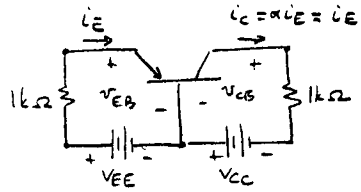
Physics 116A Fall 2004 Prob. Set 7 Solutions from Instructor's Manual for Fund. of EE, 2nd Ed. by Bobrow, © 1996 by Oxford University Press

7.3



$i_C = \alpha i_E = i_E$ for active region
Also, $v_{EB} = 0.7$ V.

(a) By KVL, $v_{EB} - V_{EE} + 1k\,i_E = 0$

$v_{EB} + 1k\,i_E = V_{EE}$

For $i_E = 5.3$mA, $V_{EE} = v_{EB} + 1k\,i_E = 0.7 + 1k(5.3m) = \underline{\underline{6\text{ V}}}$

(b) By KVL, $v_{CB} = 1k\,i_C - V_{CC}$

$V_{CC} = 1k\,i_C - v_{CB} = 1k\,i_E - v_{CB}$

For $i_E = 5.3$mA, $v_{CB} = -3.7$V, then

$V_{CC} = 1k(5.3m) - (-3.7) = \underline{\underline{9\text{ V}}}$

(c) The transistor is in the active region when $i_E > 0$ A and $v_{CB} < 0.5$V. Thus,

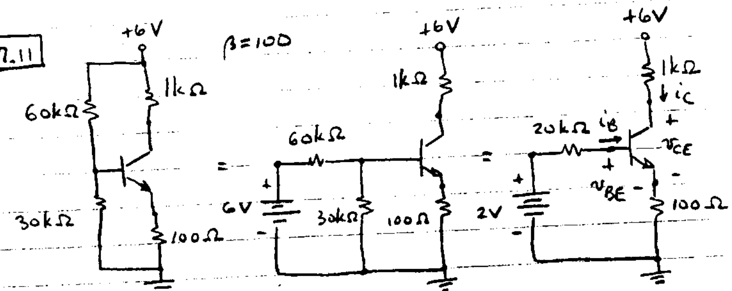
$v_{CB} = 1k\,i_C - V_{CC} < 0.5$

$1k\,i_C - 0.5 < V_{CC} \Rightarrow V_{CC} > 1k\,i_C - 0.5 = 1k\,i_E - 0.5$

For $i_E = 5.3$mA, $V_{CC} > 1k(5.3m) - 0.5 = 4.8$ V

Hence, the minimum value for V_{CC} is $\underline{\underline{4.8\text{ V}}}$.

7.11



(a) By KVL,

$2 = 20k\,i_B + v_{BE} + 100(i_B + i_C)$ For active region, $v_{BE} = 0.7$V, $i_C = \beta i_B$

$2 - 0.7 = 20k\,i_B + 100(i_B + 100 i_B) = 20k\,i_B + 10100\,i_B = 30.1k\,i_B$

$i_B = \frac{1.3}{30.1k} = \underline{\underline{43.2\,\mu A}}$

(b) $i_C = 100 i_B = 100(43.2\mu) = \underline{\underline{4.32\text{ mA}}} > 0$

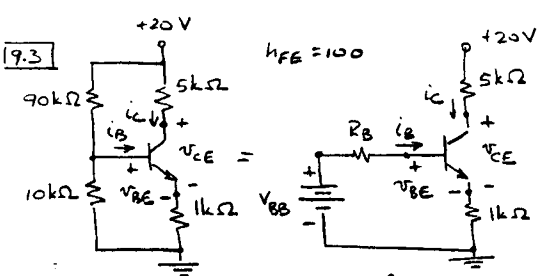
(c) $v_{CE} = -1k\,i_C + 6 - 100(i_B + i_C)$

$= -1k(4.32m) + 6 - 100(43.2\mu + 4.32m)$

$= -4.32 + 6 - 0.436$

$v_{CE} = \underline{\underline{1.2\text{ V}}} > 0.2$ V

9.3



$R_B = 10k/90k = \frac{(10k)(90k)}{10k + 90k} = \frac{900k^2}{100k} = 9k\Omega$

$V_{BB} = \frac{10k}{10k + 90k}(20) = 2$ V

For active region, $v_{BE} = 0.7$ V, $i_C = h_{FE} i_B = 100 i_B$

By KVL,

$V_{BB} = R_B i_B + v_{BE} + 1k(i_B + i_C)$

$2 = 9k\,i_B + 0.7 + 1k(i_B + 100 i_B)$

$1.3 = 110k\,i_B$

$i_B = \frac{1.3}{110k} = 11.8\,\mu A$

$i_C = h_{FE} i_B = 100(11.8\mu) = \underline{1.18\text{ mA}} = I_{CQ}$

$v_{CE} = -5k\,i_C + 20 - 1k(i_B + i_C) = -5k\,i_C + 20 - 1k(i_B + 100\,i_B)$

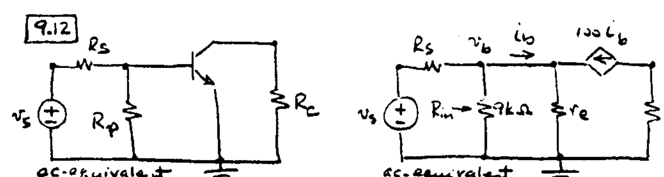
$= -5k(1.18m) + 20 - 1k(101)(11.8\mu)$

$= -5.9 + 20 - 1.19$

$= \underline{\underline{12.9\text{ V}}} = V_{CEQ}$

Since $i_B > 0$A and $v_{CE} > 0.2$V, then active-region operation is confirmed.

9.12



ac-equivalent

ac-equivalent circuit with small-signal model of BJT

$R_p = R_1 // R_2 = 90k // 10k$

$R_p = \frac{(90k)(10k)}{90k + 10k} = 9k\,\Omega$

$I_{CQ} = 10$mA

(a) $g_m = \frac{I_{CQ}}{.026} = \frac{10m}{26m} = \underline{385m℧}$

(b) $r_e = \frac{0.026}{I_{CQ}} = \frac{26m}{10m} = \underline{\underline{2.6\,\Omega}}$

(c) $v_b = r_e(i_b + 100 i_b) = 2.6(101) i_b \Rightarrow R_b = \frac{v_b}{i_b} = 2.6(101)$

$R_b = 263\,\Omega$

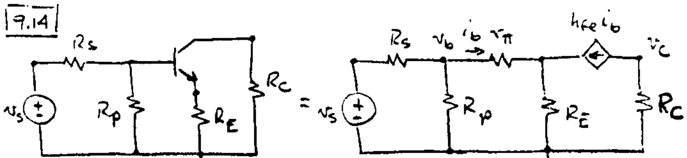
$R_{in} = R_p // R_b = 9k // 263 = \frac{(9k)(263)}{9k + 263} = \underline{\underline{256\,\Omega}}$

(d) $v_c = -1k(100 i_b) = -100k\,i_b$

$v_b = 2.6(101) i_b$

$\therefore A_v = \frac{v_c}{v_b} = \frac{-100k}{2.6(101)} = \underline{-381}$

9.14



ac-equivalent circuit

ac-equivalent circuit with small-signal model of BJT

(a) By KVL, $v_b = r_\pi i_b + R_E(i_b + h_{fe} i_b) = [r_\pi + R_E(1+h_{fe})] i_b$

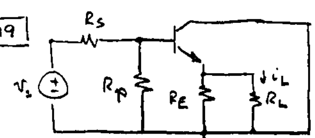
$$\therefore R_b = \frac{v_b}{i_b} = \underline{\underline{r_\pi + (1+h_{fe})R_E}}$$

(b) $v_c = -R_C h_{fe} i_b$

$v_b = [r_\pi + R_E(1+h_{fe})] i_b$

$$\therefore A_v = \frac{v_c}{v_b} = \underline{\underline{-\frac{R_C h_{fe}}{r_\pi + R_E(1+h_{fe})}}}$$

9.19



ac-equivalent circuit

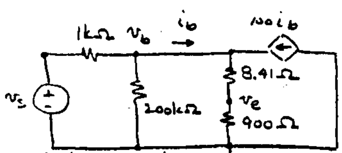
$I_{CQ} = 3.09\,mA$

$r_e = \frac{0.026}{I_{CQ}} = \frac{26m}{3.09m} = 8.41\Omega$

$R_p = R_1 // R_2 = 400k // 400k = 200k\Omega$

$R_T = R_E // R_L = 1k // 9k$

$R_T = \frac{(1k)(9k)}{1k + 9k} = 900\Omega$



ac-equivalent circuit with small-signal BJT model.

(a) $v_b = (8.41 + 900)(i_b + 100 i_b) = 91.7k\, i_b \Rightarrow R_b = \frac{v_b}{i_b} = 91.7k\Omega$

$v_e = 900(i_b + 100 i_b) = 90.9k\, i_b$

$$\therefore A_v = \frac{v_e}{v_b} = \frac{90.9}{91.7} = \underline{\underline{0.991}}$$

(b) $R_{in} = R_p // R_b = 200k // 91.7k = \frac{(200k)(91.7k)}{200k + 91.7k} = \underline{\underline{62.9k\Omega}}$

(c) By current division, $i_L = \frac{R_E}{R_E + R_L}(101 i_b) = \frac{1k}{1k + 9k}(101 i_b) = 10.1 i_b$

$$\therefore A_i = \frac{i_L}{i_b} = \underline{10.1}$$