# Review of Application of Ground Distance Protection

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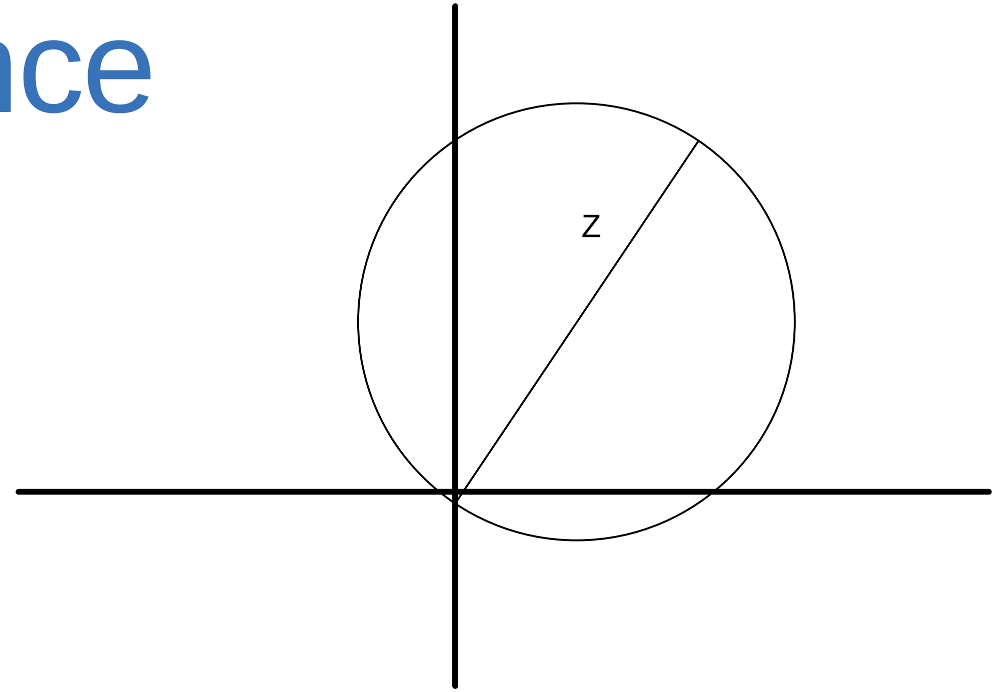
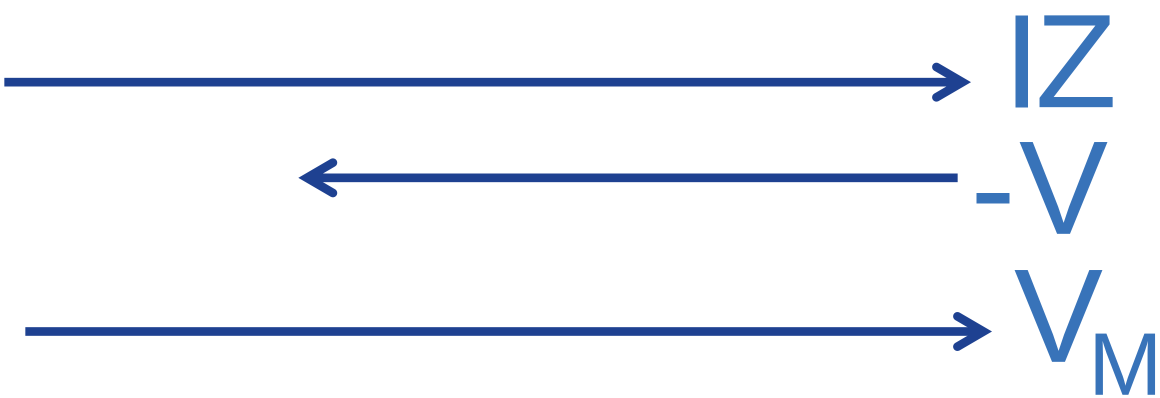
# Ground Distance Review



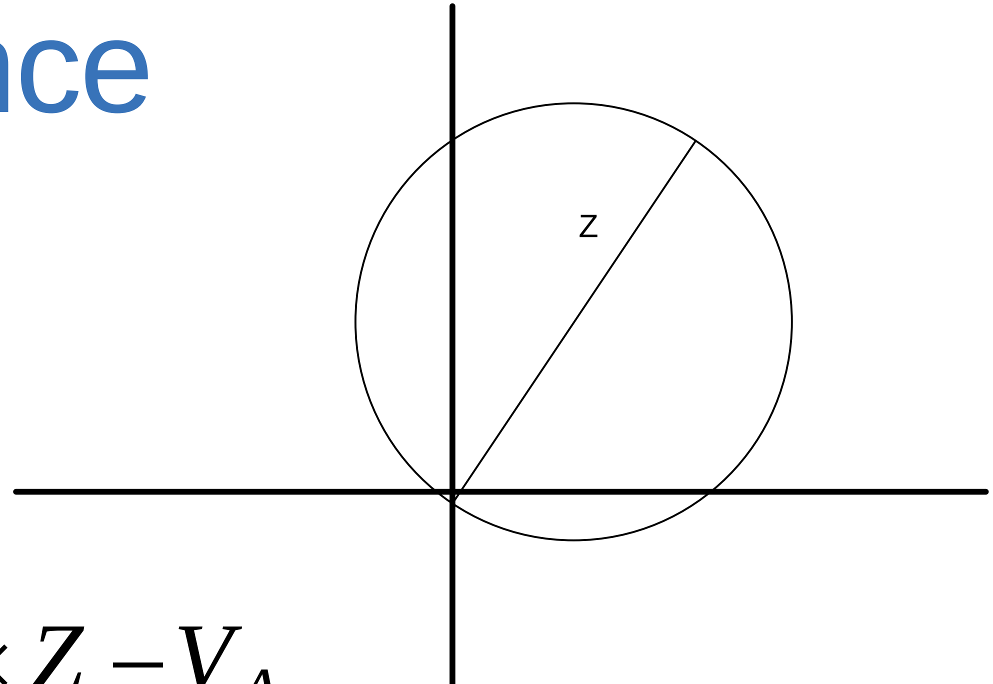

$$I \times Z - V$$

$$V_{A}\_1M$$




If drop to fault is greater than V, operate

# Ground Distance Review



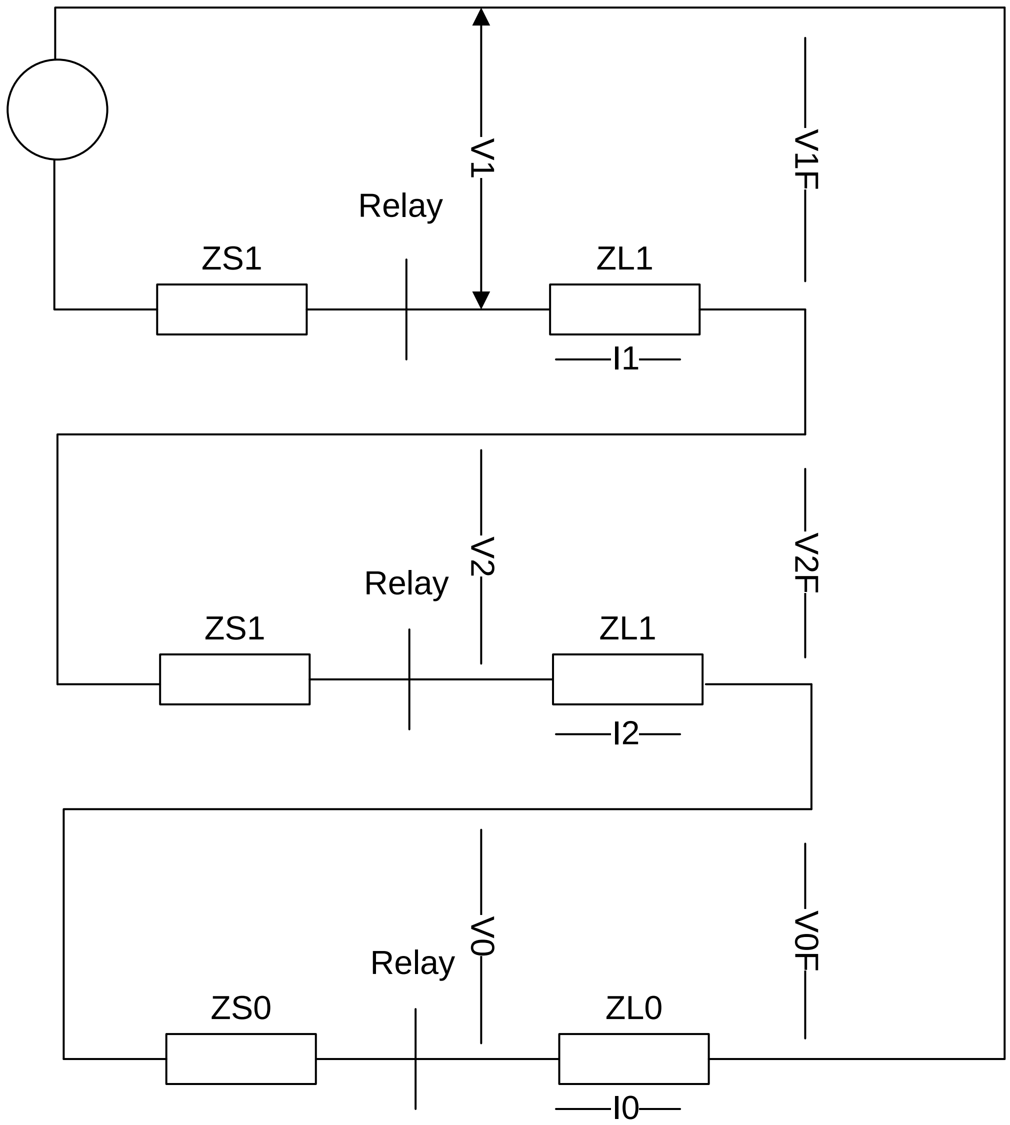

$$I \times Z - V$$

$$I_A \times Z + I_0 \times K_0 \times Z - V_A$$

$$V_A \_1M$$

$$\left(j \times I_0\right) \times e^{j\Theta}$$

# Zero Sequence Compensation Factor



# Zero Sequence Compensation Factor

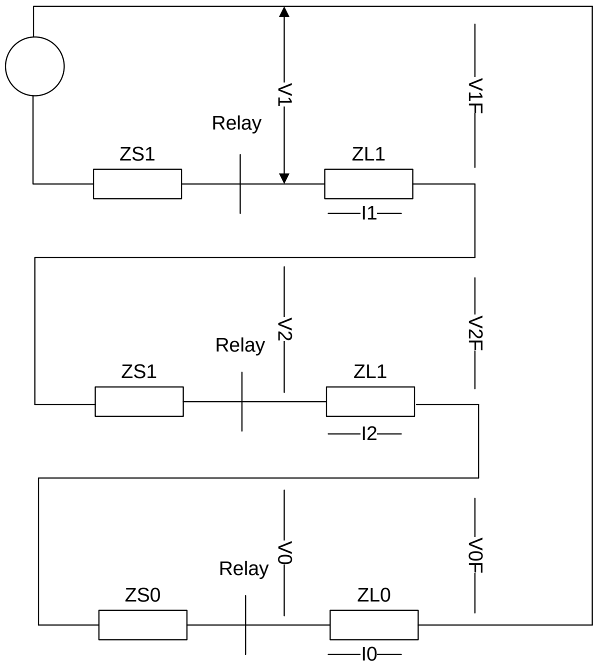
$$V_a = V_1 + V_2 + V_0$$

$$V_A = I_1 ZL_1 + I_2 ZL_1 + I_0 ZL_0 + (V_1F + V_2F + V_0F)$$

$$V_1F + V_2F + V_0F = 0$$

$$V_A = (I_1 + I_2)ZL_1 + I_0 ZL_0$$

$$I_a Z = (I_1 + I_2)ZL_1 + I_0 ZL_1$$




Since the line postive and zero sequence impedance don't equal, we must compensate for that difference.

# K0 will depend on the operate equation

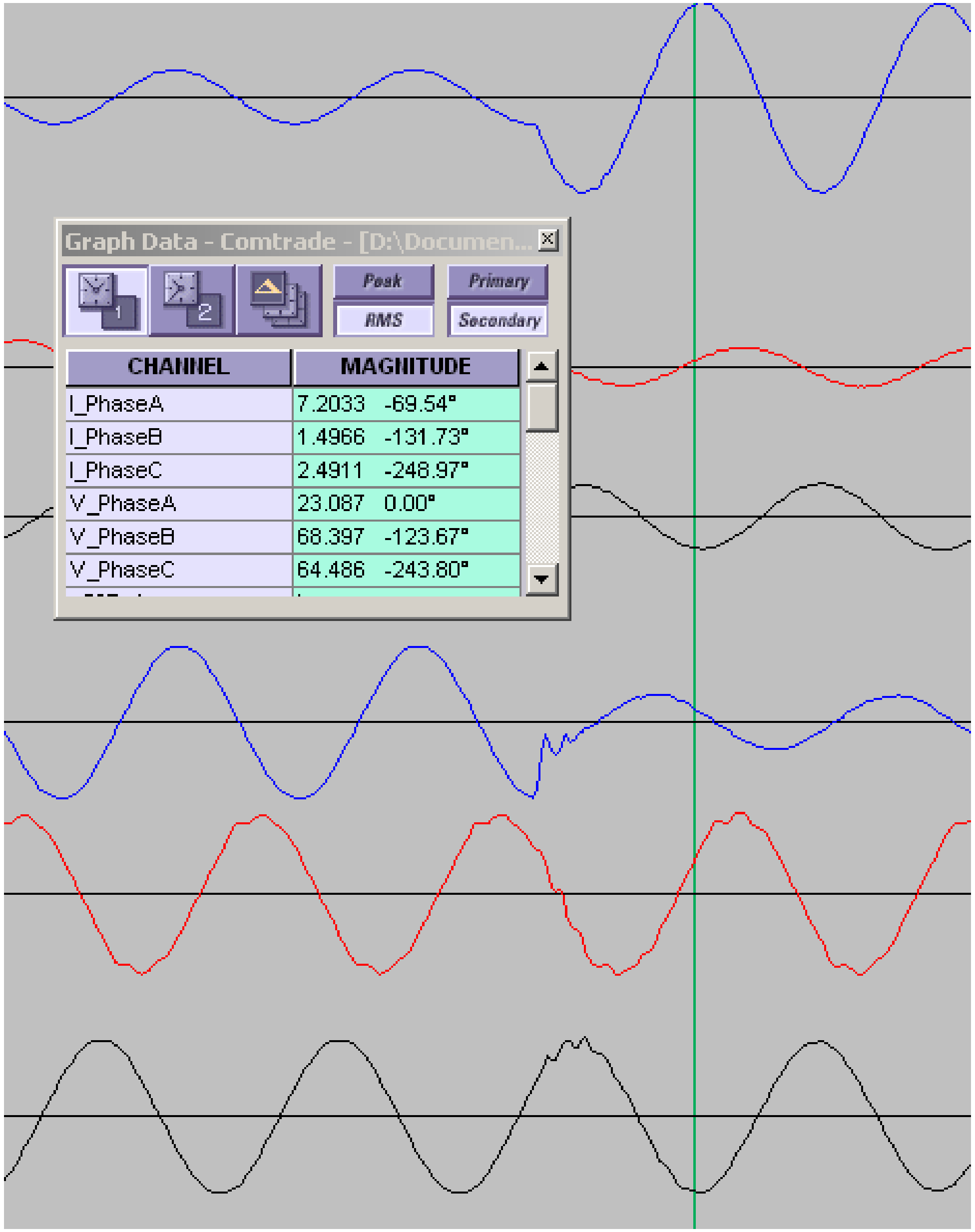
$$I_A \times Z + I_0 \times K_0 \times Z = V_A$$

$$K_0 = \frac{\frac{V_A}{Z} - I_A}{I_0}$$

$$K_0 = \frac{\frac{(I_1 + I_2)ZL_1 + I_0 ZL_0}{ZL_1} - (I_1 + I_2 + I_0)}{I_0}$$

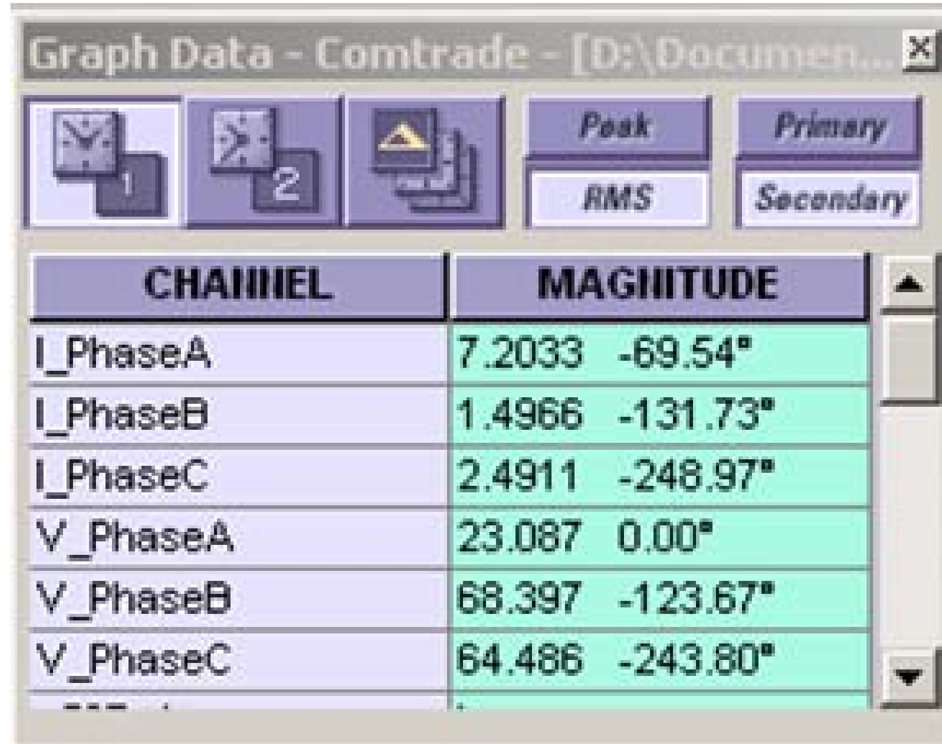
$$K_0 = \frac{ZL0}{ZL1} - 1$$

# What effect does K0 have?



# What effect does K0 have?

$$I \times Z - V$$

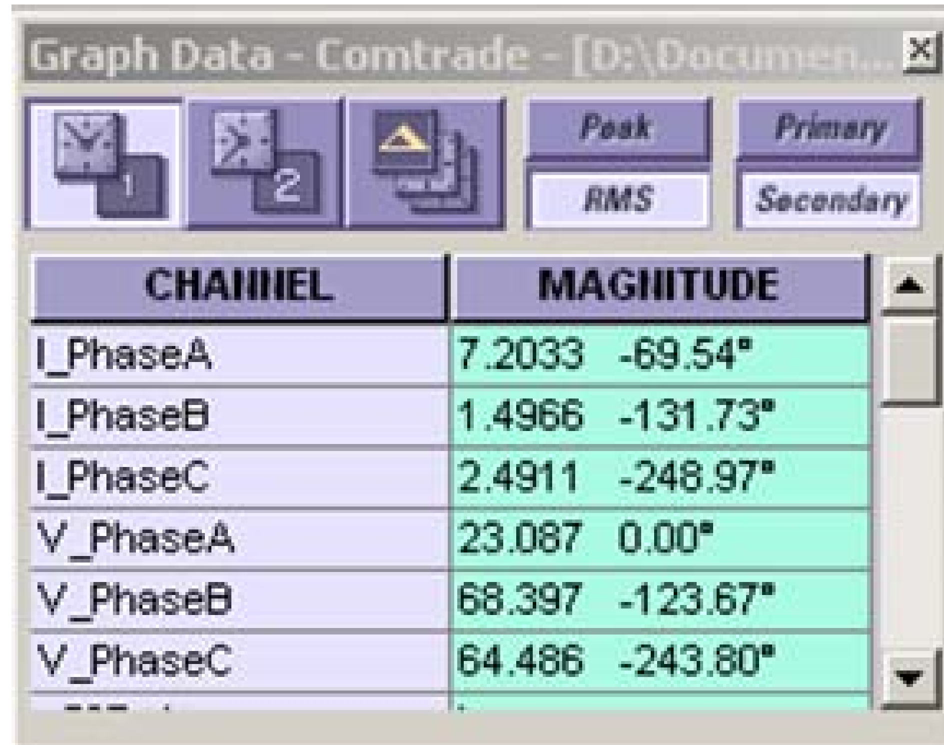



| CHANNEL | MAGNITUDE |
|---|---|
| I_PhaseA | 7.2033 -69.54° |
| I_PhaseB | 1.4966 -131.73° |
| I_PhaseC | 2.4911 -248.97° |
| V_PhaseA | 23.087 0.00° |
| V_PhaseB | 68.397 -123.67° |
| V_PhaseC | 64.486 -243.80° |

$$7.2\angle -69.54 \times 3.25\angle 85 - 23.09\angle 0 = 6.26\angle 94.7$$

# What effect does K0 have?

$$I_A \times Z + I_0 \times K_0 \times Z - V_A$$

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$$(7.2\angle -69.54 \times 3.25\angle 85) + (5.5\angle -83 \times 1.76\angle 3) - 23.09\angle 0 = 3.47\angle -70.$$

# K0 will vary depending on the operate quantity.

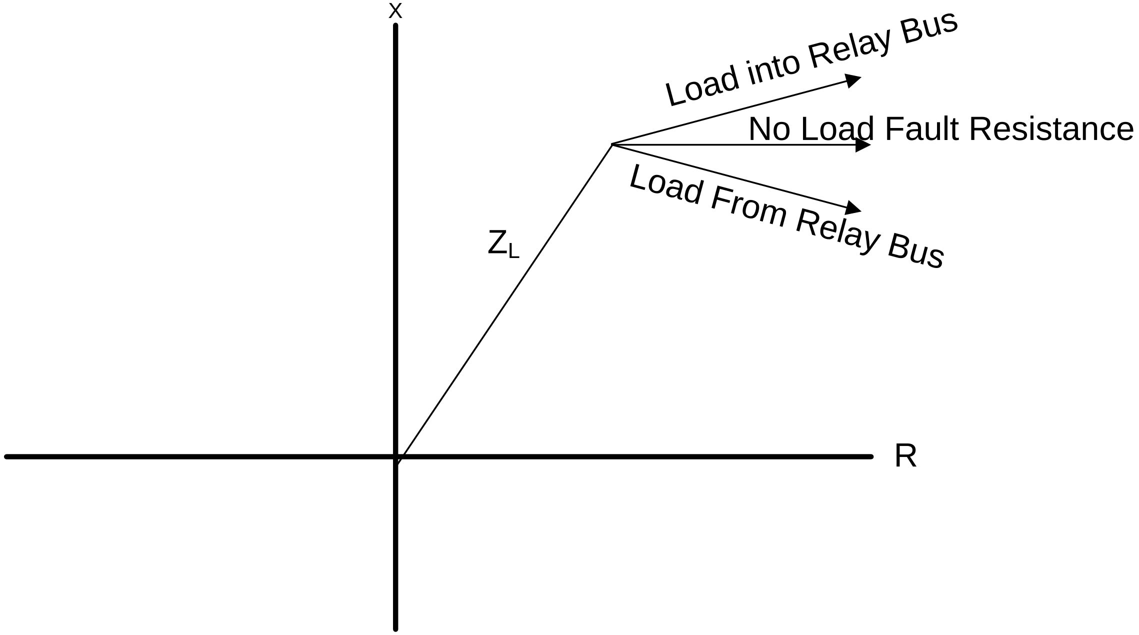
$$(I_A - I_0)Z + I_0 \times K_0 \times Z_0 - V_A$$

Different Relay Operate Quantity.

$$K0 = 1 + \frac{z0 - z1}{3z1}$$

Test Set K0

# Arc Impedance



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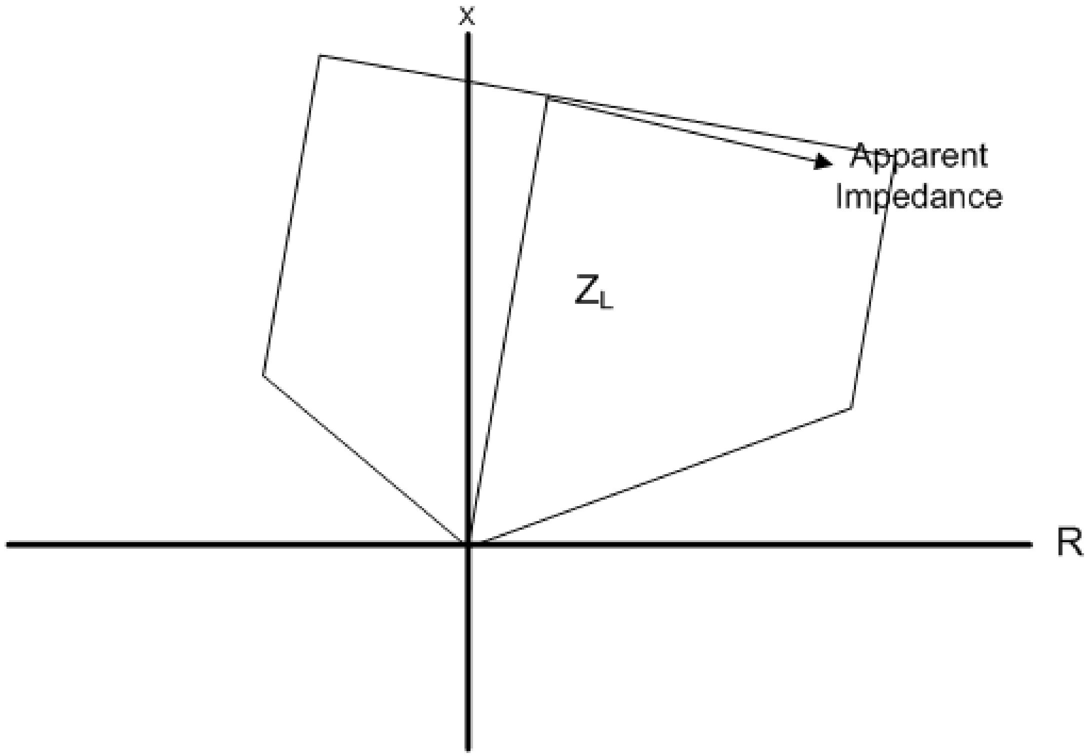

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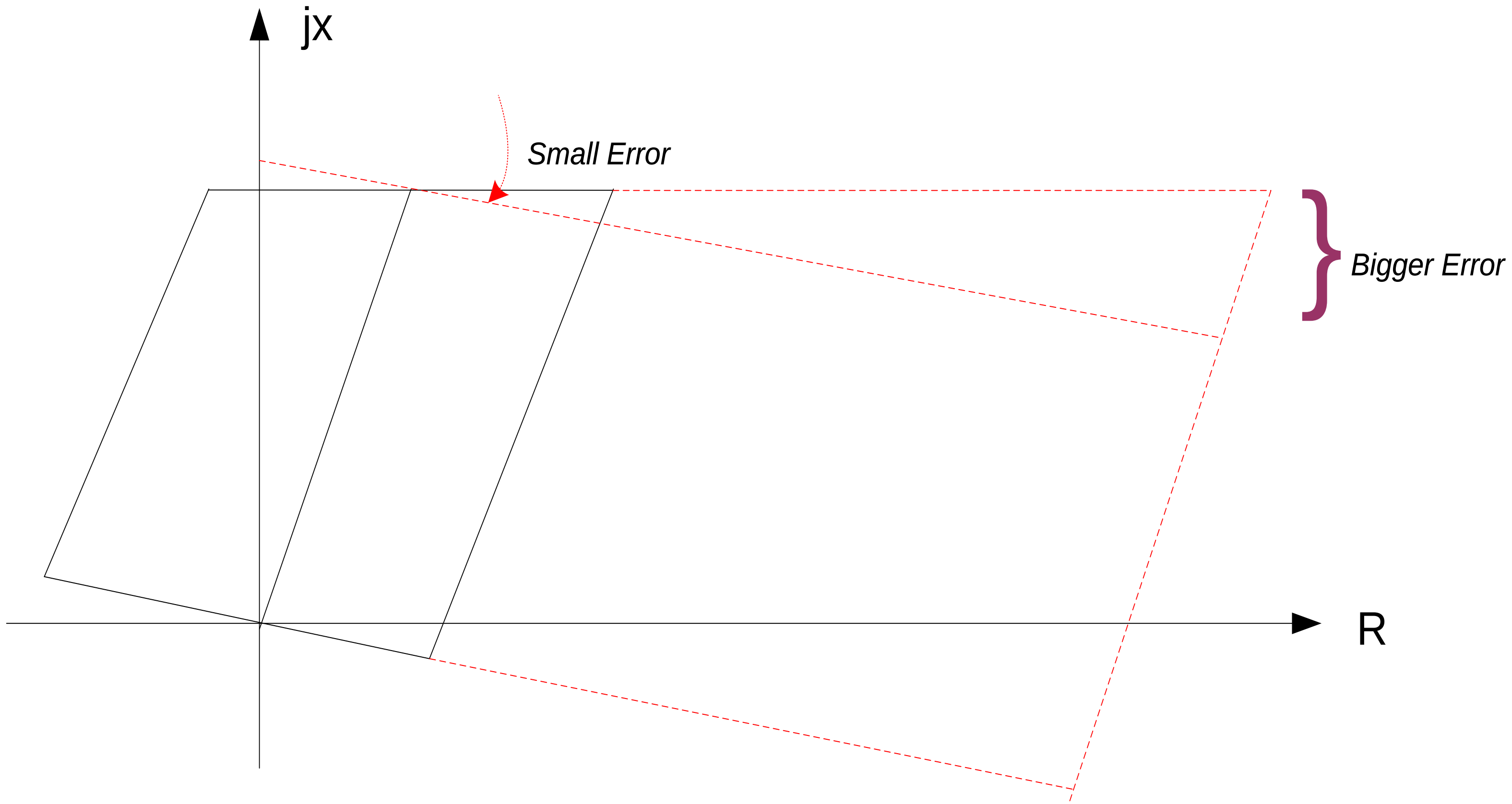
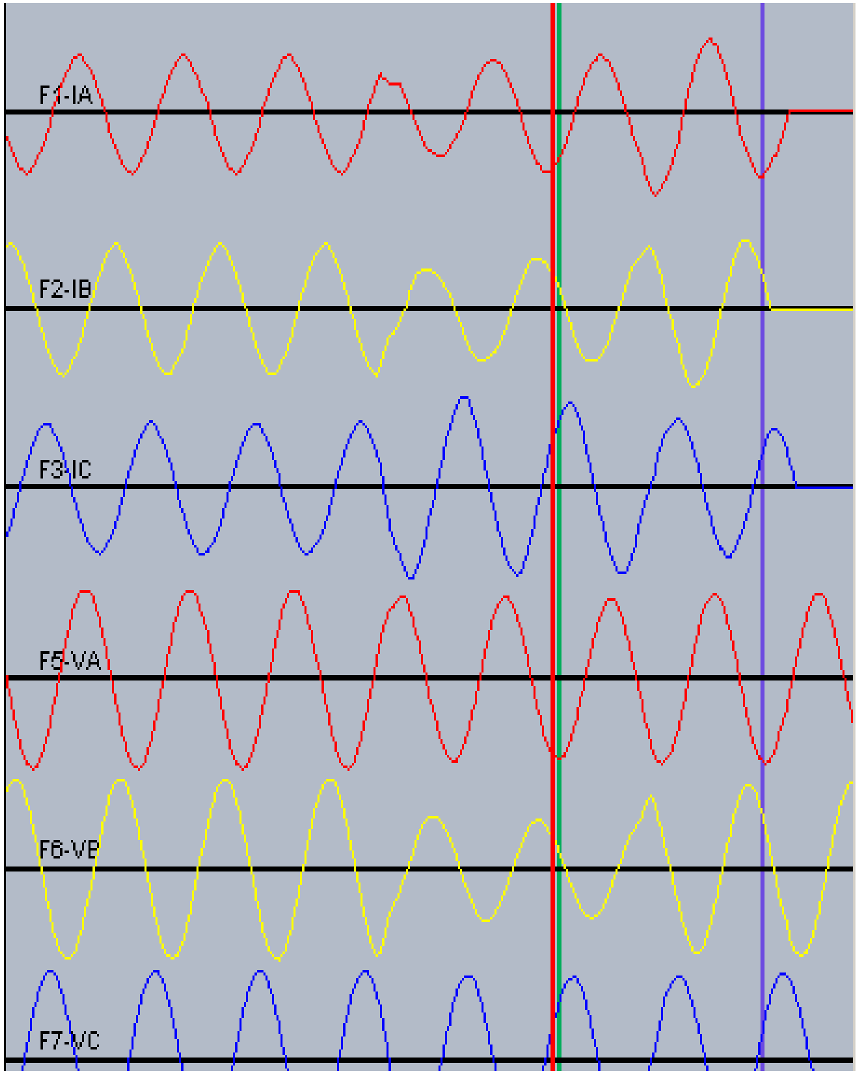


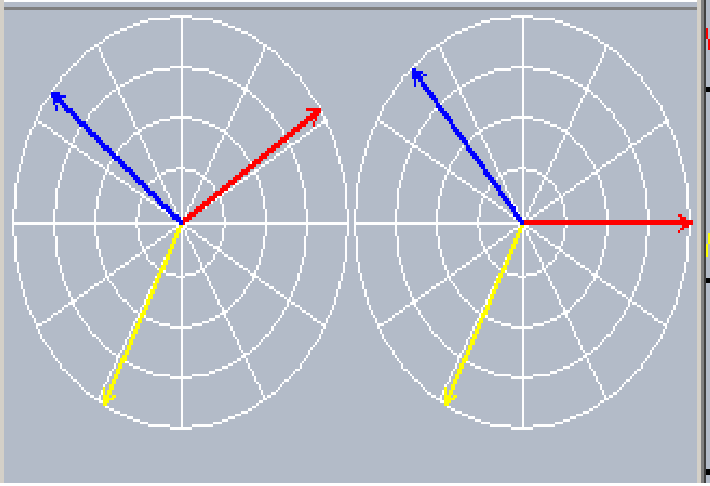
# Mutual Coupling

- Reduce reach of under-reaching element to not over-reach during coupling
- Set Over-reaching elements with enough margin that they reach the adjacent bus during coupling.
- Compensate the IZ-V term with ground current from the coupled line.
- Take a mixed approach with different settings groups.

# Current Supervision Level and Weak In-Feed




| CHANNEL | | GRAPH | MAGNITUDE / ANGLE |
|---|---|---|---|
| F1-IA | | Graph 1 | 0.28 A -325.91° |
| F2-IB | | Graph 1 | 0.25 A -117.88° |
| F3-IC | | Graph 1 | 0.35 A -219.44° |
| F5-VA | | Graph 2 | 61.10 V 0.00° |
| F6-VB | | Graph 2 | 41.81 V -118.13° |
| F7-VC | | Graph 2 | 62.50 V -229.09° |
| I_1 | | None | 0.29 A 19.70° |
| I_2 | | None | 0.01 A 21.55° |
| I_0 | | None | 0.08 A 134.09° |



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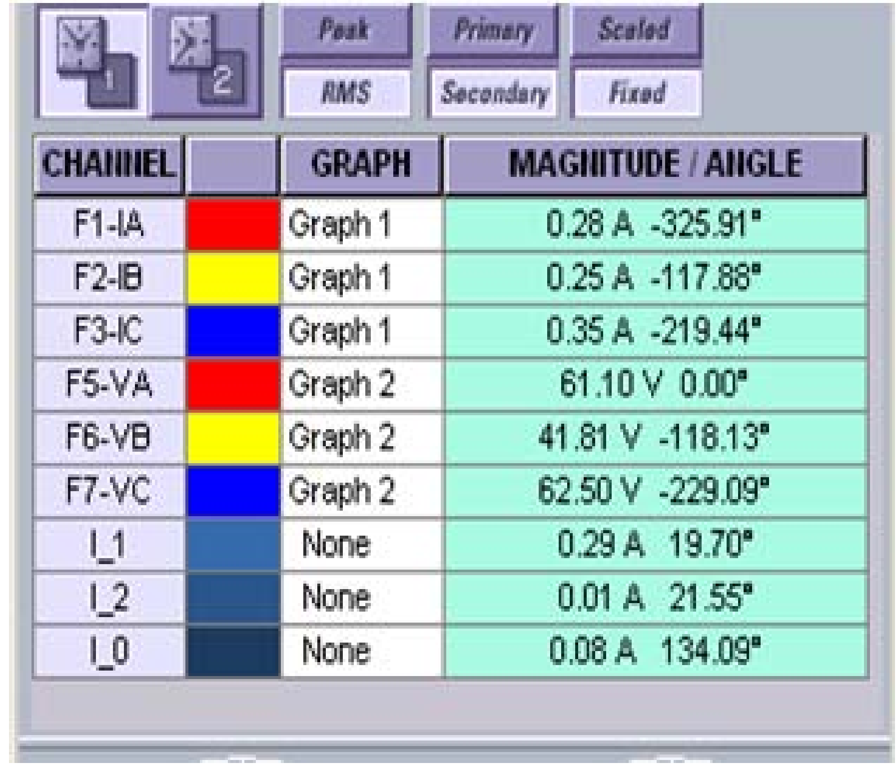


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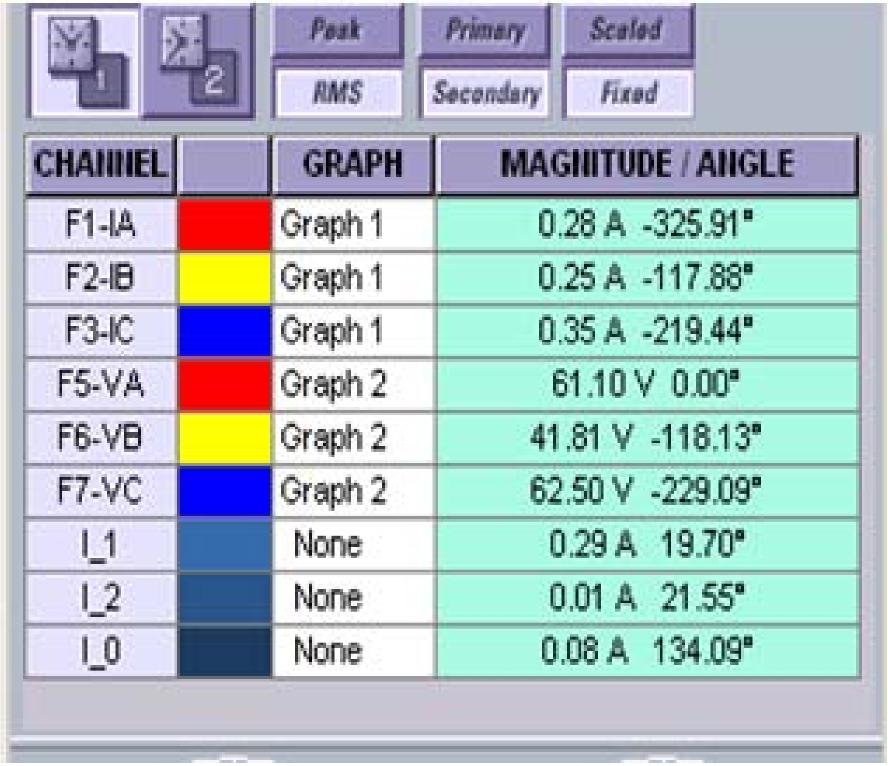
$I_A \times Z + I_0 \times K_0 \times Z - V_A$ Compared with $j \times I_0$

# Current Supervision Level and Weak In-Feed

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$$\left|3\times I_0 - 0.05\times I_1\right|$$

$$3\times 0.08 - 0.05\times 0.29 = 0.226\,Amps$$

With Positive sequence restraint it is less than the current supervision level of 0.230

# Conclusion

- The type of ground protection to be used for transmission lines will depend on system conditions.
- To understand which type to use you must understand the algorithms involved and how they are affected by those system conditions