Desk Copy

ECE 300
Spring Semester, 2004
HW Set #8

March , 2004
wlg

Name Green
Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers.** Each problem counts 10 points.

9.6 ✓ $P_L = P_C = 0$ W; $P_2 = 1.72$ W, $P_4 = 3.43$ W, $P_{sup\ 12} = 7.65$ W, $P_{abs\ 4} = 2.52$ W

9.11 ✓ $P_4 = 10.4$ W

9.15 ✓ $P_2 = 21.16$ W, $P_1 = 5.29$ W, $P_L = P_C = 0$ W, $P_{12} = 14.83$ W (supplied)
$P_{Isource} = 11.61$ W (supplied)

9.18 ✓ $P_2 = 32.4$ W

9.21 ✓ $Z_L = 5$ ohms, $P_L = 5.28$ W

9.27 ✓ $Z_L = 0.6 - j0.8$ ohms, $P_L = 47.8$ W

9.34 ✓ $V_{rms} = 2.31$ V rms

9.37 ✓ $V_{rms} = 1.63$ V rms

9.50 ✓ $V_s = 301.4\angle 7.89$ V rms

9.53 $V_s = 288.2\angle 8.48$ V rms

9.58 ✓ $C = 4103\ \mu F$

9.61 ✓ $C = 586\ \mu F$

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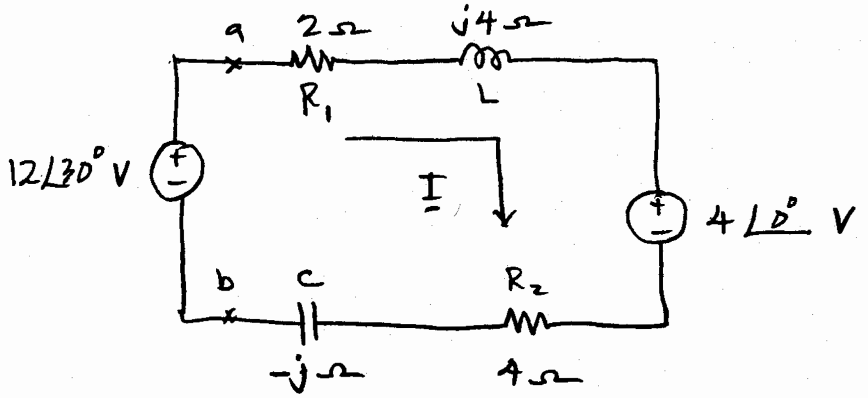
9.6

Determine the average power absorbed by the elements to the right of a-b in the following circuit.



$P_L = 0$, $P_C = 0$, $P_{R_1} = \frac{I^2 R_1}{2}$, $P_{R_2} = \frac{I^2 R_2}{2}$

$P_{ABS_{4\angle 0}} = \frac{I_m \times 4}{2} \cos(\theta_I)$

$I = \frac{12\angle 30 - 4\angle 0}{6 + j3} = 1.31\angle 16.6^\circ$ A

$P_{R_1} = \frac{(1.31)^2 \times 2}{2} = \underline{\underline{1.72\,W}}$

$P_{R_2} = \frac{(1.31)^2 \times 4}{2} = \underline{\underline{3.43\ W}}$

Checking:

$P_{ABS_{4\angle 0}} = \frac{1.31 \times 4}{2} \cos 16.3 = 2.52\,W$

$P_{sup_{12\angle 30}} = \frac{1.31 \times 12}{2} \cos(30 - 16.6) = 7.65\,W$

$7.65 \stackrel{?}{=} 2.52 + 1.72 + 3.43 = 7.67$ check

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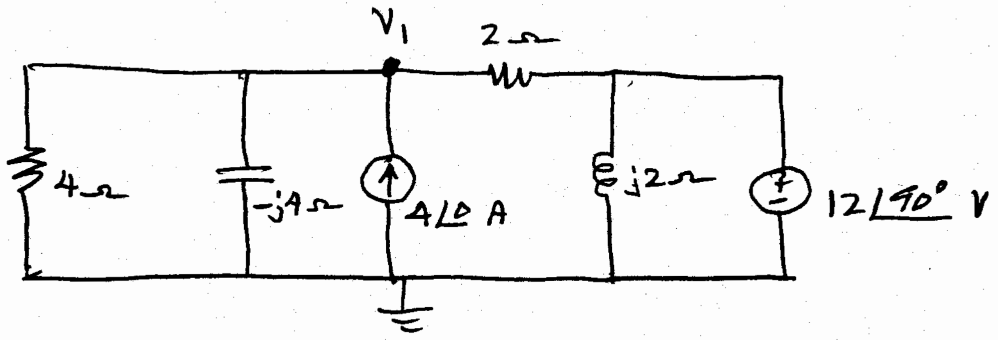
9.11

Determine the average power absorbed by the 4 Ω resistor in the network below.



$$\frac{V_1}{4} - \frac{V_1}{j4} + \frac{V_1 - 12\angle 90}{2} = 4$$

mult by 4

$$V_1 + jV_1 + 2V_1 = 16 + 24\angle 90$$

$$\underline{V}_1 = \frac{16 + j24}{3 + j1} = 9.12\angle 38^\circ \text{ V}$$

$$P_{4\Omega} = \frac{|\underline{V}_1|^2}{2 \times 4} = \frac{(9.12)^2}{8}$$

$$\boxed{P_{4\Omega} = 10.4 \text{ W}}$$

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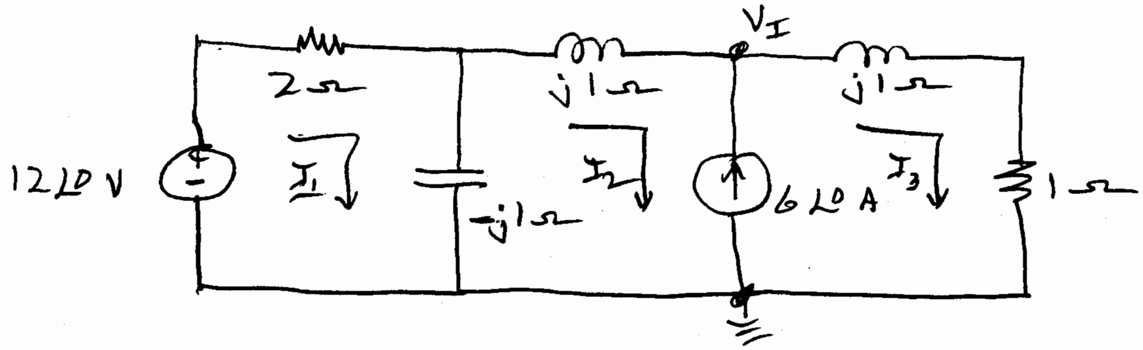
9.15 Find the average power absorbed by each element in the network below.



$$2I_1 - j(I_1 - I_2) = 12\angle 0 \qquad (1)$$

$$2I_1 + jI_2 + (1+j)I_3 = 12\angle 0 \qquad (2)$$

$$-I_2 + I_3 = 6\angle 0 \qquad (3)$$

From (1), (2), and (3)

$$\begin{bmatrix} (2-j) & j1 & 0 \\ 2 & j1 & 1+j \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 12\angle 0 \\ 12\angle 0 \\ 6\angle 0 \end{bmatrix}$$

$I_1 = 4.6\angle 57.5^\circ$ A $\quad I_2 = 6.13\angle -149.6 \quad I_3 = 3.254\angle -77.4$ A

$$P_{2\Omega} = \frac{|I_1|^2 2}{2} = 21.16\text{W}$$

$$P_{1\Omega} = \frac{|I_3|^2 \times 1}{2} = 5.29 \text{ W}$$

$P_{L's} = 0$, $\quad P_C = 0$

$$P_{sup\,12\angle 0} = \frac{12 \times 4.6}{2} \cos(57.5) = 14.83 \text{ W}$$

$$V_I = I_3(1+j) = (3.25\angle -77)(1+j) = 4.6\angle -32.7$$

$$P_{I\,source} = \frac{(4.6) \times 6}{2} \times \cos(-32.7) = 11.61 \text{ W}$$

$$11.61 + 14.83 \stackrel{?}{=} 21.16 + 5.29$$

$$26.44 = 26.45 \quad \text{OK}$$

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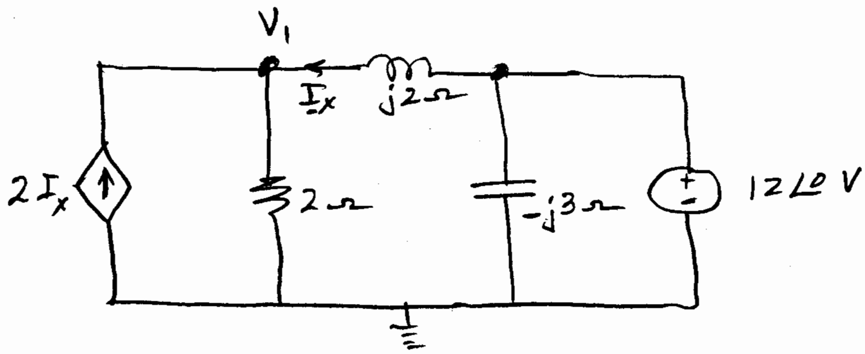
9.18

Find the average power absorbed by the $2\,\Omega$ resistor in the circuit below.



$$\frac{V_1}{2} + \frac{V_1 - 12}{j2} = 2I_x = 2\left(\frac{12 - V_1}{j2}\right)$$

mult by $j2$

$$jV_1 + V_1 - 12 = 24 - 2V_1$$

$$(3+j)V_1 = 36$$

$$V_1 = 11.38 \angle -18.44^\circ\ V$$

$$\therefore P_{2\Omega} = \frac{|V_1|^2}{2 \times 2} = \frac{11.38^2}{4}$$

$$P_{2\Omega} = 32.4\ W$$

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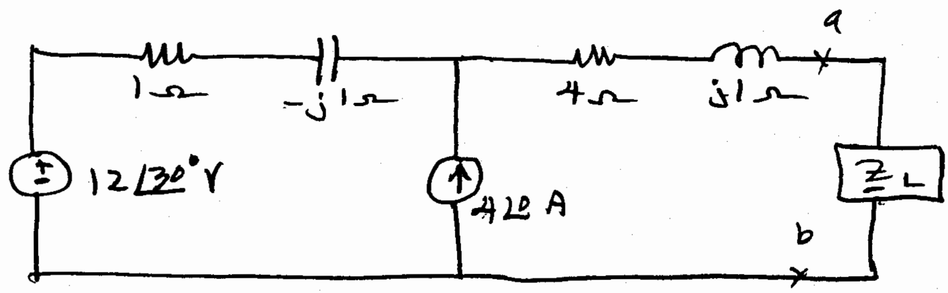
9.21

Determine the impedance Z_L for maximum power transfer and the value of the maximum average power transferred to Z_L for the circuit below.



Find V_{TH} & Z_{TH} to the left of a−b.

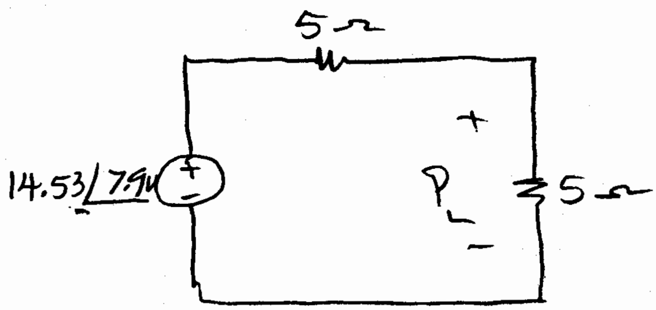
With Z_L removed,

$V_{OS} = V_{TH} = 12\angle 30 + (1-j)4\angle 0$

$V_{TH} = 14.53\angle 7.9^\circ$ V

$Z_{TH} = 1 - j1 + 4 + j1 = 5\ \Omega$

$\therefore Z_L = 5\ \Omega$



$P_L = \left[\dfrac{14.53}{10}\right]^2 \times \dfrac{5}{2} = 5.28\text{ W}$

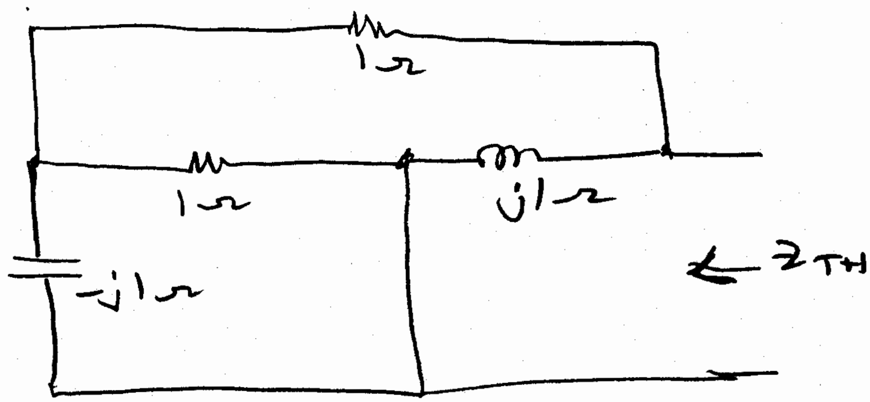
$P_L = 5.28$ W

9.27 cont.

$V_{OC} = V_{TH} = 12\angle 0 - jI_1$

$V_{TH} = 12\angle 0 - 5.37\angle 116.5°$

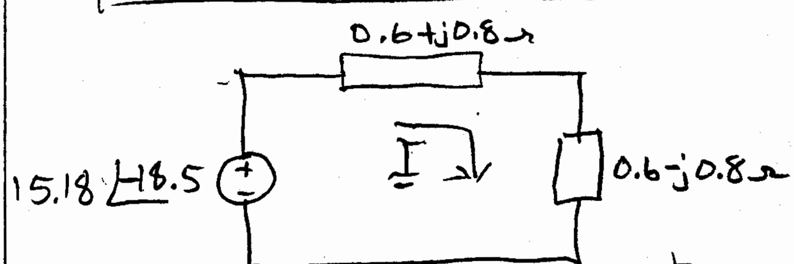
$V_{TH} = 15.18\angle -18.5° \text{ V}$



$Z_{TH} = \left(\left(\frac{-j}{1-j}\right) + 1\right) \| j1$

$Z_{TH} = \dfrac{\left(\frac{1-j2}{1-j}\right) \times j}{\frac{1-j2}{1-j} + j} = \dfrac{2+j}{2-j} = 0.6 + j0.8$

$Z_L = 0.6 - j0.8\ \Omega$



$|I| = \dfrac{15.18}{1.2}$

$P_L = \left(\dfrac{15.18}{1.2}\right)^2 \times \dfrac{0.6}{2}$

$P_L = 47.8 \text{ W}$

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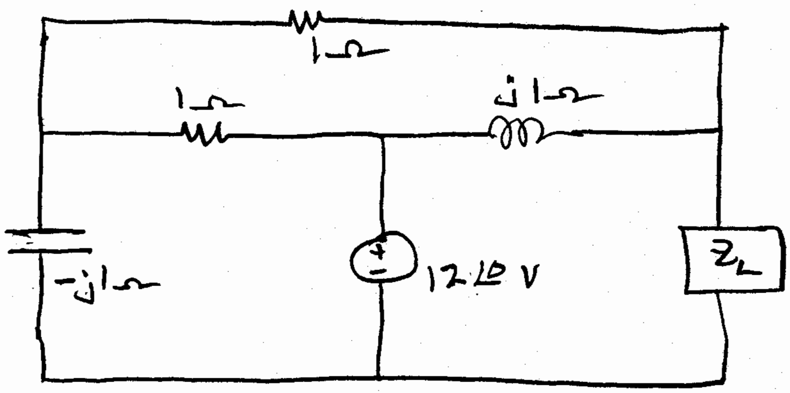
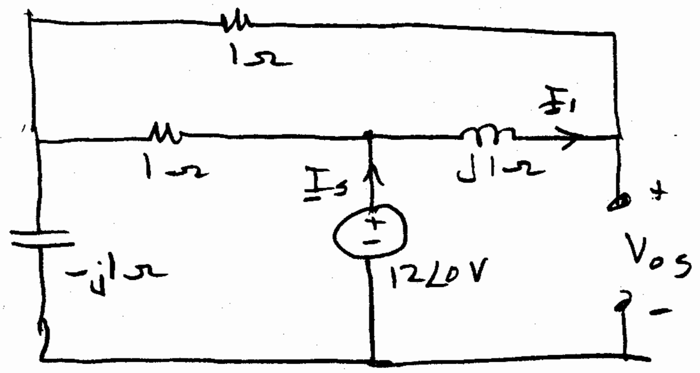
9.27 Determine the impedance Z_L for maximum average power transfer and the value of the maximum average power transferred to Z_L for the circuit below.



Find V_{TH} & Z_{TH}



$$I_s = \frac{12\angle 0}{\frac{(1+j)1}{1+1+j} - j} = \frac{(2+j)12}{1+j-j2+1} = \frac{(2+j)12\angle 0}{2-j}$$

$$I_s = 12\angle 53.1 \text{ A}$$

$$I_1 = \frac{I_s \times 1}{2+j} = 5.37\angle 26.5^\circ \text{ A}$$

continued

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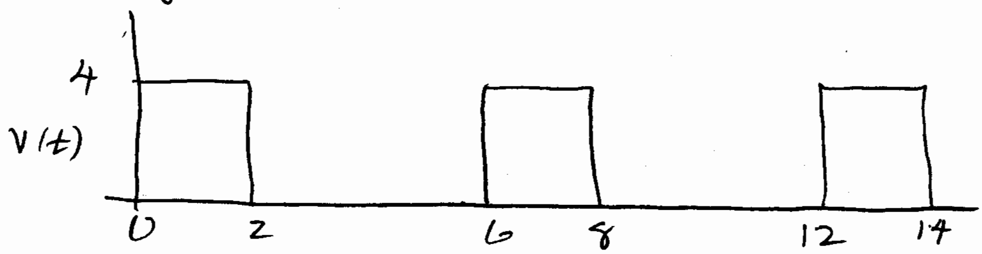
9.34

Determine the rms value of the voltage given by the following waveform.



$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v(t)^2\,dt}$$

$$V_{rms} = \sqrt{\frac{1}{6}\int_0^2 4^2\,dt} = \sqrt{\frac{16}{6} \times t \Big|_0^2}$$

$$V_{rms} = \sqrt{\frac{16 \times 2}{6}}$$

$$\boxed{V_{rms} = 2.31\ V}$$

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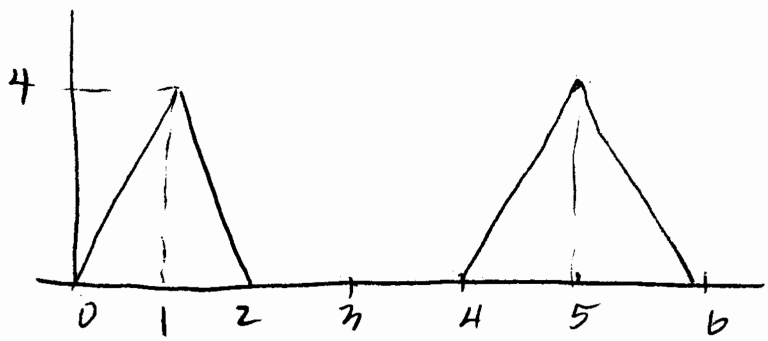
9.37 Calculate the rms of the waveform shown below.



$$V_{rms} = \sqrt{2\left[\frac{1}{4}\int_0^1 (4t)^2\,dt\right.}$$

Note: Because of wave symmetry we can multiply by 2, rms of the signal from 0 to 1.

$$V_{rms} = \sqrt{8\frac{t^3}{3}\Big|_0^1}$$

$$V_{rms} = \sqrt{\frac{8}{3}}$$

$$\boxed{V_{rms} = 1.63\ V}$$

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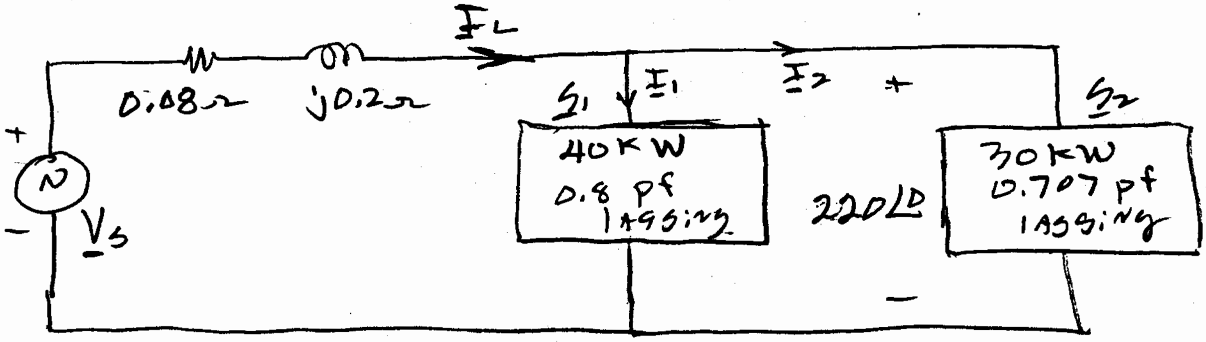
9.50

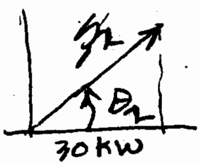
Find the source voltage for the network below



Must find I_1, I_2 then $I_L = I_1 + I_2$

Then $V_s = (0.08 + j0.2) I_L + 240\angle 0$

At load 2



$$|S_2| = \frac{30\text{ kW}}{\cos\theta_2} = \frac{30\text{ kW}}{\cos(\cos^{-1}.707)}$$

$$|S_2| = 42.43 \text{ KVA}$$

$$S_2 = 42.43k\angle 45^\circ = V_{rms} I_{rms}^*$$

$$I_2^* = \frac{42{,}43\angle 45 \text{ KVA}}{220} = 192.9\angle 45^\circ \text{ A}$$

$$I_2 = 192.9\angle -45^\circ \text{ A}$$

I_1 can be found, similarly

continued

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9.50 -

$$|\underline{S}_1| = \frac{40\,kW}{0.8} = 50\ kVA$$

$$\underline{S}_1 = 50\angle 36.9^\circ\ kVA$$

$$\underline{I}_1^* = \frac{50\angle 36.9\,K}{220} = 227.3\angle 36.9\ A$$

$$\underline{I}_1 = 227.3\angle -36.9\ A$$

$$\underline{I}_L = \underline{I}_1 + \underline{I}_2$$

$$\underline{I}_L = 192.9\angle -45 + 227.3\angle -36.9\ A$$

$$\underline{I}_L = 418.9\angle -40.6^\circ$$

$$\underline{V}_s = (0.08 + j0.2)(418.9\angle -40.6) + 220\angle 0$$

$$\boxed{\underline{V}_s = 302.9\angle 7.9^\circ\ V_{rms}}$$

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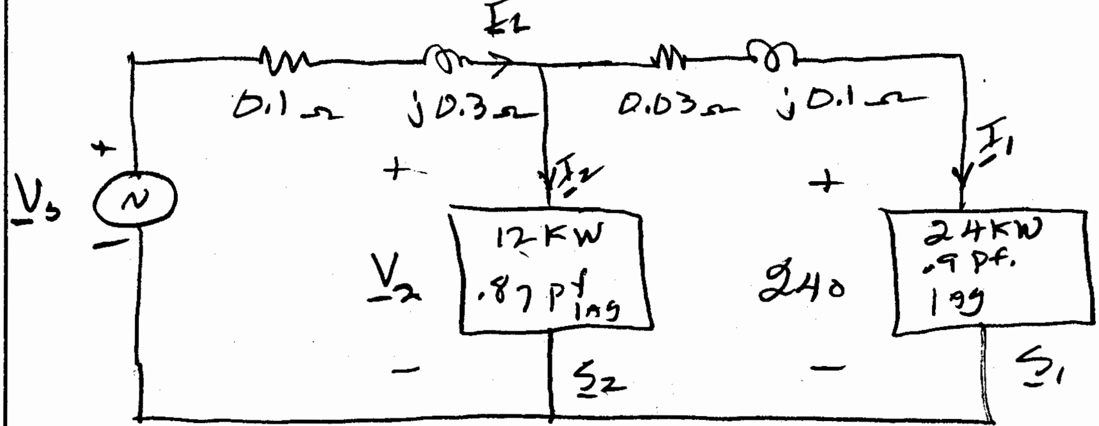
9.53

Given



$$|S_1| = \frac{P}{\cos[\cos^{-1}(.9)]} = \frac{24\text{ kW}}{.9} = 26.67\text{ KVA}$$

$$|I_2| = \frac{|S_1|}{240} = 111.13$$

$$I_2 = 111.13\angle -25.8\ \text{A}$$

$$V_2 = (0.03 + j0.1)(111.13\angle -25.8) + 240\angle 0$$

$$V_2 = 248\angle 2^\circ\ V_{rms}$$

$$|S_2| = \frac{12K}{.87} = 13.79\text{ KVA}$$

$$|I_2| = \frac{13.79K}{248} = 55.6\ \text{A}$$

$$I_2 = 55.6\angle 2 - 29.5 = 55.6\angle -27.5$$

$$I_L = I_1 + I_2 = 111.13\angle -25.8 + 55.6\angle -27.5$$

continued

wly

9.53

$$\underline{I}_L = 166.7\angle{-26.4} \quad A$$

$$V_s = (166.7\angle{-26.4})(0.1 + j0.3) + 248\angle{2^\circ}$$

$$\underline{V}_s = 288.7\angle{9.2^\circ}$$

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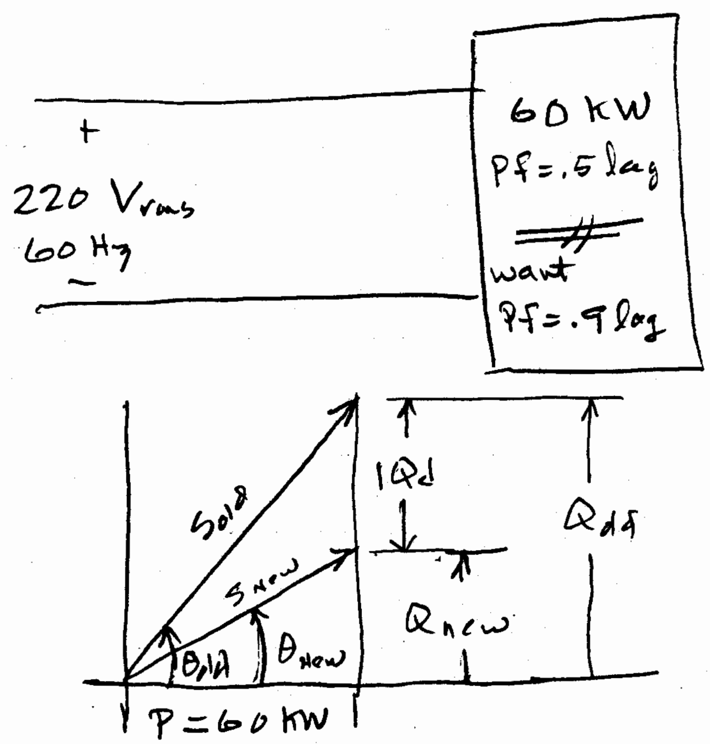
9.58

Given the following:



$\theta_{old} = \cos^{-1}(.5) = 60°$; $\theta_{new} = \cos^{-1} .9 = 25.84°$

$Q_{old} = 60\text{KW} \tan(60°) = 103.9$ KVARS

$Q_{new} = 60\text{KW} \tan(25.84) = 29.1$ KVARS

$|Q_c| = (103.9 - 29.1)$ KVARS

$|Q_c| = 74.8$ KVARS

$$C = \frac{74.8 \times 10^3}{\omega V_{rms}^2} = \frac{74.8 \times 10^3}{3.77 \times 10^2 (2.2 \times 10^2)^2}$$

C = 4100 μF

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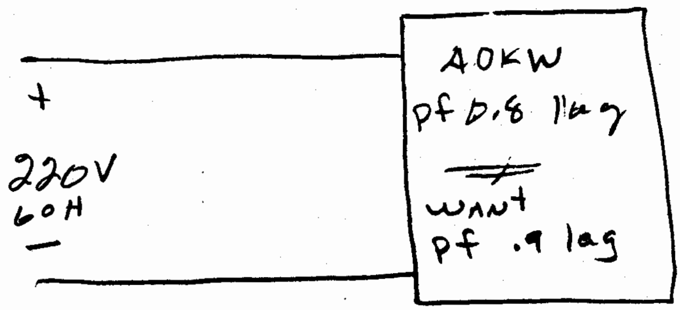
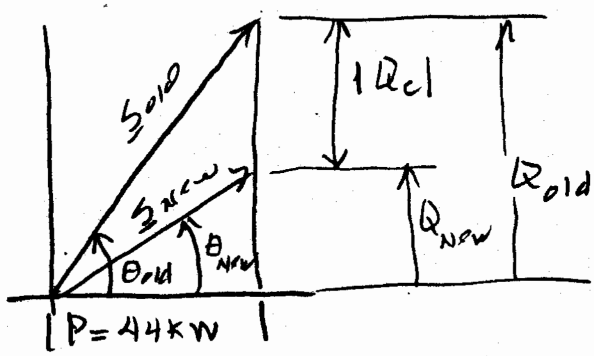
4.61

Given the following:





$\theta_{old} = \cos^{-1}(0.8 = \underline{36.9^\circ}$ $\qquad \theta_{New} = \cos^{-1}(.9) = \underline{25.8^\circ}$

$Q_{old} = P\tan(\theta_{old}) = 40\times10^3 \tan(36.9) = 30 \text{ KVARs}$

$Q_{New} = P\tan(\theta_{New}) = 40\times10^3 \tan(25.8) = 19.34 \text{ KVARs}$

$|Q_c| = Q_{old} - Q_{New} =$

$C = \dfrac{|Q_c|}{\omega V_{rms}^2} = \dfrac{10.66}{3.77\times10^2 \times (2.2\times10^2)^2}$

$\boxed{C = 584\mu F}$