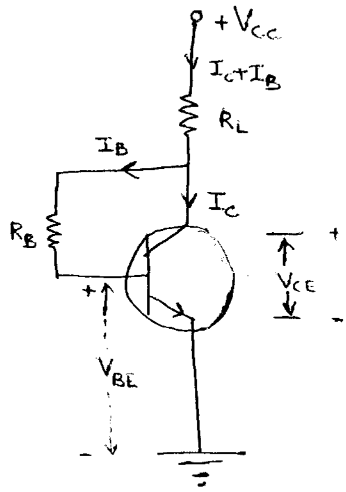
COLLECTOR TO BASE BIAS

The circuit of NPN transistor connected in CE configuration with collector to base bias. Using this circuit, there is considerable improvement in the stability.

Circuit Analysis



COLLECTOR TO BASE BIAS

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

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

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

From the output section of the circuit we have

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

$$\boxed{V_{CE} \approx V_{CC} - I_C R_C} \quad \text{---(2)} \qquad \text{since } (I_B \ll I_C)$$

Substituting (2) in (1)

$$I_B = \frac{V_{CE} - V_{BE}}{R_C + R_B}$$

Stability Factor (S)

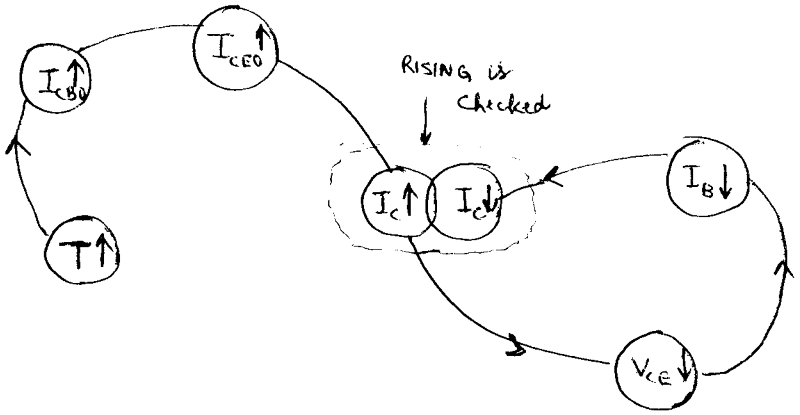
Differentiating eq (1) w.r.t I_C

$$\frac{dI_B}{dI_C} = -\frac{R_L}{R_L + R_B}$$

$$S = \frac{1+\beta}{1 - \beta \frac{dI_B}{dI_C}}$$

$$\boxed{S = \frac{1+\beta}{1 + \frac{\beta R_L}{R_L + R_B}}}$$

Suppose the temperature increases causing the leakage current (and also β) to increase. This increases the collector current $(I_C = \beta I_B + (1+\beta) I_{CO})$. As collector current increases, the V_{CE} decreases [$\because V_{CE} = V_{CC} - I_C R_C$], the reduced V_{CE} causes decrease in Base current I_B. The lowerd base current in turn reduces the original increase in collector current. This is shown below



Stability of I_C

Q Why collector-to-Base bias is seldom used?

The circuit has a tendency to stabilize the operating point against temperature and β variations. But the circuit is not very used. The R_B not only provides a dc feedback for the stabilization of operating point, but it also causes an ac. feedback. This reduces the voltage gain of the amplifier. It is not desirable. So loss of gain in amplifier is not acceptable. So It is not used.

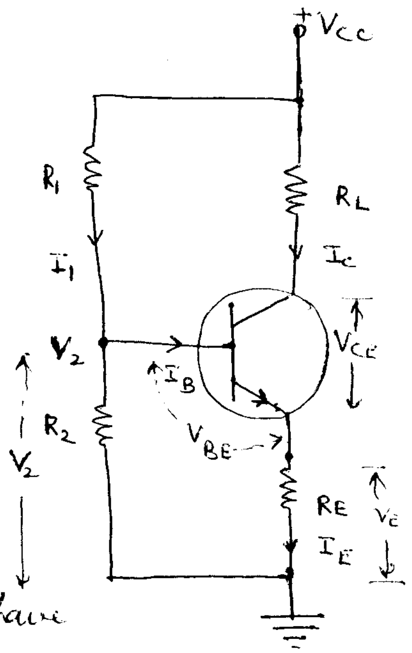
SELF BIAS OR EMITTER BIAS (VDB)

A very commonly used biasing arrangement is self Bias or emitter Bias. This is also known as Voltage divider Biasing. In this method two resistances is used R_1 and R_2 are connected accross supply voltage V_{CC} and provide biasing. The R_E provides biasing such that stabilization is increased. By suitably selecting the voltage divider network, the operating point of the transistor can be made almost independent of Beta (β). That is why this circuit is also called "Independent to Beta".

Circuit Analysis :-

The current I_1 flowing through R_1 or R_2

$$I_1 = \frac{V_{CC}}{R_1 + R_2}$$



The Voltage V_2 developed accross R_2 is given by

$$V_2 = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2$$

Applying KVL to base circuit, we have

$$V_2 = V_{BE} + V_E$$

$$V_2 = V_{BE} + I_E R_E$$

$$\boxed{I_C = \frac{V_2 - V_{BE}}{R_E}} \quad [\because I_C \simeq I_E)$$

Here I_C is almost independent of transistor parameters and hence good stabilization is ensured.

The collector emitter voltage V_{CE} can be calculated as follows

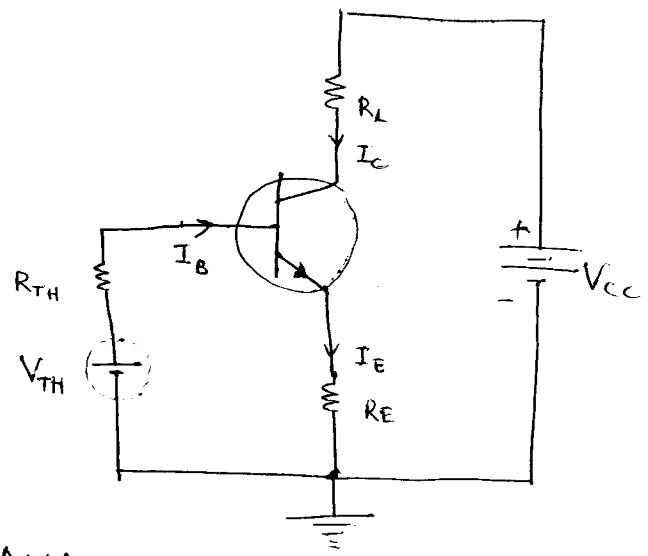
Applying KVL

$$V_{CC} = I_C R_L + V_{CE} + I_E R_E$$

$$\boxed{V_{CE} = V_{CC} - I_C (R_L + R_E)}$$

Accurate Analysis :-

Applying Thevenin's Theorem :-



$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2}$$

$$V_{TH} = \frac{R_2}{R_1 + R_2} V_{CC}$$

Applying KVL to base circuit

$$V_{TH} = I_B R_{TH} + V_{BE} + (I_B + R_c) R_E$$

differentiating the above equation

$$\frac{dI_B}{dI_c} = \frac{-R_E}{R_{TH} + R_E}$$

Stability factor $\rightarrow$ $$S = \frac{1+\beta}{1 - \beta \frac{dI_B}{dI_c}}$$

$$\boxed{S = \frac{1+\beta}{1 + \beta \frac{R_E}{R_{TH} + R_E}}}$$