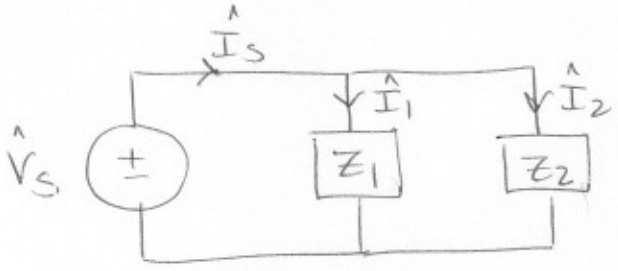
① 

Z_1: 15 kW at PF = 0.5 lag

Z_2: 20 kVAR at PF = 0.254 lag.

$\hat{V}_S = 120\angle 0^\circ$ Vrms

a) $P_1 = 15\times10^3 = 120(I_1)(.5)$ $\quad I_1 = 250$ Arms

$\angle Z_1 = \cos^{-1}(.5) = 60^\circ$

$|Z_1| = \frac{V_S}{I_1} = \frac{120}{250} = 0.48\ \Omega$

$\hat{I}_1 = 250\angle -60^\circ$ Arms

$Z_1 = 0.48\angle 60^\circ\ \Omega$

$\angle Z_2 = \cos^{-1}(.254) = 75.29^\circ$

$Q_2 = 20\times10^3 = 120(I_2)\sin(75.29^\circ)$

$I_2 = 172.31$ Arms

$|Z_2| = \frac{V_S}{I_2} = \frac{120}{172.31} = 0.696\ \Omega$

$\hat{I}_2 = 172.31\angle -75.29^\circ$ Arms

$Z_2 = 0.696\angle 75.29^\circ\ \Omega$

b) $\hat{I}_S = \hat{I}_1 + \hat{I}_2 = 418.68\angle -66.23^\circ$ Arms

c) $\hat{S}_S = \hat{V}_S \cdot \hat{I}_S^* = (120\angle 0)(418.68\angle 66.23)$

$\hat{S}_S = 50.24\angle 66.23^\circ$ kVA

Check $P_S = \mathrm{Re}[\hat{S}_S] = 20.25$ kW ← checks :)

$P_1 = 15$ kW

$P_2 = \frac{20\text{ kVAR}}{\sin(75.29)}\cdot\cos(75.29) = 5.25$ kW

$P_S = P_1 + P_2 = 20.25$ kW

① cont

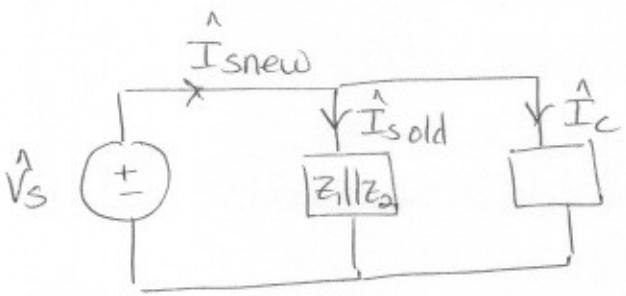
d) the angle of the loads combined is the angle of the complex powers.

$$PF_{1,2} = \cos(66.23) = 0.403 \text{ lagg.}$$

-or-

$$Z_1 || Z_2 = 0.287 \angle 66.23^\circ \ \Omega \qquad PF = \cos(66.23) = 0.403 \text{ lag.}$$

e)



$PF_{CL} = 0.95$ lag

$\hat{I}_{sold} = 418.68 \angle -66.23^\circ$ Arms

$P_S = 20.25$ kW

$\hat{V}_S = 120\angle 0^\circ$ Vrms

$20.25 \times 10^3 = 120(I_{snew})(.95)$

$I_{snew} = 177.63$ Arms

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

$\hat{I}_{snew} = 177.63 \angle -18.19^\circ$ Arms

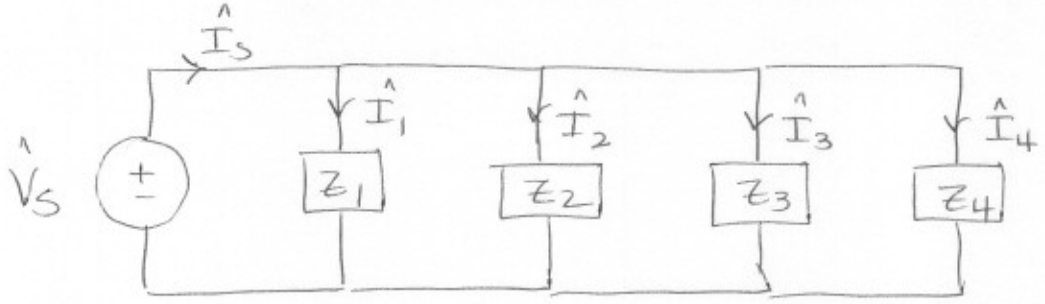
$$\hat{I}_C = \hat{I}_{snew} - \hat{I}_{sold}$$

$$= 327.71 \angle 90^\circ \text{ Arms}$$

$$Z_C = \frac{\hat{V}_S}{\hat{I}_C} = \frac{120\angle 0^\circ}{327.71\angle 90^\circ} = 0.366\angle -90^\circ \ \Omega$$

$$\boxed{Z_C = 0.366\angle -90^\circ \ \Omega}$$

(2)



$\hat{V}_s = 220\angle 0^\circ$ Vrms

a) Z_1 : $\hat{S}_1 = 10\angle 25^\circ$ kVA

$10\times10^3 = 220\, I_1$

$I_1 = 45.45$ Arms

$|Z_1| = \frac{220}{45.45} = 4.4\,\Omega$

$\hat{I}_1 = 45.45\angle -25^\circ$ Arms

$Z_1 = 4.4\angle 25^\circ\,\Omega$

Z_2 : $P_2 = 2$kW $PF_2 = 0.8$ lag $\angle Z_2 = \cos^{-1}(.8)$

$= 36.87^\circ$

$2\times10^3 = 220\,(I_2)(.8)$

$I_2 = 11.36$ Arms

$|Z_2| = \frac{V_s}{I_2} = 19.36\,\Omega$

$\hat{I}_2 = 11.36\angle -36.87^\circ$ Arms

$Z_2 = 19.36\angle 36.87^\circ\,\Omega$

Z_3 : $P_3 = 3$kW $Q_3 = 8$kVAR $\hat{S}_3 = P + jQ$

$= 8.54\angle 69.44^\circ$ kVA

$\angle Z_3 = 69.44^\circ$

$8.54\times10^3 = 220\, I_3$ $I_3 = 38.84$ Arms

$\hat{I}_3 = 38.84\angle -69.44^\circ$ Arms

$Z_3 = 5.67\angle 69.44^\circ\,\Omega$

$Z_3 = \frac{220}{38.84} = 5.67\,\Omega$

② cont.

Z_4: $I_4 = 30$ Arms $\quad Q_4 = 4$-kVAR

$4000 = 220(30)\sin(\angle Z_4)$

$\sin(\angle Z_4) = 0.606 \qquad \angle Z_4 = 37.31^\circ$

$|Z_4| = \frac{220}{30} = 7.33\,\Omega$

$\hat{I}_4 = 30\angle -37.31^\circ$ Arms

$Z_4 = 7.33\angle 37.31^\circ\,\Omega$

b). $\hat{I}_S = \hat{I}_1 + \hat{I}_2 + \hat{I}_3 + \hat{I}_4$

$\hat{I}_S = 119.15\angle -42.55^\circ$ Arms

c) $P_S = V_S I_S \cdot \cos(\theta - \phi)$

$= (220)(119.15)\cos(42.55)$

$P_S = 19.31$ kW

$Q_S = V_S I_S \sin(\theta - \phi)$

$= 220(119.15)\sin(42.55)$

$Q_S = 17.73$ kVAR

check

$P_1 = \mathrm{Re}[\hat{S}_1] = 9.06$ kW

$P_2 = 2$ kW

$P_3 = 3$ kW

$P_4 = 220(30)\cos(37.31)$
$= 5.30$ kW

$\Sigma P = 19.36$ kW

checks

② cont

d) $PF_{1-4} \Rightarrow \cos(\theta - \varphi)$ $\cos(42.55) = 0.737$ lag

e) $P_S = 19.31$ kW

$\dot{V}_S = 220 \angle 0$

$PF_{CL} = 1$ (to minimize current) $\angle Z_{CL} = 0^\circ$

$19.31 \times 10^3 = 220 (I_{snew})(1)$

$I_{snew} = 87.77$ Arms

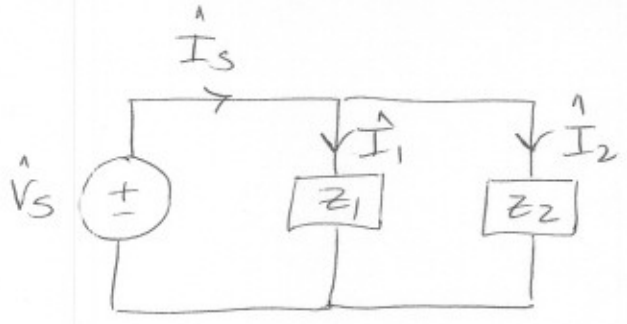
$\dot{I}_{snew} = 87.77 \angle 0^\circ$ Arms

$\dot{I}_C = \dot{I}_{snew} - \dot{I}_{sdd} = (87.77 \angle 0) - (119.15 \angle -42.55)$

$= 80.57 \angle 90^\circ$ Arms

$$Z_C = \frac{\dot{V}_S}{I_C} = 2.73 \angle -90^\circ \ \Omega$$

(3)



$I_S = 300$ Arms

$P_S = 12$ kW

$PF_S = 0.47$ lag

$12 \times 10^3 = V_S (300)(0.47)$ $\quad \cos^{-1}(.47) = 61.97°$

$V_S = 85.11$ Vrms (assume source angle is 0)

$\hat{V}_S = 85.11 \angle 0°$ Vrms

$\hat{I}_S = 300 \angle -61.97°$ Arms

Z_1: $P_1 = 4$ kW

$PF_1 = 0.3$ lag

$\angle Z_1 = \cos^{-1}(.3)$

$= 72.54°$

$4000 = 85.11(I_1)(.3)$

$I_1 = 156.68$ Arms

$\hat{I}_1 = 156.98 \angle -72.54°$ Arms

$Z_1 = \frac{85.11}{156.98} = 0.54\ \Omega$

$Z_1 = 0.54 \angle 72.54° \Omega$

$\hat{I}_2 = \hat{I}_S - \hat{I}_1$

$= (300 \angle -61.97) - (156.98 \angle -72.54)$

$= 148.50 \angle -50.79°$ Arms

$$Z_2 = \frac{\hat{V}_S}{\hat{I}_2} = 0.57 \angle 50.79° \Omega$$

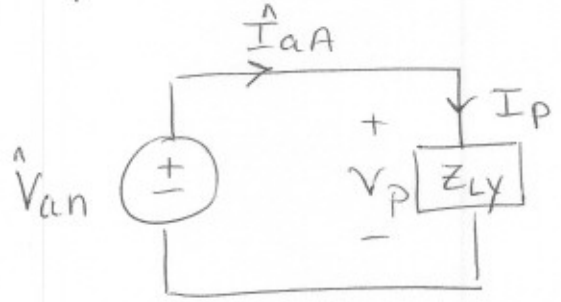
(4) $V_L = 208$ Vrms

$\overset{Z}{\perp}_{LY} \Rightarrow P_{3\phi} = 48$ kW

PF = 0.715 lag

a)

single phase ckt (Y-Y)



$$|\hat{V}_{an}| = \frac{V_L}{\sqrt{3}} = 120.09 \text{ Vrms}$$

$$\boxed{V_p = |\hat{V}_{an}| = 120.09 \text{ Vrms}}$$

$$P_{1\phi} = \frac{P_{3\phi}}{3} = \frac{48}{3} = 16 \text{ kW}$$

$$16 \times 10^3 = |\hat{V}_{an}||\hat{I}_{aA}| \cdot PF$$

$$\text{or} \quad = V_p I_p \cdot PF$$

$$16 \times 10^3 = 120.09\, I_p\, (.715)$$

$$\boxed{I_p = 186.34 \text{ Arms}}$$

b) $\hat{I}_{aA} = I_L \angle -\phi$ $\quad I_L = I_p = 186.34$

$$\angle Z_L = \cos^{-1}(.715) = 44.36^\circ$$

$$\hat{I}_{aA} = 186.34 \angle -44.36^\circ \text{ Arms}$$
$$\hat{I}_{bB} = 186.34 \angle -164.36^\circ \text{ Arms}$$
$$\hat{I}_{cC} = 186.34 \angle 75.64^\circ \text{ Arms}$$

(4) cont

d) $\hat{S}_{3\phi} = 3 \cdot \hat{V}_{an} \cdot \hat{I}_{aA}^{*}$

$= 3\,(120.09 \angle 0)(186.34 \angle 44.36)$

$\hat{S}_{3\phi} = 67.13 \angle 44.36^{\circ}$ kVA