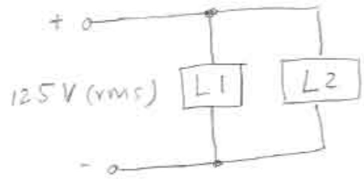
10.20



$P_t = 4500\,W$, $(Pf)_t = 0.96$ (leading)

$$\frac{P_t}{S_t} = (Pf)_t \Rightarrow S_t = \frac{P_t}{(Pf)_t} = \frac{4500}{0.96}$$

$$= 4687.5 \text{ VA}$$

$$\theta_t = -\cos^{-1}(0.96) = -16.26^\circ$$

$$\therefore \bar{S}_t = 4687.5 \angle -16.26^\circ \text{ VA} = 4500 - j1312.48 \text{ VA}$$

$P_1 = 2700\,W$, $(Pf)_1 = 0.80$ (lagging)

$$\therefore S_1 = \frac{P_1}{(Pf)_1} = \frac{2700}{0.80} = 3375 \text{ VA}$$

$$\theta_1 = +\cos^{-1}(0.80) = 36.87^\circ$$

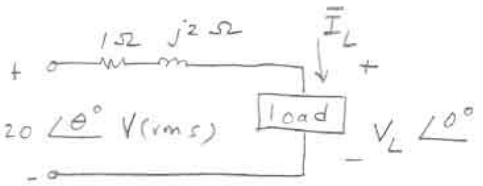
$$\therefore \bar{S}_1 = 3375 \angle 36.87^\circ = 2700 + j\,2025 \text{ VA}$$

$$\bar{S}_2 = \bar{S}_t - \bar{S}_1 = 4500 - j1312.48 - (2700 + j2025)$$

$$= 1800 - j\,3337.48 = 3791.94 \angle -61.66^\circ$$

$$\therefore (Pf)_2 = \cos 61.66^\circ = 0.4747 \text{ (leading)}.$$

10.29



a) $S_L = 600$ VA

$\theta_L = +\cos^{-1} 0.8 = 36.87°$

$\therefore \bar{S}_L = 600 \angle 36.87°$ VA

since $\bar{V}_L = V_L \angle 0° \Rightarrow \theta_{Lv} = 0°, \ \theta_{Li} = -36.87°$

$\therefore \ \bar{I}_L = I_L \angle -36.87°$ A (rms)

$\bar{S}_L = \bar{I}_L^* \ \bar{V}_L = (I_L \angle 36.87°)(V_L \angle 0°)$

$= 600 \angle 36.87°$

$\therefore \ I_L V_L = 600$ (1)

But $\quad \bar{I}_L = \dfrac{120 \angle \theta° - V_L \angle 0°}{(1 + j2)}$

$(1+j2)\,\bar{I}_L = 120 \angle \theta° - V_L \angle 0°$, using eqn. (1)

$(1 + j2) \dfrac{600}{V_L} \angle -36.87° = 120 \angle \theta° - V_L \angle 0°$

$(1+j2) \dfrac{600}{V_L} (0.8 - j0.6) = 120 \cos\theta° + j120 \sin\theta° - V_L$

$\dfrac{600}{V_L}(0.8) + \dfrac{2(600)(0.6)}{V_L} + j\left(\dfrac{2(600)(0.8)}{V_L} - \dfrac{600(0.6)}{V_L}\right)$

$= (120 \cos\theta° - V_L) + j\,120 \sin\theta°$

equating the real & imaginary parts of the previous eqn. $\Rightarrow$ ③

$$\frac{480}{V_L} + \frac{720}{V_L} = 120\cos\theta^\circ - V_L \quad (2)$$

$$\frac{960}{V_L} - \frac{360}{V_L} = 120\sin\theta^\circ \quad (3)$$

$$\Downarrow$$

$$\frac{1200}{V_L} + V_L = 120\cos\theta^\circ \quad (4)$$

$$\frac{600}{V_L} = 120\sin\theta^\circ \quad (5)$$

From (5) $\Rightarrow$ $\sin\theta^\circ = \frac{5}{V_L} \Rightarrow \cos\theta^\circ = \sqrt{1 - \frac{25}{V_L^2}}$ (6)

Subtituting (6) into (4) $\Rightarrow$

$$\frac{1200}{V_L} + V_L = 120\sqrt{1 - \frac{25}{V_L^2}}$$

$$\Downarrow$$

$$\frac{1440000}{V_L^2} + 2400 + V_L^2 = 14400\left(1 - \frac{25}{V_L^2}\right)$$

$$\therefore 1440000 + 2400V_L^2 + V_L^4 = 14400\,V_L^2 - 360000$$

$$\therefore V_L^4 - 12000\,V_L^2 + 18\times10^5 = 0 \quad (7)$$

solving 7 $\Rightarrow$ $V_L = 108.85$ V (rms)

or $V_L = 12.326$ V (rms)

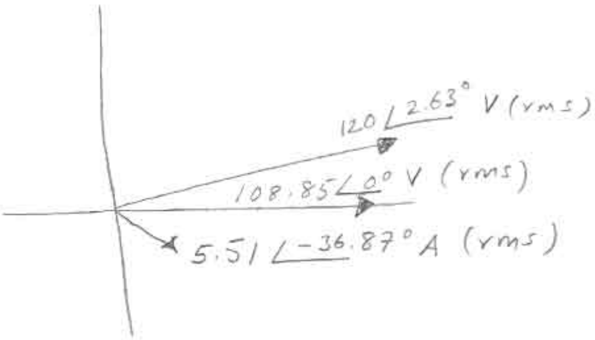
if $V_L = 108.85$ V(rms) $\Rightarrow$ $\sin\theta^\circ = \frac{5}{V_L} = 0.0459$

$\therefore \theta = 2.63^\circ$, $I_L = \frac{600}{V_L} = 5.51$ A(rms)

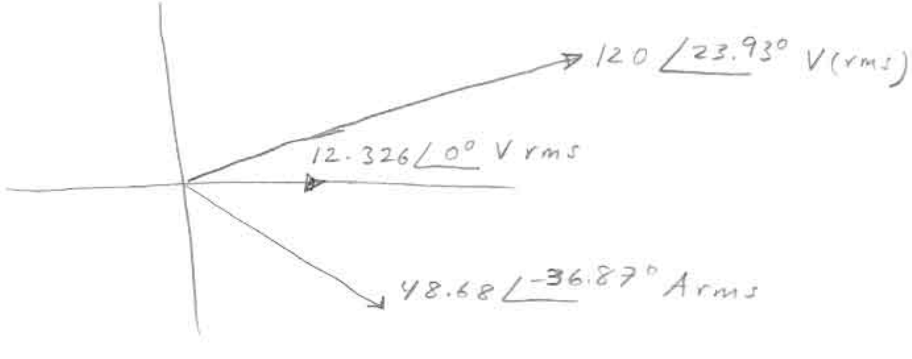
if $V_L = 12.326$ V(rms) $\Rightarrow \sin\theta^\circ = \frac{5}{V_L} = 0.406$

$\therefore \theta = 23.95^\circ$, $I_L = \frac{600}{V_L} = \frac{600}{12.326} = 48.68$ A rms

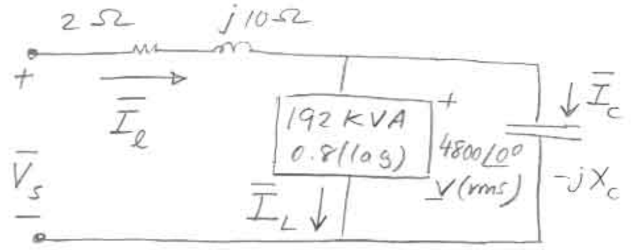
b)



$\Leftarrow$ For 1st soln.



10.31



$$S_L = 192\,000 = I_L V_L = I_L(4800) \Rightarrow I_L = 40 \text{ A rms}$$

$$\theta_L = +\cos^{-1}(0.8) = 36.87^\circ$$

$$\therefore \bar{I}_L = 40 \angle -36.87^\circ = 32 - j24 \quad A\,(\text{rms})$$

$$\bar{I}_c = \frac{4800\angle 0^\circ}{-jX_c} = \frac{4800}{X_c}\angle 90^\circ = I_c \angle 90^\circ = j I_c$$

$$\bar{I}_\ell = \bar{I}_L + \bar{I}_c = 32 - j24 + jI_c = 32 + j(I_c - 24)$$

$$\bar{V}_s = (2 + j10)\,\bar{I}_\ell + 4800$$

$$= (2 + j10)\left[32 + j(I_c - 24)\right] + 4800$$

$$= \left(64 - 10I_c + 240 + 4800\right) + j\left(320 + 2I_c - 48\right)$$

$$= (5104 - 10I_c) + j(272 + 2I_c)$$

$$\therefore V_s^2 = (4800)^2 = (5104 - 10I_c)^2 + (272 + 2I_c)^2$$

Solving $\Rightarrow I_c = 31.57$ A (rms) or

$$I_c = 939.51 \text{ A (rms)}$$

We choose $I_c = 31.57$ A (rms) to reduce the line current.

$$\therefore \quad I_c = \frac{4800}{X_c} = 31.57 \Rightarrow X_c = 152.04 \ \Omega$$

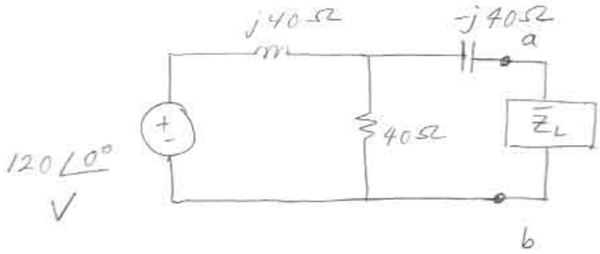
$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi(60)C} = 152.04$$

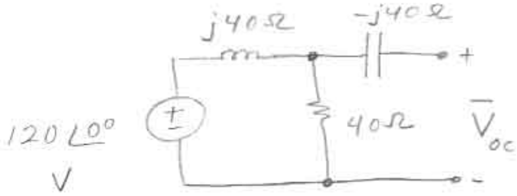
$$\Downarrow$$

$$C = 17.45 \ \mu F$$

10.33

a)





$$\bar{V}_{oc} = \left(\frac{40}{40+j40}\right)(120\angle 0^\circ) = 84.85\angle -45^\circ \text{ V}$$

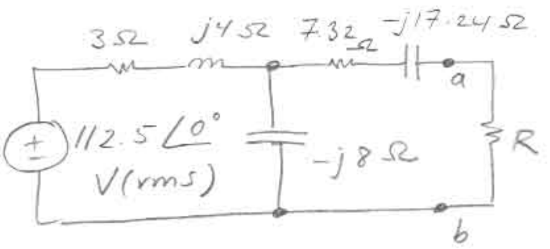
$$\bar{Z}_{th} = -j40 + (40 \,//\, j40)$$

$$= 20 - j20 \ \Omega$$

$$\therefore \ \bar{Z}_L = \bar{Z}_{th}^{*} = 20 + j20 \ \Omega$$

b) $$P_{max} = \frac{V_{th}^2}{8R_{th}} = \frac{(84.85)^2}{8(20)} = 45 \text{ W}$$

10.35



$$\bar{V}_{th} = \bar{V}_{oc} = \left(\frac{-j8}{3+j4-j8}\right)(112.5\angle 0^\circ)$$

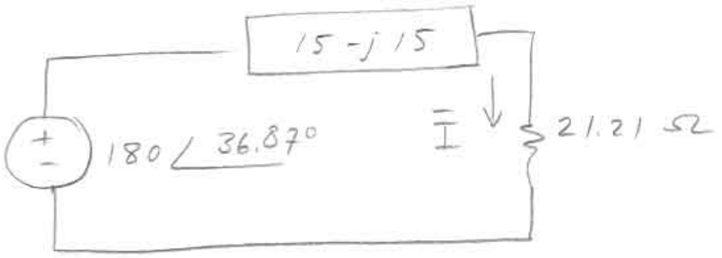
$$= \frac{(8\angle -90^\circ)(112.5\angle 0^\circ)}{5\angle -53.13^\circ} = 180\angle 36.87^\circ$$

$$\bar{Z}_{th} = 7.32 - j17.24 + (-j8 \,//\, 3+j4)$$

$$= 15 - j15 \ \Omega = 21.21 \angle -45^\circ \ \Omega$$

$$\therefore R = Z_{th} = 21.21 \ \Omega$$

b)



$$\bar{I} = \frac{180\angle 36.87^\circ}{15 - j15 + 21.21} = \frac{180\angle 36.87^\circ}{39.19\angle -22.50^\circ}$$

$$I = \frac{180}{39.19} = 4.59 \ A(rms) \Rightarrow P_R = I^2 R$$

$$= (4.59)^2(21.21) = 447.4W$$