EEL3060

Power Engineering Lab

Single Phase Distance Protection Relay

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By:

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I. Objective

To study the single-phase distance protection Relay.

II. Apparatus

- Rheostat (50Ω, 5 Amp)
- Lamp Load
- Connecting Wires
- Distance Protection Relay System Experimental Panel
- Power Supply

III. Theory

1. What is Distance Relay?

A distance relay is a protective device used in power systems to detect faults based on the distance of the fault point from the relay location. It calculates impedance using voltage and current measurements. If the measured impedance falls below a set threshold, the relay operates to isolate the faulty section.

2. Distance Relay Characteristics

The characteristics of a distance relay are represented on an RX diagram. The impedance of the transmission line is shown as a circle with radius Z. The relay operates in quadrants where fault impedance is greater than normal impedance and does not operate where restoring torque is greater than deflecting torque. The primary characteristics include:

- Operation based on measured impedance.
- Quadrant-based fault discrimination.
- Used for short, medium, and long transmission lines.

3. Types of Relays

- **Reactance Relay:** Operates based on reactance; ignores resistance.
  - **Advantages:** Fast response, immune to arc resistance.
  - **Disadvantages:** Not suitable for long transmission lines.
- **Impedance Relay:** Uses both resistance and reactance for fault detection.
  - **Advantages:** Can include a directional element for better performance.

  - **Disadvantages:** Non-directional, prone to maloperation.

- **Mho Relay:** Best suited for long transmission lines; responds to resistive and reactive faults.
  - **Advantages:** Well-defined fault area, directional.
  - **Disadvantages:** Not suitable for short transmission lines.

4. Relay Panel

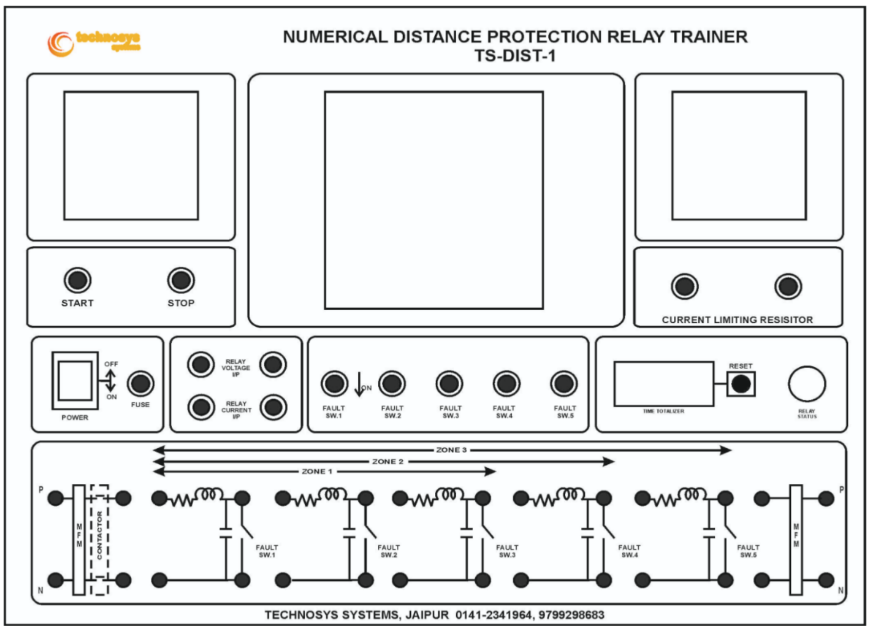

Figure 1: Relay Panel

5. Configurations of Setup Used in Lab

The experimental setup consists of three protection zones:

- **Zone 1**: Three relays at distances of 100 km, 200 km, and 300 km with a delay of 0 ms.
- **Zone 2**: One relay at 400 km with a delay of 200 ms.
- **Zone 3**: One relay at 500 km with a delay of 400 ms.

Table 1: Relay Protection Zones

Zone	**Forward Resistance (Ω)**	**Forward Reactance (Ω)**	**Backward Resistance (Ω)**	**Backward Reactance (Ω)**
1	55.10	30.80	55.10	19
2	50	22	50	23.5
3	17.93	25	55	30

- **Relay Current Angle (RCA)**: 45 degrees for all zones.
- **Line Impedance**: 35 milli-Ohms for each zone.

IV. Experimental Procedure

Steps

1. Connect the circuit as per the provided schematic.
2. Attach the 50-ohm rheostat to the terminals where faults will be simulated.
3. Program the relay according to the lab manual settings.
4. Connect the bulb load at the transmission line end.
5. Power on the system using the 2-pole MCB and press the START button.
6. Observe the lamp glowing, indicating a healthy system.
7. Apply faults by switching on the fault switch at different points along the transmission line.
8. Record the relay trip status for each fault occurrence.
9. Reset the relay using the central push button after each test.

Cirucit Diagram

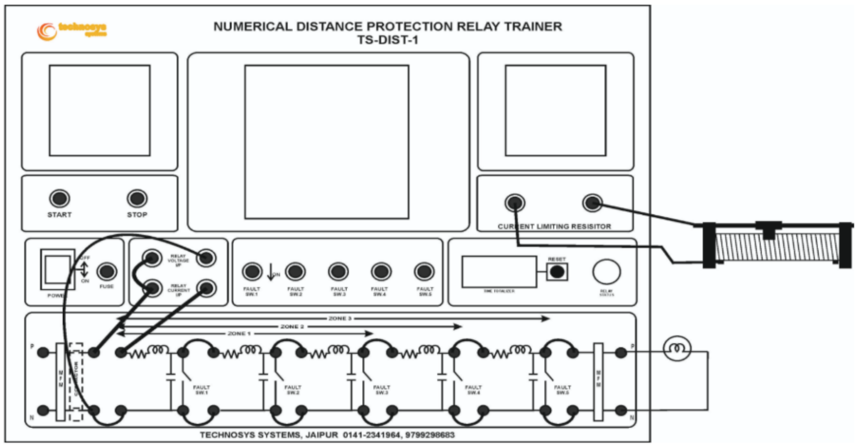

Figure 2: Circuit Diagram

Observation Table

Table 2: Observation Table

Trip Switch	R (Ω)	X (Ω)	V (V)	Observed I (A)	Distance (km)	Calculated Distance (km)
S1	42.6	4.9	233.9	5.5	100	99.009
S2	45.1	8.6	231.6	5.0	173	173.746
S3	48.0	15.6	231.8	4.6	315	315.170
S4	50.4	19.9	232.5	4.3	403	402.040
S5	53.0	24.4	234.9	4.0	492	492.950

Calculations

$$\text{Fault Distance} = \frac{X}{\text{Line Impedance}} \times \sin(\text{RCA})$$

$$\text{Fault Impedance} = \frac{V}{I} \;\text{ OR }\; \sqrt{R^2 + X^2}$$

For Trip Switch 1:

$$\text{Fault Distance} = \frac{4.9}{35 \times 10^{-3}} \times \sin(45) = 99.009\, km$$

$$\text{Fault Impedance} = \frac{233.9}{5.5} = 42.53\,\Omega$$

For Trip Switch 2:

$$\text{Fault Distance} = \frac{8.6}{35 \times 10^{-3}} \times \sin(45) = 173.746\ km$$
$$\text{Fault Impedance} = \frac{231.6}{5.0} = 46.32\ \Omega$$

For Trip Switch 3:

$$\text{Fault Distance} = \frac{15.6}{35 \times 10^{-3}} \times \sin(45) = 315.170\ km$$
$$\text{Fault Impedance} = \frac{231.8}{4.6} = 50.39\ \Omega$$

For Trip Switch 4:

$$\text{Fault Distance} = \frac{19.9}{35 \times 10^{-3}} \times \sin(45) = 402.040\ km$$
$$\text{Fault Impedance} = \frac{232.5}{4.3} = 54.07\ \Omega$$

For Trip Switch 5:

$$\text{Fault Distance} = \frac{24.4}{35 \times 10^{-3}} \times \sin(45) = 492.950\ km$$
$$\text{Fault Impedance} = \frac{234.9}{4.0} = 58.72\ \Omega$$

V. Results & Conclusion

The experiment successfully demonstrated the working principle of a single-phase distance protection relay. The relay responded correctly to faults occurring at different distances along the transmission line, based on preset impedance values. The observations confirmed the theoretical expectations regarding relay operation zones and tripping behavior.