Answers to Odd-Numbered Problems

Chapter 1

1.1 (a) −103.84 mC, (b) −198.65 mC, (c) −3.941 C, (d) −26.08 C

1.3 (a) $3t + 1$ C, (b) $t^2 + 5t$ mC, (c) $2\sin(10t + \pi/6) + 1\ \mu$C, (d) $-e^{-30t}[0.16\cos 40t + 0.12\sin 40t]$ C

1.5 25 C

1.7
$$i = \frac{dq}{dt} = \begin{cases} 10\text{ A}, & 0 < t < 1 \\ -20\text{ A}, & 1 < t < 2 \\ 0\text{ A}, & 2 < t < 3 \\ 10\text{ A}, & 3 < t < 4 \end{cases}$$

See the sketch in Fig. D.1.

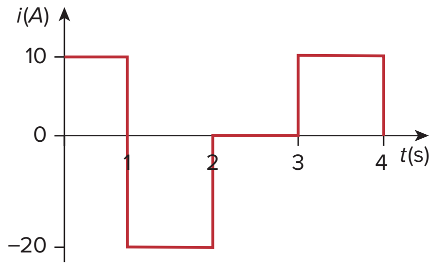


Figure D.1
For Prob. 1.7.

1.9 (a) 10 C, (b) 22.5 C, (c) 30 C

1.11 3.888 kC, 5.832 kJ

1.13 123.37 mW, 58.76 mJ

1.15 (a) 2.945 mC, (b) $-720e^{-4t}\ \mu$W, (c) −180 μJ

1.17 10 W absorbed

1.19 −6 A, −150 W, 60 W, 54 W, 36 W

1.21 2.696×10^{23} electrons, 43,200 C

1.23 $1.35

1.25 10.08 cents

1.27 (a) 43.2 kC, (b) 475.2 kJ, (c) 1.188 cents

1.29 39.6 cents

1.31 $6.451

1.33 6 C

1.35 2.333 MWh

1.37 46.3 A-hour

1.39 24 cents

Chapter 2

2.1 This is a design problem with several answers.

2.3 184.3 mm

2.5 $n = 9$, $b = 15$, $l = 7$

2.7 6 branches and 4 nodes

2.9 5 A, −8 A, 4 A

2.11 6 V, 3 V

2.13 12 A, −10 A, 5 A, −2 A

2.15 6 V, −4 A

2.17 2 V, −22 V, 10 V

2.19 −2 A, 12 W, −24 W, 20 W, 16 W

2.21 4.167 V

2.23 −100 V, 960 W

2.25 0.1 A, 2 kV, 0.2 kW

2.27 1 A

2.29 3.5 Ω

2.31 56 A, 8 A, 48 A, 32 A, 16 A

2.33 3 V, 6 A

2.35 32 V, 800 mA

2.37 60 Ω

2.39 (a) 2.182 Ω, (b) 1.5 kΩ

2.41 16 Ω

2.43 (a) 12 Ω, (b) 16 Ω

2.45 (a) 59.8 Ω, (b) 32.5 Ω

2.47 24 Ω

2.49 (a) 20 Ω, (b) R_{an} = 45 Ω, R_{bn} = 7.5 Ω, R_{cn} = 15 Ω

2.51 (a) 9.231 Ω, (b) 36.25 Ω

2.53 (a) 142.32 Ω, (b) 33.33 Ω

2.55 119.75 mA

2.57 32.44 Ω, 1.5413 A

2.59 P_{40W} = 102.4 W (means that this immediately burns out), P_{60W} = 9.6 W, P_{100W} = 16 W. The best way to wire the bulbs is to connect the 100-W bulb in series with a parallel combination of the 60-W bulb and the 40-W bulb.

2.61 Use R_1 and R_3 bulbs

2.63 0.4 Ω, ≅ 1 W

2.65 So, our circuit consists of the meter in series with an 18-kΩ resistor.

2.67 (a) 4 V, (b) 2.857 V, (c) 28.57%, (d) 6.25%

2.69 (a) 6.662 V (with), 6.786 V (without)
(b) 24.61 V (with), 26.39 V (without)
(c) 62.5 V (with), 75.4 V (without)

2.71 22.5 Ω

2.73 45 Ω

2.75 8 Ω

2.77 (a) Four 20-Ω resistors in parallel
(b) One 300-Ω resistor in series with a 1.8-Ω resistor and a parallel combination of two 20-Ω resistors
(c) Two 24-kΩ resistors in parallel connected in series with two 56-kΩ resistors in parallel
(d) A series combination of a 20-Ω resistor, 300-Ω resistor, 24-kΩ resistor, and a parallel combination of two 56-kΩ resistors

2.79 75 Ω

2.81 6.667 kΩ, 5 kΩ

2.83 3.84 kΩ, ∞ Ω (best answer)

Chapter 3

3.1 This is a design problem with several answers.

3.3 −6 A, −3 A, −2 A, 1 A, −60 V

3.5 −60 V

3.7 20 V

3.9 79.34 mA

3.11 3 V, 293.9 W, 750 mW, 121.5 W

3.13 583.3 V, 100 V

3.15 29.45 A, 144.6 W, 129.6 W, 12 W

3.17 1.73 A

3.19 10 V, 4.933 V, 12.267 V

3.21 −15 V, 0 V

3.23 90 V

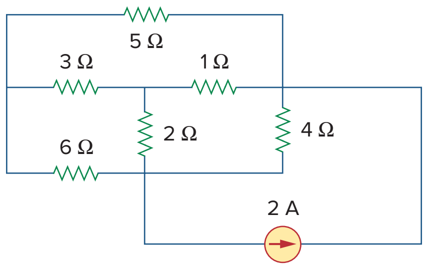
3.25 25.52 V, 22.05 V, 14.842 V, 15.055 V

3.27 625 mV, 375 mV, 1.625 V

3.29 −0.7708 V, 1.209 V, 2.309 V, 0.7076 V

3.31 4.97 V, 4.85 V, −0.12 V

3.33 (a) and (b) are both planar and can be redrawn as shown in Fig. D.2.



(a)

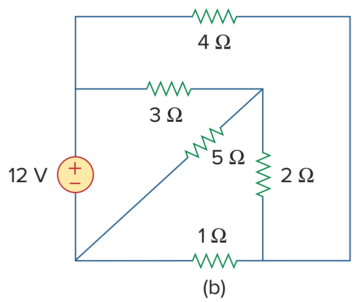


Figure D.2
For Prob. 3.33.

3.35 20 V

3.37 12 V

3.39 This is a design problem with several different answers.

3.41 1.188 A

3.43 1.7778 A, 53.33 V

3.45 8.561 A

3.47 10 V, 4.933 V, 12.267 V

3.49 114 V, 36 A

3.51 233.3 V

3.53 1.6196 mA, −1.0202 mA, −2.461 mA, 3 mA, −2.423 mA

3.55 −1 A, 0 A, 2 A

3.57 12 kΩ, 120 V, 80 V

3.59 −4.48 A, −1.0752 kV

3.61 −0.2813

3.63 −4 V, 2.105 A

3.65 2.17 A, 1.9912 A, 1.8119 A, 2.094 A, 2.249 A

3.67 −30 V

3.69 $$\begin{bmatrix} 0.35 & -0.1 & -0.05 \\ -0.1 & 0.4 & -0.2 \\ -0.05 & -0.2 & 0.25 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 100 \\ 50 \\ -10 \end{bmatrix}$$

3.71 6.255 A, 1.9599 A, 3.694 A

3.73 $$\begin{bmatrix} 30 & -10 & -10 & 0 \\ -10 & 40 & -10 & 0 \\ -10 & -10 & 50 & -10 \\ 0 & 0 & -10 & 20 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 15 \\ 0 \\ 25 \\ -10 \end{bmatrix}$$

3.75 −3 A, 0 A, 3 A

3.77 3.111 V, 1.4444 V

3.79 −10.556 V, 20.56 V, 1.3889 V, −43.75 V

3.81 26.67 V, 6.667 V, 173.33 V, −46.67 V

3.83 See Fig. D.3; −12.5 V

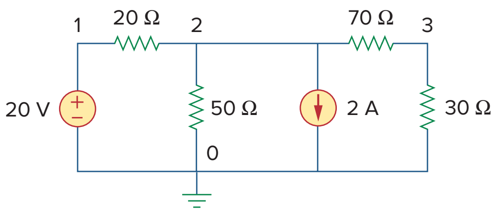


Figure D.3
For Prob. 3.83.

3.85 9 Ω

3.87 −5

3.89 22.5 μA, 12.75 V

3.91 0.8078 μA, 8.345 V, 48.79 mV

3.93 1.333 A, 1.333 A, 2.6667 A

Chapter 4

4.1 600 mA, 250 V

4.3 (a) 0.5 V, 0.5 A, (b) 5 V, 5 A, (c) 5 V, 500 mA

4.5 4.5 V

4.7 888.9 mV

4.9 2 A

4.11 17.99 V, 1.799 A

4.13 8.696 V

4.15 1.875 A, 10.55 W

4.17 −8.571 V

4.19 −16 V

4.21 This is a design problem with multiple answers.

4.23 1 A, 8 W

4.25 −6.6 V

4.27 −48 V

4.29 3 V

4.31 9.13 V

4.33 80 V, 33 Ω, 2 A

4.35 −125 mV

4.37 5 kΩ, 1 mA

4.39 20 Ω, −84 V

4.41 4 Ω, −8 V, −2 A

4.43 10 Ω, 0 V

4.45 3 Ω, 15 V

4.47 20 V, 20 Ω, 1 A

4.49 28 Ω, 3.286 V

4.51 (a) 2 Ω, 7 A, (b) 1.5 Ω, 12.667 A

4.53 10 Ω, −3 A

4.55 100 kΩ, −20 mA

4.57 10 Ω, 166.67 V, 16.667 A

4.59 22.5 Ω, 40 V, 1.7778 A

4.61 1.2 Ω, 9.6 V, 8 A

4.63 −3.333 Ω, 0 A

4.65 $V_0 = 24 - 5I_0$

4.67 25 kΩ, 49 mW

4.69 ∞ (theoretically)

4.71 8 kΩ, 1.152 W

4.73 20.77 W

4.75 250 Ω, 12 mW

4.77 (a) 3.8 Ω, 4 V, (b) 3.2 Ω, 15 V

4.79 10 Ω, 167 V

4.81 3.3 Ω, 10 V (Note, values obtained graphically)

4.83 8 Ω, 72 V

4.85 (a) 80 V, 30 kΩ, (b) 32 V

4.87 (a) 10 mA, 8 kΩ, (b) 9.926 mA

4.89 (a) 99.99 μA, (b) 99.99 μA

4.91 (a) 150 Ω, 25 Ω, (b) 150 Ω, 250 Ω

4.93 $\dfrac{V_s}{R_s + (1 + \beta)R_o}$

4.95 10.667 V, 33.33 kΩ

4.97 2 kΩ, 5 V

Chapter 5

5.1 60 μV

5.3 10 V

5.5 0.999990

5.7 −100 nV, −10 mV

5.9 2 V, 2 V

5.11 This is a design problem with multiple answers.

5.13 2.7 V, 288 μA

5.15 (a) $-\left(R_1 + R_3 + \dfrac{R_1 R_3}{R_2}\right)$, (b) −92 kΩ

5.17 (a) −2.4, (b) −16, (c) −400

5.19 −562.5 μA

5.21 −3 V

5.23 $-\dfrac{R_f}{R_1}$

5.25 9.375 V

5.27 2.7 V

5.29 $\dfrac{R_2}{R_1}$

5.31 4.545 mA

5.33 75 mW, −1 mA

5.35 If $R_i = 60$ k, $R_f = 390$ k.

5.37 -13.6 V

5.39 7 V

5.41 See Fig. D.4.

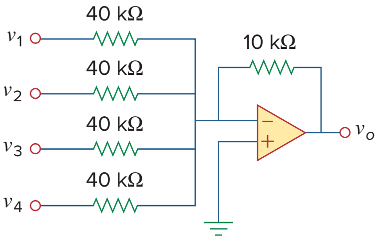


Figure D.4
For Prob. 5.41.

5.43 200 k.

5.45 This is a design problem with many correct answers. One possible design is shown in Fig. D.5.

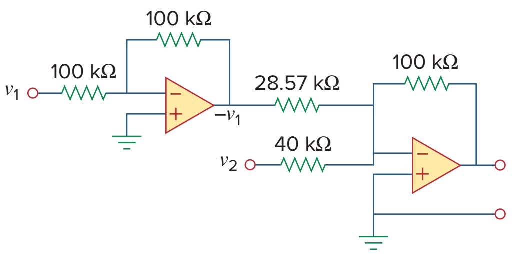


Figure D.5
For Prob. 5.45.

5.47 14.09 V

5.49 $R_1 = R_3 = 20$ kΩ, $R_2 = R_4 = 80$ kΩ

5.51 See Fig. D.6.

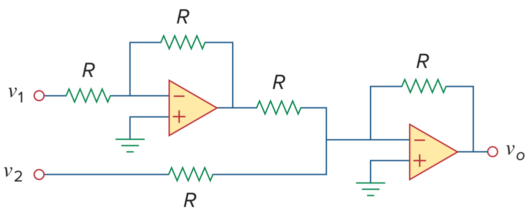


Figure D.6
For Prob. 5.51.

5.53 Proof.

5.55 7.956, 7.956, 1.989

5.57 $6v_{s1} - 6v_{s2}$

5.59 -12

5.61 7.2 V

5.63 $\dfrac{R_2R_4/R_1R_5 - R_4/R_6}{1 - R_2R_4/R_3R_5}$

5.65 2 V

5.67 -1.6 V

5.69 -25.71 mV

5.71 7.5 V

5.73 32.4 V

5.75 -2, 200 μA

5.77 -6.686 mV

5.79 -4.992 V

5.81 343.4 mV, 24.51 μA

5.83 The result depends on your design. Hence, let $R_G = 10$ k ohms, $R_1 = 10$ k ohms, $R_2 = 20$ k ohms, $R_3 = 40$ k ohms, $R_4 = 80$ k ohms, $R_5 = 160$ k ohms, $R_6 = 320$ k ohms, then,

$$\begin{aligned}-v_o &= (R_f/R_1)v_1 + \text{———} + (R_f/R_6)v_6 \\ &= v_1 + 0.5v_2 + 0.25v_3 + 0.125v_4 \\ &\quad + 0.0625v_5 + 0.03125v_6\end{aligned}$$

(a) $|v_o| = 1.1875 = 1 + 0.125 + 0.0625 = 1 + (1/8) + (1/16)$, which implies, $[v_1\ v_2\ v_3\ v_4\ v_5\ v_6] = [\mathbf{100110}]$

(b) $|v_o| = 0 + (1/2) + (1/4) + 0 + (1/16) + (1/32) = (27/32) = \mathbf{843.75\ mV}$

(c) This corresponds to [111111].

$$\begin{aligned}|v_o| &= 1 + (1/2) + (1/4) + (1/8) + (1/16) \\ &\quad + (1/32) \\ &= 63/32 = \mathbf{1.96875\ V}\end{aligned}$$

5.85 $R = 200$ kΩ, 2,000

5.87 $\left(1 + \dfrac{R_4}{R_3}\right)v_2 - \left[\left(\dfrac{R_4}{R_3}\right) + \left(\dfrac{R_2R_4}{R_1R_3}\right)\right]v_1$

Let $R_4 = R_1$ and $R_3 = R_2$;

then $v_0 = \left(1 + \dfrac{R_4}{R_3}\right)(v_2 - v_1)$

a subtractor with a gain of $\left(1 + \dfrac{R_4}{R_3}\right)$.

5.89 A summer with $v_0 = -v_1 - (5/3)v_2$ where $v_2 = 6$ V battery and an inverting amplifier with $v_1 = -12\ v_s$.

5.91 9

5.93 $A = \dfrac{1}{\left(1 + \frac{R_1}{R_3}\right)R_L - R_1\left(\frac{R_2 + R_L}{R_2R_3}\right)\left(R_4 + \frac{R_2R_L}{R_2 + R_L}\right)}$

Chapter 6

6.1 $15(1 - 3t)e^{-3t}$ A, $30t(1 - 3t)e^{-6t}$ W

6.3 This is a design problem with multiple answers.

6.5 $v = \begin{cases} 20 \text{ mA}, & 0 < t < 2 \text{ ms} \\ -20 \text{ mA}, & 2 < t < 6 \text{ ms} \\ 20 \text{ mA}, & 6 < t < 8 \text{ ms} \end{cases}$

6.7 $[0.1t^2 + 10]$ V

6.9 13.624 V, 70.66 W

6.11 $v(t) = \begin{cases} 10 + 3.75t \text{ V}, & 0 < t < 2\text{s} \\ 22.5 - 2.5t \text{ V}, & 2 < t < 4\text{s} \\ 12.5 \text{ V}, & 4 < t < 6\text{s} \\ 2.5t - 2.5 \text{ V}, & 6 < t < 8\text{s} \end{cases}$

6.13 $v_1 = 42$ V, $v_2 = 48$ V

6.15 (a) 125 mJ, 375 mJ, (b) 70.31 mJ, 23.44 mJ

6.17 (a) 3 F, (b) 8 F, (c) 1 F

6.19 10 μF

6.21 2.5 μF

6.23 This is a design problem with multiple answers.

6.25 (a) For the capacitors in series,

$$Q_1 = Q_2 \rightarrow C_1 v_1 = C_2 v_2 \rightarrow \frac{v_1}{v_2} = \frac{C_2}{C_1}$$

$$v_s = v_1 + v_2 = \frac{C_2}{C_1}v_2 + v_2 = \frac{C_1 + C_2}{C_1}v_2$$

$$\rightarrow v_2 = \frac{C_1}{C_1 + C_2}v_s$$

Similarly, $v_1 = \dfrac{C_2}{C_1 + C_2}v_s$

(b) For capacitors in parallel,

$$v_1 = v_2 = \frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

$$Q_s = Q_1 + Q_2 = \frac{C_1}{C_2}Q_2 + Q_2 = \frac{C_1 + C_2}{C_2}Q_2$$

or

$$Q_2 = \frac{C_2}{C_1 + C_2}$$

$$Q_1 = \frac{C_1}{C_1 + C_2}Q_s$$

$$i = \frac{dQ}{dt} \rightarrow i_1 = \frac{C_1}{C_1 + C_2}i_s,$$

$$i_2 = \frac{C_2}{C_1 + C_2}i_s$$

6.27 2.5 μF, 40 μF

6.29 (a) 1.6 C, (b) 1 C

6.31 $v(t) = \begin{cases} 1.5t^2 \text{ kV}, & 0 < t < 1\text{s} \\ [3t - 1.5] \text{ kV}, & 1 < t < 3\text{s}; \\ [0.75t^2 - 7.5t + 23.25] \text{ kV}, & 3 < t < 5\text{s} \end{cases}$

$i_1 = \begin{cases} 18t \text{ mA}, & 0 < t < 1\text{s} \\ 18 \text{ mA}, & 1 < t < 3\text{s}; \\ [9t - 45] \text{ mA}, & 3 < t < 5\text{s} \end{cases}$

$i_2 = \begin{cases} 12t \text{ mA}, & 0 < t < 1\text{s} \\ 12 \text{ mA}, & 1 < t < 3\text{s} \\ [6t - 30] \text{ mA}, & 3 < t < 5\text{s} \end{cases}$

6.33 15 V, 10 F

6.35 3.2 mH

6.37 $4.8 \cos 100t$ V, 96 mJ

6.39 $[-50e^{-2t} + 50 + 20t^2 + 80t]$ A

6.41 5.977 A, 35.72 J

6.43 270 μJ

6.45 $i(t) = \begin{cases} 100t^2 \text{ A}, & 0 < t < 1\text{s} \\ [400 - 400t + 100t^2] \text{ A}, & 1 < t < 2\text{s} \end{cases}$

6.47 5 Ω

6.49 15 mH

6.51 7.778 mH

6.53 20 mH

6.55 (a) 1.4 L, (b) 500 mL

6.57 6.625 H

6.59 Proof.

6.61 (a) 6.667 mH, e^{-t} mA, $2e^{-t}$ mA
(b) $-20e^{-t}$ μV (c) 1.3534 nJ

6.63 See Fig. D.7.

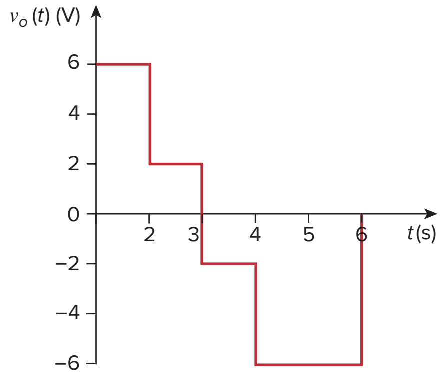


Figure D.7
For Prob. 6.63.

6.65 (a) 40 J, 40 J, (b) 80 J, (c) $5 \times 10^{-5}(e^{-200t} - 1) + 4$ A, $1.25 \times 10^{-5}(e^{-200t} - 1) - 2$ A
(d) $6.25 \times 10^{-5}(e^{-200t} - 1) + 2$ A

6.67 100 cos(50t) mV

6.69 See Fig. D.8.

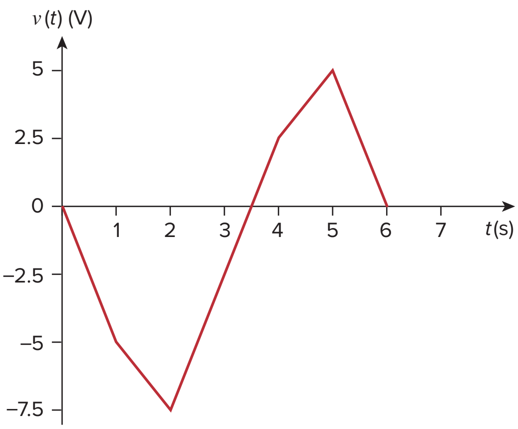


Figure D.8
For Prob. 6.69.

6.71 By combining a summer with an integrator, we get the circuit shown in Fig. D.9 where $C = 5\ \mu$F, $R_1 = 200$ kΩ, $R_2 = 50$ kΩ, and $R_3 = 20$ kΩ.

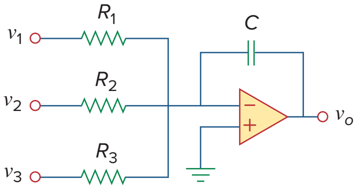


Figure D.9
For Prob. 6.71.

$$v_o = -\frac{1}{R_1 C}\int v_1\,dt - \frac{1}{R_2 C}\int v_2\,dt - \frac{1}{R_2 C}\int v_2\,dt$$

For the given problem, $C = 2\ \mu$F : $R_1 = 500$ kΩ, $R_2 = 125$ kΩ, $R_3 = 50$ kΩ.

6.73 Consider the op amp as shown in Fig. D.10.

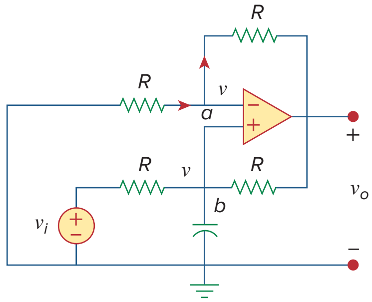


Figure D.10
For Prob. 6.73.

Let $v_a = v_b = v$. At node a,

$$\frac{0 - v}{R} = \frac{v - v_0}{R} \longrightarrow 2v - v_0 = 0 \qquad \textbf{(1)}$$

At node b, $\dfrac{v_i - v}{R} = \dfrac{v - v_0}{R} + C\dfrac{dv}{dt}$

$$v_i = 2v - v_o + RC\frac{dv}{dt} \qquad \textbf{(2)}$$

Combining Eqs. (1) and (2),

$$v_i = v_o - v_o + \frac{RC}{2}\frac{dv_o}{dt} \quad \text{or} \quad v_o = \frac{2}{RC}\int v_i dt$$

showing that the circuit is a noninverting integrator.

6.75 −17.5 mV

6.77 See Fig. D.11.

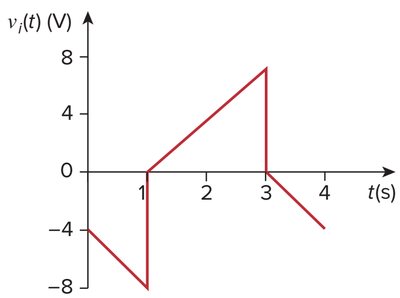


Figure D.11
For Prob. 6.77.

6.79 See Fig. D.12.

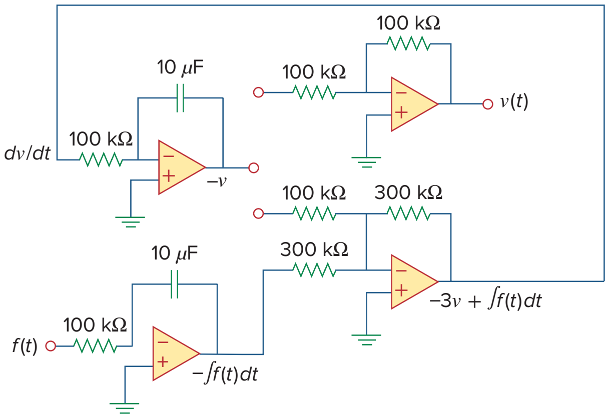


Figure D.12
For Prob. 6.79.

6.81 See Fig. D.13.

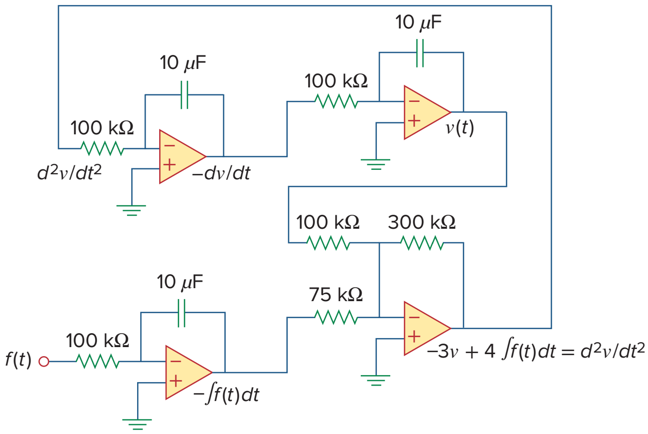


Figure D.13
For Prob. 6.81.

6.83 Eight groups in parallel with each group made up of four capacitors in series.

6.85 1.25 mH inductor

Chapter 7

7.1 (a) 0.7143 μF, (b) 5 ms, (c) 3.466 ms

7.3 1.5 μs

7.5 This is a design problem with multiple answers.

7.7 $15e^{-t}$ V for $0 < t < 1$ sec,
$5.518e^{-2(t-1)}$ V for 1 sec $< t < \infty$

7.9 $10e^{-t/12}$ V

7.11 $1.2e^{-3t}$ A

7.13 (a) 16 kΩ, 16 H, 1 ms, (b) 126.42 μJ

7.15 (a) 10 Ω, 500 ms, (b) 40 Ω, 250 μs

7.17 $[-15e^{-2t}]$ V for all $t > 0$.

7.19 $5e^{-5t}u(t)$ A

7.21 1.618 Ω

7.23 $10e^{-4t}$ V, $t > 0$, $2.5e^{-4t}$ V, $t > 0$

7.25 This is a design problem with multiple answers.

7.27 $[5u(t+1) + 10u(t) - 25u(t-1) + 15u(t-2)]$ V

7.29 (c) $z(t) = \cos 4t\,\delta(t-1) = \cos 4\delta(t-1) = -0.6536\delta(t-1)$, which is sketched below.

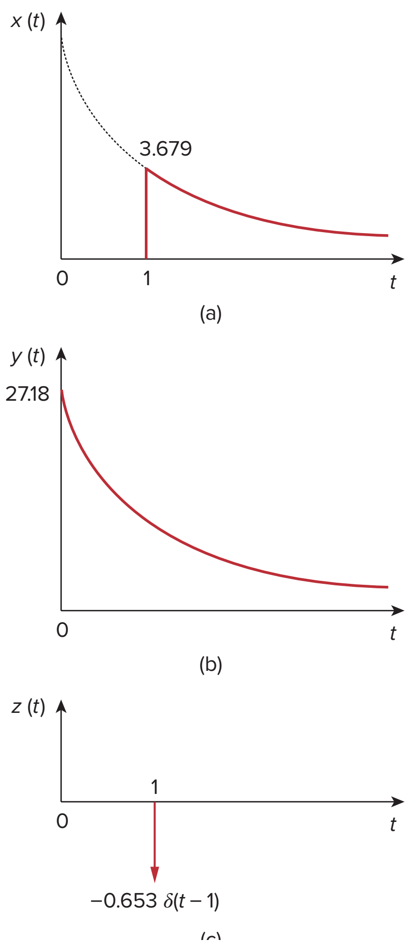


Figure D.14
For Prob. 7.29.

7.31 (a) 112×10^{-9}, (b) 7

7.33 $4.5u(t-2)$ A

7.35 (a) $-e^{-2t}\,u(t)$ V, (b) $2e^{1.5t}\,u(t)$ A

7.37 (a) 4 s, (b) 10 V, (c) $(10 - 8e^{-t/4})\,u(t)$ V

7.39 (a) 4 V, $t < 0$, $20 - 16e^{-t/8}$, $t > 0$,
(b) 4 V, $t < 0$, $12 - 8e^{-t/6}$ V, $t > 0$.

7.41 This is a design problem with multiple answers.

7.43 0.8 A, $0.8e^{-t/480}\,u(t)$ A

7.45 $[20 - 15e^{-14.286t}]\,u(t)$ V

7.47 $\begin{cases} 24(1-e^{-t})\text{V}, & 0 < t < 1 \\ 30 - 14.83e^{-(t-1)}\text{ V}, & t > 1 \end{cases}$

7.49 $\begin{cases} 8(1-e^{-t/5})\text{ V}, & 0 < t < 1 \\ [-16 + 31.17e^{-(t-1)}]\text{ V}, & t > 1 \end{cases}$

7.51 $V_S = Ri + L\dfrac{di}{dt}$

or $L\dfrac{di}{dt} = -R\left(i - \dfrac{V_S}{R}\right)$

$$\frac{di}{i - V_S/R} = \frac{-R}{L}dt$$

Integrating both sides,

$$\ln\left(i - \frac{V_S}{R}\right)\Bigg|_{I_0}^{i(t)} = \frac{-R}{L}t$$

$$\ln\left(\frac{i - V_S/R}{I_0 - V_S/R}\right) = \frac{-t}{\tau}$$

or $\dfrac{i - V_S/R}{I_0 - V_S/R} = e^{-t/\tau}$

$$i(t) = \frac{V_S}{R} + \left(I_0 - \frac{V_S}{R}\right)e^{-t/\tau}$$

which is the same as Eq. (7.60).

7.53 (a) 5 A, $5e^{-t/2}u(t)$ A, (b) 6 A, $6e^{-2t/3}u(t)$ A

7.55 96 V, $96e^{-4t}u(t)$ V

7.57 $2.4e^{-2t}u(t)$ A, $600e^{-5t}u(t)$ mA

7.59 $120e^{-4t}u(t)$ volts

7.61 $20e^{-8t}u(t)$ V, $(10 - 5e^{-8t})u(t)$ A

7.63 $2e^{-8t}u(t)$ A, $-8e^{-8t}u(t)$ V

7.65 $\begin{cases} 2(1-e^{-2t})\text{A} & 0 < t < 1 \\ 1.729e^{-2(t-1)}\text{A} & t > 1 \end{cases}$

7.67 $10e^{-t/6}u(t)$ V

7.69 $48(e^{-t/3000} - 1)\,u(t)$ V

7.71 $[-5 + 5e^{-t}]u(t)$ V

7.73 $-9e^{-5t}u(t)$ V

7.75 $[20 - 10e^{-t}]u(t)$ V, 100 μA

7.77 See Fig. D.15.

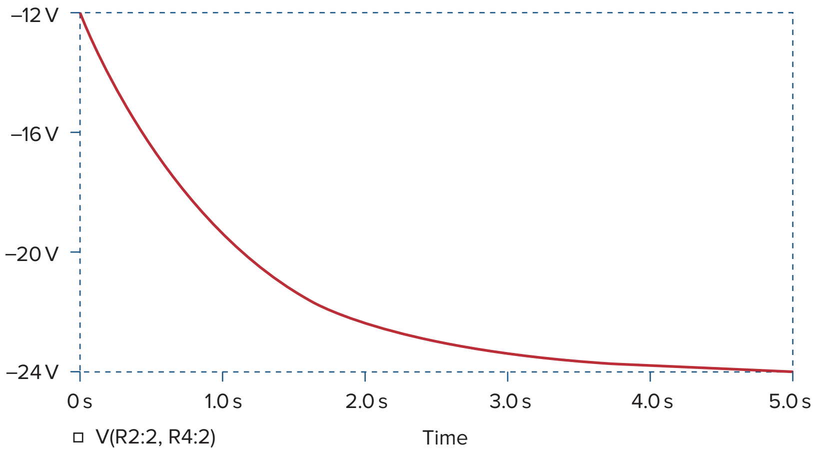


Figure D.15
For Prob. 7.77.

7.79 $[1.75 - 0.75e^{-2t}]u(t)$ A

7.81 See Fig. D.16.

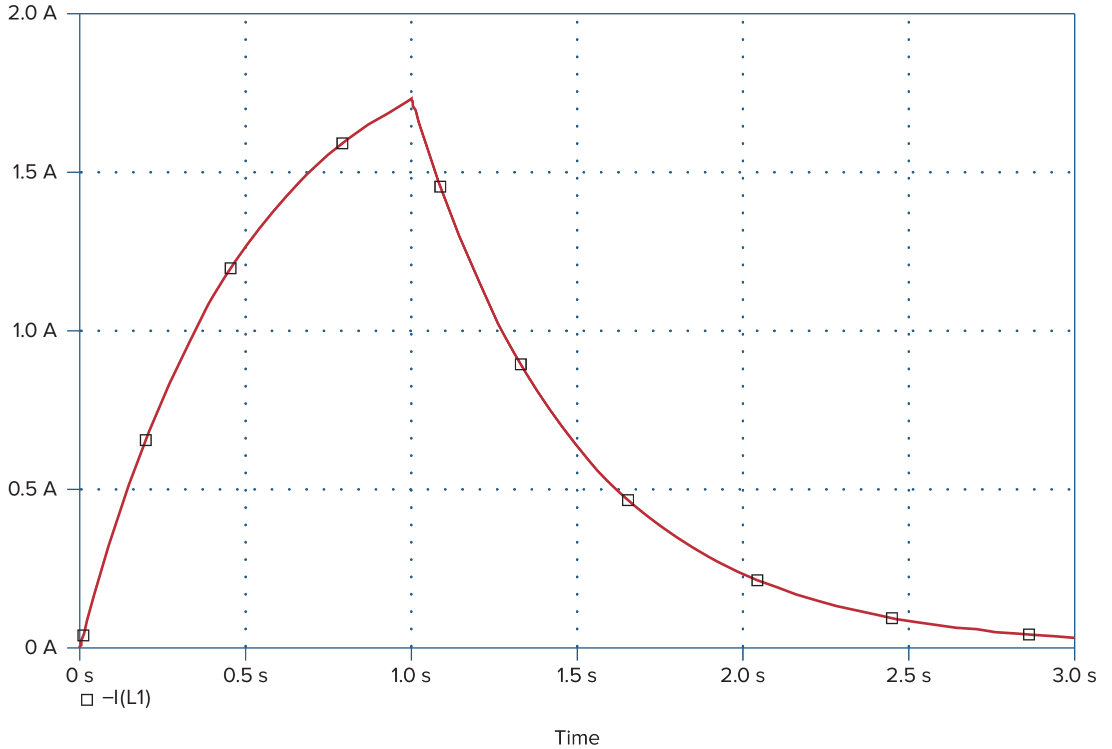


Figure D.16
For Prob. 7.81.

7.83 6.278 m/s

7.85 (a) 659.7 μs, (b) 16.636 s

7.87 441 mA

7.89 $L < 200$ mH

7.91 1.271 Ω

Chapter 8

8.1 (a) 2 A, 12 V, (b) −4 A/s, −5 V/s, (c) 0 A, 0 V

8.3 (a) 0 A, −10 V, 0 V, (b) 0 A/s, 8 V/s, 8 V/s, (c) 400 mA, 6 V, 16 V

8.5 (a) 0 A, 0 V, (b) 4 A/s, 0 V/s, (c) 2.4 A, 9.6 V

8.7 overdamped

8.9 $[(10 + 50t)e^{-5t}]$ A

8.11 $[(10 + 10t)e^{-t}]$ V

8.13 120 Ω

8.15 750 Ω, 200 μF, 25 H

8.17 $[21.55e^{-2.679t} - 1.55e^{-37.32t}]$ V

8.19 $24 \sin(0.5t)$ V

8.21 $18e^{-t} - 2e^{-9t}$ V

8.23 40 mF

8.25 This is a design problem with multiple answers.

8.27 $[3 - 3(\cos(2t) + \sin(2t))e^{-2t}]$ volts

8.29 (a) $3 - 3\cos 2t + \sin 2t$ V, (b) $2 - 4e^{-t} + e^{-4t}$ A,

(c) $3 + (2 + 3t)e^{-t}$ V,

(d) $2 + 2\cos 2te^{-t}$ A

8.31 80 V, 40 V

8.33 $[30 + 0.3078e^{-4.95t} - 15.308e^{-0.05t}]$ V

8.35 This is a design problem with multiple answers.

8.37 $5e^{-4t}$ A

8.39 $(-60 + [-0.2102e^{-47.83t} + 60.21e^{-0.167t}])$ V

8.41 $[8.7\sin(4.583t)e^{-2t}]u(t)$ A

8.43 8 Ω, 2.075 mF

8.45 $[6 - [5\cos(1.3229t)$
$+ 1.8898\sin(1.3229t)]e^{-t/2}]$ A,
$[7.559\sin(1.3229t)e^{-t/2}]$ V

8.47 $(400te^{-10t})$ V

8.49 $\{9 + [(3 + 6t)e^{-2t}]\}\, u(t)$ A

8.51 $\left[-\frac{i_0}{\omega_o C}\sin(\omega_o t)\right]$ V where $\omega_o = 1/\sqrt{LC}$

8.53 $(d^2i/dt^2) + 1.25(di/dt) + 400i = 200$

8.55 $2e^{-t/2}$ A for $t > 0$

8.57 (a) $s^2 + 10s + 9 = 0$,
(b) $[-1.75e^{-t} + 3.75e^{-9t}]u(t)$ A, $[-21e^{-t} + 45e^{-9t}]u(t)$ V

8.59 $-48te^{-2t}$ V

8.61 $2.4 - 2.667e^{-2t} + 0.2667e^{-5t}$ A,
$9.6 - 16e^{-2t} + 6.4e^{-5t}$ V

8.63 $\frac{d^2i(t)}{dt^2} = -\frac{v_s}{RCL}$

8.65 $\frac{d^2v_o}{dt^2} - \frac{v_o}{R^2C^2} = 0,\ e^{10t} - e^{-10t}$ V

Note, circuit is unstable.

8.67 $-te^{-t}u(t)$ V

8.69 See Fig. D.17.

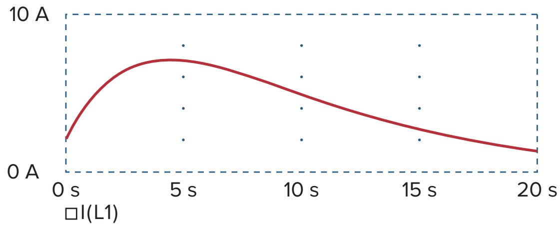


Figure D.17
For Prob. 8.69.

8.71 See Fig. D.18.

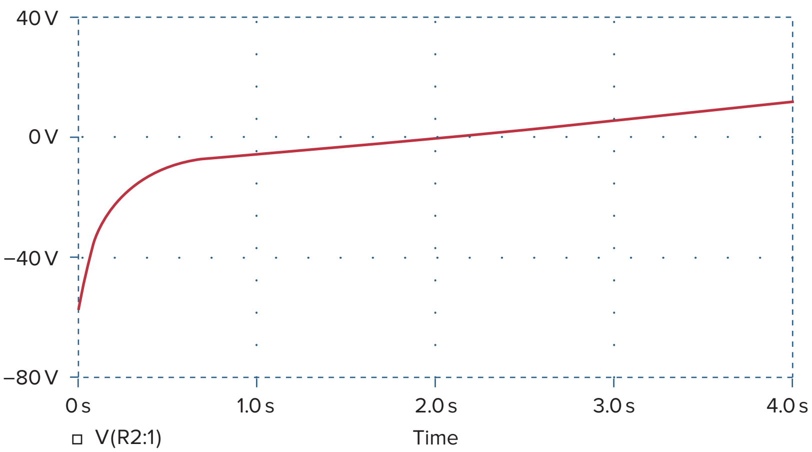


Figure D.18
For Prob. 8.71.

8.73 This is a design problem with multiple answers.

8.75 See Fig. D.19.

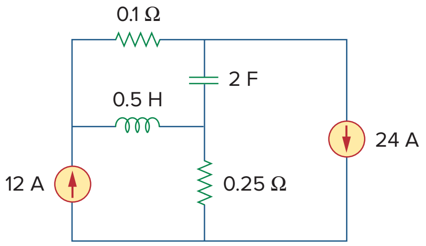


Figure D.19
For Prob. 8.75.

8.77 See Fig. D.20.

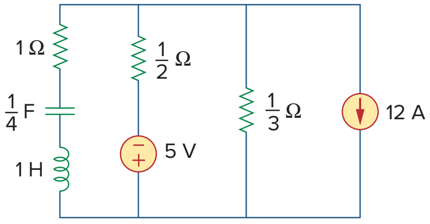


Figure D.20
For Prob. 8.77.

8.79 173.61 μF

8.81 2.533 μH, 625 μF

8.83 $\frac{d^2v}{dt^2} + \frac{R}{L}\frac{dv}{dt} + \frac{R}{LC}i_D + \frac{1}{C}\frac{di_D}{dt} = \frac{v_s}{LC}$

Chapter 9

9.1 (a) 50 V, (b) 209.4 ms, (c) 4.775 Hz, (d) 44.48 V, 0.3 rad

9.3 (a) $10\cos(\omega t - 60^\circ)$, (b) $9\cos(8t + 90^\circ)$, (c) $20\cos(\omega t + 135^\circ)$

9.5 30°, v_1 lags v_2

9.7 Proof

9.9 (a) $50.88\,\angle{-15.52^\circ}$, (b) $60.02\,\angle{-110.96^\circ}$

9.11 (a) $21\,\angle{-15^\circ}$ V, (b) $8\,\angle{160^\circ}$ mA, (c) $120\,\angle{-140^\circ}$ V, (d) $60\,\angle{-170^\circ}$ mA

9.13 (a) $-1.2749 + j0.1520$, (b) -2.083, (c) $35 + j14$

9.15 (a) $-6 - j11$, (b) $120.99 + j4.415$, (c) -1

9.17 $15.62\cos(50t - 9.8^\circ)$ V

9.19 (a) $3.32\cos(20t + 114.49^\circ)$, (b) $64.78\cos(50t - 70.89^\circ)$, (c) $9.44\cos(400t - 44.7^\circ)$

9.21 (a) $f(t) = 8.324\cos(30t + 34.86^\circ)$, (b) $g(t) = 5.565\cos(t - 62.49^\circ)$, (c) $h(t) = 1.2748\cos(40t - 168.69^\circ)$

9.23 (a) $320.1\cos(20t - 80.11^\circ)$ A, (b) $36.05\cos(5t + 93.69^\circ)$ A

9.25 (a) $0.8\cos(2t - 98.13^\circ)$ A, (b) $0.745\cos(5t - 4.56^\circ)$ A

9.27 $0.289\cos(377t - 92.45^\circ)$ V

9.29 $2\sin(10^6 t - 65^\circ)$

9.31 $900.6\cos(2t + 51.21^\circ)$ mA

9.33 139.64 V

9.35 $11.015\cos(200t - 16.7^\circ)$ A

9.37 $(25 - j25)$ mS

9.39 $9.135 + j27.47\ \Omega$, $3.972\cos(10t - 71.6^\circ)$ A

9.41 $72.74\cos(t - 18.43^\circ)$ V

9.43 $1.3868\,\angle{33.69^\circ}$ A

9.45 $j5$ A

9.47 $10.598\cos(2000t + 52.63^\circ)$ mA

9.49 $22.63\sin(200t - 45^\circ)$ V

9.51 $225\cos(2t - 53.13^\circ)$ A

9.53 $23.66\,\angle{-21.67^\circ}$ A

9.55 $(2.798 - j16.403)\ \Omega$

9.57 $0.3171 - j0.1463$ S

9.59 $(10 - j10)$ ohms

9.61 $1 + j0.5\ \Omega$

9.63 $34.69 - j6.93\ \Omega$

9.65 $17.35\angle 0.9^\circ$ A, $6.83 + j1.094\ \Omega$

9.67 (a) $14.8\angle -20.22^\circ$ mS, (b) $19.704\angle 74.56^\circ$ mS

9.69 $1.661 + j0.6647$ S

9.71 $1.058 - j2.235\ \Omega$

9.73 $0.3796 + j1.46\ \Omega$

9.75 Can be achieved by the RL circuit shown in Fig. D.21.

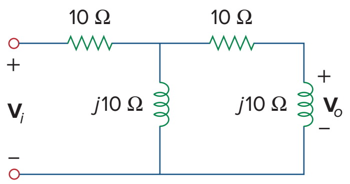


Figure D.21
For Prob. 9.75.

9.77 (a) 26.57° lagging, (b) 1 MHz

9.79 (a) 140.2°, (b) leading, (c) 18.43 V

9.81 1.8 kΩ, 0.1 μF

9.83 104.17 mH

9.85 Proof

9.87 $34.96\angle -6.54^\circ\ \Omega$

9.89 25 μF

9.91 4 μF

9.93 $3.592\angle -38.66^\circ$ A

Chapter 10

10.1 $1.9704 \cos(10t + 5.65^\circ)$ A

10.3 $3.835 \cos(4t - 35.02^\circ)$ V

10.5 $12.398 \cos(4 \times 10^3 t + 4.06^\circ)$ mA

10.7 $124.08\angle -154^\circ$ V

10.9 $6.154 \cos(10^3 t + 70.26^\circ)$ V

10.11 $199.5\angle 86.89^\circ$ mA

10.13 $29.36\angle 62.88^\circ$ A

10.15 $7.906\angle 43.49^\circ$ A

10.17 $9.25\angle -162.12^\circ$ A

10.19 $7.682\angle 50.19^\circ$ V

10.21 (a) $1, 0, -\frac{j}{R}\sqrt{\frac{L}{C}}$, (b) $0, 1, \frac{j}{R}\sqrt{\frac{L}{C}}$

10.23 $\dfrac{(1 - \omega^2 LC)V_s}{1 - \omega^2 LC + j\omega RC(2 - \omega^2 LC)}$

10.25 $1.4142 \cos(2t + 45^\circ)$ A

10.27 $7.047\angle 95.24^\circ$ A, $1.4892\angle 37.71^\circ$ A

10.29 This is a design problem with several different answers.

10.31 $1.0897\angle 61.44^\circ$ A

10.33 $7.906\angle 43.49^\circ$ A

10.35 $1.971\angle -2.1^\circ$ A

10.37 $2.38\angle -96.37^\circ$ A, $2.38\angle 143.63^\circ$ A, $2.38\angle 23.63^\circ$ A

10.39 $381.4\angle 109.6^\circ$ mA, $344.3\angle 124.4^\circ$ mA, $145.5\angle 60.42^\circ$ mA, $100.5\angle 48.5^\circ$ mA

10.41 $[14.142 \sin(2t + 45^\circ) + 26.83 \cos(4t + 26.57^\circ)]$ V

10.43 $19.804 \cos(2t - 129.17^\circ)$ A

10.45 $395.6 \cos(10t + 21.47^\circ) + 149.75 \sin(4t + 176.57^\circ)$ mA

10.47 $[4 + 0.504 \sin(t + 19.1^\circ) + 0.3352 \cos(3t - 76.43^\circ)]$ A

10.49 $883.9 \cos(20t - 30^\circ)$ mA

10.51 $109.3\angle 30^\circ$ mA

10.53 $27.44\angle -59.04^\circ$ V

10.55 (a) $\mathbf{Z}_N = \mathbf{Z}_{Th} = 22.63\angle -63.43^\circ\ \Omega$, $\mathbf{V}_{Th} = 25\angle -150^\circ$ V, $\mathbf{I}_N = 1.1181\angle -86.6^\circ$ A,
(b) $\mathbf{Z}_N = \mathbf{Z}_{Th} = 10\angle 26^\circ\ \Omega$, $\mathbf{V}_{Th} = 101\angle 58^\circ$ V, $\mathbf{I}_N = 10.176\angle 32^\circ$ A

10.57 This is a design problem with multiple answers.

10.59 $-6 + j38\ \Omega$

10.61 $(-180 + j90)$ V, $(-8 + j6)\ \Omega$

10.63 $11.314\angle 15^\circ$ A, $(10 - j10)\ \Omega$

10.65 This is a design problem with multiple answers.

10.67 $7.415\angle -84.68^\circ$ V, $656.5\angle -90.16^\circ$ mA, $11.243 + j1.079\ \Omega$

10.69 $j[1/(\omega RC)]$, $V_m \sin(\omega t + 90^\circ)$ V

10.71 $72 \cos(2t + 29.52^\circ)$ V

10.73 $21.21\angle -45^\circ$ kΩ

10.75 $0.12499\angle 180^\circ$

10.77 $\dfrac{R_2 + R_3 + j\omega C_2 R_2 R_3}{(1 + j\omega R_1 C_1)(R_3 + j\omega C_2 R_2 R_3)}$

10.79 $35.78\angle -153.44^\circ$ V

10.81 $11.27\angle 128.1$ V

10.83 $6.611 \cos(1{,}000t - 159.2^\circ)$ V

10.85 This is a design problem with multiple answers.

10.87 $15.91\angle 169.6^\circ$ V, $5.172\angle -138.6^\circ$ V, $2.27\angle -152.4^\circ$ V

10.89 Proof

10.91 (a) 180 kHz,
(b) 40 kΩ

10.93 Proof

10.95 Proof

Chapter 11

(Assume all values of currents and voltages are rms unless otherwise specified.)

11.1 $[1.320 + 2.640 \cos(100t + 60^\circ)]$ kW, 1.320 kW

11.3 213.4 W

11.5 $P_{1\Omega} = 1.4159$ W, $P_{2\Omega} = 5.097$ W, $P_{3H} = P_{0.25F} = 0$ W

11.7 1 kW

11.9 897 μW

11.11 3.472 W

11.13 28.36 W

11.15 90 W

11.17 20 Ω, 31.25 W

11.19 100 Ω, 6.25 W

11.21 19.58 Ω

11.23 This is a design problem with multiple answers.

11.25 8.165

11.27 2.887 A

11.29 17.321 A, 3.6 kW

11.31 2.944 V

11.33 5.332 A

11.35 21.6 V

11.37 This is a design problem with multiple answers.

11.39 (a) 0.8575, 17.794 kW, 10.676 kVAR,
(b) 585.1 μF

11.41 (a) 0.5547 (leading), (b) 0.9304 (lagging)

11.43 This is a design problem with multiple answers.

11.45 (a) 46.9 V, 1.061 A, (b) 20 W

11.47 (a) $S = (339.4 + j339.4)$ VA,
average power = 339.4 W,
reactive power = 339.4 VAR
(b) $S = (678.8 - j678.8)$ VA,
average power = 678.8 W,
reactive power = −678.8 VAR
(c) $S = (7.637 + j7.637)$ kVA, average power = 7.637 W, reactive power = 7.637 VAR
(d) $S = (250 + j433)$ kVA, average power = 250 kW, reactive power = 433 kVAR

11.49 (a) $4 + j2.373$ kVA,
(b) $1.6 - j1.2$ kVA,
(c) $0.4624 + j1.2705$ kVA,
(d) $110.77 + j166.16$ VA

11.51 (a) 0.9956 (lagging),
(b) 304 W,
(c) 28.64 VAR,
(d) 305.3 VA,
(e) $[304 + j28.64]$ VA

11.53 (a) $47\angle 29.8^\circ$ A, (b) 1.0 (lagging)

11.55 This is a design problem with multiple answers.

11.57 $(219 - j145.99)$ VA

11.59 $j2$ VAR, $-j2$ VAR

11.61 $66.2\angle 92.4^\circ$ A, $6.62\angle -2.4^\circ$ kVA

11.63 $129.31\angle 18.43^\circ$ A

11.65 80 μW

11.67 (a) $12.5\angle -36.87^\circ$ mVA, (b) 78.13 W

11.69 (a) 0.8 (lagging),
(b) 6.195 kW,
(c) 63.66 μF

11.71 (a) $50.14 + j1.7509$ mΩ,
(b) 0.9994 lagging,
(c) $2.392\angle -2^\circ$ kA

11.73 (a) 12.21 kVA, (b) $50.86\angle -35^\circ$ A,
(c) 4.083 kVAR, 188.03 μF, (d) $43.4\angle -16.26^\circ$ A

11.75 (a) $(32.14 + j7.357)$ kVAR, (b) 0.9748 (lagging),
(c) 100.08 μF

11.77 157.69 W

11.79 50 mW

11.81 This is a design problem with multiple answers.

11.83 (a) 688.1 W, (b) 840 VA,
(c) 481.8 VAR, (d) 0.8191 (lagging)

11.85 (a) 13 A, $21.71\angle 166.3^\circ$ A, $9.588\angle -32.43^\circ$ A,
(b) $(4.091 + j0.617)$ kVA, (c) 0.9888 (lagging)

11.87 0.5333

11.89 (a) 12 kVA, $9.36 + j7.51$ kVA,
(b) $2.866 + j2.3$ Ω

11.91 0.8182 (lagging), 1.398 μF

11.93 (a) 7.328 kW, 1.196 kVAR, (b) 0.987

11.95 (a) 2.814 kHz,
(b) 431.8 mW

11.97 1.8396 kW

Chapter 12

(Assume all values of currents and voltages are rms unless otherwise specified.)

12.1 (a) $231\angle -30^\circ$, $231\angle -150^\circ$, $231\angle 90^\circ$ V,
(b) $231\angle 30^\circ$, $231\angle 150^\circ$, $231\angle -90^\circ$ V

12.3 acb sequence, $100\angle -75^\circ$ V

12.5 $207.8\cos(\omega t + 62^\circ)$ V, $207.8\cos(\omega t - 58^\circ)$ V,
$207.8\cos(\omega t - 178^\circ)$ V

12.7 $44\angle 53.13^\circ$ A, $44\angle -66.87^\circ$ A, $44\angle 173.13^\circ$ A

12.9 $4.8\angle -36.87^\circ$ A, $4.8\angle -156.87^\circ$ A, $4.8\angle 83.13^\circ$ A

12.11 762.1 V, 366.1 A

12.13 20.43 A, 3.744 kW

12.15 13.66 A

12.17 $4.8\angle 53.13^\circ$ A, $4.8\angle -66.87^\circ$ A, $4.8\angle 173.13^\circ$ A

12.19 $13.915\angle -18.43^\circ$ A, $13.915\angle -138.43^\circ$ A,
$13.915\angle 101.57^\circ$ A,
$24.1\angle -48.43^\circ$ A, $24.1\angle -168.43^\circ$ A,
$24.1\angle 71.57^\circ$ A

12.21 $44\angle -30^\circ$ A, $76.21\angle -60^\circ$ A, 0.866

12.23 $106.61\angle -0.65^\circ$ V, $106.55\angle 119.34^\circ$ V,
$106.6\angle -120.67^\circ$ V

12.25 $17.742\angle 4.78^\circ$ A, $17.742\angle -115.22^\circ$A,
$17.742\angle 124.78^\circ$ A

12.27 91.79 V

12.29 $[5.197 + j4.586]$ kVA

12.31 (a) $6.144 + j4.608$ Ω,
(b) 36.08 A, (c) 207.2 μF

12.33 7.69 A, 360.3 V

12.35 (a) $14.61 - j5.953$ A,
(b) $[10.081 + j4.108]$ kVA,
(c) 0.9261

12.37 26.24 A, $(5.808 - j7.744)$ Ω

12.39 432 W

12.41 9.021 A

12.43 $4.373 - j1.145$ kVA

12.45 $2.109\angle 24.83^\circ$ kV

12.47 39.19 A (rms), 0.9982 (lagging)

12.49 (a) 27.65 kW, (b) 9.216 kW

12.51 $2.078\angle 120^\circ$ A, $2.078\angle 90^\circ$ A, $2.078\angle 150^\circ$ A, $2.939\angle 165^\circ$ A, $1.0759\angle 15^\circ$ A, $2.078\angle -150^\circ$ A

12.53 This is a design problem with multiple answers.

12.55 $8\angle -60^\circ$ A, $28.84\angle 133.9^\circ$ A, $21.17\angle -40.89^\circ$ A, $(8.64 + j1.6627)$ kVA

12.57 $I_a = 3.917\angle -18.1^\circ$ A, $I_b = 2.931\angle -130.55^\circ$ A, $I_c = 3.895\angle 117.82^\circ$ A

12.59 $220.6\angle -34.56^\circ$, $214.1\angle -81.49^\circ$, $49.91\angle -50.59^\circ$ V, assuming that N is grounded.

12.61 $11.15\angle 37^\circ$ A, $230.8\angle -133.4^\circ$ V, assuming that N is grounded.

12.63 $18.67\angle 158.9^\circ$ A, $12.38\angle 144.1^\circ$ A

12.65 $11.02\angle 12^\circ$ A, $11.02\angle -108^\circ$ A, $11.02\angle 132^\circ$ A

12.67 (a) 97.67 kW, 88.67 kW, 82.67 kW, (b) 108.97 A

12.69 $I_a = 94.32\angle -62.05^\circ$ A, $I_b = 94.32\angle 177.95^\circ$ A, $I_c = 94.32\angle 57.95^\circ$ A, $28.8 + j18.03$ kVA

12.71 (a) 2,590 W, 4,808 W, (b) 8,335 VA

12.73 2,360 W, −632.8 W

12.75 (a) 20 mA, (b) 200 mA

12.77 520 W

12.79 $37.29\angle -19.65^\circ$, $37.29\angle -139.65^\circ$, $37.29\angle 100.35^\circ$ A, $484.7\angle 2.97^\circ$, $484.7\angle -117.03^\circ$, $484.7\angle 122.97^\circ$ V

12.81 516 V

12.83 183.42 A

12.85 $Z_Y = 2.133\ \Omega$

12.87 $2.77\angle -176.6^\circ$ A, $(4.581 + j2.604)$ kVA, $(3.971 + j2.64)$ kVA

Chapter 13

(Assume all values of currents and voltages are rms unless otherwise specified.)

13.1 20 H

13.3 300 mH, 100 mH, 50 mH, 0.2887

13.5 (a) 247.4 mH, (b) 48.62 mH

13.7 $1.081\angle 144.16^\circ$ V

13.9 $2.074\angle 21.12^\circ$ V

13.11 $461.9 \cos(600t - 80.26^\circ)$ mA

13.13 $[4.308 + j4.538]\ \Omega$

13.15 $(11.251 + j18.754)\ \Omega$, $970.1\angle -14.04^\circ$ mA

13.17 $[25.07 + j25.86]\ \Omega$

13.19 See Fig. D.22.

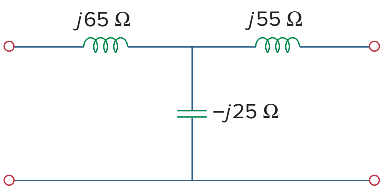


Figure D.22
For Prob. 13.19.

13.21 This is a design problem with multiple answers.

13.23 $100 \cos(100t - 90^\circ)$ V, 5 J

13.25 $2.2 \sin(2t - 4.88^\circ)$ A, $1.5085\angle 17.9^\circ\ \Omega$

13.27 191.86 W

13.29 0.9845, 521.6 mJ

13.31 This is a design problem with multiple answers.

13.33 $12.769 + j7.154\ \Omega$

13.35 $1.4754\angle -21.41^\circ$ A, $77.5\angle -134.85^\circ$ mA, $77\angle -110.41^\circ$ mA

13.37 (a) 10, (b) 208.3 A, (c) 20.83 A

13.39 $15.7\angle 20.31^\circ$ A, $78.5\angle 20.31^\circ$ A

13.41 −6 A

13.43 16.744 V, 66.98 V

13.45 36.71 mW

13.47 $109.55 \cos(3t + 5.48^\circ)$ V

13.49 $0.937 \cos(2t + 51.34^\circ)$ A

13.51 [$8 - j1.5$ Ω, $14.743\angle 10.62^\circ$ A

13.53 (a) 5, (b) 112.5 W

13.55 5 Ω

13.57 (a) $25.9\angle 69.96^\circ$, $12.95\angle 69.96^\circ$ A (rms), (b) $21.06\angle 147.4^\circ$, $42.12\angle 147.4^\circ$, $42.12\angle 147.4^\circ$ V(rms), (c) $1554\angle 20.04^\circ$ VA

13.59 420.1 W, 283.6 W, 52.52 W

13.61 6 A, 0.36 A, −60 V

13.63 $7.071\angle -45^\circ$ A, $3.536\angle -45^\circ$ A, $14.142\angle -45^\circ$ A

13.65 11.05 W

13.67 (a) 352 V, (b) 14.205 A, (c) 5.682 A

13.69 200 V, $(4 - j4)$ kΩ, $(4 + j4)$ kΩ

13.71 0.913, 7.841 A

13.73 (a) three-phase Δ-Y transformer, (b) $8.66\angle 156.87^\circ$ A, $5\angle -83.13^\circ$ A, (c) 1.8 kW

13.75 (a) 0.11547, (b) 76.98 A, 15.395 A

13.77 (a) a single-phase transformer, $1{:}n$, $n = 1/110$, (b) 7.576 mA

13.79 $1.306\angle -68.01^\circ$ A, $406.8\angle -77.86^\circ$ mA, $1.336\angle -54.92^\circ$ A

13.81 $104.5\angle 13.96^\circ$ mA, $29.54\angle -143.8^\circ$ mA, $208.8\angle 24.4^\circ$ mA

13.83 $1.08\angle 33.91^\circ$ A, $15.14\angle -34.21^\circ$ V

13.85 100 turns

13.87 0.5

13.89 0.5, 41.67 A, 83.33 A

13.91 (a) 1,875 kVA, (b) 7,812 A

13.93 (a) See Fig. D.23(a). (b) See Fig. D.23(b).

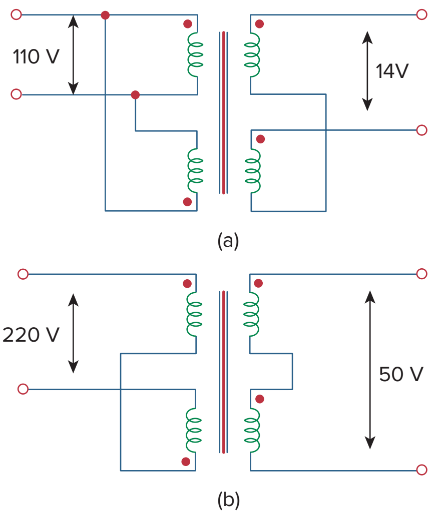


Figure D.23
For Prob. 13.93.

13.95 (a) 1/60, (b) 139 mA

Chapter 14

14.1 $\dfrac{1}{1 + j\omega/\omega_o}$, $\omega_o = \dfrac{R}{L}$

14.3 $20s/(s^2 + 4s + 1)$

14.5 $\dfrac{(Ls + R)}{(LCs^2 + RCs + 1)}$.

14.7 (a) 1.0116, (b) 0.5623, (c) 5.623×10^{10}

14.9 See Fig. D.24.

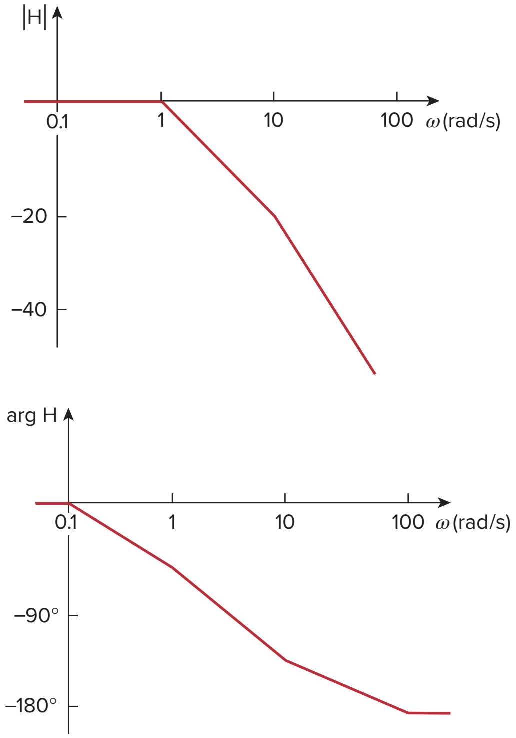


Figure D.24
For Prob. 14.9.

14.11 See Fig. D.25.

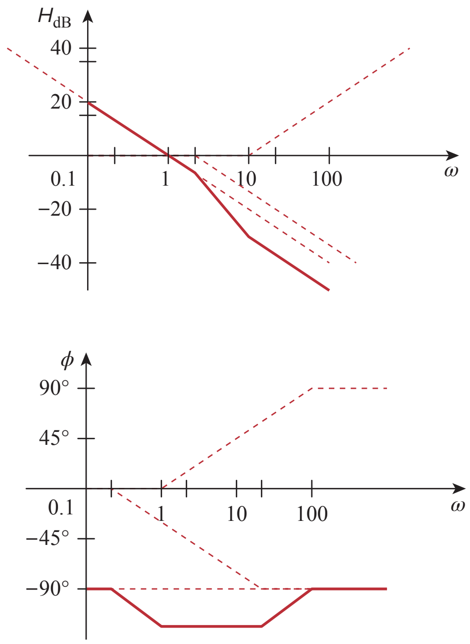


Figure D.25
For Prob. 14.11.

14.13 See Fig. D.26.

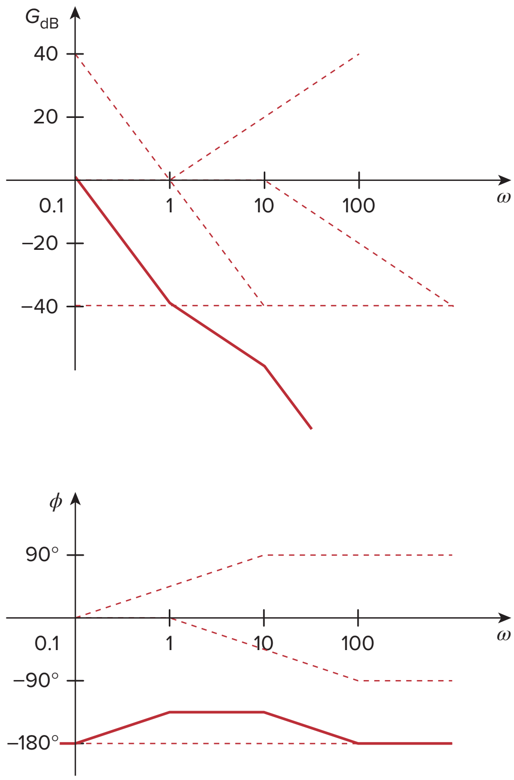


Figure D.26
For Prob. 14.13.

14.15 See Fig. D.27.

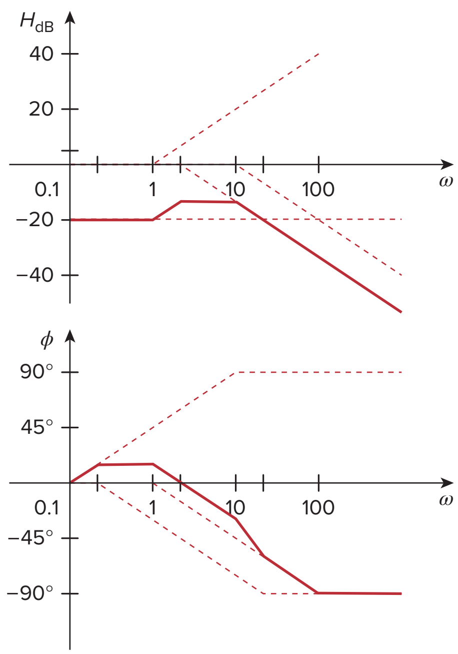


Figure D.27
For Prob. 14.15.

14.17 See Fig. D.28.

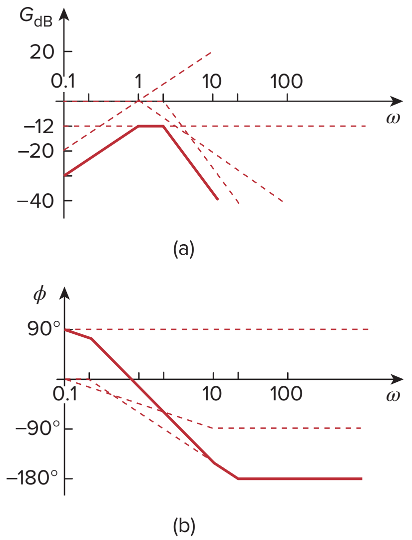


Figure D.28
For Prob. 14.17.

14.19 See Fig. D.29.

14.21 See Fig. D.30.

14.23 $\dfrac{1{,}000j\omega}{(1 + j\omega)(10 + j\omega)^2}$

(It should be noted that this function could also have a minus sign out in front and still be correct. The magnitude plot does not contain this information. It can only be obtained from the phase plot.)

14.25 2 kΩ, 2 – j0.75 kΩ, 2 – j0.3 kΩ, 2 + j0.3 kΩ, 2 + j0.75 kΩ

14.27 R = 1 Ω, L = 0.1 H, C = 25 mF

14.29 4.082 krad/s, 105.55 rad/s, 38.67

14.31 0.5, 0.25 nF, 10 kΩ

14.33 125, 5 Mrad/s

14.35 250 μF, 40, 400 krad/s

14.37 2 kΩ, (1.4212 + j53.3) Ω, (8.85 + j132.74) Ω, (8.85 – j132.74) Ω, (1.4212 – j53.3) Ω

14.39 4.841 krad/s

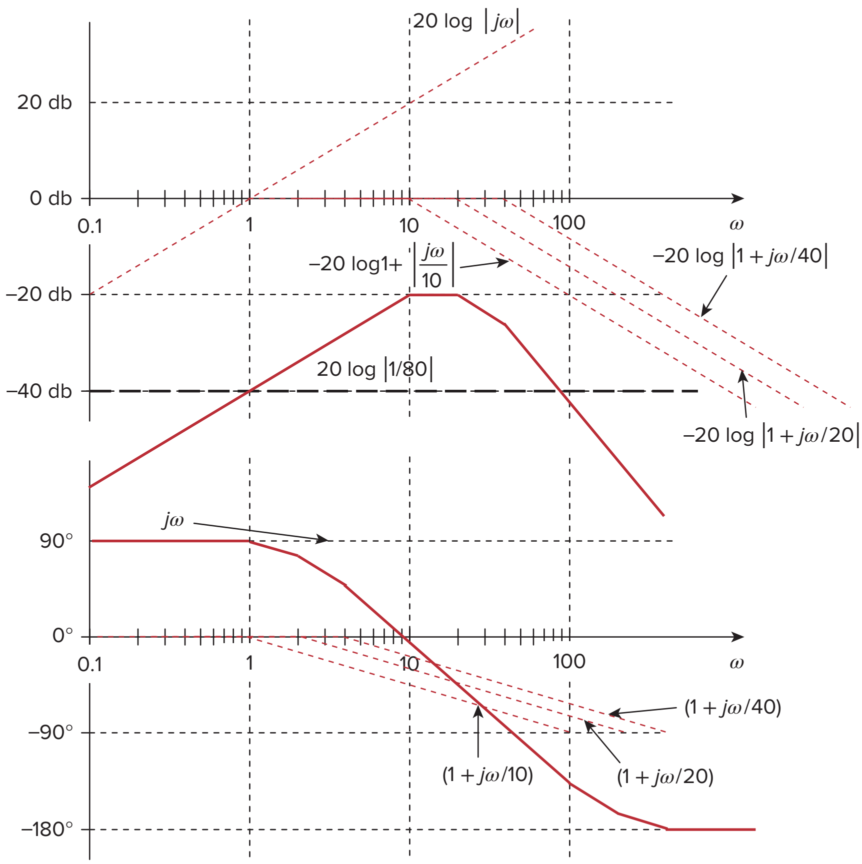


Figure D.29
For Prob. 14.19.

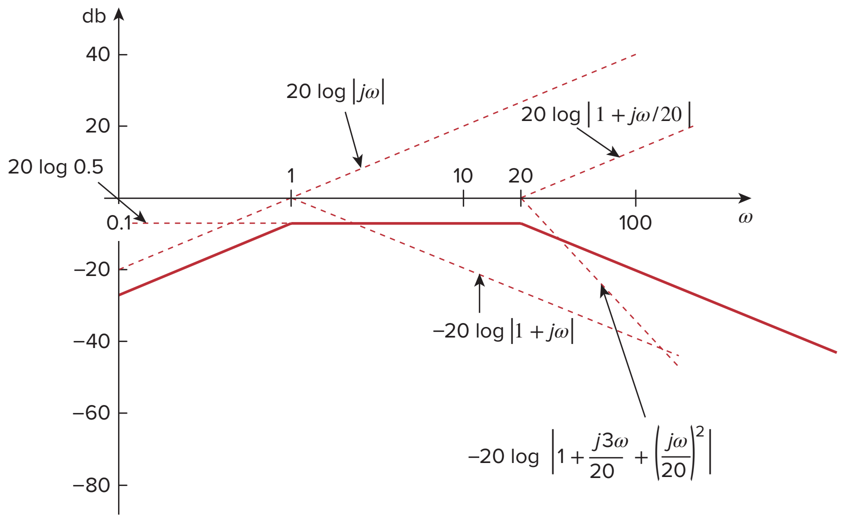


Figure D.30
For Prob. 14.21.

14.41 This is a design problem with multiple answers.

14.43 $\sqrt{\dfrac{1}{LC} - \dfrac{R^2}{L^2}}, \dfrac{1}{\sqrt{LC}}$

14.45 447.2 rad/s, 1.067 rad/s, 419.1

14.47 796 kHz

14.49 This is a design problem with multiple answers.

14.51 1.256 kΩ

14.53 18.045 kΩ. 2.872 H, 10.5

14.55 1.56 kHz $< f <$ 1.62 kHz, 25

14.57 (a) 1 rad/s, 3 rad/s, (b) 1 rad/s, 3 rad/s

14.59 2.408 krad/s, 15.811 krad/s

14.61 (a) $\dfrac{1}{1 + j\omega RC}$,
(b) $\dfrac{j\omega RC}{1 + j\omega RC}$

14.63 10 MΩ, 100 kΩ

14.65 Proof

14.67 If $R_f = 20$ kΩ, then $R_i = 80$ kΩ and $C = 15.915$ nF.

14.69 Let $R = 10$ kΩ, then $R_f = 25$ kΩ, $C = 7.96$ nF.

14.71 $K_f = 2 \times 10^{-4}$, $K_m = 5 \times 10^{-3}$

14.73 9.6 MΩ, 32 μH, 0.375 pF

14.75 200 Ω, 400 μH, 1 μF

14.77 (a) 1,200 H, 0.5208 μF, (b) 2 mH, 312.5 nF, (c) 8 mH, 7.81 pF

14.79 (a) $8s + 5 + \dfrac{10}{s}$,
(b) $0.8s + 50 + \dfrac{10^4}{s}$, 111.8 rad/s

14.81 (a) 0.4 Ω, 0.4 H, 1 mF, 1 mS, (b) 0.4 Ω, 0.4 mH, 1 μF, 1 mS

14.83 0.1 pF, 0.5 pF, 1 MΩ, 2 MΩ

14.85 See Fig. D.31.

14.87 See Fig. D.32; high-pass filter, $f_0 = 1.2$ Hz.

14.89 See Fig. D.33.

14.91 See Fig. D.34; $f_o = 800$ Hz.

14.93 $\dfrac{-RCs + 1}{RCs + 1}$

14.95 (a) 0.541 MHz $< f_o <$ 1.624 MHz, (b) 67.98, 204.1

14.97 $\dfrac{s^3 L R_L C_1 C_2}{(sR_iC_1 + 1)(s^2LC_2 + sR_LC_2 + 1) + s^2LC_1(sR_LC_2 + 1)}$

14.99 8.165 MHz, 4.188×10^6 rad/s

14.101 1.061 kΩ

14.103 $\dfrac{R_2(1 + sCR_1)}{R_1 + R_2 + sCR_1R_2}$

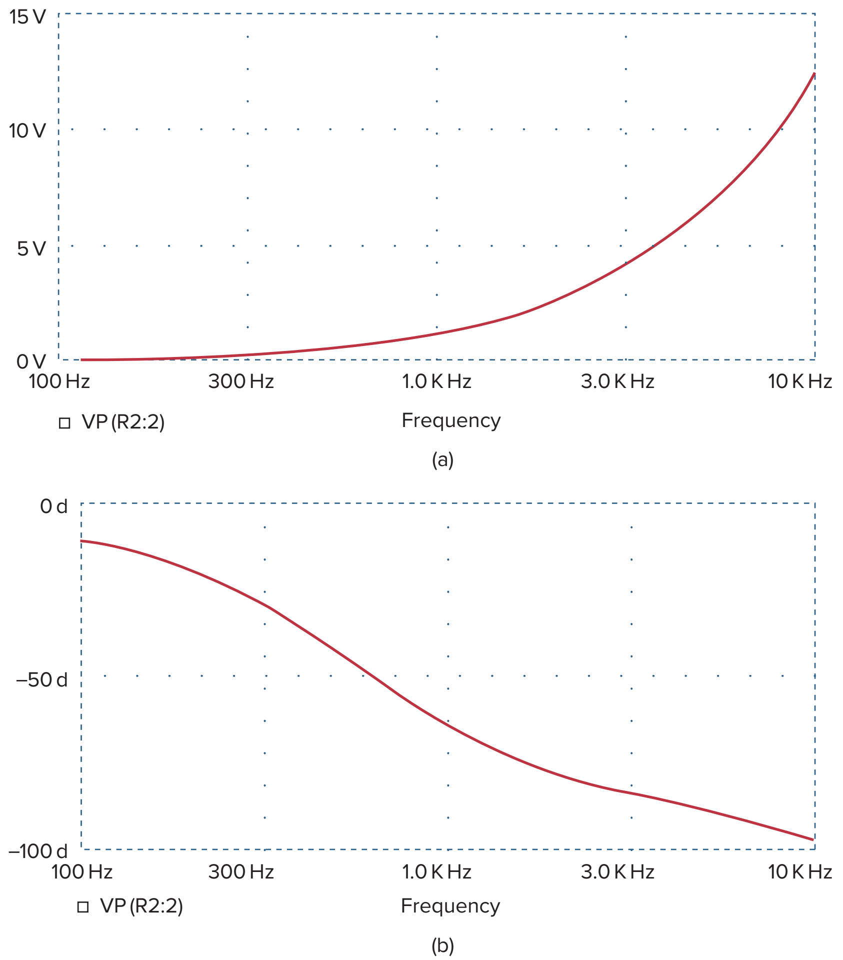


Figure D.31
For Prob. 14.85.

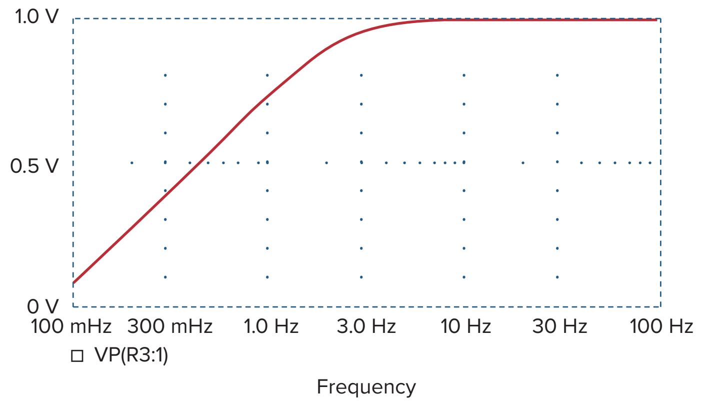


Figure D.32
For Prob. 14.87.

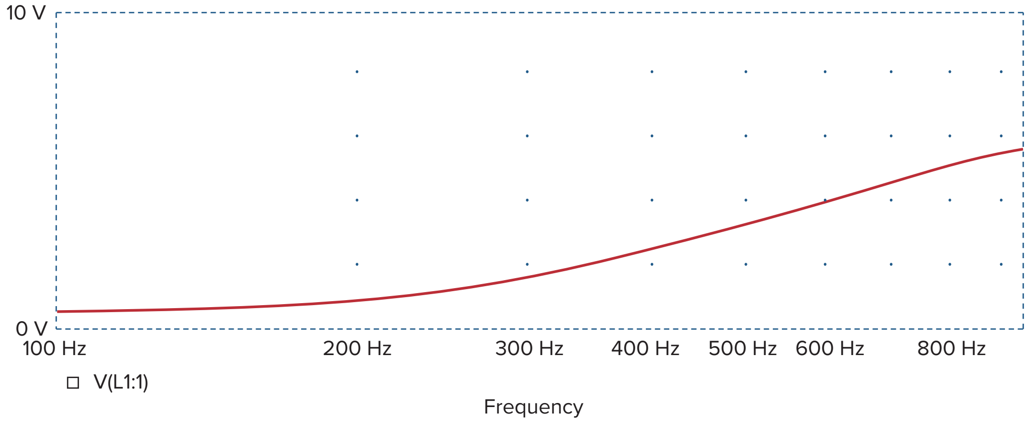


Figure D.33
For Prob. 14.89.

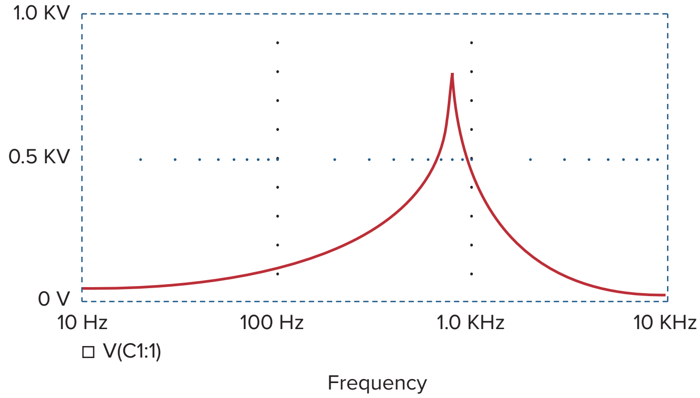


Figure D.34
For Prob. 14.91.

Chapter 15

15.1 $[2.5\,(a+b)]/[s^2+(a+b)^2] +$ $[2.5\,(a-b)]/[s^2+(a+b)^2]$

15.3 (a) $\dfrac{s+2}{(s+2)^2+9}$, (b) $\dfrac{4}{(s+2)^2+16}$, (c) $\dfrac{s+3}{(s+3)^2-4}$ (d) $\dfrac{1}{(s+4)^2-1}$, (e) $\dfrac{4(s+1)}{[(s+1)^2+4]^2}$

15.5 (a) $\dfrac{8-12\sqrt{3}s-6s^2+\sqrt{3}s^3}{(s^2+4)^3}$, (b) $\dfrac{72}{(s+2)^5}$, (c) $\dfrac{2}{s^2}-4s$, (d) $\dfrac{2e}{s+1}$, (e) $\dfrac{5}{s}$, (f) $\dfrac{18}{3s+1}$, (g) s^n

15.7 (a) $\dfrac{2}{s^2}+\dfrac{4}{s}$, (b) $\dfrac{4}{s}+\dfrac{3}{s+2}$, (c) $\dfrac{8s+18}{s^2+9}$, (d) $\dfrac{s+2}{s^2+4s-12}$

15.9 (a) $\dfrac{e^{-2s}}{s^2}-\dfrac{2e^{-2s}}{s^2}$, (b) $\dfrac{2e^{-s}}{e^4(s+4)}$, (c) $\dfrac{2.702s}{s^2+4}+\dfrac{8.415}{s^2+4}$, (d) $\dfrac{6}{s}e^{-2s}-\dfrac{6}{s}e^{-4s}$

15.11 (a) $\dfrac{6(s+1)}{s^2+2s-3}$, (b) $\dfrac{24(s+2)}{(s^2+4s-12)^2}$, (c) $\dfrac{e^{-(2s+6)}[(4e^2+4e^{-2})s+(16e^2+8e^{-2})]}{s^2+6s+8}$

15.13 (a) $\dfrac{s^2-1}{(s^2+1)^2}$,

(b) $\dfrac{2(s+1)}{(s^2+2s+2)^2}$,

(c) $\tan^{-1}\left(\dfrac{\beta}{s}\right)$

15.15 $5\dfrac{1-e^{-s}-se^{-s}}{s^2(1-e^{-3s})}$

15.17 This is a design problem with multiple answers.

15.19 $\dfrac{1}{1-e^{-2s}}$

15.21 $\dfrac{(2\pi s-1+e^{-2\pi s})}{2\pi s^2(1-e^{-2\pi s})}$

15.23 (a) $\dfrac{(1-e^{-s})^2}{s(1-e^{-2s})}$,

(b) $\dfrac{2(1-e^{-2s})-4se^{-2s}(s+s^2)}{s^3(1-e^{-2s})}$

15.25 (a) 18 and 0, (b) 18 and 0

15.27 (a) $u(t)+2e^{-t}u(t)$, (b) $3\delta(t)-11e^{-4t}u(t)$,
(c) $(2e^{-t}-2e^{-3t})u(t)$,
(d) $(3e^{-4t}-3e^{-2t}+6te^{-2t})u(t)$

15.29 $[1+2e^{-t}\cos(t+90°)]\,u(t)$

15.31 (a) $(-5e^{-t}+20e^{-2t}-15e^{-3t})u(t)$

(b) $\left(-e^{-t}+\left(1+3t-\dfrac{t^2}{2}\right)e^{-2t}\right)u(t)$,

(c) $(-0.2e^{-2t}+0.2e^{-t}\cos(2t)$
$+\,0.4e^{-t}\sin(2t))u(t)$

15.33 (a) $(3e^{-t}+3\sin(t)-3\cos(t))u(t)$,
(b) $\cos(t-\pi)u(t-\pi)$,
(c) $8\,[1-e^{-t}-te^{-t}-0.5t^2e^{-t}]u(t)$

15.35 (a) $[2e^{-(t-6)}-e^{-2(t-6)}]u(t-6)$,

(b) $\dfrac{4}{3}u(t)[e^{-t}-e^{-4t}]-\dfrac{1}{3}u(t-2)[e^{-(t-2)}-e^{-4(t-2)}]$,

(c) $\dfrac{1}{13}u(t-1)[-3e^{-3(t-1)}+3\cos 2(t-1)$
$+\,2\sin 2(t-1)]$

15.37 (a) $(2-e^{-2t})u(t)$,
(b) $[0.4e^{-3t}+0.6e^{-t}\cos t+0.8e^{-t}\sin t]u(t)$,
(c) $e^{-2(t-4)}\,u(t-4)$,
(d) $\left(\dfrac{10}{3}\cos t-\dfrac{10}{3}\cos 2t\right)u(t)$

15.39 (a) $(-1.6e^{-t}\cos 4t-4.05e^{-t}\sin 4t$
$+\,3.6e^{-2t}\cos 4t+(3.45e^{-2t}\sin 4t)\,u(t)$,
(b) $[0.08333\cos 3t+0.02778\sin 3t$
$+\,0.0944e^{-0.551t}-0.1778e^{-5.449t}]u(t)$

15.41 $$z(t)=\begin{cases}8t, & 0<t<2\\ 16-8t, & 2<t<6\\ -16, & 6<t<8\\ 8t-80, & 8<t<12\\ 112-8t, & 12<t<14\\ 0, & \text{otherwise}\end{cases}$$

15.43 (a) $$y(t)=\begin{cases}\frac{1}{2}t^2, & 0<t<1\\ -\frac{1}{2}t^2+2t-1, & 1<t<2\\ 1, & t>2\\ 0, & \text{otherwise}\end{cases}$$

(b) $y(t)=2(1-e^{-t}),\ t>0$,

(c) $$y(t)=\begin{cases}\frac{1}{2}t^2+t+\frac{1}{2}, & -1<t<0\\ -\frac{1}{2}t^2+t+\frac{1}{2}, & 0<t<2\\ \frac{1}{2}t^2-3t+\frac{9}{2}, & 2<t<3\\ 0, & \text{otherwise}\end{cases}$$

15.45 $(4e^{-2t}-8te^{-2t})u(t)$

15.47 (a) $[-6e^{-t}+12e^{-2t}]u(t)$, (b) $[6e^{-t}-6e^{-2t}]$

15.49 (a) $\left(\dfrac{t}{a}(e^{at}-1)-\dfrac{1}{a^2}-\dfrac{e^{at}}{a^2}(at-1)\right)u(t)$,
(b) $[0.5\cos(t)(t+0.5\sin(2t))$
$-\,0.5\sin(t)(\cos(t)-1)]u(t)$

15.51 $[12.5e^{-t}-7.5e^{-3t}]u(t)$

15.53 $\cos(t)+\sin(t)$ or $1.4142\cos(t-45°)$

15.55 $\left(\dfrac{1}{40}+\dfrac{1}{20}e^{-2t}-\dfrac{3}{104}e^{-4t}-\dfrac{3}{65}e^{-t}\cos(2t)\right.$
$\left.-\,\dfrac{2}{65}e^{-t}\sin(2t)\right)u(t)$

15.57 This is a design problem with multiple answers.

15.59 $[-7.5e^{-t}+36e^{-2t}-31.5e^{-3t}]u(t)$

15.61 (a) $[3+3.162\cos(2t-161.12°)]u(t)$ volts,
(b) $[2-4e^{-t}+e^{-4t}]u(t)$ amps,
(c) $[3+2e^{-t}+3te^{-t}]u(t)$ volts,
(d) $[2+2e^{-t}\cos(2t)]u(t)$ amps

Chapter 16

16.1 $[(7 + 35t)e^{-5t}]\ u(t)$ A

16.3 $[(20 + 20t)e^{-t}]u(t)$ V

16.5 750 Ω, 25 H, 200 μF

16.7 $[6 + 12e^{-t}\cos(2t) + 2\sin(2t))]u(t)$ A

16.9 $[3 + 5.924e^{-1.5505t} - 1.4235e^{-6.45t}]u(t)$ mA

16.11 20.83 Ω, 80 μF

16.13 This is a design problem with multiple answers.

16.15 120 Ω

16.17 $7.5\left(e^{-2t} - \frac{2}{\sqrt{7}}e^{-0.5t}\sin\left(\frac{\sqrt{7}}{2}t\right)\right)u(t)$ A

16.19 $[-2.333e^{-t/2} + 2.333e^{-2t}]u(t)$ volts

16.21 $[10.776\, e^{-2.679t} - 0.774e^{-37.32t}]u(t)$ volts

16.23 $24\cos(0.5t + 90°)u(t)$ volts

16.25 $[45e^{-t} - 5e^{-9t}]u(t)$ volts

16.27 $[30 - 15.309e^{-0.05051t} + 0.3078e^{-4.949t}]u(t)$ volts

16.29 $17.5\cos(8t + 90°)u(t)$ amps

16.31 $[-16 + 66.67e^{-0.8t}\cos(0.6t - 53.13°)]u(t)$ volts, $13.333e^{-0.8t}[\cos(0.6t + 90°)]u(t)$ amps

16.33 This is a design problem with multiple answers.

16.35 $[9.091e^{-t} + 19.653e^{-0.0625t}\cos(0.7044t - 117.55°]\ u(t)$ V.

16.37 $[-60 + 60.21e^{-0.1672t} - 0.21e^{-47.84t}]u(t)$ volts

16.39 $[4.364e^{-2t}\cos(4.583t - 90°)]u(t)$ amps

16.41 $[100te^{-10t}]u(t)$ volts

16.43 $[9 + 9e^{-2t} + 6te^{-2t}]u(t)$ amps

16.45 $[i_o/(\omega C)]\cos(\omega t + 90°)u(t)$ volts

16.47 $[60 - 40e^{-0.6t}\cos(0.2t) - \sin(0.2t))]u(t)$ A

16.49 $[1.0714e^{-2t} - 2.572e^{-0.5t}\cos(1.25t) + 4.791e^{-0.5t}\sin(1.25t)]u(t)$ A

16.51 $[-12 + 41.17e^{-15.125t}\cos(4.608t - 73.06°)]u(t)$ amps

16.53 $[11.547e^{-t}\cos(1.7321t + 30°)]u(t)$ volts

16.55 $[5{-}4e^{-t} - 1e^{-6t}]u(t)$ amps, $[2e^{-t} - 2e^{-6t}]u(t)$ amps

16.57 (a) $(3/s)[1 - e^{-s}]$, (b) $[(2 - 2e^{-1.5t})u(t) - (2 - 2e^{-1.5(t-1)})u(t-1)]$ V

16.59 $[5e^{-t} - 10e^{-t/2}\cos(t/2)]u(t)$ V

16.61 $[2.333 - 2.38e^{-1.2306t} + 2.033e^{-0.6347t}\cos(1.4265t + 88.68°)]u(t)$ V

16.63 $[7.5e^{-4t}\cos(2t) + 345e^{-4t}\sin(2t)]u(t)$ V, $[6 - 9e^{-4t}\cos(2t) - 17.062e^{-4t}\sin(2t)]u(t)$ A

16.65 $\{110.1e^{-3t} + 192te^{-3t} - 10.1\cos(4t) + 34.58\sin(4t)\}u(t)$ V

16.67 $[e^{10t} - e^{-10t}]\ u(t)$ volts; this is an unstable circuit!

16.69 $240(s + 1)/[s(s + 3)(3s^2 + 8s + 1)]$, $-120(s - 1)/[s(s + 3)(3s^2 + 8s + 1)]$

16.71 $160[2e^{-1.5t} - e^{-t}]u(t)$ A

16.73 $\dfrac{120s^2}{s^2 + 4}$

16.75 $6 + \dfrac{1.5s}{2(s + 3)} - \dfrac{3s(s + 2)}{s^2 + 4s + 20} - \dfrac{18s}{s^2 + 4s + 20}$

16.77 $\dfrac{9s}{3s^2 + 9s + 2}$

16.79 (a) $\dfrac{s^2 - 3}{3s^2 + 2s - 9}$, (b) $\dfrac{-3}{2s}$

16.81 $-1/(RLCs^2)$

16.83 (a) $\frac{R}{L}e^{-Rt/L}\ u(t)$, (b) $(1 - e^{-Rt/L})u(t)$

16.85 $[9e^{-t} - 9e^{-2t} - 6te^{-2t}]u(t)$

16.87 This is a design problem with multiple answers.

16.89 $\begin{bmatrix} v'_C \\ i'_L \end{bmatrix} = \begin{bmatrix} -0.25 & 1 \\ -1 & 0 \end{bmatrix}\begin{bmatrix} v'_C \\ i'_L \end{bmatrix} + \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} v_s \\ i_s \end{bmatrix}$;

$v_o(t) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}\begin{bmatrix} v_C \\ i_L \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} v_s \\ i_s \end{bmatrix}$

16.91 $\begin{bmatrix} x'_1 \\ x'_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}z(t)$;

$y(t) = [1 \quad 0]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + [0]\ z(t)$

16.93 $\begin{bmatrix} x'_1 \\ x'_2 \\ x'_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} z(t);$

$$y(t) = [1 \;\; 0 \;\; 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + [0]z(t)$$

16.95 $[-2.4 + 4.4e^{-3t}\cos(t) - 0.8e^{-3t}\sin(t)]u(t)$, $[-1.2 - 0.8e^{-3t}\cos(t) + 0.6e^{-3t}\sin(t)]u(t)$

16.97 (a) $7(e^{-t} - e^{-4t})u(t)$, (b) The system is stable.

16.99 500 μF, 333.3 H

16.101 100 μF

16.103 $-100, 400, 2 \times 10^4$

16.105 If you let $L = R^2C$ then $V_o/I_o = sL$.

Chapter 17

17.1 (a) periodic, 2, (b) not periodic, (c) periodic, 2π, (d) periodic, π, (e) periodic, 10, (f) not periodic, (g) not periodic

17.3 See Fig. D.35.

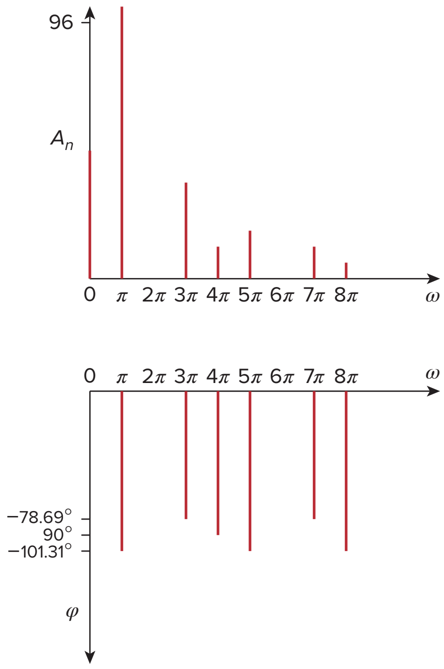


Figure D.35
For Prob. 17.3.

17.5 $-7 + \sum_{\substack{n=1 \\ n=\text{odd}}}^{\infty} \frac{84}{n\pi} \sin nt$

17.7 $1 + \sum_{n=0}^{\infty} \left[\frac{3}{n\pi} \sin \frac{4n\pi}{3} \cos \frac{2n\pi t}{3} + \frac{3}{n\pi}\left(1 - \cos \frac{4n\pi}{3}\right) \sin \frac{2n\pi t}{3} \right]$. See Fig. D.36.

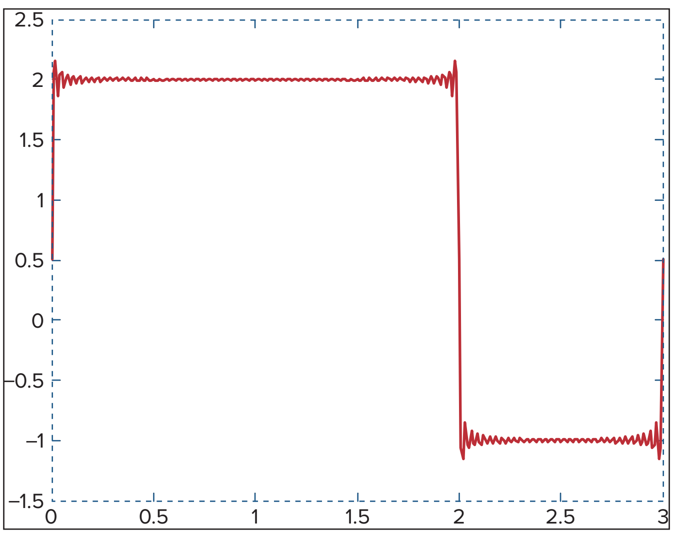


Figure D.36
For Prob. 17.7.

17.9 $a_0 = 0.7958, a_1 = 1.25, a_2 = 0.5305, a_3 = 0,$
$b_1 = 0 = b_2 = b_3$

17.11 $\sum_{n=-\infty}^{\infty} \frac{75}{4n^2\pi^2}[2 - 2\cos(n\pi/2) - 2j\sin(n\pi/2)$
$+ jn\pi\cos(n\pi/2) + n\pi(\sin(n\pi/2))]e^{jn\pi t/2}$

17.13 This is a design problem with multiple answers.

17.15 **(a)** $10 + \sum_{n=1}^{\infty}\sqrt{\frac{16}{(n^2+1)^2} + \frac{1}{n^6}}$
$\cos\left(10nt - \tan^{-1}\frac{n^2+1}{4\pi^3}\right),$
(b) $10 + \sum_{n=1}^{\infty}\sqrt{\frac{16}{(n^2+1)} + \frac{1}{n^6}}$
$\sin\left(10nt + \tan^{-1}\frac{4n^3}{n^2+1}\right)$

17.17 (a) neither odd nor even, (b) even, (c) odd, (d) even, (e) neither odd nor even

17.19 $\frac{5}{n^2\omega_o^2}\sin n\pi/2 - \frac{10}{n\omega_o}(\cos\pi n - \cos n\pi/2)$
$-\frac{5}{n^2\omega_o^2}(\sin\pi n - \sin n\pi/2) - \frac{2}{n\omega_o}\cos n\pi - \frac{\cos\pi n/2}{n\omega_o}$

17.21 $\frac{5}{2} + \sum_{n=1}^{\infty}\frac{40}{n^2\pi^2}\left[1 - \cos\left(\frac{n\pi}{2}\right)\right]\cos\left(\frac{n\pi t}{2}\right)$

17.23 This is a design problem with multiple answers.

17.25
$$\sum_{\substack{n=1\\n=\text{odd}}}^{\infty}\left\{\begin{array}{l}\left[\frac{6}{\pi^2n^2}\left(\cos\left(\frac{2\pi n}{3}\right) - 1\right) + \frac{4}{\pi n}\sin\left(\frac{2\pi n}{3}\right)\right]\cos\left(\frac{2\pi n}{3}\right)\\ + \left[\frac{6}{\pi^2n^2}\sin\left(\frac{2\pi n}{3}\right) - \frac{4}{n\pi}\cos\left(\frac{2\pi n}{3}\right)\right]\sin\left(\frac{2\pi n}{3}\right)\end{array}\right\}$$

17.27 (a) odd, (b) −0.315, (c) 2.681

17.29 $2\sum_{k=1}^{\infty}\left[\frac{2}{n^2\pi}\cos(nt) - \frac{1}{n}\sin(nt)\right], n = 2k - 1$

17.31 $\omega'_o = \frac{2\pi}{T'} = \frac{2\pi}{T/\alpha} = \alpha\omega_o$

$a'_n = \frac{2}{T'}\int_0^{T'} f(\alpha t)\cos n\omega'_o t\, dt$

Let $\alpha t = \lambda$, $dt = d\lambda/\alpha$, and $\alpha T' = T$. Then

$a'_n = \frac{2\alpha}{T}\int_0^{T} f(\lambda)\cos n\omega_o\lambda\, d\lambda/\alpha = a_n$

Similarly, $b'_n = b_n$

17.33 $v_o(t) = \sum_{n=1}^{\infty} A_n\sin(n\pi t - \theta_n)$ V,
$A_n = \frac{10(4 - 2n^2\pi^2)}{\sqrt{(20 - 10n^2\pi^2)^2 - 64n^2\pi^2}},$
$\theta_n = 90° - \tan^{-1}\left(\frac{8n\pi}{20 - 10n^2\pi^2}\right)$

17.35 $\frac{3}{8} + \sum_{n=1}^{\infty} A_n\cos\left(\frac{2\pi n}{3} + \theta_n\right)$, where
$A_n = \frac{\frac{6}{n\pi}\sin\frac{2n\pi}{3}}{\sqrt{9\pi^2n^2 + (2\pi^2n^2/3 - 3)^2}},$
$\theta_n = \frac{\pi}{2} - \tan^{-1}\left(\frac{2n\pi}{9} - \frac{1}{n\pi}\right)$

17.37 $\sum_{n=1}^{\infty}\frac{2(1 - \cos\pi n)}{\sqrt{1 + n^2\pi^2}}\cos(n\pi t - \tan^{-1}n\pi)$

17.39 $\frac{1}{10} + \frac{400}{\pi}\sum_{k=1}^{\infty} I_n\sin(n\pi t - \theta_n), n = 2k - 1,$
$\theta_n = 90° + \tan^{-1}\frac{2n^2\pi^2 - 1{,}200}{802n\pi},$
$I_n = \frac{1}{n\sqrt{(804n\pi)^2 + (2n^2\pi^2 - 1{,}200)}}$

17.41 $\frac{200}{\pi} + \sum_{n=1}^{\infty} A_n\cos(2nt + \theta_n)$ where
$A_n = \frac{2{,}000}{\pi(4n^2 - 1)\sqrt{16n^2 - 40n + 29}}$ and
$\theta_n = 90° - \tan^{-1}(2n - 2.5)$

17.43 (a) 33.91 V,
(b) 6.782 A,
(c) 203.1 W

17.45 4.263 A, 181.7 W

17.47 10%

17.49 (a) 3.162,
(b) 3.065,
(c) 3.068%

17.51 This is a design problem with multiple answers.

17.53 $\sum_{n=-\infty}^{\infty}\frac{0.6321e^{j2n\pi t}}{1 + j2n\pi}$

17.55 $\sum_{n=-\infty}^{\infty}\frac{1 + e^{-jn\pi}}{2\pi(1 - n^2)}e^{jnt}$

17.57 $-3 + \sum_{n=\infty, n\neq 0}^{\infty} \frac{3}{n^3 - 2} e^{j50nt}$

17.59 $-\sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} \frac{j4e^{-j(2n+1)\pi t}}{(2n+1)\pi}$

17.61 (a) $6 + 2.571 \cos t - 3.83 \sin t + 1.638 \cos 2t - 1.147 \sin 2t + 0.906 \cos 3t - 0.423 \sin 3t + 0.47 \cos 4t - 0.171 \sin 4t$, (b) 6.828

17.63 See Fig. D.37.

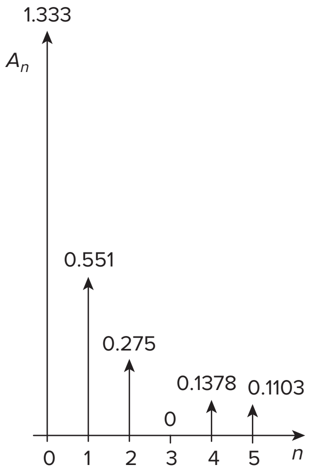


Figure D.37
For Prob. 17.63.

17.65 See Fig. D.38.

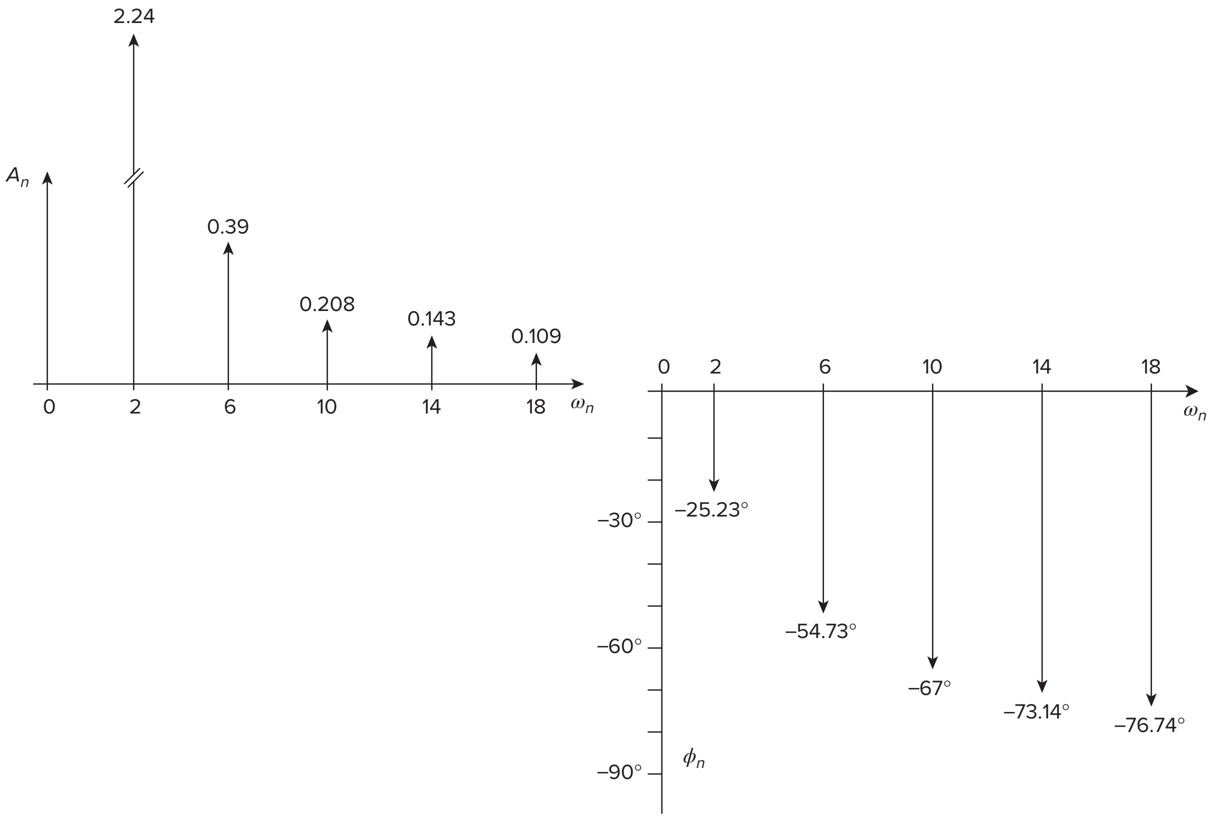


Figure D.38
For Prob. 17.65.

17.67 DC COMPONENT = 2.000396E + 00

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	1.667E-01	2.432E+00	1.000E+00	-8.996E+01	0.000E+00
2	3.334E-01	6.576E-04	2.705E-04	-8.932E+01	6.467E-01
3	5.001E-01	5.403E-01	2.222E-01	9.011E+01	1.801E+02
4	6.668E+01	3.343E-04	1.375E-04	9.134E+01	1.813E+02
5	8.335E-01	9.716E-02	3.996E-02	-8.982E+01	1.433E-01
6	1.000E+00	7.481E-06	3.076E-06	-9.000E+01	-3.581E-02
7	1.167E+00	4.968E-02	2.043E-01	-8.975E+01	2.173E-01
8	1.334E+00	1.613E-04	6.634E-05	-8.722E+01	2.748E+00
9	1.500E+00	6.002E-02	2.468E-02	-9.032E+01	1.803E+02

17.69

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	5.000E-01	4.056E-01	1.000E+00	-9.090E+01	0.000E+00
2	1.000E+00	2.977E-04	7.341E-04	-8.707E+01	3.833E+00
3	1.500E+00	4.531E-02	1.117E-01	-9.266E+01	-1.761E+00
4	2.000E+00	2.969E-04	7.320E-04	-8.414E+01	6.757E+00
5	2.500E+00	1.648E-02	4.064E-02	-9.432E+01	-3.417E+00
6	3.000E+00	2.955E-04	7.285E-04	-8.124E+01	9.659E+00
7	3.500E+00	8.535E-03	2.104E-02	-9.581E+01	-4.911E+00
8	4.000E+00	2.935E-04	7.238E-04	-7.836E+01	1.254E+01
9	4.500E+00	5.258E-03	1.296E-02	-9.710E+01	-6.197E+00

TOTAL HARMONIC DISTORTION = 1.214285+01 PERCENT

17.71 See Fig. D.39.

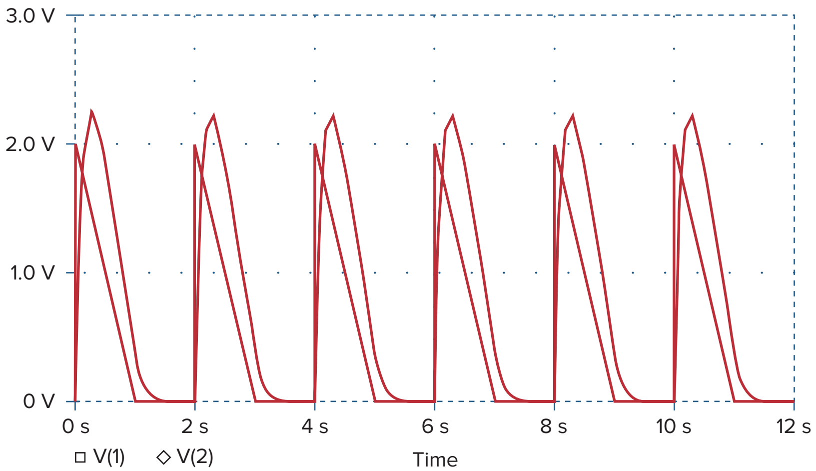


Figure D.39
For Prob. 17.71.

17.73 300 mW

17.75 24.59 mF

17.77 (a) π, (b) −2 V, (c) 11.02 V

17.79 See below for the program in *MATLAB* and the results.

```
% for problem 17.79
a = 10;
c = 4.*a/pi
for n = 1:10
  b(n) = c/(2*n-1);
end
diary
n, b
diary off
```

n	b_n
1	12.7307
2	4.2430
3	2.5461
4	1.8187
5	1.414
6	1.1573
7	0.9793
8	0.8487
9	0.7488
10	0.6700

17.81 (a) $\frac{A^2}{2}$, (b) $|c_1| = 2A/(3\pi)$, $|c_2| = 2A/(15\pi)$, $|c_3| = 2A/(35\pi)$, $|c_4| = 2A/(63\pi)$ (c) 81.1% (d) 0.72%

Chapter 18

18.1 $\frac{14(\cos 2\omega - \cos\omega)}{j\omega}$

18.3 $\frac{j8}{\omega^2}(2\omega\cos 2\omega - \sin 2\omega)$

18.5 $\frac{6j}{\omega} - \frac{6j}{\omega^2}\sin\omega$

18.7 (a) $\frac{2 - e^{-j\omega} - e^{-j2\omega}}{j\omega}$, (b) $\frac{5e^{-j2\omega}}{\omega^2}(1 + j\omega 2) - \frac{5}{\omega^2}$

18.9 (a) $\frac{10}{\omega}\sin 2\omega + \frac{20}{\omega}\sin\omega$,
(b) $\frac{10}{\omega^2} - \frac{10e^{-j\omega}}{\omega^2}(1 + j\omega)$

18.11 $\frac{11\pi}{\omega^2 - \pi^2}(e^{-j\omega 2} - 1)$

18.13 (a) $\pi e^{-j\pi/3}\,\delta(\omega - a) + \pi e^{j\pi/3}\delta(\omega + a)$,
(b) $\frac{e^{j\omega}}{\omega^2 - 1}$, (c) $\pi[\delta(\omega + b) + \delta(\omega - b)]$
$+ \frac{j\pi A}{2}[\delta(\omega + a + b) - \delta(\omega - a + b)$
$+ \delta(\omega + a - b) - \delta(\omega - a - b)]$,
(d) $\frac{1}{\omega^2} - \frac{e^{-j4\omega}}{j\omega} - \frac{e^{-j4\omega}}{\omega^2}(j4\omega + 1)$

18.15 (a) $2j\sin 3\omega$, (b) $\frac{2e^{-j\omega}}{j\omega}$, (c) $\frac{1}{3} - \frac{j\omega}{2}$

18.17 (a) $\pi[\delta(\omega + 2) + \delta(\omega - 2)] - \frac{2j\omega}{\omega^2 - 4}$,
(b) $\frac{j\pi}{4}[\delta(\omega + 10) - \delta(\omega - 10)] - \frac{5}{\omega^2 - 100}$

18.19 $\frac{2j\omega}{\omega^2 - 4\pi^2}(e^{-j\omega} - 1)$

18.21 Proof

18.23 (a) $\frac{30}{(6 - j\omega)(15 - j\omega)}$,
(b) $\frac{20e^{-j\omega/2}}{(4 + j\omega)(10 + j\omega)}$,
(c) $\frac{5}{[2 + j(\omega + 2)][5 + j(\omega + 2)]} + \frac{5}{[2 + j(\omega - 2)][5 + j(\omega - 2)]}$,
(d) $\frac{j\omega 10}{(2 + j\omega)(5 + j\omega)}$,
(e) $\frac{10}{j\omega(2 + j\omega)(5 + j\omega)} + \pi\delta(\omega)$

18.25 (a) $5e^{2t}u(t)$, (b) $6e^{-2t}$, (c) $(-10e^{t}u(t) + 10e^{2t})u(t)$

18.27 (a) $5\,\text{sgn}(t) - 10e^{-10t}\,u(t)$,
(b) $4e^{2t}u(-t) - 6e^{-3t}u(t)$,
(c) $2e^{-20t}\sin(30t)\,u(t)$, (d) $\frac{1}{4}\pi$

18.29 (a) $\frac{1}{2\pi}(1 + 8\cos 3t)$, (b) $\frac{4\sin 2t}{\pi t}$,
(c) $3\delta(t + 2) + 3\delta(t - 2)$

18.31 (a) $x(t) = e^{-at}u(t)$,
(b) $x(t) = u(t+1) - u(t-1)$,
(c) $x(t) = \frac{1}{2}\delta(t) - \frac{a}{2}e^{-at}\,u(t)$

18.33 (a) $\frac{2j \sin t}{t^2 - \pi^2}$, (b) $u(t-1) - u(t-2)$

18.35 (a) $\frac{e^{-j\omega/3}}{6 + j\omega}$, (b) $\frac{1}{2}\left[\frac{1}{2 + j(\omega + 5)} + \frac{1}{2 + j(\omega - 5)}\right]$,
(c) $\frac{j\omega}{2 + j\omega}$, (d) $\frac{1}{(2 + j\omega)^2}$, (e) $\frac{1}{(2 + j\omega)^2}$

18.37 $\frac{j\omega}{4 + j3\omega}$

18.39 $\frac{5 \times 10^3}{10^6 + j\omega}\left(\frac{1}{j\omega} + \frac{1}{\omega^2} - \frac{1}{\omega^2}e^{-j\omega}\right)$

18.41 $\frac{2j\omega(4.5 + j2\omega)}{(2 + j\omega)(4 - 2\omega^2 + j\omega)}$

18.43 $1000(e^{-1t} - e^{-1.25t})u(t)$ V

18.45 $5(e^{-t} - e^{-2t})u(t)$ A

18.47 $16(e^{-t} - e^{-2t})u(t)$ V

18.49 $0.542 \cos (t + 13.64°)$ V

18.51 16.667 J

18.53 π

18.55 682.5 J

18.57 2 J, 87.43%

18.59 $(16e^{-t} - 20e^{-2t} + 4e^{-4t})u(t)$ V

18.61 $2X(\omega) + 0.5X(\omega + \omega_0) + 0.5X(\omega - \omega_0)$

18.63 106 stations

18.65 6.8 kHz

18.67 200 Hz, 5 ms

18.69 35.24%

Chapter 19

19.1 $\begin{bmatrix} 30 & 10 \\ 10 & 30 \end{bmatrix}\,\Omega$

19.3 $\begin{bmatrix} 10 & -j10 \\ -j10 & -j10 \end{bmatrix}\,\Omega$

19.5 $\begin{bmatrix} 10\,(s+2) & 10 \\ 10 & 10 \end{bmatrix}$

19.7 $\begin{bmatrix} 20(s + 0.5) & -30 \\ -10 & -20 \end{bmatrix}\,\Omega$

19.9 $\begin{bmatrix} 2.5 & 1.25 \\ 1.25 & 3.125 \end{bmatrix}\,\Omega$

19.11 See Fig. D.40.

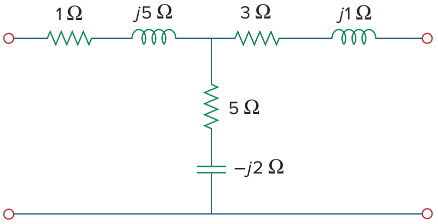


Figure D.40
For Prob. 19.11.

19.13 329.9 W

19.15 24 Ω, 1.536 kW

19.17 $\begin{bmatrix} 9.6 & -0.8 \\ -0.8 & 8.4 \end{bmatrix}\,\Omega$ and $\begin{bmatrix} 0.105 & 0.01 \\ 0.01 & 0.12 \end{bmatrix}$ S

19.19 This is a design problem with multiple answers.

19.21 See Fig. D.41.

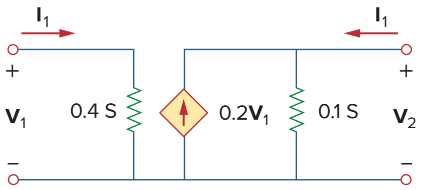


Figure D.41
For Prob. 19.21.

19.23 $\begin{bmatrix} s+2 & -(s+1) \\ -(s+1) & \dfrac{s^2+s+1}{s} \end{bmatrix}, \dfrac{0.8(s+1)}{s^2+1.8s+1.2}$

19.25 See Fig. D.42.

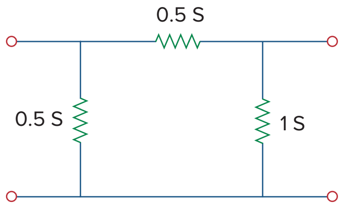


Figure D.42
For Prob. 19.25.

19.27 $\begin{bmatrix} 0.25 & 0.025 \\ 5 & 0.6 \end{bmatrix}$ S

19.29 (a) 44 V, 16 V, (b) same

19.31 $\begin{bmatrix} 3.8\ \Omega & 0.4 \\ -3.6 & 0.2\ \text{S} \end{bmatrix}$

19.33 $\begin{bmatrix} (3.077 + j1.2821)\ \Omega & 0.3846 - j0.2564 \\ -0.3846 + j0.2564 & (76.9 + 282.1)\ \text{mS} \end{bmatrix}$

19.35 $\begin{bmatrix} 2\ \Omega & 0.5 \\ -0.5 & 0 \end{bmatrix}$

19.37 3.571 V

19.39 $g_{11} = \dfrac{1}{R_1 + R_2}, g_{12} = -\dfrac{R_2}{R_1 + R_2}$

$g_{21} = \dfrac{R_2}{R_1 + R_2}, g_{22} = R_3 + \dfrac{R_1 R_2}{R_1 + R_2}$

19.41 Proof

19.43 (a) $\begin{bmatrix} 1 & \mathbf{Z} \\ 0 & 1 \end{bmatrix}$, (b) $\begin{bmatrix} 1 & 0 \\ \mathbf{Y} & 1 \end{bmatrix}$

19.45 $\begin{bmatrix} 1 & (20 + j20)\ \Omega \\ j100\ \mu s & 1 \end{bmatrix}$

19.47 $\begin{bmatrix} 0.3235 & 1.176\ \Omega \\ 0.02941\ \text{S} & 0.4706 \end{bmatrix}$

19.49 $\begin{bmatrix} \dfrac{2s+1}{s} & \dfrac{1}{s}\ \Omega \\ \dfrac{(s+1)(3s+1)}{s} S & 2 + \dfrac{1}{s} \end{bmatrix}$

19.51 $\begin{bmatrix} 2 & 2 + j5 \\ j & -2 + j \end{bmatrix}$

19.53 $z_{11} = \dfrac{A}{C}, z_{12} = \dfrac{AD - BC}{C}, z_{21} = \dfrac{1}{C}, z_{22} = \dfrac{D}{C}$

19.55 Proof

19.57 $\begin{bmatrix} 3 & 1 \\ 1 & 7 \end{bmatrix} \Omega, \begin{bmatrix} \dfrac{7}{20} & \dfrac{-1}{20} \\ \dfrac{-1}{20} & \dfrac{3}{20} \end{bmatrix} \text{S}, \begin{bmatrix} \dfrac{20}{7}\ \Omega & \dfrac{1}{7} \\ \dfrac{-1}{7} & \dfrac{1}{7}\ \text{S} \end{bmatrix},$

$\begin{bmatrix} \dfrac{1}{3}\ \text{S} & \dfrac{-1}{3} \\ \dfrac{1}{3} & \dfrac{20}{3}\ \Omega \end{bmatrix}, \begin{bmatrix} 7 & 20\ \Omega \\ 1\ \text{S} & 3 \end{bmatrix}$

19.59 $\begin{bmatrix} 16.667 & 6.667 \\ 3.333 & 3.333 \end{bmatrix} \Omega, \begin{bmatrix} 0.1 & -0.2 \\ -0.1 & 0.5 \end{bmatrix} \text{S},$

$\begin{bmatrix} 10\ \Omega & 2 \\ -1 & 0.3\ \text{S} \end{bmatrix}, \begin{bmatrix} 5\ \Omega & 10\ \Omega \\ 0.3\ \text{S} & 1 \end{bmatrix}$

19.61 (a) $\begin{bmatrix} \dfrac{5}{3} & \dfrac{4}{3} \\ \dfrac{4}{3} & \dfrac{5}{3} \end{bmatrix} \Omega$, (b) $\begin{bmatrix} \dfrac{5}{3}\ \Omega & \dfrac{4}{5} \\ \dfrac{-4}{5} & \dfrac{3}{5}\ \text{S} \end{bmatrix}$, (c) $\begin{bmatrix} \dfrac{5}{4} & \dfrac{3}{4}\ \Omega \\ \dfrac{3}{4}\ \text{S} & \dfrac{5}{4} \end{bmatrix}$

19.63 $\begin{bmatrix} 0.8 & 2.4 \\ 2.4 & 7.2 \end{bmatrix} \Omega$

19.65 $\begin{bmatrix} \dfrac{0.5}{3} & -\dfrac{1}{-0.5} \\ -\dfrac{-0.5}{3} & \dfrac{2}{5/6} \end{bmatrix}$ S

19.67 $\begin{bmatrix} 4 & 63.29\ \Omega \\ 0.1576\ \text{S} & 4.994 \end{bmatrix}$

19.69 $\begin{bmatrix} \dfrac{s+1}{s+2} & \dfrac{-(3s+2)}{2(s+2)} \\ \dfrac{-(3s+2)}{2(s+2)} & \dfrac{5s^2+4s+4}{2s(s+2)} \end{bmatrix}$

19.71 $\begin{bmatrix} 2 & -3.334 \\ 3.334 & 20.22 \end{bmatrix} \Omega$

19.73 $\begin{bmatrix} 14.628 & 3.141 \\ 5.432 & 19.625 \end{bmatrix} \Omega$

19.75 (a) $\begin{bmatrix} 0.3015 & -0.1765 \\ 0.0588 & 19.625 \end{bmatrix}$ S, (b) −0.0051

19.77 $\begin{bmatrix} 0.9488\angle -161.6^\circ & 0.3163\angle 18.42^\circ \\ 0.3163\angle -161.6^\circ & 0.9488\angle -161.6^\circ \end{bmatrix}$

19.79 $\begin{bmatrix} 4.669\angle -136.7^\circ & 2.53\angle -108.4^\circ \\ 2.53\angle -108.4^\circ & 1.789\angle -153.4^\circ \end{bmatrix} \Omega$

19.81 $\begin{bmatrix} 1.5 & -0.5 \\ 3.5 & 1.5 \end{bmatrix}$ S

19.83 $\begin{bmatrix} 0.3235 & 1.1765\ \Omega \\ 0.02941\text{ S} & 0.4706 \end{bmatrix}$

19.85 $\begin{bmatrix} 1.581\angle 71.59^\circ & -j\Omega \\ j\text{ S} & 5.661 \times 10^{-4} \end{bmatrix}$

19.87 $\begin{bmatrix} -j1{,}765 & -j1{,}765\ \Omega \\ j888.2\text{ S} & j888.2 \end{bmatrix}$

19.89 −1,613, 64.15 dB

19.91 (a) −25.64 for the transistor and −9.615 for the circuit. (b) 74.07, (c) 1.2 kΩ, (d) 51.28 kΩ

19.93 −17.74, 144.5, 31.17 Ω, −6.148 MΩ

19.95 See Fig. D.43.

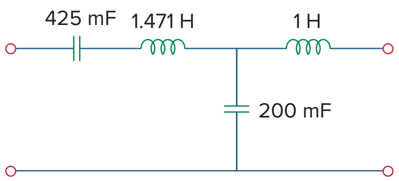


Figure D.43
For Prob. 19.95.

19.97 250 mF, 333.3 mH, 500 mF

19.99 Proof