Assignment 2

S1) 1. $P = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$

$S = V_{rms} I_{rms} \sin(\theta_v - \theta_i)$

$P > 0$ = absorbing

$P < 0$ = delivering

$Q > 0$ = absorbing mag. var

$Q < 0$ = delivering mag. var

1. $P = \frac{340 \times 20}{2} \times \cos 45 = 2.404 kW$ absorbing

$Q = \frac{340 \times 20}{2} \times \sin 45 = 2.404 kVA_r$ absorbing

2. $P = \frac{75 \times 16}{2} \times \cos(-75) = 0.155 kW$ absorbing

$Q = -\frac{75 \times 16}{2} \times \sin 75 = 0.579 kVA_r$ delivering

3. ~~$P = \frac{625 \times 4}{2} \cos(-200) =$~~

$P = \frac{625 \times 4}{2} \cos(-110) = 0.427 kW$ ~~deliv~~ delivering

$Q = \frac{625 \times 4}{2} \sin(-110) = -1.174 kVA_r$

4. $P = \frac{180 \times 10 \cos(110)}{2} = +0.307 kW$ delivering

$Q = 0.845 kVA_r$ absorbing

Q2]

$$50kW = 40kW + I_{rms}^2 \times 20$$

$$\Rightarrow I_{rms} = \sqrt{500}\ A$$

$$30\times10^3\ VAr = V_{rms}\sqrt{500}\sin(\theta)$$
$$40\times10^3\ W = V_{rms}\sqrt{500}\cos(\theta)$$
$$\Rightarrow \theta \approx 37^\circ \qquad V_{rms} = 2236.06\ V$$

$$40\times10^3 = I_{rms}^2 \times R_L \cancel{\Rightarrow R_L} = 8 \Rightarrow R_L = 80\ \Omega$$

$$30\times10^3 = I_{rms}^2 \times X_L \rightarrow X_L = 60\ \Omega$$

$$Z_L = 80 + j60\ \Omega \qquad Z_{eff} = 100 + j(60 - x)$$

$$\underset{I_{rms}}{\underset{\downarrow}{I_s}} \angle\theta = \frac{2500\angle 0^\circ}{|Z_{eff}|\angle\phi} \Rightarrow |Z_{eff}| = \frac{2500}{\sqrt{500}}$$

$$\left(\sqrt{100^2 + (60-x)^2}\right)^2 = \frac{2500^2}{500}$$

$$\cancel{100^2 + (60-x)^2 = 2500^2 \times 5^2}$$

$$100^2 + (60-x)^2 = 2500 \times 5$$

$$(60-x)^2 = 2500 \Rightarrow \underline{\underline{x = 10\ \Omega \text{ or } 110\ \Omega}}$$

Q3. 1. $V_{rms} = \sqrt{\dfrac{20^2 + 100^2 + 20^2 + 20^2 + 100^2 + 20^2}{6}} = \underline{\underline{24.5 \text{ V}}}$

2. $P_{avg} = \dfrac{\text{Total energy dissipated}}{\text{Total time tike}}$

$= \dfrac{\frac{20^2}{12} + \frac{100^2}{12} + \frac{20^2}{12} + \frac{20^2}{12} + \frac{100^2}{12} + \frac{20^2}{12}}{6}$

$= \dfrac{\overset{1800}{\cancel{2 \times 10800}}}{6 \cancel{12} \times \cancel{6}} = \underline{\underline{300 \text{ W}}}$

Q4.

1.

$R_1 = \dfrac{240\cancel{0} \times 2\cancel{400}}{(18 + j24) \times 1\cancel{0^3}} = \dfrac{240 \times 4\,(3-4j)}{(3+4j)(3-4j)} = \dfrac{\overset{48}{\cancel{240}} \times 4\,(3-4j)}{\cancel{25}\,5}$

$= \dfrac{192}{5}(3-4j)$

$= 96\,(0.6 - j0.8)$

$R_2 = \dfrac{240\cancel{0} \times \overset{4}{\cancel{2400}}}{(0.6 - j \times 0.8) \times \cancel{100} \times \cancel{10^3}}$

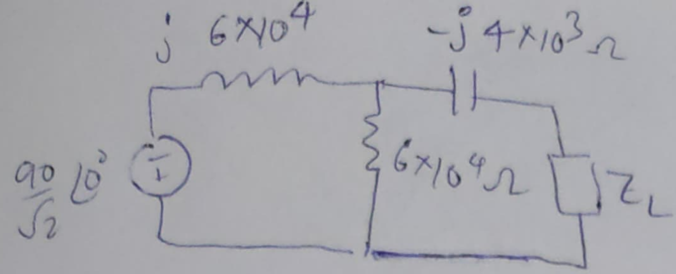
$R_3 = \dfrac{\overset{80}{\cancel{240}}\cancel{0} \times \overset{4}{\cancel{2400}}}{\cancel{3}\cancel{18} \times \cancel{10^3}} = 320\ \Omega$

$\dfrac{1}{Z_{eq}} = \dfrac{1}{320} + \dfrac{3+4j}{960} + \dfrac{0.6 - j0.8}{9\cancel{6}} = \dfrac{3 + 3 + 4j + 6 - 8j}{960} = \dfrac{12 - 4j}{960}$

$$Z_{eq} = \frac{960}{12-4j} = \frac{240}{3-j}\frac{(3+j)}{(3+j)} = 72+24j$$

2. $$pf = \frac{72}{\sqrt{72^2+24^2}} = \frac{3}{\sqrt{10}}$$

Q5)



1. $Z_{TH} = -j\times4\times10^3 + \frac{j\times6\times10^4\times\cancel{6\times10^4}}{(1+j)\,\cancel{6\times10^4}} = -j\times4\times10^3 + 30\times10^3 + j\times30\times10^3$

$= 30\times10^3 - j10\times10^3$

For max power, $Z_L = Z_{TH}^*$

$Z_L = 30\times10^3 + j10\times10^3\,\Omega$

2. $V_{TH} = \frac{90}{\sqrt{2}}\angle0^\circ \times \frac{60\,k\Omega}{60\,k\Omega + j60\,k\Omega} = \frac{45}{\sqrt{2}}\angle0^\circ(1-j) = 45\angle-45^\circ$

P_{avg} across $Z_L = Re(I_s^2 Z_L) = \cancel{Re(V_s^2}$

$= \cancel{Re(}$

$I_s = \frac{45(-45^\circ)}{60} = 0.75\angle-45^\circ$

$P_{avg} = Re(0.75\times0.75\times(30\times10^3 + j10\times10^3\,\Omega))$

$= 16.875\,kW$

Q7. 1. Balanced, ~~negative~~ +ve

2. ″ , ~~positive~~ -ve

3. ″ , ~~negative~~ +ve

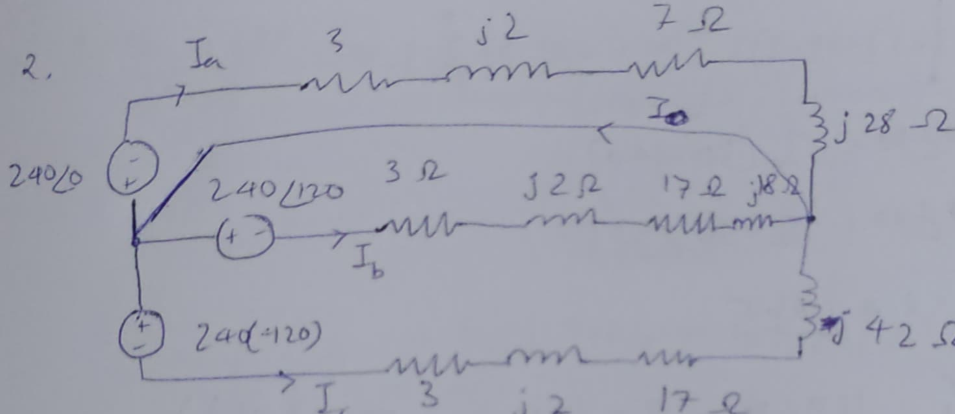
4. ″ , ~~positive~~ -ve

5. Unbalanced, V_b and V_c are not 120° apart

6. ″ ″

Q8 1. Unbalanced as load impedences are not equal

2.



$$-240\angle 0 - 3I_a - 2jI_a - 7I_a - 28jI_a = 0$$

$$-240\angle 120 - 3I_b - 2jI_b - 17I_b - 18jI_b = 0$$

$$-240\angle -120 = -3I_c - 2jI_c - 17I_c + j42I_c = 0$$

$$I_a = \frac{-240\angle 0}{10+j30} ; \quad I_b = \frac{-240\angle 120}{20+j20} ; \quad I_c = \frac{-240\angle -120}{20-j40}$$

$$= \frac{-24\angle 0}{1+j3} \qquad = \frac{-12\angle 120}{1+j} , \qquad = \frac{-12\angle -120}{1-j2}$$

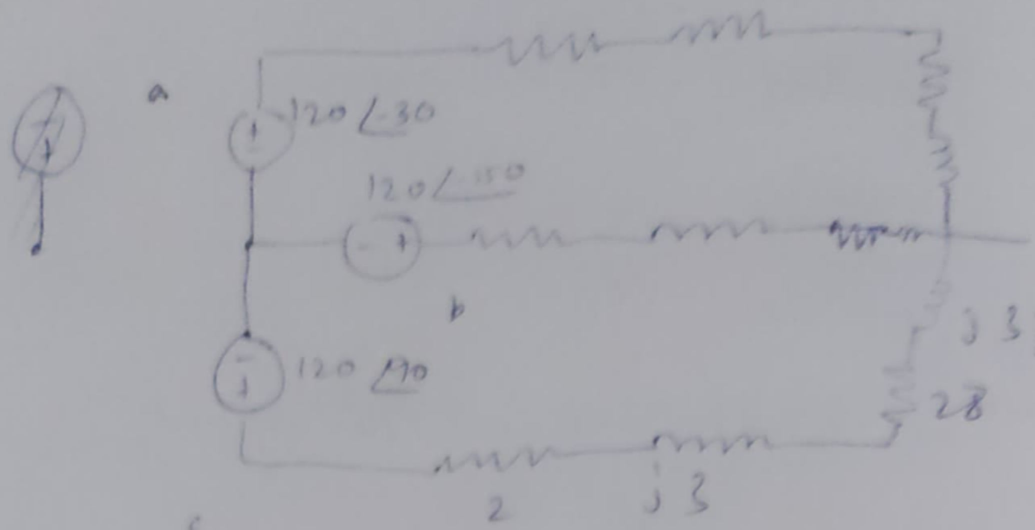
$$I_o = I_a + I_b + I_c = \frac{-24\angle 0}{1+j3} - \frac{12\angle 120}{1+j} - \frac{12\angle -120}{1-j2}$$

$$= \frac{-24\angle 0}{3.16\angle 71.56} - \frac{12\angle 120}{1.414\angle 45^\circ} - \frac{12\angle -120}{2.24\angle -63.43} = \boxed{-7.59\angle -71.56 - 8.48\angle 75^\circ - 5.36\angle -56.57}$$

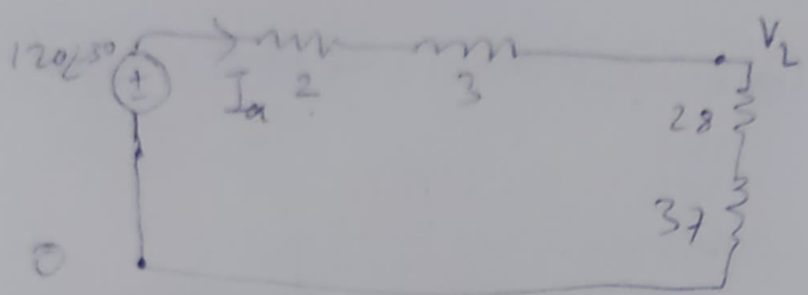
$$= (-7.59\cos(71.56) - 8.48\cos 75 - 5.36\cos(56.76)) + j(7.59\sin(71.56) + 8.48\sin 75 + 5.36\sin 56.57)$$

$$= 7.53 + j3.48 = 8.3\angle 24.8^\circ\ A$$

9.



1.



$120\angle{-30} = I_a(30+j40)$

$120\angle{-30} = I_a \times 50\angle 53.15$

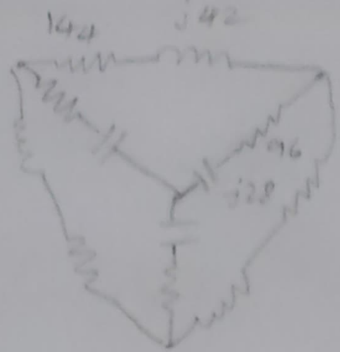
2. $I_a = 2.4\angle{-83.15^\circ}$

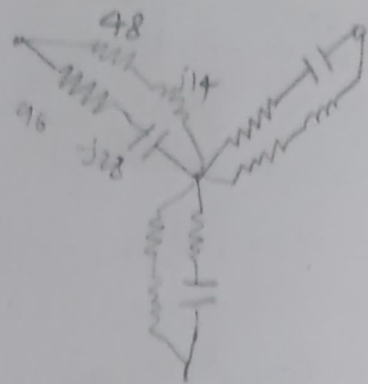
$V_L = 120\angle{-30} - 2.4\angle{-83.15} \times \sqrt{13}\ \angle \tan^{-1}\left(\frac{3}{2}\right)$

$= 120\angle{-30} - 2.4\times\sqrt{13}\ \angle{-83.15+56.34}$

3. $120\angle{-30} - 8.65\ \angle{-26.81} \approx 112\angle{-30}$

Q10.

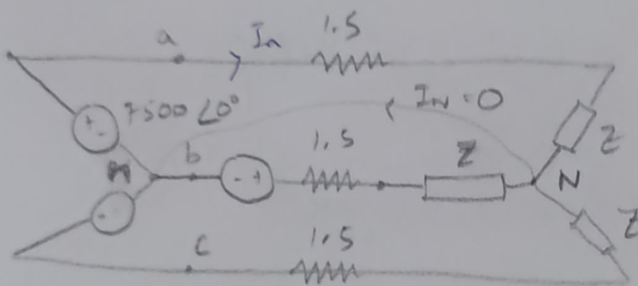




$Z_{\Delta} = \dfrac{(48+14j)\times 2(48-14j)}{48+96\ j14} = \dfrac{5000}{144-j14} = \dfrac{2500}{72-j7}$

$= \dfrac{2500(72+j7)}{5233}$

$= 34.56 \angle 5.55^\circ$



$Z = \dfrac{2500}{5233}(72+j7)$

$= 34.40 + j\,3.34$

$7500\angle 0^\circ = I_a(1.5 + 34.40 + j\,3.34) = I_a(35.94 + j\,3.34)$

$7500\angle 0^\circ = I_a \times 36.09\angle 5.3^\circ \Rightarrow I_a = 207.8\angle -5.3^\circ$

1. $|I_a| = 207.8\,A$

2. $I_\Delta = 207.8\angle -5.3^\circ \times \dfrac{96-j28}{144-j14} \times \sqrt{3} \times \dfrac{\angle -30^\circ}{\sqrt{3}}$

$|I_\Delta| = \dfrac{\sqrt{3}\times 207.8}{\sqrt{3}} \times \dfrac{100}{144.68} = \dfrac{248.76\ A}{3} = 82.92\,A$

3. $I_Y = 207.8\angle -5.3^\circ \times \dfrac{48+j14}{144-j14}$

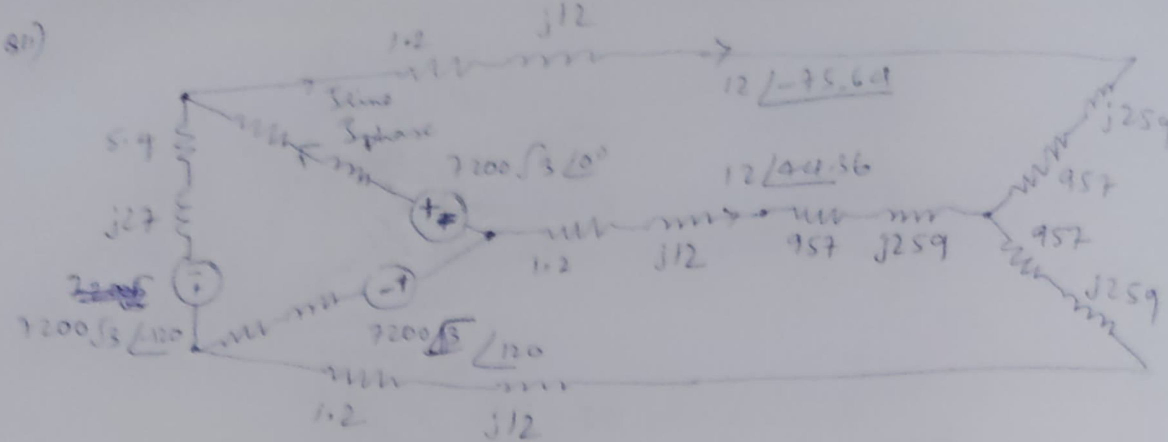
$|I_Y| = 207.8 \times \dfrac{50}{144.68} = 71.81\,A$

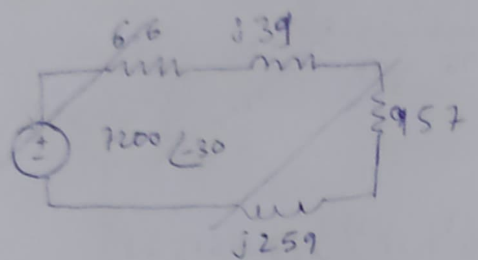
4. $7500\angle 0^\circ - 1.5 \times 207.8 \angle -5.3^\circ$

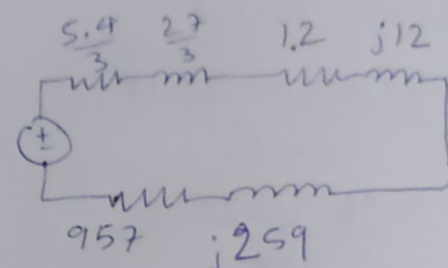
$7500\angle 0^\circ - 311.7 \angle -5.3^\circ \approx 7189.6 + j\,28.8$

$|V| \approx 7189.6\,V$

(a)







1.

2.

Phase currents $= \cancel{100}\ \dfrac{7200\angle 30^\circ}{1000+j280} = \dfrac{7200}{1038.46}\angle -45.64$

$= 6.93\angle -45.64^\circ$

line currents $= 12\angle -75.64^\circ,\ 12\angle 44.36^\circ,\ 12\angle -195.64^\circ$

$7200\sqrt{3}\angle 0^\circ = 6.93\angle -45.64\,(5.4+j27) + 12\angle -75.64\,(1.2+j12+259j+957)$

$- 12\angle -44.36\,(1.2+j12+259j+957)$

Load line voltages $= 12\angle -75.64\,(\cancel{260}\ 958.2+j271)$

$= 12\angle -75.64 \times 995.78\angle 15.79^\circ$

$11949\angle -59.85^\circ$ V

3. 6.93

4. $7200\sqrt{3}$

Q12) $S = P + jQ$

$S = 14\text{ kVA}$ $\quad P = 0.75$

$S = S_1 + S_2$

$S_1 = 9\text{ kVA}$ $\quad P_1 = 0.6$

$S = 10.5\text{ kW} + j\,9.26\text{ kVA}_r$ $\qquad S_1 = 5.4\text{ kW} + j\,7.2\text{ kVA}_r$

$S_2 = 5.1\text{ kW} + j\,2.06\text{ VA}_r$

1. $\frac{2.06}{3} = 0.6866\text{ kVA}_r \approx 0.69\text{ kVA}_r$.

2. Power $= \sqrt{3} V_L I_L \cos\theta$

$14\text{kV} = \sqrt{3} \times V_L \times \sqrt{3}\,10 \times \angle 0^\circ$

$V_L = \frac{1400}{3}\text{ V} = \underline{\underline{466.67\text{ V}}}$