Tutorial - 3

1) $V_B = 4V$ $\qquad V_E = ?$, $\alpha = ?$, $R_E = ?$

$\beta = 100$ $\qquad V_{BE} = 0.7V$

2eq → Voltage divider bias

$$\frac{R_2}{R_1+R_2} \times V_{cc} = 4$$

$$R_1 + R_2 = \frac{12}{0.1\,mA}$$

$R_2 = 40K$
$R_1 = 80K$

$$\frac{R_2}{R_1+R_2} = \frac{4}{12} = \frac{1}{3}$$

$$R_1 + R_2 = 3R_2$$
$$\Rightarrow R_1 = 2R_2$$

$$I_c = \alpha I_E$$
$$= (\beta+1) I_E = (\beta+1)1$$
$$= 101\,mA$$

$$V_{BE} = \overset{4.0}{V_B} - \overset{0.7}{V_E} \Rightarrow V_E = 3.3V$$

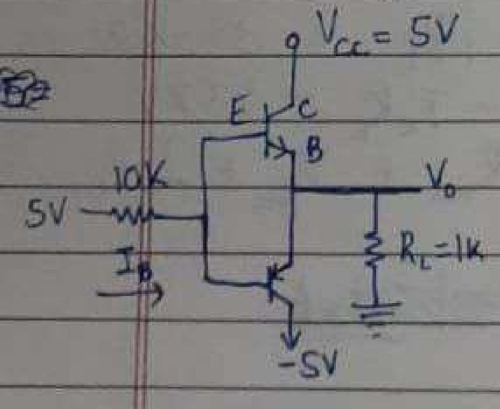
$$V_E = I_E R_E$$
$$\Rightarrow R_E = 3.3\Omega$$

$$R_c = V_{cc} - V_{CE} - I_E R_E = 12 - 0.7 - 3.3$$
$$= \underline{8\Omega}$$

2) $V_{cc} = 5V$ $\qquad$ Fig 2 → ON, Fig 3 → OFF

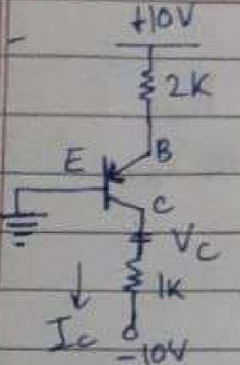
$V_{BE} = 0.7V$

$$V_{cc} = V_{CE} + I_E R_L + (10K) I_B$$
$$\Rightarrow 5 = (V_B - V_E) + (1 + \cancel{100}) I_B R_L + (10K) I_B$$
$$\Rightarrow 5 = 101 I_B + V_B - V_E + 10 I_B$$
$$\Rightarrow 5 - 0.7 = 111 I_B$$
$$\Rightarrow \frac{4.3}{111} = I_B$$
$$\Rightarrow \underline{0.039\,mA} = I_B$$



$$V_o = (1 + \beta) I_B R_L$$
$$\Rightarrow \underline{V_o = 3.939V}$$

3)-



$$V_E = V_B = 0.7$$

$$\Rightarrow I_E = \frac{10-0.7}{2} = 4.65mA$$

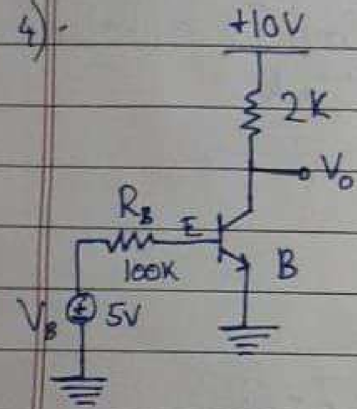
$$\alpha = \frac{1+\beta}{\beta} \Rightarrow \alpha = 0.99$$

$$I_c = \alpha I_E = 4.6035mA$$

$$V_c - 4.6035 = -10$$

$$\Rightarrow V_c = \underline{-5.3965V}$$

4)-



$$V_B - I_B R_B - V_{BE} = 0$$

$$5 - I_B(100) - 0.7 = 0$$

$$\Rightarrow \underline{I_B = 0.043}$$

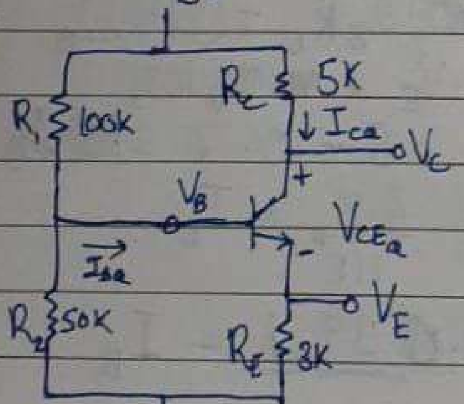
$$I_c = \beta I_B = 4.3mA$$

$$10 - I_c R_c = V_c$$

$$10 - 4.3 \times 2 = V_c = 1.4V$$

$$I_E = (1+\beta) I_B \Rightarrow I_E = \underline{4.343V}$$

5)-



$$\beta = 100$$

$$V_{BB} = \frac{15 \times R_2}{R_1 + R_2} = 5V$$

$$R_{net} = R_1 || R_2 = 33.3K\Omega$$

$$V_B = V_{BE} - I_E R_E = 4.57V$$

$$\Rightarrow V_{BB} = I_B R_{net} + V_{BE} + I_E R_E$$

$$V_{BB} - I_B R_{net} - V_{BE} - 3I_E = 0$$

$$\Rightarrow I_E = (1+\beta) I_B = 101 I_B$$

$$5 - 33.3\,k\, I_B - 0.7 - 3k\,(101 I_B) = 0$$

$$4.7 = (303 + 33.3)k\, I_B$$

$$I_B = \frac{4.7}{336.3}\, mA = \underline{0.014\, mA}$$

$$I_E = 101 I_B = 1.414 mA$$

$$I_C = \beta I_B = 1.4 mA$$

$$V_B = V_{BB} - I_B R_{net} = 5 - (0.014m)(33.3k) = (4.5)V$$

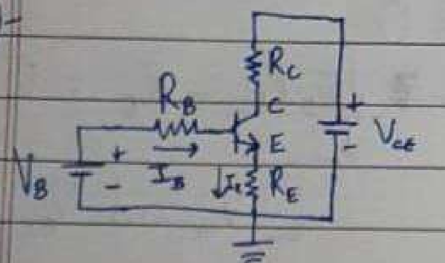
$$V_E = I_E R_E = 15k \times 1.414m = \underline{21.2V}$$

$$15 - I_C(15K) - V_{CE} - I_E(3k) = 0$$

$$\Rightarrow V_{CE} = -21.21 - 7 + 15 = \underline{-13.21V}$$

$$V_C = I_C R_C = 1.4m \times 5k = \underline{7V}$$

6)-



The extent to which collector current I_C is stabilised with varying I_{CO} is measured by stabilising factors. It is defined as the rate of change of collector current I_C w.r.t. collector base leakage current I_{CO}, keeping both the current I_B and current gain β constant. The collector current for a CE amplifier is given by -

$$I_C = \beta I_B + (1+\beta) I_{CO}$$

Diff. $\Rightarrow$ $$1 = \beta \frac{dI_B}{dI_C} + (1+\beta)\frac{dI_{CO}}{dI_C}$$

$$\Rightarrow S = \frac{1+\beta}{1-\beta\frac{dI_B}{dI_C}}$$

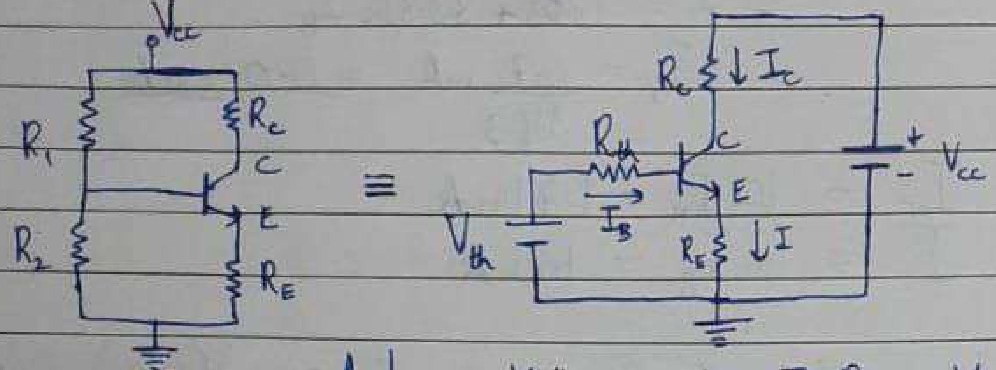
for self bias, $$S = \frac{(1+\beta)\left(1+\frac{R_B}{R_E}\right)}{1+\beta+\frac{R_B}{R_E}}$$

The stability factor S' is defined as the rate of change of I_C with

V_{BE}, keeping I_{Co} and V_{BE} constant.

$$S' = \frac{\partial I_c}{\partial V_{BE}}$$

7)



Applying KVL, $V_{th} - I_B R_{th} - V_{BE} - I_E R_E = 0$

$$I_B = \frac{V_{th} - V_{BE}}{R_{th} - (1+\beta)R_E} \quad \text{— (1)}$$

$$I_E = \frac{V_{th} - V_{BE}}{\frac{R_{th}}{1+\beta} + R_E} \approx I_c \quad (\because I_E \approx I_c)$$

$$V_{th} - I_B R_{th} - V_{BE} - (I_B + I_c) R_E = 0$$

diff. $\Rightarrow 0 - \frac{dI_B}{dI_c} R_{th} - 0 - \frac{dI_B R_E}{dI_c} - R_E = 0$

[$\because V_{th}$ and V_{BE} are constants]

$$\frac{dI_B R_{th}}{dI_c} + \frac{dI_B}{dI_c} R_E + R_E = 0$$

$$\Rightarrow \frac{dI_B}{dI_c} = \frac{-R_E}{R_{th} + R_E}$$

$$\Rightarrow S = \frac{1+\beta}{1-\beta\left(\frac{dI_B}{dI_c}\right)} = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_{th}+R_E}\right)}$$