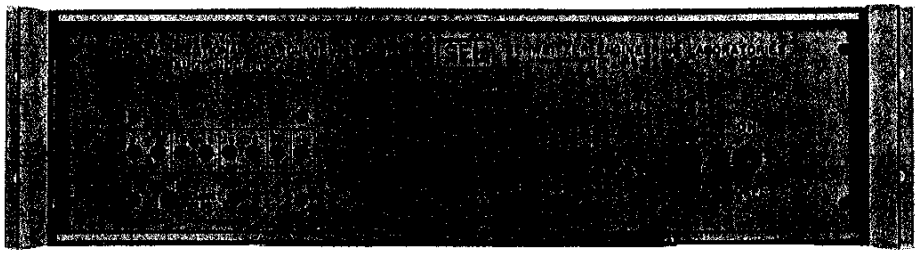
SEL-167

PHASE AND GROUND DIRECTIONAL OVERCURRENT RELAY WITH RECLOSER AND FAULT LOCATOR DATA SHEET

Also Available In LOW-PROFILE Package



* NINE PHASE-OVERCURRENT RELAYS WITH THREE TIMERS
* PHASE-TIME-OVERCURRENT ELEMENT WITH SELECTABLE CURVES
* PHASE DIRECTIONAL ELEMENTS FOR PHASE FAULTS
* THREE RESIDUAL-OVERCURRENT RELAYS AND TIMERS
* RESIDUAL-TIME-OVERCURRENT ELEMENT WITH SELECTABLE CURVES
* NEGATIVE- AND ZERO-SEQUENCE GROUND DIRECTIONAL ELEMENTS
* PROGRAMMABLE LOGIC FOR OUTPUTS, TRIPPING AND RECLOSING
* THREE-SHOT RECLOSING WITH PROGRAMMABLE INITIATE AND CANCEL
* FAULT LOCATING * EVENT REPORTING * METERING
* AUTOMATIC SELF TESTING * RS232C COMMUNICATIONS
* DEMAND AMMETER

GENERAL DESCRIPTION

The SEL-167 PHASE AND GROUND DIRECTIONAL OVERCURRENT RELAY WITH FAULT LOCATOR provides high-speed and time-delayed directional overcurrent protection for transmission lines, distribution lines and cables. Its overcurrent elements, directional elements, timers and other data and control bits are combined in a 32-bit Relay Word. Logic, programmable by the applications engineer, combines these bits to control tripping, reclosing (initiation and cancellation) and four general programmable outputs. Forward and reverse looking relay outputs are available.

Because of the many relay elements, the programmability of the SEL-167, and its low cost, the SEL-167 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 reclose initiate or cancel, alarm and trip.

The SEL-167 Relay Function Block Diagram (next page) 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 features, such as metering and fault locating.

The relay elements process the analog data. Intermediate logic is performed, such as directional supervision of the residual-overcurrent and phase-overcurrent elements, and grouping of certain elements into zones.

The states of the intermediate results and other information are recorded in the Relay Word.

Logic for tripping, closing and other purposes use the Relay Word data. Most of that logic is programmable by logic masks.

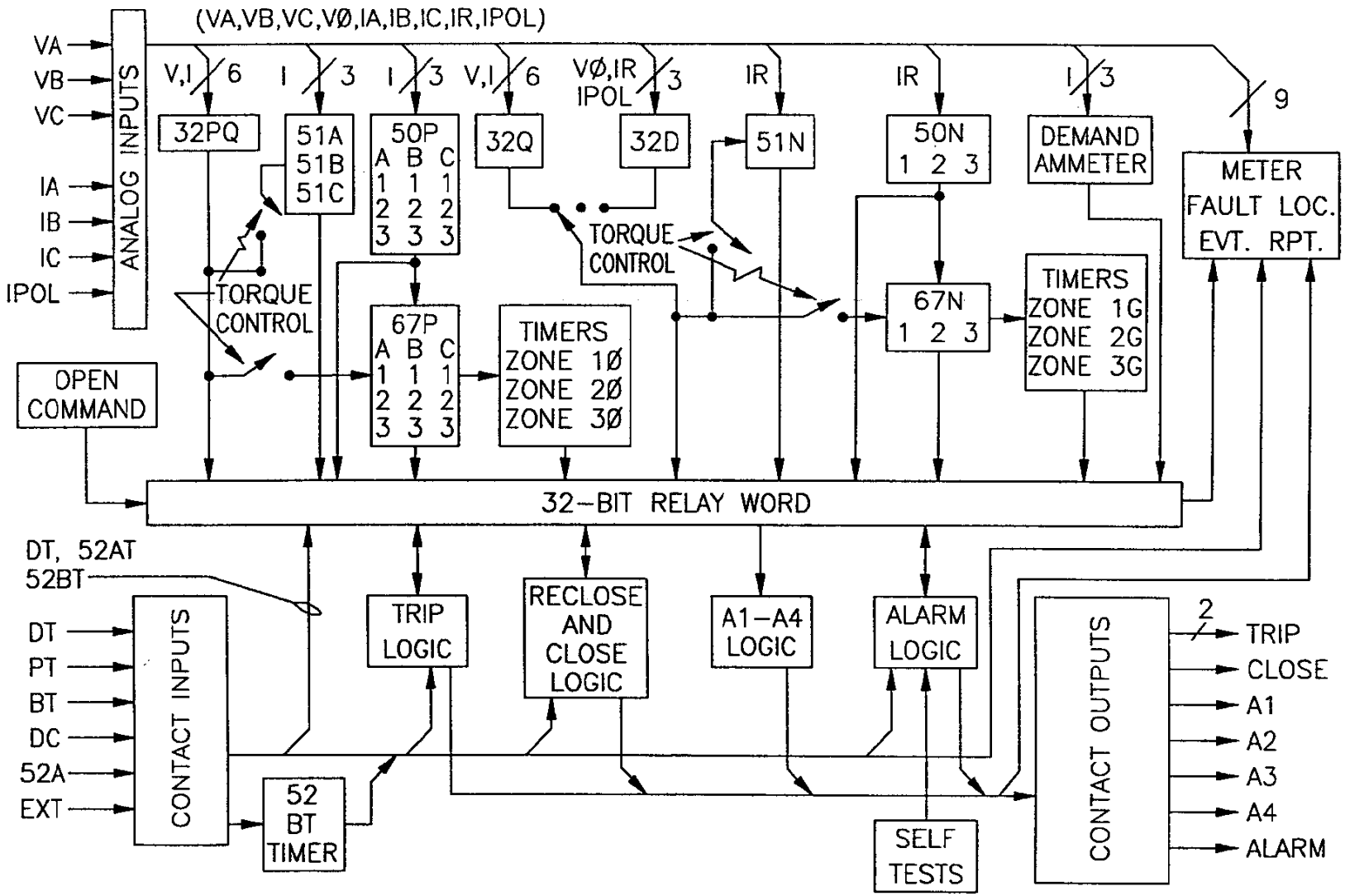
APPLICATIONS

Replacement of Outdated Protective Relays

The SEL-167 is the ideal relay to replace obsolete directional overcurrent electromechanical relay schemes. Compact size and simple field wiring make replacement especially convenient in crowded substations. 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 instrument transformer burden is negligible.

Feeder Protection

The SEL-167 provides three steps of definite-time overcurrent protection, with separate timers for phase and ground faults in all three steps. It also includes directionally-supervised time-overcurrent elements (one for phase and one for ground) with selectable curves. The exhaustive self-testing and communications capabilities are features which reduce dependence on local and remote backup schemes.



SEL-167 RELAY FUNCTION BLOCK DIAGRAM

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Backup Relaying

Where adequate high-speed primary protection already exists, the SEL-167 can be applied for backup. Programmability and remote-access capabilities allow the relay settings to be adjusted remotely to meet virtually any contingency.

Its application also adds demand ammetering, event reporting and fault locating.

Other Applications

The SEL-167 is cost-effective in these applications: fault locating, temporary installation, bus-tie breaker relaying (where frequent setting changes may be required), and remote control and monitoring.

SPECIFICATIONS

Relay Functions

Directional overcurrent protection for phase faults:

- Nine phase-overcurrent elements, in three groups
- Three timers, one per group
- Polyphase time-overcurrent element with selectable curve shapes
- Phase directional element operates on negative- and positive-sequence quantities, with the negative-sequence voltamperes weighted four times the positive-sequence voltamperes.

Directional residual-overcurrent protection for ground faults:

- Three definite-time elements
- One time-overcurrent element with selectable curve shapes
- Negative- and zero-sequence directional elements for ground faults. Zero-sequence element is dual polarized.

Automatic reclosing for selectable fault types (3 shots).

Relay Elements

Phase overcurrent:

51P phase time-overcurrent element
Selectable curve shape (4 curves)
Time Dial: 0.50 to 15.00 in steps of 0.01
Pickup: 1 to 12.6 A, +/- 0.05 A +/- 2% of setting

50A1, 50B1, 50C1 Zone 1 phase-overcurrent elements (50P1)
50A2, 50B2, 50C2 Zone 2 phase-overcurrent elements (50P2)
50A3, 50B3, 50C3 Zone 3 phase-overcurrent elements (50P3)
Pickup: 1 A to 25 times 51P pickup
Timers are provided for each zone:
Zone 1 Timer: 0-60 cycles in 0.25 cycle steps
Zone 2 Timer: 0-2000 cycles in 0.25 cycle steps
Zone 3 Timer: 0-2000 cycles in 0.25 cycle steps

Ground Overcurrent:

51N residual time-overcurrent element
Selectable curve shape (4 curves)
Time dial: 0.50 to 15.00 in steps of 0.01
Pickup: 0.25 to 6.3 A, +/- 0.05 A +/- 2% of setting
50N1, 50N2, 50N3 residual-overcurrent elements
Pickup: 0.2 to 47 times 51N pickup
Timers are provided for 50N1, 50N2 and 50N3:
Zone 1 Timer: 0-60 cycles in 0.25 cycle steps
Zone 2 Timer: 0-2000 cycles in 0.25 cycle steps
Zone 3 Timer: 0-2000 cycles in 0.25 cycle steps

Demand Overcurrent:

DCTH phase demand overcurrent element.
Pickup: 0.2 to 15 times phase time-overcurrent element pickup (51P pickup). (See Metering)

Directional Elements:

Phase directional element:
Angle: MTA (maximum torque angle) setting (47-90 degrees in 1 degree steps)
Sensitivity: 1 VA of positive-sequence and 0.25 VA of negative-sequence at MTA
Memory: Eight cycles
Negative-sequence directional element:
Angle: MTA setting (47-90 degrees in 1 degree steps)
Sensitivity: Proportional to 51P pickup:
0.35 VA at 12.6 A pickup at MTA
0.04 VA at 1 A pickup at MTA
Zero-sequence directional element:
Voltage polarization:
Angle: MTA setting (47-90 degrees in 1 deg. steps)
Sensitivity:(0.125 volts) * (51N pickup setting) at MTA in units of zero-sequence volts times residual amps, and V0 > 0.17 V
Current polarization:
Angle: Zero degrees
Sensitivity: (0.5 amps) * (51N pickup setting), at zero degrees, in units of residual amps squared, and Ipol > 0.5 amps

Note: The MTA setting is common to all three directional elements.

Three-shot reclosing relay:
79OI1 open interval 1,
79OI2 open interval 2, and
79OI3 open interval 3:
Timer ranges: 0 - 10,000 cycles in 1/4 cycle steps; A setting of 0 disables that shot and successive shots.
79RS reset interval:
Timer range: 60 - 10,000 cycles in 1/4 cycle steps

Fault Location	Fault location is computed from event reports stored following each fault. Algorithm compensates for prefault current, improving accuracy for high-resistance faults.
Metering	All metered quantities are displayed in primary units. Voltage: Phase-neutral voltages are measured, scaled to primary and displayed upon command. Calculated phase-to-phase voltages are also displayed. Current: Each phase current is measured, scaled to primary and displayed upon command. Demand: Current demand is computed with a 5 to 60 minute time constant, and displayed upon command. Peak demand is determined and stored, and is resettable by command. A demand threshold setting is provided. When the demand exceeds the setting, the DCTH bit in the Relay Word is set. It can be used for tripping, annunciation, alarm, etc. Power: MW and MVAR are determined by a three-phase, four-wire calculation and displayed by command.
Event 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 or contact closure. When tripping occurs after the end of the event report, a second report is triggered at tripping.
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	120 volts phase-to-phase, 3-phase 4-wire connection
Rated Input Current	5 amps per phase nominal 15 amps per phase continuous 390 amps for one second thermal rating
Output Contact Ratings	30 amp make per IEEE C37-90 para 6.6.2 6 amp carry continuous MOV protection provided

Logic Input Ratings	200 - 280 VDC for 250 VDC relays 60 - 200 VDC for 125 VDC relays 25 - 60 VDC for 48 VDC relays Input current: 6 mA at nominal voltage
Power Supply	85 - 200 VDC or 85 - 200 VAC; 12 watts for 250 VDC relays 85 - 200 VAC or VDC; 12 watts for 125 VDC relays 20 - 60 VDC; 12 watts for 48 VDC relays
Dielectric Strength	Routine tested: V, I inputs: 2500 VAC for 10 seconds Other: 3000 VDC for 10 seconds (excludes RS-232 and time code input)
Interference Tests	IEEE C37-90 SWC test (type tested) IEC 255-6 interference test (type tested)
Impulse Tests	IEC 255-5 0.5 joule 5000 volt test (type tested)
RFI Tests	Type-tested in field from a 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 standard 19" relay rack.
Unit Weight	21 pounds
Shipping Weight	32 pounds, including two instruction manuals
Operating Temperature	-20 deg C to + 55 deg C
Burn-in Temperature	Each SEL-167 is burned in at 60 deg C for 100 hours

LOGIC DESCRIPTION

Relay Elements

single-phase overcurrent relays	50A1 50B1 50C1	nondirectional
	50A2 50B2 50C2	nondirectional
	50A3 50B3 50C3	nondirectional
polyphase time-overcurrent relay (driven by maximum phase current)		
pickup	51PP	T.C or nondirectional
trip	51PT	T.C or nondirectional
residual time-overcurrent relay		
pickup	51NP	T.C. or nondirectional
trip	51NT	T.C. or nondirectional
residual inst-overcurrent	50N1	nondirectional
residual inst-overcurrent	50N2	nondirectional
residual inst-overcurrent	50N3	nondirectional

phase directional	32PQ	32PQF=forward; 32PQR=reverse
negative-sequence directional	32Q	32QF =forward; 32QR =reverse
zero-seq pol directional	32D	32DF =forward; 32DR =reverse

Note: The 32D is equivalent to 32V when 32VE is enabled and 32IE is disabled.
The 32D is equivalent to 32I when 32IE is enabled and 32VE is disabled.
The 32D is dual polarized when both 32VE and 32IE are enabled.

Timers

Z1GTMR	Zone 1 ground timer timeout operated by 67N1	(Z1DG setting)
Z2GTMR	Zone 2 ground timer timeout operated by 67N2	(Z2DG setting)
Z3GTMR	Zone 3 ground timer timeout operated by 67N3	(Z3DG setting)
Z1PTMR	Zone 1 phase timer timeout operated by 67P1	(Z1DP setting)
Z2PTMR	Zone 2 phase timer timeout operated by 67P2	(Z2DP setting)
Z3PTMR	Zone 3 phase timer timeout operated by 67P3	(Z3DP setting)
52AT	Time-delayed 52A (pickup and dropout)	(52BT setting)
52BT	Inverse of 52AT	(52BT setting)

Note: 52AT follows the 52A input after a settable time delay given by the 52BT setting.

79OI1	Reclosing relay first open interval expired
79OI2	Reclosing relay second open interval expired
79OI3	Reclosing relay third open interval expired
79RS	Reclosing relay reset interval timer expired

Enables from setting procedures

ZONE3 = F	Zone 3 reach is forward
ZONE3 = R	Zone 3 reach is reverse
32QE	Enables 32Q
32VE	Enables voltage polarization of 32D
32IE	Enables current polarization of 32D
67NE	Enables directional torque control for 67N1, 2, 3
67PE	Enables directional torque control for 67P1, 2, 3
51NTC	Selects directional torque control for 51N
51PTC	Selects directional torque control for 51P

Contact Inputs

direct trip	DT
permissive transfer trip	PT
block trip	BT
direct close	DC
circuit breaker monitor	52A
external trigger for event report	EXT

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.

50P3 = 50A3 + 50B3 + 50C3	Zone 3 phase fault
50P2 = 50A2 + 50B2 + 50C2	Zone 2 phase fault
50P1 = 50A1 + 50B1 + 50C1	Zone 1 phase fault
GF = 51NP + 50N1 + 50N2 + 50N3	Ground fault
PF = 51PP + 50P1 + 50P2 + 50P3	Phase fault
DFP = 32PQF * PF	Phase forward direction
DRP = 32PQR * PF	Phase reverse direction
D3P = DFP if ZONE 3 is forward	
D3P = DRP if ZONE 3 is reverse	
67P3 = (D3P + NOT (67PE)) * 50P3	Zone 3 directional phase-overcurrent element, reversible
67P2 = (DFP + NOT (67PE)) * 50P2	Zone 2 directional phase-overcurrent element
67P1 = (DFP + NOT (67PE)) * 50P1	Zone 1 directional phase-overcurrent element
DFG = 32QF * 32QE * (PF + GF) + 32DF * (32IE + 32VE) * GF + NOT (32QE + 32IE + 32VE)	Ground forward direction
DRG = 32QR * 32QE * (PF + GF) + 32DR * (32IE + 32VE) * GF	Ground reverse direction
D3G = DFG if ZONE 3 is forward	
D3G = DRG if ZONE 3 is reverse	
67N3 = [D3G + NOT (67NE)] * 50N3	Zone 3 directional ground-overcurrent element, reversible
67N2 = [DFG + NOT (67NE)] * 50N2	Zone 2 directional ground-overcurrent element
67N1 = [DFG + NOT (67NE)] * 50N1	Zone 1 directional ground-overcurrent element
Z3PT = 67P3 * Z3PTMR	Zone 3 timeout-phase
Z2PT = 67P2 * Z2PTMR	Zone 2 timeout-phase
Z1PT = 67P1 * Z1PTMR	Zone 1 timeout-phase

Z3GT = 67N3 * Z3GTMR	Zone 3 timeout-ground
Z2GT = 67N2 * Z2GTMR	Zone 2 timeout-ground
Z1GT = 67N1 * Z1GTMR	Zone 1 timeout-ground

RELAY WORD

Relay elements and intermediate logic results are represented in a 32-bit relay word (grouped into four 8-bit words). The user selects bits in this word to perform the desired functions for controlling outputs and for initiating or cancelling reclose. The selected bits are stored in masks for each function. The user programs the bits in these masks with the LOGIC command.

RELAY WORD

DRP	50N1	50N2	50N3	DFP	50P1	50P2	50P3
DRG	67N1	67N2	67N3	DFG	67P1	67P2	67P3
51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT
ALRM	TRIP	TC	DT	52BT	52AT	TOCP	DCTH

The meaning of each bit in the relay word is explained in the Relay Word Bit Summary Table listed below.

SEL-167 RELAY WORD BIT SUMMARY TABLE

DRP	-	Direction reverse--phase fault
50N1	-	Residual instantaneous-overcurrent element
50N2	-	Residual instantaneous-overcurrent element
50N3	-	Residual instantaneous-overcurrent element
DFP	-	Direction forward--phase fault
50P1	-	Phase instantaneous-overcurrent element
50P2	-	Phase instantaneous-overcurrent element
50P3	-	Phase instantaneous-overcurrent element
DRG	-	Direction reverse--ground fault
67N1	-	Zone 1 ground directional overcurrent element
67N2	-	Zone 2 ground directional overcurrent element
67N3	-	Zone 3 ground directional overcurrent element
DFG	-	Direction forward--ground fault
67P1	-	Zone 1 phase directional overcurrent element
67P2	-	Zone 2 phase directional overcurrent element
67P3	-	Zone 3 phase directional overcurrent element
51NT	-	Ground time-overcurrent trip
Z1GT	-	Zone 1 timeout-ground
Z2GT	-	Zone 2 timeout-ground
Z3GT	-	Zone 3 timeout-ground
51PT	-	Phase time-overcurrent trip
Z1PT	-	Zone 1 timeout-phase
Z2PT	-	Zone 2 timeout-phase
Z3PT	-	Zone 3 timeout-phase

ALRM - System alarm
TRIP - Circuit breaker trip
TC - Trip (OPEN) command
DT - Direct trip from DT input
52BT - Inverse of 52AT
52AT - Time delayed 52A
TOCP - Time-overcurrent pickup indicator (51PP + 51NP)
DCTH - Demand current threshold exceeded

The use of the relay word and programmable masks provide the user with great flexibility in applying the SEL-167, without rewiring panels or changing 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 by setting masks for various conditions, 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)
MPT = mask for trip (permissive trip)
MTB = mask for trip (with no blocking)
MTO = mask for trip (with breaker open)

```
then:  TRIP = R * MTU
            + R * MPT * PT
            + R * MTB * NOT (BT)
            + R * MTO * 52BT

close TRIP  = TRIP
open TRIP   = NOT (TRIP) * NOT(52A + TARGET RESET button pushed) * (60 ms
              minimum TRIP)
close CLOSE = (DC + 79OI1 + 79OI2 + 79OI3 + CLOSE command) * NOT(52A)
open CLOSE  = NOT (CLOSE) + 79RS

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

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

RECLOSING RELAY

The reclosing relay provides up to three shots of automatic reclosing for selectable fault types and relay elements contained in the 32-bit Relay Word. The programmable logic provides access to the internally derived reclose

initiate and cancel signals. Either external initiation or cancellation of reclosing is also allowed. The three open intervals and the reset timer are individually settable through the SET command.

To provide flexibility in applying the SEL-167 to various reclosing schemes, the conditions for reclose initiation and cancellation are selected in a similar way to the programming of the output relays:

RI = R * MRI
RC = R * MRC

where MRI is the mask for reclose initiation, and MRC is the mask for reclose cancellation.

The open intervals do not begin until the TRIP output unasserts. Since the TRIP output never asserts for less than 60 ms, the open interval may start several milliseconds after the fault has actually cleared and the breaker opened.

Reclose is automatically cancelled when the circuit breaker is observed to trip when a fault condition is not present or for faults during the open interval of any shot.

SETTING PROCEDURE

The SET command invokes the relay setting procedure. Each setting is presented and prompted for in turn. If a new setting value is desired, it is entered in response to the appropriate prompt, while just pressing carriage return retains the old setting and prompts for the next one.

In the example beginning on the next page only the XO value was changed. It was changed from 152.34 to 143.07. Note that the new value of 143.07 is presented at the end of the procedure before enabling, along with all other settings. 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 an option (except for the ID setting) for the SET command. All settings prior to the specified setting are skipped when the command is executed in this manner. For example, typing "SET Z3DP <CR>" will skip all settings prior to the Z3DP setting.

```
=>>SET

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

ID    : Example 69 kV Line
 ?
R1    : (Ohms pri)..... = 49.83    ?
X1    : ..... = 56.32    ?
R0    : ..... = 56.07    ?
X0    : ..... = 152.34   ? 143.07 <- operator changes X0
LL    : Line Length (mi)..... = 60.00    ?        <- could type END here

CTR   : ..... = 60.00    ?
PTR   : ..... = 600.00   ?
MTA   : Max Torque Angle (deg) = 49.00   ?
LOCAT: Locate faults (Y/N)... = Y        ?
DATC  : Demand TC (5-60min)... = 15      ?

DCTH  : Dmd Thresh (Amps pri). = 120.00  ?
79OI1: Open Int 1 (cyc)..... = 40.00     ?
79OI2: ..... = 60.00     ?
79OI3: ..... = 80.00     ?
79RS  : Reset Int..... = 240.00   ?

51PP  : PU (Amps pri)..... = 120.00   ?
51PTD: Time Dial..... = 1.00      ?
51PC  : Curve (1,2,3,or4)..... = 2        ?
51PTC: Torque Ctrl (Y/N)..... = N         ?

50P1  : PU (Amps pri)..... = 1158.00  ?
50P2  : ..... = 516.00   ?
50P3  : ..... = 210.00   ?

Z1DP  : Dly-Phase (cyc)..... = 0.00      ?
Z2DP  : ..... = 160.00    ?
Z3DP  : ..... = 30.00     ?

51NP  : PU (Amps pri)..... = 30.00    ?
51NTD: Time Dial..... = 2.00      ?
51NC  : Curve (1,2,3,or4)..... = 2        ?
51NTC: Torque Ctrl (Y/N)..... = N         ?

50N1  : PU (Amps pri)..... = 1008.00  ?
50N2  : ..... = 450.00   ?
50N3  : ..... = 30.00     ?

Z1DG  : Dly-Gnd (cyc)..... = 0.00      ?
Z2DG  : ..... = 30.00     ?
Z3DG  : ..... = 10.00     ?
```

```
52BT : Dly (cyc)..... = 30       ?
ZONE3: Dir (F=fwd or R=rvs).. = R       ?
67NE : GND Flt Dir (Y/N)..... = Y       ?
67PE : Phase Flt Dir (Y/N)... = Y       ?

32QE : Enable (Y/N)..... = N       ?
32VE : ..... = Y       ?
32IE : ..... = Y       ?

TIME1: Port 1 timeout (min).. = 5       ?
TIME2: ..... = 0       ?
AUTO : Auto port (1,2,3)..... = 2         ?
RINGS: (1-30)..... = 3       ?

New settings for: Example 69 kV Line

R1   =49.83    X1   =56.32    R0   =56.07    X0   =143.07   LL   =60.00
CTR  =60.00    PTR  =600.00   MTA  =49.00    LOCAT=Y         DATC =15
DCTH =120.00   79OI1=40.00    79OI2=60.00    79OI3=80.00    79RS =240.00
51PP =120.00   51PTD=1.00     51PC =2        51PTC=N
50P1 =1158.00  50P2 =516.00   50P3 =210.00
Z1DP =0.00     Z2DP =160.00   Z3DP =30.00
51NP =30.00    51NTD=2.00     51NC =2        51NTC=N
50N1 =1008.00  50N2 =450.00   50N3 =30.00
Z1DG =0.00     Z2DG =30.00    Z3DG =10.00
52BT =30       ZONE3=R        67NE =Y        67PE =Y
32QE =N        32VE =Y        32IE =Y
TIME1=5        TIME2=0        AUTO =2        RINGS=3

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

Example 69 kV Line Date: 3/28/88 Time: 08:45:09.366

FID=SEL-167-R100-V656m-D880327

	Currents (amps)				Voltages (kV)			Relays Outputs Inputs		
IPOL	IR	IA	IB	IC	VA	VB	VC	565565 071071 PPPNNN	TCAAAAA PL1234L	DPBD5E TTTC2T A
0	0	0	0	1	-2.6	-33.1	36.0	.....	.....	....*.
0	0	1	0	0	40.0	-22.3	-17.8	.....	.....	....*.
0	0	0	0	-1	2.6	33.1	-36.0	.....	.....	....*.
0	0	-1	0	0	-40.0	22.3	17.8	.....	.....	....*.
0	0	-1	0	1	-2.6	-33.1	36.0	.....	.....	....*.
0	0	1	0	0	40.0	-22.3	-17.8	.....	.....	....*.
0	0	1	0	-1	2.6	33.1	-36.0	.....	.....	....*.
0	0	-1	0	0	-40.0	22.3	17.8	.....	.....	....*.
0	0	-1	0	1	-2.6	-33.1	36.0	.....	.....	....*.
0	0	1	0	0	40.0	-22.2	-17.8	.....	.....	....*.
0	0	1	0	-1	2.6	33.2	-36.0	.....	.....	....*.
0	0	-1	0	0	-40.0	22.2	17.8	.....	.....	....*.
0	0	-1	0	1	-2.6	-33.2	36.0	.....	.....	....*.
0	0	1	0	0	38.8	-22.8	-18.4	.....	.....	....*.
0	37	37	0	-1	0.4	33.2	-35.9	...3..	.....	....*.
0	-7	-8	0	0	-30.6	25.4	20.9	...3..	.....	....*.
0	-420	-418	0	1	0.3	-34.2	34.8	3..3..	.....	....*.
0	246	248	0	0	20.8	-27.9	-23.2	3..2..	.....	....*.
0	886	886	0	-1	1.0	35.4	-33.6	2..22.	..*....	....*.
0	-506	-505	0	0	-17.6	28.5	23.7	22.22.	..*....	....*.
0	-1024	-1024	0	1	-1.1	-35.6	33.4	22.12.	*.*....	....*.
0	526	526	0	0	17.2	-28.6	-23.7	22.11.	*.*....	....*.
0	1025	1024	0	-1	1.1	35.6	-33.4	22.11.	*.*....	....*.
-1	-527	-526	0	-1	-17.1	28.6	23.8	22.11.	*.*....	....*.
1	-1025	-1025	0	1	-1.1	-35.6	33.4	12.11.	*.*....	.....
1	526	526	0	1	18.3	-28.0	-23.2	11.11.	*.*....	.....
-1	1012	1012	0	-1	3.2	35.6	-33.4	22.11.	*.*....	.....
0	-530	-530	0	0	-26.5	25.3	20.7	22.11.	*.*....	.....
0	-631	-629	0	1	-3.9	-34.6	34.6	22.22.	*.*....	.....
0	289	289	-1	0	36.4	-22.8	-18.5	22.22.	*.*....	.....
0	166	162	1	-1	2.5	33.4	-35.8	3..3..	*.....	.....
0	-32	-32	1	0	-39.5	22.2	18.0	...3..	*.....	.....
0	-24	-22	-1	1	-2.4	-33.2	35.9	...3..	*.....	.....
0	3	4	-1	0	40.0	-22.2	-17.9	.....	*.....	.....
0	4	3	1	-1	2.4	33.2	-35.9	.....	*.....	.....
0	-1	-1	1	0	-40.0	22.1	17.9	.....	*.....	.....
0	-1	-1	-1	1	-2.4	-33.2	35.9	.....	.....	.....
0	0	1	-1	0	40.0	-22.1	-17.9	.....	.....	.....
0	0	1	1	-1	2.4	33.2	-35.9	.....	.....	.....
0	0	-1	1	0	-40.0	22.1	18.0	.....	.....	.....
0	0	-1	-1	1	-2.4	-33.2	35.9	.....	.....	.....
0	0	1	0	0	40.0	-22.1	-18.0	.....	.....	.....
0	0	1	0	-1	2.4	33.3	-35.9	.....	.....	.....
0	0	-1	0	0	-40.0	22.1	18.0	.....	.....	.....

Event : AG Location : 9.02 mi 1.13 ohms sec
Duration: 4.75 Flt Current: 1154.4 Targets: G1

R1	=49.83	X1	=56.32	R0	=56.07	X0	=143.07	LL	=60.00
CTR	=60.00	PTR	=600.00	MTA	=49.00	LOCAT	=Y	DATC	=15
DCTH	=120.00	79OI1	=40.00	79OI2	=60.00	79OI3	=80.00	79RS	=240.00
51PP	=120.00	51PTD	=1.00	51PC	=2	51PTC	=N		
50P1	=1158.00	50P2	=516.00	50P3	=210.00				
Z1DP	=0.00	Z2DP	=160.00	Z3DP	=30.00				
51NP	=30.00	51NTD	=2.00	51NC	=2	51NTC	=N		
50N1	=1008.00	50N2	=450.00	50N3	=30.00				
Z1DG	=0.00	Z2DG	=30.00	Z3DG	=10.00				
52BT	=30	ZONE3	=R	67NE	=Y	67PE	=Y		
32QE	=N	32VE	=Y	32IE	=Y				
TIME1	=5	TIME2	=0	AUTO	=2	RINGS	=3		

Logic settings:

MTU	MPT	MTB	MTO	MA1	MA2	MA3	MA4	MRI	MRC
44	44	00	77	44	00	00	00	00	00
44	66	00	77	66	00	00	00	44	00
FF	FF	00	FF	FF	00	80	08	00	BB
30	00	00	30	00	01	00	00	00	30

EXPLANATION OF EVENT REPORT

Example 69 kV Line Date: 3/28/88 Time: 08:45:09.366

FID=SEL-167-R100-V656m-D880327

Currents (amps)					Voltages (kV)			Relays 565565 071071 PPPNNN	Outputs TCAAAAA PL1234L	Inputs DPBD5E TTTC2T A
IPOL	IR	IA	IB	IC	VA	VB	VC			
0	886	886	0	-1	1.0	35.4	-33.6	2..22.	..*....	....*.
0	-506	-505	0	0	-17.6	28.5	23.7	22.22.	..*....	....*.
0	-1024	-1024	0	1	-1.1	-35.6	33.4	22.12.	*.*....	....*.
0	526	526	0	0	17.2	-28.6	-23.7	22.11.	*.*....	....*.
0	1025	1024	0	-1	1.1	35.6	-33.4	22.11.	*.*....	....*.
-1	-527	-526	0	-1	-17.1	28.6	23.8	22.11.	*.*....	....*.

Event : AG Location : 9.02 mi 1.13 ohms sec
Duration: 4.75 Flt Current: 1154.4 Targets: G1

R1 =49.83	X1 =56.32	R0 =56.07	X0 =143.07	LL =60.00
CTR =60.00	PTR =600.00	MTA =49.00	LOCAT=Y	DATC =15
DCTH =120.00	79OI1=40.00	79OI2=60.00	79OI3=80.00	79RS =240.00
51PP =120.00	51PTD=1.00	51PC =2	51PTC=N	
50P1 =1158.00	50P2 =516.00	50P3 =210.00		
Z1DP =0.00	Z2DP =160.00	Z3DP =30.00		
51NP =30.00	51NTD=2.00	51NC =2	51NTC=N	
50N1 =1008.00	50N2 =450.00	50N3 =30.00		
Z1DG =0.00	Z2DG =30.00	Z3DG =10.00		
52BT =30	ZONE3=R	67NE =Y	67PE =Y	
32QE =N	32VE =Y	32IE =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 the Y-component, and the entry immediately underneath as the X-component. For example, from bottom rows, IAY = 1024, IAX = -526. Therefore, IA = 1151 amps RMS primary, at an angle of ATAN(1024/-526) = 117 degrees, 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	: 50P1, 50P2, 50P3	---> 1,2,3
67P : directional phase overcurrent	: 67P1, 67P2, 67P3	---> 1,2,3
51P : phase time-overcurrent	: 51PT	---> T
50N : inst ground overcurrent	: 50N1, 50N2, 50N3	---> 1,2,3
67N : directional ground overcurrent	: 67N1, 67N2, 67N3	---> 1,2,3
51N : ground time-overcurrent	: 51NT	---> T

<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>	Event type is one of the following: 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. Indeterminate distance is 999999.
<Ohms Sec>	Distance to fault in secondary ohms. Indeterminate ohms is 999999.
<Duration>	Fault duration determined from relay element(s) pickup time
<Flt Current>	Max phase current (primary amps) taken near middle of fault
<Targets>	The targets indicate the relay elements that caused the trip. These targets are the same as the targets displayed on the front panel of the SEL-167 via the TARGET 0 command. The targets field indicates any combination of the following:

P1:	Zone 1 phase fault	P3:	Zone 3 phase fault
G1:	Zone 1 ground fault	G3:	Zone 3 ground fault
P2:	Zone 2 phase fault	51P:	Phase time-overcurrent trip
G2:	Zone 2 ground fault	51N:	Residual time-overcurrent trip

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)
MTA	Maximum torque angle for the directional elements
LOCAT	Enable or disable fault locator (Y/N)
DATC	Demand ammeter time constant
DCTH	Demand current threshold
79OI1,2,3,RS	Three-shot recloser Open and Reset intervals
51PP,TD,C,TC	Phase time-overcurrent pickup, Time-Dial, Curve, Torque Control
50P1,2,3	Phase inst-overcurrent pickup settings Zones 1, 2 and 3
Z1DP,2,3	Zones 1, 2 and 3 timer settings for 3- and 2-phase faults
51NP,TD,C,TC	GND time-overcurrent Pickup, Time-Dial, Curve, Torque Control
50N1,2,3	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)
67NE,PE	Ground and phase fault torque control enables
32QE,VE,IE	Ground fault directionality from (V2,I2), or (V0/IP,I0)
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 setting.

SAMPLE COMMAND DISPLAYS

=>> HISTORY

The date, time, and type of event are shown for each of the twelve most recent events. If the event is a fault, the distance, duration, current and fault targets (if the fault caused a trip) are also shown. An example of the display is shown below.

Example 69 kV Line Date: 12/21/87 Time: 11:12:12

#	DATE	TIME	TYPE	DIST	DUR	CURR	TARGETS
1	12/21/87	11:11:28.829	AGT	54.20	10.50	366.5	51N
2	12/21/87	11:11:28.429	AG	54.54	7.50	365.7	
3	12/21/87	11:09:50.346	BC	9.20	4.00	1320.9	P1
4	12/21/87	11:08:58.787	AG	9.08	4.75	1155.9	G1
5							
.							
.							
.							
12							

Note: Only four events have occurred since the relay was set or powered on.

=>>METER

Example 69 kV Line Date: 12/21/87 Time: 01:24:56

	A	B	C	AB	BC	CA
I (A)	105	102	104	180	177	182
D (A)	100	100	100			
PD (A)	107	105	105			
V (kV)	40.0	39.9	40.1	69.3	69.2	69.4

P (MW)	12.45
Q (MVAR)	-0.08

P and Q are positive when the power flow is in the direction of the reach of the relay, i.e., out from the bus and into the line.

The second row of the meter command shows the demand current for each phase current. Peak demand current for each phase is shown in the third row.

=>>STATUS

Example 69 kV Line Date: 12/21/87 Time: 01:04:56

SELF-TESTS

W=Warn F=Fail

	IP	IR	IA	IB	IC	VA	VB	VC
OS	0	0	2	2	4	-2	-2	-2
PS	4.99		15.14		-14.85			
RAM	ROM		A/D		MOF	SET		
OK	OK		OK		OK	OK		

=>TARGETS

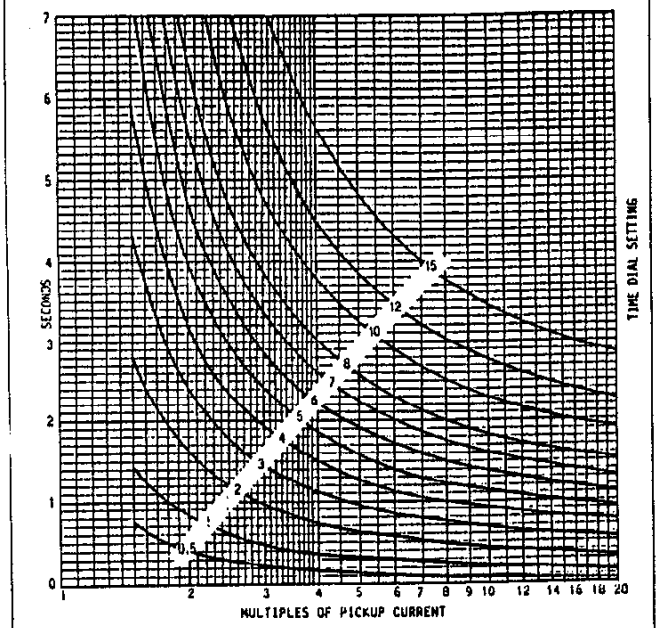
The eight-LED display on the front panel can be programmed to show targets (default), Relay Word bits, contact inputs and contact outputs, as shown below. This feature is especially useful in testing individual relay elements.

LED: N	1	2	3	4	5	6	7	8	
0	PH1	G1	PH2	G2	PH3	G3	51P	51N	RELAY TARGETS
1	DRP	50N1	50N2	50N3	DFP	50P1	50P2	50P3	RELAY WORD #1
2	DRG	67N1	67N2	67N3	DFG	67P1	67P2	67P3	RELAY WORD #2
3	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	RELAY WORD #3
4	ALRM	TRIP	TC	DT	52BT	52AT	TOCP	DCTH	RELAY WORD #4
5	52AT		ET	52A	DC	BT	PT	DT	CONTACT INPUTS
6		TRIP	CLOS	A1	A2	A3	A4	ALRM	CONTACT OUTPUTS

The front panel targets can be reset and cleared remotely or locally using the target command. Type "TARGET R <RETURN>" to reset and clear the targets.

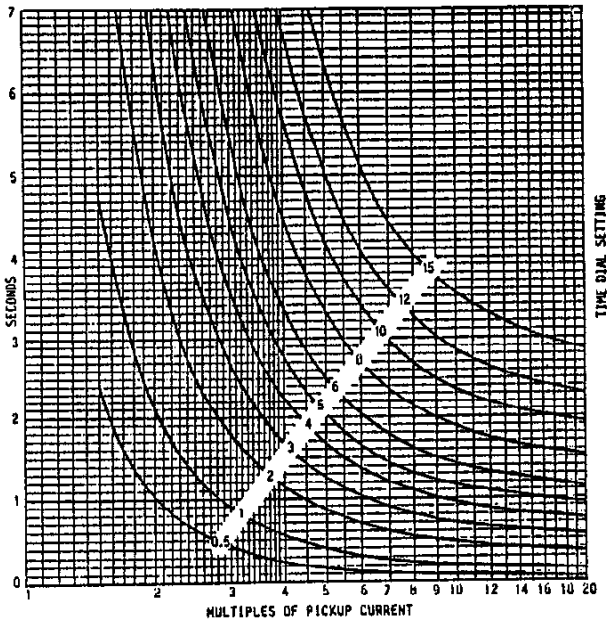
TYPICAL INSTANTANEOUS ELEMENT OPERATING TIMES

	I, Multiples of Pickup			
	2	4	10	20
50N1,2,3	24ms	16ms	15ms	12ms
50P1,2,3	23ms	17ms	14ms	12ms
67N1,2,3(32V)	27ms	21ms	19ms	19ms
67N1,2,3(32I)	32ms	28ms	25ms	20ms
67N1,2,3(32Q)	31ms	25ms	22ms	20ms
67P1,2,3(32Q)	30ms	24ms	22ms	19ms
67P1,2,3(32P)	27ms	24ms	22ms	21ms



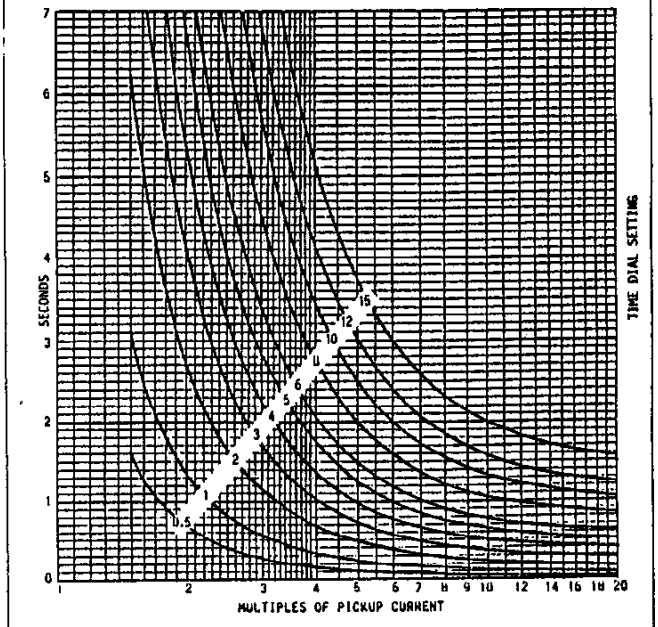
SEL-167 RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) MODERATELY INVERSE TIME CHARACTERISTIC (CURVE INDEX 1)

DWG. NO. A7-0242
DATE: 02-26-88



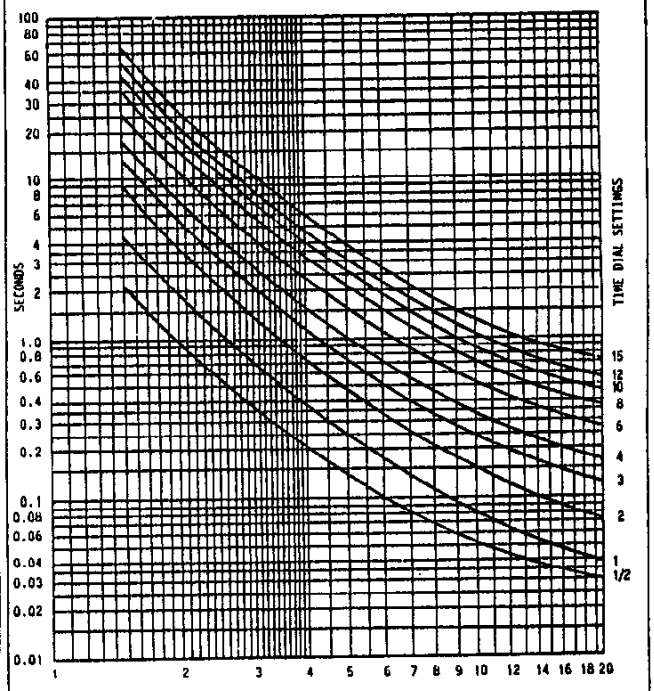
SEL-167 RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) INVERSE TIME CHARACTERISTIC (CURVE INDEX 2)

DWG. NO. A7-0243
DATE: 02-26-88



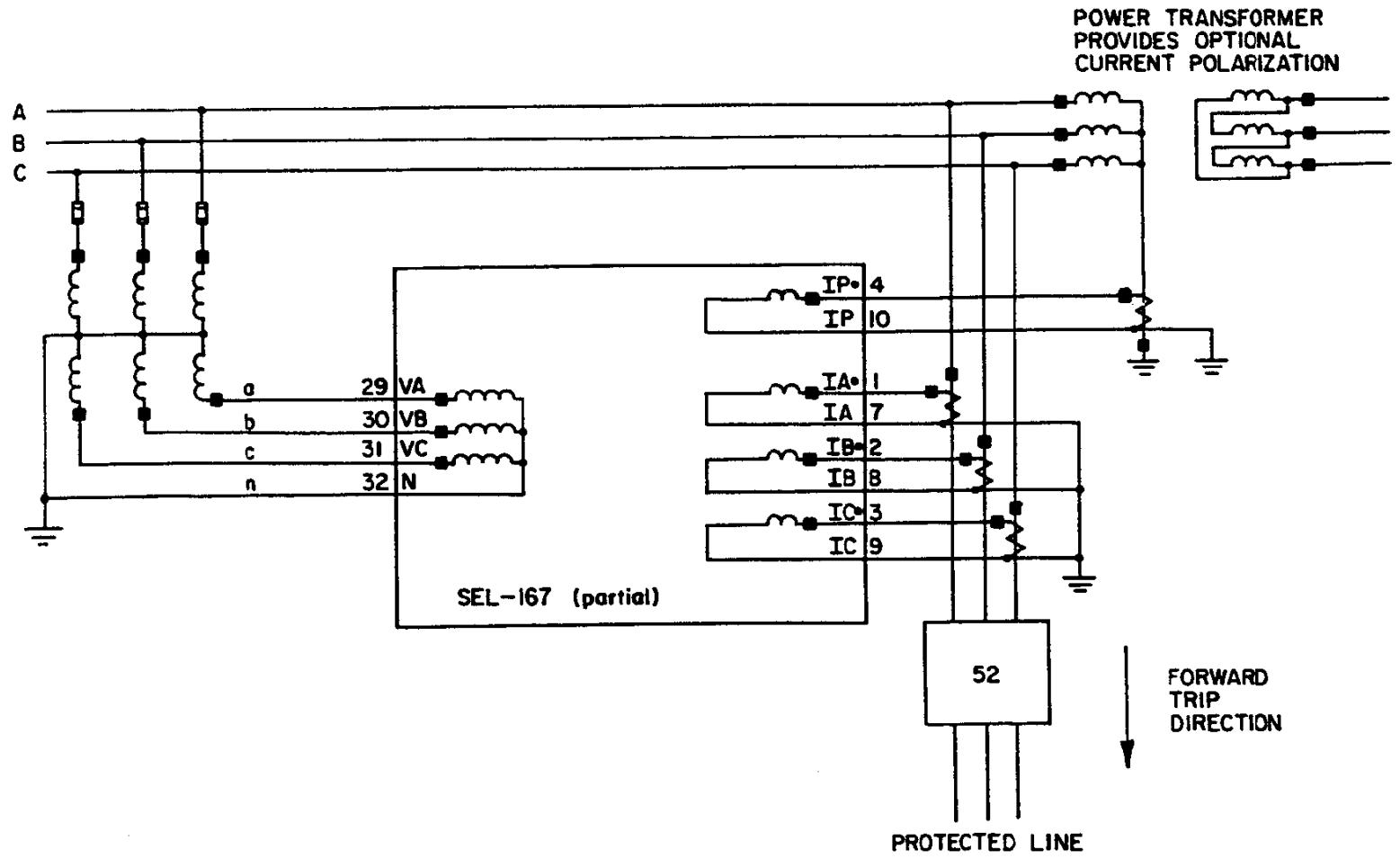
SEL-167 RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N or 51P) VERY INVERSE TIME CHARACTERISTIC (CURVE INDEX 3)

DWG. NO. A7-0244
DATE: 02-26-88



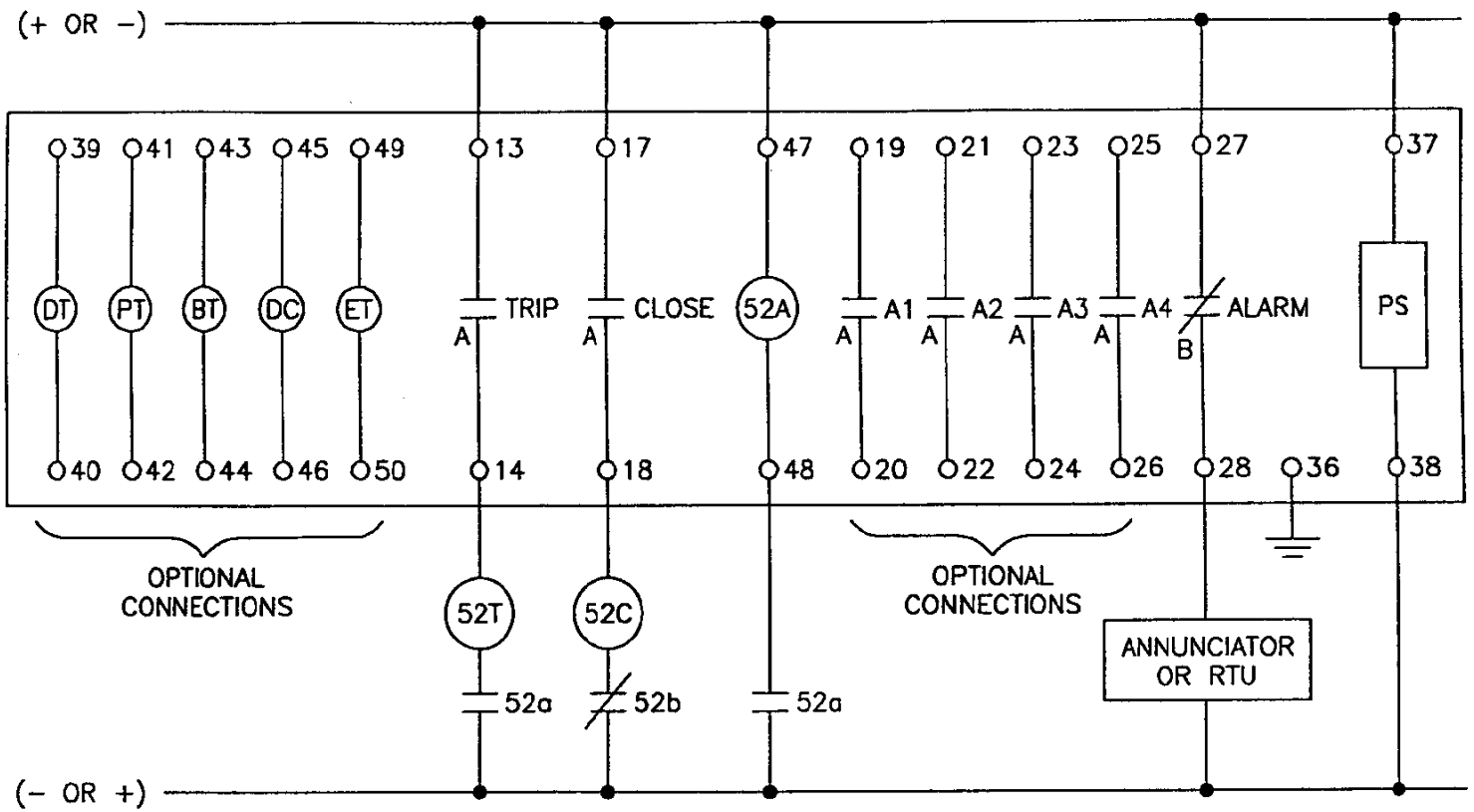
SEL-167 RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) EXTREMELY INVERSE TIME CHARACTERISTIC (CURVE INDEX 4)

DWG. NO. A7-0196
DATE: 02-26-88



SEL-167 EXTERNAL CURRENT AND VOLTAGE CONNECTIONS

DWG. NO. A7-0219
DATE: 11-16-87
REV. 5-10-88



SEL−167 DC EXTERNAL CONNECTION DIAGRAM (TYPICAL)

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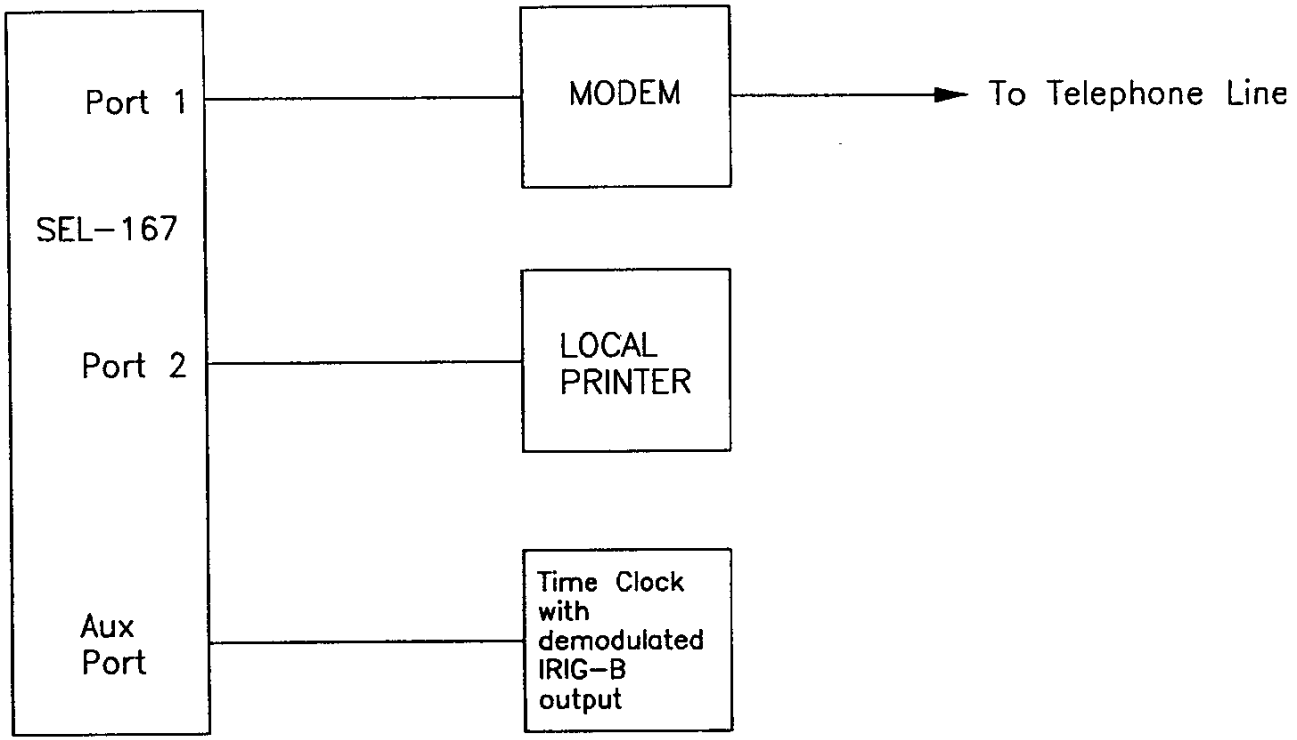
DWG. NO. A7−0284
DATE: 04−27−88
REV. 11−14−88



SEL–167 COMMUNICATIONS AND CLOCK CONNECTIONS
ONE UNIT AT ONE LOCATION

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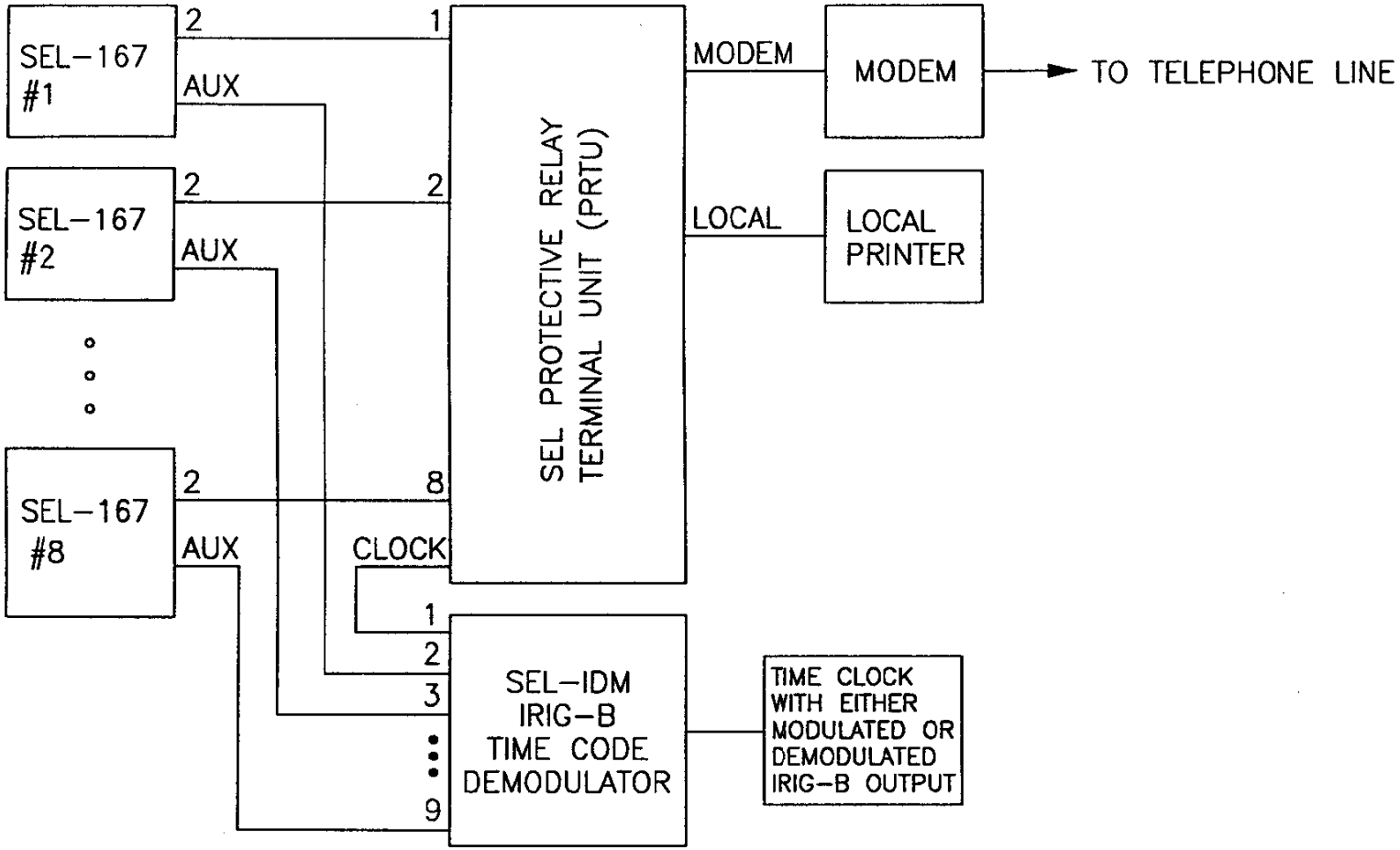
DWG. NO. A7–0223
DATE: 08–30–88
REV. 11–8–88



SEL–167 COMMUNICATIONS AND CLOCK CONNECTIONS MULTIPLE UNITS AT ONE LOCATION

NOTICE OF PROPRIETARY INFORMATION

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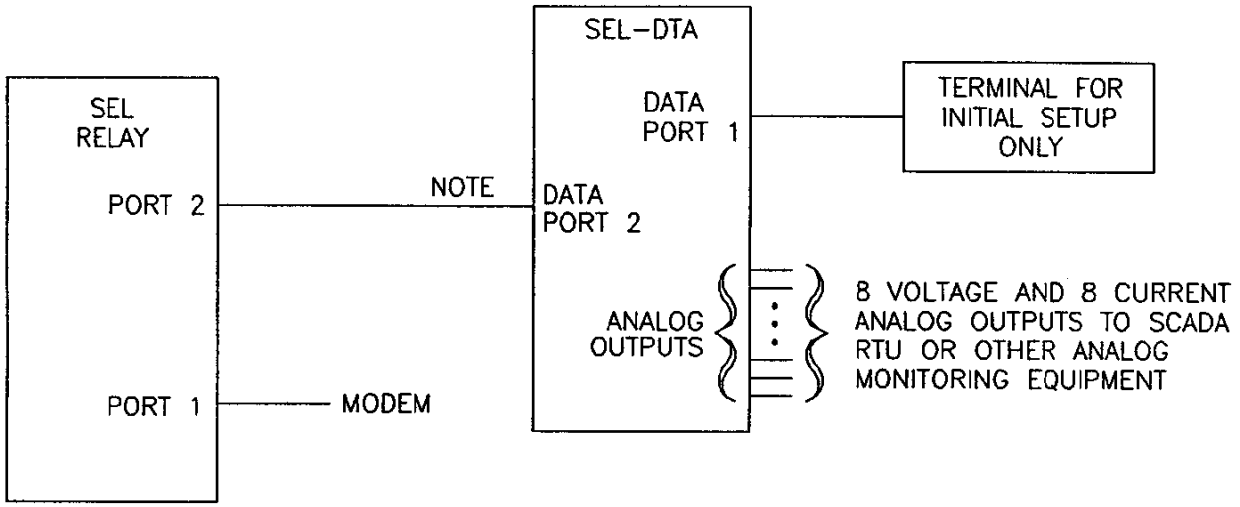
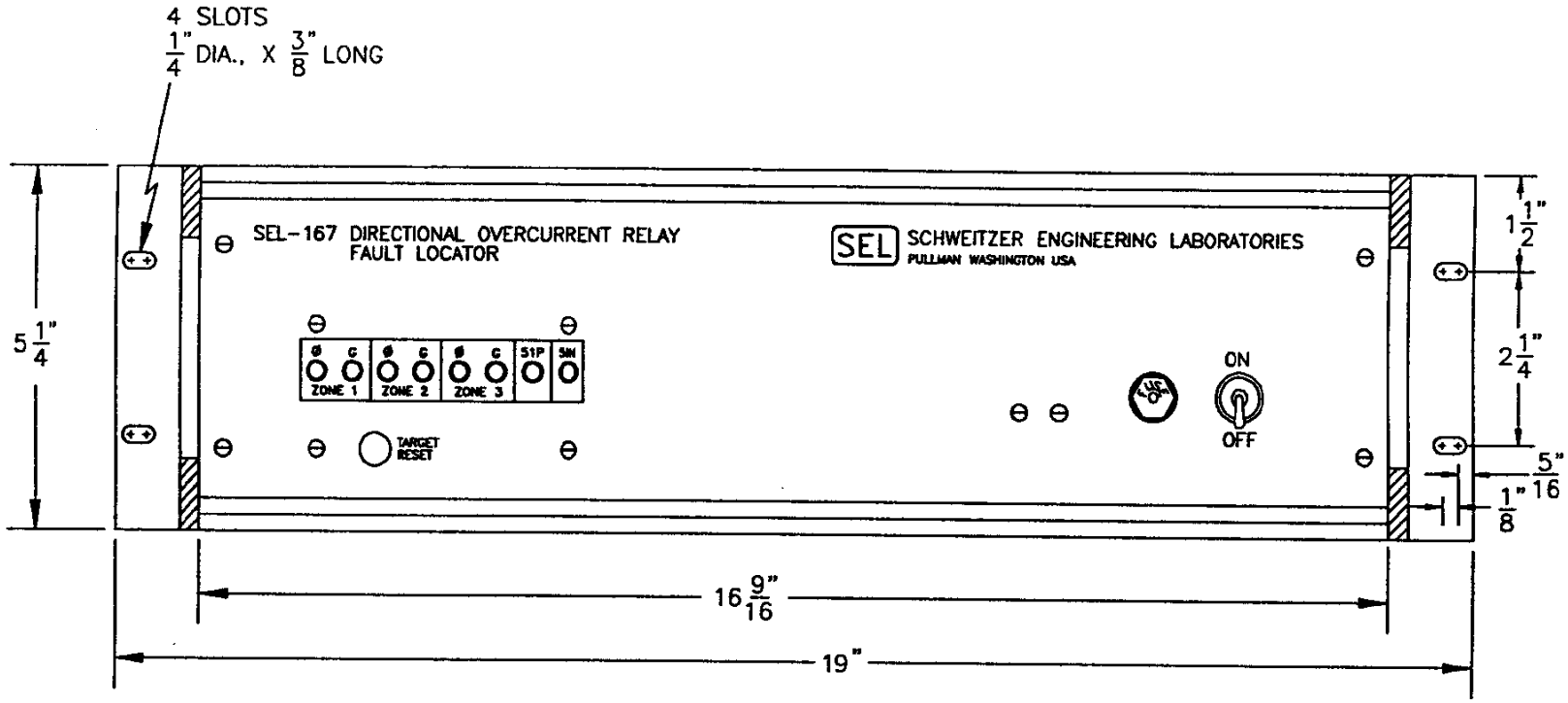
DWG. NO. A7–0224
DATE: 10–14–88
REV. 11–11–88



NOTE: SEL-DTA DISPLAY/TRANSDUCER ADAPTER (DTA)
DATA AND CONTROL POWER

SEL RELAY COMMUNICATIONS DIAGRAM FOR CONNECTION TO THE SEL-DTA

DWG. NO. A7-0413
DATE: 10-07-88



SEL-167 HORIZONTAL
FRONT PANEL DRAWING

NOTICE OF PROPRIETARY INFORMATION
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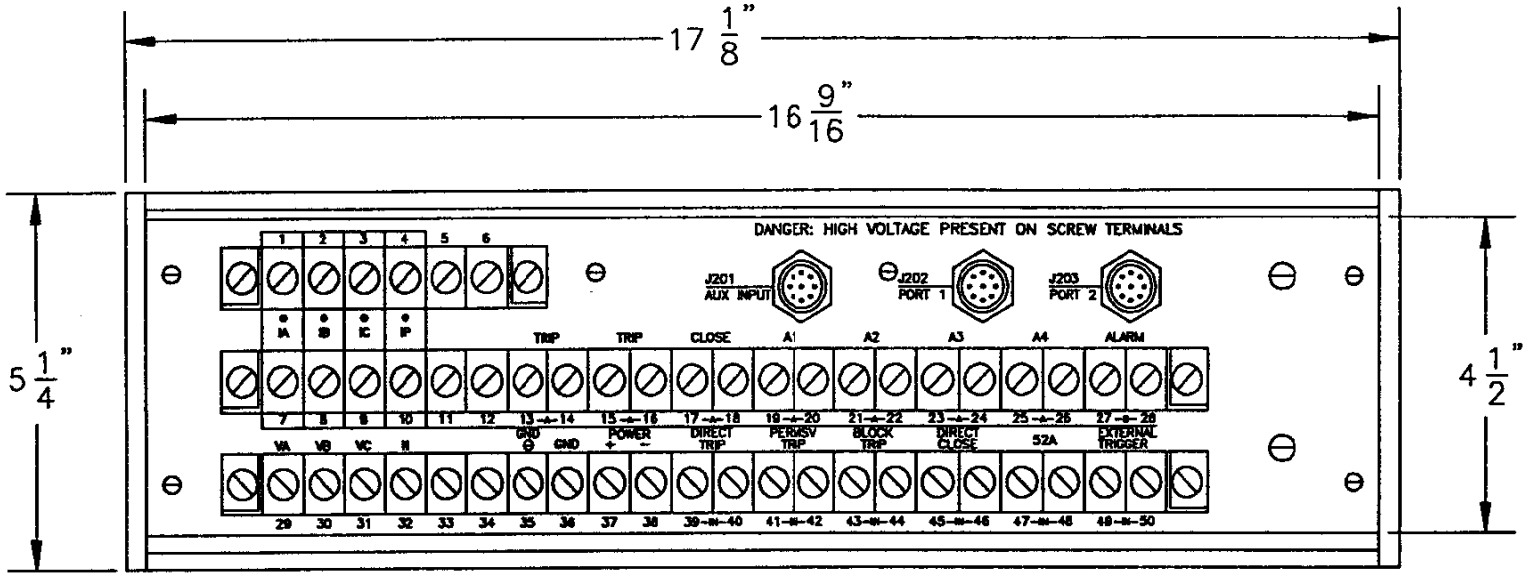
DWG. NO. A7-0232
DATE: 01-21-88
REV. 11-10-88



SEL-167 HORIZONTAL REAR PANEL DRAWING

NOTICE OF PROPRIETARY INFORMATION
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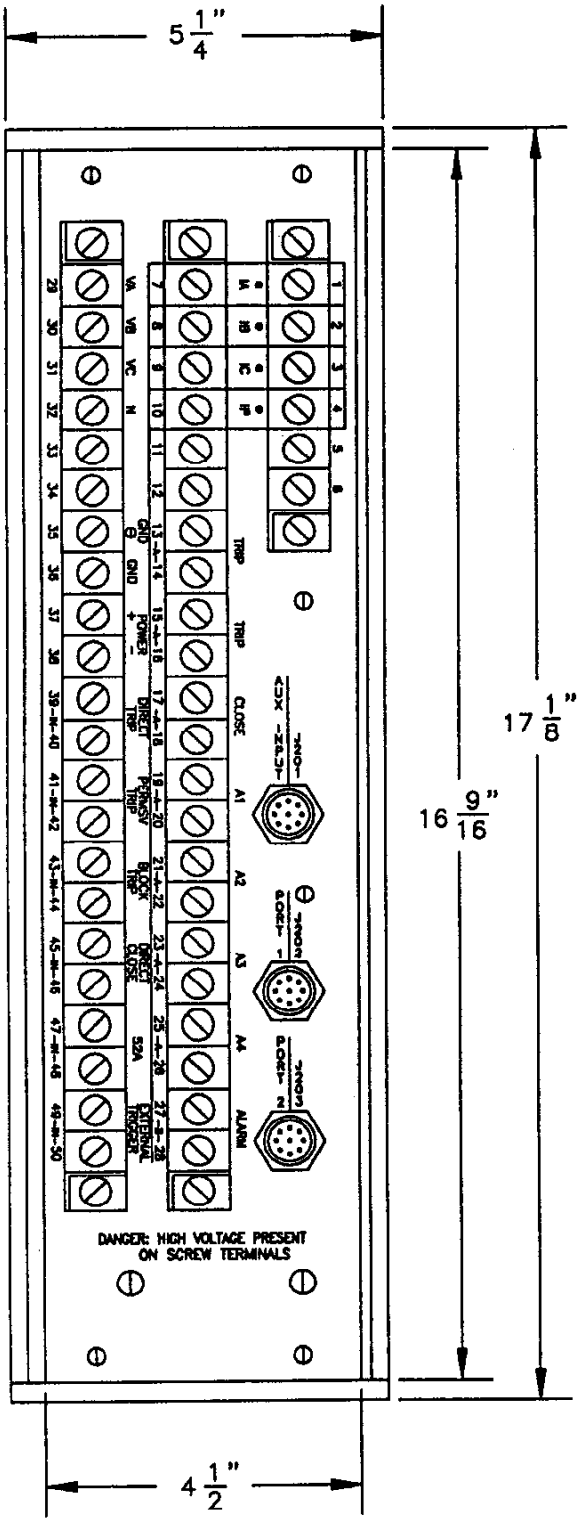
DWG. NO. A7-022
DATE: 01-16-88
REV. 11-10-88



SEL-167 VERTICAL REAR PANEL DRAWING

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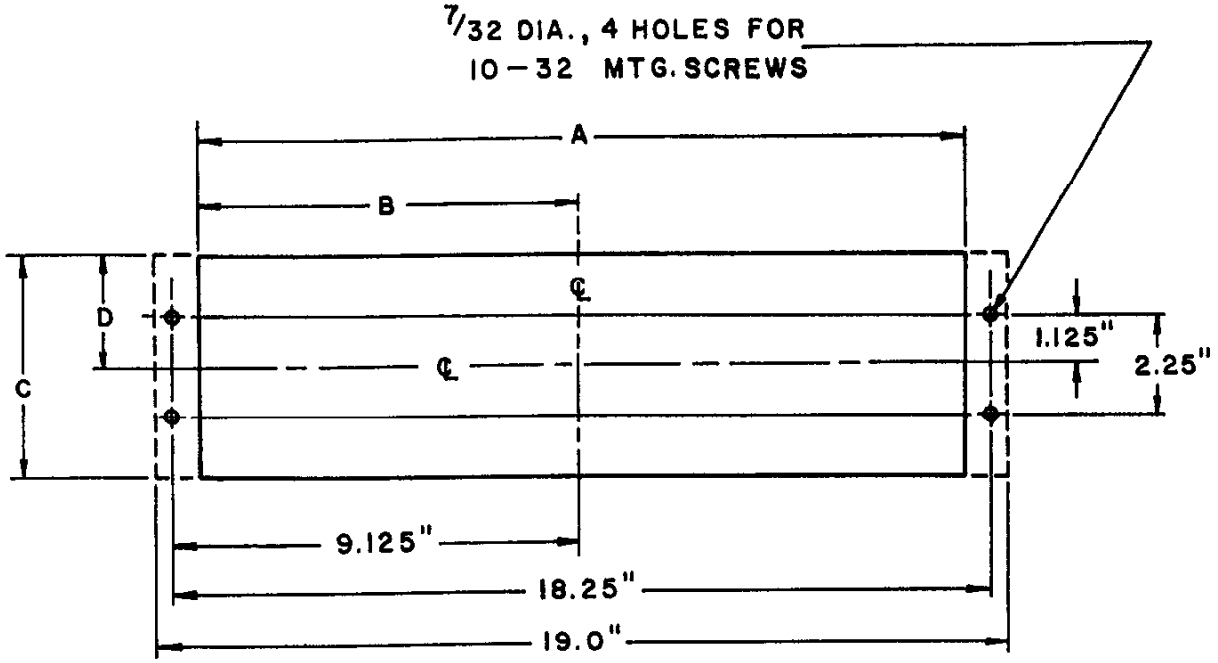
DWG. NO. A7-0234
DATE: 01-28-88
REV. 11-10-88



DIMENSION A:
CASE: 17.00"
CUT OUT: 17.25" - 17.875"
17.375" PREFERRED

DIMENSION B:
CASE: 8.5"
CUT OUT: 8.625" - 8.9375"
8.688" PREFERRED

DIMENSION C:
CASE: 5.25"
CUT OUT: 5.35" - 5.45"

DIMENSION D:
CASE: 2.625"
CUT OUT: 2.675" - 2.725"

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

PANEL CUTOUT AND DRILL PLAN FOR SEMI-FLUSH MOUNTING OF 5.25 INCH HIGH CASE

DWG. NO. A7-0174
DATE 5/11/87 JS
REV. 3/9/88

SEL-167 DIRECTIONAL OVERCURRENT 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 2/3/86 sets date to Feb. 3, 1986. This setting is overridden when IRIG-B synchronization occurs. Pulses the ALARM relay momentarily when a different year is entered than the one previously stored.

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

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

IRIG Force immediate execution of time-code synchronization task.

METER Show primary current, demand current, peak demand, voltage, and real and reactive power. METER runs once. METER N runs N times. METER R resets the peak demand currents.

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

SHOWSET Show the relay settings and logic settings--does not affect the settings. The logic settings are shown in hexadecimal format for each.

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: RELAY WORD #4	TAR 5: Contact Inputs
TAR 6: Contact Outputs	TAR R: Returns to TAR 0 and clears.

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.

LOGIC* Show or set logic masks MTU, MPT, MTO, MTB, MRI, MRC, MA1-MA4

OPEN Open circuit breaker, if allowed by jumper setting.

PASSWORD Show or set passwords. Pulses the ALARM 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.

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

* ALARM relay closes momentarily while the new settings are stored in EEPROM and event data buffers are cleared.

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