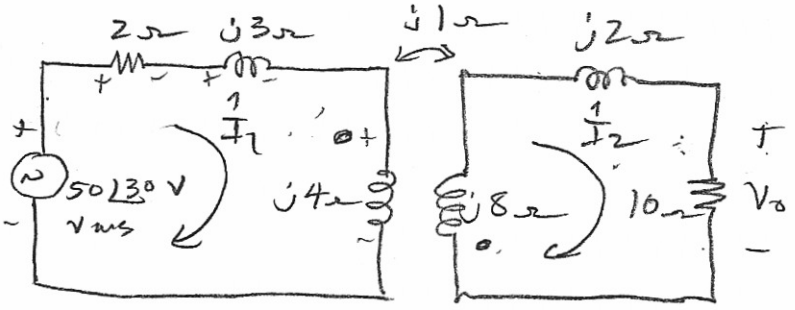
HW #11

(1) Find the phasor voltage V_o.



$$(2+j3)\hat{I}_1 + j4\hat{I}_1 + j\hat{I}_2 = 50\angle 30$$

$$\boxed{(2+j7)\hat{I}_1 + j\hat{I}_2 = 50\angle 30^\circ}$$

$$(10+j10)I_2 + j\hat{I}_1 = 0$$

$$\boxed{j\hat{I}_1 + (10+j10)\hat{I}_2 = 0}$$

$$\begin{bmatrix} 2+j7 & j \\ j & 10+j10 \end{bmatrix} \begin{bmatrix} \hat{I}_1 \\ \hat{I}_2 \end{bmatrix} = \begin{bmatrix} 50\angle 30 \\ 0 \end{bmatrix}$$

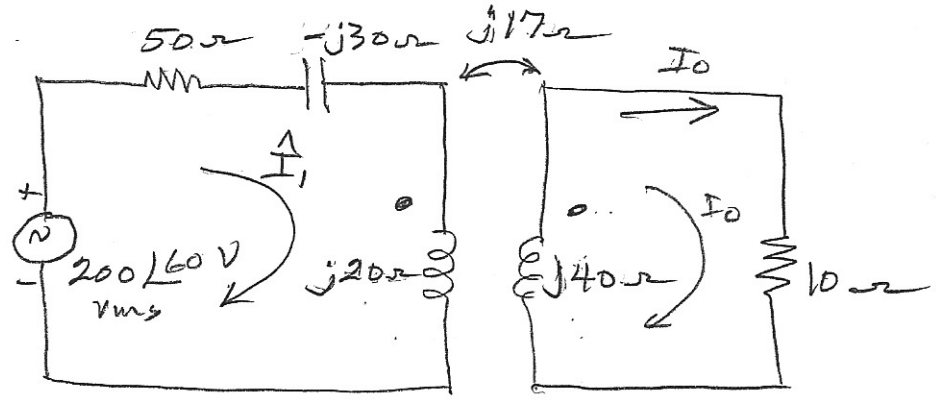
$\hat{I}_1 = 6.9\angle -43.57$ A rms

$\hat{I}_2 = 0.488\angle -178.57$ A rms

$\hat{V}_o = 10 \times I_2$

$\hat{V}_o = 4.88\angle -178.57^\circ$ V rms

(2)



$$(50-j10)\hat{I}_1 - j17\hat{I}_o = 200\angle 60^\circ$$

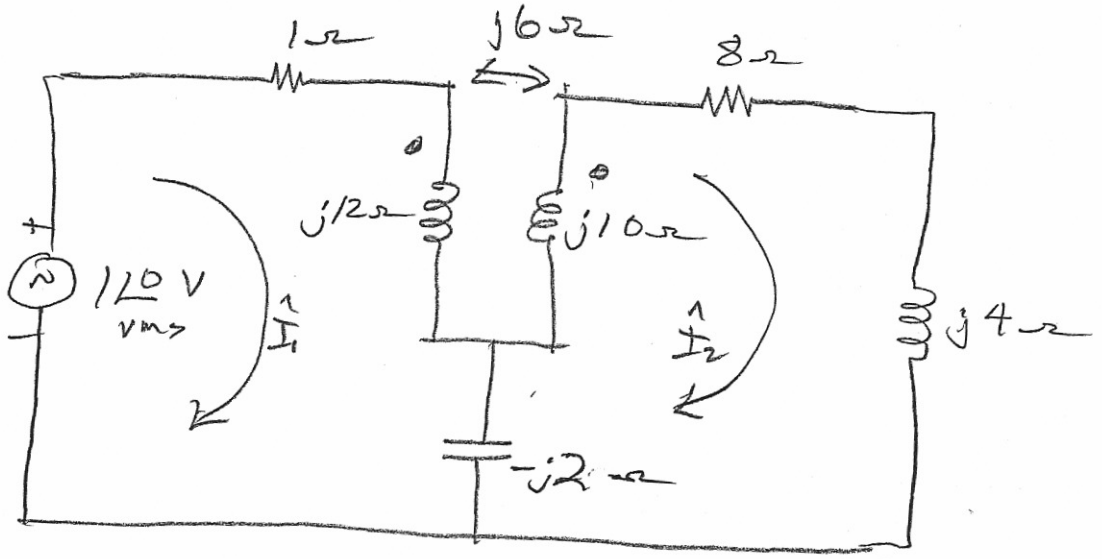
$$-j17\hat{I}_1 + (10+j40)\hat{I}_o = 0$$

$$\begin{bmatrix} 50-j10 & -j17 \\ -j17 & 10+j40 \end{bmatrix} \begin{bmatrix} \hat{I}_1 \\ \hat{I}_o \end{bmatrix} = \begin{bmatrix} 200\angle 60 \\ 0 \end{bmatrix}$$

$$\hat{I}_1 = 3.68\angle 78^\circ \text{ A rms}$$

$$\hat{I}_o = 1.52\angle 92^\circ \text{ A rms}$$

(3) Find $\hat{Z}_{ab}$



$$Z_{ab} = \frac{1}{\hat{I}_1}$$

$$(1 + j10)\hat{I}_1 + j2I_2 - j6I_2 = 1\angle 0$$

$$-j2(I_2 - I_1) + (8 + j14)I_2 - j6I_1 = 0$$

$$-j4\hat{I}_1 + (8 + j12)\hat{I}_2 = 0$$

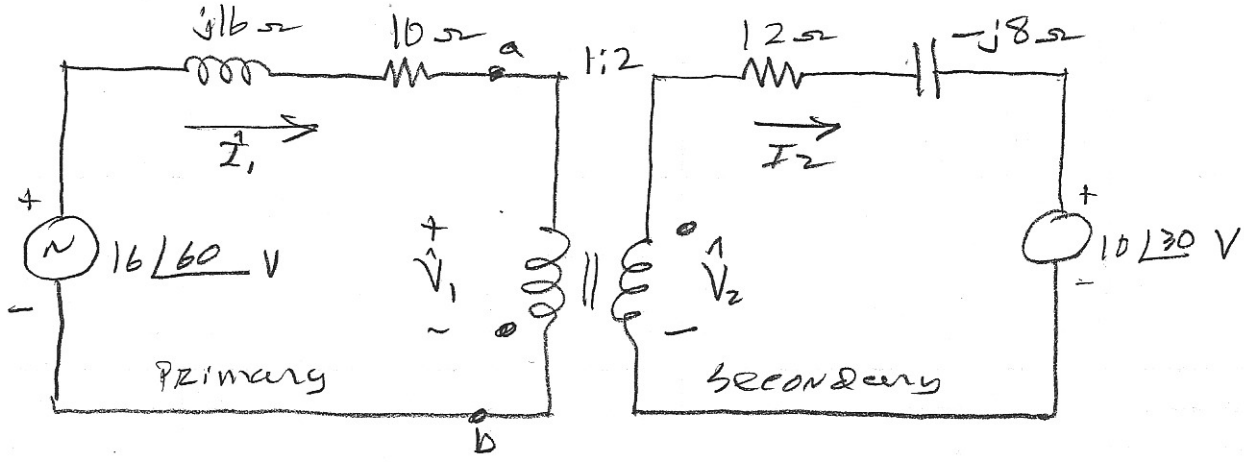
$$\begin{bmatrix} 1+j10 & -j4 \\ -j4 & 8+j12 \end{bmatrix} \begin{bmatrix} \hat{I}_1 \\ \hat{I}_2 \end{bmatrix} = \begin{bmatrix} 1\angle 0 \\ 0 \end{bmatrix}$$

$\hat{I}_1 = 0.1084\angle -80^\circ$ A rms

$\hat{I}_2 = 0.03\angle -46.2^\circ$ A rms

$$Z_{ab} = \frac{1}{.1084\angle -80} = 9.225\angle 80^\circ \ \Omega$$

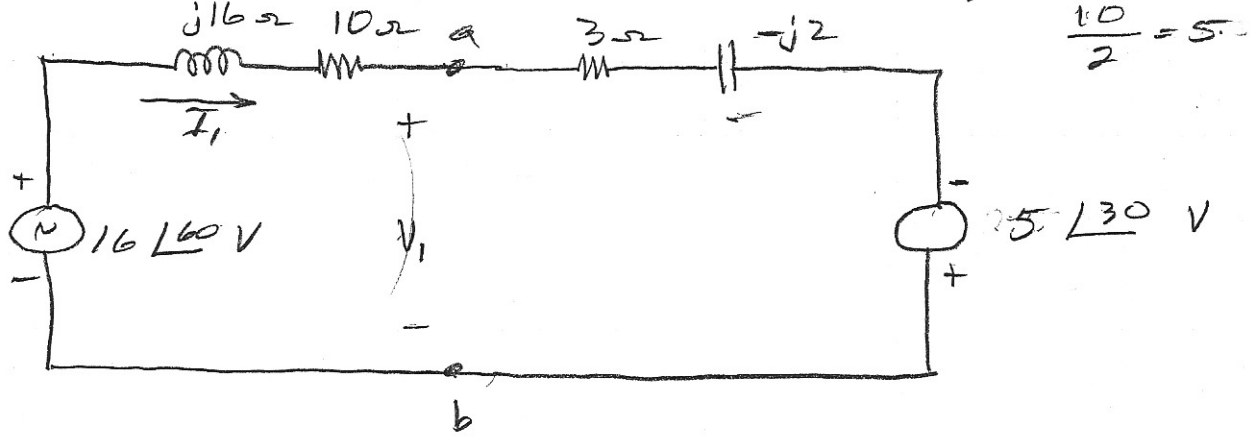
(4) For the following ideal transformer find I_1, I_2, V_1, V_2.



Reflecting the secondary to the primary gives

$\frac{12-j8}{2^2} = 3-j2$

$\frac{10}{2} = 5$



$$\vec{I}_1 = \frac{16\angle 60 + 5\angle 30}{13 + j14} = 1.07\angle 5.87^\circ \text{ A}$$

$$\frac{\vec{I}_1}{\vec{I}_2} = -2 \qquad I_2 = (-0.5)I_1 = 0.535\angle -174.1^\circ \text{ A}$$

$$\vec{V}_1 = 16\angle 60 - (10+j16)\vec{I}_1 = 4.36\angle -101.8$$

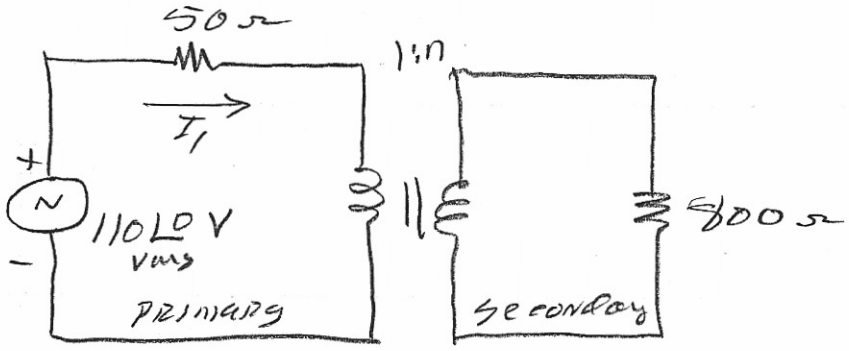
$$\vec{V}_1 = 4.36\angle -101.8^\circ \text{ V}$$

$$V_2 = -2 \times \vec{V}_1 = 8.72\angle 78.2^\circ \text{ V}$$

(5) For the circuit below:

(a) Determine n so that maximum power will be delivered to the load resistor.

(b) Determine the power delivered to the load under the condition of maximum power transfer



(a)

The load reflected to the primary is

$$\frac{800}{n^2}$$

We want this to be equal to 50 Ω for maximum power transfer.

$$\frac{800}{n^2} = 50$$

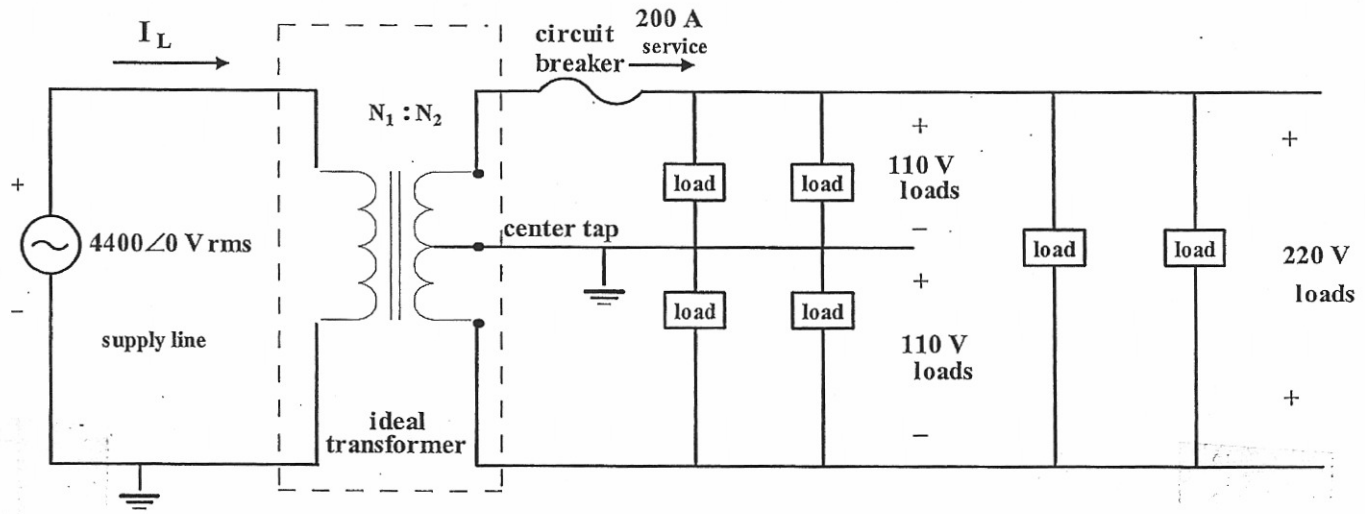
or

$$n = 4$$

(b) $$P_{OUT} = \left(\frac{110}{100}\right)^2 \times 50$$

$$\boxed{P_{OUT} = 60.5\ W}$$

(6) Consider Figure 6. The 4400∠0 V rms is supplied by your local utility to the primary of a transformer (assumed ideal) as shown.



The secondary of the transformer represents the power supplied to your home. Your home is wired so as to provide 110 V rms and 220 V rms circuits (safety ground wire is omitted for conviencew in making the drawing).

A typical home might have a circuit breaker box that can handle up to 200 A rms (called 200 amp service) as shown.

(a) What is the ratio of $N_1 : N_2$ so that the voltage is stepped-down from 4400 V rms to 220 V rms? Ans: 20

(b) If your load happens to be pulling max current of 200 A rms, what will be the current I_L on the supply line side of the transformer? Ans: 10 A.

(c) When pulling 200 A at your residence, how much average real power is the power company Supplying to you if the transformer is lossless? Ans: 44 kW

(d) If you operated your home pulling 200 A, 24-7, for 30 days and energy cost 7 cents per KWH (kilo watt hour) how much would you owe the power company for the 30 day period?

(e) As a side note: Suppose you connected 100 light bulbs, rated at 100 watts, and burned them for 24-7 for 30 days (long Christmas). How much would you owe the power company? Explain.

(6) (a)

$$\frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{220}{4400} = \boxed{\frac{1}{20} = \frac{N_2}{N_1}}$$

(b)

$$\frac{I_1}{I_2} = \frac{1}{20} \qquad I_1 = I_L$$

$$I_2 = 200\ A_{rms}$$

$$\boxed{I_2 = \frac{200}{20} = 10\ A_{rms}}$$

(c)

$$\boxed{P_{sup} = (220\,V)(200\,A) = 44\ kW}$$

(This assumes unity power factor, which is very close to 1 for residential loads)

(d) want to find kilo watt hours

$$\#\ hours = 30\ \cancel{days}\ \frac{24\ hours}{1\ \cancel{day}}$$

$$\#\ H = 720\ H$$

$$W = \#\ kW \times H = (44\ kW) \times 720\ Hr$$

$$W = 31680\ kWH$$

$$\#\ Pay = W \times \$.07 = 31680\ KWH \times \frac{\$.07}{KWH}$$

$$\boxed{\$\ Pay = \$2,217.60}$$

(e) $100 \times 100\ W = 10\ kW$

$$\boxed{\$\ cost = 10\ kW \times 720\ Hr \times \frac{\$.07}{kWH} = \$504}$$