APPENDIX G

Answers to Selected Problems

Chapter 1

1.1 8.85 ms

1.3 38 m/s

1.5 361.934 μm^2

1.7 0.962 aJ

1.9 6480 J

1.11 a) 400 W, delivering
b) Entering
c) Gain

1.15 a) 3.1 mW
b) 1.24 μJ
c) 21.67 μJ

1.18 a) 0.5 W
b) 2 mJ

1.21 a) 1.68 ms
b) 666 mW
c) 2.97 mJ

1.26 1740 W

Chapter 2

2.3 yes; 720 W

2.8 2240 W

2.11 a) 4 A
b) 144 V
c) 768 W

2.16 a) 2 A
b) $p_{5\Omega} = 320$ W; $p_{25\Omega} = 400$ W; $p_{70\Omega} = 280$ W; $p_{10\Omega} = 360$ W; $p_{8\Omega} = 800$ W
c) 2160 W

2.21 a) 60 Ω
b) 2000 W

2.26 a) 0 A
b) −60 mA
c) −240 mA

2.29 $v_1 = -50$ mV; $v_g = 6.25$ mV

Chapter 3

3.3 80 W

3.6 a) 16 Ω
b) 6 Ω

3.10 33.75 kV

3.13 $i_g = 12.5$ A; $i_o = 2$ A

3.16 26.67 Ω

3.20 a) 66 V
b) $P_{R_1} = 1.88$ W; $P_{R_2} = 1.32$ W
c) $R_1 = 17{,}672\ \Omega$; $R_2 = 12{,}408\ \Omega$

3.26 $v_x = 16$ V; $P = 75.2$ W

3.32 −0.1664 %

3.36 −27.03 %

3.46 300 mW

3.51 2 kΩ

3.54 a) 120 Ω
b) 60 W

3.56 a) 4 A
b) 1.1 A
c) 6 V
d) 2500 W

Chapter 4

4.2 40 W (absorbing)

4.5 10 V

4.9 $v_1 = 100$ V; $v_2 = 20$ V

4.13 1 A

4.17 a) 2000 W
b) 35,000 W

4.20 26 V

4.26 602.5 W

4.30 a) $i_a = 9.8$ A; $i_b = -0.2$ A; $i_c = -10$ A
b) $i_a = -1.72$ A; $i_b = 1.08$ A; $i_c = 2.8$ A

4.33 a) −1.0 mA
b) 8.5 mW
c) 0.225 mW

4.35 98 W

4.38 600 W

4.44 2 A

4.51 a) 3 mA
b) 345 mW

4.54 a) 1 A
b) 1 A

4.56 $v_{Th} = 48$ V; $R_{Th} = 16$ Ω

4.59 $v_{Th} = 52$ V; $R_{Th} = 6$ Ω

4.62 $i_N = 8$ mA; $R_N = 10$ kΩ

4.65 a) 150 kΩ
b) −1.56 %

4.69 $v_{Th} = 0$ V; $R_{Th} = 18.75$ Ω

4.74 $R_o = 2.5$ Ω, 22.5 Ω

4.77 a) 2.5 Ω
b) 2250 W

4.80 3.77 %

4.82 a) 35 Ω
b) 505.4 W
c) 21,364 W

4.84 25 V

4.87 $i_o = 2$ A; $v_o = -136$ V

4.90 a) 4 A
b) 160 W

4.96 40 W

4.98 0 A

4.101 $v_1 = 37.5$ V; $v_2 = 105$ V

Chapter 5

5.2 −200 μA

5.4 a) −400 mV
b) −6.8 V
c) 20 μA
d) 111.67 μA

5.6 −3.1 mA

5.8 a) $0 \le \sigma < 0.2$
b) 200 μA

5.11 a) 415.38 k Ω
b) 650.37 μA

5.13 $0 \le R_f \le 75$ kΩ

5.17 a) 108 kΩ
b) 270 μW

5.22 a) 7.56 V
b) $-3.97 \le v_g \le 3.97$ V
c) 35 kΩ

5.26 a) 56.3 mV
b) 114.3 kΩ
c) 80 kΩ

5.29 $R_b = 1200$ Ω; $R_f = 2000$ Ω

5.33 $v_{o1} = 15.85$ V; $v_{o2} = 13.6$ V

5.40 a) -39.997
b) 4.02 μV
c) 8000.644 Ω
d) $v_o/v_g = -40$; $v_n = 0$ V; $R_g = 8000$ Ω

5.42 23.89 kΩ

Chapter 6

6.3 a) $100e^{-10t}(1 - 10t)$ mV
b) -18.32 mW
c) delivering
d) 1.83 mJ
e) 3.38 mJ

6.5 a)
$i = 0$, $t < 0$
$i = 16t$, $0 \le t \le 25$ ms
$i = 0.8 - 16t$, $25 \le t \le 50$ ms
$i = 0t$, 50 ms $< t$

b)
$v = 0$, $t < 0$
$v = 6$ V, $0 \le t \le 25$ ms
$v = -6$ V, $25 \le t \le 50$ ms
$v = 0$, 50 ms $< t$
$p = 0$, $t < 0$
$p = 96t$ W, $0 \le t \le 25$ ms
$p = 96t - 4.8$ W, $25 \le t \le 50$ ms
$p = 0$, 50 ms $< t$
$w = 0$, $t < 0$
$w = 48t^2$ J, $0 \le t \le 25$ ms
$w = 48t^2 - 4.8t + 0.12$, J $25 \le t \le 50$ ms
$w = 0$, 50 ms $< t$

6.7 a) $-8.75e^{-2500t} + 18.75e^{-7500t}$ V
b) 152.44 μs

6.9 a) 2.77 ms
b) 64.27 V

6.12 1007 W, absorbing

6.16 a) 250 μJ
b) 19.31 mJ

6.18 a) 1.25 μC
b) 5 V
c) 2 μJ

6.21 20 H

6.25 5 nF, with initial voltage of 10 V, positive at the bottom

6.27 32.19 ms

6.31 a) 54,031.25 nJ
b) 44,031.25 nJ
c) 10,000 nJ
d) 18.51 %
e) 1.39 ms

6.35 a) $60 + 5780e^{-4t} - 5840e^{-5t}$ V
b) 0 V
c) $960 + 92{,}480e^{-4t} - 94{,}400e^{-5t} - 92{,}480e^{-9t} + 93{,}440e^{-10t}$ W
d) 960 W
e) $p_{5\Omega} = 720$ W; $p_{20\Omega} = 180$ W; $p_{60\Omega} = 60$ W

6.39 a) 0.85
b) 28 mH
c) 7

6.44 $v(t) = \frac{1}{3}v_s(t) + v(0)$, so moving the button has no effect on the change in $v(t)$

Chapter 7

7.1 a) 25 Ω
b) 12.5 ms
c) 312.5 mH
d) 2.5 J
e) 10.06 ms

7.3 33.33 %

7.5 a) $i_1(0^-) = i_2(0^-) = 0.2$ mA
b) $i_1(0^+) = 0.2$ mA; $i_2(0^+) = -0.2$ mA
c) $0.2e^{-10^6 t}$ mA, $t \ge 0$
d) $-0.2e^{-10^6 t}$ mA, $t \ge 0^+$
e) The current in the resistor can change instantaneously.

7.7 48.64 %

7.9 a) 200 A
b) 220 A
c) 307.6 μs (6 mH, not 2 mH)

7.12 a) 625 nJ
b) 625 nJ

7.14 a) $2e^{-25{,}000t}$ V, $t \geq 0^+$
b) 80 nJ
c) 59.9 μs

7.19 a) 180.34 mH
b) 93.75 %

7.22 a) $i = 15e^{-125t}$ mA, $t \geq 0^+$ $v_1 = 60e^{-125t} + 15$ V, $t \geq 0$; $v_2 = -15e^{-125t} + 15$ V, $t \geq 0$
b) 5625 μJ
c) $w_{\text{trapped}} = 1125\ \mu\text{J}$ $w_{\text{diss}} = 4500\ \mu\text{J}$

7.25 a) 125×10^{-6} A/V
b) $180e^{-1000t}$ V

7.28 a) $10e^{-5000t}$ mA, $t \geq 0^+$
b) $(-\frac{20}{3}e^{-5000t} + \frac{320}{3})$ V, $t \geq 0$
c) 2560 μJ

7.31 $-312.5e^{-500t}$ μA, $t \geq 0^+$

7.36 80.47 ms

7.39 a) $V_s = 80$ V; $R = 20\ \Omega$; $I_o = 8$ A; $L = 0.5$ H
b) 17.33 ms

7.42 $3.67 + 6.33e^{-250t}$ A, $t \geq 0$

7.44 $-60 + 90e^{-2000t}$ V, $t \geq 0$

7.47 a) $-480e^{-10t}$ V, $t \geq 0^+$
b) $4e^{-10t} + 4$ A, $t \geq 0$
c) $6e^{-10t} + 6$ A, $t \geq 0$

7.55 356.4 ms

7.60 a) $4 - 4e^{-20t}$ A, $t \geq 0$
b) $80e^{-20t}$ V, $t \geq 0^+$
c) $2.4 - 2.4e^{-20t}$ A, $t \geq 0$
d) $1.6 - 1.6e^{-20t}$ A, $t \geq 0$
e) Yes, the final values of i_o, i_1, and i_2 are consistent with conservation of flux linkage

7.63 6.63 V

7.67 0 A

7.72 $v_o = 100$ V, $0 \leq t \leq 250$ ms $v_o = 100e^{-1000(t-0.25)}$ V, 250 ms $\leq t \leq \infty$

7.76 a) $v_o = 0,\ t < 0\ \ v_o = 200e^{-32{,}000t}$ V, $0 < t \leq 50\ \mu$s $v_o = -159.62e^{-32{,}000(t-50\times10^{-6})}$ V, 50 μs$\leq t \leq \infty$
b) $v_o(50^-\ \mu\text{s}) = 40.38$ V
$v_o(50^+\ \mu\text{s}) = -159.62$ V
c) $i_o(50^-\mu\text{s}) = i_o(50^+\mu\text{s}) = 19.95$ mA

7.79 173.23 μs

7.83 27 ms

7.87 25 ms

7.94 a) 25 μs
b) 25 μs
c) 25 μs
d) 25 μs
e) 3.5 mA
f) 0.5465 mA
g) 8.86 V

7.100 a) 8.55 flashes per minute
b) 558.74 kΩ

Chapter 8

8.2 a) 3.79 sin 3.16t V
b) 0.5 Hz
c) 3.79 V

8.4 a) $R = 10$ kΩ; $C = 12.5$ nF; $D_1 = -5 \times 10^5$; $D_2 = 25$ V
b) $(25{,}000t - 7.5)e^{-4000t}$ mA

8.6 a) 12.5 kΩ
b) $(25 \times 10^4 t - 25)e^{-5000t}$ V
c) 11.16 V
d) 49.79 %

8.10 a) -5000 rad/s; $-20{,}000$ rad/s
b) overdamped

c) 7812.5 Ω

d) $(-8000 + j6000)$ rad/s; $(-8000 - j6000)$ rad/s

e) 6250 Ω

8.15 $45e^{-8000t}\cos 6000t - 60e^{-8000t}\sin 6000t$ V

8.20 $-140e^{-2000t} + 200e^{-8000t}$ V

8.24 $v_o = 0$ for $t \geq 0$, so the circuit goes directly into steady-state when the switch is closed

8.27 $12e^{-800t}\cos 600t + 16e^{-800t}\sin 600t$ V

8.29 $40 - 40e^{-5000t}\cos 5000t - 40e^{-5000t}\sin 5000t$ V

8.32 $50e^{-40t} - 50e^{-160t}$ V

8.35 $60e^{-10t}\sin 70t$ mA

8.37 a) $20e^{-1000t} - 5e^{-4000t}$ mA

b) $80e^{-1000t} - 5e^{-4000t}$ V

8.44 a) $5000t\,e^{-250t} + 20e^{-250t}$ V

b) $100 - 12{,}500te^{-250t} - 100e^{-250t}$ mA

8.48 a) 300 V

b) −12, 000 V/s

c) $300e^{-80t}\cos 60t - 200e^{-80t}\sin 60t$ V

Chapter 9

9.1 a) 2000π rad/s

b) $10\cos(2000\pi t + 54°)$ A

9.4 a) 2000 Hz

b) $150\cos(4000\pi t - \frac{\pi}{3})$ V

9.8 169.71 V

9.11 a) 50 Hz

b) 0°

c) −90°

d) 40 Ω

e) 127.32 mH

f) $j40$ Ω

9.14 $1.5\cos(5000t + 36.87°)$ mA

9.17 5000 rad/s

9.21 a) $L = 0.2$ H, 0.8 H

b) for $L = 0.2$ H, $i_g = 40\cos 10{,}000t$ mA for $L = 0.8$ H, $i_g = 20\cos 10{,}000t$ mA

9.24 a) 8000 rad/s

b) $5\cos 8000t$ V

9.29 a) $5\angle 72°$ Ω

b) i_g lags v_g by 50 μs

9.31 $50\cos(5000t - 106.26°)$ V

9.34 $31.62\cos(8000t - 71.57°)$ V

9.39 $\mathbf{I}_N = 6.4 - j4.8$ A; $Z_N = 50 - j25$ Ω

9.41 $\mathbf{V}_{Th} = 60\angle -36.87°$ V; $Z_{Th} = 8.64 + j11.52$ Ω

9.43 $\mathbf{V}_{Th} = 15\angle 36.87°$ V; $Z_{Th} = 96 + j72$ Ω

9.47 $15 + j5$ V

9.54 $9.49\cos(40{,}000t - 18.43°)$ A

9.58 $i_a = 22.02\cos(10{,}000t - 50.53°)$ A
$i_b = 24.02\cos(10{,}000t + 50.74°)$ A

9.63 30 Ω

9.68 $800 + j600$ Ω

9.72 a) $2.15\cos(10^5 t - 21.80°)$ V

b) 4.64 V

Chapter 10

10.1 a) $P = 2404.16$ W (abs); $Q = 2404.16$ VAR (abs)

b) $P = 155.29$ W (abs); $Q = -579.56$ VAR (del)

c) $P = -427.53$ W (del); $Q = -1174.62$ VAR (del)

d) $P = -307.82$ W (del); $Q = 845.72$ VAR (del)

10.4 a) 60 V (rms)

b) 300 W

10.6 80 Ω

10.8 $P = 56.25$ mW; $Q = -70.3125$ mVAR; $|S| = 90.044$ mVA

10.10 a) $\text{pf}_1 = 0.96$ lagging; $\text{rf}_1 = 0.28$; $\text{pf}_2 = 0.80$ leading; $\text{rf}_2 = -0.60$; $\text{pf}_3 = 0.6$ leading; $\text{rf}_3 = -0.8$

b) pf = 0.74 leading; rf = −0.67

10.13 a) 160 W

b) −40 W

c) 60 W

d) −80 VAR

e) generate

f) 0.6 leading
g) -0.8

10.16 a) 492.37 V(rms)
b) 102.31 μs
c) lags by 2.21° or 102.31 μs

10.19 a) $72 - j24\ \Omega$
b) 0.9487 leading

10.22 0.2727 leading

10.24 a) 414.72 W
b) 501.4 Ω
c) 1671.33 Ω
d) 37.02 W
e) 8.93 %

10.28 a) 129.15 V(rms)
b) 240 W
c) 1188.36 μF
d) 126.49 V(rms)
e) 221.184 W

10.31 a) 9 W
b) 20 Ω
c) 17.31 W; yes
d) 18.75 W
e) $R_o = 30\ \Omega$; $L_o = 9$ mH
f) yes

10.34 a) $30 + j10$ kΩ
b) 16.875 mW

10.37 a) 312.5 W
b) 10 %

10.39 a) -1700 kVAR
b) deliver
c) 0.3328 leading
d) 625 A(rms)
e) 520.83 A(rms)

10.43 612.5 W

10.46 a) $140\angle 0°$ V(rms)
b) 280 W
c) 9.72 %

10.54 $20 + j0\ \Omega$

10.57 a) 100 W
b) 44.44 %
c) 225 W

10.60 a) $a_1 = 5$; $a_2 = 40$
b) 800 mW
c) 4 V(rms)

10.65 $R_1 = R_2 = R_3 = 8\ \Omega$

Chapter 11

11.3 a) 0 A
b) $226.99\angle 116.48°$ V
c) $387.79\angle 86.48°$ V
d) unbalanced

11.6 a) 32.84 A(rms)
b) 12,845.94 V(rms)

11.10 $3.93\angle -122.69°$ A

11.14 a) $\mathbf{I}_{AB} = 92\angle -36.87°$ A; $\mathbf{I}_{BC} = 92\angle -156.87°$ A; $\mathbf{I}_{CB} = 92\angle 83.13°$ A
b) $\mathbf{I}_{aA} = 159.35\angle -66.87°$ A; $\mathbf{I}_{bB} = 159.35\angle -186.87°$ A; $\mathbf{I}_{cC} = 159.35\angle 53.13°$ A;
c) $\mathbf{I}_{ba} = 92\angle -36.87°$ A; $\mathbf{I}_{cb} = 92\angle -156.87°$ A; $\mathbf{I}_{ac} = 92\angle 83.13°$ A

11.18 a) $651 + j246$ kVA
b) 99.54 %

11.20 a) 138.46 A(rms)
b) 0.892 lagging

11.22 6990.62 V

11.24 a) 468.91 A
b) 66.2 kVAR

11.27 a) 4551.4 V
b) 97.96 %

11.32 a) 7776 VAR
b) 7776 VAR

11.37 a) $W_{m1} = 14{,}296.61$ W; $W_{m2} = 29{,}261.53$ W