
SOLUTIONS MANUAL
electronic devices
conventional current version
Wii
FLOYD

Chapter 1
Introduction to Electronics

Section 1-1 Atomic Structure

1. An atom with an atomic number of 6 has **6 electrons** and **6 protons**.

2. The third shell of an atom can have $2n^2 = 2(3)^2 =$ **18 electrons**.

Section 1-2 Materials Used in Electronics

3. The materials represented in Figure 1−21 in the textbook are
(a) insulator (b) semiconductor (c) conductor

4. An atom with four valence electrons is a **semiconductor**.

5. In a silicon crystal, each atom forms **four** covalent bonds.

Section 1-3 Current in Semiconductors

6. When heat is added to silicon, more free electrons and holes are produced.

7. Current is produced in silicon at the **conduction** band and the **valence** band.

Section 1-4 N-Type and P-Type Semiconductors

8. Doping is the carefully controlled addition of trivalent or pentavalent atoms to pure (intrinsic) semiconductor material for the purpose of increasing the number of majority carriers (free electrons or holes).

9. Antimony is a pentavalent (donor) material used for doping to increase free electrons. Boron is a trivalent (acceptor) material used for doping to increase the holes.

Section 1-5 The PN Junction

10. The electric field across the *pn* junction of a diode is created by donor atoms in the *n* region losing free electrons to acceptor atoms in the *p* region. This creates positive ions in the *n* region near the junction and negative ions in the *p* region near the junction. A field is then established between the ions.

11. The barrier potential of a diode represents an energy gradient that must be overcome by conduction electrons and produces a voltage drop, not a source of energy.

Chapter 2
Diode Applications

Section 2-1 Diode Operation

1. To forward-bias a diode, the positive terminal of a voltage source must be connected to the ***p* region**.

2. A series resistor is needed to **limit the current** through a forward-biased diode to a value that will not damage the diode because the diode itself has very little resistance.

Section 2-2 Voltage-Current Characteristic of a Diode

3. To generate the forward bias portion of the characteristic curve, connect a voltage source across the diode for forward bias and place an ammeter in series with the diode and a voltmeter across the diode. Slowly increase the voltage from zero and plot the forward voltage versus the current.

4. A temperature increase would cause the barrier potential of a silicon diode to decrease from 0.7 V to 0.6 V.

Section 2-3 Diode Models

5. (a) The diode is reverse-biased.
(b) The diode is forward-biased.
(c) The diode is forward-biased.
(d) The diode is forward-biased.

6. (a) $V_R = 5\text{ V} - 8\text{ V} = \mathbf{-3\ V}$
(b) $V_F = \mathbf{0.7\ V}$
(c) $V_F = \mathbf{0.7\ V}$
(d) $V_F = \mathbf{0.7\ V}$

7. (a) $V_R = 5\text{ V} - 8\text{ V} = \mathbf{-3\ V}$
(b) $V_F = \mathbf{0\ V}$
(c) $V_F = \mathbf{0\ V}$
(d) $V_F = \mathbf{0\ V}$

8. Ignoring r'_R:
(a) $V_R \cong 5\text{ V} - 8\text{ V} = \mathbf{-3\ V}$

(b) $$I_F = \frac{100\text{ V} - 0.7\text{ V}}{560\ \Omega + 10\ \Omega} = 174\text{ mA}$$

$$V_F = I_F r'_d + V_B = (174\text{ mA})(10\ \Omega) + 0.7\text{ V} = \mathbf{2.44\ V}$$

(c) $I_{tot} = \dfrac{30\text{ V}}{R_{tot}} = \dfrac{30\text{ V}}{4.85\text{ k}\Omega} = 6.19\text{ mA}$

$I_F = \dfrac{6.19\text{ mA}}{2} = 3.1\text{ mA}$

$V_F = I_F r_d' + 0.7\text{ V} = (3.1\text{ mA})(10\ \Omega) + 0.7\text{ V} = \mathbf{0.731\ V}$

(d) Approximately all of the current from the 20 V source is through the diode. No current from the 10 V source is through the diode.

$I_F = \dfrac{20\text{ V} - 0.7\text{ V}}{10\text{ k}\Omega + 10\ \Omega} = 1.92\text{ mA}$

$V_F = (1.92\text{ mA})(10\ \Omega) + 0.7\text{ V} = \mathbf{0.719\ V}$

Section 2-4 Half-Wave Rectifiers

9. See Figure 2-1.

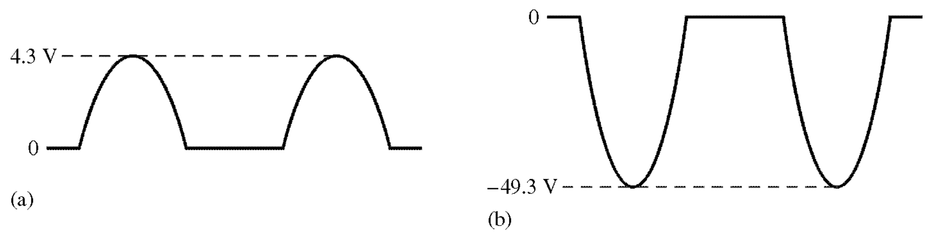

Figure 2-1

10. (a) PIV = V_p = **5 V** (b) PIV = V_p = **50 V**

11. $V_{AVG} = \dfrac{V_p}{\pi} = \dfrac{200\text{ V}}{\pi} = \mathbf{63.7\ V}$

12. (a) $I_F = \dfrac{V_{(p)in} - 0.7\text{ V}}{R} = \dfrac{5\text{ V} - 0.7\text{ V}}{47\ \Omega} = \dfrac{4.3\text{ V}}{47\ \Omega} = \mathbf{91.5\ mA}$

(b) $I_F = \dfrac{V_{(p)in} - 0.7\text{ V}}{R} = \dfrac{50\text{ V} - 0.7\text{ V}}{3.3\text{ k}\Omega} = \dfrac{49.3\text{ V}}{3.3\text{ k}\Omega} = \mathbf{14.9\ mA}$

13. $V_{sec} = nV_{pri} = (0.2)120\text{ V} = \mathbf{24\ V\ rms}$

14. $V_{sec} = nV_{pri} = (0.5)120\text{ V} = 60\text{ V rms}$

$V_{p(sec)} = 1.414(60\text{ V}) = 84.8\text{ V}$

$V_{avg(sec)} = \dfrac{V_{p(sec)}}{\pi} = \dfrac{84.8\text{ V}}{\pi} = 27.0\text{ V}$

$P_{L(p)} = \dfrac{\left(V_{p(sec)} - 0.7\text{ V}\right)^2}{R_L} = \dfrac{(84.1\text{ V})^2}{220\ \Omega} = \mathbf{32.1\ W}$

$P_{L(avg)} = \dfrac{\left(V_{avg(sec)}\right)^2}{R_L} = \dfrac{(27.0\text{ V})^2}{220\ \Omega} = \mathbf{3.31\ W}$

Chapter 2

Section 2-5 Full-Wave Rectifiers

15. (a) $V_{AVG} = \dfrac{V_p}{\pi} = \dfrac{5\text{ V}}{\pi}$ = **1.59 V**

(b) $V_{AVG} = \dfrac{2V_p}{\pi} = \dfrac{2(100\text{ V})}{\pi}$ = **63.7 V**

(c) $V_{AVG} = \dfrac{2V_p}{\pi} + 10\text{ V} = \dfrac{2(10\text{ V})}{\pi}$ + 10 V = **16.4 V**

(d) $V_{AVG} = \dfrac{2V_p}{\pi} - 15\text{ V} = \dfrac{2(40\text{ V})}{\pi}$ − 15 V = **10.5 V**

16. (a) Center-tapped full-wave rectifier

(b) $V_{p(sec)}$ = (0.25)(1.414)120 V = **42.4 V**

(c) $\dfrac{V_{p(sec)}}{2} = \dfrac{42.4\text{ V}}{2}$ = **21.2 V**

(d) See Figure 2-2. V_{RL} = 21.2 V − 0.7 V = 20.5 V

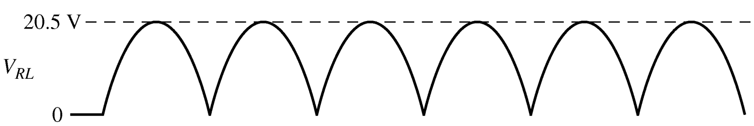

Figure 2-2

(e) $I_F = \dfrac{\dfrac{V_{p(sec)}}{2} - 0.7\text{ V}}{R_L} = \dfrac{20.5\text{ V}}{1.0\text{ k}\Omega}$ = **20.5 mA**

(f) PIV = 21.2 V + 20.5 V = **41.7 V**

17. $V_{AVG} = \dfrac{120\text{ V}}{2}$ = 60 V for each half

$V_{AVG} = \dfrac{V_p}{\pi}$

$V_p = \pi V_{AVG} = \pi(60\text{ V})$ = **186 V**

18. See Figure 2-3.

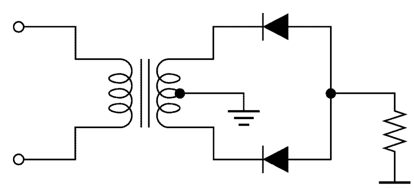

Figure 2-3

19. PIV = $V_p = \frac{\pi V_{AVG(out)}}{2} = \frac{\pi(50\text{ V})}{2}$ = **78.5 V**

20. PIV = $V_{p(out)}$ = 1.414(20 V) = **28.3 V**

21. See Figure 2-4.

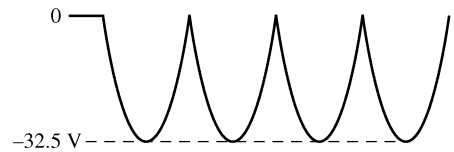

Figure 2-4

Section 2-6 Power Supply Filters and Regulators

22. $V_{r(pp)} = 0.5\text{ V}$

$$r = \frac{V_{r(pp)}}{V_{DC}} = \frac{0.5\text{ V}}{75\text{ V}} = \mathbf{0.00667}$$

23. $$V_{r(pp)} = \frac{V_{p(in)}}{fR_LC} = \frac{30\text{ V}}{(120\text{ Hz})(600\,\Omega)(50\,\mu\text{F})} = \mathbf{8.33\text{ V pp}}$$

$$V_{DC} = \left(1 - \frac{1}{2fR_LC}\right)V_{p(in)} = \left(1 - \frac{1}{(240\text{ Hz})(600\,\Omega)(50\,\mu\text{F})}\right)30\text{ V} = \mathbf{25.8\text{ V}}$$

24. $$\%r = \left(\frac{V_{r(pp)}}{V_{DC}}\right)100 = \left(\frac{8.33\text{ V}}{25.8\text{ V}}\right)100 = \mathbf{32.3\%}$$

25. $V_{r(pp)} = (0.01)(18\text{ V}) = 180\text{ mV}$

$$V_{r(pp)} = \left(\frac{1}{fR_LC}\right)V_{p(in)}$$

$$C = \left(\frac{1}{fR_LV_r}\right)V_{p(in)} = \left(\frac{1}{(120\text{ Hz})(1.5\text{ k}\Omega)(180\text{ mV})}\right)18\text{ V} = \mathbf{556\,\mu F}$$

26. $$V_{r(pp)} = \frac{V_{p(in)}}{fR_LC} = \frac{80\text{ V}}{(120\text{ Hz})(10\text{ k}\Omega)(10\,\mu\text{F})} = 6.67\text{ V}$$

$$V_{DC} = \left(1 - \frac{1}{2fR_LC}\right)V_{p(in)} = \left(1 - \frac{1}{(240\text{ Hz})(10\text{ k}\Omega)(10\,\mu\text{F})}\right)80\text{ V} = 76.7\text{ V}$$

$$r = \frac{V_{r(pp)}}{V_{DC}} = \frac{6.67\text{ V}}{76.7\text{ V}} = \mathbf{0.087}$$

27. $V_{p(sec)} = (1.414)(36\text{ V}) = 50.9\text{ V}$

$V_{r(rect)} = V_{p(sec)} - 1.4\text{ V} = 50.9\text{ V} - 1.4\text{ V} = 49.5\text{ V}$

Neglecting R_{surge}, $V_{r(pp)} = \left(\frac{1}{fR_LC}\right)V_{p(rect)} = \left(\frac{1}{(120\text{ Hz})(3.3\text{ k}\Omega)(100\ \mu\text{F})}\right)49.5\text{ V} = \mathbf{1.25\ V}$

$V_{DC} = \left(1 - \frac{1}{2fR_LC}\right)V_{p(rect)} = V_{p(rect)} - \frac{V_{r(pp)}}{2} = 49.5\text{ V} - 0.625\text{ V} = \mathbf{48.9\ V}$

28. $V_{p(sec)} = 1.414(36\text{ V}) = 50.9\text{ V}$
See Figure 2-5.

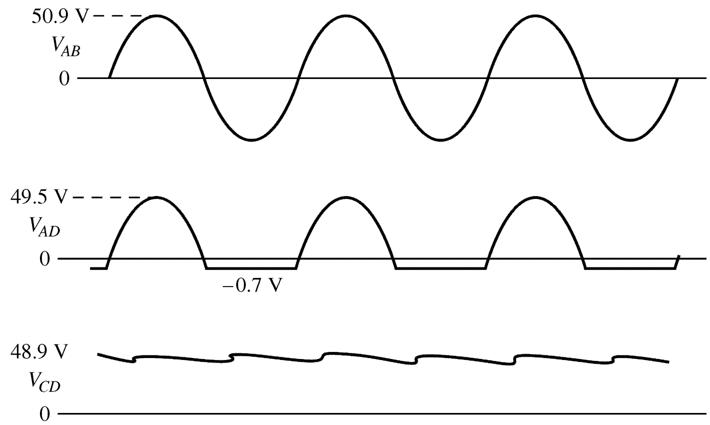

Figure 2-5

29. Load regulation $= \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right)100\% = \left(\frac{15.5\text{ V} - 14.9\text{ V}}{14.9\text{ V}}\right)100\% = \mathbf{4\%}$

30. $V_{FL} = V_{NL} - (0.005)V_{NL} = 12\text{ V} - (0.005)12\text{ V} = \mathbf{11.94\ V}$

Section 2-7 Diode Limiters and Clampers

31. See Figure 2-6.

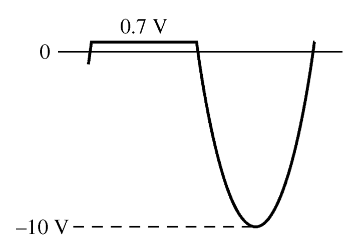

Figure 2-6

32. Apply Kirchhoff's law at the peak of the positive half cycle:

(b) $25\text{ V} = V_{R1} + V_{R2} + 0.7\text{ V}$
$2V_R = 24.3\text{ V}$
$V_R = \dfrac{24.3\text{ V}}{2} = 12.15\text{ V}$
$V_{out} = V_R + 0.7\text{ V} = 12.15\text{ V} + 0.7\text{ V} = 12.85\text{ V}$
See Figure 2-7(a).

(c) $V_R = \dfrac{11.3\text{ V}}{2} = 5.65\text{ V}$
$V_{out} = V_R + 0.7\text{ V} = 5.65\text{ V} + 0.7\text{ V} = 6.35\text{ V}$
See Figure 2-7(b).

(d) $V_R = \dfrac{4.3\text{ V}}{2} = 2.15\text{ V}$
$V_{out} = V_R + 0.7\text{ V} = 2.15\text{ V} + 0.7\text{ V} = 2.85\text{ V}$
See Figure 2-7(c).

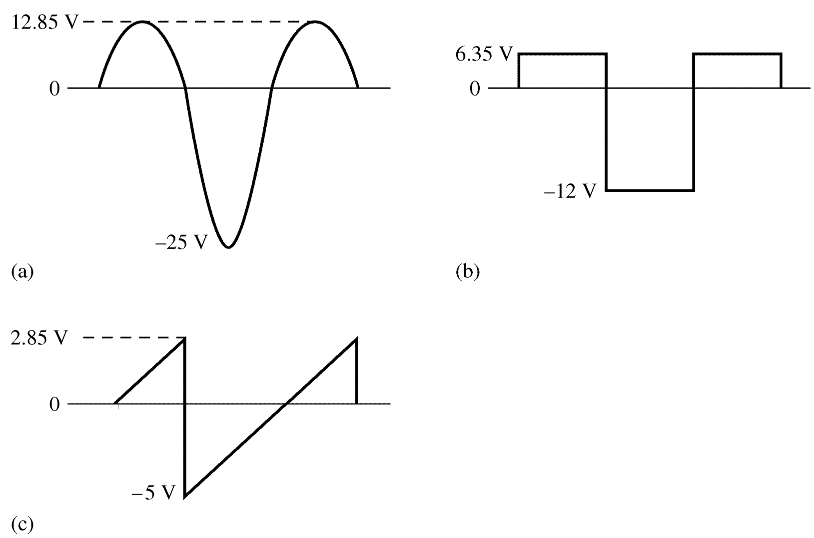

Figure 2-7

33. See Figure 2-8.

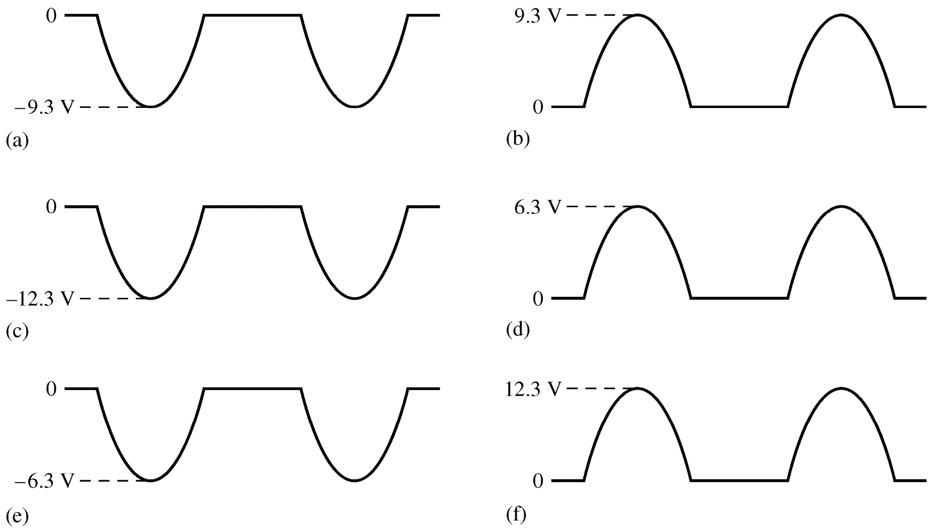

Figure 2-8

34. See Figure 2-9.

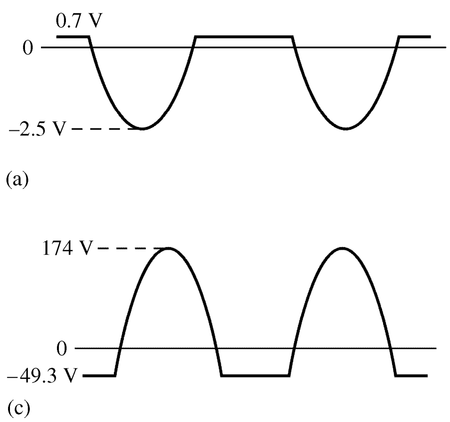

Figure 2-9

35. See Figure 2-10.

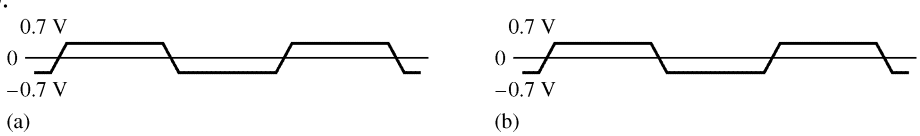

Figure 2-10

36. (a) $I_p = \dfrac{30\text{ V} - 0.7\text{ V}}{2.2\text{ k}\Omega}$ **= 13.3 mA**

(b) Same as (a).

37. (a) $I_p = \dfrac{30\text{ V} - (12\text{ V} + 0.7\text{ V})}{2.2\text{ k}\Omega}$ **= 7.86 mA**

(b) $I_p = \dfrac{30\text{ V} - (12\text{ V} - 0.7\text{ V})}{2.2\text{ k}\Omega}$ **= 8.5 mA**

(c) $I_p = \dfrac{30\text{ V} - (-11.3\text{ V})}{2.2\text{ k}\Omega}$ **= 18.8 mA**

(d) $I_p = \dfrac{30\text{ V} - (-12.7\text{ V})}{2.2\text{ k}\Omega}$ **= 19.4 mA**

38. See Figure 2-11.

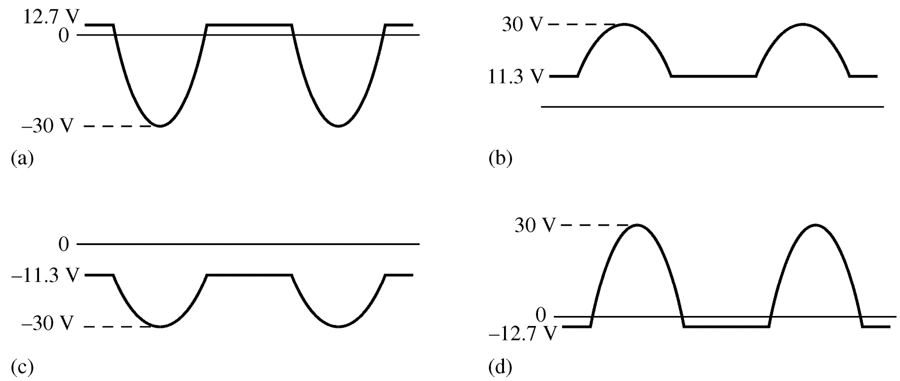

Figure 2-11

39. (a) A sine wave with a positive peak at 0.7 V, a negative peak at −7.3 V, and a dc value of −3.3 V.
(b) A sine wave with a positive peak at 29.3 V, a negative peak at −0.7 V, and a dc value of +14.3 V.
(c) A square wave varying from +0.7 V to −15.3 V with a dc value of −7.3 V.
(d) A square wave varying from +1.3 V to −0.7 V with a dc value of +0.3 V.

40. (a) A sine wave varying from −0.7 V to +7.3 V with a dc value of +3.3 V.
(b) A sine wave varying from −29.3 V to +7.3 V with a dc value of +14.3 V.
(c) A square wave varying from −0.7 V to +15.3 V with a dc value of +7.3 V.
(d) A square wave varying from −1.3 V to +0.7 V with a dc value of −0.3 V.

Section 2-8 Voltage Multipliers

41. $V_{OUT} = 2V_{p(in)} = 2(1.414)(20\text{ V}) =$ **56.6 V**
See Figure 2-12.

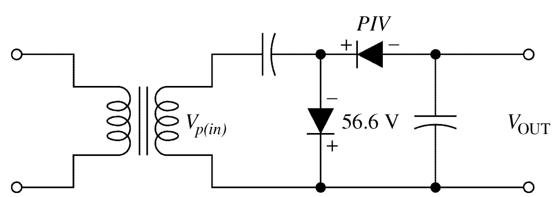

Figure 2-12

42. $V_{OUT(trip)} = 3V_{p(in)} = 3(1.414)(20\text{ V}) = \mathbf{84.8\text{ V}}$
$V_{OUT(quad)} = 4V_{p(in)} = 4(1.414)(20\text{ V}) = \mathbf{113\text{ V}}$
See Figure 2-13.

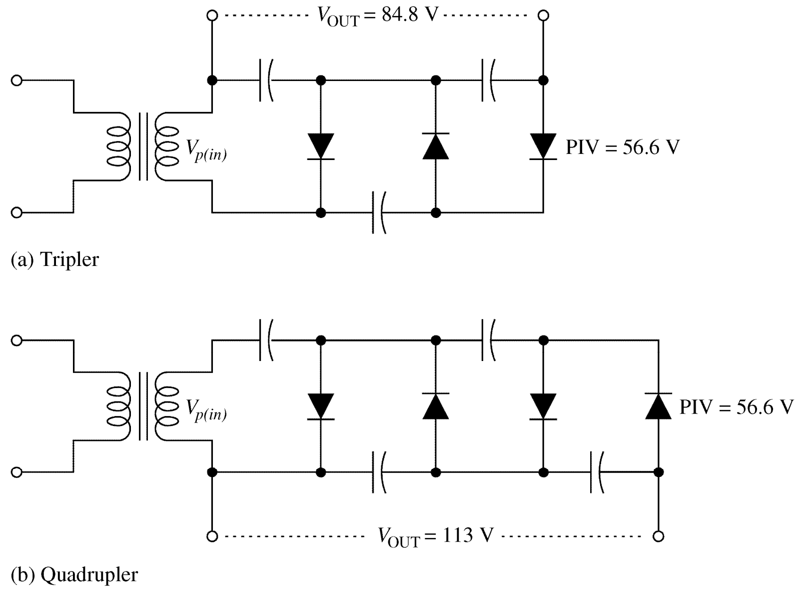

Figure 2-13

Section 2-9 The Diode Datasheet

43. The PIV is specified as the peak repetitive reverse voltage = **100 V**.

44. The PIV is specified as the peak repetitive reverse voltage = **1000 V**.

45. $I_{F(AVG)} = 1.0\text{ A}$

$$R_{L(\min)} = \frac{50\text{ V}}{1.0\text{ A}} = \mathbf{50\ \Omega}$$

Section 2-10 Troubleshooting

46. (a) Since $V_D = 25\text{ V} = 0.5V_S$, the diode is **open**.
(b) The diode is forward-biased but since $V_D = 15\text{ V} = V_S$, the diode is **open.**
(c) The diode is reverse-biased but since $V_R = 2.5\text{ V} = 0.5V_S$, the diode is **shorted**.
(d) The diode is reverse-biased and $V_R = 0\text{ V}$. The diode is **operating properly.**

47. $V_A = V_{S1} = \mathbf{+25\text{ V}}$
$V_B = V_{S1} - 0.7\text{ V} = 25\text{ V} - 0.7\text{ V} = \mathbf{+24.3\text{ V}}$
$V_C = V_{S2} + 0.7\text{ V} = 8\text{ V} + 0.7\text{ V} = \mathbf{+8.7\text{ V}}$
$V_D = V_{S2} = \mathbf{+8.0\text{ V}}$

48. If a bridge rectifier diode opens, the output becomes a half-wave voltage resulting in an increased ripple at 60 Hz.

49. $V_{avg} = \dfrac{2V_p}{\pi} = \dfrac{2(115\text{ V})(1.414)}{\pi} \cong 104\text{ V}$

The output of the bridge is correct. However, the 0 V output from the filter indicates that the **surge resistor is open** or that the **capacitor is shorted.**

50. (a) Correct
(b) Incorrect. Open diode.
(c) Correct
(d) Incorrect. Open diode.

51. $V_{sec} = \dfrac{120\text{ V}}{5} = 24\text{ V rms}$

$V_{p(sec)} = 1.414(24\text{ V}) = 33.9\text{ V}$

The peak voltage for each half of the secondary is

$$\frac{V_{p(sec)}}{2} = \frac{33.9\text{ V}}{2} = 17\text{ V}$$

The peak inverse voltage for each diode is PIV = 2(17 V) + 0.7 V = 34.7 V

The peak current through each diode is

$$I_p = \frac{\frac{V_{p(sec)}}{2} - 0.7\text{ V}}{R_L} = \frac{17.0\text{ V} - 0.7\text{ V}}{330\ \Omega} = 49.4\text{ mA}$$

The diode ratings exceed the actual PIV and peak current.
The circuit should not fail.

Application Activity Problems

52. (a) Not plugged into ac outlet or no ac available at outlet. Check plug and/or breaker.
(b) Open transformer winding or open fuse. Check transformer and/or fuse.
(c) Incorrect transformer installed. Replace.
(d) Leaky filter capacitor. Replace.
(e) Rectifier faulty. Replace.
(f) Rectifier faulty. Replace.

53. The rectifier must be connected backwards.

54. −16 V with 60 Hz ripple

Advanced Problems

55. $V_r = \left(\dfrac{1}{fR_LC}\right)V_{p(in)}$

$$C = \left(\frac{1}{fR_LV_r}\right)V_{p(in)} = \left(\frac{1}{(120\text{ Hz})(3.3\text{ k}\Omega)(0.5\text{ V})}\right)35\text{ V} = \mathbf{177\ \mu F}$$

56. $V_{DC} = \left(1 - \frac{1}{2fR_LC}\right)V_{p(in)}$

$$\frac{V_{DC}}{V_{p(in)}} = \left(1 - \frac{1}{2fR_LC}\right)$$

$$\frac{1}{2fR_LC} = 1 - \frac{V_{DC}}{V_{p(in)}}$$

$$\frac{1}{2fR_L\left(1 - \frac{V_{DC}}{V_{p(in)}}\right)} = C$$

$$C = \frac{1}{(240\text{ Hz})(1.0\text{ k}\Omega)(1-0.933)} = \frac{1}{(240\text{ Hz})(1.0\text{ k}\Omega)(0.067)} = 62.2\ \mu\text{F}$$

Then

$$V_r = \left(\frac{1}{fR_LC}\right)V_{p(in)} = \left(\frac{1}{(120\text{ Hz})(1.0\text{ k}\Omega)(62.2\ \mu\text{F})}\right)15\text{ V} = \mathbf{2\text{ V}}$$

57. The capacitor input voltage is

$V_{p(in)} = (1.414)(24\text{ V}) - 1.4\text{ V} = 32.5\text{ V}$

$$R_{surge} = \frac{V_{p(in)}}{I_{surge}} = \frac{32.5\text{ V}}{50\text{ A}} = \mathbf{651\text{ m}\Omega}$$

The nearest standard value is 680 mΩ.

58. See Figure 2-14.

The voltage at point A with respect to ground is

$V_A = 1.414(9\text{ V}) = 12.7\text{ V}$

Therefore,

$V_B = 12.7\text{ V} - 0.7\text{ V} = 12\text{ V}$

$V_r = 0.05V_B = 0.05(12\text{ V}) = 0.6\text{ V}$ peak to peak

$$C = \left(\frac{1}{fR_LV_r}\right)V_B = \left(\frac{1}{(120\text{ Hz})(680\ \Omega)(0.6\text{ V})}\right)12\text{ V} = 245\ \mu\text{F}$$

The nearest standard value is 270 μF.

Let $R_{surge} = 1.0\ \Omega$.

$$I_{surge(max)} = \frac{12\text{ V}}{1.0\ \Omega} = 12\text{ A}$$

$$I_{F(AV)} = \frac{12\text{ V}}{680\ \Omega} = \mathbf{17.6\text{ mA}}$$

$PIV = 2V_{p(out)} + 0.7\text{ V} = \mathbf{24.7\text{ V}}$

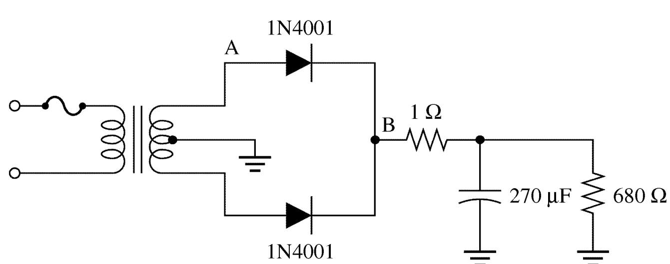

Figure 2-14

59. See Figure 2-15.

$I_{L(max)} = 100\text{ mA}$

$$R_L = \frac{9\text{ V}}{100\text{ mA}} = 90\ \Omega$$

$V_r = 1.414(0.25\text{ V}) = 0.354\text{ V}$

$V_r = 2(0.35\text{ V}) = 0.71\text{ V peak to peak}$

$$V_r = \left(\frac{1}{(120\text{ Hz})(90\ \Omega)C}\right)9\text{ V}$$

$$C = \frac{9\text{ V}}{(120\text{ Hz})(90\ \Omega)(0.71\text{ V})} = 1174\ \mu\text{F}$$

Use $C = 1200\ \mu$F.

Each half of the supply uses identical components. 1N4001 diodes are feasible since the average current is (0.318)(100 mA) = 31.8 mA.

$R_{surge} = 1.0\ \Omega$ will limit the surge current to an acceptable value.

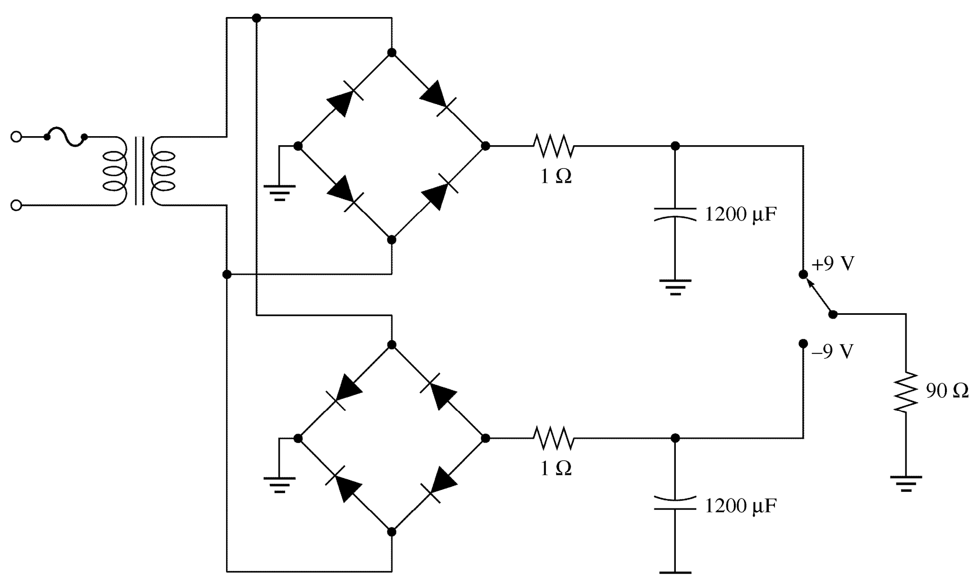

Figure 2-15

60. See Figure 2-16.

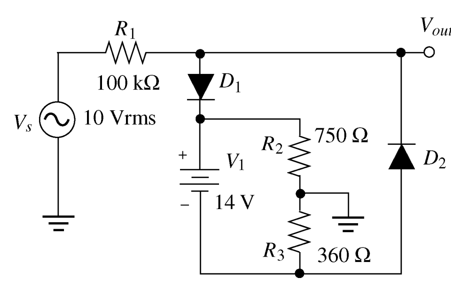

Figure 2-16

61. $V_{C1} = (1.414)(120\text{ V}) - 0.7\text{ V} = \mathbf{170\ V}$

$V_{C2} = 2(1.414)(120\text{ V}) - 2(0.7\text{ V}) = \mathbf{338\ V}$

Chapter 2

MultiSim Troubleshooting Problems

The solutions showing instrument connections for Problems 62 through 79 are available from the Instructor Resource Center. The faults in the circuit files may be accessed using the password *book* (all lowercase).

To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc to register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, locate your text in the online catalog and click on the Instructor Resources button on the left side of the catalog product page. Select a supplement, and a login page will appear. Once you have logged in, you can access instructor material for all Prentice Hall textbooks. If you have any difficulties accessing the site or downloading a supplement, please contact Customer Service at http://247.prenhall.com.

62. Diode shorted

63. Diode open

64. Diode open

65. Diode shorted

66. No fault

67. Diode shorted

68. Diode leaky

69. Diode open

70. Diode shorted

71. Diode shorted

72. Diode leaky

73. Diode open

74. Bottom diode open

75. Reduced transformer turns ratio

76. Open filter capacitor

77. Diode leaky

78. D_1 open

79. Load resistor open

Chapter 3
Special-Purpose Diodes

Section 3-1 The Zener Diode

1. See Figure 3-1.

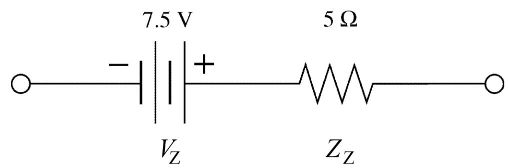

Figure 3-1

2. $I_{ZK} \cong$ **3 mA**
$V_Z \cong$ **−9 V**

3. $Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z} = \dfrac{5.65\text{ V} - 5.6\text{ V}}{30\text{ mA} - 20\text{ mA}} = \dfrac{0.05\text{ V}}{10\text{ mA}} = \mathbf{5\ \Omega}$

4. $\Delta I_Z = 50\text{ mA} - 25\text{ mA} = 25\text{ mA}$
$\Delta V_Z = \Delta I_Z Z_Z = (+25\text{ mA})(15\ \Omega) = +0.375\text{ V}$
$V_Z = V_Z + \Delta V_Z = 4.7\text{ V} + 0.375\text{ V} = \mathbf{5.08\text{ V}}$

5. $\Delta T = 70°\text{C} - 25°\text{C} = 45°\text{C}$
$V_Z = 6.8\text{ V} + \dfrac{(6.8\text{ V})(0.0004/°\text{C})}{45°\text{C}} = 6.8\text{ C} + 0.12\text{ V} = \mathbf{6.92\text{ V}}$

Section 3-2 Zener Diode Applications

6. $V_{IN(min)} = V_Z + I_{ZK}R = 14\text{ V} + (1.5\text{ mA})(560\ \Omega) = \mathbf{14.8\text{ V}}$

7. $\Delta V_Z = (I_Z - I_{ZK})Z_Z = (28.5\text{ mA})(20\ \Omega) = 0.57\text{ V}$
$V_{OUT} = V_Z - \Delta V_Z = 14\text{ V} - 0.57\text{ V} = 13.43\text{ V}$
$V_{IN(min)} = I_{ZK}R + V_{OUT} = (1.5\text{ mA})(560\ \Omega) + 13.43\text{ V} = \mathbf{14.3\text{ V}}$

8. $\Delta V_Z = I_Z Z_Z = (40\text{ mA} - 30\text{ mA})(30\ \Omega) = 0.3\text{ V}$
$V_Z = 12\text{ V} + \Delta V_Z = 12\text{ V} + 0.3\text{ V} = 12.3\text{ V}$
$R = \dfrac{V_{IN} - V_Z}{40\text{ mA}} = \dfrac{18\text{ V} - 12.3\text{ V}}{40\text{ mA}} = \mathbf{143\ \Omega}$