

SAARC Training Workshop 'Power System Studies for Synchronization of Multiple Systems'

Modeling of Unbalanced Faults

Day-2-E

Kabul, Afghanistan

20-22 October 2014



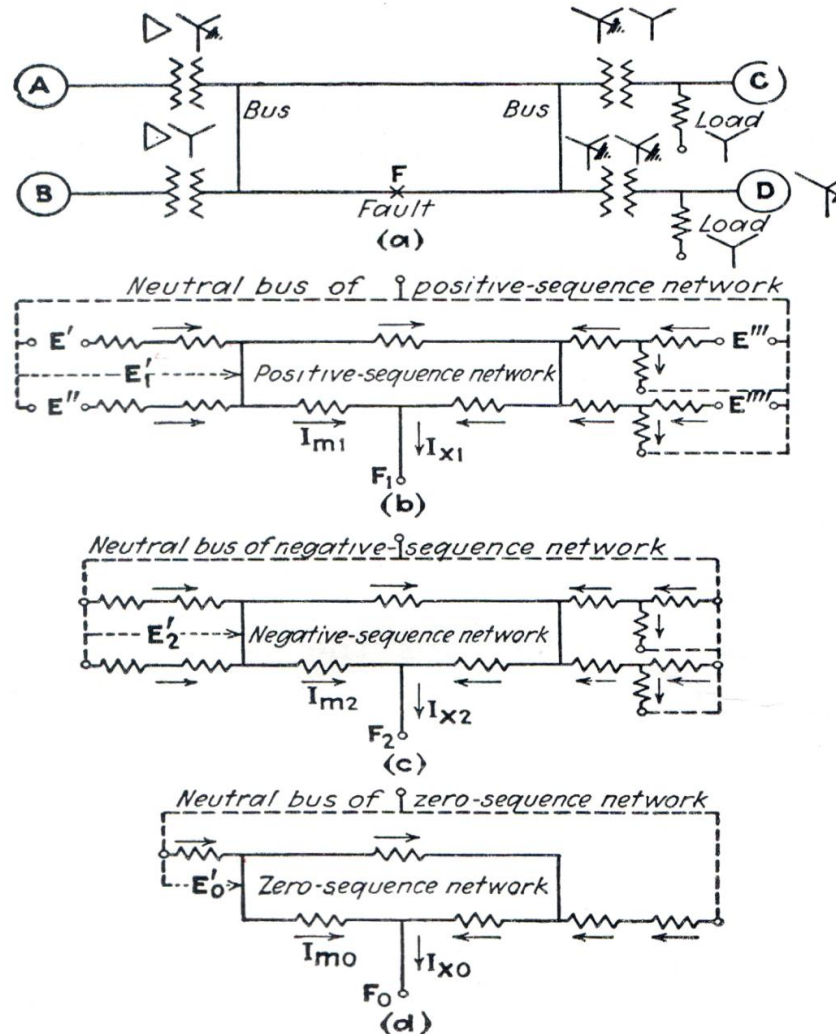
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Network modeling with symmetrical components

- Generators A, B, C and D
- GSU of A Δ -Y grounded
- GSU of B Δ -Y ungrounded
- TF1 receiving end Y-Y (G/U)
- TF 2 receiving end Y-Y (G/G)
- Gen C ungrounded
- Gen D grounded
- Loads: Y ungrounded
- Transmission line: double circuit



Single-Phase to Ground Fault (L-G)

- The conditions will be

$$E_x = 0$$

$$I_y = 0$$

$$I_z = 0$$

- The symmetrical components of current are

$$I_{x0} = \frac{1}{3} (I_x + I_y + I_z) = \frac{1}{3} (I_x)$$

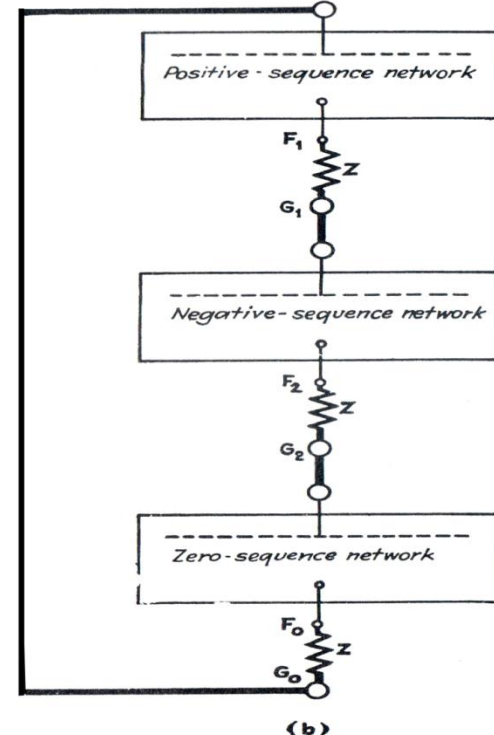
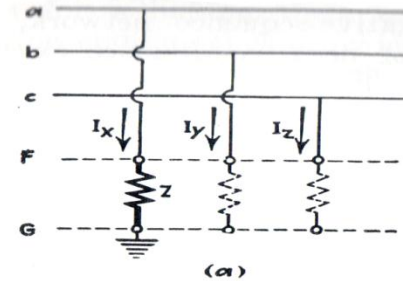
$$I_{x1} = \frac{1}{3} (I_x + aI_y + a^2 I_z) = \frac{1}{3} (I_x)$$

$$I_{x2} = \frac{1}{3} (I_x + a^2 I_y + a I_z) = \frac{1}{3} (I_x)$$

- Therefore

$$I_{x0} = I_{x1} = I_{x2}$$

- For same current to flow through Positive, Negative and Zero Sequence networks, they are to be connected in series



Line-to-Line-to-Ground Fault (L-L-G)

The conditions will be

$$I_x = 0$$

$$E_y = 0$$

$$E_z = 0$$

The symmetrical components of voltages are

$$E_{x0} = \frac{1}{3}(E_x + E_y + E_z) = \frac{1}{3}(E_x)$$

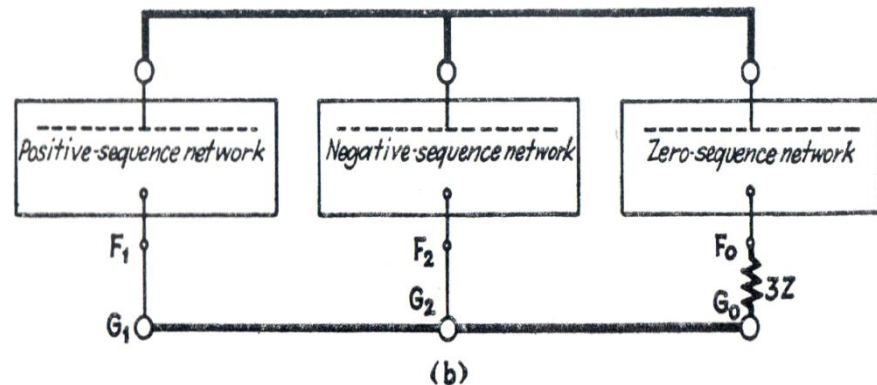
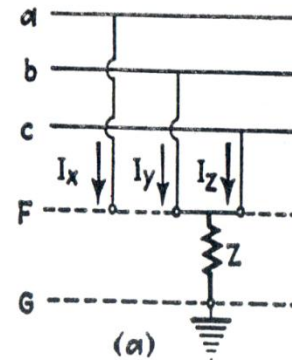
$$E_{x1} = \frac{1}{3}(E_x + aE_y + a^2 E_z) = \frac{1}{3}(E_x)$$

$$E_{x2} = \frac{1}{3}(E_x + a^2 E_y + a E_z) = \frac{1}{3}(E_x)$$

Therefore

$$E_{x0} = E_{x1} = E_{x2}$$

For same voltage across Positive, Negative and Zero Sequence networks, they are to be connected in parallel



Line-to-Line Fault (L-L)

- The conditions will be

$$I_x = 0$$

$$I_y = -I_z$$

$$E_y = E_z$$

- The symmetrical components are

$$I_{x0} = \frac{1}{3}(I_x + I_y + I_z) = \frac{1}{3}(0 - I_z + I_z) = 0$$

- Substitute $E_y = E_z$

$$E_{x1} = \frac{1}{3}(E_x + aE_y + a^2E_z) = \frac{1}{3}(E_x + (a + a^2)E_z)$$

$$E_{x2} = \frac{1}{3}(E_x + a^2E_y + aE_z) = \frac{1}{3}(E_x + (a + a^2)E_z)$$

- Therefore $E_{x1} = E_{x2}$

- Since $I_{x0} = 0$

Zero Sequence network will not be considered

- Since $E_{x1} = E_{x2}$

Positive and Negative Sequence networks are to be connected in parallel

