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CERTIFICATION COURSE

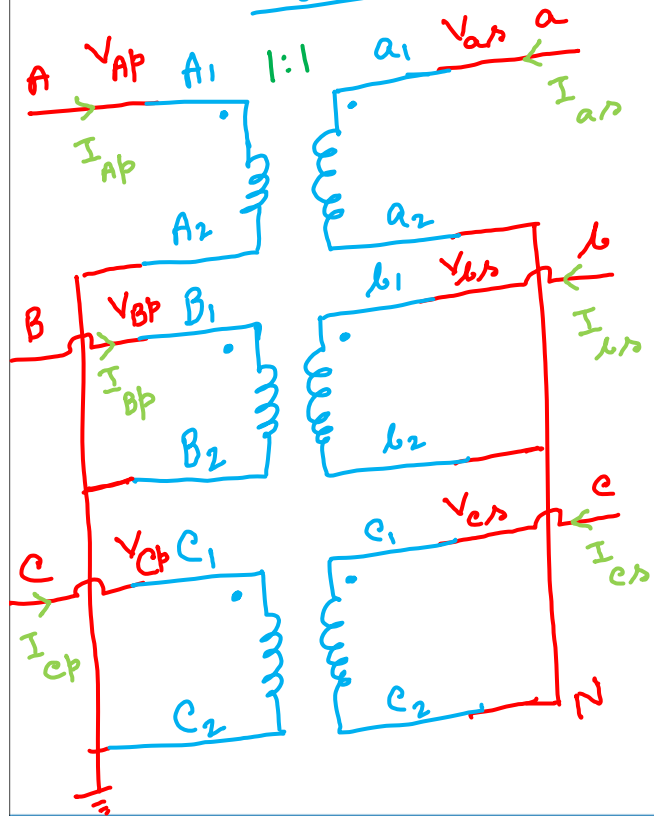
Computer aided power system analysis

Fault Analysis (Contd.)

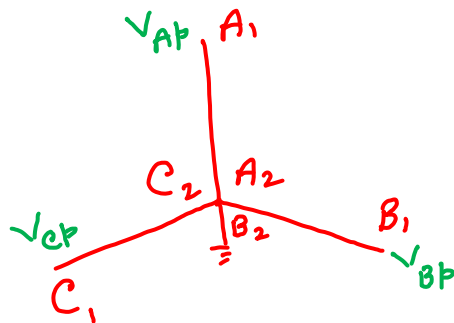
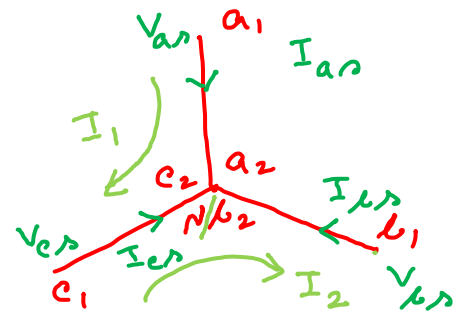
Prof. Biswarup Das
Department of Electrical Engineering



Y_g 20 Transformer



Star-grounded/star Transformer



$Z \rightarrow$ Transformer impedance

$Y = \frac{1}{Z} \rightarrow$ Transformer admittance.

KVL in loop $a_1 - c_1$

$$V_{an} - ZI_1 - V_{Ap} - Z(I_1 - I_2) + V_{Cp} - V_{cn} = 0$$



$$\Rightarrow ZI_1 + Z(I_1 - I_2) = V_{as} - V_{Ap} + V_{cp} - V_{cs}$$

$$\Rightarrow 2ZI_1 - ZI_2 = V_{as} - V_{Ap} + V_{cp} - V_{cs} \quad \text{----- (1)}$$

KVL in the loop $c_1 - b_1$

$$V_{cs} - Z(I_2 - I_1) - V_{cp} - ZI_2 + V_{bp} - V_{bs} = 0$$

$$\Rightarrow Z(I_2 - I_1) + ZI_2 = V_{cs} - V_{cp} + V_{bp} - V_{bs}$$

$$\Rightarrow -ZI_1 + 2ZI_2 = V_{cs} - V_{cp} + V_{bp} - V_{bs} \quad \text{----- (2)}$$

$$\textcircled{2} \times 2 \Rightarrow -2ZI_1 + 4ZI_2 = 2(V_{cs} - V_{cp} + V_{bp} - V_{bs}) \quad \text{-- (3)}$$

$$\textcircled{1} + \textcircled{3} \Rightarrow 3ZI_2 = \overset{\checkmark}{V_{as}} - \overset{\checkmark}{V_{Ap}} + \overset{\checkmark}{V_{cp}} - \overset{\checkmark}{V_{cs}} + 2\overset{\checkmark}{V_{cs}} - 2\overset{\checkmark}{V_{cp}} + 2\overset{\checkmark}{V_{bp}} - 2\overset{\checkmark}{V_{bs}}$$

$$\Rightarrow 3ZI_2 = -V_{Ap} + 2V_{bp} - V_{cp} + V_{as} - 2V_{bs} + V_{cs}$$



$$\Rightarrow I_2 = \frac{2}{3} (-V_{Ap} + 2V_{Bp} - V_{Cp} + V_{an} - 2V_{bn} + V_{cn}) \quad \dots\dots (4)$$

$$\text{By } (1) \times 2 \Rightarrow 4ZI_1 - 2ZI_2 = 2(V_{an} - V_{Ap} + V_{Cp} - V_{cn}) \quad \dots\dots (5)$$

$$\text{By } (5) + (2) \Rightarrow 3ZI_1 = \cancel{V_{cn}} - \cancel{V_{Cp}} + \cancel{V_{Bp}} - \cancel{V_{bn}} + 2V_{an} - 2\cancel{V_{Ap}} + 2\cancel{V_{Cp}} - 2\cancel{V_{cn}}$$

$$\Rightarrow 3ZI_1 = -2V_{Ap} + V_{Bp} + V_{Cp} + 2V_{an} - V_{bn} - V_{cn}$$

$$\Rightarrow I_1 = \frac{2}{3} (-2V_{Ap} + V_{Bp} + V_{Cp} + 2V_{an} - V_{bn} - V_{cn}) \quad \dots\dots (6)$$

$$\text{Now, } I_{an} = I_1; \quad I_{bn} = -I_2; \quad I_{cn} = I_2 - I_1$$

$$I_{bn} = \frac{2}{3} (V_{Ap} - 2V_{Bp} + V_{Cp} - V_{an} + 2V_{bn} - V_{cn}) \quad \dots\dots (7)$$

$$I_{cs} = I_2 - I_1 = \frac{2}{3} \left[-V_{Ap} + 2V_{Bp} - V_{Cp} + V_{as} - 2V_{bs} + V_{cs} \right. \\ \left. + 2V_{Ap} - V_{Bp} - V_{Cp} - 2V_{as} + V_{bs} + V_{cs} \right]$$

$$\Rightarrow I_{cs} = \frac{2}{3} \left[V_{Ap} + V_{Bp} - 2V_{Cp} - V_{as} - V_{bs} + 2V_{cs} \right] \dots \textcircled{8}$$

$$I_{Ap} = -I_{as} ; \quad I_{Bp} = -I_{bs} ; \quad I_{Cp} = -I_{cs}$$

$$\Rightarrow I_{Ap} = -I_1 ; \quad ; \quad I_{Bp} = I_2 ; \quad I_{Cp} = I_1 - I_2$$



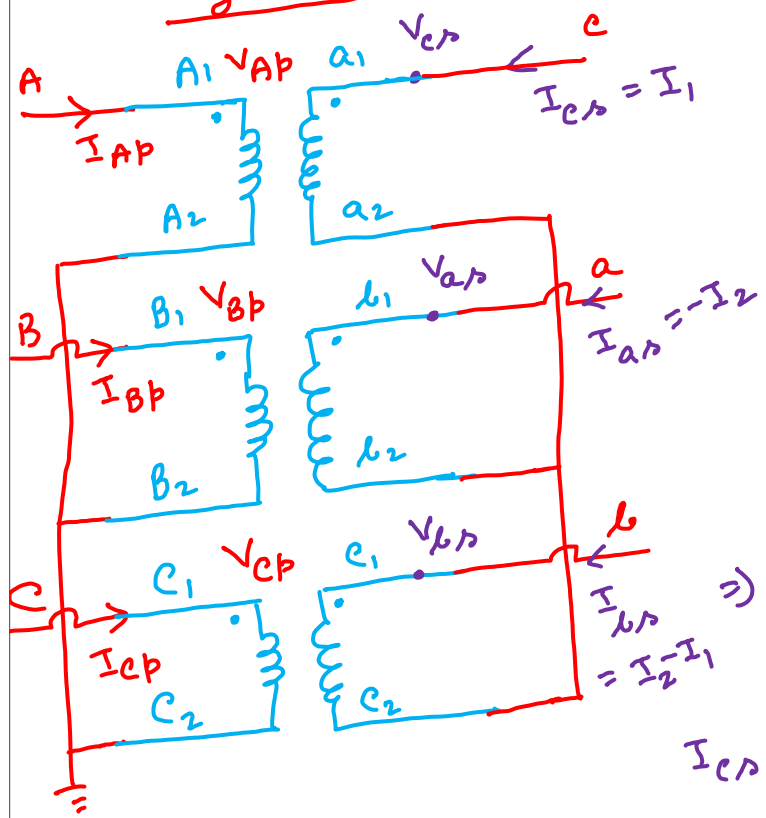
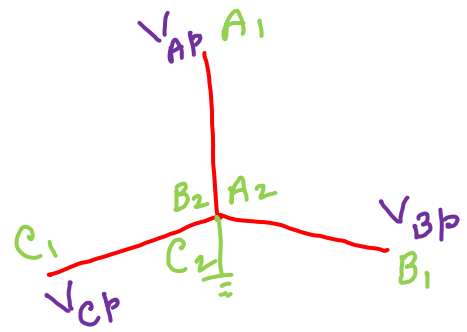
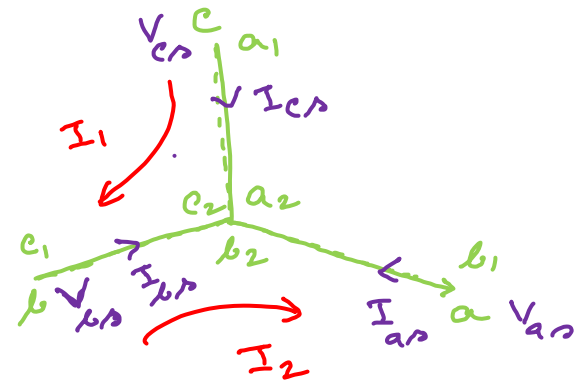
$$\begin{bmatrix} I_{Ap} \\ I_{Bp} \\ I_{Cp} \\ I_{Ar} \\ I_{Br} \\ I_{Cr} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 2 & -1 & -1 & -2 & 1 & 1 \\ -1 & 2 & -1 & 1 & -2 & 1 \\ -1 & -1 & 2 & 1 & 1 & -2 \\ -2 & 1 & 1 & 2 & -1 & -1 \\ 1 & -2 & 1 & -1 & 2 & -1 \\ 1 & 1 & -2 & -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} V_{Ap} \\ V_{Bp} \\ V_{Cp} \\ V_{Ar} \\ V_{Br} \\ V_{Cr} \end{bmatrix}$$

The matrix is partitioned into four quadrants labeled Y_I , Y_{II} , Y_{III} , and Y_{IV} in red.



Y 24

$4 \times 30 = 120^\circ$



KVL equation in a_1 - c_1 loop

$$V_{c1} - ZI_1 - V_{AP} - Z(I_1 - I_2) + V_{c1} - V_{a1} = 0$$

$$\Rightarrow 2ZI_1 - ZI_2 = V_{c1} - V_{AP} + V_{c1} - V_{a1} \quad \text{--- (1)}$$

$$\left. \begin{aligned} I_{c1} &= I_1 \\ I_{a1} &= -I_2 \\ I_{b1} &= I_2 - I_1 \end{aligned} \right\}$$



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KVL equation in c_1-b_1 loop

$$V_{\mu s} - Z(I_2 - I_1) - V_{cp} - ZI_2 + V_{bp} - V_{as} = 0$$

$$\Rightarrow -ZI_1 + 2ZI_2 = V_{\mu s} - V_{cp} + V_{bp} - V_{as} \quad \text{--- (2)}$$

$$\textcircled{1} \times 2 + \textcircled{2} \Rightarrow 3ZI_1 = V_{\mu s} - V_{cp} + V_{bp} - V_{as} + 2V_{cs} - 2V_{Ap} + 2V_{cp} - 2V_{\mu s}$$

$$\Rightarrow I_1 = \frac{2}{3} \left[-2V_{Ap} + V_{bp} + V_{cp} - V_{as} - V_{\mu s} + 2V_{cs} \right]$$

$$\Rightarrow I_2 = \frac{2}{3} \left[\quad \right]$$

$$\left. \begin{aligned} I_{Ap} &= -I_{cs}; & I_{bp} &= -I_{as}; & I_{cp} &= -I_{\mu s} \\ I_{as} &= -I_2; & I_{\mu s} &= I_2 - I_1; & I_{cs} &= I_1 \end{aligned} \right\}$$

