PS Class Test-2

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Q1. Step1 : Initial Computations

Convert all the loads in per-unit values

$$P_{L_2} = \frac{150}{100} = 1.5 \text{ pu}$$

$$Q_{L_2} = \frac{50}{100} = 0.5 \text{ pu}$$

$$P_{L_3} = \frac{50}{100} = 0.5 \text{ pu}$$

$$Q_{L_3} = \frac{20}{100} = 0.2 \text{ pu.}$$

Convert all the generation in per-unit values,

$$P_{g_2} = \frac{70}{100} = 0.7 \text{ pu}$$

$$Q_{g_2} = \frac{30}{100} = 0.3 \text{ pu.}$$

$$P_{g_3} = 0$$

$$Q_{g_3} = 0.$$

Compute net-injected power at bus 2 and 3.

$$P_2 = P_{g_2} - P_{L_2} = (0.7 - 1.5) = -0.8 \text{ pu}$$

$$Q_2 = Q_{g_2} - Q_{L_2} = (0.3 - 0.5) \text{ pu} = -0.2 \text{ pu}$$

$$P_3 = P_{g_3} - P_{L_3} = (0 - 0.5) = -0.5 \text{ pu}$$

$$Q_3 = \cancel{P_{g3}}\ Q_{g3} - Q_{L3} = (0 - 0.2) = -0.2\ pu.$$

Step 2: Formation of Y_{Bus} matrix:

$$Y_{BUS} = \begin{bmatrix} 53.85\angle -68.2^\circ & 22.36\angle 116.6^\circ & 31.62\angle 108.4^\circ \\ 22.36\angle 116.6^\circ & 58.13\angle -63.4^\circ & 35.77\angle 116.6^\circ \\ 31.62\angle 108.4^\circ & 35.77\angle 116.6^\circ & 67.23\angle -67.2^\circ \end{bmatrix}$$

Step 3: Iterative Computation

$$V_2^{(p+1)} = \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_2}{\left(V_2^{(p)}\right)^*} - Y_{21}V_1 - Y_{23}V_3^{(p)}\right]$$

~~Slack bus voltage is~~

$$V_3^{(p+1)} = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{\left(V_3^{(p)}\right)^*} - Y_{31}V_1 - Y_{32}V_2^{(p+1)}\right]$$

Slack bus Voltage

$$V_1 = (1 + j0.00)$$

Starting Voltage.

$$V_2^{(0)} = (1 + j0)$$

$$V_3^{(0)} = (1 + j0)$$

Now,

$$\frac{P_2 - jQ_2}{Y_{22}} = \frac{(-0.8+j0.2)}{58.13\angle -63.4^\circ} = 0.01418\angle -130.64^\circ$$

$$\frac{Y_{21}}{Y_{22}} = \frac{22.36\angle 116.6^\circ}{58.13\angle -63.4^\circ} = 0.3846\angle 180^\circ$$

$$= -0.3846.$$

$$\frac{Y_{23}}{Y_{22}} = \frac{55.77\angle 116.6^\circ}{58.13\angle -63.4^\circ} = -0.6153$$

$$V_2^{(p+1)} = \left[\frac{0.0142\angle -120.64^\circ}{\left(V_p^{(p)}\right)^*} + 0.3846\,V_1 + 0.6153\,V_3^{(p)}\right]$$

Now,

$$\frac{P_3 - jQ_3}{Y_{33}} = \frac{-0.5+0.2j}{67.23\angle -67.2^\circ} =$$

$$8.01\times 10^{-3}\angle -134.60^\circ$$

$$\frac{Y_{31}}{Y_{33}} = \frac{31.62\angle 108.4^\circ}{67.23\angle -67.2^\circ} = 0.47\angle 175.6^\circ$$

$$\frac{Y_{32}}{Y_{33}} = \frac{35.77\angle 116.6^\circ}{67.23\angle -67.2^\circ} = 0.532\angle 183.8^\circ$$

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$$V_3^{(P+1)} = \left[\frac{0.008 \angle -134.60^\circ}{(V_3^{(P)})^*} - 0.47 \angle 175.06^\circ \, V_1 - 0.532 \angle 183.8^\circ \, V_2^{(P+1)} \right].$$

Now, $P = 0$.

$$V_2^{(1)} = \frac{0.0142 \angle -130.64^\circ}{(1+j0)^*} + 0.3846 \times 1 + 0.6153 \times (1+j0)$$

$$= 0.9907 \angle -0.623^\circ$$

$$V_3^{(1)} = \frac{0.008 \angle -134.60^\circ}{(1+j0)^*} - 0.47 \angle 175.6^\circ \times 1 - 0.532 \angle 183.8^\circ \times 0.9907 \angle -0.623^\circ$$

$$= 0.9893 \angle -0.726$$

After 1st Iter.

$$V_2^{(1)} = 0.9907 \angle -0.623^\circ$$

$$V_3^{(1)} = 0.9892 \angle -0.726^\circ.$$

Now, $p = 1$.

$$V_2^{(2)} = \frac{0.0242 \angle -130.64^\circ}{(0.9907 \angle -0.627^\circ)^*}$$

$$+ 0.3846 \times 1 + 0.6153 \times 0.9893 \angle -0.726^\circ$$

$$= 0.9839 \angle -1.076$$

$$V_3^{(2)} = \frac{0.008 \angle -134.6^\circ}{(0.9893 \angle -0.726)^*} - 0.47 \angle 175.6^\circ \times 1$$

$$- 0.532 \angle 183.8^\circ \times 0.9839 \angle -1.076^\circ$$

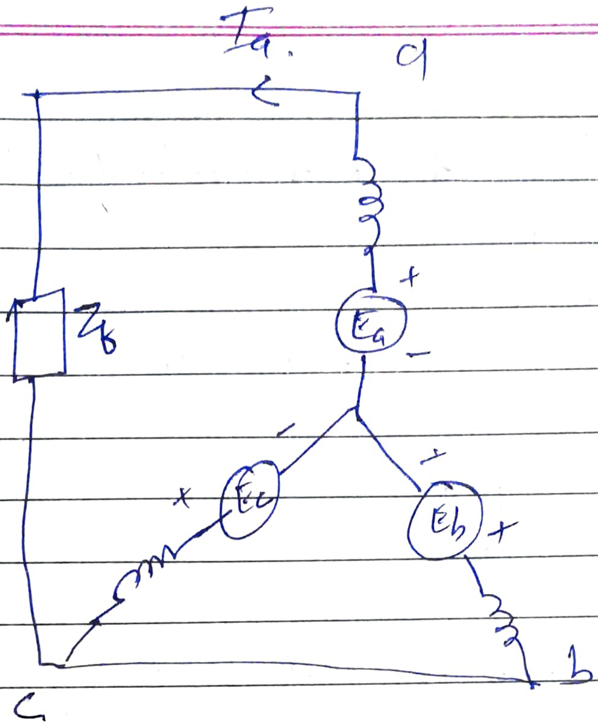
$$= 0.9858 \angle -0.98^\circ$$

After 2nd Iter,

$$V_2^{(2)} = 0.9839 \angle -1.076$$

$$V_3^{(2)} = 0.9858 \angle -0.98^\circ$$

Q2.



$$I_a + I_b + I_c = 0.$$

$$V_b = V_c.$$

$$V_a = V_b + Z_f I_a.$$

$$\begin{bmatrix} V_{a1} \\ V_{a2} \\ V_{a0} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & \beta & \beta^2 \\ 1 & \beta^2 & \beta \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} V_{a1} \\ V_{a2} \\ V_{a0} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & \beta & \beta^2 \\ 1 & \beta^2 & \beta \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} V_b + Z_f I_a \\ V_b \\ V_b \end{bmatrix}.$$

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$$V_{a1} = \frac{1}{3}\left[V_b + Z_f I_a + \beta V_b + \beta^2 V_b\right]$$

$$= \frac{1}{3}\left[V_b + Z_f I_a - V_b\right]$$

$$= \frac{Z_f I_a}{3}.$$

$$V_{a2} = \frac{1}{3}\left[V_b + Z_f I_a + \beta^2 V_b + \beta V_b\right].$$

$$= \frac{Z_f I_a}{3}.$$

$$V_{a0} = \frac{1}{3}\left[3V_b + Z_f I_a\right]$$

$$= V_b + \frac{Z_f I_a}{3}.$$

$$\begin{bmatrix} I_{a1} \\ I_{a2} \\ I_{a0} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & \beta & \beta^2 \\ 1 & \beta^2 & \beta \\ 1 & 1 & 1 \end{bmatrix}\begin{bmatrix} I_a \\ I_B \\ I_c \end{bmatrix}$$

$$I_{a1} = \frac{1}{2}\left[I_a + \beta I_B + \beta^2 I_c\right]$$

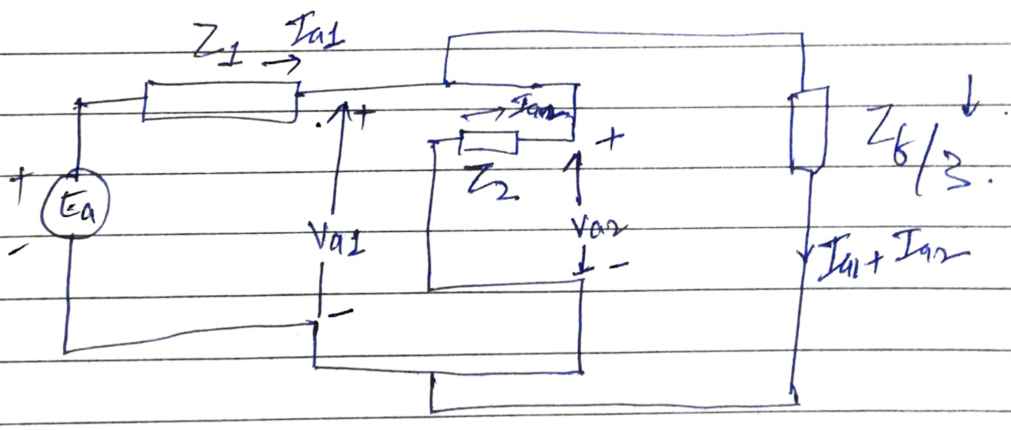
$$I_{a2} = \frac{1}{3}\left[I_a + \beta^2 I_B + \beta I_c\right]$$

$$I_{a0} = \frac{1}{3}\left[I_a + I_B + I_c\right] = \frac{0}{3} = 0$$

$$I_a = I_{a1} + I_{a2} + I_{a0}$$
$$= I_{a1} + I_{a2}.$$

$$V_{a1} = V_{a2} = (I_{a1} + I_{a2}) \frac{Z_f}{3}.$$

Then, the sequence network :-



sequence network.