Performing distance protection for overhead lines using DIGSILENT

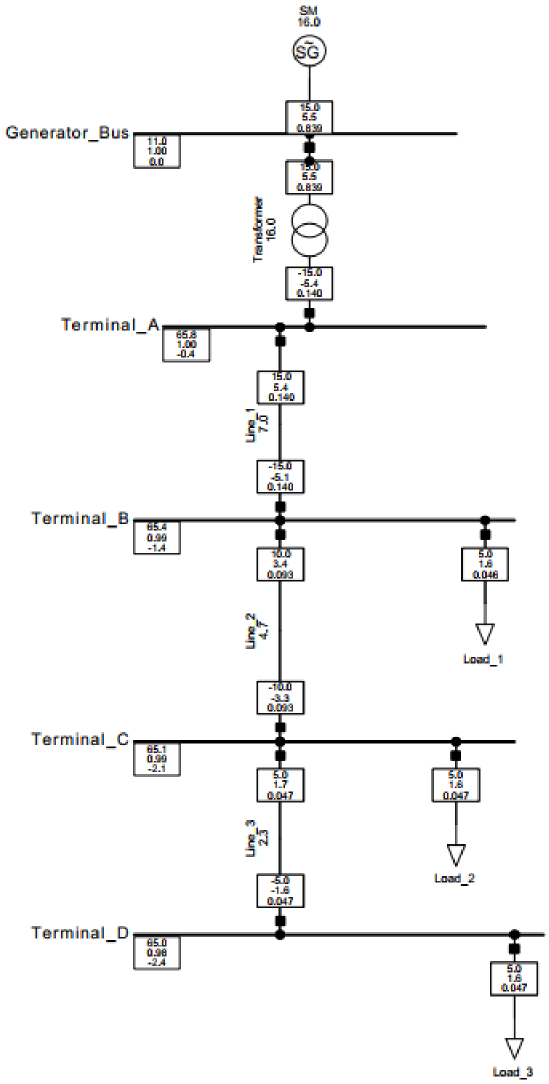

Figure 1. Test system

Data Details

Table 1:Generator data

Voltage: 11kV	Xd''=0.2 p.u, Xd'=0.3 p.u.	Size: 100MVA, 0.8 power factor

Table 2:Line data (pi-Model)

Line_1	Length: 10kms	R_{20}=0.01 Ω/km, X=0.5 Ω /km	Ampacity = 2000A

All lines have the same data as given in Table 2. Model

Table 3:Transformer data

Low Voltage: 11kV High Voltage: 66kV	Reactance (X) =5% p.u	Size: 100MVA

Load data: P=5MW @0.95 pf lagging.

Deciding CTs and PTs ratios

For relay at Terminal A, the maximum load current assuming 25% overload is

140+25% of 140 A

=175A

Assuming 1 Ampere relay to be used, the CT ratio can be selected to be 200:1. The voltage at Terminal A is 66KV, the PT ratio is selected as 66KV/110 Volts.

For Zone setting at Terminal A

Impedance of each lines (Z)= (0.1+j0.5)*10 =0.1+j5

Zone 1

= 80% of Z = 0.8*(0.1+j5) =0.08+j4 =4<88.85

Zone 2

=Z+50% of Z =0.1+j5+0.5*(0.1+j5) =0.15+J7.5 =7.5<88.85

Zone 3

=Z+Z+30% of Z = 0.1+j5+0.1+j5+0.3*(0.1+j5) =0.23+j11.5 =11.5<88.85

In secondary terminals impedance values are;

$Z_1 = \frac{CTR}{PTR} \times Z = \frac{\frac{200}{1}}{\frac{66 \times 10^3}{110}} \times 4\angle 488.85$ =1.33<88.85

$Z_2 = \frac{CTR}{PTR} \times Z = \frac{\frac{200}{1}}{\frac{66 \times 10^3}{110}} \times 7.5\angle 488.85$= 2.5<88.85

$Z_3 = \frac{CTR}{PTR} \times Z = \frac{\frac{200}{1}}{\frac{66 \times 10^3}{110}} \times 11.5\angle 488.85$ =3.83<88.85

For mho relay

$$K_1 = \frac{Z_1}{\cos(\varphi - \theta)} = \frac{1.33}{\cos(88.85 - 75)} = 1.3698$$

$$K_2 = \frac{Z_2}{\cos(\varphi - \theta)} = \frac{2.5}{\cos(88.85 - 75)} = 2.574$$

$$K_3 = \frac{Z_3}{\cos(\varphi - \theta)} = \frac{3.83}{\cos(88.85 - 75)} = 3.944$$

Results

1) Plot R-X diagram for faults at zone 1, zone 2, zone 3

When fault is applied at 40% of line in between Terminal A and Terminal B.

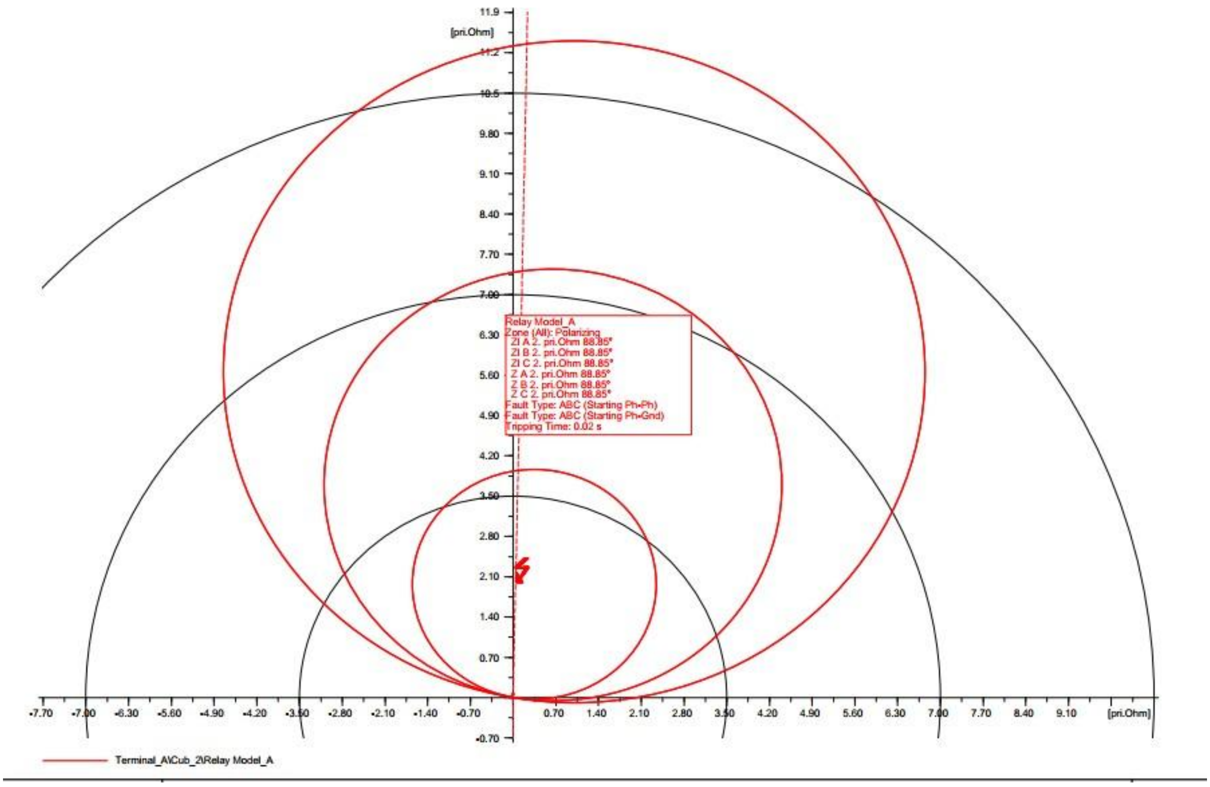

Figure 2. R-X diagram of mho relay for fault at zone 1

When fault is applied at 40% of line in between Terminal B and Terminal C.

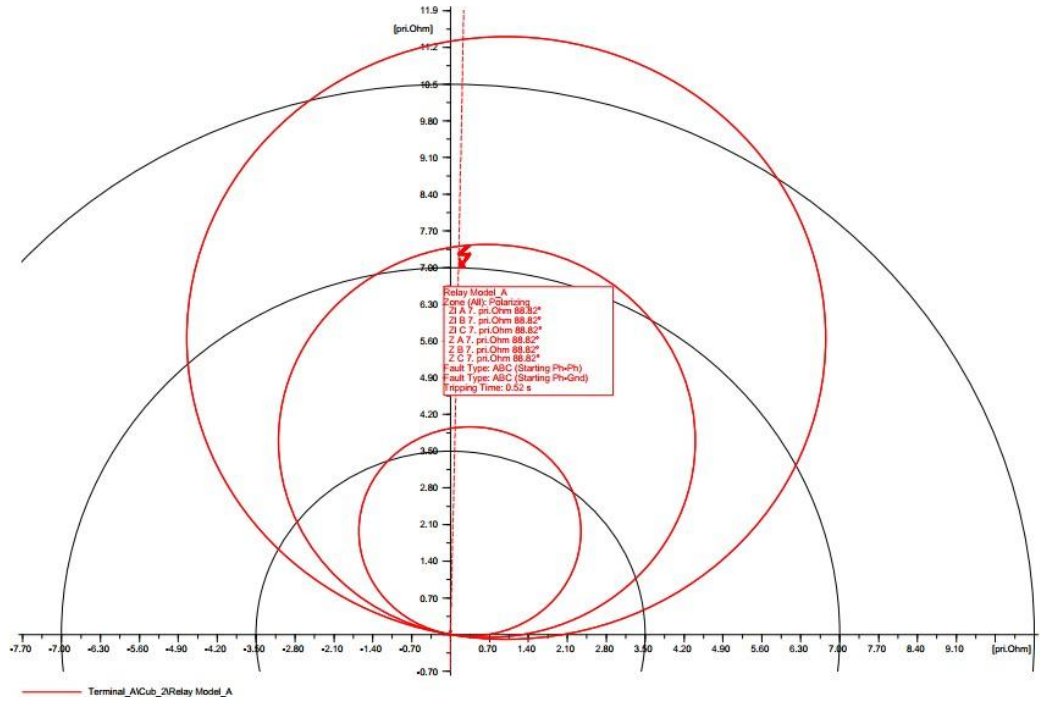

Figure 3. R-X diagram of mho relay for fault at zone 2

When fault is applied at 10% of line in between Terminal B and Terminal C.

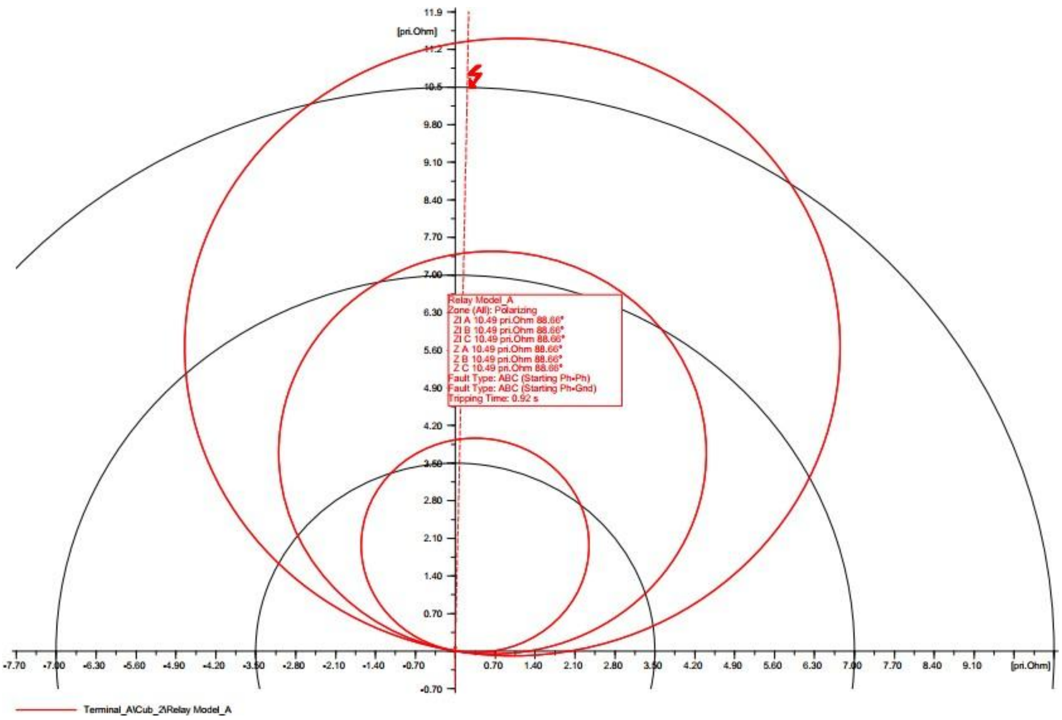

Figure 4. R-X diagram of mho relay for fault at zone 3

2) **Summarize distance relay settings**

Table 1. Distance relay setting summary

	Substation A
21	PT: 66,000/110 V CT: 200/1 A Zone1: 4Ω Zone 2: 7.5Ω Zone 3: 11.5Ω MTA: 70

Conclusion

The Mho Relay (Distance Relay) was used to implement distance protection for overhead transmission lines, and it was observed that faults were accurately detected in different zones based on distance or impedance. Zone 1 had the fastest fault clearance time of 0.02s, followed by Zone 2 at 0.52s, and Zone 3 at 0.92s. If the fault occurred outside of these zones, it was not detected by the Distance Relay, and fault clearance took an extremely long time of 9999.99s, which is beyond its intended scope. Therefore, it can be concluded that the Distance Relay Setting was properly adjusted