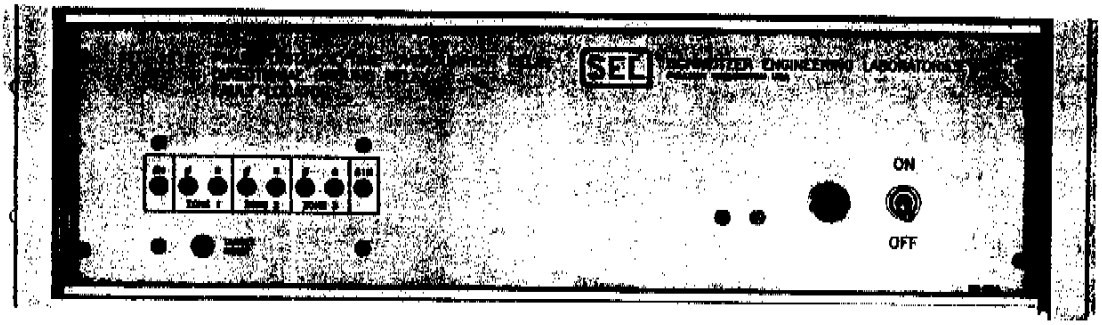
SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE HOPKINS COURT • PULLMAN, WA 99163-5603 • TEL: (509) 332-1890

Also Available In LOW-PROFILE Package

SEL-121C

PHASE DISTANCE/ TIME-OVERCURRENT RELAY GROUND DIRECTIONAL OVERCURRENT RELAY AND FAULT LOCATOR



* ZONE 1 PHASE DISTANCE ELEMENT FOR INSTANTANEOUS TRIPPING
* ZONE 2 PHASE DISTANCE ELEMENT CONTROLS TIME-OVERCURRENT ELEMENT TO COORDINATE WITH DOWNSTREAM DEVICES
* REVERSIBLE ZONE 3 PHASE DISTANCE ELEMENT FOR DEFINITE TIME TRIPPING FOR REMOTE OR LOCAL BACKUP
* RESIDUAL INSTANTANEOUS AND TIME-OVERCURRENT ELEMENTS
* REVERSIBLE RESIDUAL DEFINITE TIME-OVERCURRENT ELEMENT FOR REMOTE OR LOCAL BACKUP
* NEGATIVE- AND DUAL-POLARIZED ZERO-SEQUENCE GROUND DIRECTIONAL ELEMENTS
* PROGRAMMABLE LOGIC FOR OUTPUTS, TRIPPING, AND RECLOSING
* THREE-SHOT RECLOSING WITH SELECTABLE VOLTAGE SUPERVISION
* FAULT LOCATING * EVENT REPORTING * METERING
* AUTOMATIC SELF TESTING * RS232C COMMUNICATION

GENERAL DESCRIPTION

The SEL-121C PHASE TIME-DISTANCE RELAY AND GROUND DIRECTIONAL OVERCURRENT RELAY WITH FAULT LOCATOR provides high-speed and time-delayed phase and ground fault protection for transmission and distribution lines and cables. Zone 1 distance and high-set phase and directional residual-overcurrent elements provide fast operation. Zone 2 phase and three-phase distance elements torque-control a phase-time-overcurrent element to provide time-delayed tripping for faults beyond the reach of the zone 1. The phase time-current curve makes this relay especially easy to apply where coordination with protective devices at tapped load stations is required. The output of the zone 2 distance elements are also directly accessible for permissive overreaching transfer trip and other applications. Zone 3 phase and three-phase distance elements may be set to reach in the forward or reverse direction. For backup applications, a timer driven by the zone 3 elements is provided. The instantaneous and delayed outputs are accessible. A residual time-overcurrent element covers ground faults beyond the reach of the instantaneous overcurrent element and both its pickup and time-delayed response are accessible in the logic. A directionally-supervised residual-overcurrent element may be set to respond to forward or reverse direction faults and also drives a timer for backup.

Four types of time curves are provided for the phase and ground time-overcurrent elements: moderately inverse, inverse, very inverse, and extremely inverse. Different curve types may be selected for the phase and ground elements. Additionally, settings allow for the ground elements to be directional or nondirectional.

Loss-of-potential logic may be used to disable the mho elements whenever an unbalanced or balanced loss of potential condition exits, not associated with excessive current or current unbalance. It may also be used to cause the voltage-dependent ground-directional elements to default forward when a loss-of-potential condition exists.

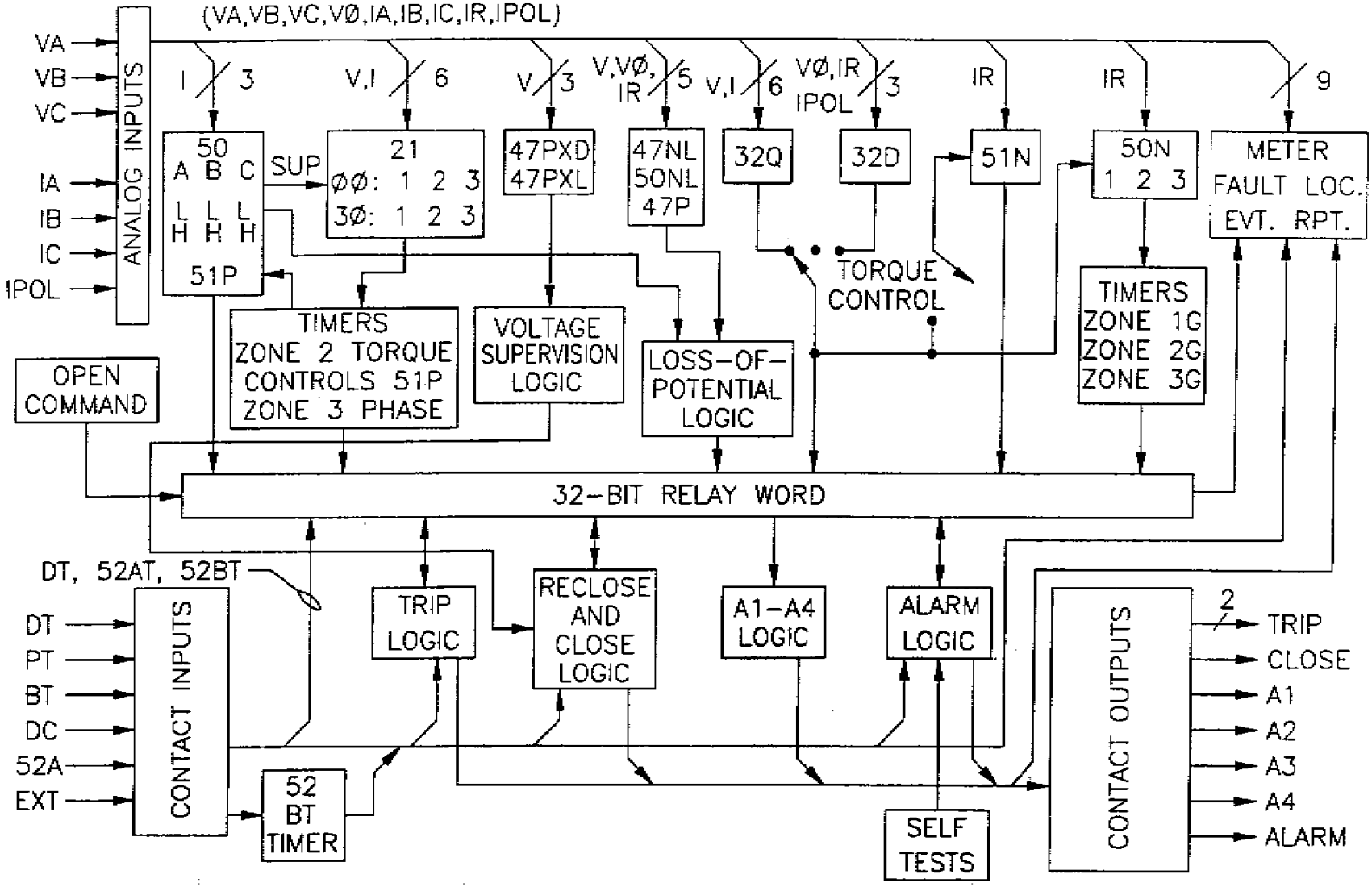
The relay elements and their timer outputs are combined in a 32-bit Relay Word. Logic, programmable by the applications engineer, combines these bits to control tripping, reclosing (initiation and cancellation), and four general programmable outputs.

A three-shot recloser is included that provides the user with three settable open interval timers, a reset timer, and voltage supervision. The reclosing initialization and closing conditions are easily defined by the applications engineer using the SET procedure.

Because of the many relay elements, the programmability of the SEL-121C relay, and its low cost, the SEL-121C 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 reclose initiate or cancel, loss of potential, alarm, and trip.

The SEL-121C 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 features, such as metering and fault locating.



SEL-121C RELAY FUNCTION BLOCK DIAGRAM

DWG. NO. A7-0336
DATE: 10-14-88
REV. 12-12-88

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 states of the intermediate results and some 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

Transmission and Subtransmission Systems

The SEL-121C relay is ideal when the protection must coordinate with downstream apparatus, taps or buses equipped with time-current protection for phase and ground faults, yet must offer high-speed phase protection over as much of the line as possible.

Replacement of Outdated Protective Relays

The SEL-121C is the ideal relay to replace obsolete electromechanical relays. Its compact size and simple field wiring make replacement especially convenient in crowded substations. 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 instrument transformer burden is negligible.

Schemes Involving Communications

Although the SEL-121C relay was designed for applications at subtransmission voltages where communications are not usually applied, the relay supports direct and permissive underreaching transfer tripping, permissive overreaching transfer tripping, and blocking schemes. Since the event report shows the voltages, currents, relay elements, inputs and outputs, it is easy to evaluate scheme performance.

Backup Relaying

Where adequate high-speed primary protection already exists, the SEL-121C relay can be applied for backup. Its programmability 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-121C relay is also cost-effective in these applications: fault locating, temporary installations, bus-tie breaker relaying (where frequent setting changes may be required), and remote control and monitoring.

SPECIFICATIONS

Relay Functions

Mho characteristics for phase-phase and three-phase faults
- Zone 1: Instantaneous trip
- Zone 2: Controls phase time-overcurrent element
- Zone 3: Definite-time trip

Residual-overcurrent protection for ground faults
- One instantaneous element
- Two 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.

Zone 3 mhos and the definite-time element may be reversed for local backup schemes or other applications.

Automatic reclosing with voltage supervision for selectable fault types (3 shots).

High-set phase-overcurrent elements

Relay Elements

Phase overcurrent:
- 50AL, 50BL, 50CL (phase fault detectors)
- 50AH, 50BH, 50CH (high-set elements)
  - 0.5 to 40 A pickup +/- 0.1 A +/- 2% of setting
- 51P phase time-overcurrent element.
  - 1 - 12 A pickup setting,
  - +/- 0.05A +/- 2% of settings above 3 A
  - +/- 0.2A +/- 5% of settings below 3 A

Three-phase and phase distance:
- 21ABC1, 21P1: 0.125 to 32 ohms
- 21ABC2, 21P2: 0.125 to 128 ohms
- 21ABC3, 21P3: 0.125 to 128 ohms

Angle setting: 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.

Mho elements operate in 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 and 0.5 < I < 2 A.

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

Memory polarization:
Zone 1, 2, and 3 three-phase elements are memory polarized using voltage from a four-cycle memory.

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 +/- 2% of setting.
50N1, 50N2, and 50N3 residual-overcurrent elements.
Pickup: 0.2 to 47 times 51N pickup.
Timers are provided for 50N2 and 50N3:
Zone 2 Timer: 0-2000 cycles in 0.25 cycle steps
Zone 3 Timer: 0-2000 cycles in 0.25 cycle steps

Ground Directional Elements:
Negative-sequence directional element:
Angle: same as mho element setting.

Zero-sequence directional element:
Voltage polarization:
Angle: same as mho element setting

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: 0.083 amps I0
Positive-sequence overvoltage element (47P)
Pickup: 14 volts
Positive-sequence dead line threshold (47PXD)
Pickup: User settable ($0 \leq 47PXD \leq 75V$), +/- 6% of setting
Positive-sequence live line threshold (47PXL)
Pickup: User settable ($0 \leq 47PXL \leq 75V$), +/- 6% of setting

Fault Location	Fault location is computed from event reports stored following each fault. Algorithm compensates for prefault current for improved accuracy for high-resistance faults.
Fault Reporting	A data record is retained for each of the 12 most recent faults, which includes date, time, location, 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	115 volt nominal 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 Current	30 amp make per IEEE C37-90 para 6.6.2 6 amp carry continuously MOV protection provided
Logic Input Ratings	25 - 60 VDC for 48 VDC relays 60 - 200 VDC for 125 VDC relays 200 - 280 VDC for 250 VDC relays Current = 6 mA at nominal voltage
Power Supply	48 Volt: 30 - 60 VDC; 12 watts 125 Volt: 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)
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. Also available for vertical mounting.
Unit Weight	21 pounds

Operating Temperature	-20 deg C to + 55 deg C
Burn-in Temperature	60 deg C for 100 hours

Basic Protective Capabilities

The SEL-121C relay provides complete protection for transmission line faults of all types.

Phase-to-Phase and Three-Phase Faults:

Three zones are provided. Zones 1, 2, and 3 are mho circles passing through the origin. Zone 3 may be reversed. The instantaneous outputs of all three elements are available. The zone 2 elements torque-control a phase time-overcurrent element, making it possible to coordinate zone 2 operations with downstream time-current devices. The zone 3 elements control a timer, so that a definite-time-delay output is available for local or remote backup.

The three-phase elements are supervised by three overcurrent elements, which must all pick up. Four-cycle memory polarization is provided for zones 1, 2, and 3.

The phase-to-phase characteristics are mho, based on the compensator-distance principle. They have no response for three-phase faults. They are supervised by three overcurrent elements. At least one overcurrent element must pick up to enable the phase-to-phase mho elements. They are also supervised by a loss-of-potential scheme, when enabled.

Three high-set nondirectional overcurrent elements provide backup to the three-phase and phase-to-phase mho elements. They are nondirectional.

Ground Faults:

Ground fault protection consists of an instantaneous residual-overcurrent element, a time-overcurrent element, and two definite time elements.

Direction is determined by a negative-sequence directional element, and a dual-polarized zero-sequence element. Settings are provided to select the negative-sequence element, or neither, either or both sources of zero-sequence polarization. When voltages are lost, the direction is assumed forward. To securely discriminate between forward and reverse-direction faults, the directional elements have a torque threshold which must be exceeded in either direction before the fault direction is declared.

The direction of the 50N3 residual-overcurrent element may be reversed, to assist in local backup and in weak-infeed schemes.

The curve shape of the time-overcurrent element is user-selectable. This element is either nondirectional or forward-reaching, as enabled.

Switch-Onto-Fault Protection:

The high-set overcurrent elements will respond to a zero-voltage three-phase fault at any time.
The four-cycle memory polarization of the three-phase elements guarantees positive action for four cycles when bus-side voltages are used.

The 52BT timer and the MTO mask may be used to select relay elements (such as the Zone 2 distance element or the pickup of the sensitive overcurrent elements) for instantaneous tripping, until a short time after the breaker is closed.

Reclosing:

A three-shot reclosing relay is provided. Reclosing may be initiated or cancelled for any of the relay elements in the Relay Word.

Voltage supervision is provided in the reclosing logic. The SEL-121C reclosing relay provides multi-shot reclosing for dead voltage, live voltage, or no voltage supervision. The voltage conditions must be satisfied to initiate the open interval timer (79OI) and to assert a close contact. An option is provided through the setting procedure (CVC) to require voltage supervision to initiate the open interval timer, but to allow closing regardless of the voltage conditions at close time. The voltage supervision can be specified to be satisfied on the first shot only, or on all shots using the VSA setting in the SET procedure.

The reclosing relay in the SEL-121C uses user-settable timers to ensure a finite reclosing time. A voltage condition timer (VCT) defines the maximum time allowed for the supervising voltage conditions to be met. If the voltage conditions are met for one cycle before the expiration of VCT timer, a successful voltage condition is declared and the open interval timer (79OI) is allowed to run. At the expiration of the open interval timer, the supervisory requirements for closing are checked against the existing voltage conditions, and if satisfied, the close contact is asserted.

LOGIC DESCRIPTION

Relay Elements

Single-phase overcurrent relays	50AL 50BL 50CL	(phase fault detectors)
High-set single phase OC relays	50AH 50BH 50CH	
Zone 3 three-phase mho distance	21ABC3	(reversible)
Zone 3 line-line mho distance	21P3	(reversible)
Zone 2 three-phase mho distance	21ABC2	torque-controls 51P
Zone 2 line-line mho distance	21P2	torque-controls 51P
Zone 1 three-phase mho distance	21ABC1	
Zone 1 line-line mho distance	21P1	

Phase time-overcurrent pickup	51PP	T.C. by 21ABC2, 21P2
Phase time-overcurrent trip	51PT	T.C. by 21ABC2, 21P2
Residual time-overcurrent pickup	51NP	T.C. or nondirectional
Residual time-overcurrent trip	51NT	T.C. or nondirectional
Residual inst-overcurrent	50N1	nondirectional
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	14 V Vo (loss-of-pot det)
Zero-sequence overcurrent	50NL	83 mA Io (loss-of-pot det)
Positive-sequence overvoltage	47P	14 V V+ (loss-of-pot det)
Positive-sequence voltage-aux	47PXD	Dead voltage detector (if $Vpos_{LL} \leq$ 47PXD => dead voltage)
Positive-sequence voltage-aux	47PXL	Live voltage detector (if $Vpos_{LL} \geq$ 47PXL => live voltage

Contact Inputs

Direct trip	DT
Permissive 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.

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

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

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

```
50L  = 50AL + 50BL + 50CL              phase fault current supervision
3P50 = 50AL * 50BL * 50CL              three-phase fault current supervision
50H  = 50AH + 50BH + 50CH              high-level overcurrent condition

Z3ABC = 21ABC3 * 3P50 * NOT (LOP)                    (3ABC in relay word)
Z2ABC = 21ABC2 * 3P50 * NOT (LOP)                    (2ABC in relay word)
Z1ABC = 21ABC1 * 3P50 * NOT (LOP)                    (1ABC in relay word)

Z3P = 21P3 * 50L * NOT (LOP)
Z2P = 21P2 * 50L * NOT (LOP)
Z1P = 21P1 * 50L * NOT (LOP)

DF  = (32QF + LOP) * 32QE + 32DF * 32IE +
      (32DF + LOP) * 32VE + NOT(32QE + 32VE + 32IE)  forward direction
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                                     T.C.
67N2 = 50N2 * DF                                     T.C.
67N3 = 50N3 * D3                                     T.C. 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 if Zone 3 = R.

```
Z2GT = 67N2 * Z2GTMR                   zone 2 timeout-ground
Z3PT = (Z3P + Z3ABC) * Z3PTMR          zone 3 timeout-phase
Z3GT = 67N3 * Z3GTMR                   zone 3 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:

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

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

SEL-121C RELAY WORD BIT SUMMARY TABLE

51PT - Phase time-overcurrent trip
1ABC - Zone 1 three-phase mho distance element
2ABC - Zone 2 three-phase mho distance element
3ABC - Zone 3 three-phase mho distance element
51PP - Phase time-overcurrent pickup

50H - High set instantaneous overcurrent element
50L - Low set instantaneous overcurrent element
LOP - Loss of potential element

51NT - Ground time-overcurrent trip
67N1 - Zone 1 ground directional overcurrent element
67N2 - Zone 2 ground directional overcurrent element
67N3 - Zone 3 ground directional overcurrent element
51NP - Ground time-overcurrent pickup
Z1P - Zone 1 phase-phase mho element
Z2P - Zone 2 phase-phase mho element
Z3P - Zone 3 phase-phase mho element

DF - Direction forward
DR - Direction reverse
Z2GT - Zone 2 timeout-ground
Z3GT - Zone 3 timeout-ground
3P50 - Three-phase overcurrent element
RC - Reclose cancellation
RI - Reclose initiation
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

The use of the relay word and programmable masks provides the user with great flexibility in applying the SEL-121C relay, 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 flag 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) * (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", the "+" indicates logical "or", and the + indicates exclusive "or".

RECLOSING RELAY

The reclosing relay provides up to three shots of automatic reclosing for selectable fault types. The three open intervals and the reset timer are individually programmable and voltage supervision can be employed.

To provide flexibility in applying the SEL-121C relay 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 SEL-121C relay has the option for voltage supervision of the reclosing function. The voltage supervision can be selected to reclose on live voltage, dead voltage or can be disabled. These conditions, as well as 47PX thresholds to define live voltage/dead voltage conditions are fully user-selectable using the SET procedure. For example, to reclose only for all Zone 1 faults, and to supervise the reclose with a dead voltage condition, the following would be representative settings:

47PXD = 10	This defines the positive sequence dead voltage threshold as 10kV phase-to-phase.
VCT = 100	The voltage condition timer insures that the reclosing relay has a finite time in which to satisfy the supervising voltage conditions. VCT defines the maximum time allowed for the supervising voltage conditions to be met. VCT begins timing after the trip unasserts and the breaker opens, as indicated by the 52A contact.
LLC = N	Disables live voltage supervision.

DLC	= Y	Enables dead voltage supervision.
CVC	= Y	When CVC is enabled, voltage supervision is required to begin the open interval timer, and voltage supervision is required at the expiration of the open interval timer to close.
VSA	= Y	Enables voltage supervision for all shots. If VSA = N, only the first shot is supervised, with subsequent shots being unsupervised.
MRI:	40 44 00 00	MRI, the mask for reclose initiation, is set so that reclosing will be initiated only for Zone 1 phase and ground faults. This is done using the "LOG MRI" command.

The SEL-121C relay voltage supervision logic assumes line side PT's for live voltage/dead voltage supervision. There are no capabilities provided in this relay for line side/bus side checking or sync-check.

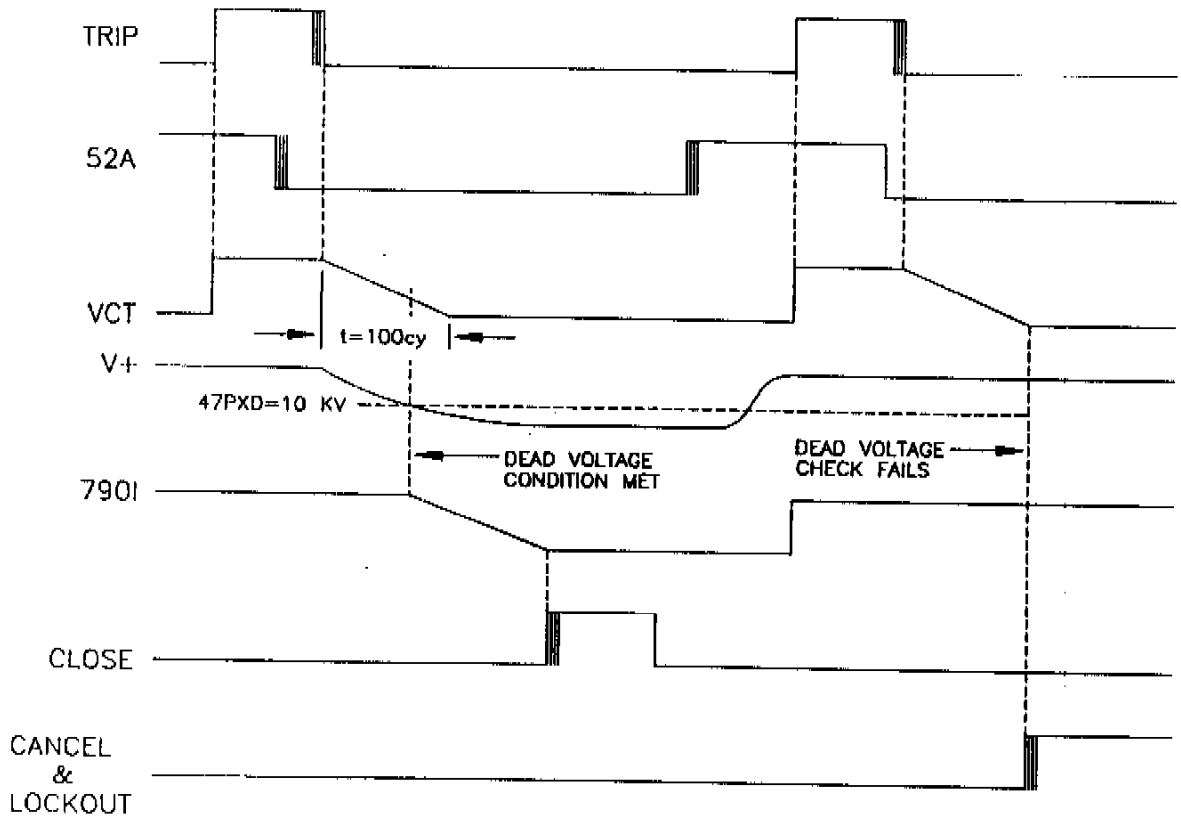
The following timing diagrams illustrate the above settings in a reclosing sequence. A first shot with dead voltage supervision is shown in all timing diagrams. The second shot illustrates some of the features of the SEL-121C reclosing relay.

Timing diagram TD1 shows the first shot of the dead voltage supervised reclose followed by a cancelled second shot. The failure of the second shot to reclose is due to the supervising voltage conditions remaining unsatisfied during the voltage condition timer period. In this case, the positive sequence voltage, V+, does not decay, and therefore the magnitude of V+ is greater than the positive sequence dead voltage threshold, 47PXD. This condition remains throughout the duration of the voltage condition timer, VCT. At the expiration of VCT, reclosing is cancelled due to voltage supervision. If, at any time during the duration of the voltage condition timer, the positive sequence voltage decays such that it is less than 47PXD and remains in this state for one power system cycle, the voltage condition would have been declared valid and the open interval timer run.

Timing diagram TD2 illustrates, again, a first shot, followed by a cancelled second shot due to voltage supervision. This diagram shows a reclose cancellation due to an unsatisfactory voltage condition at close time. The supervising voltage conditions were satisfied and the open interval timer was run. At expiration of the open interval timer (79OI), the voltage conditions are checked before the close contact is asserted. The voltage conditions are not satisfied, and the reclosing sequence is cancelled.

Timing diagram TD3 shows identical system conditions to those of TD1, but with a setting change that allows a successful reclose on the second shot. If VSA=N, only the first shot will have voltage supervision.

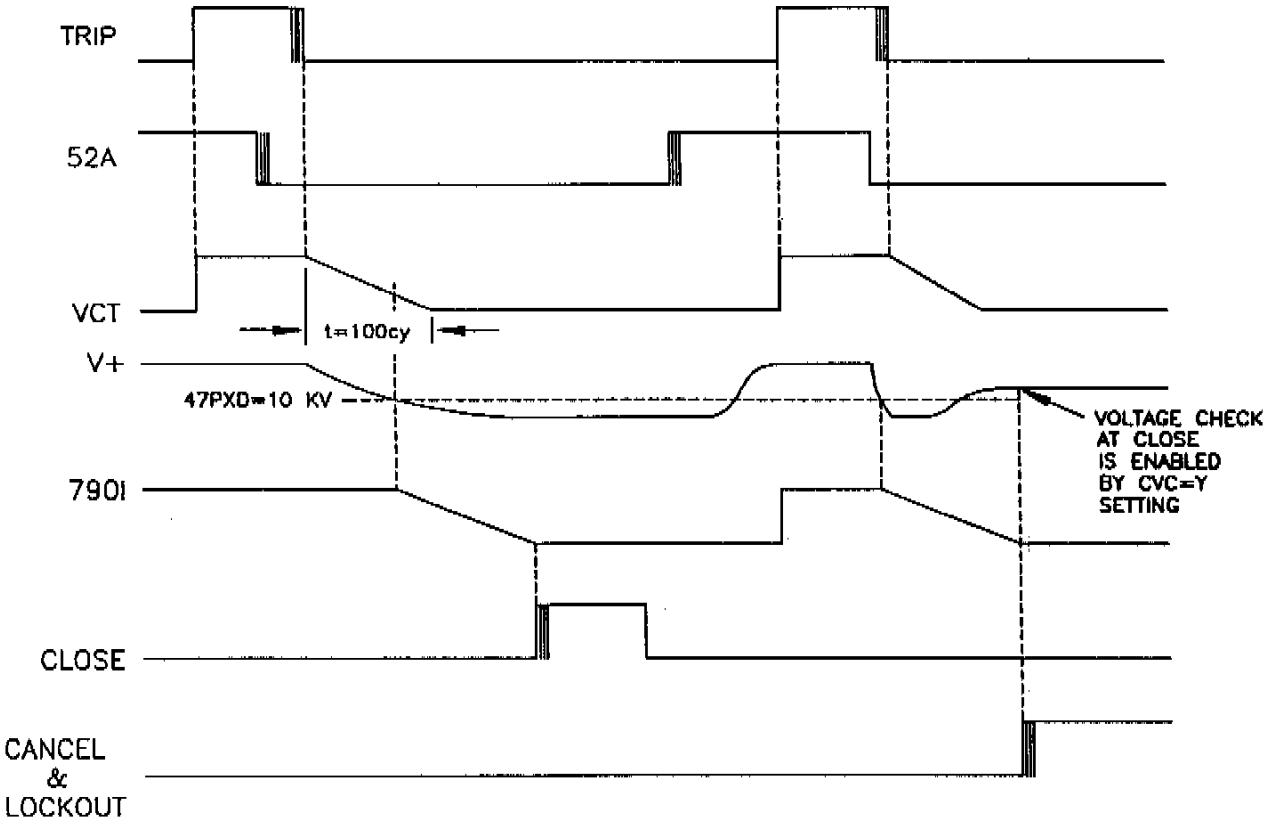
Timing diagram TD4 shows identical system conditions to those of TD2, but with no voltage supervision required at close (CVC = N). The supervising voltage conditions are met to start the open interval timer, but are not required to assert the close contact.



Timing diagram showing the first shot of a dead voltage supervised reclose, followed by a cancelled second shot due to bad voltage conditions not allowing the open interval timer to begin.

TIMING DIAGRAM TD1

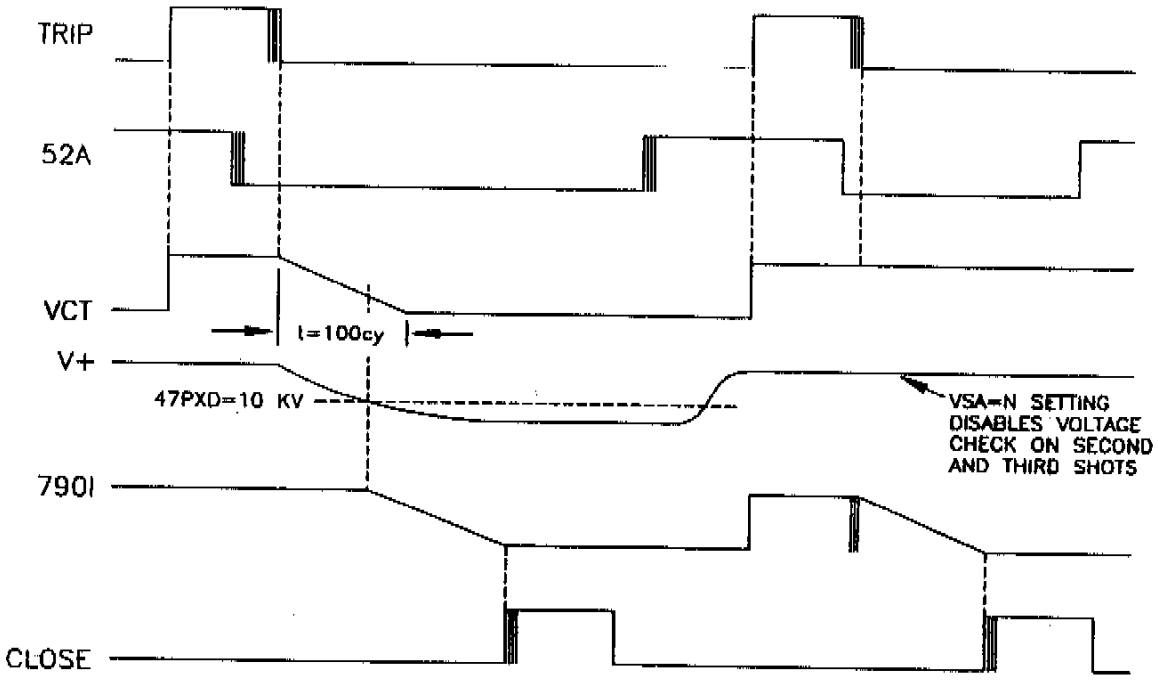
DWG. NO. A7-0421
DATE: 10-19-88



Timing diagram showing the first shot of a dead voltage supervised reclose, followed by a cancelled second shot due to bad voltage conditions at close.

TIMING DIAGRAM TD2

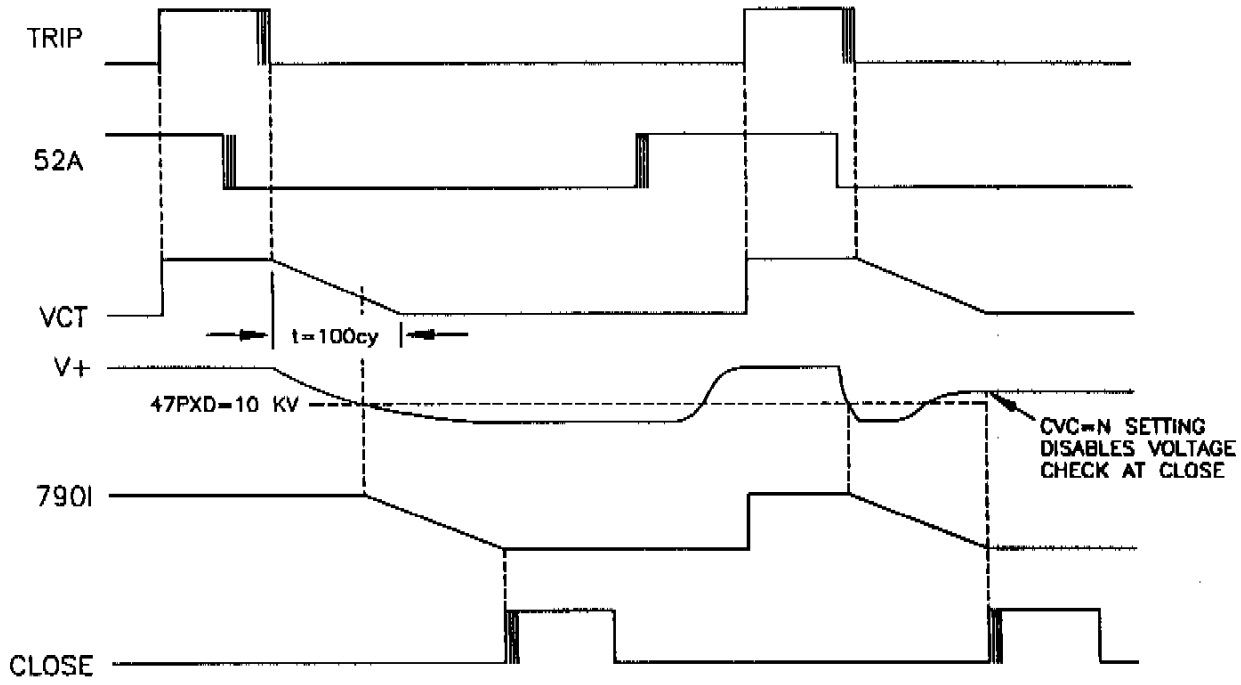
DWG. NO. A7-0422
DATE: 10-19-88



Timing diagram showing the first shot of a dead voltage supervised reclose, followed by a second shot. Voltage supervision is only required for the first shot by setting VSA=N.

TIMING DIAGRAM TD3

DWG. NO. A7-0423
DATE: 10-19-88



Timing diagram showing the first shot of a dead voltage supervised reclose, followed by a second shot. Voltage supervision is not required at close by setting CVC=N.

TIMING DIAGRAM TD4

DWG. NO. A7-0424
DATE: 10-19-88

The above illustrates the use of the SEL-121C voltage supervised reclosing relay for a dead voltage application. An analogous group of settings can be defined for an equally flexible live voltage application.

The following logic equations define the SEL-121C relay reclosing function:

- RECLOSE INITIATION

$$RI = R * MRI$$

- RUN OPEN INTERVAL TIMER 79OI WITH VOLTAGE SUPERVISION

$$VI = (LLC * 47PXL) + (DLC * \overline{47PXD}) + \overline{VSUP}$$

$$VSUP = (LLC \oplus DLC) * [(\overline{VSA} * \overline{SHOT}) \oplus VSA]$$

- RECLOSING CANCELLATION WITH VOLTAGE SUPERVISION

$$RC_V = (R * MRC) + 79RS_{exp} + \overline{wtim_{exp}} + VCT_{exp}$$

- RECLOSE TRIPPED BREAKER

$$Reclose = RI_V * \overline{RC_V} * VC * 79OI_{exp}$$

$$VC = (DLC * \overline{47PXD}) + (LLC * 47PXL) + \overline{VSUP} + CVC$$

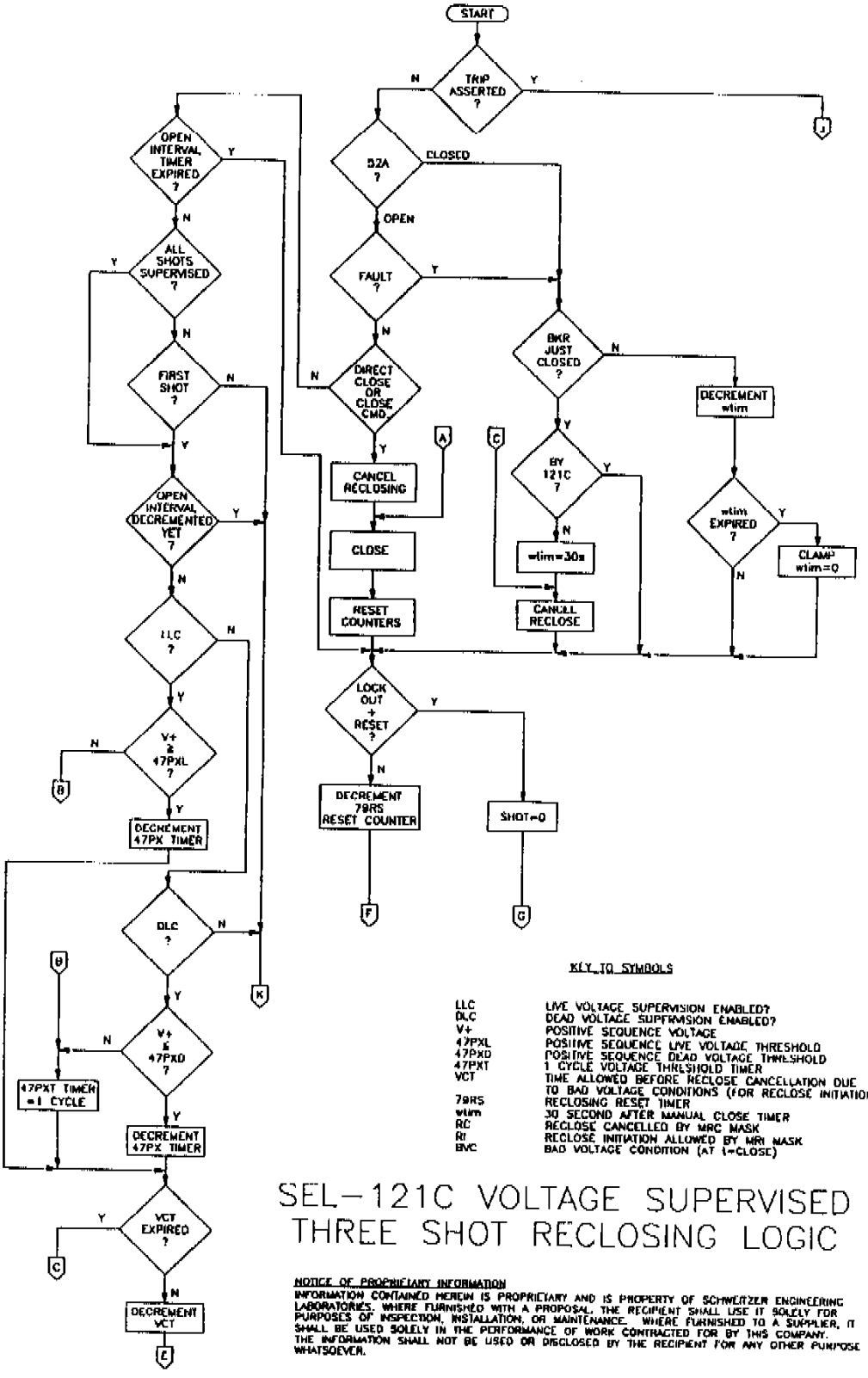
Where

RI	:	Reclose initiation
R	:	Relay word
MRI	:	Reclose initiate mask
VI	:	Voltage conditions to start 79OI timer
LLC	:	Live voltage check enabled setting
DLC	:	Dead voltage check enabled setting
47PXL	:	Positive sequence voltage - live voltage
47PXD	:	Positive sequence voltage - dead voltage
VSUP	:	Voltage supervision required for this shot
VSA	:	All shots require voltage supervision
SHOT	:	Shot counter - zero relative
RC_V	:	Reclose cancel with voltage supervision
79RS	:	Reclosing reset timer
MRC	:	Reclose cancel mask
VCT	:	Voltage condition time
wtim	:	Thirty-second timer for external close
CVC	:	Check voltage at close
79OI	:	Open interval timer
VC	:	Voltage conditions necessary to reclose

The reclose initiation and cancellation due to the logic masks (R * MRI, R * MRC) are only applicable during the time for which the trip output is asserted. For example, if reclosing is not initiated before the trip output unasserts, then the reclosing function will be locked out and no reclose will occur.

The open intervals do not begin until the TRIP output unasserts and any supervising voltage conditions are met. Since the TRIP output never asserts for less than 60 ms and the voltage condition may take a finite time to be satisfied, 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 if a fault occurs.

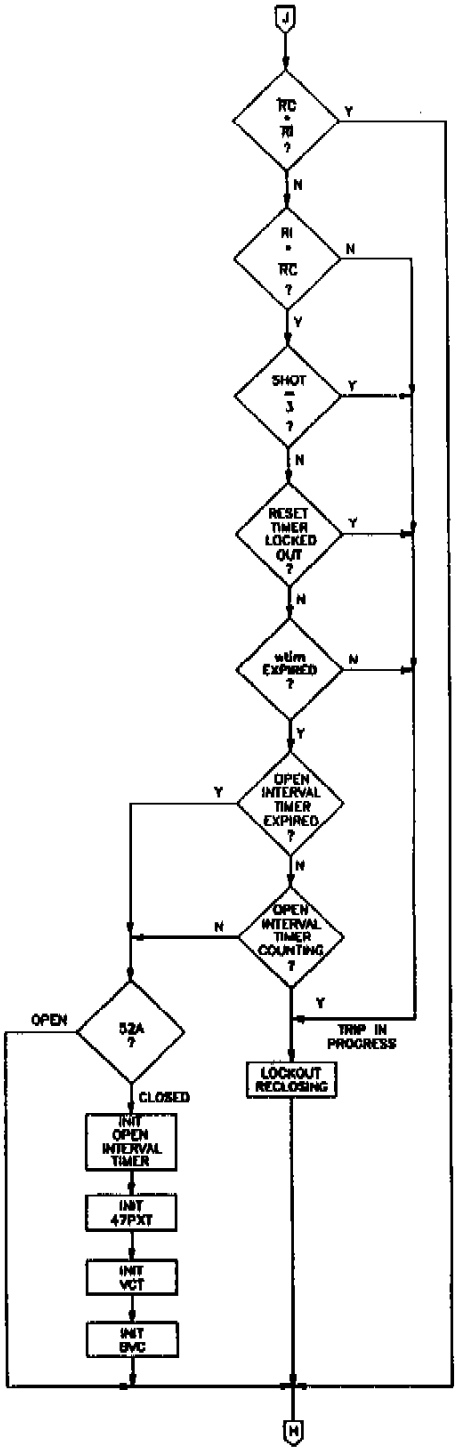


KEY TO SYMBOLS

LLC	LIVE VOLTAGE SUPERVISION ENABLED?
DLC	DEAD VOLTAGE SUPERVISION ENABLED?
V+	POSITIVE SEQUENCE VOLTAGE
47PXL	POSITIVE SEQUENCE LIVE VOLTAGE THRESHOLD
47PXD	POSITIVE SEQUENCE DEAD VOLTAGE THRESHOLD
47PXT	1 CYCLE VOLTAGE THRESHOLD TIMER
VCT	TIME ALLOWED BEFORE RECLOSE CANCELLATION DUE TO BAD VOLTAGE CONDITIONS (FOR RECLOSE INITIATION)
79RS	RECLOSING RESET TIMER
wtim	30 SECOND AFTER MANUAL CLOSE TIMER
RC	RECLOSE CANCELLED BY MRC MASK
RI	RECLOSE INITIATION ALLOWED BY MRI MASK
BVC	BAD VOLTAGE CONDITION (AT 1=CLOSE)

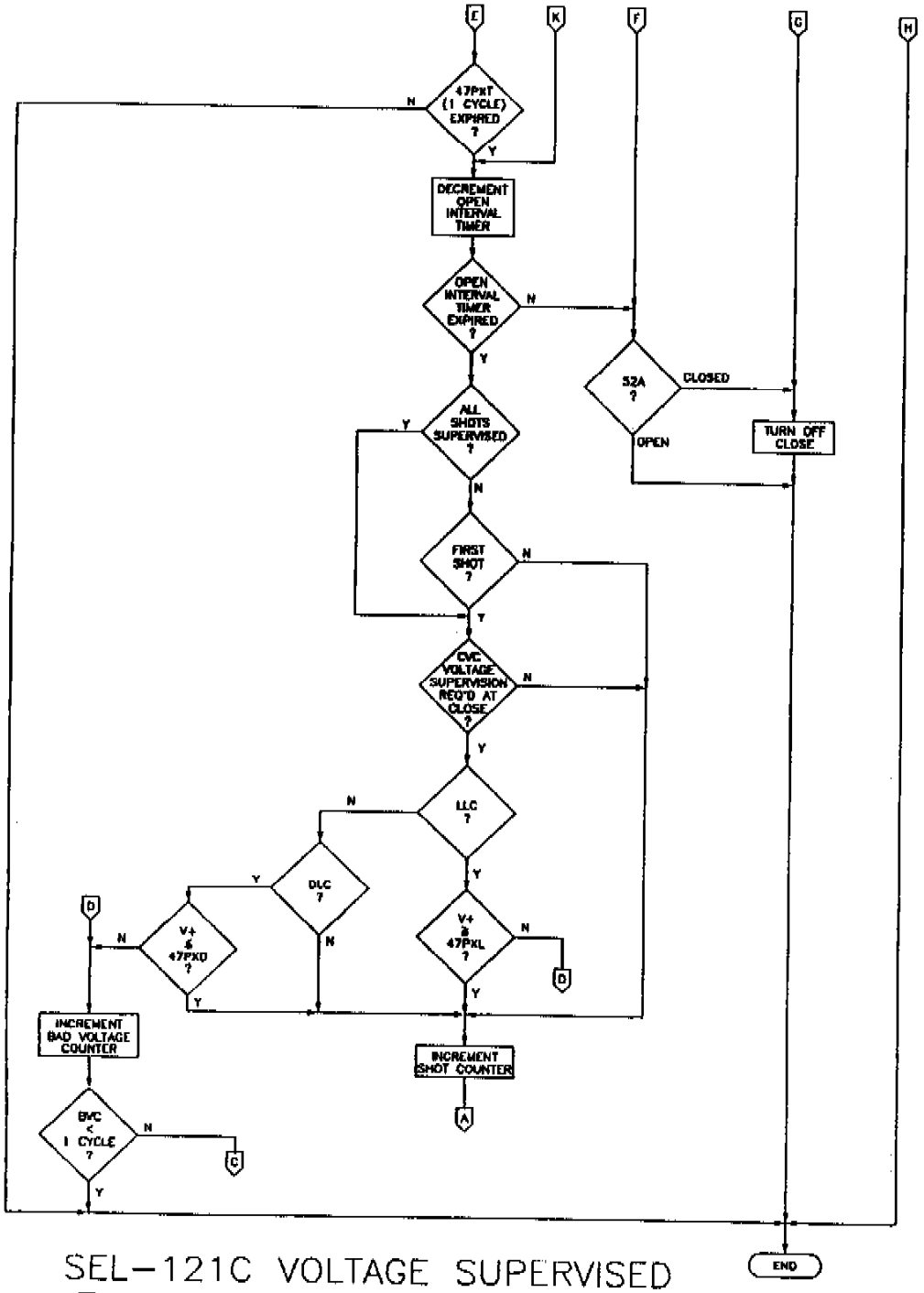
SEL-121C VOLTAGE SUPERVISED THREE SHOT RECLOSING LOGIC

DWG. NO. A7-0400A
DATE: 10-18-88
REV. 04-12-89



SEL-121C VOLTAGE SUPERVISED THREE SHOT RECLOSING LOGIC

DWG. NO. A7-0400B
DATE: 10-18-88
REV. 04-12-89



SEL–121C VOLTAGE SUPERVISED THREE SHOT RECLOSING LOGIC

DWG. NO. A7–0400C
DATE: 10–18–88

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 shown, only the XO value was changed. It was changed from 159.69 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 user 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.

```
=>SET

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

ID    : Example 69kV Line
 ?
R1    : (Ohms pri)..... = 49.83    ?
X1    : ..... = 56.32    ?
R0    : ..... = 56.07    ?
X0    : ..... = 159.69   ? 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         ?

47PXD: Dead volts (kV ph-ph). = 10.00    ?
47PXL: Live volts..... = 25.00    ?
VCT   : Volt cond timer (cyc). = 100.00   ?

LLC   : Live check only (Y/N). = N        ?
DLC   : Dead check only..... = N        ?
CVC   : Supervise at close.... = Y        ?
VSA   : V sup all shots..... = N        ?

79OI1: Open Int 1 (cyc)..... = 40.00    ?
79OI2: ..... = 60.00    ?
79OI3: ..... = 80.00    ?
79RS  : Reset Int..... = 240.00   ?
50L   : PU (Amps pri)..... = 50.00    ?

50H   : PU..... = 1500.00  ?
Z1%   : Reach (% line)..... = 80.00    ?
Z2%   : ..... = 120.00   ?
Z3%   : ..... = 150.00   ?
Z3DP  : Dly-Phase (cyc)..... = 60.00    ?
```

```
51PP : PU (Amps pri)..... = 120.00   ?
51PTD: Time Dial........... = 3.00     ?
51PC : Curve (1,2,3,4)..... = 2        ?

51NP : PU (Amps pri)..... = 100.00   ?
51NTD: Time Dial........... = 2.00     ?
51NC : Curve (1,2,3,4)..... = 3        ?
51NTC: Torque Ctrl (Y/N)..... = Y      ?

50N1P: PU (Amps pri)..... = 403.00   ?
50N2P: ..................... = 288.00   ?
50N3P: ..................... = 237.00   ?
Z2DG : Dly-Gnd (cyc)..... = 20.00    ?
Z3DG : ..................... = 40.00    ?

52BT : Dly (cyc)........... = 30.00    ?
ZONE3: Dir (F=fwd,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 (1,2,3)..... = 2      ?
RINGS: (1-30)............... = 3       ?
```

New settings for: Example 69kV 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	
47PXD=10.00	47PXL=25.00	VCT =100.00		
LLC =N	DLC =N	CVC =Y	VSA =N	
79OI1=40.00	79OI2=60.00	79OI3=80.00	79RS =240.00	50L =50.00
50H =1500.00	Z1% =80.00	Z2% =120.00	Z3% =150.00	Z3DP =60.00
51PP =120.00	51PTD=3.00	51PC =2		
51NP =100.00	51NTD=2.00	51NC =3	51NTC=Y	
50N1P=403.00	50N2P=288.00	50N3P=237.00	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
```

The following data are required to set the relay:

R1, X1	Pos. seq. primary impedance of line (0-9999 ohms)
R0, X0	Zero seq. " " " " (0-9999 ohms)
LL	Line length (0.1-999 miles)
CTR	CT ratio (e.g. for 600/5, enter 120) (1-5000)
PTR	PT ratio (e.g. 1200/1, enter 1200) (1-10,000)
MTA	Maximum torque angle for mho elements (47-90 degrees)
LOCAT	Do you want the fault locator enabled? (Y or N)

47PXD Pos. seq. ph-ph voltage threshold for dead voltage (0-2000 kV)
47PXL Pos. seq. ph-ph voltage threshold for live voltage (0-2000 kV)
VCT Voltage condition timer defines maximum time for the supervising voltage conditions to be met (0-10,000 cycles)

LLC Live voltage supervision enabled? (Y or N)
DLC Dead voltage supervision enabled? (Y or N)
CVC Check voltage at close? (Y or N)
VSA All shots supervised? (Y or N)

Note: N implies only the first shot has voltage supervision. All subsequent shots are unsupervised.

79OI1 Reclosing relay open interval 1 (1/4 to 10,000 cycles; 0 disables reclosing)
79OI2 Reclosing relay open interval 2 (1/4 to 10,000 cycles; 0 disables reclosing)
79OI3 Reclosing relay open interval 3 (1/4 to 10,000 cycles; 0 disables reclosing)
79RS Reclosing relay reset time (60 to 8,000 cycles)
50L Phase overcurrent element low pickup (0.25-50,000 primary amperes)

50H Phase overcurrent element high pickup (0.25-50,000 primary amperes)
Z1% Zone 1 reach (percent of line length: 0 to 2000%)
Z2% Zone 2 reach (percent of line length: 0 to 3200%)
Z3% Zone 3 reach (percent of line length: 0 to 3200%)
Z3DP Zone 3 delay for phase and three-phase faults (0-2000 cycles in 1/4 cycle steps)

51PP Phase time-overcurrent pickup (1-50,000 primary amperes)
51PTD Phase time-overcurrent time dial (0.5-15)
51PC Phase time-overcurrent curve index. Choices are as follows:

Use 1 to select a moderately inverse curve
Use 2 to select an inverse curve
Use 3 to select a very inverse curve
Use 4 to select an extremely inverse curve

51NP Residual time-overcurrent pickup (0.25-50,000 primary amperes)
51NTD Residual time-overcurrent time dial (0.5-15)
51NC Residual time-overcurrent curve index. Choices are as follows:

Use 1 to select a moderately inverse curve
Use 2 to select an inverse curve
Use 3 to select a very inverse curve
Use 4 to select an extremely inverse curve

51NTC Do you want residual time-overcurrent torque control? (Y or N)

50N1P Zone 1 residual instantaneous overcurrent (0.25-50,000 primary amperes)
50N2P Zone 2 residual instantaneous overcurrent (0.25-50,000 primary amperes)
50N3P Zone 3 residual instantaneous overcurrent (0.25-50,000 primary amperes)
Z2DG Zone 2 delay for ground faults (0-2000 cycles in 1/4 cycle steps)
Z3DG Zone 3 delay for ground faults (0-2000 cycles in 1/4 cycle steps)

52BT 52B time delay (0 to 10,000 cycles)
ZONE3 Zone 3 direction (F = forward or R = reverse)
32QE Do you want negative sequence directional supervision of the ground overcurrent elements? (Y or N)
32VE Do you want voltage polarization for the zero sequence directional element enabled? (Y or N)
32IE Do you want current polarization for the zero sequence directional element enabled? (Y or N)

LOPE Should tripping be blocked when loss of potential is detected? (Y or N)
TIME1 Timeout for Port 1 (0-30 minutes)
TIME2 Timeout for Port 2 (0-30 minutes)
AUTO Autoport (port 1, 2, or 3 (for both))
RINGS The number of rings after which the modem answers (1-30 rings)

As you enter the settings, they are checked against the setting limits given above. Then the relay computes internal settings from your entries, and checks them to ensure they are within the range of the relay.

For example, let CTR=1000 and 50N1P = 1. Each of these settings is admissible alone, but together they result in a secondary pickup setting of 1 mA, which is out of range. Internal setting error messages indicate such conditions after you select to enable the new settings.

The zone 1, 2, and 3 reach values are the reaches of the mho units for a zero-resistance fault on the transmission line. The maximum torque angle (MTA) for the mho circles is independently set, and the diameter of the circle is expanded to keep the reach setting in the direction of the transmission line impedance constant as the maximum torque angle is separated from the transmission line angle. Thus, the maximum torque angle setting does not affect the reach in the direction of the transmission line, and the mho circle diameter relates to the set reach and the difference between the transmission line angle and the MTA by the expression below.

$$\text{DIAMETER} = [\ \text{SET REACH}\ ] \ /\ [\ \cos\ (\ \text{T. L. ANGLE} - \text{MTA}\ )\ ]$$

SAMPLE EVENT REPORT

Example 69 kV Line Date: 12/7/88 Time: 15:12:24.658

FID=SEL-121C-R100-V656mptr-D881004

	Currents (amps)				Voltages (kV)			Relays	Outputs	Inputs
								522655	TCAAAAA	DP805E
IPOL	IR	IA	IB	IC	VA	VB	VC	011711	PL1234L	TTTC2T
								P3PNNP		A
0	-1	64	57	-121	21.6	18.6	-40.2	L.....	.....	....*.
0	1	-102	106	-6	-33.9	35.6	-1.8	L.....	.....	....*.
0	1	-64	-57	121	-21.5	-18.6	40.2	L.....	.....	....*.
0	0	102	-106	6	33.8	-35.6	1.8	L.....	.....	....*.
0	-2	64	57	-121	21.6	18.6	-40.2	L.....	.....	....*.
0	0	-102	106	-6	-33.8	35.6	-1.8	L.....	.....	....*.
0	2	-63	-57	121	-21.6	-18.6	40.2	L.....	.....	....*.
0	-1	101	-106	6	33.9	-35.6	1.8	L.....	.....	....*.
0	-1	63	57	-121	21.6	18.6	-40.2	L.....	.....	....*.
0	1	-101	106	-6	-33.9	35.6	-1.8	L.....	.....	....*.
0	1	-64	-57	121	-21.6	-18.6	40.3	L.....	.....	....*.
0	-1	102	-106	6	33.8	-35.7	1.7	L.....	.....	....*.
0	-1	64	57	-121	19.9	18.2	-40.7	L.....	.....	....*.
0	52	-35	78	6	-31.1	36.9	-0.4	L.....	.....	....*.
0	-172	-217	-40	85	-17.0	-18.1	40.9	L.....	.....	....*.
0	-61	-24	-29	-9	26.6	-38.3	-1.2	L...P.	.....	....*.
0	444	460	13	-28	15.7	18.5	-40.6	L...P.	.....	....*.
0	17	14	4	1	-26.5	38.7	1.7	L..1P.	*.*.*..	....*.
0	-556	-562	-2	5	-15.4	-18.6	40.5	L.31P.	*.*.*..	....*.
0	-13	-12	0	0	24.2	-38.8	-1.7	L.31P.	*.*.*..	.....
0	571	575	0	-1	15.4	18.6	-40.5	L.31P.	*.*.*..	.....
0	13	11	0	-1	-24.2	38.8	1.7	L.31P.	*.*.*..	.....
0	-574	-576	0	1	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-12	0	1	24.2	-38.8	-1.8	L.31P.	*.*.*..	.....
0	574	577	0	-1	15.3	18.6	-40.5	L.31P.	*.*.*..	.....
0	12	12	0	-1	-24.2	38.8	1.8	L.31P.	*.*.*..	.....
0	-574	-577	0	1	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-12	0	1	24.2	-38.8	-1.8	L.31P.	*.*.*..	.....
0	574	577	0	-1	15.3	18.6	-40.5	L.31P.	*.*.*..	.....
0	12	12	0	-1	-24.2	38.8	1.8	L.31P.	*.*.*..	.....
0	-574	-577	0	1	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-12	0	1	24.2	-38.8	-1.8	L.31P.	*.*.*..	.....
0	574	577	0	-1	15.3	18.6	-40.5	L.31P.	*.*.*..	.....
0	12	12	0	0	-24.2	38.8	1.8	L.31P.	*.*.*..	.....
0	-574	-577	0	0	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-12	0	0	24.2	-38.8	-1.8	L.31P.	*.*.*..	.....
0	574	577	0	-1	15.3	18.6	-40.5	L.31P.	*.*.*..	.....
0	12	12	0	1	-24.2	38.8	1.8	L.31P.	*.*.*..	.....
0	-574	-577	0	1	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-11	0	-1	24.3	-38.7	-1.7	L.31P.	*.*.*..	.....
0	574	576	0	0	17.0	19.0	-40.0	L.31P.	*.*.*..	.....
0	-40	-40	0	-1	-27.0	37.5	0.5	L.31P.	*.*.*..	.....
0	-401	-403	0	1	-19.8	-19.1	39.8	L..1P.	*.*.*..	.....
0	52	51	0	1	31.0	-36.6	0.5	L..1P.	*.*.*..	.....

Event : 1AG Location : 29.97 mi 3.76 ohms sec
Duration: 7.25 Flt Current: 576.8

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		
47PXD=10.00	47PXL=25.00	VCT =100.00			
LLC =N	DLC =N	CVC =Y	VSA =N		
79DI1=40.00	79DI2=60.00	79DI3=80.00	79RS =240.00	50L =50.00	
50H =1500.00	Z1% =80.00	Z2% =120.00	Z3% =150.00	Z3QP =60.00	
51PP =120.00	51PTD=3.00	51PC =2			
51NP =100.00	51NTD=2.00	51NC =3	51NTC=Y		
50N1P=403.00	50N2P=288.00	50N3P=237.00	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	MPT	MTB	MTD	MA1	MA2	MA3	MA4	MRI	MRC
C4	E4	00	F4	E4	80	00	00	00	F5
C4	E6	00	E7	E6	80	00	00	44	80
31	31	00	31	20	00	02	04	00	31
30	00	00	30	00	00	00	00	00	30

EXPLANATION OF EVENT REPORT

Example 69kV Line Date: 12/7/87 Time: 15:12:24.658

	Currents (amps)				Voltages (kV)			Relays Outputs Inputs		
								522655	TCAAAAA	DP8D5E
								011711	PL1234L	TTTC2T
IPOL	IR	IA	IB	IC	VA	VB	VC	P3PNNP		A
0	-172	-217	-40	85	-17.0	-18.1	40.9	L.....	.....	....*.
0	-61	-24	-29	-9	26.6	-38.3	-1.2	L...P.	.....	....*.
0	444	460	13	-28	15.7	18.5	-40.6	L...P.	.....	....*.
0	17	14	4	1	-24.5	38.7	1.7	L..1P.	*.*.*..	....*.
0	-556	-562	-2	5	-15.4	-18.6	40.5	L.31P.	*.*.*..	....*.
0	-13	-12	0	0	24.2	-38.8	-1.7	L.31P.	*.*.*..	.....
0	571	575	0	-1	15.4	18.6	-40.5	L.31P.	*.*.*..	.....
0	13	11	0	-1	-24.2	38.8	1.7	L.31P.	*.*.*..	.....
0	-574	-576	0	1	-15.3	-18.6	40.5	L.31P.	*.*.*..	.....
0	-12	-12	0	1	24.2	-38.8	-1.8	L.31P.	*.*.*..	.....

Event : 1AG Location : 29.97 mi 3.76 ohms sec
Duration: 7.25 Flt Current: 576.8

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 the middle rows, IAY = -562, IAX = -12. Therefore, IA = 562 amps RMS primary, at an angle of ATAN(-562/-12) = -91 degrees, with respect to the sampling clock.

<Relays> columns show states of internal relay elements ---> Designators

50P : phase overcurrent	: 50H, 50L	---> H,L
21Z : 3-phase distance	: Z1, Z2, Z3	---> 1,2,3
21P : 2-phase distance	: Z1, Z2, Z3	---> 1,2,3
67N : inst ground overcurrent	: 67N2, 67N2 67N3	---> 1,2,3
51N : ground time-overcurrent		---> P,T
51P : phase time-overcurrent		---> P,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>	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 = 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)
MTA	Maximum torque angle for mho elements
LOCAT	Enable or disable fault locator (Y/N)
47PXD,47PXL	Positive sequence voltage, dead voltage/live voltage threshold
VCT	Voltage condition timer
LLC,DLC	Live voltage/Dead voltage supervision
CVC	Voltage supervision required at close
VSA	All shots/first shot only with voltage supervision
79O1,2,3,RS	Three-shot recloser Open and Reset intervals
50L,50H	Phase fault detector and high-set instantaneous settings
Z1%,Z2%,Z3%	Reaches of 3- and 2-phase mhos, percent of line length (LL)
Z3DP	Zone 3 timer setting for 3- and 2-phase faults
51PP,TD,C	PHASE time-overcurrent Pickup, Time-Dial, Curve
51NP,TD,C,TC	GND time-overcurrent Pickup, Time-Dial, Curve, Torque Control
50N1P,2,3	Ground inst-overcurrent pickup settings zones 1, 2, and 3
Z2DG,Z3DG	Zone 2 and 3 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 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, and current are shown. An example of the display is shown below:

Example 69kV Line Date: 2/28/87 Time: 01:45:40

#	DATE	TIME	TYPE	DIST	DUR	CURR
1	2/28/87	09:03:01.092	3AGT	94.45	11.00	365.6
2	2/28/87	09:02:13.041	3ABC	95.09	7.00	364.7
3	2/28/87	09:00:39.962	1AG	9.02	7.25	1150.3
4	2/28/87	09:00:13.345	1BC	9.05	7.25	1324.0
5						
6						
7						
8						
9						
10						
11						
12						

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

=>>METER

Example 69kV Line Date: 2/28/87 Time: 13:27:05

	A	B	C	AB	BC	CA
I (A)	220	221	219	381	381	380
V (kV)	40.2	40.2	40.2	69.6	69.5	69.7

P (MW)	26.40
Q (MVAR)	0.25

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.

=>>STATUS

Example 69kV Line Date: 2/28/87 Time: 01:04:56

SELF-TESTS

W=Warn F=Fail

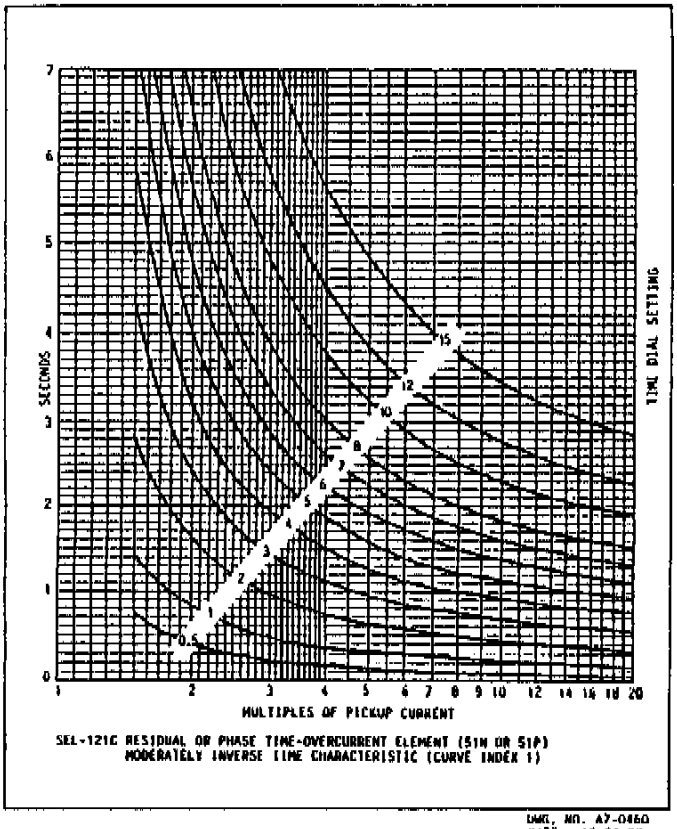
	IP	IR	IA	IB	IC	VA	VB	VC
OS	0	0	2	2	4	-2	-2	-2
PS	4.99		15.14		-14.85			
RAM	ROM		A/D		MOF	SET		
OK	OK		OK		OK	OK		

=>>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 for testing individual relay elements.

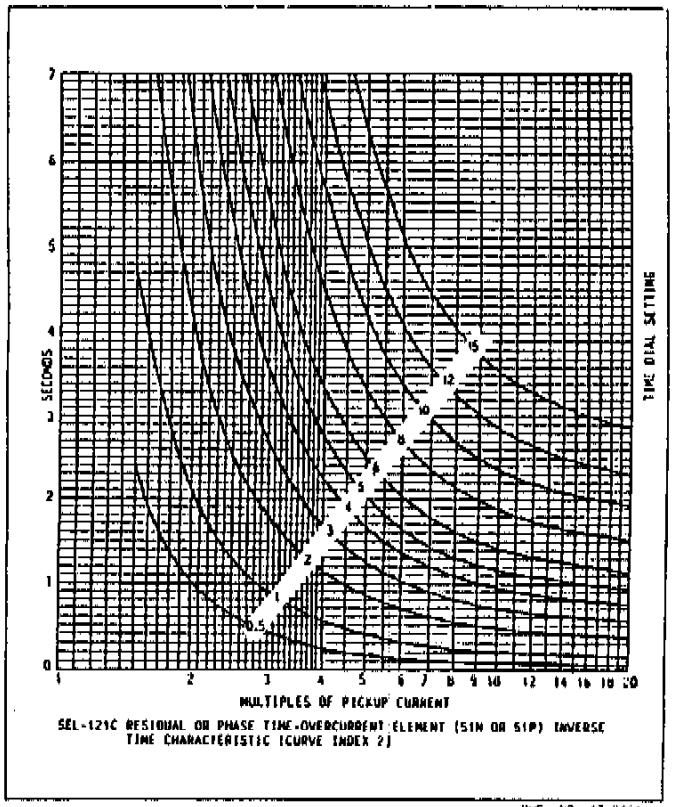
LED:	1	2	3	4	5	6	7	8	
N									
0	EN	PH1	G1	PH2	G2	PH3	G3	51N	RELAY TARGETS
1	51PT	1ABC	2ABC	3ABC	51PP	50H	50L	LOP	RELAY WORD #1
2	51NT	67N1	67N2	67N3	51NP	Z1P	Z2P	Z3P	RELAY WORD #2
3	DF	DR	Z2GT	Z3GT	3P50	RC	RI	Z3PT	RELAY WORD #3
4	ALRM	TRIP	TC	DT	52BT	52AT			RELAY WORD #4
5	52AT		ET	52A	DC	BT	PT	DT	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.



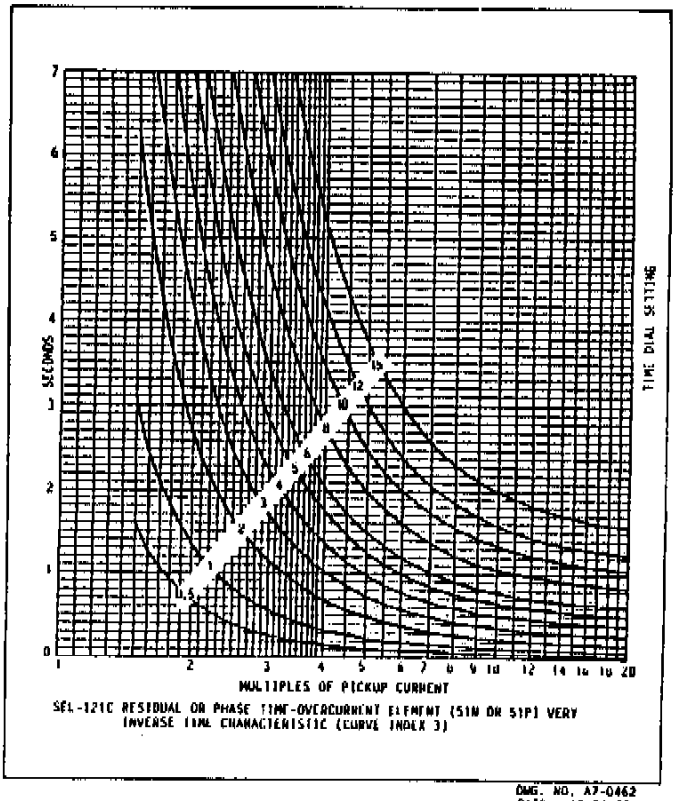
SEL-121C RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P)
MODERATELY INVERSE TIME CHARACTERISTIC (CURVE INDEX 1)

DWG. NO. A7-0460
DATE: 10-04-88



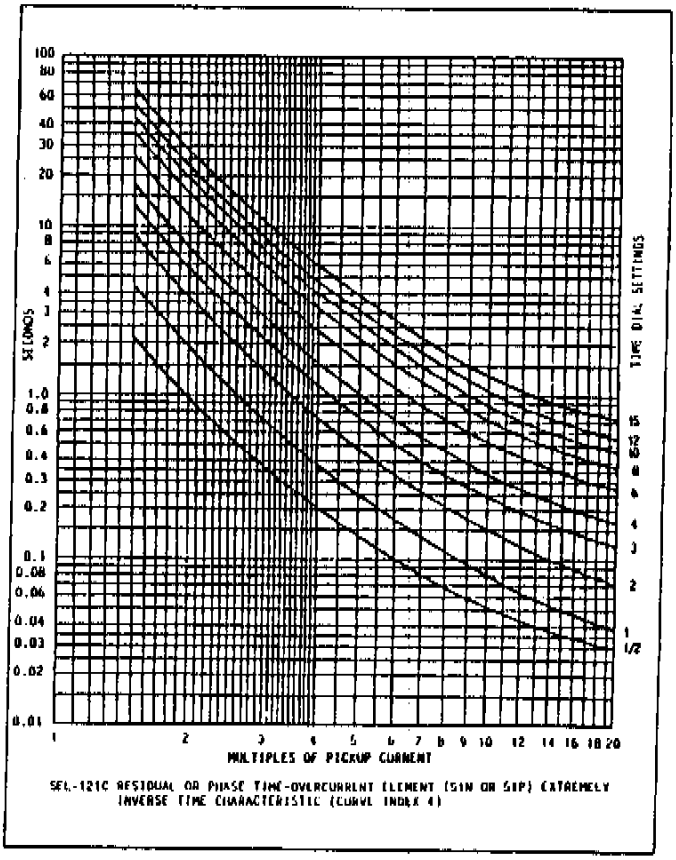
SEL-121C RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) INVERSE
TIME CHARACTERISTIC (CURVE INDEX 2)

DWG. NO. A7-0461
DATE: 10-04-88



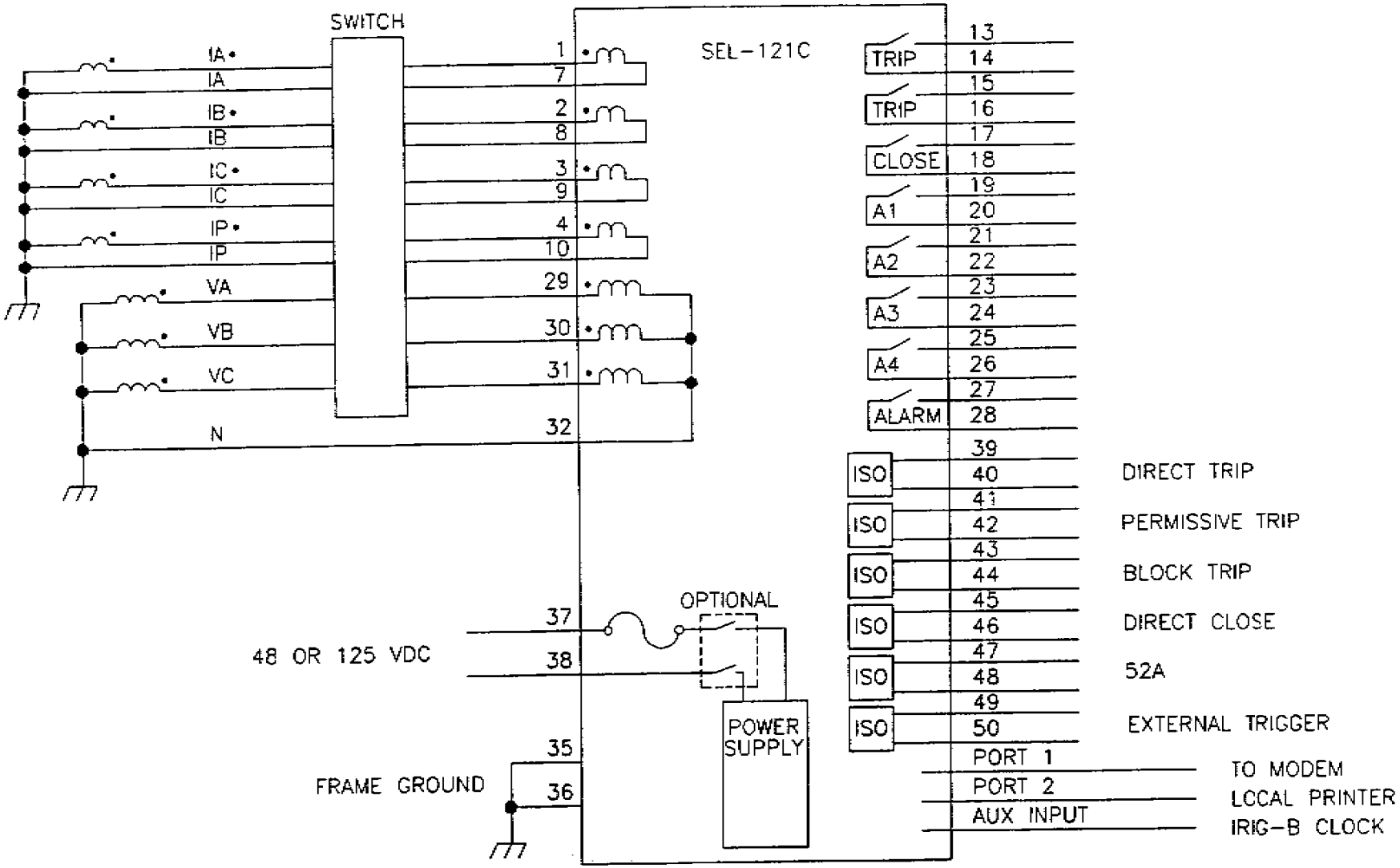
SEL-121C RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) VERY
INVERSE TIME CHARACTERISTIC (CURVE INDEX 3)

DWG. NO. A7-0462
DATE: 10-04-88



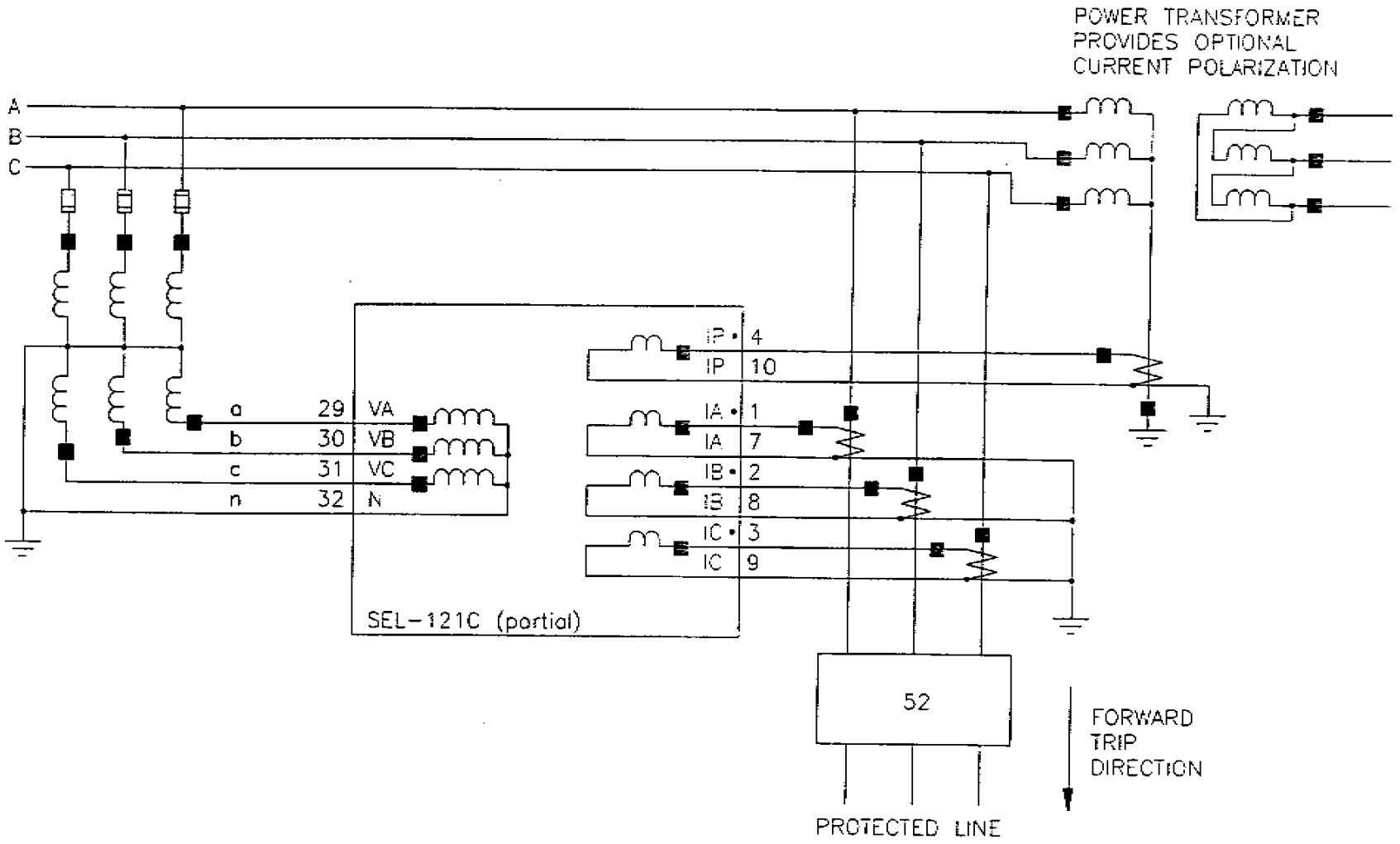
SEL-121C RESIDUAL OR PHASE TIME-OVERCURRENT ELEMENT (51N OR 51P) EXTREMELY
INVERSE TIME CHARACTERISTIC (CURVE INDEX 4)

DWG. NO. A7-0463
DATE: 10-04-88



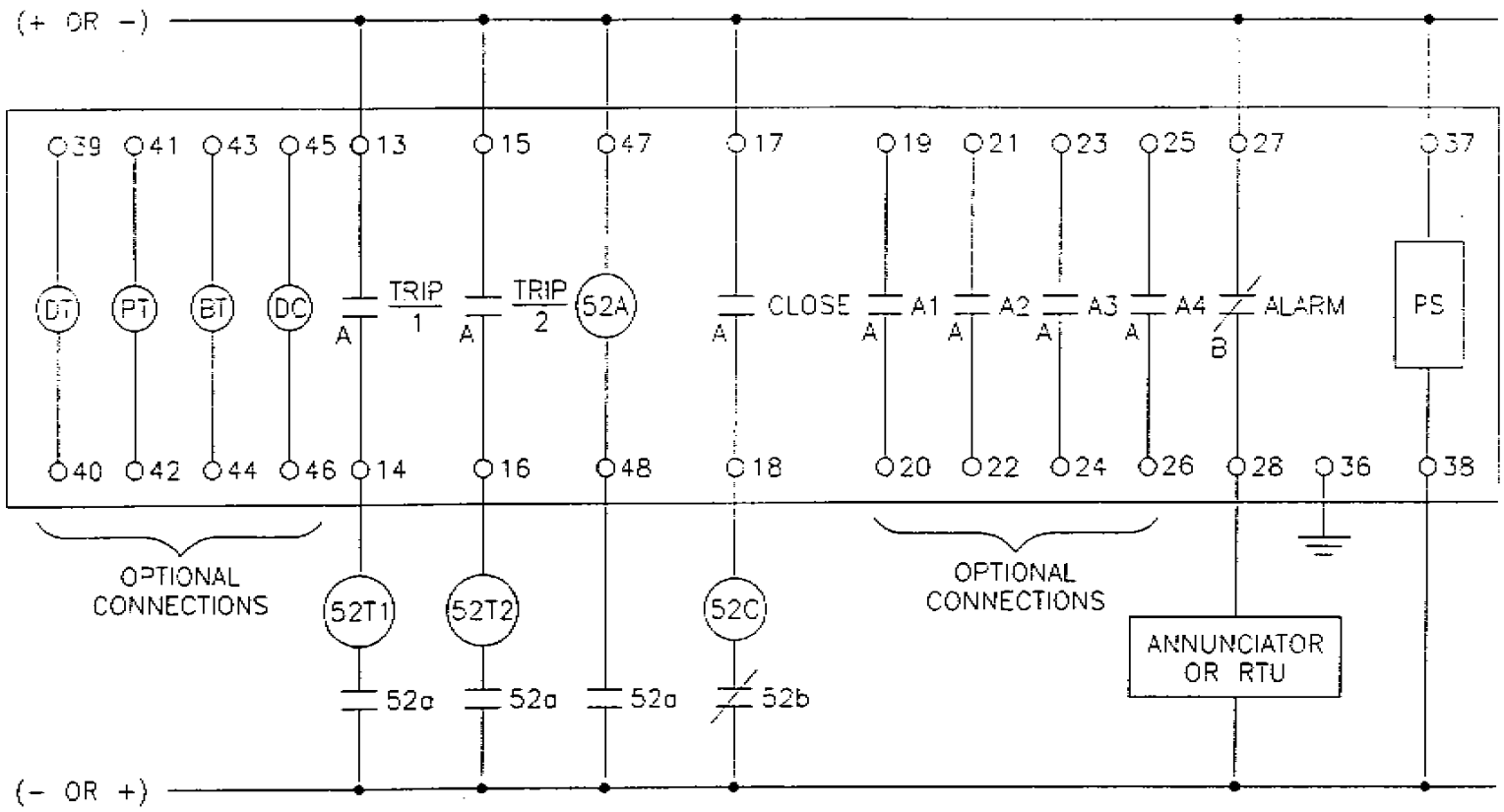
SEL-121C EXTERNAL CONNECTION DIAGRAM

DWG. NO. A7-0339
DATE: 08-24-88



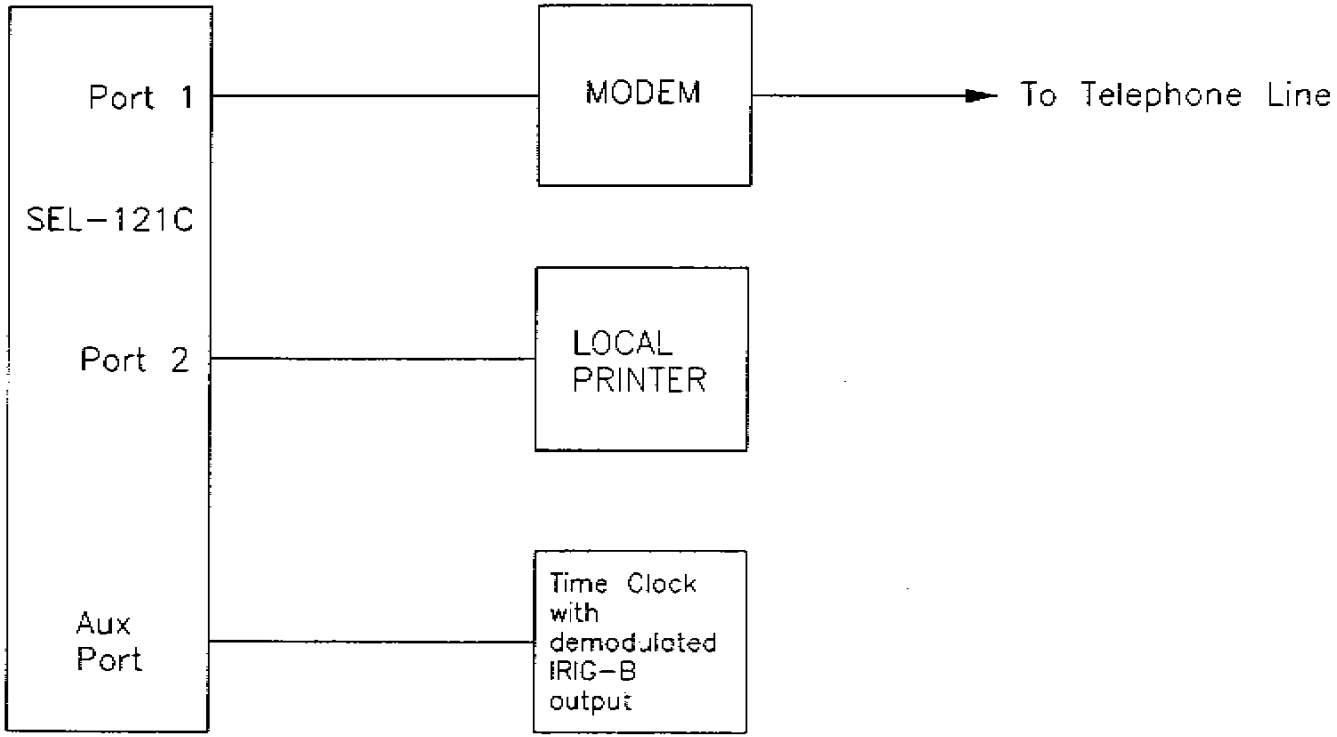
SEL-121C AC EXTERNAL CURRENT AND VOLTAGE CONNECTIONS

DWG. NO. A7-0333
DATE: 08-19-88



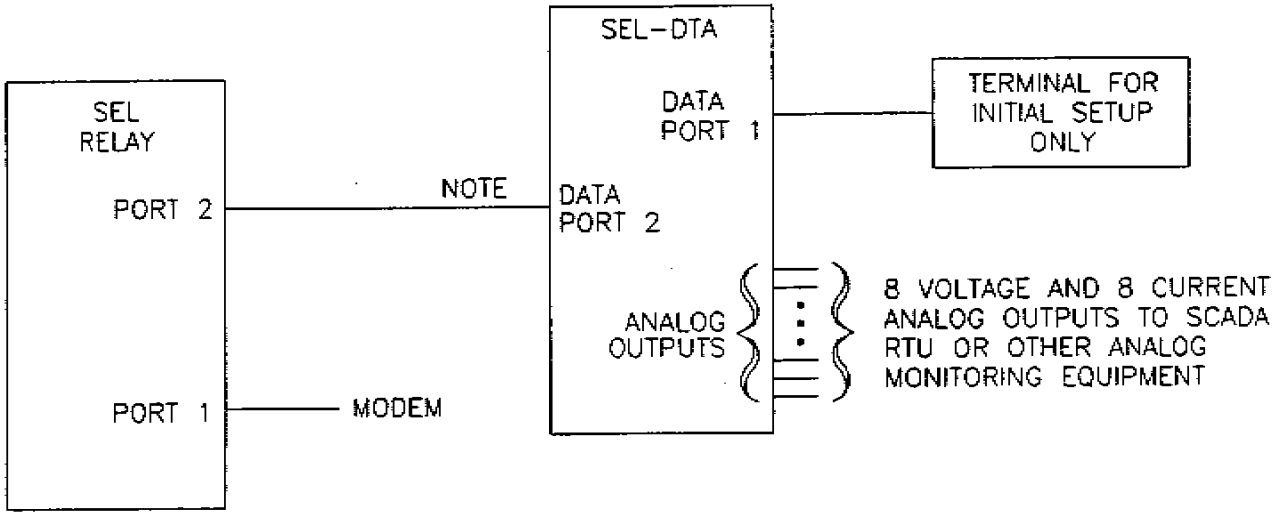
SEL−121C DC EXTERNAL CONNECTION DIAGRAM (TYPICAL)

DWG. NO. A7−0401
DATE: 10−12−88



SEL-121C COMMUNICATIONS AND CLOCK CONNECTIONS
ONE UNIT AT ONE LOCATION

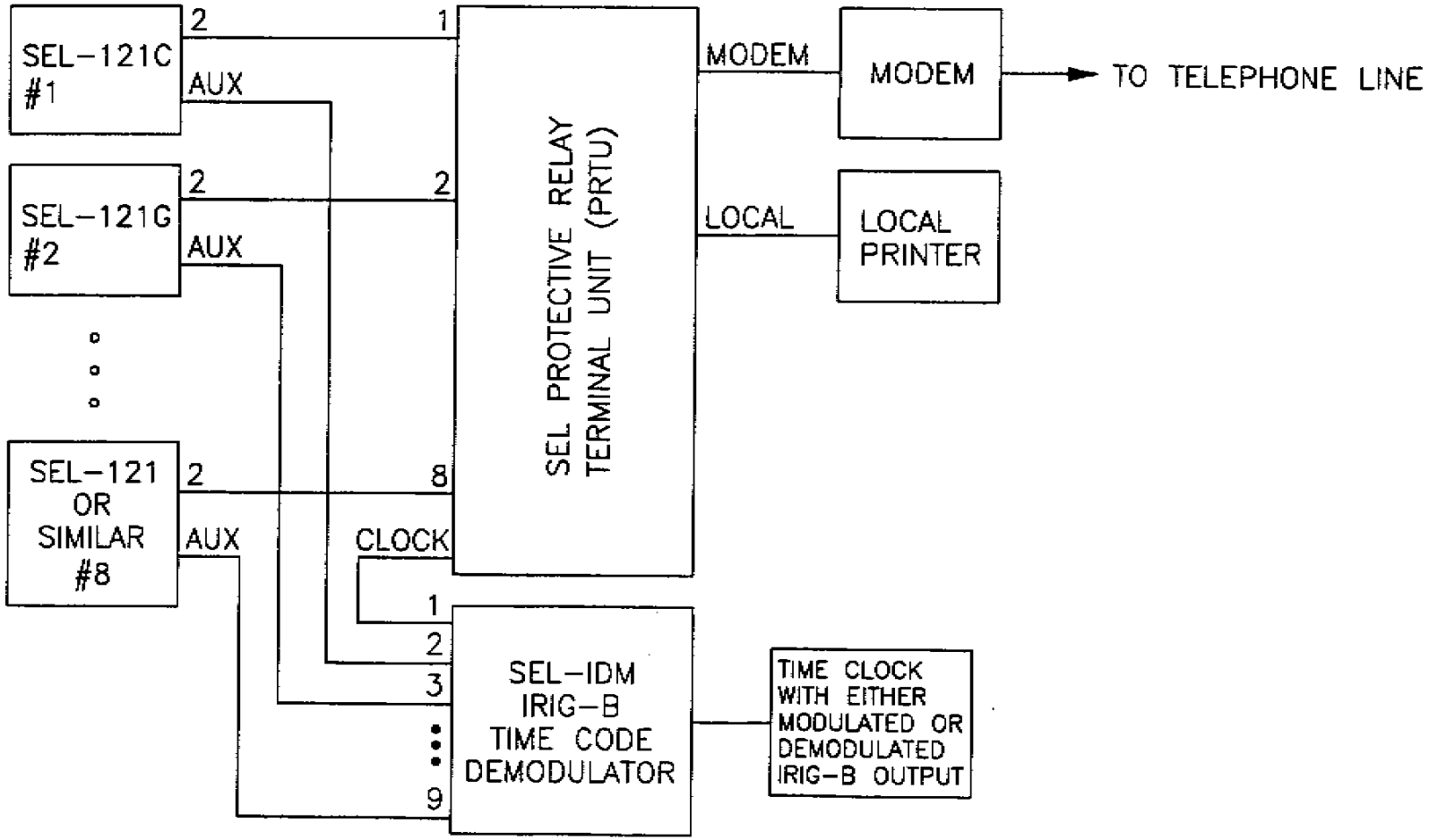
DWG. NO. A7-0330
DATE: 08-19-88



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

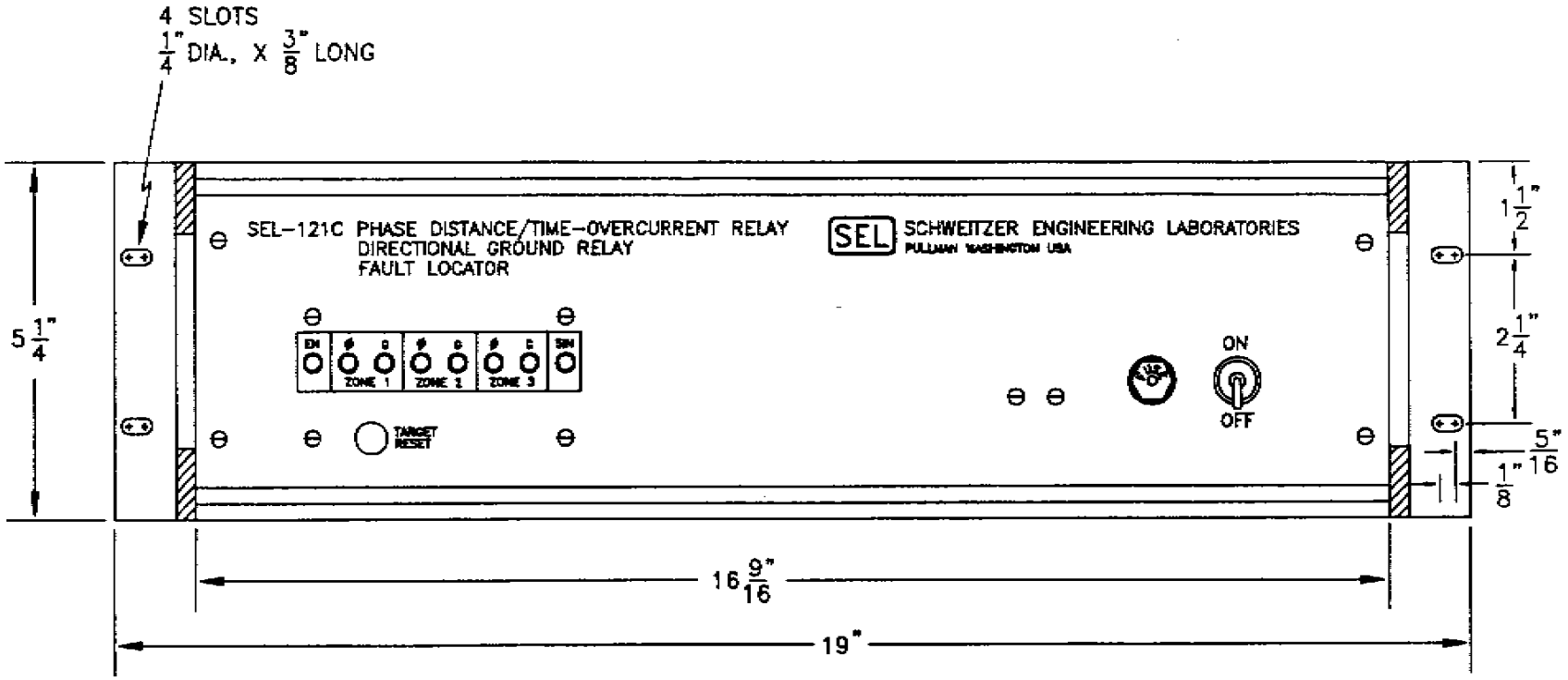
SEL RELAY COMMUNICATIONS DIAGRAM FOR CONNECTION TO THE SEL-DTA

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



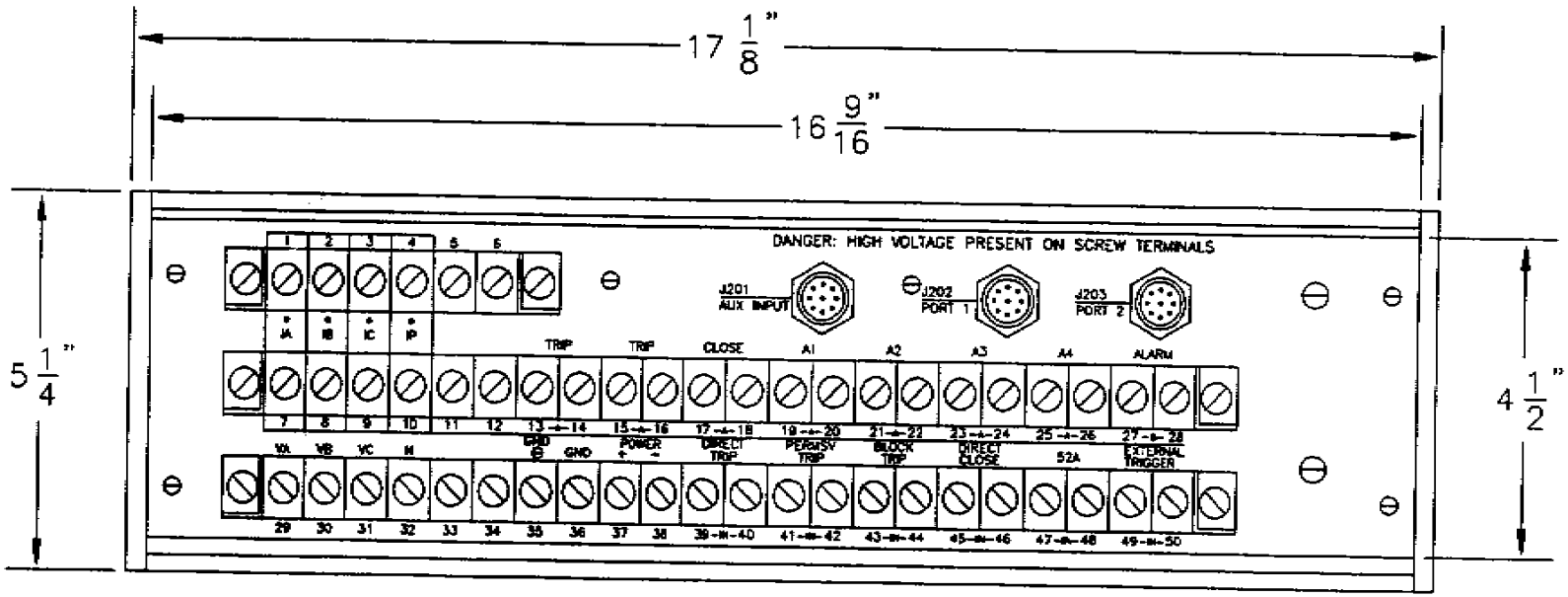
SEL-121C COMMUNICATIONS AND CLOCK CONNECTIONS MULTIPLE UNITS AT ONE LOCATION

DWG. NO. A7-0332
DATE: 10-14-88
REV. 12-12-88



SEL-121C HORIZONTAL
FRONT PANEL DRAWING

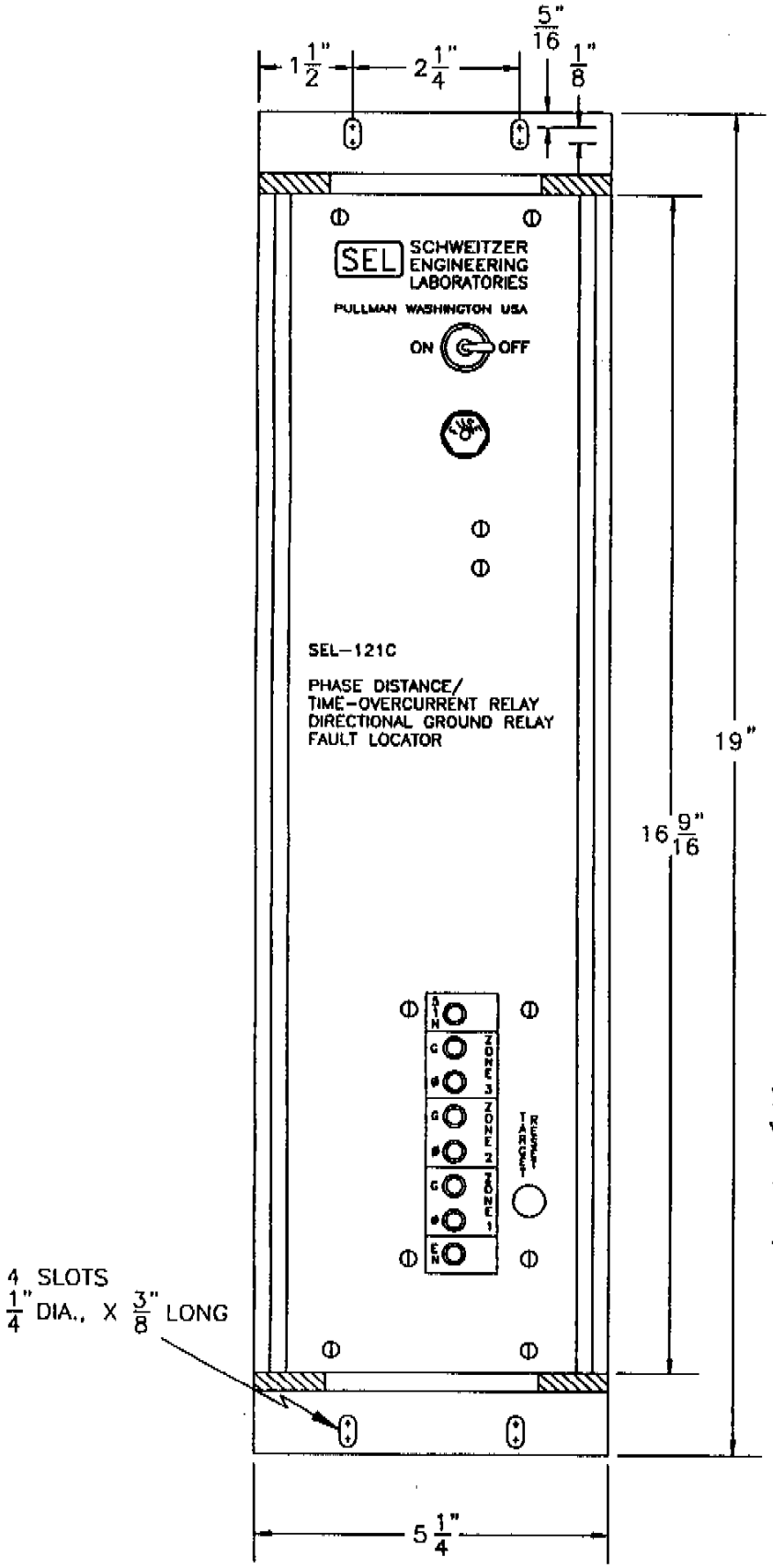
DWG. NO. A7-0334
DATE: 08-18-88



40

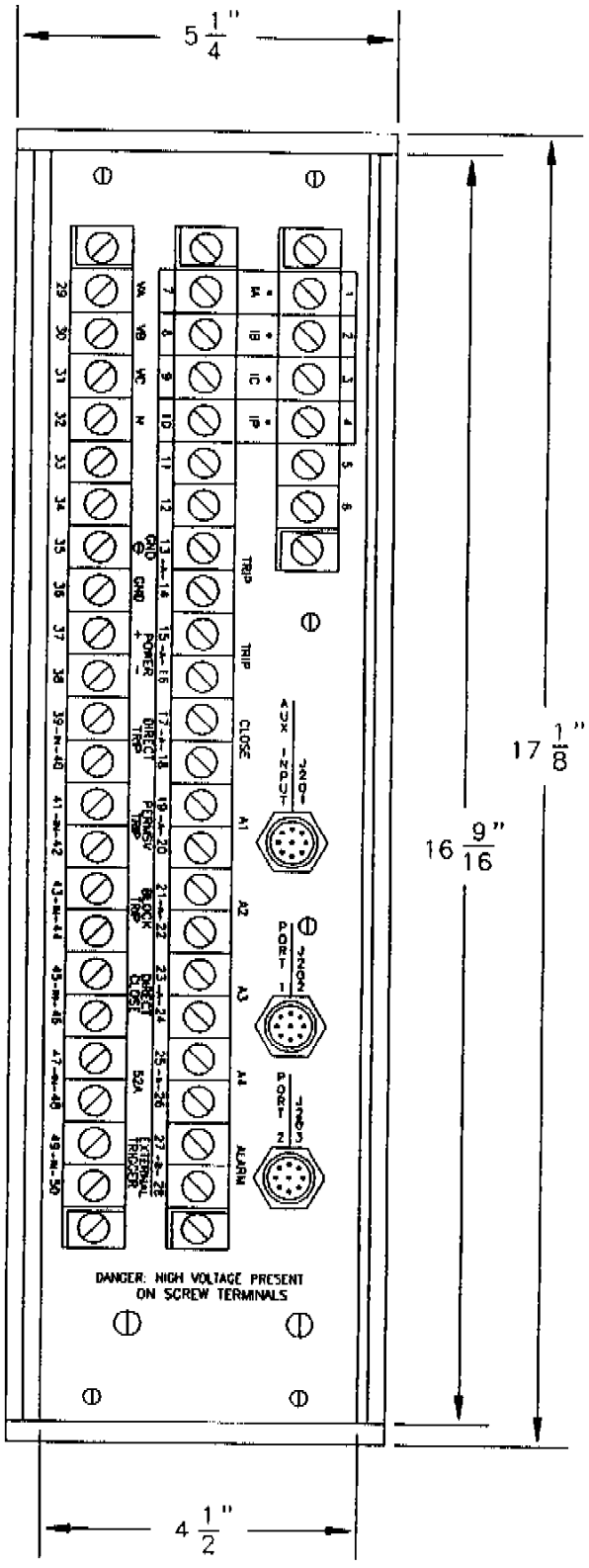
SEL-121C HORIZONTAL REAR PANEL DRAWING

DWG. NO. A7-0335
DATE: 08-19-88



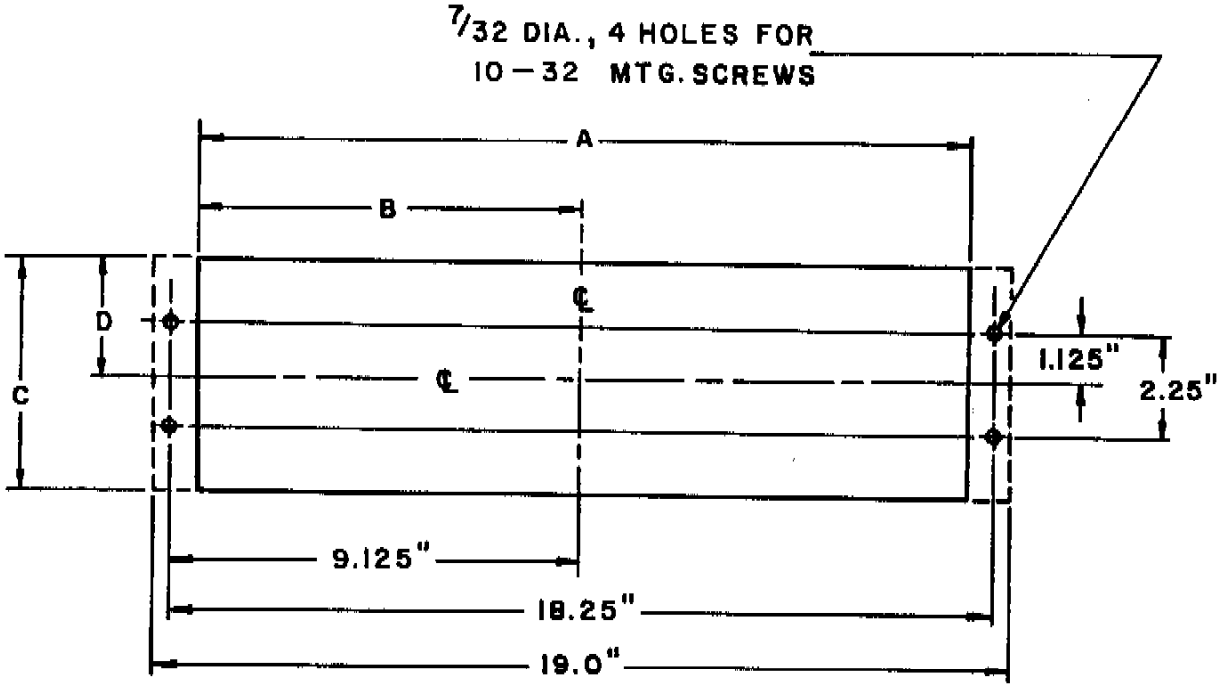
SEL-121C VERTICAL FRONT PANEL DRAWING

DWG.NO. A7-0403
DATE: 09-30-88



SEL-121C VERTICAL REAR PANEL DRAWING

DWG. NO. A7-0402
DATE: 09-30-88



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-121C 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 2/3/86 sets date to Feb. 3, 1986. This setting is overridden when IRIG-B synchronization occurs. Pulses the ALARM 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, 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.

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 new settings are being computed and event data buffers are cleared.

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court
Pullman, WA 99163-5603
Phone: (509) 332-1890 Fax: (509) 332-7990

SEL/04-89