Chapter 13, Problem 9(8).

Find $V_x$ in the network shown in Fig. 13.78.

Figure 13.78

Chapter 13, Solution 9(8).

Consider the circuit below.

For loop 1,

$$8 \angle 30^\circ = (2 + j4)I_1 - jI_2 \quad (1)$$

For loop 2,

$$(j4 + 2 - j)I_2 - jI_1 + (-j2) = 0$$

or

$$I_1 = (3 - j2)i_2 - 2 \quad (2)$$

Substituting (2) into (1),

$$8 \angle 30^\circ + (2 + j4)2 = (14 + j7)I_2$$

$$I_2 = (10.928 + j12)/(14 + j7) = 1.037 \angle 21.12^\circ$$

$$V_x = 2I_2 = 2.074 \angle 21.12^\circ$$
Chapter 13, Problem 21(14).

Find \( I_1 \) and \( I_2 \) in the circuit of Fig. 13.90. Calculate the power absorbed by the 4-\( \Omega \) resistor.

![Circuit Diagram](image)

Figure 13.90

Chapter 13, Solution 21(14).

For mesh 1, \( 36\angle30^\circ = (7 + j6)I_1 - (2 + j)I_2 \) \hspace{1cm} (1)

For mesh 2, \( 0 = (6 + j3 - j4)I_2 - 2I_1 - jI_1 = -(2 + j)I_1 + (6 - j)I_2 \) \hspace{1cm} (2)

Placing (1) and (2) into matrix form,

\[
\begin{bmatrix} 36\angle30^\circ & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 7 + j6 & -2 - j \\ -2 - j & 6 - j \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}
\]

\[ \Delta = 48 + j35 = 59.41\angle36.1^\circ, \]
\[ \Delta_1 = (6 - j)36\angle30^\circ = 219\angle20.54^\circ \]
\[ \Delta_2 = (2 + j)36\angle30^\circ = 80.5\angle56.56^\circ, \]
\[ I_1 = \Delta_1/\Delta = 3.69\angle-15.56^\circ, \]
\[ I_2 = \Delta_2/\Delta = 1.355\angle20.46^\circ \]

Power absorbed by the 4-ohm resistor, \( = 0.5(I_2)^24 = 2(1.355)^2 = 3.672 \text{ watts} \)
Chapter 13, Problem 22(15).

Find current $I_o$ in the circuit of Fig. 13.91.

![Figure 13.91](image1)

Chapter 13, Solution 22(15).

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. Figure 13.91 then becomes,

![Figure 13.91](image2)
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,

\[-50 + j20(I_3 - I_2) \cdot 40(I_1 - I_3) + j10(I_2 - I_1) - j30(I_3 - I_2) + j80(I_1 - I_2) - j10(I_1 - I_3) = 0\]

\[ j100I_1 - j60I_2 - j40I_3 = 50 \]

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

Loop # 2,

\[ j10(I_1 - I_3) + j80(I_2 - I_3) + j30(I_3 - I_2) - j30(I_2 - I_1) + j60(I_2 - I_3) - j20(I_1 - I_3) + 100I_2 = 0 \]

\[-j60I_1 + (100 + j80)I_2 - j20I_3 = 0 \] (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)

Multiplying (2) by \((1/j20)\) yields \(-3I_1 + (4 - j5)I_2 - I_3 = 0\) (4)

Multiplying (3) by \((1/4)\) yields \(-I_1 - 0.5I_2 - 0.25I_3 = 0\) (5)

Multiplying (4) by \((-1/3)\) yields \(I_1 - ((4/3) - j(5/3))I_2 + (1/3)I_3 = -j0.5\) (7)

Multiplying [(6)+(5)] by 12 yields \((-22 + j20)I_2 + 7I_3 = 0\) (8)

Multiplying [(5)+(7)] by 20 yields \(-22I_2 - 3I_3 = -j10\) (9)

(8) leads to \(I_2 = -7I_3/(-22 + j20) = 0.2355 \angle 42.3^\circ = (0.17418 + j0.15849)I_3\) (10)

(9) leads to \(I_3 = (10 - 22I_2)/3\), substituting (1) into this equation produces,

\[ I_3 = j3.333 + (-1.2273 - j1.1623)I_3 \]

or \(I_3 = I_o = 1.3040 \angle 63^\circ \text{ amp.}\)
Chapter 13, Problem 26(19).

Find $I_o$ in the circuit of Fig. 13.95. Switch the dot on the winding on the right and calculate $I_o$ again.

![Circuit Diagram](image)

Fig. 13.95.

Chapter 13, Solution (26)19.

$$M = k \sqrt{L_1 L_2}$$

$$\omega M = k \sqrt{\omega L_1 \omega L_2} = 0.6 \sqrt{20 \times 40} = 17$$

The frequency-domain equivalent circuit is shown below.

![Frequency-Domain Circuit](image)

For mesh 1,

$$200 \angle 60^\circ = (50 - j30 + j20)I_1 + j17I_2 = (50 - j10)I_1 + j17I_2 \quad (1)$$

For mesh 2,

$$0 = (10 + j40)I_2 + j17I_1 \quad (2)$$

In matrix form,

$$\begin{bmatrix} 200 \angle 60^\circ \\ 0 \end{bmatrix} = \begin{bmatrix} 50 - j10 & j17 \\ j17 & 10 + j40 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\Delta = 900 + j100, \Delta_1 = 2000 \angle 60^\circ (1 + j4) = 8246.2 \angle 136^\circ, \Delta_2 = 3400 \angle -30^\circ$$

$$I_2 = \frac{\Delta_2}{\Delta} = 3.755 \angle -36.34^\circ$$

$$I_0 = I_2 = 3.755 \angle -36.34^\circ \text{ A}$$

Switching the dot on the winding on the right only reverses the direction of $I_o$. This can be seen by looking at the resulting value of $\Delta_2$ which now becomes $3400 \angle 150^\circ$. Thus,

$$I_o = 3.755 \angle 143.66^\circ \text{ A}$$
Chapter 13, Problem 43(30).

Obtain $V_1$ and $V_2$ in the ideal transformer circuit of Fig. 13.107.

![Transformer Circuit Diagram]

Chapter 13, Solution 43(30).

Transform the two current sources to voltage sources, as shown below.

![Transformed Circuit Diagram]

Using mesh analysis,

$$-20 + 10I_1 + v_1 = 0$$

$$20 = v_1 + 10I_1 \quad (1)$$

$$12 + 12I_2 - v_2 = 0 \text{ or } 12 = v_2 - 12I_2 \quad (2)$$

At the transformer terminal,

$$v_2 = nv_1 = 4v_1 \quad (3)$$

$$I_1 = nI_2 = 4I_2 \quad (4)$$

Substituting (3) and (4) into (1) and (2), we get,

$$20 = v_1 + 40I_2 \quad (5)$$

$$12 = 4v_1 - 12I_2 \quad (6)$$

Solving (5) and (6) gives $v_1 = 4.186 \text{ V}$ and $v_2 = 4v = 16.744 \text{ V}$
Chapter 13, Problem 44(31).

In the ideal transformer circuit of Fig. 13.108, find \( i_1(t) \) and \( i_2(t) \).

\[
\begin{array}{c}
V_o \\
\text{dc}
\end{array}
\xrightarrow{R}
\begin{array}{c}
i_1(t)\\\downarrow
\end{array}
\xrightarrow{1:n}
\begin{array}{c}
\bullet \\
\text{+}
\end{array}
\xrightarrow{V_m \cos \omega t}
\begin{array}{c}
i_2(t)
\end{array}
\]

Chapter 13, Solution 44(31).

We can apply the superposition theorem.
Let \( i_1 = i_1' + i_1'' \) and \( i_2 = i_2' + i_2'' \) where the single prime \((i_1', i_2')\) is due to the DC source and the double prime \((i_1'', i_2'')\) is due to the AC source.

Since we are looking for the steady-state values of \( i_1 \) and \( i_2 \),

\[
i_1' = \frac{V_0}{R} \quad i_2' = 0. \quad \text{(No induction on the secondary at DC)}
\]

For the AC source, consider the circuit below.

\[
\begin{array}{c}
V_2/V_1 = -n, \quad I_2''/I_1'' = +1/n
\end{array}
\]

But \( V_2 = V_m, \ V_1 = -V_m/n \)

\[
i_1'' = -\frac{V_1}{R} = \frac{V_m}{Rn}
\]

\[
i_2'' = I_1''/n = -\frac{V_m}{(Rn^2)} \quad \text{Hence,}
\]

\[
i_1(t) = \frac{V_0}{R} + \left(\frac{V_m}{Rn}\right)\cos \omega t, \quad \text{(DC and AC together)}
\]

\[
i_2(t) = \left(\frac{V_m}{(n^2R)}\right)\cos \omega t \quad \text{(Only AC)}
\]
Chapter 13, Problem 56(40).

Find the power absorbed by the 10-Ω resistor in the ideal transformer circuit of Fig. 13.120.

Chapter 13, Solution 56(40).

We apply mesh analysis to the circuit as shown below.

For mesh 1,  \[ 46 = 7I_1 - 5I_2 + v_1 \]  \hspace{1cm} (1)

For mesh 2,  \[ v_2 = 15I_2 - 5I_1 \]  \hspace{1cm} (2)

At the terminals of the transformer,  \[ v_2 = nv_1 = 2v_1 \]  \hspace{1cm} (3)
\[ I_1 = nI_2 = 2I_2 \]  \hspace{1cm} (4)

Substituting (3) and (4) into (1) and (2),

\[ 46 = 9I_2 + v_1 \]  \hspace{1cm} (5)
\[ v_1 = 2.5I_2 \]  \hspace{1cm} (6)

Combining (5) and (6),  \[ 46 = 11.5I_2 \text{ or } I_2 = 4 \]

\[ P_{10} = 0.5I_2^2(10) = 80 \text{ watts}. \]
Chapter 13, Problem 61(45).

For the circuit in Fig. 13.125 below, find $I_1$, $I_2$, and $V_o$.

Chapter 13, Solution 61(45).

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

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

\[
\begin{align*}
2 \Omega & \quad 1:5 \\
24 \angle 0^\circ & \quad 14 \Omega
\end{align*}
\]

\[ 14 + 60 \parallel 90 = 14 + 36 = 50 \text{ ohms} \]

We reflect this to the primary side.

\[ Z_{R'} = Z_{L'}/(n')^2 = 50/5^2 = 2 \text{ ohms when } n' = 5 \]

\[ I_1 = 24/(2 + 2) = 6A \]

\[ 24 = 2I_1 + v_1 \text{ or } v_1 = 24 - 2I_1 = 12 \text{ V} \]

\[ v_o = -nv_1 = -60 \text{ V}. \]

\[ I_0 = -I_1/n_1 = -6/5 = -1.2 \]

\[ I_{o'} = [60/(60 + 90)]I_0 = -0.48A \]

\[ I_2 = -I_{o'}/n = 0.48/(4/3) = 0.36 \text{ A} \]