

Frequency Domain A linear circuit represented by phasors and impedances is said to be represented in the frequency domain. The equations that describe a circuit in the frequency domain are algebraic equations rather than differential equations.

Impedance Ratio of the phasor voltage V to the phasor current I for a circuit element or set of elements so that $Z = V/I$. The units are ohms.

Periodic Function Function defined by the property $x(t + T) = x(t)$ so that it repeats every T seconds.

Period T is the period of the periodic function, the time between two identical maximum points in the waveform.

Phasor Complex number associated with a circuit variable—for example, the phasor voltage V . The transform of a sinusoidal voltage or current that contains the magnitude and the phase angle information.

Phasor Diagram Relationship of phasors on the complex plane.

Reactance Imaginary part of impedance, denoted as X . The units are ohms.

Resistance Real part of impedance, denoted as R . The units are ohms.

Susceptance Imaginary part of admittance, denoted as B . The units are siemens.

Time Domain In contrast to the frequency domain, a linear circuit represented by differential equations is said to be represented in the time domain.

Transform Change in the mathematical description of a physical variable to facilitate computation.

Problems

Section 10.3 Sinusoidal Sources

P 10.3-1 Express the following summations of sinusoids in the general form $A \sin(\omega t + \theta)$ by using trigonometric identities.

(a) $i(t) = 2 \cos(6t + 120^\circ) + 4 \sin(6t - 60^\circ)$

(b) $v(t) = 5\sqrt{2} \cos 8t + 10 \sin(8t + 45^\circ)$

P 10.3-2 A sinusoidal voltage has a maximum value of 100 V, and the value is 10 V at $t = 0$. The period is $T = 1$ ms. Determine $v(t)$.

P 10.3-3 A sinusoidal current is given as $i = 300 \cos(1200\pi t + 55^\circ)$ mA. Determine the frequency f and the value of the current at $t = 2$ ms.

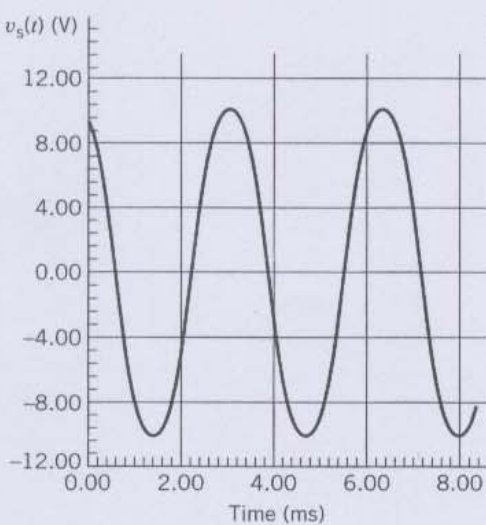
P 10.3-4 Plot a graph of the voltage signal

$$v(t) = 15 \cos(628t + 45^\circ) \text{ mV}$$

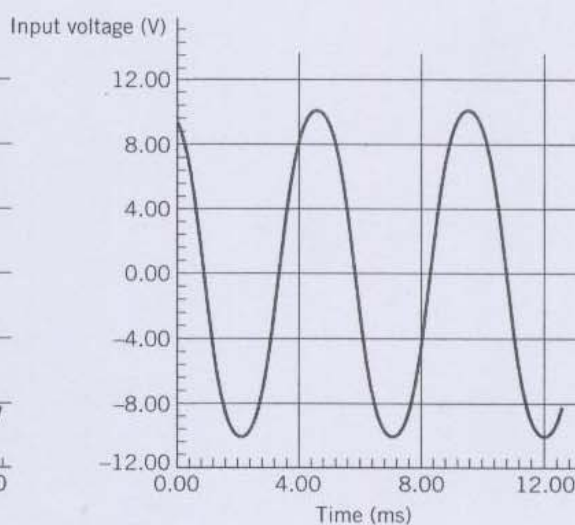
P 10.3-5 Represent each of the signals shown in Figure P 10.3-5 by a function of the form $A \cos(\omega t + \theta)$.

Answer: (a) $v_s(t) = 10 \cos(1900t + 30^\circ)$ V,

(b) $v(t) = 10 \cos(1260t + 30^\circ)$ V



(a)



(b)

Figure P 10.3-5

Section 10.4 Steady-State Response of an RL Circuit for a Sinusoidal Forcing Function

P 10.4-1 Find the forced response i for the circuit of Figure P 10.4-1 when $v_s(t) = 10 \cos(300t)$ V.

Answer: $i(t) = 1.24 \cos(300t - 68^\circ)$

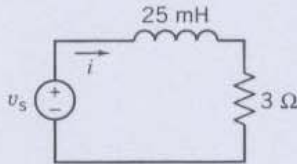


Figure P 10.4-1

P 10.4-2 Find the forced response v for the circuit of Figure P 10.4-2 when $i_s(t) = 0.5 \cos \omega t$ A and $\omega = 1000$ rad/s.

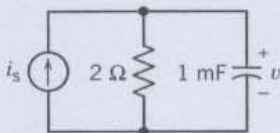


Figure P 10.4-2

P 10.4-3 Find the forced response $i(t)$ for the circuit of Figure P 10.4-3.

Answer: $i(t) = 2 \cos(4t + 45^\circ)$ mA

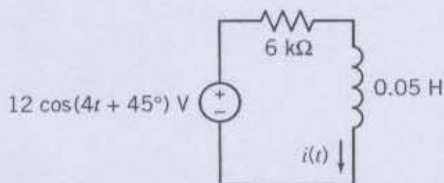


Figure P 10.4-3

Section 10.5 Complex Exponential Forcing Function

(a) Complex Numbers

P 10.5-1 Determine the polar form of the quantity

$$\frac{(5 \angle 36.9^\circ)(10 \angle -53.1^\circ)}{(4 + j3) + (6 - j8)}$$

Answer: $2\sqrt{5} \angle 10.36^\circ$

P 10.5-2 Determine the polar and rectangular form of the expression

$$5 \angle +81.87^\circ \left(4 - j3 + \frac{3\sqrt{2} \angle -45^\circ}{7 - j1} \right)$$

Answer: $28 \angle +45^\circ = 14\sqrt{2} + j14\sqrt{2}$

P 10.5-3 Given $A = 3 + j7$, $B = 6 \angle 15^\circ$, and $C = 5e^{j2.3}$, find $(A \cdot C) / B$.

Answer: $0.65 - j6.32$

P 10.5-4 Determine a and b when (angles in degrees)

$$(6 \angle 120^\circ)(-4 + j3 + 2e^{j15^\circ}) = a + jb$$

P 10.5-5 Find a , b , A , and θ as required (angles given in degrees).

(a) $A e^{j120^\circ} + jb = -4 + j3$

(b) $6 e^{j120^\circ} (-4 + jb + 8 e^{j\theta}) = 18$

(c) $(a + j4)j2 = 2 + A e^{j60^\circ}$

Section 10.5 Complex Exponential Forcing Function

(b) Response of a Circuit

P 10.5-6 For the circuit of Figure P 10.5-6 find $i(t)$ when $v_s(t) = 0.1 \cos(\omega t + 90^\circ)$ V and $\omega = 10^7$ rad/s.

Answer: $i(t) = 1 \cos(\omega t + 90^\circ)$ mA

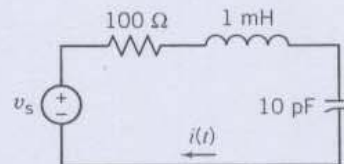


Figure P 10.5-6

P 10.5-7 For the circuit of Figure P 10.5-7 find $i(t)$ when $v_s(t) = 20 \cos(\omega t + 45^\circ)$ V when $\omega = 25$ Mrad/s.

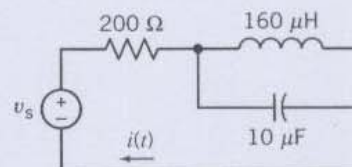


Figure P 10.5-7

Section 10.6 The Phasor Concept

P 10.6-1 For the circuit of Figure P 10.6-1 find $v(t)$ when $i_s(t) = 5 \cos(\omega t - 120^\circ)$ mA when $\omega = 10^5$ rad/s.

Answer: $v(t) = 1.5 \cos(\omega t + 60^\circ)$ V

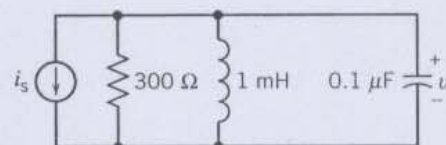


Figure P 10.6-1

P 10.6-2 For the circuit of Figure P 10.6-2 find $i(t)$ when $i_s = 25 \cos(\omega t - 120^\circ)$ mA and $\omega = 10^3$ rad/s.

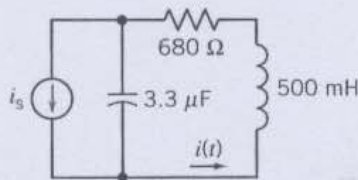


Figure P 10.6-2

P 10.6-3 For the circuit of Figure P 10.6-3, find $v(t)$ when $v_s = 2 \sin 500t$ V.

Answer: $v(t) = 1.25 \cos(500t - 141^\circ)$ V

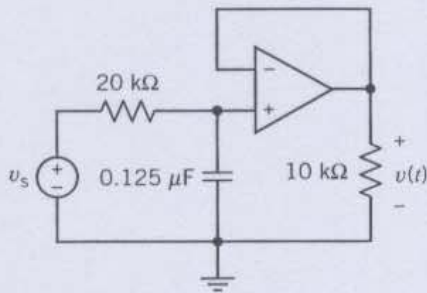


Figure P 10.6-3

Section 10.7 Phasor Relationships for R, L, and C Elements

P 10.7-1 Given the phasor $\mathbf{I} = 6 + j8$, rotate it in the phasor plane by the following amounts and express the final result in rectangular coordinates: (a) -45° ; (b) 90° .

Answer: (a) $\mathbf{I} = 7\sqrt{2} + j\sqrt{2}$
 (b) $\mathbf{I} = -8 + j6$

P 10.7-2 Add the following voltage waveforms using phasors, obtaining the resultant voltage in the form $v_1 + v_2 = A \cos(\omega t + \phi)$.

(a) $v_1 = 3 \cos(2t + 60^\circ)$; $v_2 = 8 \cos(2t - 22.5^\circ)$
 (b) $v_1 = 2\sqrt{2} \sin 4t$; $v_2 = 10 \cos(4t + 30^\circ)$

P 10.7-3 Find the two phasors \mathbf{A} and \mathbf{B} so that $|\mathbf{A}| = 5\sqrt{2}$, $|\mathbf{B}| = 4$ and so that $2\mathbf{A} + 5\mathbf{B} = j10(1 + \sqrt{3})$ and \mathbf{B} leads \mathbf{A} by 75° .

P 10.7-4 For the following voltage and current expressions, indicate whether the element is capacitive, inductive, or resistive and find the element value.

(a) $v = 15 \cos(400t + 30^\circ)$; $i = 3 \sin(400t + 30^\circ)$
 (b) $v = 8 \sin(900t + 50^\circ)$; $i = 2 \sin(900t + 140^\circ)$
 (c) $v = 20 \cos(250t + 60^\circ)$; $i = 5 \sin(250t + 150^\circ)$

Answer: (a) $L = 12.5$ mH
 (b) $C = 277.77$ μ F
 (c) $R = 4$ Ω

P 10.7-5 Two voltages appear in series so $v = v_1 + v_2$. Find v when $v_1 = 150 \cos(377t - \pi/6)$ V and $v_2 = 200 \angle +60^\circ$ V.
Answer: $v(t) = 250 \cos(377t + 23.1^\circ)$ V

Section 10.8 Impedance and Admittance

P 10.8-1 Find \mathbf{Z} and \mathbf{Y} for the circuit of Figure P 10.8-1 operating at 10 kHz.

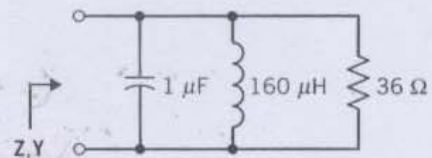


Figure P 10.8-1

P 10.8-2 Find R and L of the circuit of Figure P 10.8-2 when $v(t) = 10 \cos(\omega t + 40^\circ)$ V, $i(t) = 2 \cos(\omega t + 195^\circ)$ mA, and $\omega = 2 \times 10^6$ rad/s.

Answer: 4.532 k Ω , $L = 1.057$ mH

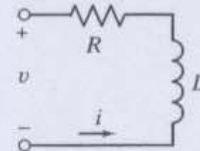


Figure P 10.8-2

P 10.8-3 Consider the circuit of Figure P 10.8-3 when $R = 6$ Ω , $L = 27$ mH, and $C = 22$ μ F. Determine the frequency f when the impedance \mathbf{Z} is purely resistive, and find the input resistance at that frequency.

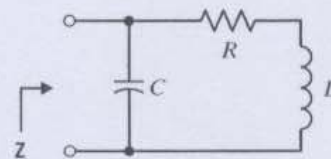


Figure P 10.8-3

P 10.8-4 Consider the circuit of Figure P 10.8-4 when $R = 10$ k Ω and $f = 1$ kHz. Find L and C so that $\mathbf{Z} = 100 + j0$ Ω .

Answer: $L = 0.1587$ H, $C = 0.158$ μ F.

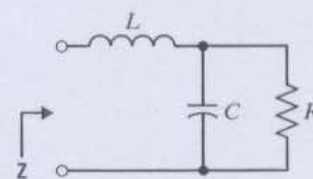


Figure P 10.8-4

P 10.8-5 For the circuit of Figure P 10.8-5 find the value of C required so that $\mathbf{Z} = 590.7$ Ω when $f = 1$ MHz.

Answer: $C = 0.27$ nF

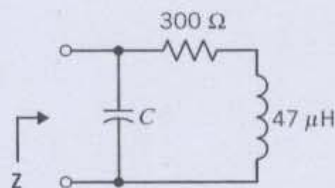


Figure P 10.8-5

Section 10.9 Kirchhoff's Laws Using Phasors

P 10.9-1 For the circuit shown in Figure P 10.9-1, find (a) the impedances Z_1 and Z_2 in polar form, (b) the total combined impedance in polar form, and (c) the steady-state current $i(t)$.

Answer: (a) $Z_1 = 5 \angle 53.1^\circ$; $Z_2 = 8\sqrt{2} \angle -45^\circ$
 (b) $Z_1 + Z_2 = 11.7 \angle -20^\circ$
 (c) $i(t) = (8.55)\cos(1250t + 20^\circ)$ A

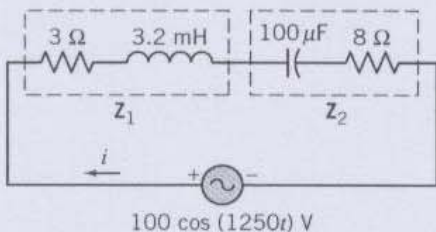


Figure P 10.9-1

P 10.9-2 Spinal cord injuries result in paralysis of the lower body and can cause loss of bladder control. Numerous electrical devices have been proposed to replace the normal nerve pathway stimulus for bladder control. Figure P 10.9-2 shows the model of a bladder control system where $v_s = 20 \cos \omega t$ V and $\omega = 100$ rad/s. Find the steady-state voltage across the 10 Ω load resistor.

Answer: $v(t) = 10\sqrt{2} \cos(100t + 45^\circ)$ V

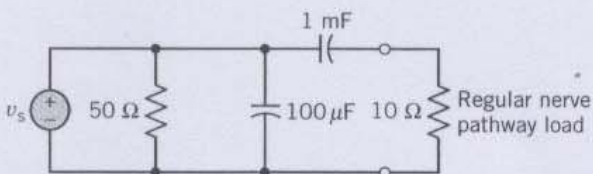


Figure P 10.9-2

P 10.9-3 There are 500 to 1000 deaths each year in the United States from electric shock. If a person makes a good contact with his hands, the circuit can be represented by Figure P 10.9-3, where $v_s = 160 \cos \omega t$ V and $\omega = 2\pi f$. Find the steady-state current i flowing through the body when (a) $f = 60$ Hz and (b) $f = 400$ Hz.

Answer: (a) $i(t) = 0.53 \cos(120\pi t + 5.9^\circ)$,
 (b) $i(t) = 0.625 \cos(800\pi t + 59.9^\circ)$ A

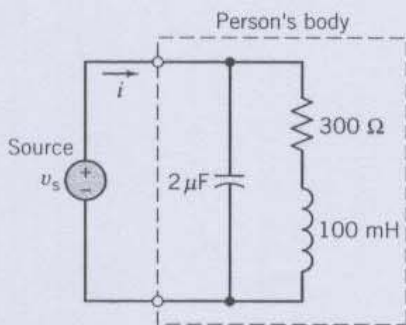


Figure P 10.9-3

P 10.9-4 Determine $i(t)$ of the RLC circuit shown in Figure P 10.9-4 when $v_s = 2 \cos(4t + 30^\circ)$ V.

Answer: $i(t) = 0.185 \cos(4t - 26.3^\circ)$ A

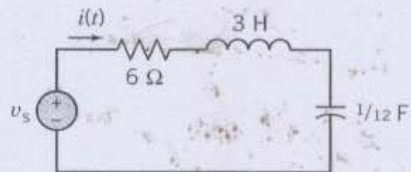


Figure P 10.9-4

P 10.9-5 The big toy from the hit movie *Big* is a child's musical fantasy come true—a sidewalk-sized piano. Like a hopscotch grid, this Christmas's hot toy invites anyone who passes to jump on, move about, and make music. The developer of the "toy" piano used a tone synthesizer and stereo speakers as shown in Figure P 10.9-5 (Gardner, 1988). Determine the current $i(t)$ for a tone at 796 Hz when $C = 10$ μ F.

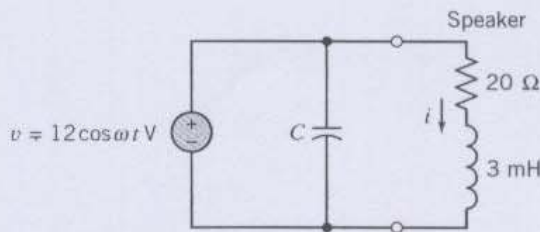


Figure P 10.9-5 Tone synthesizer.

P 10.9-6 Determine B and L for the circuit of Figure P 10.9-6 when $i(t) = B \cos(3t - 51.87^\circ)$ A.

Answer: $B = 1.6$, $L = 2$ H.

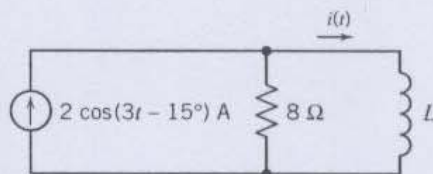


Figure P 10.9-6

Section 10.10 Node Voltage and Mesh Current Analysis Using Phasors

(a) Node Voltage Analysis

P 10.10-1 Find the phasor voltage V_c for the circuit shown in Figure P 10.10-1.

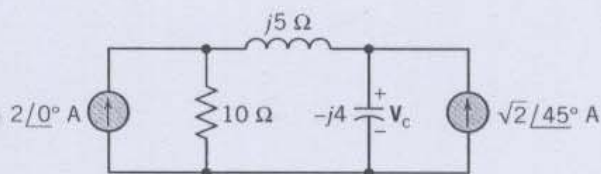


Figure P 10.10-1

P 10.10-2 For the circuit shown in Figure P 10.10-2, determine the phasor currents I_s , I_c , I_L , and I_R if $\omega = 1000$ rad/s.

Answer: $I_s = 0.347 \angle -25.5^\circ$ A
 $I_c = 0.461 \angle 112.9^\circ$ A
 $I_L = 0.720 \angle -67.1^\circ$ A
 $I_R = 0.230 \angle 22.9^\circ$ A

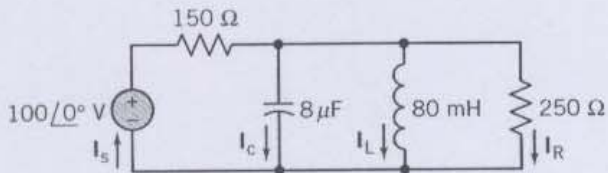


Figure P 10.10-2

P 10.10-3 Consider the circuit of Figure P 10.10-3. Using nodal analysis, find V_s when I in the 4Ω resistor is $3 \angle 45^\circ$ A.

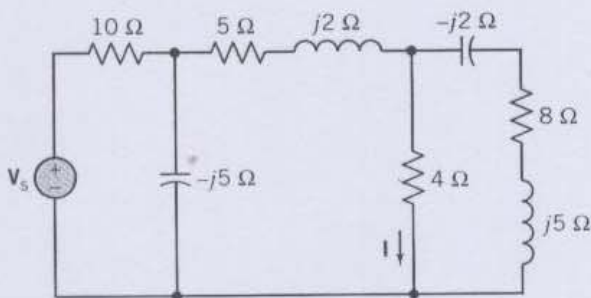


Figure P 10.10-3

P 10.10-4 Find the two node voltages $v_a(t)$ and $v_b(t)$ for the circuit of Figure P 10.10-4 when $v_s(t) = 1.2 \cos 4000t$.

Answer: $v_a(t) = 1.97 \cos(4000t - 171^\circ)$ V
 $v_b(t) = 2.21 \cos(4000t - 144^\circ)$ V

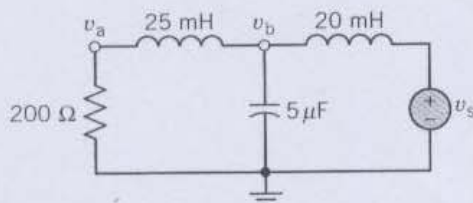


Figure P 10.10-4

P 10.10-5 The circuit shown in Figure P 10.10-5 has two sources: $v_s = 20 \cos(\omega_0 t + 90^\circ)$ V and $i_s = 6 \cos \omega_0 t$ A where $\omega_0 = 10^5$ rad/s. Determine $v_0(t)$.

Answer: $v_0(t) = 16.31 \cos(10^5 t + 71.5^\circ)$ V

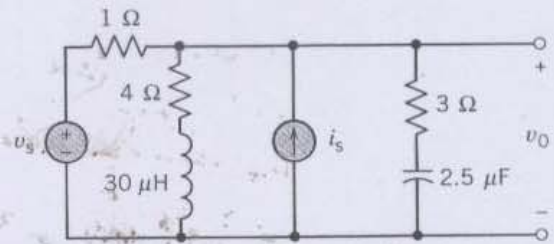


Figure P 10.10-5

P 10.10-6 Determine the voltage v_a for the circuit in Figure P 10.10-6 when $i_s = 20 \cos(\omega t + 53.13^\circ)$ A and $\omega = 10^4$ rad/s.

Answer: $v_a(t) = 339.4 \cos(10^4 t + 45^\circ)$ V

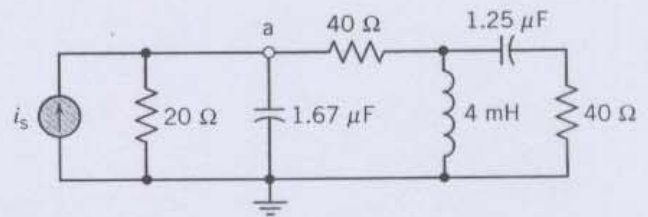


Figure P 10.10-6

P 10.10-7 A commercial airliner has sensing devices to indicate to the cockpit crew that each door and baggage hatch is closed. A device called a search coil magnetometer, also known as a proximity sensor, provides a signal indicative of the proximity of metal or other conducting material to an inductive sense coil. The inductance of the sense coil changes as the metal gets closer to the sense coil. The sense coil inductance is compared to a reference coil inductance with a circuit called a balanced inductance bridge (see Figure P 10.10-7). In the inductance bridge, a signal indicative of proximity is observed between terminals A and B by subtracting the voltage at B, v_B , from the voltage at A, v_A (Lenz, 1990).

The bridge circuit is excited by a sinusoidal voltage source $v_s = \sin(800 \pi t)$ V. The two resistors, $R = 100 \Omega$, are of equal resistance. When the door is open (no metal is present), the sense coil inductance, L_s , is equal to the reference coil inductance, $L_r = 40$ mH. In this case, what is the magnitude of the signal $V_A - V_B$?

When the airliner door is completely closed, $L_s = 60$ mH. With the door closed, what is the phasor representation of the signal $V_A - V_B$?

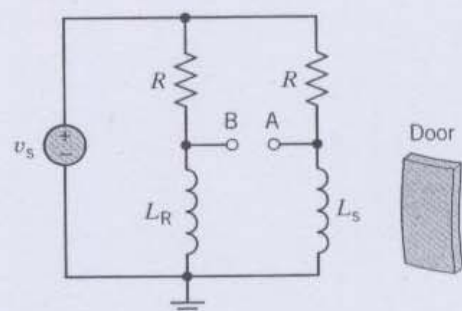


Figure P 10.10-7 Airline door sensing circuit.

P 10.10-8 Using a tiny diamond-studded burr operating at 190,000 rpm, cardiologists can remove life-threatening plaque deposits in coronary arteries. The procedure is fast, uncomplicated, and relatively painless (McCarty, 1991). The Rotablator, an angioplasty system, consists of an advancer/catheter, a guide wire, a console, and a power source. The advancer/catheter contains a tiny turbine that drives the flexible shaft that rotates the catheter burr. The model of the operational and control circuit is shown in Figure P 10.10-8. Determine $v(t)$, the voltage that drives the tip, when $v_s = \sqrt{2} \cos(40t + 135^\circ)$ V.

Answer: $v(t) = 1.414 \cos(40t - 135^\circ)$ V

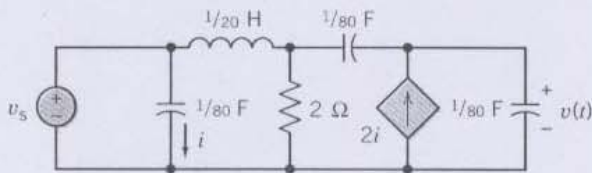


Figure P 10.10-8 Control circuit for Rotablator.

P 10.10-9 For the circuit of Figure P 10.10-9, it is known that

$$v_2(t) = 0.7571 \cos(2t + 66.7^\circ) \text{ V}$$

$$v_3(t) = 0.6064 \cos(2t - 69.8^\circ) \text{ V}$$

Determine $i_1(t)$.

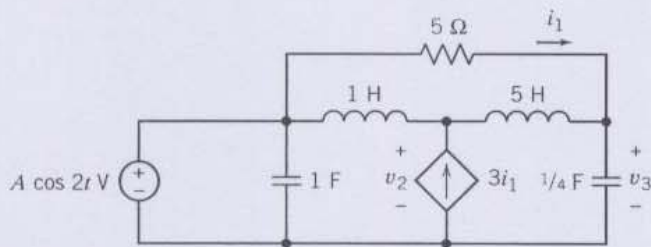


Figure P 10.10-9

Section 10.10 Node Voltage and Mesh Current Analysis Using Phasors

(b) Mesh Current Analysis

P 10.10-10 Determine I_1 , I_2 , V_L , and V_c for the circuit of Figure P 10.10-10 using KVL and mesh analysis.

Answer: $I_1 = 2.5 \angle 29.0^\circ$ A

$I_2 = 1.8 \angle 105^\circ$ A

$V_L = 16.3 \angle 78.7^\circ$ V

$V_c = 7.2 \angle 15^\circ$ V

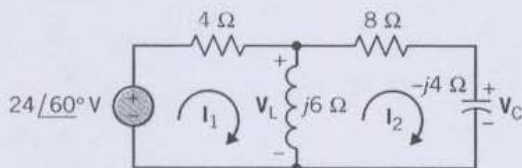


Figure P 10.10-10

P 10.10-11 The model of a high-frequency transistor amplifier is shown in Figure P 10.10-11 with a source voltage and a load resistor. The source voltage is $v_s = 10 \cos \omega t$ where $\omega = 10^8$ rad/s. Find the voltage across the load resistor.

Answer: $v_L(t) = 9.59 \times 10^4 \cos(10^8 t + 175.6^\circ)$ V

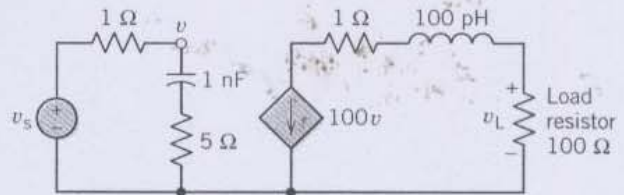


Figure P 10.10-11 Model of a high-frequency transistor amplifier.

P 10.10-12 Determine the current $i(t)$ for the circuit of Figure P 10.10-12 using mesh currents when $\omega = 1000$ rad/s.

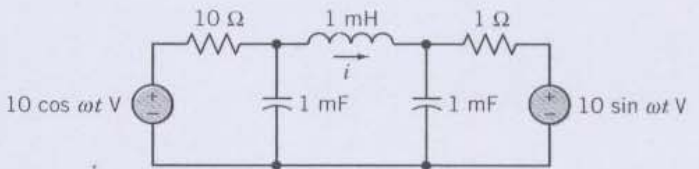


Figure P 10.10-12

P 10.10-13 The idea of using an induction coil in a lamp isn't new, but applying it in a commercially available product is. An induction coil in a bulb induces a high-frequency energy flow in mercury vapor to produce light. The lamp uses about the same amount of energy as a fluorescent bulb but lasts six times longer, with 60 times the life of a conventional incandescent bulb. The circuit model of the bulb and its associated circuit are shown in Figure P 10.10-13. Determine the voltage $v(t)$ across the 2 Ohm resistor when $C = 40 \mu\text{F}$, $L = 40 \mu\text{H}$, $v_s = 10 \cos(\omega_0 t + 30^\circ)$, and $\omega_0 = 10^5$ rad/s.

Answer: $v(t) = 6.45 \cos(10^5 t + 44^\circ)$ V

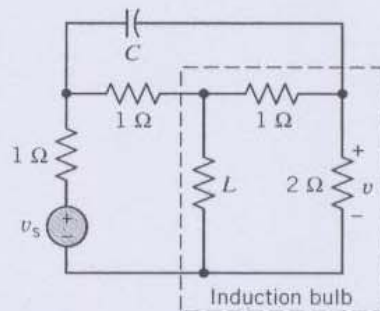


Figure P 10.10-13 Induction bulb circuit.

P 10.10-14 The development of coastal hotels in various parts of the world is a rapidly growing enterprise. The need for environmentally acceptable shark protection is manifest

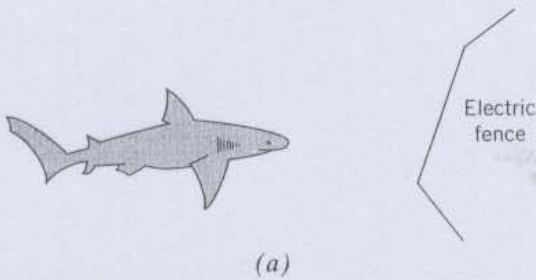
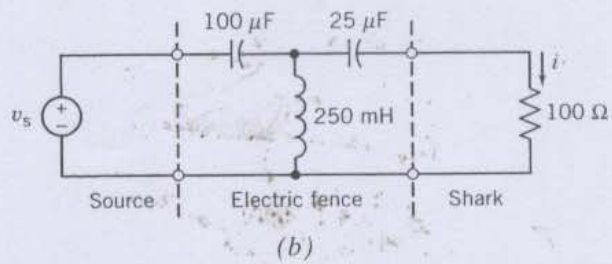


Figure P 10.10-14 Electric fence for repelling sharks.



where these developments take place alongside shark-infested waters (Smith, 1991). One concept is to use an electrified line submerged in the water in order to deter the sharks, as shown in Figure P 10.10-14a. The circuit model of the electric fence is shown in Figure P 10.10-14b where the shark is represented by an equivalent resistance of 100Ω . Determine the current flowing through the shark's body, $i(t)$, when $v_s = 375 \cos 400t$ V.

Section 10.11 Superposition, Thévenin and Norton Equivalent Circuits, and Source Transformations

(a) Superposition Principle

P 10.11-1 For the circuit of Figure P 10.11-1 find $i(t)$ when $v_1 = 12 \cos(4000t + 45^\circ)$ V and $v_2 = 5 \cos 3000t$ V.

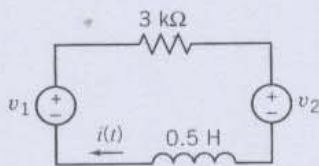


Figure P 10.11-1

P 10.11-2 Determine $i(t)$ for the circuit of Figure P 10.11-2. **Hint:** Replace the voltage source by a series combination of a dc voltage and a sinusoidal voltage source.

Answer: $i(t) = 0.166 \cos(4t - 135^\circ) + 0.5$ mA

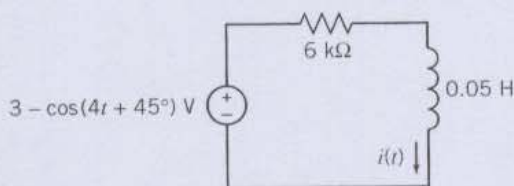


Figure P 10.11-2

P 10.11-3 Determine $i(t)$ for the circuit of Figure P 10.11-3. **Answer:** $i(t) = 2 \cos(4t + 45^\circ) - 0.833 \cos(3t - 90^\circ)$ mA

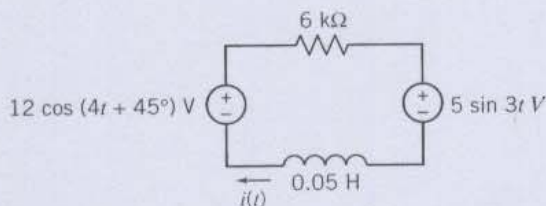


Figure P 10.11-3

Section 10.11 Superposition, Thévenin and Norton Equivalent Circuits, and Source Transformations

(b) Thévenin and Norton Equivalent Circuits

P 10.11-4 Determine the Thévenin equivalent circuit for the circuit shown in Figure P10.11-4 when $v_s = 5 \cos(4000t - 30^\circ)$.

Answer: $V_t = 5.7 \angle -21.9^\circ$ V
 $Z_t = 23 \angle -81.9^\circ \Omega$

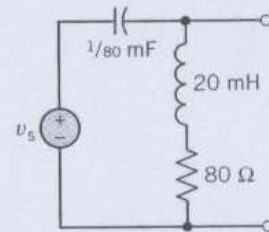


Figure P 10.11-4

P 10.11-5 Find $v_x(t)$ by first replacing the circuit to the left of terminals a-b in Figure P 10.11-5 with its Thévenin equivalent circuit when $C = 10$ mF.

Answer: $v_x(t) = 33.13 \cos(20t - 83.66^\circ)$ V

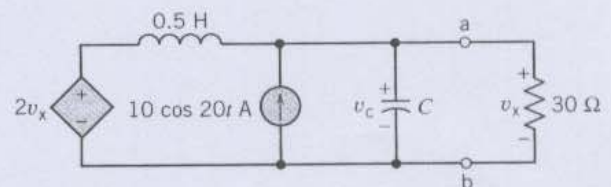


Figure P 10.11-5

P 10.11-6 Find the Thévenin equivalent circuit for the circuit shown in Figure P 10.11-6 using the mesh current method.

Answer: $V_t = 3.71 \angle -16^\circ$ V
 $Z_t = 247 \angle -16^\circ \Omega$

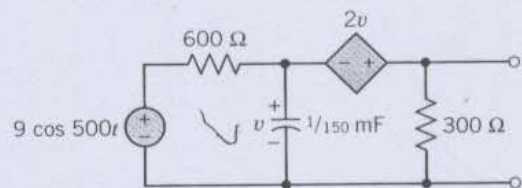


Figure P 10.11-6

P 10.11-7 For the circuit shown in Figure P 10.11-7, find the capacitance, C , if $v(t) = 100\sqrt{2} \cos(100t - 45^\circ)$ V.

Answer: $C = 1/800$ F

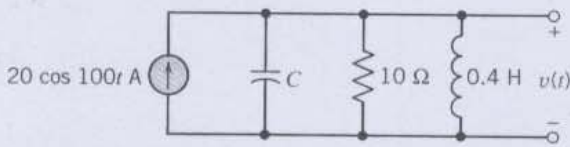


Figure P 10.11-7

at which the admittance \mathbf{Y} is a pure conductance. What is the "number" of this station on the AM radio dial?

Answer: $f_0 = 800$ Hz, which corresponds to 80 on the AM radio dial.

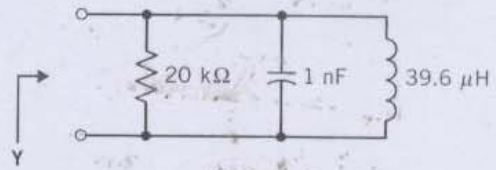


Figure P 10.11-10

P 10.11-8 A pocket-sized mini-disk CD player system has an amplifier circuit shown in Figure P 10.11-8 with a signal $v_s = 10 \cos(\omega t + 53.1^\circ)$ at $\omega = 10,000$ rad/s. Determine the Thévenin equivalent at the output terminals a–b.

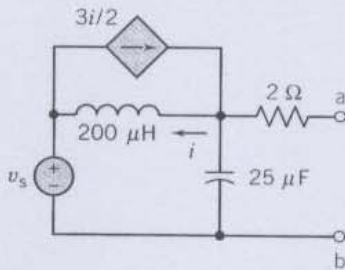


Figure P 10.11-8

P 10.11-11 A linear circuit is placed within a black box with only the terminals a–b available as shown in Figure P 10.11-11. There are three elements available in the laboratory: (1) a 50 Ω resistor, (2) a 2.5- μ F capacitor, and (3) a 50-mH inductor. These three elements are placed across terminals a–b as the load \mathbf{Z}_L , and the magnitude of \mathbf{V} is measured as (1) 25 V, (2) 100 V, and (3) 50 V, respectively. It is known that the sources within the box are sinusoidal with $\omega = 2 \times 10^3$ rad/s. Determine the Thévenin equivalent for the circuit in the box as shown in Figure P 10.11-11.

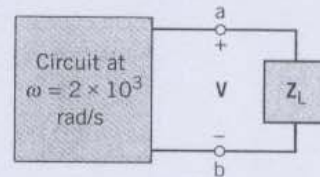


Figure P 10.11-11 A circuit within a black box is connected to a selected impedance \mathbf{Z}_L .

P 10.11-9 In the analysis of guided waves on transmission lines, circuit theory is often used. One of the simplest unit-length circuit models of a transmission line is shown in Figure P 10.11-9. The transmission line is represented by L and C , and the load by R . A line has $L = 97.5$ nH and $C = 39$ pF and operates at 100 MHz. Determine the input impedance when $R = 25 \Omega$ and 50Ω . Note that this circuit translates one of the resistances almost exactly to the input impedance. This resistance is the characteristic impedance or resistance of the transmission line.

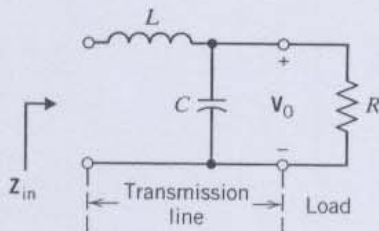


Figure P 10.11-9 Circuit model of transmission line.

Section 10.11 Superposition, Thévenin and Norton Equivalents, and Source Transformations
(c) Source Transformations

P 10.11-12 Consider the circuit of Figure P 10.11-12, where we wish to determine the current \mathbf{I} . Use a series of source transformations to find a current source in parallel with an equivalent impedance, and then find the current in the 2 Ω resistor by current division.

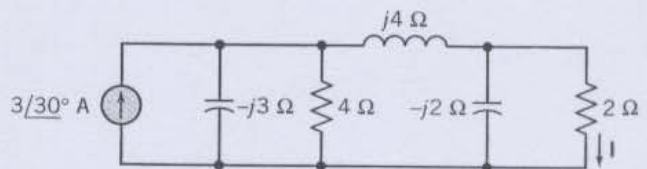


Figure P 10.11-12

P 10.11-10 An AM radio receiver uses the parallel RLC circuit shown in Figure P 10.11-10. Determine the frequency, f_0 ,

P 10.11-13 For the circuit of Figure P 10.11-13 determine the current \mathbf{I} using a series of source transformations. The source has $\omega = 25 \times 10^3$ rad/s.

Answer: $i(t) = 4 \cos(25000t - 44^\circ)$ mA

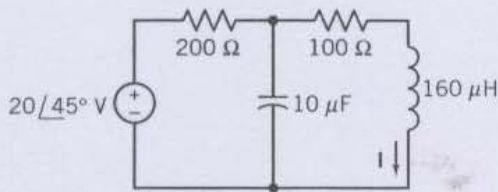


Figure P 10.11-13

Section 10.12 Phasor Diagrams

P 10.12-1 Using a phasor diagram determine \mathbf{V} when $\mathbf{V} = \mathbf{V}_1 - \mathbf{V}_2 + \mathbf{V}_3^*$ and $\mathbf{V}_1 = 3 + j3$, $\mathbf{V}_2 = 4 + j2$, and $\mathbf{V}_3 = -3 - j2$. (Units are volts.)

Answer: $\mathbf{V} = 5 \angle 143.1^\circ \text{ V}$

P 10.12-2 Consider the series RLC circuit of Figure P 10.12-2 when $R = 10 \Omega$, $L = 1 \text{ mH}$, $C = 100 \mu\text{F}$, and $\omega = 10^3 \text{ rad/s}$. Find \mathbf{I} and plot the phasor diagram.

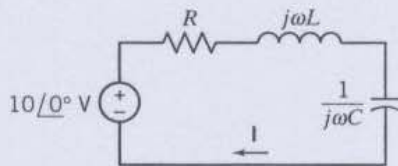


Figure P 10.12-2

P 10.12-3 Consider the signal

$$i(t) = 72\sqrt{3} \cos 8t + 36\sqrt{3} \sin(8t + 140^\circ) + 144 \cos(8t + 210^\circ) + 25 \cos(8t + \phi)$$

Using the phasor plane, for what value of ϕ does the $|I|$ attain its maximum?

Section 10.14 Phasor Circuits and the Operational Amplifier

P 10.14-1 Find the steady-state response $v_0(t)$ if $v_s(t) = \sqrt{2} \cos 1000t$ for the circuit of Figure P 10.14-1. Assume an ideal op amp.

Answer: $v_0(t) = 10 \cos(1000t - 225^\circ)$

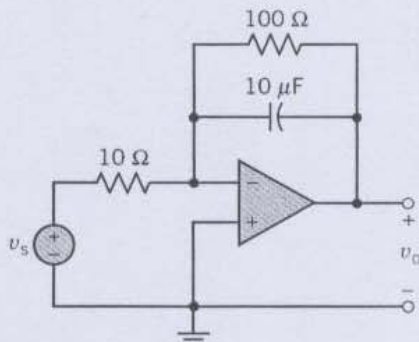


Figure P 10.14-1

P 10.14-2 Determine V_0/V_s for the op amp circuit shown in Figure P 10.14-2. Assume an ideal op amp.

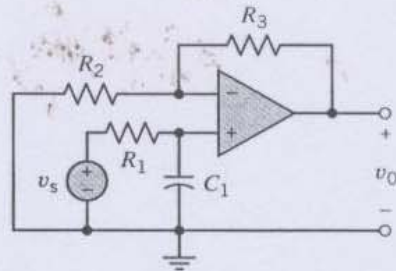


Figure P 10.14-2 Amplifier circuit for disk player.

P 10.14-3 Determine V_0/V_s for the op amp circuit shown in Figure P 10.14-3. Assume an ideal op amp.

Answer: $\frac{V_0}{V_s} = \frac{j\omega R_1 C_1 (1 + R_3/R_2)}{1 + j\omega R_1 C_1}$

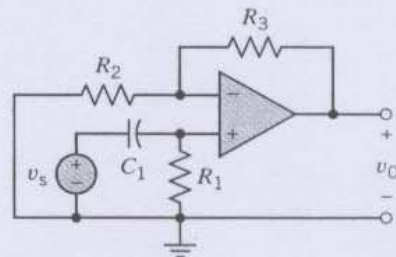


Figure P 10.14-3

P 10.14-4 For the circuit of Figure P 10.14-4 determine $v_0(t)$ when $v_s = 5 \cos \omega t \text{ mV}$ and $f = 10 \text{ kHz}$.

Answer: $v_0 = 0.5 \cos(\omega t - 89.5^\circ) \text{ mV}$

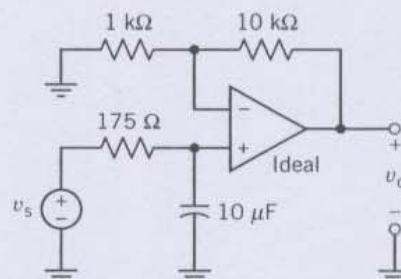


Figure P 10.14-4