DIODE FUNDAMENTALS

SAMPLE PROBLEM: FOR DIODE CURVE IN FIG. 5, CALCULATE THE DC RESISTANCE, RF @ points A & B.

Sol'n:

POINT A: $R_F = \frac{V_F}{I_F} = \frac{0.65\,V}{11\,mA} = 59.1\,\Omega$ //

POINT B: $R_F = \frac{V_F}{I_F} = \frac{0.7V}{22.5mA} = 31.1\,\Omega$ //

* CONVERT mA to A

SAMPLE PROBLEM: DETERMINE THE DC RESISTANCE LEVELS FOR THE DIODE OF THE FIGURE SHOWN IF (a) $I_F = 2\,mA$, (b) $I_F = 20mA$ and (c) $V_F = -10V$

Sol'n:

(a) I_F 2mA

$R_F = \frac{V_F}{I_F} = \frac{0.5V}{2mA}$

$= \frac{0.5V}{0.002A}$

$R_F = 250\,\Omega$ //

(b) $I_F = 20mA$

$R_F = \frac{V_F}{I_F}$

$= \frac{0.8V}{0.020A}$

$R_F = 40\,\Omega$,

(c) $V_F = -10V$

$R_F = \frac{V_F}{I_F}$

$= \frac{-10V}{0A}$

= infinite resistance

The I_F is zero, this means the diode is not conducting. In this case, the resistance would be extremely high (infinite)

SAMPLE PROBLEM: A SILICON DIODE HAS FORWARD VOLTAGE DROP OF 1.1V DIODE CURRENT, I_F, OF 1A. CALCULATE THE BULK RESISTANCE, r_B

Sol'n: $r_B = \frac{\Delta V}{\Delta I}$

$= \frac{1.1V - 0.7V}{1A - 0A}$

$= \frac{0.4V}{1A}$

$= 0.4\,\Omega$ //

* 0.7V is the required voltage for silicon diode to enable current to begin flowing through the diode.

SAMPLE PROBLEM: FIGURE SHOWN BELOW, SOLVE FOR THE LOAD VOLTAGE AND CURRENT USING FIRST, SECOND, AND THIRD APPROXIMATION.

Sol'n:
- FIRST APPROXIMATION: SEE FIG (b)

$V_L = V_{IN} = 10V\,dc$

$I_L = \dfrac{V_L}{R_L} = \dfrac{10V}{100\Omega} = 0.1A$ or $100mA$

- SECOND APPROXIMATION: SEE FIG (C)

$V_L = V_{IN} - V_B$
$= 10V - 0.7V$
$= 9.3V$

$I_L = \dfrac{V_L}{R_L} = \dfrac{9.3V}{100\Omega} = 0.093A$ or $93mA$

- THIRD APPROXIMATION SEE FIG. (D)

$I_L = \dfrac{V_{IN} - V_B}{R_L - r_B}$

$= \dfrac{10V - 0.7V}{100\Omega + 2.5\Omega}$

$= \dfrac{9.3V}{102.5\Omega}$

$= 0.0907A$

or $= 90.73mA$

$V_L = I_L R_L$
$= (90.73mA)(100\Omega)$
$= (0.0907A)(100\Omega)$
$V_L = 9.07V$

SPECIAL DIODES: LIGHT EMITTING DIODES

SAMPLE PROBLEM: CALCULATE THE LED CURRENT IN FIGURE 10a.

Sol'n: THE CURRENT THROUGH LED CAN BE FOUND BY DIVIDING THE RESISTOR VOLTAGE BY ITS RESISTANCE. ASSUME THE LED HAS A VOLTAGE DROP OF 2.0V

$I_{LED} = \dfrac{V_{IN} - V_{LED}}{R_S}$

$= \dfrac{24V - 2V}{2.2k\Omega} = \dfrac{22V}{2{,}200\Omega}$

$= 0.01A$ or $10mA$

SAMPLE PROBLEM: IN FIGURE 10b, calculate the resistance, RS, required to provide an LED current, 25mA.

Sol'n: As stated previously, assume a forward voltage of 2.0V for an LED.

$$R_S = \frac{V_{IN} - V_{LED}}{I_{LED}} = \frac{24V - 2V}{25mA}$$

$$= \frac{22V}{0.025A}$$

$$R_S = 880\ \Omega$$

SPECIAL DIODES: ZENER DIODES

SAMPLE PROBLEM: CALCULATE THE MAXIMUM RATED ZENER CURRENT FOR A 1-W, 10V zener.

Sol'n:

$$I_{ZM} = \frac{P_{ZM}}{V_Z}$$

$$= \frac{1W}{10V}$$

$$= 0.1A \text{ or } 100mA$$

SAMPLE PROBLEM: IF VZ = 10V IN FIG. 12, CALCULATE IZ.

$$I_Z = \frac{V_{IN} - V_Z}{R_S} = \frac{25V - 10V}{1k\Omega} = \frac{15V}{1000\Omega} = 0.015A \text{ or } 15mA$$

SAMPLE PROBLEM: IF RL INCREASES TO 250Ω IN FIG. 13, CALCULATE THE FF. IS, IL, IZ, and PZ

- I_S remains constant @ 75mA even through R_L changes because V_{IN}, V_Z and R_S remains constant.
- $I_L = \frac{V_Z}{R_L} = \frac{7.5V}{250\Omega} = 0.03A$ or 30mA
- $I_Z = I_S - I_L$
  $= 75mA - 30mA$
  $= 45mA$
- $P_Z = V_Z I_Z$
  $= (7.5V)(45mA)$
  $= 337.5mW$

PROPER TRANSISTOR BIASING

SAMPLE PROBLEM: A TRANSISTOR HAS THE FF. CURRENTS $I_B = 20mA$ and $I_C = 4.98A$. CALCULATE I_E.

Sol'n: $I_E = I_B + I_C$

$= 20mA + 4.98A$

$= 0.02A + 4.98A$

$I_E = 5A$ //

SAMPLE PROBLEM: A TRANSISTOR HAS THE FF. CURRENTS $I_E = 100mA$ and $I_B = 1.96mA$. CALCULATE I_C

Sol'n: $I_C = I_E - I_B$

$= 100mA - 1.96mA$

$I_C = 98.04mA$ /

SAMPLE PROBLEM: A TRANSISTOR HAS THE FF. CURRENTS $I_E = 50mA$ AND $I_C = 49mA$. CALCULATE I_B.

Sol'n: $I_B = I_E - I_C$

$= 50mA - 49mA$

$I_B = 1mA$ //

SAMPLE PROBLEM: A TRANSISTOR HAS THE FF. $I_E = 15mA$, $I_B = 60\mu A$. CALCULATE α_{dc}.

Sol'n: $I_C = I_E - I_B$

$= 15mA - 60\mu A$

$= 15mA - 0.06mA$

$I_C = 14.94mA$ //

$$\alpha_{dc} = \frac{I_C}{I_E}$$

$$= \frac{14.94mA}{15mA}$$

$\alpha_{dc} = 0.996$ /

SAMPLE PROBLEM: A TRANSISTOR HAS THE FF. CURRENTS $I_C = 10mA$, $I_B = 50\mu A$, CALCULATE β_{dc}.

sol'n:

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{10mA}{50\mu A} = \frac{10mA}{0.05mA} = 200$$

SAMPLE PROBLEM: A TRANSISTOR HAS $\beta_{dc} = 150$ and $I_B = 75\mu A$. CALCULATE I_C.

Sol'n:

$$\beta_{dc} = \frac{I_C}{I_B}$$

$$I_C = \beta_{dc} I_B$$

$$= (150)(75\mu A)$$

$$= (150)(0.075mA)$$

$$I_C = 11.25 mA$$

~~SAMPLE PROBLEM: A TRANSISTOR HAS $\beta_{dc} = 100$~~ CALCULATE α_{dc}.

$$\alpha_{dc} = \frac{\beta_{dc}}{1+\beta_{dc}} = \frac{100}{1+100} = 0.99$$

SAMPLE PROBLEM: A TRANSISTOR HAS $\alpha_{dc} = 0.995$. CALCULATE β_{dc}

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}} = \frac{0.995}{1+0.995} = 199$$

SAMPLE PROBLEM: IN THE FIGURE SHOWN BELOW, ~~FOR~~ SOLVE FOR I_B, I_C, and V_{CE}.

Sol'n:

- $I_B = \frac{V_{BB} - V_{BE}}{R_B}$

$= \frac{5V - 0.7V}{56k\Omega}$ * since the transistor is silicon $V_{BE} = 0.7V$

$= \frac{5V - 0.7V}{56{,}000\Omega}$

$= \frac{4.3V}{56{,}000\Omega}$ ~~≈~~ $7.68\mu A$

- $I_C = \beta_{dc} I_B$

$= (100)(76.78\,\mu A)$

$I_C = 7.68\,mA$ //

- $V_{CE} = V_{CC} - I_C R_C$

$= 15V - (7.68mA \times 1k\Omega)$

$= 15V - 7.68V$

$V_{CE} = 7.32V$ //

SAMPLE PROBLEM: IN FIGURE SHOWN BELOW, SOLVE FOR I_B, I_C, and V_{CE}

SOL'N:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{15V - 0.7V}{180k\Omega} = \frac{14.3V}{180k\Omega} = 79.44\,\mu A$$

$I_C = \beta_{dc} I_B$

$= (100)(79.44\,\mu A)$

$= 7.94mA$

$V_{CE} = V_{CC} - I_C R_C$

$= 15V - (7.94mA \times 1k\Omega)$

$= 15V - 7.94V$

$V_{CE} = 7.06V$

SAMPLE PROBLEM: IN FIGURE SHOWN BELOW, SOLVE FOR I_B, I_C, & V_{CE}.

Sol'n:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12V - 0.7V}{390k\Omega} = 28.97\,\mu A$$ //

$I_C = \beta_{dc} I_B$

$= (150)(28.97\,\mu A)$

$I_C = 4.35mA$ //

$V_{CE} = V_{CC} - I_C R_C$

$= 12V - (4.35mA \times 1.5k\Omega)$

$= 12V - 6.52V$

$V_{CE} = 5.48V$ //

SAMPLE PROBLEM: FOR THE CIRCUIT SHOWN IN THE FIGURE BELOW, SOLVE FOR V_B, V_E, I_c, V_c and V_{CE}

Sol'n:

- $V_E = V_B - V_{BE}$
$= 2.38V - 0.7V$
$= 1.68V$ //

$I_E = \frac{V_E}{R_E} = \frac{1.68V}{240\Omega} = 7mA$

- $I_E \approx I_c = 7mA$
- $V_c = V_{cc} - I_c R_c$
$= 15V - (7mA \times 1k\Omega)$
$= 15V - 7V$
$V_c = 8V$ //
- $V_{CE} = V_{cc} - I_c(R_c + R_E)$
$= 15V - 7mA(1k\Omega + 240\Omega)$
$= 15V - 7mA(1000\Omega + 240\Omega)$
$= 15V - 7mA(1240\Omega)$
$= 15V - 0.007A(1240\Omega)$
$= 15V - 8.68V$
$V_{CE} = 6.32V$ //

SAMPLE PROBLEM: FOR CIRCUIT SHOWN IN THE FIG. BELOW, SOLVE FOR V_B, V_E, I_c, V_c and V_{CE}.

Sol'n: • $V_B = \frac{R_2}{R_1 + R_2} \times V_{cc}$

$= \frac{5.6k\Omega}{33k\Omega + 5.6k\Omega} \times 18V = \frac{5.6k\Omega}{38.6k\Omega} \times 18V$

$= (0.1451 k\Omega)(18V)$

$V_B = 2.61V$ //

- $V_E = V_B - V_{BE}$
$= 2.61V - 0.7V$
$V_E = 1.91V$ //
- $I_E = \frac{V_E}{R_E} = \frac{1.91V}{390\Omega}$
$= 4.9mA$

since $\beta_{dc} = 200$, $I_c \cong I_E = 4.9mA$

- $V_c = V_{cc} - I_c R_c$
$= 18V - (4.9mA - 1.5k\Omega)$
$= 18V - 7.35V$
$V_c = 10.65V$ //
- $V_{CE} = V_{cc} - I_c(R_c + R_E)$
$= 18V - 4.9mA(1.5k\Omega + 390\Omega)$
$= 18V - 4.9mA(1500\Omega + 390\Omega)$
$= 18V - 4.9mA(1890\Omega)$
$V_{CE} = 18V - 9.261V$
$= 8.74V$ //

SAMPLE PROBLEM : FOR THE PNP TRANSISTOR IN THE FIGURE BELOW, SOLVE FOR V_B, V_E, I_C, V_C & V_{CE}

SOL'N:

- $V_B = \frac{R_2}{R_1 + R_2}(-V_{CC})$

$= \frac{6.2k\Omega}{6.2k\Omega + 33k\Omega}(-12V)$

$= \frac{6.2k\Omega}{39.2k\Omega}(-12V)$

$= (0.1581k\Omega)(-12V)$

$V_B = -1.90V$ //

- $V_E = V_B - V_{BE}$

$= -1.9V - (-0.7V)$

$V_E = -1.2V$ //

- Since $I_E \approx I_C$

$I_C = \frac{V_E}{R_E} = \frac{1.2V}{500\Omega} = 2.4mA$ //

- $V_C = -V_{CC} + I_C R_C$

$= -12V + (2.4mA \times 2k\Omega)$

$= -12V + (0.0024A \times 2000\Omega)$

$= -12V + 4.8V$

$V_C = -7.2V$ //

- $V_{CE} = -V_{CC} + I_C(R_C + R_E)$

$= -12V + 2.4mA\ (2k\Omega + 500\Omega)$

$= -12V + 0.0024A\ (2000\Omega + 500\Omega)$

$= -12V + 0.0024A\ (2500\Omega)$

$= -12V + 6$

$V_{CE} = -6V$ //

SAMPLE PROBLEM : IN FIG. SHOWN BELOW, CALCULATE I_E & V_C

SOL'N: $I_E = \frac{V_{EE} - V_{BE}}{R_E}$

$= \frac{6V - 0.7V}{1k\Omega}$

$= \frac{5.3V}{1000\Omega}$

$I_E = 0.0053A$

OR $5.3mA$ //

$V_C = V_{CC} - I_C R_C$

$= 15V - (5.3mA \times 1.5k\Omega)$

$= 15V - (0.0053A \times 1,500\Omega)$

$= 15V - 7.95V$

$V_C = 7.05V$ //

SAMPLE PROBLEM: IN THE FIGURE SHOWN BELOW, CALCULATE I_E and V_C

SOL'N:

- $I_E = \frac{V_{EE} - V_{BE}}{R_E} = \frac{10V - 0.7V}{2.2k\Omega} = \frac{9.3V}{2200\Omega}$

$I_E = 0.00423A$ or $4.23\,mA$

ALTERNATIVE SOLUTION FOR I_E

$$I_E = \frac{V_{EE} - V_{BE}}{R_E + \frac{R_B}{\beta_{dc}}} = \frac{10V - 0.7V}{2.2k\Omega + \frac{1k\Omega}{200\Omega}} = \frac{9.3V}{2200\Omega + \frac{1000\Omega}{200\Omega}}$$

$$I_E = \frac{9.3V}{2200\Omega + 5\Omega} = \frac{9.3V}{2205\Omega} = 0.004221A \text{ or } 4.22\,mA$$

- $V_C = V_{CC} - I_C R_C$

$= 10V - (4.23\,mA \times 1k\Omega)$

$= 10V - (0.00423A \times 1000\Omega)$

$= 10V - 4.23V$

$V_C = 5.77V$