# Problem 1.

Part A

$V_{b-hi} = 13.8\ KV$

$V_{b-lo} = 2400\ KV$

$S_b = 50\ MVA$

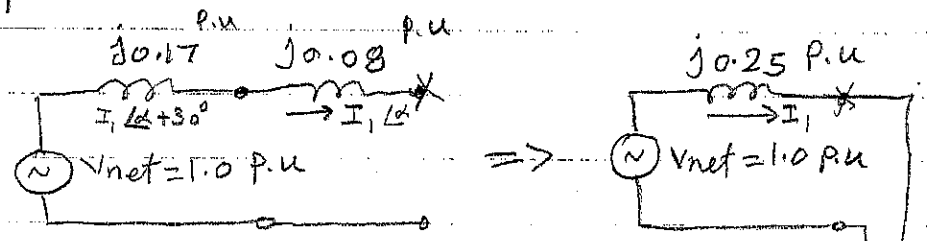
$X_{tr} = 0.08\ P.u.$

$X_{net} = \frac{V_{net}^2}{S_{net-sc}}$ $\qquad V_{net} = \frac{13.8KV}{V_{b-hi}} = 1.0\ P.u$

$S_{net-sc} = \frac{300MVA}{S_b} = 6\ P.u$

$X_{net} = \frac{1.0 P.u}{6\ p.u} = 0.17\ P.u$

+ Seq

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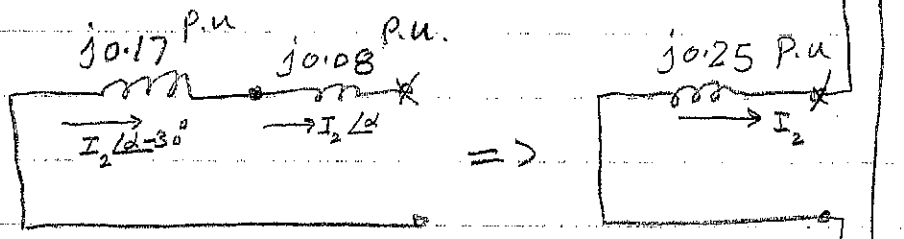


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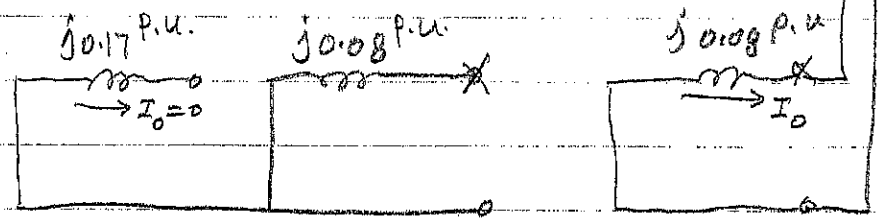



$\bar{I}_0 = \bar{I}_1 = \bar{I}_2 = \frac{V_{net} = 1.0\angle 0°}{j0.25 + j0.25 + j0.08} = -j1.74\ P.u$

$a = 1.0\angle 120°$

$\bar{I}_{abc\_LV} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 5.23\angle -90 \\ 0 \\ 0 \end{bmatrix}$ Current at LV side

$$I_{abc-hv} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} \bar{I}_0 \\ \bar{I}_1 \angle 30^\circ \\ \bar{I}_2 \angle -30^\circ \end{bmatrix} = \begin{bmatrix} 3.02 \angle -90^\circ \\ 0 \\ 3.02 \angle 90^\circ \end{bmatrix} \text{ p.u}$$

Part B

$$\bar{V}_1 = V_{net} - j X_1 \cdot \bar{I}_1 = 0.57 \angle 0^\circ \text{ p.u}$$

$$\bar{V}_2 = -j X_2 \bar{I}_2 = 0.43 \angle 180^\circ \text{ p.u}$$

$$\bar{V}_0 = -j X_0 \bar{I}_0 = 0.14 \angle 180^\circ \text{ p.u}$$

$$\bar{V}_{abc} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} \bar{V}_0 \\ \bar{V}_1 \\ \bar{V}_2 \end{bmatrix} = \begin{bmatrix} 0.0 \\ 0.89 \angle -103.59^\circ \\ 0.89 \angle 103.59^\circ \end{bmatrix} \text{ p.u.}$$

problem 2.

Use 115 kV Line side as a base.

$S_b = 100\ MVA$

$V_b = 115\ kV$

$V_{bS} = V_b \frac{13.8kV}{115kV} = 13.8kV$

$V_{bR} = V_b \cdot \frac{24kV}{115kV} = 24\ kV$

Generator 1

$S_{G1} = 200MVA$

$X_{G1} = X_{G1}^{old} \left(\frac{V_{G1}}{V_{bS}}\right)^2 \left(\frac{S_b}{S_{G1}}\right) = 0.1 \left(\frac{13.8kV}{13.8kV}\right)^2 \left(\frac{100MVA}{200MVA}\right) = 0.05\ p.u$

Transformer 1

$X/R = 25 \quad R = \frac{0.05}{25} = 0.002\ pu$ Can be neglected

$X_{Tr1} = 0.05 \left(\frac{13.8kV}{13.8kV}\right)^2 \left(\frac{100MVA}{200MVA}\right) = 0.025\ p.u$

Transmission line:

$X_L = j0.5\ p.u$

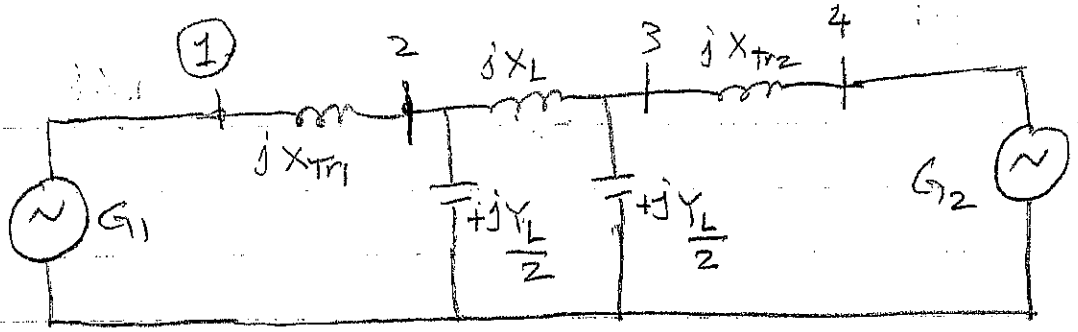
$Y_L = j0.02\ pu$

transformer 2:

$X_{Tr2} = 0.1 \left(\frac{24kV}{24kV}\right)^2 \left(\frac{100MVA}{75MVA}\right) = 0.1333\ p.u$

Generator 2:

$X_{G2} = 0.2 \left(\frac{24kV}{24kV}\right)^2 \left(\frac{100MVA}{75MVA}\right) = 0.2667\ p.u.$




$$Y_{BUS} = \begin{bmatrix} \frac{1}{jX_{Tr1}} & \frac{-1}{jX_{Tr1}} & 0 & 0 \\ \frac{-1}{jX_{Tr1}} & \left(\frac{1}{jX_{Tr1}} + \frac{1}{jX_L} + j\frac{Y_L}{2}\right) & \frac{-1}{jX_L} & 0 \\ 0 & \frac{-1}{jX_L} & \left(\frac{1}{jX_L} + \frac{1}{jX_{Tr2}} + j\frac{Y_L}{2}\right) & \frac{-1}{jX_{Tr2}} \\ 0 & 0 & \frac{-1}{jX_{Tr2}} & \frac{1}{jX_{Tr2}} \end{bmatrix}$$

$$Y_{BUS} = \begin{bmatrix} -j40 & j40 & 0 & 0 \\ j40 & -j41.99 & j2 & 0 \\ 0 & j2 & -j9.49 & j7.5 \\ 0 & 0 & j7.5 & -j7.5 \end{bmatrix}$$

# Problem 3: Method One

Part A

$$Z_{tot} = j0.45 + j0.35 + j0.34 + j0.9 = j2.04$$

$$I = \frac{1.0\angle 0}{Z_{tot}} = 0.4902\angle -90^\circ$$

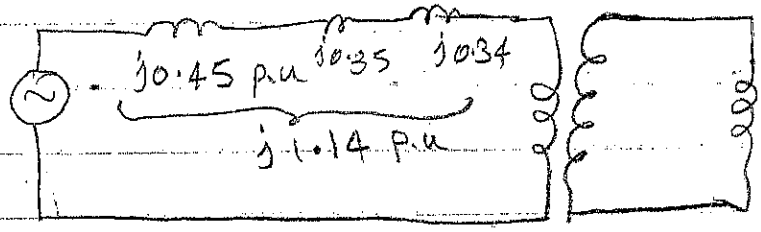
$$V_{Load} = I \cdot Z_{load} = 0.4902\angle -90^\circ \cdot 0.9\angle 90^\circ$$

$$V_{Load} = 0.441 \text{ p.u.}$$

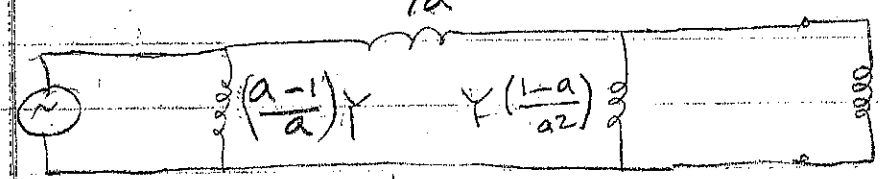
Part B

$$n = \frac{1}{10} \qquad n' = \frac{1}{8}$$

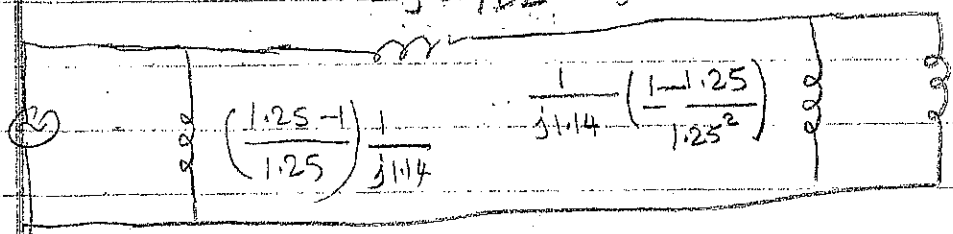
$$a = \frac{n'}{n} = \frac{\frac{1}{8}}{\frac{1}{10}} = 1.25$$

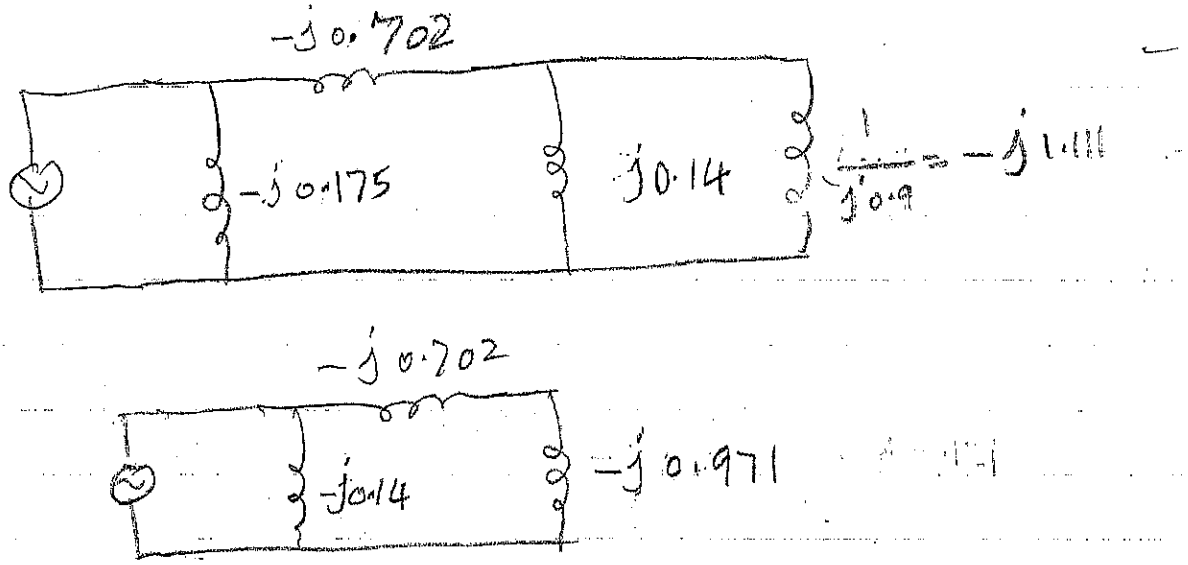



$Y = 0.877$ $\qquad$ $Y/a$ $\qquad$ 1 : 1.25




$-j0.702$






$$V_2 = \frac{1}{-j0.971} \cdot \frac{1.0\angle 0}{\frac{1}{-j0.702} + \frac{1}{-j0.971}}$$

$$V_2 = j1.03 \cdot \frac{1.0\angle 0}{j1.425 + j1.03} = 0.42 \text{ p.u}$$

Problem 3: Method two

Part A:

$$Z_{total} = j0.45 + j0.35 + j0.34 + j0.9 = j2.04$$

$$I = \frac{1.0 \angle 0^\circ}{Z_{total}} = 0.4902 \angle -90^\circ$$

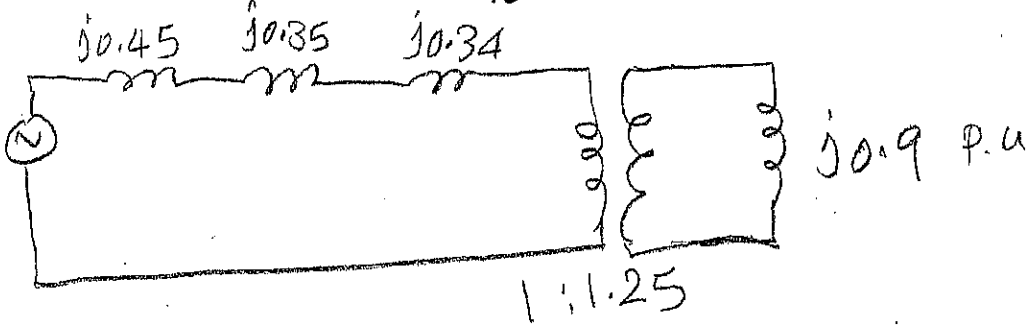
$$V_{load} = I \cdot Z_{Load} = 0.4902 \angle -90^\circ \times 0.9 \angle 90^\circ$$

$$V_{load} = 0.441 \text{ p.u.}$$

Part B

$$n = \frac{1}{10} \qquad n' = \frac{1}{8}$$

$$a = \frac{n'}{n} = \frac{1/8}{1/10} = 1.25$$



$$Z_{Load-p} = j0.9\left(\frac{1}{1.25}\right)^2 = j0.576$$

$$I_p = \frac{1.0\angle 0^\circ}{j0.45 + j0.35 + j0.34 + j0.576}$$

$$I_p = -j0.583 = 0.583\angle -90^\circ$$

$$I_s = I_p\left(\frac{1}{1.25}\right) = 0.583\angle -90^\circ \times \frac{1}{1.25}$$

$$I_s = 0.466\angle -90^\circ$$

$$V_{Load} = j0.9 \times 0.466\angle -90^\circ$$

$$V_{Load} = 0.42 \text{ p.u}$$