BJT Biasing Circuits

Theory:

In a BJT amplifier, biasing (i.e., ensuring certain DC values of I_C, V_{CE}, etc) is very important for two reasons:

(a) The DC bias point has a direct impact on the maximum swing that can be obtained at the output pin.

(b) The DC collector current I_C also determines the transconductance g_m of the BJT since $g_m = \frac{I_C}{V_T}$, V_T being the thermal voltage, $V_T = \frac{kT}{q}$, approximately 25 mV at room temperature.

A good biasing arrangement must be insensitive to variation in the gain (ß) of the BJT. This is because ß can vary significantly from transistor to transistor (even with the same part number); also ß can change appreciably as the device temperature changes.

Potential divider biasing:

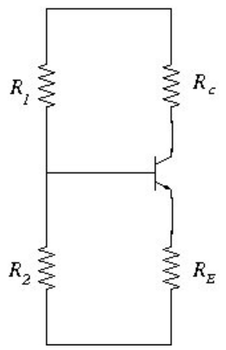

Figure 1

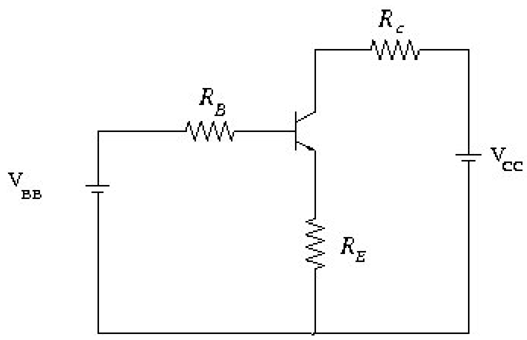

Figure 2

A potential divider consisting of R_1 and R_2 (see Fig. 1) can be used to establish the desired DC bias voltage V_{BB} at the base.

DC analysis:

1. Thevenin equivalent of base circuit gives,

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

2. $R_B = R_1 \| R_2$

3. Applying KVL to base circuit loop and collector circuit loop we get,

   $V_{BB} = I_B . R_B + I_E . R_E + V_{BE}$

   $V_{CC} = I_C . R_C + V_{CE} + I_E . R_E$

Solving we get,

$I_E = \frac{(V_{BB}-0.7)\,(\beta+1)}{R_B + (\beta+1)R_E}$ where, $V_{BE} = 0.7V$

- Since $V_{BB} >> V_{BE}$, small variations in V_{BE} can be swamped by V_{BB}.

  However, if V_{BB} it is made too large, the voltage V_{CE} gets reduced and that limits the voltage swing. Hence as a rule of thumb while designing the biasing circuit; V_{BB}, V_{CE}, and $I_C R_C$ are chosen about $\frac{1}{3}V_{CC}$.

- $R_E >> \frac{R_B}{(\beta+1)}$.

  If R_E is sufficiently large compared to R_B, any small variation in ß does not affect I_E and hence I_C to a large extent. This is achieved by choosing small R_B. However, if R_B is made too small, the input resistance of the amplifier is reduced. Typically, current through the potential divider is chosen to be about $0.1I_E$ to keep the current drain from power supply minimum.

Role of R_E: R_E provides negative feedback and stabilizes I_E and hence I_C. Any increase in I_E raises the emitter voltage V_E reducing base emitter forward bias. This reduces base current I_B and in turn I_C and hence I_E.