① Early voltage $(V_A) = 80V$.

$I_c = 0.60\ mA$ at $V_{CE} = 2V$.

$$I_c = I_c'\left(1+\frac{V_{CE}}{V_A}\right)$$

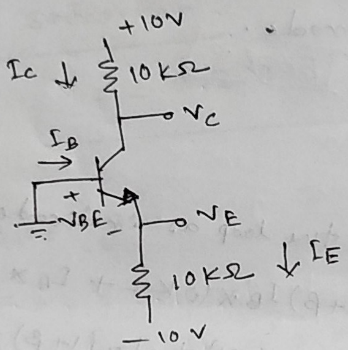
$$\therefore\ 0.60\times10^{-3} = I_c'\left(1+\frac{2}{80}\right)$$

$$\therefore\ I_c' = 0.585\ mA.$$

$$\therefore \text{ when, } V_{CE} = 5V,\ I_c = I_c'\left(1+\frac{5}{80}\right)$$

$$= 0.62\ mA.$$

Output resistance $(r_o) = \frac{V_A}{I_c'} = 136.75\ k\Omega$

② 

$$V_{BE} + I_E\cdot10\times10^3 - 10 = 0.$$

$$\therefore\ 0.7 + I_E\cdot10^4 = 10$$

$$\therefore\ I_E = \frac{9.3}{10^4} = 0.93\ mA.$$

$$I_B = \frac{I_E}{(\beta+1)}\ ;$$

$I_E = I_c + I_B$
$I_E = \beta I_B + I_B$
$I_E = (\beta+1) I_B$.

$$\therefore\ = \frac{0.93\ mA}{101}$$

$$I_B = 9.2\ \mu A.$$

$V_E = 0.7V.$

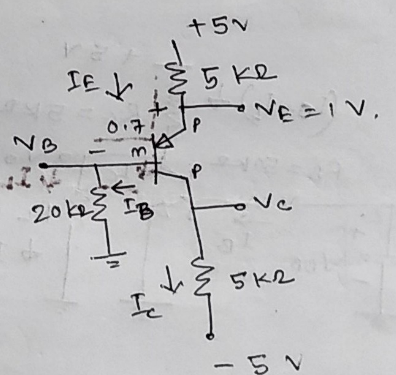
$$\therefore\ I_c = 0.921\ mA.$$

$$\therefore\ V_c = 10 - I_c\cdot\times10\ k\Omega$$

$$= 10 - 0.921\ mA\times10\ k\Omega$$

$$V_c = 0.79\ V.$$

③ $V_E = 1V$



$V_{EB} = 0.7V.$

$$\therefore\ V_B = 1 - 0.7 = 0.3V$$

$$\therefore\ I_B = \frac{0.3}{20k\Omega} = 0.015\ mA.$$

$$\therefore\ I_E = \frac{5-1}{5k\Omega} = 0.80\ mA.$$

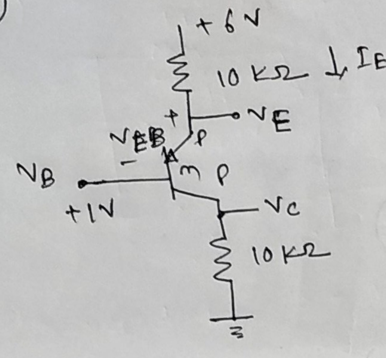
$$\therefore\ I_c = 0.80 - 0.015 = 0.785\ mA.$$

$$\therefore\ V_c = -5 + I_c\cdot 5k\Omega = -1.075V.$$

$$\alpha = \frac{I_c}{I_E} = 0.981$$

$$\beta = \frac{I_c}{I_B} = \frac{0.785}{0.015} = 52.33$$

(4)



$V_E = 1V + V_{EB}$

$V_E = 1.7\,V.$

$\therefore I_E = \dfrac{6 - 1.7}{10\,k\Omega}$

~~= 4.3 m~~

$I_E = 0.43\,mA.$

$\therefore I_C = \dfrac{\beta}{1+\beta} \cdot 0.43$

$= 0.426\,mA.$

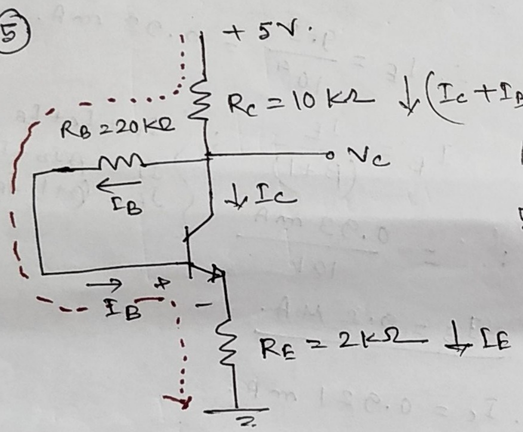
$\therefore V_C = I_C \times 10\,k\Omega$

$V_C = 4.26\,V.$

So, $V_C > V_B$, Base – collector junction (B–C) is in Forward bias.

So, BJT is in saturation mode.

(5)



Along the loop as indicated in fig.

$5 = (1+\beta) I_B \times 10\,k\Omega + I_B \times 20\,k\Omega + V_{BE}(ON) + I_B(1+\beta) \times 2\,k\Omega$

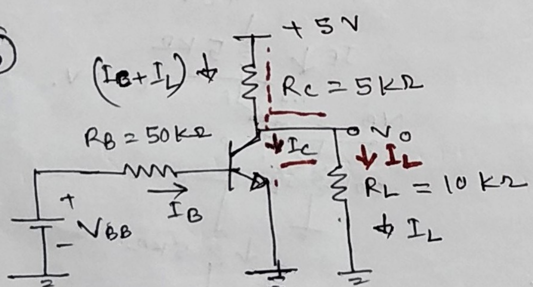
$\therefore I_B = 4.61\,\mu A.$

$\therefore I_C = \beta \times I_B = 0.346\,mA.$

$V_C = 5 - 10\,k\Omega \times (I_C + I_B)$

$= 1.5\,V.$

(6)



(a) When, $V_{BB} = 0$.

Cut-off.

$I_B = 0,\ I_C = 0.$

$\therefore V_o = \dfrac{10}{10+5} \times 5\,V.$

$V_o = 3.33\,V.$ (1)

(b) When, $V_{BB} = 1\,V$, $I_B = \dfrac{V_{BB} - V_{BE(ON)}}{R_B} = \dfrac{1 - 0.7}{50\,k\Omega} = 6\,\mu A.$

$\therefore I_C = \beta I_B = 75 \times 6\,\mu A = 0.45\,mA.$ (assuming BJT in active mode)

KCL in the marked loop,

$\dfrac{5 - V_o}{5} = I_C + \dfrac{V_o}{10}$

$\therefore V_o = 1.83\,V.$, so, BJT is in active mode as assumed.

(c) When, $V_{BB} = 2V$.

$$I_B = \frac{2-0.7}{50} = 26\ \mu A.$$

$\therefore\ I_C = \beta I_B = 1.95\ mA$. (if in active mode).

$$\frac{5-V_o}{5K} = I_c + \frac{V_o}{10K}$$

$\therefore\ 1 - 0.2V_o = 1.95 + V_o \times 0.1$

$\therefore -0.95 = 0.3 V_o$.

$\therefore\ \underline{V_o < 0}$. (BJT not in active mode, so it is in saturation).

<u>In saturation,</u>

$$\underline{V_{CE} = 0.2V = V_o.}$$

(7) $\beta = 100$ given.

<u>if</u> $I_B = I_E = 0.1\ mA$.

$\therefore\ I_c = \frac{\beta}{1+\beta} \cdot I_E = 0.099\ mA$.

(Active mode)

$\therefore\ V_o = 5 - I_c \cdot R_c = \underline{4.50\ V.}$ (i)

<u>if</u> $I_B = I_E$ ~~0.1 mA~~ $= 0.5\ mA$.

$\therefore\ I_c = \frac{\beta}{1+\beta} I_E = 0.495\ mA$. (Active mode)

$\therefore\ V_o = 5 - I_c R_c = 2.52\ V$. --- (ii)

<u>if</u> $I_B = I_E = 2\ mA$, then BJT is in saturation.

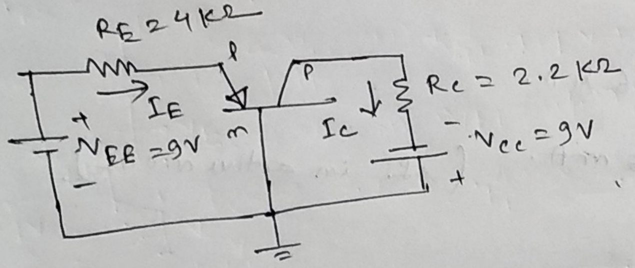
$\therefore\ V_{CE} = 0.2V$.

$\therefore\ V_{CB} + V_{BE(ON)} = 0.2V$. ; $V_{BE(sat)} = V_{BE(ON)}$) (assuming)

$\therefore\ V_{CB} = (0.2 - 0.7)V$.

$\underline{= -0.5V.}$ --- (iii).

(8)



$\alpha = 0.9920$.

$|V_{BE}(ON)| = 0.7V$.

$\therefore$ i/p loop, $9 = I_E . R_E + V_{EB\_ON}$

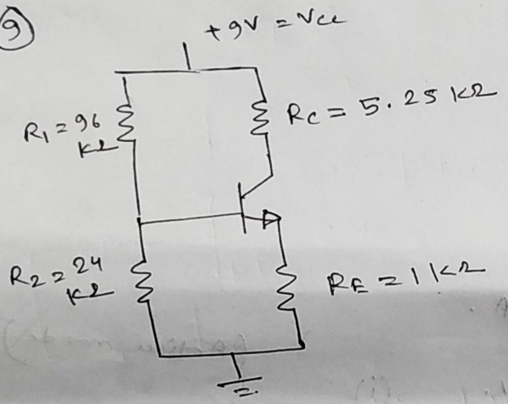
$\therefore I_E = \frac{9 - 0.7}{4\,k\Omega} = 2.075$ mA.

$\therefore I_C = \alpha I_E = 2.06$ mA.

$\therefore$ o/p loop, $V_{BC} + I_C R_C = V_{CC}$

$\therefore V_{BC} = V_{CC} - I_C R_C = 4.47$ V.

(9)



$\boxed{\beta = 80}$

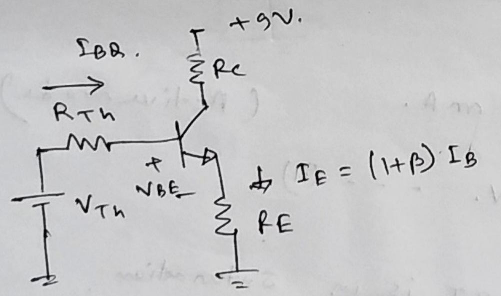
$R_{Th} = 96 \parallel 24$

$R_{Th} = \frac{96 \times 24}{96 + 24} = 19.2\,k\Omega$

$\therefore V_{Th} = 9 \times \frac{24}{96+24}$

$= 1.8$ V.

$\therefore$



$V_{Th} = I_{BQ} . R_{Th} + V_{BE} + I_E R_E$

$\therefore V_{Th} = I_{BQ} . R_{Th} + V_{BE} + (1+\beta) I_{BQ} R_E$

$\therefore I_{BQ} = \frac{V_{Th} - V_{BE}}{R_{Th} + (1+\beta) R_E}$

$= \frac{1.8 - 0.7}{19.2K + (1+80) 1\,K}$

$I_{BQ} = 10.97\ \mu A$.

$\therefore I_{CQ} = \beta I_{BQ} = 0.878$ mA.

$\therefore I_{EQ} = (\beta + 1) I_{BQ}$

$= 0.888$ mA.

$\therefore V_{CEQ} = V_{CC} - I_{CQ} . R_C - I_{EQ} . R_E$

$= 3.50$ V.

if, $\beta = 120.$

$$\therefore I_{BQ} = \frac{V_{Th} - V_{BE}}{R_{Th} + (1+\beta) R_E} = \frac{1.8 - 0.7}{19.2K + (1+120)1K}$$

$$= 7.84 \mu A.$$

$$\therefore I_{CQ} = I_{BQ} \cdot \beta$$

$$= 120 \times 7.84 \mu A. = 0.941 \ mA.$$

$$\therefore \text{change in } I_{CQ} = \frac{0.941 - 0.878}{0.878} \times 100\%. = 7.17\%.$$

Ans

$$\text{" } \quad \text{" } \quad \beta = \frac{120-80}{80} = 50\%$$

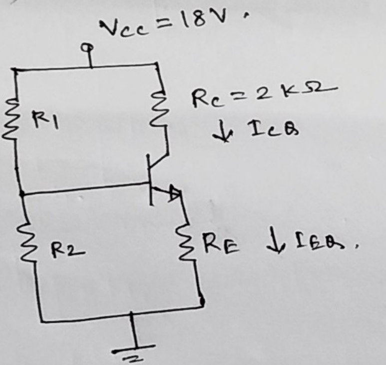
Observation: In voltage divider biasing, though β changes by 50%, the I_{CQ} changes only by 7.17%.,

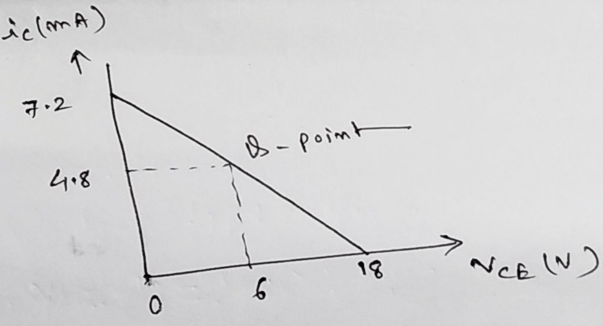
So, the circuit is quite stable in terms of change in β;

Now, Find V_{CEQ} when $\beta = 120$

Change in $V_{CEQ} = -11\%$ Ans

(10)





DC load line characteristics.

$I_{CQ} = 4.8$ mA from DC load line characteristics.

$\beta = 120 \quad \therefore \alpha = 0.9917 \quad \therefore I_{EQ} = \frac{I_{CQ}}{\alpha} = 4.84$ mA.

$V_{CEQ} = 6$ from DC load line characteristics.

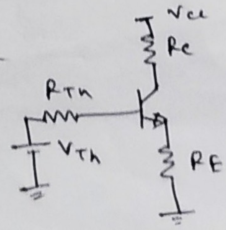
$V_{CEQ} = 18 - I_{CQ} R_C - I_{EQ} \cdot R_E$

$\therefore 6 = 18 - 4.8 \times 2 - 4.84 \times R_E.$

$\therefore R_E = 0.496 \ K\Omega = 496 \ \Omega.$

We know that for voltage devider biasing to make the circuit bias stable in terms of change in β, [Please see class note].

$R_{Th} = 0.1 \times (1+\beta) R_E = 6 \ K\Omega$



where, R_{Th} is the Thevenin's equ^n. resistance at base terminal and

$R_{Th} = (R_1 \| R_2)$ and $V_{Th} = V_{cc} \cdot \frac{R_2}{R_1 + R_2}$

$\therefore I_{BQ} = \frac{I_{CQ}}{\beta} = 0.040 \text{ mA}$

$\therefore V_{Th} = I_{BQ} \cdot R_{Th} + V_{BE(ON)} + R_E \cdot I_E$

$V_{Th} = I_{BQ} \cdot R_{Th} + V_{BE(ON)} + R_E (1+\beta) I_{BQ}$.

$V_{Th} = 0.04 \times R_{Th} + 0.7 + 0.496 \times 0.040 \times 121$

$V_{Th} = 3.34 V$.

$V_{Th} = R_{Th} \cdot \frac{1}{R_1} \cdot V_{cc}$; $\left[R_{Th} = \frac{R_1 R_2}{R_1 + R_2} \right]$

$3.34 = 6 K \cdot \frac{1}{R_1} \cdot 18 V$.

$R_1 = 32.3 \text{ K}\Omega$

$R_{Th} = \frac{R_1 R_2}{R_1 + R_2} = 6 K$.

$R_2 = 7.37 \text{ K}\Omega$.