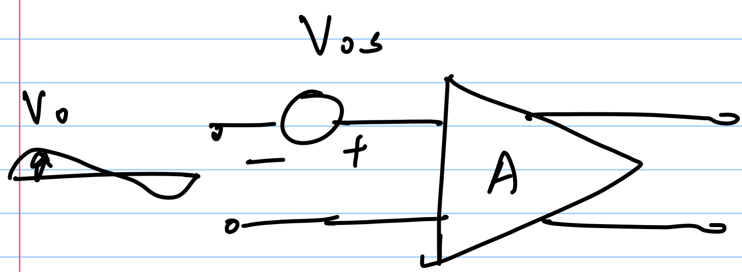
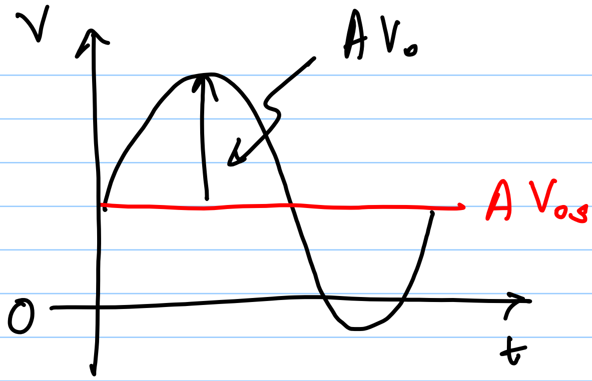
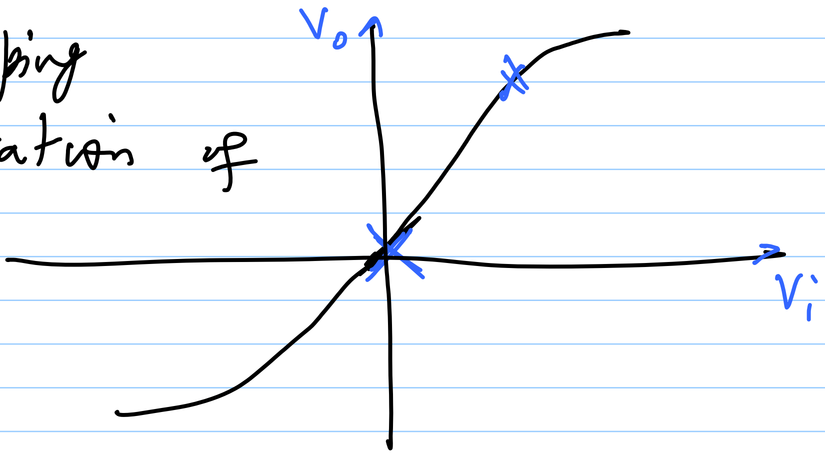
6-2-13

Lec 15

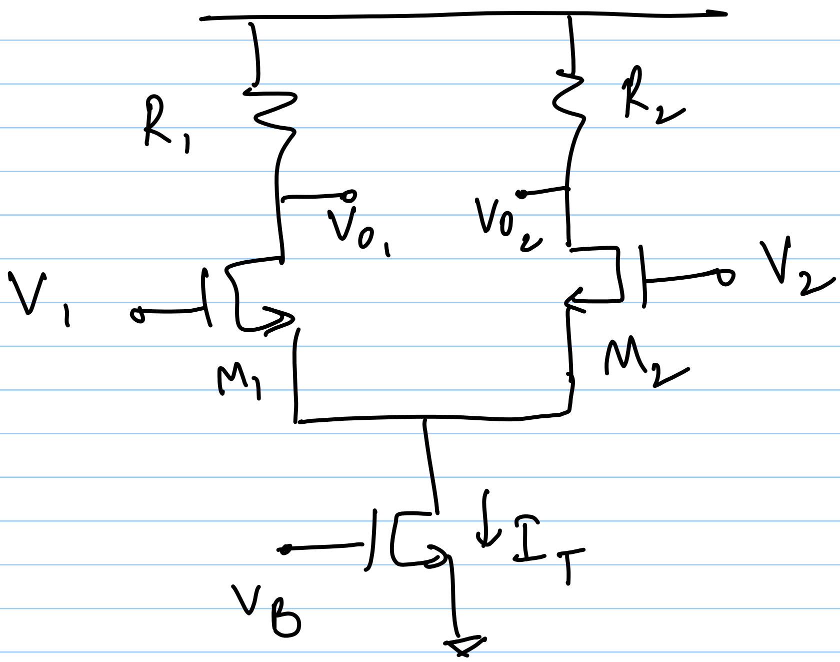




* clipping
* Saturation of gain



* Desensitisation



* DC offset is a function of temp. T
* Time-varying DC offsets

$$R = \frac{R_1 + R_2}{2}, \quad R_1 = R + \Delta R, \quad R_2 = R - \Delta R$$

$$\Delta R = (R_1 - R_2)/2$$

* $I_{OS} = 0$

* $$\frac{V_{o_1} - V_{o_2}}{A} = V_{OS}$$

$$V_{ID} = V_{GS_1} - V_{GS_2}$$

$$V_{ID} = V_1 - V_2$$

$$V_{ID} = V_{T_1} + \sqrt{\frac{2 I_{D_1}}{\beta \left(\frac{W}{L}\right)_1}} - V_{T_2} - \sqrt{\frac{2 I_{D_2}}{\beta \left(\frac{W}{L}\right)_2}}$$

$$= \Delta V_T + \left(\qquad \right)$$

$V_{OS} \equiv$ voltage to be applied @ input to drive $V_{OD} = 0$

$$V_{OD} = 0 \Rightarrow V_{o_1} = V_{o_2}$$

$$I_{D_1} R_1 = I_{D_2} R_2$$

$$\Delta I_D = I_{D_1} - I_{D_2} \; ; \; I_D = \frac{I_{D_1} + I_{D_2}}{2}$$

$$(\Delta W/L) = \left(\frac{W}{L}\right)_1 - (W/L)_2 \; ; \left(\frac{W}{L}\right) = \frac{(\;)_1 + (\;)_2}{2}$$

$$\Delta V_T = V_{T_1} - V_{T_2} \; ; \; V_T = \frac{V_{T_1} + V_{T_2}}{2}$$

$$\Delta R = R_1 - R_2 \; ; \quad R = \frac{R_1 + R_2}{2}$$

$$I_{D_1} = I_D + \frac{\Delta I_D}{2} \; ; \; \ldots$$

$$V_{os} = \Delta V_T + \sqrt{\frac{2(I_D + \Delta I_D/2)}{\beta\left[\left(\frac{W}{L}\right) + \frac{1}{2}\Delta\left(\frac{W}{L}\right)\right]}}$$

$$- \sqrt{\frac{2(I_D - \Delta I_D/2)}{\beta\left[\left(\frac{W}{L}\right) - \frac{1}{2}\Delta\left(\frac{W}{L}\right)\right]}}$$

$$(V_{GS} - V_T) = \sqrt{\frac{2 I_D}{\beta\left(\frac{W}{L}\right)}}$$

$$= \Delta V_T + (V_{GS} - V_T)\left[\sqrt{\frac{1 + \frac{\Delta I_D}{2 I_D}}{1 + \frac{\Delta(W/L)}{2(W/L)}}} - \sqrt{\frac{1 - \frac{\Delta I_D}{2 I_D}}{1 - \frac{\Delta(W/L)}{2(W/L)}}}\right]$$

Simplify this to:

$$V_{os} = \Delta V_T + \frac{(V_{GS} - V_T)}{2}\left[\frac{\Delta I_D}{I_D} - \frac{\Delta(W/L)}{(W/L)}\right]$$

$$I_{D_1} R_1 = I_{D_2} R_2$$

$$\left(I_D + \frac{\Delta I_D}{2}\right) \cdot \left(R + \frac{\Delta R}{2}\right) = \left(I_D - \frac{\Delta I_D}{2}\right) \cdot \left(R - \frac{\Delta R}{2}\right)$$

$$\cancel{I_D \cdot R} + \frac{I_D \cdot \Delta R}{2} + \frac{\Delta I_D \cdot R}{2} \simeq \cancel{I_D \cdot R} - \frac{\Delta I_D \cdot R}{2} - \frac{\Delta R \cdot I_D}{2}$$

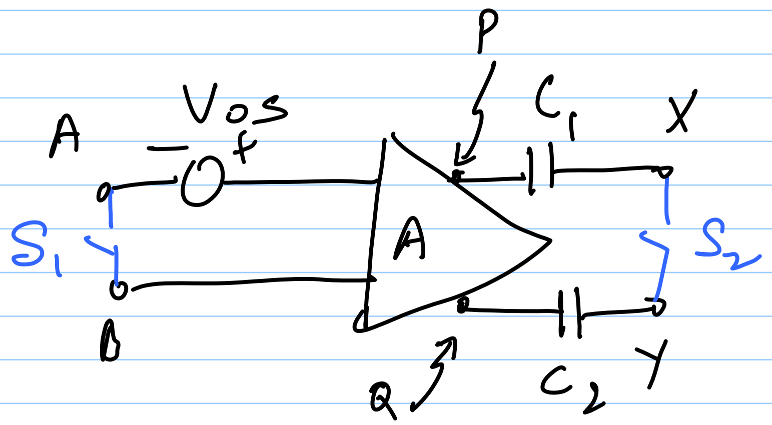
$$\frac{\Delta I_D}{I_D} = \frac{-\Delta R}{R}$$

$$\boxed{V_{OS} = \Delta V_T + \frac{(V_{GS} - V_T)}{2}\left[\frac{-\Delta R}{R} - \frac{\Delta (W/L)}{W/L}\right]}$$

* Minimize $(V_{GS} - V_T)$ to minimize V_{OS}

* ΔV_T of M_1, M_2 directly referred to input

Offset Cancellation



1) S_1 & S_2 are ON

$$V_{PQ} = A\,V_{os} = V(C_1, C_2)$$

$$V_{XY} = 0 \quad \text{with} \quad V_{AB} = 0$$

2) S_1 & S_2 OFF

* $A \cdot V_{os}$ gets sampled on C_1, C_2
* Amplifier + $C_1 - C_2$ combination between A-B to X-Y looks like an offsetless amplifier
* Problem: saturation & desensitization issues still exist
  → $A \cdot V_{os}$ exists @ amp. output