

Answers to Selected Problems

Chapter 1

- 1.1 $i = 2\text{ A}$
 1.4 $\Delta Q = 1.5\text{ C}$
 1.7 (a) $P = -18\text{ W}$ (supplied) (b) $P = -18\text{ W}$ (supplied)
 1.10 (a) $P = -12\text{ W}$ (supplied) (b) $P = 24\text{ W}$ (absorbed)
 1.13 $P_2 = 48\text{ W}$ (absorbed)
 1.17 $P_{36\text{V}} = -144\text{ W}$, $P_1 = 48\text{ W}$, $P_2 = 48\text{ W}$, $P_{\text{DS}} = -8\text{ W}$, $P_3 = 56\text{ W}$
 1.20 $V_x = 18\text{ V}$

Chapter 2

- | | |
|------------------------------------------------------------------------------------------------|------------------------------------------------------|
| 2.1 $I = 0.3\text{ mA}$, $P = 1.8\text{ mW}$ | 2.50 $I_1 = 3\text{ mA}$ |
| 2.4 $R_x = 5\text{ k}\Omega$ | 2.52 $V_o = -\frac{16}{3}\text{ V}$ |
| 2.7 $P_S = 72\text{ W}$ | 2.55 $I_o = 2\text{ mA}$ |
| 2.10 $I_1 = 6\text{ mA}$, $I_2 = 3\text{ mA}$ | 2.58 $V_S = 12\text{ V}$ |
| 2.12 $I_x = -8\text{ mA}$, $I_y = +10\text{ mA}$, $I_z = -2\text{ mA}$ | 2.60 $V_S = 48\text{ V}$ |
| 2.14 $I_x = 9\text{ mA}$, $I_y = -10\text{ mA}$, $I_z = -2\text{ mA}$ | 2.63 $V_S = 38\text{ V}$ |
| 2.17 $V_x = 3\text{ V}$ | 2.65 $V_S = 30\text{ V}$ |
| 2.19 $V_{ad} = 7\text{ V}$ | 2.68 $I_S = 4.5\text{ A}$ |
| 2.22 $V_{ad} = 9\text{ V}$, $V_{ce} = 11\text{ V}$ | 2.70 $I_o = 6\text{ mA}$ |
| 2.25 $V_x = 10\text{ V}$ | 2.72 $P = 63\text{ mW}$ |
| 2.27 $V_x = 5\text{ V}$ | 2.75 $I_o = 4\text{ A}$ |
| 2.29 $P_{30\text{k}} = 1.2\text{ mW}$ | 2.78 $V_o = 10\text{ V}$ |
| 2.31 $I_o = 90\text{ mA}$ | 2.80 $V_o = 2\text{ V}$ |
| 2.34 $I_o = 4\text{ mA}$ | 2.83 $I_o = -20\text{ mA}$ |
| 2.36 $I_L = 0.4\text{ mA}$ | 2.86 Power gain $= 1.422 \frac{\text{kW}}{\text{W}}$ |
| 2.39 $R_{AB} = 3\text{ k}\Omega$ | 2.87 $P_{10\text{k}} = 10\text{ mW}$ |
| 2.41 $R_{AB} = 2\text{ k}\Omega$ | 2FE-1 $P = 1.2\text{ W}$ |
| 2.44 (a) Min $= 950\text{ }\Omega$, Max $= 1050\text{ }\Omega$ | 2FE-4 $I_o = \frac{-4}{9}\text{ mA}$ |
| (b) Min $= 460.6\text{ }\Omega$, Max $= 479.4\text{ }\Omega$ | |
| (c) Min $= 19.8\text{ k}\Omega$, Max $= 24.2\text{ k}\Omega$ | |
| 2.47 (a) $R_{\text{Nom}} = 3\text{ }\Omega$ (b) Positive/Negative
Tolerances $= \pm 8.33\%$ | |

2

ANSWERS TO SELECTED PROBLEMS

Chapter 3

- 3.1** $I_o = 1 \text{ mA}$
3.3 $V_2 = 22 \text{ V}$
3.5 $I_o = 0.6 \text{ mA}$
3.8 $I_o = 1.25 \text{ mA}$
3.10 $I_o = 2 \text{ mA}, I_1 = -6 \text{ mA}$
3.13 $I_o = -1 \text{ mA}$
3.15 $V_o = \frac{-5}{6} \text{ V}$
3.18 $I_o = -1.5 \text{ mA}$
3.21 $V_o = 2 \text{ V}$
3.24 $I_o = -4.8 \text{ mA}$
3.27 $V_o = 4.36 \text{ V}$
3.30 $I_o = 1.5 \text{ mA}$
3.33 $V_o = \frac{4}{3} \text{ V}$
3.36 $I_o = -0.4 \text{ mA}$
3.39 $V_o = 32.25 \text{ V}$
3.42 $V_o = 4 \text{ V}$
3.44 $V_o = \frac{4}{3} \text{ V}$

- 3.47** $I_o = 7 \text{ mA}$
3.50 $I_o = 5.2 \text{ mA}$
3.53 $I_o = 0.4 \text{ mA}$
3.56 $V_o = 6 \text{ V}$
3.59 $V_o = \frac{8}{5} \text{ V}$
3.62 $V_o = 3 \text{ V}$
3.65 $V_o = 6 \text{ V}$
3.68 $V_o = \frac{-7}{8} \text{ V}$
3.70 $V_o = -5 \text{ V}$
3.73 $\frac{V_o}{i_s} = -1$
3FE-1 $V_o = \frac{10}{3} \text{ V}$
3FE-4 $V_o = -3.27 \text{ V}$
3FE-6 $V_o = 6 \text{ V}$

Chapter 4

- 4.1** $I_o = \frac{8}{7} \text{ mA}$
4.3 $V_o = 0.75 \text{ V}$
4.5 $I_o = \frac{-16}{5} \text{ mA}$
4.8 $V_o = -4.25 \text{ V}$
4.10 $I_o = 2.4 \text{ mA}$
4.12 $I_o = 0.5 \text{ mA}$
4.15 $I_o = 0.4 \text{ mA}$
4.18 $V_o = 10.5 \text{ V}$
4.21 $V_o = 2 \text{ V}$
4.24 $I_o = \frac{-7}{5} \text{ mA}$
4.27 $I_o = -1 \text{ mA}$
4.29 $I_o = -0.2 \text{ mA}$
4.31 $I_o = 0.67 \text{ mA}$
4.33 $V_o = 4.8 \text{ V}$
4.36 $V_o = 8 \text{ V}$
4.39 $V_o = \frac{8}{5} \text{ V}$
4.42 $I_o = 2 \text{ mA}$
4.44 $I_o = 1.25 \text{ mA}$
4.47 $V_o = 1.55 \text{ V}$
4.50 $R_{AB} = 1 \text{ k}\Omega$
4.52 $V_o = -6 \text{ V}$
4.55 $I_o = 5.71 \text{ mA}$
4.58 $V_o = 0.43 \text{ V}$
4.61 $V_o = 2.18 \text{ V}$
4.64 $I_o = 1.2 \text{ mA}$
4.67 $V_o = 258 \text{ mV}$
4.70 $R_L = 2 \text{ k}\Omega, P_L = 12.5 \text{ mW}$
4.72 $R_L = 6 \text{ k}\Omega, P_L = \frac{25}{6} \text{ mW}$
4.75 $V_o = 2 \text{ V}$
4FE-1 $P_L = 8 \text{ mW}$
4FE-3 $R_L = 12.92 \text{ }\Omega$

Chapter 5

5.1 $v(t = 4) = 40 \text{ V}$

5.3 $C = 120 \text{ } \mu\text{F}$

5.5 $i(t) = \pm 2.92 \cos 377t \text{ A}$

5.7 (a) $i(t) = 4.52 \cos 377t \text{ A}$

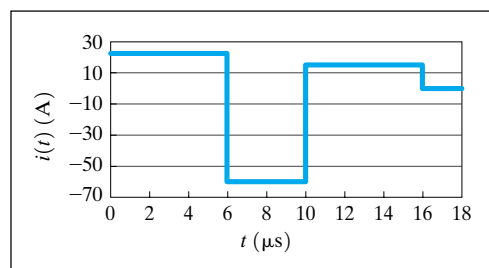
(b) $w(t) = 360 \sin(754t - 90^\circ) \text{ mJ}$

5.9 $v(t) = 100t \text{ V} \quad 0 \leq t \leq 2 \text{ ms}$
 $= 0.2 \text{ V} \quad t > 2 \text{ ms}$

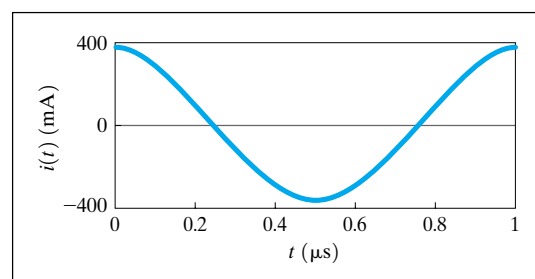
5.11 $i(t) = 6 \text{ mA} \quad 0 \leq t \leq 2 \text{ ms}$
 $= -6 \text{ mA} \quad 2 \leq t \leq 4 \text{ ms}$

5.14 $i(t) = 0.6 \text{ A} \quad 0 \leq t \leq 2 \text{ s}$
 $= -2.4 \text{ A} \quad 2 \leq t \leq 3 \text{ s}$
 $= 0.6 \text{ A} \quad 3 \leq t \leq 5 \text{ s}$
 $= 0 \quad t > 5 \text{ s}$

5.16 $i(t) = 24 \text{ A} \quad 0 \leq t \leq 6 \text{ } \mu\text{s}$
 $= -60 \text{ A} \quad 6 \leq t \leq 10 \text{ } \mu\text{s}$
 $= 16 \text{ A} \quad 10 \leq t \leq 16 \text{ } \mu\text{s}$
 $= 0 \quad t > 16 \text{ } \mu\text{s}$



5.19 $i(t) = 377 \cos(2000\pi t) \text{ mA}$



5.21 (a) $v(t) = 75.4 \cos 377t \text{ V}$

(b) $w(t) = 0.1 - 0.1 \cos 754t \text{ J}$

5.24 (a) $v(t) = 0, \quad t < 0$
 $= 250e^{-t} \text{ } \mu\text{V}, \quad t > 0$

(b) $w(t) = 1.25[1 - 2e^{-t} + e^{-2t}] \text{ } \mu\text{J}$

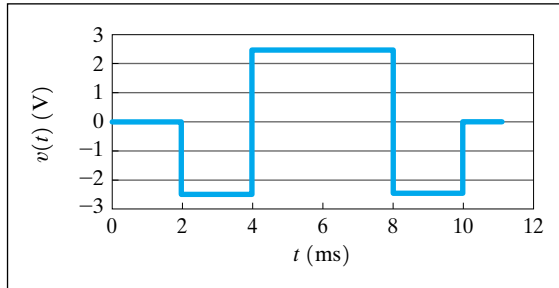
5.27 $v(t = 5 \text{ s}) = -0.91 \text{ V}$

$w(t = 5 \text{ s}) = 91.97 \text{ J}$

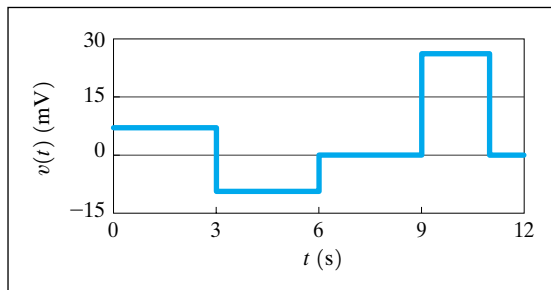
4

ANSWERS TO SELECTED PROBLEMS

5.29 $v(t) = 0 \quad 0 \leq t \leq 2 \text{ ms}$
 $= -2.5 \text{ V} \quad 2 \leq t \leq 4 \text{ ms}$
 $= 2.5 \text{ V} \quad 4 \leq t \leq 8 \text{ ms}$
 $= -2.5 \quad 8 \leq t \leq 10 \text{ ms}$
 $= 0 \quad t > 10 \text{ ms}$

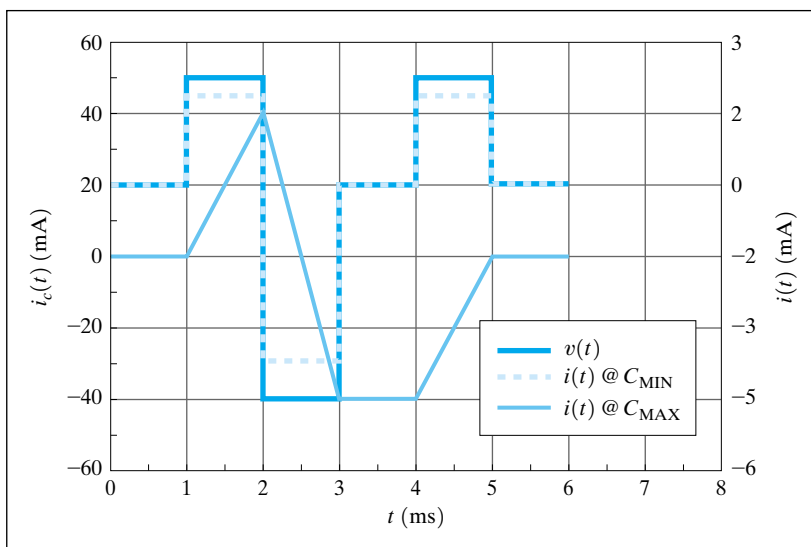


5.31 $v(t) = 6.67 \text{ mV} \quad 0 \leq t \leq 3 \text{ s}$
 $= -10 \text{ mV} \quad 3 \leq t \leq 6 \text{ s}$
 $= 0 \quad 6 \leq t \leq 9 \text{ s}$
 $= 25 \text{ mV} \quad 9 \leq t \leq 11 \text{ s}$
 $= 0 \quad t > 11 \text{ s}$

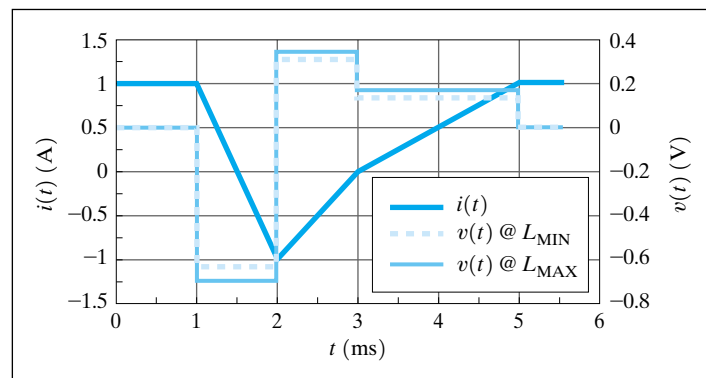
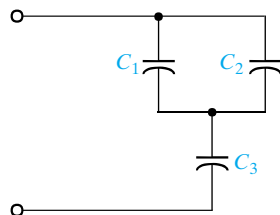


5.33 $i(t) = 0.5t \text{ A} \quad 0 \leq t \leq 2 \text{ ms}$
 $= 3 \times 10^{-3} - t \text{ A} \quad 2 \leq t \leq 3 \text{ ms}$
 $= 0 \quad t > 3 \text{ ms}$

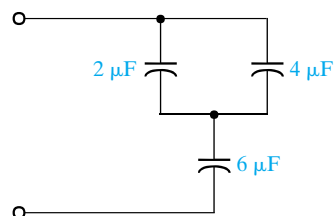
5.36



5.38

5.41 $C_1 = 1 \mu\text{F}$, $C_2 = 3 \mu\text{F}$, and $C_3 = 4 \mu\text{F}$ 5.44 $V_o = 12 \text{ V}$ 5.46 $C = 3 \mu\text{F}$ 5.49 $C_T = 2 \mu\text{F}$ 5.51 $C_T = 9 \mu\text{F}$ 5.54 (a) $C_{\text{NOM}} = 1.43 \mu\text{F}$ (b) $C_{\text{MIN}} = 1.254 \mu\text{F}$, $C_{\text{MAX}} = 1.606 \mu\text{F}$ (c) $\%_{\text{MIN}} = -12.3\%$, $\%_{\text{MAX}} = 12.3\%$ 5.56 $L = 20 \text{ mH}$ 5.59 $L_{AB} = 5 \text{ mH}$ 5.61 $L_{AB} = 6 \text{ mH}$ 5.64 $C = 1.25 \mu\text{F}$

5FE-1



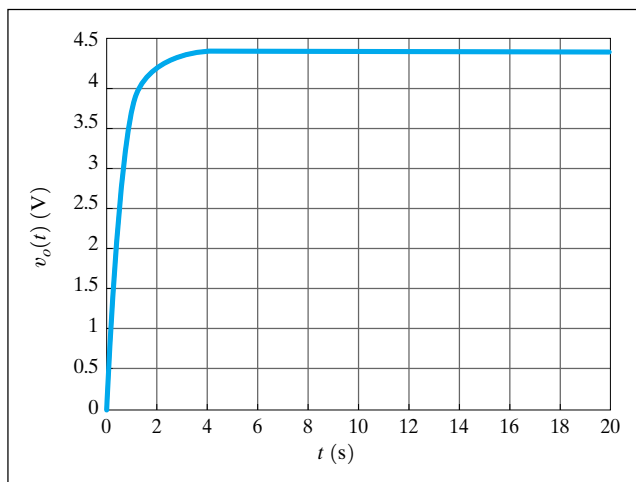
Chapter 6

6.1 $v_C(t) = 12 - 8e^{-t/0.6} \text{ V}, t > 0$ 6.3 $v_C(t) = 6e^{-t/0.4} \text{ V}, t > 0$ 6.5 $i_o(t) = \frac{2}{3}e^{-10t} \text{ A}, t > 0$

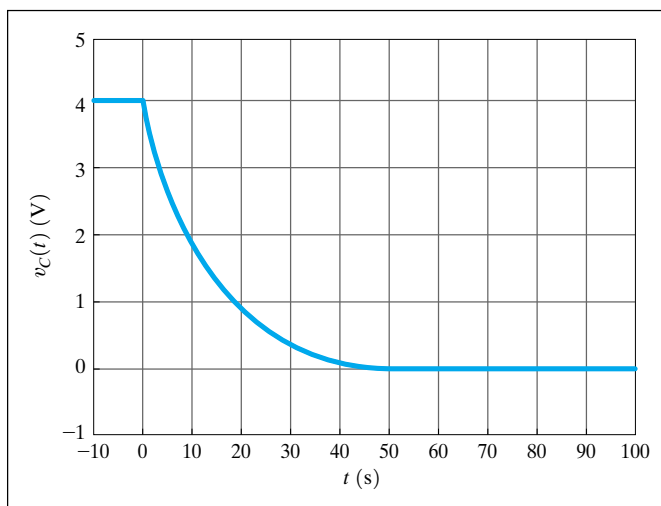
6

ANSWERS TO SELECTED PROBLEMS

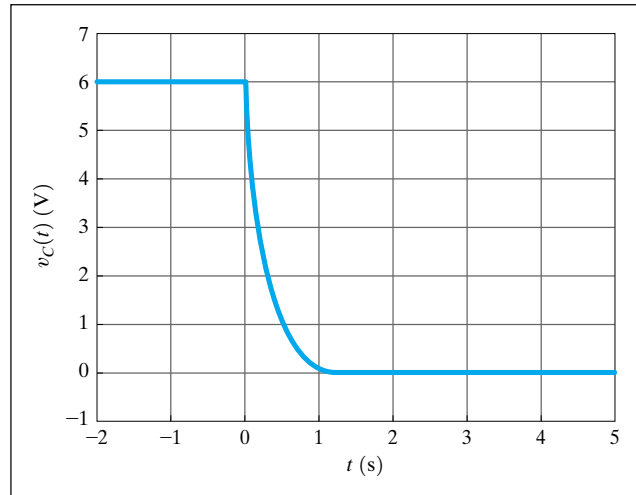
$$\begin{aligned}
 \mathbf{6.7} \quad v_o(t) &= \frac{48}{11} (1 - e^{-11t/6}) \text{ V}, \quad t > 0 \\
 &= 0, \quad t < 0
 \end{aligned}$$



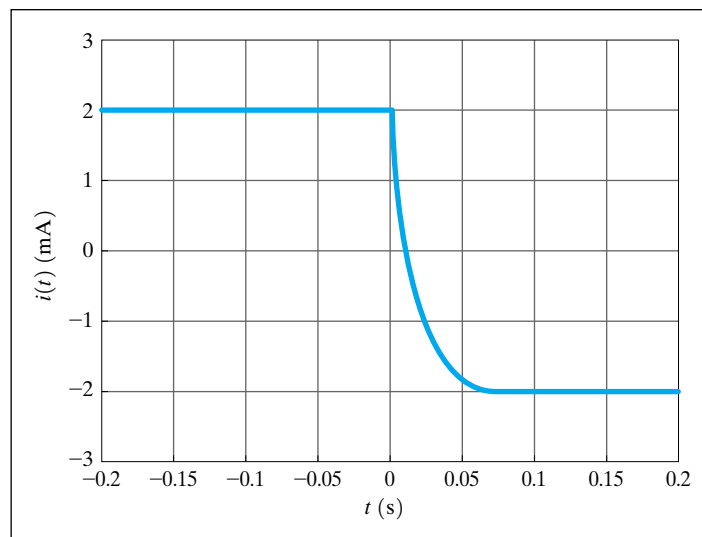
$$\begin{aligned}
 \mathbf{6.9} \quad v_C(t) &= 4 \text{ V}, \quad t < 0 \\
 &= 4e^{-t/1.2} \text{ V}, \quad t > 0
 \end{aligned}$$



6.12 $v_C(t) = 6 \text{ V}, \quad t < 0$
 $= 6e^{-15t/4} \text{ V}, \quad t > 0$



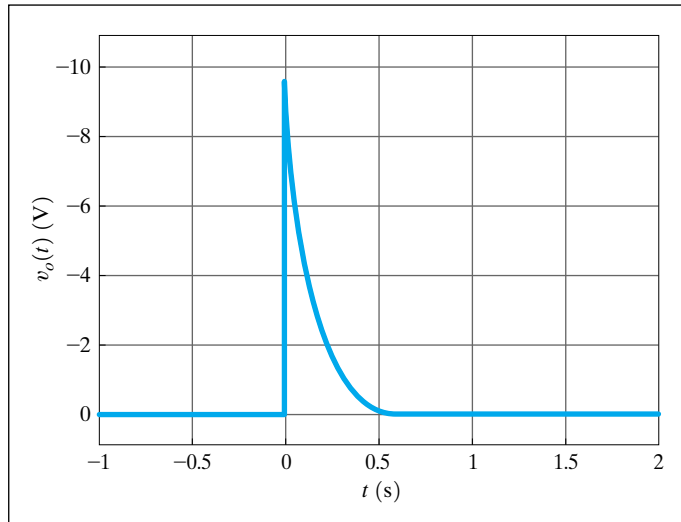
6.15 $i(t) = 2 \text{ mA}, \quad t < 0$
 $= (4e^{-2 \times 10^6 t} - 2) \text{ mA}, \quad t > 0$



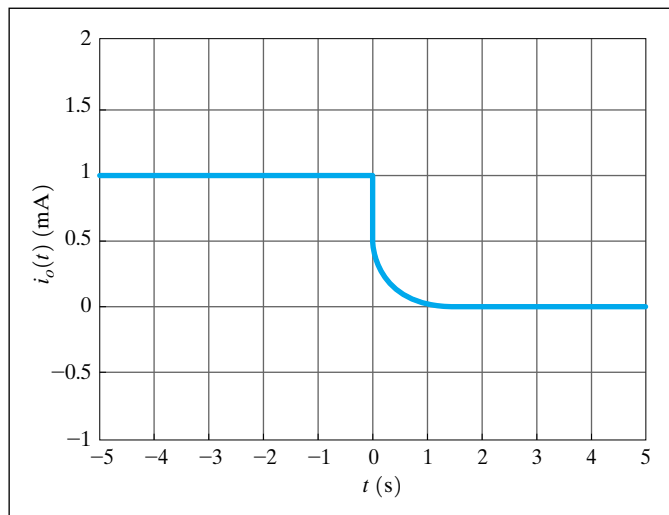
8

ANSWERS TO SELECTED PROBLEMS

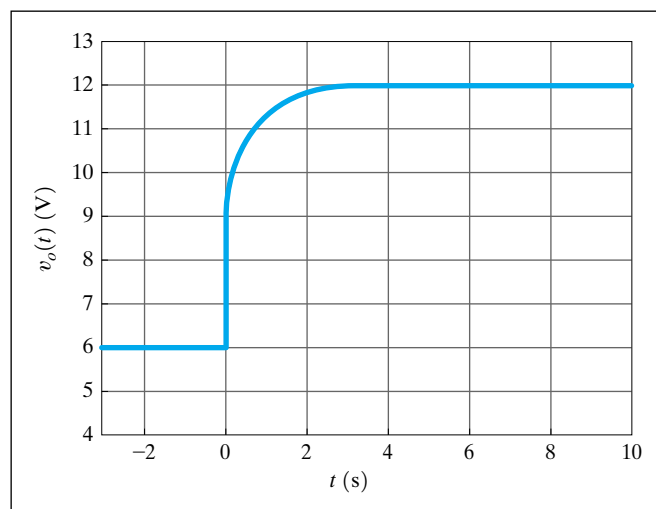
$$\begin{aligned}
 6.18 \quad v_o(t) &= 0, & t < 0 \\
 &= -9.6e^{-9.6t} \text{ V}, & t > 0
 \end{aligned}$$



$$\begin{aligned}
 6.21 \quad i_o(t) &= 1 \text{ mA}, & t < 0 \\
 &= 0.5e^{-(10/3)t} \text{ mA}, & t > 0
 \end{aligned}$$



$$\begin{aligned}
 6.24 \quad v_o(t) &= 6, & t < 0 \\
 &= 12 - 3e^{-5t/3} \text{ V}, & t > 0
 \end{aligned}$$



$$6.27 \quad i_o(t) = -3e^{-10t} \text{ A}, t > 0$$

$$6.30 \quad v_o(t) = 9e^{-5t/3} \text{ V}, t > 0$$

$$6.33 \quad i_o(t) = 2.4(1 - e^{-2.5 \times 10^5 t}) \text{ mA}, t > 0$$

$$6.36 \quad i_o(t) = 2 - \frac{e^{-3t}}{4} \text{ mA}, t > 0$$

$$6.39 \quad v_o(t) = 1.5e^{-t/0.6} \text{ V}, t > 0$$

$$6.42 \quad v_o(t) = -3.6e^{-8t} \text{ V}, t > 0$$

$$6.45 \quad i_o(t) = -0.5e^{-5t} \text{ mA}, t > 0$$

$$6.47 \quad v_o(t) = -6e^{-4t} \text{ V}, t > 0$$

$$6.50 \quad v_o(t) = -4e^{-0.889 \times 10^6 t} \text{ V}, t > 0$$

$$6.52 \quad i_o(t) = \frac{4}{3} - \frac{2}{15}e^{-9t/2} \text{ A}, t > 0$$

$$6.55 \quad (\text{a}) s^2 + 6s + 8 = 0$$

$$(\text{b}) s = -2, s = -4$$

$$(\text{c}) i_o(t) = k_1 e^{-2t} + k_2 e^{-4t}$$

$$6.58 \quad (\text{a}) s^2 + 6s + 10 = 0$$

$$(\text{b}) s = -3 + j, s = -3 - j$$

$$(\text{c}) v_o(t) = k_1 e^{-3t} \cos t + k_2 e^{-3t} \sin t$$

$$6.61 \quad v(t) = 10e^{-4t} \cos 2t - 40e^{-4t} \sin 2t$$

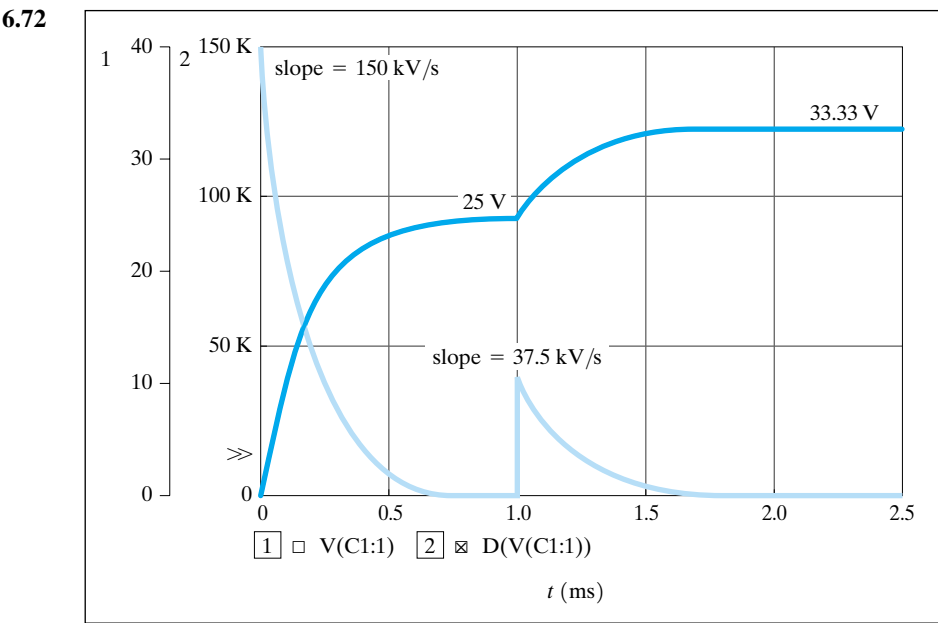
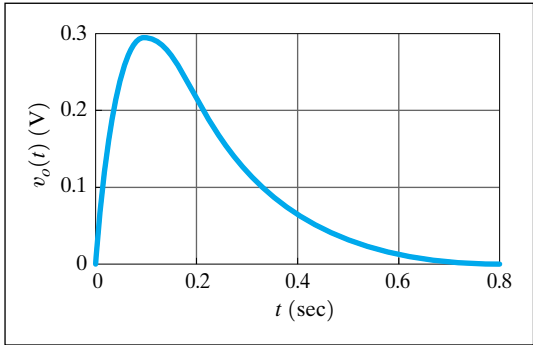
10

ANSWERS TO SELECTED PROBLEMS

6.64 $v_o(t) = 0 \qquad t < 0$
 $\qquad\qquad = 16.67(e^{-2\times 10^5 t} - e^{-8\times 10^5 t}) \text{ V}, \quad t > 0$

6.67 $i(t) = \frac{32}{7}e^{-8t} - \frac{4}{7}e^{-t} \text{ A}, \quad t > 0$

6.70 $v_o(t) = 8te^{-10t} \text{ V}, \quad t > 0$



6.75 $R = 2.5 \text{ k}\Omega, C = 10 \text{ pF}, L = 333 \text{ }\mu\text{H}$

6FE-2 $v_o(t = 1\text{s}) = 3.79 \text{ V}$

Chapter 7

7.1 $T = 0.16 \text{ s}, f = 63.66 \text{ Hz}$

7.3 $i_1(t)$ leads $i_2(t)$ by -85°

$i_2(t)$ leads $i_3(t)$ by 145°

$i_1(t)$ leads $i_3(t)$ by 60°

7.6 (a) $i(t) = 8 \cos(377t + 68^\circ) \text{ A}, \mathbf{I} = 8 \angle 68^\circ \text{ A}$

(b) $i(t) = 4 \cos(377t + 64^\circ) \text{ A}, \mathbf{I} = 4 \angle 64^\circ \text{ A}$

7.8 $\mathbf{Z} = 1 + j1 \Omega$

7.10 $\mathbf{Z} = 1.6 + j0.8 \Omega$

7.13 $\mathbf{Z} = 5.1 + j4.96 \Omega$

7.16 $\mathbf{Z} = 5 \angle -37^\circ \Omega$

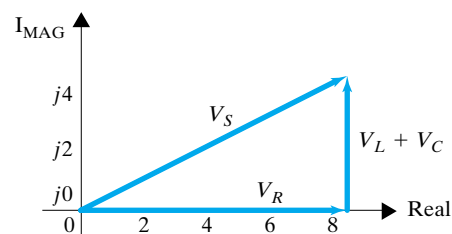
7.18 $C = 431 \mu\text{F}$

7.20 $i(t) = 4.37 \cos(377t + 0.75^\circ) \text{ A}$

7.22 $\mathbf{V}_R = 8.74 \angle 0.75^\circ \text{ V}$

$\mathbf{V}_L = 16.47 \angle 90.75^\circ \text{ V}$

$\mathbf{V}_C = 11.59 \angle -89.25^\circ \text{ V}$



7.25 $\mathbf{I}_R = 9.99 \angle 27.84^\circ \text{ A}$ and $\mathbf{I}_C = 0.38 \angle 117.84^\circ \text{ A}$

7.28 $\mathbf{V}_o = 10 \angle -53.1^\circ \text{ V}$

7.31 $\mathbf{V}_o = 1.414 \angle 15^\circ \text{ V}$

7.34 $\mathbf{I}_o = 5.89 \angle -48.4^\circ \text{ A}$

7.37 $\mathbf{V}_S = -8.54 \angle -20.56^\circ \text{ V}$

7.40 $\mathbf{I}_S = 8 + j4 \text{ A}$

7.42 $\mathbf{Z} = 2 \angle 83^\circ \Omega$

7.44 $\mathbf{I}_o = 4.69 \angle 78.69^\circ \text{ A}$

7.47 $\mathbf{V}_o = 3.09 \angle -23.83^\circ \text{ V}$

7.49 $\mathbf{V}_o = 3.58 \angle 153.43^\circ \text{ V}$

7.52 $\mathbf{V}_o = 5.55 \angle -86.9^\circ \text{ V}$

7.55 $\mathbf{V}_o = 0.8 + j2.4 \text{ V}$

12

ANSWERS TO SELECTED PROBLEMS

7.58 $V_o = 5.41 \angle 4.57^\circ \text{ V}$

7.61 $I_o = 2 \angle -37^\circ \text{ A}$

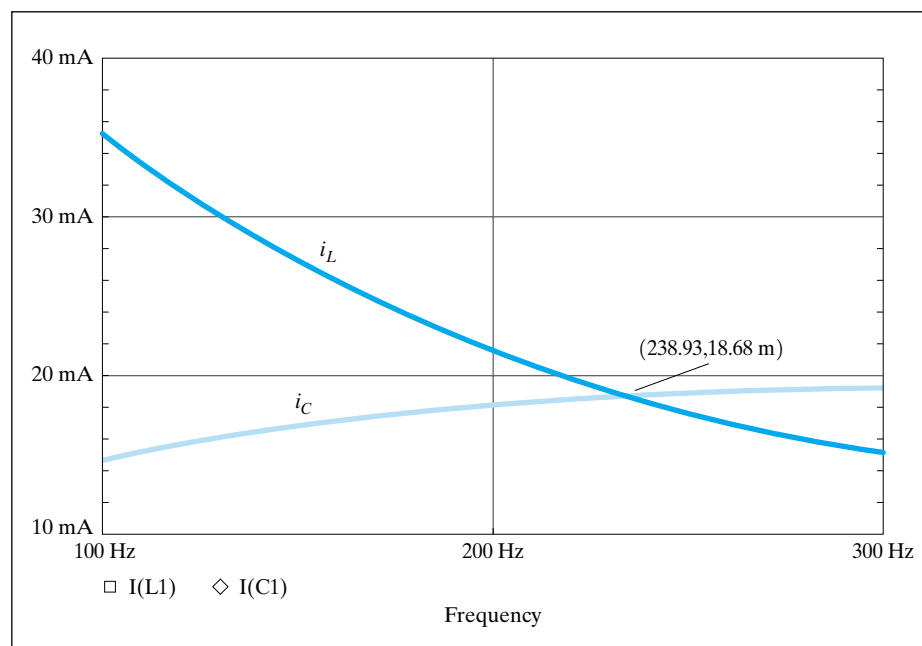
7.64 $V_o = 9.03 \angle 51.3^\circ \text{ V}$

7.67 $V_o = 1.3 \angle 12.5^\circ \text{ V}$

7.70 $V_x = 48.59 \angle -21.37^\circ \text{ V}$

7.73 $V_o = 2.53 \angle -18.43^\circ \text{ V}$

7.76 PROBE results show that the voltage and current phases are equal at 238.9 Hz.



7FE-1 $V_o = 5.06 \angle -71.6^\circ \text{ V}$

7FE-4 $\frac{V_o}{V_s} = -133.33$

Chapter 8

8.1 (a) $v_a(t) = -L_1 \frac{di_1(t)}{dt} - M \frac{di_2(t)}{dt}$

$v_b(t) = -L_2 \frac{di_2(t)}{dt} - M \frac{di_1(t)}{dt}$

(b) $v_c(t) = L_1 \frac{di_1(t)}{dt} + M \frac{di_2(t)}{dt}$

$v_d(t) = L_2 \frac{di_2(t)}{dt} + M \frac{di_1(t)}{dt}$

- 8.4 (a) $v_a(t) = L_1 \frac{di_1(t)}{dt} + M \frac{di_2(t)}{dt}$
 $v_b(t) = -L_2 \frac{di_2(t)}{dt} - M \frac{di_1(t)}{dt}$
 (b) $v_c(t) = -v_a(t) = -L_1 \frac{di_1(t)}{dt} - M \frac{di_2(t)}{dt}$
 $v_d(t) = -v_b(t) = L_2 \frac{di_2(t)}{dt} + M \frac{di_1(t)}{dt}$
- 8.7 $\mathbf{V}_o = 2.98 \angle 26.57^\circ \text{ V}$
- 8.9 $\mathbf{V}_o = 2.24 \angle -153.43^\circ \text{ V}$
- 8.11 $\mathbf{V}_o = 20.86 \angle 4.32^\circ \text{ V}$
- 8.14 $\mathbf{I}_o = 1.78 \angle 42^\circ \text{ A}$
- 8.17 $-\mathbf{V}_1 = \mathbf{I}_1(R_1 + j\omega L_1) + j\omega M \mathbf{I}_3$
 $\mathbf{V}_1 = \mathbf{I}_2 \left(j\omega L_2 - \frac{j}{\omega C_1} \right) - j\omega L_2 \mathbf{I}_3$
 $0 = j\omega M \mathbf{I}_1 - j\omega L_2 \mathbf{I}_2 + \mathbf{I}_3(R_2 + j\omega L_2 + j\omega L_3)$
- 8.20 $\mathbf{V}_o = 1.36 \angle -85.4^\circ \text{ V}$
- 8.23 $\mathbf{V}_o = 0.64 \angle -71.57^\circ \text{ V}$
- 8.26 $\mathbf{V}_o = 5.79 \angle 86.31^\circ \text{ V}$
- 8.29 $\mathbf{V}_o = 8.76 \angle 158.8^\circ \text{ V}$
- 8.32 $\mathbf{I}_o = 2.78 \angle -56.31^\circ \text{ A}$
- 8.35 $\mathbf{Z}_{\text{source}} = 1.56 \angle 42.27^\circ \Omega$
- 8.38 $\mathbf{Z}_{\text{IN}} = 1.94 \angle -33.69^\circ \Omega$
- 8.41 $L_2 = 3.6 \text{ mH}$
- 8.44 $i_1(t) = 2.46 \cos(100t + 143.1^\circ) \text{ mA}$
 $i_2(t) = 1.54 \cos(100t - 178.24^\circ) \text{ mA}$
- 8.47 $\mathbf{V}_1 = 8.89 \angle 30^\circ \text{ V}, \mathbf{I}_1 = 1.11 \angle 30^\circ \text{ A}$
 $\mathbf{V}_2 = 4.44 \angle -150^\circ \text{ V}, \mathbf{I}_2 = 2.22 \angle -150^\circ \text{ A}$
- 8.49 $\mathbf{I}_1 = 3.16 \angle -41.56^\circ \text{ A}, \mathbf{V}_1 = 4.47 \angle 3.44^\circ \text{ V}$
 $\mathbf{I}_2 = 1.58 \angle 138.44^\circ \text{ A}, \mathbf{V}_2 = 8.94 \angle 3.44^\circ \text{ V}$
- 8.52 $\mathbf{Z}_{\text{IN}} = 1.5 + j0.25 \Omega$
- 8.55 $\mathbf{Z}_S = 16 - j1 \Omega$
- 8.58 $\mathbf{V}_o = 44.72 \angle -153^\circ \text{ V}$
- 8.60 $\mathbf{I}_S = 2.91 \angle -75.95^\circ \text{ A}$
- 8.62 $\mathbf{V}_o = 15.78 \angle 189.46^\circ \text{ V}$
- 8.65 $\mathbf{V}_o = 1.8 \angle -139.86^\circ \text{ V}$
- 8FE-1 $\mathbf{Z}_S = 4.88 \angle 19.75^\circ \Omega$
- 8FE-4 $P = 11.1 \text{ W}$

14

ANSWERS TO SELECTED PROBLEMS

Chapter 9

9.1 $p(t) = 11.51 + 14.4 \cos(2\omega t + 113.1^\circ) \text{ W}$

9.3 $P = 1.58 \text{ W}$

9.5 $P_S = 4.31 \text{ W}, P_{2\Omega} = 3.06 \text{ W}, P_{4\Omega} = 1.23 \text{ W}$

9.8 $P_{\text{ABS}} = 35.95 \text{ W}$

9.11 $P_{4\Omega} = 10.4 \text{ W}$

9.13 $P_R = 4.5 \text{ W}$

9.16 $P_R = 2.5 \text{ W}$

9.18 $P_R = 32.49 \text{ W}$

9.21 $Z_L = 5 \Omega, P_L = 5.28 \text{ W}$

9.24 $Z_L = 0.55 \angle 33.69^\circ \Omega, P_{\text{MAX}} = 0.42 \text{ W}$

9.26 $Z_L = 0.9 - j0.3 \Omega, P_{\text{MAX}} = 2 \text{ W}$

9.29 $Z_L = 2.83 \angle 8.13^\circ \Omega, P_{\text{MAX}} = 1.32 \text{ W}$

9.32 $Z_L = 0.2 + j0.4 \Omega, P_{\text{MAX}} = 28.9 \text{ W}$

9.34 $V_{\text{rms}} = 2.31 \text{ V}$

9.37 $V_{\text{rms}} = 1.63 \text{ V}$

9.40 $V_{\text{rms}} = 2.67 \text{ V}$

9.43 $V_L = 440 \text{ V rms}$

9.46 $\theta = 36.87^\circ$

9.49 $PF = 0.65$ Lagging

9.51 $V_S = 281.02 \angle 8.75^\circ \text{ V rms}$

$PF_{\text{source}} = 0.756$ Lagging

9.54 $V_S = 320.06 \angle 9.95^\circ \text{ V rms}$

9.57 $C = 567.6 \mu\text{F}$

9.60 $C = 305 \mu\text{F}$

9.63 $PF = 0.88$ Lagging

9.65 $I = 18 \text{ A}$

9.68 $I_{\text{touch}} = 1.26 \text{ A rms}$, no current near the heart

9FE-1 $C = 927.6 \mu\text{F}$

9FE-3 $Z_L = 0.4 - j1.2 \Omega$

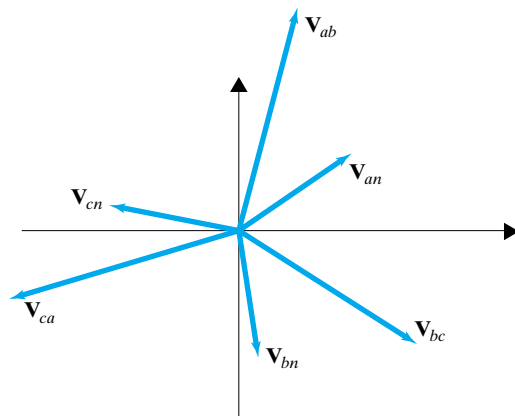
Chapter 10

Typically, only the a -phase information is listed. The two remaining phases are shifted by -120° and -240° , respectively.

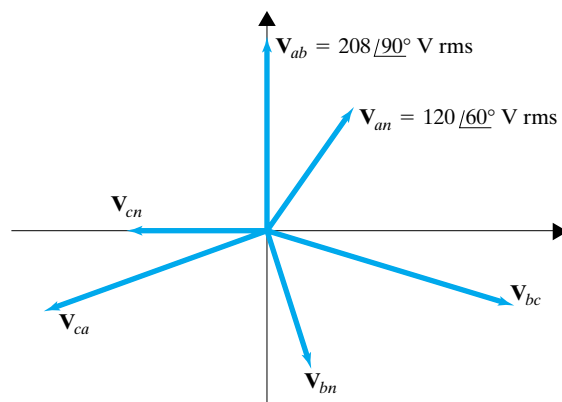
10.1 $V_{ab} = 173 \angle 25^\circ \text{ V rms}$

$V_{bc} = 173 \angle -45^\circ \text{ V rms}$

$V_{ca} = 173 \angle -165^\circ \text{ V rms}$



10.4 $V_{ab} = 208 \angle 90^\circ \text{ V rms}$
 $V_{bc} = 208 \angle -30^\circ \text{ V rms}$
 $V_{ca} = 208 \angle -150^\circ \text{ V rms}$



10.7 $I_{an} = 2.45 \angle -14^\circ \text{ A rms}$
10.10 $I_{an} = 5.56 \angle 6.3^\circ \text{ A rms}$
 $V_{an} = 111.1 \angle 59.40^\circ \text{ V rms}$
10.13 $V_{ab} = 217.4 \angle 40^\circ \text{ V rms}$
10.16 $Z_L = 15.62 \angle 39.8^\circ \Omega$
10.19 $I_{aA \text{ Max}} = 67.42 \text{ A rms}$
10.22 $Z_L = 19.95 + j21.93 \Omega$
10.25 $V_{ab} = 242.11 \angle 40.09^\circ \text{ V rms}$
10.28 $I_{aA} = 19.52 \angle 39.4^\circ \text{ A rms}$

16

ANSWERS TO SELECTED PROBLEMS

10.31 $\mathbf{Z}_L = 70.48 - j25.65 \, \Omega$

10.34 $\mathbf{Z}_L = 32.18 \angle 25^\circ \, \Omega$

10.37 $\mathbf{I}_{AN} = 9.37 \angle -4.4^\circ \, \text{A rms}$

10.40 $\mathbf{I}_{ab} = 8.64 \angle 57.9^\circ \, \text{A rms}$

10.43 $\mathbf{I}_{aA} = 37.35 \angle -1^\circ \, \text{A rms}$, $P_{Y \text{ Load}} = 7.434 \, \text{kW}$

10.46 $|\mathbf{I}_L| = 10.25 \, \text{A rms}$

10.49 $|\mathbf{I}_{aA}| = 148.56 \, \text{A rms}$, $PF_{\text{Load}} = 0.74$ Lagging

10.52 $PF_S = 0.91$ Lagging

10.55 $\mathbf{S}_{uL} = 19.94 \, \text{kVA} @ 0.60$ Lagging

10.58 $PF = 0.97$ Lagging

10.61 $C = 740.9 \, \mu\text{F}$

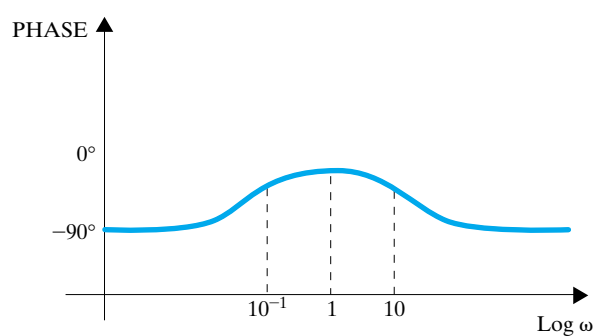
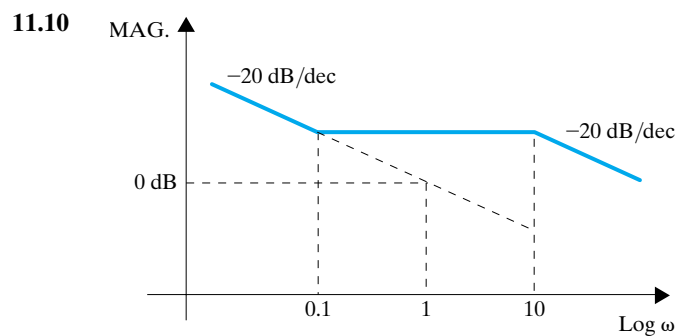
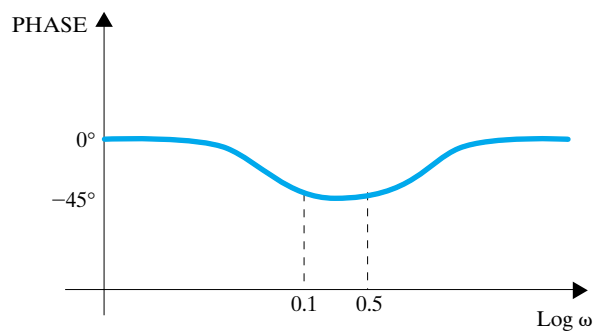
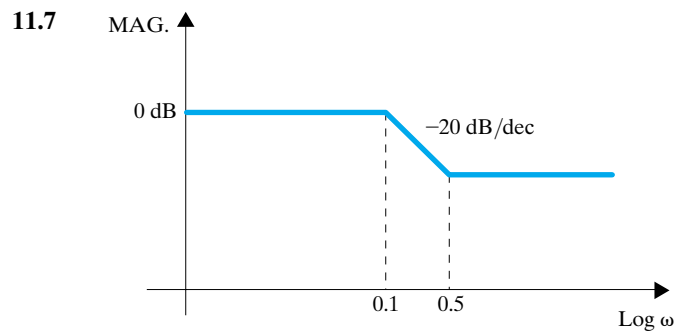
10FE-1 $\mathbf{S}_T = 2160 \angle 45^\circ \, \text{VA}$

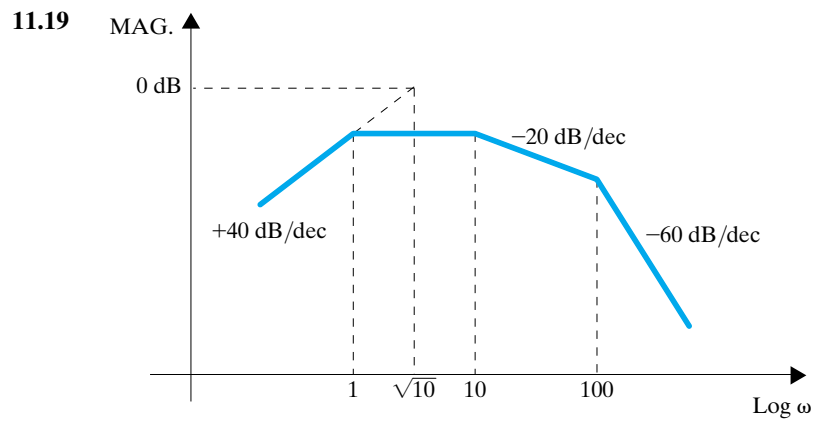
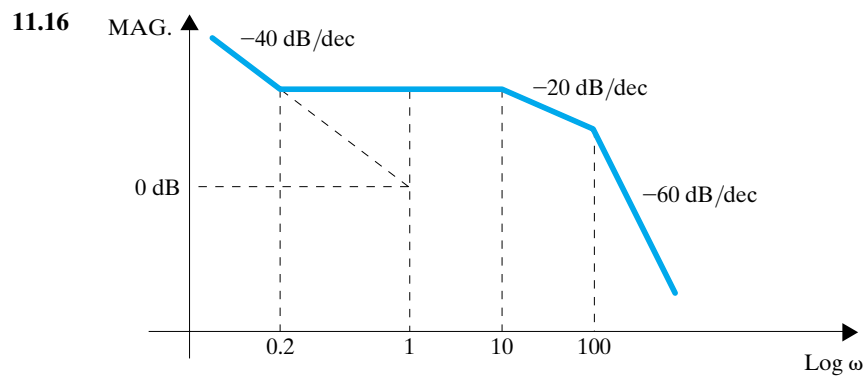
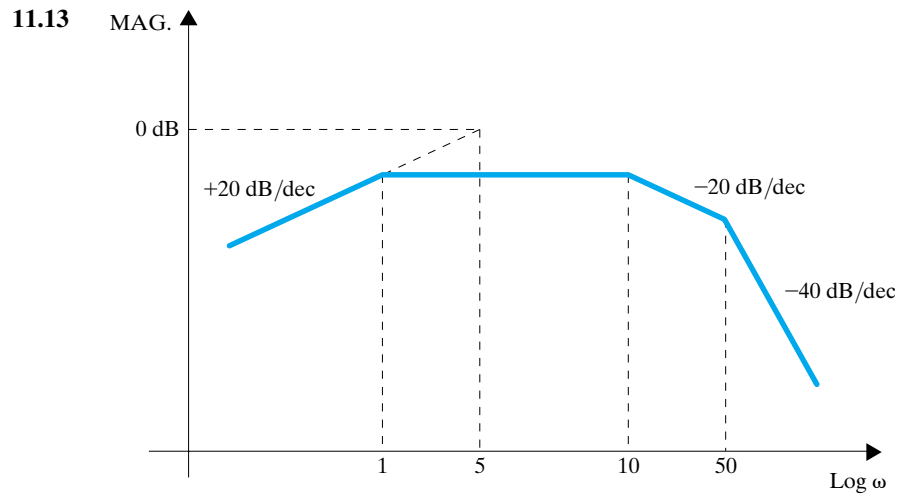
10FE-4 $P_p = 6.928 \, \text{kW}$

Chapter 11

11.1 $\mathbf{Z}(s) = \frac{s^2 LCR + sL + R}{s^2 LC + 1}$

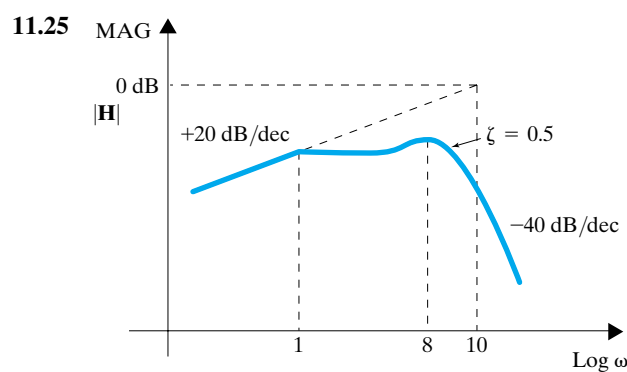
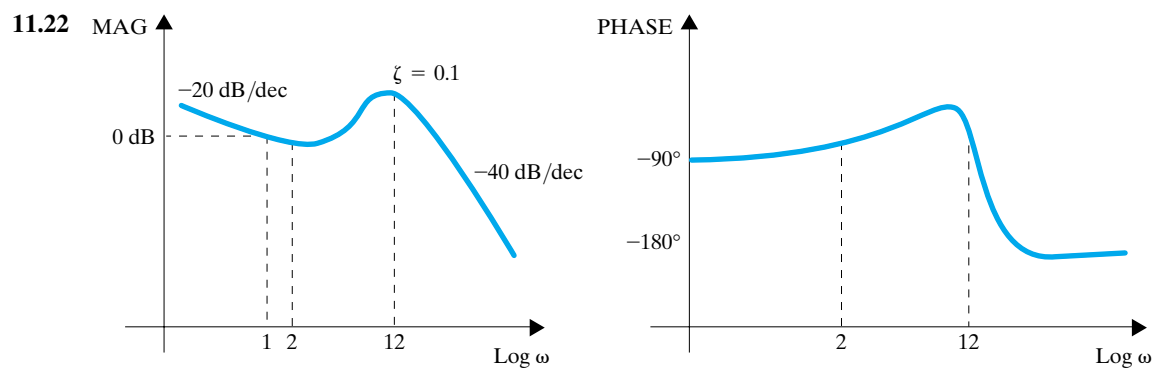
11.4 $\frac{\mathbf{V}_0}{\mathbf{I}_s} = \frac{8s(s+1)}{2s^2 + 6s + 1}$





18

ANSWERS TO SELECTED PROBLEMS



$$11.28 \quad H(j\omega) = \frac{10 \left(\frac{j\omega}{10} + 1 \right)}{(j\omega) \left(\frac{j\omega}{20} + 1 \right)^2}$$

$$11.31 \quad H(j\omega) = \frac{1(j\omega) \left(\frac{j\omega}{30} + 1 \right)}{(j\omega + 1) \left(\frac{j\omega}{100} + 1 \right) \left(\frac{j\omega}{8} + 1 \right)^2}$$

$$11.34 \quad L = 12.5 \text{ mH}, Q = 10.42, BW = 192 \text{ r/s}$$

$$11.37 \quad \omega_0 = 7071 \text{ r/s}, Q = 14.14, \omega_{\text{MAX}} = 7062 \text{ r/s}, |V_o|_{\text{max}} = 84.89 \text{ V}$$

$$11.40 \quad \omega_0 = 2 \text{ kr/s}, Q = 25, BW = 80 \text{ r/s}, P = 18 \text{ W}$$

$$11.43 \quad R = 1 \text{ k}\Omega, L = 500 \text{ }\mu\text{H}$$

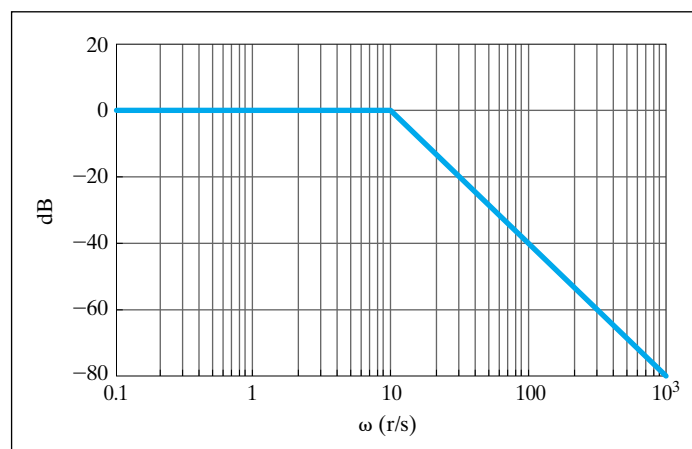
$$11.46 \quad \omega_0 = 10 \text{ kr/s}, BW = 100 \text{ r/s}, Q = 100, P_{\text{LO}} = P_{\text{HI}} = 12.5 \text{ kW}$$

$$11.49 \quad C = 25 \text{ nF}, L = 10 \text{ }\mu\text{H}$$

$$11.52 \quad R_{\text{new}} = 20 \text{ k}\Omega, L_{\text{new}} = 5 \text{ kH}, C = 12.5 \text{ }\mu\text{F}$$

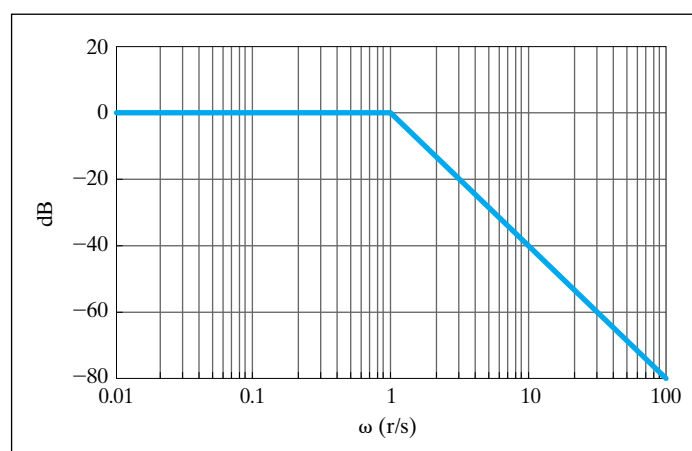
11.55 Low-pass filter

$$\frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{1}{\left(\frac{j\omega}{10}\right)^2 + \frac{j\omega}{10} + 1}$$



$$\mathbf{11.57} \quad \mathbf{G}_v = \frac{\left(1 + \frac{j\omega L}{R_1}\right)}{1 + j\omega\left(\frac{L}{R}\right)} \quad R = R_1 \parallel R_2$$

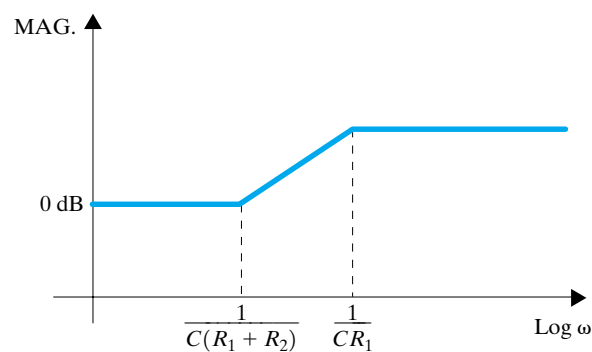
A low-pass filter



20

ANSWERS TO SELECTED PROBLEMS

11.61 $\frac{V_o}{V_i} = \frac{j\omega C(R_1 + R_2) + 1}{j\omega CR_1 + 1}$, a high-pass filter



11.63 $g_m = 100 \mu\text{S}$ and $I_{ABC} = 5 \mu\text{A}$

11.66 $L_{\text{eq}} = \frac{C}{(g_{m1}g_{m2})}$

11.68 $\frac{V_o}{V_{\text{in}}} = \frac{j\omega g_1/C_2}{-\omega^2 + j\omega \left[\frac{g_1 + g_2 + g_3 + g_3 \left(\frac{C_1}{C_2} \right)}{C_1} \right] + \frac{g_1 g_3}{C_1 C_2}}$

$$\omega_0 = \sqrt{\frac{g_1 g_3}{C_1 C_2}}, Q = \frac{\sqrt{g_1 g_2 C_1 C_2}}{C_2(g_1 + g_2 + g_3) + C_1 g_3}$$

Band-pass filter

11.71 $C = 100 \mu\text{F}$, $L = 101 \text{ mH}$

11FE-2 $\omega_0 = 1 \text{ kr/s}$, $R = 4 \Omega$

11FE-4 $L = 100 \text{ mH}$, $R = 10 \Omega$

Chapter 12

12.1 $\mathbf{F}(s) = e^{-(s+a)}$

12.4 $\mathbf{F}(s) = e^{-(s+a)} \left[\frac{\omega \cos \omega}{(s+a)^2 + \omega^2} + \frac{(s+a) \sin \omega}{(s+a)^2 + \omega^2} \right]$

12.7 $\mathbf{F}(s) = \frac{e^{-2s}}{(s+1)(s+2)}$

12.10 $\mathbf{F}(s) = e^{-(s+a)} \left[\frac{1}{(s+a)^2} + \frac{1}{s+a} \right]$

$$12.13 \quad (\mathbf{a}) \quad f(t) = \left[\frac{1}{6} + \frac{1}{2} e^{-2t} - \frac{2}{3} e^{-3t} \right] u(t)$$

$$(\mathbf{b}) \quad f(t) = \left[\frac{1}{2} - e^{-t} + \frac{3}{2} e^{-2t} \right] u(t)$$

$$12.15 \quad (\mathbf{a}) \quad f(t) = \left(\frac{1}{4} e^{-2t} + \frac{3}{4} e^{-6t} \right) u(t)$$

$$(\mathbf{b}) \quad f(t) = \left(\frac{3}{4} + \frac{1}{4} e^{-4t} \right) u(t)$$

$$12.18 \quad (\mathbf{a}) \quad f(t) = 10e^{-t} \cos t \, u(t)$$

$$(\mathbf{b}) \quad f(t) = \left[\frac{1}{5} + 0.62e^{-2t} \cos(t - 108.43^\circ) \right] u(t)$$

$$12.21 \quad (\mathbf{a}) \quad f(t) = [2e^{-3t} \cos 3t - e^{-3t}] u(t)$$

$$(\mathbf{b}) \quad f(t) = [1 + e^{-4t} \sin 4t] u(t)$$

$$12.24 \quad (\mathbf{a}) \quad f(t) = [2te^{-2t} + e^{-2t}] u(t)$$

$$(\mathbf{b}) \quad f(t) = [6 - 5te^{-t} - 6e^{-t}] u(t)$$

$$12.27 \quad f(t) = \left[-3 + 3t + \frac{12}{5} e^{-t} + \frac{2}{3} e^{-2t} \cos(2t - 26.56^\circ) \right] u(t)$$

$$12.30 \quad (\mathbf{a}) \quad f(t) = \frac{1}{2} u(t-1) + \frac{1}{2} e^{-2(t-1)} u(t-1)$$

$$(\mathbf{b}) \quad f(t) = [5e^{-(t-2)} - 5e^{-3(t-2)}] u(t-2)$$

$$12.33 \quad (\mathbf{a}) \quad f(t) = [-2e^{-(t-1)} + 4e^{-3(t-1)}] u(t-1)$$

$$(\mathbf{b}) \quad f(t) = \left[\frac{10}{3} e^{-(t-2)} + \frac{20}{3} e^{-4(t-2)} \right] u(t-2)$$

$$12.36 \quad y(t) = \left(\frac{1}{3} e^{-t} - \frac{1}{3} e^{-4t} \right) u(t)$$

$$12.39 \quad f(t) = (e^{-t} - e^{-2t}) u(t)$$

$$12.42 \quad (\mathbf{a}) \quad f(0) = 10, f(\infty) = 0$$

$$(\mathbf{b}) \quad f(0) = 0, f(\infty) = 0$$

$$(\mathbf{c}) \quad f(0) = 2, f(\infty) = 0$$

$$12.45 \quad i(t) = 4e^{-\frac{9}{2}t} u(t) \text{ A}$$

$$12.48 \quad i_L(t) = (4e^{-2t} - e^{-t}) u(t) \text{ A}$$

$$12\text{FE-2} \quad v_o(t = 0.1 \text{ s}) = 0.24 \text{ V}$$

Chapter 13

$$13.1 \quad Z(s) = \frac{6s + 8}{6s^2 + 16s + 11}$$

$$13.3 \quad v(t) = 10 u(t) \text{ V}$$

22

ANSWERS TO SELECTED PROBLEMS

$$13.5 \quad i_o(t) = \left(2 - e^{-t} - \frac{4}{3} e^{-\frac{2}{3}t} \right) u(t) \text{ A}$$

$$13.7 \quad v(t) = (5e^{-t} - 4500te^{-t})u(t) \text{ mV}$$

$$13.10 \quad v_o(t) = \frac{6}{7} (1 - e^{-\frac{7}{4}t})u(t) \text{ V}$$

$$13.13 \quad v_o(t) = (1 - 5e^{-4t})u(t) \text{ V}$$

$$13.16 \quad v_o(t) = \left(-\frac{4}{3} + 2e^{-t} - \frac{20}{3} e^{-3t} \right) u(t) \text{ V}$$

$$13.19 \quad v_o(t) = 2\sqrt{2}e^{-t} \cos(t - 45^\circ)u(t) \text{ V}$$

$$13.22 \quad i_o(t) = \left[1 - \frac{2}{3} e^{-\frac{4}{3}t} \right] u(t) \text{ A}$$

$$13.25 \quad v_o(t) = \left(\frac{8}{3} + 4e^{-2t} - \frac{17}{3} e^{-\frac{3}{2}t} \right) u(t) \text{ V}$$

$$13.28 \quad v_o(t) = 5e^{-3t}u(t) \text{ V}, t > 0$$

$$13.30 \quad i_o(t) = -e^{\frac{-t}{2}}u(t) \text{ A}, t > 0$$

$$13.32 \quad i_o(t) = \frac{3}{2} e^{-\frac{9}{2}t}u(t) \text{ A}, t > 0$$

$$13.35 \quad v_o(t) = (4 + 2e^{-\frac{5t}{12}})u(t) \text{ V}, t > 0$$

$$13.37 \quad v_o(t) = 1.15[e^{-0.42t} - e^{-1.58t}]u(t) \text{ V}, t > 0$$

$$13.40 \quad v_o(t) = 2.31[e^{-0.35t} - e^{-5.65t}]u(t) \text{ V}, t > 0$$

$$13.43 \quad v_o(t) = (8 - 8e^{-4t})u(t) - [8 - 8e^{-4(t-1)}]u(t-1) \text{ V}$$

$$13.46 \quad \frac{\mathbf{V}_o}{\mathbf{V}_s} = \left(1 + \frac{R_1}{R_2} \right) \frac{(1 + sCR)}{1 + sCR_1}, R = R_1 || R_2$$

$$13.49 \quad \frac{\mathbf{V}_o}{\mathbf{V}_s} = \frac{\frac{-s}{R_1 C_1}}{s^2 + s \left(\frac{C_1}{C_1 C_2 R_3} + \frac{C_2}{C_1 C_2 R_3} \right) + \frac{R_1 R_2}{C_1 C_2 R_1 R_2 R_3}}$$

$$13.52 \quad \text{Yes}$$

$$13.54 \quad \text{No, overdamped}$$

$$13.56 \quad C = 0.5 \text{ F}$$

$$13.59 \quad v_o(t) = 4.7 \cos(t - 45^\circ) \text{ V}$$

$$13.62 \quad i_o(t) = 12\sqrt{2} \cos(2t + 45^\circ) \text{ A}$$

$$13\text{FE-2} \quad \frac{\mathbf{V}_o}{\mathbf{V}_s} = \frac{s}{s^2 + s + 2}, \text{ the network is underdamped.}$$

Chapter 14

$$14.1 \quad f(t) = \sum_{\substack{n=-\infty \\ n \neq 0 \\ n \text{ odd}}}^{\infty} \frac{2}{jn\pi} e^{jn\omega_0 t}$$

$$14.3 \quad f(t) = \sum_{n=-\infty}^{\infty} \frac{6}{n\pi} e^{-jn\pi t} \sin\left(\frac{n\pi}{5}\right)$$

$$14.5 \quad f(t) = \frac{1}{2} + \sum_{\substack{n=-\infty \\ n \neq 0 \\ n \text{ odd}}}^{\infty} \frac{-2}{n^2\pi^2} e^{jn\pi t}$$

$$14.8 \quad v(t) = \sum_{n=1}^{\infty} (-1)^{n+1} \frac{20}{n\pi} \sin nt$$

$$14.10 \quad a_0 = \frac{1}{4}, b_n = 0$$

$$a_n = \frac{4}{n^2\pi^2} \left[\cos\left(\frac{n\pi}{2}\right) - 1 \right] + \frac{2}{n\pi} \sin\left(\frac{n\pi}{2}\right)$$

$$14.13 \quad a_0 = \frac{-\pi}{4}$$

$$a_n = \frac{1}{\pi n^2} (\cos(n\pi) - 1)$$

$$b_n = \frac{1}{n} (1 - 2 \cos n\pi)$$

$$14.16 \quad a_0 = \frac{1}{4}$$

$$a_n = \frac{1}{n^2\pi^2} (\cos(n\pi) - 1)$$

$$b_n = \frac{1}{n\pi} (\cos(n\pi) - 2)$$

$$14.19 \quad f(t) = \frac{A}{\pi} + \frac{A}{2} \sin(\pi t) + \sum_{\substack{n=2 \\ n \text{ even}}}^{\infty} \frac{2A}{\pi(1-n^2)} \cos n\omega_0 t$$

$$14.22 \quad f(t) = -4 \sin 20\pi t - 5 \sin 40\pi t - 3 \sin 60\pi t - 2 \sin 80\pi t - \sin 100\pi t$$

$$14.25 \quad i_o(t) = \frac{(-1)^{n+1} 20}{n\pi} |\mathbf{G}(n)| \cos(nt - 90^\circ + \theta_n)$$

$$\mathbf{G}(n) = \frac{jn}{1 + 3jn}, \theta_n = \angle \mathbf{G}(n)$$

$$14.28 \quad i_o(t) = 3.18 \sin(2\pi t + 89.9^\circ) - 3.18 \sin(4\pi t + 89.9^\circ) + 3.18 \sin(6\pi t + 89.9^\circ) - 3.18 \sin(8\pi t + 89.9^\circ) \text{ mA}$$

$$14.31 \quad \mathbf{V}(\omega) = \frac{2A}{j\omega} (1 - \cos \omega T)$$

24

ANSWERS TO SELECTED PROBLEMS

$$14.34 \quad \mathbf{F}(\omega) = \frac{2a}{a^2 + \omega^2}$$

$$14.37 \quad v_o(t) = (e^{-3t} - e^{-4t})u(t) \text{ V}$$

$$14.40 \quad v_o(t) = \frac{2}{3} [e^{-t} - e^{-4t}]u(t) \text{ V}$$

- 14FE-1 $a_0 = 0$ since the average value is zero
 $a_n = 0$ for all n since this is an odd function
 $b_n = 0$ for n even because of half-wave symmetry
 $b_n =$ finite numbers for n odd

Chapter 15

$$15.1 \quad (\mathbf{a}) \quad \mathbf{y}_{11} = \frac{1}{\mathbf{Z}_L}, \mathbf{y}_{12} = \frac{-1}{\mathbf{Z}_L}, \mathbf{y}_{21} = \frac{-1}{\mathbf{Z}_L}, \mathbf{y}_{22} = \frac{1}{\mathbf{Z}_L}$$

$$(\mathbf{b}) \quad \mathbf{z}_{11} = \mathbf{Z}_L, \mathbf{z}_{12} = \mathbf{Z}_L, \mathbf{z}_{21} = \mathbf{Z}_L, \mathbf{z}_{22} = \mathbf{Z}_L$$

$$15.3 \quad \mathbf{y}_{11} = \frac{1}{14} \text{ S}, \mathbf{y}_{12} = \frac{-1}{21} \text{ S}, \mathbf{y}_{21} = \frac{-1}{21} \text{ S}, \mathbf{y}_{22} = \frac{1}{7} \text{ S}$$

$$15.5 \quad \mathbf{y}_{11} = \frac{1}{\mathbf{Z}_1}, \mathbf{y}_{12} = 0, \mathbf{y}_{21} = \frac{\gamma}{\mathbf{Z}_2}, \mathbf{y}_{22} = \frac{1}{\mathbf{Z}_2}$$

$$15.8 \quad \mathbf{z}_{11} = 18 \, \Omega, \mathbf{z}_{12} = 6 \, \Omega, \mathbf{z}_{21} = 6 \, \Omega, \mathbf{z}_{22} = 9 \, \Omega$$

$$15.11 \quad \frac{\mathbf{V}_o}{\mathbf{V}_1} = -65.6$$

$$15.13 \quad \frac{\mathbf{V}_2}{\mathbf{V}_1} = -438$$

$$15.16 \quad \mathbf{z}_{11} = R_1, \mathbf{z}_{12} = nR_1, \mathbf{z}_{21} = nR_1, \mathbf{z}_{22} = n^2(R_1 + R_2)$$

$$15.19 \quad \mathbf{h}_{11} = 6 \, \Omega, \mathbf{h}_{12} = 0.5, \mathbf{h}_{21} = -0.5, \mathbf{h}_{22} = \frac{1}{8} \text{ S}$$

$$15.22 \quad A = 1, B = -j1 \, \Omega, C = 15, D = 1 - j$$

$$15.25 \quad \mathbf{A} = \frac{R_1 + R_2}{\gamma + R_2}, \mathbf{B} = \frac{R_1 R_3 + R_2 R_3 + R_1 R_2 - \gamma R_2}{\gamma + R_2}$$

$$\mathbf{C} = \frac{1}{\gamma + R_2}, \mathbf{D} = \frac{R_2 + R_3}{\gamma + R_2}$$

$$15.28 \quad \mathbf{y}_{11} = \frac{5}{11} \text{ S}, \mathbf{y}_{12} = \frac{-2}{11} \text{ S}, \mathbf{y}_{21} = \frac{-2}{11} \text{ S}, \mathbf{y}_{22} = \frac{3}{11} \text{ S}$$

$$15.31 \quad \mathbf{h}_{11} = \frac{\mathbf{z}_{11}\mathbf{z}_{22} - \mathbf{z}_{12}\mathbf{z}_{21}}{\mathbf{z}_{22}}, \mathbf{h}_{12} = \frac{\mathbf{z}_{12}}{\mathbf{z}_{22}}$$

$$\mathbf{h}_{21} = \frac{-\mathbf{z}_{21}}{\mathbf{z}_{22}}, \mathbf{h}_{22} = \frac{1}{\mathbf{z}_{22}}$$

15.33 $\mathbf{Y}_{in} = 1 \text{ S}$

15.36 $\mathbf{Z}_T = \begin{bmatrix} 18 & 6 \\ 6 & 9 \end{bmatrix}$

15.39 $\begin{bmatrix} \mathbf{A} & \mathbf{B} \\ \mathbf{C} & \mathbf{D} \end{bmatrix} = \begin{bmatrix} 3 & j8 \\ 3 - j & 3 + j8 \end{bmatrix}$

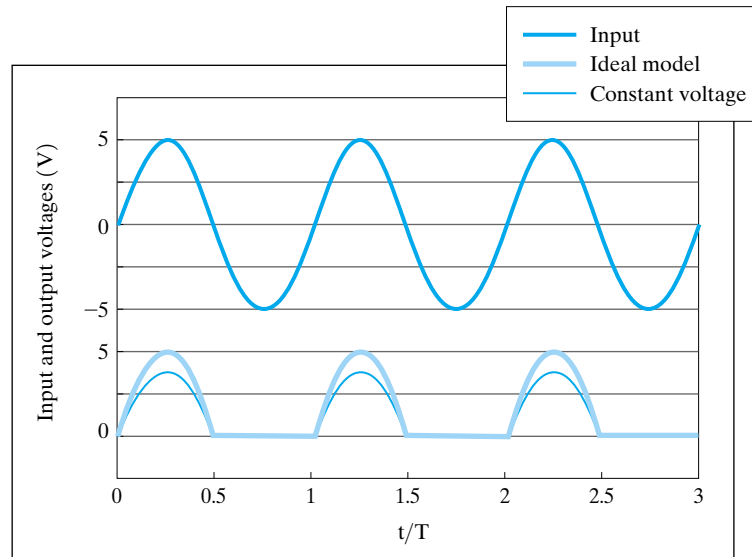
15FE-1 $V_1 = 36 \text{ V}$

Chapter 16

16.1	$\overline{V_D}(\text{V})$	$\overline{I_D}(\text{A})$
	0	0
	0.25	1.7×10^{-11}
	0.50	2.9×10^{-7}
	0.75	5.0×10^{-3}

16.3 (a) 9.4 V, (b) 10 V, (c) 3.4 V, (d) -1 V

16.5



16.8 $\frac{V_o}{V_{IN}} = \frac{g_m R_{eq}}{g_m R_{eq} + 1}, R_0 = \frac{R_{eq}}{g_m R_{eq} + 1}$
 $R_{eq} = R_S || r_{ds}$

For given values $R_o = 83.3 \Omega$

A good application is a voltage buffer much like the unity gain buffer op-amp.

16.10 $v_o = \frac{g_m R_D}{2} (v_2 - v_1)$

16.12 $R_{ON} = \frac{1}{2} \Omega, R_1 = 149.5 \Omega$

16.13 $R_{ON} \leq 1.2 \Omega$

16FE-1 When V_{IN} is greater than 6 V, D_1 is forward biased and D_2 is reverse biased. The circuit reduces to that in Figure A where

$$V_{\text{IN}} = 500I + 6$$

and

$$V_o = 300I + 6$$

Solving for V_o yields

$$V_o = 6 + 0.6(V_{\text{IN}} - 6)$$

When V_{IN} is less than -2 V, D_2 is forward biased and D_1 is reverse biased. Under these conditions, $V_o = -2$ V. For V_{IN} between -2 V and $+6$ V, both diodes are reverse biased, no current flows anywhere and $V_o = V_{\text{IN}}$. A plot of V_o versus V_{IN} is shown in Figure B.

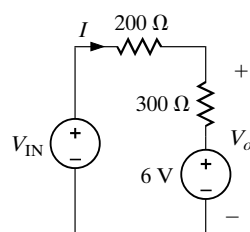


Figure A

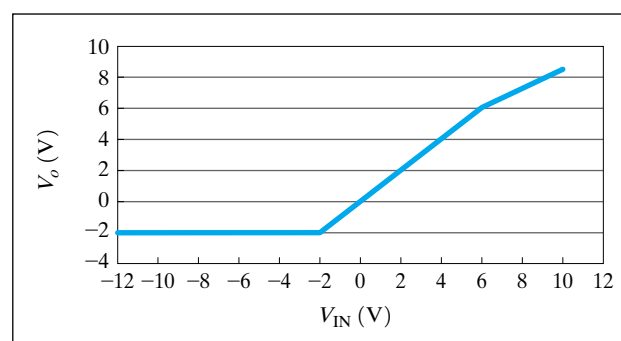


Figure B