Instructor's Resource Manual
to accompany

Introductory Electronic Devices and Circuits

Seventh Edition

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PRACTICE PROBLEM SOLUTIONS

CHAPTER 2

EXAMPLE PRACTICE PROBLEMS (CH 2)

2-1. The applied voltage is dropped across the reverse-biased diode. Therefore, $V_{R1} = V_{R2} = 0$ V

2-2. Using the ideal model, $I_T = \frac{V_S}{R_T} = \frac{12\text{ V}}{800\,\Omega} = 15\text{ mA}$

2-3. $V_R = V_S - 0.7\text{ V} = 15\text{ V} - 0.7\text{ V} = 14.3\text{ V}$

2-4. Using the practical model,

$$I_T = \frac{V_S - V_F}{R_T} = \frac{5\text{ V} - 0.7\text{ V}}{510\,\Omega} = 8.43\text{ mA}$$

2-5. $I_T = \frac{V_S - 0.7\text{ V}}{R_T} = \frac{2\text{ V} - 0.7\text{ V}}{550\,\Omega} = 2.36\text{ mA}$

2-6. There are two forward-biased diodes. Therefore,

$$I_T = \frac{V_S - 1.4\text{ V}}{R_T} = \frac{6\text{ V} - 1.4\text{ V}}{800\,\Omega} = 5.75\text{ mA}$$

2-7. Using the ideal model, $I_T = \frac{V_S}{R_T} = \frac{6\text{ V}}{800\,\Omega} = 7.5\text{ mA}$

$$\text{Error (\%)} = \frac{|5.75\text{ mA} - 7.5\text{ mA}|}{5.75\text{ mA}} \times 100 = 30.4\,\%$$

2-8. $V_{pk} = 175$ V. Adding a safety margin: $V_{RRM} = 175\text{ V} \times 1.2 = 210$ V. Thus, diodes 1N4004 through 1N4007 could be used in this circuit.

2-9. $I_F = \frac{100\text{ V} - 0.7\text{ V}}{51\,\Omega} = 1.95\text{ A}$. Adding a safety margin: $I_0 = 1.95\text{ A} \times 1.2 = 2.34$ A (minimum)

2-10. $I_F = \frac{20\text{ V} - 0.7\text{ V}}{68\,\Omega} = 284\text{ mA}$

$P_F = 284\text{ mA} \times 0.7\text{ V} = 199\text{ mW}$. Adding a safety margin: $199\text{ mW} \times 1.2 = 239$ mW (min)

2-11. $P_F = 750\text{ mA} \times 0.7\text{ V} = 525$ mW. This exceeds the 500 mW rating.

2-12. $V_F = 0.7\text{ V} + (12\text{ mA} \times 8\,\Omega) = 0.796$ V

2-13. $I_{ZM} = \frac{P_{D(\text{max})}}{V_Z} = \frac{1\text{ W}}{27\text{ V}} = 37\text{ mA}$

2-14. The derating value is found as (4.0 mW)(125°C–75°C) = 200 mW. Now, $P_{D(\text{max})}$ at 125°C is found as 500 mW – 200 mW = 300 mW.

2-15. The V_Z rating for the replacement component must be 75 V. The $P_{D(\text{max})}$ rating can be any value that is greater than or equal to 4 W. Only one diode in the figure fulfills both requirements: the 1N5374A.

2-16. $P_D = I_Z V_Z = (175\text{ mA})(6.8\text{ V}) = 1.19$ W. The diode would need parameters of $V_Z = 6.8$ V and $P_D \geq 1.19$ W. We could use the 1N5921A or 1N5342A.

2-17. The *minimum* value of V_F is used.

$$R_S = \frac{V_{\text{out(pk)}} - V_F}{I_F} = \frac{14\text{ V} - 1.4\text{ V}}{20\text{ mA}} = 630\,\Omega.$$ The lowest standard value above 630 Ω is 680 Ω.

PRACTICE PROBLEMS (CH 2)

1. The three components are in series, with the diode pointing toward the negative (–) side of the source.
2. EFV: The arrow should point in the direction of electron flow (*against* the diode arrow). CFV: The arrow should point in the direction of conventional current (*in the direction indicated by the arrow.*)
3. The three components are in series, with the diode pointing toward the positive (+) side of the source.
4. In figures (a) and (c), the diodes are reverse biased; $I = 0$. In figure (b), the diode is forward biased. Electron flow is *against the arrow.* Conventional flow is *with the arrow.*
5. In Figure 2.45a, D_1 is reverse biased and D_2 is forward biased. Both diodes in the other two figures are forward biased. For each conducting diode, electron flow is *against the arrow* and conventional flow is *with the arrow.*
6. (a) D_1 is reverse biased, so $V_{D1} = V_S = 6$ V.
   (b) D_1 is forward biased, so $V_{D1} = 0$ V (ideal).
   (c) D_1 is reverse biased, so $V_{D1} = V_S = 3$ V (ignoring the source polarity).
7. D_1 is reverse biased; therefore, $V_{D1} = V_S = 10$ V and $V_{R1} = 0$ V. D_2 is forward biased; therefore, $V_{D2} = 0$ V and $V_{R2} = 10$ V.
8. $V_{D1} = V_S = 6$ V, $V_{R1} = 0$ V, $I_T = 0$ A
9. $V_{D1} = 0.7$ V, $V_{R1} = V_S - V_F = 1\text{ V} - 0.7\text{ V} = 0.3$ V,
   $$I_T = \frac{V_S - V_F}{R_1} = \frac{0.3\text{ V}}{100\,\Omega} = 3\text{ mA}$$
10. $V_{D1} = V_S = 3$ V, $V_{R1} = V_{R2} = 0$ V, $I_T = 0$ A
11. $V_{D1} = V_S = 10$ V, $V_{R1} = 0$ V, $I_1 = 0$ A, $V_{D2} = 0.7$ V, $V_{R2} = V_S - V_F = 9.3$ V,
    $$I_2 = \frac{V_S - V_F}{R_2} = \frac{9.3\text{ V}}{1.8\text{ k}\Omega} = 5.17\text{ mA}$$
12. There are *two* forward biased diodes, so $V_{R1} = V_S - (V_{D1} + V_{D2}) = 5\text{ V} - 1.4\text{ V} = 3.6\text{ V}$ and
    $$I_T = \frac{V_S - 1.4\text{ V}}{R_1} = \frac{3.6\text{ V}}{200\,\Omega} = 18\text{ mA}$$
13. There are two forward-biased diodes, $V_{D1} = V_{D2} = 0.7$ V, $I_T = \frac{V_S - 1.4\text{ V}}{R_T} = \frac{9\text{ V} - 1.4\text{ V}}{300\,\Omega} = \frac{7.6\text{ V}}{300\,\Omega} =$ 25.3 mA, $V_{R1} = I_T R_1 = (25.3\text{ mA})(100\,\Omega) = 2.53$ V, $V_{R2} = I_T R_2 = (25.3\text{ mA})(200\,\Omega) = 5.06$ V
14. $\%\text{ of error} = \frac{|13.2\text{ V} - 12.8\text{ V}|}{13.2\text{ V}} \times 100 = 3.03\,\%$

15. Error (%) = $\frac{|880\,\mu A - 750\,\mu A|}{880\,\mu A} \times 100 = 14.8\ \%$

This error is not acceptable.

16. Error (%) = $\frac{|160\text{ mV} - 144\text{ mV}|}{160\text{ mV}} \times 100 = 10\%$ This error is acceptable.

17. $I_T = \frac{V_S - 1.4\text{ V}}{R_1 + R_2} = \frac{5\text{ V} - 1.4\text{ V}}{300\,\Omega} = 12\text{ mA}$ and

$V_{R2} = I_T R_2 = (12\text{ mA})(200\,\Omega) = 2.4\text{ V}$ The meter is measuring 2.54 V, and

$\text{Error (\%)} = \frac{|2.54\text{ V} - 2.4\text{ V}|}{2.54\text{ V}} \times 100 = 5.51\%$

18. $I_T = \frac{V_S - 2.1\text{ V}}{R_1 + R_2 + R_3} = \frac{5\text{ V} - 2.1\text{ V}}{340\,\Omega} = 8.53\text{ mA}$ and

$V_{R2} = I_T R_2 = (8.53\text{ mA})(120\,\Omega) = 1.02\text{ V}$. The meter is measuring 970 mV, and

$\text{Error (\%)} = \frac{|970\text{ mV} - 1.02\text{ V}|}{970\text{ mV}} \times 100 = 5.15\%$

19. To provide a safety margin, the minimum value of V_{RRM} is found as $V_{RRM} = 1.2V_{S(pk)} = (1.2)(100\text{ V}) = 120\text{ V}$.

20. The maximum reverse voltage across D_1 equals the peak value of V_{R2}, found as

$V_{R2} = V_S \frac{R_2}{R_T} = (100\text{ V}_{pk})\frac{5\text{ k}\Omega}{10\text{ k}\Omega} = 50\text{ V}.$

Providing a safety margin, the minimum value of V_{RRM} is found as $V_{RRM} = 1.2V_{R2(pk)} = (1.2)(50\text{ V}) = 60\text{ V}$.

21. The maximum reverse voltage across D_1 equals the negative peak value of V_{R2}, found as

$V_{R2} = V_S \frac{R_2}{R_T} = (-200\text{ V}_{pk})\frac{8.2\text{ k}\Omega}{9.2\text{ k}\Omega} = -178\text{ V}.$

Providing a safety margin, the minimum value of V_{RRM} is found as $1.2V_{R2(pk)} = (1.2)(-178\text{ V}) = 214\text{ V}$. The minimum practical value of V_{RRM} greater than 214 V is 250 V.

22. $I_F = \frac{V_S - V_F}{R_1} = \frac{50\text{ V} - 0.7\text{ V}}{5.1\text{ k}\Omega} = 9.67\text{ mA}$, and

$I_0 = 9.67\text{ mA} \times 1.2 = 11.6\text{ mA}$ (minimum)

23. From problem 22, $I_F = 9.67$ mA. $P_F = I_T V_F = (9.67\text{ mA})(0.7\text{ V}) = 6.77\text{ mW}$. Providing a safety margin, $P_{D(max)} = 1.2\,P_F = (1.2)(6.77\text{ mW}) = 8.12\text{ mW}$ (minimum).

24. $I_0 = \frac{P_{D(max)}}{V_F} = \frac{1.2\text{ W}}{0.7\text{ V}} = 1.71\text{ A}$. Providing a safety margin, $I_F = 0.8I_0 = (0.8)(1.71\text{ A}) = 1.37\text{ A}$ (maximum).

25. $I_0 = \frac{P_{D(max)}}{V_F} = \frac{750\text{ mW}}{0.7\text{ V}} = 1.07\text{ A}$. Providing a safety margin $I_F = 0.8I_0 = (0.8)(1.07\text{ A}) = 856\text{ mA}$ (maximum).

26. $V_F = 0.7\text{ V} + I_F R_B = 0.7\text{ V} + (10\text{ mA})(5\ \Omega) = 0.75\text{ V}$

27. $V_F = 0.7\text{ V} + I_F R_B = 0.7\text{ V} + (8.2\text{ mA})(12\ \Omega) = 0.798\text{ V}$

28. Equation (2.5) is transposed to obtain

$I_F = \frac{V_F - 0.7\text{ V}}{R_B}$ For $V_F = 0.8$ V:

$I_F = \frac{0.8\text{ V} - 0.7\text{ V}}{20\,\Omega} = 5\text{ mA}$

29. $V_R = I_R R_1 = (10\ \mu\text{A})(10\text{ k}\Omega) = 100\text{ mV}$

30. The peak reverse value of V_S is 100 V. Providing a safety margin, $V_{RRM} \geq (1.2)(100\text{ V}) = 120\text{ V}$. Thus, any diode from 1N5402 through 1N5408 could be used.

31. Under *electrical characteristics*, the maximum reverse current is shown to be 100 μA (rated at $T = 150°\text{C}$).

32. The surge current rating is the same for all diodes in the series: 200 A for 1 cycle.

33. The minimum V_{RRM} rating is found as 225 V × 1.2 = 270 V. The minimum I_0 rating is found as 24.5 A × 1.2 = 29.4 A. From Figure 2.27, the 1N3495 has these minimum acceptable ratings.

34. The minimum V_{RRM} rating is found as 170 V × 1.2 = 204 V. The minimum I_0 rating is found as 3.6 A × 1.2 = 4.32 A. From Figure 2.27, the MR754 has these minimum acceptable ratings.

35. The minimum V_{RRM} is 470 V × 1.2 = 564 V. The minimum I_0 rating is found as $\frac{2.8\text{ W}}{0.7\text{ V}} \times 1.2 = 4.8\text{ A}$.

From Figure 2.27, the MR756 has these minimum acceptable ratings.

36. $Z_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{25\text{ mV}}{1\text{ mA}} = 25\ \Omega$

37. Figures (a), (c), (d), and (e) are biased for normal zener operation. In each case, the device points to the (+) terminal of the source.

38. For each conducting diode, electron flow *is with the arrow* and conventional flow is *against the arrow.*

39. $I_{ZM} = \frac{P_{D(max)}}{V_Z} = \frac{1\text{ W}}{6.8\text{ V}} = 147\text{ mA}$

40. $I_{ZM} = \frac{P_{D(max)}}{V_Z} = \frac{10\text{ W}}{24\text{ V}} = 417\text{ mA}$

41. Derating value = (8 mW/°C)(120°C − 50°C) = 560 mW, P_D at 120°C = 5 W − 560 mW = 4.44 W (maximum)

42. Derating value = (1.67 mW/°C)(150°C – 50°C) = 167 mW, P_D at 150°C = 250 mW – 167 mW = 83 mW (maximum)

43. The lowest P_D rating ≥ 1.8 W is 5 W. The only diode with ratings of 28V/5W is the 1N5362A.

44. The P_D ratings ≥ 1.2 W are 1.5 W and 5 W. The diodes with these ratings and V_Z = 6.8 V are the 1N5921A and the 1N5342A. Either of these can be used.

45. $P_D = I_{ZM}V_Z = (150\text{ mA})(12\text{ V}) = 1.8\text{ W}$ Providing a safety margin, $P_{D(\text{max})} = 1.2P_D$ = (1.2)(1.8 W) = 2.16 W. From Figure 2.34, only the 1N5349A can be used in this application.

46. $R_{S(\min)} = \dfrac{V_{\text{out(pk)}} - V_F}{I_F} = \dfrac{20\text{ V} - 1.5\text{ V}}{18\text{ mA}} = 1028\,\Omega$

(Use 1.1 kΩ standard)

47. $R_{S(\min)} = \dfrac{V_{\text{out(pk)}} - V_F}{I_F} = \dfrac{32\text{ V} - 1.6\text{ V}}{20\text{ mA}} = 1520\,\Omega$

(Use 1.6 kΩ standard)

48. (a) Both readings are high. The diode is *open*. (b) Good. (c) Good. (d) Both readings are low. The diode is *shorted*.

49. The diode is *good*.

50. V_R is always equal to V_S, so V_F is 0 V. This is the symptom of a *shorted* diode.

51. V_R is always 0 V, so V_F is always equal to V_S. Since this is true even when the diode is forward biased, the device is *open*.

52. The voltage across the resistor equals the difference between the source voltage (V_S) and the zener voltage (V_Z). Therefore,

$$I_T = \frac{V_S - V_Z}{R} = \frac{16\text{ V} - 5.1\text{ V}}{120\,\Omega} = 90.8\text{ mA}$$

53. $I_T = \dfrac{V_{R1}}{R_1} = \dfrac{9\text{ V}}{820\,\Omega} = 11\text{ mA}$, and

$$P_Z = V_Z I_T = (12\text{ V})(11\text{ mA}) = 132\text{ mW}$$

54. Connect the ohmmeter so that it reverse-biases the diode. This effectively removes the diode from the circuit.

55. Derating value = (6.67 mW/°C)(150°C – 50°C) = 667 mW. At 150°C, P_D = 1 W – 667 mW = 333 mW. The maximum current at that temp is found as $I_{ZM} = \dfrac{P_D}{V_Z} = \dfrac{333\text{ mW}}{7.5\text{ V}} = 44.4\text{ mA}$

56. The 1N4738A has the following ratings: V_Z = 8.2 V and P_D = 1 W. The derating factor for the device is 6.67 mW/°C for temperatures above 50°C. For the circuit in Figure 2.56,

$$I_T = \frac{V_S - V_Z}{R_1} = \frac{60\text{ V} - 8.2\text{ V}}{910\,\Omega} = 56.9\text{ mA} \text{ and}$$

$P_D = V_Z I_T = (8.2\text{ V})(56.9\text{ mA}) \cong 467\text{ mW}$. At T = 150°C, the 1N4738A is limited to $P_{D(\max)} = 1\text{ W} - (6.67\text{ mW/°C})(150\text{°C} - 50\text{°C})$ $= 1\text{ W} - 667\text{ mW} = 333\text{ mW}$. Since this value is lower than the circuit requirement (467 mW), the component cannot be used.

57. According to the component spec sheet, the 1N5341 has a rating of V_Z = 6.2 V @ I_{ZT} = 200 mA.

58. The power dissipation of the diode when operated at V_Z equals the product of V_Z and I_{ZT}, and varies from diode to diode. For the 1N5364 (a 33 V, 5 W zener), $V_Z I_{ZT}$ = (33 V)(40 mA) = 1.32 W. (Student results will likely vary from this value.)

59. Yellow light has a range of approximately 565 to 590 nanometers (nm). Yellow LEDs are rated somewhere in this range.

CHAPTER 3

EXAMPLE PRACTICE PROBLEMS (CH 3)

3-1. $I_S = \dfrac{N_P}{N_S} I_P = \left(\dfrac{1}{12}\right)(250\text{ mA}) = 20.8\text{ mA}$

3-2. $V_{S(\text{pk})} = \dfrac{N_S}{N_P} V_{P(\text{pk})} = \left(\dfrac{1}{10}\right)(180\text{ V}) = 18\text{ V}$,

$V_{L(\text{pk})} = V_{S(\text{pk})} - 0.7\text{ V} = 18\text{ V} - 0.7\text{ V} = 17.3\text{ V}$

3-3. $V_{S(\text{pk})} = \dfrac{V_{S(\text{rms})}}{0.707} = \dfrac{12\text{ V}}{0.707} = 17\text{ V}$, $V_{L(\text{pk})} = V_{S(\text{pk})} -$ $V_F = 17\text{ V} - 0.7\text{ V} = 16.3\text{ V}$

3-4. $V_{P(\text{pk})} = \dfrac{120\text{ V}}{0.707} = 170\text{ V}$

$$V_{S(\text{pk})} = \frac{N_S}{N_P} V_{P(\text{pk})} = \left(\frac{1}{12}\right)(170\text{ V}) = 14.2\text{ V}$$

$$V_{L(\text{pk})} = V_{S(\text{pk})} - 0.7\text{ V} = 13.5\text{ V}$$

$$I_{L(\text{pk})} = \frac{V_{L(\text{pk})}}{R_L} = \frac{13.5\text{ V}}{8.2\text{ k}\Omega} = 1.65\text{ mA}$$

3-5. $V_{P(\text{pk})} = \dfrac{120\text{ V}}{0.707} = 170\text{ V}$

$$V_{S(\text{pk})} = \frac{N_S}{N_P} V_{P(\text{pk})} = \left(\frac{1}{14}\right)(170\text{ V}) = 12.1\text{ V}$$

$$V_{L(\text{pk})} = V_{S(\text{pk})} - 0.7\text{ V} = 11.4\text{ V}$$

$$V_{\text{ave}} = \frac{V_{L(\text{pk})}}{\pi} = \frac{11.4\text{ V}}{\pi} = 3.63\text{ V}$$

3-6. $I_{\text{ave}} = \dfrac{V_{\text{ave}}}{R_L} = \dfrac{24\text{ V}}{2.2\text{ k}\Omega} = 10.9\text{ mA}$

3-7. $V_{S(\text{pk})} = \dfrac{48\text{ V}}{0.707} = 67.9\text{ V}$, $V_{L(\text{pk})} = V_{S(\text{pk})} - 0.7\text{ V}$ $= 67.9\text{ V} - 0.7\text{ V} = 67.2\text{ V}$