

# Appendix H

## ANSWERS TO SELECTED ODD-NUMBERED PROBLEMS

### Chapter 1

5. 29.05 mph
11. 737.8 ft-lbs
13. (a)  $10^4$  (b)  $10^6$  (c)  $10^3$   
(d)  $10^{-3}$  (e)  $10^0$  (f)  $10^{-1}$
15. (a)  $5.22 \times 10^4$  (b)  $4.50 \times 10^5$   
(c)  $4.4 \times 10^{-4}$  (d)  $6.5 \times 10^2$
17. (a)  $1.5 \times 10^1$  (b) 4.4  
(c)  $2.296 \times 10^2$  (d)  $8.40 \times 10^3$
19. (a)  $2.50 \times 10^7$  (b)  $6.67 \times 10^{-8}$   
(c) 4.4 (d)  $1.95 \times 10^{25}$
21. (a)  $1.6 \times 10^5$  (b)  $2.16 \times 10^{-7}$   
(c)  $1.44 \times 10^3$  (d)  $1.11 \times 10^{11}$
23. (a) 300 (b)  $200.0 \times 10^3$   
(c)  $9.0 \times 10^{12}$  (d)  $150.0 \times 10^{-9}$   
(e)  $24.0 \times 10^{12}$  (f)  $800.0 \times 10^{18}$   
(g)  $56.4 \times 10^3$
25. (a) 50 ms (b) 2 ms (c)  $40 \mu\text{s}$   
(d)  $0.0084 \mu\text{s}$  (e) 4000 mm  
(f) 0.26 km
27. (a)  $10^5$  pF (b) 8 cm  
(c)  $60 \times 10^{-5}$  km  
(d)  $11.52 \times 10^6$  ms (e)  $16 \mu\text{m}$   
(f)  $60 \times 10^{-4}$  m<sup>2</sup>
29. 5,280 ft, 1760 yds, 1609.35 m,  
1.61 km
31. 3.40 s
33. 73.33 days
35. 3600 quarters
37. 345.6 m
39. 47.30 min/mi
41. (a)  $4.74 \times 10^{-3}$  Btu  
(b)  $7.1 \times 10^{-4}$  m<sup>3</sup>  
(c)  $1.21 \times 10^5$  s  
(d) 2113.38 pints
43. 13
45. 0.64
47. 2.95
49.  $1.20 \times 10^{12}$

### Chapter 2

3. (a)  $1.11 \mu\text{N}$  (b) 0.31 N  
(c) 1138.34 kN
5. 10 mm
7. 3 kV
9. 6 C
11. 4.29 mA
13. 1.92 C
15. 3 s
17.  $2.25 \times 10^{18}$  electrons
19. 22.43 mA
21. 6.67 V

23. 3.34 A
25. 60.0 Ah
35. 600 C

### Chapter 3

1. (a) 500 mils (b) 20 mils  
(c) 250 mils (d) 1000 mils  
(e) 240 mils (f) 39.37 mils
3. (a) 0.04 in. (b) 0.029 in.  
(c) 0.2 in. (d) 0.025 in.  
(e) 0.0025 in. (f) 0.01 in.
5. 92.81  $\Omega$
7. 3.58 ft
9. (a) silver (b) silver: 99  $\Omega$ ;  
copper: 5.19  $\Omega$ ;  
aluminum: 1.36  $\Omega$
11. (a) 21.71  $\mu\Omega$  (b) 35.59  $\mu\Omega$
13. 942.28 m $\Omega$
15. (a) #8: 1.13  $\Omega$ ; #18: 11.49  $\Omega$   
(b) #18: #8 = 10 : 1  
(c) #18: #8 = 1 : 10
17. (a) 1.09 mA/CM  
(b) 1.39 kA/in.<sup>2</sup> (c) 3.6 in.<sup>2</sup>
19. (a) 21.71  $\mu\Omega$  (b) 35.59  $\mu\Omega$
21. 0.15 in.
23. 2.57  $\Omega$
25. 3.67  $\Omega$
27. 46 m $\Omega$
29. (a) 27.85°C (b) -210.65°C
31. (a) 0.00393 (b) 83.61°C
33. 1.751  $\Omega$
35. 100.30  $\Omega$
41. 6.5 k $\Omega$
45. (a) Brown, red, brown, silver  
(b) Gray, red, gold, silver  
(c) Blue, gray, red, silver  
(d) Orange, orange, green, silver
47. no overlap
49. (a) 8.33 mS (b) 0.25 mS  
(c) 0.46  $\mu\text{S}$
51. 500 S
55. (a) -50°C: 10<sup>5</sup>  $\Omega$ -cm  
50°C: 500  $\Omega$ -cm  
200°C: 7  $\Omega$ -cm (b) negative  
(c) No (d) 3.6  $\Omega$ -cm/<sup>o</sup>C
57. (a) 0.5 mA: 195 V; 1 mA: 200 V;  
5 mA: 215 V (b) 20 V  
(c) 10 : 1 vs 1.08 : 1

### Chapter 4

1. 117.5 V
3. 4 k $\Omega$

5. 72 mV
7. 54.55  $\Omega$
9. 28.57  $\Omega$
11. 1.2 k $\Omega$
13. (a) 12.63  $\Omega$  (b)  $4.1 \times 10^6$  J
21. 16 s
23. 250 W
25. 4.8 W
27. 10.44 mA
29. 2.14 mA
31. 461.27  $\mu\text{A}$ , no
33. 405 mW
35. 32  $\Omega$ , 120 V
37. 70.71 mA, 1.42 kV
39. 59.80 kWh
41. 0.65¢
43. 44.44 h
45. (a) 4.1 W (b) 19.78  $\Omega$   
(c) 88.56 kJ
47. 74.21¢
49. 94.43%
51. 84.77%
53. 16.06 A
55. 56.52 A
57. 65.25%
59. 80%
61.  $\eta_1 = 40\%$ ,  $\eta_2 = 80\%$

### Chapter 5

1. (a)  $E$  and  $R_1$  (b)  $R_1$  and  $R_2$   
(c)  $E$  and  $R_1$  (d)  $E$  and  $R_1$ ,  
 $R_3$  and  $R_4$
3. (a) 7.7 k $\Omega$  (b) 17.5 k $\Omega$
5. (a) 62  $\Omega$  (b) 1.8 k $\Omega$   
(c) 27 k $\Omega$  (d)  $R_1 = 8$  k $\Omega$ ,  
 $R_2 = 16$  k $\Omega$
7. (a) 40  $\Omega$  (b) 3 A  
(c)  $V_1 = 30$  V;  $V_2 = 36$  V;  
 $V_3 = 54$  V
9. (a) 88 V (b) 20 V
11. (a) 8.18 mA, 18 V (b) 2.5 mA,  
20 V (c) 9.94  $\mu\text{A}$ , 99.35 V
13. (a) 82.0  $\Omega$ , 250 mA;  
 $V_{R_1} = 5.50$  V;  $V_{R_2} = 2.50$  V;  
 $V_{R_3} = 11.75$  V;  $V_{R_4} = 0.75$  V  
(b)  $P_{R_1} = 1.38$  W;  
 $P_{R_2} = 625.00$  mW;  
 $P_{R_3} = 2.94$  W;  
 $P_{R_4} = 187.50$  mW (c) 5.13 W  
(d) 5.13 W (e) same (f) 47  $\Omega$   
(g) dissipated (h)  $R_1$ : 2 W;  
 $R_2$ :  $\frac{1}{2}$  W;  $R_3$ : 5 W;  $R_4$ : 1/2 W

15. (a) 0.53 A (b) 8 W (c) 15 V  
(d) all out
17. (a)  $V_{ab} = 0$  V (b)  $V_{ab} = -6$  V  
(c)  $V_{ab} = 14$  V
19. (a) 10 V, 2 k $\Omega$  (b) 42 V, 1.5 k $\Omega$
21. (a) 28 V (b) 4 V
23. (a)  $V_1 = 9$  V;  $V_2 = 8$  V  
(b)  $V_1 = 11$  V;  $V_2 = 7$  V
25. (a) 8.2 k $\Omega$  (b)  $V_3$ ;  $V_2 = 8.2 : 1$   
 $V_3$ ;  $V_1 = 82 : 1$  (c) 52.90 V  
(d) 59.35 V
27. (a)  $V_1 = 60$  V;  $V_2 = 40$  V;  
 $E = 120$  V (b)  $V_1 = 40$  V;  
 $V_3 = 70$  V (c)  $V_2 = 20$  V;  
 $V_1 = 10$  V;  $E = 1030$  V  
(d)  $V_1 = 10$  V;  $V_2 = 3$  V
29. (a) 1.6 k $\Omega$  (b) 1.5  $\Omega$
31. (a)  $R_x = 80$   $\Omega$  (b)  $\frac{1}{4}$  W
33.  $V_{R_1} = 12$  V;  $V_{R_2} = 42$  V;  
 $V_{R_3} = 6$  V
35. (a)  $V_a = 4$  V;  $V_b = -8$  V;  
 $V_{ab} = 12$  V (b)  $V_a = 14$  V;  
 $V_b = 4$  V;  $V_{ab} = 10$  V  
(c)  $V_a = 13$  V;  $V_b = 6$  V;  
 $V_{ab} = 7$  V
37. (a)  $V_a = 12$  V;  $V_1 = 8$  V  
(b)  $V_a = 10$  V;  $V_1 = 12$  V
39.  $R_1 = 8$   $\Omega$ ;  $R_3 = 4$   $\Omega$
41. (a)  $V_a = 44$  V;  $V_b = 40$  V;  
 $V_c = 32$  V;  $V_d = 20$  V  
(b)  $V_{ab} = 4$  V;  $V_{cb} = -8$  V;  
 $V_{cd} = 12$  V (c)  $V_{ad} = 24$  V;  
 $V_{ca} = -12$  V
43.  $V_0 = 0$  V;  $V_{03} = 0$  V;  $V_2 = 8$  V;  
 $V_{23} = 8$  V;  $V_{12} = 12$  V;  
 $I_i = 17$  mA
45. (a) 11.82 V (b) 1.52%  
(c)  $P_s = 42.96$  W;  $P_{\text{int}} = 0.64$  W
- (d)  $I_{R_1} = 4.4$  mA;  $I_{R_2} = 2$  mA;  
 $I_{R_3} = 36.67$  mA;  $I_{R_4} = 0.79$  mA  
(e)  $I_s = 43.87$  mA =  $I_T$   
(f) always greater
15.  $V = 12$  V;  $I' = 12$  A;  $I'' = 8$  A
17. (a)  $I_s = 7.5$  A;  $I_1 = 1.5$  A  
(b)  $I_s = 9.6$  mA;  $I_1 = 0.8$  mA
19. (a)  $R_T = 867.86$   $\Omega$ ;  
 $I_{R_1} = 100$  mA;  $I_{R_2} = 3.03$  mA;  
 $I_{R_3} = 12.2$  mA  
(b)  $P_{R_1} = 10$  W;  $P_{R_2} = 0.30$  W;  
 $P_{R_3} = 1.22$  W (c) 115.2 W  
(d)  $P_s = 11.52$  W =  $P_T$   
(e)  $R_1$ —smallest resistor
21. 1.26 kW
23. (a) 14.67 A (b) 256 W  
(c) 14.67 A
25. (a)  $I_1 = 1$  A;  $I_2 = 3$  A  
(b)  $I_1 = 4$  A;  $I_2 = 9$  A;  $I_3 = 6$  A;  
 $I_4 = 13$  A
27.  $R_1 = 3$  k $\Omega$ ;  $R_3 = 6$  k $\Omega$ ;  
 $R_T = 1.33$  k $\Omega$ ;  $E = 12$  V
29.  $I_2 = 2$  A;  $I_3 = 12$  A;  $I_4 = 0.6$  A;  
 $I_T = 20.6$  A
31. (a) 9 A (b) 10, 0.9 A  
(c) 1000, 9 mA  
(d) 100,000, 90  $\mu$ A (e) little  
effect (f) 9.1 A (g) 0.91 A  
(h) 9.1 mA (i) 91  $\mu$ A
33. (a) 6 k $\Omega$  (b)  $I_1 = 24$  mA;  
 $I_2 = 8$  mA
35. (a)  $I_1 = I_2 = 3$  A (b) 36 W  
(c) 72 W (d) 6 A
37. 3 A, 2  $\Omega$
39. (a) 6.13 V (b) 9 V (c) 9 V
41. (a) 16.48 V (b) 16.47 V  
(c) 16.32 V (d)  $a$ : 13.33 V  
 $b$ : 13.25 V  $c$ : 11.43 V
43. No, 6 k $\Omega$  not connected
45. (a) 1 k $\Omega$  not connected  
(b) Used +4 V source
5. (a) 4  $\Omega$  (b)  $I_s = 9$  A;  $I_1 = 6$  A;  
 $I_2 = 3$  A (c) 6 V
7. (a)  $I_s = 16$  mA;  $I_2 = 2.33$  mA;  
 $I_6 = 2$  mA (b)  $V_1 = 28$  V;  
 $V_3 = 7.2$  V (c) 261.33 mW
9.  $I_1 = 4$  A;  $I_2 = 0.72$  A
11. (a)  $I_s = 5$  A;  $I_1 = 1$  A;  $I_3 = 4$  A;  
 $I_4 = 0.5$  A (b)  $V_a = 17$  V;  
 $V_{bc} = 10$  V
13. (a)  $I_E = 2$  mA =  $I_C$  (b) 24  $\mu$ A  
(c)  $V_B = 2.7$  V;  $V_C = 3.6$  V  
(d)  $V_{CE} = 1.6$  V;  $V_{BC} = -0.9$  V
15. (a) 174.12  $\Omega$  (b) 11.89 V  
(c) 20.11 V (d) 11.89 V  
(e) 20.54 mA
17. (a)  $I_2 = 1.67$  A;  $I_6 = 1.11$  A;  
 $I_8 = 0$  A (b)  $V_4 = 10$  V;  
 $V_8 = 0$  V
19. (a) 1.88  $\Omega$  (b)  $V_1 = V_4 = 32$  V  
(c)  $I_3 = 8$  A (d) 1.88  $\Omega$
21. (a) 6.75 A (b) 32 V
23. 8.33  $\Omega$
25. (a) 24 A (b) 8 A  
(c)  $V_3 = 48$  V;  $V_5 = 24$  V;  
 $V_7 = 16$  V (d)  $P_{R_7} = 128$  W;  
 $P_s = 5760$  W
27. 4.44 W
29. (a) 64 V  
(b)  $R_{L_2} = 4$  k $\Omega$   
 $R_{L_3} = 3$  k $\Omega$   
(c)  $R_1 = 0.5$  k $\Omega$   
 $R_2 = 1.2$  k $\Omega$   
 $R_3 = 2$  k $\Omega$
31. (a) yes (b)  $R_1 = 750$   $\Omega$ ;  
 $R_2 = 250$   $\Omega$  (c)  $R_1 = 745$   $\Omega$ ;  
 $R_2 = 255$   $\Omega$
33. (a) 1 mA (b)  $R_{\text{shunt}} = 5$  m $\Omega$
35. (a)  $R_s = 300$  k $\Omega$   
(b) 20,000  $\Omega$ /V
37. 0.05  $\mu$ A

## Chapter 6

1. (a)  $R_2$  and  $R_3$  (b)  $E$  and  $R_3$   
(c)  $E$  and  $R_1$  (d)  $R_2$ ,  $R_3$ , and  $R_4$   
(e)  $E$ ,  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  (f)  $E$ ,  
 $R_1$ ,  $R_2$ , and  $R_3$  (g)  $R_2$  and  $R_3$
3. (a) 6.04  $\Omega$  (b) 545.55  $\Omega$   
(c) 90.09  $\Omega$  (d) 5.99 k $\Omega$   
(e) 2.62  $\Omega$  (f) 0.99  $\Omega$
5. (a) 8  $\Omega$  (b) 18 k $\Omega$  (c) 20 k $\Omega$   
(d) 3.3 k $\Omega$  (e)  $R_1 = R_2 =$   
6.4 k $\Omega$ ;  $R_3 = 3.2$  k $\Omega$
7. (a) 1.6  $\Omega$  (b)  $\infty$   $\Omega$  (c)  $\infty$   $\Omega$   
(d) 1.18  $\Omega$
9. 120  $\Omega$
11. (a) 2.12  $\Omega$  (b) 18 V  
(c)  $I_s = 8.5$  A;  $I_1 = 6$  A;  $I_2 = 2$  A;  
 $I_3 = 0.5$  A (d)  $I_s = 8.5$  A =  $I_T$
13. (a) 1 k $\Omega$  (b) 1.003 k $\Omega$   
(c)  $I_3$  the most;  $I_4$  the least

## Chapter 7

1. (a)  $E$  and  $R_1$  in series;  $R_2$ ,  $R_3$ , and  
 $R_4$  in parallel (b)  $E$  and  $R_1$  in  
series;  $R_2$ ,  $R_3$ , and  $R_4$  in parallel  
(c)  $R_1$  and  $R_2$  in series;  $E$ ,  $R_3$ , and  
 $R_4$  in parallel (d)  $E$  and  $R_1$  in  
series;  $R_4$  and  $R_5$  in series;  $R_2$  and  
 $R_3$  in parallel (e)  $E$  and  $R_1$  in  
series;  $R_2$  and  $R_3$  in parallel  
(f)  $E$ ,  $R_1$ , and  $R_4$  in parallel;  $R_6$   
and  $R_7$  in series;  $R_2$  and  $R_3$  in  
parallel.
3. (a) yes (b) 6 A (c) yes  
(d) 6 V (e) 3.73  $\Omega$  (f) 1 A  
(g) 20 W

## Chapter 8

1. (a)  $I_2 = I_3 = 10$  mA (b) 10 V  
(c) 37.6 V
3. 28 V
5. 1.6 V, 0.1 A
7. (a) 3 A, 6  $\Omega$   
(b) 4.09 mA, 2.2 k $\Omega$
9. (a) 11.76 A (b) 1.2 kV, 100  $\Omega$
11. (a) 2 A (b) 8 V
13. (b)  $V_{ab} = -6.44$  V (c) 1.07 A
15. (a)  $I_{R_1} = -\frac{1}{7}$  A;  $I_{R_2} = \frac{5}{7}$  A;  
 $I_{R_3} = \frac{4}{7}$  A (b)  $I_{R_1} = 3.06$  A;  
 $I_{R_2} = 3.25$  A;  $I_{R_3} = 0.19$  A
17. (I): 8.55 A, -22.75 V  
(II): 1.27 A, -0.92 V
19. (a)  $I_B = 63.02$   $\mu$ A;  $I_C = 4.42$  mA;  
 $I_E = 4.48$  mA (b)  $V_B = 2.98$  V;

- $V_E = 2.28 \text{ V}; V_C = 10.28 \text{ V}$   
 (c) 70.14
21. (I):  $I_{R_1} = 1.45 \text{ mA};$   
 $I_{R_2} = 8.51 \text{ mA}; I_{R_3} = 7.06 \text{ mA}$   
 (II):  $I_{R_1} = 2.03 \text{ mA};$   
 $I_{R_2} = 0.80 \text{ mA};$   
 $I_{R_3} = I_{R_4} = 1.23 \text{ mA}$
23. (a) 63.69 mA
25. (I):  $I_1 = 1.21 \text{ mA};$   
 $I_2 = -0.48 \text{ mA};$   
 $I_3 = -0.62 \text{ mA}$  (all CW)  
 (II):  $I_1 = -0.24 \text{ A}; I_2 = -0.52 \text{ A};$   
 $I_3 = -1.28 \text{ A}$  (all CW)
27. (a)  $I_{24\text{V}} = I_{6\Omega} = I_{10\Omega} = I_{12\text{V}} =$   
 $3 \text{ A}$  (CW);  $I_{4\Omega} = 3 \text{ A}$  (CCW)  
 (b)  $I_{20\text{V}} = I_{4\Omega} = 5.53 \text{ A}, I_{6\Omega} =$   
 $2.47 \text{ A}, I_{8\Omega} = 0.53 \text{ A}, I_{1\Omega} = 8.53 \text{ A}$
29. (I): (b)  $I_1 = 1.45 \text{ mA};$   
 $I_2 = -8.51 \text{ mA}$  (all CW)  
 (c)  $I_{R_1} = 1.45 \text{ mA};$   
 $I_{R_2} = 8.51 \text{ mA}; I_{R_3} = 9.96 \text{ mA}$   
 (II): (b)  $I_1 = 2.03 \text{ mA};$   
 $I_2 = 1.23 \text{ mA}$  (all CW)  
 (c)  $I_{R_1} = 2.03 \text{ mA};$   
 $I_{R_2} = 0.80 \text{ mA};$   
 $I_{R_3} = I_{R_4} = 1.23 \text{ mA}$
31. 63.69 mA
33. (I):  $I_1 = 1.21 \text{ mA}; I_2 = -0.48 \text{ mA};$   
 $I_3 = -0.62 \text{ mA}$  (all CW)  
 (II):  $I_1 = -0.24 \text{ A}; I_2 = -0.52 \text{ A};$   
 $I_3 = -1.28 \text{ A}$  (all CW)
35. (a)  $V_1 = 8.08 \text{ V}; V_2 = 9.39 \text{ V}$   
 (b)  $V_1 = 4.80 \text{ V}; V_2 = 6.40 \text{ V}$
37. (I): (b)  $V_1 = -2.65 \text{ V};$   
 $V_2 = 0.95 \text{ V}$   
 (c)  $V_{R_1} = 15.35 \text{ V};$   
 $V_{R_2} = 2.05 \text{ V}; V_{R_3} = 2.65 \text{ V};$   
 $V_{R_4} = 3.60 \text{ V}; V_{R_5} = 0.95 \text{ V}$   
 (II): (b)  $V_1 = 8.88 \text{ V}; V_2 = 9.83 \text{ V};$   
 $V_3 = -3.01 \text{ V}$  (c)  $V_{R_1} = 4.12 \text{ V};$   
 $V_{R_2} = 0.84 \text{ V}; V_{R_3} = 5.17 \text{ V};$   
 $V_{R_4} = 3.01 \text{ V}; V_{R_5} = 0.95 \text{ V}$
39. (I):  $V_1 = -5.31 \text{ V}; V_2 = -0.62 \text{ V};$   
 $V_3 = 3.75 \text{ V}$   
 (II):  $V_1 = -6.92 \text{ V}; V_2 = 12 \text{ V};$   
 $V_3 = 2.3 \text{ V}$
41. (a)  $V_1 = 8.08 \text{ V}; V_2 = 9.39 \text{ V}$   
 (b)  $V_1 = 4.8 \text{ V}; V_2 = 6.4 \text{ V}$
43. (I): (b)  $V_1 = 7.24 \text{ V};$   
 $V_2 = -2.45 \text{ V};$   
 $V_3 = 1.41 \text{ V}$   
 (c)  $V_{R_1} = 7.76 \text{ V}; V_{R_2} = 2.45 \text{ V};$   
 $V_{R_3} = 1.41 \text{ V}; V_{R_4} = 3.86 \text{ V};$   
 $V_{R_5} = 9.69 \text{ V}; V_{R_6} = 5.83 \text{ V}$   
 (II): (b)  $V_1 = -6.64 \text{ V};$   
 $V_2 = 1.29 \text{ V}; V_3 = 10.66 \text{ V}$   
 (c)  $V_{R_1} = 6.64 \text{ V}; V_{R_2} = 5.34 \text{ V};$   
 $V_{R_3} = 1.29 \text{ V}; V_{R_4} = 7.93 \text{ V};$   
 $V_{R_5} = 9.37 \text{ V}; V_{R_6} = 17.30 \text{ V}$

45. (b) 40 mA (c, d) no  
 47. (b) 0 mA (c, d) yes  
 51. (a) 7.36 A (b) 1.76 mA  
 53. 2.14 A  
 55. (a)  $R_T = 1 \text{ k}\Omega$  (b) 5.71 mA

### Chapter 9

1. (a)  $I_{R_1} = 4 \text{ A}; I_{R_2} = 3 \text{ A};$   
 $I_{R_3} = 7 \text{ A}$  (b)  $E_1: 48 \text{ W};$   
 $E_2: 48 \text{ W}$  (c) 192 W (d) no
3. 3.17 A
5. 10.66 V
7. (a)  $R_{Th} = 6 \Omega; E_{Th} = 6 \text{ V}$   
 (b)  $2 \Omega: 0.75 \text{ A};$   
 $30 \Omega: 166.67 \text{ mA};$   
 $100 \Omega: 56.60 \text{ mA}$
9. (a)  $R_{Th} = 7.5 \Omega; E_{Th} = 10 \text{ V}$   
 (b)  $2 \Omega: 2.22 \text{ W}; 100 \Omega: 0.87 \text{ W}$
11.  $R_{Th} = 1.58 \text{ k}\Omega; E_{Th} = -1.15 \text{ V}$
13. (I):  $R_{Th} = 45 \Omega; E_{Th} = -5 \text{ V}$   
 (II):  $R_{Th} = 2.06 \text{ k}\Omega; E_{Th} = 16.77 \text{ V}$
15.  $R_{Th} = 4.04 \text{ k}\Omega; E_{Th} = 9.74 \text{ V}$
17. (a)  $R_{Th} = 12.5 \text{ k}\Omega; E_{Th} = 20 \text{ V}$   
 (b)  $R_{Th} = 2.72 \text{ k}\Omega; E_{Th} = 60 \text{ mV}$   
 (c)  $R_{Th} = 2.2 \text{ k}\Omega; E_{Th} = 16 \text{ V}$
19. (a)  $R_N = 7.5 \Omega; I_N = 1.34 \text{ A}$
21. (I): (a)  $R_N = 9.76 \Omega; I_N = 0.95 \text{ A}$   
 (II): (b)  $R_N = 2 \Omega; I_N = 30 \text{ A}$
23. (a)  $R_N = 3 \Omega; I_N = 5 \text{ A}$   
 (b)  $R_N = 2 \Omega; I_N = 0.75 \text{ A}$
25. (I): (a) 10  $\Omega$   
 (b) 100 mW  
 (II): (a) 4.03 k $\Omega$   
 (b) 8.93 mW
27. (a) 2  $\Omega$  (b) 60.5 W
29. (a)  $\infty \Omega$  (b) no
31. 6.12 A, 18.37 V
33. 0.38 A, 76.52 V
35. 2.32 mA, 15.78 V
39. (a) 0.5 mA (b) 0.5 mA  
 (c) yes
41. (a) 4 V (b) 4 V (c) yes

### Chapter 10

1. (a)  $9 \times 10^3 \text{ N/C}$   
 (b)  $36 \times 10^9 \text{ N/C}$
3. 120  $\mu\text{F}$
5. 50 V/m
7.  $8 \times 10^3 \text{ V/m}$
9. 1.11 nF
11. mica
13. (a)  $10^6 \text{ V/m}$  (b) 4.96  $\mu\text{C}$   
 (c) 24.80 nF
15. 29.04 kV
17. 0.35  $\mu\text{F}$
19. 176  $\mu\text{F} \rightarrow 264 \mu\text{F}$
21. (a) 0.51 s  
 (b)  $v_C = 20 \text{ V} (1 - e^{-t/0.51 \text{ s}})$

- (c)  $1\tau: 12.64 \text{ V}; 3\tau: 19 \text{ V};$   
 $5\tau: 19.87 \text{ V}$   
 (d)  $i_C = 0.2 \text{ mA } e^{-t/0.51 \text{ s}},$   
 $v_R = 20 \text{ V } e^{-t/0.51 \text{ s}}$
23. (a) 5.5 ms  
 (b)  $v_C = 100 \text{ V} (1 - e^{-t/5.5 \text{ ms}})$   
 (c)  $1\tau: 63.21 \text{ V};$   
 $3\tau: 95.02 \text{ V}; 5\tau: 99.33 \text{ V}$   
 (d)  $i_C = 18.18 \text{ mA } e^{-t/5.5 \text{ ms}},$   
 $v_R = 60 \text{ V } e^{-t/5.5 \text{ ms}}$
25. (a) 5 ms (b) 19.8 mV  
 (c) 60 mV
27. (a) 200 ms  
 (b)  $v_C = 8 \text{ V} (1 - e^{-t/200 \text{ ms}});$   
 $i_C = 4 \text{ mA } e^{-t/200 \text{ ms}}$   
 (c)  $v_C = 7.95 \text{ V}; i_C = 26.95 \mu\text{A}$   
 (d)  $v_C = 7.95 \text{ V } e^{-t/200 \text{ ms}};$   
 $i_C = 3.98 \text{ mA } e^{-t/200 \text{ ms}}$
29. (a)  $v_C = 50 \text{ V} (1 - e^{-t/100 \text{ ms}});$   
 $i_C = 10 \text{ mA } e^{-t/100 \text{ ms}};$   
 $v_{R_1} = 30 \text{ V } e^{-t/100 \text{ ms}}$   
 (b)  $v_C = 31.6 \text{ V}; i_C = 3.68 \text{ mA};$   
 $v_{R_1} = 11.04 \text{ V}$   
 (c)  $v_C = 31.6 \text{ V } e^{-t/40 \text{ ms}};$   
 $i_C = -15.8 \text{ mA } e^{-t/40 \text{ ms}};$   
 $v_{R_2} = -31.6 \text{ V } e^{-t/40 \text{ ms}}$
31. (a) 10  $\mu\text{s}$  (b) 3 kA  
 (c) yes
33.  $v_C = 40 \text{ V } e^{-t/4.4 \text{ s}};$   
 $i_C = 18.18 \text{ mA } e^{-t/4.4 \text{ s}};$   
 $v_R = 40 \text{ V } e^{-t/4.4 \text{ s}}$
35. (a)  $v_C = 52 \text{ V} - 40 \text{ V } e^{-t/123.8 \text{ ms}};$   
 $i_C = 2.20 \text{ mA } e^{-t/123.8 \text{ ms}}$   
 37. 0.73 s
39. (a) 166.80 ms (b) 1 mA  
 (c) 43.20 mW
41. (a) 22.07 V (b) 0.81  $\mu\text{A}$   
 (c) 3.58 s
43. (a)  $v_C = 27.2 \text{ V} - 25.2 \text{ V } e^{-t/18.26 \text{ ms}};$   
 $i_C = 3.04 \text{ mA } e^{-t/18.26 \text{ ms}}$
45. (a)  $v_C = 3.27 \text{ V} (1 - e^{-t/53.80 \text{ ms}});$   
 $i_C = 1.22 \text{ mA } e^{-t/53.80 \text{ ms}}$
47. (a) 19.63 V (b) 2.32 s  
 (c) 1.15 s
49.  $0 \rightarrow 20 \mu\text{s}: i_C = -1.18 \text{ A}; 20 \rightarrow$   
 $30 \mu\text{s}: i_C = 0 \text{ A}; 30 \rightarrow 50 \mu\text{s}: i_C =$   
 $2.35 \text{ A}; 50 \rightarrow 80 \mu\text{s}: i_C =$   
 $-2.35 \text{ A}; 80 \rightarrow 90 \mu\text{s}: i_C =$   
 $4.7 \text{ A}; 90 \rightarrow 100 \mu\text{s}: i_C = 0 \text{ A}$
51. 12  $\mu\text{F}$
53.  $V_1 = 10 \text{ V}; Q_1 = 60 \mu\text{C};$   
 $V_2 = 6.67 \text{ V}; Q_2 = 40 \mu\text{C};$   
 $V_3 = 3.33 \text{ V}; Q_3 = 40 \mu\text{C}$
55.  $V_1 = 16 \text{ V}; Q_1 = 144 \mu\text{C};$   
 $V_2 = 8 \text{ V}; Q_2 = 80 \mu\text{C};$   
 $V_3 = 7.11 \text{ V}; Q_3 = 64 \mu\text{C};$   
 $V_4 = 0.89 \text{ V}; Q_4 = 64 \mu\text{C}$
57. 8,640 pJ
59. (a)  $W_{6\mu\text{F}} = 1.19 \text{ mJ};$   
 $W_{12\mu\text{F}} = 0.38 \text{ mJ}$

- (b)  $W_{6\ \mu\text{F}} = 85.23\ \mu\text{J}$ ;  
 $W_{12\ \mu\text{F}} = 42.77\ \mu\text{J}$

## Chapter 11

- (a)  $0.04\ \text{Wb/m}^2$  (b)  $0.04\ \text{T}$   
(c)  $88\ \text{At}$  (d)  $0.4 \times 10^3\ \text{gauss}$
- $12.54\ \text{mH}$
- (a)  $45\ \text{mH}$  (b)  $1.67\ \text{mH}$   
(c)  $80\ \text{mH}$  (d)  $1875\ \text{mH}$
- $6.0\ \text{V}$
- $14\ \text{turns}$
- $5\ \text{V}$
- (a)  $2.27\ \mu\text{s}$  (b)  $i_L = 5.45\ \text{mA} (1 - e^{-t/2.27\ \mu\text{s}})$   
(c)  $v_L = 12\ \text{V} e^{-t/2.27\ \mu\text{s}}$ ;  
 $v_R = 12\ \text{V} (1 - e^{-t/2.27\ \mu\text{s}})$   
(d)  $i_L: 1\tau = 3.45\ \text{mA}$ ;  
 $3\tau = 5.18\ \text{mA}$ ;  $5\tau = 5.41\ \text{mA}$   
 $v_L: 1\tau = 4.42\ \text{V}$ ;  $3\tau = 0.60\ \text{V}$ ;  
 $5\tau = 0.08\ \text{V}$
- (a)  $i_L = 9.23\ \text{mA} - 1.23\ \text{mA} e^{-t/30.77\ \mu\text{s}}$   
 $v_L = 4.8\ \text{V} e^{-t/30.77\ \mu\text{s}}$
- (a)  $i_L = 1.76\ \text{mA} - 4.76\ \text{mA} e^{-t/588.2\ \mu\text{s}}$   
 $v_L = 16.2\ \text{V} e^{-t/588.2\ \mu\text{s}}$
- (a)  $i_L = 2\ \text{mA} (1 - e^{-t/1\ \mu\text{s}})$ ;  $v_L = 20\ \text{V} e^{-t/1\ \mu\text{s}}$  (b)  $i_L = 2\ \text{mA} e^{-t/1\ \mu\text{s}}$ ;  
 $v_L = -40\ \text{V} e^{-t/1\ \mu\text{s}}$
- (a)  $i_L = 0.88\ \text{mA} (1 - e^{-t/0.74\ \mu\text{s}})$ ;  
 $v_L = 6\ \text{V} e^{-t/0.74\ \mu\text{s}}$  (b)  $i_L = 0.88\ \text{mA} e^{-t/0.33\ \mu\text{s}}$ ;  
 $v_L = -13.23\ \text{V} e^{-t/0.33\ \mu\text{s}}$
- (a)  $i_L = 1.33\ \text{mA} (1 - e^{-t/55.56\ \text{ns}})$ ;  
 $v_L = 48\ \text{V} e^{-t/55.56\ \text{ns}}$  (b)  $i_L = 1.11\ \text{mA}$ ;  $v_L = 7.93\ \text{V}$
- (a)  $0.24\ \text{V}$  (b)  $29.47\ \text{V}$   
(c)  $18.96\ \text{V}$  (d)  $2.03\ \text{ms}$
- (a)  $i_L = 3\ \text{mA} (1 - e^{-t/6.67\ \mu\text{s}})$ ;  
 $v_L = 2.25\ \text{V} e^{-t/6.67\ \mu\text{s}}$   
(b)  $i_L = 2.60\ \text{mA}$ ;  $v_L = 0.30\ \text{V}$   
(c)  $i_L = 2.60\ \text{mA} e^{-t/3.33\ \mu\text{s}}$ ;  
 $v_L = -3.90\ \text{V} e^{-t/3.33\ \mu\text{s}}$
- (a)  $i_L = -3.48\ \text{mA} - 7.43\ \text{mA} e^{-t/173.9\ \mu\text{s}}$   
 $v_L = 51.28\ \text{V} e^{-t/173.9\ \mu\text{s}}$
- (a)  $20\ \text{V}$  (b)  $12\ \mu\text{A}$   
(c)  $5.38\ \mu\text{s}$  (d)  $0.37\ \text{V}$
- $0 \rightarrow 2\ \text{ms}: -50\ \text{mV}$ ;  
 $2 \rightarrow 5\ \text{ms}: 0\ \text{V}$ ;  $5 \rightarrow 11\ \text{ms}: 25\ \text{mV}$ ;  
 $11 \rightarrow 18\ \text{ms}: -7.14\ \text{V}$ ;  
 $18\ \text{ms} \rightarrow: 0\ \text{V}$
- (a)  $10\ \text{H}$  (b)  $2.4\ \text{H}$
- (a)  $16\ \text{mH}$  in series with  $18\ \mu\text{F}$
- (a)  $i_L = 3.56\ \text{mA} (1 - e^{-t/8.33\ \mu\text{s}})$ ;  
 $v_L = 12.8\ \text{V} e^{-t/8.33\ \mu\text{s}}$
- $I_1 = 7\ \text{A}$ ;  $I_2 = 2\ \text{A}$
- $I_1 = 3\ \text{A}$ ;  $I_2 = 0\ \text{A}$ ;  $V_1 = 12\ \text{V}$ ;  
 $V_2 = 0\ \text{V}$

## Chapter 12

- ( $\Phi$ ) CGS:  $5 \times 10^4$  Maxwells;  
English:  $5 \times 10^4$  lines  
( $B$ ) CGS:  $8\ \text{Gauss}$ ; English:  
 $51.62\ \text{lines/in.}^2$
- (a)  $0.04\ \text{T}$
- $952.4 \times 10^3\ \text{At/Wb}$
- $2,624.67\ \text{At/m}$
- $2.13\ \text{A}$
- (a)  $60\ \text{t}$   
(b)  $13.34 \times 10^{-4}\ \text{Wb/Am}$
- $2.70\ \text{A}$
- $1.35\ \text{N}$
- (a)  $2.02\ \text{A}$  (b)  $2\ \text{N}$
- $6.12\ \text{mWb}$
- (a)  $B = 1.5\ \text{T} (1 - e^{-H/700\ \text{At/m}})$   
(b)  $900\ \text{At/m}: 1.09\ \text{T}$ ;  
 $1800\ \text{At/m}: 1.39\ \text{T}$ ;  
 $2700\ \text{At/m}: 1.47\ \text{T}$   
(c)  $H = -700 \log_e \left[ 1 - \frac{B}{1.5} \right]$   
(d)  $1\ \text{T}: 769.03\ \text{At/m}$ ;  
 $1.4\ \text{T}: 1895\ \text{At/m}$  (e)  $40.1\ \text{mA}$

## Chapter 13

- (a)  $20\ \text{mA}$  (b)  $15\ \text{ms}: -20\ \text{mA}$ ,  
 $20\ \text{ms}: 0\ \text{mA}$  (c)  $40\ \text{mA}$   
(d)  $20\ \text{ms}$  (e)  $2.5\ \text{cycles}$
- (a)  $8\ \text{mV}$  (b)  $3\ \mu\text{s}: -8\ \text{mV}$ ,  
 $9\ \mu\text{s}: 0\ \text{mV}$  (c)  $16\ \text{mV}$   
(d)  $4.5\ \mu\text{s}$  (e)  $2.22\ \text{cycles}$
- (a)  $60\ \text{Hz}$  (b)  $100\ \text{Hz}$   
(c)  $25\ \text{Hz}$  (d)  $40\ \text{kHz}$
- $0.3\ \text{ms}$
- (a)  $150\ \text{mV}$  (b)  $40\ \mu\text{s}$   
(c)  $25\ \text{kHz}$
- (a)  $45^\circ$  (b)  $30^\circ$  (c)  $18^\circ$   
(d)  $108^\circ$
- (a)  $314.16\ \text{rad/s}$   
(b)  $3769.91\ \text{rad/s}$   
(c)  $12.56 \times 10^3\ \text{rad/s}$   
(d)  $25.13 \times 10^3\ \text{rad/s}$
- $2.08\ \text{ms}$
- (a)  $20, 60\ \text{Hz}$  (b)  $5, 120\ \text{Hz}$   
(c)  $10^6, 1591.55\ \text{Hz}$  (d)  $-6.4,$   
 $149.92\ \text{Hz}$
- $0.48\ \text{A}$
- $11.54^\circ, 168.46^\circ$
- (a)  $v = 25 \sin(\omega t + 30^\circ)$   
(b)  $i = 3 \times 10^{-3} \sin(6.28 \times 10^3 t - 60^\circ)$
- $v$  leads  $i$  by  $10^\circ$
- $i$  leads  $v$  by  $80^\circ$
- $i$  leads  $v$  by  $190^\circ$
- $13.95\ \mu\text{s}$
- $2\ \text{V}$
- $3.87\ \text{mA}$
- (a)  $40\ \mu\text{s}$  (b)  $25\ \text{kHz}$   
(c)  $17.13\ \text{mV}$

- (a)  $v = 14.14 \sin 377t$   
(b)  $i = 70.7 \times 10^{-3} \sin 377t$   
(c)  $v = 2.83 \times 10^3 \sin 377t$
- $2.16\ \text{V}$
- (a)  $T = 40\ \mu\text{s}, f = 25\ \text{kHz}$ ,  
Average =  $20\ \text{mV}$ , Peak =  $40\ \text{mV}$ ,  
rms =  $34.64\ \text{mV}$  (b)  $T = 100\ \mu\text{s}$ ,  
 $f = 10\ \text{kHz}$ , Average =  $-0.3\ \text{V}$ ,  
Peak =  $0.3\ \text{mV}$ , rms =  $367.42\ \text{mV}$

## Chapter 14

- (a)  $3770 \cos 377t$   
(b)  $452.4 \cos(754t + 20^\circ)$   
(c)  $4440.63 \cos(157t - 20^\circ)$   
(d)  $200 \cos t$
- (a)  $v = 700 \sin 1000t$   
(b)  $v = 14.8 \sin(400t - 120^\circ)$   
(c)  $v = 42 \times 10^{-3} \sin(\omega t + 88^\circ)$   
(d)  $v = 28 \sin \omega t$
- (a)  $1.59\ \text{H}$  (b)  $2.65\ \text{H}$   
(c)  $1.68\ \text{H}$
- (a)  $v = 100 \sin(\omega t + 90^\circ)$   
(b)  $v = 0.8 \sin(\omega t + 150^\circ)$   
(c)  $v = 120 \sin(\omega t - 120^\circ)$   
(d)  $v = 60 \sin(\omega t + 190^\circ)$
- (a)  $i = 2.4 \sin(\omega t - 90^\circ)$   
(b)  $i = 0.6 \sin(\omega t - 70^\circ)$   
(c)  $i = 0.8 \sin(\omega t + 10^\circ)$   
(d)  $i = 1.6 \sin(377t + 130^\circ)$
- (a)  $\infty\ \Omega$  (b)  $530.79\ \Omega$   
(c)  $265.39\ \Omega$  (d)  $15.92\ \Omega$   
(e)  $62.83\ \Omega$
- (a)  $31.83\ \text{Hz}$  (b)  $4.66\ \text{Hz}$   
(c)  $9.31\ \text{Hz}$  (d)  $1.59\ \text{Hz}$
- (a)  $i = 6 \times 10^{-3} \sin(200t + 90^\circ)$   
(b)  $i = 22.64 \times 10^{-6} \sin(377t + 90^\circ)$  (c)  $i = 44.94 \times 10^{-3} \sin(374t + 300^\circ)$   
(d)  $i = 56 \times 10^{-3} \sin(\omega t + 160^\circ)$
- (a)  $v = 1334 \sin(300t - 90^\circ)$   
(b)  $v = 42.48 \sin(377t - 90^\circ)$   
(c)  $v = 159 \sin 754t$   
(d)  $v = 100 \sin(1600t - 170^\circ)$
- (a)  $C$  (b)  $L = 254.78\ \text{mH}$   
(c)  $R = 5\ \Omega$
- $318.47\ \text{mH}$
- $5.07\ \text{nF}$
- $0\ \text{W}$
- $192\ \text{W}$
- $i = 40 \sin(\omega t - 50^\circ)$
- (a)  $i = 4 \sin(314t - 30^\circ)$   
(b)  $79.62\ \text{mH}$  (c)  $0\ \text{W}$
- (a)  $i_1 = 3.39 \sin(10^4 t + 150^\circ)$ ,  
 $i_2 = 16.97 \sin(10^4 t + 150^\circ)$   
(b)  $i_s = 20.36 \sin(10^4 t + 150^\circ)$
- (a)  $5.0 \angle 36.87^\circ$  (b)  $2.83 \angle 45^\circ$   
(c)  $17.09 \angle 69.44^\circ$  (d)  $1.0 \times 10^3 \angle 84.29^\circ$  (e)  $1077.03 \angle 21.80^\circ$   
(f)  $6.58 \times 10^{-3} \angle 81.25^\circ$   
(g)  $11.78 \angle -49.82^\circ$

- (h)  $8.94 \angle -153.43^\circ$
- (i)  $61.85 \angle -104.04^\circ$
- (j)  $101.73 \angle -39.94^\circ$
- (k)  $4,326.66 \angle 123.69^\circ$
- (l)  $25.5 \times 10^{-3} \angle -78.69^\circ$
- 41. (a)  $15.03 \angle 86.19^\circ$
- (b)  $60.21 \angle 4.76^\circ$
- (c)  $0.30 \angle 88.09^\circ$
- (d)  $223.61 \angle -63.43^\circ$
- (e)  $86.18 \angle 93.73^\circ$
- (f)  $38.69 \angle -94.0^\circ$
- 43. (a)  $11.8 + j 7.0$
- (b)  $151.90 + j 49.90$
- (c)  $4.72 \times 10^{-6} + j 71$
- (d)  $5.20 + j 1.60$
- (e)  $209.30 + j 311.0$
- (f)  $-21.20 + j 12.0$
- (g)  $7.03 + j 9.93$
- (h)  $95.7 + j 22.77$
- 45. (a)  $6.0 \angle -50^\circ$
- (b)  $200 \times 10^{-6} \angle 60^\circ$
- (c)  $109 \angle -170^\circ$
- (d)  $76.47 \angle -80^\circ$  (e)  $4 \angle 0^\circ$
- (f)  $5.93 \angle -134.47^\circ$
- (g)  $4.21 \times 10^{-3} \angle 161.10^\circ$
- (h)  $9.30 \angle -43.99^\circ$
- 47. (a)  $x = 4, y = 3$  (b)  $4$
- (c)  $x = 3, y = 6$  or  $x = 6, y = 3$
- (d)  $30^\circ$
- 49. (a)  $56.57 \sin(377t + 20^\circ)$
- (b)  $169.68 \sin(377t + 10^\circ)$
- (c)  $11.31 \times 10^{-3} \sin(377t + 120^\circ)$
- (d)  $7.07 \sin(377t + 90^\circ)$
- (e)  $1696.8 \sin(377t - 50^\circ)$
- (f)  $6000 \sin(377t - 180^\circ)$
- 51.  $i_1 = 20.88 \times 10^{-6} \sin(\omega t + 76.70^\circ)$
- 53.  $i_s = -21.21 \times 10^{-3} \sin 377t$

**Chapter 15**

- 1. (a)  $6.8 \Omega \angle 0^\circ = 6.8$
- (b)  $452.4 \Omega \angle 90^\circ = j 452.4 \Omega$
- (c)  $15.7 \Omega \angle 90^\circ = j 15.7 \Omega$
- (d)  $1 \text{ k}\Omega \angle -90^\circ = -j 1 \text{ k}\Omega$
- (e)  $318.47 \Omega \angle -90^\circ = -j 318.47 \Omega$  (f)  $220 \Omega \angle 0^\circ = 220 \Omega$
- 3. (a)  $v = 88 \times 10^{-3} \sin \omega t$
- (b)  $v = 16.98 \sin(1000t + 150^\circ)$
- (c)  $v = 254.7 \sin(157t - 50^\circ)$
- 5. (a)  $Z_T = 3 \Omega - j 1 \Omega = 3.16 \Omega \angle -18.43^\circ$  (b)  $Z_T = 1 \text{ k}\Omega + j 4 \text{ k}\Omega = 4.12 \text{ k}\Omega \angle 75.96^\circ$
- (c)  $Z_T = 470 \Omega - j 80 \Omega = 476.76 \Omega \angle -9.66^\circ$
- 7. (a)  $10 \Omega \angle 36.87^\circ$
- (c)  $I = 10 \text{ A} \angle -36.87^\circ$ ,  $V_R = 80 \text{ V} \angle -36.87^\circ$ ,  $V_L = 60 \text{ V} \angle 53.13^\circ$
- (f)  $800 \text{ W}$  (g)  $0.8$  lagging
- (h)  $v_R = 113.12 \sin(\omega t - 36.87^\circ)$

- $v_L = 84.84 \sin(\omega t + 53.13^\circ)$
- $i = 14.14 \sin(\omega t - 36.87^\circ)$
- 9. (a)  $2.34 \text{ k}\Omega \angle -19.89^\circ$
- (b)  $6.04 \text{ mA} \angle 19.89^\circ$
- (c)  $V_R = 13.29 \text{ V} \angle 19.89^\circ$ ,  $V_C = 4.81 \text{ V} \angle -70.11^\circ$
- (d)  $80.26 \text{ mW}$ ,  $0.94$  leading
- 11. (a)  $2.16 \text{ k}\Omega \angle 33.69^\circ$  (c)  $5.31 \mu\text{F}$ ,  $6.37 \text{ H}$
- (d)  $I = 1.96 \text{ mA} \angle 26.31^\circ$ ,  $V_R = 3.53 \text{ V} \angle 26.31^\circ$ ,  $V_L = 2.68 \text{ V} \angle 116.31^\circ$ ,  $V_C = 1.18 \text{ V} \angle -63.69^\circ$
- (g)  $6.91 \text{ mW}$  (h)  $0.832$  lagging
- (i)  $i = 2.77 \times 10^{-3} \sin(\omega t + 26.31^\circ)$
- $v_R = 4.99 \sin(\omega t + 26.31^\circ)$
- $v_L = 3.79 \sin(\omega t + 116.31^\circ)$
- $v_C = 1.67 \sin(\omega t - 63.69^\circ)$
- 13. (a)  $40 \text{ mH}$  (b)  $220 \Omega$
- 15. (a)  $V_1 = 29.09 \text{ V} \angle -15.96^\circ$ ,  $V_2 = 116.36 \text{ V} \angle 74.04^\circ$
- (b)  $V_1 = 48.69 \text{ V} \angle 40.75^\circ$ ,  $V_2 = 26.78 \text{ V} \angle -49.25^\circ$
- 17. (a)  $I = 39 \text{ mA} \angle 126.65^\circ$ ,  $V_R = 1.17 \text{ V} \angle 126.65^\circ$ ,  $V_C = 25.86 \text{ V} \angle 36.65^\circ$
- (b)  $0.058$  leading (c)  $45.63 \text{ mW}$
- (f)  $V_R = 1.17 \text{ V} \angle 126.65^\circ$ ,  $V_C = 25.84 \text{ V} \angle 36.65^\circ$
- (g)  $Z_T = 30 \Omega - j 512.2 \Omega$
- 19.  $3.2 \Omega + j 2.4 \Omega$
- 25. (a)  $Z_T = 91 \Omega \angle 0^\circ$ ,  $Y_T = 10.99 \text{ mS} \angle 0^\circ$
- (b)  $Z_T = 200 \Omega \angle 90^\circ$ ,  $Y_T = 5 \text{ mS} \angle -90^\circ$  (c)  $Z_T = 0.2 \text{ k}\Omega \angle -90^\circ$ ,  $Y_T = 5 \text{ mS} \angle 90^\circ$
- (d)  $Z_T = 9.86 \Omega \angle 9.46^\circ$ ,  $Y_T = 0.10 \text{ S} \angle -9.46^\circ$
- (e)  $Z_T = 1.90 \Omega \angle -18.43^\circ$ ,  $Y_T = 0.53 \text{ S} \angle 18.43^\circ$
- (f)  $Z_T = 2.94 \text{ k}\Omega \angle 9.55^\circ$ ,  $Y_T = 0.34 \text{ mS} \angle -9.55^\circ$
- 27. (a)  $R = 5.85 \Omega$ ,  $X_C = 2.13 \Omega$
- (b)  $R = 23.26 \text{ k}\Omega$ ,  $X_C = 4.07 \text{ k}\Omega$
- (c)  $R = 80 \text{ k}\Omega$ ,  $X_L = 46.19 \text{ k}\Omega$
- 29. (a)  $Y_T = 0.112 \text{ mS} \angle 26.57^\circ$
- (c)  $E = 17.89 \text{ V} \angle -6.57^\circ$ ,  $I_R = 1.79 \text{ mA} \angle -6.57^\circ$ ,  $I_C = 0.90 \text{ mA} \angle 83.44^\circ$  (f)  $32.04 \text{ mW}$
- (g)  $0.894$  leading (h)  $i_s = 2.83 \times 10^{-3} \sin(\omega t + 20^\circ)$
- $i_R = 2.53 \times 10^{-3} \sin(\omega t - 6.57^\circ)$
- $i_C = 1.27 \times 10^{-3} \sin(\omega t + 83.44^\circ)$
- $e = 25.3 \sin(\omega t - 6.57^\circ)$
- 31. (a)  $Y_T = 0.89 \text{ S} \angle -19.81^\circ$ ,  $Z_T = 1.12 \Omega \angle 19.81^\circ$
- (c)  $531 \mu\text{F}$ ,  $5.31 \text{ mH}$
- (d)  $E = 2.40 \text{ V} \angle 79.81^\circ$ ,  $I_R = 2.00 \text{ A} \angle 79.81^\circ$ ,  $I_L = 1.20 \text{ A} \angle -10.19^\circ$ ,  $I_C = 0.48 \text{ A} \angle 169.81^\circ$  (g)  $4.8 \text{ W}$

- (h)  $0.941$  lagging
- (i)  $e = 3.39 \sin(377t + 79.81^\circ)$
- $i_R = 2.83 \sin(377t + 79.81^\circ)$
- $i_L = 1.70 \sin(377t - 10.19^\circ)$
- $i_C = 0.68 \sin(377t + 169.81^\circ)$
- 33. (a)  $Y_T = 0.11 \text{ S} \angle 65.77^\circ$ ,  $Z_T = 9.09 \Omega \angle -65.77^\circ$
- (c)  $636.9 \mu\text{F}$ ,  $31.8 \text{ mH}$
- (d)  $E = 25.03 \text{ V} \angle 60^\circ$ ,  $I_s = 2.75 \text{ A} \angle 125.77^\circ$ ,  $I_C = 5 \text{ A} \angle 150^\circ$ ,  $I_R = 1.14 \text{ A} \angle 60^\circ$ ,  $I_L = 2.50 \text{ A} \angle -30^\circ$
- (g)  $28.59 \text{ W}$  (h)  $0.409$  leading
- (i)  $e = 35.4 \sin(314t + 60^\circ)$
- $i_s = 3.89 \sin(314t + 125.77^\circ)$
- $i_C = 7.07 \sin(314t + 150^\circ)$
- $i_R = 1.61 \sin(314t + 60^\circ)$
- $i_L = 3.54 \sin(314t - 30^\circ)$
- 41. (a)  $7.02 \text{ k}\Omega - j 2.88 \text{ k}\Omega$
- (b)  $17.48 \Omega + j 29.72 \Omega$
- 43. (a)  $E = 75.6 \text{ V} \angle -70.11^\circ$ ,  $I_R = 0.34 \text{ A} \angle -70.11^\circ$ ,  $I_L = 12.04 \text{ mA} \angle -160.11^\circ$
- (b)  $0.340$  leading (c)  $25.97 \text{ W}$
- (f)  $0.47 \text{ A} \angle 19.63^\circ$
- (g)  $25.72 \Omega - j 71.08 \Omega$
- 47. (I): (a)  $v_1$  leads  $v_2$  by  $72^\circ$
- (b)  $v_1$ : p-p =  $2.5 \text{ V}$ , rms =  $0.88 \text{ V}$
- $v_2$ : p-p =  $1.2 \text{ V}$ , rms =  $0.42 \text{ V}$
- (c)  $1.25 \text{ kHz}$
- (II): (a)  $v_1$  leads  $v_2$  by  $132^\circ$
- (b)  $v_1$ : p-p =  $5.6 \text{ V}$ , rms =  $1.98 \text{ V}$
- $v_2$ : p-p =  $8 \text{ V}$ , rms =  $2.83 \text{ V}$
- (c)  $16.67 \text{ kHz}$

**Chapter 16**

- 1. (a)  $2.33 \Omega \angle 30.96^\circ$
- (b)  $5.15 \text{ A} \angle -30.96^\circ$
- (c)  $5.15 \text{ A} \angle -30.96^\circ$
- (d)  $I_2 = 3.09 \text{ A} \angle -30.96^\circ$ ,  $I_3 = 2.06 \text{ A} \angle -30.96^\circ$
- (e)  $30.9 \text{ V} \angle 59.04^\circ$
- 3. (a)  $Z_T = 19.86 \Omega \angle 37.17^\circ$ ,  $Y_T = 50.35 \text{ mS} \angle -37.17^\circ$
- (b)  $3.02 \text{ A} \angle -7.17^\circ$
- (c)  $3.98 \text{ A} \angle 82.83^\circ$
- (d)  $47.81 \text{ V} \angle -7.17^\circ$
- (e)  $167.07 \text{ W}$
- 5. (a)  $0.25 \text{ A} \angle -6.34^\circ$
- (b)  $70.71 \text{ V} \angle -45^\circ$
- (c)  $24.85 \text{ W}$
- 7. (a)  $1.42 \text{ A} \angle 18.26^\circ$
- (b)  $26.57 \text{ V} \angle 4.76^\circ$
- (c)  $54.07 \text{ W}$
- 9. (a)  $82.51 \text{ mS} \angle -8.11^\circ$
- (b)  $V_1 = 20.4 \text{ V} \angle 30^\circ$ ,  $V_2 = 10.89 \text{ V} \angle 58.13^\circ$
- (c)  $1.93 \text{ A} \angle 11.11^\circ$



11. 32.89 A  $\angle 38.89^\circ$   
 13. 139.71 mW

### Chapter 17

3. (a)  $Z = 21.93 \Omega \angle -46.85^\circ$ ,  
 $E = 10.97 \text{ V} \angle 13.15^\circ$   
 (b)  $Z = 5.15 \Omega \angle 59.04^\circ$ ,  
 $E = 10.30 \text{ V} \angle 179.04^\circ$   
 5. (a) 5.15 A  $\angle -24.5^\circ$   
 (b) 0.44 A  $\angle 143.48^\circ$   
 7. (a) 13.07 A  $\angle -33.71^\circ$   
 (b) 48.33 A  $\angle -77.57^\circ$   
 9.  $I_L = -3.17 \times 10^{-3} \text{ V} \angle 137.29^\circ$   
 11.  $I_{1\text{k}\Omega} = 10 \text{ mA} \angle 0^\circ$ ,  
 $I_{2\text{k}\Omega} = 1.67 \text{ mA} \angle 0^\circ$   
 13. 1.38 mA  $\angle -56.31^\circ$   
 15. (a)  $V_1 = 19.86 \text{ V} \angle 43.8^\circ$ ,  
 $V_2 = 8.94 \text{ V} \angle 106.9^\circ$   
 (b)  $V_1 = 19.78 \text{ V} \angle 132.48^\circ$ ,  
 $V_2 = 13.37 \text{ V} \angle 98.78^\circ$   
 17.  $V_1 = 100 \text{ V} \angle 90^\circ$ ,  $V_2 =$   
 $96.66 \text{ V} \angle -12.43^\circ$ ,  $V_3 = 0 \text{ V} \angle 0^\circ$   
 19.  $V_1 = 14.62 \text{ V} \angle -5.86^\circ$ ,  
 $V_2 = 35.03 \text{ V} \angle -37.69^\circ$   
 $V_3 = 32.4 \text{ V} \angle -73.34^\circ$ ,  
 $V_4 = 5.67 \text{ V} \angle 23.53^\circ$   
 21.  $V_{1\text{k}\Omega} = 2.25 \text{ V} \angle 17.63^\circ$   
 23.  $V_{2\text{k}\Omega} = 10.67 \text{ V} \angle 180^\circ$   
 25.  $V_L = -2451.92 E_i$   
 27. (a) no (b) 1.76 mA  $\angle -71.54^\circ$   
 (c) 7.03 V  $\angle -18.46^\circ$   
 29. yes  
 31.  $L_x = R_2 L_3 / R_1$   
 33. (a) 11.57 A  $\angle -67.13^\circ$   
 (b) 36.9 A  $\angle 23.87^\circ$

### Chapter 18

1. (a) 6.09 A  $\angle -32.12^\circ$   
 (b) 3.77 A  $\angle -93.8^\circ$   
 3.  $0.5 + 1.58 \sin(\omega t - 26.57^\circ)$   
 5. 6.26 mA  $\angle -63.43^\circ$   
 7.  $-22.09 \text{ V} \angle 6.34^\circ$   
 9. 19.62 V  $\angle 53^\circ$   
 11. 10 V  $\angle 0^\circ$   
 13. (a)  $E_{Th} = 2.13 \text{ V} \angle 32.2^\circ$ ,  
 $Z_{Th} = 21.31 \Omega \angle 32.2^\circ$   
 (b)  $E_{Th} = 57.95 \text{ V} \angle 11.10^\circ$ ,  
 $Z_{Th} = 6.81 \Omega \angle -54.23^\circ$   
 15. (a)  $E_{Th} = 4 \text{ V} + 10 \text{ V} \angle 0^\circ$ ,  
 $Z_{Th} = 4 \Omega \angle 90^\circ$   
 (b)  $0.5 + 1.58 \sin(\omega t - 26.57^\circ)$   
 17. (a)  $E_{Th} = 31.31 \text{ V} \angle -26.57^\circ$ ,  
 $Z_{Th} = 4.47 \text{ k}\Omega \angle -26.57^\circ$   
 (b) 6.26 mA  $\angle 63.44^\circ$   
 19.  $E_{Th} = -444.45 \times 10^3 \text{ I} \angle 0.26^\circ$ ,  
 $Z_{Th} = 4.44 \text{ k}\Omega \angle -0.03^\circ$   
 21.  $E_{Th} = -50 \text{ V} \angle 0^\circ$ ,  
 $Z_{Th} = 5.10 \text{ k}\Omega \angle -11.31^\circ$   
 23.  $E_{Th} = 20 \text{ V} \angle 53^\circ$ ,  
 $Z_{Th} = -39.22 \Omega \angle 0^\circ$

25.  $E_{Th} = 1.62 \text{ V} \angle 0^\circ$ ,  
 $Z_{Th} = 607.42 \Omega \angle 0^\circ$   
 27. (a)  $I_N = 0.1 \text{ A} \angle 0^\circ$ ,  
 $Z_N = 21.31 \Omega \angle 32.2^\circ$   
 (b)  $I_N = 8.51 \text{ A} \angle 65.32^\circ$ ,  
 $Z_N = 6.81 \Omega \angle -54.23^\circ$   
 29. (a)  $I_N = 2.15 \text{ A} \angle -42.87^\circ$ ,  
 $Z_N = 9.66 \Omega \angle 14.93^\circ$   
 (b)  $I_N = 22.83 \text{ A} \angle -34.65^\circ$ ,  
 $Z_N = 4.37 \Omega \angle 55.67^\circ$   
 31. (a)  $I_N = 1.33 \text{ A} + 2.67 \text{ A} \angle 0^\circ$ ,  
 $Z_N = 9 \Omega \angle 0^\circ$   
 (b) 12 V + 2.65 V  $\angle -83.66^\circ$   
 33.  $I_N = -1.96 \times 10^{-3} \text{ V} \angle 11.31^\circ$ ,  
 $Z_N = 5.1 \text{ k}\Omega \angle -11.31^\circ$   
 35.  $I_N = 9.81 \text{ mA} \angle 11.31^\circ$ ,  
 $Z_N = 5.1 \text{ k}\Omega \angle -11.31^\circ$   
 37.  $I_N = 0.79 \text{ mA} \angle 0^\circ$ ,  
 $Z_N = 6.63 \text{ k}\Omega \angle 0^\circ$   
 39. (a)  $Z_L = 8.32 \Omega \angle 3.18^\circ$ ,  
 1198.2 W (b)  $Z_L =$   
 $1.56 \Omega \angle 14.47^\circ$ , 1.61 W  
 41. 40 k $\Omega$ , 25 W  
 43. (a) 9  $\Omega$  (b) 20 W  
 45. (a) 1.41 k $\Omega$  (b) 516.53 mW  
 49. 25.77 mA  $\angle 104.4^\circ$

### Chapter 19

1. (a) 120 W (b)  $Q_T = 0 \text{ VAR}$ ,  
 $S_T = 120 \text{ VA}$  (c) 0.5 A  
 (d) 20 W: 720  $\Omega$ , 40 W: 360  $\Omega$   
 (e)  $I_1 = 0.17 \text{ A}$ ,  $I_2 = 0.33 \text{ A}$   
 3. (a)  $P_T = 400 \text{ W}$ ,  $Q_T =$   
 $-400 \text{ VAR}$  (C),  $S_T = 565.69 \text{ VA}$ ,  
 $F_p = 0.707$  leading  
 (c) 5.66 A  $\angle 135^\circ$   
 5. (a)  $P_T = 500 \text{ W}$ ,  $Q_T =$   
 $-200 \text{ VAR}$  (C),  $S_T = 538.52 \text{ VA}$   
 (b)  $F_p = 0.928$  leading  
 (d) 10.78 A  $\angle 21.88^\circ$   
 7. (a) R: 200 W, L: 0 W, C: 0 W  
 (b) R: 0 VAR, L: 100 VAR, C:  
 80 VAR (c) R: 200 VA, L: 100  
 VAR, C: 80 VA (d)  $P_T = 200 \text{ W}$ ,  
 $Q_T = 20 \text{ VAR}$  (L),  $S_T = 200 \text{ VA}$ ,  
 $F_p = 0.995$  lagging  
 (f) 10.05 A  $\angle -5.73^\circ$   
 9. (a-c) L: 0 W, 126.74 VAR,  
 126.74 VA, C: 0 W, 46.92 VAR,  
 46.92 VA, R: 38.99 W, 0 VAR,  
 38.99 VA (d)  $P_T = 38.99 \text{ W}$ ,  
 $Q_T = 79.82 \text{ VAR}$  (L),  
 $S_T = 88.83 \text{ VA}$ ,  $F_p = 0.439$   
 lagging (f)  $W_R = 0.31 \text{ J}$   
 (g)  $W_L = 0.32 \text{ J}$ ,  $W_C = 0.12 \text{ J}$   
 11. (a)  $Z = 2.30 \Omega + j 1.73 \Omega$   
 (b) 4000 W  
 13. (a)  $P_T = 900 \text{ W}$ ,  $Q_T = 0 \text{ VAR}$ ,  
 $S_T = 900 \text{ VA}$ ,  $F_p = 1$   
 (b) 9 A  $\angle 0^\circ$  (d)  $Z_1: X_C = 20 \Omega$ ,

- $Z_2: R = 2.83 \Omega$ ,  $Z_3: R = 5.66 \Omega$ ,  
 $X_L = 4.72 \Omega$   
 15. (a)  $P_T = 1100 \text{ W}$ ,  $Q_T =$   
 $2366.26 \text{ VAR}$ ,  $S_T = 2609.44 \text{ VA}$ ,  
 $F_p = 0.422$  leading  
 (b) 521.89 V  $\angle -65.07^\circ$   
 (c)  $Z_1: R = 1743.38 \Omega$ ,  
 $X_C = 1307.53 \Omega$ ,  $Z_2: R = 43.59 \Omega$ ,  
 $X_C = 99.88 \Omega$   
 17. (a) 7.81 kVA (b) 0.640 lagging  
 (c) 65.08 A (d) 1105  $\mu\text{F}$   
 (e) 41.67 A  
 19. (a) 128.14 W (b) a-b: 42.69 W,  
 b-c: 64.03 W, a-c: 106.72 W,  
 a-d: 106.72 W, c-d: 0 W,  
 d-e: 0 W, f-e: 21.34 W  
 21. (a)  $R = 5 \Omega$ , 132.03 mH  
 (b) 10  $\Omega$  (c) 15  $\Omega$ , 262.39 mH

### Chapter 20

1. (a)  $\omega_s = 250 \text{ rad/s}$ ,  $f_s = 39.79 \text{ Hz}$   
 (b)  $\omega_s = 3535.53 \text{ rad/s}$ ,  
 $f_s = 562.7 \text{ Hz}$   
 (c)  $\omega_s = 21,880 \text{ rad/s}$ ,  
 $f_s = 3482.31 \text{ Hz}$   
 3. (a) 40  $\Omega$  (b) 10 mA  
 (c)  $V_R = 20 \text{ mV}$ ,  $V_L = 400 \text{ mV}$ ,  
 $V_C = 400 \text{ mV}$  (d) 20 (high)  
 (e) 1.27 mH, 795.77 nF  
 (f) 250 Hz  
 (g) 4.88 kHz, 5.13 kHz  
 5. (a) 400 Hz (b) 5800 Hz,  
 6200 Hz (c) 45  $\Omega$   
 (d) 375 mW  
 7. (a) 10 (b) 20  $\Omega$  (c) 1.59 mH,  
 3.98  $\mu\text{F}$  (d) 1900 Hz, 2100 Hz  
 9.  $R = 10 \Omega$ ,  $L = 13.26 \text{ mH}$ ,  
 $C = 27.07 \text{ nF}$ , 8340 Hz, 8460 Hz  
 11. (a) 1 MHz (b) 160 kHz  
 (c)  $R = 720 \Omega$ ,  $L = 0.716 \text{ mH}$ ,  
 $C = 35.37 \text{ pF}$  (d) 56.25  $\Omega$   
 13. (a) 159.16 kHz (b) 4 V  
 (c) 40 mA (d) 20  
 15. (a) 11,253.95 Hz (b) 1.77 (no)  
 (c)  $f_p = 9,280.24 \text{ Hz}$ ,  
 $f_m = 10,794.41 \text{ Hz}$   
 (d)  $X_L = 5.83 \Omega$ ,  $X_C = 8.57 \Omega$ ,  
 $X_C > X_L$  (e) 12.5  $\Omega$  (f) 25 mV  
 (g)  $Q_p = 1.46$ ,  $BW = 6.36 \text{ kHz}$   
 (h)  $I_C = 2.92 \text{ mA}$ ,  $I_L = 3.54 \text{ mA}$   
 17. (a) 30  $\Omega$  (b) 225  $\Omega$   
 (c)  $I_C = 0.6 \text{ A} \angle 90^\circ$ ,  $I_L \equiv$   
 $0.6 \text{ A} \angle -86.19^\circ$  (d)  $L =$   
 $0.239 \text{ mH}$ ,  $C = 265.26 \text{ nF}$   
 (e)  $Q_p = 7.5$ ,  $BW = 2.67 \text{ kHz}$   
 19. (a)  $f_s = 7.12 \text{ kHz}$ ,  $f_p = 6.65 \text{ kHz}$ ,  
 $f_m = 7 \text{ kHz}$ , low  $Q_p$   
 (b)  $X_L = 20.88 \Omega$ ,  $X_C = 23.94 \Omega$   
 (c) 55.56  $\Omega$  (d)  $Q_p = 2.32$ ,  
 $BW = 2.87 \text{ kHz}$

- (e)  $I_C = 92.73 \text{ mA}$ ,  $I_L = 99.28 \text{ mA}$   
 (f) 2.22 V
21. (a) 3558.81 Hz (b) 138.2 V  
 (c) 691 mW (d) 575.86 Hz
23. (a) 98.54  $\Omega$  (b) 8.21  
 (c) 8.05 kHz (d) 4.83 V  
 (e)  $f_1 = 7.55 \text{ kHz}$ ,  $f_2 = 8.55 \text{ kHz}$
25.  $R_s = 3.24 \text{ k}\Omega$ ,  $C = 31.66 \text{ nF}$
27. (a) 251.65 kHz, (b) 4.44 k $\Omega$   
 (c) 14.05, (d) 17.91 kHz  
 (e) **a:** 251.65 kHz, **b:** 49.94  $\Omega$ ,  
**c:** 2.04, **d:** 95.55 kHz  
 (f) **a:** 251.65 kHz, **b:** 13.33 k $\Omega$ ,  
**c:** 21.08, **d:** 11.94 kHz  
 (g) Network:  $100 \times 10^3$ , **part (e):**  
 $1 \times 10^3$ , **part (f):**  $400 \times 10^3$   
 (h) As  $L/C$  increased,  $BW$   
 decreased

### Chapter 21

1. (a) 1.54 kHz, 5.62 kHz  
 (b) 0.22 V, 0.52 V
3. (a) 1000 (b)  $10^{12}$  (c) 1.59  
 (d) 1.1 (e)  $10^{10}$  (f) 1513.56  
 (g) 10.02 (h) 1,258,925.41
5. 1.68  
 7. -0.30
9. (a) 1.85 bels (b) 18.45 bels
11. 13.01 dB
13. 38.49 dB<sub>v</sub>
15. 24.08 dB<sub>v</sub>
19. (a)  $f_c: 0.707$ ,  $0.1f_c: 0.995$ ,  $0.5f_c:$   
 $0.894$ ,  $2f_c: 0.447$ ,  $10f_c: 0.0995$   
 (b)  $f_c: -45^\circ$ ,  $0.1f_c: -5.71^\circ$ ,  
 $0.5f_c: -26.57^\circ$ ,  $2f_c: -63.43^\circ$ ,  
 $10f_c: -84.29^\circ$
21.  $C = 0.265 \mu\text{F}$
23. (a)  $f_c: 0.707$ ,  $2f_c: 0.894$ ,  $0.5f_c:$   
 $0.447$ ,  $10f_c: 0.995$ ,  $0.1f_c: 0.0995$   
 (b)  $f_c: 45^\circ$ ,  $2f_c: 26.57^\circ$ ,  $0.5f_c:$   
 $63.43^\circ$ ,  $10f_c: 5.71^\circ$ ,  $0.1f_c: 84.29^\circ$
25.  $R = 797 \Omega$
27. (a) low-pass:  $f_{c1} = 795.77 \text{ Hz}$ ,  
 high-pass:  $f_{c2} = 1989.44 \text{ Hz}$   
 (b)  $f_c = 1940 \text{ Hz}$ ,  $BW \cong 2.9 \text{ kHz}$
29. (a) 100.66 kHz (b)  $Q_s = 18.39$ ,  
 $BW = 5.473.52 \text{ Hz}$  (d)  $f_s: 0.93 \text{ V}$ ,  
 $f_1: 0.66 \text{ V}$ ,  $f_2: 0.66 \text{ V}$
31. (a) 12.2 (b)  $BW = 409.84 \text{ Hz}$ ,  
 $f_1 = 4.80 \text{ kHz}$ ,  $f_2 = 5.20 \text{ kHz}$   
 (d) little change
33. (a)  $f_p = 726.44 \text{ kHz}$  (band-stop),  
 $f = 2.01 \text{ MHz}$  (pass-band)
35. (a-b)  $f_c = 772.55 \text{ Hz}$   
 (c)  $f_c: -3 \text{ dB}$ ,  $0.5f_c: -7 \text{ dB}$ ,  
 $2f_c: -0.969 \text{ dB}$ ,  $0.1f_c: -20.04 \text{ dB}$ ,  
 $10f_c: -0.043 \text{ dB}$  (d)  $f_c: 0.707$ ,  
 $0.5f_c: 0.447$ ,  $2f_c: 0.894$  (e)  $f_c: 45^\circ$ ,  
 $0.5f_c: 63.43^\circ$ ,  $2f_c: 26.57^\circ$

37. (a-b)  $f_c = 13.26 \text{ kHz}$   
 (c)  $f_c: -3 \text{ dB}$ ,  $0.5f_c: -0.97 \text{ dB}$ ,  
 $2f_c: -6.99 \text{ dB}$ ,  $0.1f_c: -0.04 \text{ dB}$ ,  
 $10f_c: -20.04 \text{ dB}$  (d)  $f_c: 0.707$ ,  
 $0.5f_c: 0.894$ ,  $2f_c: 0.447$   
 (e)  $f_c: -45^\circ$ ,  $0.5f_c: -26.57^\circ$ ,  
 $2f_c: -63.43^\circ$
39. (a)  $f_1 = 663.15 \text{ Hz}$ ,  $f_c = 468.1 \text{ Hz}$   
 (b)  $f_1: 45^\circ$ ,  $f_c: 54.78^\circ$ ,  $2f_1: 26.57^\circ$ ,  
 $10f_1: 5.71^\circ$
41. (a)  $f_1 = 19,894.37 \text{ Hz}$ ,  
 $f_c = 1,989.44 \text{ Hz}$   
 (b)  $f_1: -39.29^\circ$ ,  $f_c: -39.29^\circ$ ,  
 $10 \text{ kHz}: -52.06^\circ$
43. (a)  $f_1 = 964.58 \text{ Hz}$ ,  
 $f_c = 7,334.33 \text{ Hz}$  (b)  $f_1: 37.51^\circ$ ,  
 $f_c: 37.51^\circ$ ,  $1.3 \text{ kHz}: 43.38^\circ$
45. (a)  $f = 180 \text{ Hz}: A_{v_{dB}} \cong -3 \text{ dB}$ ,  
 $f = 18 \text{ kHz}: A_{v_{dB}} = -3.105 \text{ dB}$   
 (b)  $f = 180 \text{ Hz}: \cong 90^\circ$ ,  
 $f = 1.8 \text{ kHz}: \cong 0^\circ$ ,  
 $f = 18 \text{ kHz}: \cong -90^\circ$
47.  $A_v = \frac{-120}{[1 - j\frac{50}{f}][1 - j\frac{200}{f}][1 + j\frac{f}{36\text{kHz}}]}$
49.  $f_c = 2 \text{ kHz}$
51.  $f_1 = 1 \text{ kHz}: A_{v_{dB}} = 3.06 \text{ dB}$ ,  
 $f_2 = 2 \text{ kHz}: A_{v_{dB}} = 6.81 \text{ dB}$ ,  
 $f_3 = 3 \text{ kHz}: A_{v_{dB}} = 9.1 \text{ dB}$
53. (a) Woofer: 400 Hz:  $A_v = 0.673$   
 Tweeter: 5 kHz:  $A_v = 0.678$   
 (b) Woofer: 3 kHz:  $A_v = 0.015$   
 Tweeter: 3 kHz:  $A_v = 0.337$   
 (c) mid-range: 3 kHz:  $A_v = 0.998$

### Chapter 22

1. (a) 0.2 H (b)  $e_p = 1.6 \text{ V}$ ,  
 $e_s = 5.12 \text{ V}$  (c)  $e_p = 15 \text{ V}$ ,  
 $e_s = 24 \text{ V}$
3. (a) 158.02 mH (b)  $e_p = 24 \text{ V}$ ,  
 $e_s = 1.8 \text{ V}$  (c)  $e_p = 15 \text{ V}$ ,  
 $e_s = 24 \text{ V}$
5. (a) 3.13 V (b) 391.02  $\mu\text{Wb}$
7. 56.31 Hz
9. 400  $\Omega$
11. 12,000 turns
13. (a) 3 (b) 2.78 W
15. (a) 360.56  $\Omega \angle 86.82^\circ$   
 (b) 332.82 mA  $\angle -86.82^\circ$   
 (c)  $V_{R_e} = 6.66 \text{ V} \angle -36.82^\circ$ ,  
 $V_{X_c} = 13.31 \text{ V} \angle 3.18^\circ$ ,  
 $V_{X_L} = 106.50 \text{ V} \angle 3.18^\circ$
19. 1.35 H
21.  $\mathbf{I}_1(\mathbf{Z}_{R_1} + \mathbf{Z}_{L_1}) + \mathbf{I}_2(\mathbf{Z}_m) = \mathbf{E}_1$   
 $\mathbf{I}_1(\mathbf{Z}_m) + \mathbf{I}_2(\mathbf{Z}_{L_2} + \mathbf{Z}_{R_2}) = 0$   
 $\mathbf{X}_m = -\omega M \angle 90^\circ$

23. (a) 20 (b) 83.33 A (c) 4.17 A  
 (d) **a:** 0.05, **b:** 4.17 A, **c:** 83.33 A
25. (a)  $V_L = 25 \text{ V} \angle 0^\circ$ ,  $\mathbf{I}_s = 5 \text{ A} \angle 0^\circ$   
 (b) 80  $\Omega \angle 0^\circ$  (c) 20  $\Omega \angle 0^\circ$
27. (a)  $\mathbf{E}_2 = 40 \text{ V} \angle 60^\circ$ ,  $\mathbf{I}_2 =$   
 $3.33 \text{ A} \angle 60^\circ$ ,  $\mathbf{E}_3 = 30 \text{ V} \angle 60^\circ$ ,  
 $\mathbf{I}_3 = 3 \text{ A} \angle 60^\circ$  (b) 64.52  $\Omega$

### Chapter 23

1. (a) 120.1 V (b) 120.1 V  
 (c) 12.01 A (d) 12.01 A
3. (a) 120.1 V (b) 120.1 V  
 (c) 16.98 A (d) 16.98 A
5. (a)  $\theta_2 = -120^\circ$ ,  $\theta_3 = +120^\circ$   
 (b)  $\mathbf{V}_{an} = 120 \text{ V} \angle 0^\circ$ ,  $\mathbf{V}_{bn} =$   
 $120 \text{ V} \angle -120^\circ$ ,  $\mathbf{V}_{cn} =$   
 $120 \text{ V} \angle 120^\circ$   
 (c)  $\mathbf{I}_{an} = 8 \text{ A} \angle -53.13^\circ$ ,  
 $\mathbf{I}_{bn} = 8 \text{ A} \angle -173.13^\circ$ ,  
 $\mathbf{I}_{cn} = 8 \text{ A} \angle 66.87^\circ$  (e) 8 A  
 (f) 207.85 V
7.  $V_\phi = 127.0 \text{ V}$ ,  $\mathbf{I}_\phi = 8.98 \text{ A}$ ,  
 $\mathbf{I}_L = 8.98 \text{ A}$
9. (a)  $\mathbf{E}_{AN} = 12.7 \text{ kV} \angle -30^\circ$ ,  
 $\mathbf{E}_{BN} = 12.7 \text{ kV} \angle -150^\circ$ ,  
 $\mathbf{E}_{CN} = 12.7 \text{ kV} \angle 90^\circ$   
 (b-c)  $\mathbf{I}_{an} = \mathbf{I}_{Aa} =$   
 $11.29 \text{ A} \angle -97.54^\circ$ ,  $\mathbf{I}_{bn} = \mathbf{I}_{Bb} =$   
 $11.29 \text{ A} \angle -217.54^\circ$ ,  $\mathbf{I}_{cn} = \mathbf{I}_{Cc} =$   
 $11.29 \text{ A} \angle 22.46^\circ$  (d)  $\mathbf{V}_{an} =$   
 $12.16 \text{ kV} \angle -29.34^\circ$ ,  $\mathbf{V}_{bn} =$   
 $12.16 \text{ kV} \angle -149.34^\circ$ ,  $\mathbf{V}_{cn} =$   
 $12.16 \text{ kV} \angle 90.66^\circ$
11. (a) 120.1 V (b) 208 V  
 (c) 13.36 A (d) 23.15 A
13. (a)  $\theta_2 = -120^\circ$ ,  $\theta_3 = +120^\circ$   
 (b)  $\mathbf{V}_{ab} = 208 \text{ V} \angle 0^\circ$ ,  
 $\mathbf{V}_{bc} = 208 \text{ V} \angle -120^\circ$ ,  
 $\mathbf{V}_{ca} = 208 \text{ V} \angle 120^\circ$   
 (d)  $\mathbf{I}_{ab} = 9.46 \text{ A} \angle 0^\circ$ ,  
 $\mathbf{I}_{bc} = 9.46 \text{ A} \angle -120^\circ$ ,  
 $\mathbf{I}_{ca} = 9.46 \text{ A} \angle 120^\circ$   
 (e) 16.38 A (f) 120.1 V
15. (a)  $\theta_2 = -120^\circ$ ,  $\theta_3 = +120^\circ$   
 (b)  $\mathbf{V}_{ab} = 208 \text{ V} \angle 0^\circ$ ,  $\mathbf{V}_{bc} =$   
 $208 \text{ V} \angle -120^\circ$ ,  
 $\mathbf{V}_{ca} = 208 \text{ V} \angle 120^\circ$   
 (d)  $\mathbf{I}_{ab} = 86.67 \text{ A} \angle -36.87^\circ$ ,  
 $\mathbf{I}_{bc} = 16.67 \text{ A} \angle -156.87^\circ$   
 $\mathbf{I}_{ca} = 86.67 \text{ A} \angle 83.13^\circ$   
 (e) 150.11 A (f) 120.1 V
17. (a)  $\mathbf{I}_{ab} = 15.33 \text{ A} \angle -73.30^\circ$ ,  
 $\mathbf{I}_{bc} = 15.33 \text{ A} \angle -193.30^\circ$ ,  
 $\mathbf{I}_{ca} = 15.33 \text{ A} \angle 46.7^\circ$   
 (b)  $\mathbf{I}_{Aa} = 26.55 \text{ A} \angle -103.30^\circ$ ,  
 $\mathbf{I}_{Bb} = 26.55 \text{ A} \angle 136.70^\circ$ ,  
 $\mathbf{I}_{Cc} = 26.55 \text{ A} \angle 16.70^\circ$   
 (c)  $\mathbf{E}_{AB} = 17.01 \text{ kV} \angle -0.59^\circ$ ,  
 $\mathbf{E}_{BC} = 17.01 \text{ kV} \angle -120.59^\circ$ ,  
 $\mathbf{E}_{CA} = 17.01 \text{ kV} \angle 119.41^\circ$

19. (a) 208 V (b) 120.09 V  
(c) 7.08 A (d) 7.08 A
21.  $V_\phi = 69.28$  V,  $I_\phi = 2.89$  A,  
 $I_L = 2.89$  A
23.  $V_\phi = 69.28$  V,  $I_\phi = 5.77$  A,  
 $I_L = 5.77$  A
25. (a) 440 V (b) 440 V  
(c) 29.33 A (d) 50.8 A
27. (a)  $\theta_2 = -120^\circ$ ,  $\theta_3 = +120^\circ$   
(b)  $V_{ab} = 100$  V  $\angle 0^\circ$ ,  $V_{bc} = 100$  V  $\angle -120^\circ$ ,  $V_{ca} = 100$  V  $\angle 120^\circ$   
(d)  $I_{ab} = 5$  A  $\angle 0^\circ$ ,  $I_{bc} = 5$  A  $\angle -120^\circ$ ,  $I_{ca} = 5$  A  $\angle 120^\circ$   
(e) 8.66 A
29. (a)  $\theta_2 = -120^\circ$ ,  $\theta_3 = +120^\circ$   
(b)  $V_{ab} = 100$  V  $\angle 0^\circ$ ,  $V_{bc} = 100$  V  $\angle -120^\circ$ ,  $V_{ca} = 100$  V  $\angle 120^\circ$   
(d)  $I_{ab} = 7.07$  A  $\angle 45^\circ$ ,  
 $I_{bc} = 7.07$  A  $\angle -75^\circ$ ,  $I_{ca} = 7.07$  A  $\angle 165^\circ$  (e) 12.25 A
31.  $P_T = 2160$  W,  $Q_T = 0$  VAR,  
 $S_T = 2160$  VA,  $F_p = 1$
33.  $P_T = 7210.67$  W,  
 $Q_T = 7210.67$  VAR (C),  
 $S_T = 10,197.42$  VA,  $F_p = 0.707$  (leading)
35.  $P_T = 7.26$  kW,  $Q_T = 7.26$  kVAR  
(L),  $S_T = 10.27$  kVA,  $F_p = 0.707$  (lagging)
37.  $P_T = 287.93$  W,  $Q_T = 575.86$  VAR (L),  $S_T = 643.83$  VA,  
 $F_p = 0.447$  (lagging)
39.  $P_T = 900$  W,  $Q_T = 1200$  VAR (L),  
 $S_T = 1500$  VA,  $F_p = 0.6$  (lagging)
41.  $12.98 \Omega -j 7.31 \Omega$
43. (a) 9,237.6 V (b) 80 A  
(c) 1276.8 kW (d) 0.576 lagging

- (e)  $I_{Aa} = 80$  A  $\angle -54.83^\circ$   
(f)  $V_{an} = 7773.45$  V  $\angle -4.87^\circ$   
(g)  $62.52 \Omega + j 74.38 \Omega$   
(h) System: 0.576 lagging; Load: 0.643 lagging (i) 93.98%
45. (b)  $P_T = 5899.64$  W,  
 $P_{\text{meter}} = 1966.55$  W
49. (a) 120.09 V (b)  $I_{an} = 8.49$  A,  
 $I_{bn} = 7.08$  A,  $I_{cn} = 42.47$  A  
(c)  $P_T = 4.93$  kW,  $Q_T = 4.93$  kVAR (L),  $S_T = 6.97$  kVA,  
 $F_p = 0.707$  (lagging)  
(d)  $I_{an} = 8.49$  A  $\angle -75^\circ$ ,  
 $I_{bn} = 7.08$  A  $\angle -195^\circ$ ,  
 $I_{cn} = 42.47$  A  $\angle 45^\circ$   
(e) 35.09 A  $\angle -43.00^\circ$

## Chapter 24

1. (a) positive-going (b) 2 V  
(c) 0.2 ms (d) 6 V (e) 6.5%
3. (a) positive-going (b) 10 mV  
(c) 3.2 ms (d) 20 mV  
(e) 6.9%
5.  $V_2 = 13.58$  mV
7. (a)  $120 \mu\text{s}$  (b) 8.33 kHz  
(c) maximum: 440 mV  
minimum: 80 mV
9. prf = 125 kHz  
Duty cycle = 62.5%
11. (a)  $8 \mu\text{s}$  (b)  $2 \mu\text{s}$  (c) 125 kHz  
(d) 0 V (e) 3.46 mV
13. 18.88 mV
15. 117 mV
17.  $v_C = 4$  V  $(1 - e^{-t/20\text{ms}})$
19.  $i_C = -8$  mA  $e^{-t}$
21.  $i_C = 4$  mA  $e^{-t/0.2\text{ms}}$

23.  $0 \rightarrow \frac{1}{2}T: v_C = 20$  V,  
 $\frac{1}{2}T \rightarrow T: v_C = 20$  V  $e^{-t/0.2\text{ms}}$ ,  
 $T \rightarrow \frac{3}{2}T: v_C = 20$  V  $(1 - e^{-t/0.2\text{ms}})$   
 $\frac{3}{2}T \rightarrow 2T: v_C = 20$  V  $e^{-t/0.2\text{ms}}$ ,
25.  $V_{\text{scope}} = 10$  V  $\angle 0^\circ$ ,  
 $\theta_{z_S} = \theta_{z_P} = -59.5^\circ$

## Chapter 25

1. (I): (a) no (b) no (c) yes  
(d) no (e) yes  
(II): (a) yes (b) yes (c) yes  
(d) yes (e) no  
(III): (a) yes (b) yes (c) no  
(d) yes (e) yes  
(IV): (a) no (b) no (c) yes  
(d) yes (e) yes
7. (a) 19.04 V (b) 4.53 A
9. 71.87 W
11. (a)  $2 + 2.08 \sin(400t - 33.69^\circ) + 0.5 \sin(800t - 53.13^\circ)$   
(b) 2.51 A (c) 24 +  
 $24.96 \sin(400t - 33.69^\circ) + 6 \sin(800t - 53.13^\circ)$  (d) 30.09 V  
(e)  $16.64 \sin(400t + 56.31^\circ) + 8 \sin(800t + 36.87^\circ)$  (f) 13.06 V  
(g) 75.48 W
13. (a)  $1.2 \sin(400t + 53.13^\circ)$   
(b) 0.85 A (c)  $18 \sin(400t + 53.13^\circ)$  (d) 12.73 V  
(e)  $18 + 23.98 \sin(400t - 36.87^\circ)$   
(f) 24.73 V (g) 10.79 W
15.  $2.26 \times 10^{-3} \sin(377t + 93.66^\circ) + 1.92 \times 10^{-3} \sin(754t + 1.64^\circ)$
17.  $30 + 30.27 \sin(20t + 7.59^\circ) + 0.5 \sin(40t - 30^\circ)$