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ECE 300
Spring Semester, 2004
Test #3

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Name Green
Last, First

Work the exam on your own paper. Work on one side of your paper only. Attach your work to the back of this exam sheet and staple in the top left hand corner. You may omit either problem 4 or 5. Indicate at the top of the exam cover sheet which problem you omit.

1. You are given the circuit of Figure 1. Use a cosine reference for this problem.

   (a) Find the phasor currents $\underline{I}_1$ and $\underline{I}_2$.
   (b) Find the power factor of the 50cos(100t + 30°) source.
   (b) Find the average real power supplied by the 50cos(100t + 30°) source.
   (c) Find the quadrature power supplied by the 50cos(100t + 30°) source.
   (d) Find the complex power supplied by the 50cos(100t + 30°) source.

25%

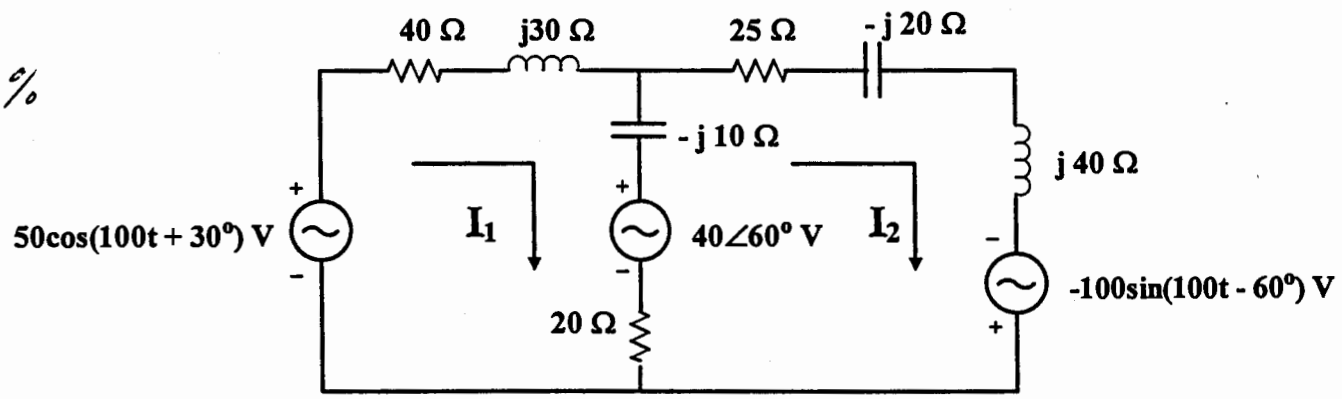

Figure 1: Circuit for problem 1.

2. A small plant has a bank of induction motors that consume 64 kW at a power factor of 0.68 lagging. The 60-Hz line voltage across the motors is 220∠0° V rms. The local power company has told the plant to raise the power factor to 0.92 lagging in order to receive a discount of 10% on the billing. What value of capacitance is required?

20%

3. Find the input impedance, Z_{in}, (expressed in rectangular form) for the circuit shown in Figure 3.

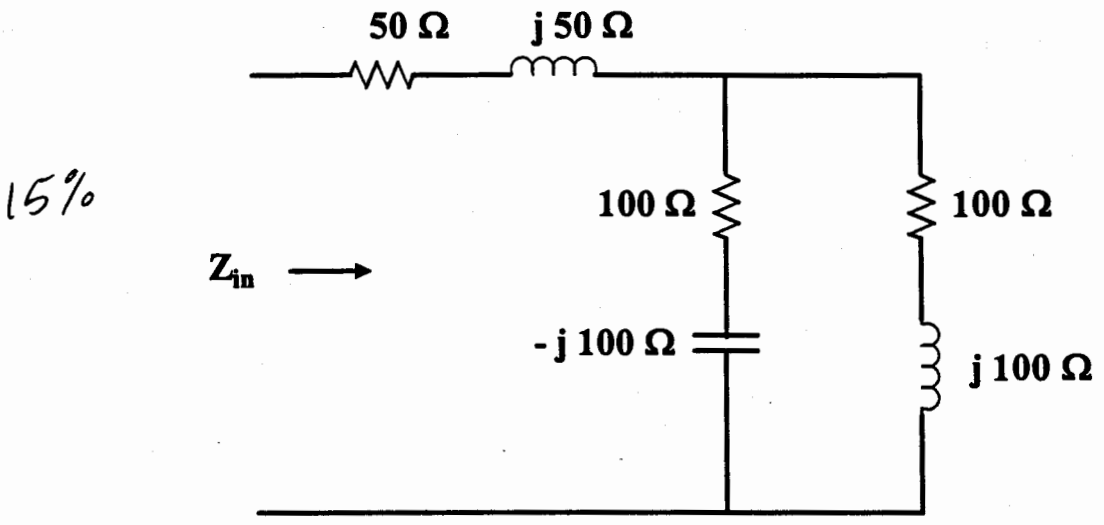

Figure 3: Circuit for problem 3.

4. Two coils, in the same circuit, are linked through a mutual inductance that has impedance of j10 Ω. This circuit is shown in Figure 4. Find the indicated phasor current, $\underline{\mathbf{I}}$.

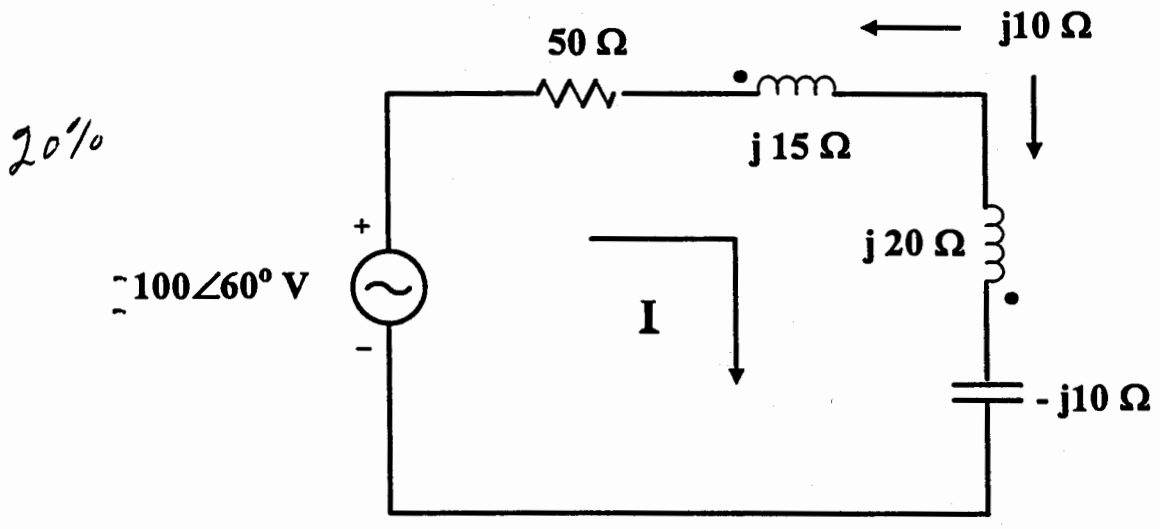

Figure 4: Circuit for problem 4.

5. Find the phasor voltage, $\underline{V}_x$, in the circuit of Figure 5.

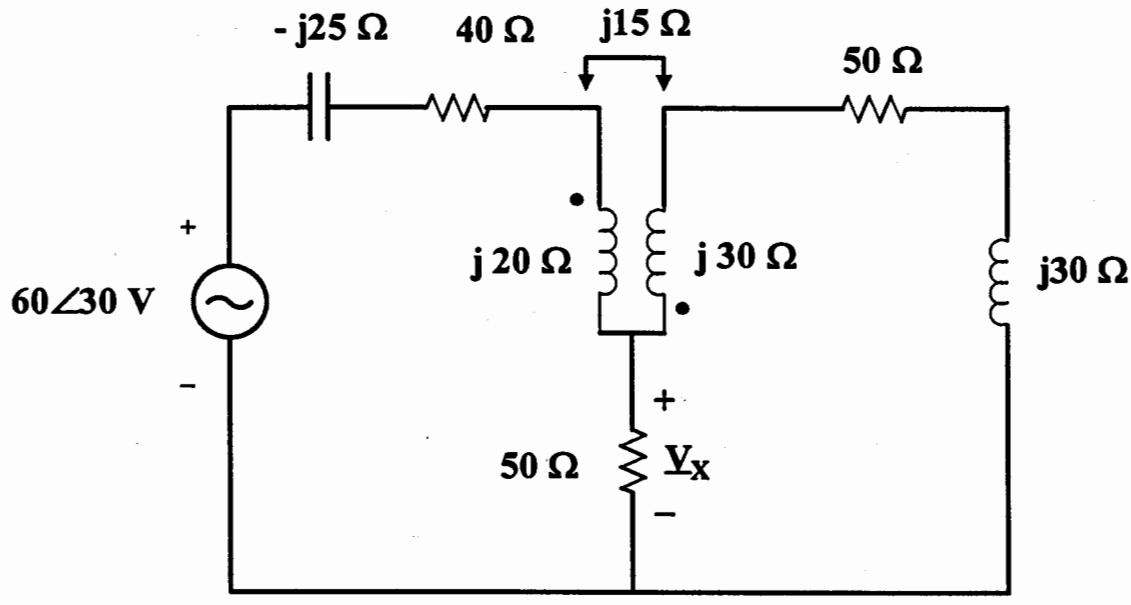

Figure 5: Circuit for problem 5.

6. Two ideal transformers are placed in a circuit as shown in Figure 6.

   (a) Find the phasor current $\underline{I}_1$ expressed in rms amps.
   (b) Find the phasor voltages $\underline{V}_1$ and $\underline{V}_3$ expressed in rms volts.
   (c) Find the average real power consumed by the 1 Ω resistor.

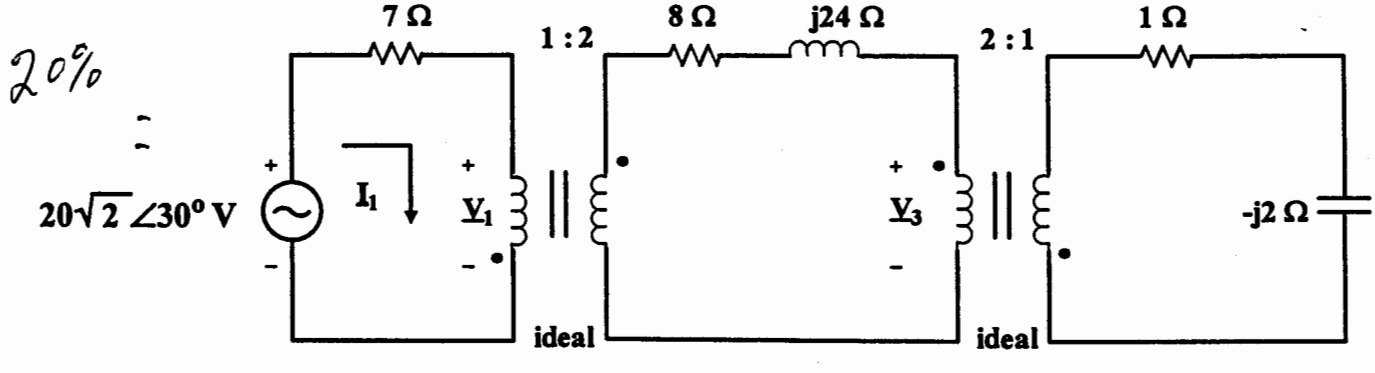

Figure 6: Circuit for problem 6.

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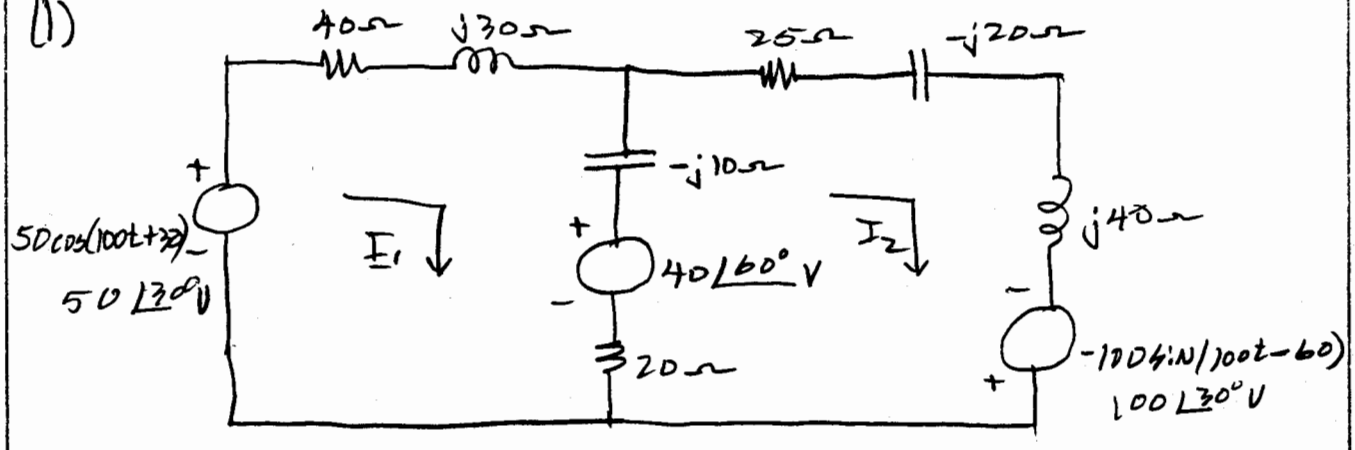
Test #3

(1)



Cosine reference

$50\cos(100t+30)\ V \longrightarrow 50\angle 30$

$-100\sin(100t-60)\ V \longrightarrow 100\angle 30$

(a) Find the phasor currents $\underline{I}_1$ and $\underline{I}_2$

$$(60+j20)\underline{I}_1 - (20-j10)\underline{I}_2 = 50\angle 30 - 40\angle 60$$

$$-(20-j10)\underline{I}_1 + (45+j10)\underline{I}_2 = 40\angle 60 + 100\angle 30$$

$$\underline{I}_1 = 1.17 - j0.82 = 1.43\angle -35.1^\circ\ A$$

$$\underline{I}_2 = 2.85 + j0.63 = 2.91\angle 12.4^\circ\ A$$

(b) Find the power factor of the $50\cos(100t+30^\circ)$ source.

$\angle \underline{I}_1 = \angle \underline{I}_1 = -35^\circ$

$\angle \underline{V} = \angle \text{source} = 30^\circ$

p.f. angle $= \angle \underline{V} - \angle \underline{I}_1 = 30 - (-35) = 65^\circ$

p.f. $= \cos(65^\circ) = 0.42$

(continued)

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(1)

continued

(2)

(c) FIND the AVERAGE REAL POWER supplied by the $50\cos(100t+30)$ source

$$P_s = \frac{1}{2}|V_s||\underline{I}_1|\cos(\theta_{pf}) = \frac{1}{2}\times 50\times 1.43\cos 65^\circ$$

$$P_s = 15.11\ W$$

(d) FIND quadrature power.

Solution: Several ways, here

$$\underline{S} = \frac{1}{2}\underline{V}_s \times \underline{I}_1^* = P_s + jQ_s$$

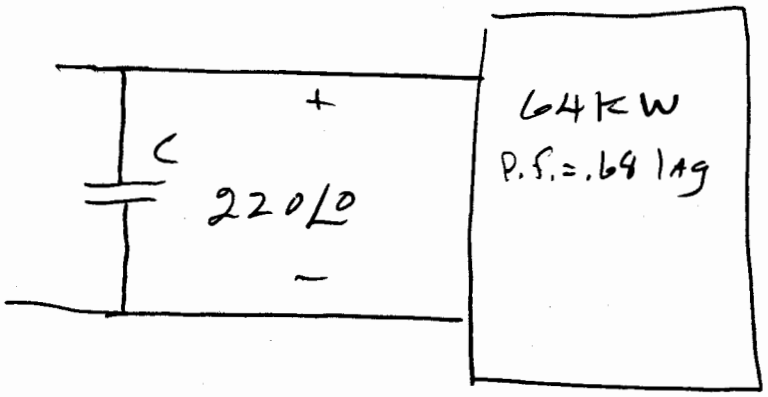
$$\underline{S} = \frac{1}{2}50\angle 30 \times 1.43\angle 35$$

$$\underline{S} = 15.11 + j32.4$$

$\therefore Q = 32.4$ VARS

(e) $\underline{S} = 15.11 + j32.4$ VA $= 35.8\angle 65$ VA

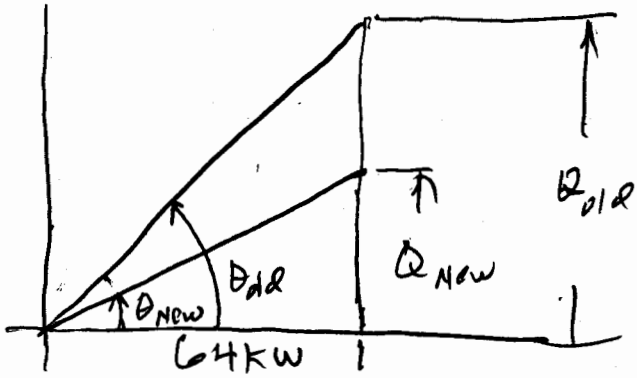
(2)



$\theta_{old} = \cos^{-1}(.68)$

$\theta_{old} = 47.16°$

want to find C so that the load P.f. is 0.92 lagging.



$\theta_{new} = \cos^{-1}(.92) = 23.1°$

$|Q_c| = |Q_{old} - Q_{new}| = 64k\tan(47.16) - 64k\tan(23.1)$

$|Q_c| = 41.72\,KVARs = \omega C V_{rms}^2$; $\omega = 377$ rad/sec

$C = \dfrac{41.7K}{377 \times 220^2} = \dfrac{4.17 \times 10^4}{3.77 \times 10^2 \times (2.2)^2 \times 10^4}$

$\underline{C = 0.23 \times 10^{-2} F = 2300 \mu F}$

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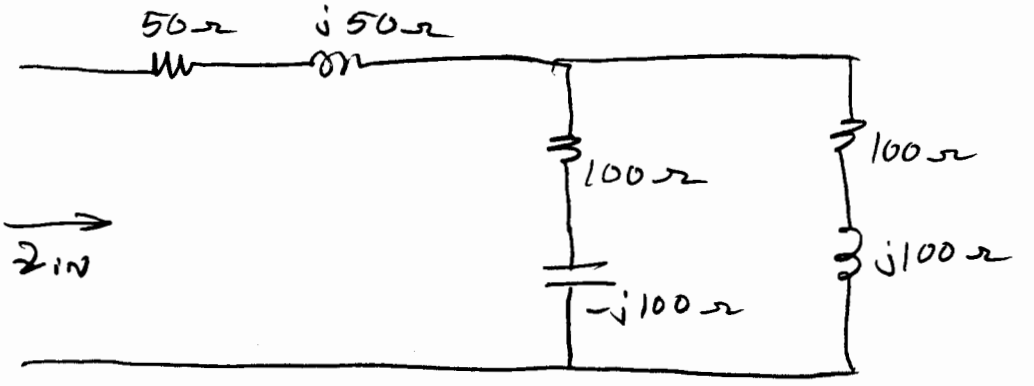
(3) Find Z_{IN} for the following network,



$$Z_{IN} = (50 + j50) + \frac{(100 - j100)(100 + j100)}{100 - j100 + 100 + j100}$$

$$Z_{IN} = 50 + j50 + 100\ \Omega$$

$$\boxed{Z_{IN} = 150 + j50\ \Omega}$$

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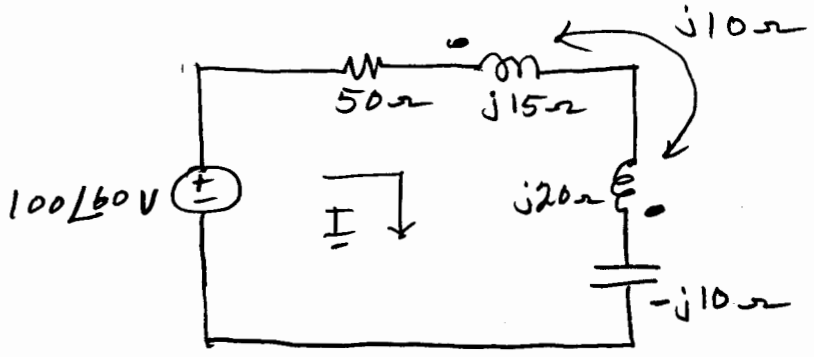
④ Find $\underline{I}$ in the following circuit.



$$(50 + j15 + j20 - j10)\underline{I}_1 - j10\underline{I}_1 - j10\underline{I}_1 = 100\angle 60$$

$$(50 + j5)\underline{I}_1 = 100\angle 60$$

$$\underline{I}_1 = \frac{100\angle 60}{50 + j5}$$

$$\underline{I}_1 = 1.16 + j1.62 = 1.99\angle 54.3^\circ \text{ A}$$

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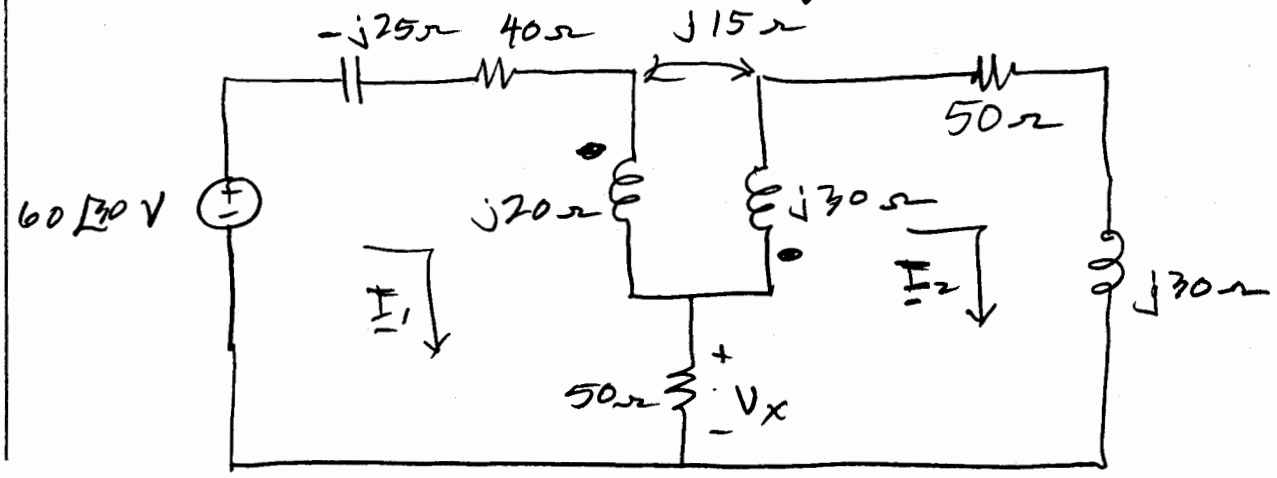
(5)

FIND V_x IN the following circuit.



$$(-j25+40+j20+50)\underline{I}_1 + j15\underline{I}_2 - 50\underline{I}_2 = 60\angle 30$$

$$\boxed{(90-j5)\underline{I}_1 + (-50+j15)\underline{I}_2 = 60\angle 30\ V}$$

$$(-50+j15)\underline{I}_1 + (50+j30+50+j30)\underline{I}_2 = 0$$

$$\boxed{(-50+j15)\underline{I}_1 + (100+j60)\underline{I}_2 = 0}$$

$$\begin{bmatrix} 90-j5 & -50+j15 \\ -50+j15 & 100+j60 \end{bmatrix} \begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} 60\angle 30 \\ 0 \end{bmatrix}$$

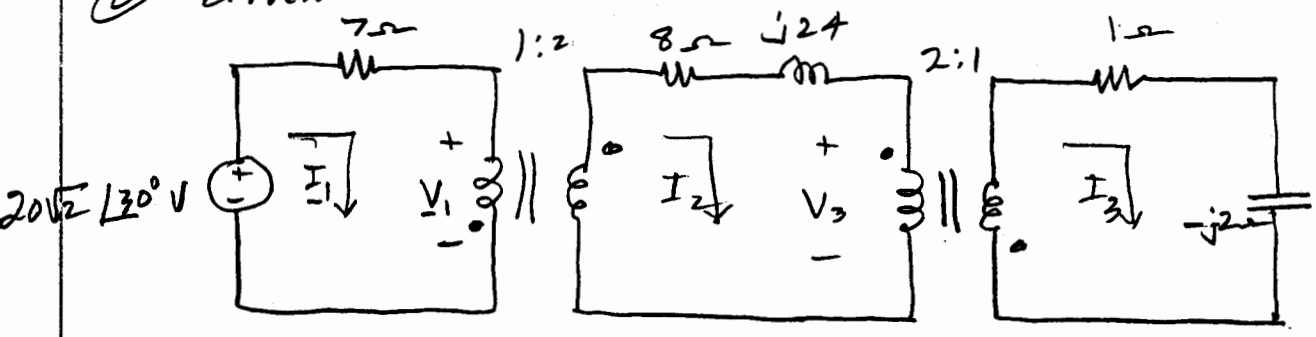
$$\underline{I}_1 = 0.7+j0.24 = 0.74\angle 18.63\ A$$

$$\underline{I}_2 = 0.29-j0.16 = 0.33\angle -28.9\ A$$

$$\underline{V}_x = 50(\underline{I}_1 - \underline{I}_2) = 50(0.41+j0.4)$$

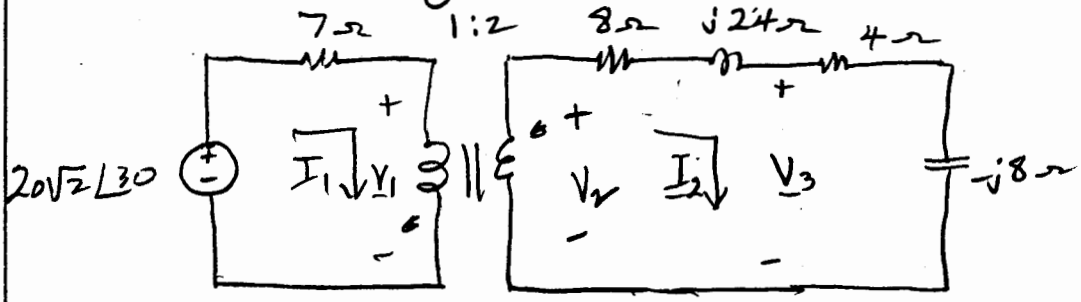
$$V_x = 28.64\angle 44.3^\circ\ V$$

⑥ Given

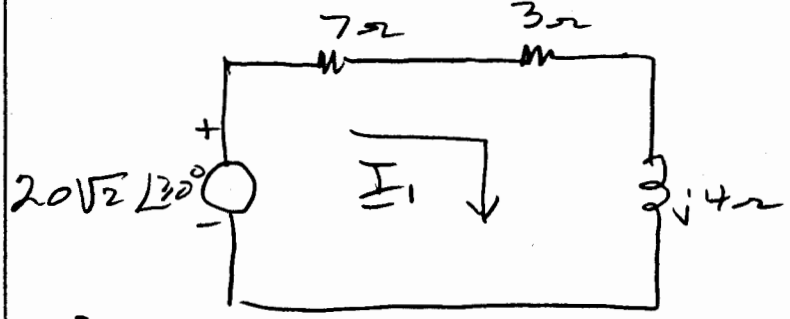


(a) Find the phasor current $\underline{I}_1$, rms

Approach: Reflect the impedance to the primary



$$\frac{1-j2}{(0.5)^2} = 4-j8$$



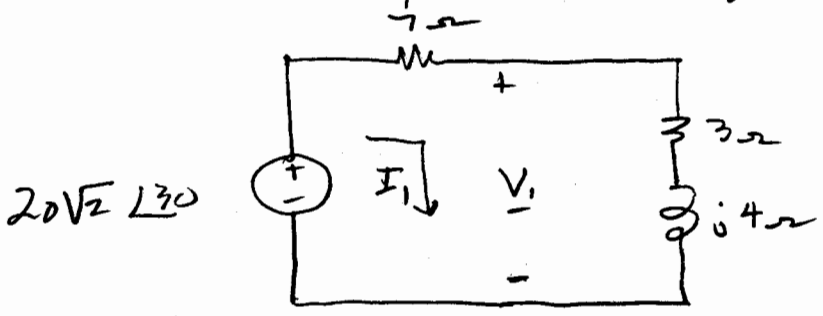
$$\frac{12+j16}{2^2} = 3+j4$$

$$\underline{I}_1 = \frac{20\angle 30}{10+j4} = 1.86\angle 8.2° \text{ A rms}$$

CONTINUED

(6) continued

(b) Find phasor voltages $\underline{V}_1$ and $\underline{V}_3$



$$\underline{V}_1 = 20\angle 30 - 7 \times \underline{I}_1 = 20\angle 30 - 7 \times 1.86\angle 8.2$$

$$= ((20\angle 30) + (13.02\angle -171.8))$$

$$\boxed{\underline{V}_1 = 9.27\angle 61.4 \text{ V rms}}$$

$$\frac{V_2}{V_1} = -2 \quad \text{OR} \quad V_2 = -2V_1$$

$$V_3 = \frac{V_2(4-j8)}{8+j24+4-j8} = \frac{-2V_1(4-j8)}{12+j16} = \frac{2V_1(-4+j8)}{12+j16}$$

$$\underline{V}_3 = \frac{(2 \times 9.27\angle 61.4)(-4+j8)}{12+j16}$$

$$\boxed{V_3 = 8.29\angle 124.8^\circ \text{ V}}$$

(c) Average real power consumed by 1Ω resistor.

$$\frac{I_1}{I_2} = -2 \quad \text{OR} \quad I_2 = -0.5I_1$$

continued

(b)

$$\underline{I}_2 = -0.5\,(1.86\angle 8.2^\circ)$$

$$\underline{I}_2 = 0.93\angle -171.8$$

Now

$$\frac{\underline{I}_3}{\underline{I}_2} = -2$$

$$\underline{I}_3 = -2\,(0.93\angle -171.8$$

$$\underline{I}_3 = 1.86\angle 8.2 \quad A = \underline{I}_1$$

$$P_1 = |\underline{I}_3|^2 \times 1 = (1.86)^2 \times 1$$

$$P_{1\Omega} = 3.46 \ W$$