

# Appendix E

## Answers to Odd-Numbered Problems

### Chapter 1

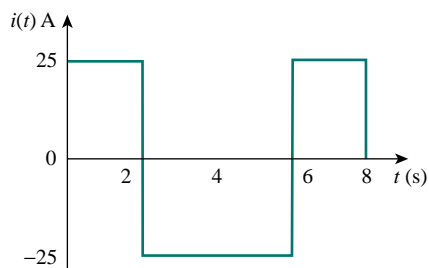
**1.1** (a)  $-0.1038\text{ C}$ , (b)  $-0.19865\text{ C}$ , (c)  $-3.941\text{ C}$ , (d)  $-26.08\text{ C}$

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

**1.5**  $490\text{ }\mu\text{C}$

$$\mathbf{1.7} \quad i = \begin{cases} 25\text{ A}, & 0 < t < 2 \\ -25\text{ A}, & 2 < t < 6 \\ 25\text{ A}, & 6 < t < 8 \end{cases}$$

See the sketch in Fig. E.1.



**Figure E.1** For Prob. 1.7.

**1.9** (a)  $10\text{ C}$ , (b)  $22.5\text{ C}$ , (c)  $30\text{ C}$

**1.11** (a)  $2.131\text{ C}$ , (b)  $-8.188\text{ W}$

**1.13**  $916.7\text{ mJ}$

**1.15**  $P_1 = -300\text{ W}$ ,  $P_2 = 100\text{ W}$ ,  $P_3 = 200\text{ W}$ ,  $P_4 = -32\text{ W}$ ,  $P_5 = -48\text{ W}$

**1.17**  $18\text{ V}$

**1.19** (a)  $60\text{ W}$ ,  $100\text{ W}$ , (b)  $4\text{ W}$ , (c)  $110\text{ W}$ , (d)  $700\text{ W}$ , (h)  $350\text{ W}$

**1.21**  $21.6\text{ cents}$

**1.23** (a)  $43\text{ kC}$ , (b)  $475.2\text{ kJ}$ , (c)  $1.188\text{ cents}$

**1.25**  $39.6\text{ cents}$

**1.27**  $750\text{ ks}$

**1.29** (a)  $10.4\text{ kWh}$ , (b)  $433.3\text{ W/h}$

**1.31** (a)  $4\text{ A}$ , (b)  $1.852\text{ days}$

**1.33**  $13.43 \times 10^6\text{ J}$

### Chapter 2

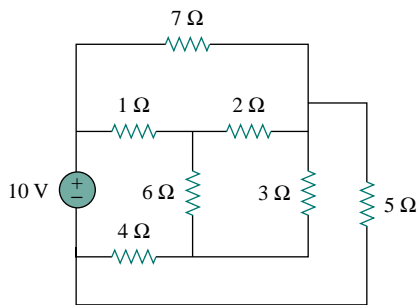
**2.1**  $3.2\text{ mA}$

**2.3**  $20.8\text{ }\mu\text{S}$

- 2.5**      $n = 9, b = 15, l = 7$   
**2.7**     7 branches and 5 nodes  
**2.9**     11 A, 4 A, 1 A  
**2.11**     $-4 \text{ V}, -6 \text{ V}, 4 \text{ V}, -2 \text{ V}$   
**2.13**    14 V, 22 V  
**2.15**    4 A, 28 V  
**2.17**    4 A  
**2.19**     $-4.444 \text{ V}, 98.75 \text{ W}$   
**2.21**    0.1 A, 2 kV, 0.2 kW  
**2.23**    6 V, 18 V  
**2.25**    12 V, 3 A, 0 A, 0 V  
**2.27**    10 V, 1 A, 4 W  
**2.29**    3 V, 6 A  
**2.31**    8 V, 0.2 A  
**2.33**    12  $\Omega$   
**2.35**    (a) 0 A, (b) R, (c) R, (d) R, (e)  $\frac{6}{11} R$   
**2.37**    16  $\Omega$   
**2.39**    (a) 12  $\Omega$ , (b) 16  $\Omega$   
**2.41**    (a) 76  $\Omega$ , (b) 54  $\Omega$   
**2.43**    (a)  $R_a = R_b = R_c = 30 \Omega$ , (b)  $R_a = 103.3 \Omega$ ,  $R_b = 155 \Omega$ ,  $R_c = 62 \Omega$   
**2.45**    889  $\Omega$   
**2.47**    (a) 125  $\Omega$ , (b) 275  $\Omega$   
**2.49**    0.9974 A  
**2.51**    12.21  $\Omega$ , 1.64 A  
**2.53**    1.2 A  
**2.55**    Use  $R_1$  and  $R_2$  bulbs  
**2.57**    11  $\Omega$ , 99  $\Omega$   
**2.59**    (a) 800 k $\Omega$ , (b) 2 mW  
**2.61**    (a) 100 mA, (b) 975.6 mA, (c) 2.44 %  
**2.63**    45  $\Omega$   
**2.65**    (a) 19.9 k $\Omega$ , (b) 20 k $\Omega$   
**2.67**    (a) Four 20- $\Omega$  resistors in parallel.  
           (b) One 300- $\Omega$  resistor in series with a 1.8- $\Omega$  resistor and a parallel combination of two 20- $\Omega$  resistor.  
           (c) Two 24-k $\Omega$  resistors in parallel connected in series with two 56-k $\Omega$  resistors in parallel.  
           (d) A series combination of a 20- $\Omega$  resistor, 300- $\Omega$  resistor, 24-k $\Omega$  resistor and a parallel combination of two 56-k $\Omega$  resistors.  
**2.69**    75  $\Omega$   
**2.71**    38 k $\Omega$ , 3.33 k $\Omega$   
**2.73**    375  $\Omega$ , 257.1  $\Omega$

**Chapter 3**

- 3.1**     $9.143 \text{ V}$ ,  $-10.286 \text{ V}$ ,  $p_{8\Omega} = 10.45 \text{ W}$ ,  $p_{4\Omega} = 94.37 \text{ W}$ ,  $p_{2\Omega} = 52.9 \text{ W}$   
**3.3**     $4 \text{ A}$ ,  $2 \text{ A}$ ,  $1.333 \text{ A}$ ,  $0.667 \text{ A}$ ,  $40 \text{ V}$   
**3.5**     $20 \text{ V}$   
**3.7**     $2.778 \text{ V}$   
**3.9**     $-4 \text{ A}$   
**3.11**     $1.072 \text{ A}$ ,  $2.041 \text{ A}$   
**3.13**     $20 \text{ V}$   
**3.15**     $18.86 \text{ V}$ ,  $6.286 \text{ V}$ ,  $13 \text{ V}$   
**3.17**     $10 \text{ V}$ ,  $20 \text{ V}$ ,  $20 \text{ V}$   
**3.19**     $-10.91 \text{ V}$ ,  $-100.36 \text{ V}$   
**3.21**     $20 \text{ V}$ ,  $0 \text{ A}$   
**3.23**     $-1.344 \text{ kV}$ ,  $-5.6 \text{ A}$   
**3.25**     $2 \text{ V}$ ,  $12 \text{ V}$ ,  $-8 \text{ V}$   
**3.27**    (a) planar, redrawn as shown in Fig. E.2, (b) nonplanar



**Figure E.2**    For Prob. 3.27(a).

- 3.29**     $8.727 \text{ V}$   
**3.31**     $3.652 \text{ V}$   
**3.33**     $1.188 \text{ A}$   
**3.35**     $-1.733 \text{ A}$   
**3.37**     $33.78 \text{ V}$ ,  $10.67 \text{ A}$   
**3.39**     $20 \text{ V}$   
**3.41**     $1.072 \text{ A}$ ,  $2.041 \text{ A}$   
**3.43**     $6 \text{ V}$ ,  $6 \text{ V}$   
**3.45**     $-1.344 \text{ kV}$ ,  $-5.6 \text{ A}$   
**3.47**     $-0.3$   
**3.49**     $-4 \text{ V}$ ,  $2.105 \text{ A}$   
**3.51**    
$$\begin{bmatrix} 1.25 & -1 \\ -1 & 1.5 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 3 \\ -1 \end{bmatrix}$$
  
 $V_1 = 4 \text{ V}$ ,  $V_2 = 2 \text{ V}$

$$3.53 \quad \begin{bmatrix} 1.75 & -0.25 & -1 \\ -0.25 & 1 & -0.25 \\ -1 & -0.25 & 1.25 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$$

$$3.55 \quad \begin{bmatrix} 6 & -2 & -0 \\ -2 & 12 & -2 \\ 0 & -2 & 7 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ -8 \\ -20 \end{bmatrix}, 6.52 \text{ W}$$

$$3.57 \quad \begin{bmatrix} 9 & -3 & -4 & 0 \\ -3 & 8 & 0 & 0 \\ -4 & 0 & 6 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 6 \\ 4 \\ 2 \\ -3 \end{bmatrix}$$

$$3.59 \quad -1 \text{ A}, 0 \text{ A}, 2 \text{ A}$$

$$3.61 \quad -3 \text{ A}, 0 \text{ A}, 3 \text{ A}$$

$$3.63 \quad 26.667 \text{ V}, 6.667 \text{ V}, 173.3 \text{ V}, -46.67 \text{ V}$$

$$3.65 \quad \text{See Fig. E.3; } -12.5 \text{ V}$$

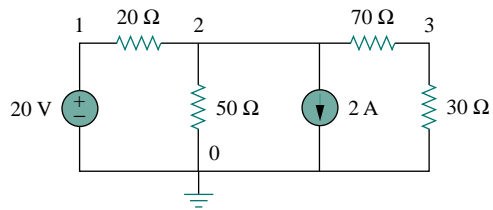


Figure E.3 For Prob. 3.65.

$$3.67 \quad -0.187 \text{ V}$$

$$3.69 \quad -80$$

$$3.71 \quad 5.23 \text{ V}$$

$$3.73 \quad 12.296 \mu\text{A}, 5.791 \text{ V}$$

## Chapter 4

$$4.1 \quad 0.1, 1 \text{ A}$$

$$4.3 \quad (\text{a}) 0.5 \text{ V}, 0.5 \text{ A}, (\text{b}) 5 \text{ V}, 5 \text{ A}, (\text{c}) 5 \text{ V}, 0.5 \text{ A}$$

$$4.5 \quad 4.5 \text{ V}$$

$$4.7 \quad -1.32 \text{ A}, 17.43 \text{ W}$$

$$4.9 \quad 3 \text{ A}$$

$$4.11 \quad 8 \text{ V}$$

$$4.13 \quad 0.1111 \text{ A}$$

$$4.15 \quad -0.1176 \text{ A}$$

$$4.17 \quad 3 \text{ A}$$

$$4.19 \quad 0.555 \text{ A}$$

$$4.21 \quad -8.57 \text{ V}$$

$$4.23 \quad 0.1111 \text{ A}$$

$$4.25 \quad 3.652 \text{ V}$$

- 4.27** (a)  $8\ \Omega$ ,  $16\ \text{V}$ , (b)  $20\ \Omega$ ,  $50\ \text{V}$   
**4.29**  $-0.125\ \text{V}$   
**4.31**  $2.5\ \Omega$ ,  $6\ \text{V}$   
**4.33**  $10\ \Omega$ ,  $10\ \text{V}$   
**4.35** (a)  $3.857\ \Omega$ ,  $4\ \text{V}$ , (b)  $3.214\ \Omega$ ,  $15\ \text{V}$   
**4.37** (a)  $8\ \Omega$ ,  $2\ \text{A}$ , (b)  $20\ \Omega$ ,  $2.5\ \text{A}$   
**4.39**  $28\ \Omega$ ,  $3.286\ \text{A}$   
**4.41** (a)  $2\ \Omega$ ,  $7\ \text{A}$ , (b)  $1.5\ \Omega$ ,  $12.67\ \text{A}$   
**4.43**  $3\ \Omega$ ,  $1\ \text{A}$   
**4.45**  $1.875\ \text{A}$   
**4.47**  $-\frac{R_2[R_1(1 + \beta)R_2]}{\beta(R_1 + R_2)}$   
**4.49**  $R_{\text{Th}} = R_{\text{N}} = 3.333\ \Omega$ ,  $V_{\text{Th}} = 10\ \text{V}$ ,  $I_{\text{N}} = 3\ \text{A}$   
**4.51**  $31.73\ \Omega$ ,  $0\ \text{V}$   
**4.53**  $-1\ \Omega$ ,  $0\ \text{V}$   
**4.55**  $7.2\ \Omega$ ,  $1.25\ \text{W}$   
**4.57**  $-1.187\ \text{kW}$   
**4.59** (a)  $12\ \Omega$ ,  $40\ \text{V}$ , (b)  $2\ \text{A}$ , (c)  $12\ \Omega$ , (d)  $33.33\ \text{W}$   
**4.61**  $1\ \text{k}\Omega$   
**4.63** (a)  $3.8\ \Omega$ ,  $4\ \text{V}$ , (b)  $3.2\ \Omega$ ,  $15\ \text{V}$   
**4.65**  $10\ \Omega$ ,  $167\ \text{V}$   
**4.67**  $3.333\ \Omega$ ,  $10\ \text{V}$   
**4.69**  $8\ \Omega$ ,  $12\ \text{V}$   
**4.71** (a)  $10\ \text{mA}$ ,  $8\ \text{k}\Omega$ , (b)  $9.926\ \text{A}$   
**4.73** (a)  $100\ \Omega$ ,  $20\ \Omega$ , (b)  $100\ \Omega$ ,  $200\ \Omega$   
**4.75**  $\frac{V_s}{R_s + (1 + \beta)R_o}$   
**4.77**  $5.333\ \text{V}$ ,  $66.67\ \text{k}\Omega$   
**4.79**  $2.4\ \text{k}\Omega$ ,  $4.8\ \text{V}$

## Chapter 5

- 5.1** (a)  $1.5\ \text{M}\Omega$ , (b)  $60\ \Omega$ , (c)  $98.06\ \text{dB}$   
**5.3**  $10\ \text{V}$   
**5.5**  $0.9999990$   
**5.7**  $-100\ \text{nV}$ ,  $-10\ \text{mV}$   
**5.9** (a)  $2\ \text{V}$ , (b)  $2\ \text{V}$   
**5.11**  $-2\ \text{V}$ ,  $-1\ \text{mA}$   
**5.13**  $2.7\ \text{V}$ ,  $288\ \mu\text{A}$   
**5.15** (a) Proof, (b)  $-35$

- 5.17  $-11.764$
- 5.19  $-1.6364$
- 5.21 If  $R_1 = 10 \text{ k}\Omega$ , then  $R_f = 150 \text{ k}\Omega$
- 5.23 (a) 10.2, (b)  $1.471 \cos 120\pi t$
- 5.25  $100 \text{ }\mu\text{A}$ ,  $2 \text{ }\mu\text{W}$
- 5.27  $600 \text{ nA}$ ,  $12 \text{ mV}$ ,  $2.4 \text{ nW}$
- 5.29 If  $R_1 = 10 \text{ k}\Omega$ , then  $R_f = 90 \text{ k}\Omega$
- 5.31  $-120 \text{ mV}$
- 5.33  $3 \text{ k}\Omega$
- 5.35 See Fig. E.4, where  $R \leq 100 \text{ k}\Omega$ .

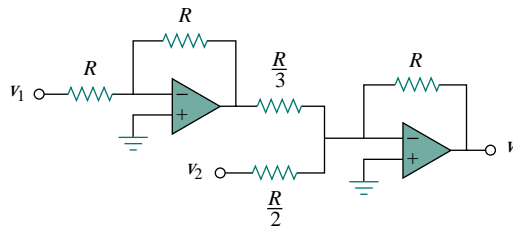


Figure E.4 For Prob. 5.35.

- 5.37  $-2 \text{ V}$ ,  $-2.4 \text{ mA}$
- 5.39  $R_1 = R_3 = 10 \text{ k}\Omega$ ,  $R_2 = R_4 = 20 \text{ k}\Omega$
- 5.41 See Fig. E.5.

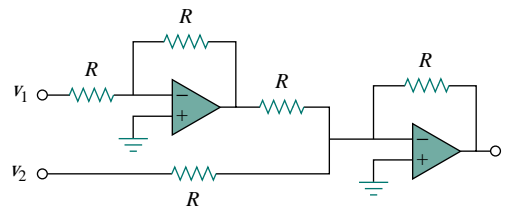


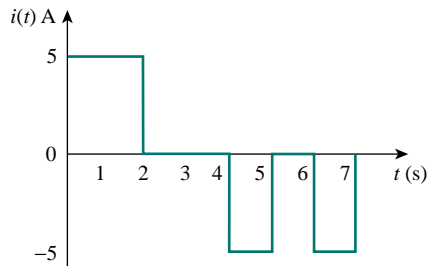
Figure E.5 For Prob. 5.41.

- 5.43 (a) 300, (b) 3.333
- 5.45 (a)  $36 \text{ }\mu\text{A}$ , (b)  $30 \cos 377t \text{ }\mu\text{A}$
- 5.47  $-1.333$
- 5.49  $\frac{R_2 R_4}{R_1 R_5} v_1 - \frac{R_4}{R_5} v_2$
- 5.51  $\frac{R_2 R_4 / R_1 R_3 - R_4 / R_6}{1 - R_2 R_4 / R_3 R_5}$
- 5.53  $2.4 \text{ V}$
- 5.55  $-17.14 \text{ mV}$
- 5.57  $-1 \text{ V}$

- 5.59**  $100 \mu\text{A}$   
**5.61**  $-374.8 \mu\text{A}$   
**5.63**  $0.6677 \text{ V}$   
**5.65**  $12 \text{ V}$   
**5.67**  $0.25 \text{ V}$   
**5.69** (a) Proof, (b)  $0.825 \text{ V}$ , (c)  $0.375 \text{ V}$   
**5.71** (a)  $-3.2 \text{ V}$ , (b)  $1.8 \text{ V}$   
**5.73**  $14.67$   
**5.75**  $5$   
**5.77**  $5.5$

## Chapter 6

- 6.1**  $10(1 - 3t)e^{-3t} \text{ A}$ ,  $20t(1 - 3t)e^{-6t} \text{ W}$   
**6.3**  $0.48 \text{ A}$   
**6.5**  $v = \begin{cases} 100t^2 \text{ kV}, & 0 < t < 1 \\ 100(4t - t^2 - 2) \text{ kV}, & 1 < t < 2 \end{cases}$   
**6.7**  $0.04t^2 + 10 \text{ V}$   
**6.9** See Fig. E.6.



**Figure E.6** For Prob. 6.9.

- 6.11**  $-0.72\pi \sin 4\pi t \text{ A}$ ,  $-5.4 \text{ J}$   
**6.13** (a)  $120 \text{ mF}$ , (b)  $7.5 \text{ mF}$   
**6.15** (a)  $3 \text{ F}$ , (b)  $8 \text{ F}$ , (c)  $1 \text{ F}$   
**6.17**  $4 \text{ mF}$   
**6.19**  $50 \mu\text{F}$   
**6.21** (a)  $V_{30} = 90 \text{ V}$ ,  $V_{60} = 30 \text{ V}$ ,  $V_{14} = 60 \text{ V}$ ,  $V_{20} = 48 \text{ V}$ ,  $V_{80} = 12 \text{ V}$ ,  
 (b)  $W_{30} = 121.5 \text{ mJ}$ ,  $W_{60} = 27 \text{ mJ}$ ,  $W_{14} = 25.2 \text{ mJ}$ ,  $W_{20} = 23.04 \text{ mJ}$ ,  
 $W_{80} = 5.76 \text{ mJ}$   
**6.23** (a)  $35 \mu\text{F}$ , (b)  $0.75 \text{ mF}$ ,  $1.5 \text{ mC}$ ,  $3 \text{ mC}$ , (c)  $393.4 \text{ J}$   
**6.25**  $22.39 \mu\text{F}$   
**6.27**  $v_o(t) = \begin{cases} 10t^2 \text{ kV}, & 0 < t < 1 \\ 40t - 10t^2 - 20 \text{ kV}, & 1 < t < 2 \end{cases}$

**6.29** (a) 8 V, (b)  $-480e^{-3t} \mu\text{A}$ ,  $-6 + 8e^{-3t} \mu\text{A}$ , (c)  $-480e^{-3t} \mu\text{A}$ ,  $-180e^{-3t} \mu\text{A}$ ,  $-300e^{-3t} \mu\text{A}$

**6.31** 0.2 H

**6.33**  $4.8 \cos 100t$ , 96 mJ

**6.35** 5.977 A, 35.72 J

**6.37**  $144 \mu\text{J}$

**6.39**  $i(t) = \begin{cases} 0.25t^2 \text{ kA}, & 0 < t < 1 \\ 1 - t + 0.25t^2 \text{ kA}, & 1 < t < 2 \end{cases}$

**6.41**  $5 \Omega$

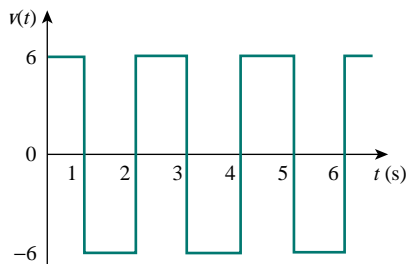
**6.43** (a) 7 H, (b) 3 H, (c) 2 H

**6.45** 7.778 H

**6.47** 7 H

**6.49**  $\frac{5}{8} \text{ L}$

**6.51** See Fig. E.7.



**Figure E.7** For Prob. 6.51.

**6.53** (a) 2 mA, (b)  $2.4e^{-2t} \text{ mA}$ ,  $3.6e^{-2t} \text{ mA}$ , (c)  $-0.12e^{-2t} \text{ mV}$ ,  $-0.144e^{-2t} \text{ mV}$ , (d)  $W_{10} = 24.36 \text{ nJ}$ ,  $W_{30} = 11.693 \text{ nJ}$ ,  $W_{20} = 17.54 \text{ nJ}$

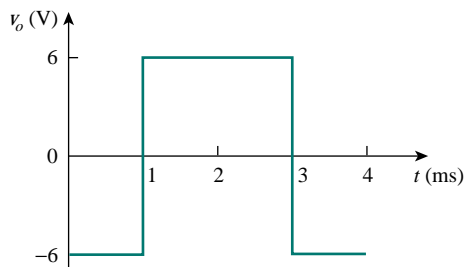
**6.55**  $50(1 - \cos 4t) \text{ mA}$ ,  $4.8 \sin 4t \text{ mV}$

**6.57** 6s

**6.59** One possibility is letting  $R = 100 \text{ k}\Omega$ , then  $C = 0.2 \mu\text{F}$

**6.61** 5.625 mV

**6.63** See Fig. E.8.



**Figure E.8** For Prob. 6.63.



6.65 See Fig. E.9.

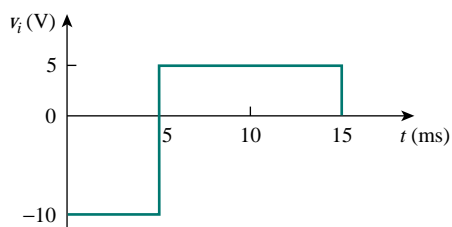


Figure E.9 For Prob. 6.65.

6.67 See Fig. E.10.

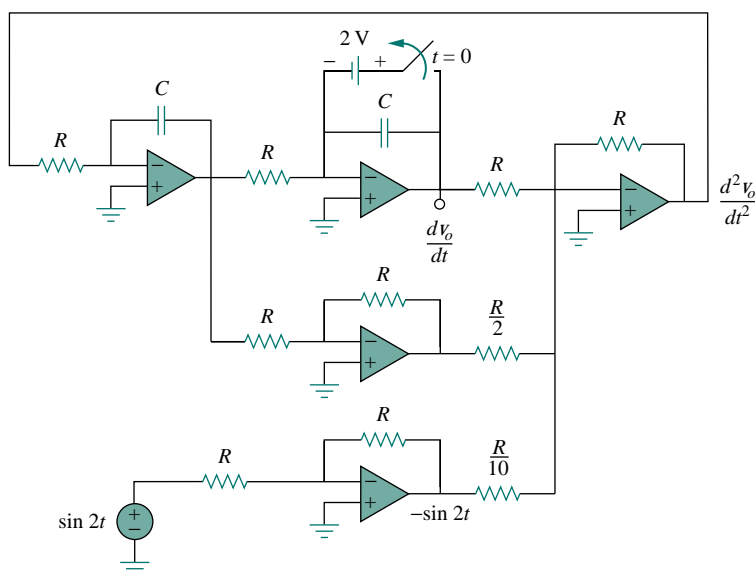


Figure E.10 For Prob. 6.67.

6.69  $\frac{d^2 v_o}{dt^2} + 5 \frac{dv_o}{dt} + 2v_o = f(t)$

6.71 150 nF

6.73 (a) 1250  $\mu$ F, (b) 400 J

## Chapter 7

7.1 Proof

7.3 6 ms

7.5 1.195 V

7.7 (a) 50  $\Omega$ , 5 mF, (b) 0.25 s, (c) 250 mJ, (d) 86.6 ms

7.9  $3e^{-10t}$  A

7.11  $4e^{-2t}$  A

7.13  $2 \mu\text{s}$

7.15  $-2e^{-16t} \text{ V}$

7.17  $2e^{-5t} \text{ A}$

7.19  $13.33 \Omega$

7.21  $2e^{-4t} \text{ V}, t > 0, 0.5e^{-4t} \text{ V}, t > 0$

7.23 (a)  $u(t+1) - 2u(t) + u(t-1)$ ,  
 (b)  $2u(t-2) - r(t-2) + r(t-4)$ ,  
 (c)  $2u(t-2) + 2u(t-4) - 4u(t-6)$ ,  
 (d)  $-r(t-1) - u(t-1) + r(t-2) + 2u(t-2)$

7.25 See Fig. E.11.

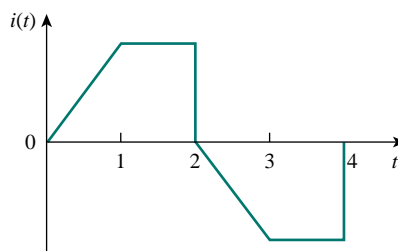


Figure E.11 For Prob. 7.25.

7.27 (a)  $112 \times 10^{-9}$ , (b) 7

7.29 (a)  $-2e^{-5t/3} \text{ V}$ , (b)  $5e^{2t/3} \text{ V}$

7.31 (a)  $4 \text{ V}, t < 0, 20 - 12e^{-t/8}, t > 0$ , (b)  $4 \text{ V}, t < 0, 12 - 8e^{-t/6} \text{ V}$

7.33  $10(1 - e^{-0.2t}) \text{ V}$

7.35  $0.8 \text{ A}, 0.8e^{-t/160} \text{ A}$

7.37  $1.25(1 - e^{-t/5}) \text{ V}, 0.125e^{-t/5} \text{ A}$

7.39  $10e^{-t/3} \text{ V}, -\frac{1}{3}e^{-t/3} \text{ A}$

7.41  $7.5(3 - e^{-4t}) \text{ mA}, t > 0$

7.43  $2 \text{ A}$

7.45 (a)  $1 \text{ A}, \frac{1}{7}(6 - e^{-2t}) \text{ A}$ , (b)  $2 \text{ A}, 3 - e^{-9t/4} \text{ A}$

7.47  $-4e^{-20t} \text{ V}$

7.49  $15 + 5e^{-16t} \text{ V}$

7.51  $16e^{-0.5t} \text{ V}$

$$7.53 \quad i(t) = \begin{cases} \frac{1}{6}(1 - e^{-t}) \text{ A}, & 0 < t < 1 \\ 0.5 - 0.3746e^{-(t-1)} \text{ A}, & t > 1 \end{cases}$$

7.55  $1.667(1 - e^{-t}) \text{ V}$

7.57  $0.4e^{-50t} \text{ mA}, t > 0$

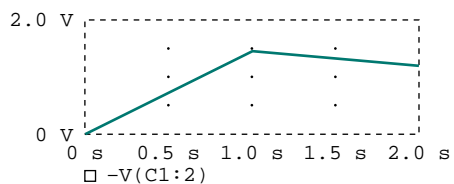
7.59  $8(1 - e^{-4t}) \text{ V}, t > 0$

7.61  $20(1 + 10t) \text{ mV}$

**7.63**  $0.5e^{-10t}$  mA,  $t > 0$

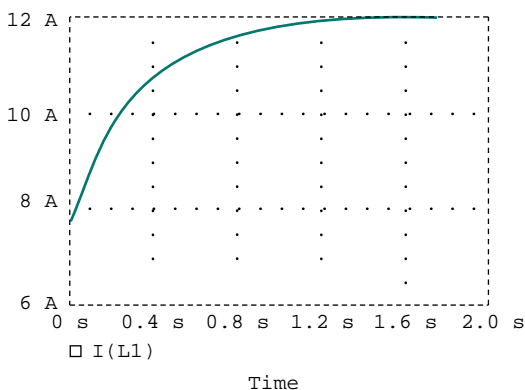
**7.65**  $0.1(2e^{-10t} - 1)$  V

**7.67** See Fig. E.12.



**Figure E.12** For Prob. 7.67.

**7.69** See Fig. E.13.



**Figure E.13** For Prob. 7.69.

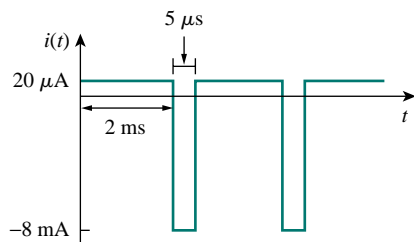
**7.71**  $30\ \Omega$

**7.73**  $0.2197 < t_0 < 2.197$

**7.75** (a) 0.6 ms, (b)  $6\ \mu\text{s}$

**7.77**  $\frac{2}{3}\ \text{M}\Omega$ , 25 pF

**7.79** See Fig. E.14.

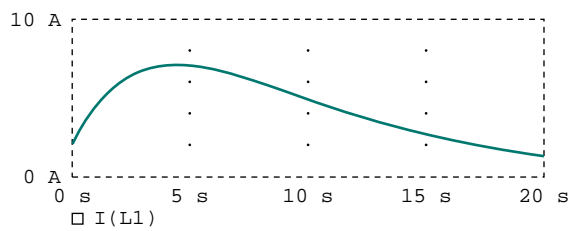


**Figure E.14** For Prob. 7.79 (not to scale).

## Chapter 8

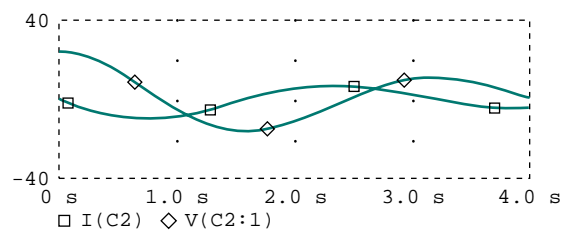
- 8.1** (a) 2 A, 12 V, (b)  $-4$  A/s,  $-5$  V/s, (c) 0 A, 0 V
- 8.3** (a) 0 A,  $-10$  V, 20 V, (b) 0 A/s, 0 V/s, 0 V/s, (c) 0.4 A, 6 V, 16 V
- 8.5** (a) 0 A, 0 V, (b) 0.25 A/s, 0 V/s, (c) 2.4 A, 9.6 V
- 8.7**  $s^2 + 4s + 4 = 0$ ,  $(1 + t)e^{-2t}$
- 8.9**  $(10 + 50t)e^{-5t}$  A
- 8.11**  $10(1 + t)e^{-t}$  V
- 8.13** 120  $\Omega$
- 8.15** 750  $\Omega$ , 200  $\mu$ F, 25 H
- 8.17**  $24 \sin 0.5t$  V
- 8.19**  $18e^{-t} - 2e^{-9t}$  V
- 8.21** 40 mF
- 8.23**  $(24 \cos 1.984t + 3.024 \sin 1.984t)e^{-t/4}$  V
- 8.25**  $3 - 3(\cos 2t + \sin 2t)e^{-2t}$  V
- 8.27** (a)  $3 - 3 \cos 2t + \sin 2t$  V, (b)  $2 - 4e^{-t} + 4e^{-4t}$  A, (c)  $3 + (2 + 3t)e^{-t}$  V, (d)  $2 + 2 \cos 2te^{-t}$  A
- 8.29**  $50 - e^{-3t}(62 \cos 4t + 46.5 \sin 4t)$  V
- 8.31**  $-10 \sin 8t$  A
- 8.33**  $35 - (15 \cos 0.6t + 20 \sin 0.67t)e^{-0.8t}$  V,  $5 \sin 0.6te^{-0.8t}$  A
- 8.35**  $2.46e^{-0.903t} - 0.667e^{-4.3t}$  A
- 8.37**  $(3 - 9t)e^{-5t}$  A
- 8.39**  $-12 + (4 \cos 4t + 3 \sin 4t)e^{-3t}$  V
- 8.41**  $6 - 6e^{-50t}(\cos 5000t + 0.01 \sin 5000t)$  mA
- 8.43**  $-2(1 + t)e^{-2t}$  A,  $(2 + 4t)e^{-2t}$  V
- 8.45**  $9 + 2e^{-10t} - 8e^{-2.5t}$  A
- 8.47**  $R_1 C_1 R_2 C_2 \frac{d^2 v_o}{dt^2} + (R_1 C_1 + R_2 C_2 + R_1 C_2) \frac{dv_o}{dt} = R_1 C_1 \frac{dv_s}{dt}$
- 8.49**  $7.45 - 3.45e^{-7.25t}$  V,  $t > 0$
- 8.51** (a)  $s^2 + 20s + 36 = 0$ , (b)  $-\frac{3}{4}e^{-2t} - \frac{5}{4}e^{-18t}$  A,  $6e^{-2t} + 10e^{-18t}$  V
- 8.53**  $2.4 - 2.667e^{-2t} + 0.2667e^{-5t}$  A,  $9.6 - 16e^{-2t} + 6.4e^{-5t}$  V
- 8.55**  $\frac{d^2 v_o}{dt^2} + \left( \frac{1}{R_2} + \frac{1}{R_1 C_1} \right) \frac{dv_o}{dt} + \frac{v_o}{R_1 R_2 C_1 C_2} = -\frac{1}{R_1 C_2} \frac{dv_s}{dt}$
- 8.57**  $\frac{d^2 v_o}{dt^2} + \frac{v_o}{R^2 C^2} = 0$ ,  $2 \sin 10t$
- 8.59**  $-te^{-t}u(t)$  V

**8.61** See Fig. E.15.



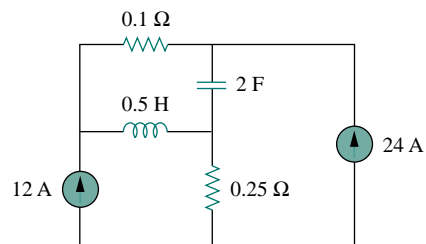
**Figure E.15** For Prob. 8.61.

**8.63** See Fig. E.16.



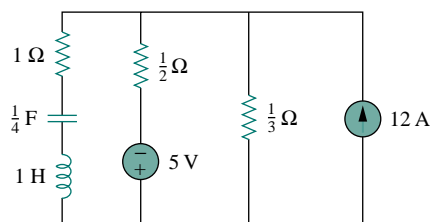
**Figure E.16** For Prob. 8.63.

**8.65** See Fig. E.17.



**Figure E.17** For Prob. 8.65.

**8.67** See Fig. E.18.



**Figure E.18** For Prob. 8.67.

**8.69** 14.26- $\Omega$  resistor in parallel with a 176- $\mu$ F capacitor

**8.71** 2.5  $\mu$ M, 625  $\mu$ F

$$\mathbf{8.73} \quad \frac{d^2 v}{dt^2} + \frac{R}{L} \frac{dv}{dt} + \frac{R}{LC} i_D + \frac{1}{C} \frac{di_D}{dt} = \frac{v_s}{LC}$$

## Chapter 9

**9.1** (a)  $10^3$  rad/s, (b) 159.2 Hz, (c) 6.283 ms, (d)  $12 \cos(10^3 t - 66^\circ)$  V, (e) 2.65 V

**9.3** (a)  $4 \cos(\omega t - 120^\circ)$ , (b)  $2 \cos(6t + 90^\circ)$ , (c)  $10 \cos(\omega t + 110^\circ)$

**9.5**  $20^\circ$ ,  $v_1$  lags  $v_2$

**9.7** Proof

**9.9** (a)  $1.809 + j0.4944$ , (b)  $4.201 - j1.392$ , (c)  $-0.5042 - j2.243$

**9.11** (a)  $118.3 \angle -39.45^\circ$ , (b)  $10.45 \angle -10.4^\circ$ , (c)  $1.849 \angle -39.45^\circ$

**9.13** (a)  $10 \angle -105^\circ$ , (b)  $5 \angle -100^\circ$ , (c)  $5 \angle -36.87^\circ$

**9.15** (a)  $60 \cos(t + 15^\circ)$ , (b)  $10 \cos(40t + 53.13^\circ)$ , (c)  $2.8 \cos(377t - \pi/3)$ , (d)  $1.3 \cos(10^3 t + 247.4^\circ)$

**9.17** (a)  $40 \cos(\omega t - 60^\circ)$ , (b)  $38.36 \sin(\omega t + 96.8^\circ)$ , (c)  $6 \cos(\omega t + 80^\circ)$ , (d)  $11.5 \cos(\omega t - 52.06^\circ)$

**9.19** (a)  $0.8 \cos(2t - 98.13^\circ)$ , (b)  $0.745 \cos(2t - 4.56^\circ)$

**9.21**  $0.289 \cos(377t - 92.45^\circ)$  V

**9.23**  $2 \sin(10^6 t - 65^\circ)$

**9.25** 6.5- $\Omega$  resistor

**9.27** 69.82 V

**9.29**  $-5 \sin 2t$  V

**9.31** (a)  $4.472 \cos(3t - 18.43^\circ)$  A,  $17.89 \cos(3t - 18.43^\circ)$  V, (b)  $10 \cos(4t + 36.87^\circ)$  A,  $41.6 \cos(4t + 33.69^\circ)$  V

**9.33** (a)  $1.872 \cos(t - 22.05^\circ)$  A, (b)  $0.89 \cos(5t - 69.14^\circ)$  A, (c)  $0.4417 \cos(10t - 83.66^\circ)$  A

**9.35**  $17.14 \cos 200t$  V

**9.37**  $0.96 \cos(200t - 7.956^\circ)$  A

**9.39**  $2.325 \cos(10t + 94.46^\circ)$  A

**9.41**  $25 \cos(2t - 53.13^\circ)$  A

**9.43**  $8.485 \angle 135^\circ$  A

**9.45** (a)  $0.75 + j0.25 \Omega$ , (b)  $20 + j30 \Omega$

**9.47**  $1 + j0.5 \Omega$

**9.49**  $17.35 \angle 0.9^\circ$  A,  $6.83 + j1.094 \Omega$

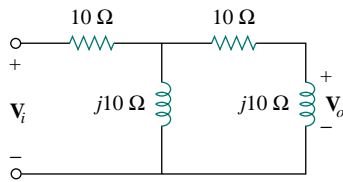
**9.51** (a)  $0.0148 \angle -20.22^\circ$  S, (b)  $0.0197 \angle 74.57^\circ$  S

**9.53**  $1.661 + j0.6647$  S

**9.55**  $1.058 - j2.235 \Omega$

**9.57**  $0.3796 + j1.46 \Omega$

**9.59** Can be achieved by the RL circuit shown in Fig. E.19.



**Figure E.19** For Prob. 9.59.

**9.61** (a)  $140.2^\circ$ , (b) leading, (c) 18.43 V

**9.63** 1.8 k $\Omega$ , 0.1  $\mu$ F

**9.65** 104.2 mH

**9.67** Proof

**9.69**  $38.21 \angle -8.975^\circ \Omega$

**9.71** 2 mH

**9.73** 235 pF

## Chapter 10

**10.1**  $15.73 \cos(t + 247.9^\circ)$  V

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

**10.5**  $6.154 \cos(10^3 t + 70.26^\circ)$  V

**10.7**  $35.74 \sin(1000t - 116.6^\circ)$  A

**10.9**  $7.906 \angle 43.49^\circ$  A

**10.11**  $10.58 \angle -112.4^\circ$  A

**10.13**  $16.64 \angle 56.31^\circ$  V

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

**10.17** 
$$\frac{\mathbf{V}_s(R + j\omega L + 1/j\omega C_2)}{(1/j\omega C_1 + 1/j\omega C_2)(R + j\omega L + 1/j\omega C_1) + 1/\omega^2 C_1 C_2},$$
  

$$\frac{\mathbf{V}_s/j\omega C_2}{(1/j\omega C_1 + 1/j\omega C_2)(R + j\omega L + 1/j\omega C_1) + 1/\omega^2 C_1 C_2}$$

**10.19**  $6.154 \cos(10^3 t + 70.25^\circ)$  V

**10.21**  $4.67 \angle -20.17^\circ$  A,  $1.79 \angle 37.35^\circ$  A

**10.23**  $2.179 \angle 61.44^\circ$  A

**10.25**  $7.906 \angle 43.49^\circ$  A

**10.27**  $1.971 \angle -2.1^\circ$  A

**10.29**  $3.35 \angle 174.3^\circ$  A

**10.31**  $9.902 \cos(2t - 129.17^\circ)$  A

**10.33**  $10 + 21.45 \sin(2t + 26.56^\circ) + 10.73 \cos(3t - 26.56^\circ)$  V

- 10.35**  $0.1 + 0.217 \cos(2000t + 134.1^\circ) - 1.365 \sin(4000t + 14.21^\circ)$  A
- 10.37**  $3.615 \cos(10^5 t - 40.6^\circ)$  V
- 10.39**  $5.238 \angle 17.35^\circ$  A
- 10.41** (a)  $Z_N = Z_{Th} = 22.63 \angle -63.43^\circ \Omega$ ,  $V_{Th} = -50 \angle 30^\circ$  V,  
 $I_N = 2.236 \angle 273.4^\circ$  A, (b)  $Z_N = Z_{Th} = 10 \angle 26^\circ \Omega$ ,  
 $V_{Th} = 33.92 \angle 58^\circ$  V,  $I_N = 3.392 \angle 32^\circ$  A
- 10.43**  $Z_N = Z_{Th} = 21.633 \angle -33.7^\circ \Omega$ ,  $V_{Th} = 107.3 \angle 146.56^\circ$  V,  
 $I_N = 4.961 \angle -179.7^\circ$  A
- 10.45**  $15.73 \cos(t + 247.9^\circ)$  V
- 10.47**  $3.855 \cos(4t - 35.02^\circ)$  V
- 10.49**  $1 \text{ k}\Omega$ ,  $5.657 \cos(200t + 75^\circ)$  A
- 10.51**  $0.542 \cos(2t - 77.47^\circ)$  A
- 10.53**  $-j\omega RC$ ,  $-V_m \cos \omega t$
- 10.55**  $35.76 \cos(10^4 t - 26.56^\circ)$   $\mu\text{A}$
- 10.57**  $\frac{C_1}{C_2} \left( \frac{1 + j\omega R_2 C_2}{1 + j\omega R_1 C_1} \right)$ ,  $\frac{C_1}{C_2}$ ,  $\frac{R_2}{R_1}$ ,  $\frac{C_1}{C_2} \left( \frac{1 + jR_2 C_2 / R_1 C_1}{1 + j} \right)$ ,  
 $\frac{C_1}{C_2} \left( \frac{1 + j}{1 + jR_1 C_1 / R_2 C_2} \right)$
- 10.59**  $\frac{R_2 + R_3 + j\omega C_2 R_2 R_3}{(1 + j\omega R_1 C_1)(R_3 + j\omega C_2 R_2 R_3)}$
- 10.61**  $35.78 \cos(1000t + 26.56^\circ)$  V
- 10.63**  $1.465 \angle 79.59^\circ$  A
- 10.65**  $1.664 \angle -146.4^\circ$  V
- 10.67**  $15.91 \angle 169.6^\circ$ ,  $5.172 \angle -138.6^\circ$ ,  $2.27 \angle -152.4^\circ$  V
- 10.69** Proof
- 10.71** (a) 180 kHz, (b) 40 k $\Omega$
- 10.73** Proof
- 10.75** Proof

## Chapter 11

- 11.1**  $800 + 1600 \cos(100t + 60^\circ)$ , 800 W
- 11.3** 7.5 W, 5 W, 0 W, 2.5 W, 0 W
- 11.5** 12.48 W
- 11.7** 43.78 W
- 11.9** 0 W
- 11.11** (a)  $0.471 + j1.882 \Omega$ , 15.99 W, (b)  $2.5 - j1.167 \Omega$ , 1.389 W
- 11.13**  $0.5 - j0.5 \Omega$ , 90 W
- 11.15**  $21.23 - j10.15 \Omega$
- 11.17**  $6.792 \Omega$ , 6.569 W



- 11.19** 9.574 V  
**11.21** 7.906 V  
**11.23** 2.92 V, 4.267 W  
**11.25** 1.08 V  
**11.27** 6.667 A  
**11.29** 275.6 VA, 0.1876 (lagging)  
**11.31** (a) 0.5547 (leading), (b) 0.9304 (lagging)  
**11.33** (a)  $95.26 - j55$  VA, 110 VA, 95.26 W, 55 VAR, leading pf  
           (b)  $1497.2 + j401.2$  VA, 1550 VA, 1497.2 W, 401.2 VAR, lagging pf  
           (c)  $278.2 + j74.54$  VA, 288 VA, 278.2 W, 74.54 VAR, lagging pf  
           (d)  $-961.7 - j961.7$  VA, 1360 V,  $-961.7$  W,  $-961.7$  VAR, leading pf  
**11.35** (a)  $269 - j150$  VA, (b)  $4129 - j2000$  VA, (c)  $396.9 + j450$  VA,  
           (d)  $1000 + j681.2$  VA  
**11.37** (a)  $30.98 - j23.23 \Omega$ , (b)  $10.42 + j13.89 \Omega$ , (c)  $0.8 + j1.386 \Omega$   
**11.39**  $-j3.84$  VA (capacitor), 5.12 VA (resistor),  $j6.4$  VA (inductor)  
**11.41**  $4.543 + j1.396$  VA  
**11.43** 51.2 mVA  
**11.45**  $7.098 \angle 32.29^\circ$ , 0.8454 (lagging)  
**11.47**  $120.1 \angle 0.03145^\circ$  V  
**11.49** 80  $\mu$ W  
**11.51** No power across the capacitors,  $S_{10} = 4 \times 10^{-4}$ ,  $S_{20} = 8 \times 10^{-4}$ ,  
            $S_{40} = 4 \times 10^{-4}$  VA  
**11.53** (a) 0.6402, (b) 295.1 W, (c) 130.4  $\mu$ F  
**11.55** (a) 2.734 mF, (b) 6.3 mF  
**11.57** (a) 0.8992, (b) 5.74 mF  
**11.59** 9.476 W  
**11.61** 4.691 W  
**11.63** \$76.26  
**11.65**  $75 - j103.55 \Omega$   
**11.67** (a) 126.2 W, (b) 220 VA  
**11.69** 968.2 kVAR  
**11.71** (a) 32.91 kVAR, 86.51 kVA, (b) 0.9248, (c) 157.3 A  
**11.73** (a) \$ 14,521.80, (b) \$ 31,579.2, (c) Yes  
**11.75** (a)  $40 - j8 \Omega$ , (b) 66.61 W

## Chapter 12

- 12.1** (a)  $231 \angle -30^\circ$ ,  $231 \angle -150^\circ$ ,  $231 \angle -270^\circ$  V,  
           (b)  $231 \angle 30^\circ$ ,  $231 \angle 150^\circ$ ,  $231 \angle -90^\circ$  V  
**12.3**  $acb$  sequence,  $208 \angle 250^\circ$  V  
**12.5**  $242.5 \angle -30^\circ$ ,  $242.5 \angle -150^\circ$ ,  $242.5 \angle 90^\circ$  V

- 12.7**  $44 \angle 53.13^\circ$ ,  $44 \angle -66.87^\circ$ ,  $44 \angle 173.1^\circ$  A  
**12.9**  $4.8 \angle -36.87^\circ$ ,  $4.8 \angle -156.9^\circ$ ,  $4.8 \angle 83.13^\circ$  A  
**12.11**  $127 \angle 100^\circ$  V,  $220 \angle 130^\circ$  V,  $17.32 \angle 150^\circ$  A,  $12.7 \angle -80^\circ$   $\Omega$   
**12.13** 13.66 A  
**12.15**  $172.6 \angle 34.76^\circ$ ,  $172.6 \angle -85.24^\circ$ ,  $172.6 \angle 154.8^\circ$  V,  $11.51 \angle -18.37^\circ$ ,  
 $11.51 \angle -138.4^\circ$ ,  $11.51 \angle 101.6^\circ$  A  
**12.17**  $5.47 \angle -18.43^\circ$ ,  $5.47 \angle -138.43^\circ$ ,  $5.47 \angle 101.57^\circ$  A,  
 $9.474 \angle -48.43^\circ$ ,  $9.474 \angle -168.43^\circ$ ,  $9.474 \angle 71.57^\circ$  A  
**12.19**  $15.53 \angle -28.4^\circ$ ,  $15.53 \angle -148.4^\circ$ ,  $15.53 \angle 91.6^\circ$  A  
**12.21**  $17.74 \angle 4.78^\circ$ ,  $17.74 \angle -115.2^\circ$ ,  $17.74 \angle 124.8^\circ$  A  
**12.23**  $5.081 \angle -46.87^\circ$ ,  $5.081 \angle -166.87^\circ$ ,  $5.081 \angle 73.13^\circ$  A  
**12.25**  $4.15 - j5.53 \Omega$ ,  $5000 - j6667$  VA  
**12.27** 7.69 A, 360.3 V  
**12.29** 55.51 A,  $1.298 - j1.731 \Omega$   
**12.31** 423.1 W  
**12.33** 9.021 A  
**12.35**  $4.373 - j1.145$  kVA  
**12.37**  $6346 \angle 28.92^\circ$  V  
**12.39** 40.42 A (rms), 0.9677 (lagging)  
**12.41**  $5.75 \angle 220^\circ$  A  
**12.43**  $3.464 \angle 30^\circ$ ,  $3.464 \angle 0^\circ$ ,  $3.464 \angle 60^\circ$  A  
**12.45** (a)  $132 \angle 30^\circ$  A,  $47.23 \angle 143.8^\circ$  A,  $120.9 \angle 230.9^\circ$  A, (b) 29.04 kW,  
(c)  $29.04 - j58.08$  kVA  
**12.47**  $220.6 \angle -34.56^\circ$ ,  $214.1 \angle -81.49^\circ$ ,  $49.91 \angle -50.59^\circ$  V, assuming  
that  $N$  is grounded.  
**12.49**  $11.15 \angle 37^\circ$  A,  $230.8 \angle -133.4^\circ$  V, assuming  $N$  is grounded.  
**12.51**  $\mathbf{I}_{aA} = 4.71 \angle 71.38^\circ$ ,  $\mathbf{I}_{bB} = 6.781 \angle -142.6^\circ$ ,  
 $\mathbf{I}_{cC} = 3.898 \angle -5.076^\circ$  V,  $\mathbf{I}_{AB} = 3.547 \angle 61.57^\circ$ ,  
 $\mathbf{I}_{BC} = 3.831 \angle -164.9^\circ$ ,  $\mathbf{I}_{AC} = 1.357 \angle 97.8^\circ$  V  
**12.53** (a) 120 V, (b) 2.5, 3, 2, 0.866 A, (c) 300, 360, 240 W, (d) 900 W  
**12.55** (a) 4801 VA, (b) 0.9372, (c) 8.4 A, (d) 190.5 V  
**12.57** (a) 2590 W, 4808 W, (b) 8335 VA  
**12.59** -2995 W, 2995 W  
**12.61** (a) 20 mA, (b) 200 mA  
**12.63** 320 W  
**12.65**  $17.15 \angle -19.65^\circ$ ,  $15.14 \angle -139.6^\circ$ ,  $15.14 \angle 100.3^\circ$  A,  
 $196.8 \angle 2.97^\circ$ ,  $196.8 \angle -117^\circ$ ,  $196.82 \angle 123^\circ$  V  
**12.67** 516 V

**12.69**  $Z_Y = 2.133 \, \Omega$

**12.71**  $1.448 \angle -176.6^\circ \text{ A}, 1252 + j711.6 \text{ VA}, 1085 + j721.2 \text{ VA}$

### Chapter 13

**13.1** 10 H

**13.3** 150 mH, 50 mH, 25 mH, 0.2887

**13.5**  $(R_1 + j\omega L_1)\mathbf{I}_1 - j\omega M\mathbf{I}_2, -j\omega M\mathbf{I}_1 + (R_2 + j\omega L_2)\mathbf{I}_2$

**13.7**  $2.392 \angle 94.57^\circ \text{ V}$

**13.9**  $\frac{jI_m(\omega L - 1/\omega C)}{R + j\omega L + 1/j\omega C}$

**13.11**  $V_{Th} = 5.349 \angle 34.11^\circ \text{ V}, Z_{Th} = 2.332 \angle 50^\circ \, \Omega$

**13.13**  $2.462 \angle 72.18^\circ \text{ A}, 0.878 \angle -97.48^\circ \text{ A}, 3.329 \angle 74.89^\circ \text{ A}, 43.67 \text{ mJ}$

**13.15**  $3.199 \angle -175.2^\circ \text{ A}$

**13.17** (a) 0.3535, (b)  $0.3217 \cos(4t + 57.6^\circ) \text{ V}$ , (c) 1.168 J

**13.19**  $3.755 \angle -36.34^\circ \text{ A}, 3.755 \angle 143.7^\circ \text{ A}$

**13.21** 0.984, 130.5 mJ

**13.23** (a)  $L_a = 10 \text{ H}, L_b = 15 \text{ H}, L_c = 5 \text{ H}$ , (b)  $L_A = 18.33 \text{ H}, L_B = 27.5 \text{ H}, L_C = 55 \text{ H}$

**13.25**  $12.77 + j7.15 \, \Omega$

**13.27**  $1.324 \angle -53.05^\circ \text{ k}\Omega$

**13.29** 0.5 A, -1.5 A

**13.31**  $\frac{V_m}{nR} \cos \omega t \text{ A}, -\frac{V_m}{n^2 R} \cos \omega t$

**13.33**  $2.963 \angle 32.9^\circ \text{ V}, 2.963 \angle -147.1^\circ \text{ V}$

**13.35**  $8 - j1.5 \, \Omega, 2.95 \angle 10.62^\circ \text{ A}$

**13.37** (a) 5, (b) 8 W

**13.39** 1054 W

**13.41** (a)  $25.9 \angle 69.96^\circ, 12.95 \angle 69.96^\circ \text{ A (rms)}$ , (b)  $21.06 \angle 147.4^\circ, 42.12 \angle 147.4^\circ, 42.12 \angle 147.4^\circ \text{ V (rms)}$ , (c)  $1554 \angle 20.04^\circ \text{ VA}$

**13.43**  $P_{8\Omega} = 2.778 \text{ W}, P_{2\Omega} = 11.11 \text{ W}, P_{4\Omega} = 5.556 \text{ W}$

**13.45** 6 A, 0.36 A, -60 V

**13.47**  $3.795 \angle 18.43^\circ, 1.897 \angle 18.43^\circ, 0.6325 \angle 161.6^\circ$

**13.49**  $1.245 \angle -33.76^\circ, 0.8893 \angle -33.76^\circ, 0.3557 \angle 146.2^\circ \text{ A}, 7.51 \text{ W}$

**13.51** 74.9 W

**13.53** (a)  $\frac{1}{3}$ , (b) 1604, 2778 A, (c) 2778, 4812 A

**13.55** (a) delta-delta connection, (b) 66.67, 13.05 A, (c) 16.67, 28.87 A, (d) 55 kVA

**13.57** (a) 144.3 A, (b) 238.7, (c) 13.05 A

**13.59**  $4.253 \angle -8.526^\circ \text{ A}, 1.564 \angle 27.49^\circ \text{ A}, 4.892 \text{ W}$

**13.61**  $1.304 \angle 62.92^\circ \text{ A}$

**13.63**  $19.55 \angle 83.32^\circ \text{ V}$ ,  $68.47 \angle 46.4^\circ \text{ V}$ ,  $0.4434 \angle -92.6^\circ \text{ A}$

**13.65**  $4.028 \angle -52.38^\circ$ ,  $2.019 \angle -52.11^\circ$ ,  $1.338 \angle -52.2^\circ \text{ A}$

**13.67**  $7.5 \text{ k}\Omega$

**13.69**  $315 \text{ W}$

**13.71** (a) 0.1, (b) 25 turns, (c) 1.667 A, 16.67 A

**13.73** (a) 112 V, (b) 0.2613 A, 11.2 A, (c) 1254 W

**13.75** (a) 733.4 V, (b) 440 V

## Chapter 14

**14.1**  $\frac{j\omega/\omega_o}{1 + j\omega/\omega_o}$ ,  $\omega_o = \frac{1}{RC}$

**14.3** (a)  $\frac{1}{s^2 R^2 C^2 + 3sRC + 1}$ , (b)  $-4.787$ ,  $-32.712$

**14.5** (a)  $\frac{1}{1 + j\omega RC - \omega^2 LC}$ , (b)  $\frac{j\omega L - \omega^2 RLC}{R + j\omega L - \omega^2 RLC}$

**14.7** (a) 1.005773, (b) 0.4898, (c)  $1.718 \times 10^5$

**14.9** See Fig. E.20.

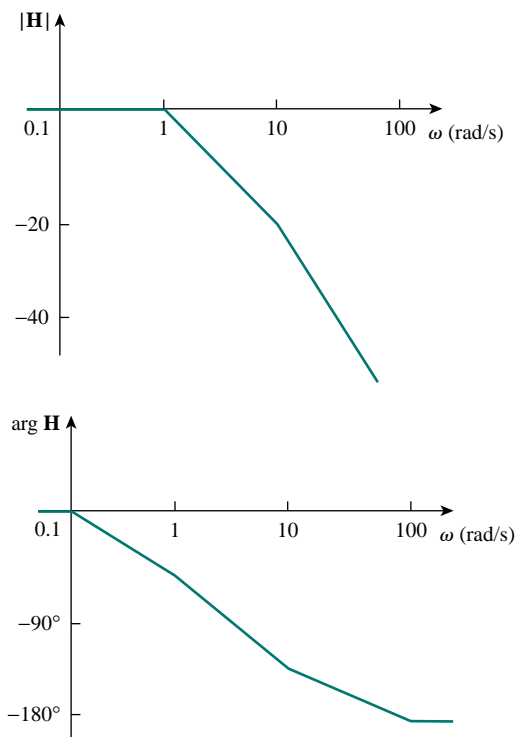
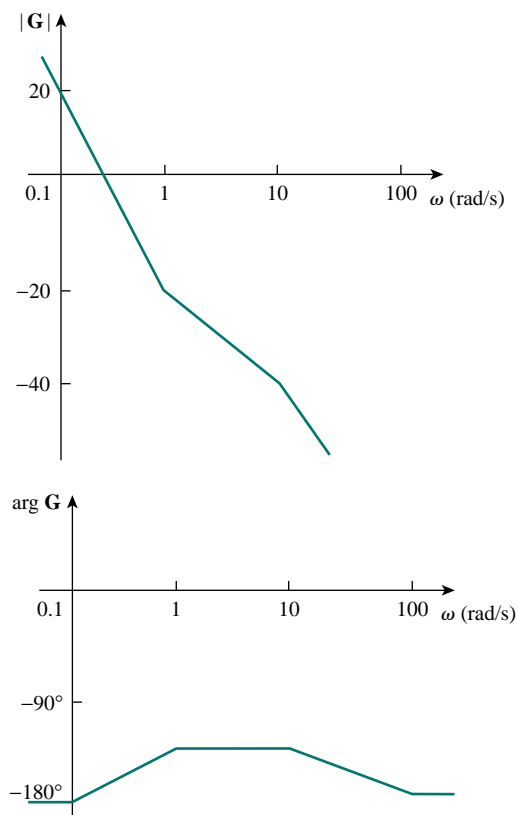


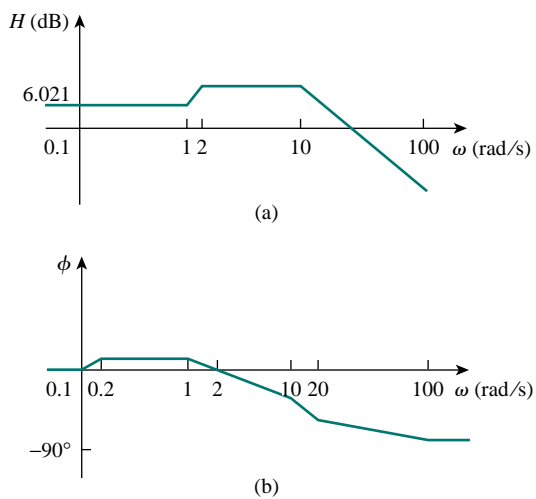
Figure E.20 For Prob. 14.9.

**14.11** See Fig. E.21.



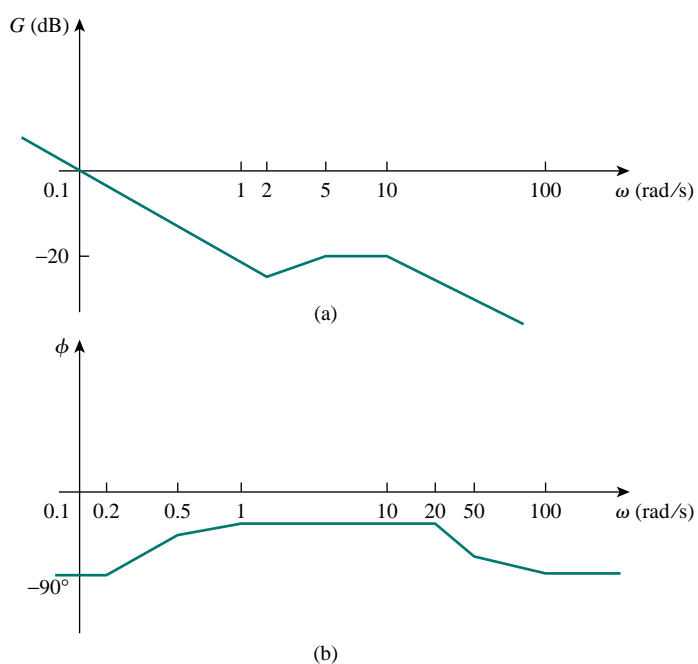
**Figure E.21** For Prob. 14.11.

**14.13** See Fig. E.22.



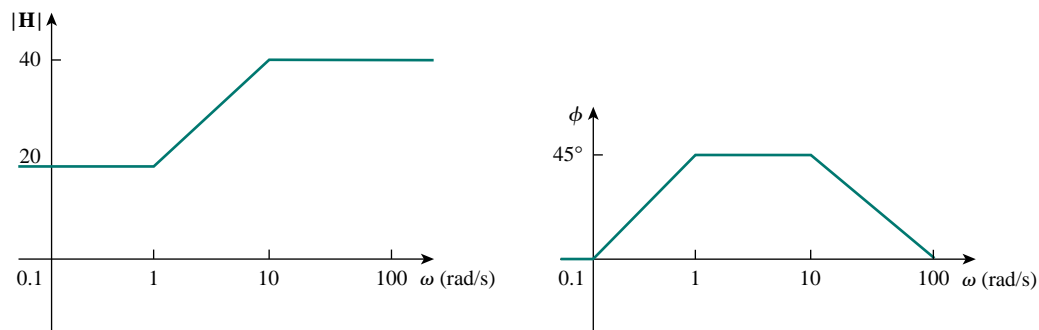
**Figure E.22** For Prob. 14.13: (a) magnitude plot, (b) phase plot.

**14.15** See Fig. E.23.



**Figure E.23** For Prob. 14.15: (a) magnitude plot, (b) phase plot.

**14.17** See Fig. E.24.



**Figure E.24** For Prob. 14.17.

**14.19** 
$$\frac{10^4(2 + j\omega)}{(20 + j\omega)(100 + j\omega)}$$

**14.21** 
$$\frac{Kj\omega}{(1 + j\omega)(100 + j\omega)}, K = \text{constant}$$

**14.23**  $R = 10 \, \Omega, L = 16 \, \text{H}, C = 25 \, \mu\text{F}, 0.625 \, \text{rad/s}$

**14.25**  $0.7861 \, \text{rad/s}$

**14.27**  $50 \, \text{rad/s}, 5.975 \times 10^6 \, \text{rad/s}, 6.025 \times 10^6 \, \text{rad/s}$

**14.29**  $2 \text{ k}\Omega$ ,  $0.6154 + j0.923 \text{ k}\Omega$ ,  $1.471 + j0.8824 \text{ k}\Omega$ ,  $1.471 - j0.8824 \text{ k}\Omega$ ,  $0.6154 - j0.923 \text{ k}\Omega$

**14.31** (a)  $5 \text{ rad/s}$ ,  $0.625$ ,  $8 \text{ rad/s}$ , (b)  $5 \text{ krad/s}$ ,  $20$ ,  $250 \text{ rad/s}$

**14.33** (a)  $3.333 \text{ krad/s}$ , (b)  $0.9997 \angle 1.205^\circ \Omega$

**14.35** (a)  $\frac{j\omega}{2(1+j\omega)^2}$ , (b)  $0.25$

**14.37**  $\frac{R}{R + j\omega L - \omega^2 RLC}$ , Proof

**14.39** Highpass filter,  $318.3 \text{ Hz}$

**14.41**  $31.42 \text{ k}\Omega$

**14.43**  $1.56 \text{ kHz} < f < 1.59 \text{ kHz}$ ,  $25$

**14.45** (a)  $1 \text{ rad/s}$ ,  $3 \text{ rad/s}$ , (b)  $1 \text{ rad/s}$ ,  $3 \text{ rad/s}$

**14.47**  $9.6 \text{ krad/s}$ ,  $5 \text{ krad/s}$

**14.49** (a)  $23.53 \text{ mV}$ , (b)  $107.3 \text{ mV}$ , (c)  $119.4 \text{ mV}$

**14.51**  $\left(1 + \frac{R_f}{R_i}\right), \frac{1}{RC}$

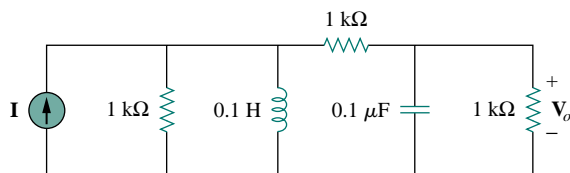
**14.53** If  $R_f = 20 \text{ k}\Omega$ , then  $R_i = 80 \text{ k}\Omega$  and  $C = 31.83 \text{ nF}$ .

**14.55** Let  $R = 10 \text{ k}\Omega$ , then  $R_f = 25 \text{ k}\Omega$ ,  $C = 7.96 \text{ nF}$ .

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

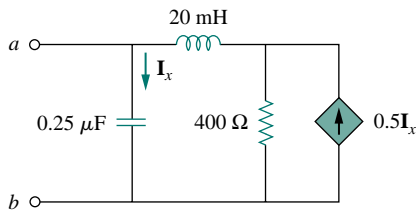
**14.59**  $9.6 \text{ M}\Omega$ ,  $32 \mu\text{H}$ ,  $0.375 \text{ pF}$

**14.61** See Fig. E.25.



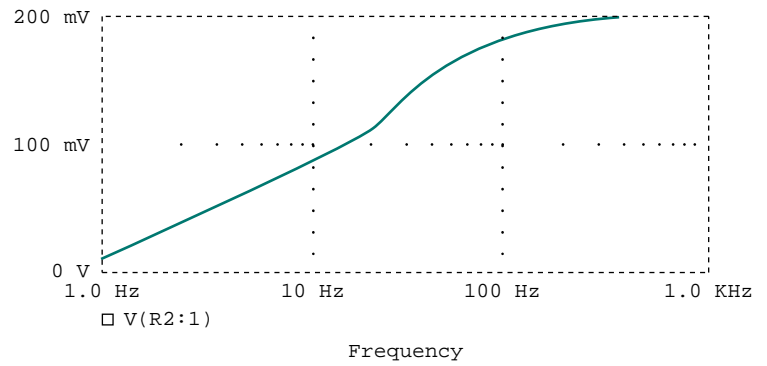
**Figure E.25** For Prob. 14.61.

**14.63** (a) See Fig. E.26, (b)  $894.4 \angle 26.7^\circ \Omega$

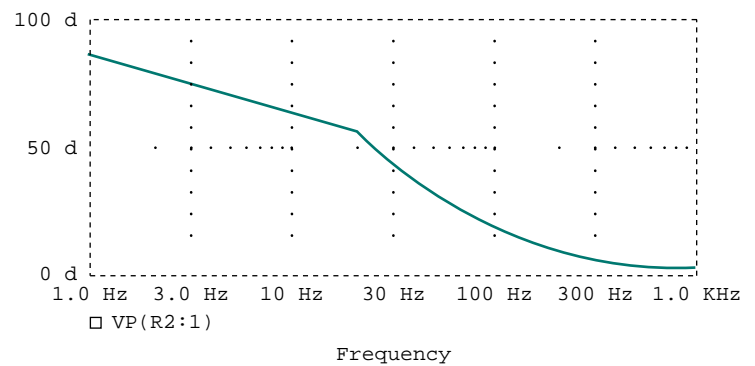


**Figure E.26** For Prob. 14.63.

**14.65** See Fig. E.27.



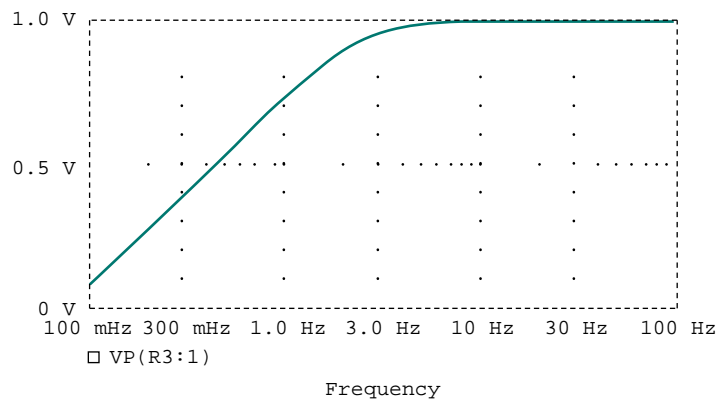
(a)



(b)

**Figure E.27** For Prob. 14.65.

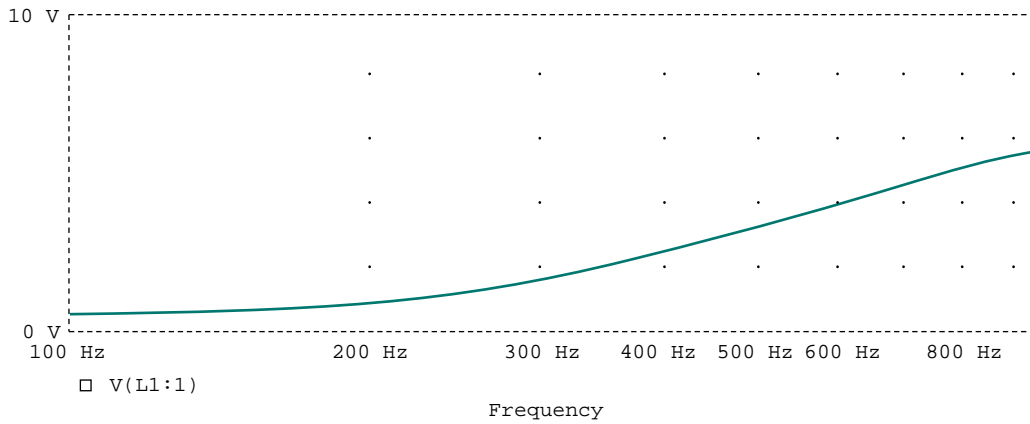
**14.67** See Fig. E.28; high pass filter,  $f_0 = 1.2$  Hz.



**Figure E.28** For Prob. 14.67.

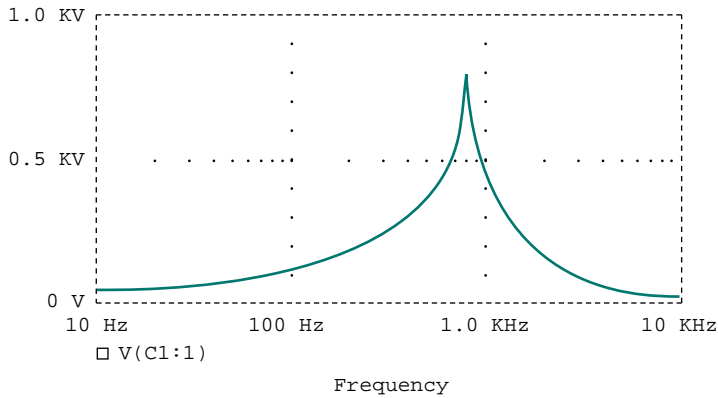


**14.69** See Fig. E.29.



**Figure E.29** For Prob. 14.69.

**14.71** See Fig. E.30;  $f_o = 800$  Hz.



**Figure E.30** For Prob. 14.71.

**14.73** 938 kHz, remains the same

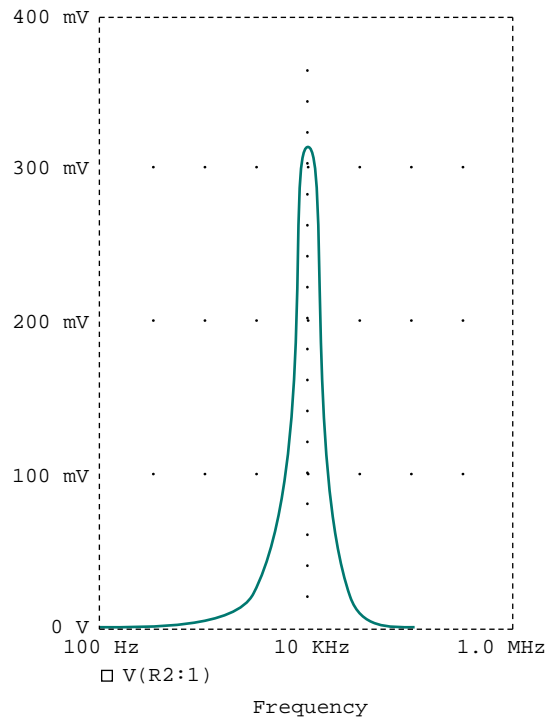
**14.75** 
$$\frac{R_L(R_L + sL + s^2 R_L L C_2)}{(R_L + sL + s^2 R_L C_2 L)(sL + R_L + s^2 R_L L C_2 + R_i + s R_i R_L C_2 + s^3 R_i R_L C_2 + s R_i R_L C_1 + s^3 R_i R_L L C_1 C_2)}$$

**14.77** 440 Hz

**14.79** 15.91  $\Omega$

**14.81** (a) 2 kHz, (b) 1.59 kHz

**14.83** See Fig. E.31.



**Figure E.31** For Prob. 14.83.

## Chapter 15

**15.1** (a)  $\frac{s}{s^2 - a^2}$ , (b)  $\frac{a}{s^2 - a^2}$

**15.3** (a)  $\frac{s+2}{(s+2)^2+9}$ , (b)  $\frac{4}{(s+2)^2+16}$ , (c)  $\frac{s+3}{(s+3)^2-4}$ , (d)  $\frac{1}{(s+4)^2-1}$ ,

(e)  $\frac{4(s+1)}{[(s+1)^2-4]^4}$

**15.5** (a)  $2e^{-s}$ , (b)  $\frac{10}{s}e^{-2s}$ , (c)  $\frac{1}{s^2} + \frac{1}{s}$ , (d)  $\frac{2e^{-4s}}{e^4(s+1)}$

**15.7** (a)  $\frac{3}{2} + \frac{6}{s} + \frac{4}{s+2} - \frac{10}{s+3}$ , (b)  $\frac{e^{-(s+1)}}{(s+1)^2} + \frac{e^{-(s+1)}}{s+1}$ , (c)  $\frac{se^{-s}}{s^2+4}$ ,

(d)  $\frac{4}{s^2+16}(1 - e^{-\pi s})$

**15.9** (a)  $-\frac{(s+2)}{s^2+2s+2}$ , (b)  $\frac{-(s+2)}{s^2+2s+2}$

**15.11**  $\frac{5}{s^2}(1 - 2e^{-s} + e^{-2s})$

**15.13**  $\frac{1}{s}(5 - 3e^{-s} + 3e^{-3s} - 5e^{-4s})$

- 15.15** (a)  $\frac{1}{s}(1 + e^{-s} + e^{-2s} - 3e^{-3s})$ , (b)  $\frac{2}{s^2}(1 - e^{-s} - e^{-3s} + e^{-4s})$
- 15.17**  $\frac{\pi(1 + e^{-s})}{(s^2 + \pi^2)(1 - e^{-2s})}$
- 15.19** (a)  $\frac{2(1 - e^{-s} + se^{-s})}{s^2(1 - e^{-s})}$ , (b)  $\frac{1}{s} + \frac{2}{s^2} \frac{(1 - e^{-s})^2}{(1 - e^{-2s})}$
- 15.21** (a)  $\infty$ , 0, (b)  $f(0) = 1$ ,  $f(\infty)$  does not exist, (c) 0, 0
- 15.23** (a) 1, 0, (b)  $f(0) = 1$ ,  $f(\infty)$  does not exist
- 15.25** (a)  $-5e^{-t} + 20e^{-2t} - 15e^{-3t}$  (b)  $-e^{-t} + \left(1 + 3t - \frac{t^2}{2}\right)e^{-2t}$ ,  
(c)  $e^{-t}(-0.2 + 0.2 \cos 2t + 0.4 \sin 2t)$
- 15.27** (a)  $3 \sin t - \cos t + 3e^{-t}$ , (b)  $\cos(t - \pi)u(t - \pi)$ ,  
(c)  $8u(t)[1 - e^{-t} - te^{-t} - 0.5t^2e^{-t}]$
- 15.29** (a)  $[2e^{-(t-6)} - e^{-2(t-6)}]u(t - 6)$ ,  
(b)  $\frac{4}{3}u(t)[e^{-t} - e^{-4t}] - \frac{1}{3}u(t - 2)[e^{-(t-2)} - e^{-4(t-2)}]$ ,  
(c)  $\frac{1}{13}u(t)[-3e^{-3(t-1)} + 3 \cos 2(t - 1) + 2 \sin 2(t - 1)]$
- 15.31** (a)  $3[1 - \cos 2(t - 2)]u(t - 2)$ ,  
(b)  $\frac{1}{4} \cos t + \frac{1}{8} \sin t - \frac{1}{4} \cos 3t - \frac{1}{24} \sin 3t$ ,  
(c)  $4e^{-2t}(-1 + t + \cos 3t - 5 \sin 3t)$
- 15.33** (a)  $-3.138e^{-t} \cos 4t - 2.358e^{-t} \sin 4t + 5.138e^{-2t} \cos 4t + 1.142e^{-2t} \sin 4t$ ,  
(b)  $\left[\frac{1}{4} \cos 3t + \frac{1}{12} \sin 4t - \frac{1}{8}e^{-0.551t} + \frac{1}{8}e^{-5.449t}\right]u(t)$
- 15.35**  $2e^{-t} - 2e^{-3t} \cos t - 4e^{-3t} \sin t$  V
- 15.37**  $(0.5 + 2.887e^{-t} \sin 1.732t)u(t)$  A,  $-1.732e^{-t} \sin 1.732tu(t)$  A
- 15.39**  $[2e^{-2t} - e^{-t}]u(t)$  A
- 15.41**  $0.7143e^{-2t} - 1.714e^{-0.5t} \cos 1.118t + 2.3e^{-0.5t} \sin 1.118t$  A
- 15.43**  $-(2 + 4.333e^{-t/2} + 1.333e^{-2t})u(t)$  V
- 15.45**  $(5e^{-4t} \cos 2t + 230e^{-4t} \sin 2t)u(t)$  V,  
 $6u(t) - 6e^{-4t} \cos 2t - 11.37e^{-4t} \sin 2t$  A,  $t > 0$
- 15.47**  $(e^{-5t} - e^{-2t})u(t)$
- 15.49**  $2.91(e^{-4.581t} - e^{-0.438t})u(t)$
- 15.51**  $12u(t)$
- 15.53** (a)  $[0.6 - 0.6e^{-2t} \cos t - 0.2e^{-2t} \sin t]u(t)$ ,  
(b)  $[6e^{-2t} + 6te^{-2t} - 6e^{-2t} \cos t - 6e^{-2t} \sin t]u(t)$
- 15.55**  $\frac{20}{2s^2 + 9s + 30}$
- 15.57** 9
- 15.59** (a)  $\frac{1}{s^3 + 2s^2 + 3s + 2}$ , (b)  $\frac{1}{s^3 + s^2 + 2s + 2}$ , (c)  $\frac{1}{s^3 + s^2 + 3s + 2}$ ,  
(d)  $\frac{1}{s^3 + 2s^2 + 3s + 2}$

$$15.61 \quad (a) \frac{R}{L} e^{-Rt/L} u(t), (b) (1 - e^{-Rt/L}) u(t)$$

$$15.63 \quad 0.5e^{-t/2} u(t)$$

$$15.65 \quad (a) y(t) = \begin{cases} \frac{1}{2}t^2, & 0 < t < 1 \\ -\frac{1}{2}t^2 + 2t - 1, & 1 < t < 2 \\ 1, & t > 2 \\ 0, & \text{otherwise} \end{cases}$$

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

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

15.67 Proof

$$15.69 \quad \frac{1}{2}t \cos t + \frac{1}{2} \sin t$$

$$15.71 \quad \frac{9}{26} \cos 2t + \frac{6}{26} \sin 2t + \frac{17}{26} e^{-t} \cos 3t - \frac{47}{78} e^{-t} \sin 2t$$

$$15.73 \quad \frac{27}{4} e^{-2t} - \frac{75}{13} e^{-3t} + \frac{1}{52} \cos 2t + \frac{5}{52} \sin 2t$$

$$15.75 \quad \left[ \frac{1}{10} e^{-2t} - \frac{1}{26} e^{-4t} - \frac{4}{65} e^{-t} \cos 2t - \frac{1}{130} e^{-t} \sin 2t \right] u(t)$$

$$15.77 \quad -0.4 \sin 2t + \cos 3t + 0.6 \sin 3t$$

$$15.79 \quad -6.235e^{-t} + 7.329e^{-1.5t} - 0.0935 \cos 4t - 0.06445 \sin 4t$$

$$15.81 \quad (a) (e^{-t} - e^{-4t})u(t), (b) \text{stable}$$

$$15.83 \quad L = 0.333 \text{ H}, C = 0.5 \text{ F}$$

$$15.85 \quad C_1 = C_2 = 100 \mu\text{F}$$

$$15.87 \quad a = -100, b = 400, c = 20,000$$

15.89 Proof

## Chapter 16

16.1 (a) periodic, 2, (b) not periodic, (c) periodic, 2, (d) periodic,  $\pi$ , (e) periodic, 10, (f) not periodic, (g) not periodic

$$16.3 \quad a_0 = 3, 75, a_n = \begin{cases} -\frac{5}{n\pi} (-1)^{n-1/2}, & n = \text{odd} \\ 0, & n = \text{even} \end{cases},$$

$$b_n = \frac{5}{n\pi} \left[ 3 - 2 \cos n\pi - \cos \frac{n\pi}{2} \right]$$

$$16.5 \quad \frac{2\pi^2}{3} - \sum_{n=1}^{\infty} \frac{4}{n^2} \cos nt$$

$$16.7 \quad 2 + \sum_{n=1}^{\infty} \left[ \frac{10}{n^3 + 1} \cos \frac{n\pi}{4} \cos n\pi t - \frac{10}{n^3 + 1} \sin \frac{n\pi}{4} \sin 2nt \right]$$

- 16.9**  $\frac{8}{\pi^2} \left[ \sin \frac{\pi t}{2} - \frac{1}{9} \sin \frac{3\pi t}{2} + \frac{1}{25} \sin \frac{5\pi t}{2} + \cdots \right]$
- 16.11** (a)  $\pi$ , odd, (b)  $2\pi/3$ , even, (c)  $\pi/2$ , even and half-wave symmetric
- 16.13**  $2 + \frac{24}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \left( \cos \frac{2n\pi}{3} - \cos \frac{n\pi}{3} \right) \cos \frac{n\pi t}{3}$ , 3.756
- 16.15**  $a_0 = 1$ ,  $b_n = 0$ ,  $a_n = \frac{16}{n^2\pi^2} \left( \cos \frac{n\pi}{2} - 1 \right) + \frac{8}{n\pi} \sin \frac{n\pi}{2}$
- 16.17** (a)  $a_2 = 0$ ,  $b_2 = -0.3183$ , (b)  $0.06366 \angle -90^\circ$ , (c) 1.384, which is 8% off the exact value of 1.5, (d) Proof
- 16.19**  $1 + \sum_{n=1}^{\infty} \frac{4}{n\pi} \left[ \left( \sin \frac{3n\pi}{2} - \sin \frac{n\pi}{2} \right) \cos \frac{n\pi t}{2} + (\cos n\pi - 1) \sin \frac{n\pi t}{2} \right]$
- 16.21**  $\sum_{k=1}^{\infty} \left[ \frac{8}{n^2\pi^2} \cos n\pi t + \frac{4}{n\pi} \sin n\pi t \right]$ ,  $n = 2k - 1$
- 16.23**  $\frac{1}{3} + \sum_{n=1}^{\infty} \frac{1}{3n^2\sqrt{1+4n^2}} \cos(3n - \tan^{-1} 2n)$  A
- 16.25**  $\frac{3}{8} + \sum_{n=\text{odd}}^{\infty} A_n \cos \left( \frac{2\pi n}{3} + \theta_n \right)$ , where  

$$A_n = \frac{\frac{6}{n\pi} \sin \frac{2n\pi}{3}}{\sqrt{9\pi^2 n^2 + (2\pi^2 n^2/3 - 3)^2}}, \theta_n = \frac{\pi}{2} - \tan^{-1} \left( \frac{2n\pi}{9} - \frac{1}{n\pi} \right)$$
- 16.27**  $\frac{100}{\pi} \sum_{k=1}^{\infty} \frac{\sin(n\pi t - 90^\circ + \tan^{-1} 5/n\pi)}{n\sqrt{25 + n^2\pi^2}}$ ,  $n = 2k - 1$  V
- 16.29**  $\frac{3}{4} + \sum_{n=1}^{\infty} V_n \cos(n\pi t + \theta_n)$  V, where  

$$V_n = \frac{12}{\sqrt{64 + n^2\pi^2}} \sqrt{\frac{4}{n^2\pi^2} + \frac{16}{\pi^4(2n-1)^4}},$$
  

$$\theta_n = \tan^{-1} \frac{n\pi}{8} - \tan^{-1} \frac{\pi(2n-1)^2}{2n}$$
- 16.31** (a) 33.91 V, (b) 6.782 A, (c) 203.1 W
- 16.33** (a) 1.155, (b) 0.8162
- 16.35** (a)  $40 + 0.01431 \cos(10t - 18.43^\circ) + 0.05821 \cos(20t - 136^\circ)$  V,  
 (b) 800 mW
- 16.37** (a)  $\frac{\pi^2}{3} + \sum_{n=-\infty, n \neq 0}^{\infty} \frac{2(-1)^n}{n^2} e^{jnt}$
- 16.39**  $\sum_{n=-\infty}^{\infty} \frac{0.6321 e^{j2n\pi t}}{1 + j2n\pi}$
- 16.41**  $\sum_{n=-\infty}^{\infty} \frac{1 + e^{-jn\pi}}{2\pi(1 - n^2)} e^{jnt}$
- 16.43**  $-3 + \sum_{n=-\infty, n \neq 0}^{\infty} \frac{3}{n^3 - 2} e^{j50nt}$

$$16.45 \quad \frac{1}{2} - \sum_{n=-\infty, n \neq 0}^{\infty} \frac{j5e^{j(2n+1)\pi t}}{(2n+1)\pi}$$

$$16.47 \quad (a) 6 + 2.571 \cos t - 3.83 \sin t + 1.638 \cos 2t - 1.147 \sin 2t + 0.906 \cos 3t - 0.423 \sin 3t + 0.47 \cos 4t - 0.171 \sin 4t, (b) 6.828$$

16.49 See Fig. E.32.

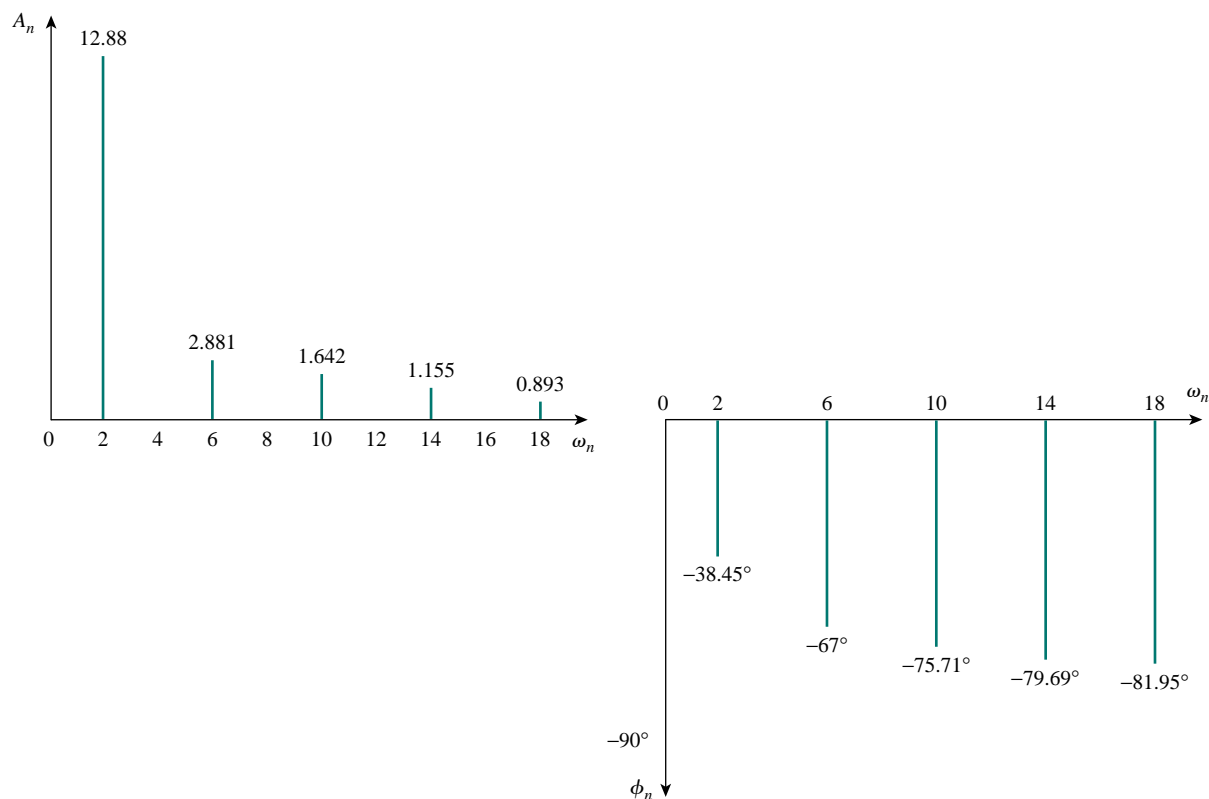


Figure E.32 For Prob. 16.49.

16.51 DC COMPONENT = 4.950000E-01

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

**16.53** DC COMPONENT = 7.658051E-01

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	5.000E-01	1.070E+00	1.000E+00	1.004E+01	0.000E+00
2	1.000E+00	3.758E-01	3.512E-01	-3.924E+01	-4.928E+01
3	1.500E+00	2.111E-01	1.973E-01	-3.985E+01	-4.990E+01
4	2.000E+00	1.247E-01	1.166E-01	-5.870E+01	-6.874E+01
5	2.500E+00	8.538E-02	7.980E-02	-5.680E+01	-6.685E+01
6	3.000E+00	6.139E-02	5.738E-02	-6.563E+01	-7.567E+01
7	3.500E+00	4.743E-02	4.433E-02	-6.520E+01	-7.524E+01
8	4.000E+00	3.711E-02	3.469E-02	-7.222E+01	-8.226E+01
9	4.500E+00	2.997E-02	2.802E-02	-7.088E+01	-8.092E+01

**16.55**  $\frac{20}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \left( 1 - \cos \frac{2n\pi}{5} \right) \sin \frac{2n\pi t}{5}$

**16.57** (a)  $4 + 10 \cos(100\pi t - 36.87^\circ) - 5 \cos(200\pi t - 36.87^\circ)$  A, (b) 157 W

**16.59** (a)  $\pi$ , (b) 2 V, (c) 11.02 V

**16.61** See below for the program in Fortran and the results.

```

C FOR PROBLEM 16.16
      DIMENSION B(20)

      A = 10
      PIE = 3.142
      C = 4.*A/PIE
      DO 10 N=1, 10
        B(N) = C/(2.*FLOAT(N) - 1.)
        PRINTS *, N, B(N)
10    CONTINUE
      STOP
      END

```

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

**16.63** (a)  $\frac{A^2}{2}$ , (b)  $c_1 = \frac{8A^2}{9\pi^2}$ ,  $c_2 = \frac{2A^2}{225\pi^2}$ ,  $c_3 = \frac{8A^2}{1225\pi^2}$ ,  $c_4 = \frac{8A^2}{3969\pi^2}$ ,

(c) 81.1%, (d) 0.72%

## Chapter 17

$$17.1 \quad \frac{2(\cos 2\omega - \cos \omega)}{j\omega}$$

$$17.3 \quad \frac{j}{\omega^2}(\sin 2\omega - 2\omega \cos 2\omega)$$

$$17.5 \quad (a) \frac{1}{j\omega}(2 - e^{-j\omega} - e^{-j2\omega}), (b) \frac{2}{\omega^2}[e^{-j\omega} + j\omega e^{-j\omega^2} - 1]$$

$$17.7 \quad \frac{\pi}{\omega^2 - \pi^2}(e^{-j\omega^2} - 1)$$

$$17.9 \quad (a) \frac{-(1 + j\omega)}{(1 + j\omega)^2 + 9}, (b) \frac{2j\pi \sin \omega}{\pi^2 - \omega^2}, (c) \frac{-(2 + j\omega)e^{j\omega-2}}{(2 + j\omega)^2 + \pi^2},$$

$$(d) \frac{j\omega - 2}{(\omega - 2)^2 + 16}, (e) \frac{6}{j\omega}e^{-j\omega^2} + 3 - 2\pi\delta(\omega)e^{-j\omega^2}$$

$$17.11 \quad (a) -4\pi|\omega|, (b) 4\pi e^{-2|\omega|}$$

$$17.13 \quad \frac{1 + j\omega}{2 + j2\omega - \omega^2}$$

$$17.15 \quad (a) \text{Proof}, (b) \frac{1}{2}\delta(\omega) - \sum_{\substack{n=-\infty \\ n \neq 0 \\ n = \text{odd}}}^{\infty} \frac{j}{n\pi}\delta(\omega - n)$$

$$17.17 \quad (a) \frac{30}{(6 - j\omega)(15 - j\omega)}, (b) \frac{20e^{-j\omega/2}}{(4 + j\omega)(10 + j\omega)},$$

$$(c) \frac{5}{[2 + j(\omega + 2)][5 + j(\omega + 2)]} + \frac{5}{[2 + j(\omega - 2)][5 + j(\omega - 2)]},$$

$$(d) \frac{j\omega 10}{(2 + j\omega)(5 + j\omega)}, (e) \frac{10}{j\omega(2 + j\omega)(5 + j\omega)} + \pi\delta(\omega)$$

$$17.19 \quad (a) \frac{5}{2}\text{sgn}(t) - 5e^{-2t}u(t), (b) (-5e^{-t} + 6e^{-2t})u(t)$$

$$17.21 \quad (a) 0.05, (b) \frac{(-2 + j)}{2\pi}e^{-j2t}, (c) \frac{(1 - j)}{\pi}e^{jt}, (d) u(t) - e^{-5t}$$

$$17.23 \quad (a) e^{(t+1)}u(-t - 1), (b) \frac{2}{\pi(t^2 + 1)},$$

$$(c) \frac{1}{4}(t + 1)e^{-t}u(t) + \frac{1}{4}(t - 1)e^t u(t), (d) \frac{1}{2\pi}$$

$$17.25 \quad \frac{20}{\pi} \text{sinc } 2t + \frac{10}{\pi} \text{sinc } t$$

$$17.27 \quad \frac{j\omega}{4 + j3\omega}$$

$$17.29 \quad \frac{1}{2}[\text{sgn}(t) + \text{sgn}(t - 2) - 2\text{sgn}(t - 1)] - e^{-0.5t}u(t)$$

$$-e^{-0.5(t-2)}u(t - 2) - 2e^{-0.5(t-1)}u(t - 1)$$

$$17.31 \quad 4\delta(t) - 8e^{-2t}u(t) \text{ A}$$

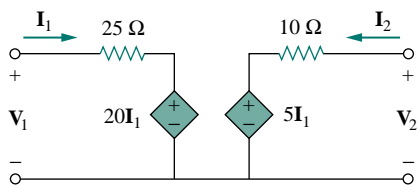
$$17.33 \quad -3e^{-2t} + 1.875e^{2t}u(-t) - 1.125e^{-6t} \cos 8tu(t) + 0.375e^{-6t} \sin 8tu(t) \text{ V}$$



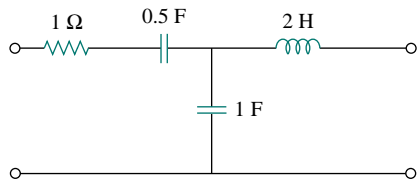
- 17.35**  $\frac{8(2 + j\omega)}{2 + j\omega 5 - 3\omega^2}$   
**17.37**  $0.542 \cos(t + 13.64^\circ) \text{ V}$   
**17.39**  $\frac{1}{6}$   
**17.41** 8 J  
**17.43** 0.15 J  
**17.45** (a) 5 kHz, (b) 4.9 kHz, (c) 5.1 kHz  
**17.47**  $6.5 < f < 9.6 \text{ kHz}$ ,  $10.4 < f < 13.5 \text{ kHz}$   
**17.49** 100 stations  
**17.51** 111 ns  
**17.53** 21.37%

## Chapter 18

- 18.1**  $\begin{bmatrix} 4 & 1 \\ 1 & 1.667 \end{bmatrix} \Omega$   
**18.3** (a)  $\begin{bmatrix} 1 + j & j \\ j & 0 \end{bmatrix} \Omega$ , (b)  $\begin{bmatrix} 1.5 + j0.5 & 1.5 - j0.5 \\ 1.5 - j0.5 & 1.5 - j1.5 \end{bmatrix} \Omega$   
**18.5**  $\begin{bmatrix} \frac{s^2 + s + 1}{s^3 + 2s^2 + 3s + 1} & \frac{1}{s^3 + 2s^2 + 3s + 1} \\ \frac{1}{s^3 + 2s^2 + 3s + 1} & \frac{s^2 + 2s + 2}{s^3 + 2s^2 + 3s + 1} \end{bmatrix} \Omega$   
**18.7**  $\begin{bmatrix} 1.6667 & 0.2222 \\ -0.6667 & 1.111 \end{bmatrix} \Omega$   
**18.9** See Fig. E.33.



(a)



(b)

Figure E.33 For Prob. 18.9.

**18.11** 5.877 kW

**18.13**  $Z_{Th} = 6.4 \, \Omega$ ,  $V_{Th} = 6 \angle 90^\circ \text{ V}$ ,  $3.18 \cos(2t + 148^\circ) \text{ V}$

**18.15** 
$$\begin{bmatrix} \frac{1}{8} & -\frac{1}{12} \\ -\frac{1}{12} & \frac{1}{2} \end{bmatrix} \text{ S}$$

**18.17** See Fig. E.34.

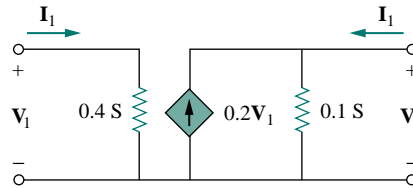


Figure E.34 For Prob. 18.17.

**18.19** See Fig. E.35.

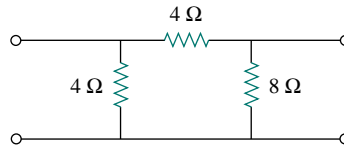


Figure E.35 For Prob. 18.19.

**18.21** 
$$\begin{bmatrix} 0.25 & 0.25 \\ 5 & 0.6 \end{bmatrix} \Omega$$

**18.23** (a) 8 V, 22 V, (b) same

**18.25** 
$$\begin{bmatrix} 3.8 \, \Omega & 0.4 \\ -3.6 & 0.2 \text{ S} \end{bmatrix}$$

**18.27** 
$$\begin{bmatrix} 85 \, \Omega & 0.25 \\ 14.75 & 0.0725 \text{ S} \end{bmatrix}, \begin{bmatrix} 0.02929 \text{ S} & -0.101 \\ -5.96 & 34.34 \, \Omega \end{bmatrix}$$

**18.29** (a) 0.2941, (b)  $-1.6$ , (c)  $7.353 \times 10^{-3} \text{ S}$ , (d)  $40 \, \Omega$

**18.31**  $800 \, \Omega$

**18.33** Proof

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

**18.37** 
$$\begin{bmatrix} -3.5 & \frac{5}{6} \, \Omega \\ -2.5 \text{ S} & 0.5 \end{bmatrix}$$

$$18.39 \quad \begin{bmatrix} \frac{2}{2s+1} & \frac{1}{s} \\ \frac{(s+1)(3s+1)}{s} & 2 + \frac{1}{s} \end{bmatrix}$$

$$18.41 \quad \begin{bmatrix} 2 & 2+j5 \\ j & -2+j \end{bmatrix}$$

$$18.43 \quad z_{11} = \frac{A}{C}, z_{12} = \frac{AD-BC}{C}, z_{21} = \frac{1}{C}, z_{22} = \frac{D}{C}$$

18.45 Proof

$$18.47 \quad (a) \begin{bmatrix} 1 & -2 \\ -2 & 4.4 \end{bmatrix} \text{ S}, (b) \begin{bmatrix} 2.2 & 0.5 \, \Omega \\ 0.2 \text{ S} & 0.5 \end{bmatrix}$$

$$18.49 \quad (a) \begin{bmatrix} 1.786 & 0.7143 \\ 0.3571 & 2.143 \end{bmatrix} \Omega, (b) \begin{bmatrix} 1.667 \, \Omega & 0.3333 \\ -0.1667 & 0.4667 \text{ S} \end{bmatrix},$$

$$(c) \begin{bmatrix} 3 & 5 \, \Omega \\ 1.4 \text{ S} & 2.5 \end{bmatrix}$$

$$18.51 \quad \begin{bmatrix} 40 & 0 \\ 105 & 40 \end{bmatrix} \text{ k}\Omega, \begin{bmatrix} 0.381 & 15.24 \text{ k}\Omega \\ 9.52 \, \mu\text{S} & 0.381 \end{bmatrix}$$

$$18.53 \quad \begin{bmatrix} \frac{1}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{2}{3} \end{bmatrix} \text{ S}$$

$$18.55 \quad \begin{bmatrix} 1.25 & 0.75 \, \Omega \\ 0.75 \text{ S} & 1.25 \end{bmatrix}$$

$$18.57 \quad \begin{bmatrix} 0.063 + j0.1954 & -0.103 + j0.144 \\ -0.103 + j0.1446 & 0.183 - j0.205 \end{bmatrix} \text{ S}$$

$$18.59 \quad \begin{bmatrix} 0.06 \text{ S} & -1.3 \\ 0.7 & 23.5 \, \Omega \end{bmatrix}$$

$$18.61 \quad \begin{bmatrix} 7 & 12 \, \Omega \\ 4 \text{ S} & 7 \end{bmatrix}, \frac{12}{7} \, \Omega$$

$$18.63 \quad \begin{bmatrix} 0.1269 & 0.01154 \\ 0.01154 & -0.03923 \end{bmatrix} \text{ S}$$

$$18.65 \quad \begin{bmatrix} 4.669 \angle -136.7^\circ & 2.53 \angle -108.4^\circ \\ 2.53 \angle -108.4^\circ & 1.789 \angle -153.4^\circ \end{bmatrix} \Omega$$

$$18.67 \quad \begin{bmatrix} 1.5 & -0.5 \\ 3.5 & 1.5 \end{bmatrix} \text{ S}$$

$$18.69 \quad \begin{bmatrix} 1.4 & -0.8 \, \Omega \\ 1.4 \text{ S} & -1.8 \end{bmatrix}$$

$$18.71 \quad \begin{bmatrix} 2.727 \text{ S} & 0 \\ 0 & 0 \end{bmatrix}$$

$$\mathbf{18.73} \quad Z_{\text{in}} = \frac{y_{22} + Y_L}{\Delta y + y_{11}Y_L}, \quad Z_{\text{out}} = \frac{y_{11} + Y_s}{\Delta y + y_{22}Y_s}, \quad A_i = \frac{-y_{21}Y_L}{\Delta y + y_{11}Y_L},$$

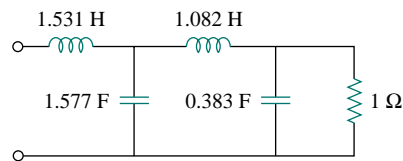
$$A_v = \frac{-y_{21}}{y_{22} + Y_L}$$

**18.75** (a) 250 k $\Omega$ , (b) -3333, 20, 65 k $\Omega$ , (c) -13.33 V

**18.77** -17.1, 89.29, 25.63 k $\Omega$ , 182.9 k $\Omega$

**18.79**  $2 \times 10^5$ , 200  $\Omega$

**18.81** See Fig. E.36.



**Figure E.36** For Prob. 18.81.

**18.83** Proof