SCOPE

This test procedure covers the testing and maintenance of the ABB KLF-1 loss of excitation relay. The Westinghouse Protective Relay Division was purchased by ABB, and new relays carry the ABB label. Refer to IL 41-748.1 for support information and component level identification.

DESCRIPTION

The Westinghouse KLF-1 is a loss of field relay used for generator protection. The relay is designed to operate on lagging VAR flow (directional unit), a change in impedance (distance unit), and a loss of generator voltage (under-voltage unit). The trip contacts of these elements are in series and the trip output closes when the under-voltage element operates.

The directional unit operates on the interaction between the polarizing circuit flux and the operating circuit flux and closes its contacts for lagging VAR flow into the generator. Its primary function is to prevent operation of the relay during external faults.

The distance unit measures impedance of the generator as viewed from its terminals. This is accomplished by the use of two compensators, designated $T_a$ for long reach and $T_c$ for short reach. Any reach ohm setting can be made within $\pm 1.5\%$ by auto-transformer taps. Reversing links are included in the short reach compensator, $T_c$, for including or excluding the origin of R-X diagram from the distance unit characteristic.

The under-voltage unit construction is similar to the directional unit and consists of two pairs of voltage coils. One pair of coils is in series with adjustable resistor $R_v$ which is used to shift the phase angle between the two sets of coils to produce torque.

OPERATION

The contacts of all three units are connected in series to the telephone type relay (designated X). The operation of both the direction and distance unit sounds an alarm. The operation of the under-voltage unit completes the trip circuit to the ICS and trips the generator. Relay X is designed to provide 15 cycles time delay on dropout before energizing the trip coil ICS. This time delay insures positive contact coordination under all possible operating conditions.
PRE-TEST CONDITIONS

Reversing links are set in vertical position. \((T_c+)\)

Calculations:
Assume Long Reach, \(Z_a = 27.6\) ohm, Short reach, \(Z_c = 3.29\) ohm. Use IL 41-748.1 (pg. 10ff) calculations as a guide for setting \(T, S,\) and \(M\). (See Appendix A for assistance with calculations.)

Test connections:
Use IL 41-748.1, figures 4 and 13 for relay connections
\(V_n =\) Terminal 4
\(V_a =\) Terminal 5
\(V_b =\) Terminal 6
\(V_c =\) Terminal 7
\(I_1 = 9 +, 8 –\)
Sensing = 1 to 10

**NOTE:** If relay is cold, connect three phase voltage to the relay and run for 15 minutes at 120 Vac, otherwise use single phase voltage as directed.

UNDERVOLTAGE UNIT (IL Pg. 7)

\(V_c = 7\) (polarity) to 4
Block directional and distance contacts closed. (To sense with the test set, you may need to jumper from the upper right contact of the telephone relay as you look at the back to terminal 1.)
The spiral spring adjusts this setting between 65% and 85% of normal system voltage. Start at nominal voltage (80v) and ramp down until contacts close.

DIRECTIONAL UNIT (IL Pg. 7)

\(V_b = 6\) (polarity) to 4
\(I_a = 9\) (polarity) to 8
Sensing = 1 to 10
BLOCK the distance and under-voltage contacts closed

MTA TEST
\(V_b=2<0^0, I_a=5\text{amp}<43^0.\)
(Or \(I_a 8(+)\) to 9, \(V_b @ 0^0\) and \(I_a@-137^0\))
(Or \(V_a = 60v<0^0, V_b = 1v<240^0,\) and \(I_a = 5a<283^0\))
Rotate current angle CW and CCW until dropout on both sides. The average of the two dropout values is the MTA.
Tolerance = +/- 5 degrees
Adjust reactor \(X_d\) as required

DIRECTIONAL UNIT PICKUP
\(V=1, I=5.0\text{amp} @ \text{MTA}\)
Ramp I up to pickup
Tolerance = +/- 10%
Adjustment: Spiral spring adjuster.
**IMPEDEANCE UNIT**

Test connections:
- $V_a = 5$ (polarity) to 4
- $I_a = 9$ (polarity) to 8
- Sensing = 1 to 10

BLOCK the directional unit and under-voltage unit contacts closed

**MTA TEST**

Unit MTA = 90 degree $I$ lag

$$I = \frac{1.2V}{Z} \quad (1.2 \text{ is just to be sure I is above min. pickup})$$

$$V = 60 \quad , \quad Z = Z_d = 27.6 \, \Omega$$

Set $I$ to calculated value, $V = 60$. Rotate current angle CW and CCW until dropout on both sides. The average of the two dropout values is the MTA.

Tolerance is 85 – 95 degrees

Adjustment is resistor $R_b$ (lower rear)

**LONG REACH TEST**

All tests:

Calculate $I$ as required.

$$I = \frac{V}{Z} \quad \text{where} \quad Z = Z_d, \quad V = 60$$

Start ramp at $.8 \times I$ to PU $Z_d$ Long Reach at 90 degree $I$ Lag

Tolerance = +/- 3%

Adjustment is spiral spring adjuster or $T_d$ taps.

$Z_d$ Long Reach at 150 degree $I$ Lag

Tolerance = +/- 20%

$$I = \frac{V}{(1.5 \times Z)} , \quad Z = \left( X^2 + R^2 \right)^{0.5}$$

$$R = \frac{Z_d + Z_c}{2} \quad \text{radius of characteristic}$$

$$X = Z_d - R \quad \text{origin to center of characteristic}$$

**NOTE:** $V$ is derived by vectorially adding voltage across $T_d$ and $T_c$

$Z_d$ Long Reach at 30 degree $I$ Lag

Tolerance = +/- 20%

Calculations same as 150 degrees

**NOTE:** If reach is not approximately same as 150 degree reach, adjust resistor $R_b$ and retest. Check 90 degree and 150 degree reach.

**SHORT REACH TEST**

All tests

Calculate $I$ as required. $V = 23$

Start ramp at $.8 \times I$ to PU

$Z_c$ Short Reach at **270** degrees $I$ lag

Tolerance = +/- 3%

Adjustment is $T_c$ taps

$$I = \frac{V}{Z}, \quad Z = Z_c$$
AUX RELAY
DC voltage = 10(+) to 3(-)
Sense on unused N.O. contacts of telephone relay
Pickup
Pickup = 55 Vdc
Start ramp 0.5 * PU
Tolerance = +/- 20%
Drop Out
DC voltage = 120 Vdc to 10(+) and 3(-)
Drop to zero
Contact DO =250ms
Tolerance = +/-20%

ICS
Check the target unit pickup tap to determine the setting
Connect DC current to terminals 1 and 10
Block the directional and impedance contacts closed
Raise the dc current until the target unit just picks up
Verify that the target drops smoothly.
Release the trip contact and verify that the target unit remains sealed in.
Lower the dc current until the target unit drops out.

3 PHASE TEST
If you have a 3 phase test set, you can mimic the field wiring, per IL Figure 3, pg 6.
Vn = terminal 4
Va < 0 = terminal 5
Vb < 240 = terminal 6
Vc < 120 = terminal 7
I1 = terminals 8(+) – 9
Sense = terminals 1 – 10
Tests:
Apply 30 volts to all 3 phase voltages. This should be low enough to close the undervoltage unit.
Apply 2 amps at 90 degrees. This should be enough to close the impedance unit.
Vary the phase angle to determine the maximum torque angle.

Similarly vary voltage and current to determine when the impedance and undervoltage units operate. Example: 60v, 1a < 90°, directional unit should pick up, ramp voltage down until UV element picks up, continue ramping down until impedance unit picks up – should be around 26v.
Figure 1

KLF Internal Schematic

INTERNAL SCHEMATIC

TELEPHONE RELAY

INDICATING CONTATOR SWITCH

NOTES:
1. WITH RELATIVE INSTANTANEOUS POLARITIES AS SHOWN, THE DIRECTIONAL CONTACTS CLOSE.
2. REVERSING LINKS SHOWN FOR \( +Z_C \).
Figure 2

KLF-1 Internal Schematic

TELEPHONE RELAY

INDICATING CONTACTOR SWITCH

ICS

500 D - 48 Vdc
2000 D - 125 Vdc
6000 D - 250 Vdc

With relative instantaneous polarities as shown the directional contacts closed.

UNDER VOLTAGE UNIT
(LOWER UNIT)

LONG REACH COMPENSATOR

IMPEDANCE UNIT
(CENTER UNIT)

SHORT REACH COMPENSATOR

REVERSING LINKS

LONG REACH COMPENSATOR

DIRECTIONAL UNIT
(TOP UNIT)

CHASSIS OPERATED SHORTING SWITCH

RED HANDLE CURRENT JACK
TEST SWITCH

TERMINAL
Appendix A  Setting Calculations for Za = 27.6 ohms and Zc = 3.29 ohms.

IL 41-748 walks you through these calculations beginning on page 10 with Equation (5). The steps begin on page 12:

Set Long Reach taps – Za = 27.6 ohms:

Step 1. 18.65 x Sa > 27.6, choices are 1, 2, 3, (1 x 18.65 < 27.6; 2 x 18.65 > 27.6) so set Sa at 2

Step 2. Ta nearest to 27.6 / 2 = 13.8, set Ta at 15.8

Step 3. (TaSa / Za) – 1 = (15.8 x 2 / 27.6) – 1 = +0.145, set Ma = +0.15

Check: Actual Za = TaSa / 1+/- M = (15.8 x 2) / (1 + 0.15) = 31.6/1.15 = 27.5 which is 99.6% of 27.6

Set Short Reach taps – Zc = 3.29 ohms:

Step 1. 6 x Sc > 3.29, set Sc = 1

Step 2. Tc nearest to 3.29 / Sc = 3.29, set Tc = 3.64

Step 3. (TcSc / Zc) – 1 = (3.64 x 1 / 3.29) – 1 = +0.107, set Mc = +0.12

Check: Actual Zc = TcSc / (1+M) = 3.64 / 0.12 = 3.25 which is 98.7% of 3.29

Impedance MTA:

$I = 1.2V / Z$  (1.2 is just to be sure value is above min pickup)

$V = 60$, $Z = Za = 27.6 \Omega$

$I = 2.6 a$

Long Reach Test

Calculate $I$ as required.

$I = V / Z$ where $Z = Za$, $V = 60$  $I = 2.2 a$

Short Reach Test

$I = V / Z$, $Z = Zc$

60 / 3.3 = 18.2

If the test set won’t drive through the relay impedance, reduce voltage:

50 / 3.3 = 15.2

40 / 3.3 = 12.1