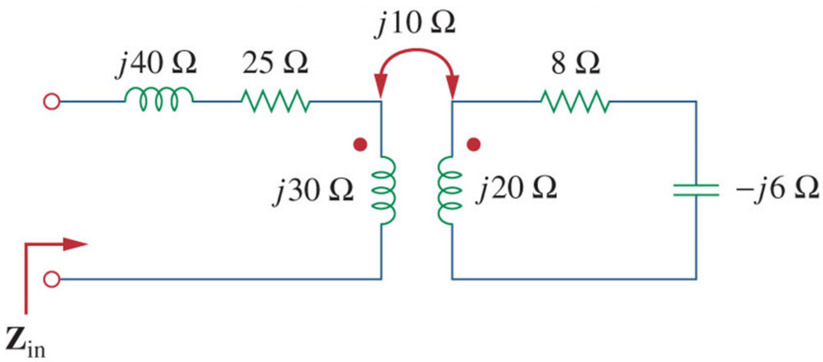
1. (Prob. 13.30 in text) For the circuit shown, find the input impedance by:
   a. Using the concept of reflected impedance Z_R
   b. Replacing the linear transformer by its T equivalent circuit



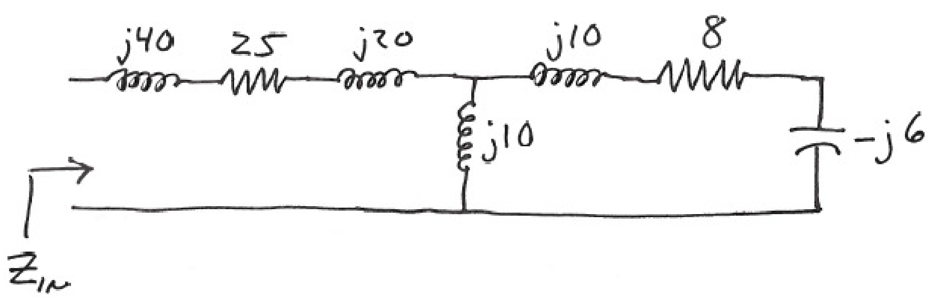
a) $Z_{IN} = Z_{primary} + Z_{Reflected}$

$$= (j40 + 25 + j30) + \frac{(\omega M)^2}{j\omega L_2 + 8 - j6}$$

$$= (25 + j70) + \frac{10^2}{j20 + 8 - j6} = \boxed{28.06 + j64.62\ \Omega}$$

b) T equivalent:

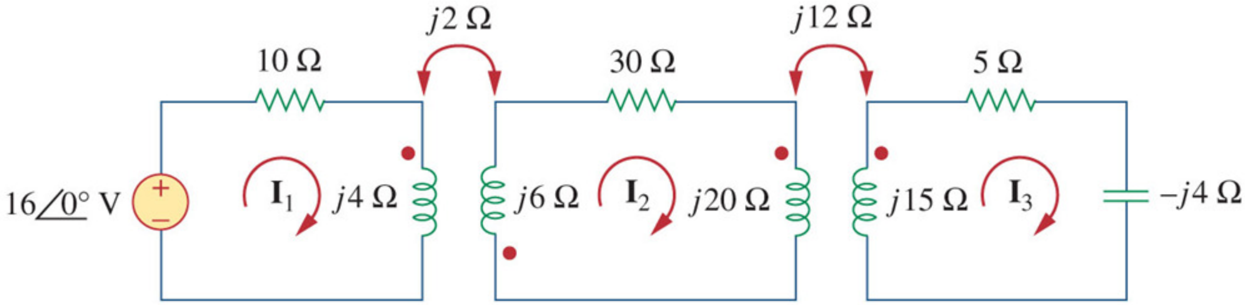
$$L_a = L_1 - M = 30 - 10 = 20$$
$$L_b = L_2 - M = 20 - 10 = 10$$
$$L_c = M = 10$$

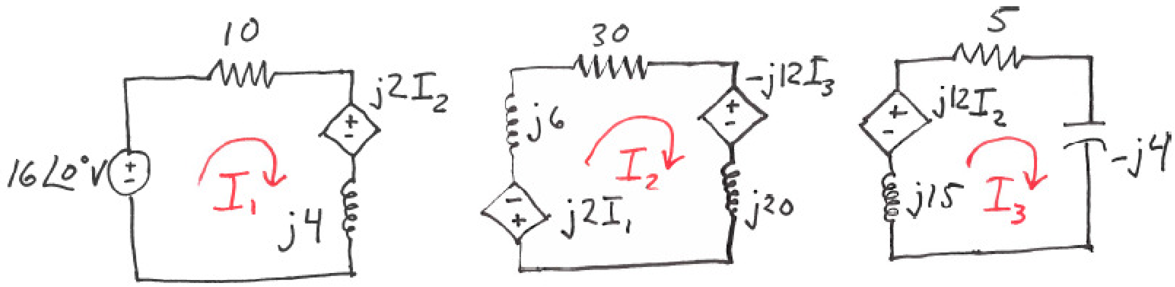


$$Z_{IN} = (j40 + 25 + j20) + (j10) \| (j10 + 8 - j6)$$

$$= (25 + j60) + \frac{(j10)(8+j4)}{j10 + 8 + j4} = \boxed{28.06 + j64.62\ \Omega}$$

2. (Prob. 13.35 from Text) Find currents $\mathbf{I}_1$, $\mathbf{I}_2$, and $\mathbf{I}_3$ in the circuit below:





MESH #1: $-16\angle 0° + 10I_1 + j2I_2 + j4I_1 = 0 \Rightarrow (10+j4)I_1 + j2I_2 = 16\angle 0°$

MESH #2: $j2I_1 + j6I_2 + 30I_2 - j12I_3 + j20I_2 = 0 \Rightarrow j2I_1 + (30+j26)I_2 - j12I_3 = 0$

MESH #3: $j15I_3 - j12I_2 + 5I_3 - j4I_3 \Rightarrow -j12I_2 + (5+j11)I_3 = 0$

$$\begin{bmatrix} (10+j4) & j2 & 0 \\ j2 & (30+j26) & -j12 \\ 0 & -j12 & (5+j11) \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 16\angle 0° \\ 0 \\ 0 \end{bmatrix}$$

USE MATLAB (SEE OTHER PAGE)

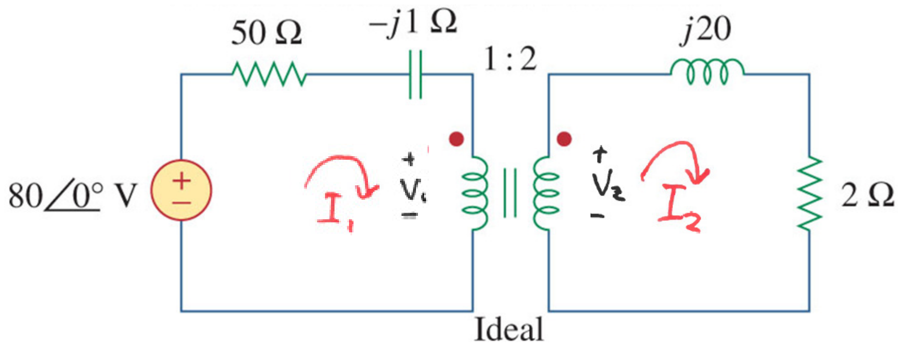
Problem 13.35 MATLAB output

```
>> A=[(10+4i) 2i 0; 2i (30+26i) -12i; 0 -12i (5+11i)]

A =

  10.0000 + 4.0000i   0.0000 + 2.0000i   0.0000 + 0.0000i
   0.0000 + 2.0000i  30.0000 +26.0000i   0.0000 -12.0000i
   0.0000 + 0.0000i   0.0000 -12.0000i   5.0000 +11.0000i

>> b=[16;0;0]

b =

    16
     0
     0

>> x=A\b

x =
```

$$\boxed{\begin{aligned} 1.3736 - 0.5385i &= I_1 = 1.4754\angle -21.41^\circ \\ -0.0547 - 0.0549i &= I_2 = 0.0775\angle -134.85^\circ \\ -0.0268 - 0.0721i &= I_3 = 0.0770\angle -110.41^\circ \end{aligned}}$$

```
>> abs(x)

ans =

   1.4754
   0.0775
   0.0770

>> angle(x)*180/pi()

ans =

  -21.4072
 -134.8548
 -110.4109
```

3. (Prob. 13.42 from Text) For the circuit shown, determine the power absorbed by the 2 Ω resistor. (Assume the 80 V is a rms value).



$V_2 = nV_1 = 2V_1$

$I_2 = \frac{I_1}{n} = 0.5 I_1$

MESH #1: $-80\angle 0° + 50 I_1 - jI_1 + V_1 = 0 \Rightarrow (50 - j)I_1 + V_1 = 80\angle 0°$

MESH #2: $-V_2 + j20 I_2 + 2I_2 = 0 \Rightarrow (j20 + 2)\frac{I_1}{2} - 2V_1 = 0$

$(1 + j10)I_1 - 2V_1 = 0$

$$\begin{bmatrix} (50-j) & 1 \\ (1+j10) & -2 \end{bmatrix} \begin{bmatrix} I_1 \\ V_1 \end{bmatrix} = \begin{bmatrix} 80\angle 0° \\ 0 \end{bmatrix}$$

USE MATLAB (SEE OTHER PAGE)

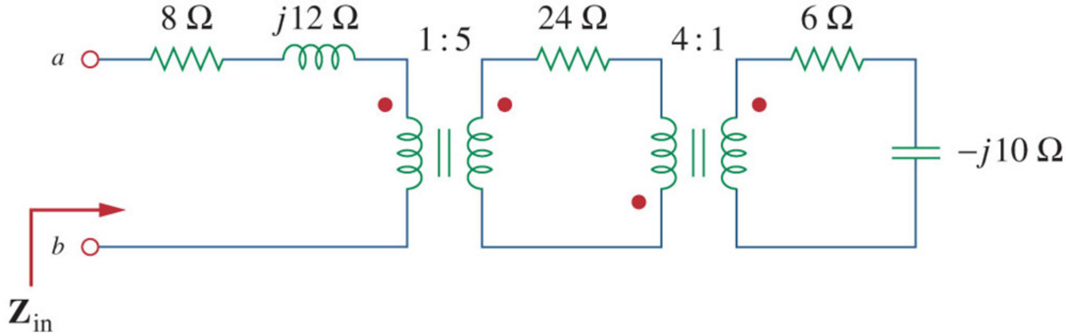
$I_1 = 1.579 \angle -4.53° \text{ A}$

$I_2 = 0.5 I_1 = 0.7896 \angle -4.53° \text{ A}$

POWER ABSORBED BY 2Ω RESISTOR IS

$P = |I_2|^2 R = (0.7896)^2 (2) = \boxed{1.2469 \text{ W}}$

4. (Prob. 13.50 from Text) Calculate the input impedance for the network below:



$n_1 = 5 \qquad n_2 = \frac{1}{4}$

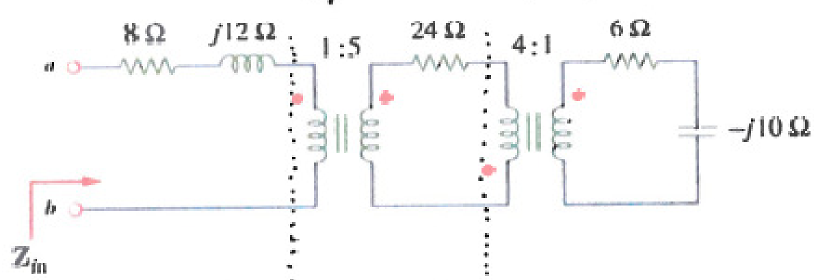


Figure 13.115
For Prob. 13.50.

$$Z_{r_2} = \frac{Z_{L_2}}{n_2^2} = \frac{6-j10}{(\frac{1}{4})^2} = 96 - j160$$

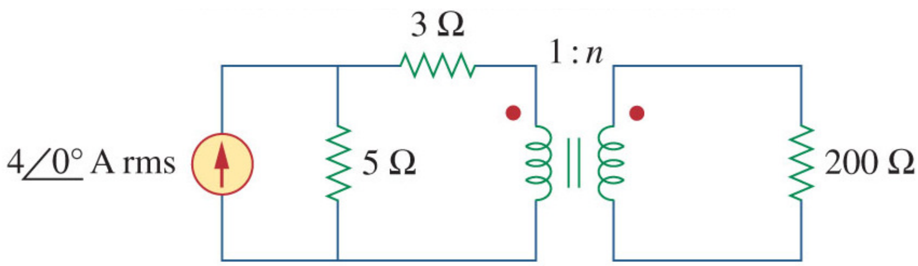
$$Z_{r_1} = \frac{Z_{L_1}}{n_1^2} = \frac{24 + (96 - j160)}{5^2}$$

$$Z_{r_1} = 4.8 - j6.4$$

$$Z_{IN} = (8 + j12) + (4.8 - j6.4)$$

$$\boxed{Z_{IN} = 12.8 + j5.6\ \Omega}$$

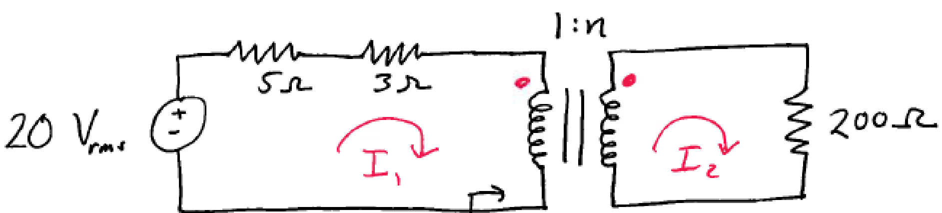
5. ("Based on" Prob. 13.53 from Text) Refer to the figure below for the following:
   a.) Find the turns ratio n for maximum power supplied to the 200 Ω load.
   b.) Find the average power ($P_{ave} = I_{rms}^2 R$) in the 200 Ω load at this turns ratio.
   c.) Find the average power in the 200 Ω load if the turns ratio $n = 6$.



DOTS "SAME"

$V_2 = n V_1$

$I_2 = \frac{I_1}{n}$



$Z_R = \frac{Z_L}{n^2} = \frac{200}{n^2} = 8\,\Omega$ for max power transfer

a.) $n^2 = \frac{200}{8} = 25 \Rightarrow \boxed{n = 5}$

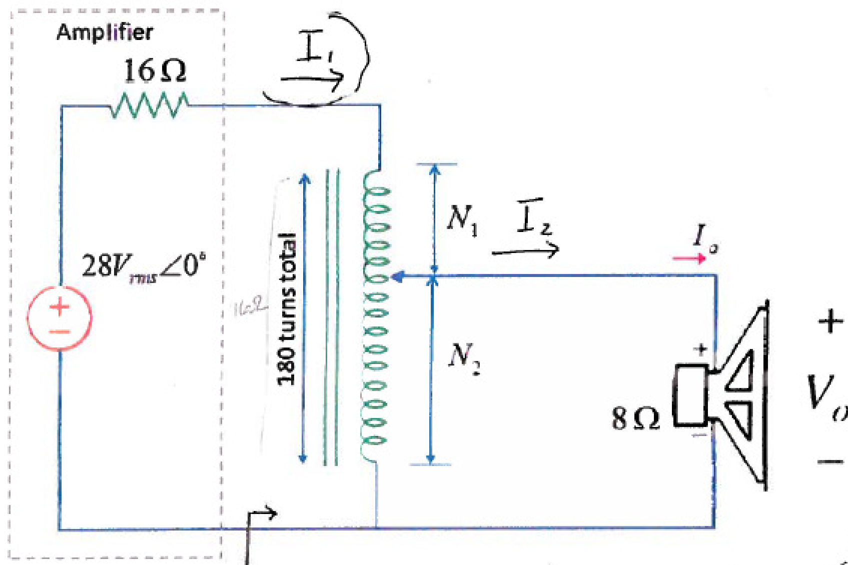
b.) $I_1 = \frac{20}{5+3+8} = 1.25$; $I_2 = \frac{I_1}{n} = \frac{1.25}{5} = 0.25$

$P_{ave} = I_2^2 R = (0.25)^2 200 = \boxed{12.5\ W}$

c.) $Z_R = \frac{200}{(6)^2} = 5.555\,\Omega \Rightarrow I_1 = \frac{20}{(5+3)+(5.555)} = 1.475$

$I_2 = \frac{1.475}{6} = 0.2459 \Rightarrow P_{ave} = (0.2459)^2(200) = \boxed{12.09\ W}$

6. An audio amplifier with an internal Thevenin impedance of 16 Ω uses a source matching autotransformer shown below to match an 8 Ω speaker for maximum power transfer.
   a. Find the location of the tap N_2 for maximum power transfer to the speaker.
   b. Find the Voltage V_o and Current I_o delivered to the speaker.
   c. Find the average power P_{ave} delivered to the speaker.
   d. Find the location of the tap N_2 if we replaced speaker with a 4 Ω speaker.
   e. Find the average power P_{ave} delivered to the 4 Ω speaker.



$N_1 + N_2 = 180$

$Z_{IN} = \underline{16\,\Omega}$ for max power transfer $= \underbrace{\left(\frac{N_1+N_2}{N_2}\right)^2 Z_L}_{\text{from lecture notes can also derive from } V \,\&\, I \text{ relationships}}$

a.) $16 = \left(\frac{180}{N_2}\right)^2 8 \Rightarrow \frac{16}{8} = \left(\frac{180}{N_2}\right)^2 \Rightarrow \sqrt{2} = \frac{180}{N_2}$

$N_2 = \frac{180}{\sqrt{2}} = \boxed{127.3 \text{ turns}}$

b) $I_1 = \frac{28}{16+16} = 0.875\text{ A} \Rightarrow I_2 = \left(\frac{N_1+N_2}{N_2}\right) I_1 = \frac{180}{\left(\frac{180}{\sqrt{2}}\right)} 0.875$

Z_{IN} for max power is 16 Ω

$\boxed{I_2 = 1.24\text{ A} = I_o}$

c.) $P_{ave_{rms}} = I_o V_o = (1.24)(9.9) = \boxed{12.25\text{ W}}$

$\boxed{V_o = I_o R = (1.24)(8) = 9.9\text{ V}}$

d) $16 = \left(\frac{180}{N_2}\right)^2 4 \Rightarrow 4 = \left(\frac{180}{N_2}\right)^2 \Rightarrow 2 = \frac{180}{N_2} \Rightarrow \boxed{N_2 = 90 \text{ turns}}$

e) $I_1 = \frac{28}{16+16} = 0.875\ A \Rightarrow I_2 = \left(\frac{N_1+N_2}{N_2}\right) I_1 = \left(\frac{180}{90}\right)(0.875)$

$I_2 = \boxed{1.75\ A = I_o}$

$V_o = I_o R = (1.75)(4) = \boxed{7.0\ V}$

$P_{ave} = I_o V_o = (1.75)(7.0) = \boxed{12.25\ W}$

Note: should be same as part c because we have set N_2 for max power transfer.

Lossless transformer

$P_{ave} = I_1^2 Z_{IN} = (0.875)^2 (16)$

$\boxed{P_{ave} = 12.25\ W \text{ Also!}}$