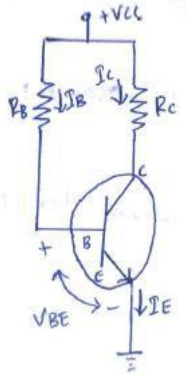
Topic 1.3 : Fixed Bias configuration

Different types of Biasing circuits / Various biasing Methods for BJT

1. Fixed Bias
2. Collector to Base Bias / Biasing with Feedback Resistor
3. Self Bias (or) Voltage Divider Bias

1. Fixed Bias / Base Bias



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

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

$$I_B R_B = V_{cc} - V_{BE}$$

$$I_B = \frac{V_{cc} - V_{BE}}{R_B}$$

* When V_{cc} & R_B are selected for a circuit I_B is fixed. Hence, The circuit is called Fixed bias circuit.

$$I_c = \beta I_B = \beta \left(\frac{V_{cc} - V_{BE}}{R_B} \right)$$

Collector Emitter Voltage (V_{CE})

* Apply KVL to the collector - Emitter circuit

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

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

Load line Analysis

* Apply KVL to the collector- Emitter circuit

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

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

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

* This eqn represents dc load line with slope of $-\frac{1}{R_C}$ & y-intercept of $\frac{V_{CC}}{R_C}$.

* When $I_C = 0$ i.e the transistor is in cutoff region

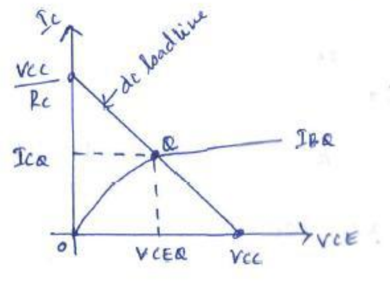
$$V_{CE} = V_{CC}$$

* When $V_{CE} = 0$ i.e : the transistor is in saturation region

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

* Thus the 2 end points are $(V_{CC}, 0)$ & $(0, \frac{V_{CC}}{R_C})$
  (V_{CC} → (x) → V_{CE}; 0 → (y) → I_C; 0 → x → V_{CE}; $\frac{V_{CC}}{R_C}$ → y → I_C)

* By joining this 2 end points Dc load line is drawn.



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

Stability factors

S:

$$S = \frac{\partial I_C}{\partial I_{CO}} \Big| V_{BE} \,\&\, \beta \text{ constant} \quad (\text{or}) \quad \frac{\Delta I_C}{\Delta I_{CO}} \Big| V_{BE} \,\&\, \beta \text{ constant}$$

* We know that

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

* No collector current present in this equation. So $\frac{\partial I_B}{\partial I_C} = 0$ —(1)

* We know I_c

$$I_c = \beta I_B + (1+\beta) I_{co}$$

* differentiate I_c with respect to I_c we get

$$\frac{\partial I_c}{\partial I_c} = \beta \frac{\partial I_B}{\partial I_c} + (1+\beta) \frac{\partial I_{co}}{\partial I_c} \qquad \because \frac{\partial I_c}{\partial I_{co}} = S$$

$$1 = \beta \frac{\partial I_B}{\partial I_c} + (1+\beta) \times \frac{1}{S}$$

$$1 - \beta \frac{\partial I_B}{\partial I_c} = \frac{1+\beta}{S}$$

$$\boxed{S = \frac{1+\beta}{1 - \beta \frac{\partial I_B}{\partial I_c}}} \quad — ②$$

* Substitute ① in ②

$$S = \frac{1+\beta}{1-\beta(0)}$$

$$\boxed{S = 1+\beta}$$

S' :

$$S' = \left.\frac{\partial I_c}{\partial V_{BE}}\right|_{I_{co} \;\&\; \beta \text{ constant}} \text{ (or) } \left.\frac{\Delta I_c}{\Delta V_{BE}}\right|_{I_{co} \;\&\; \beta \text{ constant}}$$

* W.K.T

$$I_c = \beta I_B + (1+\beta) I_{co}$$

* substitute I_B in I_c

$$I_c = \beta \left(\frac{V_{cc} - V_{BE}}{R_B} \right) + (1+\beta) I_{co}$$

$$I_c = \frac{\beta V_{cc}}{R_B} - \frac{\beta V_{BE}}{R_B} + (1+\beta) I_{co} \quad — ③$$

* differentiate w.r.to V_{BE}

$$\frac{\partial I_c}{\partial V_{BE}} = 0 - \beta/R_B + 0$$

$$\boxed{S' = -\frac{\beta}{R_B}}$$

Relation between S & S'

$S = 1+\beta \qquad S' = \frac{-\beta}{R_B}$

In S' Multiply numerator & denominator by $(1+\beta)$ we get

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

S'':

$$S'' = \frac{\partial I_C}{\partial \beta}\Big|_{V_{BE}\ \&\ I_{CO}\ \text{constant}} = \frac{\Delta I_C}{\Delta \beta}\Big|_{V_{BE}\ \&\ I_{CO}\ \text{constant}}$$

From (3)

$$I_C = \frac{\beta V_{CC}}{R_B} - \frac{\beta V_{BE}}{R_B} + (1+\beta) I_{CO}$$

differentiate w.r.to 'β'

$$\frac{\partial I_C}{\partial \beta} = \frac{V_{CC}}{R_B} - \frac{V_{BE}}{R_B} + I_{CO}$$

$$\because I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$$= I_B + I_{CO} \qquad \because I_B \gg I_{CO}$$

$$= I_B + 0$$

$$\frac{\partial I_C}{\partial \beta} = \frac{I_C}{\beta} \qquad \because I_B = \frac{I_C}{\beta}$$

$$\boxed{S'' = \frac{\partial I_C}{\partial \beta} = \frac{I_C}{\beta}}$$

Relation b/w S & S''

$S = 1+\beta \qquad S'' = \frac{I_C}{\beta}$

In S'' Multiply Numerator & denominator by $(1+\beta)$ we get

$$S'' = \frac{I_C(1+\beta)}{\beta(1+\beta)} = \frac{I_C S}{\beta(1+\beta)} \qquad \because S = 1+\beta$$

Advantages:

* Simple circuit which uses very few components.
* The operating point can be fixed anywhere in the active region of the characteristics by simply changing the value of R_B. Thus it provides maximum flexibility in the design.

· Disadvantages

1. Thermal stability is not provided by this circuit. so the operatii point is not maintained.

$$I_C = \beta I_B + I_{CEO}$$

2. Since $I_C = \beta I_B$ & I_B is already fixed ; I_C depends on β which changes unit to unit & shifts the operating point.

The stabilization of operating point is very poor in the fixed bias circuit. Because of this reason the fixed bias circuit need some modifications.

In the modified circuit, R_B is connected b/w collector & base. Hence the circuit is called collector to base bias circuit.