EE 202 - Summer 2006-2007.
Exam #4

(1) In the following circuit $|V_L| = 240$ V (RMS) at all times. The following information about the loads are given:

α_1: absorbs 180 Watts and 240 VARs.

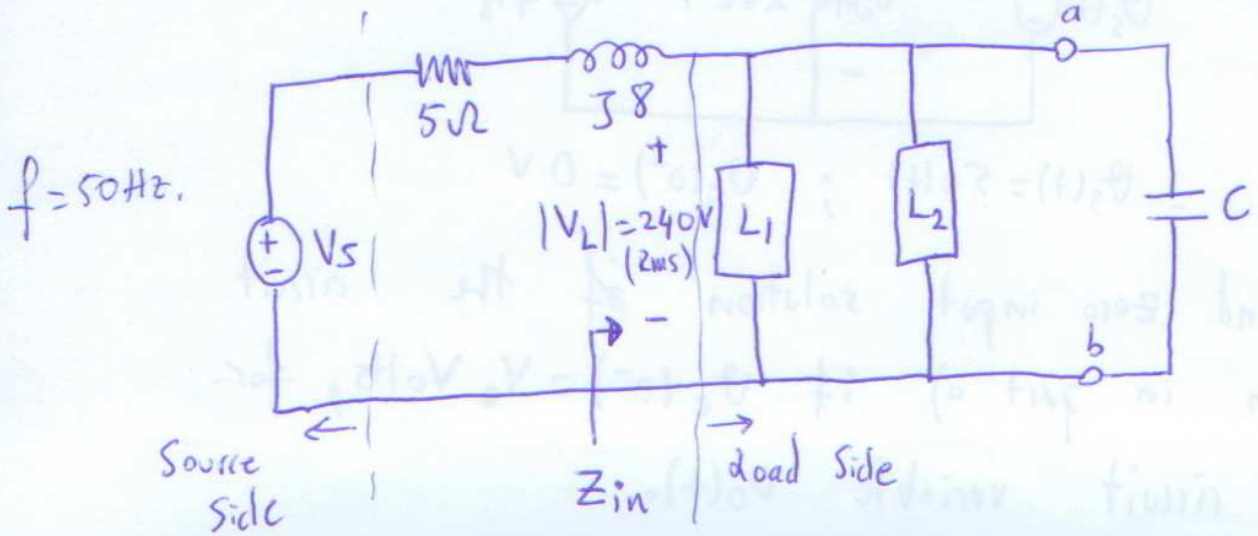
α_2: absorbs 600 VA at 0.6 pf lagging

a) Assume there is no capacitor connected between a-b terminals. Find input impedance at the load side, source voltage $|V_S|$ (in RMS) and p.f. on source side.

b) Now, the capacitor is connected between a-b terminals. Find value of C such that average power absorbed by 5 ohm resistor is minimum. Find $|V_S|$ with the compensation capacitor.

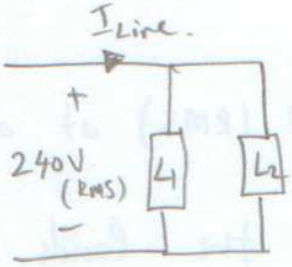
c) Find value of C such that load side p.f. is 0.9 lagging.

Find $|V_S|$ with compensation capacitor.



Exam 4 Solutions

(1)



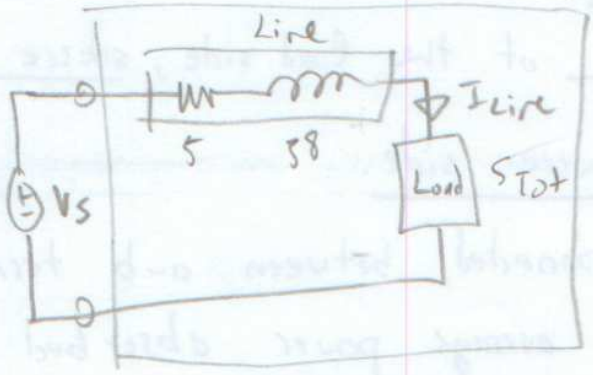
$$S_{L_1} = 180 + j240$$

$$+ \quad S_{L_2} = 600\angle\cos^{-1}(0.6) = 360 + j480$$

$$S_{Total} = 540 + j720$$

a) $$|I_{Line}| = \frac{|S_{Total}|}{240} = \frac{900}{240} = 3.75 \text{ A (RMS)}.$$

$$S_{Total} = |I_{Line}|^2 \cdot Z \longrightarrow \boxed{Z = \frac{540 + j720}{(3.75)^2} = 38.4 + j51.2 = 64\angle 53.1^\circ}$$



$$S_{Line} = |I_{Line}|^2 (5 + j8) = 70.3125 + j112.5$$

$$S_{source} = S_{Line} + S_{Total} = 610.31 + j832.5$$

$$|S_{source}| = |I_{Line}| \cdot |V_S| \longrightarrow |V_S| = \frac{|610.31 + j832.5|}{3.75} = 275.26 \text{ V}_{RMS}.$$

p.f on source side: $\cos\left(\tan^{-1}\frac{832.5}{610.31}\right) = 0.59$ lagging.

b) $S^{before} = 540 + j720$

$I_{Line}^{before} = 3.75 \text{ A}$

$S^{after} = 540 + j720 - j720 = 540$ ← compensation

$$I_{Line}^{after} = \frac{540}{240} = 2.25 \text{ A}$$

$$S_{Line} = (2.25)^2 (5 + j8) = 25.31 + j40.5.$$

$$S_{source} = 540 + 25.31 + j40.5 \Longrightarrow$$

After:

$S_{source} = 565.31 + j40.5$ (2)

$|S_{source}| = 566.75 = |V_s| \cdot |I_{Line}| \rightarrow$

$\rightarrow |V_s| = 251.89\ V(RMS)$

$S_{compensator} = -j720$

$S_{compensator} = \frac{|V_{cap}|^2}{X_C^*}$ ← 240

$X_C = \frac{|V_{cap}|^2}{S_{comp}^*} = \frac{(240)^2}{j720}$

$= -j80.$

$X_C = \frac{-j}{\omega C}$

$X_C = -j80 \rightarrow C = \frac{1}{(2\pi 50)80} = 39.8\,\mu F.$

(In this problem, to minimize power loss on line resistor, the current through the resistor should be minimized. Therefor load side p.f. should be 1.0 after compensation to minimize loss)

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c)

After

540

$\cos^{-1}(0.9) = 25.84$

$S^{After} = 540 + j\tan(25.84°)\,540$

$= 540 + j261$

$S^{After} = S^{before} + S^{compensation}$

$S_{compensation} = -j458.5.$

$X_C = -j\frac{(240)^2}{458.5} = -j125.63;\ C = \frac{1}{100\times 125.6}$

$= 25.3\,\mu F$

$$|I_{Line}|^{after} = \frac{|S^{after}|}{240} = \frac{540/0.9}{240} = 2.5\,A.$$ (3)

$$S^{line} = (2.5)^2 (5 + j8) = 31.25 + j50$$

$$S^{source} = 571.25 + j301 \quad (supplied).$$

$$|S^{source}| = |V_s| \cdot |I_{Line}| \rightarrow \boxed{V_s = 258.27\,V\ (rms)}$$

($|S^{source}|$: 645; $|I_{Line}|$: 2.5)