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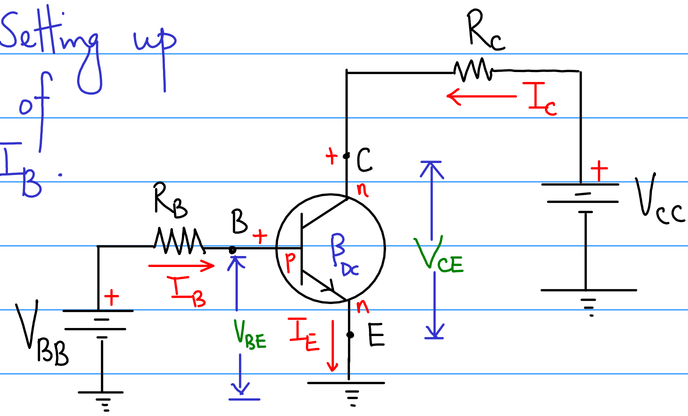
BJT Biasing Circuits

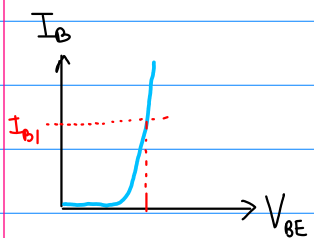
- Base-Emitter : Forward
- Collector-Base : Reverse

① Base Bias : Setting up a fixed value of base current I_B.



$$I_E = I_B + I_C$$

$$I_C = \beta_{DC} \cdot I_B$$



$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$ --- sets-up the base current.

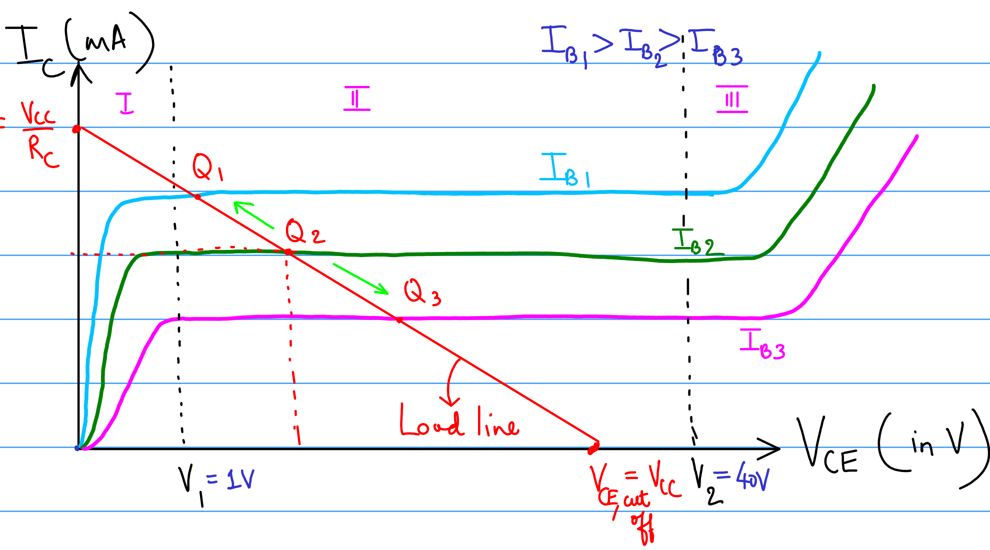
Typically, for Silicon BJTs, $V_{BE} = 0.7\,V$

$$I_B \uparrow = \frac{V_{BB}\uparrow - 0.7\,V}{R_B}$$

Once, I_B is fixed, then we see the variation of I_C with V_{CE}.

For different set of value of I_B, we have different output characteristic curves

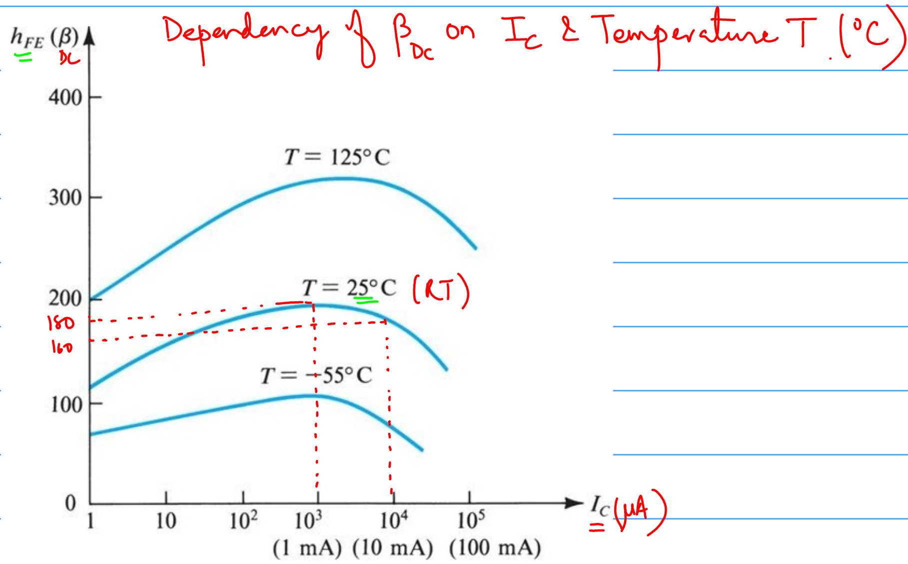
Operating points
- Q_1 : V_{CE1}, I_{C1}
- Q_2 : V_{CE2}, I_{C2}
- Q_3 : V_{CE3}, I_{C3}



$$I_C = \left(\frac{-1}{R_C}\right) V_{CE} + \frac{V_{CC}}{R_C}$$ ... st. line eqn. $(Y = mx + c)$

Here, the operating point Q (V_{CEQ}, I_{CQ}) depends upon the value of $\underline{\underline{I_B}}$ and the ckt. elements (V_{CC}, V_{BB}, R_C, R_B) and the value of 'β_{DC}'.

$$\text{Since, } \underline{\underline{I_C}} = \underbrace{\beta_{DC}}_{\text{dependency of } \beta_{DC}} I_B$$

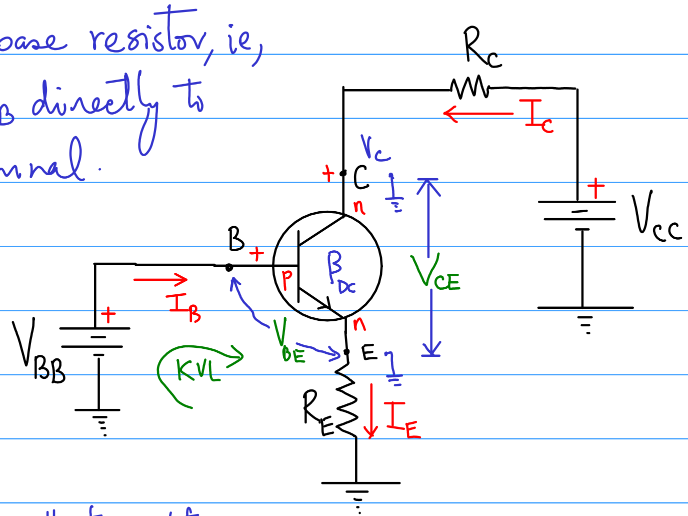


- Typically, the base bias ckt. is simple biasing ckt to understand the operation of a BJT, however it is heavily dependent on the value of β_{DC}.
- For amplifier ckt, the active region of the characteristic curve is used. Therefore, we need to immune the ckt. such that it withstand the the changes due to β_{DC}. — ie, design a biasing ckt which is independent of the value of β_{DC}.

Therefore, we need to re-design a bias ckt. to make it β_{DC} independent.

(2) Emitter-Biasing ckt.

- Removing the base resistor, ie, connect the V_{BB} directly to the base terminal.
- Connect a resistor R_E to the emitter terminal.
- No change in the collector ckt.



$$V_{BB} = V_{BE} + I_E R_E$$

$$\Rightarrow \quad I_E = \frac{V_{BB} - V_{BE}}{R_E}$$

(here, assume $V_{BE} = 0.7\,V$ for Silicon BJTs)

Since, $\quad I_C \approx I_E$

(Since $I_E = I_B + I_C$
$I_B = \mu A$; $I_C \sim mA$)

$$\Rightarrow \quad V_C = V_{CC} - I_C R_C$$

From this, we can determine,

$$V_{CE} = V_C - V_E \qquad \text{where, } V_E = I_E R_E \checkmark$$

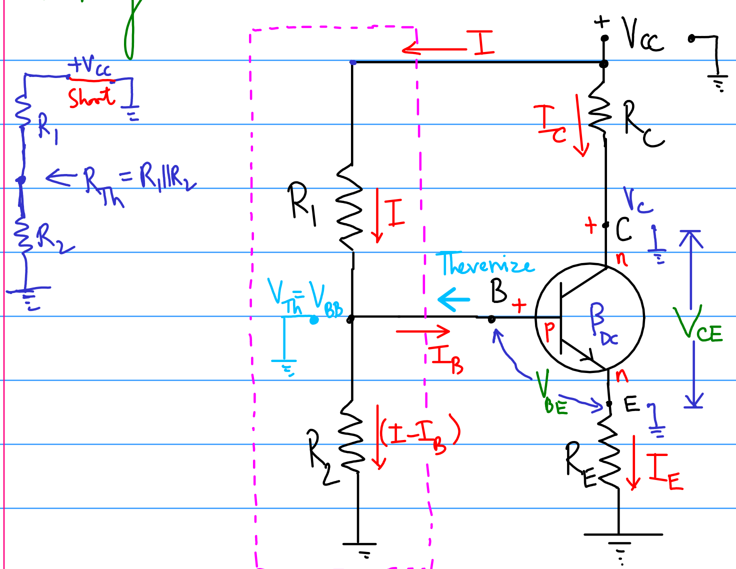
$\Rightarrow$ Operating point Q (V_{CE}, I_C) becomes independent of β_{DC}

Note: In previous biasing ckts (Base-Bias / Emitter-Bias), we are using two sources, ie, V_{BB} & V_{CC}.

Can we design a biasing ckt. with only one source?

YES.

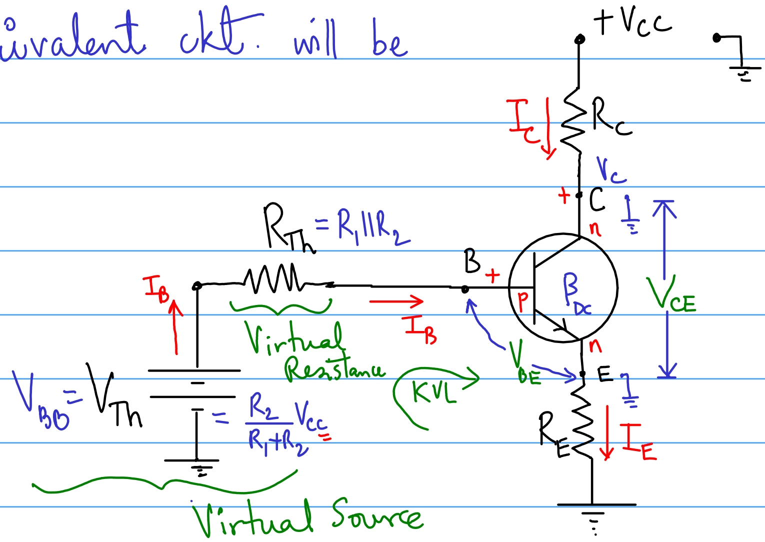
(3) Voltage-Divider Bias Circuit: Use single dc source V_{CC} to bias the BJT.



$$V_{Th} = V_{BB} = \frac{R_2}{R_1+R_2} V_{CC}$$

$$R_{Th} = R_1 \| R_2 = \frac{R_1 R_2}{R_1+R_2}$$

Equivalent ckt. will be



$$I_E = I_B + I_C$$

Reference: Chapter 6 & 7 from Malvino & Bates.