Homework on BJT DC Analysis

From Boylestad

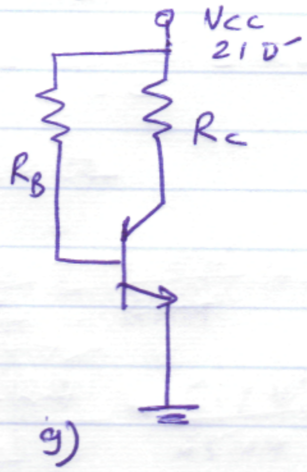
Q5.

a) $I_C = \frac{V_{CC}}{R_C} = \frac{21V}{3k\Omega} = 7mA$

b) $I_B \approx 25\mu A$ $R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{21 - 0.7}{25\mu A} = 812\ k\Omega$

c) $I_{CQ} \approx 3.4\ mA$

$V_{CEQ} \approx 10.75\ V$



d) $\beta = \frac{I_C}{I_B} = \frac{3.4 \cdot 10^{-3}}{25 \cdot 10^{-6}} = 136$

e) $\alpha = \frac{\beta}{\beta + 1} = \frac{136}{136+1} = 0.992$

f) $I_{C(sat)} = \frac{V_{CC}}{R_C} = \frac{21V}{3k\Omega} = 7mA$

h) $P_D = V_{CEQ} \cdot I_{CQ} = (10.75V) \times (3.4mA) = 36.55\ mW$

i) $P_s = V_{CC}(I_C + I_B) = 21(3.4mA + 25\mu A) = 71.92\ mW$

j) $P_R = P_S - P_D = 71.92 - 36.55 = 35.37\ mW$

Q7.

Homework on BJT DC analysis

From Boylestad

5. Given the BJT transistor characteristics of Fig. 4.76:
   (a) Draw a load line on the characteristics determined by $E = 21$ V and $R_C = 3$ kΩ for a fixed-bias configuration.
   (b) Choose an operating point midway between cutoff and saturation. Determine the value of R_B to establish the resulting operating point.
   (c) What are the resulting values of I_{C_Q} and V_{CE_Q}?
   (d) What is the value of β at the operating point?
   (e) What is the value of α defined by the operating point?
   (f) What is the saturation ($I_{C_{sat}}$) current for the design?
   (g) Sketch the resulting fixed-bias configuration.
   (h) What is the dc power dissipated by the device at the operating point?
   (i) What is the power supplied by V_{CC}?
   (j) Determine the power dissipated by the resistive elements by taking the difference between the results of parts (h) and (i).

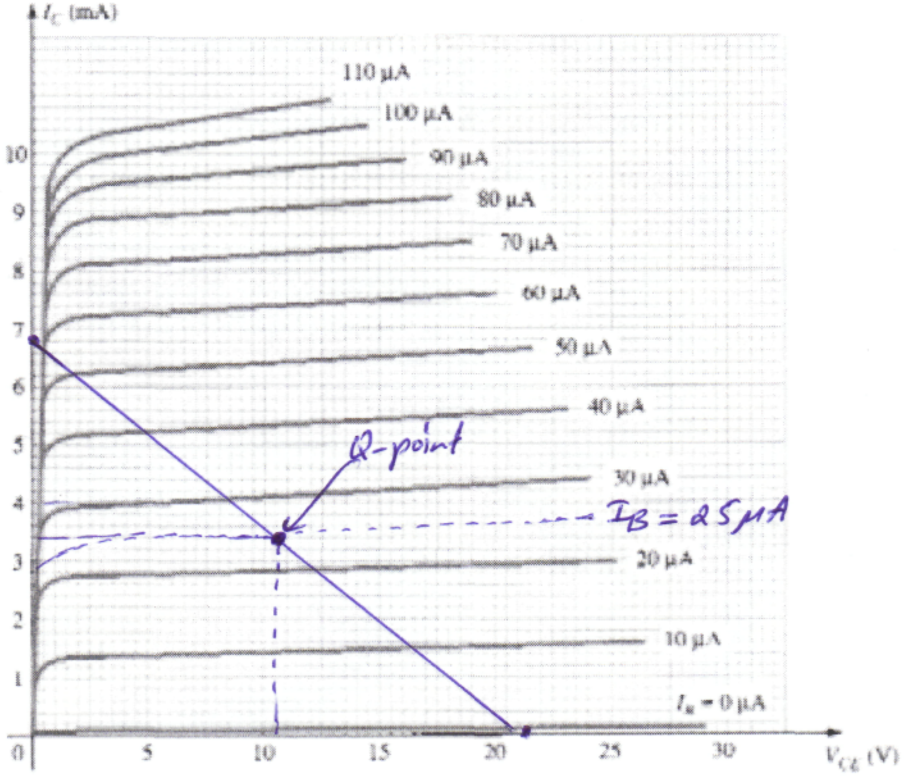
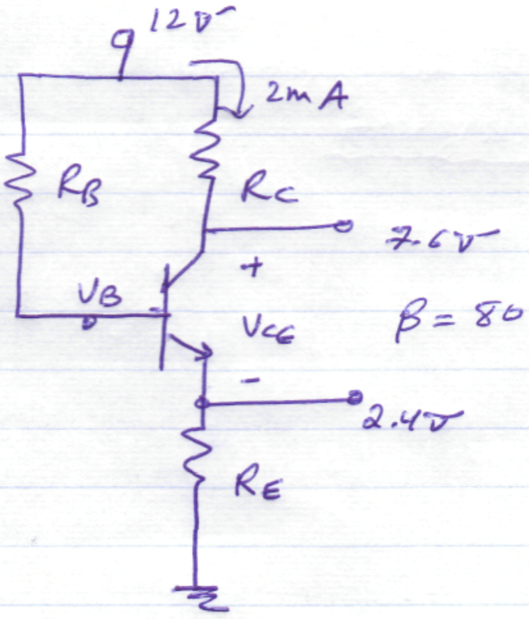


Figure 4.76 Problems 5, 10, 19, 35, 36

Q7.



a) $R_C = \dfrac{V_{CC} - V_C}{I_C} = \dfrac{12 - 7.6}{2mA} = \dfrac{4.4V}{2mA} = 2.2 K\Omega$

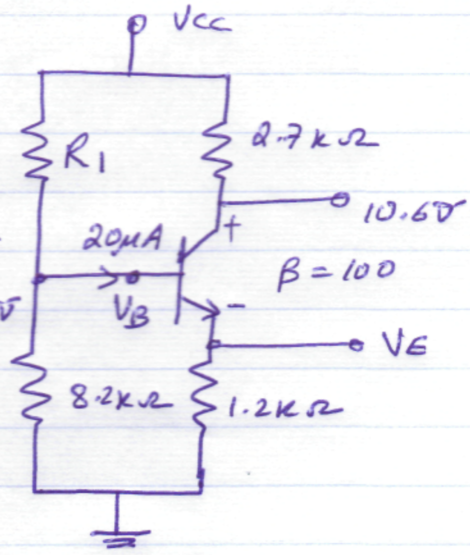
b) $I_E \approx I_C$, $V_E = I_E \cdot R_E \Longrightarrow R_E = \dfrac{V_E}{I_E} = \dfrac{2.4V}{2mA} = 1.2 K\Omega$

c) $R_B = \dfrac{V_{RB}}{I_B} = \dfrac{V_{CC} - V_{BE} - V_E}{I_B} = \dfrac{12 - 0.7 - 2.4}{\left(\frac{2mA}{80}\right)} = \dfrac{8.9V}{25\mu A} = 356 K\Omega$

d) $V_{CE} = V_C - V_E = 7.6 - 2.4 = 5.2V$

e) $V_B = V_{BE} + V_E = 0.7 + 2.4 = 3.1V$

Q14.



(a) $I_C = \beta I_B = 100 \cdot 20\mu A = 2mA$

(b) $I_E = I_C + I_B = 2mA + 20\mu A = 2.02mA$

$V_E = I_E \cdot R_E = 2.02mA \cdot 1.2k\Omega = 2.42V$

(c) $V_{CC} = V_C + I_C R_C$

$= 10.6 + 5.4V$

$= 16V$

(d) $V_{CE} = V_C - V_E = 10.6 - 2.42 = 8.18V$

(e) $V_B = V_E + V_{BE} = 2.42 + 0.7 = 3.12V$

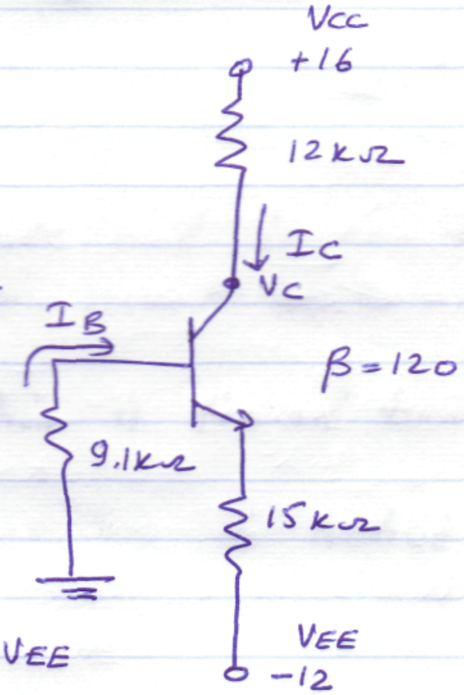
Q14.

(f) $I_{R1} = I_{R2} + I_B$

$= \frac{3.12\,V}{8.2k\Omega} + 20\mu A = 400.5\,\mu A$

$R_1 = \frac{V_{CC} - V_B}{I_{R1}} = \frac{16 - 3.12}{400.5\mu A} = 32.16\,k\Omega$

Q28.



(a) $I_B = \frac{V_{EE} - V_{BE}}{R_B + (\beta+1) R_E}$

$= \frac{12 - 0.7}{9k\Omega + (120+1)15k\Omega}$

$= 6.2\,\mu A$

(b) $I_C = \beta I_B = (120)\,6.2\mu A$

$= 0.744\,mA$

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

$= 16 + 12 - I_C(R_C + R_E)$

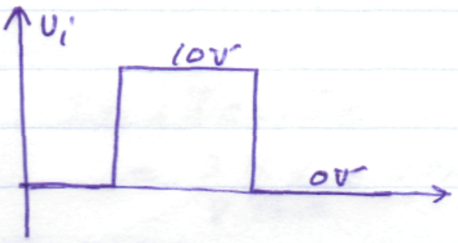
$= 28 - (0.744mA)(12K + 15K)$

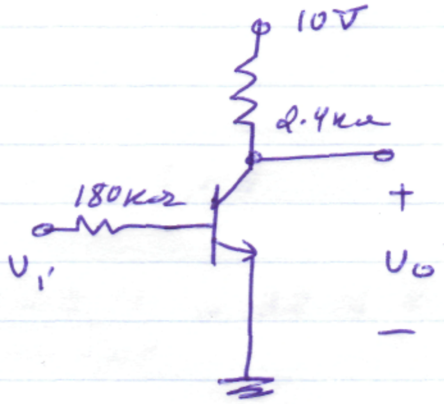
$= 7.91\,V$

(d) $V_C = V_{CC} - I_C R_C = 16 - (0.744mA)(12k\Omega)$

$= 7.07\,V$

Q36.





$\beta = 130$

<u>Solution</u>

1) when $U_i = 0$, $I_B = 0$, $I_C = 0$

BJT is in cut-off mode and it can be modeled by an open circuit $\Rightarrow V_o = 10V$

2) when $U_i = 10V$, BE junction is forward biased and BJT can be either in active mode or in saturation mode

Assume BJT in saturation mode & $V_{CE} = V_{CE(sat)} = 0.2V$

$$I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_C} = \frac{10 - 0.2V}{2.4k\Omega} = 4.167\ mA$$

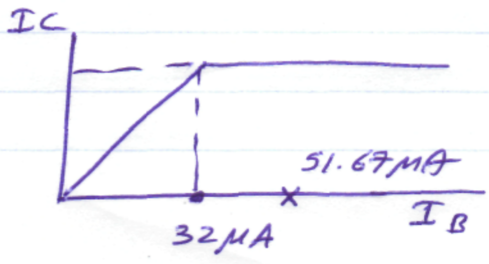
$$I_{B(min)} = \frac{I_{C(sat)}}{\beta} = \frac{4.167mA}{30} \cong 32\ \mu A$$

Now calculate actual value of I_B

$$I_B = \frac{U_i - V_{BE}}{R_B} = \frac{10 - 0.7}{180k\Omega} = 51.67\ \mu A$$

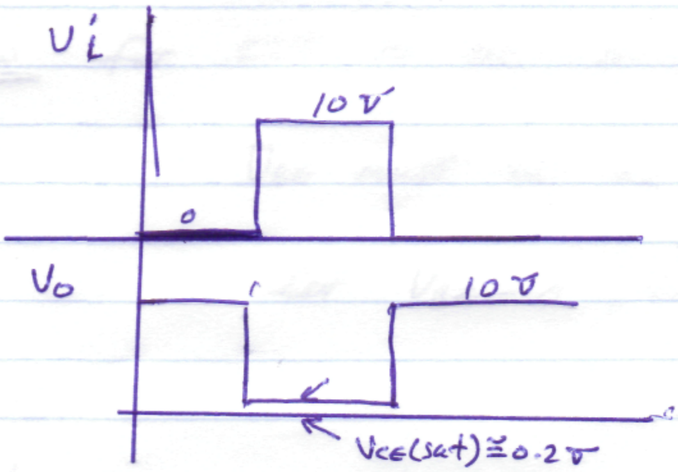
Since $I_B > I_{B(min)}$
BJT is in saturation

$V_o = V_{CE(sat)} \cong 0.2V$



Q36.

sketch of V_o waveform



From Floyd

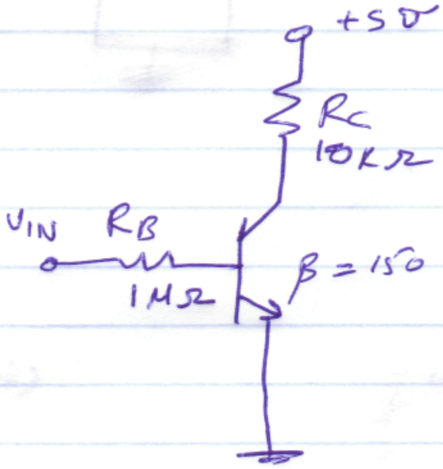
Q4.25

$$I_{C(sat)} = \frac{5 - V_{CE(sat)}}{10k\Omega} = 0.5\,mA$$

$$I_{B(min)} = \frac{I_{C(sat)}}{\beta} = 3.33\,\mu A$$

$$V_{IN(min)} = R_B I_{B(min)} + 0.7$$

$$= 4.03\ V$$



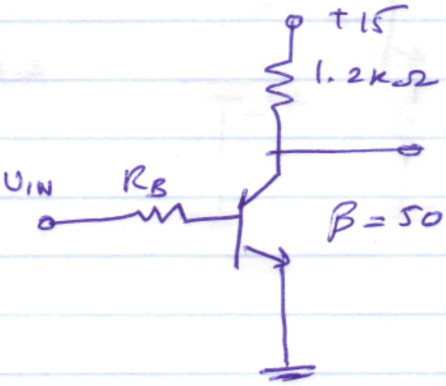
Q.26

$$I_{C(sat)} = \frac{15 - 0}{1.2k\Omega} = 12.5\,mA$$

$$I_{B(min)} = \frac{I_{C(sat)}}{\beta} = 0.25\,mA$$

$$I_B = \frac{V_i - 0.7}{R_B} > I_{B(min)}$$

$$R_B < \frac{V_i - 0.7}{I_{B(min)}} = 17.2\ k\Omega$$



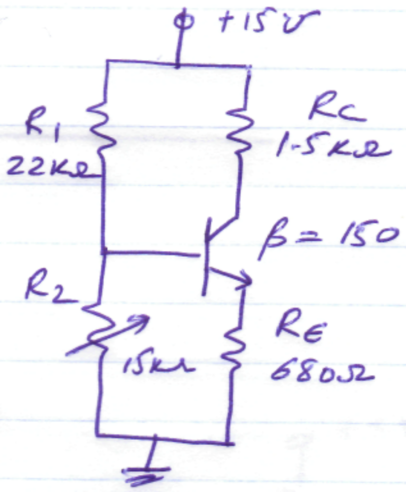
$\therefore$ let $R_B = 15\,k\Omega$

__Now__ for BJT to be in cut-off,

V_{BE} must be < 0.7, and $I_B = 0$

let $V_{BE} = 0$, $\therefore$ $V_i = 0$

__Q5.10__



to be in saturation

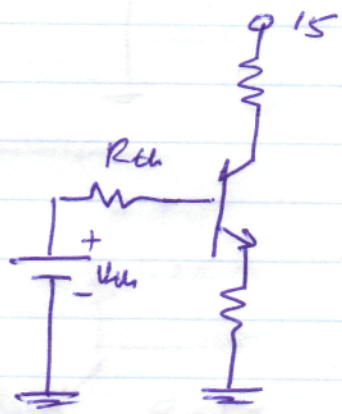
$I_B > I_{B(min)}$

$$I_{B(min)} = \frac{I_{C(sat)}}{\beta}$$

$$= \frac{15 - 0.2}{(0.68 + 1.5)\,k\Omega} \cdot \frac{1}{\beta}$$

$$= 0.0453\ mA$$

To find $R_{2(min)}$ let $I_B = I_{B(min)}$



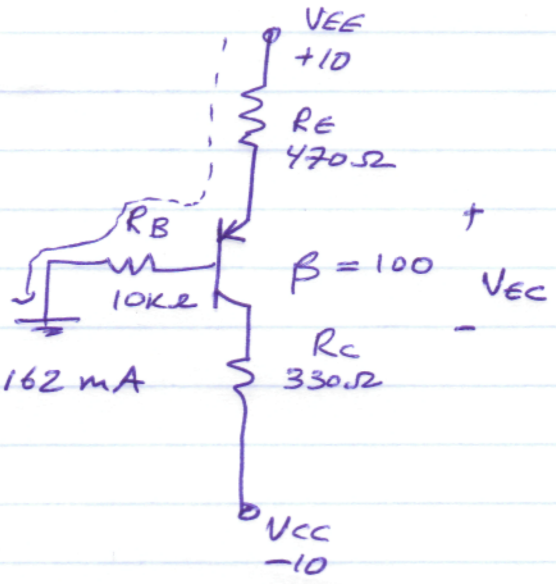
$$V_{th} = R_{th} I_B + V_{BE} + I_E R_E$$

$$\frac{15 \cdot R_2}{22 + R_2} = \frac{22 \cdot R_2}{22 + R_2}(0.0453\,mA) + 0.7$$

$$+ 6.834\ mA \cdot 0.68\ k\Omega$$

$\Rightarrow R_2 \cong 14.79\ k\Omega$

Q5.25



KVL for Input loop

$$10 = 0.47k\Omega \cdot I_E + V_{EB} + 10k\Omega \cdot I_B$$

$$I_E = (\beta+1)\, I_B$$

$$I_B = \frac{10 - V_{EB}}{10k\Omega + 0.47k\Omega(100+1)} = 0.162\ mA$$

$$I_C = \beta I_B = 16.2\ mA$$

$$V_{EC} \cong 20 - (0.47k\Omega + 0.33k\Omega) \cdot 16.2\ mA$$

$$= 7\ V$$