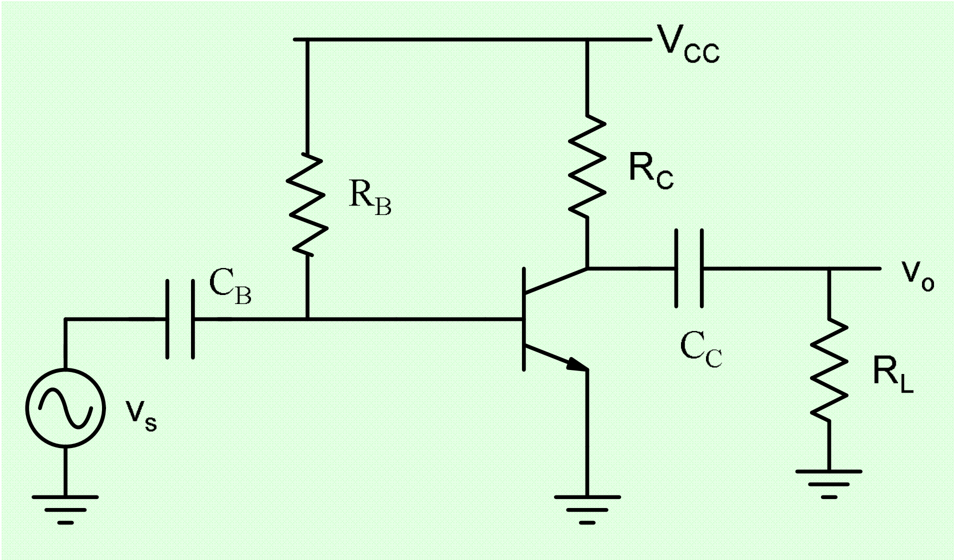
EEE210: Microelectronics-I

Lecture-16 :BJT Amplifier-part-5
Biasing

Instructor - Y. S. Chauhan

Slides from: B. Mazhari
Dept. of EE, IIT Kanpur



$$\text{Bias Point}: \ \mathrm{I}_{CQ}, V_{CEQ}$$

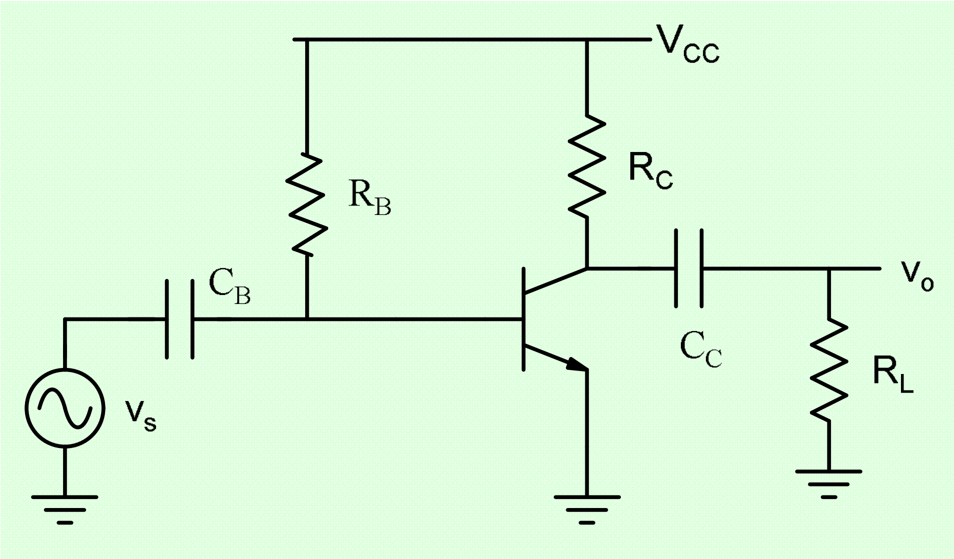
$$R_{in} \sim r_\pi = \frac{V_T}{I_{CQ}}\beta$$

$$|A_{VO}| = \frac{V_{CC} - V_{CEQ}}{V_T}$$

$$v_{om} = Min\left\{V_{CEQ} - V_{CEsat}; \left(I_{CQ} \times R_C \| R_L\right) \times \left(\frac{HD_2}{25}\right)\right\}$$

G-Number

Bias Stability



Bias Point : I_{CQ}, V_{CEQ}

Sources of variation:

1. Supply voltage
2. Temperature
3. Current gain β

$$I_{CQ} = \left(\frac{V_{CC} - V_{BE}}{R_B} \right) \times \beta$$

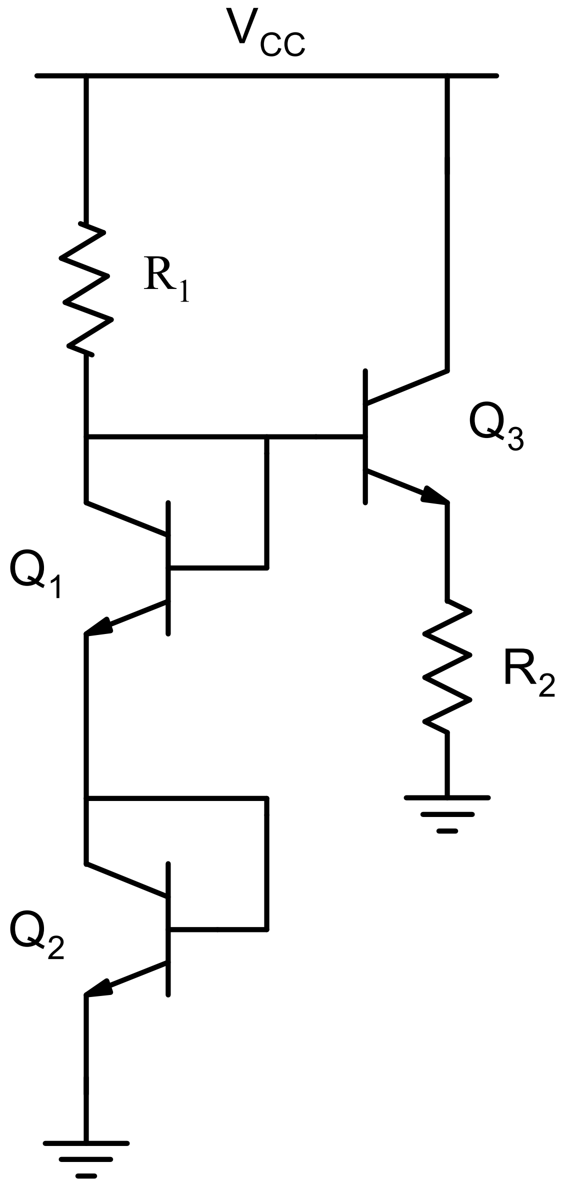
$$S_x = \frac{\Delta I_{CQ} / I_{CQ}}{\Delta x / x}$$

$$S_{V_{CC}} = \frac{\Delta I_{CQ} / I_{CQ}}{\Delta V_{CC} / V_{CC}} = \frac{V_{CC}}{V_{CC} - 0.7}$$

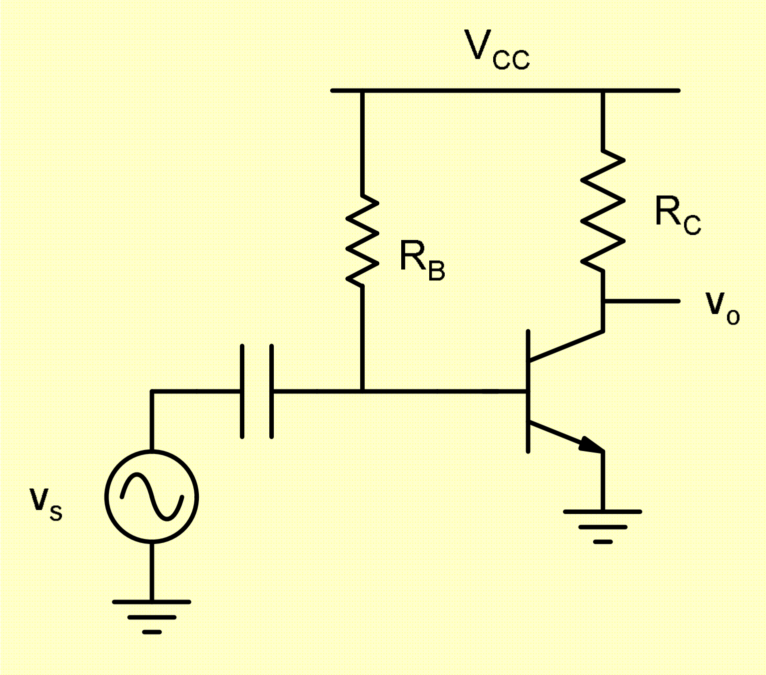
$$S_{V_{BE}} = \frac{V_{BE}}{V_{CC} - 0.7}$$

$$S_\beta = 1$$

Supply Independent Current (?)



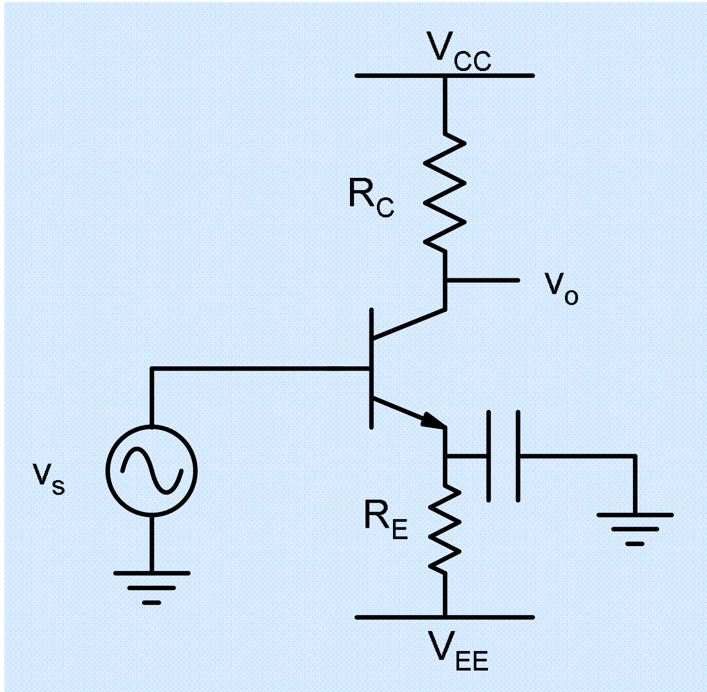
$$I_{R2} \sim \frac{0.7}{R_2}$$



$$I_{CQ} = \beta \times I_{BQ}$$

$$I_{BQ} = \frac{V_{CC} - 0.7}{R_B}$$

$$S_\beta = \frac{\Delta I_{CQ} / I_{CQ}}{\Delta\beta / \beta} = 1$$

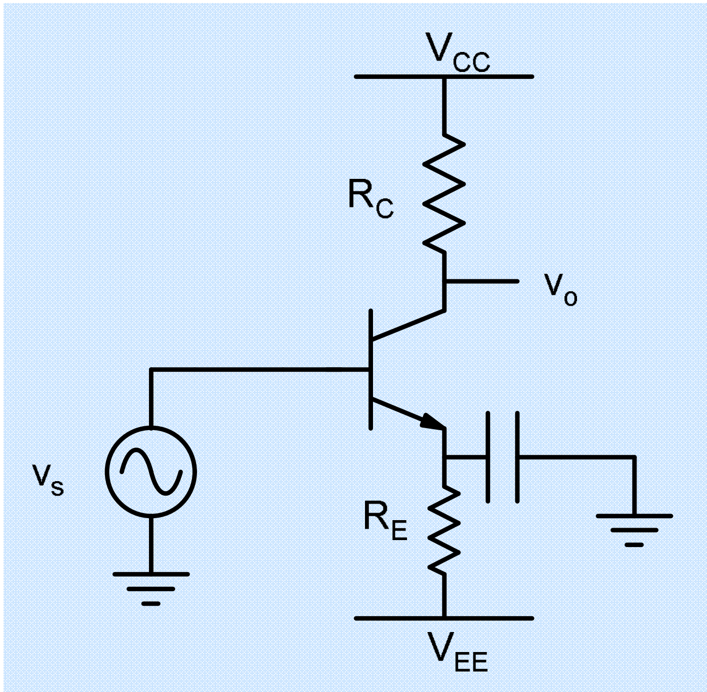


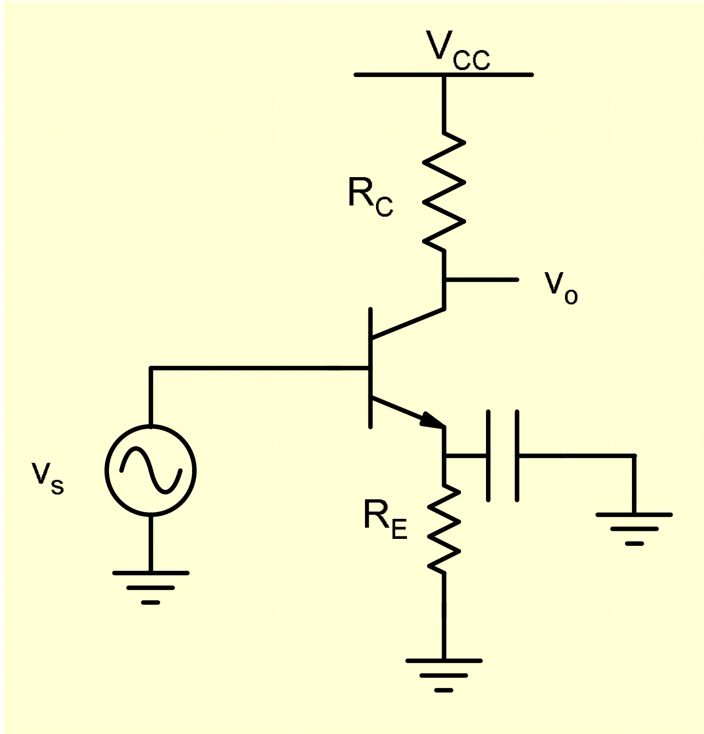
$$I_{CQ} = \left(\frac{\beta}{\beta + 1}\right) I_{EQ}$$

$$I_{EQ} = \frac{-0.7 - V_{EE}}{R_E}$$

$$S_\beta << 1$$

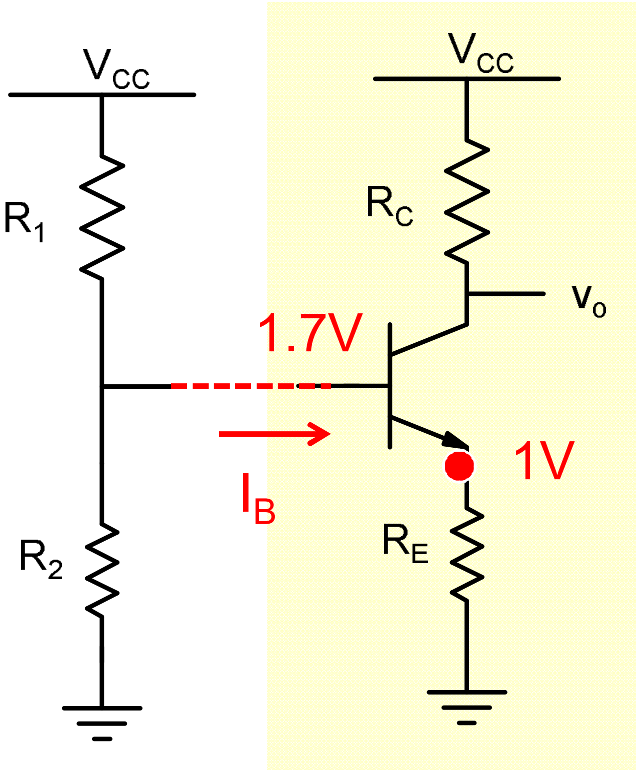
G-Number





$$I_{EQ} = \frac{V_E}{R_E}$$

$$I_{CQ} = \left(\frac{\beta}{\beta + 1}\right) I_{EQ}$$



$$I_{EQ} = \frac{V_E}{R_E}$$

2V 2V 1V

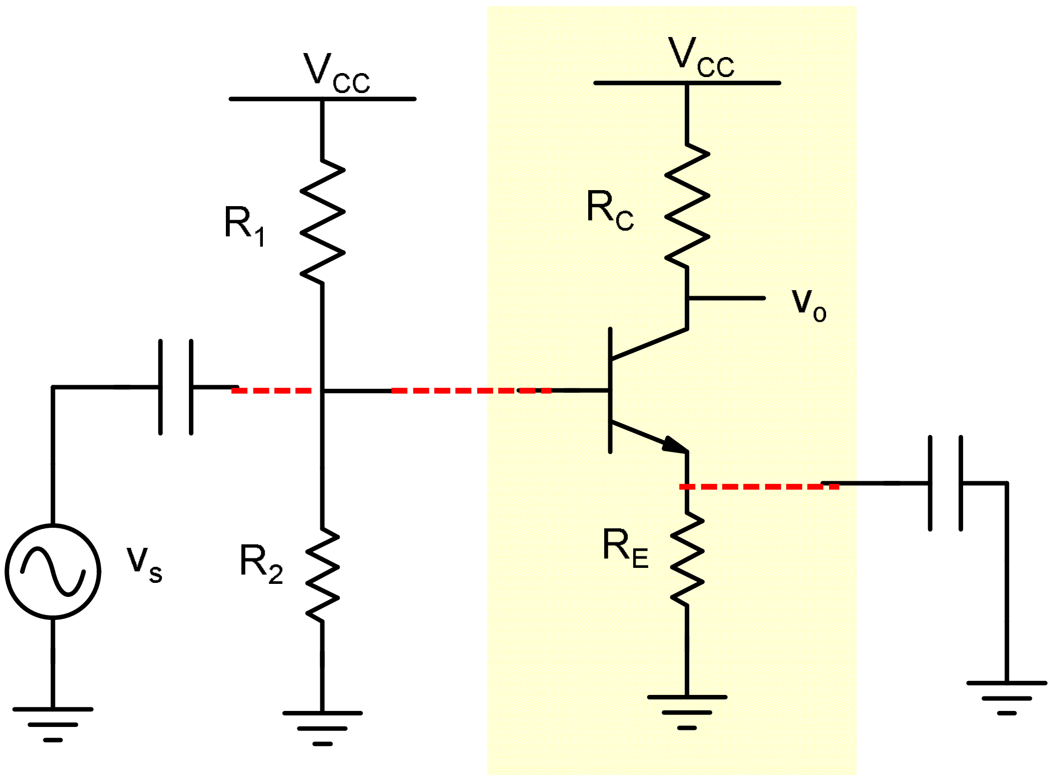
$$V_{CC} = I_{CQ}R_C + V_{CEQ} + V_{EQ}$$

$$\left|A_{VO}\right| = \frac{I_{CQ}R_C}{V_T}$$

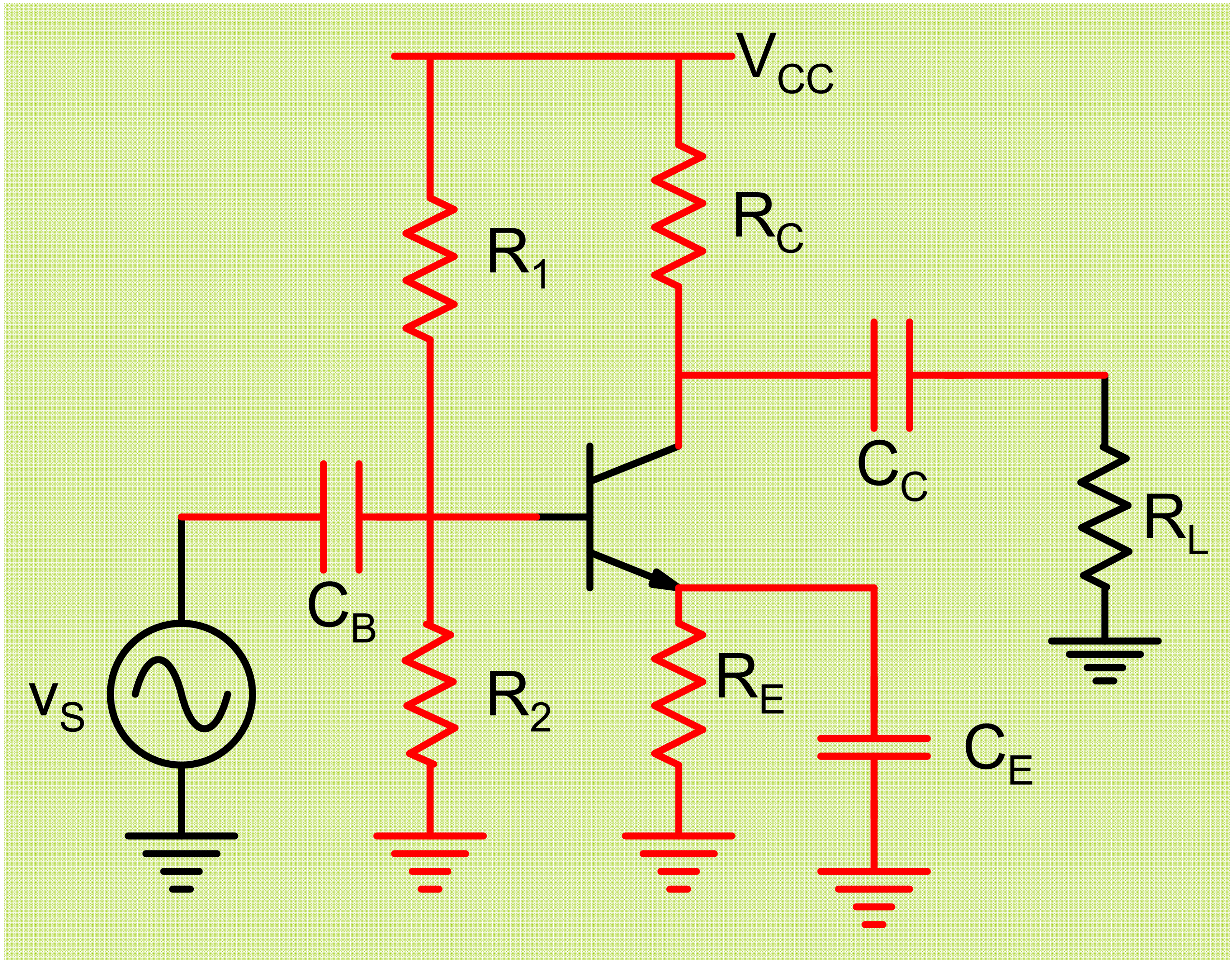
$$v_{om} = Min\left\{V_{CEQ} - V_{CEsat}; \left(I_{CQ} \times R_C \| R_L\right) \times \left(\frac{HD_2}{25}\right)\right\}$$

$$V_{CC}\left(\frac{R_2}{R_1 + R_2}\right) = 1.7$$

$$\frac{V_{CC}}{R_1 + R_2} >> I_B$$

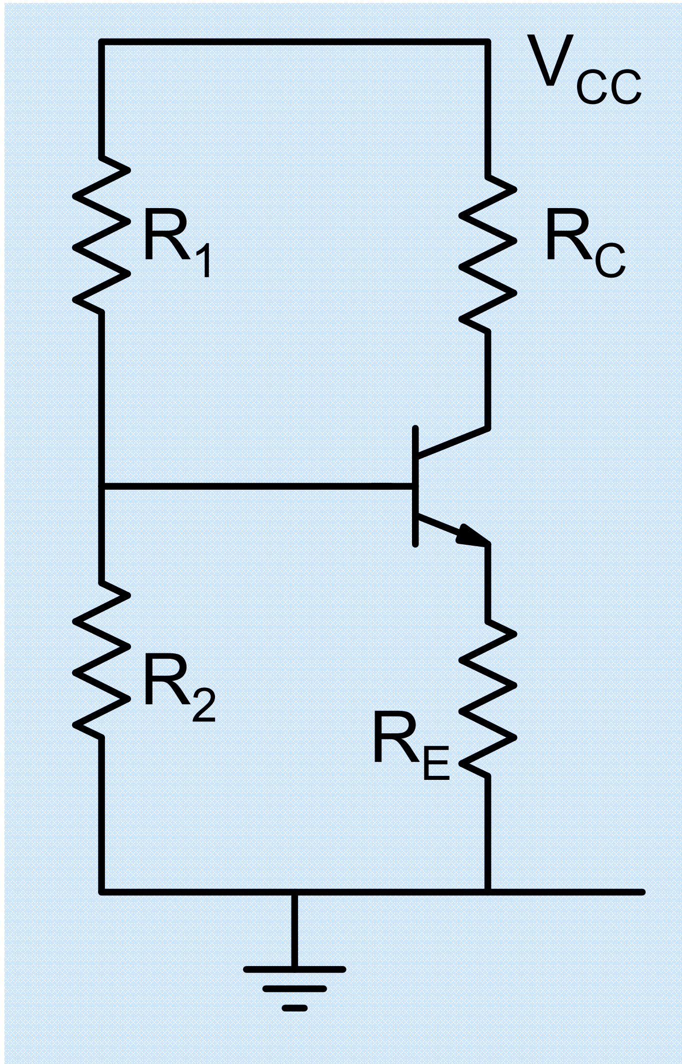


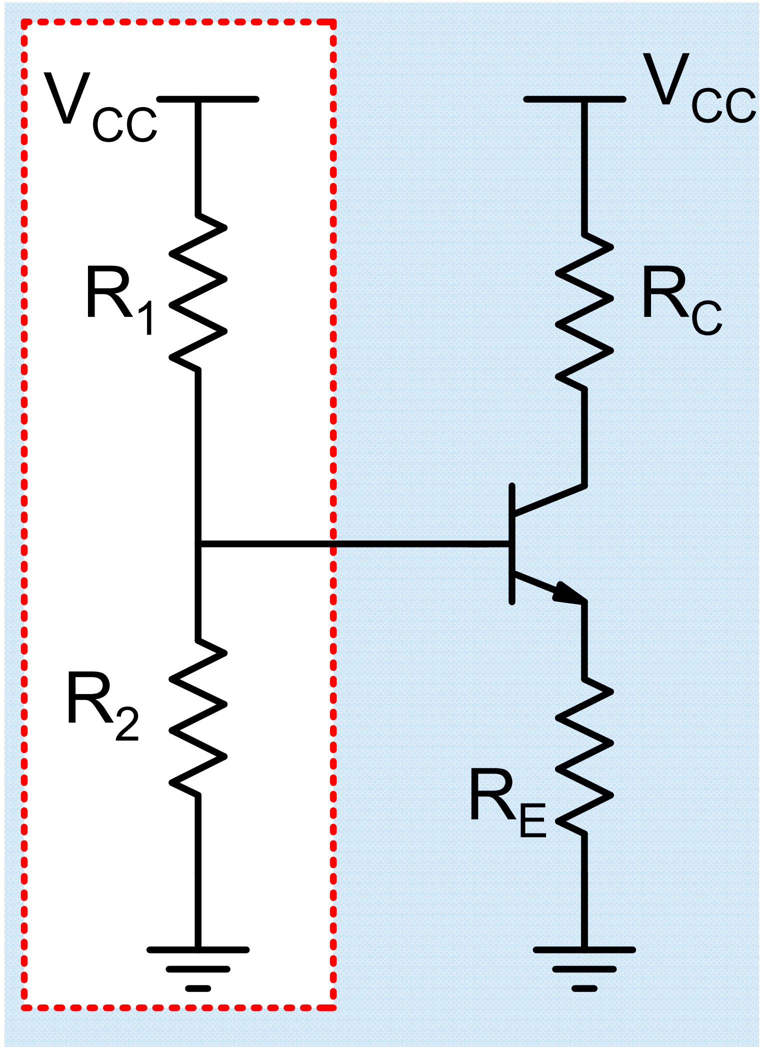
V_{CC}
V_{CC}
R_1
R_C
v_o
v_s
R_2
R_E



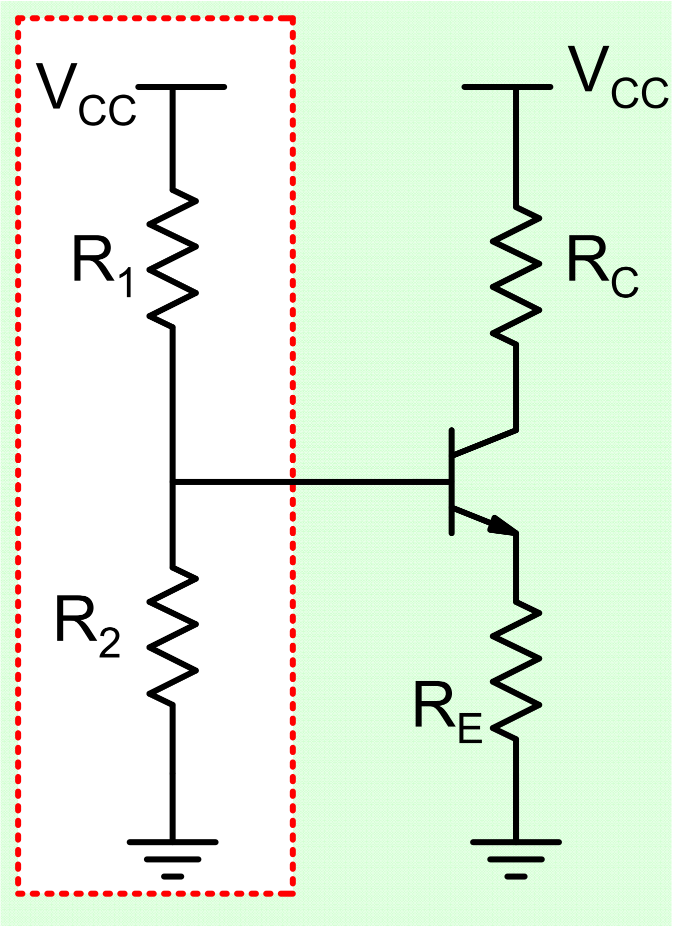
A good biasing circuit for discrete implementation

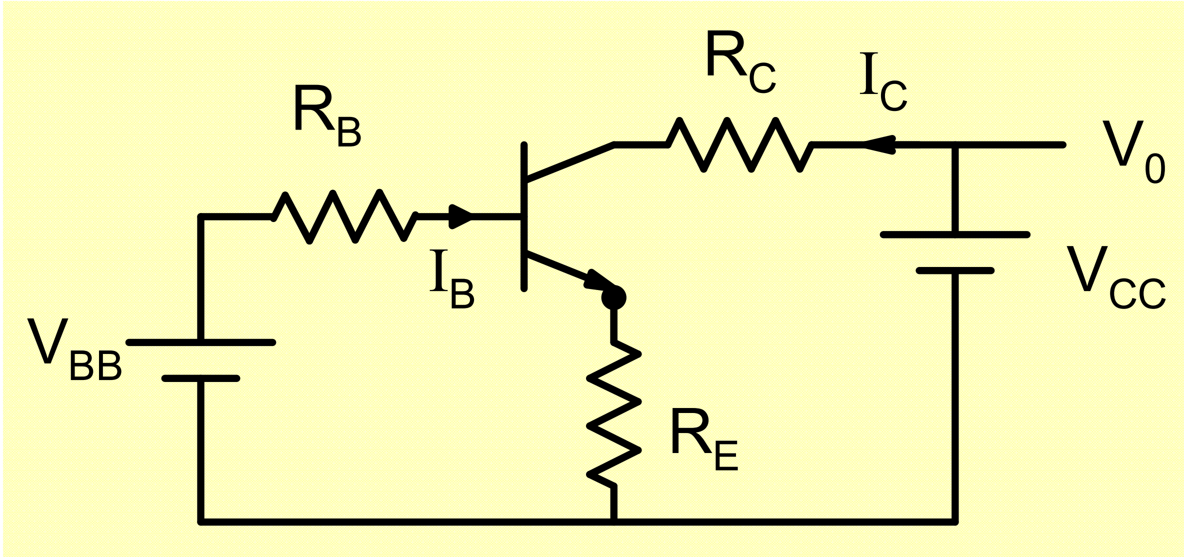
Bias Point dc Analysis





dc Analysis

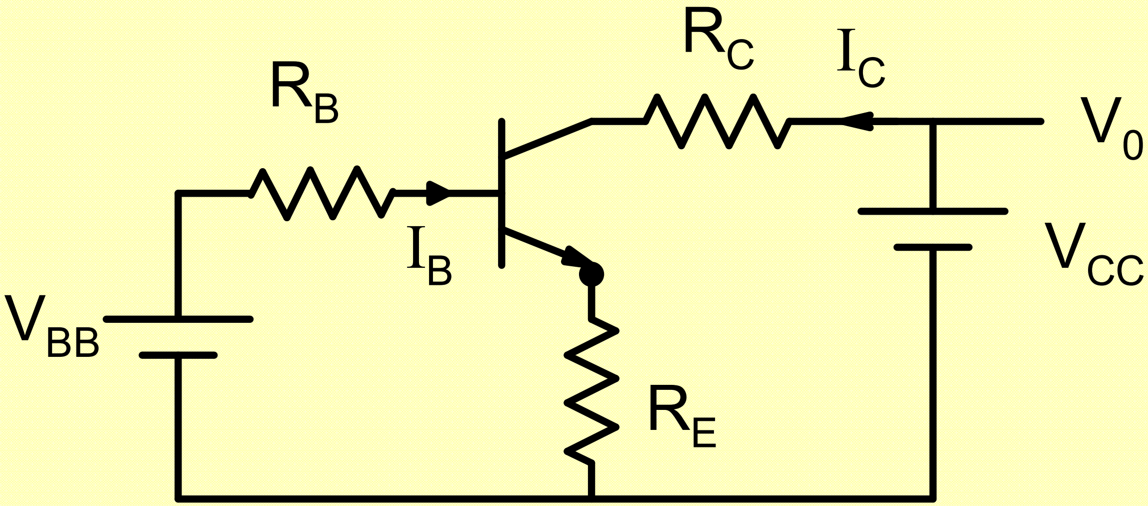




$$V_{TH} = V_{BB} = \frac{V_{CC} R_2}{R_1 + R_2}$$

$$R_{TH} = R_B = R_1 \parallel R_2$$

dc Analysis



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

$$R_B = R_1 \parallel R_2$$

$$V_{BB} \cong I_B R_B + V_{BE} + I_C R_E$$

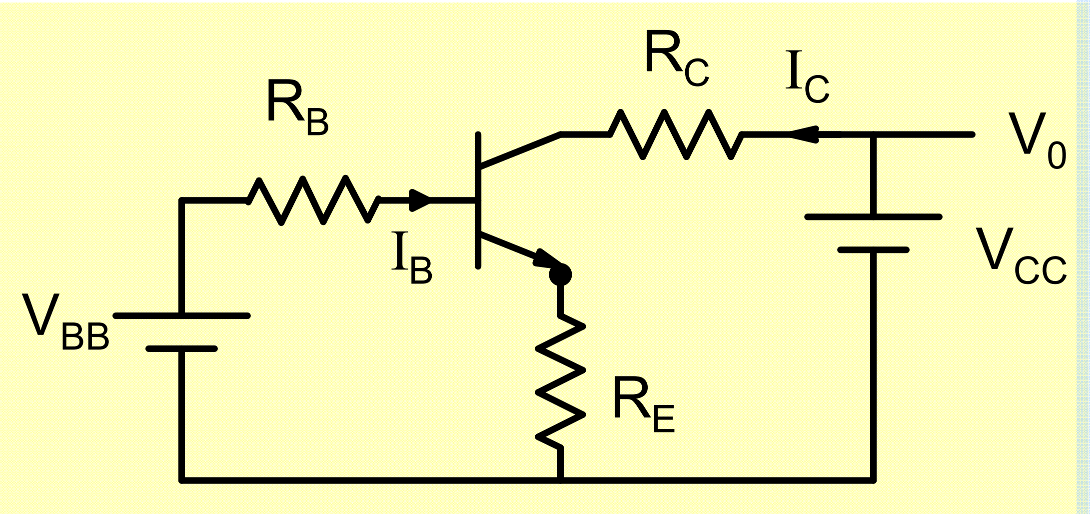
$$S = \frac{\Delta I_C / I_C}{\Delta\beta / \beta} = \frac{1}{1 + \dfrac{R_E \beta}{R_B}}$$

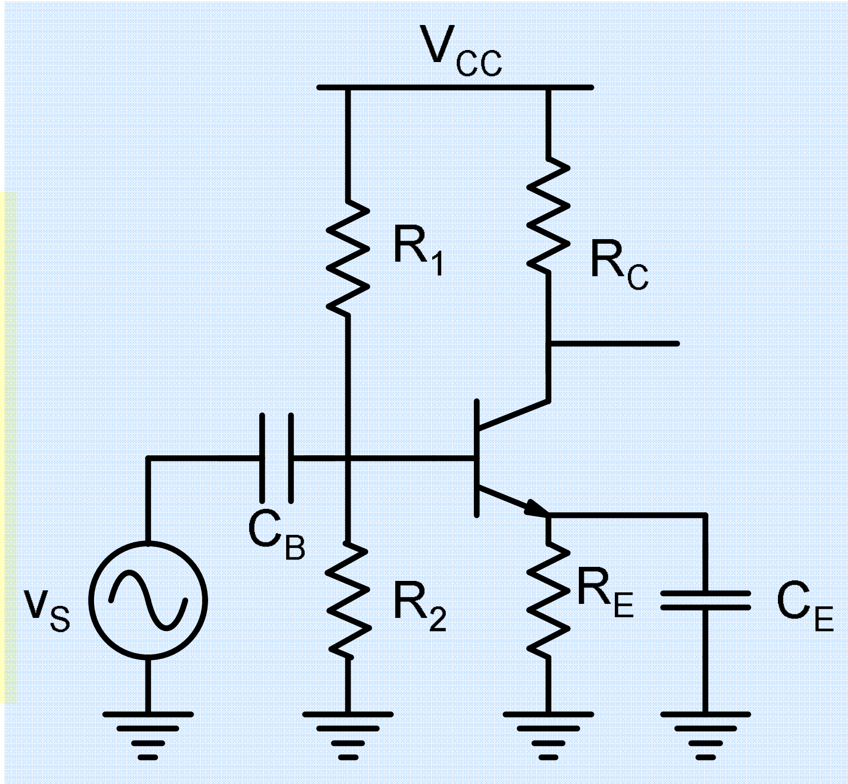
$$I_C = \frac{V_{BB} - V_{BE}}{\dfrac{R_B}{\beta} + R_E}$$

$$R_E >> \frac{R_B}{\beta}$$

$$R_E >> \frac{R_B}{\beta}$$

$$I_{CQ}R_E >> I_{CQ}\frac{R_B}{\beta} = I_B R_B$$





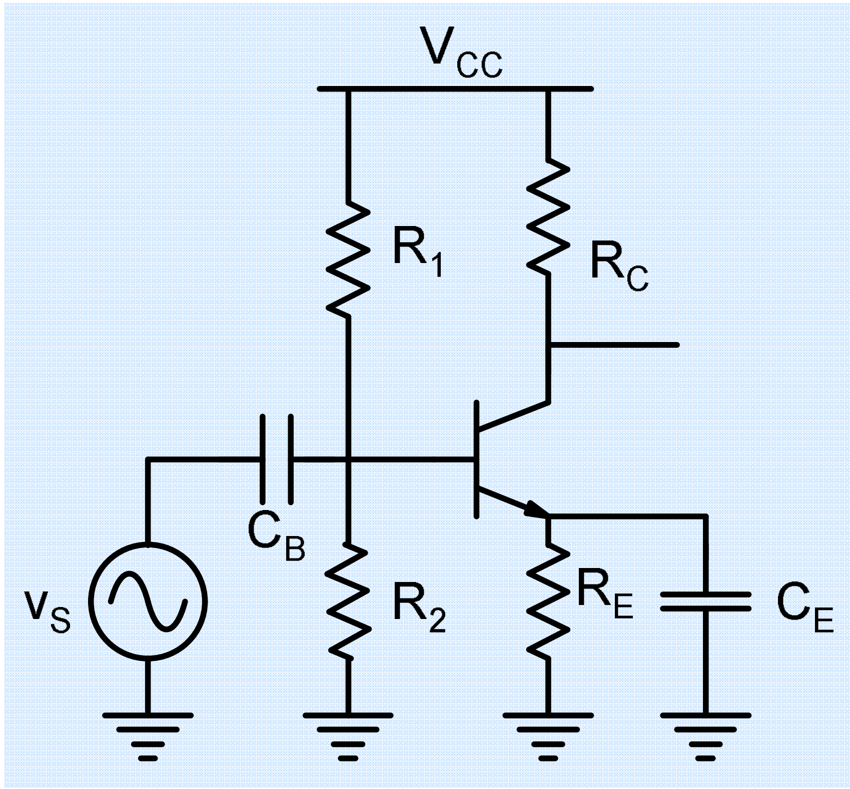
$$V_{BB} = I_B R_B + V_{BE} + I_C R_E$$
$$\cong V_{BE} + I_C R_E$$

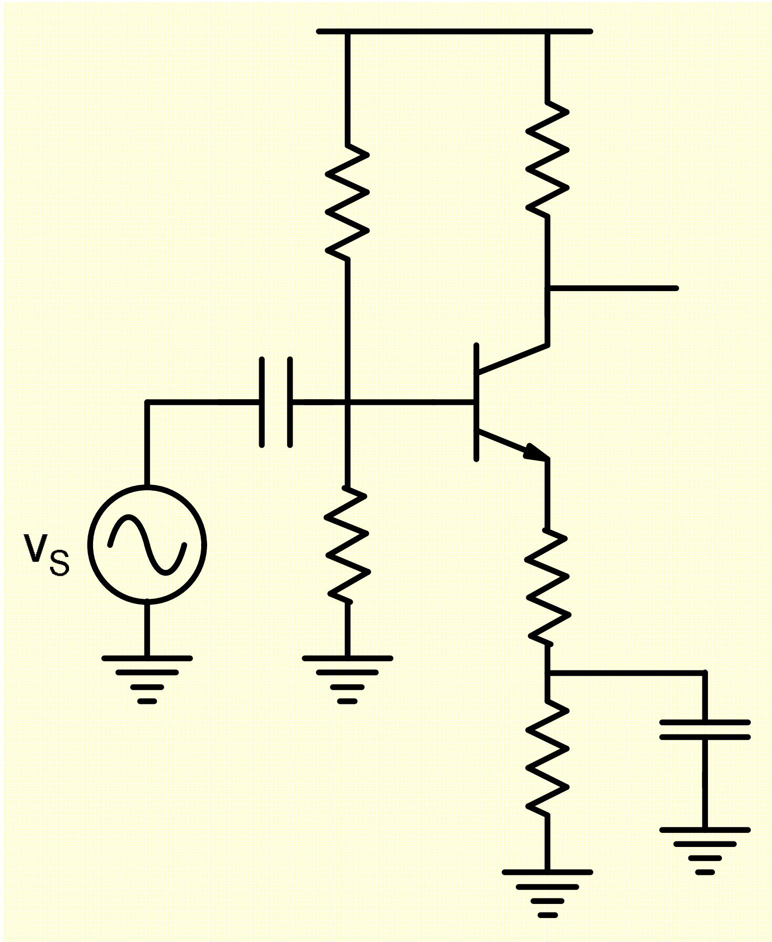
$$V_{CC} = I_{CQ}R_C + V_{CEQ} + V_{EQ}$$

$$V_{BB} \cong \frac{V_{CC}R_2}{R_1 + R_2}$$

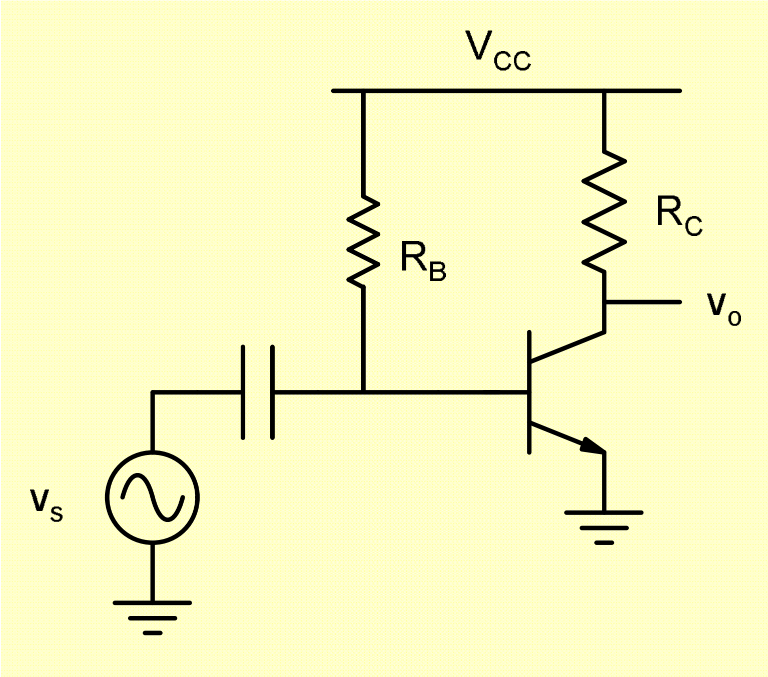
Stability comes at a price of reduced gain , swing etc

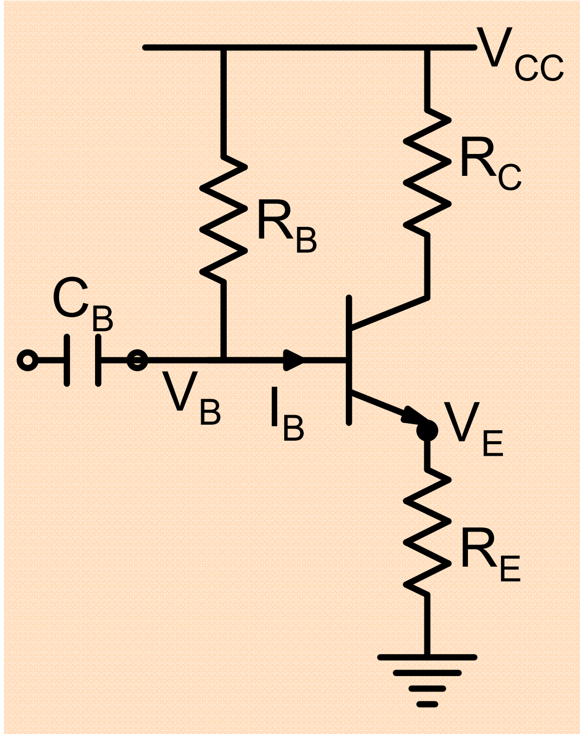
G-Number





Bypassed emitter resistance for stability and un-bypassed for improving linearity, input resistance etc





$$(\uparrow)\beta \longrightarrow I_C(\uparrow) \longrightarrow V_E(\uparrow)$$

$$I_B(\downarrow)$$

$$V_B(\uparrow)$$

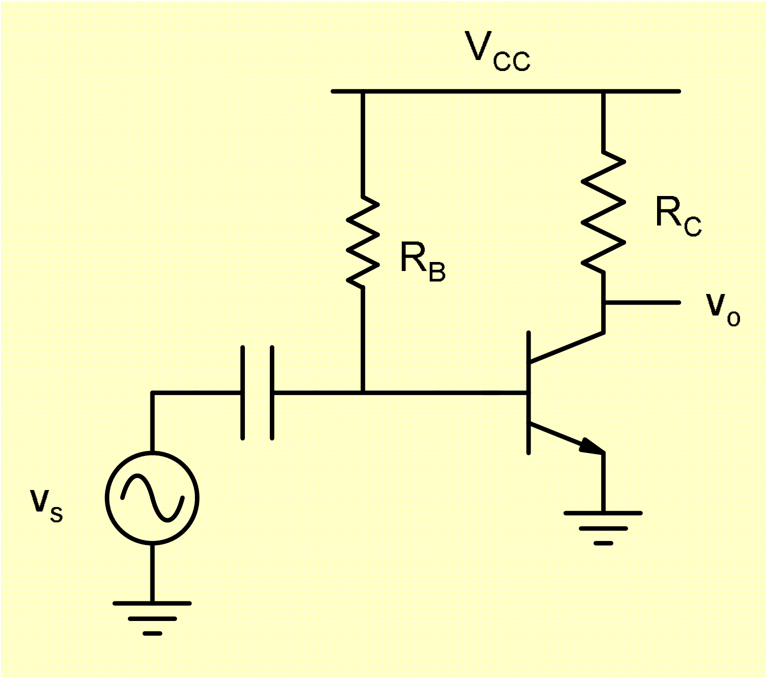
$$S = \frac{\Delta I_C / I_C}{\Delta\beta / \beta} = \frac{1}{1 + \dfrac{R_E}{R_B/\beta}}$$

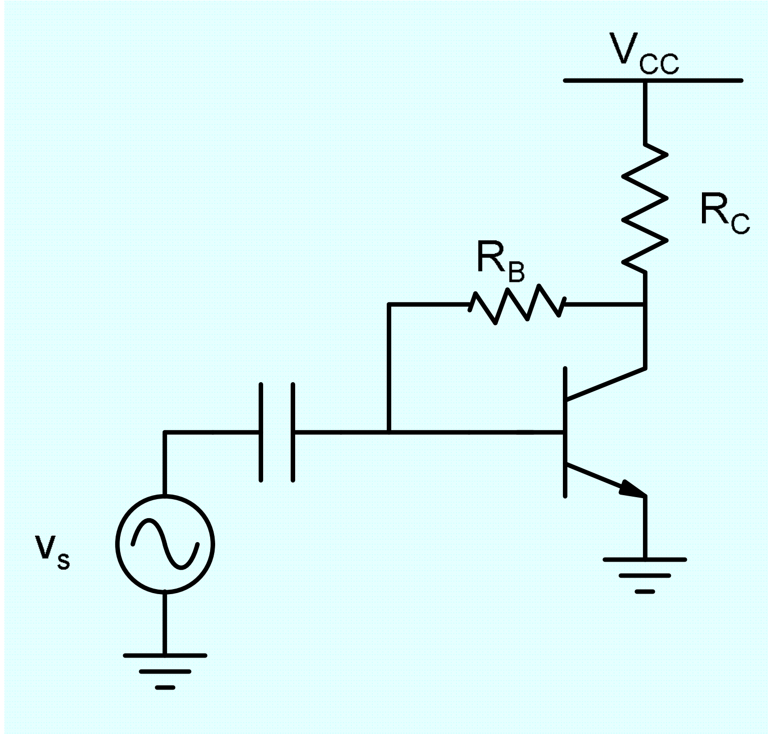
$$R_E >> \frac{R_B}{\beta}$$

$$I_{CQ} R_E >> I_{CQ} \frac{R_B}{\beta} = I_B R_B$$

$$V_{CC} = I_{CQ} R_C + V_{CEQ} + V_{EQ}$$

$$V_{CC} = I_{BQ} R_B + V_{BEQ} + V_E$$
$$\cong V_{BEQ} + V_E$$

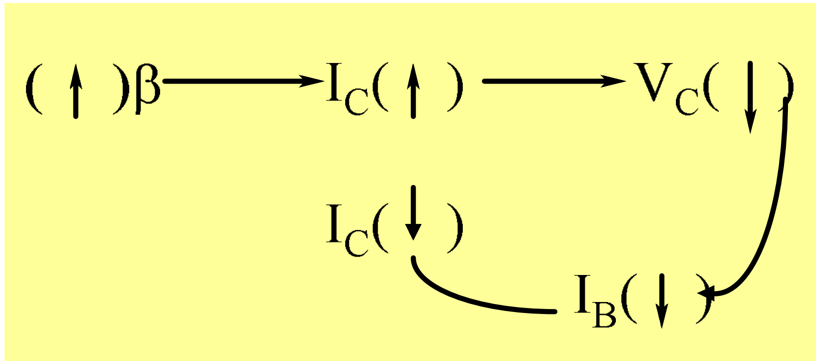




$$I_C = \left(\frac{V_{CC} - 0.7}{R_C}\right) \times \left(\frac{\beta}{1 + \beta + R_B/R_C}\right)$$

$$V_{CEQ} = V_{CC}\left(\frac{1 + R_B/R_C}{1 + \beta + R_B/R_C}\right) + 0.7\left(\frac{\beta}{1 + \beta + R_B/R_C}\right)$$

$$R_{in} = r_\pi \left\| \frac{R_B}{1 - A_V} \right.$$



G-Number