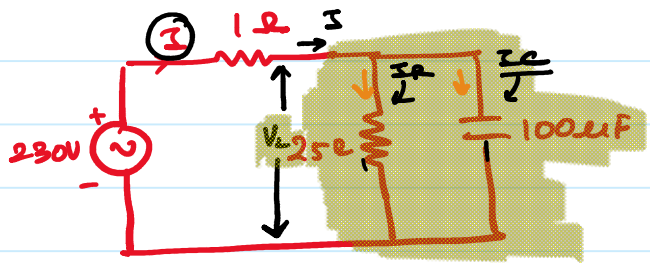
3.2 AC Power

28 January 2022 15:42

Q1



$R_{line} = 1\Omega \quad R_L = 25\Omega \quad Z_C = \frac{1}{j \times 377 \times 100 \times 10^{-6}}$

$|S|_{load} \quad V = 230\angle 0^\circ V \quad I = \frac{V}{Z_{TOTAL}}$

$|S|_{source} \quad \omega = 377 \text{ rad/s}$

a) $Z_{load} \rightarrow R_L \| Z_C$

$$\frac{1}{Z_{LOAD}} = \frac{1}{25} + j\,377 \times 100 \times 10^{-6}$$

$Z_{LOAD} = 18.193\angle -43.3^\circ \Omega = 13.24 - j12.478\ \Omega$

b) $Z_{TOTAL} = Z_{line} + Z_{load}$

$= 1 + 18.193\angle -43.3^\circ$

$= 18.933\angle -41.23\ \Omega$

c) $I = \frac{V}{Z_{TOTAL}} = \frac{230\angle 0}{18.933\angle -41.23}$

$= 12.15\angle 41.23^\circ A.$

d) $|S_{LOAD}| = |V_{LOAD}|\,|I_{LOAD}|$

$V_{LOAD} = V - I(R_{line})$

$= 230\angle 0 - 12.15\angle 41.23(1)$

$= 221\angle -2.09^\circ V$

$I_{LOAD} = I = 12.15\angle 41.23^\circ$

$|S_{LOAD}| = |221| \times |12.15| = 2685\ VA.$

e) LOAD POWER FACTOR ?

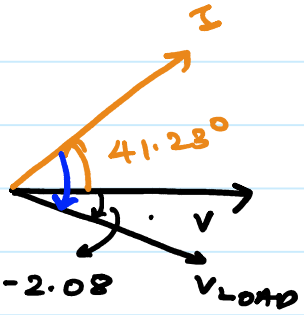
$\angle Z_L \rightarrow 43.3 \rightarrow \cos 43.3 \rightarrow 0.728$ lag

$\cos\theta_L = \dfrac{P_L}{|S_{LOAD}|} =$

$\angle I$ and V_{LOAD}

$= 41.23 + 2.08$

$\rightarrow 0.728$ leading.



$P_L = \dfrac{V_{LOAD}^2}{R} = \dfrac{|221|^2}{25}$

$= 1953.6\ W.$

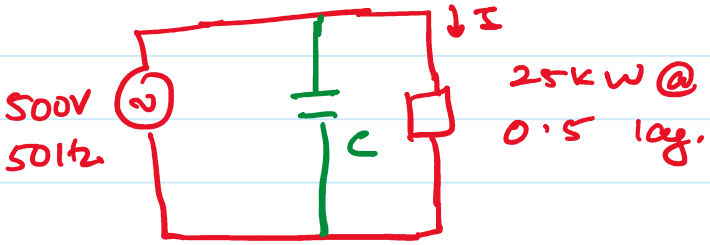
$\cos\theta_L = \dfrac{1953.6}{2685} = 0.727$ leading

$P_L = \dfrac{V_{LOAD}^2}{R} = \dfrac{V_{LOAD} \times V_{LOAD}^*}{R} = \dfrac{|V_{LOAD}^2|}{R}$

f) $|S_{source}| = |V||I|$

$= 230 \times 12.15 = 2794\ VA.$

2)



$P = 25kW \quad pf = 0.5 \Rightarrow \theta = 60°$

$V = 500\angle 0° \quad f = 50Hz.$

$P = |V||I| \cos\theta.$

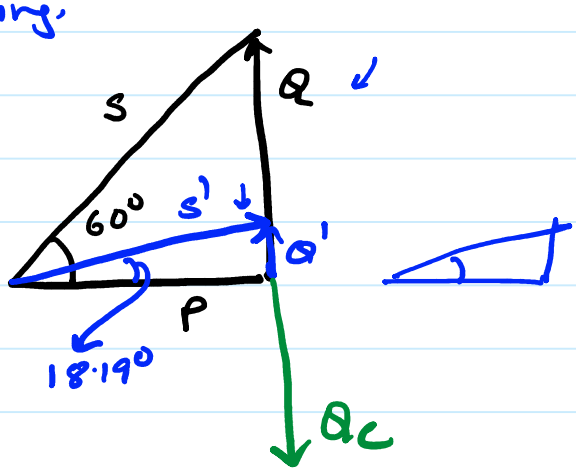
a) $|I| = \frac{25 \times 10^3}{500 \times 0.5} = 100A.$

b) $I = 100\angle -60^\circ$ [lagging p.f.]

c) improve p.f to 0.95 lagging.

→ $\cos\theta' = 0.95$ lagging.

⇒ $\theta' = 18.19^\circ$



$Q = P \tan\theta$.

$= 25 \times 10^3 \times \tan 60^\circ$

$= 43301$ VAR

$Q' = P \tan\theta'$

$= 25 \times 10^3 \times \tan 18.19^\circ$

$= 8214.74$ VAR.

$Q_c = Q' - Q = 8214.74 - 43301$

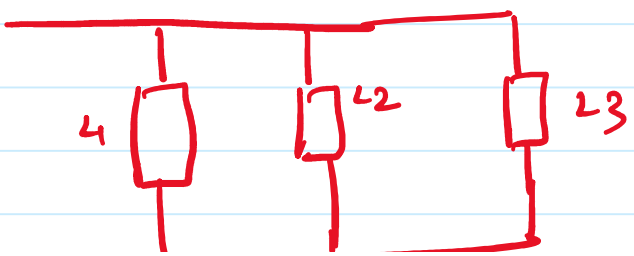
$= -35086$ VAR

$= -\omega C V^2$

⇒ $C = \frac{Q_c}{-\omega V^2} = \frac{+35086}{+100\pi \times 500^2}$

$= 446.73\ \mu F$

a)



LOAD	P	cos θ	θ [P.T.]	Q = P tan θ
L_1	5 KW	0.8 lag.	36.87	3750 VAR
L_2	10KW	0.6 lag	53.13°	13333.33 VAR
L_3	15KW	0.8 lead	−36.87°	−11250 VAR.

$P = P_1 + P_2 + P_3 = 30\text{KW}$.

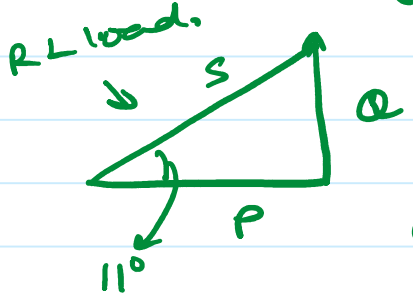
$Q = Q_1 + Q_2 + Q_3 = 5833.33\ \text{VAR}$

$S = P + jQ = 30000 + j5833.33$

$= |S| \angle\theta = 30561.9 \angle 11^\circ\ \text{VA}$

P.F as seen by source $= \frac{P}{|S|} = \frac{30000}{30561.9}$

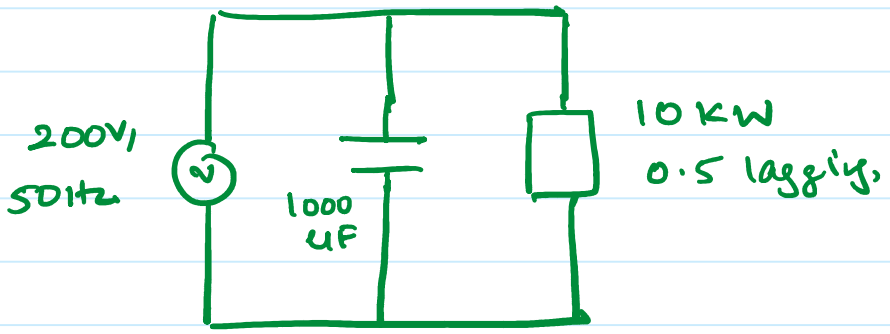
$= 0.982$ lagging.



$\cos(11^\circ) = 0.982$ lagg.

4)

4)



$P = 10\,KW \qquad \cos\theta = 0.5 \text{ lag} \rightarrow \theta = 60^\circ$

$V = 200\angle 0^\circ V$

$P = |V||I|\cos\theta$

$|I| = \frac{10 \times 10^3}{200 \times 0.5} = 100A.$

$I = 100\angle -60^\circ$ [lagging p.f.]

Method ①

$C = 1000\mu F.$

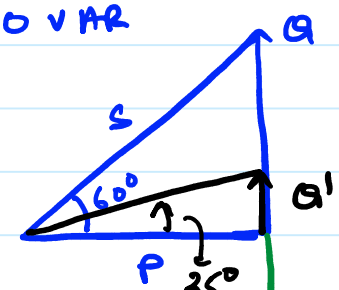
$Q_c = -\omega C V^2$

$= -12566.4\ VAR$

$Q = P \tan\theta$

$= 10000 \times \tan 60$

$= 17320\ VAR$



$Q' = Q + Q_c$

$= 17320 + (-12566.4)$

$= 4753.6\ VAR.$

$\theta' = \tan^{-1}\frac{Q'}{P} = 25^\circ$

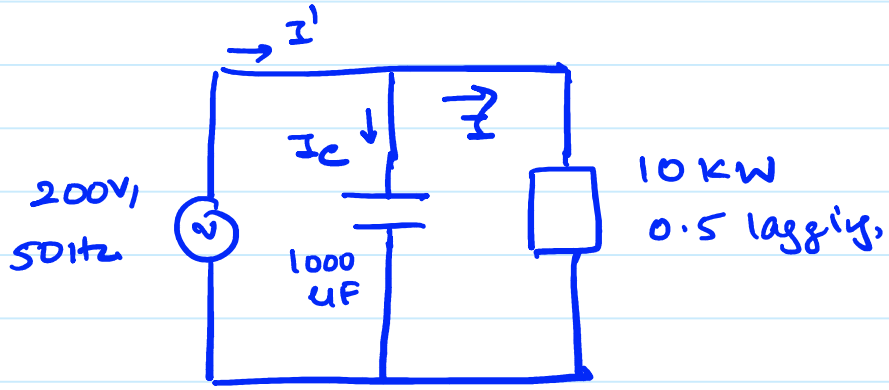
$P = |V||I'|\cos\theta'$

$|I'| = \frac{10\,000}{200 \times 0.902}$

$= 55.38$

New p.f $= \cos\theta' = 0.902$ lagging.

Method (2)



$I = 100\angle -60^\circ \text{ A}$

$$I_C = \frac{V}{Z_C} = \frac{200\angle 0}{\frac{1}{j\omega C}} = 200\angle 0 \times j\omega C$$

$$= 200\angle 0 \times 100\pi \times 1000 \times 10^{-6}\angle 90^\circ$$

$$= 62.8\angle 90^\circ \text{ A}$$

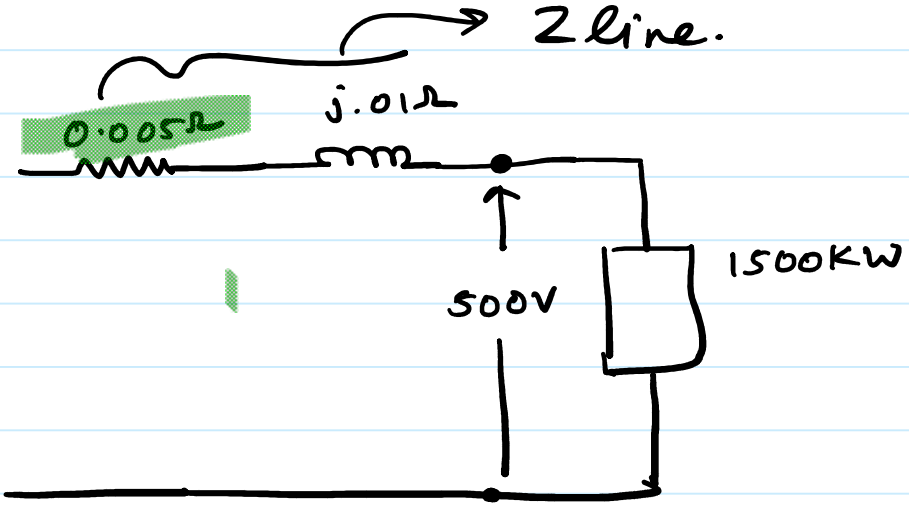
$$I' = I + I_C = 100\angle -60 + 62.8\angle 90^\circ$$

$$= 55.38\angle -25.45^\circ$$

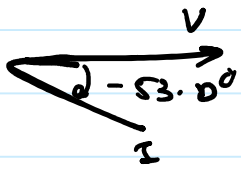
P.F = cos(25.45°) lagging.

= 0.902 lagging.

5)



a) p.f = 0.6 lag. $\rightarrow \theta_1 = -53.13^\circ$



$P = 1500 \times 10^3 = |V||I_1| \cos\theta_1$

$\Rightarrow |I_1| = \dfrac{1500 \times 10^3}{500 \times 0.6} = 5000A$

$P_{line_1} = |I_1|^2 \cdot R = 5000^2 \times 0.005$

$= 125kW$

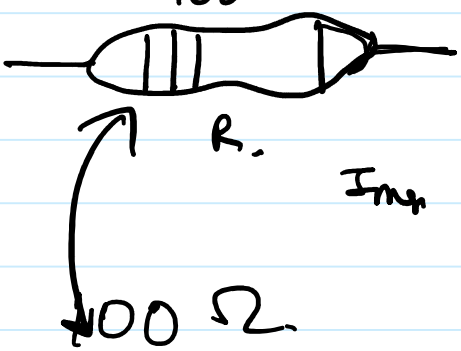
b) p.f = 1 $\rightarrow \theta_2 = 0^\circ$

$P = 1500 \times 10^3 = |V||I_2| \cos\theta_2$

$|I_2| = \dfrac{1500 \times 10^3}{500 \times 1} = 3000A.$

$P_{line_2} = |I_2|^2 \times R = 3000^2 \times 0.005$

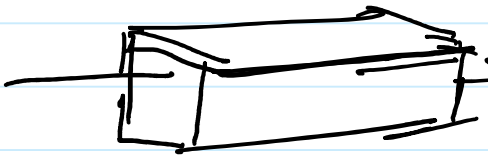
$= 45kW$



$0.25W = I_{max}^2 R$

$I_{max} = \sqrt{\dfrac{0.25}{100}} = \dfrac{0.5}{10}$

$= 0.05A$ or $50mA$.



$I_{max} = \sqrt{\dfrac{10}{100}} = \sqrt{\dfrac{1}{10}}$

$10W = 0.316A$

$= 316\,mA$