SEL-121B
PHASE DISTANCE RELAY
GROUND DIRECTIONAL OVERCURRENT RELAY
SELECTABLE SETTING GROUPS
FAULT LOCATOR

DATA SHEET

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

Also Available In LOW-PROFILE Package
GENERAL DESCRIPTION

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

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

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

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

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

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

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

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

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

The SEL-121B relay is compatible with the SEL-PRTU Protective Relay Terminal Unit, the SEL-DTA Display Transducer Adapter, and the SEL-PROFILE Fault Analysis Program.
Figure 1: Relay Function Block Diagram
APPLICATIONS

**Bus-tie or Line Substitute Breaker Schemes**

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

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

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

**Replacement of Outdated Protective Relays**

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

**Time-Step Relaying**

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

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

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

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

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

Its application also adds event reporting and fault locating.

Other Applications

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

SPECIFICATIONS

Relay Functions

Who characteristics for phase-phase and three-phase faults
  Three phase-to-phase zones
  Three three-phase zones
Residual overcurrent protection for ground faults
  Three definite-time elements
  One inverse-time element with selectable curve shapes
Negative- and zero-sequence directional elements for ground faults. Zero-sequence element is dual polarized
Zone 3 mhos and definite time element may be reversed
High-set phase overcurrent elements
Medium-set phase overcurrent elements may be enabled on loss of potential.

Relay Elements

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

Distance Elements

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

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

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

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

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

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

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

Ground Overcurrent Elements
- 5IN residual time overcurrent element:
  Selectable curve shape (4 curves)
  Pickup: 0.25 to 6.3 A, ± 0.05 A ± 3% of setting
- 5ON1, 5ON2, 5ON3 residual overcurrent elements:
  Pickup: 0.25 A to 48 times 5IN pickup for 5IN pickup < 3.15 A
  0.5 A to 48 times 5IN pickup for 5IN pickup ≥ 3.15 A
  Transient overreach: 5% of set pickup
  Timers are provided for 5ON1, 5ON2, and 5ON3

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

Zero-sequence directional element:
- Voltage polarization:
  Angle: same as mho element setting
  Sensitivity: refer to the table below
Voltage Polarization Sensitivities for 32Q and 32V

*Z1 (ohms)  **32Q Sens. (VA)  ***32V Sens. (VA)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125 - 0.5</td>
<td>0.04 / Z1</td>
<td>0.14 * 51N</td>
</tr>
<tr>
<td>0.5 - 2.0</td>
<td>0.14 * Z1</td>
<td>0.26 * 51N * Z1</td>
</tr>
<tr>
<td>2.0 - 8.0</td>
<td>0.04 * Z1</td>
<td>0.07 * 51N * Z1</td>
</tr>
<tr>
<td>8.0 - 32.0</td>
<td>0.01 * Z1</td>
<td>0.02 * 51N * Z1</td>
</tr>
</tbody>
</table>

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

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

Sequence-Component Elements
Zero-sequence overvoltage element (47NL)
   Pickup: 14 volts V0
Zero-sequence overcurrent element (50NL)
   Pickup: 10 = 0.083 amps for 51N pickup < 3.15 amps
   10 = (0.083 amps) * (51N pickup / 3.15 amps) for 51N pickup ≥ 3.15 amps
Positive-sequence overvoltage element (47P)
   Pickup: 14 volts V1

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

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

<table>
<thead>
<tr>
<th>Setting Groups</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting #1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Setting #2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Setting #3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Setting #4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Setting #5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Setting #6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Setting #7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Setting #8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Remote</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

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

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

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

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

**Fault Reporting**
A data record is retained for each of the 12 most recent faults, which includes current, voltage, relay element, input contact, and output contact information. The report may also be triggered by
command. When tripping occurs after the end of the event report, a second report is triggered at tripping. Records are erased when the settings are changed or a new setting group is activated.

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

**Rated Input Voltage**
- 115 volt nominal phase-to-phase, 3 phase 4 wire connection

**Rated Input Current**
- 5 amps per phase nominal
- 15 amps per phase continuous
- 500 amps for one second thermal rating

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

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

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

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

**Interference Tests**
- IEEE C37-90 SWC test (type-tested)
- IEC 255-6 interference test (type-tested)

**Impulse Tests**
- IEC 255-5 0.5 joule 5000 volt test (type-tested)

**RFI Tests**
- Type-tested near a 1/4-wave antenna driven by 20 watts at 150 MHz and 450 MHz, randomly keyed on and off, at a distance of 1 meter from relay.
**Dimensions**
5 1/4" x 19" x 13". Mounts in EIA 19" rack, or panel cutout. Also available for vertical mounting.

**Unit Weight**
21 pounds

**Shipping Weight**
32 pounds, including two instruction manuals

**Operating Temp.**
-20 degrees C to +55 degrees C

**Burn-in Temp.**
Each SEL-121B relay is burned in at 60 degrees C for 100 hours.

**LOGIC DESCRIPTION**

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

**Relay Elements**

Single-phase overcurrent relays 50AL 50BL 50CL (Phase fault detectors)  
Medium-set single phase OC relays 50AM 50BM 50CM (Selectable for loss of pot)  
High-set single phase OC relays 50AH 50BH 50CH (Always available)  

Zone 3 three-phase mho distance 21ABC3 (Reversible)  
Zone 3 line-line mho distance 21P3 (Reversible)  

Zone 2 three-phase mho distance 21ABC2  
Zone 2 line-line mho distance 21P2  

Zone 1 three-phase mho distance 21ABC1 (Includes delay if ZIDP not 0.00)  
Zone 1 line-line mho distance 21P1 (Includes delay if ZIDP not 0.00)  

Residual time-overcurrent pickup 51NP Directional  
Residual time-overcurrent trip 51NT Directional  
Residual overcurrent 50N1 Nondirectional (Includes delay if ZIDG not 0.00)  

Residual inst-overcurrent 50N2 Nondirectional  
Residual inst-overcurrent 50N3 Nondirectional  

Negative-sequence directional 32Q 32QF=forward; 32QR=reverse  
Zero-sequence dual pol directional 32D 32DF=forward; 32DR=reverse  

Zero-sequence overvoltage 47NL Used for loss-of-pot detection  
Zero-sequence overcurrent 50NL Used for loss-of-pot detection  
Positive-sequence overvoltage 47P Used for loss-of-pot detection
Contact Inputs

Setting group selector  S1
Setting group selector  S2
Setting group selector  S3
Setting group selector  S4
Setting group selector  S5
Circuit breaker monitor  S2A

Contact Outputs

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

INTERMEDIATE LOGIC

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

Loss-of-Potential Logic

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

Clear $\text{LOP} = \text{NOT}(47NL) * 47P$

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

Phase Overcurrent Conditions

5OL  = 50AL + 50BL + 50CL  Phase fault current supervision
3P50 = 50AL * 50BL * 50CL  Three-phase fault current supervision
5OM  = 50AM + 50BM + 50CM  Medium-level overcurrent condition
5OMF = 50M * [LOP + NOT(LOPE)] * (50MFD)  Asserts a settable delay after LOP and 50M overcurrent, or just 50M overcurrent if LOP is disabled
5OH  = 50AH + 50BH + 50CH  High-level overcurrent condition
Distance Relay Logic

\[ Z3ABC = 21ABC3 \times 3P50 \times \text{NOT}(L0P \times L0PE) \]  
\[ Z2ABC = 21ABC2 \times 3P50 \times \text{NOT}(L0P \times L0PE) \]  
\[ Z1ABC = 21ABC1 \times 3P50 \times \text{NOT}(L0P \times L0PE) \times Z1PTMR \]  
\[ Z3P = 21P3 \times 5OL \times \text{NOT}(L0P \times L0PE) \]  
\[ Z2P = 21P2 \times 5OL \times \text{NOT}(L0P \times L0PE) \]  
\[ Z1P = 21P1 \times 5OL \times \text{NOT}(L0P \times L0PE) \times Z1PTMR \]  
\[ Z3PT = (Z3P + Z3ABC) \times Z3PTMR \]  
\[ Z2PT = (Z2P + Z2ABC) \times Z2PTMR \]

Zone 3 timeout-phase
Zone 2 timeout-phase

Ground Overcurrent Conditions

\[ DF = \left[[32QF + [L0P \times L0PE]] \times 32QE\right] + \left[[32DF + [L0P \times L0PE]] \times 32VE\right] + \text{NOT}(32QE + 32VE + 32IE) \]  
Forward direction
\[ DR = 32QR \times 32QE + 32DR \times (32IE + 32VE) \]  
Reverse direction

\[ D3 = DF \text{ if Zone 3 is forward} \]  
\[ D3 = DR \text{ if Zone 3 is reverse} \]  
\[ 67N1 = 50N1 \times DF \times Z1GTMR \]  
\[ 67N2 = 50N2 \times DF \]  
\[ 67N3 = 50N3 \times D3 \]  
(Includes delay if Z1DG not 0.00)

(Reversible)

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

\[ Z3GT = 67N3 \times Z3GTMR \]  
Zone 3 timeout-ground
\[ Z2GT = 67N2 \times Z2GTMR \]  
Zone 2 timeout-ground

RELAY WORD

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

<table>
<thead>
<tr>
<th>Relay Word</th>
<th>1ABC</th>
<th>2ABC</th>
<th>3ABC</th>
<th>L0P</th>
<th>50H</th>
<th>50M</th>
<th>50MF</th>
<th>50L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>51NT</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>51NP</td>
<td>Z1P</td>
<td>Z2P</td>
<td>Z3P</td>
</tr>
<tr>
<td></td>
<td>Z2PT</td>
<td>Z3PT</td>
<td>Z2GT</td>
<td>Z3GT</td>
<td>ALRM</td>
<td>TRIP</td>
<td>TC</td>
<td>DF</td>
</tr>
</tbody>
</table>

12
The Relay Word Bit Summary Table (below) explains the meaning of each bit in the relay word.

**Relay Word Bit Summary Table**

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

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

**OUTPUT EQUATIONS**

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

Let \( R \) = Relay Word

\[ \text{MTU} = \text{mask for trip (unconditional)} \]
\[ \text{MTO} = \text{mask for trip (with breaker open)} \]

Then:
\[ \text{TRIP} = R \times \text{MTU} + R \times \text{MTO} \times 52BT \]

Close TRIP contact = TRIP

Open TRIP contact = NOT(TRIP) \times [NOT(52A) + \text{TARGET RESET button pushed}] \times (60 \text{ ms minimum TRIP})

Close CLOSE contact = (CLOSE Command) \times NOT(52A) \times NOT(TRIP)

Open CLOSE contact = NOT(CLOSE)

\[ A_1 = R \times MA_1 \]
\[ A_2 = R \times MA_2 \]
\[ A_3 = R \times MA_3 \]
\[ A_4 = R \times MA_4 \]

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

**SETTING PROCEDURE**

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

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

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

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

ID 3: Example 230 kV Line

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

R1 : (Ohms pri.) = 13.90 ?
X1 : ........................ = 79.96 ?
R0 : ........................ = 51.50 ?
X0 ........................ = 29.40 ? 248.57 <= operator changes X0
LL : Line Length (mi.)  = 100.00 ?

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

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

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

SOL : PU (Amps pri).......... = 100.00 ?
SOM : PU (Amps mid)......... = 200.00 ?
SOMF : Dly (cyc)............. = 20.00 ?

SNP : PU (Amps pri).......... = 100.00 ?
SNTD : Time Delay (....).... = 3.00 ?
SINC : Curve (1,2,3, or 4)... = 2 ?

SN1TP : PU (Amps pri)..... = 1000.00 ?
SN2TP : .......................... = 700.00 ?
SN3TP : .......................... = 600.00 ?

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

Z2BT : Dly (cyc)............. = 30.00 ?
ZON3 : DIF (Adv or Rev Pol.) = F ?
Z3OE : Enable (Y/N)........ = N ?
Z3OV : ............................ = Y ?
Z3OZ : ............................ = Y ?

LOPE : Loss of Pot (Y/N).... = Y ?
TIME1 : Port 1 timeout (min) = 5 ?
TIME2 : ................................ = 0 ?
AUTO : Auto port (1,2)....... = 2 ?
RINGS : (1-99).............. = 3 ?

New settings for group 3: Example 230 kV Line

R1 = 13.90 X1 = 79.96 R0 = 61.50 X0 = 248.57 LL = 100.00
CTP = N CTR = 200.00 PRI = 2000.00 MTA = 80.80 LOCAT = Y
Z1% = 80.00 Z2% = 120.00 Z3% = 150.00
Z1DP = 0.00 Z2DP = 30.00 Z3DP = 60.00
SOL = 100.00 SOM = 200.00 SOMF = 20.00
SNP = 100.00 SNTD = 3.00 SINC = 2
SN1TP = 1000.00 SN2TP = 700.00 SN3TP = 600.00
Z1DG = 0.00 Z2DG = 20.00 Z3DG = 40.00
Z2BT = 30.00 ZON3 = F Z3OE = N Z3OV = Y Z3OZ = Y
LOPE = Y TIME1 = 5 TIME2 = 0 AUTO = 2 RINGS = 3

OK (Y/N) ? Y
Please wait...
Enabled
## SAMPLE EVENT REPORT

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

<table>
<thead>
<tr>
<th>Polarity</th>
<th>IR</th>
<th>IA</th>
<th>IB</th>
<th>IC</th>
<th>VA</th>
<th>VB</th>
<th>VC</th>
<th>5226SL</th>
<th>5266SL</th>
<th>TCAAAA</th>
<th>SSSS555</th>
<th>51712F</th>
<th>51714L</th>
<th>51715L</th>
<th>P5PNP</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>123</td>
<td>76</td>
<td>-201</td>
<td>93.0</td>
<td>37.0</td>
<td>-129.5</td>
<td>M.....</td>
<td>......</td>
<td>...</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-160</td>
<td>199</td>
<td>-28</td>
<td>-95.8</td>
<td>128.3</td>
<td>-31.5</td>
<td>M.....</td>
<td>......</td>
<td>...</td>
<td>......</td>
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<td>......</td>
<td>......</td>
<td>......</td>
<td></td>
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<tr>
<td>0</td>
<td>0</td>
<td>160</td>
<td>-199</td>
<td>28</td>
<td>-95.8</td>
<td>128.3</td>
<td>-31.5</td>
<td>M.....</td>
<td>......</td>
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<td>......</td>
<td>......</td>
<td>......</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>123</td>
<td>76</td>
<td>-195</td>
<td>93.0</td>
<td>37.0</td>
<td>-129.5</td>
<td>M.....</td>
<td>......</td>
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<td>......</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-160</td>
<td>199</td>
<td>-28</td>
<td>-95.8</td>
<td>128.3</td>
<td>-31.5</td>
<td>M.....</td>
<td>......</td>
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</tr>
<tr>
<td>0</td>
<td>0</td>
<td>160</td>
<td>-199</td>
<td>28</td>
<td>-95.8</td>
<td>128.3</td>
<td>-31.5</td>
<td>M.....</td>
<td>......</td>
<td>...</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td></td>
</tr>
</tbody>
</table>

- **Event:** 1AG  
- **Location:** 74.81 mi 6.07 ohms sec  
- **Duration:** 4.75 ms  

---

**Logic settings:**  
- MTU  
- MTO  
- MA1  
- MA2  
- MA3  
- MA4  
- BA  
- EA  
- 80  
- 40  
- 20  
- 00  
- F2  
- F2  
- 00  
- 50  
- 00
EXPLANATION OF EVENT REPORT

3: Example 230 kv Line  
Date: 9/15/89 Time: 02:51:45.198  
FID=SEL-1218-400-VA6Aeptr-086916  

Currents (amps) | Voltages (KV) | Relays Outputs Inputs 
---|---|---
IPOL | IR | IA | IB | IC | VA | VB | VC | D1171D | PL1234L | 123452 | P3PNNP | A 
0 | -202 | -321 | -76 | 198 | 86.6 | -34.0 | 132.6 | M... | ........ | **W** | 
0 | -470 | -308 | -189 | 28 | 81.5 | -132.5 | 27.3 | M...P | ........ | **W** | 
568 | 689 | 79 | -198 | 72.7 | 30.0 | -136.6 | M...P | ........ | **W** | 
624 | 459 | 189 | -28 | -73.7 | 135.4 | -22.2 | M...P | ........ | **W** | 
-726 | -879 | -79 | 198 | -77.4 | -28.7 | 135.5 | M...P | ........ | **W** | 
-667 | -481 | -192 | 28 | 72.8 | -135.7 | 23.8 | M...P | ........ | **W** | 

Event ID: 1AQ  
Location: 74.81 ft  
Chase sec:  
Duration: 4.75  
FT Current: 1027.5  

Currents and voltages are in primary Amps and KV. Rows are 1/4 cycle apart. Time runs down grid, with value and angle using any entry as Y-axis component and the entry immediately underneath as the X-component. For example, from bottom rows, \[ \text{IA} = -879, \text{IAX} = -481 \]. Therefore, \[ \text{IA} = 1.02 \text{amps RMS primary, at an angle of ATAN}(-879/-481) = -119 \text{ degrees}, \] with respect to the sampling clock.

<Setting Grp>  
The first digit in row 1 indicates the setting group selected. For this example, setting group number three is in use.  

<Relays>  
Row 2 shows the firmware identification data. This line varies according to version.  

<Inputs>  
columns show states of input contacts: ON = 1, OFF = 0  

<Outputs>  
columns show states of output contacts: ON = 1, OFF = 0  

<Location>  
Time to fault in miles, 99999 is Indeterminate distance  

<Duration>  
Fault duration determined from relay elements(s) pickup time  

<Zones>  
Primary series impedance settings for transmission line  

<Logic settings>  
See Locid command for a description of mask settings
SAMPLE COMMAND DISPLAYS

Sample History Command

>>>HISTORY
3: Example 230 kV Line Date: 8/28/89 Time: 09:03:40
# DATE TIME TYPE DIST DUR CURR
1 8/28/89 09:03:01.092 3AG 100.2 7.25 798
2 8/28/89 09:02:13.041 3AG 76.9 7.00 1016
3 8/28/89 09:00:39.042 1AG 25.5 7.25 2162
4 8/28/89 09:00:13.345 1BC 25.5 7.25 3167

Sample Meter Command

>>>METER
3: Example 230 kV Line Date: 8/28/89 Time: 09:27:05
A 994 994 994 1723 1724 1724
V (kV) 134.4 134.3 134.2 235.1 235.2 235.9
P (MW) 401.12
Q (MVAR) 1.00

Sample Self-Test Status Report

>>>STATUS
3: Example 230 kV Line Date: 8/28/89 Time: 09:32:56
SELF-TESTS
W=Warm F=Fail
OK 0 0 0 0 0 0 0
OS 4.99 15.14 15.14 95
RAM ROM A/D HOF SET
OK OK OK OK OK

Targets Command

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

>>>TARGETS [M]

LED: 1 2 3 4 5 6 7 8
W
0 EN PH1 G1 PH2 G2 PH3 G3 51N RELAY TARGETS
1 1ABC 2ABC 3ABC LOP 50N 50M 50M 50L RELAY WORD #1
2 51NT 67N1 67N2 67N3 51NP 21P 22P 23P RELAY WORD #2
3 22PT 23PT 22GT 23GT ALRM TRIP TC DF RELAY WORD #3
4 S1 S2 S3 S4 S5 52A CONTACT INPUTS
5 TRIP CLOS A1 A2 A3 A4 ALRM CONTACT OUTPUTS

Use the TARGET command to reset and clear the front panel targets remotely or locally. Type "TARGET R <RETURN>" to reset and clear the targets.
Figure 2: Residual Time-Overcurrent Curves
Figure 3: External AC Current and Voltage Connections

Figure 4: External DC Connection Diagram (Typical)
Figure 5: Selector Switch Wiring Diagram
Figure 6: Communications and Clock Connections - One Unit at One Location

Figure 7: Communications and Clock Connections - Multiple Units at One Location
Figure 8: SEL Relay Communications Diagram for Connection to the SEL-DTA
Figure 9: Horizontal Front and Rear Panel Drawings
Figure 10: Vertical Front and Rear Panel Drawings
Figure 11: Relay Dimensions, Panel Cutout, and Drill Plan
SEL-121B DISTANCE RELAY/FAULT LOCATOR COMMAND SUMMARY

Level 0

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

Level 1

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

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

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

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

IRIG
Force immediate execution of time-code synchronization task.

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

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

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

STATUS
Show self-test status.

TARGETS
Show date and set target lights as follows:

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

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

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

Level 2

CLOSE
Close circuit breaker, if allowed by jumper setting.

COPY*
Copy settings from one setting group to another.

GROUP*
Change the active setting group. "GROUP N" activates setting group N (N = 1-8). This command only works when contact inputs 52 and 53 are asserted.

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

OPEN
Open circuit breaker, if allowed by jumper setting.

PASSWORD
Show or set passwords. Pulses the ALARM relay momentarily when new passwords are set.

PAR 1 OTTER sets Level 1 password to OTTER.
PAR 2 TAIL sets Level 2 password to TAIL.

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

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

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

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 N.C. Hopkins Court
Pullman, WA 99163
TEL: (509) 332-1890 FAX: (509) 332-7990
SEL/11-89