BE1-81O/U
Frequency Protection

Washington State University
Hands-On Relay School
As many as four independent, adjustable frequency setpoints and time delays
Each setpoint has output relays and target indicators
Setting range is 40 Hz—70 Hz
Field selection of overfrequency or underfrequency
Undervoltage inhibit prevents false trips
3-cycle pickup timer provides security
Why Frequency (81) Relay?

Load-shedding generator protection

8% load shed

12% load shed

H=3
Overload=20%
Freq-Measuring Compensation

- Full-cycle frequency measurement prevents dc offset from affecting results
- Filtering prevents high-frequency transients
- 3-second security timer

[Graph showing frequency measurement with fault altering measurement at 77Hz, 64Hz, and 50Hz]
Early relays lack timing range switches
Contact-Outputs Ratings

Inductive Rating

- 120 Vac, 125 Vdc, 250 Vdc: Break 0.3 A (L/R = 0.04)
  (L/R of 0.04 is about 15.1 X/R at 60-Hz, inductive)

Resistive Rating

- 120 Vac: Make, break, and carry 7 Aac continuously
- 250 Vdc: Make and carry 30 Adc for 0.2 s, carry 7 Adc continuously, and break 0.3 Adc
- 500 Vdc: Make and carry 15 Adc for 0.2 s, carry 7 Adc continuously, and break 0.3 Adc
Two Types of Targets

Internally operated or current operated targets

Internally operated—electronically latching
• Manual-reset targets indicate that a setpoint contact has energized.
• Select internally operated targets if the relay has normally closed output contacts.

Current-operated
• Require a minimum trip circuit current of 200 mA
  › Continuous rating of 3 amperes
  › Two-minute rating of 7 amperes
  › One-second rating of 30 amperes
**Wide-range, isolated, low-burden, flyback switching**

Input power (source voltage) is NOT polarity sensitive

<table>
<thead>
<tr>
<th>Type (Range)</th>
<th>Input Voltage Nominal</th>
<th>Input Voltage Range</th>
<th>Burden (Nominal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K (midrange)</td>
<td>48 Vdc</td>
<td>24 to 150 Vdc</td>
<td>3.6 W</td>
</tr>
<tr>
<td>J (midrange)</td>
<td>125 Vdc</td>
<td>25 to 150 Vdc</td>
<td>3.9 W</td>
</tr>
<tr>
<td></td>
<td>120 Vac</td>
<td>90 to 132 Vac</td>
<td>16.0 VA</td>
</tr>
<tr>
<td>L (low range)</td>
<td>24 Vdc</td>
<td>12 to 32 Vdc*</td>
<td>3.7 W</td>
</tr>
<tr>
<td>Y (midrange)</td>
<td>48 Vdc</td>
<td>24 to 150 Vdc</td>
<td>3.6 W</td>
</tr>
<tr>
<td></td>
<td>125 Vdc</td>
<td>25 to 150 Vdc</td>
<td>3.9 W</td>
</tr>
<tr>
<td>Z (high range)</td>
<td>250 Vdc</td>
<td>68 to 280 Vdc</td>
<td>3.9 W</td>
</tr>
<tr>
<td></td>
<td>240 Vac</td>
<td>90 to 270 Vac</td>
<td>24.6 VA</td>
</tr>
</tbody>
</table>

*Type L begins operation at 14 Vdc; Once operating, voltage can be reduced to 12 Vdc
Range:  40–70 Hz
Increment:  0.01 Hz
Accuracy:  ±0.01 Hz of the setpoint
Older models
  • Some relays lack timing-range switches
  • Some are only in cycles or seconds
Selector Switch S7

- Sets definite time in seconds or cycles
- Multiplier of 1, 10, or 100

Early BE1-80/U (timing option E1) was 3–99 cycles only

- Selector Switch S7 emulates the E1 range
Switch S7 might not exist on older models.

Figure 2-2. Location of Selector Switch S7
Cycles

- 3 to 99 cycles in 1-cycle increments
- 10 to 990 cycles in 10-cycle increments
- 100 to 9900 cycles in 100-cycle increments

Accuracy

- +2 cycles or -1 cycle for 0.02 Hz to 1 Hz variation from setpoint
- ±1 cycle for freq. variation greater than 1 Hz from setpoint
Time Delay Range and Accuracy

Seconds

- 0.1 to 9.9 seconds in 1-second increments
- 1.0 to 99 seconds in 10-second increments
- 10 to 990 seconds in 100-second increments

Accuracy

- ±2% of the setting or ±50 ms, whichever is greater from 0.02 Hz to 1 Hz variation from setpoint
- ±2% of the setting or ±25 ms, whichever is greater for frequency variation greater than 1-Hz variation from setpoint
Calculate delay with zero crossings
Tripping time depends on relay version
Trip in 2 to 3 cycles
Do not use settings 00, 01, and 02 without testing trip time

\[
\text{Delay (s)} = \frac{\text{delay setting in cycles}}{\text{applied frequency in hertz}} (\pm \text{spec. accuracy})
\]
Assume relay is set @ 6 cycles; applied freq = 58.0 Hz

1 cycle is 1/58 seconds, or 0.01724 seconds (compare to 1/60 = 0.01667 seconds)

Example:

6 cycles delay at 58.0 Hz, t6 at 58

$t6 \text{ at } 58 = 6 \cdot 0.017241 = 103.45 \text{ ms}$

6 cycles delay at 60.0 Hz, t6 at 60

$t6 \text{ at } 60 = 6 \cdot 0.016667 = 100 \text{ ms}$
Be aware of how test set reports cycles of delay; some will report delay @ 60 Hz only. For example, the test set reports delay at 103.45 ms • 60 Hz = 6.207 cycles. Convert Test-Set Cycles to Relay Cycles: multiply Test-Set-Reported Delay • 58/60. 6.207 cycles • 58/60 = 6 cycles—Correct! 103.45 ms • 58/60 = 100 ms—Correct!
Increase dependability—don’t trip on low voltage
Setting range 40–120 Vac ± 5 percent
Careful setting UV Inhibit—takes time to activate

PU Delay of UV-Inhibit adds time:
See Application Note PC-8101
(website and CD):
Front-Panel Controls

Figure 2-1. Front Panel Controls and Indicators
Front-Panel Controls

Figure 2-1. Front Panel Controls and Indicators
Out-of-Range LED
(Older Relays)

Not in present I-M
Switch S7 varies with relay age
Might not exist on older models

Figure 2-2. Location of Selector Switch S7
Logic

Analog Filter

AC Input Signal

Input Signal Conditioning

Zero Crossing Logic

Period Clock Gen.

EDPR Overfrequency

Out of Range

Underfrequency

Period Clock

Minimum Period Difference Logic

Maximum Period Difference Logic

Measured Frequency Converter

80 Hz

30 Hz

BCD Frequency Data

F1 Over/Under

Setpoint 1
Options 1-6, 1-7, 1-8, 1-9

Target Driver

Target

Output Relay

Time Delay Logic

Frequency Comparator Logic

0/U Select
Frequency Select
Time Delay Select

Auxiliary Output

Pickup LED

Beyond Limits

To Trip Circuit
Internal Parts

Not in present IM
Internal Connections

Figure 4-20: Internal Relay Connections
External Connections
Test Equipment

Minimum test equipment requirements are listed below. Test connections are shown in Figure 5-1.

NOTE

One of the commercially available frequency relay test set may be used to test the relay. These test sets have electronic switching and frequency and time generating accuracies that exceed the accuracy of the BE1-81O/U relay.

- ac or dc power source for relay operating power
- ac source for relay frequency sensing *
- Hardware (battery and lamp, multimeter, etc.) or method of determining when the relay output contacts close

* A source with frequency stability of 0.00002 hertz must exhibit phase noise of less than 90 decibels for accurate measurement. The accuracy and stability of this source is necessary as the relay precisely measures the period between positive going zero-crossings of the applied waveform and responds instantaneously to the sensed condition.
Test Connections

Figure 5-1. BE1-81O/U Test Setup

NOTES:
- Typical setpoint test connection, connect to each remaining setpoint output as applicable (one at a time).
- Suitable ac/dc external power

ILBS-05
6-26-92
High and Low Frequency Pickup

1. Connect the relay as shown in Figure 5-1.
2. Adjust Selector Switch S7 for setpoint 1, located on the definite time circuit board controlling setpoint 1, to obtain a time delay in cycles with a x1 multiplier (S7-1 down, S7-2 down, and S7-3 up).
3. Adjust the front panel, setpoint 1 controls to the following settings.
   - Over/Under Selector Switch: Over (O) position
   - Frequency Selector Switch: 70.00
   - Time Delay Selector Switch: 25
4. Apply operating power to the relay.
5. Apply 60 Hz voltage to the relay sensing input. The level of voltage must exceed the setting of the adjustable, front panel Undervoltage Inhibit control.
6. Slowly increase the sensing input frequency until the setpoint 1 Pickup indicator just lights. The sensing input frequency should be 70 Hz, ±0.01 Hz.
7. Adjust the front panel, setpoint 1 controls to the following settings.
   - Over/Under Selector Switch: Under (U) position
   - Frequency Selector Switch: 50.00
8. Slowly decrease the sensing input frequency until the setpoint 1 Pickup indicator just lights. The sensing input frequency should be 50 Hz, ±0.01 Hz.
**Frequency Selector Settings**

1. Connect the relay as shown in Figure 5-1.
2. Adjust the front panel, setpoint 1 controls to the following settings.
   - Over/Under Selector Switch: Under (U) position
   - Frequency Selector Switch: 51.11
3. Apply operating power to the relay.
4. Apply 60 Hz voltage to the relay sensing input. The level of voltage must exceed the setting of the adjustable, front panel Undervoltage Inhibit control.
5. Slowly decrease the sensing input frequency until the setpoint 1 Pickup indicator just lights. The sensing input frequency should be 51.11 Hz, ±0.01 Hz.
6. Repeat steps 4 and 5 for Frequency Selector Switch settings of 52.22, 54.44, and 58.88.
Definite Time Delay – Cycles

1. Connect the relay as shown in Figure 5-1.
2. Adjust Selector Switch S7 for setpoint 1, located on the definite time circuit board controlling setpoint 1, to obtain a time delay in cycles with a x1 multiplier (S7-1 down, S7-2 down, and S7-3 up).
3. Adjust the front panel, setpoint 1 controls to the following settings:
   - Over/Under Selector Switch: Under (U) position
   - Frequency Selector Switch: 55.00
   - Time Delay Selector Switch: 11
4. Apply operating power to the relay.
5. Apply 60 Hz voltage to the relay sensing input. The level of voltage must exceed the setting of the adjustable, front panel Undervoltage Inhibit control.
6. Ensure that the target indicators are reset.
7. Step the sensing input frequency down from 60 Hz to 53 Hz. The setpoint 1 Pickup indicator lights and the test set timer begins counting. When the time delay ends, the setpoint 1 output relay and target trips, and the test set timer stops counting. The timer should indicate 0.208 seconds (11 cycles x 1/53, ±1.0 cycles).
8. Restore the sensing input frequency to 60 Hz and reset the targets.
9. Repeat steps 7 and 8 for Time Delay Selector Switch settings of 22, 44, and 88.
10. If desired, the above steps may be performed with Selector Switch S7 configured for a time delay multiplier of x10 (S7-1 up and S7-2 down) or x100 (S7-1 up and S7-2 up).
Definite Time Delay – Seconds

1. Connect the relay as shown in Figure 5-1.

2. Adjust Selector Switch S7 for setpoint 1, located on the definite time circuit board controlling setpoint 1, to obtain a time delay in seconds with a x1 multiplier (S7-1 down, S7-2 down, and S7-3 down).

3. Adjust the front panel, setpoint 1 controls to the following settings.
   - Over/Under Selector Switch: Under (U) position
   - Frequency Selector Switch: 55.00
   - Time Delay Selector Switch: 25

4. Apply operating power to the relay.

5. Apply 60 Hz voltage to the relay sensing input. The level of voltage must exceed the setting of the adjustable, front panel Undervoltage Inhibit control.

6. Ensure that the target indicators are reset.

7. Step the sensing input frequency down from 60 Hz to 53 Hz. The setpoint 1 Pickup indicator lights and the test set timer begins counting. When the time delay ends, the setpoint 1 output relay and target trips, and the test set timer stops counting. The timer should indicate 2.5 seconds, ±0.05 seconds.

8. Restore the sensing input frequency to 60 Hz and reset the targets.

9. Repeat steps 7 and 8 for Time Delay Selector Switch settings of 22, 44, and 88.

10. If desired, the above steps may be performed with Selector Switch S7 configured for a time delay multiplier of x10 (S7-1 up and S7-2 down) or x100 (S7-1 up and S7-2 up).
Test Undervoltage Inhibit

Undervoltage Inhibit

1. Connect the relay as shown in Figure 5-1.
2. Adjust the front panel, setpoint 1 controls to the following settings.
   - Over/Under Selector Switch: Under (U) position
   - Frequency Selector Switch: 60.00
   - Time Delay Selector Switch: 25
3. Apply operating power to the relay.
4. Apply 60 Hz voltage to the relay sensing input. The level of voltage must exceed the setting of the adjustable, front panel Undervoltage Inhibit control.
5. Decrease the level of the sensing input voltage until it is considerably less than the Undervoltage Inhibit control setting. (BE1-81O/U relays are delivered with an undervoltage inhibit setting of 80 Vac.) The Undervoltage Inhibit indicator should light.
6. Decrease the frequency of the sensing input voltage to 59 Hz. The setpoint 1 Pickup indicator should not light and the setpoint 1 output relay should not trip.
7. Increase the level of the sensing input voltage until it exceeds the level of the undervoltage inhibit setting. The Undervoltage Inhibit indicator should turn off, the setpoint 1 Pickup indicator should light, and the setpoint 1 output relay should trip after the Time Delay Selector switch setting expires.
Questions?