

Experiment

3a

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19EE10039

Verification of Directional relay characteristics

- Q3. For 2 datasets, directional overcurrent relay characteristics were plotted:

Case ①

$$\beta = 750^\circ, \gamma = 30^\circ, I_{\text{fault}} = 2.67A$$

$$I_{\text{nom}} = 5A, I_S = 0.3 I_{\text{nom}} = 1.5A$$

Trip region is observed between -27° to 149° , and block region from 149° to 333° .

Observed plot agrees with theoretical parameters.

Case ②

$$\beta = 170^\circ, \gamma = 110^\circ, I_{\text{fault}} = 2.67A$$

$$I_{\text{nom}} = 5A, I_S = 0.3 I_{\text{nom}} = 1.5A$$

Trip region is observed between 78° to 243° , and block region from -117° to 78° . The experimental error is very less.

Taking small interval for observation, can improve accuracy and reduce error by varying phase angle between voltage & current.

Q4. Performance improved using positive sequence component. operating them with block region with sufficient safety & use quadrature voltages to know if relay should trip when fault is close to relay.

Testing improved by taking more observation at smaller interval angle between voltage & current phasors. Use a more sensitive phase shifter to get more accurate β & γ values.

$$\text{Q5. } \beta = 160^\circ, \gamma = -20^\circ, I_{\text{pickup}} = 0.3 \text{ kA}$$

$$\text{Case ① } I_a = 0.08 \angle -87.91^\circ \text{ kA}$$

$$\begin{array}{l} \text{Block region. } |I_a| < I_{\text{pickup}} \\ \qquad \qquad \qquad \left. \begin{array}{l} \angle V_a = 78.43 - (-87.91) \\ = 166.34 > \beta \end{array} \right\} \end{array}$$

$$I_B = 0.72 \angle 96.16^\circ \text{ kA}$$

$$V_B = 53.84 \angle -85.74^\circ \text{ kV} \quad \left. \begin{array}{l} \text{wrt } I_B \end{array} \right\}$$

$$|I_B| > I_{\text{pickup}} \quad \left. \begin{array}{l} \angle V_B = 10.42 < \beta \end{array} \right\}$$

$$I_C = 0.79 \angle 84.78^\circ \text{ kA}$$

$$V_C = 54.96 \angle -117.07^\circ \text{ kV} \quad \left. \begin{array}{l} \text{wrt } I_C \end{array} \right\}$$

$$|I_C| > I_{\text{pickup}} \quad \left. \begin{array}{l} \angle V_C = -201.77 \\ = 158.23^\circ < \beta \end{array} \right\}$$

\therefore Directional relay Trip in this case.

Q5. Case(2)

$$I_{\text{pickup}} = 0.3 \text{ kA}, \beta = 160^\circ, \gamma = -20^\circ$$

Block
region

$$I_a = 0.63 \angle -164.74^\circ \text{ kA}$$

$$V_a = 22.52 \angle 96.26^\circ \text{ kV} \quad \text{wrt } I_a$$

$$|I_a| > I_{\text{pickup}}$$

$$\angle V_a = 263^\circ$$

$$= -97^\circ < \gamma$$

Block
region

$$I_b = 0.64 \angle 53.15^\circ \text{ kA}$$

$$V_b = 22.94 \angle -19.90^\circ \text{ kV} \quad \text{wrt } I_b$$

$$|I_b| > I_{\text{pickup}}$$

$$\angle V_b = -73.05^\circ < \gamma$$

Block
region

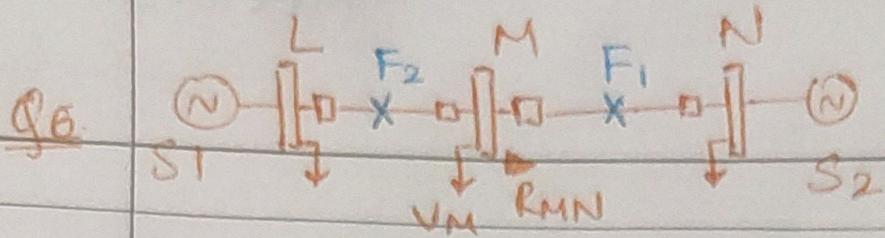
$$I_c = 0.61 \angle -45.39^\circ \text{ kA}$$

$$V_c = 22.10 \angle -139.94^\circ \text{ kV} \quad \text{wrt } I_c$$

$$|I_c| > I_{\text{pickup}}$$

$$\angle V_c = -94.58^\circ < \gamma$$

So directional relay will not operate in this case



Roll number: 19EE10039.

Fault Position	Fault Resistance	Positive Sequence Voltage / $\angle \theta$	Positive Sequence Current / $\angle \phi$	Negative Sequence Voltage / $\angle \theta$	Negative Sequence Current / $\angle \phi$	Decision
F ₁	9Ω	28.25°	-11.05°	40.98°	-5.49°	Trip
F ₂	9Ω	28.21°	-174.2°	40.95°	175.9°	No Trip

positive sequence

$$\angle V - \angle I = 28.25 - (-11.05) = 39.30^\circ$$

negative sequence

$$\begin{aligned} \angle V - \angle I &= 28.21 - (-174.2) = 202.41^\circ \\ &= 40.98 - (-5.49) \end{aligned}$$

fault

$$= 35.49^\circ$$

∴ Current is lagging faulted voltage. Relay Trips.
Forward Fault.

positive sequence

$$\begin{aligned} \angle V - \angle I &= 28.21 - (-174.2) = 202.41^\circ \\ &\equiv -157.59^\circ \end{aligned}$$

negative sequence

$$\begin{aligned} \angle V - \angle I &= 40.95 - (-175.9) = 226.85^\circ \\ &= -133.15^\circ \end{aligned}$$

∴ fault current is leading voltage. Relay doesn't Trip.
Reverse Fault.

case 1.

$$I_{\text{fault}} = 20.62 \text{ A}$$

$$I_{\text{nom}} = 5 \text{ A}$$

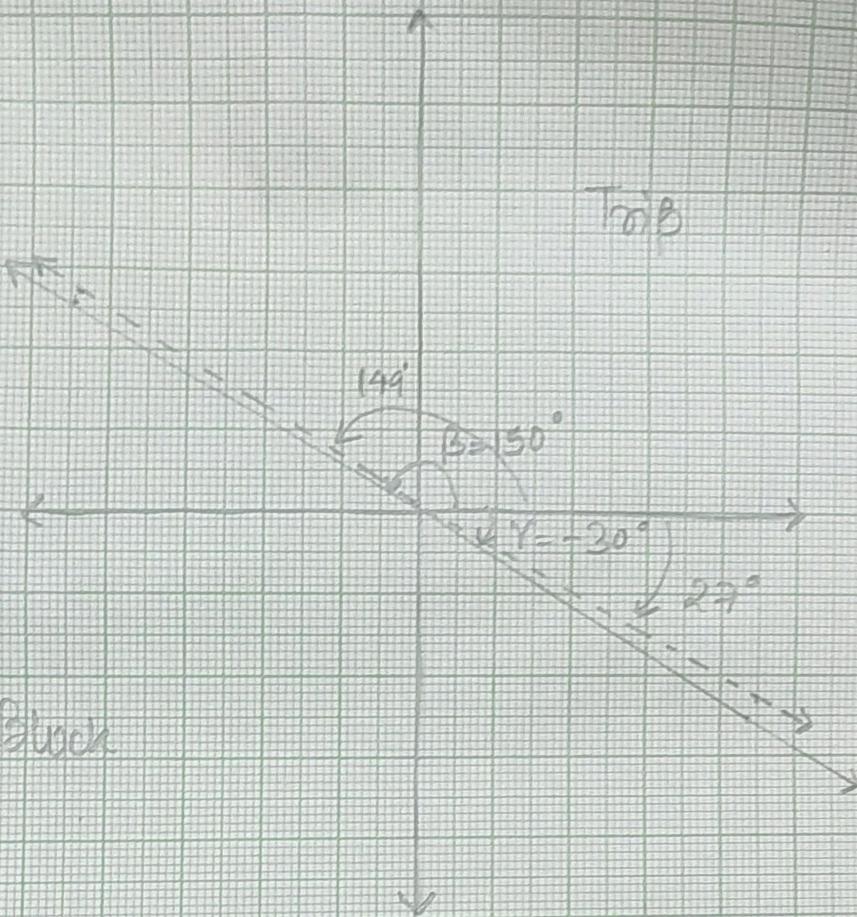
$$\beta = 150^\circ, \gamma = -30^\circ$$

$$\text{min. trip time} = 0.25$$

--- observed

— set characteristics

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Case 2

$$I_{\text{fault}} = 20.62 \text{ A}$$

$$I_{\text{nom}} = 5 \text{ A}$$

$$\beta = 70^\circ, \gamma = -110^\circ$$

$$\text{min. trip time} = 0.25$$

--- observed

— calculated

