SEL-267-5
SEL-167-5
Phase and Ground Directional Overcurrent Relay With Recloser and Fault Locator

Instruction Manual

20010314

SCHWEITZER ENGINEERING LABORATORIES, INC.

⚠CAUTION

Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

⚠ATTENTION

Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

⚠WARNING

Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.

⚠AVERTISSEMENT

Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

⚠WARNING

Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

⚠AVERTISSEMENT

L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.

⚠DANGER

Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠DANGER

Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

⚠DANGER

Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠DANGER

Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessuers ou la mort.

PM267-03

SECTION 1: SEL-200 SERIES RELAY ADDENDUM

The SEL-200 series relays with 125 Vdc optical isolator inputs now have level-sensitive inputs. These inputs compare to the original SEL-200 series relays as follows:

Original SEL-200 Series Optical Isolator Logic Input Rating

125 Vdc: 80 - 150 Vdc; 4 milliamps at nominal voltage

New SEL-200 Series Optical Isolator Logic Input Rating

125 Vdc: 100 - 150 Vdc; 6 milliamps at nominal voltage

The optical isolator input does not assert for applied voltages less than 75 Vdc. The firmware remains unchanged.

JUMPER INSTALLATION INSTRUCTIONS FOR ALL 200-SERIES RELAYS EXCEPT SEL-279 AND SEL-279H

The power available from these ports is limited and should be used only for SEL-RDs, SEL-DTAs, dc-powered modems, or other low-wattage devices approved by SEL.

The power is available on either Port 1 or Port 2R. Port 2F, located on the front of the relay, does NOT have power available.

To install jumpers for supplying power through the rear EIA RS-232-C ports on all SEL-200 series relays (except SEL-279 and SEL-279H Relays), perform the following steps:

1. Remove the relay top cover or withdraw the main circuit board.
2. Locate jumpers JMP12 (+5 Vdc), JMP13 (+12 Vdc) and JMP14 (-12 Vdc) near the AUX INPUT connector.
3. Remove and install the needed jumpers in the "on" position.
4. Replace the top cover or re-insert the main circuit board. (Ensure that the board is correctly seated and the cables to the power supply and input transformers are reconnected.)

SEL-200 SERIES (SHALLOW) RELAY HARDWARE ADDENDUM

The shallow SEL-200 series hardware brings a reduction in unit depth and weight. It compares to the original SEL-200 series relay hardware as follows:

ORIGINAL SEL-200 SERIES RELAY HARDWARE SPECIFICATIONS

3.47" x 19.00" x 11.66" (8.81 cm x 48.26 cm x 29.62 cm) (H x W x D)

16 pounds (7.3 kg)

SEL-200 SERIES (SHALLOW) RELAY HARDWARE SPECIFICATIONS

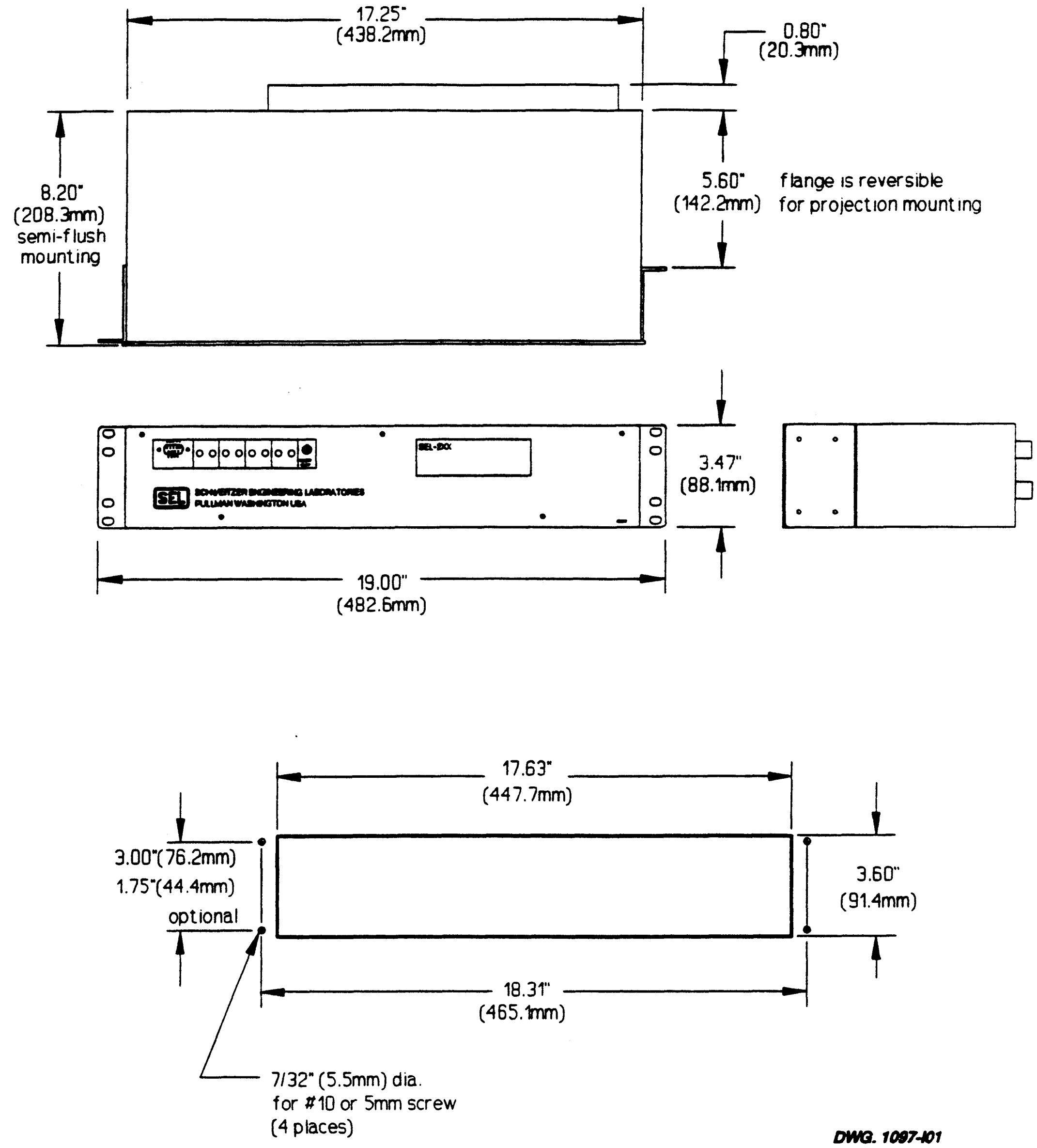
3.47" x 19.00" x 9.00" (8.81 cm x 48.26 cm x 22.86 cm) (H x W x D)

12 pounds (5.5 kg)

Depth (dimension D) is to the end of the rear panel terminal blocks.

This hardware is also equipped for low-level testing. The firmware remains unchanged.

The shallow SEL-200 series relay dimensions, panel cutout, and drill diagrams are on the following page. Note that the long cutout dimension has increased by 0.25" to 17.63" (44.77 cm).



SEL-200 Series (Shallow) Relay Dimensions, Panel Cutout, and Drill Diagrams

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INTRODUCTION

GETTING STARTED

This instruction manual applies to SEL-167-5 and SEL-267-5 Relays. The SEL-267-5 and SEL-167-5 Relays have identical protection features, but use different hardware designs. Where there are differences between the two relay models, both relays are described.

OVERVIEW

The SEL-267-5 Relay phase and ground directional overcurrent relay with fault locator may be applied to protect transmission, subtransmission and distribution lines.

Relay features include:

- Directional Overcurrent Protection for Phase and Ground Faults
- Versatile User-Programmable Logic
- Three-Shot Reclosing with Fuse Saving Capability
- Loss-of-Potential Detection Logic
- Fault Locating
- Event Recording
- Automatic Self-Testing
- Metering, Including Demand
- Target Indicators for Faults and Testing
- Time Code Input
- Compact and Economical

BASIC PROTECTIVE CAPABILITIES

The SEL-267-5 Relay provides complete directional overcurrent protection for faults of all types. The demand ammeter, with its programmable threshold and time constant, offers overload protection and alarm functions.

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. Some intermediate logic is performed, including directional supervision of overcurrent elements and grouping of certain elements.
The states of the intermediate results and other data are recorded in the Relay Word.

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

Phase and Three-Phase Faults

Phase fault protection consists of three instantaneous phase overcurrent elements and a time-overcurrent element. The three overcurrent elements are directionally supervised by the phase directional element for both three-phase and phase-phase faults. To securely discriminate between forward- and reverse-direction faults, the torque threshold of the phase directional element must be exceeded for faults in either direction before fault direction is declared.

Each of the directionally-supervised outputs of the overcurrent elements drive timers. The Relay Word contains the instantaneous nondirectional outputs (50P1, 50P2, 50P3), the instantaneous directional outputs (67P1, 67P2, 67P3), and the definite-time delayed outputs (Z1PT, Z2PT, Z3PT). The direction of 67P3/Z3PT may be reversed. The directionality for all three elements may also be disabled (67NE=N, 67PE=N).

A time-overcurrent element (51P) with selectable curve shapes is provided. It may be directionally supervised if desired.

Ground Faults

Ground fault protection consists of three instantaneous residual-overcurrent elements (50N1, 50N2, 50N3) and a residual time-overcurrent element (51N).

Direction is determined by either a negative-sequence directional element or a dual-polarized zero-sequence element. Settings are provided to select either negative-sequence polarization or zero-sequence polarization of the ground overcurrent elements. 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 relay function block diagram is declared. The directionally-supervised instantaneous elements are designated 67N1, 67N2, and 67N3. They drive timers whose outputs are Z1GT, Z2GT, and Z3GT.

The direction of 67N3/Z3GT may be reversed to assist in blocking schemes, weak-infeed schemes, and local bus protection for looped or double-feed circuits. Directionality may also be disabled for all three elements.

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

Overload Alarm or Protection

The relay demand ammeter feature has a programmable time constant and a settable threshold. When demand (maximum of the three phases) reaches the setpoint, a bit (DCTH) in the Relay Word is set. By programming a mask, this bit may be routed to one of the programmable outputs for an alarm to initiate tripping, or perform any other desired function. Since the demand interval (time constant) is settable, it may be programmed to match the time constant of a protected piece of apparatus, e.g., transformer, reactor or line.

Reclosing

A three-shot reclosing relay is provided. Reclosing may be initiated or cancelled for any conditions recorded in the Relay Word and is accomplished by programming the Reclose Initiate and Reclose Cancel masks. The relay Direct Close input has been modified to operate as a reclose enable. The reclosing function does not operate unless the Direct Close input is asserted.

The Shot 1 (SH1) bit is included in the Relay Word for fuse saving schemes. The SH1 bit sets after the first reclose in a reclose sequence and remains asserted during the following reclose shots. You may program one of the four programmable output contacts with the SH1 bit. This programmable output may then be used to energize the relay Block Trip (BT) input. The elements in the MTB mask can then be programmed to be blocked from tripping during the next reclose attempts thus creating a fuse saving scheme.

GENERAL INFORMATION

Communications functions provide remote and local examination of a wide range of data, including the voltages and currents presented to the instrument, relay settings, and a history of the twelve most recent events. Relay settings may be entered and modified remotely. The relay also allows circuit breaker control via the communications channels. A secure two-level password access scheme protects settings and circuit breaker control. An alarm contact output monitors the relay and may be used to alert personnel of an unauthorized access attempt.

The relay includes a fault locator which uses fault type, prefault, and fault conditions to provide an accurate estimate of fault location without the need for communications channels, special instrument transformers, or source impedances, even during conditions of substantial load flow and fault resistance.

The relay generates a detailed event report after every fault. This report includes all data needed to quantitatively examine the prefault, fault, and postfault voltages and currents. Parameters such as fault current sensed by the relay, relay response time, and total fault clearing time can easily be determined. The event report includes the distance to the fault, fault type, and the state of all relay units during the event. Each event is time-tagged by a self-contained clock. In addition to the automatic generation of this report for faults, operators may generate a report upon command, or by asserting one of several control inputs to the instrument. This allows users to trigger the report from other equipment, such as oscillographic starting units or other relaying systems. The relay retains the twelve most recent event reports. A user may recall any of these reports on command.

Phasor diagrams of the voltages and currents showing prefault, fault, and postfault conditions can be constructed from the fault report. This accurate information is useful in verifying short-circuit and load-flow calculations, verifying transmission line constants, and measuring voltage and current unbalance. It can also be used to check the input connections for proper phase-sequence rotation and polarity.

This instrument is designed to provide long-term accuracy and availability. Amplitude-dependent measurements are made with respect to an internal voltage reference which is stable and precise. Extensive self-testing functions monitor the voltage reference. Long-term phase stability is guaranteed, since all phase-shifting operations are performed by precise time delays controlled from a quartz crystal oscillator.

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RELAY STANDARDS AND INPUT PARAMETERS

Rated Input Voltage	115 volts phase-to-phase, 3-phase 4-wire connection
Rated Input Current	5 A per phase nominal 15 A per phase continuous 500 A for one second thermal rating
Output Contact Ratings	30 A make per IEEE C37-90 para 6.7.2 6 A carry continuously MOV protection provided
Logic Input Ratings	24 Vdc: 10 - 30 Vdc 48 Vdc: 25 - 60 Vdc 125 Vdc: 60 - 200 Vdc 250 Vdc: 200 - 280 Vdc Input current: 4 mA at nominal voltage
Power Supply	24/48 V: 20 - 60 Vdc; 12 W 125/250 V: 85 - 350 Vdc or 85 - 264; 12 W
Dielectric Strength	Routine tested: V, I inputs: 2500 Vac for 10 seconds Other: 3000 Vdc for 10 seconds (excludes EIA RS-232-C 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 quarter-wave antenna driven by 20 W at 150 MHz and 450 MHz, randomly keyed on and off at a distance of 1 meter from relay.
Dimensions	3.5" x 19" x 10.5" (8.89 cm x 48.2 cm x 26.7 cm) (H x W x D), SEL-267-5 5.25" x 19" x 13" (13.3 cm x 48.2 cm x 33.0 cm) (H x W x D), SEL-167-5
Unit Weight	16 pounds (7.3 kg), SEL-267-5 21 pounds (9.5 kg), SEL-167-5
Shipping Weight	26 pounds (11.8 kg), including two instruction manuals, SEL-267-5 32 pounds (14.5 kg), including two instruction manuals, SEL-167-5

Operating Temp. -40° F to 158° F (-40° C to 70° C)

Burn-in Temp. Each relay is burned in at 60° C for 100 hours

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 from negative-sequence and positive-sequence quantities. The negative-sequence voltamperes are 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

Loss-of-Potential (LOP) Detection

- Detects blown secondary fuse(s) condition
- Enabled or disabled via setting
- When enabled, an LOP condition blocks all directional phase overcurrent elements, directional ground overcurrent elements default forward
- LOP detection may be selected to close an output relay for alarm purposes

Automatic Reclosing

For selectable fault types (three shots)

Fault Location

Fault location is computed using event reports stored following each fault. The 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 on command. Calculated phase-to-phase currents are also displayed.

Demand: Current demand is computed with a 5 to 60 minute time constant. To see the current demand issue a METER 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.

Event Reporting

The relay retains a data record with current, voltage, relay element, and input/output contact information for each of the twelve most recent faults. 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

DETAILED SPECIFICATIONS

Phase Overcurrent (Secondary Values)

- 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
- 50AM, 50BM, 50CM (medium-set phase fault detectors used in loss-of-potential logic)
  Pickup: 0.5 to 40 A, ± 0.1 A ± 2% of setting

Ground Overcurrent (Secondary Values)

- 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: 51PP ≤ 4.0 A, secondary; 0.7 to 60.2 A, secondary
  51PP > 4.0 A, secondary; 0.2 to 14.9 times 51PP setting, where 51PP is the phase time-overcurrent element pickup setting. See Meter function description.

Directional Elements

- Phase directional element:
  Angle: MTA (maximum torque angle) setting (47° - 90° in 1° 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° in 1° steps).
  Sensitivity: Proportional to 51P pickup for 4A < 51PP < 12.6A:
  0.35VA at 12.6 A pickup at MTA
  0.11VA at 4.0 A pickup and below at MTA

Zero-Sequence Directional Element

- Voltage polarization:
  Angle: MTA setting (47° - 90° in 1° steps).
  Sensitivity: (0.125 V) x (51N pickup setting) at MTA in units of zero-sequence volts times residual amps, and V0 > 0.17V.

- Current polarization:
  Angle: 0°
  Sensitivity: (0.5 A) x (51N pickup setting), at 0°, in units of residual amps squared, and Ipol > 0.5 A.

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

LOP Sequence-Component Elements

- Negative-sequence overvoltage element (47QL)
  Pickup: 14 volts of V2
- Negative-sequence overcurrent element (50QL)
  Pickup: 0.083 A of I2
- Positive-sequence overvoltage element (47P)
  Pickup: 14 volts of V1

Three-Shot Reclosing Relay

- 79OI1 open interval 1,
- 79OI2 open interval 2,
- 79OI3 open interval 3:
  Timer range: 0 - 10,000 cycles in 0.25 cycle steps. A setting of 0 disables that shot and successive shots.
- 79RS reset interval:
  Timer range: 60 - 8,000 cycles in 0.25 cycle steps

HARDWARE DESCRIPTION

Figure 2.1 illustrates the major parts of the relay. Current and voltage inputs are isolated by magnetic input transformers. The signals are low-pass filtered, sampled by sample/hold amplifiers, and multiplexed to a programmable-gain amplifier. Its output drives an analog-to-digital converter. Each analog channel is sampled four times per power-system cycle.

The microcomputer consists of an eight-bit microprocessor, ROM (read-only memory) for program storage, RAM (random-access memory) for data storage, and EEPROM (electrically-erasable programmable ROM) for storing the relay settings. The EEPROM saves settings even during power loss. Input/output (I/O) devices connected to the microcomputer bus provide for the control of the output relays, targets, and monitor inputs such as the state of the breaker 52A contact. Other I/O devices provide communications for setting, reporting fault location, and other purposes. The relay includes an input for time code which allows users to synchronize the internal time clock with an external source of time code.

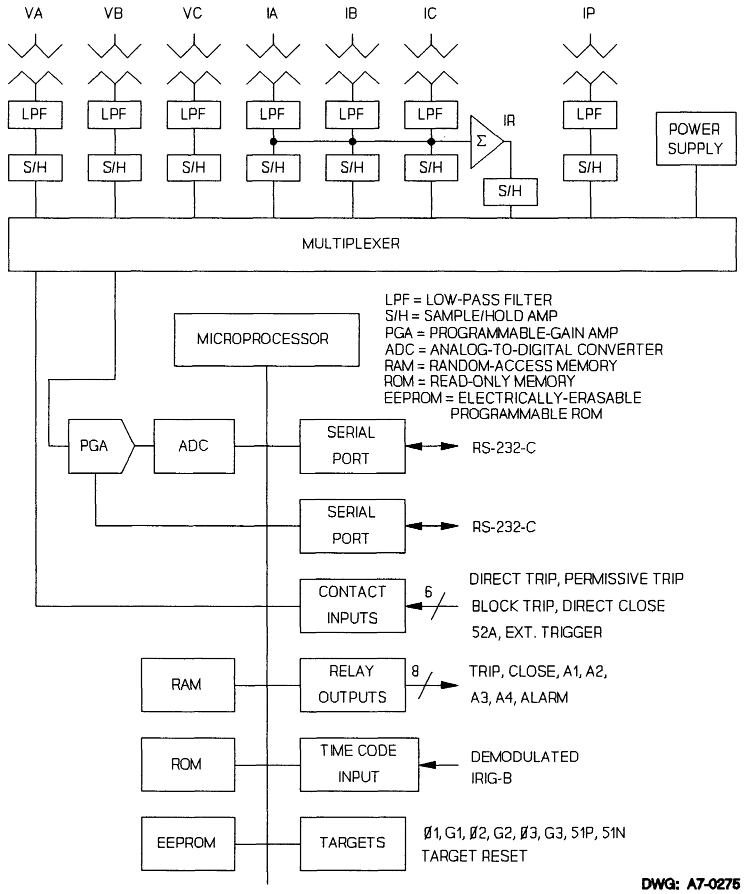


Figure 2.1: Hardware Block Diagram

SIGNAL PROCESSING

The relay low-pass filters all analog input channels to remove high frequency components. Next it samples each channel four times per power system cycle. After low-pass filtering, the relay digitally filters each sample with the CAL digital filter method. The CAL filter eliminates dc offset and reduces the decaying exponential offset that may be present on the input signal following a fault.

The digital filter has the properties of a double differentiator smoother and requires only addition and subtraction of data samples. Let the latest four samples of one channel be X1, X2, X3, and X4. Then the digital filter is defined:

$$P = X1 - X2 - X3 + X4.$$

This filter eliminates dc offsets. When all samples are set to the same value, the filter output is zero. It also eliminates ramps, which you may verify by setting the samples equal to 1, 2, 3, and 4. Again, the output is zero.

Every quarter-cycle, the relay computes a new value of P for each input. The current value of P combines with the previous value (renamed Q) to form a Cartesian coordinate pair. This pair represents the input signal as a phasor (P, Q). The relay processes these phasor representations of the input signals.

INPUTS AND OUTPUTS

Serial Interfaces

The SEL-267-5 Relay is equipped with two EIA RS-232-C serial communications ports. Port 2 has 9-pin connectors on both the front and rear panels, designated Port 2F and Port 2R, respectively.

Port 2R, located on the relay rear panel, is typically used with an SEL-DTA Display/ Transducer Adapter, SEL-RD Relay Display, or local printer. Port 2F is always available for short term local communications with a portable computer or printing terminal. Simply plug the device into the front panel port. The relay automatically discontinues communications with Port 2R and addresses Port 2F. When testing or data retrieval is complete, unplug the temporary device from Port 2F. The relay automatically resumes communication with the device connected to Port 2R.

Serial communications Port 1 and the Auxiliary Input for demodulated IRIG-B time code input remain on the relay rear panel.

The SEL-167-5 Relay does not include a front panel connector for Port 2.

Input Power

Terminals marked + and - should be connected to a source of control voltage. Polarity of dc power is unimportant. Power requirement is approximately 12 watts. Terminal marked GND connects to the instrument frame, and should be wired to the relay rack ground reference.

Contact Inputs

Six input circuits are provided. They are listed below:

Direct Trip	Direct Close
Permissive Trip	52A Monitor
Block Trip	External Trigger

To assert an input, nominal control voltage is applied to the appropriate terminal pair. Polarity is unimportant. The following table shows input parameters.

Table 2.1: Input Parameters

Logic Input Rating	Contact Input Range	Current at Nominal Voltage
24 Vdc	10 - 40 Vdc	4 mA
48 Vdc	25 - 60 Vdc	4 mA
125 Vdc	60 - 200 Vdc	4 mA
250 Vdc	200 - 280 Vdc	4 mA

Input functions are explained below:

Direct Trip (DT)

Assertion of the DT input causes the TRIP output to close immediately and unconditionally if so enabled (see LOGIC MTU command). It also cancels any reclose initiation or reclose sequence if so enabled in the MRC mask (see the LOGIC MRC command) and triggers an event report. The TRIP output remains closed as long as the DT input is asserted and drops out about 0.5 cycle after the DT input deasserts or approximately 60 ms after the TRIP output first closed, whichever is later. Applications include reclose cancel, test trip and Direct Underreaching Transfer Trip (DUTT) schemes. The OPEN command has the same effect as the DT input.

Direct Close (DC)

The Direct Close input functions as a reclose enable. Assert the input to enable the relay reclosing function.

Permissive Trip (PT)

The PT input is normally used in permissive transfer tripping schemes. When it asserts, an event is triggered and additional tripping conditions are allowed as selected in the logic setting procedure (see the LOGIC MPT command).

Block Trip (BT)

The BT input is normally used in blocking and fuse saving schemes. When it is not asserted, selected tripping conditions are allowed (see the LOGIC MTB command). This input also triggers an event report.

Circuit Breaker Monitor (52A)

The 52A input indicates the state of the breaker. The 52A is used by the tripping and closing functions and in the reclosing relay.

External Trigger for Event Report (ET)

An event report is triggered whenever the external trigger input is asserted. Asserting this input does not influence the protective functions in any way.

Relay Outputs

Seven output relays are provided. They are listed below with terminal numbers and contact types.

Table 2.2: Relay Outputs

Output Relay	Contact Type
TRIP	a
CLOSE	a or b
A1	a or b
A2	a or b
A3	a or b
A4	a or b
ALARM	a or b

All relay contacts are rated for circuit breaker tripping duty.

Three of the seven output relays perform fixed functions; the remaining four can be programmed with the LOGIC command.

TRIP Output

This output closes for any number of user-selected conditions. The conditions are grouped as follows: unconditional, subject to PT input assertion, subject to the absence of BT input, and subject to the breaker being open. The TRIP output never closes for less than the duration of the TDUR setting. After this interval, it opens when the fault condition ceases and the over-current elements in Relay Word Row 1 have dropped out, or when the TARGET RESET button is pressed. The latter facilitates relay testing without using a breaker simulator.

CLOSE Output

This output closes for reclose operations and in response to the CLOSE command. It opens when the 52A input is asserted or after the reclosing relay reset interval, whichever occurs first.

ALARM Output

The ALARM output closes for the following conditions:

Three unsuccessful Level 1 access attempts: 1 second pulse
Any Level 2 access attempt: 1 second pulse
Self-test failures: permanent contact closure or 1 second pulse, as directed by self-test.

The ALARM output also closes momentarily when operators change settings or enter a date with a different year than the one currently stored in EEPROM (see the DATE command).

Programmable Outputs (A1, A2, A3, A4)

These four outputs may be assigned to any combination of the bits in the Relay Word.

Potential Inputs

The potential inputs should be driven from a set of three line potential transformers with their primaries connected in a grounded-wye configuration and their secondaries connected in four-wire wye. The relay contains a set of three input transformers connected in four-wire wye. Since the relay includes zero-sequence voltage polarization, it is necessary to connect the neutral input terminal to the star point of the PT secondaries. The nominal voltage rating is 115 volts line-to-line or 67 volts line-to-neutral.

Note that the relay determines the zero-sequence voltage from the three voltage inputs VA, VB, and VC, so a separate V0 input is not needed.

The PT secondary star point should be grounded only once, preferably at the PT location. A second ground of the neutral wiring causes ground potential differences to appear in the PT secondary measurements as a neutral shift.

Current Inputs

The rating of the input current transformers in the relay is 5 amperes nominal, 15 amperes continuous, and 500 amperes for one second.

DEFINITION OF LOGIC VARIABLES

The relay output states depend on the following:

- Relay elements
- Contact-monitoring inputs
- Setting parameters
- Logic programming
- Commands received over communications link
- Status of self-tests

Since so many binary variables are involved, we define the functioning with Boolean logic equations. The logic variables involved are defined in the following section. Elements available in the Relay Word appear in boldface.

LOGIC DESCRIPTION

Relay Elements

Single-phase overcurrent relays	50A1 50B1 50C1	Nondirectional
	50A2 50B2 50C2	Nondirectional
	50A3 50B3 50C3	Nondirectional
Medium-set single-phase O/C relays	50AM 50BM 50CM (selectable for loss-of-potential)	
Polyphase time-overcurrent relay (driven by maximum phase current)		
Pickup	**51PP**	Torque Control or nondirectional
Trip	**51PT**	Torque Control or nondirectional
Residual time-overcurrent relay		
Pickup	**51NP**	Torque Control or nondirectional
Trip	**51NT**	Torque Control or nondirectional
Residual instantaneous-overcurrent	**50N1**	Nondirectional
Residual instantaneous-overcurrent	**50N2**	Nondirectional
Residual instantaneous-overcurrent	**50N3**	Nondirectional

Negative-sequence overvoltage	47QL	LOP detection
Negative-sequence overcurrent	50QL	LOP detection
Positive-sequence overvoltage	47P	LOP detection
Phase directional	32PQ	32PQF=forward; 32PQR=reverse
Negative-sequence directional	32Q	32QF=forward; 32QR=reverse
Zero-sequence dual pol. directional	32D	32DF=forward; 32DR=reverse

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

Timers

Z1DG	Zone 1 ground timer timeout operated by **67N1**	(Z1DG setting)
Z2DG	Zone 2 ground timer timeout operated by **67N2**	(Z2DG setting)
Z3DG	Zone 3 ground timer timeout operated by **67N3**	(Z3DG setting)
Z1DP	Zone 1 phase timer timeout operated by **67P1**	(Z1DP setting)
Z2DP	Zone 2 phase timer timeout operated by **67P2**	(Z2DP setting)
Z3DP	Zone 3 phase timer timeout operated by **67P3**	(Z3DP setting)
52BT	Time delayed inverse of 52A	(**52BT** setting)
79OI1	Reclosing relay first open interval	(79OI1 setting)
79OI2	Reclosing relay second open interval	(79OI2 setting)
79OI3	Reclosing relay third open interval	(79OI3 setting)
79RS	Reclosing relay reset interval timer	(79RS setting)

Enables from Setting Procedure

ZONE3 = F	Zone 3 is forward
ZONE3 = R	Zone 3 is reverse
32QE	Enables 32Q
32VE	Enables voltage polarization of 32D
32IE	Enables current polarization of 32D
67NE	Enables directional torque control for **67N1**, **67N2**, and **67N3**
67PE	Enables directional torque control for **67P1**, **67P2**, and **67P3**
51NTC	Selects torque control for 51N
51PTC	Selects torque control for 51P
LOPE	Selects loss-of-potential logic scheme

Contact Inputs

DT	Direct trip
PT	Permissive transfer trip
BT	Block trip
DC	Direct close
52	Circuit breaker monitor
EXT	External trigger for event report

Contact Outputs

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

INTERMEDIATE LOGIC

Intermediate Logic

The logic equations below represent combinations of the relay elements and other conditions. In the following equations the "*" indicates logical "and", while the "+" indicates logical "or". Elements available in the Relay Word appear in boldface.

Loss-of-Potential (LOP) Logic

Set **LOP** = 47QL * NOT (50QL)

+ NOT (47P) * NOT (50M)

Set **LOP** includes a three-cycle pickup delay.

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

Different set and clear conditions ensure LOP stays latched during subsequent faults, and clears when balanced voltages and currents return.

Determine how the relay uses loss-of-potential detection by selecting the appropriate LOPE setting listed below:

- N Relay sets LOP bit when loss-of-potential condition is detected.
  Directional phase and ground overcurrent elements are not affected by the LOP condition.
  Set the LOP bit in a programmable logic mask to indicate condition, if desired.

- Y Relay sets LOP bit when loss-of-potential condition is detected. Directional phase overcurrent elements are blocked. Directional ground overcurrent elements default forward.
  Set the LOP bit in a programmable logic mask to indicate condition, if desired.

- 1 If the 52A input is asserted while LOP is detected, the Relay Word LOP bit is asserted. Directional phase overcurrent elements are blocked. Directional ground overcurrent elements default forward.
  If the 52A input is not asserted while LOP is detected, the Relay Word LOP bit does not assert.
  If desired, set the LOP bit in a programmable logic mask to indicate a loss-of-potential condition while the breaker is closed.

- 2 Relay sets LOP bit when loss-of-potential condition is detected. Directional phase overcurrent elements are blocked. Directional ground overcurrent elements default forward.
  Relay asserts ALARM contact to indicate the LOP condition.

- 3 If the 52A input is asserted while LOP is detected, the Relay Word LOP bit is asserted. Directional phase overcurrent elements are blocked. Directional ground overcurrent elements default forward.
  If the 52A input is not asserted while LOP is detected, the Relay Word LOP bit is not asserted.
  Relay asserts ALARM contact while the Relay Word LOP bit is asserted.

- 4 Relay sets LOP bit when loss-of-potential condition is detected.
  Relay asserts ALARM contact to indicate the LOP condition.
  Directional phase and ground overcurrent elements are not affected by the LOP condition.

The following table summarizes the available LOPE settings and their results.

Table 2.3: LOPE Settings

LOPE Setting	Block Directional Phase on LOP	52A Supervises LOP Relay Word Bit	Close ALARM Contact on LOP Bit Assertion
N	No	No	No
Y	Yes	No	No
1	Yes	Yes	No
2	Yes	No	Yes
3	Yes	Yes	Yes
4	No	No	Yes

The logic equations below represent combinations of the relay elements and other conditions. In the following equations the "*" indicates logical "and", while the "+" indicates logical "or". Elements available in the Relay Word appear in boldface.

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*NOT(**LOP***LOPE=Y,1,2,3)	Phase forward direction
DRP	=	32PQR*PF	
D3P	=	**DFP**	If ZONE3 is forward
D3P	=	DRP	If ZONE3 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
50MF	=	50M * [**LOP** + LOPE=N,4)] * 50MFD	Asserts a settable delay after LOP and 50M overcurrent, or 50M overcurrent only if LOP is disabled
DFG	=	(32QF + **LOP** * (LOPE=Y,1,2,3)) * 32QE * (PF + GF) + 32DF * 32IE * GF + (32DF + **LOP** * (LOPE=Y,1,2,3)) * 32VE * GF + NOT(32QE + 32VE + 32IE)	Ground forward direction
DRG	=	32QR * 32QE * (PF + GF) + 32DR * (32IE + 32VE) * GF	Ground reverse direction
D3G	=	**DFG**	If ZONE3 is forward
D3G	=	DRG	If ZONE3 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** * Z3DP	Zone 3 timeout phase
Z2PT	=	**67P2** * Z2DP	Zone 2 timeout phase
Z1PT	=	**67P1** * Z1DP	Zone 1 timeout phase

Z3GT	=	**67N3** * Z3DG	Zone 3 timeout ground
Z2GT	=	**67N2** * Z2DG	Zone 2 timeout ground
Z1GT	=	**67N1** * Z1DG	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 initiating or cancelling reclose. The selected bits are stored in masks for each function. You can program the bits in these masks with the LOGIC command.

Table 2.4 shows the Relay Word for the relay.

Table 2.4: Relay Word

51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3
DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3
51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT
LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH

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

Table 2.5: Relay Word Bit Summary

51NP	-	Residual time-overcurrent element pickup
50N1	-	Residual instantaneous-overcurrent element (nondirectional)
50N2	-	Residual instantaneous-overcurrent element (nondirectional)
50N3	-	Residual instantaneous-overcurrent element (nondirectional)
51PP	-	Phase time-overcurrent element pickup
50P1	-	Zone 1 phase instantaneous-overcurrent element (nondirectional)
50P2	-	Zone 2 phase instantaneous-overcurrent element (nondirectional)
50P3	-	Zone 3 phase instantaneous-overcurrent element (nondirectional)
DFP	-	Direction forward-phase fault
67N1	-	Zone 1 ground directional overcurrent element (directional as enabled)
67N2	-	Zone 2 ground directional overcurrent element (directional as enabled)
67N3	-	Zone 3 ground directional overcurrent element (directional as enabled)
DFG	-	Direction forward--ground fault
67P1	-	Zone 1 phase directional overcurrent element (directional as enabled)
67P2	-	Zone 2 phase directional overcurrent element (directional as enabled)
67P3	-	Zone 3 phase directional overcurrent element (directional as enabled)
51NT	-	Ground time-overcurrent trip (directional as enabled)
Z1GT	-	Zone 1 timeout-ground
Z2GT	-	Zone 2 timeout-ground
Z3GT	-	Zone 3 timeout-ground
51PT	-	Phase time-overcurrent trip (directional as enabled)
Z1PT	-	Zone 1 timeout phase
Z2PT	-	Zone 2 timeout phase
Z3PT	-	Zone 3 timeout phase
LOP	-	Loss-of-potential condition
TRIP	-	Circuit breaker trip
TC	-	Trip (OPEN) command
DT	-	Direct trip from **DT** input
52BT	-	Time delayed inverse of 52A
SH1	-	Shot 1 reclosing detector
50MF	-	Assert a settable delay after LOP and 50M pickup (delay set by 50MFD)
DCTH	-	Demand current threshold exceeded

The use of the Relay Word and programmable masks provides application flexibility without rewiring panels or changing jumpers on circuit boards.

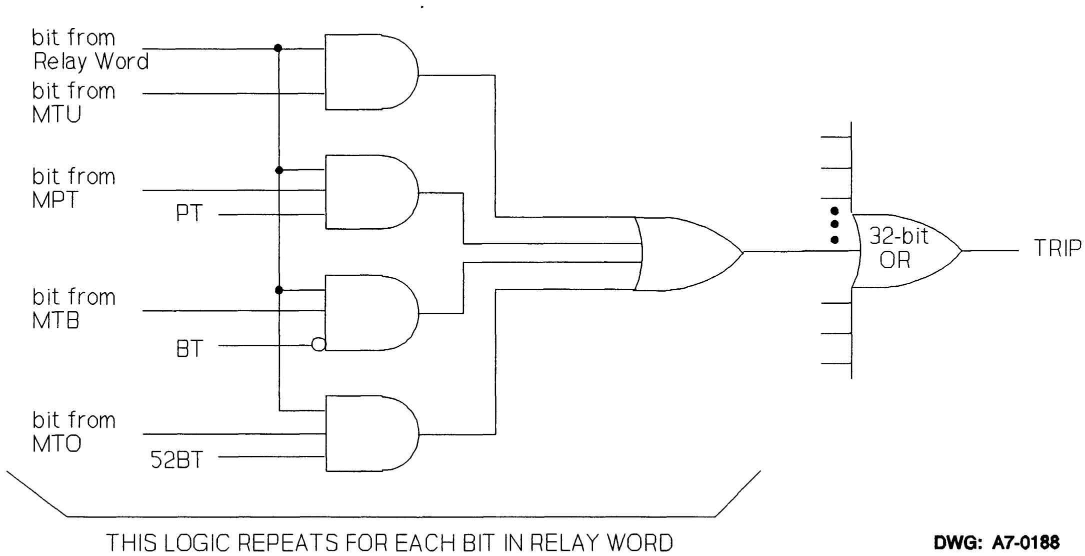


Figure 2.2: Programmable Trip Logic Diagram

OUTPUT EQUATIONS

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

The Programmable Trip Logic is shown in Figure 2.2.

The general form for each output equation follows:

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** contact	=	**TRIP**
Open **TRIP** contact	=	NOT (**TRIP**) * [NOT(Any element in Relay Word Row 1 picked up) + (TARGET RESET button pushed] * [Trip Duration timer expired (TDUR)]
Close CLOSE contact	=	(DC + 79OI1 + 79OI2 + 79OI3 + CLOSE command) * NOT (52A)
Open CLOSE contact	=	NOT (CLOSE) + 79RS

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

The "*" symbol indicates logical "and", while 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. The three open intervals and the reset timer are individually settable through the SET command. The Direct Close input operates as a recloser enable. Assert this input to enable the reclosing function.

To provide flexibility in applying the SEL-267-5 Relay to various reclosing schemes, the conditions for reclose initiation and cancellation are selected similarly to the output relay programming:

RI = R * MRI	MRI selects reclose initiate conditions from the Relay Word
RC = R * MRC	MRC selects reclose cancel conditions from the Relay Word

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 deasserts. Since the TRIP output never asserts for less than the TDUR timer setting, 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 with no fault condition present or for faults during the open interval of any shot.

TARGETS

The front panel targets illuminate for the conditions are shown in the table below.

Table 2.6: Front Panel Target Conditions for Illumination

Target LED	Conditions for Illumination
EN	Relay is operational
INST	Trip by instantaneous phase or ground element
TIME	Trip by time delayed phase or ground element
A	A-phase involved
B	B-phase involved
C	C-phase involved
G	Ground involved
LO	Recloser is in locked out state

The targets display the latest relay element condition at the time of tripping. If a new fault occurs, the targets show the new fault.

To clear the targets, press the TARGET RESET button. All eight indicators illuminate for approximately one second as a lamp test. If they do not, the relay is disabled due to a self-test failure. After a new fault occurs, the targets are cleared before the new fault targets are presented, so targets show the most recent fault. Pressing the TARGET RESET button unlatches the TRIP output from the overcurrent element which supervises the TRIP output. This feature is useful during relay testing and reduces the risk of installing the relay with the TRIP output asserted.

SELF-TESTS

The relay runs a variety of self-tests. Some tests have warning and failure states; others only have failure states. The relay generates a report after any change in self-test status.

The relay closes the ALARM contacts after any self-test fails. When it detects certain failures, the relay disables the breaker control functions and places the relay output driver port in an input mode. No outputs may be asserted when the instrument is in this configuration.

The relay runs all self-tests on power up and before enabling new settings. During normal operation, it performs self-tests at least every few minutes.

Offset

The relay measures the offset voltage of each analog input channel and compares the value against fixed limits. It issues a warning when offset is greater than 50 millivolts in any channel and declares a failure when offset exceeds 75 millivolts. Offset levels for all channels appear in the STATUS command format.

Power Supply

Power supply voltages are limit-checked. The table below summarizes voltage limits.

Table 2.7: Power Supply Self-Test Limits

Supply	Warning Thresholds		Failure Thresholds	
+5 V	+5.3 V	+4.7 V	+5.4 V	+4.6 V
+15 V	+15.8 V	+14.2 V	+16.2 V	+13.8 V
-15 V	-15.8 V	-14.2 V	-16.2 V	-13.8 V

The relay transmits a STATUS command response for any self-test failure or warning. A +5 volt supply failure deenergizes all output relays and blocks their operation. A ±15 volt supply failure disables protective relay functions while control functions remain intact. The ALARM relay remains closed after a power supply failure.

Random Access Memory

The relay checks random access memory (RAM) to ensure that each byte can be written to and read from. There is no warning state for this test. If the relay detects a problem, it transmits a STATUS command message with the socket designation of the affected RAM IC. A RAM failure disables protective and control functions and closes the ALARM output relay contacts.

Read Only Memory

The relay checks read only memory (ROM) by computing a checksum. If the computed value does not agree with the stored value, the relay declares a ROM failure. It transmits a STATUS command response with the socket designation of the affected ROM IC. A ROM failure disables protective and control functions and closes the ALARM output relay contacts.

Analog-to-Digital Converter

The analog-to-digital converter (A/D) changes voltage signals derived from power system voltages and currents into numbers for processing by the microcomputer. The A/D test verifies converter function by checking conversion time. The test fails if conversion time is excessive or a conversion starts and never finishes. There is no warning state for this test.

Though an A/D failure disables protective functions, control functions remain intact. The relay transmits a STATUS command response and closes the ALARM relay contacts.

Master Offset

The master offset (MOF) test checks offset in the multiplexer/analog to digital converter circuit. A grounded input is selected and sampled for dc offset. The warning threshold is 50 mV; failure threshold is 75 mV. A failure pulses the ALARM contact closed for one second.

Settings

The relay stores two images of the system settings in nonvolatile memory. These are compared when the relay is initially set and periodically thereafter. If the images disagree, the setting test fails and the relay disables all protective and control functions. It transmits the STATUS message to indicate a failed test. The ALARM relay remains closed after a setting failure.

Table 2.8 shows relay actions for any self-test condition: warning (W) or failure (F).

Table 2.8: Self-Test Summary

Self-Test	Limits	Status Message	Protection Disabled	Control Disabled	Alarm Output
RAM	----	F	YES	YES	permanent contact assertion
ROM	----	F	YES	YES	permanent contact assertion
SETTINGS	----	F	YES	YES	permanent contact assertion
A/D	----	F	YES	NO	permanent contact assertion
+5 V	±0.3 V	W	NO	NO	no ALARM contact assertion
	±0.4 V	F	YES	YES	permanent contact assertion
±15 V	±0.8 V	W	NO	NO	no ALARM contact assertion
	±1.2 V	F	YES	NO	permanent contact assertion
CHANNEL OFFSETS	50 mV	W	NO	NO	no ALARM contact assertion
	75 mV	F	NO	NO	one second contact pulse
MASTER OFFSET	50 mV	W	NO	NO	no ALARM contact assertion
	75 mV	F	NO	NO	one second contact pulse

SETTING PROCEDURE

You may enter the relay settings with the SET and LOGIC commands via the serial interfaces. The settings are stored in nonvolatile memory, so they are retained when the power is off.

The SET and LOGIC command descriptions explain how to enter settings.

EVENT REPORT

The relay records an eleven-cycle event report following any of these elements picking up:

67N1	67P1	51N
67N2	67P2	51P
67N3	67P3	

Event reports are also recorded due to assertion of the following inputs and execution of the following commands:

External Trigger input	Permissive Trip input
Direct Trip input	Block Trip input
OPEN command	TRIGGER command

A second report is triggered for the same fault if the trip occurs after the first report expires, so the beginning and end of each fault for which the relay trips is recorded. A second event report is not provided, however, if the TRIP output first asserts at or less than seven cycles after the first report is triggered. (Note that reports are triggered at the 16th quarter-cycle of data.)

Timing of the triggering instant is recorded to the nearest quarter-cycle, so that the duration of long faults can be computed from the time the first report is triggered by the fault, and the time the second report is triggered by the trip. The reported event time corresponds to the 16th quarter-cycle of the event report in all cases. The event report contains voltages, currents, system settings, and other information. It is described in detail in the EVENT REPORTING section.

Execution of the CLOSE command does not trigger an event.

The twelve most recent event reports are stored in memory and may be retrieved using the EVENT command. A short history of the twelve most recent events is available using the HISTORY command.

FAULT LOCATOR

The relay fault locator is automatically triggered by any of several events. These events include pickup of certain relay elements, assertion of certain contact inputs or outputs, and user-entered commands. However, the fault locator can be either enabled or disabled with the LOCAT setting in the setting procedure.

Specifically, the triggering events are:

(1) RELAY ELEMENTS (high-level trigger)
Ground overcurrent Zones 1, 2, or 3 (67N1, 67N2, 67N3)
Phase overcurrent Zones 1, 2, or 3 (67P1, 67P2, 67P3)
Ground time-overcurrent 51N pickup
Phase time-overcurrent 51P pickup

(2) CONTACT INPUTS (rising edge trigger)
External Trigger
Direct Trip
Permissive Trip
Block Trip

(3) CONTACT OUTPUTS (rising edge trigger)
TRIP

(4) USER ENTERED COMMANDS (rising edge trigger)
TRIGGER
OPEN

Note that the fault locator is triggered by the relay elements in a level sensitive manner. That is, additional event reports are not generated when additional relay elements pick up. Only the first relay element of any contiguous sequence triggers an event report.

Furthermore, all triggering relay elements must drop out for at least four cycles before they may initiate another event report. (This helps eliminate triggering multiple records for boundary faults.)

All other triggering events are rising-edge sensitive, meaning that for these events, additional reports are generated even while any or all relay elements remain picked up. This strategy permits, for example, the recording of fault clearing even when it occurs long after the initial event report is completed.

The fault location is always determined for event records in which any triggering relay elements are picked up, providing they are not picked up in the first seven rows of prefault data, or only in the last five rows of the event report. Furthermore, whenever the locator is able to determine the fault location, the corresponding record is labeled according to fault type, regardless of what actually triggered the event report. On the other hand, event records taken when no triggering relay elements are picked up are labeled as follows:

"EXT"for reports triggered externally via input contacts or by the "TRIGGER" command

or

"TRIP"for reports triggered by the assertion of the "TRIP" output contact.

The actual fault location algorithm is composed of two steps. First the fault type must be determined, and then the location calculated.

For the event reports, the fault type is determined largely independently of the relay element operations. Only the indicated zone is determined by relay elements, whereas the involved phases are determined by fault current comparison. (This is different from the TARGET data, which is completely derived from relay element operations.)

The compared currents are taken from the two rows at the middle of the stored fault data. If the uncompensated current magnitudes are in large ratios between phases (4:1 or more), then the fault type becomes immediately apparent as single- or two-phase. If not, the same current is load compensated by the two corresponding prefault current rows in the first cycle of the event report. If these fault current component magnitudes are in moderate ratios (1.5:1 or more), then the fault type is taken as single- or two-phase, or if the ratios are all less than 1.5, then the fault type is taken as three-phase. The explicit fault classification logic is as follows, where "I" values are uncompensated midfault currents, and "If" values are midfault currents compensated for load, yielding true fault current components:

IF	(Imax > 4 x Imed)	THEN Single-phase
ELSE IF	(Imed > 4 x Imin)	THEN Two-phase
ELSE IF	(Ifmax > 1.5 x Ifmed)	THEN Single-phase
ELSE IF	(Ifmed > 1.5 x Ifmin)	THEN Two-phase
ELSE IF	(none of the above)	THEN Three-phase.

This algorithm is largely immune to load and system grounding variations.

Once the fault type is determined, the fault locator employs the Takagi algorithm to locate the fault. Using both prefault and fault data, it compensates for the errors introduced by fault resistance in the presence of load flow. On the other hand, if no prefault data are provided by the event record, the relay gives a location based on a simple reactance measurement.

The fault locator depends on accurate transmission line parameters and instrument transformer ratios. Pay special attention to these potential sources of difficulty:

- Instrument transformer ratio errors due to overburden by other devices
- Capacitive potential transformer capacitor value
- Transmission line parameter errors

Although the fault-location computation takes several seconds, faults in quick succession, such as occur in a reclosing sequence, are handled. This is because the fault data are stored, and subsequently processed in turn. As an example, suppose three faults occur within a few seconds. The data from them are stored as they occur. The fault-location computations begin with the first (oldest) fault and proceed until all three faults are processed. Each of the summary event reports is transmitted as soon as the corresponding fault location is available.

Shunt capacitance of the transmission line is not taken into account. The capacitance causes the fault location to appear more remote by, approximately, a factor of 1/cos(bL), where bL is the line length in radians at 60 Hz. One wavelength at 60 Hz is 3100 miles. For example, the line length of a 100-mile line in radians is calculated:

$$(100/3100) \times 2 \times 3.14159 = 0.2027 \text{ radians.}$$

The indication neglecting capacitance is about cos (0.2027) = 0.98 times the actual location, or about 2 miles short for a fault at the far end of a 100-mile line.

When compensation using shunt reactors is employed, and when the measured current equals the reactor current plus the line current, the shunt reactors reduce the errors due to neglecting the shunt capacitance of the transmission line.

DIRECTIONAL ELEMENTS

The relay contains three directional elements, applied as shown below:

Fault Type	Criterion	Directional Element
ABC AB, BC, CA, ABG, BCG, CAG	50A3+50B3+50C3	phase directional (32PQ)

AG, BG, CG	Depends on 32VE, 32IE, and 32QE	Zero-sequence or negative-sequence settings only

The directional elements are phasor-product derived. For the negative-sequence element, the product is negative-sequence voltage times negative-sequence current, adjusted by the maximum torque angle (MTA) setting.

For the zero-sequence element, the product is the residual current adjusted by the MTA setting times the sum of the residual voltage plus polarizing current shifted in phase by the MTA setting.

The phase directional element is the positive-sequence voltage (eight cycles of memory polarization) times the positive-sequence current minus four times the negative-sequence voltage times the negative-sequence current, adjusted by the MTA setting.

TIME-OVERCURRENT ELEMENTS AND CURVES

The 51N and 51P time-overcurrent elements provide directional-forward or nondirectional protection. The pickup (51NP and 51PP) and trip (51NT and 51PT) states for both elements are available in the Relay Word for programming into any masks.

You can select the time dial and the curve shape with the setting procedure. Four curve shapes are available. The curves and equations are provided at the end of this section.

The 51N and 51P characteristic is formed by a recursive sum of the magnitude or magnitude-squared of the residual current for the 51N or maximum phase current for the 51P, adjusted by the pickup setting for the appropriate element.

The time dial setting determines the limit the recursive sum must reach for a trip.

TIME-OVERCURRENT CURVE EQUATIONS

Let t = operating time in seconds,
TD = time dial setting,
M = multiples of pickup.

Curve 1 -- Moderately Inverse

$$t_M = TD\left[0.157 + \frac{0.668}{M-1}\right]$$

Curve 2 -- Inverse

$$t_M = TD\left[0.180 + \frac{5.95}{M^2-1}\right]$$

Curve 3 -- Very Inverse

$$t_M = TD\left[0.0963 + \frac{3.88}{M^2-1}\right]$$

Curve 4 -- Extremely Inverse

$$t_M = TD\left[0.0352 + \frac{5.67}{M^2-1}\right]$$

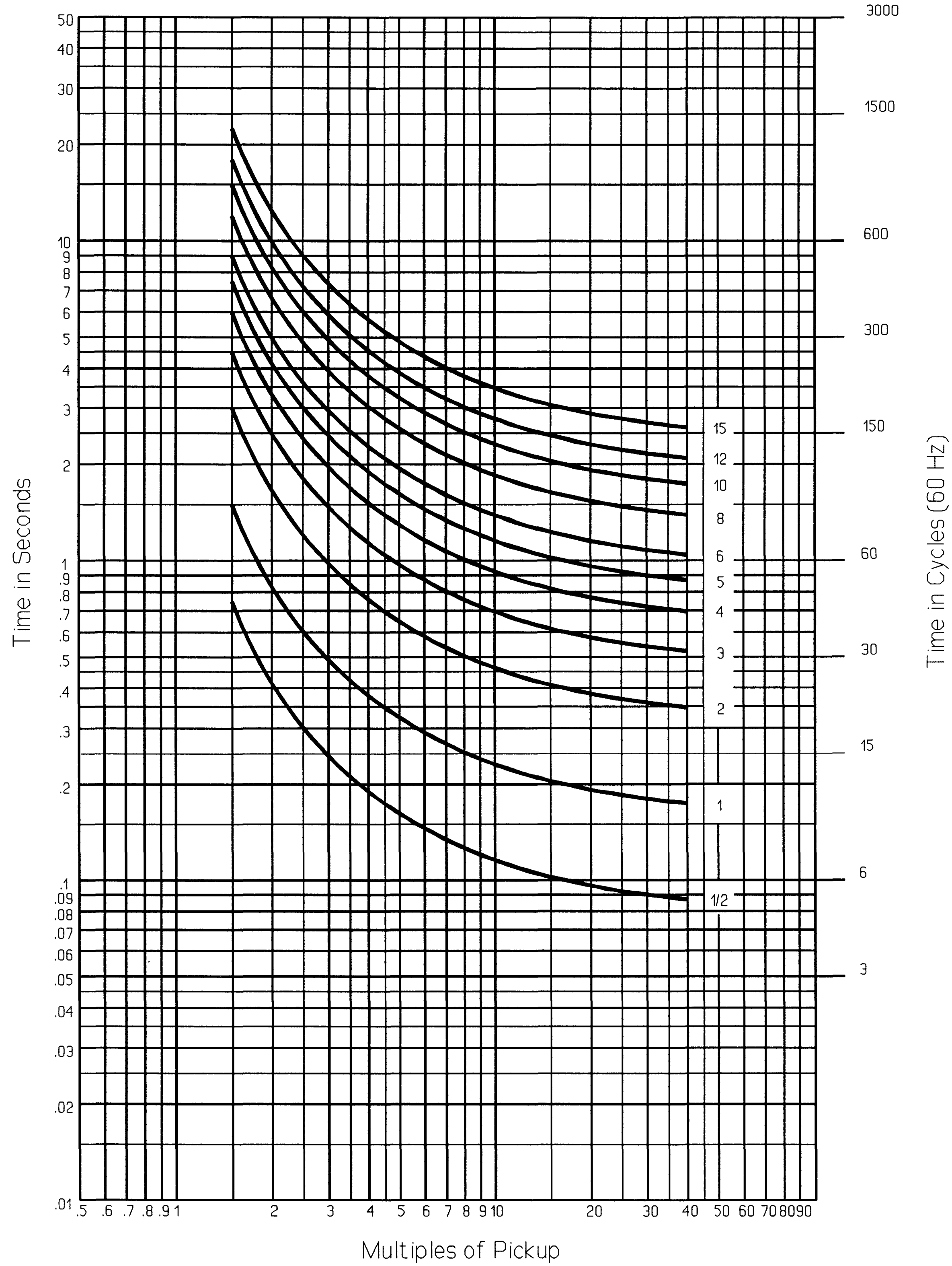


Figure 2.3: Time-Overcurrent Element Moderately Inverse Time Characteristic (Curve 1)

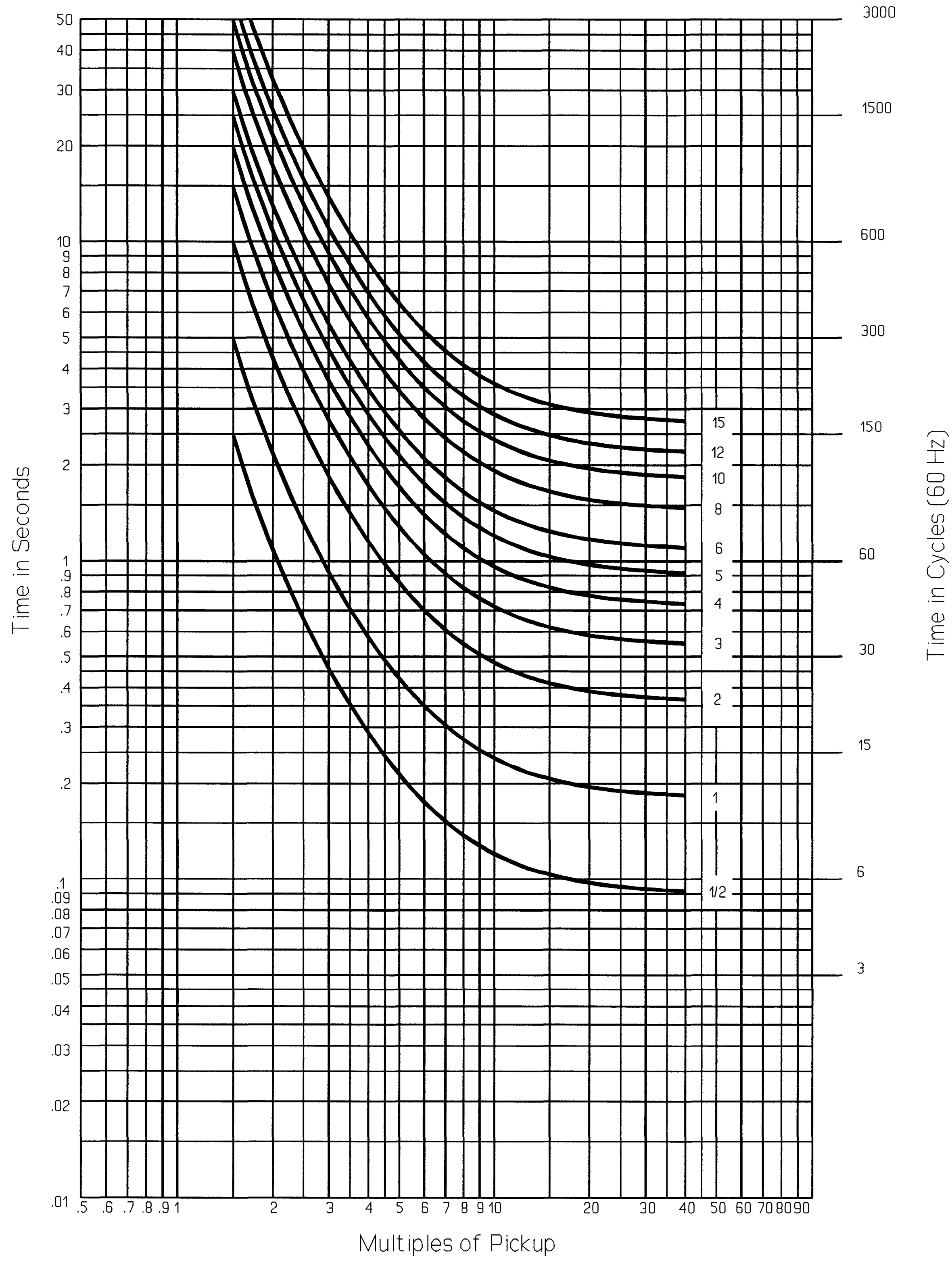


Figure 2.4: Time-Overcurrent Element Inverse Time Characteristic (Curve 2)

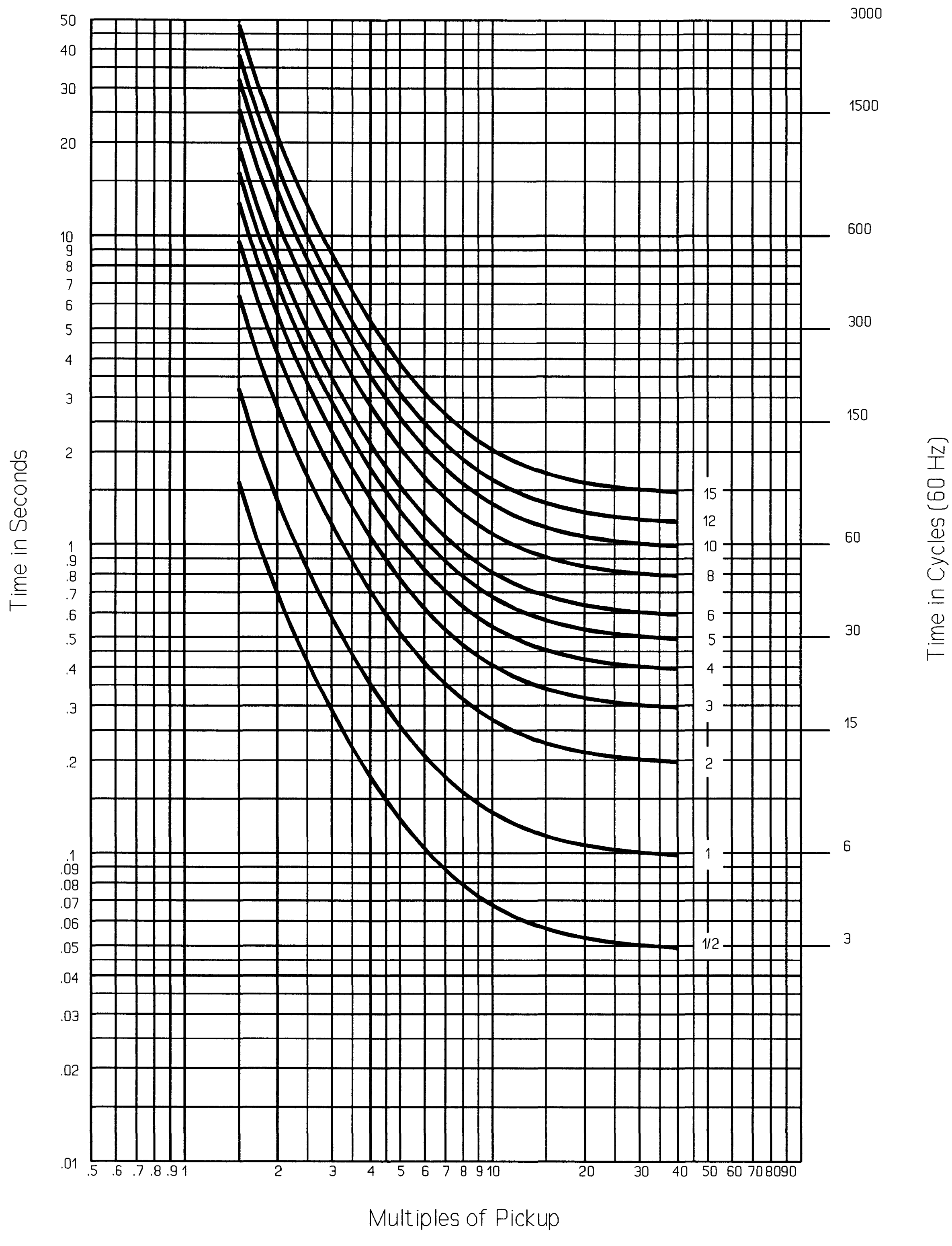


Figure 2.5: Time-Overcurrent Element Very Inverse Time Characteristic (Curve 3)

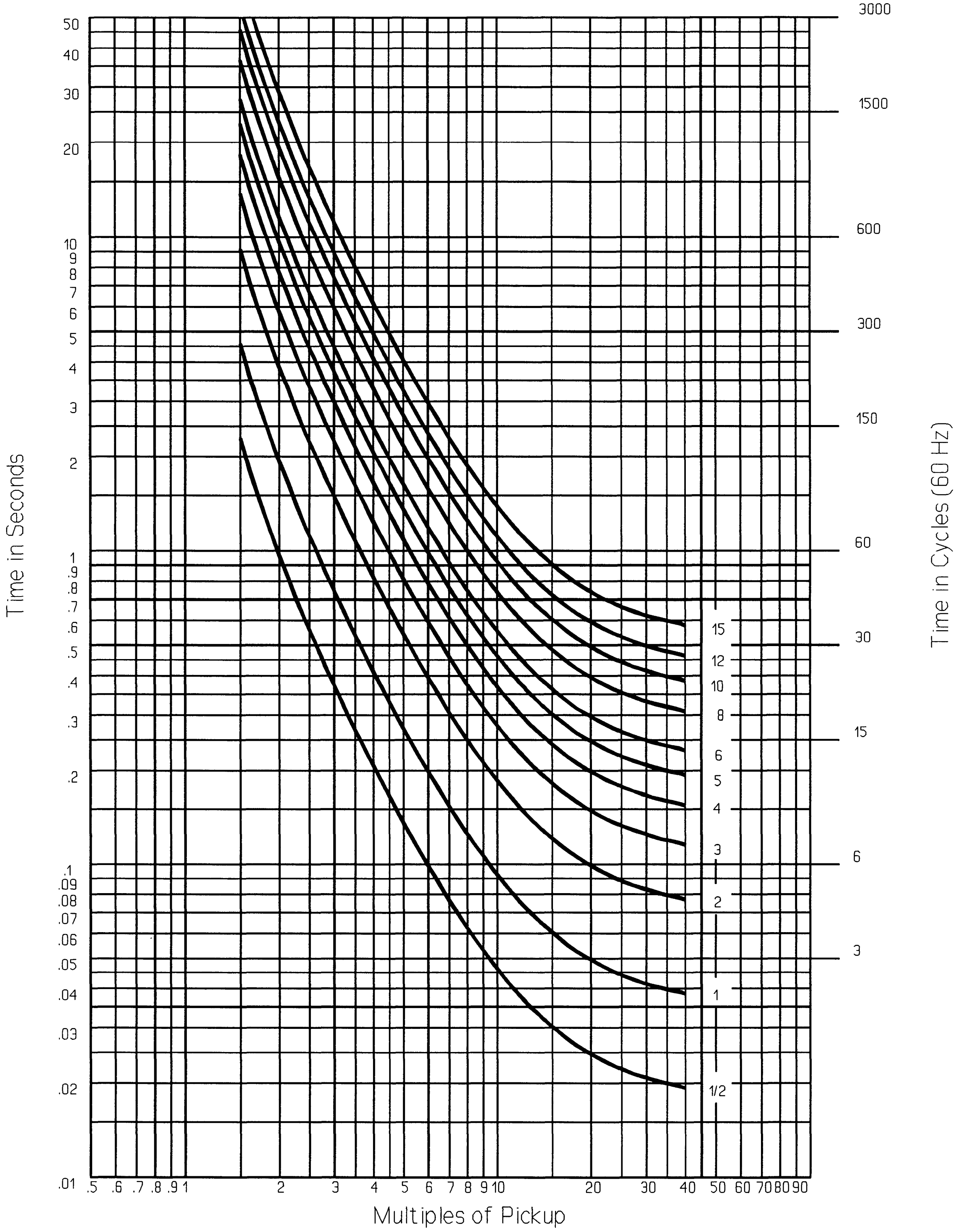
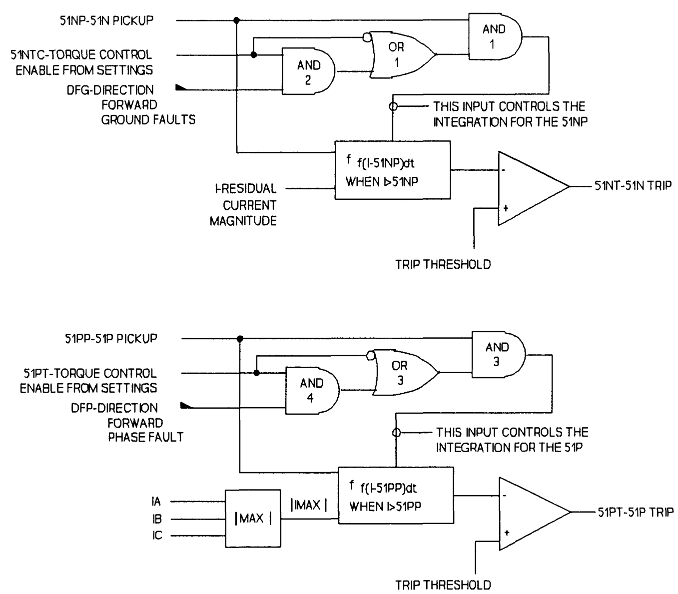
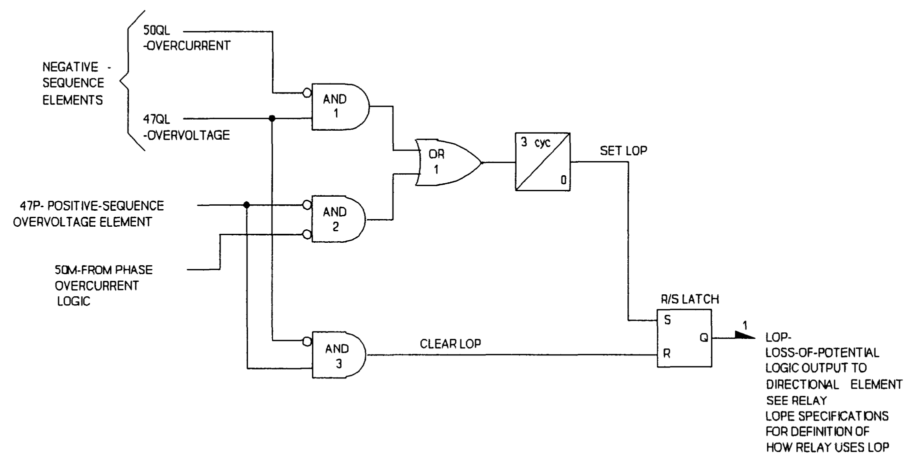


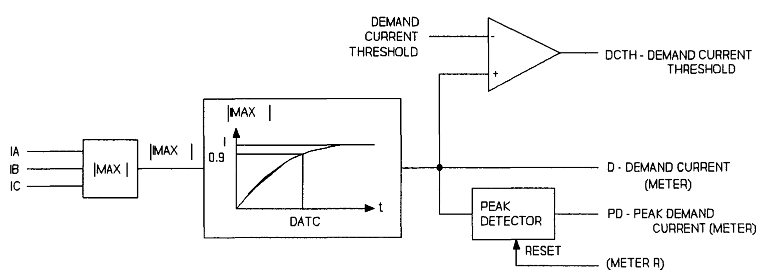
Figure 2.6: Time-Overcurrent Element Extremely Inverse Time Characteristic (Curve 4)



PHASE TIME-OVERCURRENT (51P) AND GROUND TIME OVERCURRENT (51N) LOGIC DIAGRAM

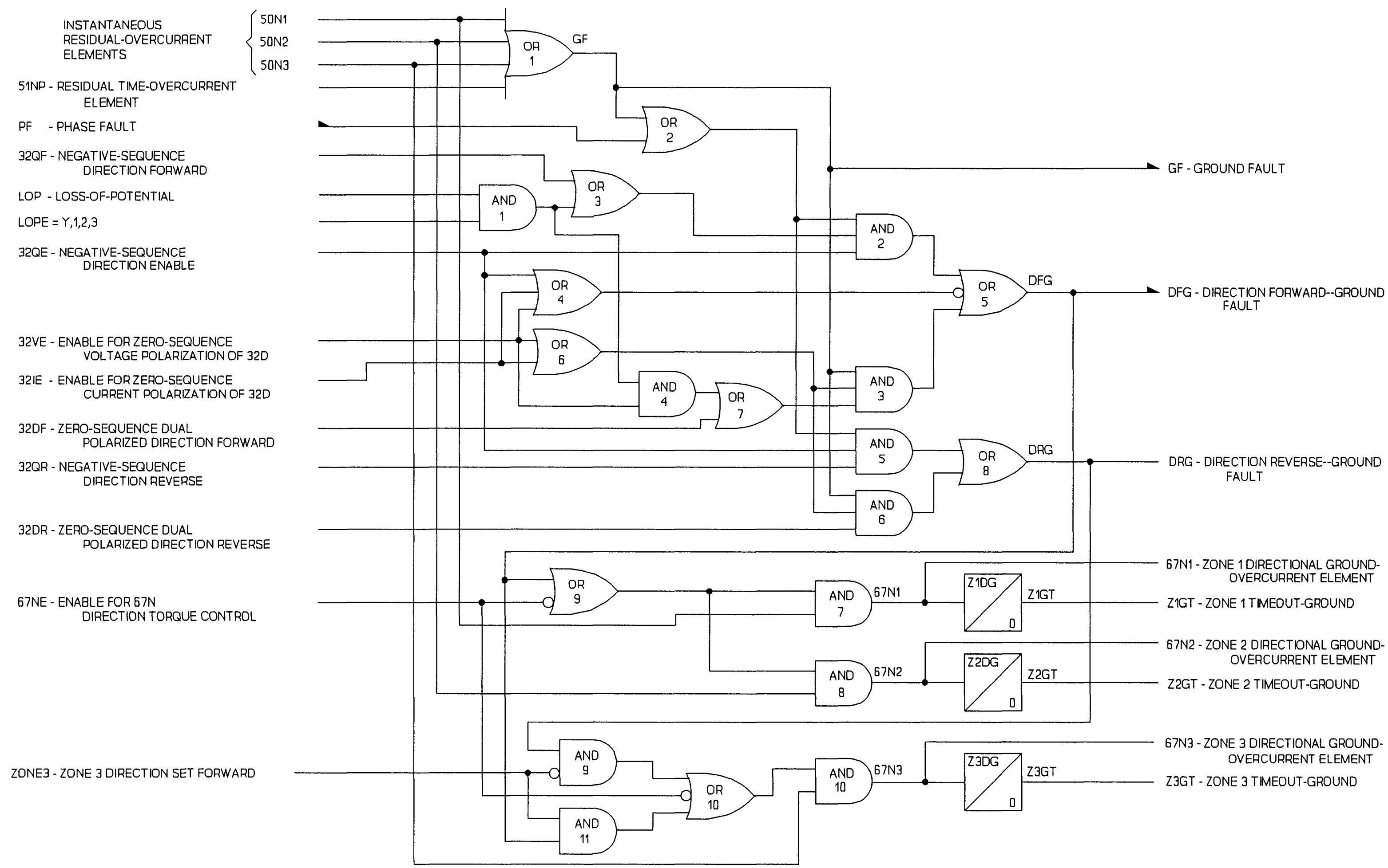


LOSS-OF-POTENTIAL LOGIC DIAGRAM



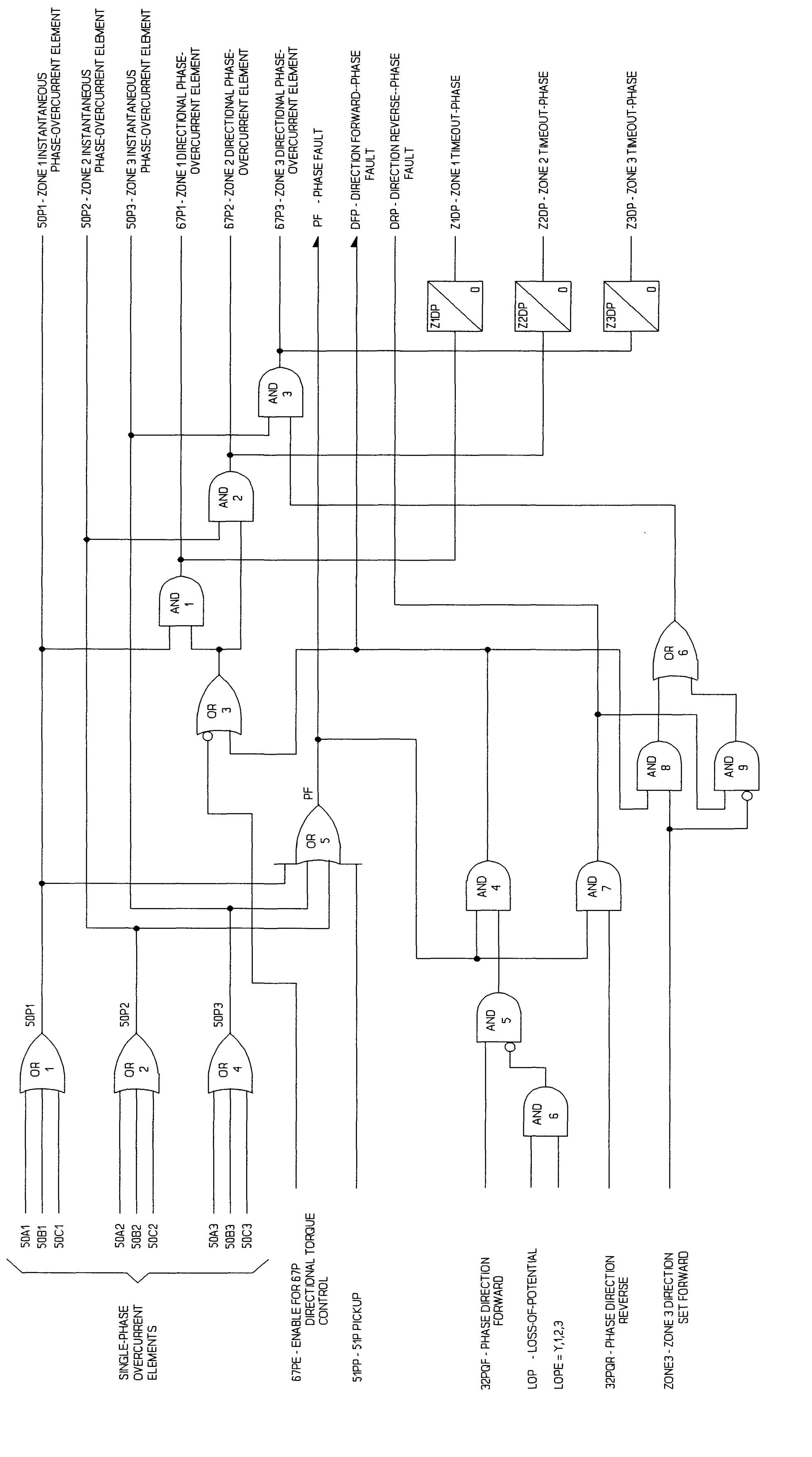
DEMAND AMMETER

DWG: 1090101A



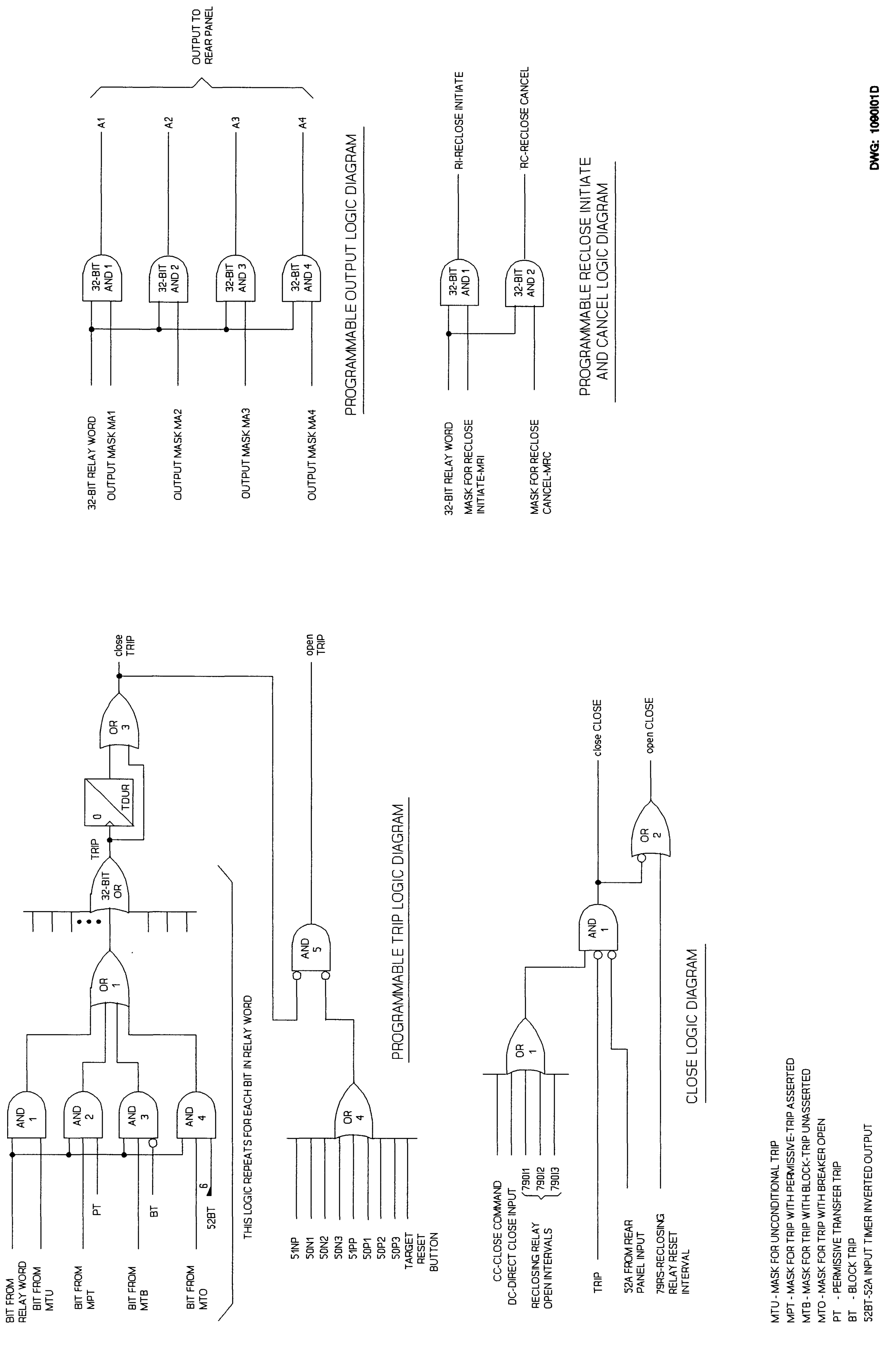
INSTANTANEOUS AND DIRECTIONAL GROUND-OVERCURRENT LOGIC DIAGRAM

DWG: 1080I01B



INSTANTANEOUS AND DIRECTIONAL PHASE-OVERCURRENT LOGIC DIAGRAM

DWG: 1060I01C



PROGRAMMABLE TRIP LOGIC DIAGRAM
BIT FROM RELAY WORD
BIT FROM MTU
BIT FROM MPT
PT
BIT FROM MTB
BT
BIT FROM MTO
52BT
6
AND 1
AND 2
AND 3
AND 4
OR 1
32-BIT OR
TRIP
0
TDUR
OR 3
close TRIP
open TRIP
THIS LOGIC REPEATS FOR EACH BIT IN RELAY WORD
51NP
50N1
50N2
50N3
51PP
50P1
50P2
50P3
TARGET RESET BUTTON
OR 4
AND 5
CLOSE LOGIC DIAGRAM
CC-CLOSE COMMAND
DC-DIRECT CLOSE INPUT
RECLOSING RELAY OPEN INTERVALS
79OI1
79OI2
79OI3
TRIP
52A FROM REAR PANEL INPUT
79RS-RECLOSING RELAY RESET INTERVAL
OR 1
AND 1
OR 2
close CLOSE
open CLOSE
PROGRAMMABLE OUTPUT LOGIC DIAGRAM
32-BIT RELAY WORD
OUTPUT MASK MA1
OUTPUT MASK MA2
OUTPUT MASK MA3
OUTPUT MASK MA4
32-BIT AND 1
32-BIT AND 2
32-BIT AND 3
32-BIT AND 4
A1
A2
A3
A4
OUTPUT TO REAR PANEL
PROGRAMMABLE RECLOSE INITIATE AND CANCEL LOGIC DIAGRAM
32-BIT RELAY WORD
MASK FOR RECLOSE INITIATE-MRI
MASK FOR RECLOSE CANCEL-MRC
32-BIT AND 1
32-BIT AND 2
RI-RECLOSE INITIATE
RC-RECLOSE CANCEL
MTU - MASK FOR UNCONDITIONAL TRIP
MPT - MASK FOR TRIP WITH PERMISSIVE-TRIP ASSERTED
MTB - MASK FOR TRIP WITH BLOCK-TRIP UNASSERTED
MTO - MASK FOR TRIP WITH BREAKER OPEN
PT - PERMISSIVE TRANSFER TRIP
BT - BLOCK TRIP
52BT-52A INPUT TIMER INVERTED OUTPUT
DWG: 1090I01D

COMMUNICATIONS
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FIGURES

COMMUNICATIONS

INTRODUCTION

The relay is set and operated via serial communications interfaces connected to a terminal and/or a modem or the SEL Protective Relay Terminal Unit. Communications serve these purposes:

The relay receives and executes relay/fault locating settings.

The relay transmits messages in response to changes in system status, such as self-test warnings.

The relay generates an event record for any of the following conditions:

- A fault
- Assertion of the EXTERNAL TRIGGER input
- Assertion of the DIRECT TRIP input
- Assertion of the PERMISSIVE TRIP input
- Assertion of the BLOCK TRIP input
- In response to the TRIGGER command
- Assertion of the TRIP output

No event record is made for assertion of the DIRECT CLOSE input, assertion of the 52A input or execution of the CLOSE command.

The relay responds to commands spanning all functions of the instrument, such as metering, setting the clock, and control operations.

Two access levels with separate passwords protect against unauthorized access through the communications ports.

It is impossible to disable any relaying or control functions via communications, unless a user enters erroneous or improper settings using the SET or LOGIC command.

SERIAL PORT CONNECTIONS AND CONFIGURATIONS

The SEL-267-5 Relay is equipped with two EIA RS-232-C serial communications ports. Port 2 has 9-pin connectors on both the front and rear panels, designated Port 2F and Port 2R, respectively.

Port 2R, located on the relay rear panel, is typically used with an SEL-DTA Display/ Transducer Adapter, SEL-RD Relay Display, or local printer. Port 2F is always available for short term local communications with a portable computer or printing terminal. Simply plug the device into the front panel port. The relay automatically discontinues communications with Port 2R and addresses Port 2F. When testing or data retrieval is complete, unplug the temporary device from Port 2F. The relay automatically resumes communication with the device connected to Port 2R.

Serial communications Port 1 and the Auxiliary Input for demodulated IRIG-B time code input remain on the relay rear panel.

The SEL-167-5 does not include a front panel connector for Port 2.

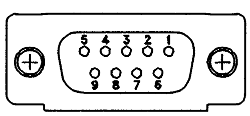
Communications port baud rate jumpers are located along the front edge of the circuit board. To select a baud rate for Port 1 or Ports 2, remove the relay front panel. The jumpers are visible to the right of the target LEDs. Carefully move the jumpers using needle-nosed pliers. Available rates are 300, 600, 1200, 2400, 4800, and 9600 baud.

Caution: Do not select two baud rates for the same port as this can damage the relay baud rate generator. The relay is shipped with Port 1 set to 300 baud and Port 2F/2R set to 2400 baud.

The serial data format is:

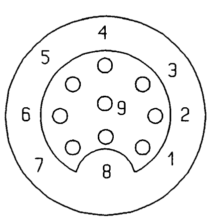
Eight data bits
Two stop bits
No parity bit

This format cannot be altered.



(female chassis connector, as viewed from outside panel)

Figure 3.1: SEL-267-5 9-Pin Connector Pin Number Convention



(female chassis connector, as viewed from outside rear panel)

Figure 3.2: SEL-167-5 9-Pin Connector Pin Number Convention

Table 3.1 lists port pin assignments and signal definitions.

Table 3.1: SEL-267-5 Relay Serial Port Connector Pin Assignments

Pin	Port 1, Port 2R	Port 2F	Description
1	+5 Vdc	N/C	
2	RXD	RXD	Receive data input.
3	TXD	TXD	Transmit data output.
4	+12 Vdc	N/C	
5	GND	GND	
6	-12 Vdc	N/C	
7	RTS	RTS	The relay asserts this line under normal conditions. When its received-data buffer is full, the line is deasserted, and asserts again when the buffer has sufficient room to receive more data. Connected devices should monitor RTS (usually with their CTS input) and stop transmission whenever the line deasserts. If transmission continues, data may be lost.
8	CTS	CTS	The relay monitors CTS, and transmits characters only if CTS is asserted.
9	GND	GND	Ground for ground wires and shields

The port pin assignments and signal definitions are given below.

Table 3.2: Port Pin Assignments

Pin	Port 1, Port 2R	Port 2F	Description
1	+5 Vdc	N/C	
2	RXD	RXD	Receive data input.
3	TXD	TXD	Transmit data output.
4	+12 Vdc	N/C	
5	GND	GND	
6	-12 Vdc	N/C	
7	RTS	RTS	The relay asserts this line under normal conditions. When its received-data buffer is full, the line is deasserted, and asserts again when the buffer has sufficient room to receive more data. Connected devices should monitor RTS (usually with their CTS input) and stop transmission whenever the line deasserts. If transmission continues, data may be lost.
8	CTS	CTS	The relay monitors CTS, and transmits characters only if CTS is asserted.
9	GND	GND	Ground for ground wires and shields

COMMUNICATIONS PROTOCOL

Communications protocol consists of hardware and software features. Hardware protocol includes the control line functions described above. This section also describes a software protocol designed for manual and automatic communications.

1. All commands received by the relay must be of the form:

   <command><CR> or <command><CRLF>

   Thus, a command transmitted to the relay should consist of the command name, followed by either a carriage return or a carriage return and a line feed. When entering commands, you may truncate to the first three characters. Upper or lower cases are irrelevant for all command entries except passwords.

2. All messages transmitted by the relay are of the following format:

   <STX> <MESSAGE LINE 1> <CRLF>
   <MESSAGE LINE 2> <CRLF>
   .
   .
   <LAST MESSAGE LINE> <CRLF> <PROMPT> <ETX>

   That is, each message begins with the start-of-transmission character (ASCII 02), and ends with the end-of-transmission character (ASCII 03), and each line of the message includes a carriage return and line feed at its end.

   Note: The ENTER key on most key boards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the ENTER key after commands, which should send the proper ASCII code to the relay.

3. The relay indicates the volume of data in its received-data buffer by an XON/XOFF protocol.

   XON (ASCII hex 11) is transmitted by the relay when the buffer drops below one-quarter full. The relay also asserts the RTS output.

   XOFF (ASCII hex 13) is transmitted when the buffer fills above 3/4 full. The relay deasserts the RTS output when the buffer is approximately 95% full. Automatic transmitting sources should monitor for the XOFF character and suspend transmission so that they won't overwrite the buffer. Transmission should resume when the XON character is received.

4. An XON/XOFF procedure may be used to control data transmission by the relay. When the relay receives XOFF while transmitting, it pauses until an XON character is received. If no message is being transmitted when XOFF is received, the relay blocks transmission of any message presented to its transmitting buffer. The message will be transmitted when XON is received.

   Reception of the CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating unwanted transmissions.

5. Control characters can be sent from most keyboards using the following keystrokes:

XON:	**<CTRL> Q**	(hold down the Control key and press Q)
XOFF:	**<CTRL> S**	(hold down the Control key and press S)
CAN:	**<CTRL> X**	(hold down the Control key and press X)

COMMAND CHARACTERISTICS

The relay responds to commands sent to either serial communications interface. A two-level password system provides security against unauthorized access.

When the relay is first turned on, the instrument is in Access Level 0 and honors only the ACCESS command. It responds "Invalid command" or "Invalid access level" to any other entries.

Most commands may be used in Access Level 1, which is entered with the ACCESS command and the first password. This password is factory-set to OTTER, and may be changed with the PASSWORD command (Access Level 2).

Critical functions such as circuit breaker control and changing settings may be executed only from Access Level 2. You may enter Access Level 2 using the 2ACCESS command and the second password. The Level 2 password is factory-set to TAIL, and may be changed with the PASSWORD command.

Startup

After the relay is turned on, the instrument transmits the following message to the port designated as the "automatic" port:

```
Example 69 kV Line                    Date:  04/01/93  Time:  01:01:01

SEL-167
=
```

You should also hear the ALARM relay pull in, opening its "b" contact. The instrument is shipped with Port 2 designated as the automatic port; you may use the SET command and the AUTO setting to select either Port 1, 2, or both for the transmission of automatic responses from the SEL-267-5 Relay (see SET command).

To enter Level 1, type the following on a terminal connected to Port 2:

```
=ACCESS <ENTER>
```

The response is:

```
Password: ? @@@@@@
```

Enter the Level 1 password, e.g., **OTTER** and press **<ENTER>**. The response is:

```
Example 69 kV Line                    Date:  04/01/93  Time:  01:01:44

Level 1
=>
```

The equal sign and greater-than sign represent the Access Level 1 prompt. Any Level 1 command can be executed from this prompt.

Use a similar procedure to enter Access Level 2:

Type **2ACCESS <ENTER>** and listen for the ALARM relay to drop out and pull in. This command always pulses the ALARM relay contact for about one second, indicating an attempt at Level 2 Access. Enter the proper password, e.g., TAIL, when you receive the second password prompt. After you enter the second password, the relay opens access to Level 2, as indicated by the following message and the Level 2 prompt:

```
Example 69 kV Line                    Date:  04/01/93  Time:  01:01:50

Level 2
=>>
```

Any Level 1 or Level 2 command may be executed from this prompt.

Command Format

Commands consist of three or more characters; you may truncate commands to the first three characters to expedite entry. Upper or lower case characters may be used without distinction, except in passwords.

Arguments must be separated from the command by spaces, commas, semicolons, colons, or slashes.

Commands may be entered any time after an appropriate prompt is displayed.

COMMAND DESCRIPTIONS

Access Level 0 Command

ACCESS

Use ACCESS to enter the system from the Level 0 prompt (=). After typing **ACCESS <ENTER>**, a prompt for the Level 1 password appears. Type the first password, and press **<ENTER>**. The factory set Level 1 password is OTTER, but should ultimately be changed by the end-user with the PASSWORD command from Access Level 2.

Successful access is indicated by the display example shown below:

```
=ACCESS <ENTER>
Password: ? OTTER <ENTER>


Example 69 kV Line                    Date:  04/01/93  Time:  01:02:05

Level 1
=>
```

The => prompt indicates that you have reached Access Level 1.

After three successive failed access attempts, the ALARM contact is pulsed closed for one second. This feature can be used to alert operations personnel that possible unauthorized access is being attempted if the ALARM contact is connected to a monitoring system such as SCADA.

Access Level 1 Commands

2ACCESS

Use 2ACCESS to continue from Level 1 to Level 2. Type **2ACCESS <ENTER>** to display the prompt for the Level 2 password. Enter the second password in the same manner as the first and press **<ENTER>**. The factory set Level 2 password is TAIL, but should ultimately be changed by the end-user with the PASSWORD command.

Successful access is indicated by the display example shown below:

```
=>2ACCESS <ENTER>
Password: ? TAIL <ENTER>

Example 69 kV Line                 Date:  04/01/93  Time:  01:02:13

Level 2
=>>
```

The =>> prompt signifies that Access Level 1 and 2 commands may be entered. The ALARM contact is pulsed closed for one second (if no alarm condition exists, such as self-test failure) for any Level 2 access attempt, successful or otherwise.

DATE mm/dd/yy

To display the current date stored in the internal calendar/clock, type **DATE <ENTER>**. To set the date, type **DATE mm/dd/yy <ENTER>**.

To set the date to April 1, 1993, enter:

```
DATE 4/1/93 <ENTER>
```

The relay responds by setting the date, pulsing closes the ALARM, and the year is stored in EEPROM.

EVENT n

You may view event records using an event report. To display the event report for the nth event, type **EVENT n <ENTER>**. The parameter n is 1 for the most recent event and 12 for the oldest event stored in the relay memory. If n is not specified, the report defaults to one.

To inspect the newest report type **EVENT 1 <ENTER>**, or **EVE <ENTER>**. The report provides the relay identifier string, date, and time the event occurred. The next part of the event report displays eleven cycles of data for the five current channels (IPOL, IR, IA, IB, and IC), three voltage channels (VA, VB, and VC), and the states of the internal relay elements, outputs and inputs. Next, the report shows the type of event, fault location in miles, primary ohms to the fault location, duration, and the maximum phase current measured at the midpoint of the fault. When a fault causes a trip, the fault targets are shown as well. The relay and logic settings are displayed at the end of the report.

Recall (from the COMMUNICATIONS PROTOCOL description) that you may use the **<CTRL> X** (cancel) sequence to terminate any transmission from the relay, **<CTRL> S** to pause, and **<CTRL> Q** to continue. These are useful in reviewing or terminating an event report.

When the event buffers are cleared by a control power interruption, all event data are lost. If the buffer is empty when an event is requested, the relay returns this message:

```
Invalid event
```

The EVENT REPORTING section provides a sample event report and explanation.

HISTORY

This command displays the date, time, and type of event 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 provided below:

```
=>HISTORY <ENTER>

Example 69 kV Line                    Date:  04/01/93  Time:   11:12:12

#  DATE      TIME              TYPE    DIST    DUR     CURR      TARGETS
1  2/28/90   11:11:28.829      AGT     54.23   10.50   366.5     51N
2  2/28/90   11:11:28.429      AG      54.10   7.50    365.7
3  2/28/90   11:09:50.141      BC      9.05    4.00    1320.9    P1
4  2/28/90   11:08:58.787      BC      8.98    4.75    1155.9    G1
5
6
7
8
9
10
11
12
=>
```

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

Each event report is time tagged to the nearest quarter-cycle (4.17 ms) and referenced to the 16th row of data in the report. All reports trigger at row 16. Thus, the duration of a long fault that triggers a report when the fault occurs and a second report when TRIP occurs is calculated using the difference between the two report times.

The TYPE column provides an abbreviated indication of event type found in the report. This is the same data presented as EVENT in the event summary automatically generated for each fault.

For faults, the indication includes phase involvement information. The phase involvement is determined independently from relay elements. Phase involvement is determined solely from uncompensated and load compensated current magnitudes at the midpoint of the first contiguous relay pickup sequence in the event report. See the FAULT LOCATOR section for algorithmic details.

The phase involvement is indicated as one of:

AG	:	For A-phase to ground faults
BG	:	For B-phase to ground faults
CG	:	For C-phase to ground faults
AB	:	For A-B two-phase faults
BC	:	For B-C two-phase faults
CA	:	For C-A two-phase faults
ABG	:	For A-B two-phase to ground faults
BCG	:	For B-C two-phase to ground faults
CAG	:	For C-A two-phase to ground faults
ABC	:	For three-phase faults

For event reports triggered by the assertion of the TRIP output, the TYPE designation is appended with a "T". This aids in determining clearing times for faults which persist beyond the end of the first event report. For example, if the SEL-267-5 Relay trips for a BG fault after completing the initial report, the second report shows "BGT" for TYPE.

For events other than faults, the TYPE indication is either "TRIP" or "EXT". The TYPE shows "TRIP" when the relay generates an event report in response to assertion of the TRIP output, which results from execution of the OPEN command during no-fault conditions. For all other events, TYPE shows "EXT", indicating a report generated in response to some external stimulus such as the assertion of the ET (External Trigger), PT (Permissive Trip), BT (Block Trip), or DT (Direct Trip) inputs or by execution of the TRIGGER command.

The DIST column presents the equivalent distance to a fault in miles. This is calculated using either the Takagi algorithm or a reactance measurement, depending on whether prefault data are available in the event report. For some boundary faults of long duration with sporadic relay operation, the fault-locator may not be able to locate the fault for every report generated. The DIST column can display "999999" in such cases (while this behavior can be contrived under test conditions, it is extremely rare in actual practice).

The column labeled DUR gives a measure of the fault duration. This is calculated using the first pickup of a Zone 1, 2, 3, 51N, or 51P relay element until the first dropout of all said relay elements. In other words, it is the duration of the first contiguous pickup of relay elements found in the long event report converted to units of cycles.

The CURR column shows the magnitude of the maximum phase-current measured at the middle of the fault in primary amperes.

The TARGETS column shows fault targets for faults which cause a trip to occur. If no trip occurred for the fault or the event is not a fault, this column is blank. These targets are the same as the relay front panel targets.

IRIG

The IRIG command directs the relay to read the demodulated IRIG-B time code input if present at J201 on the rear panel.

If the time code is successfully read, the interval clock/calendar time and date are updated to the time code reading, and the relay transmits a message consisting of relay ID string, date, and time. An example of a successful read is shown below.

```
=>IRIG <ENTER>
Example 69 kV Line                    Date:  04/01/93   Time: 15:05:22

=>
```

If no time code signal is present at the AUX port or if the time code cannot be successfully decoded, the relay sends the error message "IRIGB DATA ERROR." An unsuccessful read causes the following output:

```
=>IRIG <ENTER>
IRIGB DATA ERROR

=>
```

Note: When the relay is connected to a time code signal via the AUX port it is normally unnecessary to synchronize using this command; the relay synchronizes automatically every few minutes. The command is provided as a test and setup feature, to avoid waiting for automatic synchronization during test and installation.

METER n

The currents, demand currents, peak demand currents, voltages, and real and reactive power are displayed in primary quantities of amperes, kilovolts, megawatts, and megavars. An example is shown below:

```
=>METER <ENTER>

Example 69 kV Line                 Date:  04/01/93  Time:  13:27:05


              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 out from the bus and into the line.

The optional command parameter n selects the number of times meter data are displayed. To view a series of eight meter readings type **METER 8 <ENTER>**.

Peak demand currents are reset when the optional command parameter n is selected as R. The command METER R resets the peak demand currents to the present demand current level.

QUIT

The QUIT command returns control to Access Level 0 from Access Level 1 or 2 and resets the targets to the Relay Targets (TAR 0). The terminal displays the relay I.D., date, and time. Use this command when you finish communicating with the relay to prevent unauthorized access. Note that control returns to Access Level 0 automatically after a settable interval of no activity. See the TIME1 and TIME2 settings of the SET command.

SHOWSET

Use SHOWSET to inspect the relay settings. The command displays the current relay and logic settings. Settings cannot be entered or modified with this command; they are entered using the SET and LOGIC commands in Access Level 2.

An example of the output from executing SHOWSET appears below:

```
=>SHOWSET <ENTER>

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   50M  =300.00   50MFD=30.00
Z1DG =0.00     Z2DG =30.00   Z3DG =10.00   TDUR =9.00
52BT =30       ZONE3=R       67NE =Y       67PE =Y
32QE =N        32VE =Y       32IE =Y       LOPE =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

=>
```

A brief line-by-line description of the settings follows:

Line 1: Positive- and zero-sequence impedances of the transmission line (primary ohms), and the line length (miles) for which the impedances are given.

Line 2: Current and voltage transformer ratios, maximum torque angle for the directional elements, fault locator enable, and demand ammeter time constant.

Line 3: Demand current threshold, three reclosing open interval delays and one reset delay.

Line 4: Phase time-overcurrent pickup, time dial, curve, and torque control by direction.

Line 5: Pickup settings for the three-phase overcurrent elements.

Line 6: Zones 1, 2, and 3 time delays for the phase overcurrent elements.

Line 7: Residual time-overcurrent pickup, time dial, curve, and torque control enable.

Line 8: Zones 1, 2, and 3 residual instantaneous-overcurrent element pickup thresholds.

Line 9: Zones 1, 2, and 3 time delays for ground faults; minimum trip duration timer.

Line 10: 52B time delay, Zone 3 direction selection, and the enables for directionality of the ground and phase instantaneous elements.

Line 11: The enables for the negative-sequence directional, voltage polarized zero-sequence directional, and current polarized zero-sequence directional elements.

Line 12: Port 1 and 2 timeouts, the autoport for automatically transmitted messages, and the number of rings after which the modem will automatically answer.

The SET command provides a complete description of the settings.

The LOGIC command description has a detailed explanation of the logic settings. Each column in the logic settings display shows the masks for the four rows of the Relay Word as follows:

Row 1, of any column:	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3
Row 2, of any column:	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3
Row 3, of any column:	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT
Row 4, of any column:	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH

Logic settings appear in hexadecimal format. The following table shows the equivalencies between hexadecimal (hex) and binary numbers to facilitate examination of the logic settings display.

Table 3.3: Hexadecimal/Binary Conversion

Hexadecimal	Binary	Hexadecimal	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

For example, consider row 2 of mask MA1, which is set to 66 hex format. Using the table to convert 66 to binary:

66 -> 0110 0110.

Now build row 2 of the Relay Word for mask MA1 as follows:

DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3
0	1	1	0	0	1	1	0
	6				6		

STATUS

The STATUS command allows inspection of the self-test status. The relay also automatically executes this command whenever a self-test enters a warning or failure state, transmitting a STATUS report to the port selected for automatic transmissions (see AUTO setting of the SET procedure).

The STATUS report format is shown below:

```
=>STATUS <ENTER>

Example 69 kV Line                    Date: 04/01/93   Time: 01:08:44

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

=>
```

The OS row indicates measured offset voltages for the eight analog channels. They are expressed in millivolts at the system point immediately ahead of the programmable-gain amplifier. Warning and failure thresholds are 50 and 75 millivolt deviations from zero, respectively.

An out-of-tolerance offset is indicated by a W (warning) or F (failure) following the displayed offset value.

The PS row indicates voltages for the three power supplies. Suffixes of W or F indicate warning or failure states of power supply voltage tests. Warning and failure levels are deviations by 0.3 and 0.4 volts for the 5 volt supply and 0.8 and 1.2 volts for the 15 volt supplies.

The last two rows report status for five tests. If a RAM or ROM test fails, the IC socket number of the defective part is indicated in place of OK.

The A/D self-test checks the A/D conversion time. If it exceeds a threshold, the test fails and protective functions are disabled. The MOF test checks the offset in the MUX-PGA-A/D circuit when a grounded input is selected. It has the same warning and failure thresholds as the offset tests.

The SET self-test compares two copies of the settings stored in nonvolatile memory. Failure of this test disables relay and control functions.

TARGETS n k

This command selects the information displayed on the front-panel target LEDs and communicates the state of selected LEDs.

When relay power is turned on, the LED display indicates the functions marked on the front panel. The LEDs default to displaying fault information shown in the RELAY TARGETS row of the following table.

Using the TARGET command, you may select any one of seven sets of data listed below to be printed and displayed on the front panel LEDs.

LED: 1		2	3	4	5	6	7	8	
N									
0	EN	INST	TIME	A	B	C	G	LO	Relay Targets
1	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	Relay Word Row #1
2	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	Relay Word Row #2
3	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	Relay Word Row #3
4	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	Relay Word Row #4
5		52AT	ET	52A	DC	BT	PT	DT	Contact Inputs
6		TRIP	CLOS	A1	A2	A3	A4	ALRM	Contact Outputs

These selections are useful in testing, checking contact states, and remotely reading targets. "1" indicates an asserted element; "0" indicates an deasserted element.

The ALRM (ALARM) bit in target 4 (Relay Word Row 4) and target 6 (Contact Outputs) asserts for the ACCESS command, 2ACCESS command, and self-test failures. It does not assert for the SET, LOGIC, PASSWORD, and DATE commands. This differs from the ALARM output relay, which asserts for all the above conditions.

The optional command parameter k selects the number of times the target data are repeatedly displayed for a given choice of parameter n. To see a series of ten readings of Relay Word Row 4, type **TARGET 4 10 <ENTER>**.

Be sure to return the target function to display the fault targets, so field personnel do not misinterpret the displayed data. The TAR 0 command displays fault targets.

Pressing the TARGET RESET button on the front panel clears the TAR 0 data and lights all target LEDs for approximately one second as a lamp test. Further, pressing the TARGET RESET button unlatches the TRIP output from the 52A input. This feature is useful during relay testing and minimizes the risk of re-installing the relay with the TRIP output asserted. The lamp test fails if the relay is disabled due to a self-test failure.

The front panel targets can be reset to TAR 0 and cleared remotely or locally using the TARGET command. Type **TARGET R <ENTER>** to reset and clear the targets.

TIME hh:mm:ss

To check the internal clock, type **TIME <ENTER>**. To set the clock, type **TIME** followed by the desired setting and **<ENTER>**. Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas or slashes. For example, to set the clock to 23:30:00, enter: **TIME 23 30 00 <ENTER>** or **TIME 23:30:00 <ENTER>**, etc.

A quartz crystal oscillator provides the time base for the internal clock. The relay time code input may be used to synchronize its clock to an external clock with a demodulated IRIG-B time code output.

TRIGGER

Type **TRIGGER <ENTER>** to generate an event record. The relay transmits a response of "Triggered." The computer formats the just-triggered record (after a short delay), and a summary of the record is displayed.

The TRIGGER command is useful when inspecting phasor voltages and currents. When the relay is first installed, execute the TRIGGER command, draw the phasors (the EVENT REPORTING section explains how to do this), and check for the proper polarity and phase-sequence of the inputs.

Event records may also be generated without control action by asserting the EXTERNAL TRIGGER input.

Access Level 2 Commands

All commands are available from Access Level 2. However, the commands listed below are available only from Access Level 2. Recall that any attempt, successful or otherwise, to enter Access Level 2 causes the ALARM relay to assert for one second.

CLOSE

The CLOSE output relay may be closed by executing the CLOSE command or asserting the DIRECT CLOSE input as long as the 52A input is not asserted. The CLOSE output relay remains closed until the 52A input is asserted (indicating that the circuit breaker is closed) or until the reclose reset internal time (79RS) expires.

To close the circuit breaker using this command, type **CLOSE <ENTER>**. The prompting message "Close BREAKER (Y/N) ?" is displayed. Answering **Y <ENTER>** yields a second prompting string: "Are you sure (Y/N) ?". Typing **Y <ENTER>** closes the CLOSE output relay as long as 52A is not asserted. The message "Breaker CLOSED" is transmitted once the breaker closes or if it is already closed (as determined by the state of the 52A input). Answering **N <ENTER>** to either of the above prompts aborts the closing operation and transmits the message "Aborted".

The CLOSE command aborts unless the remote open/close jumper (JMP104) is in place on the main circuit board.

LOGIC n

The logic command programs a series of masks used for controlling the outputs and reclosing operations of the relay.

The parameter n specifies a mask to program and can be any of the following:

MTU - Mask for unconditional trip
MPT - Mask for trip with permissive-trip input asserted
MTB - Mask for trip with block-trip input deasserted
MTO - Mask for trip with breaker open
MA1 - Mask for A1 relay control
MA2 - Mask for A2 relay control
MA3 - Mask for A3 relay control
MA4 - Mask for A4 relay control
MRI - Mask for reclose initiate
MRC - Mask for reclose cancel

The logic programming procedure requires entry of changes to the mask, or pressing **<ENTER>** to indicate no change. Each of the masks listed above is split into sections corresponding to the four rows of the Relay Word as follows:

Relay Word Row 1	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3
Relay Word Row 2	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3
Relay Word Row 3	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT
Relay Word Row 4	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH

When all data are provided for each row of the Relay Word, the new logic settings are displayed and a prompt issued requesting your approval to enable the relay with the new logic settings. Answering "Y" enters the new data, pulses the ALARM contact closed momentarily, and clears event buffers. "N" retains the old settings.

When executed, the logic command displays a header for each row of the Relay Word (as shown above) and the present logic masking for that particular mask. The relay displays a question mark prompt and waits for input. Enter only ones and zeros without spaces as input; one selects and zero de-selects a member of a Relay Word. Press **<ENTER>** if the entry is satisfactory. If you wish to change any member of a group, all eight members must be input, even if no change is needed for some members. If an error occurs during input of new data, the existing settings and question mark prompt are redisplayed to allow corrections.

An example below shows the removal of the Z3PT bit from the MTU logic mask.

```
=>> LOG MTU <ENTER>

1 selects, 0 deselects.

51NP 50N1 50N2 50N3 51PP 50P1 50P2 50P3
 0    1    0    0    0    1    0    0
 ? <ENTER>
DFP  67N1 67N2 67N3 DFG  67P1 67P2 67P3
 0    1    0    0    0    1    0    0
 ? <ENTER>
51NT Z1GT Z2GT Z3GT 51PT Z1PT Z2PT Z3PT
 1    1    1    1    1    1    1    1
 ? 11111110 <ENTER>
 1    1    1    1    1    1    1    0
 ? <ENTER>
LOP  TRIP TC   DT   52BT SH1  50MF DCTH
 0    0    1    1    0    0    0    0
 ? <ENTER>


New MTU :

51NP 50N1 50N2 50N3 51PP 50P1 50P2 50P3
 0    1    0    0    0    1    0    0
DFP  67N1 67N2 67N3 DFG  67P1 67P2 67P3
 0    1    0    0    0    1    0    0
51NT Z1GT Z2GT Z3GT 51PT Z1PT Z2PT Z3PT
 1    1    1    1    1    1    1    0
LOP  TRIP TC   DT   52BT SH1  50MF DCTH
 0    0    1    1    0    0    0    0

OK (Y/N) ? Y <ENTER>
Enabled

Example 69 kV Line                 Date: 04/01/93   Time: 01:37:25

=>>
```

OPEN

The TRIP output relay closes in response to the OPEN command. The TRIP relay remains closed until the overcurrent elements in Relay Word row 1 have dropped out. In all cases the TRIP output remains asserted at least TDUR cycles. If TDUR=0, the OPEN command is aborted.

To open the power circuit breaker by command, type **OPEN <ENTER>**. The prompt "Open BREAKER (Y/N) ?" is transmitted. Answering **Y <ENTER>** yields a second prompt: "Are you Sure (Y/N) ?". Answering **Y <ENTER>** again causes the TRIP output relay to close as described above. Answering **N <ENTER>** to either prompt aborts the OPEN command with the message "Aborted".

The OPEN command aborts unless the remote open/close jumper (JMP104) is in place on the main circuit board.

PASSWORD (1 or 2) PASSWORD

To inspect the passwords, type **PASSWORD <ENTER>**.

To change the password for Access Level 1 to BIKE enter:

```
PASSWORD 1 BIKE <ENTER>
```

The relay responds by setting the password, pulsing closed the ALARM relay, and transmitting the response "Set".

AFTER ENTERING NEW PASSWORDS, EXECUTE **PASS <ENTER>** TO INSPECT THEM. MAKE SURE THEY ARE WHAT YOU INTENDED. BE SURE TO WRITE DOWN THE PASSWORDS AFTER CHANGING THEM.

Passwords can be any length up to six numbers, letters, or any other printable character except the delimiters (space, comma, semicolon, colon, slash). Upper and lower case letters are treated as different characters. Examples of valid, distinct passwords include:

OTTER otter Ot3456 +TAIL+ !@#$%^ SEL-267-5 123456 12345. 12345 ab1CDE

If passwords are lost or you need to operate the relay without password protection, install Jumper JMP103 on the main circuit board (no password protection). With no password protection, you may gain access without knowing the passwords and execute the PASSWORD command to discover or change the "forgotten" passwords.

SET n

The setting procedure involves answering prompting messages with new data or pressing **<ENTER>** to indicate no change. When all data are provided, the new settings are displayed and a prompt issued requesting your approval to enable the relay with the new settings. When you complete all desired setting changes, it is not necessary to scroll through the remaining settings. Type **END <ENTER>** after the last setting change to proceed to the new settings display and enable prompt. The END statement should not be used for the relay I.D. setting. Use **<CTRL X>** to abort the set procedure instead.

Error messages indicate when the entered data result in out-of-range settings. If no error messages are received, the relay is enabled with the new settings, the ALARM contact closes momentarily, and the event buffer is cleared.

The optional command parameter n can be one of the setting descriptors (except for the ID setting). The setting descriptor is the abbreviated description of the setting (e.g., 50P1 is the setting descriptor for the Zone 1 phase overcurrent element). See the following list for more descriptors. All settings prior to the one specified are skipped when the parameter n is input. For example, typing **SET Z3DP <ENTER>** will skip to the Z3DP setting and start the set procedure there.

The following data are required to set the relay:

R1, X1	Positive-sequence primary impedance of line 0-9999 ohms
R0, X0	Zero-sequence primary impedance of line 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 directional elements (47°- 90°)
LOCAT	Do you want the fault locator enabled? (Y or N)
DATC	Demand ammeter time constant (5-60 minutes)
DCTH	Demand current threshold (25-50,000 primary amperes)
79OI1	Reclosing relay open interval 1 (quarter to 10,000 cycles; 0 disables reclosing for intervals 1, 2, and 3)
790I2	Reclosing relay open interval 2 (quarter to 10,000 cycles; 0 disables reclosing for intervals 2 and 3)
790I3	Reclosing relay open interval 3 (quarter to 10,000 cycles; 0 disables reclosing for interval 3)
79RS	Reclosing relay reset time (60 to 8,000 cycles)
51PP	Phase time-overcurrent pickup (0.25-50,000 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

51PTC	Do you want phase time-overcurrent directional torque control? (Y or N)
50P1	Zone 1 phase overcurrent element pickup (0.25-50,000 primary amperes)
50P2	Zone 2 phase overcurrent element pickup (0.25-50,000 primary amperes)
50P3	Zone 3 phase overcurrent element pickup (0.25-50,000 primary amperes)
Z1DP	Zone 1 delay for phase and three-phase faults (0-60 cycles in quarter-cycle steps)
Z2DP	Zone 2 delay for phase and three-phase faults (0-2000 cycles in quarter-cycle steps)
Z3DP	Zone 3 delay for phase and three-phase faults (0-2000 cycles in quarter-cycle steps)
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 directional torque control? (Y or N)
50N1	Zone 1 residual instantaneous-overcurrent (0.25-50,000 primary amperes)
50N2	Zone 2 residual instantaneous-overcurrent (0.25-50,000 primary amperes)
50N3	Zone 3 residual instantaneous-overcurrent (0.25-50,000 primary amperes)
50M	Phase overcurrent element medium pickup (0.25-50,000 primary amperes)
50MFD	Phase overcurrent delay on loss-of-potential (0 - 60 cycles in quarter-cycle steps)
Z1DG	Zone 1 delay for ground faults (0-60 cycles in quarter-cycle steps) e.g., enter 10.25 for a delay of 10 quarter-cycles.
Z2DG	Zone 2 delay for ground faults (0-2000 cycles in quarter-cycle steps)
Z3DG	Zone 3 delay for ground faults (0-2000 cycles in quarter-cycle steps)
TDUR	Minimum trip duration timer (0-2000 cycles in quarter-cycle steps)
52BT	52B time delay (0.5 to 10,000 cycles in quarter-cycle steps)
ZONE3	Zone 3 direction (F = forward or R = reverse)
67NE	Do you want directional torque control for the residual instantaneous-overcurrent elements? (Y or N)
67PE	Do you want directional torque control for the phase instantaneous-overcurrent elements? (Y or N)
32QE	Do you want negative-sequence directional supervision of the ground-overcurrent elements? (Y or N)
32VE	Do you want zero-sequence voltage-polarization for the directional element enabled? (Y or N)
32IE	Do you want zero-sequence current-polarization for the directional element enabled? (Y or N)
LOPE	Loss-of-potential detection function (Y,N,1,2,3,4)

SEL-267-5 DIRECTIONAL OVERCURRENT COMMAND SUMMARY

Access Level 0

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

Access 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 4/1/93 sets date to April 1, 1993. Pulses the ALARM relay momentarily when a different year is entered than previously stored year. The month and date settings are overridden when IRIG-B synchronization occurs.
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 and logic settings. This command does not affect the settings. The logic settings are shown in hexadecimal format for each mask.
STATUS	Show self-test status.
TARGETS	Show data and set target lights as follows: TAR 0: Relay Targets — TAR 1: RELAY WORD #1 TAR 2: RELAY WORD #2 — TAR 3: RELAY WORD #3 TAR 4: RELAY WORD #4 — TAR 5: Contact Inputs TAR 6: Contact Outputs — TAR R: Clears targets and returns to TAR 0 Be sure to return to TAR 0 when done, so LEDs display fault targets.
TIME	Show or set time. TIM 13/32/00 sets clock to 1:32:00 PM. This setting is overridden when IRIG-B synchronization occurs.
TRIGGER	Trigger and save an event record. (Type of event is EXT).

Access 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. ALARM relay closes while new settings are being computed, and event data buffers are cleared.
OPEN	Open circuit breaker, if allowed by jumper setting.
PASSWORD	Show or set passwords. Pulses the ALARM relay momentarily when new passwords are set. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.
SET	Initiate setting procedure. ALARM relay closes while new settings are being computed, and event data buffers are cleared.

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

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EVENT REPORTING
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EVENT REPORTING

INTRODUCTION

The relay transmits a summary event report in response to several events and saves a full event report in its memory. The summary report includes the identifier message entered at the beginning of the setting procedure as well as date, time, and type of event. If the event is a fault, the report displays fault location in miles, secondary ohms, fault duration, and a maximum fault current measurement. The report includes fault targets if the fault caused a trip (a setting permits disabling the fault locator).

The summary report is automatically transmitted from the designated automatic port (refer to AUTO setting) regardless of access level, as long as that port has not timed out. If the automatic transmissions are monitored by a dedicated channel or printed on a dedicated printer, enter zero for the timeout interval of the appropriate port (refer to TIME1, TIME2 settings).

The full report contains current and voltage information from which phasor diagrams of the prefault, fault, and postfault conditions may be constructed. It also contains status points spanning the states of all relay elements, inputs, and outputs. These are useful in reviewing fault duration, relay element responses, arrival time of transfer-trip signalling with respect to local relay response, etc.

The full report is not transmitted automatically due to its length (about one page). You may request a full report with the EVENT command, e.g., EVENT 1.

The twelve most recent events are stored in relay volatile memory. These data are retained as long as the control power remains on. This differs from the relay settings, which are retained in nonvolatile memory. Settings are retained until changed by the SET command, regardless of control power cycling. You may quickly review stored events with the HISTORY command.

Event reporting is triggered by any of the following:

Fault in any zone
Assertion of DIRECT TRIP input
Assertion of BLOCK TRIP input
Assertion of PERMISSIVE TRIP input
Assertion of EXTERNAL TRIGGER Input
Execution of OPEN command
Execution of TRIGGER command

Another event report is triggered for the same fault if the trip occurs after the end of the first report.

Event reporting is not triggered by any of the following:

Assertion of DIRECT CLOSE Input
Execution of the CLOSE command
Changes to the 52A input

See the FAULT LOCATOR subsection in the FUNCTIONAL DESCRIPTION section for more explicit information on event report triggering.

EXAMPLE EVENT REPORT

A full event report is provided at the end of this section. The report was generated in response to a simulated fault on the Example 69 kV Line described in the INITIAL CHECK-OUT section of this manual. The report details an A-to-ground fault 9.00 miles away. Test set settings were computed using the BASIC program in the appendices and assume a source impedance of 0.2 of the total line impedance. A latching relay was used to simulate the circuit breaker action and to provide a contact whose state is sensed by the relay 52A input.

The settings for the test set appear below.

VA	VB	VC	IA	
28.71	76.59	68.45	19.18	V or A
0	-125	129	-59	degrees

In primary units of kilovolts and amperes, the voltages and currents are:

VA	VB	VC	IA	
17.2	46.0	41.1	1151	kV or A

These were obtained using the potential and current transformer ratios assumed in the Example 69 kV Line. Note that these ratios are displayed at the end of the report:

PTR = 600 CTR = 60.

The following paragraphs describe the response of the relay to this simulated fault using information from the full event report.

INTERPRETATION OF VOLTAGE AND CURRENT DATA

The voltage and current data provided in the event report are determined using the secondary quantities presented to the rear panel of the relay through the processing steps outlined below.

- The input analog signals are filtered by two-pole low-pass filters with cutoff frequencies of about 85 Hz.
- The filtered analog signals are sampled four times per power system cycle and converted into numerical values.

- The sampled data are processed by digital filters which remove dc and ramp components. The unit sample response of these filters is:

  1, -1, -1, 1

  This filter has the property of a double differentiator-smoother.

- The digital filter output data are scaled into primary quantities using the current and potential transformer ratios entered in the setting procedure. Since the samples are taken four times per power system cycle and the four most recent samples are processed through the digital filter every quarter-cycle, successive outputs of the filter arrive every 90°. So, with respect to the present value of the filter output, the previous value was taken one-quarter cycle earlier and appears to be leading the present value by 90°.

These filter output values can be used to represent the signals as phasors:

The PRESENT value of the output is the X-component of the phasor.
The PREVIOUS value of the output is the Y-component of the phasor.

It may seem confusing to refer to the older data as the leading component of the phasor. The following example may help. Consider a sinewave with zero phase shift with respect to t=0 and a peak amplitude of 1. Now consider two samples, one taken at t=0, and the other taken 90° later. They have values 0 and 1, respectively. By the above rules, the phasor components are (X,Y) = (1,0). Now consider a cosine function. Its samples, taken at the same time instants, are 1 and 0, while its phasor representation is (0,1). The phasor (0,1) leads the phasor (1,0) by 90°, and this agrees with the 90° lead of the cosine function with respect to the sine function.

To construct a phasor diagram of voltages and currents, select a pair of adjacent rows in a region of interest on the event report, e.g., prefault, fault, or postfault. On Cartesian coordinates, plot the lower row (more recent data) as the X-components and the upper row (older data) as the Y-components. Complete phasor diagrams may be rotated to the preferred angle of reference. The effective value of any phasor equals the square root of the sum of the squares of its components.

Note that moving forward one quarter-cycle causes all phasors to rotate 90°, as can be seen by plotting the phasor diagram using rows 1 and 2, then rows 2 and 3.

For example, refer to the first and second rows of cycle 6 of data in the full report:

Currents					Voltages			
IPOL	IR	IA	IB	IC	VA	VB	VC	
0	-1024	-1024	0	1	-1.1	-35.6	3.4	Y-component
0	526	526	0	0	17.2	-28.6	-23.7	X-component

These were taken near the "middle" of the fault, as can be judged from the action of residual-overcurrent elements.

Convert these to polar form (magnitude and angle):

	Currents				Voltages			
IPOL	IR	IA	IB	IC	VA	VB	VC	
0	1151	1151	0	0	17.2	45.7	41.0	magnitude
*	-63	-63	*	*	-4	-129	125	angle
*	-59	-59	*	*	0	-125	129	angle + 4

In the third row, four degrees are added to all angles of the second row to assign the phase-A voltage phasor as the 0° reference. The magnitude and shifted angles can be compared to the test set settings given earlier. Angle measurement errors are one degree or less, while magnitude errors are less than 1%.

The event report indicates a fault current of 1154.4 amperes primary, which concurs with the 1151 ampere test set current as referred to primary.

The indicated fault location is 9.02 miles. The "actual" fault location is 9.00 miles. The error is 9.02 - 9.00, or 0.02 mile, less than 1.0% of the actual fault location for this example.

RELAY ELEMENTS STATUS INDICATORS

The columns headed "Relays" indicate the states of all relay elements. Active states of the various relay elements are indicated by designator symbols corresponding with the relay element names. Inactive states are indicated by periods placed in the columns. The entries for active relay elements are shown below.

50P: Phase overcurrent elements	:	1=50P1	high-set picked up
		2=50P2	medium-set
		3=50P3	low-set
67P: Directional phase overcurrent elements	:	1=67P1	high-set picked up
		2=67P2	medium-set
		3=67P3	low-set
51P: Phase time-overcurrent element	:	P=51PP	element picked up
	:	T=51PT	trip threshold reached
50N: Residual-overcurrent elements	:	1=50N1	high-set picked up
		2=50N2	medium-set
		3=50N3	low-set
67N: Directional ground-overcurrent units	:	1=67N1	high-set picked up
		2=67N2	medium-set
		3=67N3	low-set

51N: Residual time-overcurrent element	:	P=51NP	element picked up
	:	T=51NT	trip threshold reached

The states of all output and input contacts are shown in the next two column groups, headed "Outputs" and "Inputs". Assertion of any output or input contact is indicated by an asterisk (*) in the corresponding column; nonassertion is indicated by a period. The contents of the columns are:

Outputs

TP : TRIP output
CL : CLOSE output
A1 : PROGRAMMABLE output 1
A2 : PROGRAMMABLE output 2
A3 : PROGRAMMABLE output 3
A4 : PROGRAMMABLE output 4
AL : ALARM output

Inputs

DT : DIRECT TRIP input
PT : PERMISSIVE TRIP input
BT : BLOCK TRIP input
DC : DIRECT CLOSE input
52A : BREAKER AUXILIARY 52A SWITCH input
ET : EXTERNAL TRIGGER (for event report) input

In the example event report, the first element to detect the fault picks up in the third quarter-cycle of the fourth cycle of the event report.

This is the low-set residual-overcurrent element (50N3), as indicated by the "3" in the 50N column. For almost every actual fault, the first element(s) to pick up will be found near the sixteenth row of data.

In the sixteenth row, a P appears in the 51NP column indicating that the 51NP element has picked up.

In the seventeenth row of the report, the Zone 3 phase overcurrent element picks up, as indicated by the "3" in the 50P column. The Zone 2 residual-overcurrent element picks up in the eighteenth row, as indicated by the "2" in the 50N column. In the next quarter-cycle, the 67N2 element picks up and the A1 programmable output asserts. For the example settings, the A1 output is programmed to generate an over-reaching permissive signal for a POTT scheme, so it asserts as soon as any Zone 2 directional element picks up.

In the twenty-first quarter-cycle, the Zone 1 residual-overcurrent element (50N1) picks up. The TRIP output asserts in response, because the 50N1 element was selected in the UNCONDITIONAL TRIP MASK (MTU) of the LOGIC settings.

The 52A contact input monitors the latching relay (circuit breaker simulator) state. This input deasserts in the 28th row of the report, indicating that the latching relay had changed to the "open" state about two cycles after tripping was initiated.

Fault duration can be estimated from the total time the relay elements are picked up. In the Sample Event Report, relay elements were picked up for a total of nineteen quarter-cycles, or 4.75 cycles. This value is reported near the bottom of the report: Duration: 4.75.

See the HISTORY command description for further explanation of the data in this report.

SAMPLE EVENT REPORT

```
Example 69 kV Line                         Date:  4/1/93       Time:  08:45:09.366
FID=SEL-1674-R40-V656mp12-D900323

                   Currents                        Voltages        Relays Outputs Inputs
                    (amps)                           (kV)
                                                                   565565 TCAAAAA DPBD5E
  IPOL     IR      IA       IB      IC      VA      VB      VC     071071 PL1234L TTTC2T
                                                                   PPPNNN              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.P ....... ....*.

     0   -420    -418        0       1     0.3   -34.2    34.8     3..3.P ....... ....*.
     0    246     248        0       0    20.8   -27.9   -23.2     3..2.P ....... ....*.
     0    886     886        0      -1     1.0    35.4   -33.6     2..22P ..*.... ....*.
     0   -506    -505        0       0   -17.6    28.5    23.7     22.22P ..*.... ....*.

     0  -1024   -1024        0       1    -1.1   -35.6    33.4     22.12P *.*.... ....*.
     0    526     526        0       0    17.2   -28.6   -23.7     22.11P *.*.... ....*.
     0   1025    1024        0      -1     1.1    35.6   -33.4     22.11P *.*.... ....*.
    -1   -527    -526        0      -1   -17.1    28.6    23.8     22.11P *.*.... ....*.

     1  -1025   -1025        0       1    -1.1   -35.6    33.4     12.11P *.*.... ....*.
     1    526     526        0       1    18.3   -28.0   -23.2     11.11P *.*.... ....*.
    -1   1012    1012        0      -1     3.2    35.6   -33.4     22.11P *.*.... ....*.
     0   -530    -530        0       0   -26.5    25.3    20.7     22.11P *.*.... ....*.

     0   -631    -629        0       1    -3.9   -34.6    34.6     22.22P *.*.... ......
     0    289     289       -1       0    36.4   -22.8   -18.5     22.22P *.*.... ......
     0    166     162        1      -1     2.5    33.4   -35.8     3..3.P *...... ......
     0    -32     -32        1       0   -39.5    22.2    18.0     ...3.P *...... ......

     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    50M  =300      50MFD=30.00
Z1DG =0.00     Z2DG =30.00    Z3DG =10.00    TDUR =9.00
52BT =30       ZONE3=R        67NE =Y        67PE =Y
32QE =N        32VE =Y        32IE =Y        LOPE =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
```

INSTALLATION
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FIGURES

INSTALLATION

MOUNTING

The SEL-267-5 Relay is designed for mounting by its front vertical flange in a 19-inch vertical relay rack. It may also be mounted semi-flush in a switchboard panel. Four #10 screws should be used for mounting. Front and rear panel drawings are included in the appendices.

FRAME GROUND CONNECTION

Terminal 46 on the rear panel must be connected to frame ground for safety and performance. These terminals connect directly to the chassis ground of the instrument.

POWER CONNECTIONS

Terminals 44 and 45 on the rear panel must be connected to a source of control voltage. Control power passes through these terminals to the fuse or fuses and toggle switch, if installed. It continues through a surge filter and connects to the switching power supply. The control power circuitry is isolated from the frame ground.

SECONDARY CIRCUITS

The relay presents a very low burden to the secondary current and potential circuits. Each current circuit is independent of the others; there is no interconnection of current circuits inside the instrument. When current polarization is not desired or required, Terminals 35 and 36 may be left open-circuited.

The relay requires four-wire wye potentials because it includes the option of zero-sequence voltage-polarization of the ground relaying functions. It is not possible to directly apply the relay to circuits where line-to-line potential transformers are used. Please consider the SEL-267D Relay for such applications.

CONTROL CIRCUITS

The control inputs are dry. To assert the 52A input, control voltage must be applied to the 52A input terminals. Each input is individually isolated, and a terminal pair is brought out for each input. There are no internal connections between control inputs.

Control outputs are dry relay contacts rated for tripping duty. Each contact is protected by a metal-oxide varistor.

COMMUNICATIONS CIRCUITS

Connections to the two EIA RS-232-C serial communications ports are made via the two 9-pin connectors labeled Port 1 and Port 2R on the rear panel and Port 2F on the front panel. Pins 5 and 9 connect directly to frame (chassis) ground. **These connections should not be relied upon for safety grounding, since their current-carrying capacity is less than control-power, short-circuit current, and protection levels.**

The communications circuits are protected by low-energy, low-voltage MOVs and passive RC filters. Communications circuit difficulties can be minimized by keeping the length of the EIA RS-232-C cables as short as possible. Lengths of 12 feet or less are recommended; in no case should the cable length exceed 100 feet. SEL recommends shielded communications cable for lengths in excess of 10 feet. Modems are required for communications over long distances.

Route the communications cables well away from the secondary and control circuits. Do not bundle the communications wiring with secondary or control circuit wiring. Noise could be coupled into the communications wiring from the control or secondary wiring. This noise could exceed the communications logic thresholds, introducing communications errors. The IRIG-B clock cable should also be routed away from control wiring and secondary circuits.

JUMPER SELECTION

All jumpers are located on the front edge of the main board. They are easily accessed by removing the top cover or pulling the drawout assembly out from the front.

EIA RS-232-C Jumpers

Jumper J105 provides for EIA RS-232-C baud rate selection. The available baud rates are 300, 600, 1200, 2400, 4800, and 9600. To select a baud rate for a particular port, place the jumper so it connects the pin labeled with the desired port to a pin labeled with the desired baud rate.

Caution: Do not select two baud rates for the same port. This can damage the baud rate generator.

Password Protection Jumpers

When Jumper JMP103 is in place the password protection is disabled. This feature is useful if passwords are not required or when passwords are forgotten.

Remote Trip/Close Enable Jumper

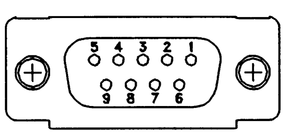
You may execute remote trip/close commands when Jumper JMP104 is in place. If Jumper JMP104 is removed, attempts to use the OPEN or CLOSE commands result in an "Aborted" message.

EIA RS-232-C AND IRIG-B INSTALLATION

This section contains specific information concerning pinouts of the communications ports.

A pin definition of the 9-pin port connectors and cabling information for the EIA RS-232-C ports appears below. Several types of EIA RS-232-C cables are given. These and other cables are available from SEL. Cable configuration sheets are also available at no charge for a large number of devices. Contact the factory to request configuration sheets.

9-Pin Connector Pin Number Convention



(female chassis connector, as viewed from outside panel)

EIA RS-232-C Cables

```
SEL-267-5                         9-Pin *DTE DEVICE

GND  5 ---------------------- 5   GND
TXD  3 ---------------------- 2   RXD
RXD  2 ---------------------- 3   TXD           (SEL  CABLE 234)
RTS  7 --+
         | Jumper
CTS  8 --+
                           +-- 1   DCD
                           +-- 4   DTR
                   Jumper  +-- 6   DSR
                           +-- 8   CTS
                               9   RI

SEL-267-5                         **DCE DEVICE

GND   5 --------------------- 7   GND
TXD   3 --------------------- 2   RXD
RTS   7 --------------------- 20  DTR           (SEL  CABLE 222)
RXD   2 --------------------- 3   TXD
CTS   8 --------------------- 8   CD
GND   9 --------------------- 1   GND

PRTU                          SEL-267-5

GND   1 --------------------- 5   GND
TXD   2 --------------------- 2   RXD
RXD   4 --------------------- 3   TXD           (SEL  CABLE 231)
CTS   5 --------------------- 7   RTS
+12   7 --------------------- 8   CTS
GND   9 --------------------- 9   GND
```

* DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)
** DCE = Data Communications Equipment (Modem, etc.)

IRIG-B Input Description

The port labeled J201/AUX INPUT is intended for the demodulated IRIG-B time code input. The pin definitions are shown below.

Table 5.1: Pin Definitions

Pin	Name	Description
1	+5	*
2	IRIGIN HI	Positive IRIGB input.
3	IRIGIN LOW	Negative IRIGB input.
4	+12	*
6	-12	*
5, 9	GND	Ground for ground wires and shields.

* Consult the factory before using these power supply outputs.

The current drive for an IRIG-B "one" is 10 to 20 mA. The input circuit consists of a 56 ohm resistor in series with the photodiode input of an optical isolator. The photodiode has a forward voltage drop of about 1.8 volts. The input may be driven directly by the output of a TTL-level driver with sufficient current capability. Inputs may also be driven in a current loop from a higher-voltage driver.

The IRIG-B serial format consists of a one second long, 100 pulse code divided into fields. The relay decodes the second, minute, hour and day fields.

When IRIG-B data acquisition is activated either manually (with the IRIG command) or automatically, two consecutive frames are taken. The older frame is updated by one second and the two frames are compared. If they do not agree, the data are considered erroneous and discarded.

Automatic execution is invoked about once every five minutes, except near midnight on New Year's Eve. At this time IRIG-B data acquisition is halted so the system clock may implement the year change without interference from the IRIG-B clock.

This port accepts the demodulated version of the IRIG-B time code. An IRIG-B demodulator (SEL-IDM) is available from SEL to convert a modulated IRIG-B into eleven sources of demodulated IRIG-B.

INSTALLATION CHECKOUT

The following suggestions may be used or combined with your normal practice. In no case should a recommendation be followed unless it is allowed by the rules of your normal practice.

A portable terminal or computer is a convenient tool for providing local communications with the SEL-267-5 Relay during checkout in the field. Such a device should be connected to Port 2R or Port 2F for checkout (with Port 2 being designated as the automatic port using the AUTO setting in the SET command).

1. Apply control power and make sure the terminal displays the startup message. If not, set AUTO = 2, using the SET command on Access Level 2. Check the settings with the ACCESS and SHOWSET commands. Use the TIME and DATE commands to set the clock and date.

2. Apply three-phase voltages. Execute the METER command and verify that the readings are accurate. If not, be sure the correct PT ratio was entered and recall that displayed values are in primary line-to-neutral and line-to-line kV.

3. Use the TRIGGER command to save an event record. Type the EVENT 1 command and examine the triggered event record. Referring to the top row of data as the "Y" components and the next row as the "X" components, plot the three voltage phasors to ensure that they are 120° apart, of reasonable magnitudes, and rotating in the positive-sequence direction. The zero-sequence voltage Y and X components (times a factor of three) are the total of the three Y components and the total of the three X components. These sums should be near zero if balanced three-phase potentials are present.

4. Use the TARGET command to check the state of all contact inputs and outputs. For example, if the connections to the circuit breaker 52A contact are made when the circuit breaker is closed, the TARGET command with option 5 should show a one (1) under the 52A heading (type **TARGET 5 <ENTER>**).

5. Proceed to Access Level 2 with the 2ACCESS command and appropriate password. Be sure that the ALARM relay contacts close and open when the 2ACCESS command is executed (The ALARM pulse will not be detectable if the ALARM contacts are permanently asserted due to any other alarm condition).

6. The tripping function may be tested in any of three ways. First, be sure the circuit breaker can be tripped by the relay when you execute the OPEN command. Be sure the TC bit is set in the MTU mask. Second, the circuit breaker should trip when you assert the DIRECT TRIP input, assuming that the DT bit is selected in the MTU mask. The TRIP output relay opens in both of these cases after the 52A input is deasserted, indicating that the circuit breaker has indeed opened. This function of monitoring the 52A contact ensures that the output relay does not inadvertently open while trip coil current is flowing in response to a control operation. Third, the circuit breaker should trip when you apply voltages and currents representing a fault condition for which the relay should respond. Here, the TRIP relay asserts regardless of the state of the 52A

contact. It opens when current stops flowing in the breaker fault conditions no longer exist. The TRIP output always remains closed for at least TDUR time.

7. You may close the circuit breaker by executing the CLOSE command. The CLOSE output relay asserts if the 52A input is deasserted (indicating that the circuit breaker is open). The CLOSE relay deasserts when the 52A input is asserted or when the reclosing relay reset interval expires, whichever occurs first.

8. If the PERMISSIVE TRIP and BLOCK TRIP inputs are used, they should also be checked for proper operation (see the LOGIC MPT and LOGIC MTB settings). An event report should be generated for assertion of either the PT or BT inputs.

9. Asserting the EXTERNAL TRIGGER input should trigger the relay to record an event record. It does not affect the protective relaying functions in any way.

10. Use the STATUS command to inspect the self-test status. You may wish to save the reading as part of an "as-left" record.

When local checkout is complete, communications with the instrument via a remote interface (if used) should be tested. Be sure, in particular, that the automatic port is properly assigned, and that desired timeout intervals are selected for each port. Also, be sure to record password settings.

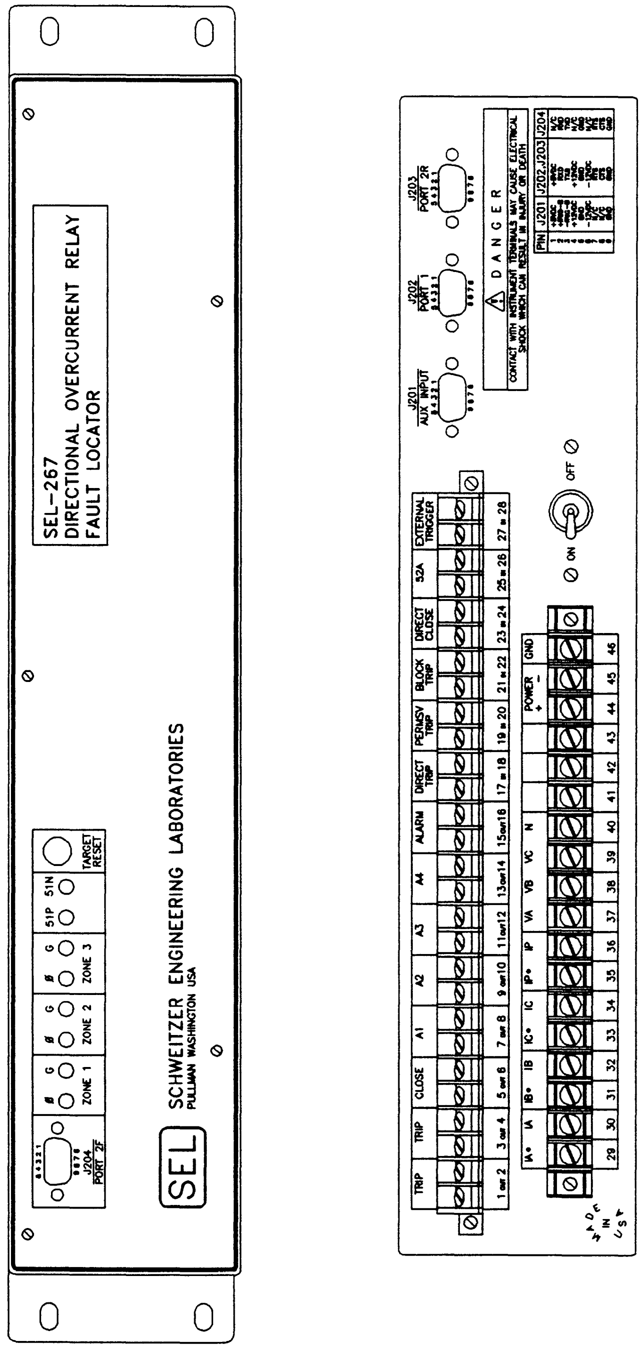


Figure 5.1: SEL-267-5 Horizontal Front and Rear Panel Drawing

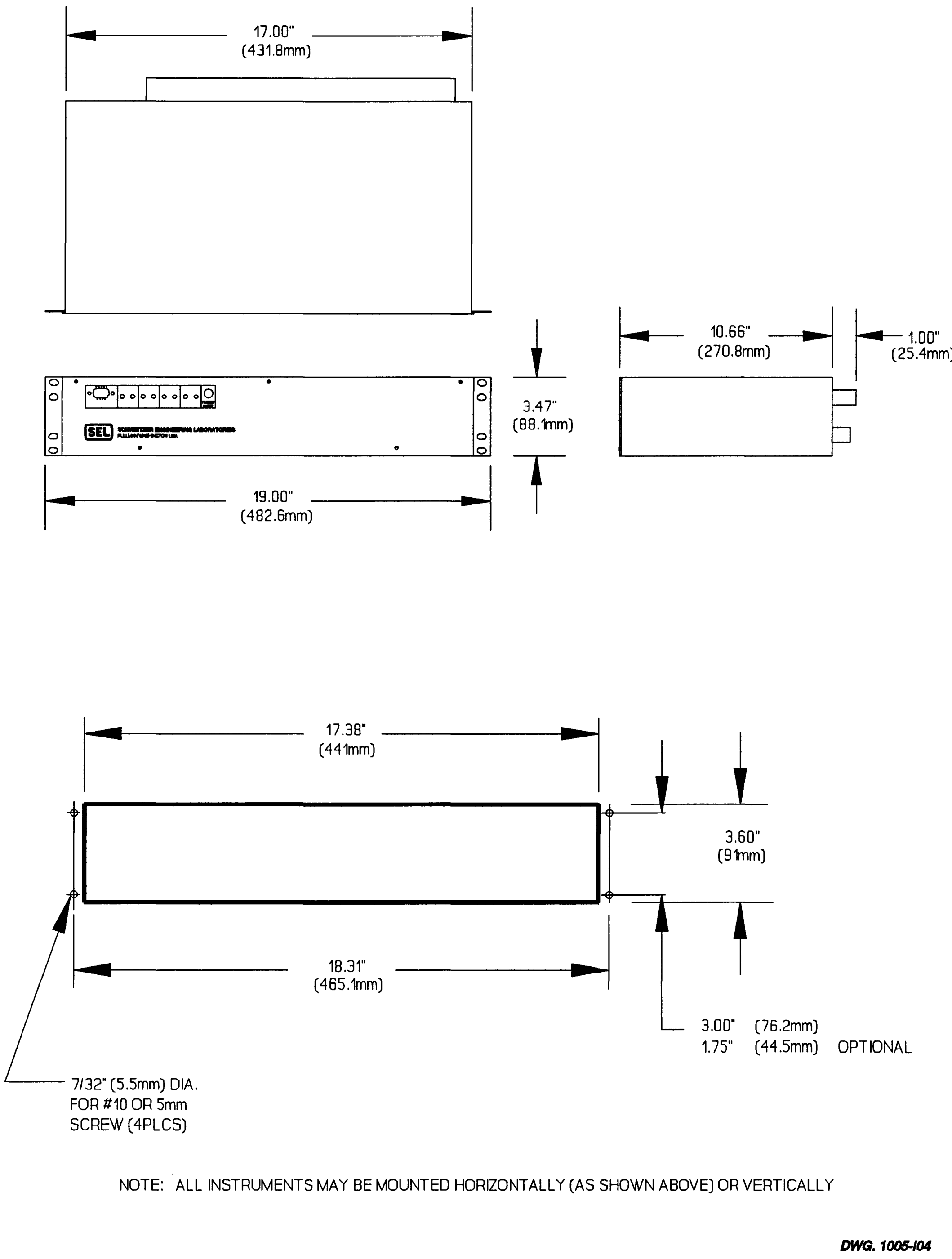


Figure 5.2: Panel Cutout and Drill Patterns for SEL Low-Profile Instruments

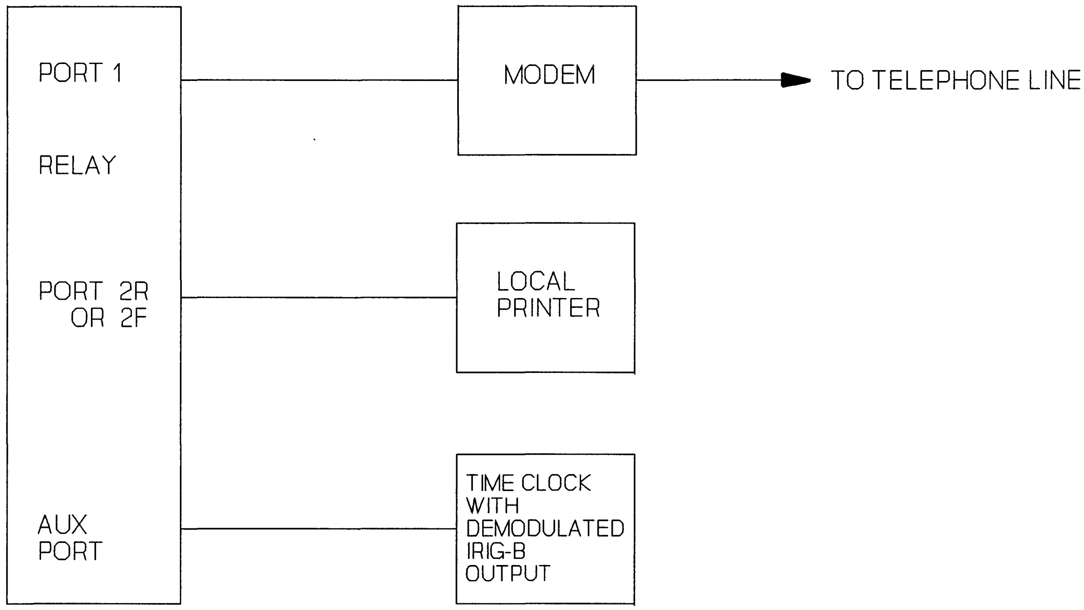


Figure 5.3: Communication and Clock Connections (One Unit at One Location)

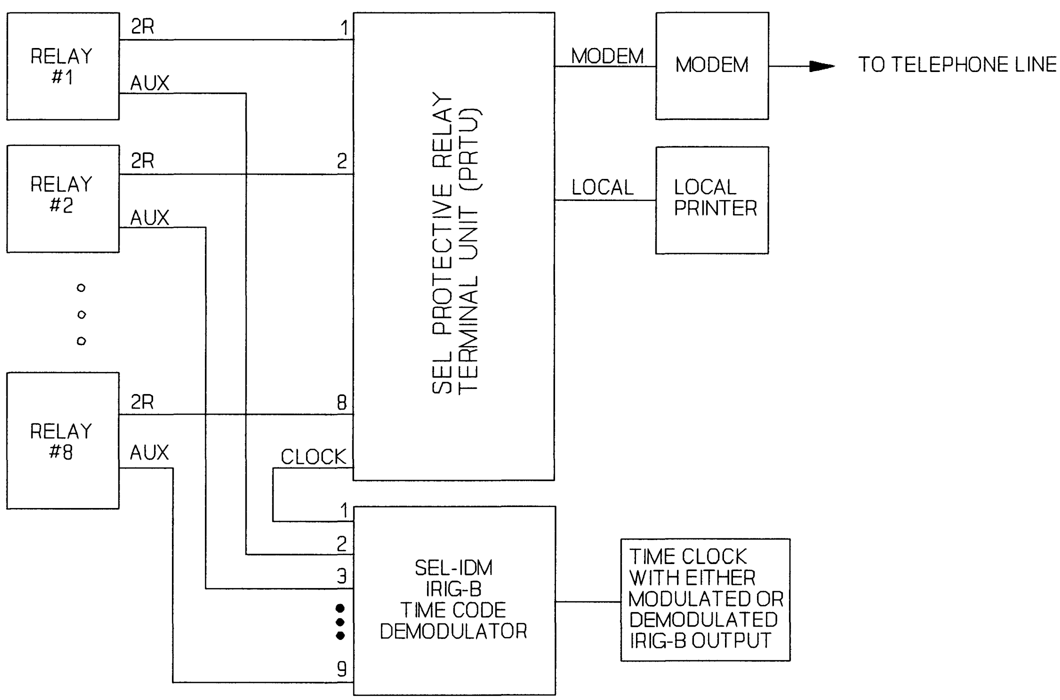


Figure 5.4: Communication and Clock Connections (Multiple Units at One Location)

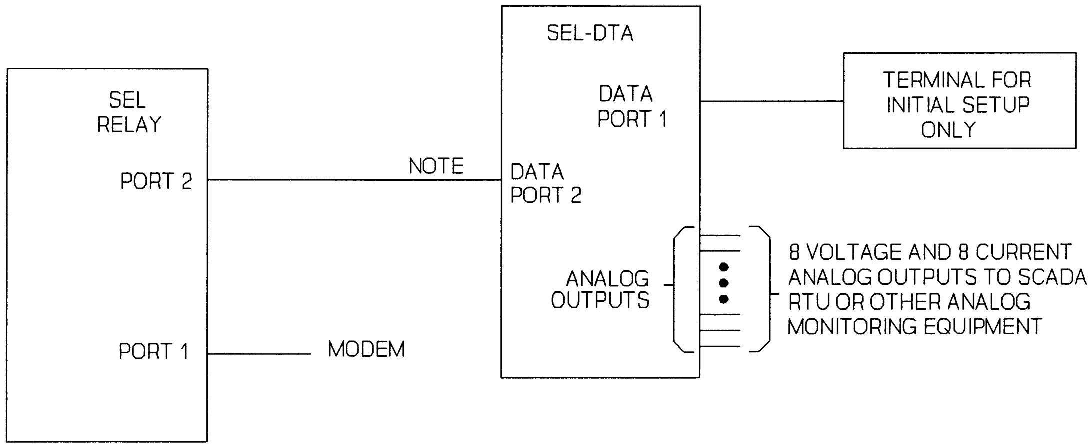


Figure 5.5: Communications Diagram for Connection to the SEL-DTA

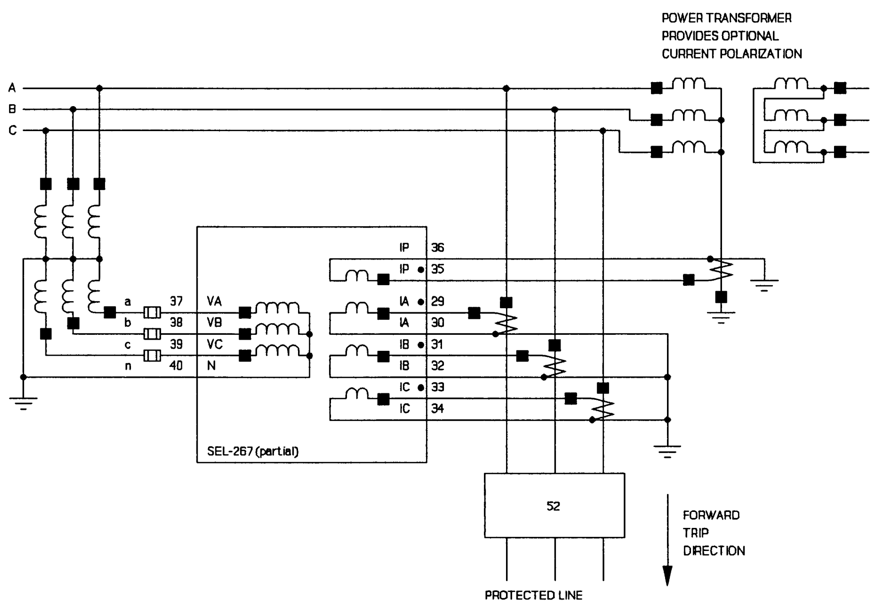


Figure 5.6: SEL-267-5 External Ac Current and Voltage Connections

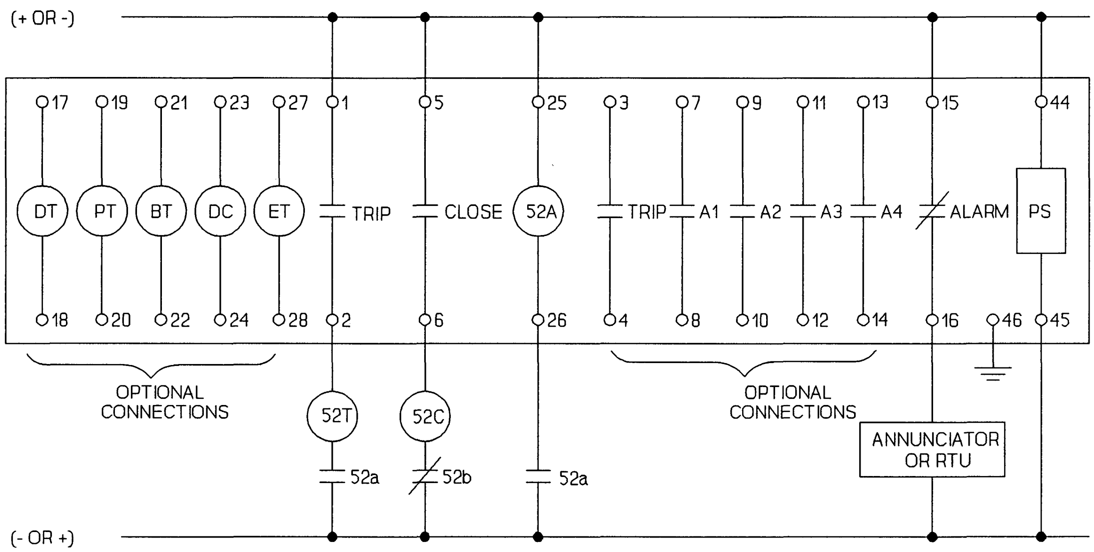


Figure 5.7: SEL-267-5 Dc External Connection Diagram (Typical)

SEL DIRECTION AND POLARITY CHECK FORM

STATION ______________________ DATE: ___/___/___ TESTED BY ______________

SWITCH NO. ______________ EQUIPMENT ______________________________

INSTALLATION ________ ROUTINE ________ OTHER ______________________

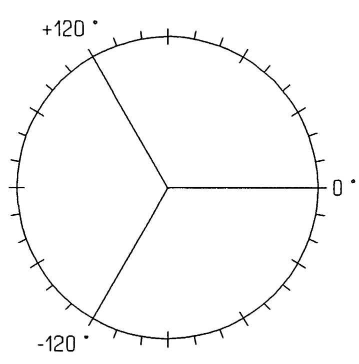
LOAD CONDITIONS:

STATION READINGS: ________ MW (OUT)(IN) ________ MVAR (OUT)(IN) ________ VOLTS ________ AMPS

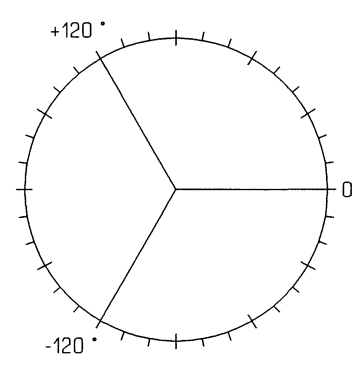
SEL READINGS: ________ MW (+)(-) ________ MVAR (+)(-)

AS SEEN ON SCREEN	Ia	Ib	Ic	Va	Vb	Vc	
COMPANY NOTATION	I( )	I( )	I( )	V( )	V( )	V( )	
1st LINE CHOSEN (Y COMPONENT)							
2nd LINE CHOSEN (X COMPONENT)							
CALCULATED MAGNITUDE $\sqrt{X^2 + Y^2}$							ROW 1
ANGLE IN DEGREES ARCTAN Y/X							
VALUE OF Va DEGREES TO SUBTRACT TO OBTAIN Va DEGREES = 0							
@ Va DEGREES = 0, ANGLE USED TO DRAW PHASOR DIAGRAM							ROW 2

USE THE VALUES IN ROWS 1 AND 2 ABOVE TO DRAW PHASOR DIAGRAMS BELOW



CURRENTS



VOLTAGES

SEL DIRECTION AND POLARITY CHECK FORM

STATION ______________________ DATE: ___/___/___ TESTED BY ______________

SWITCH NO. ______________ EQUIPMENT ______________________________

INSTALLATION ________ ROUTINE ________ OTHER ______________________

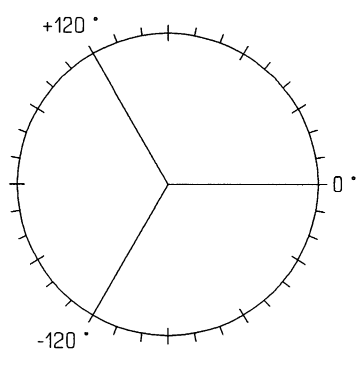
LOAD CONDITIONS:

STATION READINGS: ________ MW (OUT)(IN) ________ MVAR (OUT)(IN) ________ VOLTS ________ AMPS

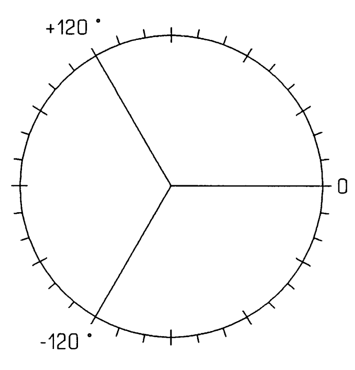
SEL READINGS: ________ MW (+)(-) ________ MVAR (+)(-)

AS SEEN ON SCREEN	Ia	Ib	Ic	Va	Vb	Vc	
COMPANY NOTATION	I( )	I( )	I( )	V( )	V( )	V( )	
1st LINE CHOSEN (Y COMPONENT)							
2nd LINE CHOSEN (X COMPONENT)							
CALCULATED MAGNITUDE $\sqrt{X^2 + Y^2}$							ROW 1
ANGLE IN DEGREES ARCTAN Y/X							
VALUE OF Va DEGREES TO SUBTRACT TO OBTAIN Va DEGREES = 0							
@ Va DEGREES = 0, ANGLE USED TO DRAW PHASOR DIAGRAM							ROW 2

USE THE VALUES IN ROWS 1 AND 2 ABOVE TO DRAW PHASOR DIAGRAMS BELOW



CURRENTS



VOLTAGES

MAINTENANCE & TESTING
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MAINTENANCE AND TESTING

INITIAL CHECKOUT

The initial checkout of the relay is intended to familiarize you with the instrument and ensure that all functions are operational.

Equipment Required

The following equipment is necessary for initial checkout of the relay.

- Computer or dumb terminal with EIA RS-232-C serial interface.
- Interconnecting cable between terminal and relay.
- Source of control power.
- Source of three-phase voltages and at least two currents.

Checkout Procedure

In the following procedure, you will use several of the relay commands. The COMMANDS AND SERIAL COMMUNICATIONS Section provides full explanations of all commands. However, the following information should allow you to complete the checkout without referring to the detailed descriptions.

Inspect the instrument for physical damage such as dents or rattles.

Connect a computer terminal to Port 2 on the front or rear panel of the relay. The terminal should be configured to 2400 baud, eight data bits, two stop bits, and no parity. Be sure your terminal is compatibly configured. The FUNCTIONAL DESCRIPTION Section provides additional details concerning port configuration. Baud rate selection is described in the EIA RS-232-C Jumpers Subsection of JUMPER SELECTION in the INSTALLATION section.

Connect a frame ground to terminal marked GND on the rear panel. Connect control power to terminals marked + and -.

Turn on the power and push the target reset button. All eight target LED's should illuminate for a lamp test and to indicate no self-test failures. If not, be sure that power is present and check the fuse or fuses.

The following message should appear on the terminal:

```
Example 69 kV Line                    Date:  4/1/93   Time:  01:01:01

SEL-167
=
```

The ALARM relay should pull in, holding its "b" contacts open. If the relay pulls in but no message is received, check the terminal configuration. If neither occurs, turn off the power and refer to the TROUBLESHOOTING guide.

The equal sign is a prompt indicating that communications with the relay are at Access Level 0, the lowest of three access levels to the relay. The only command allowed at this level is ACCESS, which admits you to Access Level 1, as described below.

Type the command **ACCESS** and press **<ENTER>**. At the prompt, enter the password **OTTER** and press **<ENTER>**. The prompt => should appear, indicating that you have established communications at Access Level 1.

The relay is shipped with demonstration settings which you may inspect using the SHOWSET command. Type **SHOWSET** and press **<ENTER>** to view these settings. The terminal should display the following:

```
=>SHOWSET

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   50M  =300.00  50MFD=30.00
Z1DG=0.00      Z2DG =30.00   Z3DG =10.00   TDUR =9.00
52BT=30        ZONE3=R       67NE =Y       67PE =Y
32QE=N         32VE =Y       32IE =Y       LOPE =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
```

A brief line-by-line description of the settings follows:

Line 1: Positive- and zero-sequence impedances of the transmission line (primary ohms) and line length (miles) for which the impedances are given.

Line 2: Current and voltage transformer ratios, maximum torque angle for the directional elements, fault locator enable, and demand ammeter time constant.

Line 3: Demand current threshold, three reclosing open interval delays and one reset delay.

Line 4: Phase time-overcurrent pickup, time dial, curve, and torque control by direction.

Line 5: Pickup settings for the three phase overcurrent elements.

Line 6: Zones 1, 2, and 3 time delays for the phase overcurrent elements.

Line 7: Residual time-overcurrent pickup, time dial, curve, and torque control enable.

Line 8: Zones 1, 2, and 3 residual instantaneous-overcurrent element pickup thresholds.

Line 9: Zones 1, 2, and 3 time delays for ground faults; minimum trip duration timer.

Line 10: 52B time delay, Zone 3 direction selection, and the enables for directionality of the ground and phase instantaneous elements.

Line 11: This enables for the negative-sequence directional, voltage polarized zero-sequence directional, and current polarized zero-sequence directional elements.

Line 12: Port 1 and 2 timeouts, the autoport for automatically transmitted messages, and the number of rings after which the modem automatically answers.

A complete description of the settings appears under the SET command.

The description of the LOGIC command includes a detailed explanation of the logic settings. Each column in the logic settings display shows the masks for the Relay Word as follows:

Row 1, of any column:	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3
Row 2, of any column:	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3
Row 3, of any column:	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT
Row 4, of any column:	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH

Logic settings are shown in hexadecimal format. The SHOWSET command description in the COMMAND DESCRIPTIONS Section includes a table and example of hexadecimal to binary conversion.

Turn the power off and connect a source of three-phase voltages to the relay at terminals marked VA, VB, and VC. Apply 67 volts per phase (line-to-neutral) in positive-sequence. Wye-connect the two current sources to generate balanced positive-sequence currents.

Connect A and B current sources to the dotted A and B current input terminals. Connect the undotted A and B current input terminals both to the undotted C current input terminal. Connect the dotted C current input terminal to both the A and B current source returns. Set the A-phase current source to 1 ampere, at the same angle as the A-phase voltage. Set the B-phase current source to 1 ampere, at the same angle as the B-phase voltage.

Turn the relay power back on, execute the ACCESS command and enter the password **OTTER** again.

Use the METER command to measure voltages and currents. With applied voltages of 67 volts per phase and a potential transformer ratio of 600:1, the line to neutral voltages displayed should be 40.2 kV. With applied currents of 1.0 ampere per phase and a current transformer ratio of 60, the currents displayed should be 60 amperes. Further, all line-to-line quantities should be balanced, differing from the line-to-neutral measurements by a factor of 1.73.

Test the digital relay/fault locator with the voltages and currents listed in the following chart. They were obtained assuming a source impedance of 0.2 times the total 60-mile line impedance and single-end feed for faults at the indicated locations and types. The appendices provide a BASIC program which you may find helpful when computing test set settings.

Table 6.1: Fault Listings

LOCATION	TYPE	VA	VB	VC	IA	IB	IC	UNITS
9 miles	AG	28.71	76.59	68.45	19.18	0	0	V or A
		0	-124.5	129.3	-58.70	0	0	Degrees
	BC	67.00	41.72	41.72	0	22.05	22.05	V or A
		0	-143.4	143.4	0	-138.5	41.50	Degrees
36 miles	AG	50.25	71.14	67.41	8.39	0	0	V or A
		0	-122.1	124.1	-58.70	0	0	Degrees
	BC	67.00	54.92	54.92	0	9.64	9.64	V or A
		0	-127.6	127.6	0	-138.5	41.50	Degrees
54 miles	AG	54.80	70.00	67.26	6.10	0	0	V or A
		0	-121.6	123.0	-58.70	0	0	Degrees
	BC	67.00	58.10	58.10	0	7.01	7.01	V or A
		0	-125.2	125.2	0	-138.5	41.50	Degrees

The fault listings in the preceding table should cause certain combinations of output relays to remain closed and front panel LEDs to remain illuminated as long as the fault condition persists. The following table shows the results.

Table 6.2: Fault Results

Location	Type	Output Relays	Target LED's
9 miles	AG	TRIP, A1, A2, A3, A4	INST, A, G
9 miles	BC	TRIP, A1, A2, A4	INST, A, B
36 miles	AG	TRIP, A1, A2, A3, A4	TIME, A, G
36 miles	AG	TRIP, A1, A2, A4	TIME, A, B
54 miles	AG	TRIP, A1, A2, A3, A4	TIME, A, G
54 miles	BC	TRIP, A1, A2, A4	TIME, A, B

The output relay A1 is set to key permissive trip for any Zone 1 fault, directionally supervised Zone 2 fault, and time delayed trip element. From the table, output relay A1 should close for all faults.

The A2 output relay monitors the demand current threshold. Since the demand current exceeds the demand current threshold, the A2 output relay operates for all of the faults shown in the first table.

The A3 output relay monitors the residual time-overcurrent trip (51NT). Since the fault condition persists longer than the 51N time delay, the output relay A3 operates for any of the ground faults shown in the first table as determined by the settings.

The output relay A4 is set to monitor the phase time-overcurrent trip (51PT). The polyphase time-overcurrent relay element operates on the largest phase current magnitude. Therefore, the A4 output asserts for both phase and ground faults as shown in the table.

The LOGIC command section provides a detailed description of the programming of the output relays A1-A4 and six other logic masks (MRC, MRI, etc.).

The INST, A, and G targets illuminated for the ground fault at 9 miles because the Zone 1 ground overcurrent relay element caused the trip (Z1DG set to zero or instantaneous trip for the example 69 kV line) and A-phase and ground were involved in the fault. The fault targets are automatically cleared by the next fault, before the new fault targets are presented.

Each fault generates a short event report. Type **EVENT 1** and press **<ENTER>** to display a full event report for the last fault. The report provides an eleven cycle record of the currents, voltages, relay element states, and states of all contact inputs and outputs. The twelve newest reports are saved.

This checkout procedure demonstrates only a few of the relay features. Study the FUNCTIONAL DESCRIPTION, COMMAND, and EVENT REPORT sections of this manual to obtain a complete understanding of the relay capabilities.

FUNCTIONAL TESTS

Setting Test

To make sure the relay accepts settings, perform the following steps:

1. Gain Level 2 Access (see ACCESS and 2ACCESS commands).
2. Type **SET** and press **<ENTER>**.
3. Change one setting. For example, change the maximum torque angle (MTA) from 49° to 60°.
4. Type **END <ENTER>** to complete the setting procedure. When you receive the "OK (Y or N) ?" prompt, answer **YES <ENTER>**. The ALARM contact should close for several seconds while the relay computes internal settings, unless an alarm condition exists (i.e., self-test failure).
5. Use SHOWSET to inspect the settings; make sure your change was accepted.
6. Use SET and SHOWSET again to restore and check the settings.
7. Type **LOG MTU <ENTER>**.
8. Change one bit.
9. Complete the logic setting procedure.
10. Type **LOG MTU <ENTER>** again, and make sure the bit change is present. Restore the setting, and use SHOWSET to check the original setting.

METER Test

This single-phase test checks the magnitude accuracy and phase balance.

1. Connect the voltage input terminals VA, VB, and VC. Apply 50 Vac from the terminals to the neutral point.
2. Connect the current inputs in series and apply a current of five amperes through the three inputs. One way to do so without a test set is to derive this current using a resistor and a stepdown transformer energized from the same source. When the instruments provide 50 Vac input to the voltage inputs, the phase angle between the current and the voltage is nearly zero.

3. Use the METER command to inspect the measured voltages, currents, and power. Voltages VA, VB, and VC should equal the applied voltage times the potential transformer ratio setting. With the Example 69 kV Line settings, you should obtain:

$$VA = VB = VC = 50 \times 600 = 30 \text{ kV}. \quad (\pm 0.5\ \%)$$

   Voltages VAB, VBC, and VCA should be less than 0.3 kV.

   Similarly, currents IA, IB, and IC should equal the applied current times the current transformer ratio. With the Example 69 kV Line settings, you should obtain:

$$IA = IB = IC = 5 \times 60 = 300 \text{ A}. \quad (\pm 1\ \%)$$

   Difference currents IAB, IBC, and ICA should be less than 6 amperes.

   The power reading should be:

$$VA \times IA + VB \times IB + VC \times IC = 27 \text{ MW}.$$

   The reactive power reading should be less than 0.24 MVAR.

Directional Element Checking

Type **TAR 2 <ENTER>** (TARGETS command) to observe Relay Word Row 2 with the DFP and DFG bits for testing the negative-sequence element. The DFP bit status is displayed on the first LED from the left. The DFG bit status is displayed on the fifth LED from the left.

The negative-sequence element may be checked as follows:

Apply VA = 30 volts, VB = 0, and VC = 0. This results in an applied V2 = 10 volts.

Apply IA = 3 amperes, corresponding to a negative-sequence current of 1 ampere.

Move the phase of the current with respect to the voltage, and observe the boundary of the directional element at MTA ±90°.

The voltage polarized part of the zero-sequence element is checked identically to the negative-sequence element, except the DFG bit is used for indication. Type **TARGET 2 <ENTER>** to display Relay Word Row 2.

Apply the same voltages and currents used for the negative-sequence element test. This yields an applied V0 = 10 volts and I0 of 1 ampere.

Move the phase of the current with respect to the voltage, and observe the boundary of the zero-sequence directional element at MTA ±90°.

The current polarization is checked by turning off the voltage and applying a second current source to the polarizing current input (IP). Use an amplitude of 3 amperes and move the phase of IA with respect to IP. Maximum torque is at 0°, so you should observe the boundary of the characteristic at ±90°.

Observe the DFP bit to check the positive-sequence element. Apply the following balanced three-phase voltages to the relay:

	VA	VB	VC	
Magnitude	67	67	67	volts
Angle	0	-120	120	degree

Use an amplitude of 5 amperes for IA and move the phase of IA with respect to the balanced three-phase currents. Observe the boundary of the positive-sequence directional element at MTA ±90°.

Overcurrent Element Checking

Type **TARGET 1 <ENTER>** to check pickup of the 50N1, 50N2, and 50N3 residual-overcurrent elements. The command displays Relay Word Row 1 with the overcurrent element bits on the target LEDs.

Apply current to one phase, and observe the pickup and dropout of each element.

Check the pickup and dropout of the phase overcurrent elements in a similar manner by typing **TARGET 1 <ENTER>** to display the 50P1, 50P2, and 50P3 bits on the LEDs. Apply current to one phase, and observe the pickup and dropout of each element.

Check the pickup of residual time-overcurrent element (51NP) and phase time-overcurrent element (51PP) with the 51NP and 51PP bits in Relay Word Row 1. Type **TARGET 1 <ENTER>** to check these pickups. Apply current to one phase (close in magnitude to the set pickup) and observe the pickup and dropout of the elements.

Testing the Input Circuits

1. Use the TARGETS command to set the LEDs to follow the contact inputs. Type **TAR 5 <ENTER>**.

2. Apply control voltage to each input and observe that the corresponding target LED turns on. Event reports should be triggered whenever you energize the DT, PT, BT, and ET inputs.

Testing the Serial Ports

The Initial Checkout procedure assumes that you connect a terminal to Port 2. Set the baud rate of Port 1 to the same value as that of Port 2 and switch your terminal from Port 2 to Port 1. Make sure you can communicate through this port.

Testing the IRIG-B Time Code Input

1. Connect a source of demodulated IRIG-B time code to the Auxiliary Port of the relay with a series resistor to monitor the current. Adjust the source to obtain an "ON" current of about 10 mA.

2. Execute the IRIG command, and make sure the relay clock displays the correct date and time.

Note: For a convenient, inexpensive test of the IRIG-B port, use a recording of the IRIG-B signal passed through a simple demodulator. Please contact the factory for further details.

Testing the Power Supply Voltages

1. Execute the STATUS command and inspect the voltage readings for the +5 and ±15 volt supplies.

2. At the Auxiliary Port, use a voltmeter to read the +5 and ±12 volt outputs. The 12 volt outputs are derived from the 15 volt supplies using three-terminal regulators.

3. Compare the +5 volt readings from the status report and the voltmeter. The voltage difference should be less than 50 mV, and both readings should be within 0.15 volts of five volts.

4. The 12 volt supplies should be within 0.5 volt of their nominal values.

CALIBRATION

Each SEL Relay is factory calibrated. If you suspect that the relay is out of calibration, please contact the factory.

TROUBLESHOOTING GUIDE

Inspection Procedure

The following inspection procedure should be completed before the system is disturbed. After you finish the inspection procedure, proceed to the TROUBLESHOOTING TABLE.

- Measure and record control power voltage present at terminals marked + and -.
- Check to see that the power is on, but do not turn system off if it is on.
- Measure and record the voltage present at all control inputs.
- Measure and record the state of all output relays.
- Inspect the cabling to the serial communications ports and be sure that a communications device is connected to at least one communications port.

TROUBLESHOOTING TABLE

All Front Panel LED'S Dark when TARGET RESET Button is Pushed

- Power is off.
- Blown fuse.
- Input power not present.
- Self-test failure.
- Target command improperly set.

Note: For 1, 2, 3, and 4, the ALARM relay contacts should be closed.

System Does Not Respond to Commands

- Communications device not connected to system.
- Relay or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.
- Internal connector loose or disconnected.

- System is currently processing event record (wait several seconds).
- System is attempting to transmit information, but cannot due to handshake line conflict (check communications cabling).
- System is in the XOFF state, halting communications (type **<CTRL> Q** to put system in XON state).

Tripping Output Relay Remains Closed Following Fault

- Tripping condition still present.
- Output relay contacts burned closed.
- Failure of main board.

No Prompting Message Issued to Terminal upon Power-Up

- Terminal not connected to system.
- Wrong baud rate.
- Improper connection of terminal to system.
- Other port designated as the AUTOMATIC port (see AUTO setting in the SET command).
- Port timeout interval set to a value other than zero.
- Failure of main board.

System Does Not Respond to Faults

- Relay improperly set. Review your settings with the SET and LOGIC commands.
- Improper test set settings.
- CT or PT input cable wiring error. Check input voltages and currents with METER command and TRIGGER and EVENT sequence.
- Analog input cable between transformer and main board loose or defective.
- Check built-in-test status with STATUS command.

Terminal Displays Meaningless Characters

- Baud rate incorrectly set. Check terminal configuration: see Section 3: COMMUNICATIONS section.

Self-Test Failure: +5 Volts

- Power supply +5 volt output out of tolerance. See STATUS command.
- A/D converter failure.

Self-Test Failure: +15 Volts

- Power supply +15 volt output out of tolerance. See STATUS command.
- A/D converter failure.

Self-Test Failure: -15 Volts

- Power supply -15 volt output out of tolerance. See STATUS command.
- A/D converter failure.

Self-Test Failure: Offset

- Offset drift (adjust offsets).
- A/D converter drift.
- Loose ribbon cable from transformers to main board.

Self-Test Failure: ROM Checksum

- EPROM failure (replace EPROMs).

Self-Test Failure: RAM

- Failure of static RAM IC (replace RAM).

Self-Test Failure: A/D Converter

- A/D converter failure.
- RAM error not detected by RAM test.

Stall Relay Closed (Alarm)

- Power is off.
- Blown fuse.
- Power supply failure.
- Improper EPROMs or EPROM failure.
- Main board failure.

Firmware Upgrade Instructions, SEL-167-5 Relay

SEL may occasionally offer firmware upgrades to improve the performance of your relay. These instructions explain how to install new firmware.

The modifications require that you power down the relay, remove its front panel, pull out the drawout unit, exchange several integrated circuit chips, and reassemble the relay. If you do not wish to perform the modifications yourself, we can assist you. Simply return the relay and integrated circuit chips to us. We will install the new chips and return the unit to you within a few days.

Warning: This procedure requires that you handle electrostatic discharge sensitive components. If your facility is not equipped to work with these components, we recommend that you return the relay to SEL for firmware installation.

Upgrade Instructions

1. If the relay is in service, disable its control functions.
2. Turn off control power to the relay.
3. Remove the front panel by unscrewing the four front panel screws (one in each corner).
4. With the front panel leaning forward, you can see the aluminum drawout chassis. The main board is attached to the top of the drawout chassis. The power supply and interface board are attached to the bottom of the drawout chassis. Several ribbon cables connect the boards to each other and to other portions of the relay.

5. Disconnect the analog input ribbon cable (the right-most cable) from the main board.

6. The front panel display cable connects the relay interface board to the front panel display board. It is located on the left side of the front panel. Disconnect this cable from the display board.

7. Two hex head screws hold the drawout chassis in place. These screws are on the bottom of the chassis in each front corner. Remove both screws.

8. Remove the drawout assembly by pulling the spacers on the bottom of the drawout chassis. You should be able to remove the assembly with your fingers.

9. Because steps 10 through 12 involve handling electrostatic discharge (ESD) sensitive devices and assemblies, perform these steps at an ESD safe work station. This will help prevent possible damage by electrostatic discharge.

10. Note the orientation of the ICs to be replaced. Use a small screwdriver to pry the indicated ICs free from their sockets. Be careful not to bend the IC pins or damage adjacent components.

11. Carefully place the new ICs in the appropriate sockets.

12. Check the orientation of the ICs. Be sure that each IC is in its corresponding socket. Look for IC pins that bent under or did not enter a socket hole.

13. Slide the drawout assembly back into the relay chassis. Using your fingers, push the assembly in until the retaining screw holes in the drawout assembly align with corresponding holes in the relay chassis.

14. Install the retaining screws and reconnect the two ribbon cables.

15. With breaker control disabled, turn relay power back on and enter your settings. Execute the STATUS, METER, and TRIGGER commands to ensure that all functions are operational. Set and record your Access Level 1 and 2 passwords and the date and time. The relay is now ready to resume protective functions.

16. Please return the old ICs to Schweitzer Engineering Laboratories, Inc. in the same packing materials. New chips are shipped with a mailing label to simplify this process. When we receive the old parts, we will record a firmware upgrade for each of your relays.

Firmware Upgrade Instructions, SEL-267-5 Relay

1. If the relay is in service, disable its control functions. Turn off control power to the relay.

2. Remove the relay front panel by unscrewing the five front panel screws. With the front panel removed, you can see the aluminum drawout chassis. The main board is attached to the top of the drawout chassis. The power supply and transformer assembly are attached to the bottom of the relay chassis.

3. Disconnect the power supply and transformer secondary cables from the underside of the drawout assembly.

4. Remove the drawout assembly by pulling the spacers on the bottom of the drawout chassis. You should be able to remove the assembly with your fingers. Because steps 5 and 6 involve handling electrostatic discharge (ESD) sensitive devices and assemblies, perform these steps at an ESD safe work station. This will help prevent possible damage by electrostatic discharge.

5. Note the orientation of the ICs to be replaced. Use a small screwdriver to pry the indicated ICs free from their sockets. Be careful not to bend the IC pins or damage adjacent components.

6. Carefully place the new ICs in the appropriate sockets. Check the orientation of the ICs. Be sure that each IC is in its corresponding socket. Look for IC pins that bent under or did not enter a socket hole.

7. Slide the drawout assembly into the relay chassis. Using your fingers, push the assembly in until the front of the assembly is flush with the front of the relay chassis. Reconnect the power supply and transformer secondary cables to the receivers on the underside of the drawout assembly. Replace the relay front panel.

8. With breaker control disabled, turn relay power on and enter your settings. Execute the STATUS, METER, and TRIGGER commands to ensure that all functions are operational. Set and record your Access Level 1 and 2 passwords and the date and time. The relay is now ready to resume protective functions.

Factory Assistance

If you have any questions regarding the performance, application, or repair of this or any other SEL product, do not hesitate to contact the factory. Our staff is happy to assist you.

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603
Tel: (509) 332-1890
FAX: (509) 332-7990

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

ONEBUS: PROGRAM TO COMPUTE TEST SET SETTINGS FOR TESTING DISTANCE RELAYS

The BASIC program in this note determines voltages and currents which would appear on distance relay terminals for ground and phase faults on a radial system with source impedance at the same angle as line impedance. It is useful in determining test voltage and current settings for SEL distance relays and fault locating equipment.

The program was initially designed to run on a TRS-80 Model 100 briefcase computer but may be installed on virtually any personal computer or laptop.

The program first prompts you for the positive and zero-sequence impedances of the transmission line. Enter the data in secondary ohms for the entire length of the protected line.

Next, you may enter fault resistance, which is used in the ground-fault computations.

Enter source impedance as a per-unit value with a base of the previously-entered transmission line data. For example, if the radial system has a source impedance of about ten percent of the entered line impedance, enter 0.1 for the per-unit distance from the source to the bus.

Specify the distance from the bus to the fault as a fraction of the total line length. To obtain the voltages and currents for a fault one-half the way down the line from the bus, enter 0.5 for the distance from the bus to the fault.

After you enter this data, the program begins computations. The display then shows voltages and currents for both an AG and BC fault. These data can be entered into any active test source.

The bottom line of the display offers you a choice of entering new impedance data (I), changing the distance from the source to the bus (B), specifying a new fault location (F), or quitting (Q).

```
1       REM SCHWEITZER ENGINEERING LABORATORIES, INC.
2       REM 2350 NE Hopkins Court
3       REM Pullman, WA  99163-5603
4       REM
10      REM COMPUTE DOBLE SETTINGS FOR A ONE-BUS SYSTEM
20      REM HOMOGENEOUS SYSTEM
30      REM SOURCE VOLTS= 67 L-N
40      REM
50      REM ENTER IMPEDANCES FOR 100% OF LINE
60      INPUT "ENTER Z1: R,X";R1,S1
70      INPUT "ENTER Z0: R,X";R0,S0
75      INPUT "ENTER RF FOR GND FLTS";RF
80      REM
90      REM ENTER BUS LOC. FROM SOURCE
100     INPUT "DIST SOURCE TO BUS (PU OF LINE)";S
120     INPUT "DIST BUS TO FAULT (PU OF LINE)";F
130     REM
140     REM  PHASE A TO GROUND
150     REM COMPUTE POS SEQ CURRENT
160     X = R0+2*R1: Y = S0+2*S1
170     R3 = R1-R0:   S3 = S1-S0
180     AR=1/(S+F):  AI=0
190     BR=X      :  BI=Y
195     BR=BR+3*RF/(S+F)
200     GOSUB 2000
210     I = RR    :   J = RI
220     IA = 3*67*I:  JA=3*67*J
225     IB=0:JB=0:IC=0:JC=0
230     AR=X:AI=Y:BR=I:BI=J
232     GOSUB 1000
234     UA=67*(1-S*RR):VA=67*(-S*RI)
240     AR=R3      :AI=S3
250     BR=I       :BI=J
260     GOSUB 1000
270     TR=S*RR    :TS=S*RI
280     UB=67*(-0.5+TR)
290     VB=67*(-SQR(3)/2+TS)
300     UC=67*(-0.5+TR)
310     VC=67*(SQR(3)/2+TS)
315     FF$="A-G"
320     GOSUB 4041
500     REM  B-C FAULT
510     AR=1: AI=0
520     BR=2*R1*(S+F):BI=2*S1*(S+F)
530     GOSUB 2000
540     I=RR:J=RI
550     IA=0:JA=0
560     AR=I:AI=J:BR=0:BI=-67*SQR(3)
570     GOSUB 1000
580     IB=RR:JB=RI:IC=-IB:JC=-JB
590     UA=67:VA=0
600     AR=I:AI=J:BR=S*RI:BI=S*S1
610     GOSUB 1000
620     AR=RR:AI=RI:BR=0:BI=SQR(3)
630     GOSUB 1000
635     TR=RR:TS=RI
640     UB=67*(-0.5+TR)
650     VB=67*(-SQR(3)/2+TS)
660     UC=67*(-0.5-TR)
670     VC=67*(0.5*SQR(3)-TS)
675     FF$="B-C"
680     GOSUB 4041
900     INPUT "IMP BUS FAULT OR QUIT (I,B,F,Q)";A$
910     IF A$ = "I" THEN GOTO 50
920     IF A$ = "B" THEN GOTO  75
930     IF A$ = "F" THEN GOTO 120 ELSE GOTO 999
999     END
1000    REM MULT SUBROUTINE
1010    REM AR,AI * BR,BI = RR,RI
1020    RR=AR*BR-AI*BI
1030    RI=AI*BR+AR*BI
1040    RETURN
2000    REM DIVISION SUBROUTINE
2010    REM AR,AI / BR,BI = RR,RI
2020    D = BR*BR + BI*BI
2030    RR = AR*BR + AI*BI
2040    RR = RR/D
2050    RI = BR*AI - AR*BI
2060    RI = RI/D
2070    RETURN
3000    REM RECT TO POLAR CONV
3010    REM AR,AI, TO RH, TH
3020    PI = 3.14159265358
3030    IF (AR=0 AND AI=0) THEN    RH=0: TH=0: RETURN
3040    IF (AR=0 AND AI>0) THEN    RH=AI: TH=90:RETURN
3050    IF (AR=0 AND AI<0) THEN RH=-AI: TH=-90: RETURN
3060    IF (AR>0) THEN TH=(180/PI)*ATN(AI/AR)
3070    IF (AR<0) THEN TH=(180/PI)*ATN(AI/AR)+180
3080    IF TH>180 THEN TH = TH-360
3090    RH=SQR(AR*AR+AI*AI)
3100    RETURN
4041    AR=UA:AI=VA:GOSUB 3000
4042    UA=RH:VA=TH
4043    AR=UB:AI=VB:GOSUB 3000
4044    UB=RH:VB=TH-VA
4045    AR=UC:AI=VC:GOSUB 3000
4046    UC=RH:VC=TH-VA
4047    AR=IA:AI=JA:GOSUB 3000
4048    IA=RH:JA=TH-VA
4049    AR=IB:AI=JB:GOSUB 3000
4050    IB=RH:JB=TH-VA
4055    AR=IC:AI=JC:GOSUB 3000
4060    IC=RH:JC=TH-VA
4061    VA=0
4100    PRINT " VA   VB   VC   IA   IB   IC"
4130    PRINT USING"##.# ";UA;UB;UC;IA;IB;IC,
4132    PRINT FF$
4140    PRINT USING"#### ";VA;VB;VC;JA;JB;JC
4150    RETURN
```

APPENDICES
TABLE OF CONTENTS

APPENDIX A - FIRMWARE VERSIONS

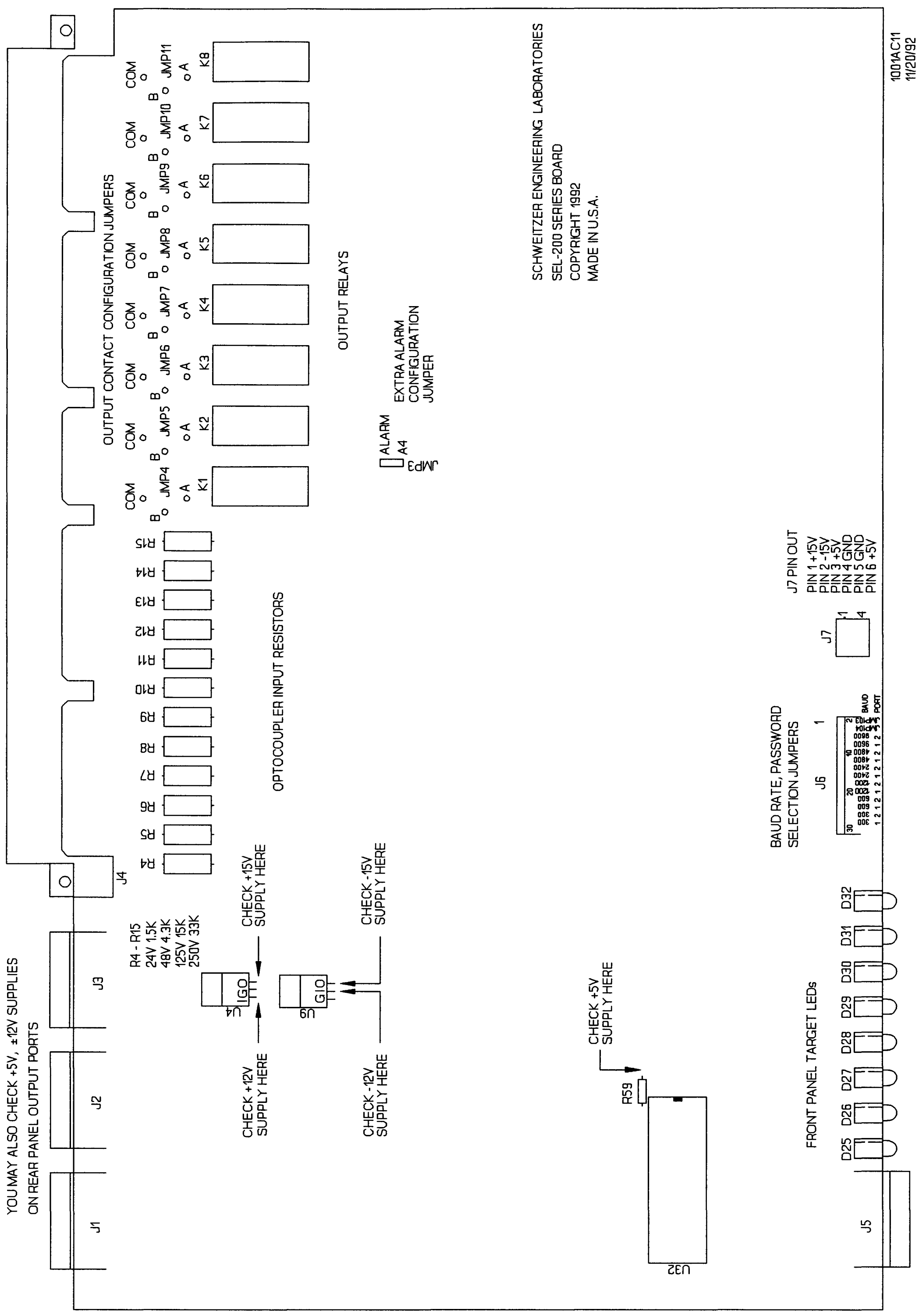
This manual covers SEL relays that contain firmware bearing the following part numbers and revision numbers:

Firmware Part/Revision No.	Description of Firmware
SEL-167-5-R406-D010313	This firmware differs from different versions as follows: – Fixed ground directional logic, which was incorrectly allowing 32Q forward polarization of ground elements when 32QE was set to "N." – Fixed event report logic to include event type, target, location, and duration information when triggered events only contain 51P or 51N element assertions. 60 Hz, 5 Amp, Mi, ABC Rotation
SEL-167-5-R405-D980417	60 Hz, 5 Amp, Mi, ABC Rotation
SEL-167-5-R404	This firmware differs from previous versions as follows: – Fixed LOP problem where the 50QL threshold value was incorrect after cycling power to the relay. 60 Hz, 5 Amp, Mi, ABC Rotation
SEL-167-5-R403	This firmware differs from previous versions as follows: – Blocked OPEN command when TDUR=0. – Allow CR and CRLF to operate identically. – Allow recloser to reset if breaker is manually closed external to the relay. 60 Hz, 5 Amp, Mi, ABC Rotation
SEL-167-5-R402	60 Hz, 5 Amp, Mi, ABC Rotation

To find the firmware revision number in your relay, obtain an event report (which identifies the firmware) using the EVENT command. This is an FID number with the Part/Revision number in bold:

FID=**SEL-167-5-R402**-656mp212-D960110

For a detailed explanation of the Firmware Identification Number (FID) refer to Section 4: EVENT REPORTING.



SEL-200 Series Main Board Troubleshooting Test Points and Jumper Locations

SETTINGS SHEET
FOR SEL-267-5/167-5 RELAY

DATE ______

SUBSTATION ______ CIRCUIT ______

BREAKER ______ DEVICE NO. ______

FUNCTION ______

MAKE ______ C.T. SETTING ______

MODEL/STYLE NO. ______ P.T. SETTING ______

PART # ______ SOFTWARE VERSION ______

SERIAL #______ POWER SUPPLY ______ VOLTS ac/dc LOGIC INPUT ____ Vdc

SECONDARY INPUTS: V/ø = 67L-N, NOMINAL AMPS = 5, Hz = 60

HEXADECIMAL REPRESENTATION

MASK: MTU (UNCONDITIONAL TRIP)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MPT (PERMISSIVE TRIP)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MTB (BLOCK TRIP)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

SETTINGS SHEET
FOR SEL-267-5/167-5 RELAY

MASK: MTO (SWITCH ONTO FAULT)

									HEXADECIMAL REPRESENTATION SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MA1 (A1 CONTACT)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MA2 (A2 CONTACT)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MA3 (A3 CONTACT)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

SETTINGS SHEET
FOR SEL-267-5/167-5 RELAY

DATE ____________

MASK: MA4 (A4 CONTACT)

									HEXADECIMAL REPRESENTATION SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MRI (RECLOSE INITIATE)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

MASK: MRC (RECLOSE CANCEL)

									SETTING
ROW #1: RELAY WORD BINARY REPRESENTATION	51NP	50N1	50N2	50N3	51PP	50P1	50P2	50P3	
ROW #2: RELAY WORD BINARY REPRESENTATION	DFP	67N1	67N2	67N3	DFG	67P1	67P2	67P3	
ROW #3: RELAY WORD BINARY REPRESENTATION	51NT	Z1GT	Z2GT	Z3GT	51PT	Z1PT	Z2PT	Z3PT	
ROW #4: RELAY WORD BINARY REPRESENTATION	LOP	TRIP	TC	DT	52BT	SH1	50MF	DCTH	

BINARY	HEXADECIMAL
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

ACCESS Command passwords: (6 Characters excluding "SPACE, COMMA, SEMI-COLON and SLASH")

LEVEL 0: "=" **ACCESS <ENTER>**
PASSWORD: ________________________

LEVEL 1: "=>" **2ACCESS <ENTER>**
PASSWORD: ________________________

LEVEL 2: "=>>" ENTER SETTINGS PER MATRIX TABLE

Note: FOR NEW RELAYS BEGIN WITH LEVEL 1 PASSWORD = OTTER AND LEVEL 2 PASSWORD = TAIL. WHEN IN LEVEL 2 MODIFY PASSWORDS VIA PASSWORD 1 AND 2 COMMANDS.

SETTINGS SHEET
FOR SEL-267-5/167-5 RELAY

DATE ________

DESCRIP. RANGE	POS-SEQ. IMPEDANCE 0-9999 (PRI. OHMS)		ZERO-SEQ. IMPEDANCE 0-9999 (PRI. OHMS)		LINE LENGTH* 0.1-999 MILES
ABBREV. SETTING	**R1**	**X1**	**R0**	**X0**	**LL**
DESCRIP. RANGE	C. T. RATIO 1-5000:1	P. T. RATIO 1-10,000:1	MAX. TORQUE ANGLE 47°- 90°	ENABLE FAULT LOCATOR (Y OR N)	DEMAND AMMETER TIME CONSTANT 5 - 60 MINUTES
ABBREV. SETTING	**CTR**	**PTR**	**MTA**	**LOCAT**	**DATC**
DESCRIP. RANGE	DEMAND CURRENT THRESHOLD 0.25-50,000 AMP PRI.	RECL. OPEN INTERVAL 1 0-10,000 CYCLES (¼ CYCLE STEPS)	RECL. OPEN INTERVAL 2 0-10,000 CYCLES (¼ CYCLE STEPS)	RECL. OPEN INTERVAL 3 0-10,000 CYCLES (¼ CYCLE STEPS)	RECL. RESET TIME 60-8,000 CYCLES (¼ CYCLE STEPS)
ABBREV. SETTING	**DCTH**	**79OI1**	**79OI2**	**79OI3**	**79RS**
DESCRIP. RANGE	PHASE TIME O/C PICKUP 0.25-50,000 AMP PRI.	PHASE TIME O/C TIME DIAL 0.5-15 (0.01 STEPS)	PHASE TIME O/C CURVE SHAPE 1, 2, 3, OR 4	PHASE TIME O/C TORQUE CONTROL (Y OR N)	
ABBREV. SETTING	**51PP**	**51PTD**	**51PC**	**51PTC**	
DESCRIP. RANGE	ZONE 1 PHASE O/C PICKUP 0.25-50,000 AMP PRI.	ZONE 2 PHASE O/C PICKUP 0.25-50,000 AMP PRI.	ZONE 3 PHASE O/C PICKUP 0.25-50,000 AMP PRI.		
ABBREV. SETTING	**50P1**	**50P2**	**50P3**		
DESCR. RANGE	ZONE 1 ØØ & 3Ø TIMER 0-60 CYCLES (¼ CYCLE STEPS)	ZONE 2 ØØ & 3Ø TIME-STEP BACKUP TIMER 0-2000 CYCLES (¼ CYCLE STEPS)	ZONE 3 ØØ & 3Ø TIME-STEP BACKUP TIMER 0-2000 CYCLES (¼ CYCLE STEPS)		
ABBREV. SETTING	**Z1DP**	**Z2DP**	**Z3DP**		
DESCR. RANGE	GND TIME O/C PICKUP (0.25-6.3A SEC) 0.25-50,000 AMP PRI.	GND TIME O/C TIME DIAL 0.5-15 (0.01 STEPS)	GND TIME O/C CURVE SHAPE 1, 2, 3, OR 4	GND TIME O/C TORQUE CONTROL (Y OR N)	
ABBREV. SETTING	**51NP**	**51NTD**	**51NC**	**51NTC**	

SETTINGS SHEET
FOR SEL-267-5/167-5 RELAY

DATE ____________

DESCR. RANGE	ZONE 1 GND INST. O/C (0.2A-47x51NP 0.25-50,000 AMP PRI.	ZONE 2 GND INST. O/C (0.2A-47x51NP 0.25-50,000 AMP PRI.	ZONE 3 GND INST. O/C (0.2A-47x51NP 0.25-50,000 AMP PRI.	Ø O/C MEDIUM -SET PICKUP (0.5-40A SEC.) 0.25-50,000 AMP PRI.	Ø O/C LOP DELAY (LOSS-OF -POTENTIAL) 0-60 CYCLES (¼ CYCLE STEPS)
ABBREV. SETTING	**50N1**	**50N2**	**50N3**	**50M**	**50MFD**
DESCR. RANGE	ZONE 1 GND TIMER 0-60 CYCLES (¼ CYCLE STEPS)	ZONE 2 GND TIME-STEP BACKUP TIMER 0-2000 CYCLES (¼ CYCLE STEPS)	ZONE 3 GND TIME-STEP BACKUP TIMER 0-2000 CYCLES (¼ CYCLE STEPS)	MINIMUM TRIP DURATION TIMER 0-2000 CYCLES (¼ CYCLE STEPS)	
ABBREV. SETTING	**Z1DG**	**Z2DG**	**Z3DG**	**TDUR**	
DESCR. RANGE	52BT TIME DELAY 0.5-10,000 CYCLES	ZONE 3 DIRECTION (F OR R)	GND INSTANT. O/C TORQUE CONTROL (Y OR N)	PHASE INSTANT. O/C TORQUE CONTROL (Y OR N)	
ABBREV. SETTING	**52BT**	**ZONE3**	**67NE**	**67PE**	
DESCR. RANGE	GND O/C NEGATIVE-SEQ. POLAR. (Y OR N)	GND O/C ZERO-SEQ. VOLTAGE POLAR. (Y OR N)	GND O/C ZERO-SEQ. CURRENT POLAR. (Y OR N)	LOSS-OF-POTENTIAL ENABLE (Y OR N)	
ABBREV. SETTING	**32QE**	**32VE**	**32IE**	**LOPE**	
DESCR. RANGE	PORT #1 TIMEOUT 0-30 MINUTES	PORT #2 TIMEOUT 0-30 MINUTES	AUTOMATIC MESSAGE TRANSMIT AUTOPORT SELECTION PORT 1, 2, OR 3(BOTH)	# RINGS AFTER WHICH MODEM ANSWERS 1-30	
ABBREV. SETTING	**TIME1**	**TIME2**	**AUTO**	**RINGS**	

* Line Length = Station #1 (relay location) to Station #2; the full distance in miles between stations.

NOTE: Length can also be represented in metric units, primary or secondary ohms, etc., but conversion to miles would be required.

Comments: ______________________________

Settings recommended by ______________________________

Settings approved by ______________________________

Settings approved by ______________________________

Settings performed by ______________________________

Test printout required. ______ Yes ______ No   Substation ______

SEL-267-5 DIRECTIONAL OVERCURRENT COMMAND SUMMARY

Access Level 0

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

Access 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 4/1/93 sets date to April 1, 1993. Pulses the ALARM relay momentarily when a different year is entered than previously stored year. The month and date settings are overridden when IRIG-B synchronization occurs.
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 and logic settings. This command does not affect the settings. The logic settings are shown in hexadecimal format for each mask.
STATUS	Show self-test status.
TARGETS	Show data and set target lights as follows: TAR 0: Relay Targets — TAR 1: RELAY WORD #1 TAR 2: RELAY WORD #2 — TAR 3: RELAY WORD #3 TAR 4: RELAY WORD #4 — TAR 5: Contact Inputs TAR 6: Contact Outputs — TAR R: Clears targets and returns to TAR 0 Be sure to return to TAR 0 when done, so LEDs display fault targets.
TIME	Show or set time. TIM 13/32/00 sets clock to 1:32:00 PM. This setting is overridden when IRIG-B synchronization occurs.
TRIGGER	Trigger and save an event record. (Type of event is EXT).

Access 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. ALARM relay closes while new settings are being computed, and event data buffers are cleared.
OPEN	Open circuit breaker, if allowed by jumper setting.
PASSWORD	Show or set passwords. Pulses the ALARM relay momentarily when new passwords are set. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.
SET	Initiate setting procedure. ALARM relay closes while new settings are being computed, and event data buffers are cleared.

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

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

EXPLANATION OF EVENT REPORT

```
Example 69 kV Line                          Date:  4/1/93      Time: 08:45:09.366

FID=SEL-267-R400-V656mp12-D900323

                Currents                        Voltages        Relays Outputs Inputs
                 (amps)                           (kV)
                                                                565565 TCAAAAA DPBD5E
  IPOL      IR      IA      IB      IC      VA      VB      VC  071071 PL1234L TTTC2T
                                                                PPPNNN              A

     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     50M  =300.00    50MFD=30.00
Z1DG =0.00      Z2DG =30.00     Z3DG =10.00     TDUR =9.00
52BT =30        ZONE3=R         67NE =Y         67PE =Y
32QE =N         32VE =Y         32IE =Y         LOPE =Y
TIME1=5         TIME2=0         AUTO =2         RINGS=3

Currents and voltages are in primary amps and kV. Rows are 1/4 cycle apart.  Time runs down
page. Obtain phasor RMS value and angle using any entry as Y-component, and the entry
immediately underneath as the X-component. For example, from bottom rows, IAY = 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 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 9999.
<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-267 via the TARGET 0 command.  The
                   targets field indicates any combination of the following:
                                  P1:  Zone 1 phase fault
                                  G1:  Zone 1 ground fault
                                  P2:  Zone 2 phase fault
                                  G2:  Zone 2 ground fault
                                  P3:  Zone 3 phase fault
                                  G3:  Zone 3 ground fault
                                  51P: Phase time-overcurrent trip
                                  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
TDUR           Minimum Trip Duration Timer
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.
```

SEL-267-5 DIRECTIONAL OVERCURRENT COMMAND SUMMARY

Access Level 0

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

Access 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 4/1/93 sets date to April 1, 1993. Pulses the ALARM relay momentarily when a different year is entered than previously stored year. The month and date settings are overridden when IRIG-B synchronization occurs.
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 and logic settings. This command does not affect the settings. The logic settings are shown in hexadecimal format for each mask.
STATUS	Show self-test status.
TARGETS	Show data and set target lights as follows: TAR 0: Relay Targets — TAR 1: RELAY WORD #1 TAR 2: RELAY WORD #2 — TAR 3: RELAY WORD #3 TAR 4: RELAY WORD #4 — TAR 5: Contact Inputs TAR 6: Contact Outputs — TAR R: Clears targets and returns to TAR 0 Be sure to return to TAR 0 when done, so LEDs display fault targets.
TIME	Show or set time. TIM 13/32/00 sets clock to 1:32:00 PM. This setting is overridden when IRIG-B synchronization occurs.
TRIGGER	Trigger and save an event record. (Type of event is EXT).

Access 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. ALARM relay closes while new settings are being computed, and event data buffers are cleared.
OPEN	Open circuit breaker, if allowed by jumper setting.
PASSWORD	Show or set passwords. Pulses the ALARM relay momentarily when new passwords are set. PAS 1 OTTER sets Level 1 password to OTTER. PAS 2 TAIL sets Level 2 password to TAIL.
SET	Initiate setting procedure. ALARM relay closes while new settings are being computed, and event data buffers are cleared.

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

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 SEL/4-93

EXPLANATION OF EVENT REPORT

```
Example 69 kV Line                           Date:  4/1/93       Time: 08:45:09.366

FID=SEL-267-R400-V656mp12-D900323

                  Currents                       Voltages        Relays Outputs Inputs
                   (amps)                          (kV)
                                                                 565565 TCAAAAA DPBD5E
  IPOL      IR      IA      IB      IC      VA      VB      VC   071071 PL1234L TTTC2T
                                                                 PPPNNN              A

     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    50M  =300.00   50MFD=30.00
Z1DG =0.00     Z2DG =30.00    Z3DG =10.00    TDUR =9.00
52BT =30       ZONE3=R        67NE =Y        67PE =Y
32QE =N        32VE =Y        32IE =Y        LOPE =Y
TIME1=5        TIME2=0        AUTO =2        RINGS=3
```

Currents and voltages are in primary amps and kV. Rows are 1/4 cycle apart. Time runs down page. Obtain phasor RMS value and angle using any entry as Y-component, and the entry immediately underneath as the X-component. For example, from bottom rows, IAY = 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 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 9999.
<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-267 via the TARGET 0 command.  The
                  targets field indicates any combination of the following:
                               P1:  Zone 1 phase fault
                               G1:  Zone 1 ground fault
                               P2:  Zone 2 phase fault
                               G2:  Zone 2 ground fault
                               P3:  Zone 3 phase fault
                               G3:  Zone 3 ground fault
                               51P: Phase time-overcurrent trip
                               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
TDUR           Minimum Trip Duration Timer
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.
```