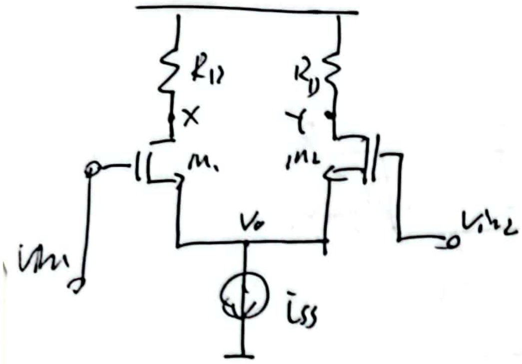
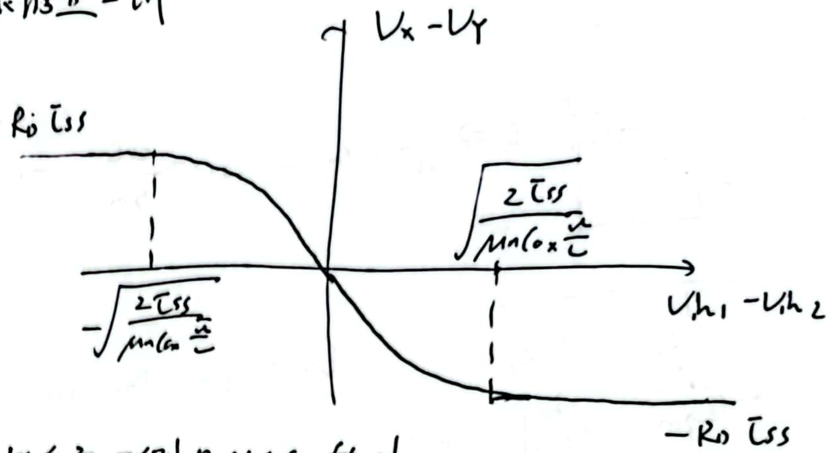
根据上一问





$V_{in1}-V_{in2}$ 足够大/小，以至于一边的MOS off时

假设 $V_{in1}-V_{in2}$ 足够大，M_2 off

$$V_{in2}-V_{TH}=V_0$$

$$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{in1}-V_0-V_{TH})^2=I_{SS} \Rightarrow V_{in1}-V_0-V_{TH}=\sqrt{\frac{2I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$$

$$V_{in1}-V_{in2}=\sqrt{\frac{2I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}$$

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

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

If $(V_{in1}-V_{in2})^2 \ll \frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}}$，即 接近 origin point 时

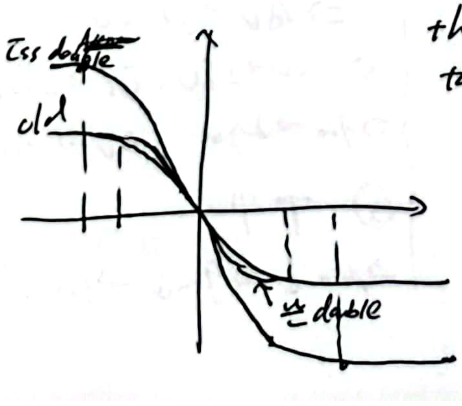
$$V_X-V_Y=-\frac{R_D}{2}\mu_n C_{ox}\frac{W}{L}\sqrt{\frac{4I_{SS}}{\mu_n C_{ox}\frac{W}{L}}}(V_{in1}-V_{in2})$$

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

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

when close to origin point, $k=-R_D\sqrt{\mu_n C_{ox}\frac{W}{L}I_{SS}}$

① I_{SS} is doubled. slope changes to $k=-\sqrt{\mu_n C_{ox}\frac{W}{L}2I_{SS}}\,R_D$



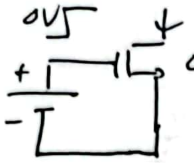
the circuit becomes more linear because it can take a larger input difference without "dying".

② $\frac{W}{L}$ is doubled.

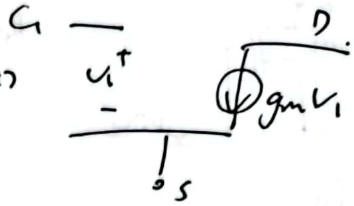
The circuit becomes less linear, because it can take only a smaller input difference before it "dies".

Small-Signal Behavior of MOS Diff Pair.

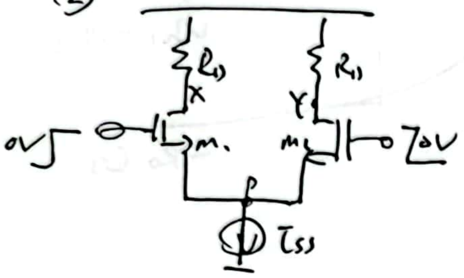
- A Few Points.

① 

$\Delta I \Rightarrow \frac{\Delta I}{\Delta V} = g_m \Rightarrow \Delta V = \frac{\Delta I}{g_m} \Rightarrow$



②



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

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

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

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

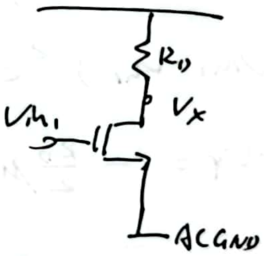
$\therefore \frac{\sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}\,\Delta V}{g_m} = \Delta V \Rightarrow g_m = \sqrt{\mu_n C_{ox}\frac{W}{L} I_{SS}}$ 考虑到[illegible]

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

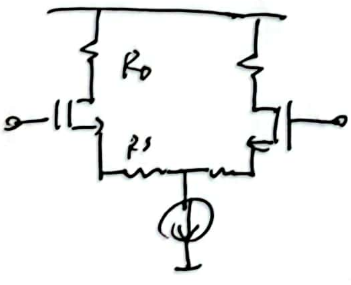
V_P doesn't change $\Rightarrow$ P is AC GND.

CS stage

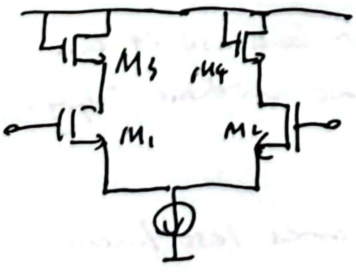
$\Rightarrow \frac{V_X}{V_{in1}} = -g_m R_D \Rightarrow \frac{V_X - V_Y}{V_{in1} - V_{in2}} = -g_m R_D$



Example



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



$\frac{V_X}{V_{in1}} = -\frac{\frac{1}{g_{m3}}}{\frac{1}{g_{m1}}} = -g_{m1}\frac{1}{g_{m3}}$

Observations

① $W \to 2W$.

$\Rightarrow g_m \to \sqrt{2}\,g_m$

$\Rightarrow A_V \to \sqrt{2}\,A_V$

② $W \to 2W$, $I_{SS} \to 2I_{SS}$

$\Rightarrow g_m \to 2g_m$, $A_V \to 2A_V$

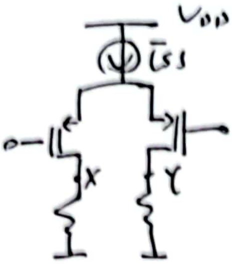
③ $T\uparrow$

$\Rightarrow \mu_n\downarrow \Rightarrow g_m\downarrow \Rightarrow |A_V|\downarrow$

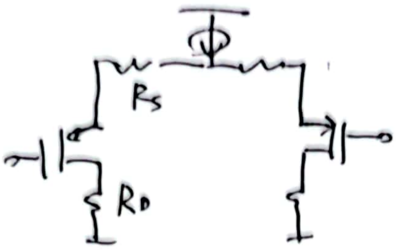
CS 扫描全能王
3亿人都在用的扫描App

P-Type Diff Pair

P

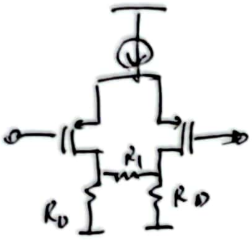


the same as N-Type

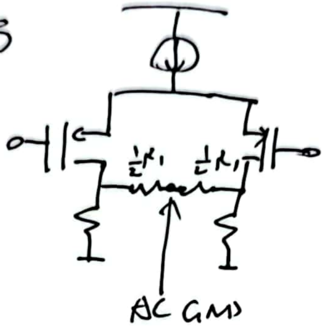


$$A_v = -\frac{R_D}{\frac{1}{g_m}+R_s}$$

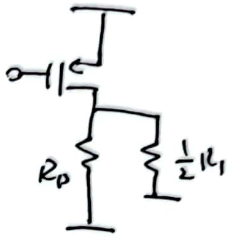
Example



同样、半分



$\Rightarrow$



$$\therefore \frac{V_x}{V_{in}} = -g_m\left(R_D \parallel \frac{1}{2}R_1\right)$$