



KD-10 (0.75 – 21.0 ohm)

SCOPE

This test procedure covers the testing and maintenance of the Westinghouse KD-10 medium reach (.75–21.0 ohm range) relay. The Westinghouse Protective Relay Division was purchased by ABB, and new relays carry the ABB label. The phase to phase potential rating of this relay is 120 Vac and the continuous current rating is 10 amps with a one second rating of 240 amps. Refer to IL 41-490 for testing support and component level identification.

SAFETY

KD relays are heavy and often become extremely warm during operation. They are also often mounted in a location that makes them awkward to handle. Use caution to avoid injury when pulling and returning the relays from their cases.

Current-shortening test switches used for KD relays may malfunction and develop high voltage levels. Use caution when using the test switches; make sure they are functioning properly.

Inductors and capacitors on KD relays accumulate high voltage levels during operation and testing. Use extreme caution when handling an energized relay.

Older KD relays contain capacitors with PCB-contaminated electrolyte. Treat any spilled liquid from the capacitors as if it were PCB-contaminated.

INTRODUCTION

KD relays are polyphase compensator electro-mechanical relays that provide single-zone phase protection for all three phases. They provide instantaneous tripping for phase-to-phase faults, two-phase-to-ground faults, and three-phase faults within the reach setting and sensitivity level of the relay. Figure 3 show an internal schematic of the medium reach (0.75 – 21.0 ohm) relay.

The component most likely to fail in a KD relay is the C3C capacitor. Failure is caused by voltage stress in a series resonant memory circuit. A three-phase unit with a maximum torque angle that cannot be adjusted to meet specifications may indicate failure of this capacitor.

Removing KD relays for testing may leave portions of a transmission line unprotected. If removing a relay leaves a transmission line unprotected; then the relay should be replaced with another one during testing.

TOOLS, EQUIPMENT, AND MATERIALS

- Two or three variable ac voltage / current, variable phase-angle sources
- Variable dc current source
- Phase angle meter

INSPECTION

1. Take the cover off the relay, taking care to not shake or jar the relay or other relays around it.
2. Open the relay test switches to disable the trip circuit and remove the voltage and current inputs.
NOTE: Open the trip output circuit first. Disconnecting the voltage inputs may cause the relay to operate.
3. Lift the relay out of the case.
4. Visually check the relay for any obvious problems.
5. Clean the relay thoroughly.
6. Burnish the surfaces of all contacts. Be sure to remove any tarnish.
7. Check that all relay connections are tight.
NOTE: The current input hardware on Westinghouse relays is frequently loose and requires special attention.
8. Check that there is vertical free play in three phase and phase to phase contact assemblies. The upper pin bearing should be screwed down until there is approximately 0.025 inch between it and the top of the shaft bearing. One complete turn back off from a touching of the upper pin bearing and shaft bearing should be sufficient.
9. Check that the contact gap on the three-phase unit and phase-to-phase unit is 0.020 inches. Adjust the gap setting if necessary. Two thirds of a turn back off from a touching of the stationary and moving contact should be sufficient. (Use a 0.020-inch feeler gauge.)
10. After the mechanical checks have been made, ensure that the contacts move freely. With AC voltage removed from the relay, the movable contacts should have positive opening restraint. You should be able to lightly blow on a movable contact to close the contact and it should return open. (See IL 41-490 for minimum movement specifications)
11. Testing of this relay is best performed while the relay is warm (energized for a period of time), level, and in case.

TESTING THE THREE PHASE UNIT

1. Prepare the test setup as shown in Figure 2.
2. Monitor contact continuity at Terminals 10 and 20.
3. Choose a fault voltage level that is between 10 volts phase to phase and a voltage that will prevent an over range of current for the test set in use. Optimally, a voltage of 30 volts or greater that requires between 5 and 10 amps of test current should be used. Use the relay settings to calculate the appropriate pickup current with the chosen fault voltage level. Formulas for calculation of the relay impedance setting and fault currents are shown on page 10.
4. Initiate the voltages and current as calculated with the current lagging the A-N voltage by 75 degrees (maximum torque angle). Step increase the current until the three-phase unit just picks up.
5. If the measured pickup current varies more than 3% (+/-) from the calculated pickup current, adjust the maximum torque angle and relay core as specified in the Maximum Torque Angle Adjustment Procedure, Three-phase Unit, and the Core Adjustment Procedure, Three-phase Unit.
6. Initiate test quantities with the current set approximately 20% higher than the pickup point.
7. Adjust the current phase angle until the three-phase unit drops out in the clockwise direction; then adjust the current phase angle until the three-phase unit drops out in the counterclockwise direction.
8. Calculate the average of the phase angles at the two dropout points.
NOTE: The resulting figure is the maximum torque angle (MTA).
9. Check that the maximum torque angle measured is consistent with the maximum torque angle listed on the relay or in the relay instruction manual. (It may deviate by 2 degrees.)

If the maximum torque angle varies by more than 2 degrees (+ /-), adjust the maximum torque angle and relay core as specified in the Maximum Torque Angle Adjustment Procedure, Three-phase Unit, and the Core Adjustment Procedure, Three-phase Unit.

TESTING THE PHASE TO PHASE UNIT

1. Prepare the test setup as shown in Figure 2.
2. Monitor contact continuity at Terminals 10 and 11.
3. Choose a fault voltage level that is between 10 volts phase to phase and a voltage that will prevent an over range of current for the test set in use. Optimally, a voltage of 30 volts or greater that requires between 5 and 10 amps of test current should be used. Use the relay settings to calculate the appropriate pickup current with the chosen fault voltage level. Formulas for calculation of the relay impedance setting and fault currents are shown on page 10.
4. Starting with an A-B test, initiate the voltages and current as calculated, with the current lagging the A-N voltage by 45 degrees (lagging the A-B voltage by 75 degrees). Step increase the current until the phase to phase unit just picks up.
5. If the measured pickup current varies by more than 3% (+ /-) from the calculated pickup current, adjust the maximum torque angle and relay core as specified in the Maximum Torque Angle Adjustment Procedure, Phase-to-phase Unit and the Core Adjustment Procedure, Phase-to-phase Unit.
6. Set the current approximately 20% higher than the pickup point.
7. Adjust the phase angle until the phase-to-phase unit drops out in the clockwise direction. Then adjust the phase angle until the phase-to-phase unit drops out in the counterclockwise direction.
8. Calculate the average of the phase angles at the two dropout points.
NOTE: The resulting figure is the maximum torque angle (MTA).
9. Check that the maximum torque angle measured is consistent with the maximum torque angle listed on the relay or in the relay instruction manual. (It may deviate by 2 degrees.)

If the maximum torque angle varies by more than 2 degrees (+ /-), adjust the maximum torque angle and relay core as specified in the Maximum Torque Angle Adjustment Procedure, Phase-to-phase Unit and the Core Adjustment Procedure, Phase-to-phase Unit.
10. Repeat Steps 4 through 9 for the B-C and C-A phase tests. Shift the fault voltages and currents accordingly.

TESTING THE TARGET AND SEAL-IN

1. Pick up the target unit manually and ensure that the contacts have a 1/32-inch wiper and that the target drops freely when the contacts pick up.
If necessary, adjust the target unit so the target drops freely when the unit picks up.
2. Prepare the test setup as shown in Figure 1.
3. Hold the three-phase trip target contacts closed and raise the dc current until the target unit just picks up. Then verify that the target drops smoothly.
NOTE: The pickup current should meet the specifications listed in Table 1.
4. Release the trip contact and verify that the target unit remains sealed in.
5. Lower the dc current until the target unit drops out.
NOTE: The dropout current should meet the specifications listed in Table 1.
6. Repeat Steps 3 through 5 for the phase-to-phase trip target unit.

Figure 1

Target Unit schematic

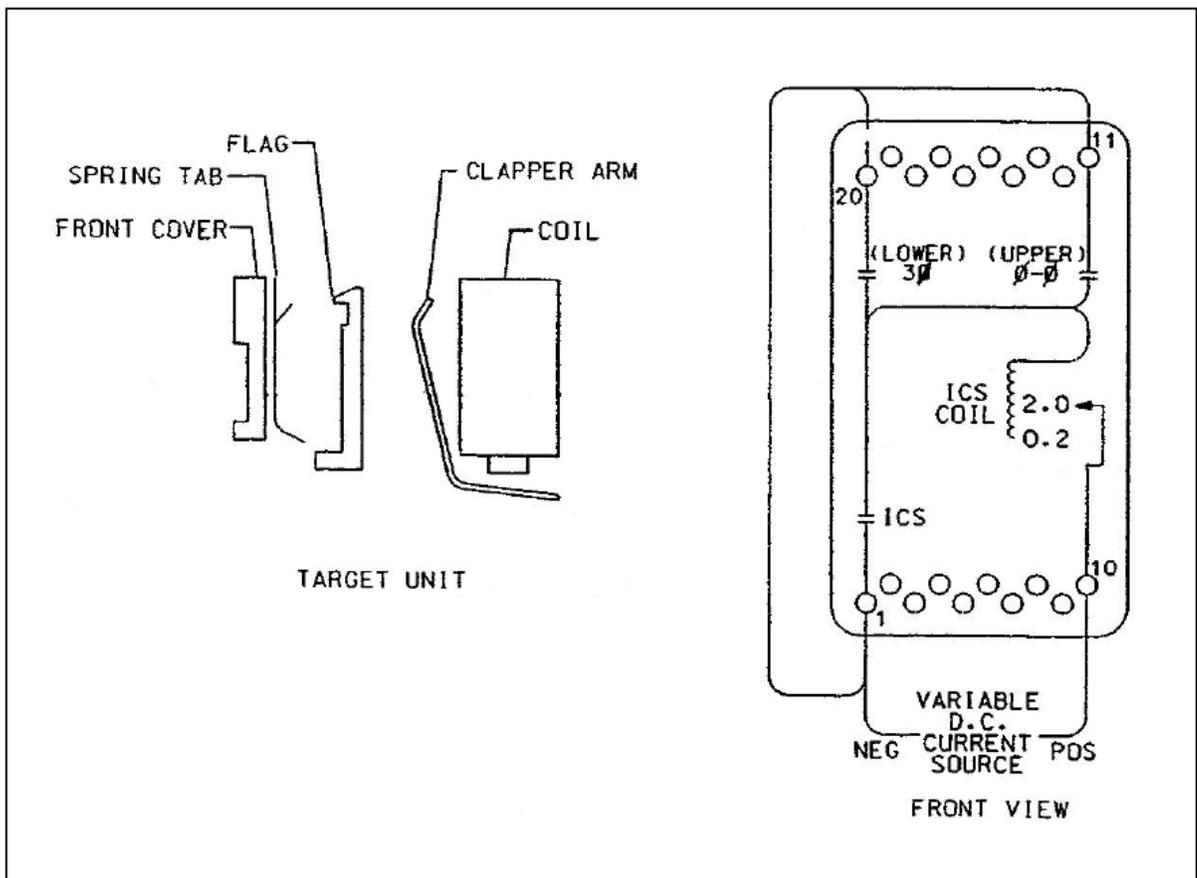


Table 1

Target Unit Specifications

Tap Setting	Pickup Current	Dropout Current
0.2	0.15 to 0.195 A	0.05 A or more
2.0	1.50 to 1.95 A	0.55 A or more

MAXIMUM TORQUE ANGLE ADJUSTMENT

Three Phase Unit

1. Lift the “L” lead from the secondary winding on the M autotransformer.
2. Hook the voltage channel polarity to the “L” lead and the voltage channel non-polarity to the side of R3 with multiple leads.
3. Hook the current source polarity through the phase angle meter to Terminal 19 on the relay.
4. Hook the current source non-polarity to Terminal 18 on the relay.
5. Pass 10A through the relay and phase angle meter.
NOTE: The voltage induced in the secondary winding of compensator T will be approximately the product of T tap and the current multiplied by 1.5. Adjust P3 until the maximum torque angle meets specifications.

Phase to Phase Unit

1. Lift the “L” leads from the MA and MC autotransformers.
2. Hook the current source polarity through the phase angle meter to Terminal 14 on the relay.
3. Hook the current source non-polarity to Terminal 15 on the relay.
4. For compensator TAB, hook the voltage channel polarity to the “L” lead on the MA autotransformer and the voltage channel non-polarity to the side of R2A with multiple leads.
5. Pass 10A through the relay and phase angle meter.
NOTE: The voltage induced in the secondary winding of the TAB compensator will be approximately the product of T tap and the current. Adjust P2A until the phase angle equals the maximum torque angle desired.
6. For compensator TBC, hook the voltage channel polarity to the “L” lead on the MC autotransformer and the voltage channel non-polarity to the side of R2C with multiple leads.
7. Pass 10 A through the relay and phase angle meter.
NOTE: The voltage induced in the secondary winding of the TAB compensator will be approximately the product of T tap and the current. Adjust P2C until the maximum torque angle meets specifications.

CORE ADJUSTMENT

Three Phase Unit

1. Disconnect the test current leads.
2. Adjust the spring tension on the three phase contact assembly until the movable contact just floats.
3. Jumper Terminal 8 to the front lead on C3C.
4. Apply 120 V to Terminals 7 and 8.
5. Adjust the core until the movable contact just floats or restrains very slightly.
NOTE: During the core adjustment there may be multiple points at which the contact will float.
6. Remove the jumper.
7. Jumper Terminal 7 to Terminal 9 and apply 120 V to Terminals 7 and 8. Adjust P3A (fine-adjustment resistor) and R3F (coarse-adjustment resistor) until the contact just floats or restrains very slightly.
NOTE: Decreasing resistance moves the contact to the right; increasing resistance moves the contact to the left.
8. Jumper terminals 7, 8 and 9 together.
9. Inject 5 amps to 30 amps from Terminal 18 to Terminal 19 in convenient steps. The three phase contacts should remain open. If the contacts close, repeat steps 3 through 5 at an alternate core adjustment null point.
10. Readjust the spring tension and check contact gap.

Phase to Phase Unit

1. Disconnect the test current leads.
2. Adjust the spring tension on the phase to phase contact assembly until the movable contact just floats.
3. Determine which circuit the XLAC reactor is in (phase A or phase C).

We must first verify the physical position of the C2A and C2C capacitors. Some KD10 relays have these two capacitors reversed from what the factory IL shows.

- a. Lift the “L” leads from the MA and MC autotransformers.
- b. Measure the resistance between each “L” lead and the back side (multiple lead side) of C2A and C2C.

NOTE: The resistance is approximately 800 K-ohms +/- in respective circuits (MA “L” lead to C2A and MC “L” lead to C2C)

- c. Make note of the capacitor positions and reconnect the “L” leads to the MA and MC autotransformers
 - d. Measure the resistance between Terminal 8 and the front side of C2A and C2C to determine which circuit the XLAC reactor is in (phase A or phase C).
NOTE: The resistance in the circuit with the XLAC reactor is approximately 180 ohms +/-.
4. In the circuit with the XLAC reactor, jumper out the winding resistor RA (mid left side above R2A) or RC (mid right side below R2C).
NOTE: This will short out the movement winding in one circuit.
 5. Apply 120 V to the circuit not containing the XLAC reactor (Terminals 7 and 8 for A phase; Terminals 8 and 9 for C phase).
 6. Adjust the core until the movable contact just floats.
NOTE: Temporary removal of the two tap block support screws will give a bit of play to the tap block and allow easier access to the phase to phase core screw.
 7. Remove the jumper.
 8. Jumper Terminal 7 to Terminal 9 and apply 120 V to Terminals 7 and 8. Adjust reactor XLAC until the movable contact just floats.
 9. Readjust the spring tension and check contact gap.

Figure 2
Test Setup

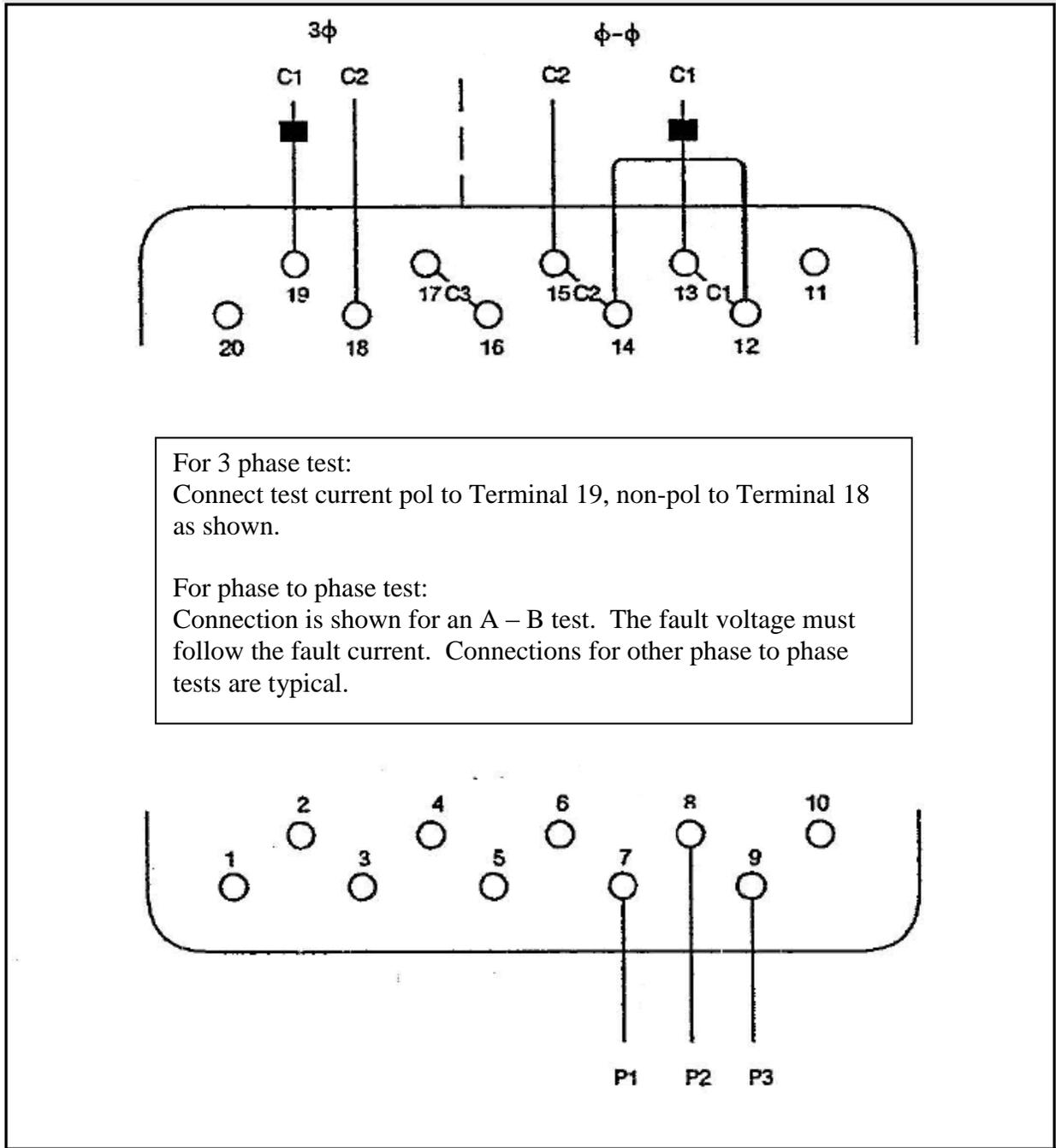


Figure 3
 KD-10 (0.75 – 21.0 ohm) Internal Schematic

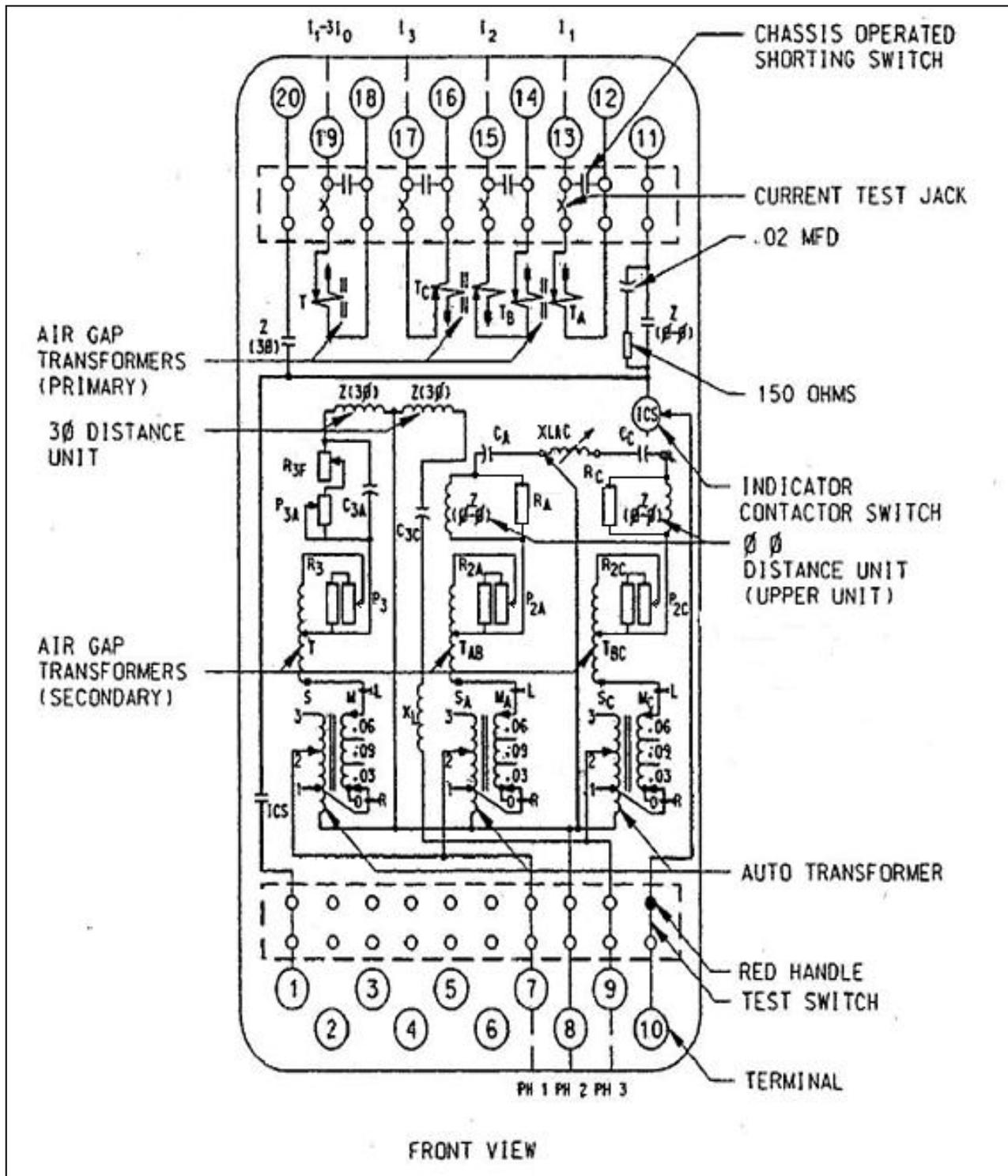
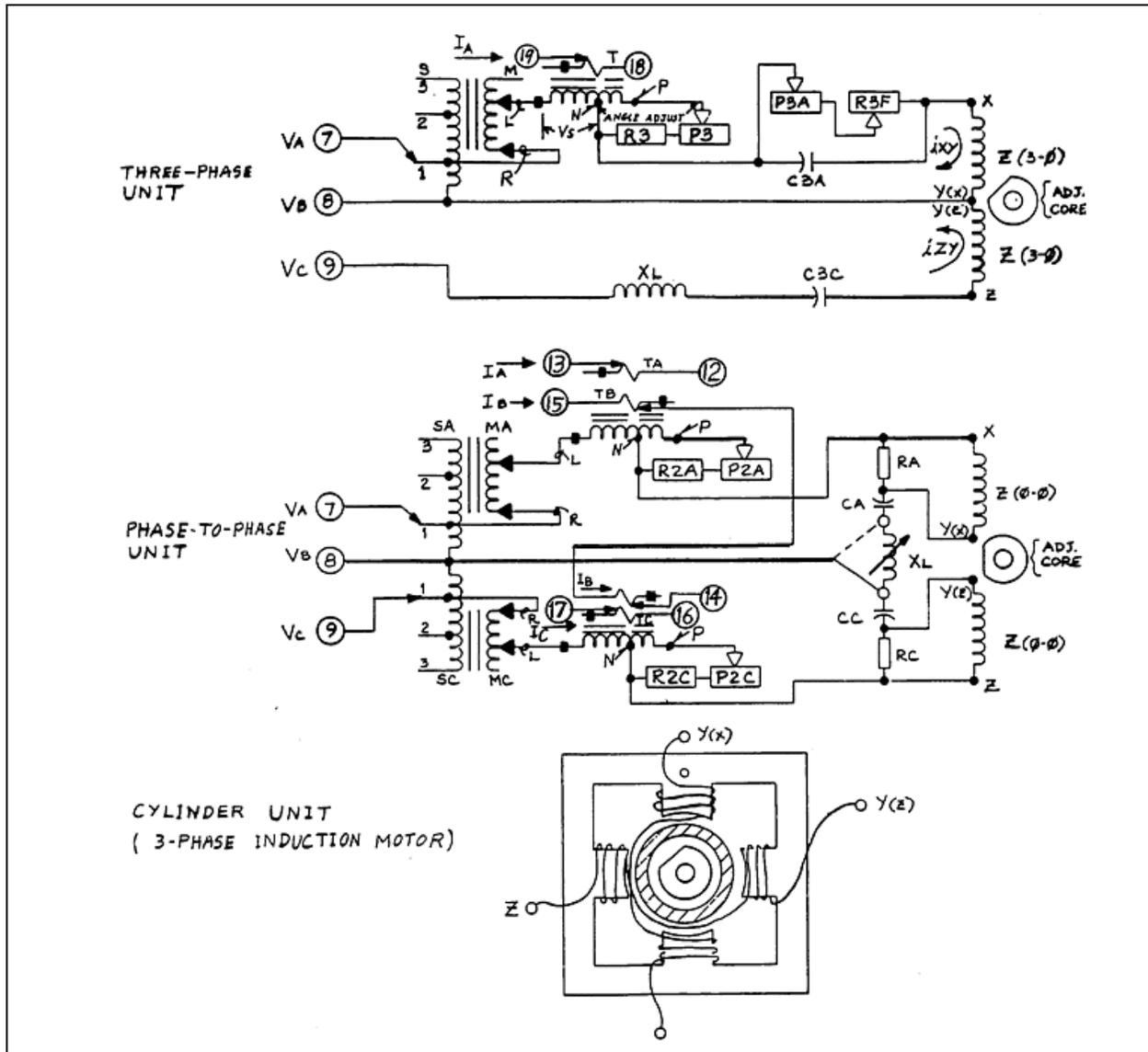


Figure 4

- KD-10 (0.75 – 21.0 ohm) 3 Phase and Phase to Phase Component Schematic



Setting and testing formulas:

Relay setting calculation

$$Z_{Setting} = \frac{ST}{1 \pm M}$$

Impedance measured by 3 phase unit

$$Z_r = \frac{V_{L-L}}{\sqrt{3} \times I_L} \quad I_L = \frac{V_{L-L}}{\sqrt{3} Z_{Setting}}$$

Impedance measured by phase to phase unit

$$Z_r = \frac{V_{L-L}}{2 \times I_L} \quad I_L = \frac{V_{L-L}}{2 \times Z_{Setting}}$$

Typical calculations from line data

Line Data from Station A to Station B:

$$\begin{aligned} \text{PRI OHMS} &= 1.620 + j9.534 \\ &= \mathbf{9.671 @ 80.36 \text{ deg}} \end{aligned}$$

$$\begin{aligned} \text{SEC OHMS} &= 9.671 @ 80.36 * (\text{CT} / \text{PT}) \\ &= 9.671 @ 80.36 * 400 / 1000 \\ &= \mathbf{3.868 @ 80.36 \text{ deg}} \end{aligned}$$

$$\begin{aligned} \text{ZONE 1 SETTING} &= 90\% \text{ of line} \\ &= 0.9 * 3.868 @ 80.36 \text{ deg} \\ &= \mathbf{3.481 @ 80.36 \text{ deg (sec ohms at line angle)}} \end{aligned}$$

The MTA of the relay is 75 degrees so we need to convert the line secondary ohms at 80.36 degrees to relay ohms at 75 degrees.

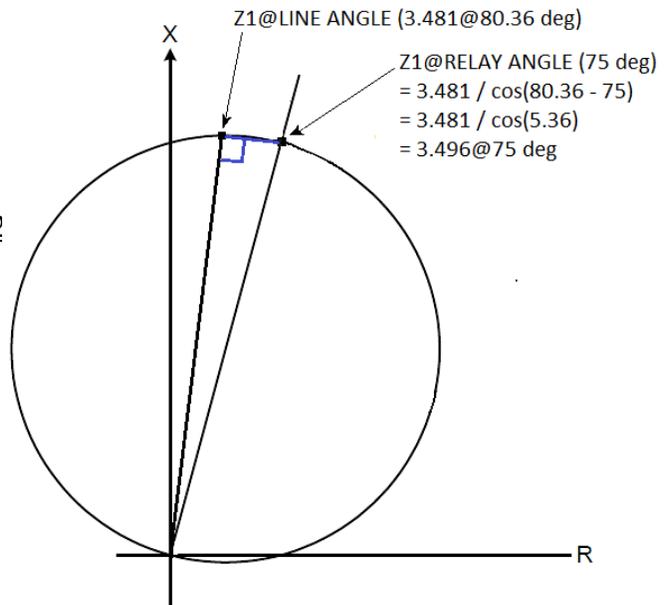
NOTE: Line segments originating at the diameter end of a circle will intersect the circle at a 90 degree angle from opposite diameter end.

$$\begin{aligned} \text{RELAY OHMS} &= 3.481 / \cos(80.36 - 75) \\ &= 3.481 / \cos(5.36) \\ &= \mathbf{3.496 @ 75 \text{ deg}} \end{aligned}$$

Relay settings for 3.496 ohms from IL Table#2

The closest we can get is 3.53 ohms:

$$\begin{aligned} \text{S} &= 1 \\ \text{T} &= 4.06 \\ \text{M} &= +0.15 \end{aligned}$$



Picking a fault voltage level of 40 Vac phase to phase

Three Phase Testing

$$\begin{aligned} I &= E_{L-L} / (\text{sqr}(3) * Z) \\ &= 40 / (\text{sqr}(3) * 3.53) \\ &= \mathbf{6.54 \text{ amps}} \end{aligned}$$

Phase to Phase Testing

$$\begin{aligned} I &= E_{L-L} / (2 * Z) \\ &= 40 / (2 * 3.53) \\ &= \mathbf{5.67 \text{ amps}} \end{aligned}$$