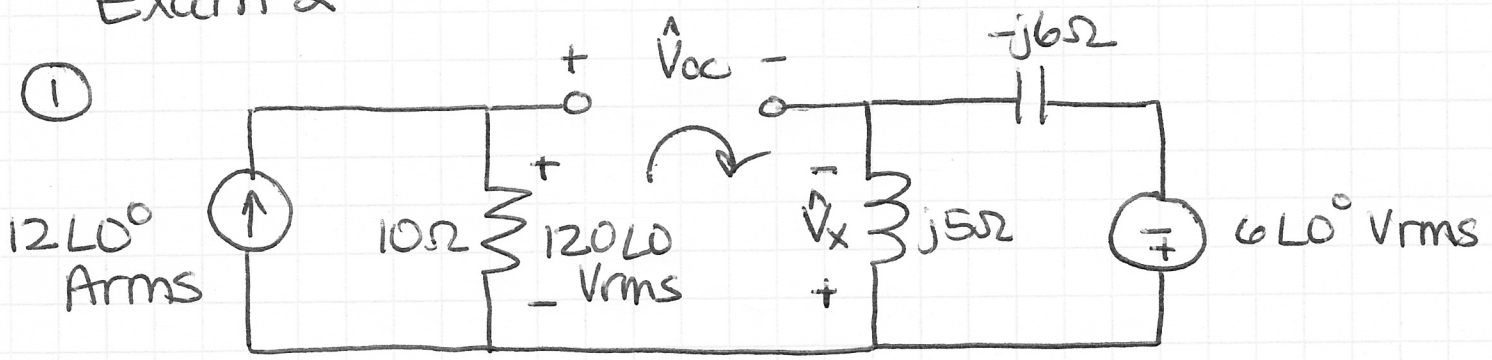
Practice Problems
Exam 2

(1)

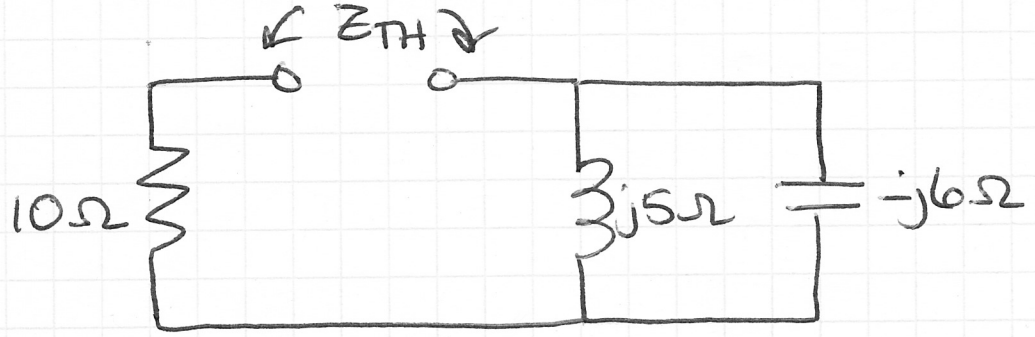


$$\hat{V}_x = (6\angle 0)\left(\frac{j5}{j5-j6}\right) = 30\angle 180^\circ \text{ Vrms}$$

by KVL: $120\angle 0 - \hat{V}_{oc} + \hat{V}_x = 0$

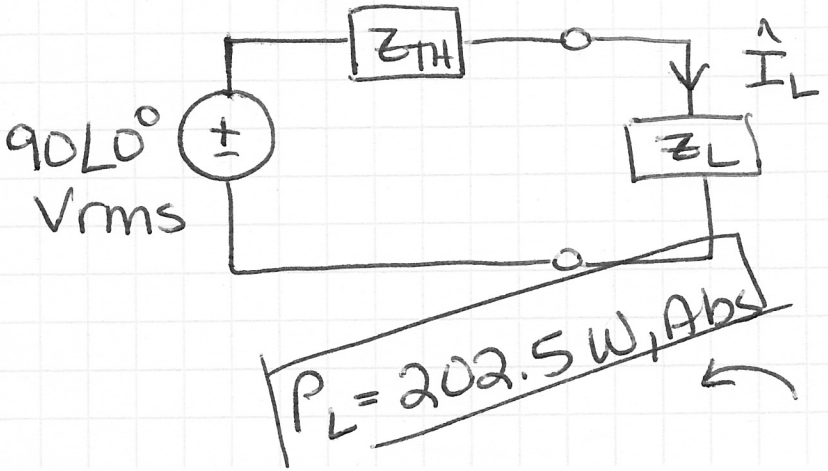
$$\hat{V}_{oc} = 120\angle 0 + \hat{V}_x$$

$$= 90\angle 0^\circ \text{ Vrms}$$



$$Z_{TH} = 10 + (j5 \,||\, -j6) = 31.62\angle 71.56^\circ\ \Omega$$

$$Z_L = Z_{TH}^* = 31.62\angle -71.56^\circ\ \Omega$$



$$\hat{I}_L = \frac{90\angle 0}{Z_{TH} + Z_L}$$

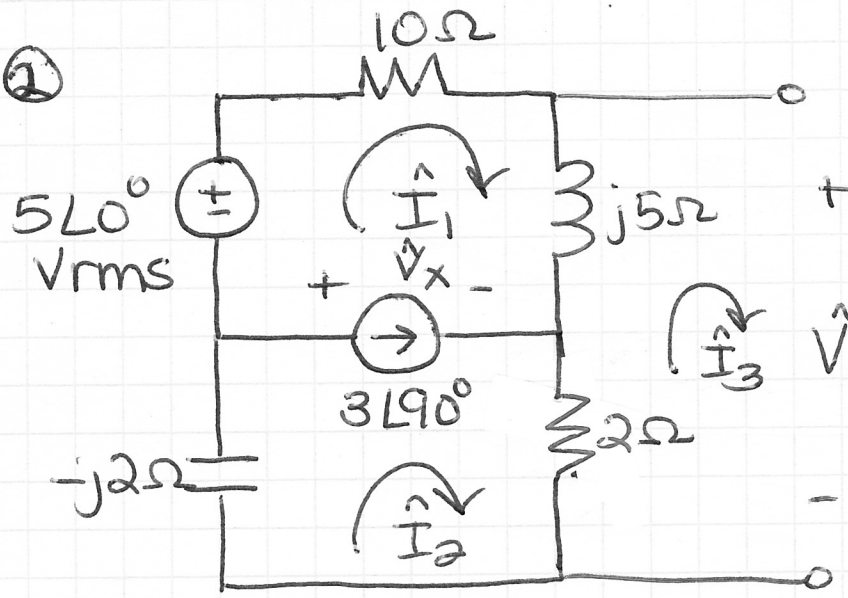
$$= 4.5\angle 0^\circ \text{ Arms}$$

$$P_L = (I_L)^2 \, Re[Z_L]$$

$$= (4.5)^2(10)$$

$P_L = 202.5$ W, Abs

②



$\hat{I}_3 = 0$

$\hat{I}_2 - \hat{I}_1 = 3\angle 90°$

$5\angle 0 - 10\hat{I}_1 - j5(\hat{I}_1 - \hat{I}_3) + \hat{V}_x = 0$

$-\hat{V}_x - 2(\hat{I}_2 - \hat{I}_3) - (-j2)\hat{I}_2 = 0$

add ↗ $5\angle 0 - 10\hat{I}_1 - j5\hat{I}_1 - 2\hat{I}_2 + j2\hat{I}_2 = 0$

$\hat{I}_1(-10-j5) + \hat{I}_2(-2+j2) = 5\angle 180°$

$\hat{I}_1(1\angle 180) + \hat{I}_2(1) = 3\angle 90°$

$\hat{I}_1 = 0.49\angle -113.50°$ Arms

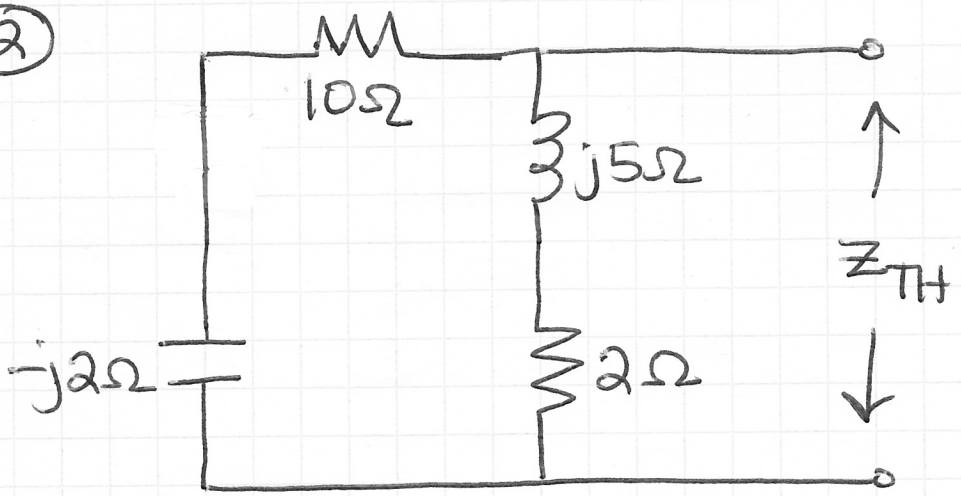
$\hat{I}_2 = 2.56\angle 94.40°$ Arms

M3: $-\hat{V}_{OC} - 2(\hat{I}_3 - \hat{I}_2) - j5(\hat{I}_3 - \hat{I}_2)$

$\hat{V}_{OC} = 2\hat{I}_2 + j5\hat{I}_2$

$= 13.79\angle 162.60°$ Vrms

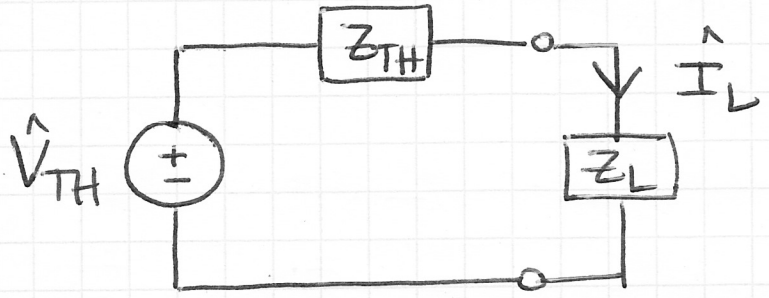
(2)



$$Z_{TH} = (10-j2) \,||\, (2+j5)$$

$$= 4.44 \angle 42.85^\circ \Omega$$

$$Z_L = Z_{TH}^* = 4.44 \angle -42.85^\circ \Omega$$



$$\hat{I}_L = \frac{13.79 \angle 162.60}{4.44 \angle 42.85 + 4.44 \angle -42.85}$$

$$= 2.12 \angle 162.60^\circ \text{ Arms}$$

$$P_L = (2.12)^2 \, \text{Re}[Z_L]$$

$$= 14.63 \text{ W, Abs}$$

(3)

a) Z_1: $P+jQ = 48+j27$ kVA

$= 55.07\angle 29.36^\circ$ kVA

$55.07\angle 29.36^\circ$ kVA $= (120\angle 0)\,\hat{I}_1^*$

$\hat{I}_1 = 458.94\angle -29.36^\circ$ Arms

Z_2: $\hat{S}_2 = 32\angle 65$ kVA $= (120\angle 0)(\hat{I}_2^*)$

$\hat{I}_2 = 266.67\angle -65^\circ$ Arms

Z_3: $\angle Z_3 = \cos^{-1}(.4) = 66.42^\circ$

$\hat{I}_3 = 20\angle -66.42^\circ$ Arms

$\hat{I}_S = \hat{I}_1 + \hat{I}_2 + \hat{I}_3 = 711.59\angle -42.97^\circ$ Arms

b) $Z_1 = \dfrac{120\angle 0}{\hat{I}_1} = 0.261\angle 29.36^\circ\ \Omega$

$Z_2 = \dfrac{120\angle 0}{\hat{I}_2} = 0.45\angle 65^\circ\ \Omega$

$Z_3 = \dfrac{120\angle 0}{\hat{I}_3} = 6\angle 66.42^\circ\ \Omega$

c) $\hat{S}_S = (120\angle 0)(\hat{I}_S^*) = 85.39\angle 42.97^\circ$ kVA

$P_S = \mathrm{Re}[\hat{S}_S] = 62.48$ kW

$Q_S = \mathrm{Im}[\hat{S}_S] = 58.20$ kVAR

③ $P_S = 62.48\ kW$

d) $\hat{I}_{Sold} = 711.59 \angle -42.97^\circ\ Arms$

$$62.48 \times 10^3 = 120(I_{Snew})(0.95)$$

$$I_{Snew} = 548.07\ Arms$$

$$\angle Z_{eff} = \cos^{-1}(.95) = 18.19^\circ$$

$$\hat{I}_{Snew} = 548.07 \angle -18.19^\circ$$

$$\hat{I}_C = \hat{I}_{Snew} - \hat{I}_{Sold} = 313.94 \angle 90^\circ\ Arms$$

$$Z_C = \frac{120 \angle 0}{\hat{I}_C} = 0.382 \angle -90^\circ\ \Omega$$

e) $\frac{1}{\omega C} = 0.382 \qquad \omega = 377\ rad/s$

$$\boxed{C = 6.94\ mF}$$

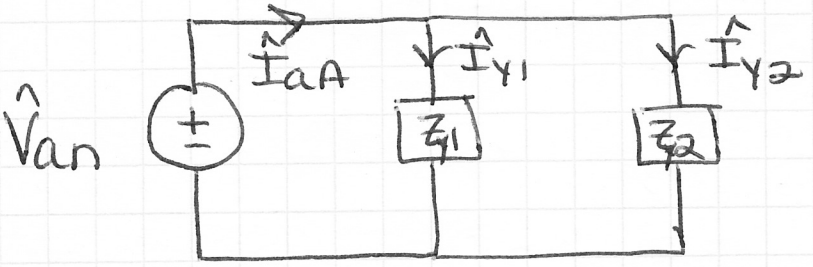
f) to minimize source current mag. $PF_{eff} = 1$

$$62.48 \times 10^3 = 120(I_{Snew})(1)$$

$$I_{Snew} = 520.67\ Arms$$

④ cont

assume both are Y-connected



$$\hat{V}_{an} = \frac{V_L}{\sqrt{3}} \angle 0^\circ = 138.56 \angle 0^\circ \text{ Vrms}$$

Z_{Y1}: $30 \times 10^3 = \sqrt{3} V_L I_{L1}$ $\quad \angle Z_{Y1} = \cos^{-1}(.5) = 60^\circ$

$$I_{L1} = 72.17 \text{ Arms}$$

$$\hat{I}_{Y1} = 72.17 \angle -60^\circ \text{ Arms}$$

Z_{Y2}: $18 \angle 20^\circ$ kVA

$18 \times 10^3 = \sqrt{3} V_L I_{L2}$ $\quad \angle Z_{Y2} = 20^\circ$

$$I_{L2} = 43.30 \text{ Arms}$$

$$\hat{I}_{Y2} = 43.30 \angle -20^\circ \text{ Arms}$$

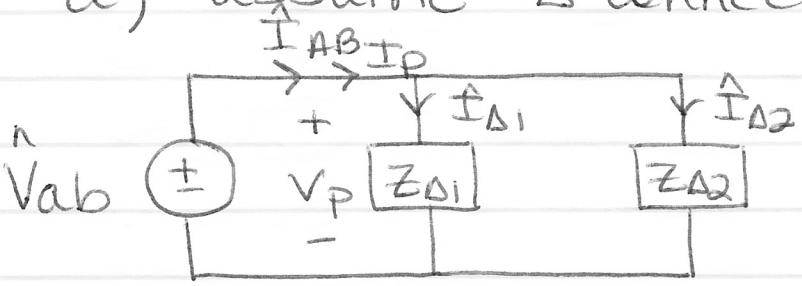
$$\hat{I}_{aA} = \hat{I}_{Y1} + \hat{I}_{Y2} = 108.95 \angle -45.20^\circ \text{ Arms}$$

$$Z_{Y1} = \frac{\hat{V}_{an}}{\hat{I}_{Y1}} = 1.92 \angle 60^\circ \Omega$$

$$Z_{Y2} = \frac{\hat{V}_{an}}{\hat{I}_{Y2}} = 3.2 \angle 20^\circ \Omega \qquad Z_{\Delta 2} = (Z_{Y2})3 = 9.6 \angle 20^\circ \Omega$$

(5)

a) assume Δ connected



$$V_p = |\hat{V}_{ab}| = \sqrt{3}\,|\hat{V}_{an}| = 207.85 \text{ Vrms}$$

$\underline{Z_{\Delta 1}}$: $39 \times 10^3 = \sqrt{3}\, V_L I_{L1}$

$$I_{L1} = 108.33 \text{ Arms}$$

$$I_{p1} = \frac{I_{L1}}{\sqrt{3}} = 62.55 \text{ Arms}$$

$$\angle Z_{\Delta 1} = \cos^{-1}(.7) = 45.57^\circ$$

$$\hat{I}_{\Delta 1} = 62.55 \angle -15.57^\circ \text{ Arms}$$

$$Z_{\Delta 1} = \frac{\hat{V}_{ab}}{\hat{I}_{\Delta 1}} = 3.32 \angle 45.57^\circ \Omega$$

$\underline{Z_{\Delta 2}}$: $15 \times 10^3 = \sqrt{3}\, V_L I_{L2}$ $\quad \angle Z_{\Delta 2} = 0$

$$I_{L2} = 41.67 \text{ Arms}$$

$$I_{p2} = \frac{I_{L2}}{\sqrt{3}} = 24.05 \text{ Arms}$$

$$\hat{I}_{\Delta 2} = 24.05 \angle 30^\circ \text{ Arms}$$

Cont

(5)

$$Z_{\Delta 2} = \frac{\hat{V}_{ab}}{\hat{I}_{\Delta 2}} = 8.64 \angle 0^\circ \ \Omega$$

$$\hat{I}_{AB} = \hat{I}_{\Delta 1} + \hat{I}_{\Delta 2} = 81.22 \angle -3.36^\circ \text{ Arms}$$

$$I_p = |\hat{I}_{AB}| = 81.22 \text{ Arms}$$

$$\hat{I}_{aA} = \hat{I}_{AB} - \hat{I}_{cA} = 140.68 \angle -33.36^\circ \text{ Arms}$$

b) Assume Y-loads

from part a: $\hat{I}_{Y1} = 108.33 \angle -45.57^\circ$ Arms

$\hat{I}_{Y2} = 41.67 \angle 0^\circ$ Arms

$$\hat{I}_{aA} = \hat{I}_{Y1} + \hat{I}_{Y2} = 140.68 \angle -33.36^\circ \text{ Arms}$$

$\therefore I_p = I_L = 140.68$ Arms

$V_p = |\hat{V}_{an}| = 120$ Vrms

$$Z_{Y1} = \frac{\hat{V}_{an}}{\hat{I}_{Y1}} = 1.11 \angle 45.57^\circ \ \Omega$$

$$Z_{Y2} = \frac{\hat{V}_{an}}{\hat{I}_{Y2}} = 2.88 \angle 0^\circ \ \Omega$$