Problems

Section 9.1

9.1 Consider the sinusoidal voltage

$$v(t) = 80 \cos(1000\pi t - 30^\circ) \text{ V}.$$

a) What is the maximum amplitude of the voltage?
b) What is the frequency in hertz?
c) What is the frequency in radians per second?
d) What is the phase angle in radians?
e) What is the phase angle in degrees?
f) What is the period in milliseconds?
g) What is the first time after $t = 0$ that $v = 80$ V?
h) The sinusoidal function is shifted 2/3 ms to the left along the time axis. What is the expression for $v(t)$?
i) What is the minimum number of milliseconds that the function must be shifted to the right if the expression for $v(t)$ is $80 \sin 1000\pi t$ V?
j) What is the minimum number of milliseconds that the function must be shifted to the left if the expression for $v(t)$ is $80 \cos 1000\pi t$ V?

9.2 At $t = -2$ ms, a sinusoidal voltage is known to be zero and going positive. The voltage is next zero at $t = 8$ ms. It is also known that the voltage is 80.9 V at $t = 0$.

a) What is the frequency of v in hertz?
b) What is the expression for v?

9.3 A sinusoidal current is zero at $t = -625\ \mu$s and increasing at a rate of 8000π A/s. The maximum amplitude of the current is 20 A.

a) What is the frequency of i in radians per second?
b) What is the expression for i?

9.4 A sinusoidal voltage is given by the expression

$$v = 10 \cos(3769.91t - 53.13^\circ) \text{ V}.$$

Find (a) f in hertz; (b) T in milliseconds; (c) V_m; (d) $v(0)$; (e) ϕ in degrees and radians; (f) the smallest positive value of t at which $v = 0$; and (g) the smallest positive value of t at which $dv/dt = 0$.

9.5 In a single graph, sketch $v = 100 \cos(\omega t + \phi)$ versus ωt for $\phi = -60^\circ, -30^\circ, 0^\circ, 30^\circ$, and 60°.

a) State whether the voltage function is shifting to the right or left as ϕ becomes more positive.
b) What is the direction of shift if ϕ changes from 0 to 30°?

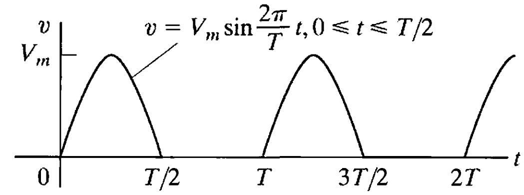
9.6 Show that

$$\int_{t_0}^{t_0+T} V_m^2 \cos^2(\omega t + \phi)dt = \frac{V_m^2 T}{2}$$

9.7 The rms value of the sinusoidal voltage supplied to the convenience outlet of a home in Scotland is 240 V. What is the maximum value of the voltage at the outlet?

9.8 Find the rms value of the half-wave rectified sinusoidal voltage shown.

Figure P9.8



Section 9.2

9.9 The voltage applied to the circuit shown in Fig. 9.5 at $t = 0$ is $20 \cos(800t + 25^\circ)$ V. The circuit resistance is 80 Ω and the initial current in the 75 mH inductor is zero.

a) Find $i(t)$ for $t \geq 0$.
b) Write the expressions for the transient and steady-state components of $i(t)$.
c) Find the numerical value of i after the switch has been closed for 1.875 ms.
d) What are the maximum amplitude, frequency (in radians per second), and phase angle of the steady-state current?
e) By how many degrees are the voltage and the steady-state current out of phase?

9.10 a) Verify that Eq. 9.9 is the solution of Eq. 9.8. This can be done by substituting Eq. 9.9 into the left-hand side of Eq. 9.8 and then noting that it equals the right-hand side for all values of $t > 0$. At $t = 0$, Eq. 9.9 should reduce to the initial value of the current.

b) Because the transient component vanishes as time elapses and because our solution must satisfy the differential equation for all values of t, the steady-state component, by itself, must also satisfy the differential equation. Verify this observation by showing that the steady-state component of Eq. 9.9 satisfies Eq. 9.8.

Sections 9.3–9.4

9.11 Use the concept of the phasor to combine the following sinusoidal functions into a single trigonometric expression:

a) $y = 50 \cos(500t + 60^\circ) + 100 \cos(500t - 30^\circ)$,
b) $y = 200 \cos(377t + 50^\circ) - 100 \sin(377t + 150^\circ)$,

c) $y = 80\cos(100t + 30^\circ) - 100\sin(100t - 135^\circ) + 50\cos(100t - 90^\circ)$, and

d) $y = 250\cos\omega t + 250\cos(\omega t + 120^\circ) + 250\cos(\omega t - 120^\circ)$.

9.12 The expressions for the steady-state voltage and current at the terminals of the circuit seen in Fig. P9.12 are

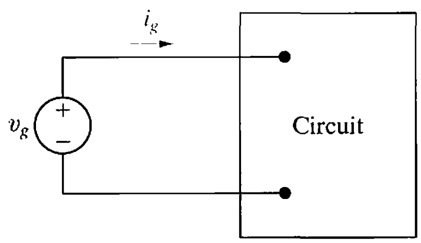
$$v_g = 300\cos(5000\pi t + 78^\circ)\text{ V},$$

$$i_g = 6\sin(5000\pi t + 123^\circ)\text{ A}$$

a) What is the impedance seen by the source?

b) By how many microseconds is the current out of phase with the voltage?

Figure P9.12



9.13 A 80 kHz sinusoidal voltage has zero phase angle and a maximum amplitude of 25 mV. When this voltage is applied across the terminals of a capacitor, the resulting steady-state current has a maximum amplitude of 628.32 μA.

a) What is the frequency of the current in radians per second?

b) What is the phase angle of the current?

c) What is the capacitive reactance of the capacitor?

d) What is the capacitance of the capacitor in microfarads?

e) What is the impedance of the capacitor?

9.14 A 400 Hz sinusoidal voltage with a maximum amplitude of 100 V at $t = 0$ is applied across the terminals of an inductor. The maximum amplitude of the steady-state current in the inductor is 20 A.

a) What is the frequency of the inductor current?

b) If the phase angle of the voltage is zero, what is the phase angle of the current?

c) What is the inductive reactance of the inductor?

d) What is the inductance of the inductor in millihenrys?

e) What is the impedance of the inductor?

Sections 9.5 and 9.6

9.15 PSPICE MULTISIM A 40 Ω resistor, a 5 mH inductor, and a 1.25 μF capacitor are connected in series. The series-connected elements are energized by a sinusoidal voltage source whose voltage is $600\cos(8000t + 20^\circ)$V.

a) Draw the frequency-domain equivalent circuit.

b) Reference the current in the direction of the voltage rise across the source, and find the phasor current.

c) Find the steady-state expression for $i(t)$.

9.16 PSPICE MULTISIM A 10 Ω resistor and a 5 μF capacitor are connected in parallel. This parallel combination is also in parallel with the series combination of an 8 Ω resistor and a 300 μH inductor. These three parallel branches are driven by a sinusoidal current source whose current is $922\cos(20{,}000t + 30^\circ)$ A.

a) Draw the frequency-domain equivalent circuit.

b) Reference the voltage across the current source as a rise in the direction of the source current, and find the phasor voltage.

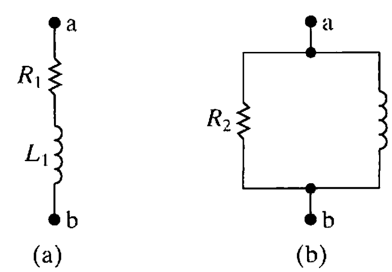
c) Find the steady-state expression for $v(t)$.

9.17 a) Show that, at a given frequency ω, the circuits in Fig. P9.17(a) and (b) will have the same impedance between the terminals a,b if

$$R_1 = \frac{\omega^2 L_2^2 R_2}{R_2^2 + \omega^2 L_2^2}, \qquad L_1 = \frac{R_2^2 L_2}{R_2^2 + \omega^2 L_2^2}.$$

b) Find the values of resistance and inductance that when connected in series will have the same impedance at 4 krad/s as that of a 5 kΩ resistor connected in parallel with a 1.25 H inductor.

Figure P9.17



9.18 a) Show that at a given frequency ω, the circuits in Fig. P9.17(a) and (b) will have the same impedance between the terminals a,b if

$$R_2 = \frac{R_1^2 + \omega^2 L_1^2}{R_1}, \qquad L_2 = \frac{R_1^2 + \omega^2 L_1^2}{\omega^2 L_1}.$$

(*Hint:* The two circuits will have the same impedance if they have the same admittance.)

b) Find the values of resistance and inductance that when connected in parallel will have the same impedance at 1 krad/s as an 8 kΩ resistor connected in series with a 4 H inductor.

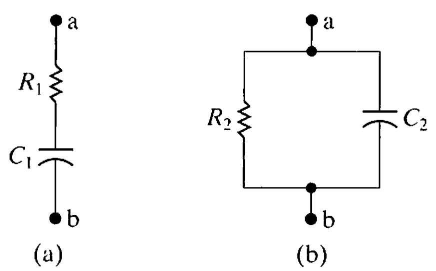
9.19 a) Show that at a given frequency ω, the circuits in Fig. P9.19(a) and (b) will have the same impedance between the terminals a,b if

$$R_1 = \frac{R_2}{1 + \omega^2 R_2^2 C_2^2},$$

$$C_1 = \frac{1 + \omega^2 R_2^2 C_2^2}{\omega^2 R_2^2 C_2}.$$

b) Find the values of resistance and capacitance that when connected in series will have the same impedance at 40 krad/s as that of a 1000 Ω resistor connected in parallel with a 50 nF capacitor.

Figure P9.19



9.20 a) Show that at a given frequency ω, the circuits in Fig 9.19(a) and (b) will have the same impedance between the terminals a,b if

$$R_2 = \frac{1 + \omega^2 R_1^2 C_1^2}{\omega^2 R_1 C_1^2},$$

$$C_2 = \frac{C_1}{1 + \omega^2 R_1^2 C_1^2}.$$

(*Hint:* The two circuits will have the same impedance if they have the same admittance.)

b) Find the values of resistance and capacitance that when connected in parallel will give the same impedance at 50 krad/s as that of a 1 kΩ resistor connected in series with a capacitance of 40 nF.

9.21 a) Using component values from Appendix H, combine at least one resistor, inductor, and capacitor in series to create an impedance of 300 − j400 Ω at a frequency of 10,000 rad/s.

b) At what frequency does the circuit from part (a) have an impedance that is purely resistive?

9.22 a) Using component values from Appendix H, combine at least one resistor and one inductor in parallel to create an impedance of 40 + j20 Ω at a frequency of 5000 rad/s. (*Hint:* Use the results of Problem 9.18.)

b) Using component values from Appendix H, combine at least one resistor and one capacitor in parallel to create an impedance of 40 − j20 Ω at a frequency of 5000 rad/s. (*Hint:* Use the result of Problem 9.20.)

9.23 a) Using component values from Appendix H, find a single capacitor or a network of capacitors that, when combined in parallel with the RL circuit from Problem 9.22(a), gives an equivalent impedance that is purely resistive at a frequency of 5000 rad/s.

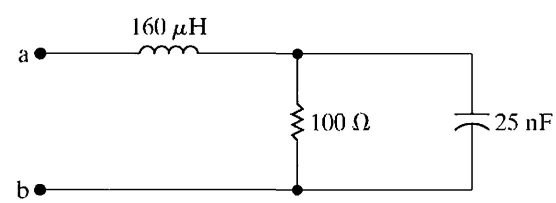
b) Using component values from Appendix H, find a single inductor or a network of inductors that, when combined in parallel with the RC circuit from Problem 9.22(b), gives an equivalent impedance that is purely resistive at a frequency of 5000 rad/s.

9.24 Three branches having impedances of 3 + j4 Ω, 16 − j12 Ω, and −j4 Ω, respectively, are connected in parallel. What are the equivalent (a) admittance, (b) conductance, and (c) susceptance of the parallel connection in millisiemens? (d) If the parallel branches are excited from a sinusoidal current source where $i = 8 \cos \omega t$ A, what is the maximum amplitude of the current in the purely capacitive branch?

9.25 PSPICE MULTISIM a) For the circuit shown in Fig. P9.25, find the frequency (in radians per second) at which the impedance Z_{ab} is purely resistive.

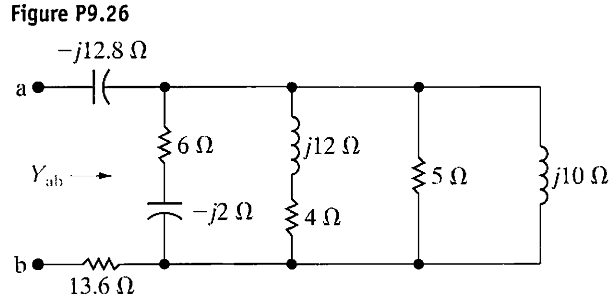
b) Find the value of Z_{ab} at the frequency of (a).

Figure P9.25



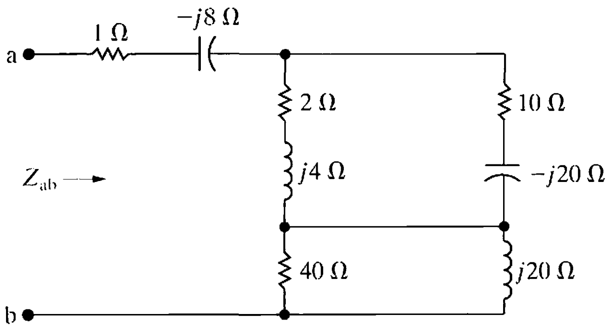
9.26 Find the admittance Y_{ab} in the circuit seen in Fig. P9.26. Express Y_{ab} in both polar and rectangular form. Give the value of Y_{ab} in millisiemens.

Figure P9.26



9.27 Find the impedance Z_{ab} in the circuit seen in Fig. P9.27. Express Z_{ab} in both polar and rectangular form.

Figure P9.27

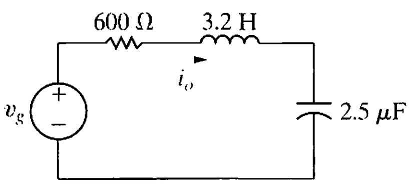


9.28 The circuit shown in Fig. P9.28 is operating in the sinusoidal steady state. Find the value of ω if

$$i_o = 40 \sin(\omega t + 21.87^\circ)\ \text{mA},$$

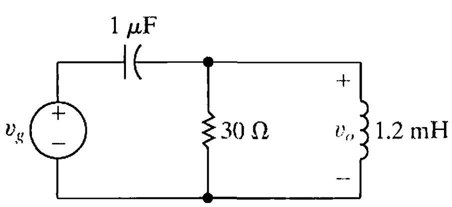
$$v_g = 40 \cos(\omega t - 15^\circ)\ \text{V}.$$

Figure P9.28



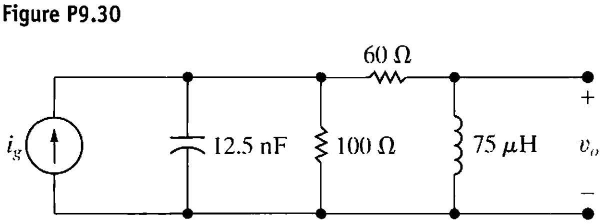
9.29 PSPICE MULTISIM The circuit in Fig. P9.29 is operating in the sinusoidal steady state. Find the steady-state expression for $v_o(t)$ if $v_g = 40 \cos 50{,}000t$ V.

Figure P9.29



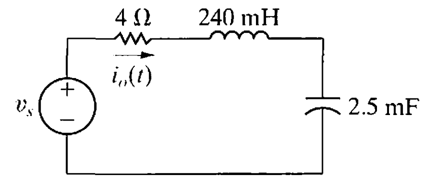
9.30 PSPICE MULTISIM
a) For the circuit shown in Fig. P9.30, find the steady-state expression for v_o if $i_g = 2 \cos(16 \times 10^5 t)$ A.
b) By how many nanoseconds does v_o lag i_g?

Figure P9.30



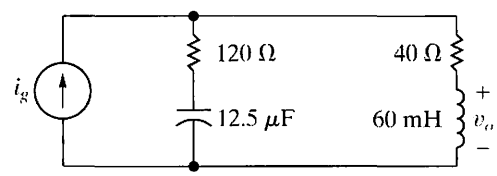
9.31 PSPICE MULTISIM Find the steady-state expression for $i_o(t)$ in the circuit in Fig. P9.31 if $v_s = 100 \sin 50t$ mV.

Figure P9.31



9.32 Find the steady-state expression for v_o in the circuit of Fig. P9.32 if $i_g = 500 \cos 2000t$ mA.

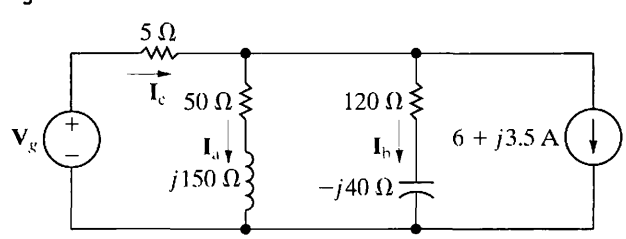
Figure P9.32



9.33 PSPICE MULTISIM The phasor current $\mathbf{I}_a$ in the circuit shown in Fig. P9.33 is $2\angle 0^\circ$ A.

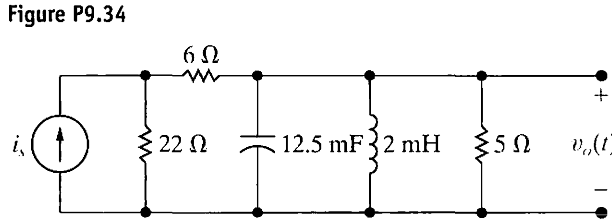
a) Find $\mathbf{I}_b$, $\mathbf{I}_c$, and $\mathbf{V}_g$.
b) If $\omega = 800$ rad/s, write the expressions for $i_b(t)$, $i_c(t)$, and $v_g(t)$.

Figure P9.33



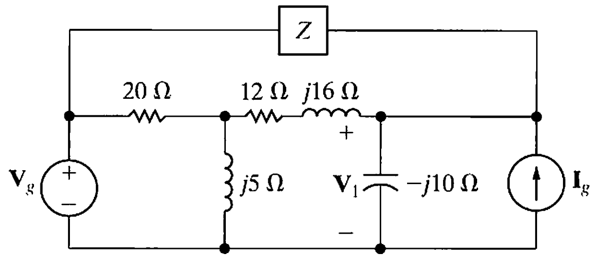
9.34 PSPICE MULTISIM The circuit in Fig. P9.34 is operating in the sinusoidal steady state. Find $v_o(t)$ if $i_s(t) = 3 \cos 200t$ mA.

Figure P9.34



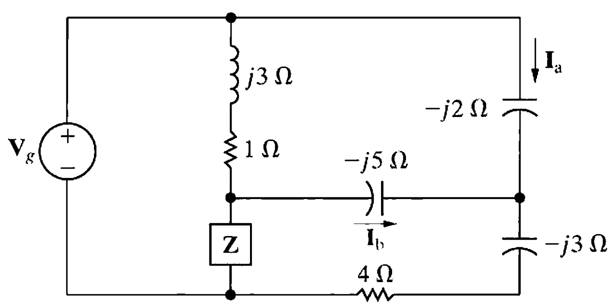
9.35 Find the value of Z in the circuit seen in Fig. P9.35 if $\mathbf{V}_g = 100 - j50$ V, $\mathbf{I}_g = 30 + j20$ A, and $\mathbf{V}_1 = 140 + j30$ V.

Figure P9.35



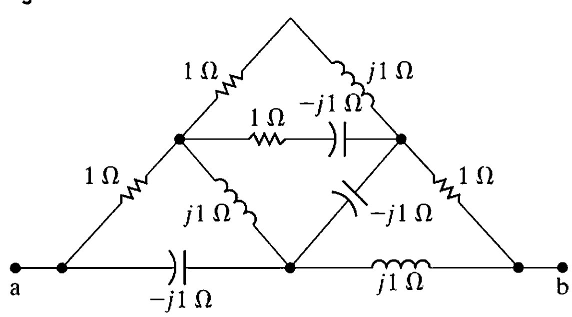
9.36 Find $\mathbf{I}_b$ and Z in the circuit shown in Fig. P9.36 if $\mathbf{V}_g = 25\angle 0^\circ$ V and $\mathbf{I}_a = 5\angle 90^\circ$ A.

Figure P9.36



9.37 Find Z_{ab} for the circuit shown in Fig P9.37.

Figure P9.37

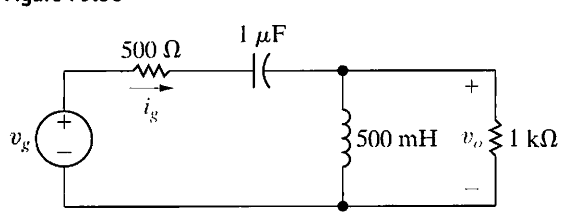


9.38 a) The frequency of the source voltage in the circuit in Fig. P9.38 is adjusted until i_g is in phase with v_g. What is the value of ω in radians per second?

PSPICE
MULTISIM

b) If $v_g = 20 \cos \omega t$ V (where ω is the frequency found in [a]), what is the steady-state expression for v_o?

Figure P9.38



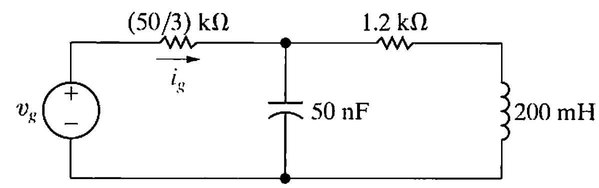
9.39 The frequency of the sinusoidal voltage source in the circuit in Fig. P9.39 is adjusted until the current i_o is in phase with v_g.

PSPICE
MULTISIM

a) Find the frequency in hertz.

b) Find the steady-state expression for i_g (at the frequency found in [a]) if $v_g = 30 \cos \omega t$ V.

Figure P9.39



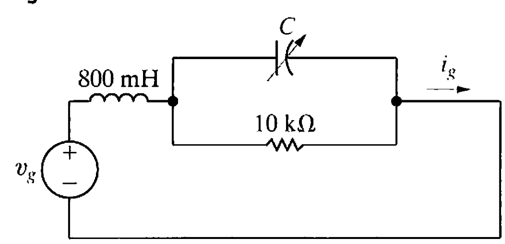
9.40 The circuit shown in Fig. P9.40 is operating in the sinusoidal steady state. The capacitor is adjusted until the current i_g is in phase with the sinusoidal voltage v_g.

PSPICE
MULTISIM

a) Specify the capacitance in microfarads if $v_g = 80 \cos 5000t$ V.

b) Give the steady-state expression for i_g when C has the value found in (a).

Figure P9.40

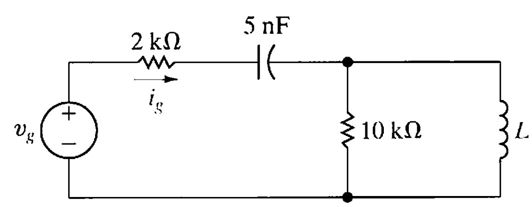


9.41 a) The source voltage in the circuit in Fig. P9.41 is $v_g = 50 \cos 50{,}000t$ V. Find the values of L such that i_g is in phase with v_g when the circuit is operating in the steady state.

PSPICE
MULTISIM

b) For the values of L found in (a), find the steady-state expressions for i_g.

Figure P9.41



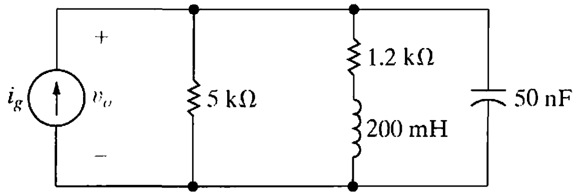
9.42 The frequency of the sinusoidal current source in the circuit in Fig. P9.42 is adjusted until v_o is in phase with i_g.

PSPICE
MULTISIM

a) What is the value of ω in radians per second?

b) If $i_g = 2.5 \cos \omega t$ mA (where ω is the frequency found in [a]), what is the steady-state expression for v_o?

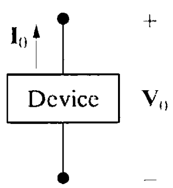
Figure P9.42



Section 9.7

9.43 The device in Fig. P9.43 is represented in the frequency domain by a Norton equivalent. When a resistor having an impedance of 5 kΩ is connected across the device, the value of $\mathbf{V}_0$ is $5 - j15$ V. When a capacitor having an impedance of $-j3$ kΩ is connected across the device, the value of $\mathbf{I}_0$ is $4.5 - j6$ mA. Find the Norton current $\mathbf{I}_N$ and the Norton impedance Z_N.

Figure P9.43



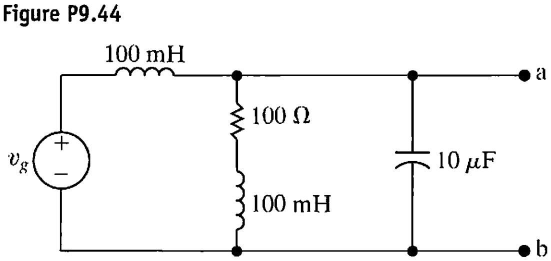
9.44 The sinusoidal voltage source in the circuit in Fig. P9.44 is developing a voltage equal to $247.49 \cos(1000t + 45°)$ V.

a) Find the Thévenin voltage with respect to the terminals a,b.

b) Find the Thévenin impedance with respect to the terminals a,b.

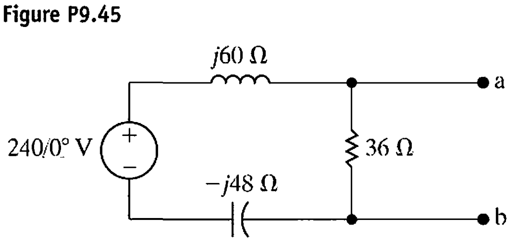
c) Draw the Thévenin equivalent.

Figure P9.44



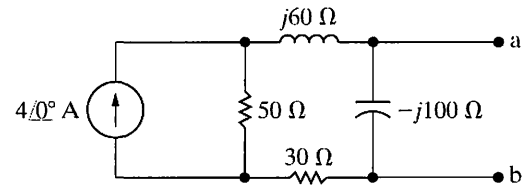
9.45 Use source transformations to find the Thévenin equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.45.

Figure P9.45



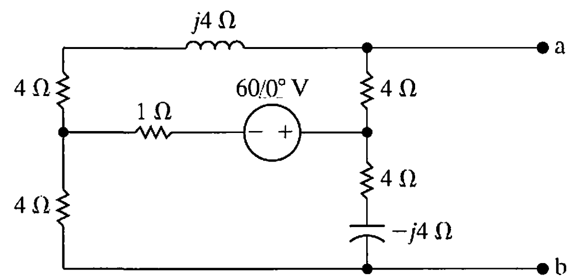
9.46 Use source transformations to find the Norton equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.46.

Figure P9.46



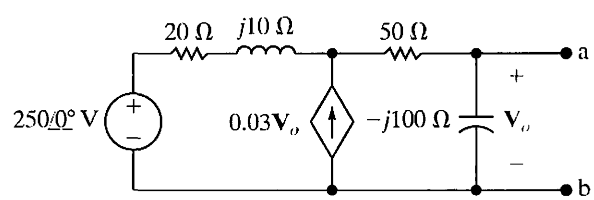
9.47 Find the Thévenin equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.47.

Figure P9.47



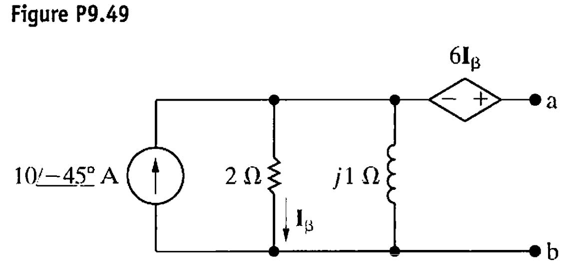
9.48 Find the Thévenin equivalent circuit with respect to the terminals a,b of the circuit shown in Fig. P9.48.

Figure P9.48



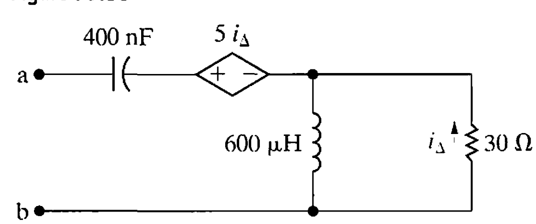
9.49 Find the Norton equivalent with respect to terminals a,b in the circuit of Fig. P9.49.

Figure P9.49



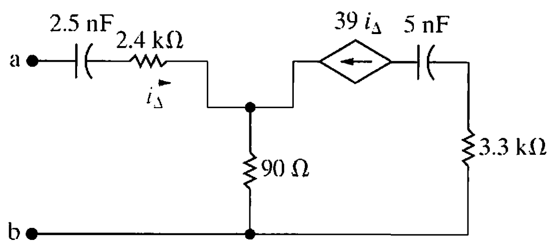
9.50 Find Z_{ab} in the circuit shown in Fig. P9.50 when the circuit is operating at a frequency of 100 krad/s.

Figure P9.50



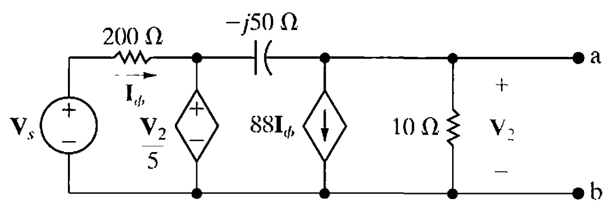
9.51 Find the Thévenin impedance seen looking into the terminals a,b of the circuit in Fig. P9.51 if the frequency of operation is $(25/\pi)$ kHz.

Figure P9.51



9.52 Find the Norton equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.52 when $\mathbf{V}_s = 5\angle 0^\circ$ V.

Figure P9.52



9.53 The circuit shown in Fig. P9.53 is operating at a frequency of 10 rad/s. Assume α is real and lies between −10 and +10, that is, $-10 \leq \alpha \leq 10$.

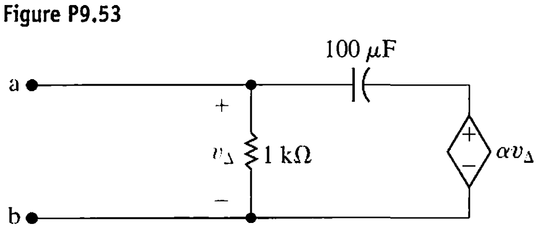
a) Find the value of α so that the Thévenin impedance looking into the terminals a,b is purely resistive.

b) What is the value of the Thévenin impedance for the α found in (a)?

c) Can α be adjusted so that the Thévenin impedance equals $500 - j500\ \Omega$? If so, what is the value of α?

d) For what values of α will the Thévenin impedance be inductive?

Figure P9.53



Section 9.8

9.54 Use the node-voltage method to find the steady-state expression for $v_o(t)$ in the circuit in Fig. P9.54 if
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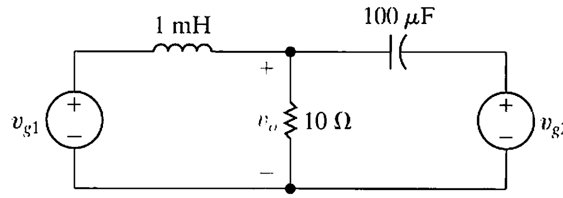
$$v_{g1} = 20\cos(2000t - 36.87^\circ)\ \text{V},$$

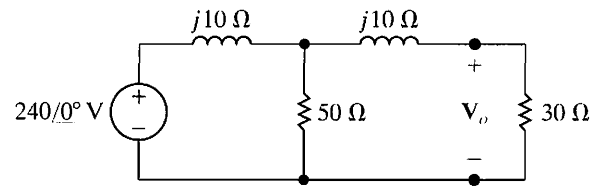
$$v_{g2} = 50\sin(2000t - 16.26^\circ)\ \text{V}.$$

Figure P9.54



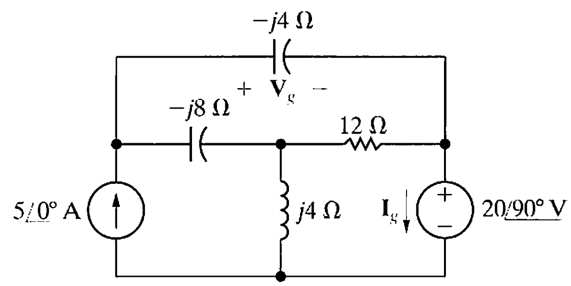
9.55 Use the node-voltage method to find $\mathbf{V}_o$ in the circuit in Fig. P9.55.

Figure P9.55



9.56 Use the node-voltage method to find the phasor voltage $\mathbf{V}_g$ in the circuit shown in Fig. P9.56.

Figure P9.56



9.57 Use the node voltage method to find the steady-state expressions for the branch currents i_a, i_b, and i_c in the circuit seen in Fig. P9.57 if $v_a = 50\sin 10^6 t$ V and $v_b = 25\cos(10^6 t + 90^\circ)$ V.
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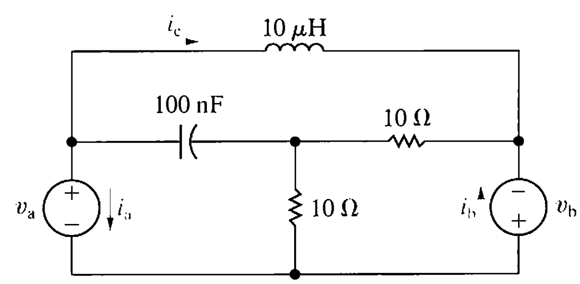
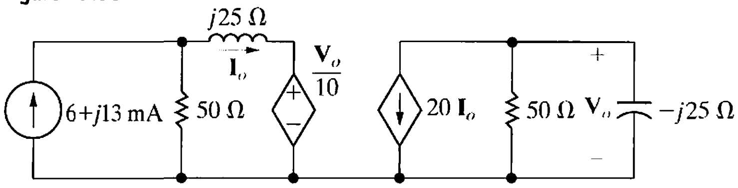
Figure P9.57



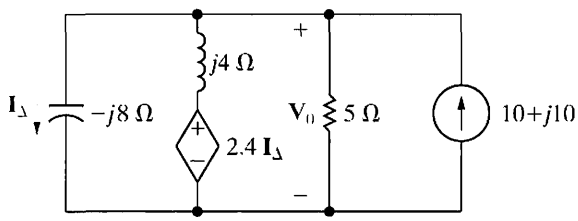
9.58 Use the node-voltage method to find $\mathbf{V}_o$ and $\mathbf{I}_o$ in the circuit seen in Fig. P9.58.

Figure P9.58



9.59 Use the node-voltage method to find the phasor voltage $\mathbf{V}_o$ in the circuit shown in Fig. P9.59. Express the voltage in both polar and rectangular form.

Figure P9.59



Section 9.9

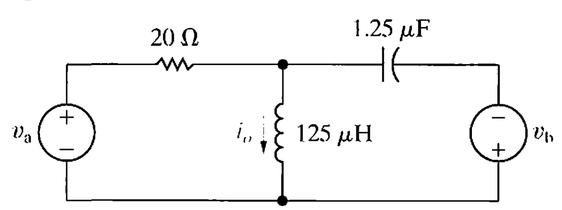
9.60 Use the mesh-current method to find the steady-state expression for $v_o(t)$ in the circuit in Fig. P9.54.

9.61 Use the mesh-current method to find the steady-state expression for $i_o(t)$ in the circuit in Fig. P9.61 if

$$v_a = 60 \cos 40{,}000t \text{ V},$$

$$v_b = 90 \sin (40{,}000t + 180^\circ) \text{ V}.$$

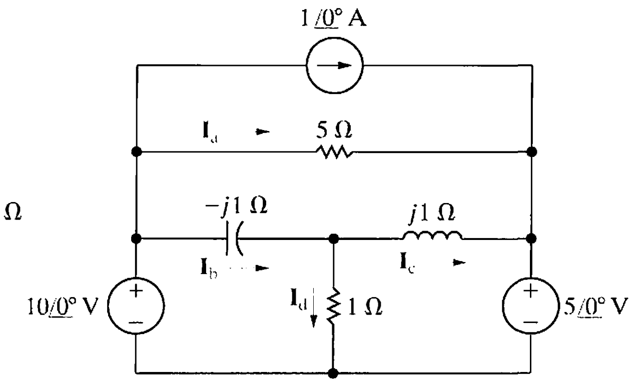
Figure P9.61



9.62 Use the mesh-current method to find the phasor current $\mathbf{I}_g$ in the circuit in Fig. P9.56.

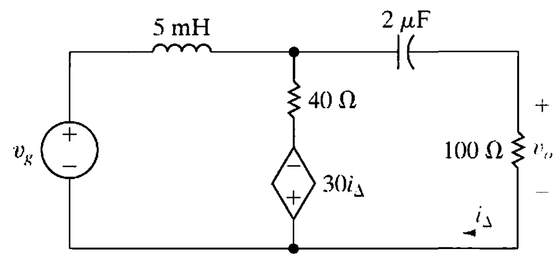
9.63 Use the mesh-current method to find the branch currents $\mathbf{I}_a$, $\mathbf{I}_b$, $\mathbf{I}_c$, and $\mathbf{I}_d$ in the circuit shown in Fig. P9.63.

Figure P9.63



9.64 PSPICE MULTISIM Use the mesh-current method to find the steady-state expression for v_o in the circuit seen in Fig. P9.64 if v_g equals $130 \cos 10{,}000t$ V.

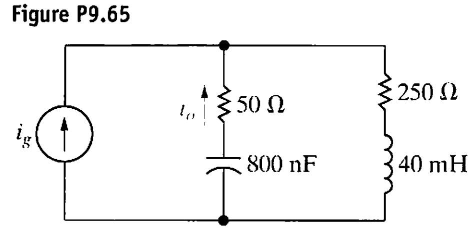
Figure P9.64



Sections 9.5–9.9

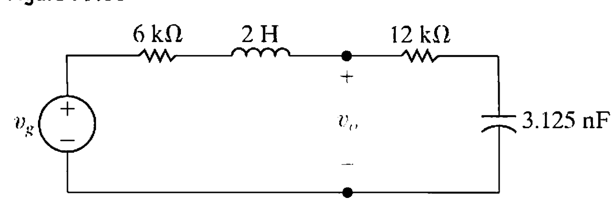
9.65 PSPICE MULTISIM Use the concept of current division to find the steady-state expression for i_o in the circuit in Fig. P9.65 if $i_g = 125 \cos 12{,}500t$ mA.

Figure P9.65



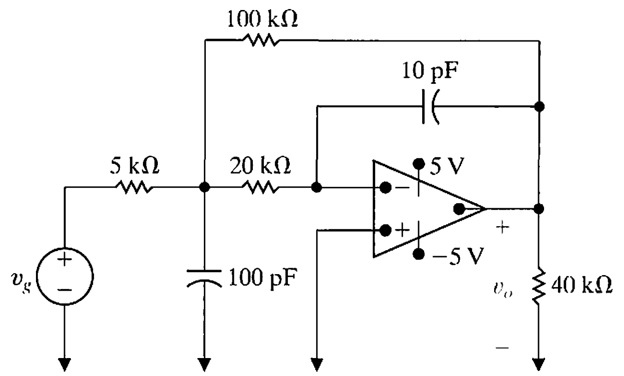
9.66 PSPICE MULTISIM Use the concept of voltage division to find the steady-state expression for $v_o(t)$ in the circuit in Fig. P9.66 if $v_g = 75 \cos 20{,}000t$ V.

Figure P9.66



9.67 The op amp in the circuit seen in Fig. P9.67 is ideal. Find the steady-state expression for $v_o(t)$ when $v_g = 2\cos 10^6 t$ V.
PSPICE MULTISIM

Figure P9.67

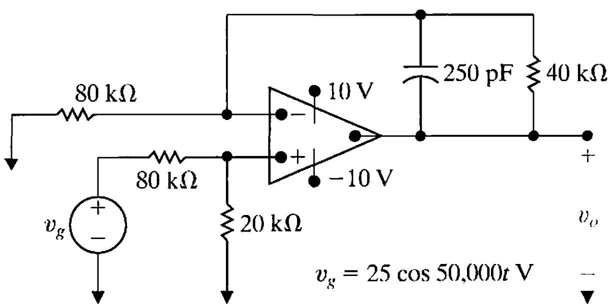


9.68 The op amp in the circuit in Fig. P9.68 is ideal.
PSPICE MULTISIM

a) Find the steady-state expression for $v_o(t)$.

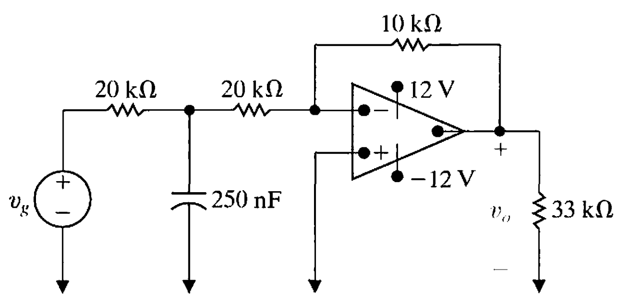
b) How large can the amplitude of v_g be before the amplifier saturates?

Figure P9.68



9.69 The sinusoidal voltage source in the circuit shown in Fig. P9.69 is generating the voltage $v_g = 4\cos 200t$ V. If the op amp is ideal, what is the steady-state expression for $v_o(t)$?
PSPICE MULTISIM

Figure P9.69



9.70 The 250 nF capacitor in the circuit seen in Fig. P9.69 is replaced with a variable capacitor. The capacitor is adjusted until the output voltage leads the input voltage by 135°.
PSPICE MULTISIM

a) Find the value of C in microfarads.

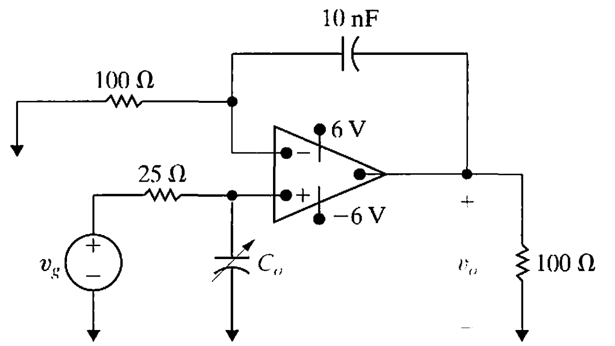
b) Write the steady-state expression for $v_o(t)$ when C has the value found in (a).

9.71 The operational amplifier in the circuit shown in Fig. P9.71 is ideal. The voltage of the ideal sinusoidal source is $v_g = 30\cos 10^6 t$ V.
PSPICE MULTISIM

a) How small can C_o be before the steady-state output voltage no longer has a pure sinusoidal waveform?

b) For the value of C_o found in (a), write the steady-state expression for v_o.

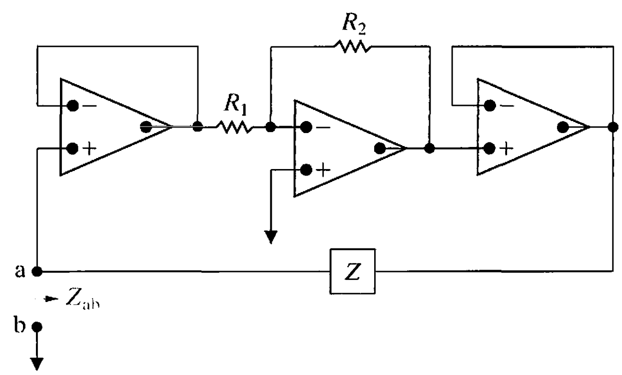
Figure P9.71



9.72 a) Find the input impedance Z_{ab} for the circuit in Fig. P9.72. Express Z_{ab} as a function of Z and K where $K = (R_2/R_1)$.

b) If Z is a pure capacitive element, what is the capacitance seen looking into the terminals a,b?

Figure P9.72



9.73 For the circuit in Fig. P9.73 suppose

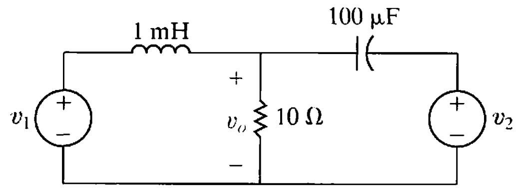
$$v_1 = 20\cos(2000t - 36.87°)\text{ V}$$

$$v_2 = 10\cos(5000t + 16.26°)\text{ V}$$

a) What circuit analysis technique must be used to find the steady-state expression for $v_o(t)$?

b) Find the steady-state expression for $v_o(t)$.

Figure P9.73



9.74 For the circuit in Fig. P9.61, suppose

$$v_a = 5\cos 80{,}000t \text{ V}$$

$$v_b = -2.5\cos 320{,}000t \text{ V}.$$

a) What circuit analysis technique must be used to find the steady-state expression for $i_o(t)$?

b) Find the steady-state expression for $i_o(t)$?

Section 9.10

9.75 A series combination of a 300 Ω resistor and a 100 mH inductor is connected to a sinusoidal voltage source by a linear transformer. The source is operating at a frequency of 1 krad/s. At this frequency, the internal impedance of the source is $100 + j13.74$ Ω. The rms voltage at the terminals of the source is 50 V when it is not loaded. The parameters of the linear transformer are $R_1 = 41.68$ Ω, $L_1 = 180$ mH, $R_2 = 500$ Ω, $L_2 = 500$ mH, and $M = 270$ mH.

a) What is the value of the impedance reflected into the primary?

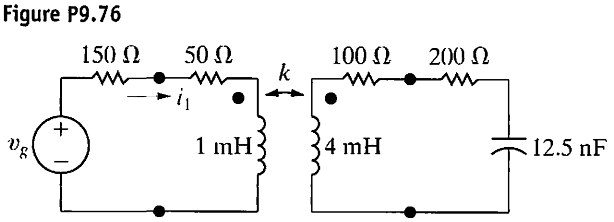
b) What is the value of the impedance seen from the terminals of the practical source?

9.76 PSPICE MULTISIM The sinusoidal voltage source in the circuit seen in Fig. P9.76 is operating at a frequency of 200 krad/s. The coefficient of coupling is adjusted until the peak amplitude of i_1 is maximum.

a) What is the value of k?

b) What is the peak amplitude of i_1 if $v_g = 560\cos(2 \times 10^5 t)$ V?

Figure P9.76

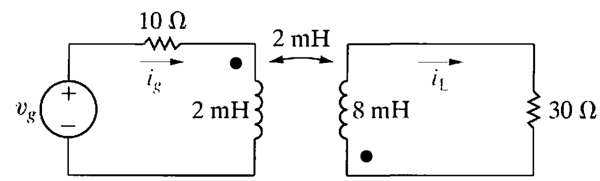


9.77 PSPICE MULTISIM a) Find the steady-state expressions for the currents i_g and i_L in the circuit in Fig. P9.77 when $v_g = 70\cos 5000t$ V.

b) Find the coefficient of coupling.

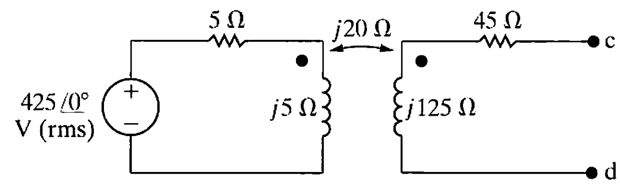
c) Find the energy stored in the magnetically coupled coils at $t = 100\pi$ μs and $t = 200\pi$ μs.

Figure P9.77



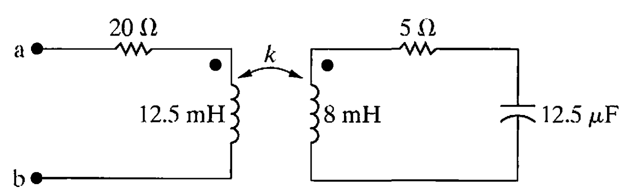
9.78 For the circuit in Fig. P9.78, find the Thévenin equivalent with respect to the terminals c,d.

Figure P9.78



9.79 The value of k in the circuit in Fig. P9.79 is adjusted so that Z_{ab} is purely resistive when $\omega = 4$ krad/s. Find Z_{ab}.

Figure P9.79



Section 9.11

9.80 At first glance, it may appear from Eq. 9.69 that an inductive load could make the reactance seen looking into the primary terminals (i.e., X_{ab}) look capacitive. Intuitively, we know this is impossible. Show that X_{ab} can never be negative if X_L is an inductive reactance.

9.81 a) Show that the impedance seen looking into the terminals a,b in the circuit in Fig. P9.81 on the next page is given by the expression

$$Z_{ab} = \left(1 + \frac{N_1}{N_2}\right)^2 Z_L.$$

10.43 Suppose an impedance equal to the conjugate of the Thévenin impedance is connected to the terminals c,d of the circuit shown in Fig. P9.78.

a) Find the average power developed by the sinusoidal voltage source.

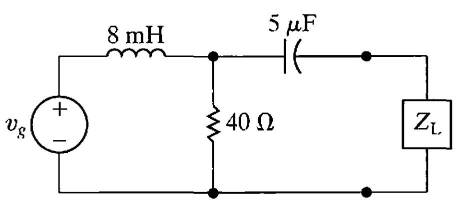
b) What percentage of the power developed by the source is lost in the linear transformer?

10.44 a) Determine the load impedance for the circuit shown in Fig. P10.44 that will result in maximum average power being transferred to the load if $\omega = 5$ krad/s.

b) Determine the maximum average power delivered to the load from part (a) if $v_g = 80 \cos 5000t$ V.

c) Repeat part (a) when Z_L. consists of two components from Appendix H whose values yield a maximum average power closest to the value calculated in part (b).

Figure P10.44



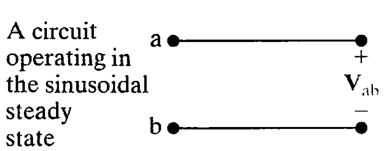
10.45 The phasor voltage $\mathbf{V}_{ab}$ in the circuit shown in Fig. P10.45 is $240\angle 0^\circ$ V (rms) when no external load is connected to the terminals a,b. When a load having an impedance of $90 - j30\ \Omega$ is connected across a,b, the value of $\mathbf{V}_{ab}$ is $115.2 - j86.4$ V (rms).

a) Find the impedance that should be connected across a,b for maximum average power transfer.

b) Find the maximum average power transferred to the load of (a).

c) Construct the impedance of part (a) using components from Appendix H if the source frequency is 60 Hz.

Figure P10.45

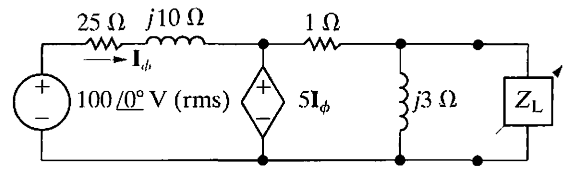


10.46 The load impedance Z_L for the circuit shown in Fig. P10.46 is adjusted until maximum average power is delivered to Z_L.

a) Find the maximum average power delivered to Z_L.

b) What percentage of the total power developed in the circuit is delivered to Z_L?

Figure P10.46



10.47 The peak amplitude of the sinusoidal voltage source in the circuit shown in Fig. P10.47 is 180 V, and its frequency is 5000 rad/s. The load resistor can be varied from 0 to 4000 Ω, and the load capacitor can be varied from 0.1 μF to 0.5 μF.
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a) Calculate the average power delivered to the load when $R_o = 2000\ \Omega$ and $C_o = 0.2\ \mu$F.

b) Determine the settings of R_o and C_o that will result in the most average power being transferred to R_o.

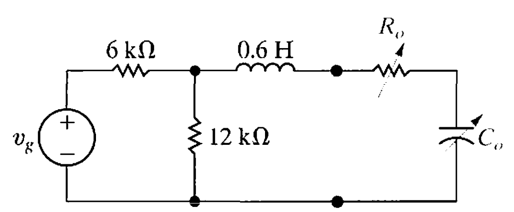
c) What is the most average power in (b)? Is it greater than the power in (a)?

d) If there are no constraints on R_o and C_o, what is the maximum average power that can be delivered to a load?

e) What are the values of R_o and C_o for the condition of (d)?

f) Is the average power calculated in (d) larger than that calculated in (c)?

Figure P10.47



10.48 a) Assume that R_o in Fig. P10.47 can be varied between 0 and 10 kΩ. Repeat (b) and (c) of Problem 10.47.
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b) Is the new average power calculated in (a) greater than that found in Problem 10.47(a)?

c) Is the new average power calculated in (a) less than that found in 10.47(d)?

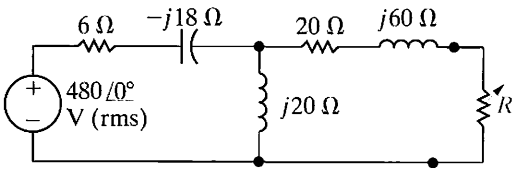
10.49 The variable resistor in the circuit shown in Fig. P10.49 is adjusted until the average power it absorbs is maximum.

a) Find R.

b) Find the maximum average power.

c) Find a resistor in Appendix H that would have the most average power delivered to it.

Figure P10.49



10.50 The variable resistor R_o in the circuit shown in Fig. P10.50 is adjusted until maximum average power is delivered to R_o.

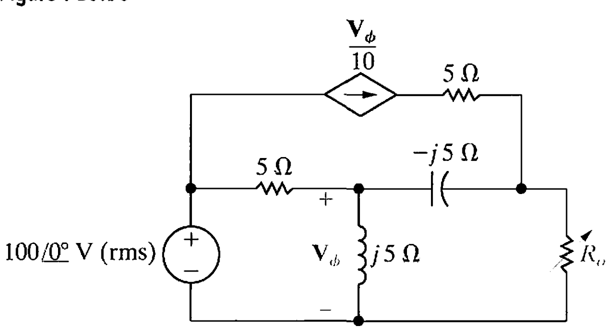
a) What is the value of R_o in ohms?

b) Calculate the average power delivered to R_o.

c) If R_o is replaced with a variable impedance Z_o, what is the maximum average power that can be delivered to Z_o?

d) In (c), what percentage of the circuit's developed power is delivered to the load Z_o?

Figure P10.50



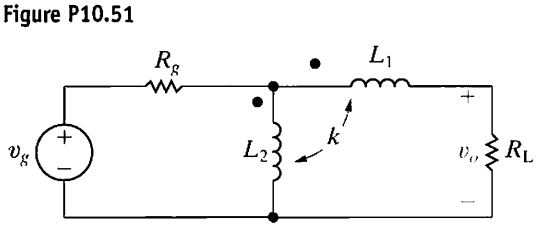
10.51 The values of the parameters in the circuit shown in Fig. P10.51 are $L_1 = 8$ mH; $L_2 = 2$ mH; $k = 0.75$; $R_g = 1\ \Omega$; and $R_L = 7\ \Omega$. If $v_g = 54\sqrt{2}\cos 1000t$ V, find

a) the rms magnitude of v_o

b) the average power delivered to R_L

c) the percentage of the average power generated by the ideal voltage source that is delivered to R_L.

Figure P10.51



10.52 Assume the coefficient of coupling in the circuit in Fig. P10.51 is adjustable.

a) Find the value of k that makes v_o equal to zero.

b) Find the power developed by the source when k has the value found in (a).

10.53 Assume the load resistor (R_L) in the circuit in Fig. P10.51 is adjustable.

a) What value of R_L will result in the maximum average power being transferred to R_L?

b) What is the value of the maximum power transferred?

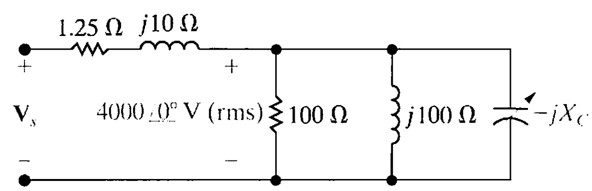
10.54 The sending-end voltage in the circuit seen in Fig. P10.54 is adjusted so that the rms value of the load voltage is always 4000 V. The variable capacitor is adjusted until the average power dissipated in the line resistance is minimum.

a) If the frequency of the sinusoidal source is 60 Hz, what is the value of the capacitance in microfarads?

b) If the capacitor is removed from the circuit, what percentage increase in the magnitude of $\mathbf{V}_s$ is necessary to maintain 4000 V at the load?

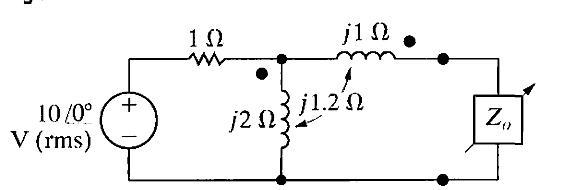
c) If the capacitor is removed from the circuit, what is the percentage increase in line loss?

Figure P10.54



10.55 Find the impedance seen by the ideal voltage source in the circuit in Fig. P10.55 when Z_o is adjusted for maximum average power transfer to Z_o.

Figure P10.55



10.56 The impedance Z_L in the circuit in Fig. P10.56 is adjusted for maximum average power transfer to Z_L. The internal impedance of the sinusoidal voltage source is $4 + j7\ \Omega$.

a) What is the maximum average power delivered to Z_L?

b) What percentage of the average power delivered to the linear transformer is delivered to Z_L?