SEL-167

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

Also Available In LOW-PROFILE Package

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

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

Because of the many relay elements, the programmability of the SEL-167, and its low cost, the SEL-167 meets the requirements of a broad spectrum of applications. The flexible yet simple programmability provides access to the relay elements (before and after time delays) and logic results such as reclose initiate or cancel, alarm and trip.

The SEL-167 Relay Function Block Diagram (next page) illustrates the basic configuration of the protective capabilities.

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

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

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

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

APPLICATIONS

Replacement of Outdated Protective Relays

The SEL-167 is the ideal relay to replace obsolete directional overcurrent electromechanical relay schemes. Compact size and simple field wiring make replacement especially convenient in crowded substations. Event-reporting and fault-locating features economically provide valuable engineering and operating information, eliminating the need for event recorders and oscillographs in most applications. Its instrument transformer burden is negligible.

Feeder Protection

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

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

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

Other Applications

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

SPECIFICATIONS

relay Functions

Directional overcurrent protection for phase faults:

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

Directional residual-overcurrent protection for ground faults:

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

Automatic reclosing for selectable fault types (3 shots).

relay Elements

Phase overcurrent:

51P phase time-overcurrent element
Selectable curve shape (4 curves)
Time Dial: 0.50 to 15.00 in steps of 0.01
Pickup: 1 to 12.6 A, +/- 0.05 A +/- 2% of setting
50A1, 50B1, 50C1 Zone 1 phase-overcurrent elements (50P1)
50A2, 50B2, 50C2 Zone 2 phase-overcurrent elements (50P2)
50A3, 50B3, 50C3 Zone 3 phase-overcurrent elements (50P3)
Pickup: 1 A to 25 times 51P pickup
Timers are provided for each zone:
Zone 1 Timer: 0-60 cycles in 0.25 cycle steps
Zone 2 Timer: 0-2000 cycles in 0.25 cycle steps
Zone 3 Timer: 0-2000 cycles in 0.25 cycle steps

Ground Overcurrent:

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

Demand Overcurrent:

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

Directional Elements:

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

Note: The MTA setting is common to all three directional elements.
Three-shot reclosing relay:
790I1 open interval 1, 
790I2 open interval 2, and 
790I3 open interval 3:
Timer ranges: 0 - 10,000 cycles in 1/4 cycle steps; A setting of 0 disables that shot and successive shots.

79RS reset interval:
Timer range: 60 - 10,000 cycles in 1/4 cycle steps

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

Metering
All metered quantities are displayed in primary units. Voltage: Phase-neutral voltages are measured, scaled to primary and displayed upon command. Calculated phase-to-phase voltages are also displayed. Current: Each phase current is measured, scaled to primary and displayed upon command.

Demand: Current demand is computed with a 5 to 60 minute time constant, and displayed upon command. Peak demand is determined and stored, and is resettable by command. A demand threshold setting is provided. When the demand exceeds the setting, the DCTH bit in the Relay Word is set. It can be used for tripping, annunciation, alarm, etc.

Power: MW and MVAR are determined by a three-phase, four-wire calculation and displayed by command.

Event Reporting
A data record is retained for each of the 12 most-recent faults, which includes current, voltage, relay element, input contact and output contact information. The report may also be triggered by command or contact closure. When tripping occurs after the end of the event report, a second report is triggered at tripping.

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

Rated Input Voltage
120 volts phase-to-phase, 3-phase 4-wire connection

Rated Input Current
5 amps per phase nominal
15 amps per phase continuous
390 amps for one second thermal rating

Output Contact Ratings
30 amp make per IEEE C37-90 para 6.6.2
6 amp carry continuous
MOV protection provided
Logic Input Ratings
200 - 280 VDC for 250 VDC relays
60 - 200 VDC for 125 VDC relays
25 - 60 VDC for 48 VDC relays
Input current: 6 mA at nominal voltage

Power Supply
85 - 200 VDC or 85 - 200 VAC; 12 watts for 250 VDC relays
85 - 200 VAC or VDC; 12 watts for 125 VDC relays
20 - 60 VDC; 12 watts for 48 VDC relays

Dielectric Strength
Routine tested:
V, I inputs: 2500 VAC for 10 seconds
Other: 3000 VDC for 10 seconds (excludes RS-232 and time code input)

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

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

RFI Tests
Type-tested in field from a 1/4-wave antenna driven by 20 watts at 150 MHz and 450 MHz, randomly keyed on and off, at a distance of 1 meter from relay.

Dimensions
5 1/4" x 19" x 13". Mounts in standard 19" relay rack.

Unit Weight
21 pounds

Shipping Weight
32 pounds, including two instruction manuals

Operating Temperature
-20 deg C to + 55 deg C

Burn-in Temperature
Each SEL-167 is burned in at 60 deg C for 100 hours

LOGIC DESCRIPTION

Relay Elements

single-phase overcurrent relays
50A1 50B1 50C1 nondirectional
50A2 50B2 50C2 nondirectional
50A3 50B3 50C3 nondirectional

polyphase time-overcurrent relay (driven by maximum phase current)
pickup 51PP T.C or nondirectional
trip 51PT T.C or nondirectional

residual time-overcurrent relay
pickup 51NP T.C. or nondirectional
trip 51NT T.C. or nondirectional

residual inst-overcurrent
50N1 nondirectional
50N2 nondirectional
50N3 nondirectional
phase directional 32PQ 32PQF=forward; 32PQR=reverse
negative-sequence directional 32Q 32QF=forward; 32QR=reverse
zero-seq pol directional 32D 32DF=forward; 32DR=reverse

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

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

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

790I1 Reclosing relay first open interval expired
790I2 Reclosing relay second open interval expired
790I3 Reclosing relay third open interval expired
79RS Reclosing relay reset interval timer expired

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

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

circuit breaker trip  TRIP
 circuit breaker close  CLOSE
 programmable output 1  A1
 programmable output 2  A2
 programmable output 3  A3
 programmable output 4  A4
 system alarm  ALARM

INTERMEDIATE LOGIC

The logic equations developed below represent combinations of the relay elements and other conditions.

5OP3 = 5OA3 + 5OB3 + 5OC3  Zone 3 phase fault
5OP2 = 5OA2 + 5OB2 + 5OC2  Zone 2 phase fault
5OP1 = 5OA1 + 5OB1 + 5OC1  Zone 1 phase fault

GF = 51NP + 50N1 + 50N2 + 50N3  Ground fault
PF = 51PP + 50P1 + 50P2 + 50P3  Phase fault

DFP = 32PQF * PF
DRP = 32PQR * PF
D3P = DFP  if ZONE 3 is forward
D3P = DRP  if ZONE 3 is reverse

67P3 = ( D3P + NOT (67PE) ) * 5OP3  Zone 3 directional phase-overcurrent element, reversible
67P2 = ( DFP + NOT (67PE) ) * 5OP2  Zone 2 directional phase-overcurrent element
67P1 = ( DFP + NOT (67PE) ) * 5OP1  Zone 1 directional phase-overcurrent element

DFG = 32QF * 32QE * (PF + GF)
+ 32DF * (32IE + 32VE) * GF
+ NOT (32QE + 32IE + 32VE)

DRG = 32QR * 32QE * (PF + GF)
+ 32DR * (32IE + 32VE) * GF

D3G = DFG  if ZONE 3 is forward
D3G = DRG  if ZONE 3 is reverse

67N3 = [D3G + NOT (67NE)] * 50N3  Zone 3 directional ground-overcurrent element, reversible
67N2 = [DFG + NOT (67NE)] * 50N2  Zone 2 directional ground-overcurrent element
67N1 = [DFG + NOT (67NE)] * 50N1  Zone 1 directional ground-overcurrent element

Z3PT = 67P3 * Z3PTMR
Z2PT = 67P2 * Z2PTMR
Z1PT = 67P1 * Z1PTMR

Zone 3 timeout-phase
Zone 2 timeout-phase
Zone 1 timeout-phase
Z3GT = 67N3 * Z3GTM
Z2GT = 67N2 * Z2GTM
Z1GT = 67N1 * Z1GTM

Zone 3 timeout-ground
Zone 2 timeout-ground
Zone 1 timeout-ground

RELAY WORD

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

RELAY WORD

<table>
<thead>
<tr>
<th>DRP</th>
<th>50N1</th>
<th>50N2</th>
<th>50N3</th>
<th>DFP</th>
<th>50P1</th>
<th>50P2</th>
<th>50P3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRG</td>
<td>67N1</td>
<td>67N2</td>
<td>67N3</td>
<td>DFG</td>
<td>67P1</td>
<td>67P2</td>
<td>67P3</td>
</tr>
<tr>
<td>51NT</td>
<td>Z1GT</td>
<td>Z2GT</td>
<td>Z3GT</td>
<td>51PT</td>
<td>Z1PT</td>
<td>Z2PT</td>
<td>Z3PT</td>
</tr>
<tr>
<td>ALRM</td>
<td>TRIP</td>
<td>TC</td>
<td>DT</td>
<td>52BT</td>
<td>52AT</td>
<td>TOCP</td>
<td>DCTH</td>
</tr>
</tbody>
</table>

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

SFL-167 RELAY WORD BIT SUMMARY TABLE

<table>
<thead>
<tr>
<th>DRP</th>
<th>Direction reverse--phase fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>50N1</td>
<td>Residual instantaneous-overcurrent element</td>
</tr>
<tr>
<td>50N2</td>
<td>Residual instantaneous-overcurrent element</td>
</tr>
<tr>
<td>50N3</td>
<td>Residual instantaneous-overcurrent element</td>
</tr>
<tr>
<td>DFP</td>
<td>Direction forward--phase fault</td>
</tr>
<tr>
<td>50P1</td>
<td>Phase instantaneous-overcurrent element</td>
</tr>
<tr>
<td>50P2</td>
<td>Phase instantaneous-overcurrent element</td>
</tr>
<tr>
<td>50P3</td>
<td>Phase instantaneous-overcurrent element</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DRG</th>
<th>Direction reverse--ground fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>67N1</td>
<td>Zone 1 ground directional overcurrent element</td>
</tr>
<tr>
<td>67N2</td>
<td>Zone 2 ground directional overcurrent element</td>
</tr>
<tr>
<td>67N3</td>
<td>Zone 3 ground directional overcurrent element</td>
</tr>
<tr>
<td>DFG</td>
<td>Direction forward--ground fault</td>
</tr>
<tr>
<td>67P1</td>
<td>Zone 1 phase directional overcurrent element</td>
</tr>
<tr>
<td>67P2</td>
<td>Zone 2 phase directional overcurrent element</td>
</tr>
<tr>
<td>67P3</td>
<td>Zone 3 phase directional overcurrent element</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>51NT</th>
<th>Ground time-overcurrent trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1GT</td>
<td>Zone 1 timeout-ground</td>
</tr>
<tr>
<td>Z2GT</td>
<td>Zone 2 timeout-ground</td>
</tr>
<tr>
<td>Z3GT</td>
<td>Zone 3 timeout-ground</td>
</tr>
<tr>
<td>51PT</td>
<td>Phase time-overcurrent trip</td>
</tr>
<tr>
<td>Z1PT</td>
<td>Zone 1 timeout-phase</td>
</tr>
<tr>
<td>Z2PT</td>
<td>Zone 2 timeout-phase</td>
</tr>
<tr>
<td>Z3PT</td>
<td>Zone 3 timeout-phase</td>
</tr>
</tbody>
</table>

10
ALRM - System alarm
TRIP - Circuit breaker trip
TC - Trip (OPEN) command
DT - Direct trip from DT input
S2BT - Inverse of 52AT
S2AT - Time delayed 52A
TOCP - Time-overcurrent pickup indicator (51PP + 51NP)
DCTH - Demand current threshold exceeded

The use of the relay word and programmable masks provide the user with great flexibility in applying the SEL-167, without rewiring panels or changing jumpers on circuit boards.

OUTPUT EQUATIONS

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

The general forms for each of the output equations follow:

Let \( R \) = relay word

\[
\begin{align*}
MTU &= \text{mask for trip (unconditional)} \\
MPT &= \text{mask for trip (permissive trip)} \\
MTB &= \text{mask for trip (with no blocking)} \\
MTO &= \text{mask for trip (with breaker open)}
\end{align*}
\]

then: \( TRIP = R \times MTU + R \times MPT \times PT + R \times MTB \times \neg (BT) + R \times MTO \times S2BT \)

\[
\begin{align*}
close\ TRIP &= TRIP \\
open\ TRIP &= \neg (TRIP) \times \neg (S2A + \text{TARGET\ RESET\ button\ pushed}) \times (60\ \text{ms minimum TRIP}) \\
close\ CLOSE &= (D + 79012 + 79012 + 79013 + \text{CLOSE\ command}) \times \neg (S2A) \\
open\ CLOSE &= \neg (CLOSE) + 79RS
\end{align*}
\]

\( A1 = R \times MA1 \)
\( A2 = R \times MA2 \)
\( A3 = R \times MA3 \)
\( A4 = R \times MA4 \)

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

RECLOSE RELAY

The reclosing relay provides up to three shots of automatic reclosing for selectable fault types and relay elements contained in the 32-bit Relay Word. The programmable logic provides access to the internally derived reclose
initiate and cancel signals. Either external initiation or cancellation of reclosing is also allowed. The three open intervals and the reset timer are individually settable through the SET command.

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

\[ RI = R \ast MRI \]
\[ RC = R \ast MRC \]

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

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

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

**SETTING PROCEDURE**

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

In the example beginning on the next page only the XO value was changed. It was changed from 152.34 to 143.07. Note that the new value of 143.07 is presented at the end of the procedure before enabling, along with all other settings. This provides a final inspection for typographical or other errors.

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

The operator could have also typed any setting descriptor as an option (except for the ID setting) for the SET command. All settings prior to the specified setting are skipped when the command is executed in this manner. For example, typing "SET Z3DP <CR>" will skip all settings prior to the Z3DP setting.
## SET

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

<table>
<thead>
<tr>
<th>ID</th>
<th>Example 69 kV Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>(Ohms pri)</td>
</tr>
<tr>
<td>X1</td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td></td>
</tr>
<tr>
<td>X0</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>Line Length (mi)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>DCTH</th>
<th>Dmd Thresh (Amps pri)</th>
</tr>
</thead>
<tbody>
<tr>
<td>790I1</td>
<td>Open Int 1 (cyc)</td>
</tr>
<tr>
<td>790I2</td>
<td>60.00</td>
</tr>
<tr>
<td>790I3</td>
<td>80.00</td>
</tr>
<tr>
<td>79RS</td>
<td>Reset Int.</td>
</tr>
</tbody>
</table>

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

| 50P1 | PU (Amps pri) 1158.00 |
| 50P2 |                  516.00 |
| 50P3 |                  210.00 |

| Z1DP | Dly-Phase (cyc) |
| Z2DP |                |
| Z3DP |                |

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

| 50N1 | PU (Amps pri) 1008.00 |
| 50N2 |                  450.00 |
| 50N3 |                  30.00 |

| Z1DG | Dly-Gnd (cyc) |
| Z2DG |                |
| Z3DG |                |
52BT : Dly (cyc)............. = 30
ZONE3: Dir (F=fwd or R=rvs).. = R
67NE : GND Flt Dir (Y/N)..... = Y
67PE : Phase Flt Dir (Y/N)... = Y

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

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

New settings for: Example 69 kV Line

<table>
<thead>
<tr>
<th>R1</th>
<th>-49.83</th>
<th>X1</th>
<th>-56.32</th>
<th>R0</th>
<th>-56.07</th>
<th>X0</th>
<th>-143.07</th>
<th>LL</th>
<th>-60.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR</td>
<td>-60.00</td>
<td>PTR</td>
<td>-600.00</td>
<td>MTA</td>
<td>-49.00</td>
<td>LOCAT</td>
<td>Y</td>
<td>DATC</td>
<td>-15</td>
</tr>
<tr>
<td>DCTH</td>
<td>-120.00</td>
<td>790I1</td>
<td>-40.00</td>
<td>790I2</td>
<td>-60.00</td>
<td>790I3</td>
<td>-80.00</td>
<td>79RS</td>
<td>-240.00</td>
</tr>
<tr>
<td>51PP</td>
<td>-120.00</td>
<td>51PTD</td>
<td>1.00</td>
<td>51PC</td>
<td>2</td>
<td>51PTC</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50P1</td>
<td>-158.00</td>
<td>50P2</td>
<td>-516.00</td>
<td>50P3</td>
<td>-210.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z1DP</td>
<td>0.00</td>
<td>Z2DP</td>
<td>160.00</td>
<td>Z3DP</td>
<td>30.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51NP</td>
<td>30.00</td>
<td>51NTD</td>
<td>2.00</td>
<td>51NC</td>
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OK (Y/N) ? Y
Please wait...
Enabled
### Currents (amps)

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### Event: AG

Location: 9.02 mi 1.13 ohms sec

Duration: 4.75 sec

F1 Current: 1144.4 A

Targets: 61

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EXPLANATION OF EVENT REPORT

Example 69 kV Line

Date: 3/28/88 Time: 08:45:09.366

FID=SEL-167-R100-V656m-D880327

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

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Currents and voltages are in primary Amps and kV. Rows are 1/4 cycle apart. Time runs down page. Obtain phasor RMS value and angle using any entry as the Y-component, and the entry immediately underneath as the X-component. For example, from bottom rows, IAY = 1024, IAX = -526. Therefore, IA = 1151 amps RMS primary, at an angle of ATAN(1024/-526) = 117 degrees, with respect to the sampling clock.

<FID>  Row 2 shows the Firmware Identification Data. This line varies according to version.

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

50P: phase overcurrent ............... : 50P1, 50P2, 50P3 ---> 1,2,3
67P: directional phase overcurrent : 67P1, 67P2, 67P3 ---> 1,2,3
51P: phase time-overcurrent ...........: 51PT ---> T
50N: inst ground overcurrent ...........: 50N1, 50N2, 50N3 ---> 1,2,3
67N: directional ground overcurrent : 67N1, 67N2, 67N3 ---> 1,2,3
51N: ground time-overcurrent .........: 51NT ---> T
Columns show states of output contacts: ON = "*", OFF = "." 
TP=TRIP, CL=CLOSE, A1-A4=PROGRAMMABLE, AL=ALARM 

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 type is one of the following: 
AG,BG,CG = single-phase, AB,BC,CA = 2-phase 
ABG,BCG,CAG = 2-phase to ground, ABC = 3-phase followed by a "T" if a TRIP triggered the report 
Other indications are TRIP = triggered by TRIP output and EXT = externally or otherwise triggered 

Distance to fault in miles. Indeterminate distance is 999999. 
Distance to fault in secondary ohms. Indeterminate ohms is 999999. 

Fault duration determined from relay element(s) pickup time 
Max phase current (primary amps) taken near middle of fault 
The targets indicate the relay elements that caused the trip. These targets are the same as the targets displayed on the front panel of the SEL-167 via the TARGET 0 command. The targets field indicates any combination of the following: 
P1: Zone 1 phase fault P3: Zone 3 phase fault 
P1: Zone 1 ground fault G3: Zone 3 ground fault 
P2: Zone 2 phase fault 51P: Phase time-overcurrent trip 
P2: Zone 2 ground fault 51N: Residual time-overcurrent trip 

R1,X1,RO,XO 
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 
790I1,2,3,RS 
Three-shot recloser Open and Reset intervals 
51PP,T,D,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,T,D,C,TC 
GND time-overcurrent Pickup, Time-Dial, Curve, Torque Control 
50N1,2,3 
Ground inst-overcurrent pickup settings Zones 1, 2 and 3 
Z1DG,2,3 
Zone timers for ground faults 
52BT 
52B delay setting (for switch-onto-fault coordination) 
ZONE3 
Directional orientation of ALL Zone 3 elements (Fwd/Rvs) 
67NE,PE 
Ground and phase fault torque control enables 
32QE,VE,IE 
Ground fault directionality from (V2,I2), or (V0/IP,IO) 
TIME1,2 
Communications port timeout intervals (automatic log-off) 
AUTO 
Auto port assignment for automatic message transmissions 
RINGS 
Number of rings to wait before modem answers telephone 

.Logic Settings> See LOGIC command for a description of mask setting.
SAMPLE COMMAND DISPLAYS

=> HISTORY

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

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

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<th>CURR</th>
<th>TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12/21/87</td>
<td>11:11:28.829</td>
<td>AGT</td>
<td>54.20</td>
<td>10.50</td>
<td>366.5</td>
<td>51N</td>
</tr>
<tr>
<td>2</td>
<td>12/21/87</td>
<td>11:11:28.429</td>
<td>AG</td>
<td>54.54</td>
<td>7.50</td>
<td>365.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>12/21/87</td>
<td>11:09:50.346</td>
<td>BC</td>
<td>9.20</td>
<td>4.00</td>
<td>1320.9</td>
<td>P1</td>
</tr>
<tr>
<td>4</td>
<td>12/21/87</td>
<td>11:08:58.787</td>
<td>AG</td>
<td>9.08</td>
<td>4.75</td>
<td>1155.9</td>
<td>G1</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

=> METER

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

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>AB</th>
<th>BC</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (A)</td>
<td>105</td>
<td>102</td>
<td>104</td>
<td>180</td>
<td>177</td>
<td>182</td>
</tr>
<tr>
<td>D (A)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD (A)</td>
<td>107</td>
<td>105</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V (kv)</td>
<td>40.0</td>
<td>39.9</td>
<td>40.1</td>
<td>69.3</td>
<td>69.2</td>
<td>69.4</td>
</tr>
</tbody>
</table>

P (MW)  12.45
Q (MVAR) -0.08

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

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

=> STATUS

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

SELF-TESTS

W-Warn   F-Fail

<table>
<thead>
<tr>
<th>IP</th>
<th>IR</th>
<th>IA</th>
<th>IB</th>
<th>IC</th>
<th>VA</th>
<th>VB</th>
<th>VC</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>PS</td>
<td>4.99</td>
<td>15.14</td>
<td>-14.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAM</td>
<td>ROM</td>
<td>A/D</td>
<td>MOF</td>
<td>SET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18
TARGETS

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

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

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

TYPICAL INSTANTANEOUS ELEMENT OPERATING TIMES

<table>
<thead>
<tr>
<th>I, Multiples of Pickup</th>
<th>2</th>
<th>4</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>50N1,2,3</td>
<td>24ms</td>
<td>16ms</td>
<td>15ms</td>
<td>12ms</td>
</tr>
<tr>
<td>50P1,2,3</td>
<td>23ms</td>
<td>17ms</td>
<td>14ms</td>
<td>12ms</td>
</tr>
<tr>
<td>67N1,2,3(32V)</td>
<td>27ms</td>
<td>21ms</td>
<td>19ms</td>
<td>19ms</td>
</tr>
<tr>
<td>67N1,2,3(32I)</td>
<td>32ms</td>
<td>28ms</td>
<td>25ms</td>
<td>20ms</td>
</tr>
<tr>
<td>67N1,2,3(32Q)</td>
<td>31ms</td>
<td>25ms</td>
<td>22ms</td>
<td>20ms</td>
</tr>
<tr>
<td>67P1,2,3(32Q)</td>
<td>30ms</td>
<td>24ms</td>
<td>22ms</td>
<td>19ms</td>
</tr>
<tr>
<td>67P1,2,3(32P)</td>
<td>27ms</td>
<td>24ms</td>
<td>22ms</td>
<td>21ms</td>
</tr>
</tbody>
</table>
OPTIONAL CONNECTIONS

52T

52C

52a

52b

52a

OPTIONAL CONNECTIONS

ANNUNCIATOR OR RTU

SEL-167 DC EXTERNAL CONNECTION DIAGRAM (TYPICAL)

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DWG. NO. A7-0284
DATE: 04-27-88
REV. 11-14-88
SEL-167 COMMUNICATIONS AND CLOCK CONNECTIONS
ONE UNIT AT ONE LOCATION
SEL-167 COMMUNICATIONS AND CLOCK CONNECTIONS
MULTIPLE UNITS AT ONE LOCATION

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DWG. NO. A7-0224
DATE: 10-14-88
REV. 11-11-88
NOTE: SEL–DTA DISPLAY/TRANSUCER ADAPTER (DTA)
DATA AND CONTROL POWER

SEL RELAY COMMUNICATIONS DIAGRAM FOR CONNECTION
TO THE SEL–DTA

NOTE: 8 VOLTAGE AND 8 CURRENT
ANALOG OUTPUTS TO SCADA
RTU OR OTHER ANALOG
MONITORING EQUIPMENT
SEL-167 HORIZONTAL FRONT PANEL DRAWING

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DWG. NO. A7-0232
DATE: 01-21-88
REV. 11-10-88
7/32 DIA., 4 HOLES FOR 10-32 MTG. SCREWS

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

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

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

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

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

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

DWG. NO. A7-0174
DATE 5/11/87 JS
REV. 3/9/88
SEL-167 DIRECTIONAL OVERCURRENT RELAY/FAULT LOCATOR COMMAND SUMMARY

Level 0

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

Level 1

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

DATE  Show or set date. DAT 2/3/86 sets date to Feb. 3, 1986. This setting is overridden when IRIG-B synchronization occurs. Pulses the ALARM relay momentarily when a different year is entered than the one previously stored.

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

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

IRIG  Force immediate execution of time-code synchronization task.

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

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

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

STATUS  Show self-test status.

TARGETS  Show data and set target lights as follows:

- TAR 0: Relay Targets
- TAR 1: RELAY WORD #1
- TAR 2: RELAY WORD #2
- TAR 3: RELAY WORD #3
- TAR 4: RELAY WORD #4
- TAR 5: Contact Inputs
- TAR 6: Contact Outputs
- TAR R: Returns to TAR 0 and clears.

Be sure to return to TAR 0 when done, so LEDs display fault targets.

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

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

Level 2

CLOSE  Close circuit breaker, if allowed by jumper setting.

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

OPEN  Open circuit breaker, if allowed by jumper setting.

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

- PAS 1 OTTER sets Level 1 password to OTTER.
- PAS 2 TAIL sets Level 2 password to TAIL.

SET*  Initiate setting procedure.

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

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

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