Chapter 10, Problem 12.

By nodal analysis, find $i_o$ in the circuit of Fig. 10.61.

![Circuit Diagram]

Figure 10.61
For Prob. 10.12.

Chapter 10, Solution 12.

\[
\begin{align*}
20 \sin(1000t) & \longrightarrow 20 \angle 0^\circ, \quad \omega = 1000 \\
10 \text{ mH} & \longrightarrow j\omega L = j0 \\
50 \mu\text{F} & \longrightarrow \frac{1}{j\omega C} = \frac{1}{j(10^3)(50 \times 10^{-6})} = -j20
\end{align*}
\]

The frequency-domain equivalent circuit is shown below.

![Equivalent Circuit Diagram]
At node 1,

\[ 20 = 2I_o + \frac{V_1}{20} + \frac{V_1 - V_2}{10}, \]

where

\[ I_o = \frac{V_2}{j10} \]

\[ 20 = \frac{2V_2}{j10} + \frac{V_1}{20} + \frac{V_1 - V_2}{10} \]

\[ 400 = 3V_1 - (2 + j4)V_2 \]

(1)

At node 2,

\[ \frac{2V_2}{j10} + \frac{V_1 - V_2}{10} = \frac{V_2}{j20} + \frac{V_2}{j10} \]

\[ j2V_1 = (-3 + j2)V_2 \]

or

\[ V_1 = (1 + j1.5)V_2 \]

(2)

Substituting (2) into (1),

\[ 400 = (3 + j4.5)V_2 - (2 + j4)V_2 = (1 + j0.5)V_2 \]

\[ V_2 = \frac{400}{1 + j0.5} \]

\[ I_o = \frac{V_2}{j10} = \frac{40}{j(1 + j0.5)} = 35.74 \angle -116.6^\circ \]

Therefore, \[ i_o(t) = 35.74 \sin(1000t - 116.6^\circ) \text{ A} \]
Chapter 10, Problem 16.

Use nodal analysis to find $V_x$ in the circuit shown in Fig. 10.65.

Figure 10.65
For Prob. 10.16.

Chapter 10, Solution 16.

Consider the circuit as shown in the figure below.
At node 1,

\[-2 + \frac{V_1 - 0}{5} + \frac{V_1 - V_2}{j^4} = 0\]
\[(0.2 - j0.25)V_1 + j0.25V_2 = 2\]  \hspace{1cm} (1)

At node 2,

\[\frac{V_2 - V_1}{j^4} + \frac{V_2 - 0}{-j^3} - 3\angle45^\circ = 0\]
\[j0.25V_1 + j0.08333V_2 = 2.121 + j2.121\]  \hspace{1cm} (2)

In matrix form, (1) and (2) become

\[
\begin{bmatrix}
0.2 - j0.25 & j0.25 \\
0.25 & j0.08333
\end{bmatrix}
\begin{bmatrix}
V_1 \\
V_2
\end{bmatrix}
= \begin{bmatrix}
2 \\
2.121 + j2.121
\end{bmatrix}
\]

Solving this using MATLAB, we get,

\[
Y = [(0.2-0.25i),0.25i;0.25i,0.08333i]
\]

\[
Y =
\begin{bmatrix}
0.2000 - 0.2500i & 0 + 0.2500i \\
0 + 0.2500i & 0 + 0.0833i
\end{bmatrix}
\]

\[
I = [2;(2.121+2.121i)]
\]

\[
V =
\begin{bmatrix}
5.2793 - 5.4190i \\
9.6145 - 9.1955i
\end{bmatrix}
\]

\[
V_8 = V_1 - V_2 = -4.335 + j3.776 = 5.749\angle138.94^\circ V.
\]
Chapter 10, Solution 19.

We have a supernode as shown in the circuit below.

At the supernode,

\[
\frac{V_3 - V_2}{4} = \frac{V_2}{-j4} + \frac{V_1}{2} + \frac{V_1 - V_3}{j2}
\]

\[0 = (2 - j2) V_1 + (1 + j) V_2 + (-1 + j2) V_3\]  

(1)

At node 3,

\[
0.2V_1 + \frac{V_1 - V_3}{j2} = \frac{V_3 - V_2}{4}
\]

\[(0.8 - j2) V_1 + V_2 + (-1 + j2) V_3 = 0\]  

(2)

Subtracting (2) from (1),

\[0 = 1.2V_1 + j V_2\]  

(3)

But at the supernode,

\[V_1 = 12 \angle 0^\circ + V_2\]

or

\[V_2 = V_1 - 12\]  

(4)

Substituting (4) into (3),

\[0 = 1.2V_1 + j(V_1 - 12)\]

\[V_1 = \frac{j12}{1.2 + j} = V_o\]

\[V_o = \frac{12 \angle 90^\circ}{1.562 \angle 39.81^\circ} = 7.682 \angle 50.19^\circ\]

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Chapter 10, Solution 25.

\[ \omega = 2 \]
\[ 10 \cos(2t) \rightarrow 10 \angle 0^\circ \]
\[ 6 \sin(2t) \rightarrow 6 \angle -90^\circ = -j6 \]
\[ 2 \text{ H} \rightarrow j\omega L = j4 \]
\[ 0.25 \text{ F} \rightarrow \frac{1}{j\omega C} = \frac{1}{j(2)(1/4)} = -j2 \]

The circuit is shown below.

For loop 1,
\[ -10 + (4 - j2)I_1 + j2I_2 = 0 \]
\[ 5 = (2 - j)I_1 + jI_2 \]
\[ (1) \]

For loop 2,
\[ j2I_1 + (j4 - j2)I_2 + (-j6) = 0 \]
\[ I_1 + I_2 = 3 \]
\[ (2) \]

In matrix form (1) and (2) become
\[
\begin{bmatrix}
2 - j & j \\
1 & 1
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2
\end{bmatrix}
=
\begin{bmatrix}
5 \\
3
\end{bmatrix}
\]

\[ \Delta = 2(1 - j), \quad \Delta_1 = 5 - j3, \quad \Delta_2 = 1 - j3 \]

\[ I_o = I_1 - I_2 = \frac{\Delta_1 - \Delta_2}{\Delta} = \frac{4}{2(1 - j)} = 1 + j = 1.414 \angle 45^\circ \]

Therefore, \( i_o(t) = 1.4142 \cos(2t + 45^\circ) A \)
Chapter 10, Problem 30.

Use mesh analysis to find $v_o$ in the circuit of Fig. 10.78. Let $v_{s1} = 120 \cos(100t + 90^\circ)$ V, $v_{s2} = 80 \cos 100t$ V.

Figure 10.78
For Prob. 10.30.

Chapter 10, Solution 30.

$$300 \text{mH} \quad \rightarrow \quad j\omega L = j100 \times 300 \times 10^{-3} = j30$$
$$200 \text{mH} \quad \rightarrow \quad j\omega L = j100 \times 200 \times 10^{-3} = j20$$
$$400 \text{mH} \quad \rightarrow \quad j\omega L = j100 \times 400 \times 10^{-3} = j40$$

$$50 \mu \text{F} \quad \rightarrow \quad \frac{1}{j\omega C} = \frac{1}{j100 \times 50 \times 10^{-6}} = -j200$$

The circuit becomes that shown below.
For mesh 1,
\[-120 < 90^\circ + (20 + j30)I_1 - j30I_2 = 0 \quad \longrightarrow \quad j120 = (20 + j30)I_1 - j30I_2 \quad (1)\]
For mesh 2,
\[-j30 I_1 + (j30 + j40 - j200)I_2 + j200I_3 = 0 \quad \longrightarrow \quad 0 = -3I_1 - 13I_2 + 20I_3 \quad (2)\]
For mesh 3,
\[80 + j200I_2 + (10 - j180)I_3 = 0 \quad \longrightarrow \quad -8 = j20I_2 + (1 - j180)I_3 \quad (3)\]

We put (1) to (3) in matrix form.

\[
\begin{bmatrix}
2 + j3 & -j3 & 0 \\
-3 & -13 & 20 \\
0 & j20 & 1 - j180
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3
\end{bmatrix}
= 
\begin{bmatrix}
j120 \\
0 \\
-8
\end{bmatrix}
\]

This is an excellent candidate for MATLAB.

\[
Z = \begin{bmatrix}
2.0000 + 3.0000i & 0 - 3.0000i & 0 \\
-3.0000 & -13.0000 & 20.0000 \\
0 & 0 + 20.0000i & 1.0000 - 18.0000i
\end{bmatrix}
\]

\[
V = \begin{bmatrix}
12i;0;\text{-}8
\end{bmatrix}
\]

\[
V = \begin{bmatrix}
0 + 12.0000i \\
0 \\
-8.0000
\end{bmatrix}
\]

\[
I = \begin{bmatrix}
2.0557 + 3.5651i \\
0.4324 + 2.1946i \\
0.5894 + 1.9612i
\end{bmatrix}
\]

\[V_0 = -j200(I_2 - I_3) = -j200(-0.157 + j0.2334) = 46.68 + j31.4 = 56.26^\circ + 33.93^\circ \sqrt{2}
\]

\[v_0 = 56.26\cos(100t) + 33.93^\circ \sqrt{2}
\]

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Chapter 10, Problem 58.
For the circuit depicted in Fig. 10.101, find the Thevenin equivalent circuit at terminals a-b.

Figure 10.101
For Prob. 10.58.

Chapter 10, Solution 58.
Consider the circuit in Fig. (a) to find $Z_{th}$.

$$Z_{th} = j10 \parallel (8 - j6) = \frac{(j10)(8 - j6)}{8 + j4} = 5(2 + j)$$

$= 11.18 \angle 26.56^\circ \Omega$

Consider the circuit in Fig. (b) to find $V_{th}$.

$$I_o = \frac{8 - j6}{8 - j6 + j10} (5 \angle 45^\circ) = \frac{4 - j3}{4 + j2} (5 \angle 45^\circ)$$

$$V_{th} = j10I_o = \frac{(j10)(4 - j3)(5 \angle 45^\circ)}{(2)(2 + j)} = 55.9 \angle 71.56^\circ \text{ V}$$