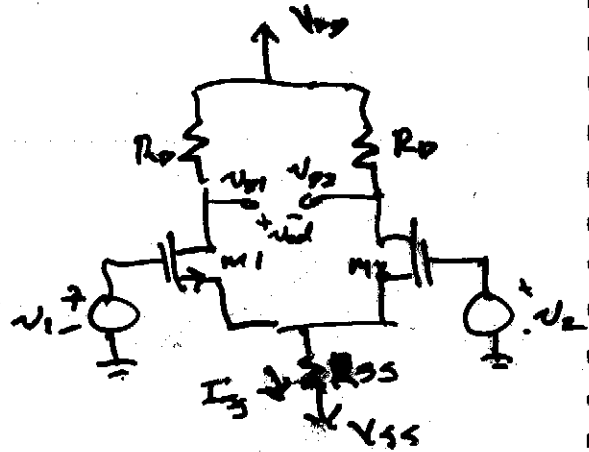
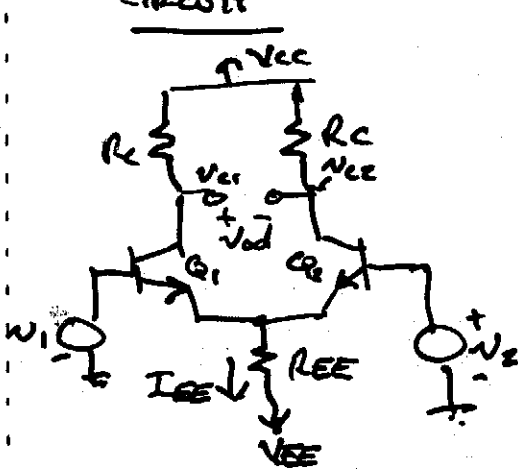


Differential Amplifiers

Amps that amplify the difference between 2 voltages and reject the avg of the 2 voltages.

circuit



DC analysis (assume $v_1 = v_2 = 0$)

$$I_{EE} = \frac{V_{EE} - V_{BE}}{R_{EE}}$$

$$I_E = \frac{I_{EE}}{2}, I_C = \alpha I_E$$

$$I_B = I_C / \beta_F$$

$$V_C = V_{CC} - I_C R_C$$

$$I_{CS} = \frac{V_{DD} - V_{GS}}{R_{SS}}$$

$$I_{OS} = \frac{I_{CS}}{2}$$

$$V_O = V_{DD} - I_{OS} R_D$$

Example: $V_{DD} = 5V$, $V_{SS} = -5V$, $R_{SS} = 10K$, $R_D = 10K$, $K_n = \frac{1mA}{V^2}$, $V_{TH} = 1V$

$$V_{SS} = V_{GS} + I_{OS} R_{SS} = V_{GS} + 2I_{OS} R_{SS}$$

$$V_{SS} = V_{GS} + 2R_{SS} \frac{1}{2} K_n (V_{GS} - V_T)^2 = V_{GS} + 10(V_{GS} - 1)^2$$

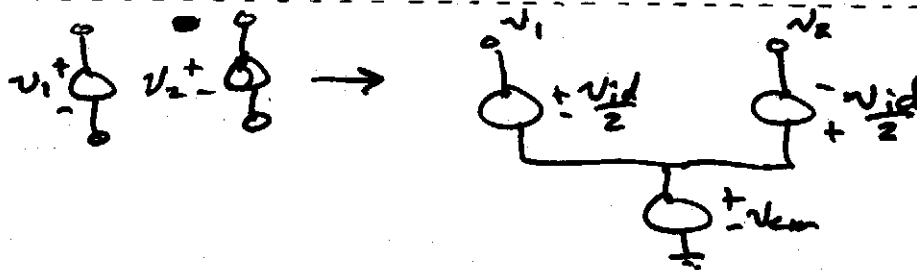
$$\therefore V_{GS}^2 - 2V_{GS} + \frac{1}{10}V_{GS} + 0.5 = V_{GS}^2 - 1.9V_{GS} + 0.5 = 0$$

$$V_{GS} = 0.95 \pm 0.634 = 1.584V$$

$$\therefore I_{OS} = \frac{1mA/V^2}{2} (0.584)^2 = 170.8\mu A \Rightarrow I_{CS} = 341.6\mu A$$

$$V_O = 5 - 10(0.1708) = 3.29V, V_S = -1.584V$$

$$\hookrightarrow V_{OS} = \underline{4.876V} \rightarrow \text{SATURATED}$$



Differential mode input : $v_{id} = v_1 - v_2$

Common mode input : $v_{cm} = \frac{v_1 + v_2}{2}$

$\therefore v_1 = \frac{v_{id}}{2} + v_{cm} \quad v_2 = -\frac{v_{id}}{2} + v_{cm}$

Differential mode HALF-

