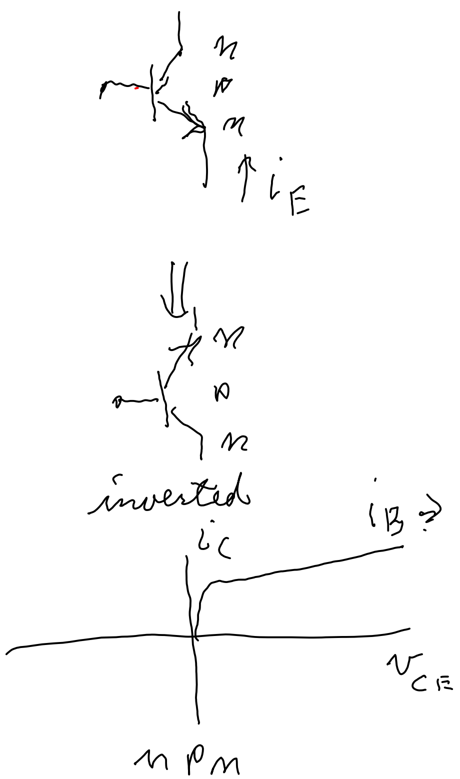
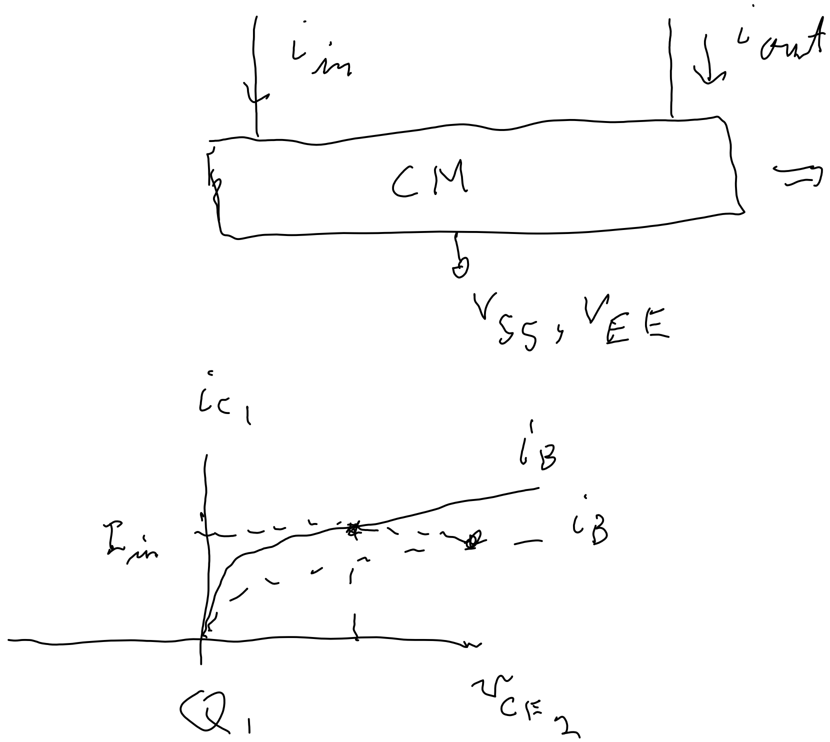
ENEE303
02/28/19

Note Title 2/28/2019

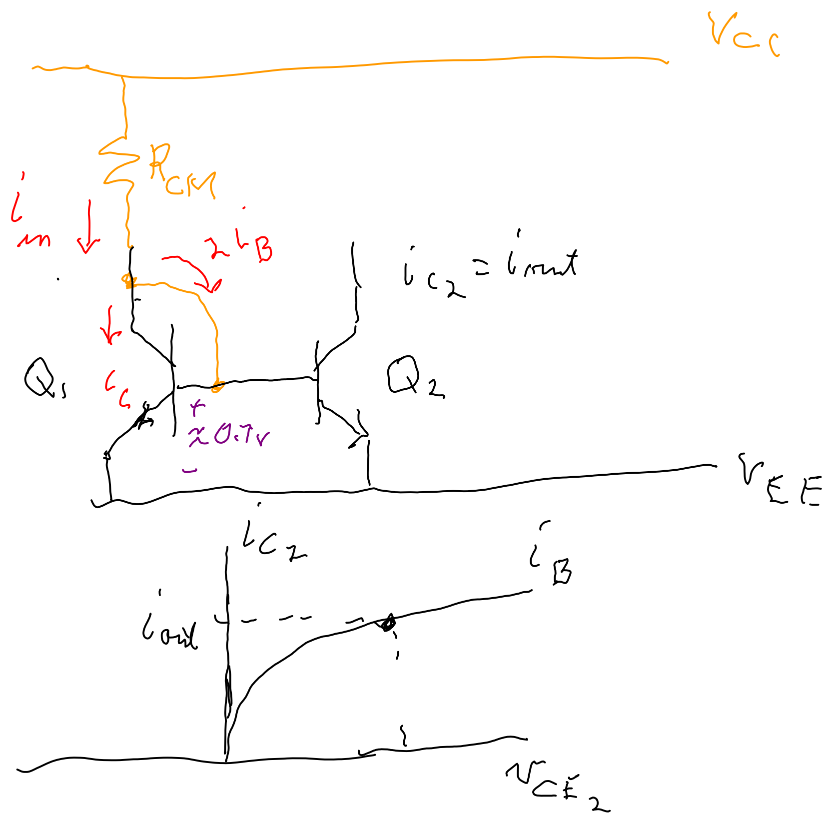


β = beta = h_{fe} ; $i_C = \beta i_b$

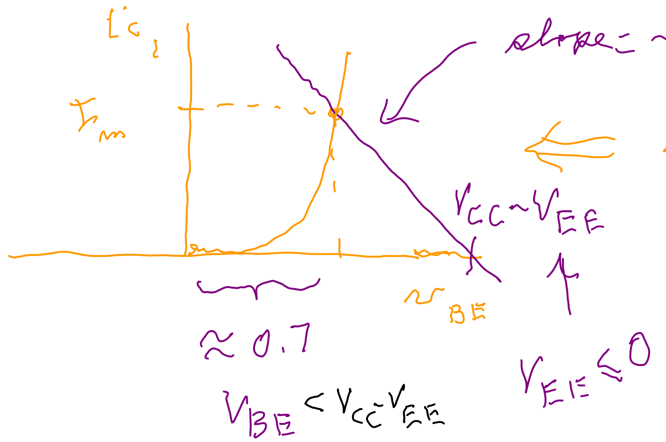
$= B_f$



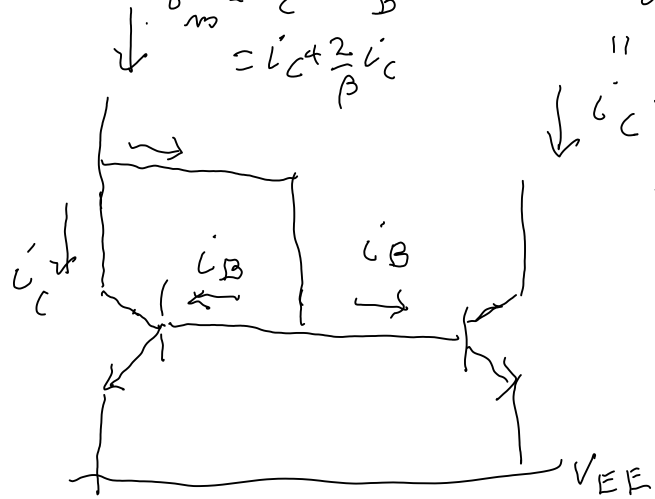
i_{in}
i_{out}
CM
V_{SS}, V_{EE}
i_{C_1}
i_B
I_{in}
Q_1
v_{CE_2}



V_{CC}
R_{CM}
i_{in}
$2i_B$
$i_{C_2} = i_{out}$
Q_1
Q_2
i_C
$+ \approx 0.7V -$
V_{EE}
i_{C_2}
i_{out}
i_B
v_{CE_2}

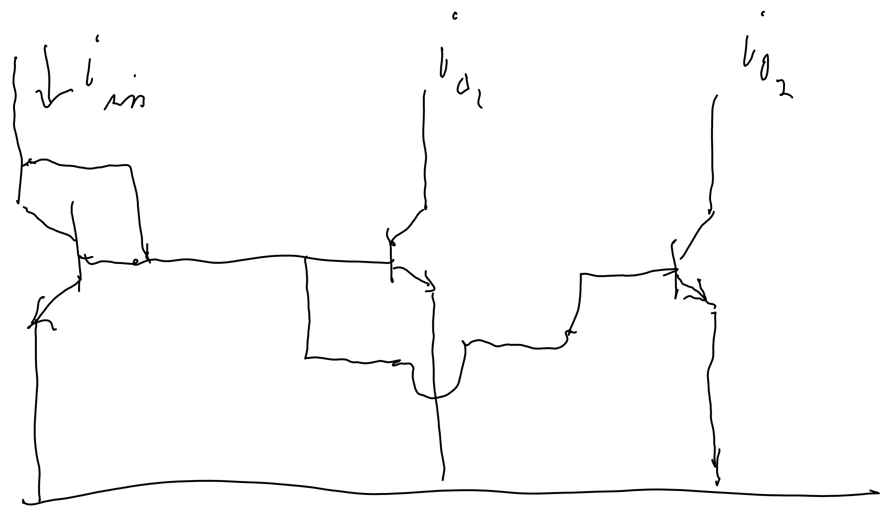


← fixes v_{BE} given i_{in}



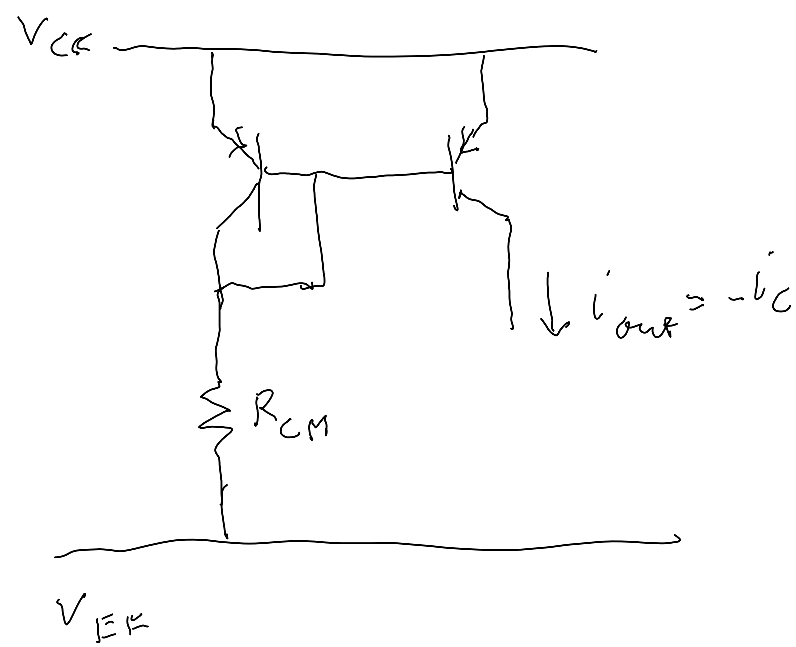
$$i_{in} = i_C + 2 i_B = i_C + \frac{2}{\beta} i_C$$

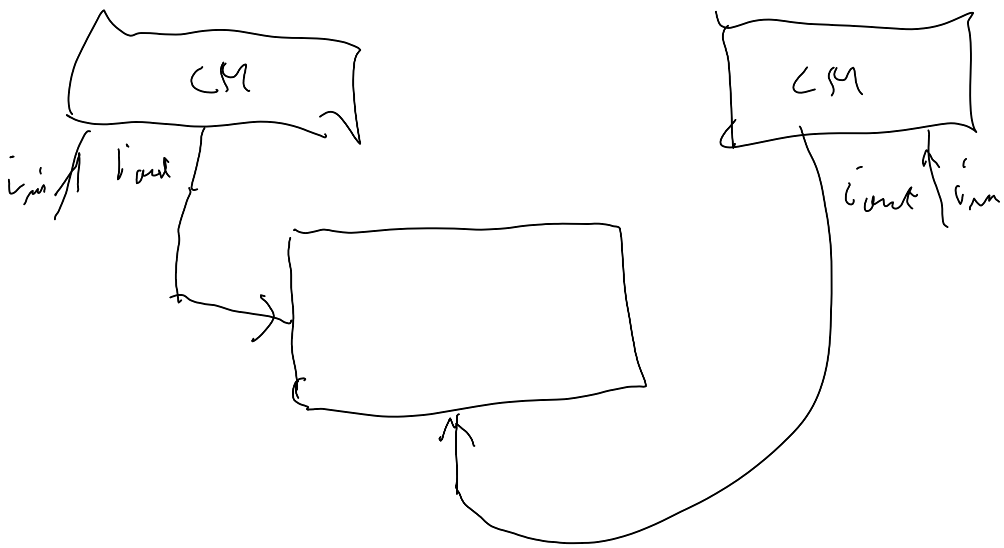
$$i_{out} = i_C = \beta i_B = \frac{i_{in}}{1 + 2/\beta} \approx i_{in}$$



can send i_{in} to many i_o's

For sourcing

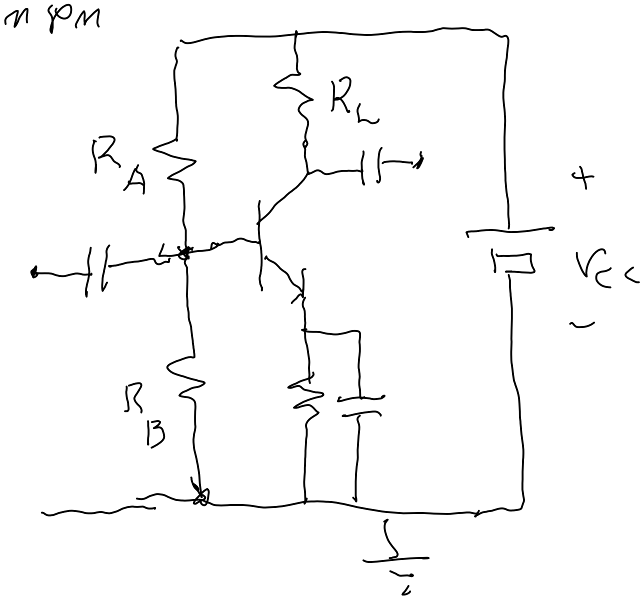




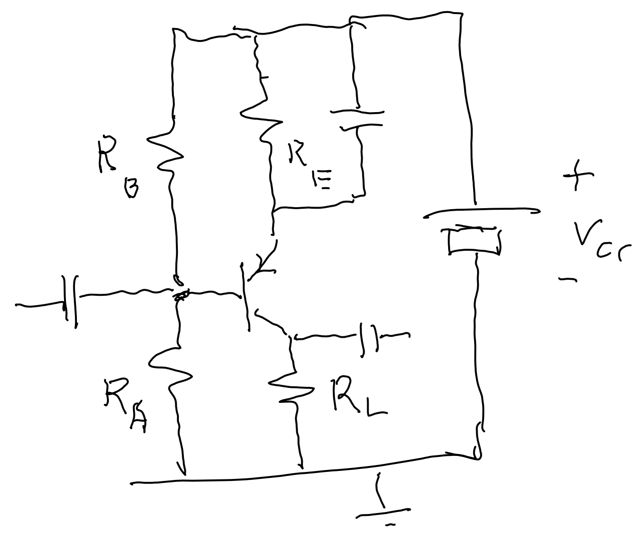
for sourcing

CE using pnp

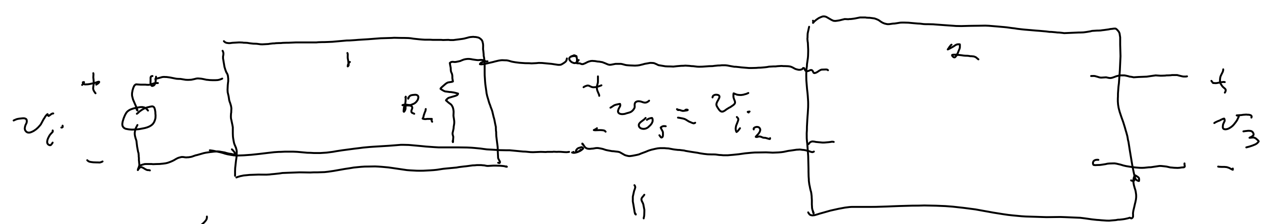
for npn



for pnp



cascade connection



$$v_{o_1} = -g_{m_1} R_{L_1}$$

$$v_3 = -g_{m_2} R_{L_2}$$

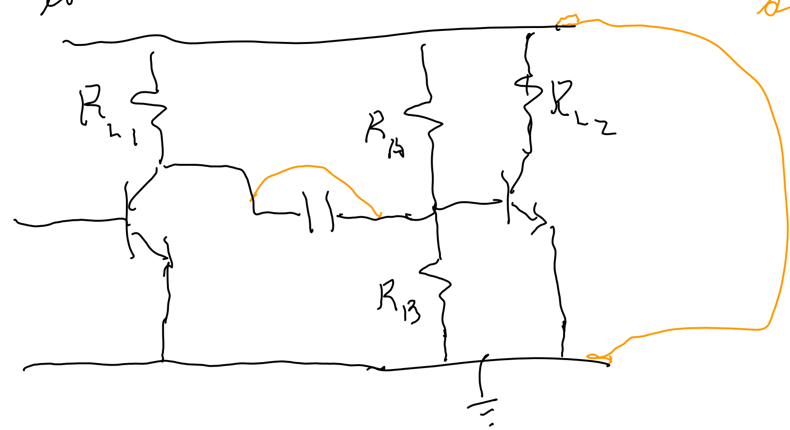
$$\frac{v_3}{v_i} = \frac{v_3}{v_{i_1}} \cdot \left.\frac{v_{i_2}}{v_i}\right| v_{i_2} = v_{o_1}$$

← when loaded

$$= (-g_{m_1} R_{L_1 \text{loaded}})$$

$$\times (-g_{m_2} R_{L_2})$$

small signal



$R_{L_1} \Rightarrow R_{L_1}$ in parallel with $\frac{R_A R_B}{R_A + R_B}$

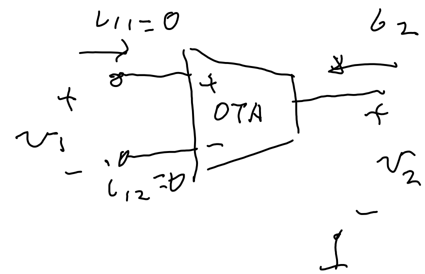
$R_{L_1 \text{loaded}}$

$$R_{L1,\,loaded} = \frac{R_{L1} \times \dfrac{R_A R_{13}}{R_A + R_{13}}}{R_{L1} + \dfrac{R_A R_{13}}{R_A + R_{13}}}$$

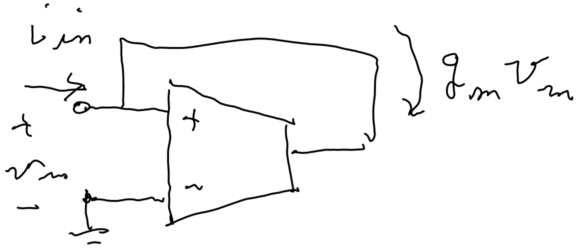
OTA = operational transconductance amplifier
= differential pair with current mirror load

MOS = p. 646, Fig. 9.32
BJT = p. 651, Fig. 9.36

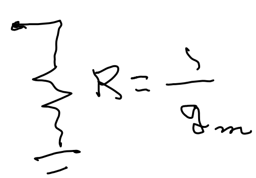
diff pair $\Rightarrow$ OTA

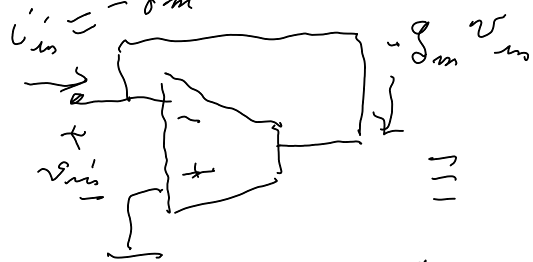


$$Y = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} ; \quad \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

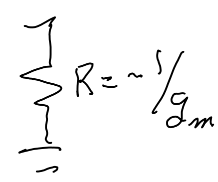


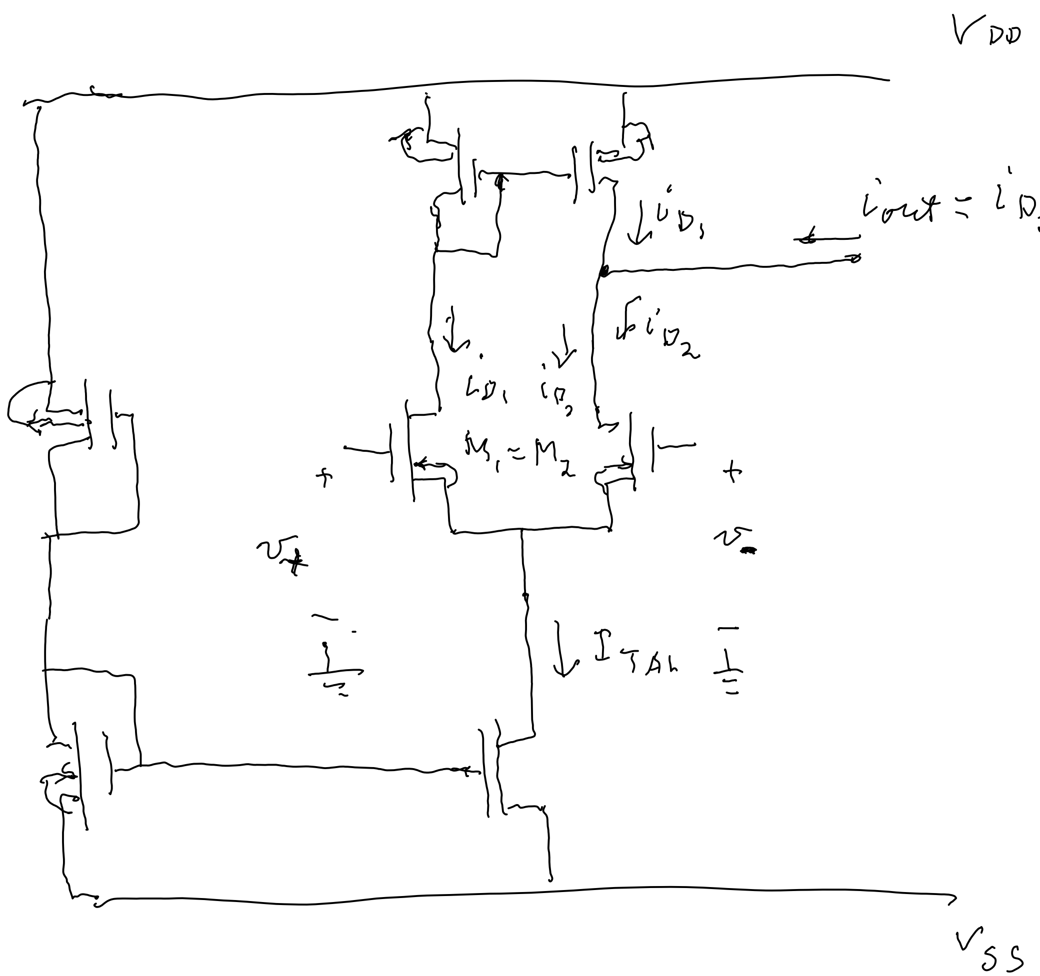
$\equiv$





$\equiv$

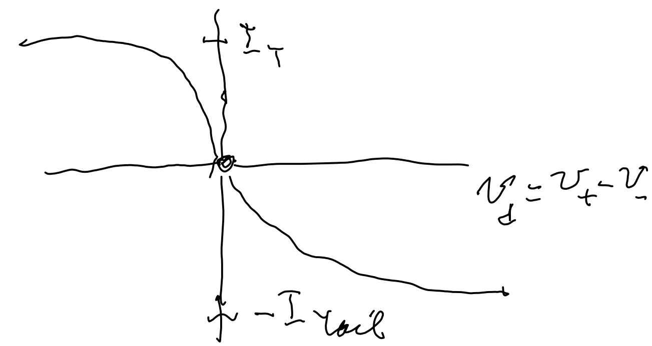


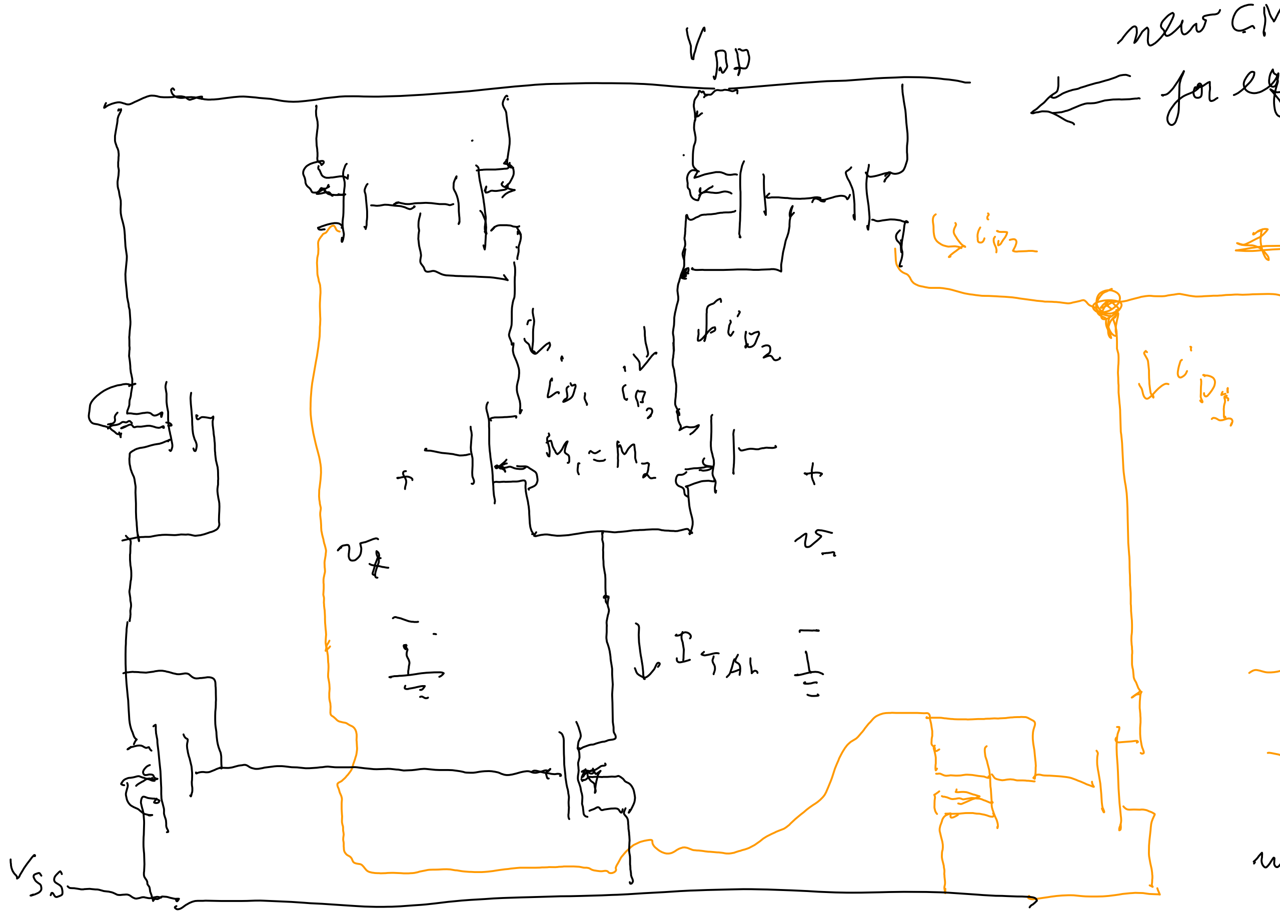


$i_{out} = i_{D_2} - i_{D_1}$

if $M_1 = M_2 \Rightarrow Q_1 = Q_2$

$= -I_T \tanh\left(\frac{v_+ - v_-}{2V_T}\right)$



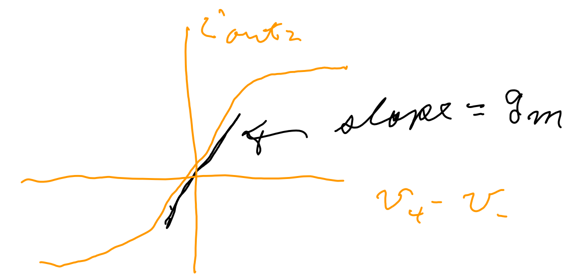


new CM
← for equal load on M_1 & M_2

$i_{out_2} = -i_{out_1}$

$i_{D_1} - i_{D_2}$

$i_D = g_m(v_+ - v_-)$



usually $V_{SS} = -V_{DD}$