Desk Copy

ECE 301
HW #10

wlg
Due: November 29, '07 revision B

Name wlg

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 15 points.

(5.70) (a) On your own (b) pf = .6 lagging (c) P = 27 kW (d) Q = 36 kVAR (e) S = 45 kVA

(5.72) (a) pf = .866 lagging (b) P = 173.2 kW (c) Q = 100 kVAR (d) S = 200 kVA

(5.76) P_A = 8.82 kW, Q_A = -0.418 kVAR delivered

P_B = 7.467 kW absorbed Q_B = -3.125 kVAR absorbed

P_R = 1.353 kW absorbed

Q_L = 2.707 kVAR absorbed

(5.78) Z = 11.62 + j15.49 ohms; R = 11.62 ohms; L = 0.0411 H

(5.79) (a) I = 11.32∠-27.97° A rms (b) S = (10,000 + j5309) VA from which, P = 10 KW, Q = 5309 VAR S = 11320 VA; (c) p.f. = cos27.97° = 0.8832 lagging

(5.81 On this problem you need to draw the power triangle for each load, load A and load B. You will find that S_A = 11.11∠25.8° kVA, S_B = 15∠36.9 KVA. This gives **S** = $S_A + S_B$ = 26∠32.18° KVA Or in rectangular form **S** = (22 + j13.84) kVA = P + jQ. From this you see that

P_S = 22 kW, Q_S = 13.84 kVAR, and S = 26 kVA: This seems to be the most direct way to work the problem. However, there are other variations that could be used.

Pf = 0.8462 lagging

(5.83) P = 5000W; Q = 383.9 VAR; pf = 0.9971 lagging

5.85 (a) I_{rms} (magnitude) = 400 A; $\hat{I} = 400x\sqrt{2}\ \angle -75.5^o\ A$: Note that the original rms line current is 400 A; The capacitor is suppose to reduce this.

(b) You will find that Q_c = - 387.3 kVAR; The rating of the capacitor is the absolute value of this Or 387.3 kVAR.. The value of C = 1027 μF

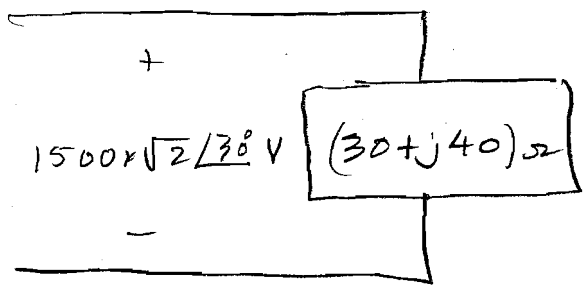
(c) With the capacitor you will find that the new I_{rms} of the line current is 100 A. So the Line current has been reduced from 400 A, to 100 A. This is quite significant.

Wlg

ECE 301
H.W. #10
Fall 2007

5.70

Given the circuit load below with the indicated applied voltage.



(a) Is the load inductive or capacitive?

Ans: It is inductive because we have +j40.

(b) Determine the pf.

Ans: The pf angle is the same as the angle of the load impedance.

$\hat{Z} = (30+j40) = 50\angle 53.1$

$p.f. = \cos 53.1 = 0.6$ lagging

$\hat{S} = \frac{|V_{rms}|^2}{Z^*} = \frac{(1500)^2}{(30-j40)} = 45\angle 53.1$ KVA

$\hat{S} = (27+j36)$ K VA

(c) $P = 27$ K W (d) $Q = 36$ K VAR

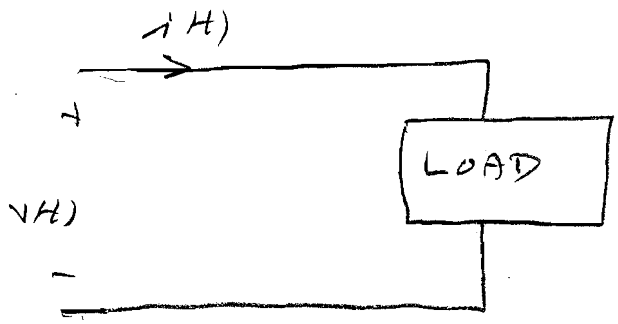
(e) $S = 45$ K VA

5.72

Given

$v(t) = 1\times10^4\sqrt{2}\cos(\omega t + 10^\circ)$ V

$i(t) = 20\sqrt{2}\cos(\omega t - 20^\circ)$ A



The phasor voltage and current become

$\hat{V} = 1\times10^4\sqrt{2}\angle 10^\circ$ V

$\hat{I} = 20\times\sqrt{2}\angle -20^\circ$ V

(a) Determine the p.f.

Ans:

$pf = \cos(\theta_V - \theta_I)$

$\theta_V = 10^\circ, \quad \theta_I = -20^\circ$

$pf = \cos(10+20) = 0.866$ lagging

lagging because the current lags the voltage.

(b)

Determine the power:

$P = \frac{|V||I|}{2}\cos(\theta_V - \theta_I) = 1\times10^4 \times 20\cos(30^\circ)$

$P = 173.2$ kW

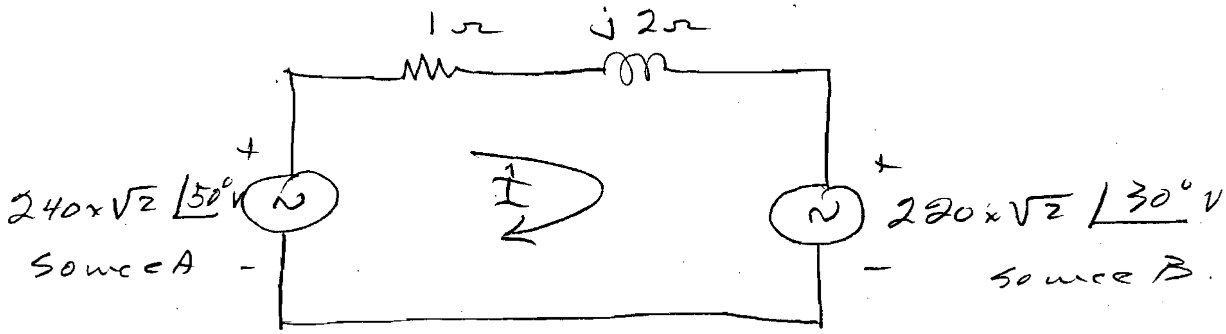
(c) $Q = 20\times10^4 \sin 30^\circ$

$Q = 100$ kVAR

(d) $S = |V_{rms}||I_{rms}| = 200$ kVA

5.76

Determine the power for each source shown in the diagram below. Also, state whether each source is delivering or absorbing energy



work with rms

$$-240\angle 50 + (1+j2)\vec{I} + 220\angle 30^\circ = 0$$

$$\hat{I}_{rms} = \frac{240\angle 50 - 220\angle 30}{1+j2}$$

$$\hat{I}_{rms} = 36.79\angle 52.7\,A$$

$$S_{A\,del_A} = (240\angle 50)(36.79\angle -52.7) = 8829.6\angle -2.7$$

$$S_{del_A} = 8819.8 - j415.9$$

$P_{A\,del} = 8.82\,kW$ del; $Q = -0.416$ kV del.

$$\hat{S}_B = (220\angle -150)(36.79\angle -52.7).$$

$$\hat{S}_{B\,del} = (-7466.8 + j3123)\,VA$$

$P_{B\,ABS} = 7.47\,kW$ $\quad Q_{ABS} = -3.12$ kVAR

5.76

complex power to the $(1+j2)\Omega$ load

$$S_{ciR} = |I_{rms}|^2 Z = (36.79)^2(1+j2)$$

$$S_{ciR} = 1353.5 + j\,2707$$

$$P_R = 1.354\ kW$$
$$Q_L = 2.707\ kVAR$$

check

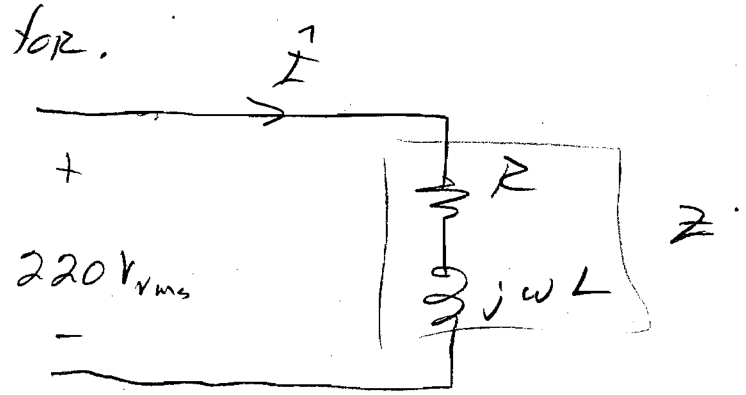
$$\Sigma\ \bar{S}_A + \bar{S}_B = 8.82\ kW - j\,0.416\ kVAR$$
$$-7.467\ kW + j\,3.12\ kV$$
$$= (1.35 + j\,2.7)\ kVA$$

$$P_{sup} = 1.35\ kW$$
$$Q_{sup} = 2.7\ kVAR$$

$$P_R = 1.354\ kW$$
$$P_L = 2.707\ kVAR$$ Check!

5.78

A 60 Hz, 220 V_{rms} source supplies power to a load consisting of a resistance in series with an inductor.



$P_{sup} = 1500\text{ W}$ $\quad$ $\underline{S} = 2500\text{ VA}$

Find R and L

Since

$$\vec{S} = \frac{|\vec{V}_{rms}|^2}{Z^*}$$

$$S = \frac{V_{rms}^2}{Z}$$

$$Z = \frac{220^2}{2500} = 19.36\ \Omega$$

$$\cos\theta = \frac{P}{S} = \frac{1500}{2500} = 0.6$$

$$\theta = \cos^{-1} 0.6 = 53.1^\circ$$ lagging since we have $j\omega L$ for part of the load.

$$\hat{Z} = 19.36\angle 53.1^\circ = (11.6 + j15.48)\ \Omega$$

$R = 11.6\ \Omega$

$\omega L = 15.48$

$$L = \frac{15.48}{2\pi \times 60} = 0.041\text{ H}$$

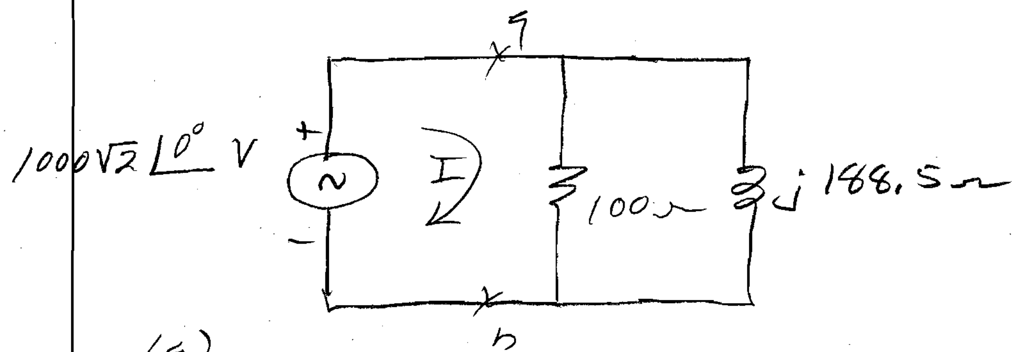
5.79

Consider the circuit shown below.

(a) Find the current $\vec{I}$.

(b) Find the power, reactive power, apparent power delivered by the source.

(c) Find the p.f.



(a)

$$\hat{I}_{rms} = \frac{1000}{100} + \frac{1000}{j\,188.5}$$

$$\vec{I}_{rms} = (10 - j5.31)\ A = 11.32\angle -27.97^\circ\ A$$

(b)

$$\vec{S}_{source} = (1000\angle 0)(11.32\angle 27.97)$$

$$\vec{S} = 11320\angle 27.97\ VA$$

$$\vec{S}_{source} = 10{,}000 + j\,5309$$

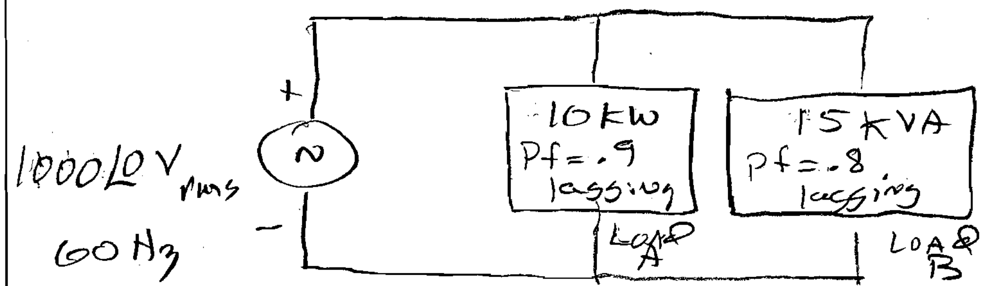
$\therefore$ $P = 10\,kW$, $Q = 5.31\,kVAR$

$S = 11.32\,kVA$

(c) $p.f. = \cos 27.97 = 0.8832$ lagging

5.81

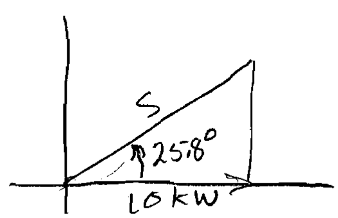
Two loads are connected in parallel across a 1 KV rms 60 Hz line as shown below.



(a) Find the power, reactive power and apparent power delivered by the source

(b) What is the power factor seen by the source

(a) Draw the power triangle for Load A and determine $\hat{S}_A$.



$\cos\theta = .9$

$\theta = 25.8°$

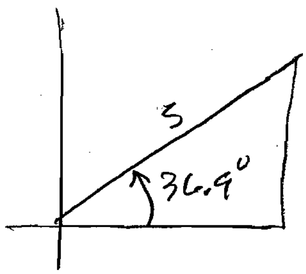
$\cos\theta = .9 = \frac{10K}{S}$

$S = \frac{10K}{.9} = 11.11$ KVA

$\hat{S}_A = 11.11 \angle 25.8°$ KVA

5.81 continued

Power triangle for load B



$\cos\theta = .8$

$\theta = 36.9°$

$S = 15$ KVA so,

$\hat{S}_B = (15\angle 36.9 \text{ KVA})$

$\hat{S} = \hat{S}_A + \hat{S}_B = [(11.11\angle 25.8) + (15\angle 36.9)]$ KVA

$\hat{S} = 26\angle 32.18°$ KVA $= (22 + j13.84)$ KVA

$\hat{S} = P + jQ$

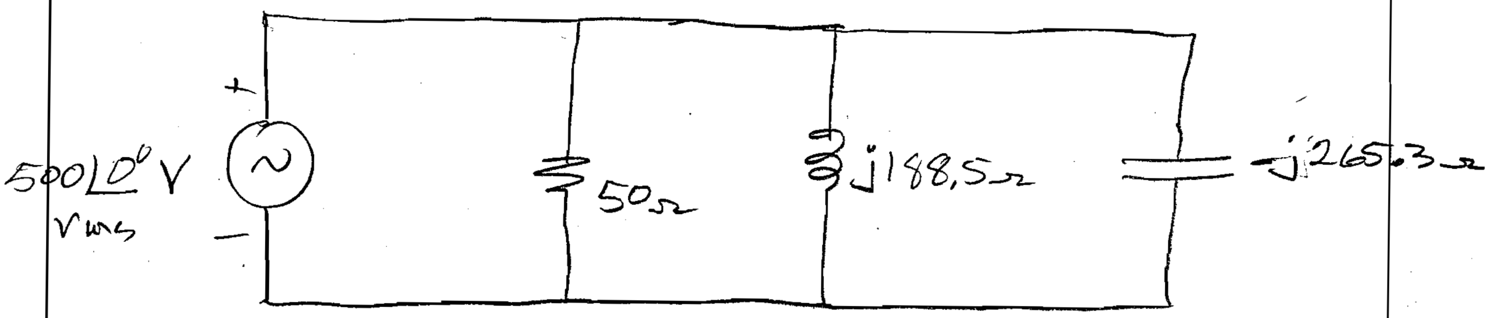
ANS: $P = 22$ KW $Q = 13.84$ KVAR

$S = 26$ KVA

(b) P.F. = cos 32.18 = 0.8464 lagging

5.83

For the circuit below, find the power, the reactive power and the apparent power. Find the power factor.



$$P = \frac{(V_{rms})^2}{R} = \frac{500^2}{50} = 5000\,W$$

$$Q_L = \frac{V_{rms}^2}{X_L} = \frac{500^2}{188.5} = 1326.26$$

$$Q_C = \frac{V_{rms}^2}{X_C} = \frac{500^2}{-265.3} = -942.33$$

$$Q = Q_L + Q_C = 1326.26 - 942.33$$

$$Q = 383.93$$

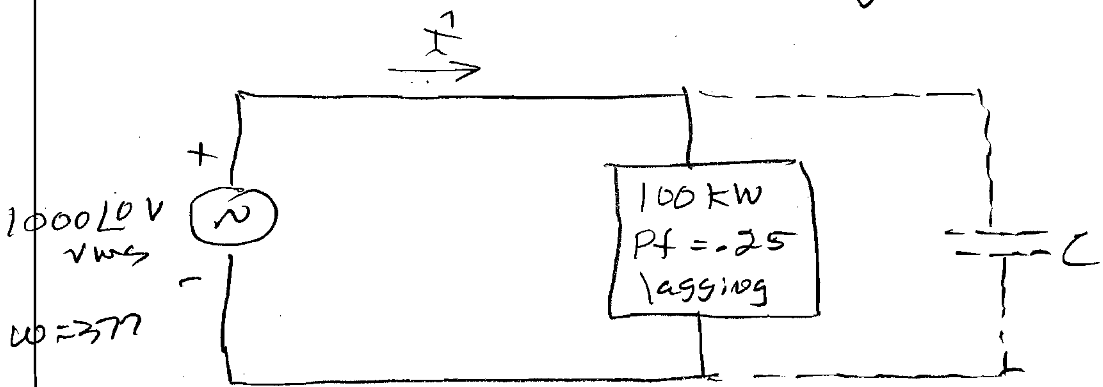
$$\vec{S} = (5000 + j\,383.93)\ VA = 5014.72\angle 4.39$$

$$S = 5014.7\ VA$$

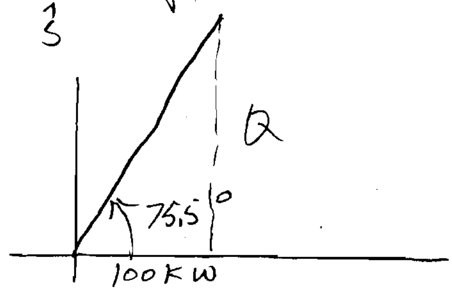
P.f. = 0.9971 lagging

5.85

Consider the following circuit



(a) Find the phasor current $\hat{I}$,
Use the power triangle to find $\hat{S}$



$\cos\theta = .25$
$\theta = 75.5°$

$$\cos\theta = .25 = \frac{100k}{S}$$

$$S = \frac{100k}{.25} = 400 \text{ KVA}$$

$$\hat{S} = 400\angle 75.7 \text{ KVA} = \hat{V}_{rms} \times I^*_{rms}$$

$$\hat{I}^*_{rms} = \frac{400\angle 75.7 \text{ KVA}}{1K\angle 0} = 400\angle 75.7$$

$$\hat{I} = 400\angle -75.7° \text{ A rms}$$

(b) Find C to bring the pf to unity.

5.85 cont

Find Q from the earlier triangle,

$$\frac{Q}{S} = \sin 75.5$$

$$Q = S \sin 75.5 = 400 \times \sin 75.5 \text{ KVAR}$$

$$Q = 387.26 \text{ KVAR}$$

so we know that

$$\left| -\omega C V_{rms}^2 \right| = 387.26\text{K}$$

$$C = \frac{387.26\text{K}}{(1000)^2 \times 377}$$

$$C = 1030 \mu F$$

(c) Rating of the capacitor in KVAR is 387.26 KVAR

(d) The new line current will be

$$S = P + jQ = 100\text{KW} = V_{rms} I_{rms}$$

$$I_{rms} = \frac{100\text{k}}{1\text{k}} = 100\text{ A}$$

Reduced the current from 400A to 100A — factor of 4

I^2R loss reduced by a factor of 16.