Stability Factor Analysis

Bias Stability

Mathematical Model

$\boxed{\text{Stability factor Analysis}}$

objective – To ensure bias stability

$$I_{CQ} = I_{CQ}(\beta, V_{BE}, I_{CBO})$$

$$dI_{CQ} = \frac{\partial I_{CQ}}{\partial \beta} d\beta + \frac{\partial I_{CQ}}{\partial V_{BE}} dV_{BE} + \frac{\partial I_{CQ}}{\partial I_{CBO}} dI_{CBO}$$

If the changes are small

then

$$dI_{CQ} = \Delta I_{CQ}$$
$$d\beta = \Delta \beta$$
$$dV_{BE} = \Delta V_{BE}$$
$$dI_{CBO} = \Delta I_{CBO}$$

&

$$\frac{\partial I_{CQ}}{\partial \beta} = \frac{\Delta I_{CQ}}{\Delta \beta}.$$

$$\frac{\partial I_{CQ}}{\partial V_{BE}} = \frac{\Delta I_{CQ}}{\Delta V_{BE}}$$

$$\frac{\partial I_{CQ}}{\partial I_{CBO}} = \frac{\Delta I_{CQ}}{\Delta I_{CBO}}.$$

Mathematical Model

So.

$$\Delta I_{CQ} = \frac{\Delta I_{CQ}}{\Delta \beta} \Delta \beta + \frac{\Delta I_{CQ}}{\Delta V_{BE}} \Delta V_{BE} + \frac{\Delta I_{CQ}}{\Delta I_{CBO}} \Delta I_{CBO}$$

Let,

$$\frac{\Delta I_{CQ}}{\Delta \beta} = S_\beta = \text{Gain sensitivity}$$

$$\frac{\Delta I_{CQ}}{\Delta V_{BE}} = S_V = \text{Voltage Sensitivity}$$

$$\frac{\Delta I_{CQ}}{\Delta I_{CBO}} = S_I = \text{Current Sensitivity}$$

$$\boxed{\Delta I_{CQ} = S_\beta \Delta \beta + S_V \Delta V_{BE} + S_I \Delta I_{CBO}}$$

Mathematical Model

Changes of β is not small & taken care at the time of developing biasing circuit.

So

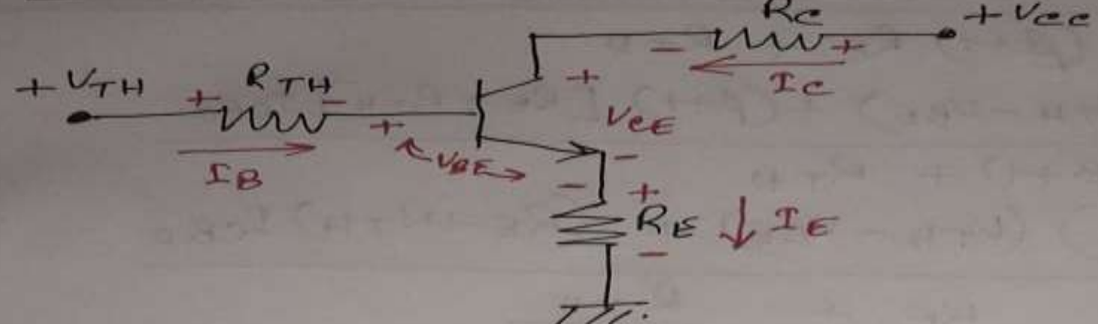
$$\boxed{\Delta I_{CQ} = S_V \Delta V_{BE} + S_I \Delta I_{CBO}}$$

To get $\Delta I_{CQ} \longrightarrow 0$

S_I & S_V should approach zero.

Mathematical Model

For Voltage divider bias ckt.



$$V_{TH} - I_B R_{TH} - V_{BE} - I_E R_E = 0$$

$$I_B = \frac{I_E}{\beta+1} - I_{CBO}.$$

$$V_{TH} - \left(\frac{I_E}{\beta+1} - I_{CBO}\right) R_{TH} - V_{BE} - I_E R_E = 0$$

$$\therefore \quad (V_{TH} - V_{BE}) + I_{CBO} R_{TH} - I_E\left(R_E + \frac{R_{TH}}{\beta+1}\right) = 0$$

$$\therefore \quad I_E = \frac{V_{TH} - V_{BE} + I_{CBO} R_{TH}}{R_E + R_{TH}/\beta+1}$$

Mathematical Model

$$I_C = \frac{\beta}{\beta+1} I_E + I_{CBO}$$

$$\therefore\ I_E = \frac{\beta+1}{\beta}\left(I_C - I_{CBO}\right)$$

$$\frac{\beta+1}{\beta}\left(I_C - I_{CBO}\right) = \frac{V_{TH} - V_{BE} + I_{CBO} R_{TH}}{R_E + \frac{R_{TH}}{\beta+1}}.$$

$$\cdot\ I_C = \frac{\beta\left(V_{TH} - V_{BE}\right) + \beta I_{CBO} R_{TH}}{R_E(\beta+1) + R_{TH}} + I_{CBO}$$

Mathematical Model

$$I_C = \frac{\beta(V_{TH} - V_{BE}) + \beta I_{CBO} R_{TH} + R_E(\beta+1) I_{CBO} + R_{TH} I_{CBO}}{(\beta+1) R_E + R_{TH}}$$

$$\therefore I_C = \frac{\beta(V_{TH} - V_{BE}) + (\beta+1)[R_E + R_{TH}] I_{CBO}}{R_E(\beta+1) + R_{TH}}$$

$$\therefore I_C = \frac{\left(\frac{\beta}{\beta+1}\right)(V_{TH} - V_{BE}) + (R_E + R_{TH}) I_{CBO}}{R_E + \frac{R_{TH}}{\beta+1}}$$

Using approximations.

$$\beta/\beta+1 \simeq 1$$

$$R_E >> \frac{R_{TH}}{\beta+1}.$$

$$I_C = \frac{(V_{TH} - V_{BE}) + (R_E + R_{TH}) I_{CBO}}{R_E}$$

Outcome

$$S_V = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{\partial I_C}{\partial V_{BE}} = -\frac{1}{R_E}$$

$S_V \to 0,\ R_E \longrightarrow$ very large.

$$S_I = \frac{\Delta I_C}{\Delta I_{CBO}} = \frac{\partial I_C}{\partial I_{CBO}} = \left(1 + \frac{R_{TH}}{R_E}\right)$$

Stability factor.