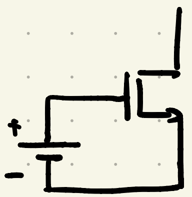
Lec 14

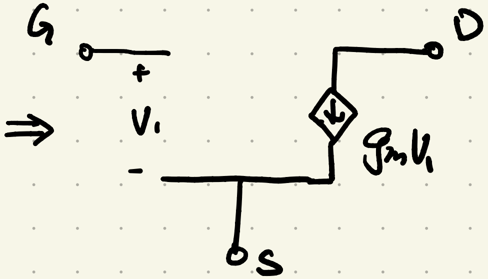
— Applications of some Circuit Techniques

— Small-Signal Analysis of MOS Diff. Pair.

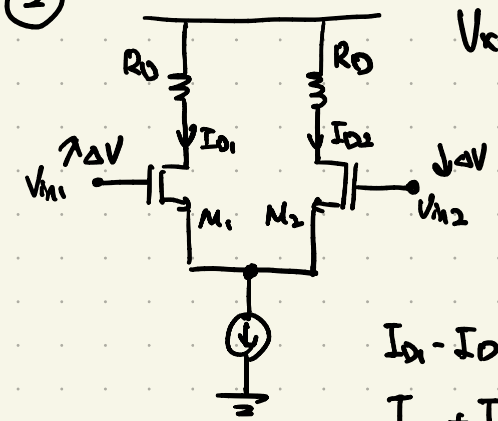
A Few Points

① $\Delta V = \dfrac{\Delta I}{g_m} \Rightarrow$





②



$$V_X - V_Y = -R_D\sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\,(V_{in1} - V_{in2})$$

$$= -R_D\sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\,(2\Delta V)$$

$$V_X - V_Y = -R_D(I_{D1} - I_{D2})$$

$$I_{D1} - I_{D2} = \sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\,(2\Delta V)$$

$$I_{D1} + I_{D2} = I_{SS}$$

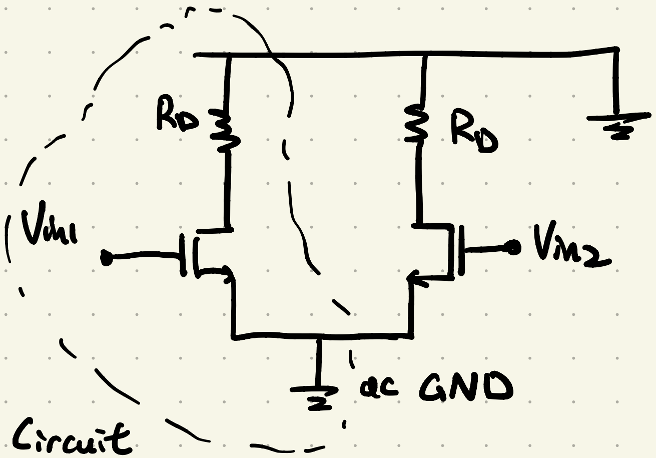
$$\Rightarrow I_{D1} = \frac{I_{SS}}{2} + \underbrace{\sqrt{\mu_n C_{ox}\frac{W}{L}}\,\Delta V}_{\text{change in } I_{D1}}$$

V_{GS1} changes by $\dfrac{\sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\,\Delta V}{g_{m1}} = \Delta V$

$$g_{m1} = \sqrt{2\mu_n C_{ox}\frac{W}{L} I_D}$$

$\Rightarrow V_P$ doesn't change $\Rightarrow$ P is ac GND

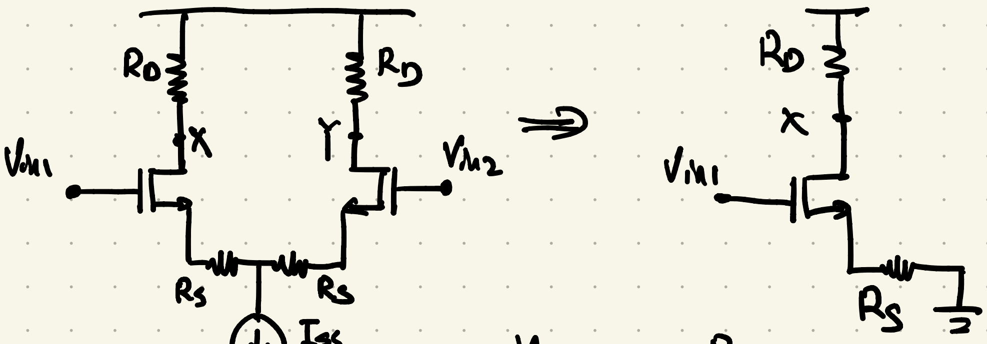
Small-Signal Operation



Half Circuit

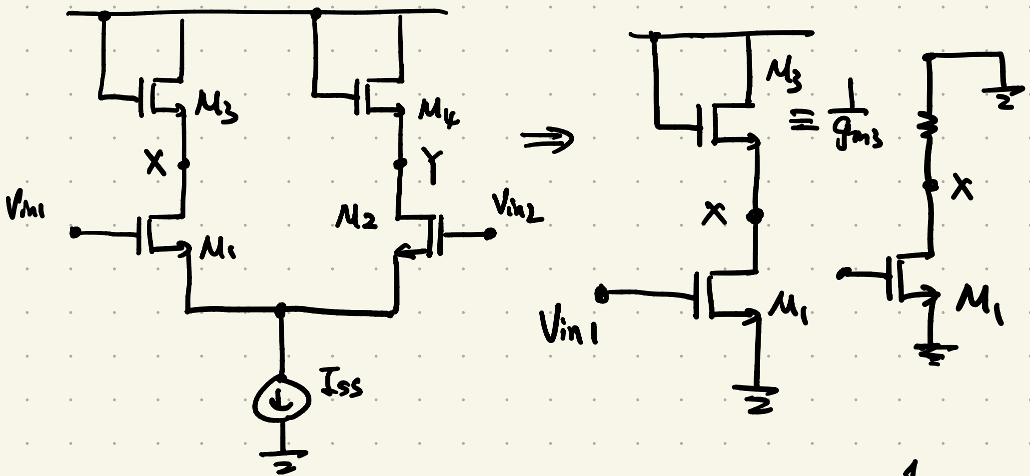
$$\frac{V_X}{V_{in1}} = -g_m R_D \Rightarrow \frac{V_X - V_Y}{V_{in1} - V_{in2}} = -g_m R_D$$

Example



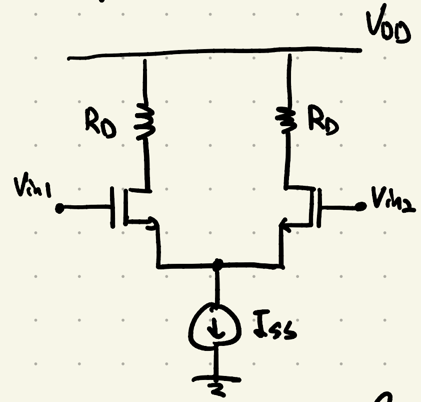
$$\frac{V_X}{V_{in1}} = -\frac{R_D}{\frac{1}{g_m} + R_S}$$

Example



$$A_v = -g_{m1}\frac{1}{g_{m3}}$$

Example



$W \rightarrow 2W$

what happens to A_v?

$$A_v = -g_m R_D$$

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

$$g_m \rightarrow \sqrt{2}\,g_m$$

$$A_v \rightarrow \sqrt{2}\,A_v$$

Example

What happens if both W and Iss are doubled?

$$g_m \rightarrow 2g_m \Rightarrow A_v \rightarrow 2A_v$$

Example

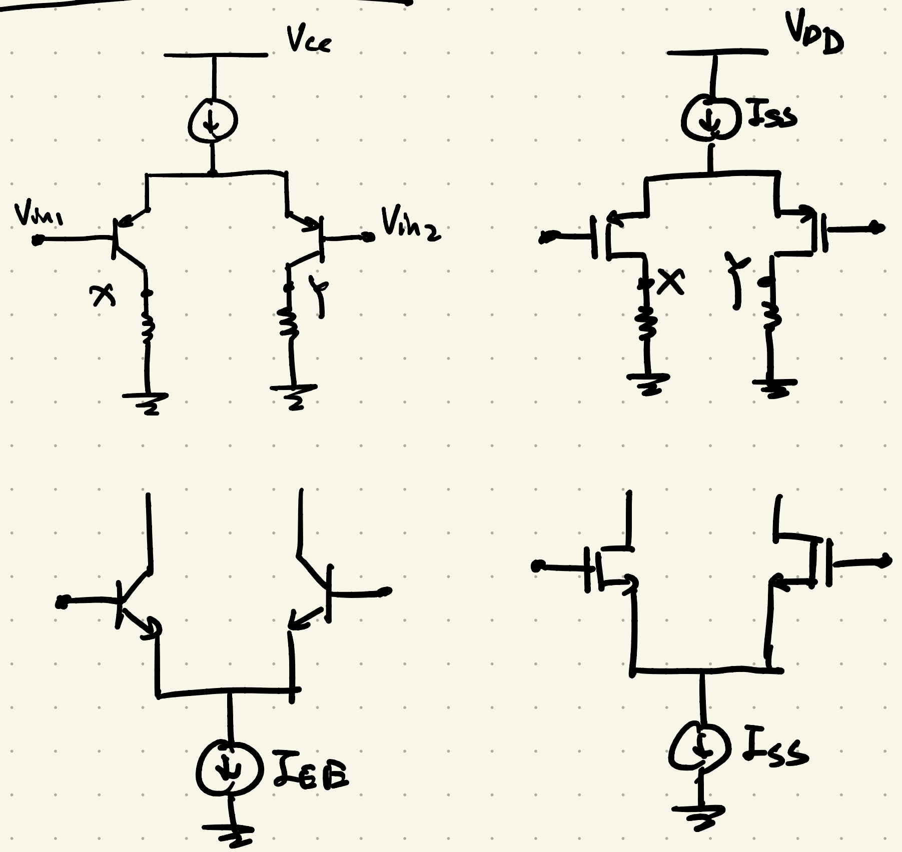
What happens if the temperature rises?

$$\mu_n \downarrow \quad g_m \downarrow \Rightarrow A_v \downarrow$$

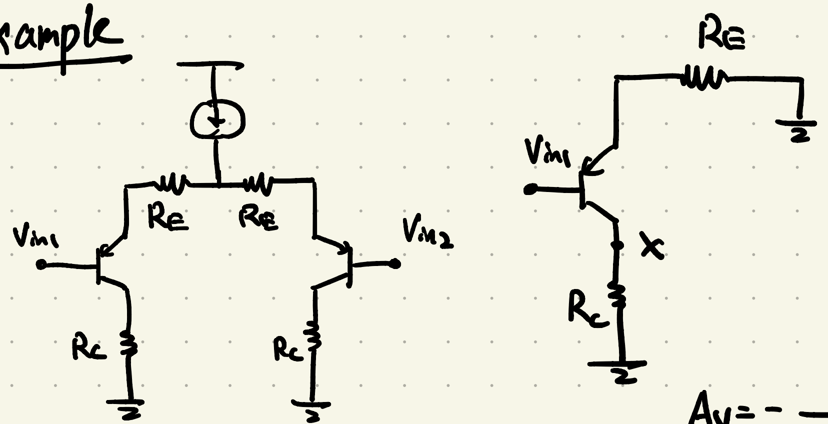
P-Type Diff. Pair

P

N

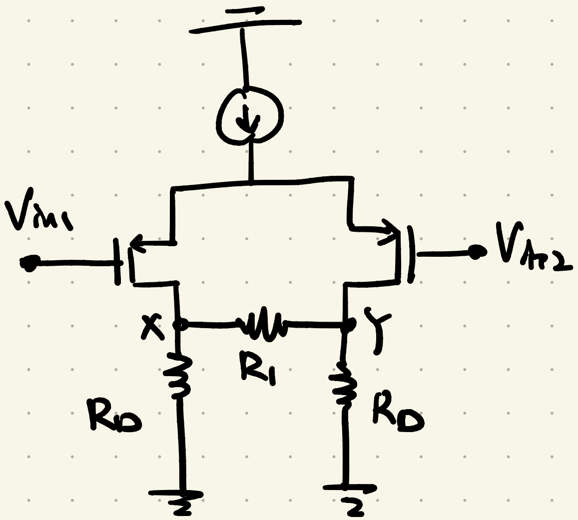


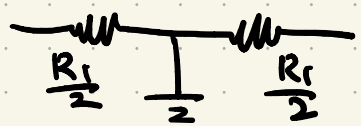
Example

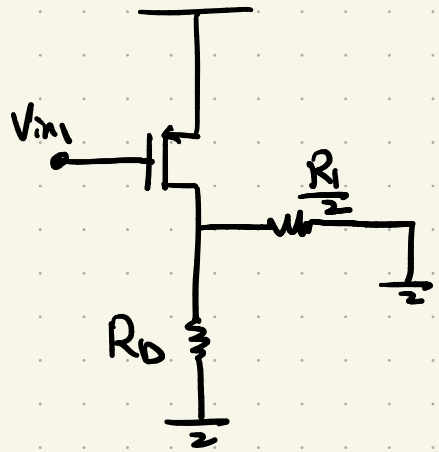


$$A_v = -\frac{R_C}{\frac{1}{g_m} + R_E}$$

Example







$$A_v = -g_m \left(R_D // \frac{R_1}{2} \right)$$