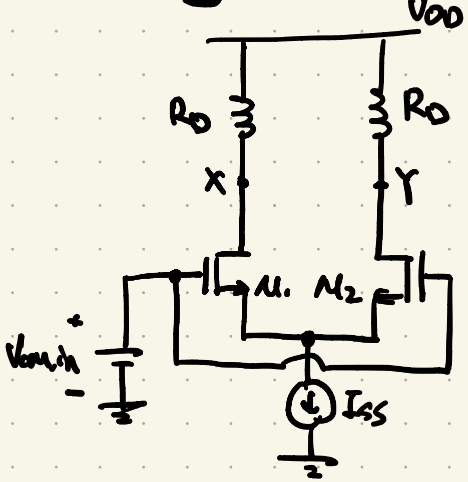
Lec 13

- Detailed Analysis of MOS Diff. Pair's Large-Signal Response
  - Overall Input-Output Characteristic
  - Dependencies on Various Parameters

Summary of the Results



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

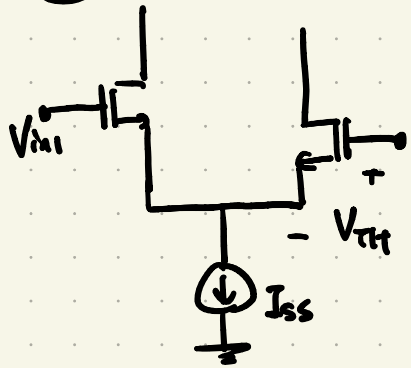
$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2$$

$$V_{GS} = \sqrt{\frac{2I_D}{\mu_n C_{ox}\frac{W}{L}}} + V_{TH}$$

$$V_{GS} - V_{TH} = \sqrt{\frac{I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$$

Equilibrium Overdrive

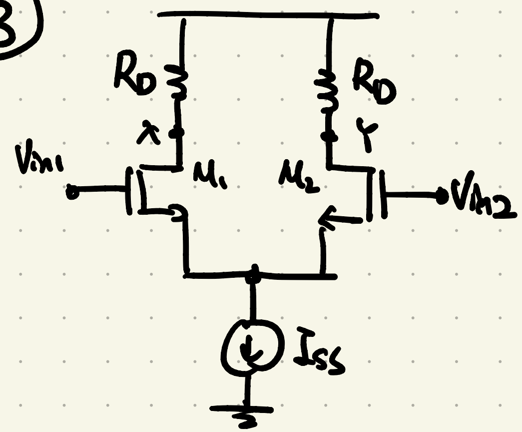
②

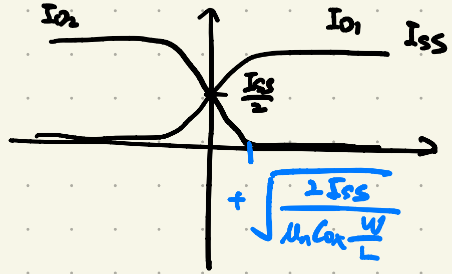


Min $|V_{in1} - V_{in2}|$ necessary to turn off one side:

$$\sqrt{\frac{2I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$$

③





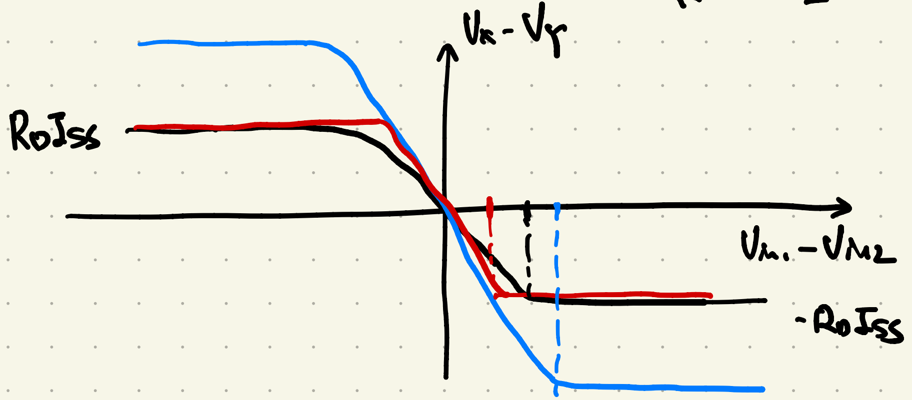
$$I_{D1} - I_{D2} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{in1} - V_{in2})\sqrt{\frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}} - (V_{in1} - V_{in2})^2}$$

valid if M_1 and M_2 are on or near turning off

- If $V_{in1} - V_{in2} = 0 \Rightarrow I_{D1} = I_{D2}$
- This equation is valid only if $|V_{in1} - V_{in2}| \le \sqrt{\frac{2I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$

Minimum $|V_{in1} - V_{in2}|$ to turn off one side $=$
$\sqrt{2} \times$ Equilibrium Overdrive Voltage

④ $V_X - V_Y = -\frac{R_D}{2}\mu_n C_{ox}\frac{W}{L}(V_{in1}-V_{in2})\sqrt{\frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}} - (V_{in1}-V_{in2})^2}$



If $(V_{in1}-V_{in2})^2 \ll \frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}}$

$$\Rightarrow V_X - V_Y \approx -\frac{R_D}{2}\mu_n C_{ox}\frac{W}{L}\sqrt{\frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$$

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

The Slope $= -\sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\, R_D$

Example

What happens if I_{SS} is doubled? $\boxed{\text{blue line}}$

- Slope' $= \sqrt{2}$ slope
- The circuit becomes more linear because it can take a larger input difference without "dying"

Quiz: What happens is $\frac{W}{L}$ is doubled? $\boxed{\text{red line}}$

The circuit become less linear