Examp

Let us calculate the power absorbed by each element in the circuit given in Example 4.6.

Figure 4.23 shows the circuit in the frequency domain, where the currents $\mathbf{I}_1 = 1.30\angle 2.49°$ A and $\mathbf{I}_2 = 1.24\angle -15.9°$ A were previously determined.

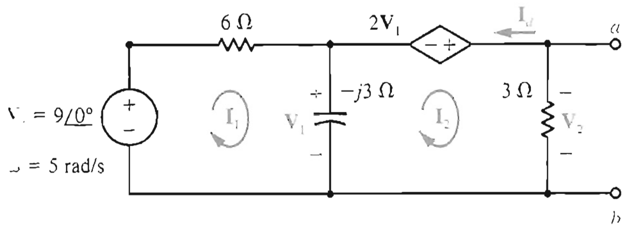

Fig. **4.23** Circuit from Example 4.6.

Since $|\mathbf{I}_2| = 1.24$ A, the average power absorbed by the 3-Ω resistor is

$$P_3 = \tfrac{1}{2}R_3|\mathbf{I}_2|^2 = \tfrac{1}{2}(3)(1.24)^2 = 2.31 \text{ W}$$

By Ohm's law, $\mathbf{V}_2 = 3\mathbf{I}_2 = 3(1.24\angle -15.9°) = 3.72\angle -15.9°$ V. By KVL,

$$\mathbf{V}_2 = 2\mathbf{V}_1 + \mathbf{V}_1 = 3\mathbf{V}_1 \quad \Rightarrow \quad \mathbf{V}_1 = \frac{\mathbf{V}_2}{3} = 1.24\angle -15.9° \text{ V}$$

The average power absorbed by the dependent voltage source is

$$P_d = \tfrac{1}{2}|2\mathbf{V}_1|\,|\mathbf{I}_d| \cos[\text{ang}(2\mathbf{V}_1) - \text{ang}(\mathbf{I}_d)]$$

Since $2\mathbf{V}_1 = 2(1.24\angle -15.9°) = 2.48\angle -15.9°$ V, then $|2\mathbf{V}_1| = 2.48$ and $\text{ang}(2\mathbf{V}_1) = -15.9°$. Also, since $\mathbf{I}_d = -\mathbf{I}_2 = (-1)\mathbf{I}_2 = (1\angle 180°)(1.24\angle -15.9°) = 1.24\angle 164°)$ A, then $|\mathbf{I}_d| = 1.24$ A and $\text{ang}(\mathbf{I}_d) = 164°$. Thus

$$P_d = \tfrac{1}{2}(2.48)(1.24)\cos(-15.9° - 164°) = -1.54 \text{ W}$$

4.18 For the circuit shown in Fig. P4.17, find the Thévenin equivalent of the circuit in the shaded box when $v_s(t) = 4\cos(2t - 60°)$ V. Use this to determine $v_o(t)$.

4.19 Find the frequency-domain Thévenin equivalent (to the left of terminals a and b) of the circuit shown in Fig. 4.20 on p. 211. (*Hint:* Use the fact that $\mathbf{Z}_o = \mathbf{V}_{oc}/\mathbf{I}_{sc}$.)

4.20 The frequency-domain Thévenin equivalent of a circuit having $\omega = 5$ rad/s has $\mathbf{V}_{oc} = 3.71\underline{/-15.9°}$ V and $\mathbf{Z}_o = 2.38 - j0.667\ \Omega$. Determine a corresponding time-domain Thévenin-equivalent circuit.

4.21 For the op-amp circuit shown in Fig. P4.21, find $v_o(t)$ when $v_s(t) = 6\sin 2t$ V.

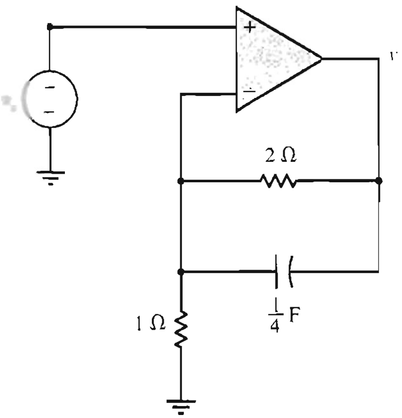

Fig. P4.21

4.22 For the op-amp circuit given in Fig. P4.22, find $v_o(t)$ when $v_s(t) = 3\cos 2t$ V.

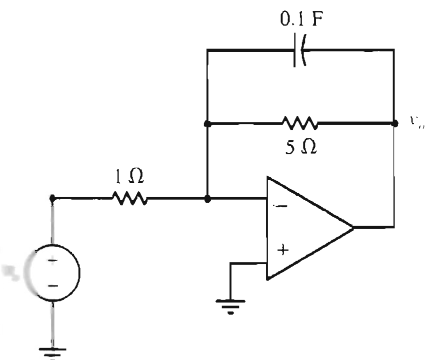

Fig. P4.22

4.23 For the op-amp circuit shown in Fig. P4.23, find $v_o(t)$ when $v_s(t) = 4\cos(2t - 30°)$ V. (See p. 258.)

4.24 For the circuit shown in Fig. P4.24, find the currents $\mathbf{I}_1$ and $\mathbf{I}_2$ when $\mathbf{V}_{s1} = 250\sqrt{2}\underline{/-30°}$ V, $\mathbf{V}_{s2} = 250\sqrt{2}\underline{/-90°}$ V, and $\mathbf{Z} = 78 - j45\ \Omega$.

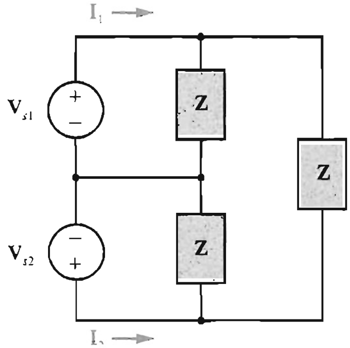

Fig. P4.24

4.25 Use mesh analysis to find $\mathbf{I}_1$ and $\mathbf{I}_2$ for the circuit given in Fig. P4.25 when $\mathbf{V}_{s1} = 250\sqrt{2}\underline{/-30°}$ V, $\mathbf{V}_{s2} = 250\sqrt{2}\underline{/-90°}$ V, and $\mathbf{Z} = 26 - j15\ \Omega$.

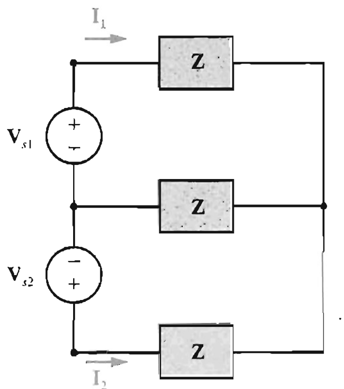

Fig. P4.25

4.26 For the circuit shown in Fig. P4.9, when $i_s(t) = 5\cos 3t$ A then $v_o(t) = 4.47\cos(3t + 26.6°)$ V. Find the average power absorbed by each element in the circuit.

4.27 For the circuit shown in Fig. P4.17, when $v_s(t) = 10\cos 4t$ V, then the Thévenin equivalent of the portion of the circuit in the shaded box is $\mathbf{V}_{oc} =$

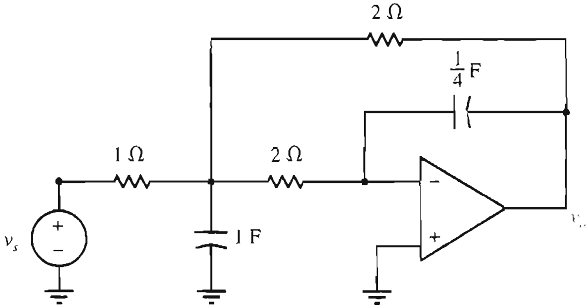

Fig. P4.23

$4.47\underline{/-63.4^\circ}$ V and $\mathbf{Z}_o = 1.6 + j4.8\ \Omega$. (a) Replace the 4-Ω load resistor by an impedance $\mathbf{Z}_L$ that absorbs the maximum average power, and determine this maximum power. (b) Replace the 4-Ω load resistor with a resistance R_L that absorbs the maximum power for resistive loads, and determine this power.

4.28 For the *RLC* circuit shown in Fig. P4.28, suppose that $v_s(t) = 10 \cos 3t$ V. Find the average power absorbed by the 4-Ω resistor for the case that (a) $C = \frac{1}{6}$ F; (b) $C = \frac{1}{18}$ F; (c) $C = \frac{1}{30}$ F.

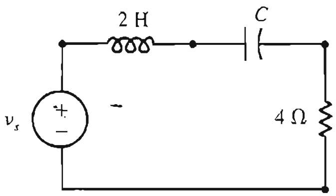

Fig. P4.28

4.29 For the circuit shown in Fig. P4.29, suppose that $v_s(t) = 8 \cos 2t$ V. Find the average power absorbed by each element in the circuit for the case that $\mathbf{Z}_L = 1\ \Omega$.

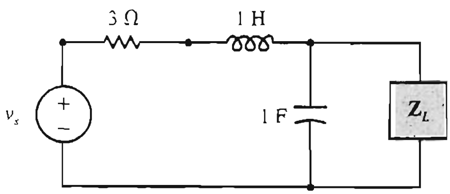

Fig. P4.29

4.30 For the circuit shown in Fig. P4.29, change the value of the resistor to 2 Ω and the value of the capacitor to $\frac{1}{4}$ F. Suppose that $v_s(t) = 8 \cos 2t$ V. (a) Find the load impedance $\mathbf{Z}_L$ that absorbs the maximum average power, and determine this power. (b) Find the load resistance R_L that absorbs the maximum power for resistive loads, and determine this power.

4.31 For the op-amp circuit given in Fig. P4.21, when $v_s(t) = 6 \sin 2t$ V, then the output voltage $v_o(t) = 13.4 \cos(2t - 117^\circ)$ V. Find the average power absorbed by each element.

4.32 For the op-amp circuit given in Fig. P4.22, when $v_s(t) = 3 \cos 2t$ V, then the output voltage $v_o(t) = 10.6 \cos(2t + 135^\circ)$ V. Find the average power absorbed by each element.

4.33 For the op-amp circuit given in Fig. P4.23, when $v_s(t) = 4 \cos(2t - 30^\circ)$ V, then $v_1(t) = 1.6\cos(2t - 66.9^\circ)$ V and $v_o(t) = 1.6\cos(2t + 23.1^\circ)$ V. Find the average power absorbed by each element.

4.34 For the circuit given in Fig. P4.24, when $\mathbf{V}_{s1} = 250\sqrt{2}\underline{/-30^\circ}$ V, $\mathbf{V}_{s2} = 250\sqrt{2}\underline{/-90^\circ}$ V, and $\mathbf{Z} = 78 - j45\ \Omega$, then $\mathbf{I}_1 = 6.8\underline{/30^\circ}$ A and $\mathbf{I}_2 = 6.8\underline{/-90^\circ}$ A. (a) Find the average power absorbed by each impedance. (b) Find the average power supplied by each source.

4.35 For the circuit given in Fig. P4.25, when $\mathbf{V}_{s1} = 250\sqrt{2}\underline{/-30^\circ}$ V, $\mathbf{V}_{s2} = 250\sqrt{2}\underline{/-90^\circ}$ V, and $\mathbf{Z} = 26 - j15\ \Omega$, then $\mathbf{I}_1 = 6.8\underline{/30^\circ}$ A and $\mathbf{I}_2 = 6.8\underline{/-90^\circ}$ A. (a) Find the average power absorbed by each impedance. (b) Find the average power supplied by each source.