Type KLF
Loss-of-Field Relay
(For Class 1E Application)

1. APPLICATION

These relays have been specially designed and tested to establish their suitability for Class 1E applications in accordance with the ABB Power T&D Company program for Class 1E Qualification Testing as detailed in bulletin STR-1. Materials have been selected and tested to insure that the relays will perform their intended functions for their design life when operated in a normal environment as defined by ANSI standards when exposed to radiation levels up to $10^4$ rads, and when subjected to seismic events producing a Shock Response Spectrum within the limits of the relay rating.

“Class 1E” is the safety classification of the electronic equipment and systems in nuclear power generating stations that are essential to emergency shutdown of the reactor, containment isolation, cooling the reactor, and heat removal from the containment and reactor, or otherwise are essential in preventing significant release of radioactive material to the environment.

The KLF relay is a single-phase relay connected to the ac side of a synchronous machine and contains three units connected so that the operation of two units sounds an alarm warning the operator of a low excitation condition, and the additional operation of the third unit sets up the trip circuit. The relay can be applied without modification to all types of synchronous machines, such as turbo generators, water wheel generators or motors.

The KLF relay is designed for use with 3-phase 3-wire voltage supply and may use wye or delta-connected voltage transformers. The type KLF-1 relay may be used to increase security during inadvertent loss-of-potential (such as due to a blown potential fuse).

2. CONSTRUCTION

The relay consists of two (2) air-gap transformers (compensators), two tapped auto-transformers, one reactor, one cylinder-type distance IT, directional unit with adjustable reactor, an under-voltage unit with adjustable resistor, telephone relay with solid state time delay circuit, and an ICS indicating contactor switch.

2.1 Compensator

The compensators, which are designated $T_A$ and $T_C$, are two (2) winding air-gap transformers (Figure 2). The primary or current winding of the long-reach compensator $T_A$ has seven taps which terminate at the tap block. They are marked 2.4, 3.16, 4.35, 5.93, 8.3, 11.5, 15.8. The primary winding of the short-reach compensator $T_C$ also has seven taps which terminate at this tap block. They are marked 0.0, 0.91, 1.27, 1.82, 2.55, 3.64, 5.1. Voltage is induced in the secondary which is proportional to the primary tap and current magnitude. This proportionality is established by the cross sectional area of the laminated steel core, the length of an air gap which is located in the center of the coil, and the tightness of the laminations. All of these factors which influence the secondary voltage proportionality have been precisely set at the factory.

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB representative should be contacted.
The clamps which hold the laminations should not be disturbed by either tightening or loosening the clamp screws.

The secondary winding is connected in series with the relay terminal voltage. Thus voltage, which is proportional to the line current, is added vectorially to the relay terminal voltage.

2.2 Auto-Transformer

The auto-transformer has three taps on its main winding, S, which are numbered 1, 2, and 3 on the tap block. A tertiary winding M has four taps which may be connected additively or subtratively to inversely modify the setting by any value from -15 to +15 percent in steps of 3 percent.

The sign of M is negative when the R lead is above the L lead. M is positive when L is in a tap location which is above the tap location of the R lead. The M setting is determined by the sum of per unit values between the R and L lead. The actual per unit values which appear on the tap plate between taps are 0,.03,.06, and .06.

The auto-transformer makes it possible to expand the basic ranges of the long and the short reach compensators by a multiplier of \( \frac{S}{1 \pm M} \). Any relay ohm setting can be made within ± 1.5 percent from 2.08 ohms to 56 ohms for the long-reach and from .79 ohms to 18 ohms for the short-reach.
2.3 Impedance Tripping Unit

The distance unit is a four pole induction cylinder type unit. The operating torque of the unit is proportional to the product of the voltage quantities applied to the unit and the sine of the phase angle between the applied voltages. The direction of the torque depends on the impedance phasor seen by the relay with respect to its characteristic circle.

Mechanically, the cylinder unit is composed of four basic components: A die-cast aluminum frame, and electromagnet, a moving element assembly, and a molded bridge. The frame serves as a mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured by the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two sets of two series connected coils mounted diametrically opposite one another to excite each set of poles. Locating pins on the electromagnet are used to accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying number, and an aluminum cylinder assembled to a molded hub which holds the shaft. The hub to which the moving-contact arm is clamped has a wedge and cam construction, to provide low-bounce contact action. A casual inspection of the assembly might lead one to think that the contact arm bracket does not clamp on the hub as tightly as it should. However, this adjustment is accurately made at the factory and is locked in place with a lock nut and should not be changed. Optimum contact action is obtained when a force of 4 to 10 grams pressure applied to the face of the moving contact will make the arm slip from the condition of reset to the point where the clamp projection begins to ride up on the wedge. The free travel can vary between 15 to 20.

The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air-gap formed by the electromagnet and the magnetic core. The stops are an integral part of the bridge.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. This stationary contact has .002 to .006 inch follow which is set at the factory by means of the adjusting screw. After the adjustment is made the screw is sealed in position with a material which flows around the threads and then solidifies. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

When contacts close, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring and out to the spring adjuster clamp.

2.4 Directional Unit

The directional unit is an induction cylinder unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of the same basic components as the distance unit: a die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two series-connected operating coils
mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring-type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

2.5 Undervoltage Unit

The voltage unit is an induction-cylinder unit.

Mechanically, the voltage unit is composed, like the directional unit, of four components: A die-cast aluminum frame, and electromagnet, a moving element assembly, and a molded bridge.

The electromagnet has two pairs of voltage coils. Each pair of diametrically opposed coils is connected in series. In addition one pair is in series with an adjustable resistor. These sets are in parallel as shown in Figure 3. The adjustable resistor serves not only to shift the phase angle of the one flux with respect to the other to produce torque, but it also provides a pickup adjustment.
Otherwise the undervoltage unit is similar in its construction to the directional unit.

2.6 Solid State Time Delay Circuit

The telephone relay (x) is energized through a solid state time delay circuit (TD) as shown in Figure 3. The solid state time delay circuit shown in Figure 4 consists basically of an adjustable integrating RC circuit with quick reset. The RC circuit is adjusted to provide the voltage level to trigger the SCR through a multi-layer silicon switch. The SCR in turn energizes the relay.

2.7 Indicating Contactor Switch Unit (ICS)

The dc indicating contactor switch is a small clapper-type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover. The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup of the switch.

3. OPERATION

The relay is connected and applied to the system as shown if Figure 5. The directional unit closes its contacts for lagging VAR flow into the machine. Its zero torque line has been set at -13 from the R-axis. Its primary function is to prevent operation of the relay during external faults. The impedance unit closes its contacts when, as a result of reduction in excitation, the impedance of the machine as viewed from its terminals is less than a predetermined value. The operation of both impedance and directional units energizes the time delay circuit which operates the X unit after 4 ± 0.05 seconds. The operation of impedance, directional and X unit sounds an alarm, and the additional operation of the under voltage unit trips the machine. This time delay is to insure positive contact coordination under all possible operating conditions. During a seismic event which exposes the relay to a ZPA level of 5.7g, the operate time of the X unit may vary from .25 second to 1.25 seconds due to bounce induced in the Z and D contacts. During normal conditions, all contacts are open.

3.1 Principle of Distance Unit Operation

The distance unit is an induction cylinder unit having directional characteristics. Operation depends on the phase relationship between magnetic fluxes in the poles of the electromagnet.
As shown in Figure 5, one-half of $V_{23}$, voltage is physically derived in the relay at midtap of a reactor connected across voltage $V_{23}$.

Reach of the distance unit is determined by compensators $T_A$ and $T_C$ as modified by auto-transformer settings. Compensators $T_A$ and $T_C$ are designed so their mutual impedances $Z_A$ and $Z_C$ have known and adjustable values as described below under "CHARACTERISTICS" and "SETTING CALCULATIONS". The mutual impedance of a compensator is defined here as the ratio of secondary induced voltage to primary current and is equal to $T$. Each secondary compensator voltage is in series with the voltage $V_{1T}$. Compensator voltages are equal to $1.5 I_1 Z_A$ for long reach compensator and $1.5 I_1 Z_C$ for short reach compensator, where $I_1$ is the relay current.

Figure 6 shows how the compensation voltages $1.5 I_1 Z_A$ and $1.5 I_1 Z_C$ influence the R-X circle. Notice that $Z_A$ independently determines the "long reach", while $Z_C$ independently determines the "short reach". With the reversing links in the normal position (+$Z_C$) the circle includes the origin; with the opposite link position (-$Z_C$) the circle misses the origin. The following paragraphs explain this compensator action.

Referring to Figure 5 notice that resistor $R_B$ and capacitor $C_B$ cause the polarizing voltage to be shifted 90° in the leading direction. Thus, when the current is zero, polarizing voltage $V_{POL}$ leads the operating voltage $V_{OP}$ by 90° and of sufficient magnitude to operate the relay. This means the apparent impedance is along the X axis. Notice in Figure 7(b) that the $Z_A$ compensation reverses the operating voltage phase position. The relay balances when this voltage is zero. Note also this balance is unaffected by the $Z_C$ compensation, since this compensation merely increases the size of $V_{POL}$.

For lagging current conditions notice Figure 7(c) illustrates how $V_{POL}$ is reversed by the $Z_C$ compensation. In this case the $Z_A$ compensation has no effect of the balance point. This explains why the reach point is fixed independently by $Z_C$.

Figure 7 assumes that $Z_C$ is positive (circle includes origin). If the current coil link is reversed,
the compensation becomes +1.5 \( Z_C \). In Figure 7(b) this change would result in \( V_{POL} \) being reduced rather than increased by the compensation. As the current increases \( V_{POL} \) will finally be reversed establishing restraining torque. Thus, the current need not reverse in order to obtain a “short reach” balance point. Instead the apparent impedance need only move towards the origin in the - X circle region to find the balance point. Therefore the circle does not include the origin with a reversed link position.

4. CHARACTERISTICS

The type KLF relay is available in one range.

4.1 Distance Unit

The distance unit can be set to have characteristic circles that pass through origin, include it, or exclude it, as shown in Figure 6.

The \( Z_A \) and \( Z_C \) values are determined by compensator settings and modified by auto-transformer settings, S, L, and R. The impedance settings in ohms reach can be made for any value from 2.08 to 56 ohms for \( Z_A \), and from 0.79 ohm to 18 ohms for \( Z_C \) in steps of 3 percent.

The taps are marked as follows:

\[
T_A
\begin{align*}
2.4, 3.16, 4.35, 5.93, 8.3, 11.5, 15.8
\end{align*}
\]

\[
T_C
\begin{align*}
0.0, 0.91, 1.27, 1.82, 2.55, 3.64, 5.1
\end{align*}
\]

\[
(S_A, S_C)
\begin{align*}
1, 2, 3
\end{align*}
\]

\[
(M_A, M_C)
\begin{align*}
\text{values between taps .03, .06, .06}
\end{align*}
\]

4.2 Directional Unit

The KLF relay is designed for potential polarization with an internal phase shifter, so that maximum torque occurs when the operating current leads the polarizing voltage by approximately 13 degrees. The minimum pickup has been set by the spring tension to be approximately 1 volt and 5 amperes at maximum torque angle.

4.3 Undervoltage Unit

The undervoltage unit is designed to close its contacts when the voltage is lower than the set value. The undervoltage unit is energized with \( V_{1T} \)-voltage. This voltage is equal to 1.5 \( V_{1N} \) voltage. The contacts can be adjusted to close over the range of 65 to 85 percent of normal system voltage. The dropout ratio of the unit is 98 percent or higher.

4.4 Trip Circuit

The main contacts will safely close 30 amperes at 250 volts dc and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

4.5 Trip Circuit Constant

<table>
<thead>
<tr>
<th>Indicating Contactor Switch (ICS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2 ampere rating</td>
</tr>
<tr>
<td>1.0 ampere rating</td>
</tr>
<tr>
<td>2.0 ampere rating</td>
</tr>
<tr>
<td>8.5 ohm dc resistance</td>
</tr>
<tr>
<td>.37 ohms dc resistance</td>
</tr>
<tr>
<td>.1 ohm dc resistance</td>
</tr>
</tbody>
</table>

4.6 Burden

<table>
<thead>
<tr>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 amps, 60 Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( T_A ) &amp; ( T_C ) Settings</th>
<th>VA</th>
<th>Angle of LAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX.</td>
<td>18.6</td>
<td>77°</td>
</tr>
<tr>
<td>MIN.</td>
<td>3.8</td>
<td>51°</td>
</tr>
</tbody>
</table>

POTENTIAL

<table>
<thead>
<tr>
<th>120 VOLTS, 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase AB</td>
</tr>
<tr>
<td>S_A = S_C VA</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>dc Circuit</th>
<th>Watts + Rated</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>3.9</td>
</tr>
<tr>
<td>250</td>
<td>7.8</td>
</tr>
</tbody>
</table>

4.7 Thermal Ratings

Potential: 132 volts (L-L) continuous

Current: 8 amperes continuous

200 amperes for 1 second

5. SETTING CALCULATIONS

5.1 General Setting Recommendations

The KLF relay may be applied as a single-zone device, or two relays may be used to provide two-zone protection. The single-zone setting may be fully offset (Zone 1) or may include the origin (Zone 2). The two-zone application would require a
Zone 1 KLF and a Zone 2 KLF, approximately equivalent to two-zone step-distance line protection. A generalized external schematic, which is applicable to either Zone 1 or Zone 2 relays is shown in Figure 10. The recommended settings and relative advantages of these various configurations are summarized on Table 1.

The single-zone and two-zone setting recommendations are modified when two or more machines are bussed at the machine terminals. The voltage and time delay considerations are treated in detail in other sections of this leaflet. The recommended settings are outlined in Table 2.

5.2 Zone 2 Setting Calculations (Distance Unit)

Set the distance unit to operate before the steady-state stability limit is exceeded. Also, to allow maximum output without an alarm, set the distance unit to allow the machine to operate at maximum hydrogen pressure and 0.95 per unit voltage (lowest voltage for which the capability curve machine cannot be realized without exceeding the steady-state stability limit, set the distance unit to operate before the steady-state limit is exceeded. Capability curves similar to Figure 8 are obtained from the generator manufacturer.

To determine the desired setting convert the capability curve Figure 8 of the impedance curve Figure 9 by calculating \[ \frac{V_T^2}{(KVA)_C} \], where \( V_T \) is the per unit terminal voltage and \( (KVA)_C \) is the per unit output. The angle of each point on the impedance curve (from the horizontal) is the same angle as the corresponding point on the capability curve.

For example, from Figure 8, an output of 0.6 per unit KW on 30# hydrogen pressure curve is -0.4 per unit reactive KVA. Therefore,

\[
(KVA)_C = \sqrt{(0.6)^2 + (-0.4)^2} = 0.715 \text{ per unit}
\]

and,

\[
\theta = \tan^{-1}\left(\frac{-0.4}{0.6}\right) = -33.6^\circ
\]

Converting to the impedance curve:

\[
|Z| = \frac{V_T^2}{(KVA)_C} = \frac{1.0^2}{0.715} = 1.4 \text{ per unit}
\]

Since the angle remains the same, the impedance plot conversion is:

\[ Z = 1.4 \angle -33.6^\circ, \text{ as shown in Figure 9.} \]

After plotting the steady-state stability limit and the machine capability curves on the R-X diagram, plot the relay circle between the stability limit and the capability curve. (Note in Figure 9 that the relay circle cannot be plotted within the 60# -\( V_T = 0.95 \) curve, since the machine is beyond the steady-state stability limit for these conditions.) This plot defines the desired reach \( Z_A \) and radius \( R \) of the relay circle. Then use the following procedure to select tap settings.

\[
Z_{base} = \frac{1000(kv)^2 R_C}{(kva)R_Y} \text{ ohms (2)}
\]

where

\[ Z_{base} = \text{ one per unit primary ohms/ as seen from the relay.} \]
\[ kv = \text{ rated phase-to-phase voltage of the machine.} \]
\[ kVA = \text{ rated kVA of the machine.} \]
\[ R_C = \text{ the current transformer ratio.} \]
\[ R_Y = \text{ the potential transformer ratio.} \]

The actual settings, \( Z_A \) and \( Z_C \), are:

\[
Z_A = (Z_A \text{ per unit}) \times (Z_{base}) \quad (3)
\]
\[
Z_C = (Z_C \text{ per unit}) \times (Z_{base}) \quad (4)
\]

Where \( R = \text{ radius of circle in per unit.} \)

The tap-plate settings are made according to equations:

\[
Z_A(\text{or} Z_C) = \frac{TS}{1 \pm M} \quad (5)
\]

where:

\[ T = \text{ compensator tap value.} \]
\[ S = \text{ auto-transformer primary tap value.} \]
\[ M = \text{ auto-transformer secondary tap value.} \]

\( M \) is a per unit value determined by taking the sum of the values between the L and the R leads. The sign is positive when L is above R and acts to
lower the Z setting. The sign is negative when R is above L and acts to raise the Z setting).

The following procedure should be followed to obtain an optimum setting of the relay:

1. Select the lowest tap S which give a product of 18.6S_A greater than desired Z_A and a product of 6S_C greater than desired Z_C.

2. Select a value of M that will most nearly make it equal to:

\[ M = \frac{TS}{Z} - 1. \]

If the sign is negative, then the M taps are connected with the R lead above the L lead to raise the setting.

### 5.3 Sample Calculations

Assume that a KLF relay is to be applied to the following machine:

- 3-phase, 60 hertz, 3600 rpm, 18 kV, rated at 0.9 pf, 183,500 kVA at 45°H₂.
- \( R_C = 1400/1 \quad R_V = 150/1 \)

If the recommended setting from Figure 9 is used:

- \( Z_A \) per unit = 1.68
- \( Z_C \) per unit = \( 2R - Z_A = 2 \times 0.94 - 1.68 = 0.20 \)

(The relay circle in Figure 9 was obtained by trial and error using a compass to get the desired radius and offset.)

\[
\frac{1000}{1}(kv)_R \quad \frac{1000 \times (18)^2 \times 1400}{183,500 \times 150} = 16.48 \text{Ω}
\]

\[
Z_A = Z_A(\text{per unit})Z_{\text{base}} = (1.68)(16.48) = 27.6 \text{Ω}
\]

\[
Z_C = Z_C(\text{per unit})Z_{\text{base}} = (0.20)(16.45) = 3.29 \text{Ω}
\]

To set \( Z_A = 27.6 \)

Step 1: The lowest tap \( S_A \) for 18.6 \( S_A \) greater than \( Z_A = 27.6 \) is 2. Set \( S_A \) in tap 2.

Step 2: \( T_A \) nearest to \( \frac{27.6}{2} = 13.8 \) is \( T_A = 15.8 \)

Set \( T_A \) in 15.8 tap

### Step 3:

\[
M_A = \frac{T_A S_A}{Z} - 1 = \frac{15.8 \times 2}{27.6} = 1.145 - 1 = .145
\]

Set \( M = .15 \). Place R lead in 0, L lead in upper .06. The relay setting is now:

\[
\frac{1}{M + \frac{1}{1 + 0.15}} = \frac{15.8 \times 2}{31.6} = \frac{31.6}{1.15} = 27.5
\]

This is 99.7% of the desired setting.

To set \( Z_C = 3.29 \) ohms:

Step 1: The lowest tap \( S_C \) for 6 \( S_C \) greater than 3.29 is \( S_C = 1 \).

Set \( S_C = 1 \)

Step 2: \( T_C \) nearest to \( \frac{3.29}{1} = 3.29 \) is \( 3.64 \)

Set \( T_C \) in 3.64 tap.

Step 3:

\[
M_C = \frac{T_C S_C}{Z_C} - 1 = \frac{3.64 \times 1}{3.29} = 1.107 - 1 = .107
\]

Hence, the nearest \( M_C \) value is + .12. Now set R lead in 0.03 tap and L lead in the upper .06 tap.

(Since \( M_C \) has plus sign lead L must be over R.)

Then, \( Z_C = \frac{T_C S_C}{(1 + M_C)} = \frac{3.64 \times 1}{1 + 0.12} = 3.25 \text{Ω} \), or

98.8% of the desired value.

### 5.4 Undervoltage Unit

A. The undervoltage unit is usually set to a value corresponding to the minimum safe system voltage for stability. This voltage depends on many factors, but is usually between 70 and 80 percent of normal system voltage. The undervoltage unit is set at the factory for 77% of normal system voltage, or 92 \( V_{L-L} \) (equivalent to 80 volts on the undervoltage unit). In cases where each generator is equipped with its own transformer (unit connected system) the standard factory setting is usually satisfactory for the undervoltage unit.

B. In applications where multiple units are connected to the same bus, loss of field of one unit may not depress the bus voltage to the point where the undervoltage unit will operate if it has the standard setting. The following recommenda-
### TABLE 1
**RECOMMENDED SETTINGS FOR KLF RELAY**

<table>
<thead>
<tr>
<th>IMPEDANCE SETTING</th>
<th>ZONE 1 (ALONE)</th>
<th>ZONE 2 (ALONE)</th>
<th>BOTH ZONE 1 AND 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VOLTAGE SETTING</strong></td>
<td>See Figure 11</td>
<td>See Figure 12</td>
<td>See Figures 11 &amp; 12</td>
</tr>
<tr>
<td>(a) Contact shorted or</td>
<td>80%</td>
<td>Zone 1 voltage contact shorted with Zone 2 set at 80%</td>
<td></td>
</tr>
<tr>
<td>(b) Set at 80% for security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TD-1</strong></td>
<td>1/4 to 1 sec (1 sec preferred)</td>
<td>1/4 to 1 sec (1 sec preferred)</td>
<td>Zone 1 timer = 1/4 sec Zone 2 timer = 1 sec</td>
</tr>
<tr>
<td><strong>TD-2</strong></td>
<td>Not required for (a) above. For (b) above use 1 Min.</td>
<td>1 Min.</td>
<td>1 Min</td>
</tr>
<tr>
<td><strong>ADVANTAGES</strong></td>
<td>Less sensitive to stable system swings</td>
<td>1) More sensitive to LOF condition 2) Can operate on partial LOF 3) Provide alarm features for manual operation</td>
<td>(1) Same as (1), (2) and (3) at left. (2) Provides back-up protection</td>
</tr>
</tbody>
</table>

### TABLE 2
**SPECIAL SETTINGS FOR MULTI MACHINES BUSSED AT MACHINE TERMINALS**

<table>
<thead>
<tr>
<th>IMPEDANCE SETTING</th>
<th>ZONE 1 (ALONE)</th>
<th>ZONE 2 (ALONE)</th>
<th>BOTH ZONE 1 AND 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VOLTAGE SETTING</strong></td>
<td>See Figure 11</td>
<td>See Figure 12</td>
<td>See Figures 11 &amp; 12</td>
</tr>
<tr>
<td>(a) Contact shorted or</td>
<td>87%</td>
<td>Zone 1 voltage contact shorted with Zone 2 set at 87%</td>
<td></td>
</tr>
<tr>
<td>(b) Set at 87% for security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TD-1</strong></td>
<td>1/4 to 1 sec (1 sec preferred)</td>
<td>1/4 to 1 sec (1 sec preferred)</td>
<td>Zone 1 timer = 1/4 sec Zone 2 timer = 1 sec</td>
</tr>
<tr>
<td><strong>TD-2</strong></td>
<td>Not required for (a) above. For (b) above use 10 sec for cond. cooled, 25 sec for conv. cooled</td>
<td>10 sec for cond. cooled. 25 sec for conv. cooled.</td>
<td>10 sec for cond. cooled. 25 sec for conv. cooled.</td>
</tr>
</tbody>
</table>
tions should be considered:

1. For cross-compound turbine generator applications, the dropout voltage (i.e., the voltage at which the back contact of the undervoltage unit closes) of the undervoltage unit should be set for 87% of normal voltage (equivalent to 90 volts on the undervoltage unit).

2. For waterwheel generator applications, with multiple machine tied to a common bus, the dropout voltage of the undervoltage unit should be set at 87%.

3. For all applications where the alarm function is not to be used the undervoltage unit contact should be jumped (shorted).

4. For industrial applications, with two or more generators on the same bus, the undervoltage unit contact should be jumped (shorted) and the alarm circuit not used.

5. For small Synchronous condenser and large motor applications, the undervoltage unit contact should, in general, be jumped (shorted), and the alarm circuit not used. In special cases the machine may be treated as in 2, above, where knowledge exists of expected undervoltage level.

6. For gas turbine units, with high generator impedance, the undervoltage unit may not operate. For these applications the undervoltage contacts should be short circuited.

C. The desired undervoltage unit setting is computed by:

Setting = \( V_{IT} = 1.5 \cdot V_{IN} \)

where \( V_{IN} \) is phase-to-neutral voltage.

**NOTE:** An electrical check of this particular setting is outlined in this instruction leaflet, under the heading “Acceptance Check”.

5.5 Time Delay Considerations

It may be conservatively stated that the rotor structure and stator heating, as a result of a shorted field can be tolerated for 10 seconds on a conductor-cooled machine and 25 seconds for a conventional machine. This time may be as low as 5 seconds for an open field (as opposed to a field closed through a field discharge resistor or an exciter armature) and as high as one minute where the concern is protection of an adjacent tandem compound unit against partial loss-of-excitation in the faulted machine.

In view of the above considerations, it is often desirable to use an external timer in conjunction with the KLF Relay. The following examples are applications where an external timer would be desirable:

1. Cross-compound units, with undervoltage unit setting of 90 volts, should use an external timer to assure tripping before thermal damage can result. The timer is energized at the alarm output and should be set for 10 seconds for a cross-compound conductor cooled machine. For a conventionally cooled cross-compound machine, the external timer should be set for 25 seconds.

As an alternative to this, the KLF with shorted undervoltage contacts may be applied and the alarm feature not used. With this arrangement, tripping takes place after the 0.4 second time delay provided by the X unit in KLF relay.

2. Machines connected to a common high voltage bus may be protected against loss of voltage due to loss-of-excitation in an adjacent machine by using a one minute timer driven by the alarm output of the loss-of-field relay.

3. In some critical applications 2 zone loss-of-field protection may be desirable. In this case, the Zone 1 KLF impedance circle should be small and fully offset in the negative reactance region. The long-reach should be set equal to synchronous reactance, \( X_d \). The short-reach should be set equal to one-half transient reactance, \( X_{D1}/2 \). The trip circuit should trip directly, with no time delay. The alarm circuit should operate a timer which may be set from 0.4 - 1.0 seconds, depending on user preference. If the condition persists, this timer permits tripping.

The second-zone KLF may be set with a larger impedance characteristic and will detect partial loss-of-field conditions. A typical setting would be to just allow the machine to operate at maximum hydrogen pressure.
and 9.5 per unit voltage. If a low voltage condition occurs, it is recommended that tripping be accomplished through a timer set for 0.6 second. Added to the X unit operate time of 0.4 second, this gives an overall time of 1.0 second. If the voltage is maintained, then the alarm circuit should start a “last-ditch” timer. This timer may be set anywhere from 10 seconds to one minute depending on machine type and user preference.

5.6 Performance During Reduced Frequency
During major system break-ups, it is possible that the generators may be called upon to operate at reduced frequency for long periods of time. During this condition the loss-of-field relay should be secure and not over-trip for load conditions. The KLF relay has a favorable characteristic during this condition, since its tripping characteristic becomes more secure during reduced frequencies, as shown in Figure 13.

6. SETTING THE RELAY
The type KLF relay requires a setting for each of the two compensators \( T_A \) and \( T_C \), for each of the two auto-transformers, primaries \( S_A \) and \( S_C \), and for the undervoltage unit.

6.1 Compensator (\( T_A \) and \( T_C \))
Each set of compensator taps terminates in inserts which are grouped on a socket and form approximately three quarters of a circle around a center insert which is the common connection for all the taps. Electrical connections between common insert and tap inserts are made with a link that is held in place with two connectors screws, one in the common and one in the tap.

A compensator tap setting is made by loosening the connector screw in the center. Remove the connector screw in the tap end of the link, swing the link around until it is in position over the insert for the desired tap setting, replace the connector screw to bind the link to this insert, and retighten the connector screw in the center. Since the link and connector screws carry operating current, be sure that the screws are turned to bind snugly.

Compensator \( T_C \) requires an additional setting for including or excluding the origin of R-X diagram from the distance unit characteristic. If the desired characteristic is similar to that shown on Figure 6b, the links should be set vertically in the \( + T_C \) arrow direction. If a characteristic similar to that shown in Figure 6c is desired, set links horizontally in the \( - T_C \) arrow direction.

6.2 Auto-Transformer Primary (\( S_A \) and \( S_C \))
Primary tap connections are made through a single lead for each transformer. The lead comes out of the tap plate through a small hole located just below the taps and is held in place on the proper tap by a connector screw.

An S setting is made by removing the connector screw, placing the connector in position over the insert of the desired setting, replacing and tightening the connector screw. The connector should never make electrical contact with more than one tap at a time.

6.3 Auto-Transformer Secondary (\( M_A \) and \( M_C \))
Secondary tap connections are made through two leads identified as L and R for each transformer. These leads comes out of the tap plate each through a small hole, one on each side of the vertical row of M tap inserts. The lead connectors are held in place on the proper tap by connector screws.

Values for which an M setting can be made are from -.15 to +.15 in steps of .03. The value of a setting is the sum of the numbers that are crossed when going from the R lead position to the L lead position. The sign of the M value is determined by which lead is in the higher position on the tap plate. The sign is positive (+) if the L lead is higher and negative (-) if the R lead is higher.

<table>
<thead>
<tr>
<th>Z</th>
<th>M</th>
<th>L Lead</th>
<th>R Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.87 TS</td>
<td>+.15</td>
<td>Upper .06</td>
<td>0</td>
</tr>
<tr>
<td>0.89 TS</td>
<td>+.12</td>
<td>Upper .06</td>
<td>.03</td>
</tr>
<tr>
<td>0.92 TS</td>
<td>+.09</td>
<td>Lower .06</td>
<td>0</td>
</tr>
<tr>
<td>0.94 TS</td>
<td>+.06</td>
<td>Upper .06</td>
<td>.03</td>
</tr>
<tr>
<td>0.97 TS</td>
<td>+.03</td>
<td>.03</td>
<td>0</td>
</tr>
<tr>
<td>TS</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.03 TS</td>
<td>-.03</td>
<td>0</td>
<td>.03</td>
</tr>
<tr>
<td>1.06 TS</td>
<td>-.06</td>
<td>Lower .06</td>
<td>Upper .06</td>
</tr>
<tr>
<td>1.1 TS</td>
<td>-.09</td>
<td>0</td>
<td>Lower .06</td>
</tr>
<tr>
<td>1.14 TS</td>
<td>-.12</td>
<td>.03</td>
<td>Upper .06</td>
</tr>
<tr>
<td>1.18 TS</td>
<td>-.15</td>
<td>0</td>
<td>Upper .06</td>
</tr>
</tbody>
</table>

An M setting may be made in the following manner: Remove the connector screws so that the L and R leads are free. Determine from the following table the desired M value and tap positions. Neither lead connector should make electrical contact with more than one tap at a time.
6.4 Undervoltage Unit
The voltage unit is calibrated to close its contact when the applied voltage is reduced to 80 volts. The voltage unit can be set to close its contacts from 70 volts to 90 volts by adjusting the resistor located next to the directional unit (to the left of the upper operating unit). The spiral spring is not disturbed when making any setting other than the calibrated setting of 80 volts.

The undervoltage unit range of 70 to 90 volts is equivalent to 80 to 104 $V_{L-N}$ (or 67% to 87% normal system voltage). This is because the voltage on the unit is equal to 1.5 times $V_{L-N}$.

6.5 Directional Setting
There is no setting to be made on the directional unit.

6.6 Indicating Contactor Switch (ICS)
No setting is required on the ICS.

7. INSTALLATION
The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting of the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT Case information refer to I.L. 41-076.

8. ADJUSTMENTS AND MAINTENANCE
The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS," should be required.

8.1 Performance Check
The following check is recommended to insure that the relay is in proper working order. Relay should be energized for at least one hour.

A. Distance Unit (Z)

1. Connect the relay as shown in Figure 14 with the switch in position 2 and the trip circuit deenergized.

2. Make the following tap settings:
   \[ T_A = 11.5 \quad T_C = 2.55 \]
   \[ S_A = 2 \quad S_C = 1 \]
   \[ M_A = -.03 \quad M_C = -.09 \]

   $T_C$ link in middle block should be set for $+T_C$ direction.

   This setting corresponds to $Z_A = 23.7$, $Z_C = 2.80$

   Adjust the phase shifter for $90^\circ$ current lagging the voltage.

3. With the terminal voltage at 80 volts, increase current until contacts just close. This current should be within $\pm 3\%$ of 2.25 amps (2.32 - 2.18 amps). This value corresponds to 1.5 $Z_A$ setting since the voltage as applied to terminals 4 and 5 is equivalent to 1.5 $V_{IN}$ voltage, or
   \[ Z_A = \frac{V_{IN}}{11} = \frac{80}{1.5 \times \frac{1}{2.25}} = 23.7\Omega \]

4. Adjust phase shifter for $90^\circ$ current leading the voltage.

5. With the terminal voltage at 80 volts increase current until contacts just close. This current should be within $\pm 3\%$ of 19.0 amps. (19.6 - 18.4 amps.) This value corresponds 1.5$Z_C$ setting for the same reason as explained above.

5. Contact Gap
   The gap between the stationary contact and moving contact with the relay in deenergized position should be approximately 0.040".

B. Directional Unit Circuit (D)

1. Connect the relay as shown in Figure 14 with the switch in position 1 and the trip circuit deenergized.

2. With a terminal voltage of 1 volt and 5 amperes applied, turn the phase shifter to $13^\circ$ (current leads voltage). The contacts should be closed. This is the maximum torque position.

3. Raise the voltage to 120 volts and vary the phase shifter to obtain the two angles where
the moving contact just makes with the left hand contact. These two angles (where
torque reverses) should be where the current
leads the voltage by 283° and 103°, ± 4°.

4. Contact Gap

The gap between the stationary contact and
moving contact with the relay in deenergized
position should be approximately 0.020".

C. Undervoltage Circuit

1. Connect the relay as shown in Figure 14 with
switch in position 2 and the trip circuit deener-
ergized.

2. Decrease the voltage until the contacts close
to the left. This value should be 80 ± 3%
vols.

D. Reactor Check

Apply 120 volts ac across terminals 6 and 7. Mea-
sure voltage from terminal 6 to 4 and 7 to 4. These
voltages should be equal to each other within
± 1 volt.

E. Solid State Time Delay Circuit

Block the contacts of the Z unit closed. Apply 125
volts dc with positive at terminal 10 and negative at
terminal 3. Manually close the contacts of the D
unit. Using oscilloscope measure the time delay by
observing the voltage block waveform between the
relay terminal 3 (-) and terminal 1 (+). Operate time
should be 0.4 ± 0.05 second.

F. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient
dc current through the trip circuit to close the con-
acts of the ICS. This value of current should not
be greater than the particular ICS nameplate rat-
ing. The indicator target should drop freely.

Repeat above except pass 85% of ICS nameplate
current. Contacts should not pickup and tar-
get should not drop.

8.2 Routine Maintenance

All relays should be inspected periodically. They
should receive a "Performance Check" at least
once every year or at such other time intervals as
may be dictated by experience to be suitable to the
particular application. A minimum suggest check
on the relay system is to close the contacts manu-
ally so that the breaker trips and the target drops.

Then release the contacts and observe that they
open positively.

All contacts should be checked and cleaned if ne-
cessary. A contact burnisher Number 182A836H01
is recommended for this purpose. The use of abra-
sive material for cleaning contacts is not recom-
mented, because of the danger of embedding
small particles in the face of the soft silver and
thus impairing the contact.

8.3 Repair Calibration

Relay should be energized for at least one hour.

A. Auto-transformer check

Auto-transformers may be checked for turns ratio
and polarity by applying ac voltage to terminals 4
and 5 and following the procedure below.

1. Set $S_A$ and $S_C$ on tap number 3. Set the "R"
leads of $M_A$ and $M_C$ all on 0.0 and discon-
nect the "L" leads. Adjust the voltage for 90
volts. Measure voltage from terminal 5 to the
tap #1 of $S_A$. It should be 30 voltages (± 1).
From terminal 5 to tap #2 of $S_A$ should be 60
volts. The same procedure should be fol-
lowed for taps #1 and #2 of $S_C$.

2. Set $S_A$ and $S_C$ on 1 and adjust the voltage at
the relay terminals for 100 volts. Measure
voltage drop from terminals 5 to each of the
$M_A$ and $M_C$ taps. This voltage should be
equal to 100 (± 1) plus the sum of values
between R and tap being measured. Example
100 (1 + .03 +.06) = 109 volts

Transformers that have an output different from
nominal by more than 1.0 volt probably have been damaged and should be
replaced.

B. Distance Unit (Middle Unit) Calibration

Make the following tap plate settings.

$T_A = 15.8; T_C = 5.1$

$S_A = S_C = 1$

Make $M_A = M_C = .15$ settings:

"L" lead should be connected to the "O" insert.

"R" lead should be connected to the upper ".06" insert. (-.03-.06 -.06 = -.15 between L & R)

For the most accurate calibration preheat relay
for at least an hour by energizing terminals 5, 6,
& 7 with 120 volts, 3 phase.

The links in the middle tap block should be set for the +Tc direction.

1. Contact Gap Adjustment
   The spring type pressure clamp holding the stationary contact in position should not be loosened to make the necessary gap adjustments.

   With moving contact in the opened position, i.e., against right stop on bridge, screw in stationary contact until both contacts just make (use neon light for indication). Then screw the stationary contact away from the moving contact 1\(\frac{1}{3}\) turn for a contact gap of .040".

2. Sensitivity Adjustment
   Using the connections of Figure 14 apply 10 volts ac 90\(^o\) lagging, to terminals 4 and 5 pass .420 amperes through current circuit (terminals 9 and 8). The spiral spring is to be adjusted such that the contacts will just close. Deenergize the relay. The moving contact should return to open position against the right hand stop.

C. Impedance characteristic Check

1. Maximum Torque Angle
   Adjust resistor \(R_B\) (mounted on the back of the relay) to measure 8800 ohms. Applying 100 volts ac to terminals 5 and 4 and passing 5.2 amperes, through the current circuit turn the phase shifter until the moving contact opens. Turn the phase shifter back (few degrees) until contacts close. Note degrees. Continue to turn the phase shifter until contact closes again. Note degrees. The maximum torque angle should be (±3\(^o\)) computed as follows:

   Degrees to Close Contacts at Left +
   Degrees to Close Contacts at Right = 90\(^o\)

   Adjust resistor \(R_B\) until the correct maximum-torque angle is obtained.

2. Impedance Check
   a. Adjust voltage to be 90 volts.

      For current lagging 90\(^o\) the impedance unit should close its contacts at 3.12 – 3.35 amp.

      Reverse current leads, the impedance unit should close its contacts at 9.7 – 10.3 amperes.

   b. Reverse the links in the middle tap block to -Tc position. Apply current of 10 amps. The contacts should stay open. Reverse current leads to original position. The contacts should open when current is increased above 9.7 – 10.3 amperes.

   Set links back to +Tc position. Change \(S_A\) and \(S_C\) to setting “2”. Keeping voltage at 90 volts, 90\(^o\) lagging, check pick-up current. It should be 1.56 – 1.68 amperes. Now set the phase shifter so that voltage leads the current by 90\(^o\). Impedance unit should trip now at 4.85 – 5.15 amperes.

   c. Set \(T_A = 11.5\), \(T_C = 2.55\), \(S_A = 2\), \(S_C = 1\), \(M_A = -.03\) \(M_C = -.09\). Set voltage at 90 volts leading the current by 90\(^o\). Impedance unit should trip at 2.61 – 2.45 amp. Reverse current leads. Pickup should be 20.8 – 22.1 amp.

   Change \(S_A\), \(S_C = 3\). Check pickup. It should be 6.95 – 7.35 amperes. Reverse current leads. Pick-up should now be 1.74 – 1.63 amps.

D. Directional Unit (Top Unit)

1. Contact Gap Adjustment
   The spring type pressure clamp holding the stationary contact in position should not be loosened to make the necessary gap adjustments.

   With moving contact in the open position, i.e., against right stop bridge, screw in stationary contact until both contacts just make. Then screw the stationary contact away from the moving contact 3/4 of one turn for a contact gap of .022”.

2. Sensitivity Adjustment
   With reactor X having its core screwed out by about 1/8 inch apply 1.00 volt to terminals 6 and 7. Observing polarities as per schematic, and 5 amperes current leading the voltage by 13\(^o\), the spiral spring is to be
adjusted such that the contacts will just close. The adjustment of the spring is accomplished by rotating the spring adjuster which is located on the underside of the bridge. The spring adjuster has a notched periphery so that a tool may be used to rotate it. The spring type clamp holding the spring adjuster should not be loosened prior to rotating the spring adjuster.

3. Plug adjustment for Reversing of Spurious Torques
   a. Set $T_C = 0.0$. Connect a heavy current lead from $T_A$ center link to terminal 8.
   b. Short circuit terminals 6 and 7.
   c. Screw in both plugs as far as possible prior to starting the adjustment.
   d. Apply 80 amps only momentarily, and the directional unit need not be cooled during initial rough adjustment. But, the directional unit should be cool when final adjustment is made.
   e. When relay contact closes to the left, screw out the right hand plug until spurious torque is reversed.
   f. When plug adjustment is completed check to see that there is no closing torque when relay is energized with 40 amps and voltage terminals 6 and 7 short-circuited.

4. Maximum Torque Angle Check
   With 120 volts and 5 amperes applied, vary the phase shifter to obtain the two angles where the moving contacts just close. These two angles (where torque reverses) should be where the current leads the voltage by $283^\circ \pm 4$ and $103^\circ \pm 1$. Readjust the reactor $X_d$ if necessary.

E. Undervoltage Unit (Lower Unit)

NOTE: The moving contact is in closed position to the left when deenergized.

1. Contact Gap Adjustments
   a. L.H. (Normally Closed) Contact Adjustment
      With the moving contact arm in the closed position, against left hand side of bridge, screw the left-hand contact in to just touch the moving contact (use neon light for indication) and then continue for one more complete turn.
   b. R.H. (Normally Open) Contact Adjustment
      With moving contact arm against the left hand stationary contact, screw the right hand stationary contact until it just touches the moving contact. Then back the right hand contact out two-thirds of one turn to give 0.020 inch contact gap.

2. Sensitivity Adjustment
   a. Apply voltage to terminals 4 and 5. With the adjustable resistor, which is located at the upper left hand corner, set for maximum resistance (2500 ohms) adjust the spring so that contacts make (to the left) at 70 volts. The contacts should open when unit is energized with 71 or more volts.
   b. Relay is shipped with 80 volts setting. This is accomplished by lowering resistance value until contacts make at 80 volts and open when unit is energized with 81 or more volts. The spring should not be used for this setting.

F. Solid State Time Delay Circuit
   Refer to Figure 4 for the following test.
   a. Connect a jumper between the “D” contacts (top unit) and connect a switch between the D-contact and relay terminal 10.
   b. Connect a scope probe, common and external trigger to relay terminals 1, 3 and contact “D” respectively.
   c. Connect a rated dc power supply between relay terminals 10 (+) and 3 (-).
   d. Turn on the dc power supply and then turn on the switch. The voltage at terminal 1 should jump from 0 to the rated voltage after a time delay of $0.4 \pm 10\%$ seconds. A trimpot on the PC board can be adjusted to obtain the desired time delay from 0.3 to 0.5 seconds.

G. Indicating Contactor Switch (ICS)
   Initially adjust unit on pedestal so that armature fingers do not touch the yoke in the reset position. This can be done by loosening the mounting screw
in the molded pedestal and moving the ICS in the downward direction.

1. Contact Wipe. Adjust the stationary contacts so that both stationary contacts make with the moving contacts simultaneously and wipe 1/64" to 3/64" when the armature is against the core.

2. Target. Manually raise the moving contacts and check to see that the target drops at the same time as the contacts make or up to 1/16" ahead. The cover may be removed and the tab holding the target reformed slightly if necessary. However, care should be exercised so that the target will not drop with a slight jar.

3. Pickup. Unit should pickup at 98% of rating and not pickup at 85% of rating. If necessary the cover leaf springs may be adjusted. To lower the pickup current use a tweezer or similar tool and squeeze each leaf spring approximately equal by applying the tweezer between the leaf spring and the front surface of the cover at the bottom of the lower window.

If the pickup is low, the front cover must be removed and the leaf springs bent outward equally.

2. Disconnect the L-leads of sections MA and MC


4. Measure the compensator voltage with an accurate high resistance voltmeter (5000 ohms/volt).

5. Compensator A-voltage should be checked between lead LA and terminal 5.

For TA = 15.8 the voltage measured should be 23.7 volts (±3%).

6. Compensator C voltage should be checked between lead LC and the fixed terminal on the resistor which is mounted in the rear.

For TC = 5.1, the voltage should be 76.5 volts (±3%).

7. For all other taps the compensator voltage is 1.5IT (±3%).

   Where I = relay current
   T = tap setting

H. Compensator Check

Accuracy of the mutual impedance T of the compensators is set within very close tolerances at factory and should not change under normal conditions. The mutual impedance of the compensators can be checked with accurate instruments by the procedure outlined below:

1. Set TA on the 15.8 tap
   TC on the 5.1 tap

9. RENEWAL PARTS

Repair work can be done and the relay recertified most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data. Note that replacement parts are not “certified” and repair work done outside the factory can not be certified by ABB.
Figure 8. Typical Machine Capability Curves
Figure 9. Typical Machine Capability Curves and Sample KLF Relay Setting
Figure 10. Generalized External Schematic

Figure 11. Zone 1 Impedance Characteristic
Figure 12. Zone 2 Impedance Characteristic

NOTE - FOR 50 HZ RELAY ALL FREQUENCY VALUES SHOULD BE MULTIPLIED BY A FACTOR OF 0.8333

Figure 13. KLF Frequency Response for Impedance Unit
Figure 14. Diagram of Test Connections for KLF Relay
Figure 15. Outline and Drilling Plan for the Type KLF Relay in the FT-41 Case