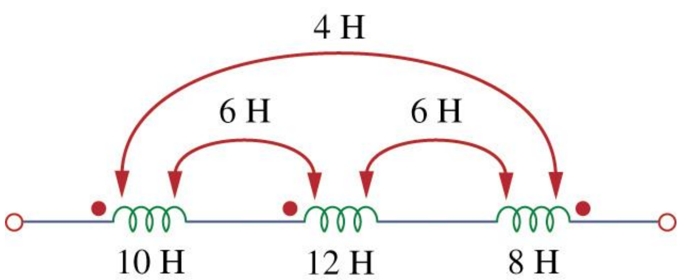
Problem 13.2 Determine the inductance of the three series-connected inductors.



Consider the polarities of the coupled inductances.

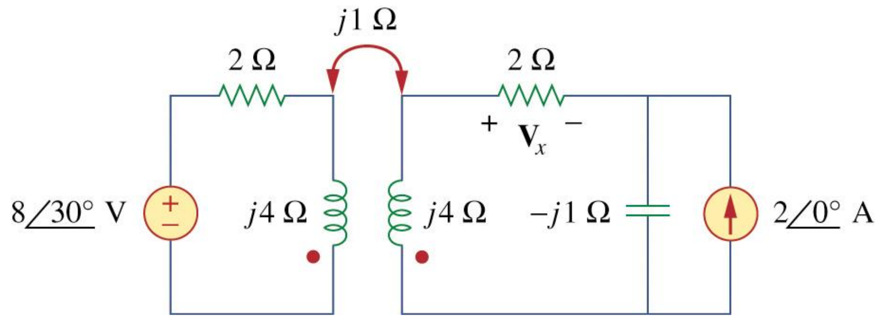
M_{12} is series adding while M_{23} and M_{31} are series opposing.

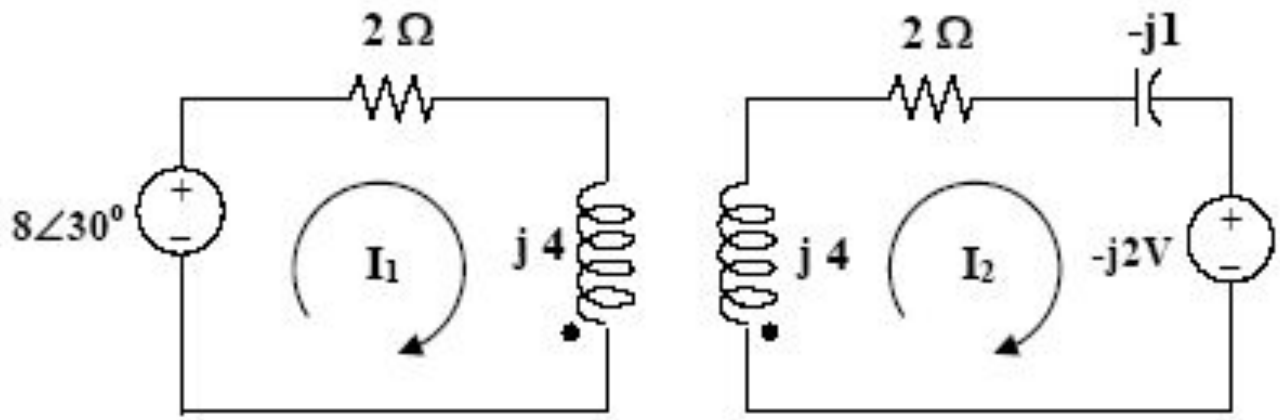
$$L = L_1 + L_2 + L_3 + 2M_{12} - 2M_{23} - 2M_{31}$$

$$= 10 + 12 + 8 + 2x6 - 2x6 - 2x4$$

$$= \underline{\mathbf{22H}}$$

Problem 13.9 Find V_x in the network shown.





For loop 1, $8\angle30° = (2 + j4)I_1 - jI_2$ (1)

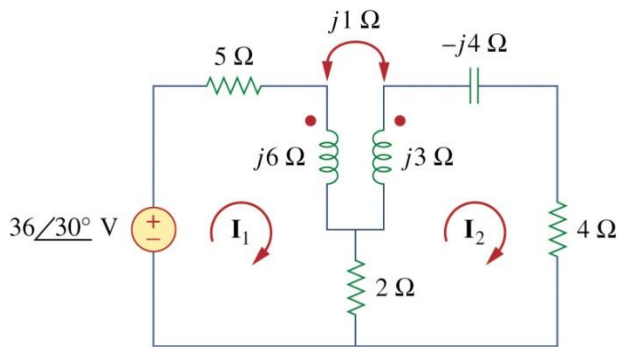
For loop 2, $((j4 + 2 - j)I_2 - jI_1 + (-j2) = 0 \quad I_1 = (3 - j2)i_2 - 2$ (2)

Substituting (2) into (1), $8\angle30° + (2 + j4)2 = (14 + j7)I_2$

$I_2 = (10.928 + j12)/(14 + j7) = 1.037\angle21.12°$

$V_x = 2I_2 = \underline{2.074\angle21.12°}$

Problem 13.21 Find I_1 and I_2 in the circuit. 13.90. Calculate the power absorbed by the 4-Ω resistor.



For mesh 1, $36\angle 30° = (7+j6)I_1 - (2+j)I_2$ (1)

For mesh 2, $0 = (6+j3-j4)I_2 - 2I_1 - jI_1 = -(2+j)I_1 + (6-j)I_2$ (2)

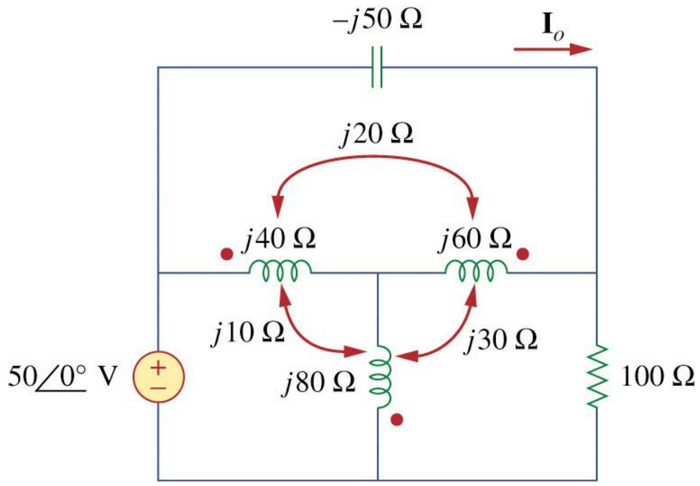
Placing (1) and (2) into matrix form, $\begin{bmatrix} 36\angle 30° \\ 0 \end{bmatrix} = \begin{bmatrix} 7+j6 & -2-j \\ -2-j & 6-j \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$

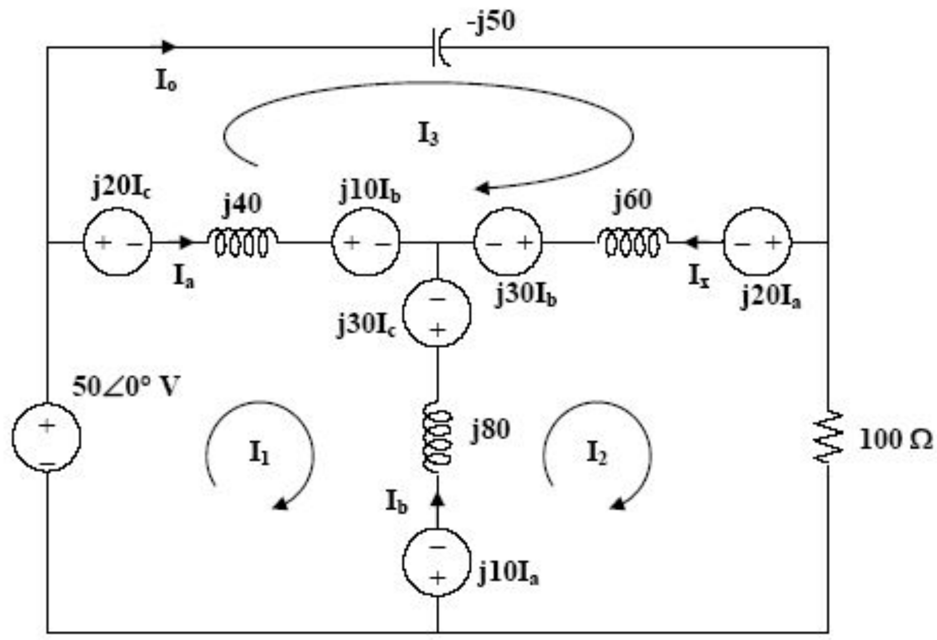
$\Delta = 45 + j25 = 51.48\angle 29.05°$, $\Delta_1 = (6-j)36\angle 30° = 219\angle 20.54°$

$\Delta_2 = (2+j)36\angle 30° = 80.5\angle 56.57°$, $I_1 = \Delta_1/\Delta =$ **$\underline{4.254\angle -8.51° \text{ A}}$**, $I_2 = \Delta_2/\Delta =$ **$\underline{1.5637\angle 27.52° \text{ A}}$**

Power absorbed by the 4-ohm resistor, $= 0.5(I_2)^2 4 = 2(1.5637)^2 =$ **$\underline{4.89 \text{ watts}}$**

Problem 13.22 Find current I_o in the circuit.





With more complex mutually coupled circuits, it may be easier to show the effects of the coupling as sources in terms of currents that enter or leave the dot side of the coil. The Figure then becomes,

Problem 13.22 Find current I_o in the circuit.

Note the following, $I_a = I_1 - I_3$ $I_b = I_2 - I_1$ $I_c = I_3 - I_2$ and $I_o = I_3$

Now all we need to do is to write the mesh equations and to solve for I_o.

Loop # 1,

$$-50 + j20(I_3 - I_2)\,j\,40(I_1 - I_3) + j10(I_2 - I_1) - j30(I_3 - I_2) + j80(I_1 - I_2) - j10(I_1 - I_3) = 0$$

$$j100I_1 - j60I_2 - j40I_3 = 50$$

Multiplying everything by (1/j10) yields $10I_1 - 6I_2 - 4I_3 = -j5$ (1)

Loop # 2,

$$j10(I_1 - I_3) + j80(I_2 - I_1) + j30(I_3 - I_2) - j30(I_2 - I_1) + j60(I_2 - I_3) - j20(I_1 - I_3) + 100I_2 = 0$$

$$-j60I_1 + (100 + j80)I_2 - j20I_3 = 0 \qquad (2)$$

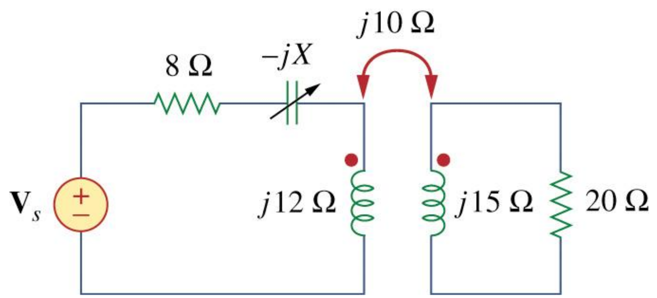
Loop # 3,

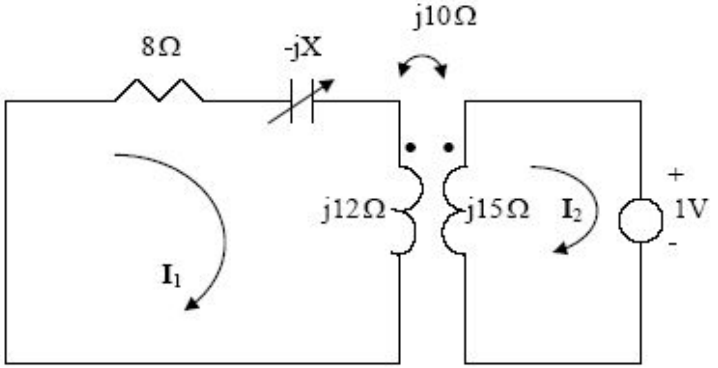
$$-j50I_3 + j20(I_1 - I_3) + j60(I_3 - I_2) + j30(I_2 - I_1) - j10(I_2 - I_1) + j40(I_3 - I_1) - j20(I_3 - I_2) = 0$$

$$-j40I_1 - j20I_2 + j10I_3 = 0$$

Multiplying by (1/j10) yields, $-4I_1 - 2I_2 + I_3 = 0$ (3)

Problem 13.28 **find the value of X that will give maximum power transfer to the 20-Ω load.**





We find Z_{Th} by replacing the 20-ohm load with a unit source as shown below.

For mesh 1, $$0 = (8 - jX + j12)I_1 - j10I_2 \qquad (1)$$

For mesh 2, $$1 + j15I_2 - j10I_1 = 0 \longrightarrow I_1 = 1.5I_2 - 0.1j \qquad (2)$$

Substituting (2) into (1) leads to $I_2 = \dfrac{-1.2 + j0.8 + 0.1X}{12 + j8 - j1.5X}$

$$Z_{Th} = \frac{1}{-I_2} = \frac{12 + j8 - j1.5X}{1.2 - j0.8 - 0.1X}$$

$$|Z_{Th}| = 20 = \frac{\sqrt{12^2 + (8 - 1.5X)^2}}{\sqrt{(1.2 - 0.1X)^2 + 0.8^2}} \longrightarrow 0 = 1.75X^2 + 72X - 624$$

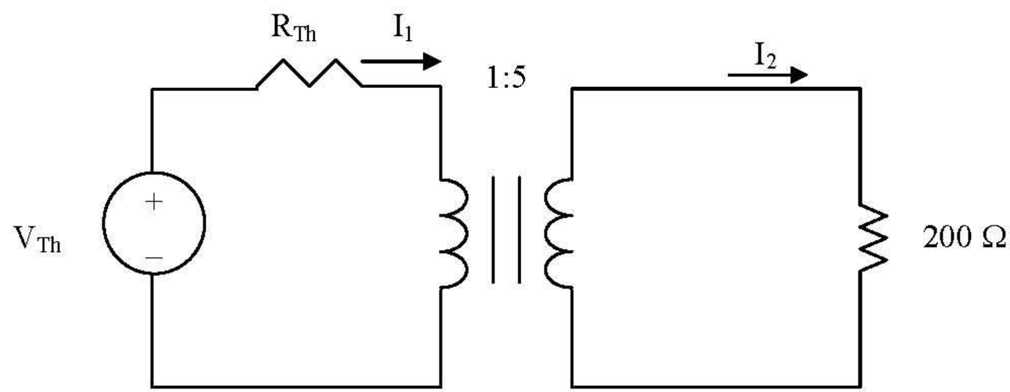
Solving the quadratic equation yields $\underline{X = 6.425}$

Chapter 13, Problem 40.

The primary of an ideal transformer with a turns ratio of 5 is connected to a voltage source with Thevenin parameters v_{Th} = 10 cos 2000t V and R_{Th} = 100 Ω Determine the average power delivered to a 200- Ω load connected across the secondary winding.

Chapter 13, Solution 40.

Consider the circuit as shown below.



We reflect the 200-Ω load to the primary side.

$$Z_p = 100 + \frac{200}{5^2} = 108$$

$$I_1 = \frac{10}{108}, \qquad I_2 = \frac{I_1}{n} = \frac{2}{108}$$

$$P = \frac{1}{2}|I_2|^2 R_L = \frac{1}{2}\left(\frac{2}{108}\right)^2(200) = \underline{34.3\text{ mW}}$$

Chapter 13, Problem 45.

PS ML For the circuit shown in Fig. 13.110, find the value of the average power absorbed by the 8- Ω resistor.

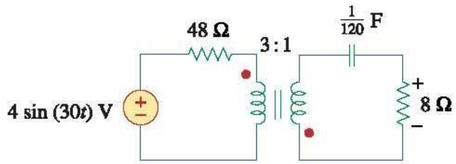
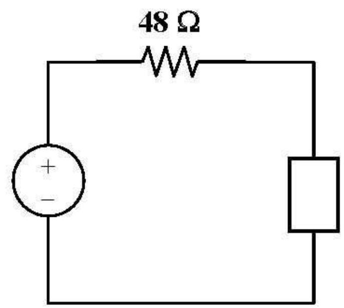


Figure 13.110
For Prob. 13.45.

Chapter 13, Solution 45.



$$Z_L = 8 - \frac{j}{\omega C} = 8 - j4, \quad n = 1/3$$

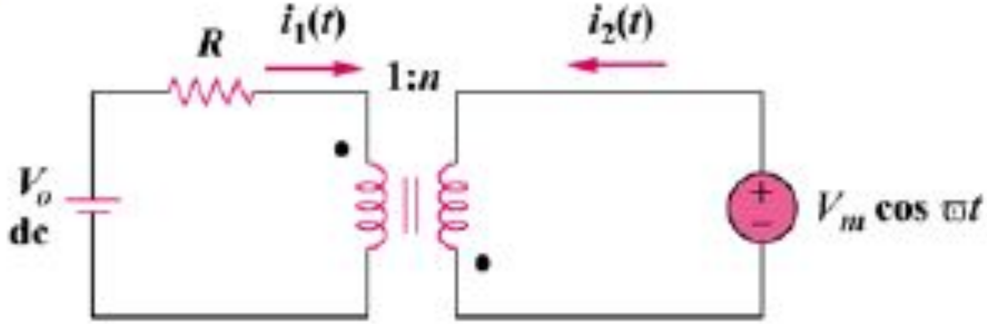
$$Z = \frac{Z_L}{n^2} = 9Z_L = 72 - j36$$

$$I = \frac{4\angle -90°}{48 + 72 - j36} = \frac{4\angle -90°}{125.28\angle -16.7°} = 0.03193\angle -73.3°$$

We now have some choices, we can go ahead and calculate the current in the second loop and calculate the power delivered to the 8-ohm resistor directly or we can merely say that the power delivered to the equivalent resistor in the primary side must be the same as the power delivered to the 8-ohm resistor. Therefore,

$$P_{8\Omega} = \left|\frac{I^2}{2}\right| 72 = 0.5098\text{x}10^{-3} 72 = \underline{\mathbf{36.71\ mW}}$$

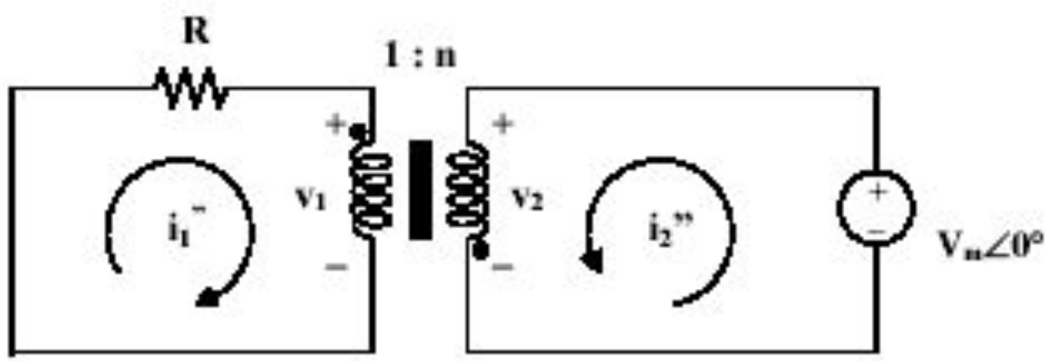
Chapter 13, Problem 44. In the ideal transformer circuit , find $i_1(t)$ and $i_2(t)$.



We can apply the superposition theorem. Let $i_1 = i_1' + i_1''$ and $i_2 = i_2' + i_2''$ where the single prime is due to the DC source and the double prime is due to the AC source. Since we are looking for the steady-state values of i_1 and i_2,

$i_1' = V_o/R$ $\qquad$ $i_2' = 0$ (No induction in the secondary at DC)

For the AC source, consider the circuit below.

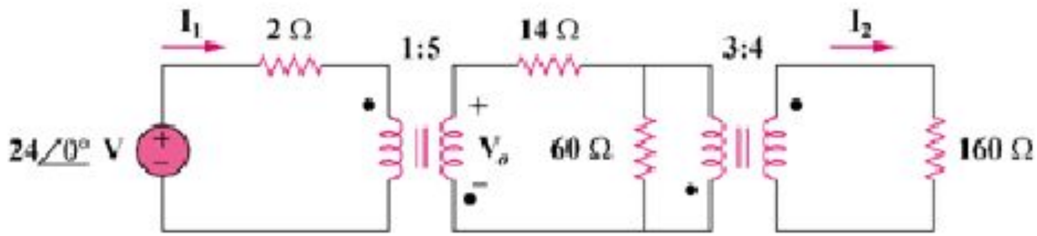


$v_2/v_1 = -n, \quad I_2''/I_1'' = 1/n$

But $V_2 = V_m,\ V_1 = -V_m/n$ or $I_1'' = -V_1/R = V_m/(Rn)\quad I_2'' = I_1''/n = -V_m/(Rn^2)$

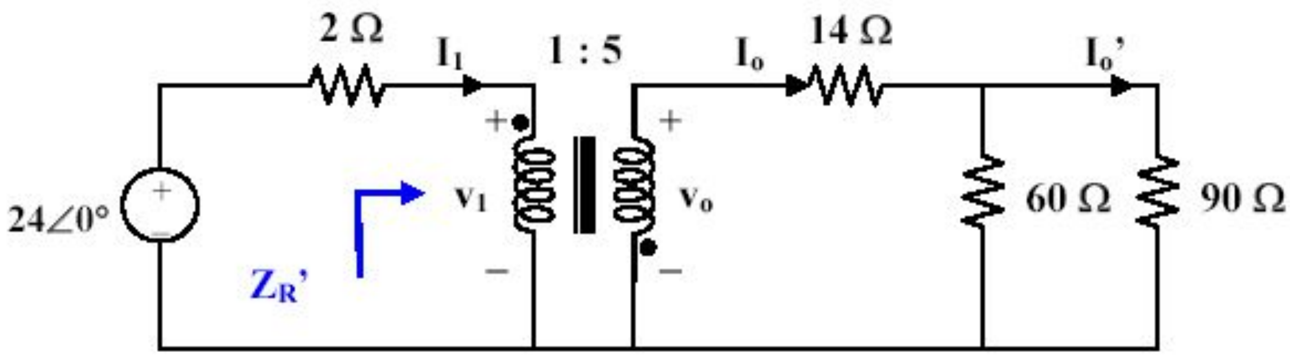
$i_1(t) = V_o/R +$ $\underline{\mathbf{(V_m/Rn)\cos\omega t\ A}}$ (DC and AC), $i_2(t) =$ $\underline{\mathbf{[V_m/(n^2R)]\cos\omega t\ A}}$ **(AC only)**

Chapter 13, Problem 61. For the circuit below, find I_1, I_2, and V_o.



Solution: We reflect the 160-ohm load to the middle circuit.

$$Z_R = Z_L/n^2 = 160/(4/3)^2 = 90 \text{ ohms, where } n = 4/3$$



$$14 + 60||90 = 14 + 36 = 50 \text{ ohms}$$

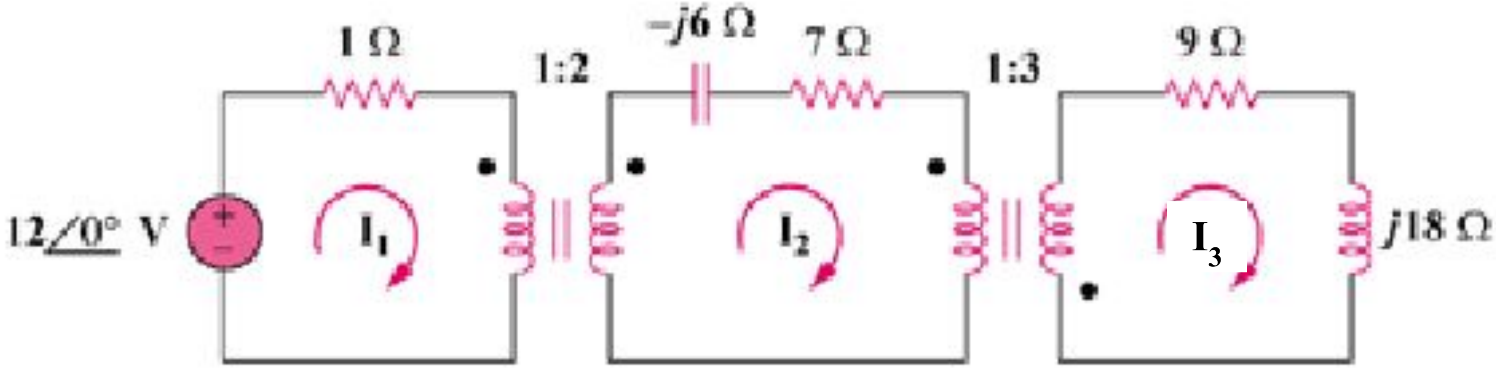
We reflect to primary side. $Z_R' = Z_L'/(n')^2 = 50/5^2 = 2$ ohms when $n' = 5$

$I_1 = 24/(2+2) = \underline{6A}$ $\quad$ $24 = 2I_1 + v_1$ or $v_1 = 24 - 2I_1 = 12$ V

$v_o = -nv_1 = \underline{-60 \text{ V}}.$ $\quad$ $I_o = -I_1/n_1 = -6/5 = -1.2$

$I_o' = [60/(60+90)]I_o = -0.48A$ $\quad$ $I_2 = -I_o'/n = 0.48/(4/3) = \underline{0.36 \text{ A}}$

Chapter 13, Problem 63. Find the mesh currents in the circuit below.



Chapter 13, Solution 63.

Reflecting the (9 + j18)-ohm load to the middle circuit gives,

$Z_{in}' = 7 - j6 + (9 + j18)/(n')^2 = 7 - j6 + 1 + j2 = 8 - j4$ when $n' = 3$

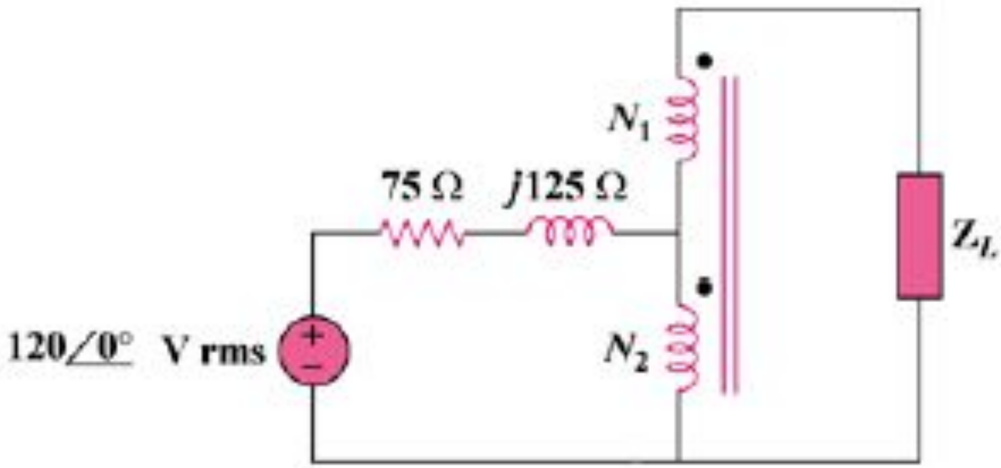
Reflecting this to the primary side,

$Z_{in} = 1 + Z_{in}'/n^2 = 1 + 2 - j = 3 - j$, where $n = 2$

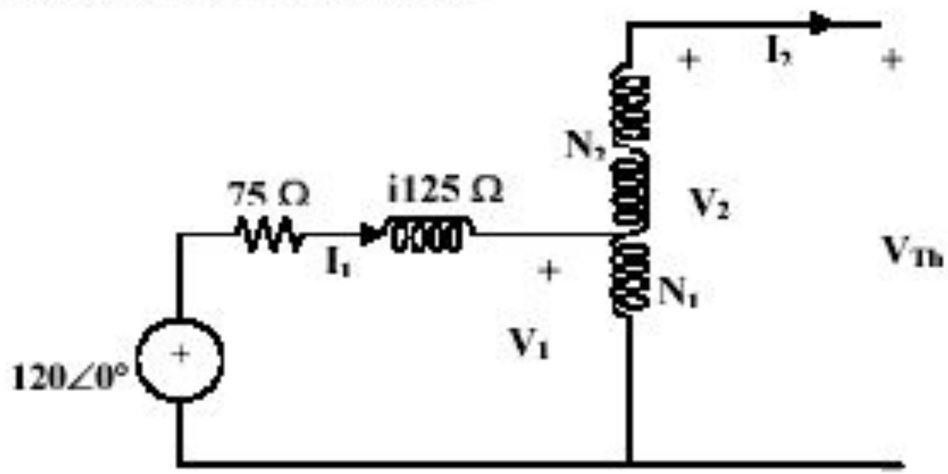
$I_1 = 12\angle 0°/(3 - j) = 12/3.162\angle -18.43° =$ $\underline{3.795\angle 18.43 A}$

$I_2 = I_1/n =$ $\underline{1.8975\angle 18.43° \text{ A}}$ $\quad I_3 = -I_2/n^2 =$ $\underline{632.5\angle 161.57° \text{ mA}}$

Chapter 13, Problem 69. In the circuit , Z_L is adjusted until maximum average power is delivered to Z_L. Find Z_L and the maximum average power transferred to it. Take N_1 = 600 turns and N_2 = 200 turns.



We can find the Thevenin equivalent.

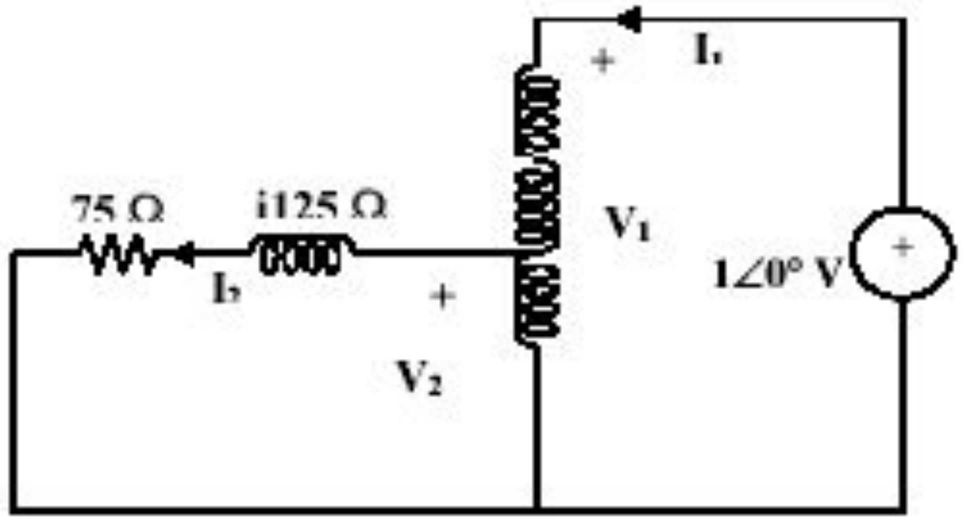


$I_1 = I_2 = 0$ As a step up transformer, $V_1/V_2 = N_1/(N_1 + N_2) = 600/800 = 3/4$

$$V_2 = 4V_1/3 = 4(120)/3 = 160\angle 0° \text{ Rms} = V_{Th}.$$

To find Z_{Th}, connect a 1-V source at the secondary terminals.

We now have a step-down transformer.



$$V_1 = 1V,\ V_2 = I_2(75 + j125)$$

But $V_1/V_2 = (N_1 + N_2)/N_1 = 800/200$ which leads to $V_1 = 4V_2 = 1$, $V_2 = 0.25$

$$I_1/I_2 = 200/800 = 1/4 \text{ which leads to } I_2 = 4I_1$$

Hence, $0.25 = 4I_1(75 + j125)$ or $I_1 = 1/[16(75 + j125)$

$Z_{Th} = 1/I_1 = 16(75 + j125)$ Therefore, $Z_L = Z_{Th}^* =$ **(1.2 – j2) kΩ**

Since V_{Th} is Rms, $P = (|V_{Th}|/2)^2/R_L = (80)^2/1200 =$ **5.333 Watts**