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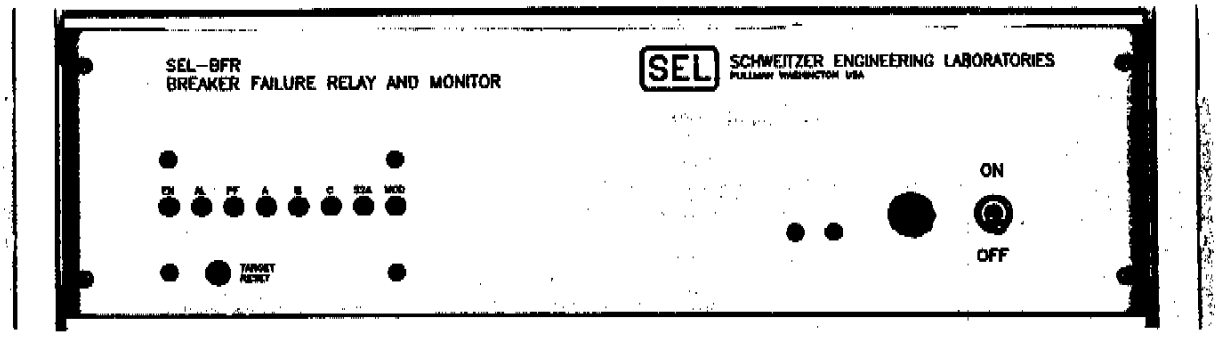


SEL-BFR
BREAKER FAILURE RELAY AND MONITOR

Also Available In LOW-PROFILE Package

DATA SHEET

- Detects failure to interrupt fault, load, or line-charging currents
- Apply to single-breaker, ring-bus, and breaker-and-a-half installations
- Operates in single- or three-pole trip schemes
- Thermal models protect trip and close resistors
- Detects current unbalance when one or two poles fail to close
- Provides detailed breaker operation data with fifteen-cycle event reports
- Stores 100 breaker operation summaries
- Programmable mask logic for flexible application and testing
- Serial communication ports allow local or remote interaction with the relay

GENERAL DESCRIPTION

The SEL-BFR relay is a single- or three-pole breaker failure protection and monitoring package. The relay provides classical overcurrent-based breaker failure protection for a wide variety of breaker arrangements. Additional features include metering, breaker operating time monitors, energy interruption monitors, and breaker resistor thermal protection. These features combine with event reporting and remote setting capabilities to make the SEL-BFR relay an excellent choice for circuit breaker protection.

Current-Driven Circuit Breaker Protection Logic

The SEL-BFR relay has five current-driven breaker protection schemes, including one specially designed for ring-bus or breaker-and-a-half applications. Tailor the relay to your circuit breaker protection requirements by selecting the most appropriate scheme.

The relay detects failures to interrupt fault, load, or line-charging current. It also detects failures of breaker poles to complete a close sequence. When potential transformers are used, the relay can detect open breaker pole flashover failures.

Independent phase current detectors, protection logic, and timers make the relay easy to apply on both simple systems and more complicated breaker arrangements such as single-pole trip installations.

When you use a motor-operated disconnect switch (MOD) with the protected breaker, the SEL-BFR relay can trip the MOD to isolate the failed breaker when phase current drops below a settable value. This logic replaces an overstress scheme on the MOD. When an MOD is not installed, the MOD logic may be used to indicate a 'Safe to Disconnect' condition to personnel.

Thermal Models

A breaker can occasionally operate incompletely, leaving trip or close resistors in service. The energy dissipated in a breaker resistor due to current flow can exceed the resistor thermal rating within seconds, resulting in dangerous and expensive resistor failure.

When potential transformer inputs are used, the SEL-BFR relay monitors energy dissipated in breaker trip and close resistors using six thermal models. When a resistor temperature estimate reaches preset limits, the SEL-BFR relay can alarm, generate an event report, or trip the lockout relay. Resistor thermal models have pending failure and failure temperature levels.

The thermal protection function does not require an initiating input; it monitors the breaker continuously. Thermal protection can be disabled when trip and close resistors are not used.

Event Reporting and Breaker Monitoring

The SEL-BFR relay stores the nine latest event reports. These fifteen-cycle reports contain current, voltage, input, output, and relay element data presented on a quarter-cycle basis. This information simplifies event analysis and improves understanding of the protective scheme operation. An operator can retrieve the event reports locally or remotely to determine the causes of relay and breaker operations.

The SEL-BFR relay stores summaries of the 100 latest events in nonvolatile memory. Event type, mechanical and electrical operating times, and breaker energy are stored along with the date and time of operation. Using this breaker history, operators can monitor breaker wear and effectively schedule routine breaker maintenance.

Programmable Mask Logic

Programmable Mask Logic is another feature included in the SEL-BFR relay. Programmable Mask Logic allows you to configure the 86BF TRIP and five auxiliary outputs to operate when any of 40 protective elements or logic outputs pick up. You can implement complete application-specific protective schemes with a minimum of wiring and panel space. Programmable Mask Logic also simplifies relay testing.

Serial Communication Ports

The relay has two serial communication ports which provide local or remote access to setting, metering, and event reporting capabilities.

A two-level password security scheme prevents unauthorized access to the relay. The user examines settings and data in the first level. Setting and logic changes can be made from the second level only.

The relay requires no special communication software. Access the relay with a dumb terminal, printing terminal, or computer with serial port and terminal emulation software.

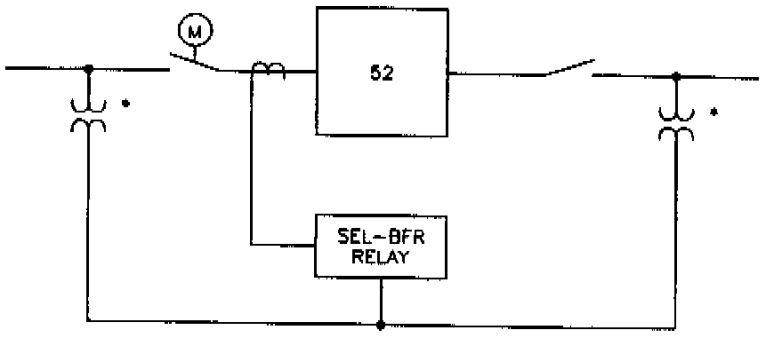


Figure 1: Basic Ac Connections of the SEL-BFR Relay

GENERAL SPECIFICATIONS

Voltage Inputs	0 - 150 Vac rms line-to-neutral 0.07 VA burden at 67 V line-to-neutral
Current Inputs	5 amps per phase nominal; 0.06 VA burden 15 amps per phase continuous; 500 amps for one second thermal rating
Output Contact Current Ratings	30 amp make per IEEE C37.90 para 6.6.2 6 amp carry continuously; MOV protection provided
Power Supply	48 Volt: 30 - 60 Vdc; 12 watts 125/250 Volt: 85 -280 Vdc or 85 - 200 Vac; 12 watts
Optical Isolator Logic Input Ratings	48 Vdc: 25 - 60 Vdc 125 Vdc: 60 -200 Vdc 250 Vdc: 200 -280 Vdc
Time Code Input	Relay accepts demodulated IRIG-B time code.
Communications	Two EIA RS-232-C serial communications ports
Dimensions	5¼" x 19" x 13" (13.3 cm x 48.2 cm x 33.0 cm) (H x W x D)
Mounting	Available in horizontal or vertical mounting configurations.
Dielectric Strength	V, I inputs: 2500 Vac for 10 seconds Other: 3000 Vdc for 10 seconds (excludes RS-232-C)
Operating Temp.	-4°F to 131°F (-20°C to 55°C)
Environment	IEC 68-2-30 Temperature/Humidity Cycle Test - six day (type tested)
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 ¼-wave antenna driven by 20 watts at 150 MHz and 450 MHz randomly keyed on and off one meter from relay.
Weight	21 lb (9.1 kg); shipping weight 32 lb (14.1 kg), including two manuals.
Burn-in	140°F (60°C) for 100 hours.
Warranty	Four years from date of purchase.

RELAY ELEMENT AND TIMER SPECIFICATION

Overcurrent Elements

50FT Fault Current Element
- setting range . . . . . 0.50 - 45.0 A secondary
- pickup time . . . . . less than 0.84 cycle at 2 multiples of pickup
- dropout time . . . . . less than 1.10 cycle
- pickup and dropout . . . . . ±0.025 A secondary ±5% of setting

50MD MOD Current Element

50LD Load/Line-Charging Current Element
- setting ranges . . . . . 0.10 - 45.0 A secondary
- pickup time . . . . . less than 1.10 cycle at 2 multiples of pickup
- dropout time . . . . . less than 1.55 cycle
- pickup and dropout . . . . . ±0.025 A secondary ±5% of setting

Overvoltage Elements

59FO Flashover Voltage Element
- setting range . . . . . 1.0 - 67 V secondary
- pickup time . . . . . less than 1.35 cycle
- dropout time . . . . . less than 1.55 cycle
- pickup and dropout . . . . . ±0.09 V secondary ±5% of setting

47Q Negative-Sequence Overvoltage Element
- setting range . . . . . 2.0 - 170.0 V secondary
- pickup time . . . . . less than 1.35 cycle
- dropout time . . . . . less than 1.55 cycle
- pickup and dropout . . . . . ±0.27 V secondary ±15% of setting

59H Flashover Voltage Element
- fixed setting . . . . . 67 V secondary
- pickup time . . . . . less than 1.35 cycle
- dropout time . . . . . less than 1.55 cycle
- pickup and dropout . . . . . ±3.5 V secondary

Vwarn Voltage Across Closed Breaker Element
- setting range . . . . . 0.5 - 7.5 V secondary
- pickup time . . . . . less than 3 seconds
- pickup and dropout . . . . . ±0.09 V secondary ±5% of setting

Current Unbalance Element

87UB Phase Current Unbalance Element

87UB detects phase discordance when the protected breaker closes. For example, A-phase is unbalanced if phase current is above the 50LD setting in one or more phases and:

$|IA| < (|IA| + |IB| + |IC|) / 87UB\ setting$

where 87UB setting = 8, 16, 32, or 64.

Stabilization time . . . . . less than 1.35 cycle.

Overpower Elements

37OP Breaker Overpower Element
setting range . . . . . 0.10 - 3400.0 watts secondary
pickup time . . . . . less than 2.10 cycles
dropout time . . . . . less than 3.00 cycles
maximum element error, secondary units:
±2.25 mW ±10.25%(measured input power)
±2.63%(measured voltage) ±9.45%(measured current)

Breaker Resistor Thermal Elements

26CF Close Resistor Failure Element
26CP Close Resistor Pending Failure Element
26TF Trip Resistor Failure Element
26TP Trip Resistor Pending Failure Element
setting ranges . . . . . 0.01 - 1000.0 joules secondary

Settable Timers

62TT Failure to Trip Fault Current Trip Input Timer
62FC Failure to Trip Fault Current Failure Timer
62LD Failure to Trip Load Current Failure Timer
62LP Failure to Trip Load Current Pending Failure Timer
62FF Flashover Failure Timer
62FP Flashover Pending Failure Timer
62UC Phase Discordance Close Input Pickup Timer
setting ranges . . . . . 0.25 - 63.75 cycles in 0.25 cycle steps

62OP Trip and Close Resistor Heating Pickup Timer
setting range . . . . . 0.25 - 63.75 cycles in 0.25 cycle steps

62UF	Phase Discordance Failure Timer	
62UP	Phase Discordance Pending Failure Timer	
62M1	Maximum Bus Clearing Time	
62M2	Maximum MOD Operate Time	
	setting ranges . . . . . 0.25 - 16,383.75 cycles in 0.25 cycle steps	

Fixed Timers

62F1	Flashover Voltage Time Delayed Dropout Timer	5 cycles
62F2	Load Current Pickup Timer (Flashover Logic)	5 cycles
62F3	Trip or Close Dropout Timer (Flashover Logic)	6 cycles
62M3	86BF Reset Signal Duration Timer	60 cycles
62M4	86BF Reset Time Delay, MOD Logic Enabled	300 cycles

Note: All timers are crystal controlled. Any significant ambiguities in timing are due to pickup/dropout times of measuring elements, inputs, and outputs. However, the 62OP timer has an accuracy of plus or minus one half cycle.

LOGIC INPUTS

Six input circuits are provided. To assert an input, apply nominal control voltage to the appropriate terminal pair.

Table 1 lists the inputs and their functions.

Table 1: Logic Input Functions

Input	Function
TRIP A	A-Phase Trip Signal Input
TRIP B	B-Phase Trip Signal Input
TRIP C	C-Phase Trip Signal Input
52A STATUS	Breaker Auxiliary Contact Input
MOD STATUS	MOD Auxiliary Contact Input
CLOSE	Breaker CLOSE Signal Input

For three-pole trip breakers, connect the trip inputs so that any time the breaker trip coil is energized, all three trip inputs are asserted. For single-pole trip breakers, connect the trip inputs so that only the corresponding trip input is asserted when a single-pole trip coil is energized.

The CLOSE input is three-pole. In single-pole trip installations, connect the close input so that it is asserted each time any single-pole close coil is energized.

Connect the 52A STATUS and MOD STATUS inputs such that when the corresponding equipment is in a closed position, the input is asserted.

RELAY OUTPUTS

The SEL-BFR relay has seven output relays. All outputs except the ALARM output are programmed with the LOGIC command. All can be tested with the OUT n command.

All relay contacts are rated for circuit breaker tripping duty. Any of the programmable outputs or the ALARM contacts may be configured as "a" or "b" when you order the relay. The 86BF TRIP output contacts are always "a."

86BF TRIP Output

Use this output to assert the bus lockout relay when a breaker failure occurs.

Programmable Outputs (A1, A2, A3, A4, A5)

Use these five outputs to trip motor-operated disconnect switches, retrip the protected breaker following a Trip input assertion, or indicate a number of conditions detected by the relay.

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 depending on which self test fails (see Self Test Description).

The standard relay has the ALARM contact configured as "b." In this case, it is held open during normal relay operation and closes if control power is lost or any other alarm condition occurs.

RELAY WORD

The Relay Word consists of five eight-bit rows containing relay elements, timer outputs, and logic outputs. Each bit in the Relay Word is either a logical 1 or logical 0:

- 1 indicates that the element is picked up or logic condition is true
- 0 indicates that the element is dropped out or logic condition is false

The Logic Description defines the logic conditions in the Relay Word. The relay updates the Relay Word each quarter cycle.

SEL-BFR Relay Word

FBF	LBF	LPF	50FT	50LD	50MD	52BV	TTF
FOBF	FOPF	59FO	59H	ALRM	TC	TB	TA
PDBF	PDPF	87UA	87UB	87UC	86RS	MDT	CTF
CRFA	CRPA	TRFA	TRPA	CRFB	CRPB	TRFB	TRPB
CRFC	CRPC	TRFC	TRPC	DOPA	DOPB	DOPC	47Q

Table 2 explains each bit in the Relay Word.

Table 2: Relay Word Bit Summary Table

Row #1	
FBF	Fault Current Breaker Failure
LBF	Load Current Breaker Failure
LPF	Load Current Pending Failure
50FT	Fault Current Overcurrent Element
50LD	Load Current Overcurrent Element
50MD	MOD Overcurrent Element
52BV	Current-Verified 52B
TTF	Trip Resistor Thermal Failure

Row #2	
FOBF	Flashover Breaker Failure
FOPF	Flashover Pending Failure
59FO	Overvoltage Element
59H	Flashover Overvoltage Element
ALRM	Breaker Operation Alarms
TC	C-phase TRIP Input
TB	B-phase TRIP Input
TA	A-phase TRIP Input

Row #3	
PDBF	Phase Discordance Breaker Failure
PDPF	Phase Discordance Pending Failure
87UA	A-phase Discordance
87UB	B-phase Discordance
87UC	C-phase Discordance
86RS	86BF Reset
MDT	MOD Trip
CTF	Close Resistor Thermal Failure

Row #4	
CRFA	A-Phase Close Resistor Failure
CRPA	A-Phase Close Resistor Pending Failure
TRFA	A-Phase Trip Resistor Failure
TRPA	A-Phase Trip Resistor Pending Failure
CRFB	B-Phase Close Resistor Failure
CRPB	B-Phase Close Resistor Pending Failure
TRFB	B-Phase Trip Resistor Failure
TRPB	B-Phase Trip Resistor Pending Failure

Row #5	
CRFC	C-Phase Close Resistor Failure
CRPC	C-Phase Close Resistor Pending Failure
TRFC	C-Phase Trip Resistor Failure
TRPC	C-Phase Trip Resistor Pending Failure
DOPA	A-Phase Delayed Overpower
DOPB	B-Phase Delayed Overpower
DOPC	C-Phase Delayed Overpower
47Q	Negative-Sequence Overvoltage Element

PROGRAMMABLE OUTPUT LOGIC

The relay uses programmable logic masks to control the 86BF TRIP and programmable output relays. Logic masks are saved in nonvolatile memory with the other settings. They are set with the LOGIC command and retained through losses of control power.

Select Relay Word elements to program each logic mask. If any Relay Word element selected in a logic mask asserts, the output contact associated with the logic mask operates.

Output equations are below ("*" indicates a logical "and," while "+" indicates a logical "or").

Let R = Relay Word

Close 86BF Trip = R * M86T
Open 86BF Trip conditions are defined in the Logic Description.

A1 = R * MA1
A2 = R * MA2
A3 = R * MA3
A4 = R * MA4
A5 = R * MA5

ALARM = (Self Test Warning or Failure)
+ (Level 1 Password Violation)
+ (Setting or Logic Changes)
+ (Level 2 Access Attempts)

RELAY TARGETS

The relay normally displays the targets identified on the front panel. Under normal operating conditions, the Enable (EN) target lamp is lit. The AL, PF, A, B, and C target LEDs latch. Front panel targets illuminate for conditions as shown below.

Table 3: Target Illumination Conditions

Target LED	Conditions for Illumination
EN	Normal Operation
AL	ALARM condition
PF	PEND FAIL condition
A	Phase A Breaker Failure
B	Phase B Breaker Failure
C	Phase C Breaker Failure
52A	52A STATUS input assertion
MOD	MOD STATUS input assertion

The Enable (EN) LED indicates that the relay is energized and operating.

The Alarm (AL) LED asserts for Level 1 access failures, Level 2 access attempts, and self test warnings or failures. When the ALRM bit asserts, the AL LED does not assert, but the AL LED latches.

The PF LED illuminates if any pending failure bits routed to an output contact assert.

If the relay asserts the 86BF TRIP output, the A, B, or C targets latch to indicate the failed breaker pole.

The 52A and MOD LEDs illuminate if the associated rear panel input is asserted.

Target LEDs illuminated during the last trip output stay lit until one of the following occurs:

- Operator presses front panel TARGET RESET button
- Operator executes TARGET R command

The relay does not clear the targets when additional trip outputs occur. New and old tripping targets are displayed in a cumulative fashion until an operator clears them as described above.

SIGNAL PROCESSING

The relay filters current and voltage channels and samples the signals four times per power system cycle. The relay stores the analog low-pass filtered samples for event reporting. The microprocessor digitally filters each signal. The relay stores digital filter outputs for magnitude calculations.

Digital and analog filter net frequency response is centered on system frequency and completely rejects dc and double-frequency harmonics. Thus, relay elements respond only to the system frequency currents or voltages, not to harmonics or offsets caused by system faults. The computer determines magnitude for each voltage and current from the digital filter output.

LOGIC DESCRIPTION

The SEL-BFR relay provides protection for several Circuit Breaker failure modes:

Failure to clear a fault (five available schemes)
Failure to trip under load
Failure to complete trip sequence due to trip resistor(s) remaining inserted
Failure to complete close sequence due to close resistor(s) remaining inserted
Failure to close
Failure while open: breaker pole flashover detected

The SEL-BFR relay provides reset logic for applications with and without motor-operated disconnects. The relay also provides logic for a verified 52B output. The following sections describe the logic for each of these protection schemes.

Protection While Tripping Fault Current

The SEL-BFR relay provides five different protection schemes to safeguard the circuit breaker under fault current conditions. While the schemes share elements and timers, each is independent. You may enable only one protection scheme at a time. The SEL-BFR relay applies the single chosen scheme to all three breaker poles.

In ring-bus and breaker-and-a-half installations, two circuit breakers must operate to interrupt line current. Current distribution between the two breakers is unknown until the first breaker opens. This causes an uncertainty with respect to the timing of 50FT overcurrent element assertion. This uncertainty is not present in a single breaker arrangement.

Timing uncertainty is accounted for in the SEL-BFR relay breaker protection schemes intended for these complex bus/breaker arrangements. The SEL-BFR relay is intended to protect a single breaker, regardless of the bus/breaker arrangement. In breaker-and-a-half and ring-bus arrangements, you must use an independent breaker failure relay for each breaker.

An overview of the five protection schemes is shown below.

Scheme 1: Protection for Simple and Complex Arrangements

In this scheme, the breaker failure timer starts independently from 50FT assertion. This independence allows scheme usage in bus configurations where the 50FT element may assert after trip input assertion, such as ring-bus and breaker-and-a-half bus arrangements.

Logic latches in the trip signal so that trip signal dropout does not affect the breaker protection scheme.

Scheme 2: Basic Protection for Simple Arrangements

In a single breaker arrangement, fault current causes 50FT assertion immediately after fault inception and just prior to trip input assertion. In Scheme 2, the breaker failure timer does not start until the trip input and 50FT element are asserted. This allows definite, predictable scheme timing in single-breaker configurations.

Scheme 3: Simple Arrangement Protection Independent of 50FT Reset Time

Scheme 3 is intended for a single breaker arrangement. When a fault occurs, 50FT asserts. The line protective relay asserts the SEL-BFR relay trip input and the breaker failure timer starts. If the trip input and 50FT are asserted until the timer expires, the FBF bit asserts.

In Scheme 3, the trip input must remain asserted while current flows in the protected breaker. Scheme 3 resets when either the trip input deasserts or the 50FT element drops out.

Scheme 4: Sensitive Scheme for Simple or Complex Arrangements

When the SEL-BFR relay trip input is asserted, the breaker failure pickup timer starts. The trip input is latched and may be deasserted after a single quarter-cycle assertion. The breaker failure timer output asserts a settable time after a trip input asserts. The FBF bit asserts if the timer output is high and the phase 50FT element is asserted.

Scheme 5: Scheme for Simple or Complex Arrangements

When the trip input is asserted, the breaker failure timer starts. If 50FT is asserted when the timer expires, the Relay Word FBF bit asserts. If the trip input deasserts or 50FT drops out before the timer expires, the logic resets and FBF does not assert.

This scheme is similar to Scheme 3 because the trip input must remain asserted while current still flows in the protected breaker.

Protection While Tripping Load or Line-Charging Current

The 50LD overcurrent element is used in the failure to trip load current breaker protection scheme. The 50LD element should pick up when the protected breaker is closed. This scheme detects failures of the breaker to open when breaker current is lower than the 50FT setting, such as end-of-section faults and load breaking operations.

When the protected breaker is part of a ring-bus or breaker-and-a-half installation, load current may be very low due to unequal current distribution between the two breakers. Failure to trip load current logic may still be used to protect the breaker.

Thermal Protection of Close and Trip Resistors

If the protected breaker is equipped with trip and close resistors and three-phase potentials are available on both sides of the breaker, you can use the SEL-BFR relay thermal protective elements to protect breaker resistors. Occasionally, a trip or close resistor can be left in service following a breaker operation. The SEL-BFR relay can detect that condition, model the energy accumulated in the resistor, and trip the protected breaker or 86 lockout relay when resistor energy reaches a preset level.

The Relay Word bits CTF (Close resistor Thermal Failure) and TTF (Trip resistor Thermal Failure) assert when any Close or Trip resistor thermal model has reached the failure energy level and current is flowing in the hot resistor phase. If you set the CTF and TTF bits in the M86T logic mask, the relay asserts the 86BF TRIP outputs when a resistor thermal failure occurs.

The relay models cooling of the breaker resistors using settable time constants. The thermal elements do not drop out until the resistor thermal models have cooled below the element thresholds. This function helps prevent hot resistors from being returned to service.

Protection for Current Through an Open Breaker (Flashover)

The relay contains logic to detect breaker pole flashover failure. If a flashover is detected and continues until the 62FP and 62FF timers expire, the FOPF (Flashover Pending Failure) bit, then the FOBF (Flashover Breaker Failure) bit asserts in the Relay Word.

Protection for Failure to Close

The SEL-BFR relay includes logic which detects a failure of one or two breaker poles to close. Because the logic operates based on current flowing in the breaker poles, protection is not dependent upon the operation of auxiliary contacts. Thus, this logic is not subject to misoperation due to mechanical failures in the breaker or contacts.

MOD Trip Logic

You can set the SEL-BFR relay to operate a motor-operated disconnect switch following a breaker failure. The protection scheme must meet two requirements:

- The relay must be able to measure all current flowing in the MOD.
- The MOD must have an "a" configuration auxiliary contact to indicate status.

If you do not use an MOD on the protected breaker, consider using this logic to indicate a "Safe to Disconnect" condition for station personnel.

52BV Logic

The 52BV Relay Word bit asserts if the 52A input is deasserted while no phase current is above the 50LD setting. The 52BV bit deasserts when the 52A input asserts, or when any phase current exceeds the 50LD setting.

Alarm Logic

In addition to the relay ALARM output described above, the ALRM bit is available in the Relay Word. The ALRM bit indicates dangerous or abnormal conditions related to operation of the protected circuit breaker.

The relay sets the ALRM bit for one second and stores a message in the alarm message buffer when any of the following conditions are detected:

Failed CB trip resistors put in service
Failed CB close resistors put in service
52A contradicts voltage
Current while open
Trip while open
CB didn't close
Blown pot fuse
Current after MOD Trip
MOD contradicts current
Volts across closed CB
Slow trip
Slow close

SERIAL INTERFACES

Connectors labeled PORT 1 and PORT 2 are EIA RS-232-C serial data interfaces. Generally, PORT 1 is used for remote communications via a modem, while PORT 2 is used for local communications via a terminal or SEL-PRTU protective relay terminal unit.

The baud rate for each port is set by jumpers near the front of the main board. You can access these jumpers by removing either the top cover or front panel. Available baud rates are 300, 600, 1200, 2400, 4800, and 9600. The serial data format is:

Eight data bits
Two stop bits
No parity

IRIG-B INPUT DESCRIPTION

The port labelled J201 / AUX INPUT accepts demodulated IRIG-B time code input.

The IRIG-B serial data format consists of a one second frame with 100 pulses divided into fields. The relay reads the time code automatically about once every five minutes. The relay decodes second, minute, hour, and day fields and sets the relay clock accordingly.

EVENT REPORTING

The relay retains a fifteen-cycle data record for each of the last nine events. The record includes input currents and voltages, Relay Word elements, input contacts, and output contacts. The relay saves a report when any of the following occur:

- The relay trips
- User selected Relay Word bits, inputs, or outputs assert
- User executes the TRIGGER command

The relay stores the last nine event reports in a buffer. You can examine any full length report stored in the relay using the EVENT command. The relay clears the event buffer when relay power is interrupted or when you make a setting or logic change.

The relay stores 100 event summaries in nonvolatile memory. The event summaries are retained through setting changes and losses of control power. Summaries contain breaker operation data such as event type, mechanical and electrical breaker operating times, and the event date and time. You can use this data to monitor breaker wear and more effectively schedule routine breaker maintenance.

METERING

The meter function shows the values of ac current through the protected breaker, voltage across it, and real and reactive power dissipated in it. You can execute the METER command locally or remotely to check breaker conditions.

SELF TESTING

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

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

Table 4 lists self tests performed by the relay.

Table 4: Relay Self Tests

Test	Description
Offset	Measures dc offset of analog input channels.
Power Supply	Measures internal power supply voltages.
Random-Access Memory	Verifies RAM operation.
Read-Only Memory	Verifies ROM operation.
Analog-to-Digital Converter	Verifies A/D operation.
Master Offset	Measures dc offset of multiplexer channel.
Settings	Verifies checksum of setting group.

SEL-BFR RELAY CONNECTIONS

To effectively protect a power circuit breaker which includes tripping or closing resistors, the SEL-BFR relay must measure current flowing through each breaker pole and voltage drop across it. Figure 4 shows ac current and voltage inputs to the relay.

Apply current to the relay from current transformers on each phase of the protected breaker. The relay calculates voltage drop across each phase breaker by measuring the difference voltage between the secondaries of potential transformers connected on both sides of the protected breaker.

If you do not wish to use voltage-based breaker protection features such as resistor thermal protection, flashover protection, and breaker voltage warning, you need not connect the voltage inputs.

Figures 2 and 3 show dc connections to the relay for an example protection scheme. When you use the relay in a single-pole tripping scheme, consider wiring single-pole breaker auxiliary contacts in series for connection to the SEL-BFR relay 52A input.

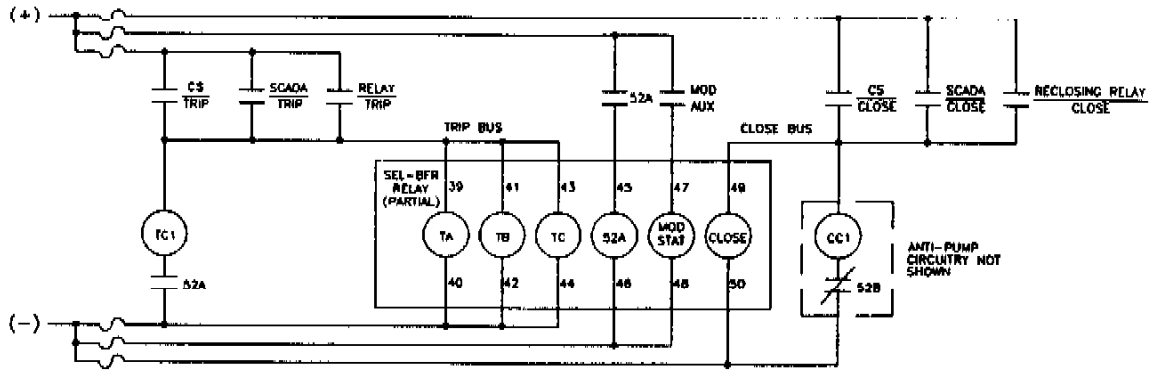
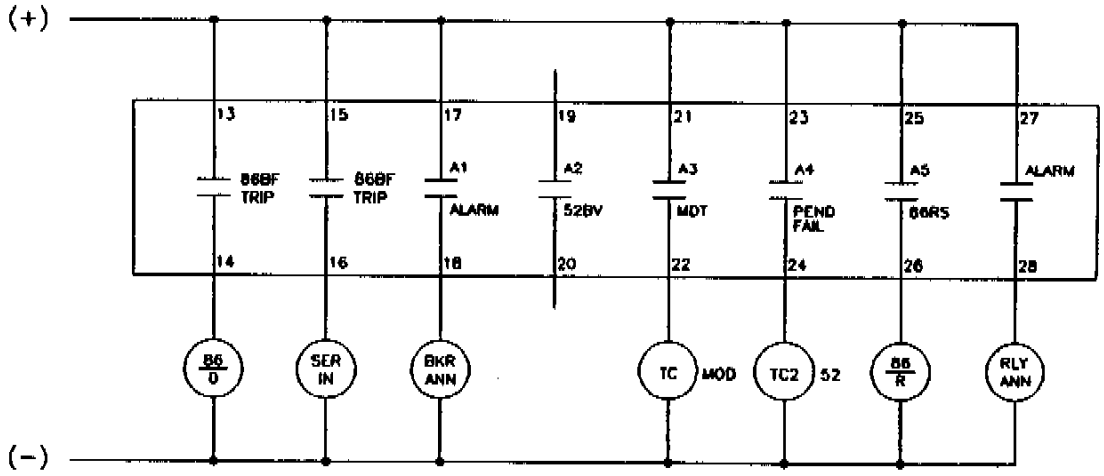


Figure 2: Example Dc Input Connections



SER IN: Input to Sequence-of-Events Recorder
BKR ANN: Circuit Breaker Alarm Annunciator
RLY ANN: SEL-BFR Relay Alarm Annunciator

Figure 3: Example Contact Output Connections

Programmable Output Applications

The versatility of programmable output contacts allows you to perform many tasks not detailed above. The following examples describe additional programmable output contact applications using the SEL-BFR relay.

Breaker Operation Alarm

You can set a programmable output contact to close and indicate when the relay detects a breaker operation alarm condition.

Three-Pole Instantaneous Retrip

You may use an SEL-BFR relay programmable output contact to perform instantaneous retrip of the protected circuit breaker. Set a single programmable logic mask with TA, TB, and TC equal to one. Connect the contact in series with a breaker 52A contact and Breaker Trip coil #2. Each time any SEL-BFR relay trip input is asserted, the relay asserts the A1 contact, energizing the second breaker trip coil.

Single-Pole Instantaneous Retrip

You may use three programmable output contacts to perform single-pole instantaneous retrip of the protected circuit breaker. In this application, set three individual programmable output contacts to close when a single breaker trip input is asserted. For instance, MA1 could contain the TA bit, MA2 the TB bit, and MA3 the TC bit. Connect each contact in series with the appropriate 52A contact and single-pole trip coil. Each time a single-phase trip input to the SEL-BFR relay asserts, the relay asserts the corresponding programmable output contact, energizing the second breaker trip coil and retripping the protected breaker pole.

Loss-of-Potential Indication

In three-pole trip installations, the relay 47Q element asserts to indicate that a potential fuse has blown. Set 47Q in a programmable output contact logic mask and monitor that contact externally using an annunciator, indicator lamp, or sequence of events recorder input. When 47Q asserts, the programmable output contact closes, indicating a blown potential fuse.

In single-pole trip installations, you may use the 47Q element in the same manner. However, because the element may assert during single-pole-open intervals, you may want to use a time delayed pickup timer between the relay output contact and the annunciator input or indicator lamp. The time delay should be set longer than the maximum single-pole-open interval. Thus, only permanent output contact closures activate the annunciator.

Hot Resistor Indication

When you use the SEL-BFR relay breaker resistor thermal protection elements, you can set a programmable output contact to close, indicating when one or more breaker resistor thermal models contain energy above the pending failure or failure level. Set a programmable output contact mask with the appropriate trip and close resistor thermal failure or pending failure bits. The relay asserts the contact whenever the programmed bits assert. You can monitor the contact using an annunciator input, indicator lamp, or sequence of events recorder input.

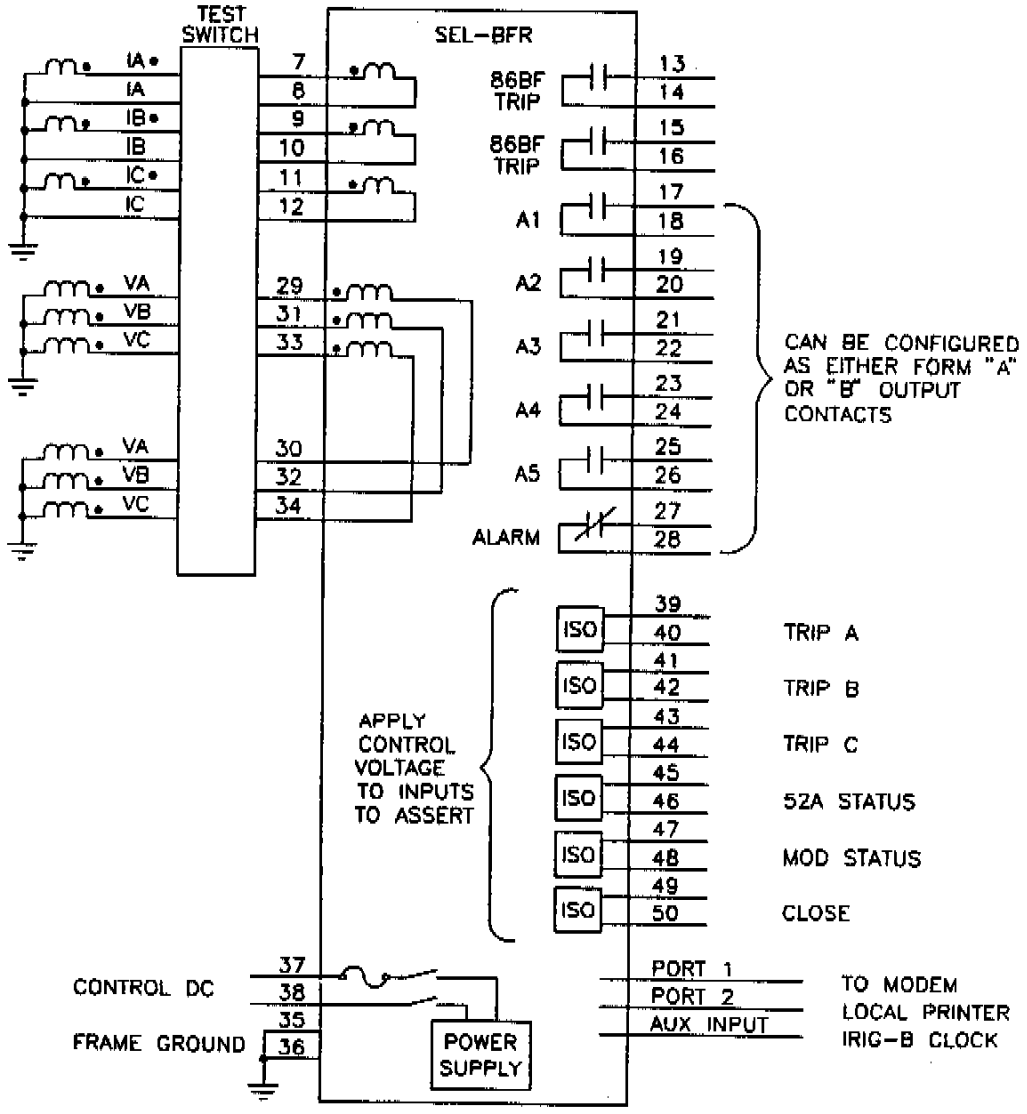
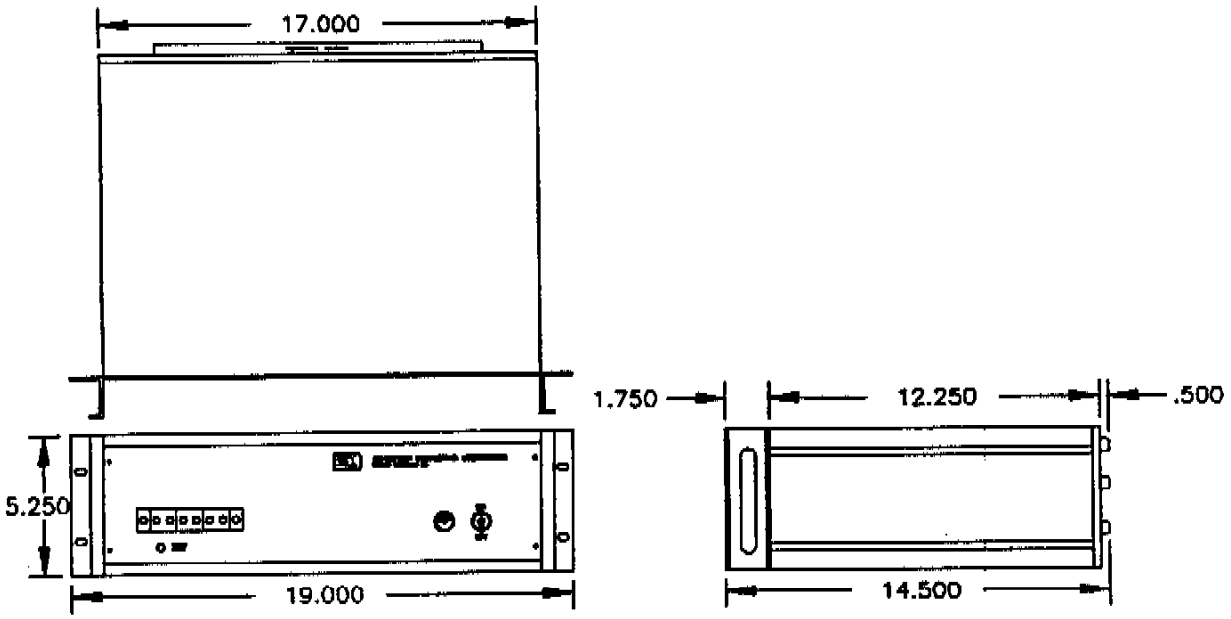
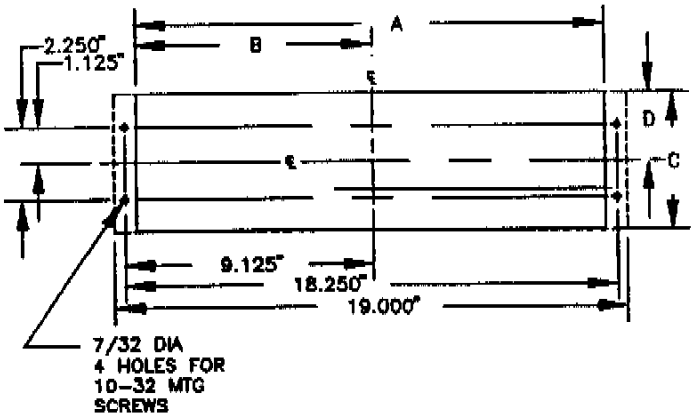


Figure 4: External Current and Voltage Connections





DIMENSION A:
CUT OUT: 17.250" – 17.875"
17.375" PREFERRED

DIMENSION B:
CUT OUT: 8.625" – 8.9375"
8.688" PREFERRED

DIMENSION C:
CUT OUT: 5.350" – 5.450"

DIMENSION D:
CUT OUT: 2.675" – 2.725"

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

Figure 5: Relay Dimensions, Panel Cutout, and Drill Plan

EXPLANATION OF SEL-BFR EVENT REPORT

```
Example 500 kV Breaker                          Date: 04/12/91    Time: 09:17:54.454
FID=SEL-BFR-R105-V1-D910212

                Amps and Volts Sec

        Currents                Voltages          Relay Word     Outs     Ins
                                                                 8AAAAAA  TTT5MC
                                                                 612345L  PPP2OL
     IA      IB      IC      VA      VB      VC    R1 R2 R3 R4 R5  T        ABCAD

  -3.28   -5.79    8.95   -0.08    0.00    0.00   1C 07 00 00 00  .1.....  TTT5M.
   8.45   -7.13   -1.44    0.00    0.00   -0.08   1C 07 00 00 00  .1.....  TTT5M.

Type: TRIP3   52A (cyc):  2.75   IV-Time (cyc):  2.75   Energy (MJ):  14.31

Schm= 2         50FT = 8.60     TTpu = 6.00     TTdo = 2.00     62FC = 4.00
50LD= 0.52      62LD = 5.50     62LP = 3.25
37OP= 2.25      26CF = 1.45     26CP = 1.09     26TF = 4.56     26TP = 3.42
47Q = 18.70     62OP = 3.00     CRTC = 80       TRTC = 80
59FO= 4.01      62FF = 30.00    62FP = 25.00
87UB= 16        62UC = 12.00    62UF = 60.00    62UP = 50.00
50MD= 0.10      62M1 = 600.00   62M2 = 600.00   ModTrip= Y
CTR = 600       PTR  = 4300
Topen= 2.25      Tclose= 10.25    Vwarn= 0.47
TIME1= 5         TIME2= 0         AUTO = 2        RINGS= 3

Logic settings:
M86T  MA1  MA2  MA3  MA4  MA5  MER
  C1   00   02   00   20   00   20
  80   07   00   00   40   00   48
  81   00   00   02   40   04   42
  00   00   00   00   55   00   55
  00   00   00   00   50   00   5F
  --   --   --   --   --   --   00
  --   --   --   --   --   --   07
```

Currents and voltages are in secondary units. Lines are ¼ cycle apart. Time runs down the page. Obtain RMS value and angle using one value as the Y component, and the entry immediately underneath as the X component. For example, IAY = -3.28, IAX = 8.45. Therefore, $|IA| = SQRT((-3.28)^2 + (8.45)^2) = 9.06$ A RMS secondary, at an angle of: ATAN(-3.28/8.45) = -21 degrees, with respect to sampling clock.

<FID>	Firmware Identification Data
<Relay Word>	Columns show hexadecimal representation of the 5 rows of the RELAY WORD on a quarter cycle basis
<Outputs>	Columns show the states of the SEL-BFR outputs: "T" under "86T" for 86BF TRIP; 1-5 under A1 - A5 programmable output contacts, and "A" under "AL" for ALARM
<Inputs>	Columns show the states of the SEL-BFR inputs: "T" in "TPA," "TPB," or "TPC" for TRIPA, TRIPB, or TRIPC respectively; "5" in "52A" for 52A status; "M" in "MOD" for MOD status; and "C" in "CL" for CLOSE
<Event>	Cause of event trigger
<52A>	Mechanical operating time of circuit breaker (cycles)
<IV-time>	Electrical operating time of circuit breaker (cycles)
<Energy>	Energy dissipated in circuit breaker during first 14 cycles of report
Schm	Failure to trip fault current protection scheme enabled
50FT	Fault overcurrent element setting
TTpu,TTdo	62TT timer pickup and dropout time delays
62FC	62FC timer pickup delay
50LD	Load detecting overcurrent element
62LD,62LP	Failure to trip load current failure and pending failure timers
37OP	Resistor thermal protection phase overpower element pickup setting
26XX	Trip or Close Resistor thermal failure or pending failure energy levels
47Q	Negative-sequence overvoltage element, detects blown potential fuse
62OP	Overpower element pickup time delay
XRTC	Trip or Close resistor cooling time constant
59FO	Pole flashover overvoltage element
62FF,62FP	Pole flashover failure and pending failure timers
87UB	Phase discordance current unbalance ratio
62UC	Phase discordance Close signal time delay pickup timer
62UF,62UP	Phase discordance failure and pending failure timers
50MD	MODTrip phase overcurrent element
62M1,62M2	Trip and Reset logic timers
ModTrip	Y enables MODTrip logic, N disables
CTR,PTR	Current and Potential transformer ratios
Topen,Tclose	Breaker operating time warning settings
Vwarn	Closed breaker voltage warning setting
TIME1,2	Communications port timeout intervals
AUTO	Port assignment for automatic message transmissions
RINGS	Number of rings external modem waits before answering telephone
<Logic Settings>	See LOGIC command for a description of mask settings

SEL-BFR BREAKER FAILURE RELAY COMMAND SUMMARY

Level 0

ACCESS	Answer with password (if password protection is enabled) to gain access to Level 1. Third unsuccessful attempt pulses ALARM relay.

Level 1

2ACCESS	Answer with password (if password protection enabled) to gain access to Level 2. This command always pulses the ALARM relay.
DATE m/d/y	Without arguments, relay displays date; **DATE 6/15/91 <ENTER>** sets the date to June 15, 1991. IRIG-B synchronization overrides month and day settings.
EVENT n l	Show record for event number n, l signifies long version: **EVENT 1 l <ENTER>** shows the long form of the latest event. **EVENT 100 <ENTER>** shows the short form of the oldest event.
HEAT n	Show internal energy of 3 close and 3 open resistors n times.
HISTORY	Show DATE, TIME, TYPE, ENERGY, IV-TIME, and 52A-TIME for the 100 most recent events.
IRIG	Force immediate execution of IRIG-B time-code synchronization.
METER n	Show primary current, voltage, real and reactive power n times. METER runs once; METER n runs n times (n = 1 to 255).
QUIT	Return to Access Level 0.
SHOWSET	Display settings without affecting them.
STATUS	Show self test status and ALARM history.
TARGET n	Show data and set target lights as follows: TAR 0: Relay Targets TAR 1: Relay Word Row 1 TAR 2: Relay Word Row 2 TAR 3: Relay Word Row 3 TAR 4: Relay Word Row 4 TAR 5: Relay Word Row 5 TAR 6: Relay Outputs TAR 7: Relay Inputs TAR R: Clear Targets and return to TAR 0.
TIME h/m/s	Show or set time. TIME 13/32/00 sets clock to 1:32:00 PM. IRIG-B synchronization overrides this setting.
TRACE n	Trace voltage and current inputs, Relay Word bits, relay inputs and outputs n times.
TRIGGER	Trigger event report generation (event type is INT).

Level 2

LOGIC n	Show or set logic masks M86T, MA1, MA2, MA3, MA4, MA5. Command pulses ALARM contact closed and clears event buffers when new settings are stored.
OUT n	Close designated output contacts if jumper JMP104 is in place (n = T, 1, 2, 3, 4, 5, or A).
PASSWORD	Show or change passwords: **PASSWORD 1 OTTER <ENTER>** changes Level 1 password to OTTER. **PASSWORD 2 TAIL <ENTER>** changes Level 2 password to TAIL.
SET n	Initiate setting procedure. Optional n directs relay to begin procedure at that setting. SET 50LD starts procedure at 50LD setting. SET initiates procedure at beginning. ALARM relay closes while relay computes new settings and clears long event data.

Use space, comma, semicolon, or slash to separate commands and parameters from one another. Only the first three letters of commands are significant.

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