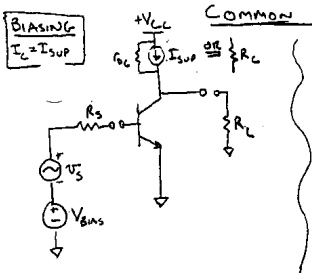
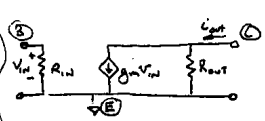
Single-Stage Transistor Amplifiers

Common Emitter

Biasing: $I_C = I_{SUP}$





- Gain stage
- Transconductance amp.

$$\frac{i_{OUT}}{v_{IN}} = \left(\frac{R_{IN}}{R_{IN}+R_S}\right) g_m \left(\frac{R_{OUT}}{R_{OUT}+R_L}\right)$$

$$\frac{v_{OUT}}{v_{IN}} = -R_L\left(\frac{i_{OUT}}{v_{IN}}\right)$$

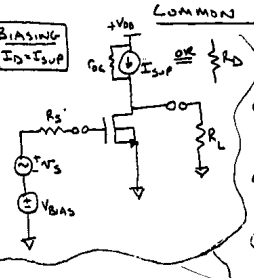
$$g_m = \frac{I_C}{V_{TH}}$$

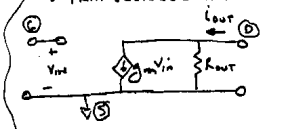
- $R_{IN} = r_\pi$ ← LARGE
- $R_{OUT} = \begin{cases} r_o \parallel r_{OC} \\ \text{or} \\ r_o \parallel R_L \end{cases}$ ← LARGE

$$r_o = \frac{V_A}{I_C}$$

Common Source

Biasing: $I_D = I_{SUP}$





- Gain stage
- Transconductance amp.

$$\frac{i_{OUT}}{v_{IN}} = 1 \cdot g_m \left(\frac{R_{OUT}}{R_{OUT}+R_L}\right)$$

$$\frac{v_{OUT}}{v_{IN}} = -R_L\left(\frac{i_{OUT}}{v_{IN}}\right)$$

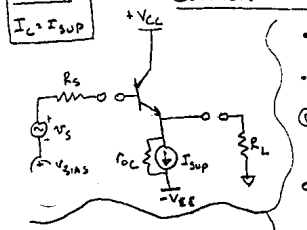
$$g_m = \sqrt{2 I_D \frac{W}{L} \mu C_{ox}}$$

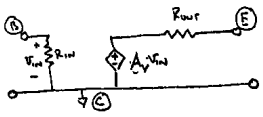
- $R_{IN} = \infty$ ← LARGE
- $R_{OUT} = \begin{cases} r_o \parallel r_{OC} \\ \text{or} \\ r_o \parallel R_D \end{cases}$ ← LARGE

$$r_o = \frac{1}{\lambda I_D}$$

Common Collector (Emitter Follower)

Biasing: $I_C = I_{SUP}$





- Voltage buffer
- Voltage amplifier

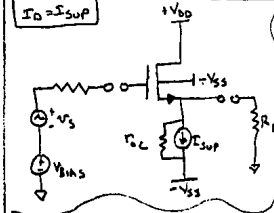
$$\frac{v_{OUT}}{v_{IN}} = \left(\frac{R_{IN}}{R_{IN}+R_S}\right) A_V \left(\frac{R_L}{R_L+R_{OUT}}\right)$$

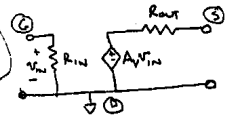
$$A_V = \frac{1}{1 + \frac{r_\pi}{(r_o \parallel r_{OC})(\beta_o+1)}} \approx 1$$

- $R_{IN} = r_\pi + \beta_o (r_o \parallel r_{OC} \parallel R_L)$ ← LARGE
- $R_{OUT} = \frac{1}{g_m} + \frac{R_S}{\beta_o}$ ← SMALL

Common Drain (Source Follower)

Biasing: $I_D = I_{SUP}$





- Voltage buffer
- Voltage amplifier

$$\frac{v_{OUT}}{v_{IN}} = 1 \cdot A_V \left(\frac{R_L'}{R_L'+R_{OUT}}\right)$$

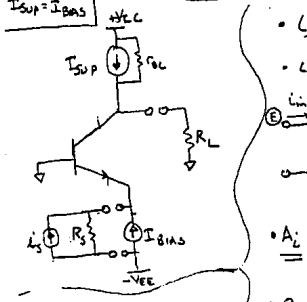
$$R_L' = R_L \parallel r_{OC} \parallel r_O$$

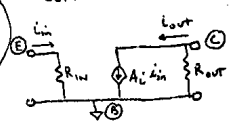
$$A_V = \frac{g_m}{g_m + g_{mb}}$$

- $R_{IN} = \infty$ ← LARGE
- $R_{OUT} = \frac{1}{g_m + g_{mb}}$ ← SMALL

Common Base

Biasing: $I_{SUP} = I_{BIAS}$





- Current buffer
- Current amplifier

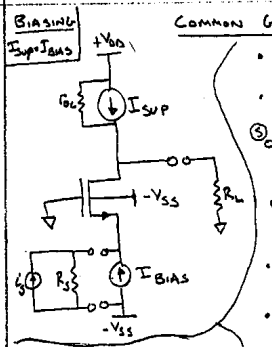
$$\frac{i_{IN}}{i_S} = \left(\frac{R_S}{R_S+R_{IN}}\right) A_i \left(\frac{R_{OUT}}{R_{OUT}+R_L}\right)$$

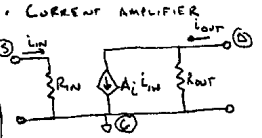
$$A_i = \frac{-\beta_o}{1+\beta_o} \approx -1$$

- $R_{IN} = \frac{1}{\frac{1}{r_\pi} + g_m + \frac{1 - g_m (r_{OC} \parallel R_L)}{r_o + (r_{OC} \parallel R_L)}} \approx \frac{1}{g_m}$ ← SMALL
- $R_{OUT} \approx r_{OC} \parallel \left[r_o \left[1 + g_m (r_\pi \parallel R_S) \right] \right]$ ← LARGE

Common Gate

Biasing: $I_{SUP} = I_{BIAS}$





- Current buffer
- Current amplifier

$$\frac{i_{OUT}}{i_{IN}} = \left(\frac{R_S}{R_S+R_{IN}}\right) A_i \left(\frac{R_{OUT}}{R_{OUT}+R_L}\right)$$

$$A_i = -1$$

- $R_{IN} \approx \frac{1}{g_m + g_{mb}}$ ← SMALL
- $R_{OUT} \approx r_{OC} \parallel \left\{ r_O \left(1 + g_m R_S \right) \right\}$ ← LARGE