21.02.2022

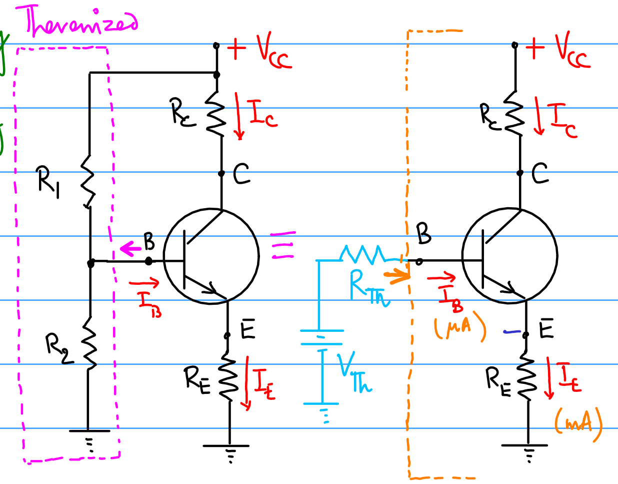
BJT Baising Circuits

Reference: Chapter 6 & 7
Book: Malvino & Bates

Recap: (1) Base-Bias ckt. : Fix I_B ; β_{DC}-dependency

(2) Emitter-Bias ckt: R_E ; β-independent

(3) Voltage-Divider Bias ckt:

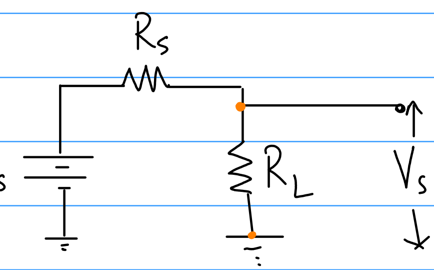


Effectively, one can say that

V_{Th} is the source which bias the base-emitter junction, and R_{Th} is the source resistance.

where, $\underbrace{V_{Th} = \frac{R_2}{R_1+R_2} \cdot V_{cc}}$; $\underbrace{R_{Th} = R_1 \| R_2}$

The condition under which all source voltage to be dropped across the load is called "Stiff".



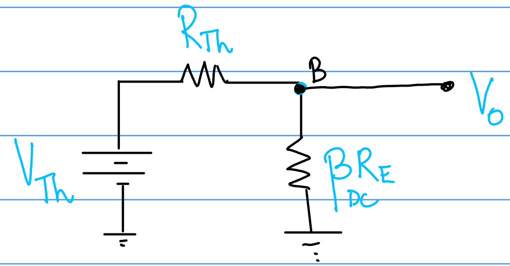
$$\boxed{R_L \geq 100 R_s}$$

---- Refer to chap 1.

Here, to estimate the effective load to the base terminal, we can compare the base-current (I_B) with emitter current (I_E)

Since $I_E \approx I_C = \beta_{DC} I_B$

Since $\boxed{I \propto \frac{1}{R}}$ $\Rightarrow$ Effective load as seen from the base terminal is $\beta_{DC} R_E$



$$V_o = \frac{\beta_{DC} R_E}{\beta_{DC} R_E + R_{Th}} \cdot V_{Th}$$

$\beta_{DC} R_E \geq 100\, R_{Th}$ --- stiff condition.

$V_o \approx V_{Th}$

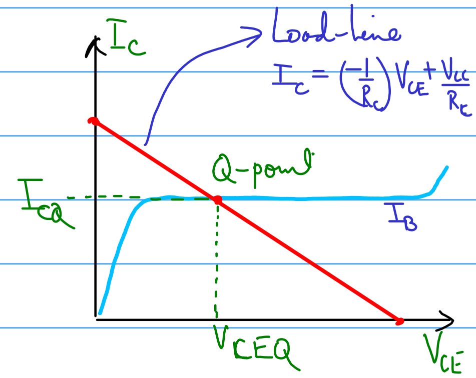
$$\Rightarrow \boxed{\beta_{DC} R_E \geq 100\,(R_1 \| R_2)}$$

Summary: For designing a voltage-divider bias ckt.

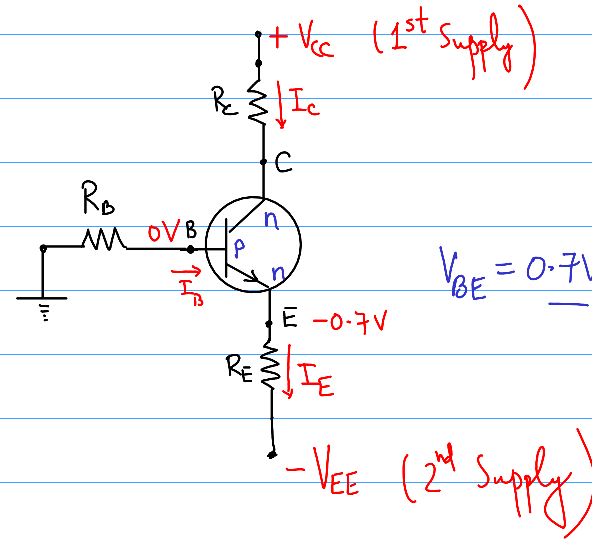
- Verify the condition for 'stiff' voltage source ie,

$$\beta_{DC} R_E \geq 100\,(R_1 \| R_2)$$

- $I_E = \dfrac{V_E}{R_E}$
- $I_C = I_E$
- $V_C = V_{CC} - I_C R_C$
- $V_{CE} = V_C - V_E$
- Q-point (V_{CEQ}, I_{CQ})



(4) Two-supply Emitter Bias :



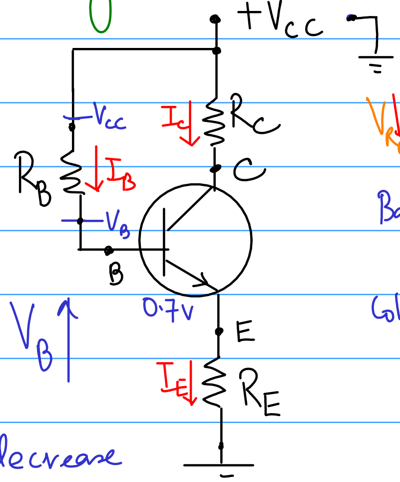
- $V_B = 0\,V$
- $V_E = -0.7V$
- $I_E = \dfrac{V_{EE} - 0.7V}{R_E}$ ✓

$V_{BE} = 0.7V$

- $I_C \approx I_E$
- $V_C = V_{CC} - I_C R$
- $V_{CE} = V_C - V_E = V_C + 0.7V$
- Operating point (Q-point) : V_{CEQ}, I_{CQ}

(5) Feedback Bias Ckt. :

(i) Emitter-Feedback ckt. (Negative Feedback)



$V_{R_B} \downarrow = V_{cc} - V_B \uparrow$

Base-Emitter: Forward

Collector-Base: Reverse

In this ckt., suppose while operation, the collector-current increases.

ie,

$$I_C \uparrow \Rightarrow I_E \uparrow \Rightarrow V_E \uparrow \Rightarrow V_B \uparrow$$

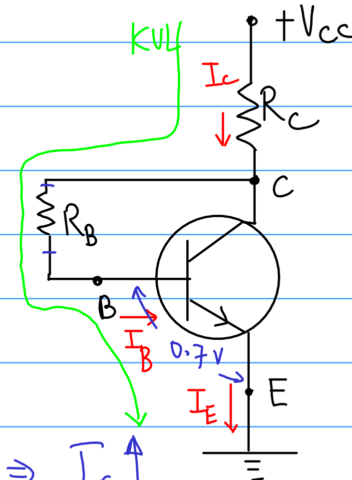
effectively, the voltage drop across R_B decrease

$$V_{R_B}\downarrow \Rightarrow I_B\downarrow \Rightarrow I_C\downarrow$$ ... since $I_C = \beta I_B$

ie, any increase in the value of I_C, the ckt. behaves as "negative feedback", and effectively reduces the value of I_C. $I_C \uparrow\downarrow \Rightarrow Q\uparrow\downarrow$ or $I_C\downarrow\uparrow \Rightarrow Q\downarrow\uparrow$

(ii) Collector-feedback ckt:

- $I_C\uparrow \Rightarrow V_C\downarrow \Rightarrow V_{R_B}\downarrow \Rightarrow I_B\downarrow$
  $\Rightarrow I_C\downarrow$



$V_C = V_{CC} - I_C R_C$

or,

- $I_C\downarrow \Rightarrow V_C\uparrow \Rightarrow V_{R_B}\uparrow \Rightarrow I_B\uparrow \Rightarrow I_C\uparrow$

$$V_{CC} = I_C R_C + I_B R_B + V_{BE}$$

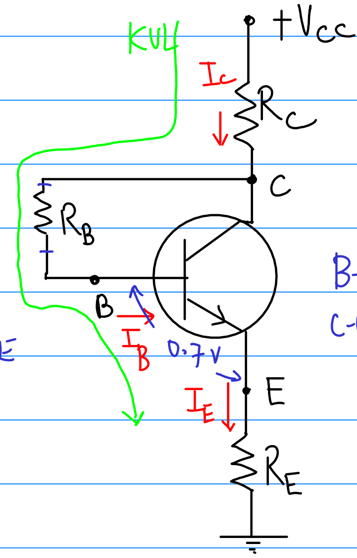
$$V_{CC} - V_{BE} = I_C R_C + \frac{I_C}{\beta_{DC}} R_B$$

$$\Rightarrow I_C = \frac{V_{CC} - V_{BE}}{R_C + \frac{R_B}{\beta_{DC}}}$$

Therefore, $V_C = V_{CC} - I_C R_C$

Q-point (V_{CEQ}, I_{CQ})

(iii) Emitter-Collector feedback ckt.



B-E Junct: Forwa

C-B Junct: Revers

$$V_{CC} = I_C R_C + I_B R_B + V_{BE} + I_E R_E$$

Since, $I_C \approx I_E$; $I_B = \dfrac{I_C}{\beta_{DC}}$

$$\Rightarrow V_{CC} = I_C R_C + \frac{I_C}{\beta_{DC}} R_B + V_{BE} + I_C R_E$$

$$\Rightarrow I_C = \frac{V_{CC} - V_{BE}}{R_C + \dfrac{R_B}{\beta_{DC}} + R_E}$$

Therefore, $V_C = V_{CC} - I_C R_C$

$$V_E = I_E R_E$$

$$V_{CE} = V_C - V_E$$

Q-point (V_{CEQ}, I_{CQ})