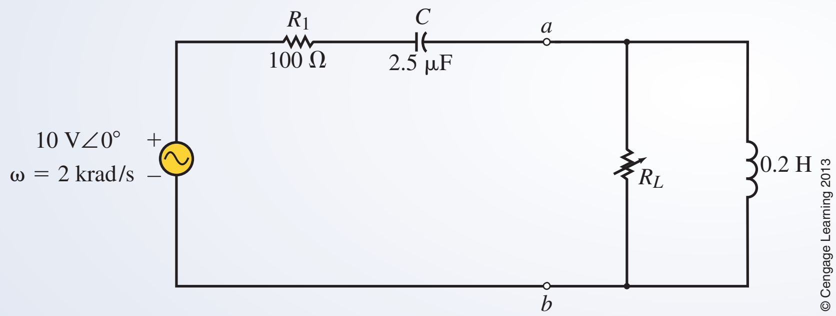
Putting It into Practice

In this chapter, you learned how to solve for the required load impedance to enable maximum power transfer to the load. In all cases, you worked with load impedances that were in series with the output terminals. This will not always be the case. The circuit shown in the accompanying figure shows a load that consists of a resistor in parallel with an inductor.



Determine the value of the resistor R_L needed to result in maximum power delivered to the load. Although several methods are possible, you may find that this example lends itself to being solved by using calculus.

Problems

20.1 Superposition Theorem—Independent Sources

1. Use superposition to determine the current in the indicated branch of the circuit in Figure 20–68.
2. Repeat Problem 1 for the circuit of Figure 20–69.
3. Use superposition to determine the voltage $\mathbf{V}_{ab}$ for the circuit of Figure 20–68.
4. Repeat Problem 3 for the circuit of Figure 20–69.
5. Consider the circuit of Figure 20–70.
   a. Use superposition to determine the indicated voltage, **V**.
   b. Show that the power dissipated by the indicated resistor cannot be determined by superposition.

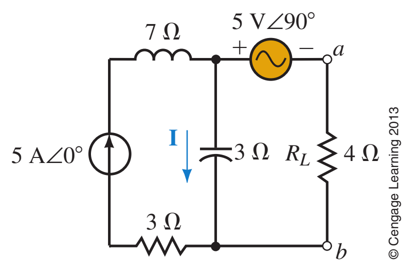


FIGURE 20–68

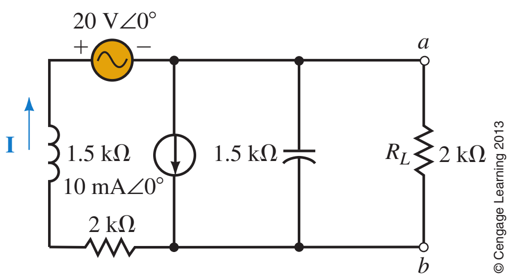


FIGURE 20–69

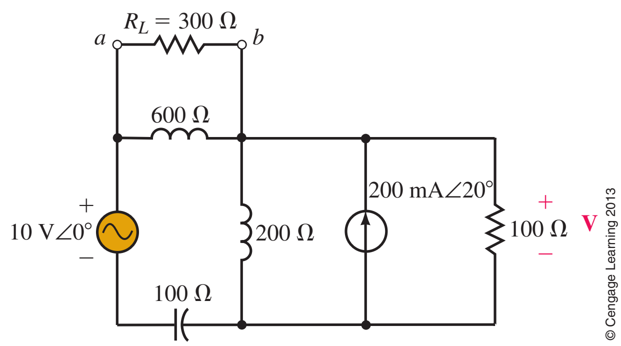


FIGURE 20–70

6. Repeat Problem 5 for the circuit of Figure 20–71.

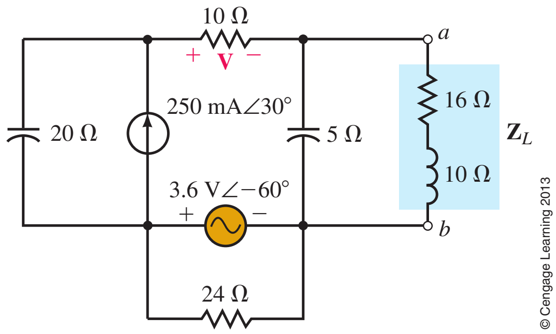


FIGURE 20–71

7. Use superposition to determine the current **I** in the circuit of Figure 20–72.

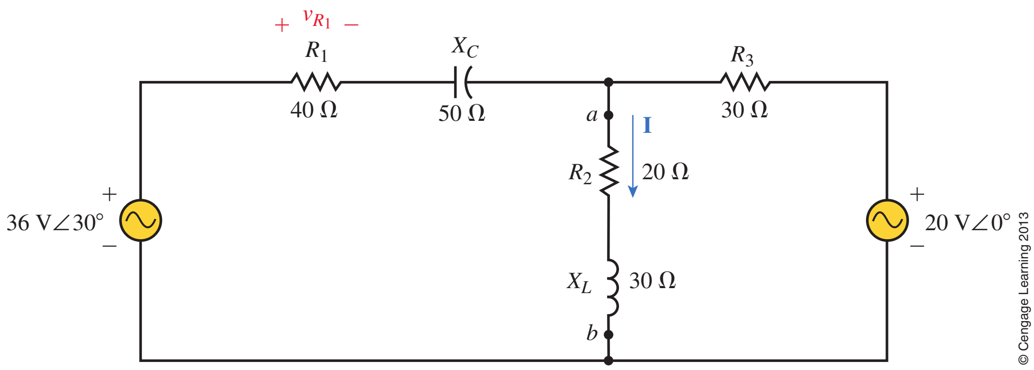


FIGURE 20–72

8. Repeat Problem 7 for the circuit of Figure 20–73.
9. Use superposition to determine the sinusoidal voltage, v_{R_1} for the circuit of Figure 20–72.
10. Repeat Problem 9 for the circuit of Figure 20–73.

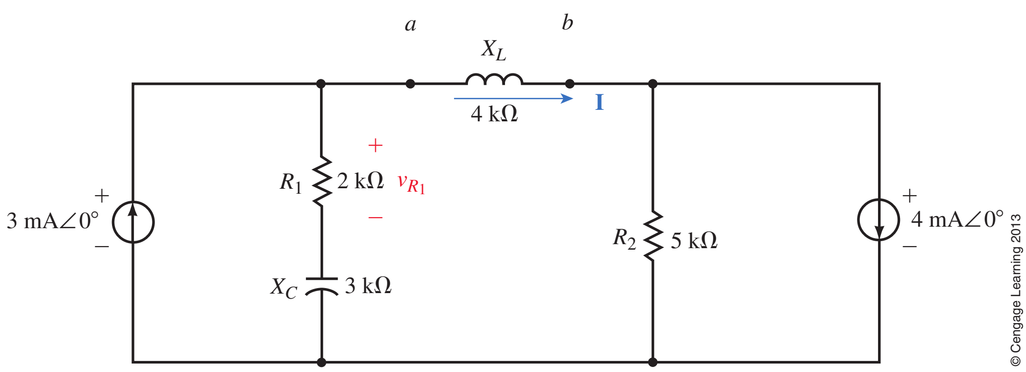


FIGURE 20–73

20.2 Superposition Theorem—Dependent Sources

11. Refer to the circuit of Figure 20–74.
    a. Use superposition to find $\mathbf{V}_L$.
    b. If the magnitude of the applied voltage **V** is increased to 200 mV, solve for the resulting $\mathbf{V}_L$.

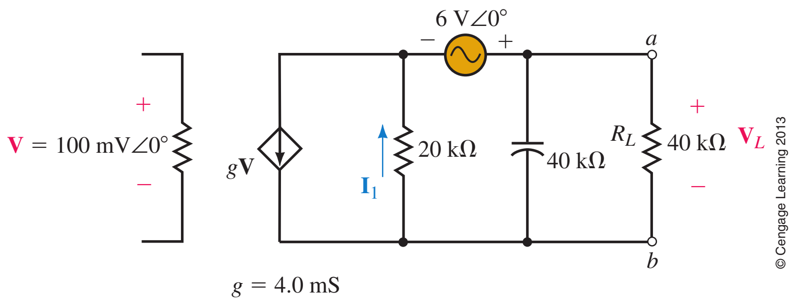


FIGURE 20–74

12. Consider the circuit of Figure 20–75.
    a. Use superposition to find $\mathbf{V}_L$.
    b. If the magnitude of the applied current **I** is decreased to 2 mA, solve for the resulting $\mathbf{V}_L$.
13. Use superposition to find the current $\mathbf{I}_1$ in the circuit of Figure 20–74.
14. Repeat Problem 13 for the circuit of Figure 20–75.
15. Find $\mathbf{V}_L$ in the circuit of Figure 20–76.

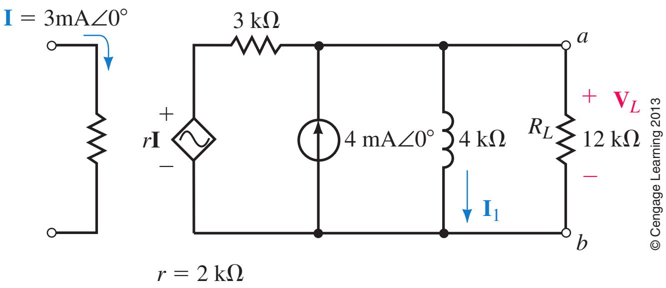


FIGURE 20–75

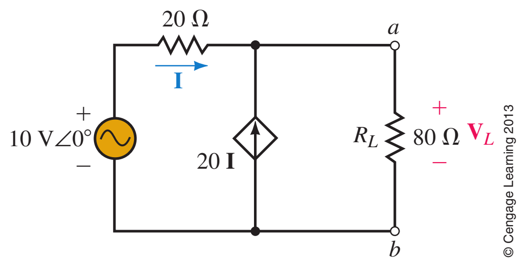


FIGURE 20–76

16. Find $\mathbf{V}_L$ in the circuit of Figure 20–77.
17. Determine the voltage $\mathbf{V}_{ab}$ for the circuit of Figure 20–78.

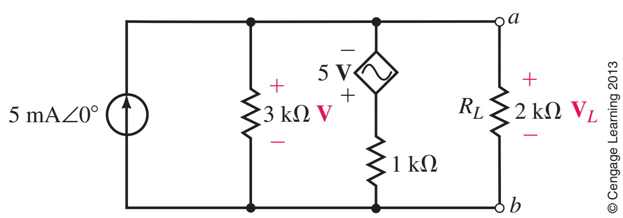


FIGURE 20–77

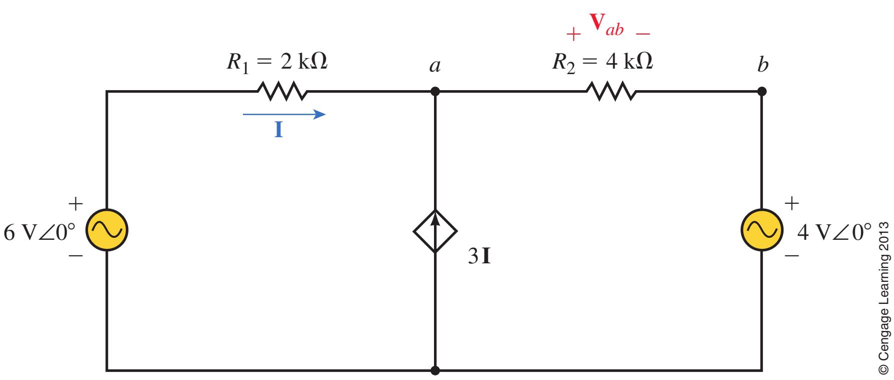


FIGURE 20–78

18. Determine the current **I** for the circuit of Figure 20–79.

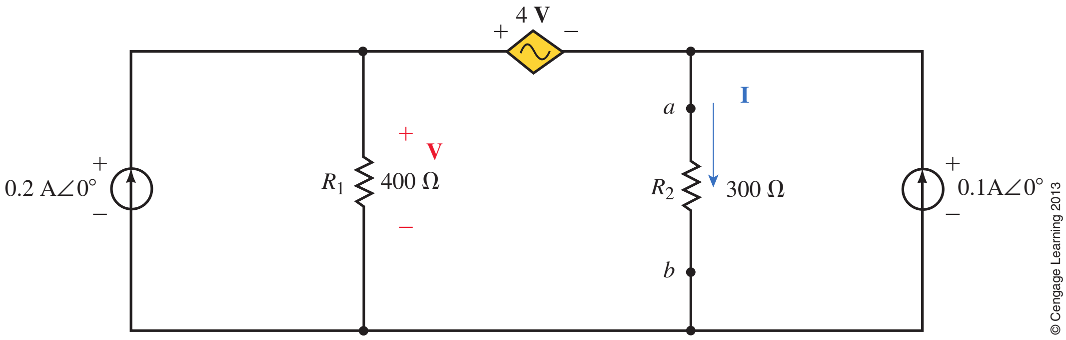


FIGURE 20–79

20.3 Thévenin's Theorem—Independent Sources

19. Find the Thévenin equivalent circuit external to the load impedance of Figure 20–68.
20. Refer to the circuit of Figure 20–80.
    a. Find the Thévenin equivalent circuit external to the indicated load.
    b. Determine the power dissipated by the load.
21. Refer to the circuit of Figure 20–81.
    a. Find the Thévenin equivalent circuit external to the indicated load at a frequency of 5 kHz.
    b. Determine the power dissipated by the load if $\mathbf{Z}_L = 100\ \Omega\angle 30°$.

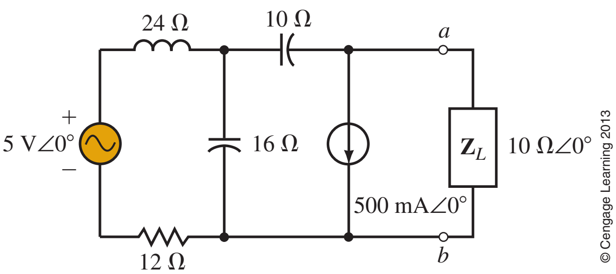


FIGURE 20–80

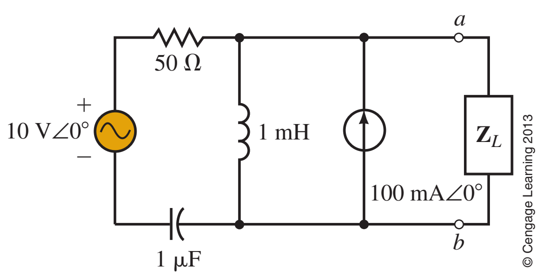


FIGURE 20–81

22. Repeat Problem 21 for a frequency of 1 kHz.
23. Find the Thévenin equivalent circuit external to R_L in the circuit of Figure 20–72.
24. Repeat Problem 23 for the circuit of Figure 20–69.
25. Repeat Problem 23 for the circuit of Figure 20–70.
26. Find the Thévenin equivalent circuit external to Z_L in the circuit of Figure 20–71.
27. Consider the circuit of Figure 20–82.
    a. Find the Thévenin equivalent circuit external to the indicated load.
    b. Determine the power dissipated by the load if $\mathbf{Z}_L = 20\ \Omega\angle -60°$.
28. Repeat Problem 27 if a 10-Ω resistor is placed in series with the voltage source.

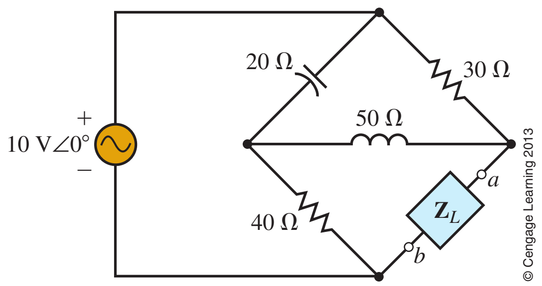


FIGURE 20–82

20.4 Norton's Theorem—Independent Sources

29. Find the Norton equivalent circuit external to the load impedance of Figure 20–68.
30. Repeat Problem 29 for the circuit of Figure 20–69.
31. a. Using the outlined procedure, find the Norton equivalent circuit external to terminals *a* and *b* in Figure 20–72.
    b. Determine the current through the indicated load.
    c. Find the power dissipated by the load.
32. Repeat Problem 31 for the circuit of Figure 20–73.
33. a. Using the outlined procedure, find the Norton equivalent circuit external to the indicated load impedance (located between terminals *a* and *b*) in Figure 20–70.
    b. Determine the current through the indicated load.
    c. Find the power dissipated by the load.
34. Repeat Problem 33 for the circuit of Figure 20–71.
35. Suppose that the circuit of Figure 20–81 operates at a frequency of 2 kHz.
    a. Find the Norton equivalent circuit external to the load impedance.
    b. If a 30-Ω load resistor is connected between terminals *a* and *b*, find the current through the load.
36. Repeat Problem 35 for a frequency of 8 kHz.

20.5 Thévenin's and Norton's Theorems for Dependent Sources

37. a. Find the Thévenin equivalent circuit external to the load impedance in Figure 20–74.
    b. Solve for the current through R_L.
    c. Determine the power dissipated by R_L.
38. a. Find the Norton equivalent circuit external to the load impedance in Figure 20–75.
    b. Solve for the current through R_L.
    c. Determine the power dissipated by R_L.
39. Find the Thévenin and Norton equivalent circuits external to the load impedance of Figure 20–76.
40. Find the Thévenin equivalent circuit external to the load impedance of Figure 20–77.

20.6 Maximum Power Transfer Theorem

41. Refer to the circuit of Figure 20–83.
    a. Determine the load impedance, $\mathbf{Z}_L$, needed to ensure that the load receives maximum power.
    b. Find the maximum power to the load.
42. Repeat Problem 41 for the circuit of Figure 20–84.

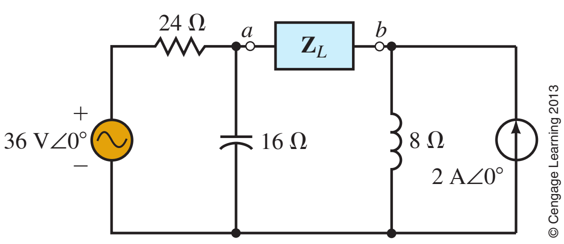


FIGURE 20–83

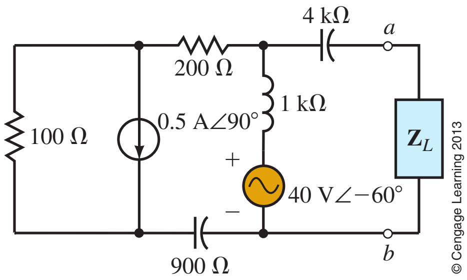


FIGURE 20–84

43. Repeat Problem 41 for the circuit of Figure 20–85.
44. Repeat Problem 41 for the circuit of Figure 20–86.

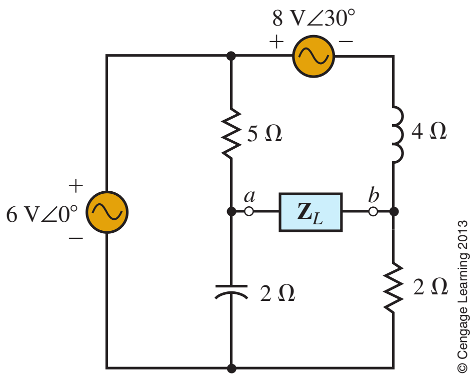


FIGURE 20–85

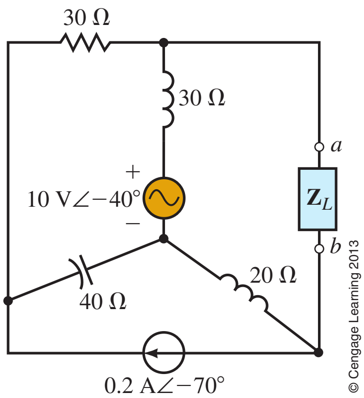


FIGURE 20–86

45. What load impedance is required for the circuit of Figure 20–71 to ensure that the load receives maximum power from the circuit?
46. Determine the load impedance required for the circuit of Figure 20–82 to ensure that the load receives maximum power from the circuit.
47. a. Determine the required load impedance, $\mathbf{Z}_L$, for the circuit of Figure 20–81 to deliver maximum power to the load at a frequency of 5 kHz.
    b. If the load impedance contains a resistor and a 1-μF capacitor, determine the value of the resistor to result in a relative maximum power transfer.
    c. Solve for the power delivered to the load in (b).
48. a. Determine the required load impedance, $\mathbf{Z}_L$, for the circuit of Figure 20–81 to deliver maximum power to the load at a frequency of 1 kHz.
    b. If the load impedance contains a resistor and a 1-μF capacitor, determine the value of the resistor to result in a relative maximum power transfer.
    c. Solve for the power delivered to the load in (b).