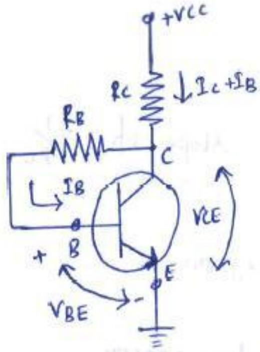
Topic 1.4 : Collector-to-base Bias configuration

2. Collector to Base Bias | Biasing with Feedback Resistor



* It's an improvement over the fixed bias method
* The resistor is connected b/w the base & the collector of the transistor. Hence, the circuit is called collector to base bias circuit.
* Thus I_B flows through R_B & (I_C+I_B) flows through the R_C.

Dc Analysis

* For Dc $f=0$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{0} = \infty$$

Collector Current I_C

* Apply KVL to the base-Emitter circuit

$$V_{CC} - (I_B+I_C)R_C - I_B R_B - V_{BE} = 0$$

$$V_{CC} - (\beta+1)I_B R_C - I_B R_B - V_{BE} = 0$$

$$V_{CC} - I_B((\beta+1)R_C + R_B) - V_{BE} = 0$$

$$V_{CC} - V_{BE} = I_B((\beta+1)R_C + R_B)$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1)R_C}}$$

* If there is a change in β due to piece to piece variation b/w Transistors, then I_C tends to increase. As the result voltage drop across R_C increases.
* The supply voltage V_{CC} is constant, due to increase in $I_C R_C$, V_{CE} decreases. Due to reduction in V_{CE}, I_B decreases. This I_B reduction in lead to increase I_C.

W.K.T $I_B = \frac{I_C}{\beta} \Rightarrow I_C = \beta I_B$

$$I_C = \beta \left[\frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_C} \right]$$

Collector Emitter Voltage V_{CE}

* Apply KVL to the collector - Emitter circuit

$$V_{CC} - (I_B + I_C) R_C - V_{CE} = 0$$

$$V_{CE} = V_{CC} - (I_B + I_C) R_C$$

Load Line Analysis

* Apply KVL to the collector - Emitter circuit

$$V_{CC} - (I_B + I_C) R_C - V_{CE} = 0$$

* Assume $I_B + I_C \simeq I_C$

$$V_{CC} - I_C R_C - V_{CE} = 0$$

$$I_C = -\frac{1}{R_C} V_{CE} + \frac{V_{CC}}{R_C}$$

* The equation represents a DC load line with slope of $-\frac{1}{R_C}$ & y-intercept $\frac{V_{CC}}{R_C}$.

* When $I_C = 0$ ie Transistor is in cut-off region

$$V_{CE} = V_{CC}$$

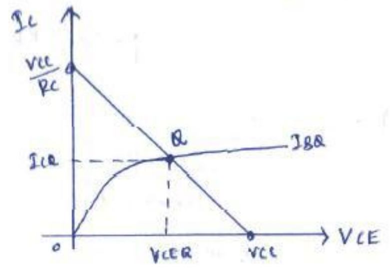
* When $V_{CE} = 0$ ie Transistor is in saturation region

$$I_C = \frac{V_{CC}}{R_C}$$

* Thus the 2 end points are $(V_{CC}, 0)$ & $(0, \frac{V_{CC}}{R_C})$. by joining the 2 end points DC load line is drawn.

* From Base - Emitter circuit

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_C}$$



The saturation current for the circuit is $I_{C\,sat} = \frac{V_{CC}}{R_C}$

Stability Factors

S:

* Apply KVL to the base - Emitter junction

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

* When I_B changes by ∂I_B & I_C changes by ∂I_C There is no effect on V_{CC} & V_{BE}

* So the equation becomes

$$0 = \partial I_C R_C + \partial I_B (R_C + R_B) + 0$$

$$\partial I_B (R_C + R_B) = -\partial I_C R_C$$

$$\frac{\partial I_B}{\partial I_C} = -\frac{R_C}{R_C + R_B} \quad -①$$

* substitute ① in S

$$S = \frac{1+\beta}{1-\beta\left(\frac{\partial I_B}{\partial I_C}\right)} = \frac{1+\beta}{1-\beta\left(\frac{-R_C}{R_C+R_B}\right)}$$

$$S = \frac{1+\beta}{1+\beta\left(\frac{R_C}{R_C+R_B}\right)}$$

* The collector - Base bias circuit is having Lesser stability factor Than fixed bias circuit.

* Hence the circuit provides better stability than fixed bias circuit

S':

$$S' = \frac{-\beta}{R_B + (1+\beta)R_C}$$

S'':

$$S'' = \frac{I_C}{\beta}\left(\frac{S}{1+\beta}\right)$$