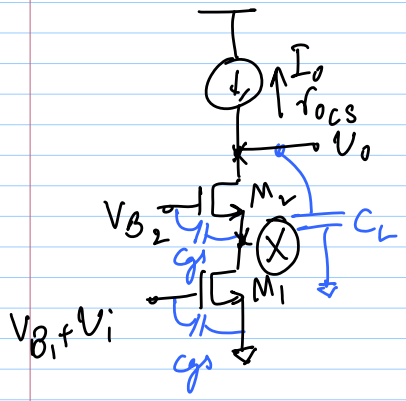
# Lec 4

Note Title 22-01-2014

22/1/14

$\frac{1}{r_{ds} C_{gs}}$ vs. $\frac{g_m}{C_{gs}}$ ✓




$\text{gain} = -(g_m r_{ds})^2$

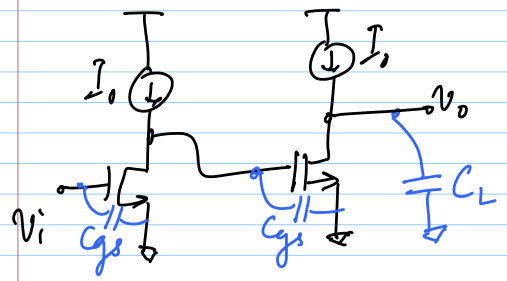
* $P_{dins}$

* $R_{out}$

* Freqv. Response

$$|\omega_{p_1}| = \frac{1}{r_{out} \cdot C_L}$$

$$|\omega_{p_2}| = \frac{g_m}{C_{gs}}$$

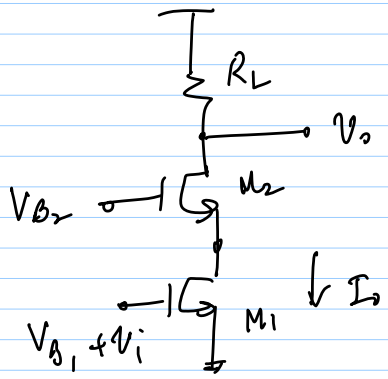



2 poles!

$$|\omega_{p_1}| = \frac{1}{r_{ds} C_{gs}}$$

$$|\omega_{p_2}| = \frac{1}{r_{ds} C_L}$$

2 dominant poles




$V_{B_2} = ?$

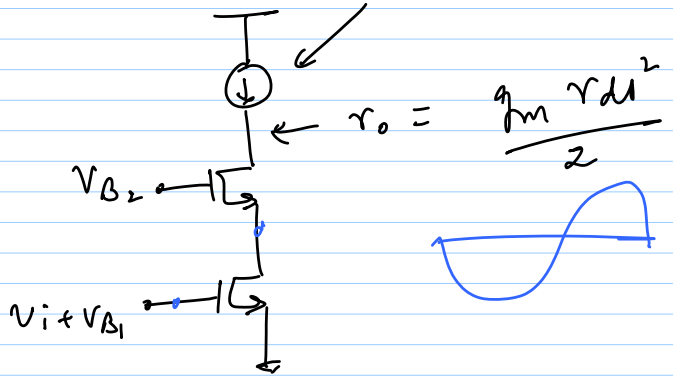
* $M_1$ in sat. (min $V_B$)

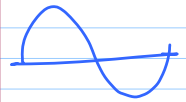
* $M_2$ in sat. (max. $V_B$)

$$\downarrow I_0 (V_{GS_2} + V_{DSAT_1}) \leq V_{B_2} \leq (V_{T_2} + V_{DD} - I_0 R_L)$$

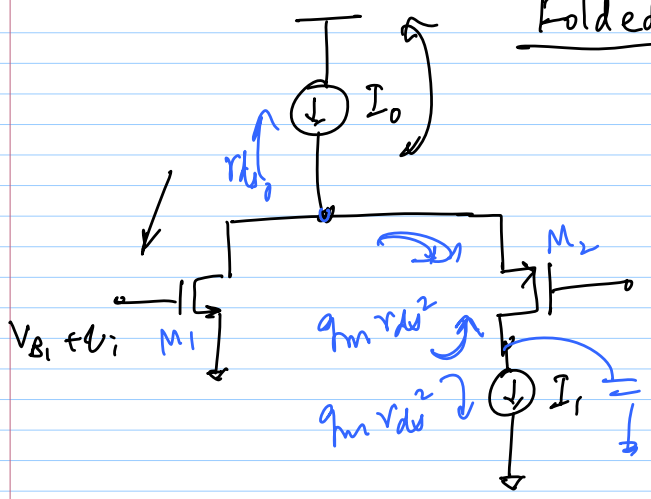
$V_{B_1} = V_{GS_1}$ @ $I_0$

cascode C-S.



# Folded Cascode



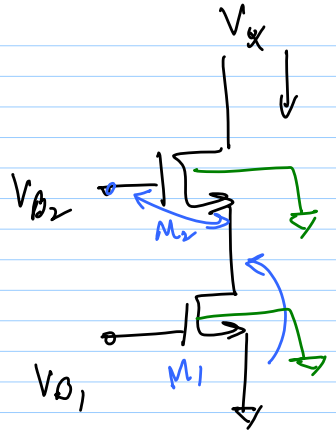

1 dominant pole

$V_{O\,min} = 2V_{DSAT}$

$V_{i\,max} = V_{DD} - V_{DSAT_1} + V_T$

NMOS CS + PMOS C.G.

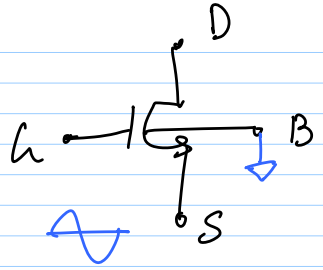
* Input CM is dis connected from o/p CM




$V_{x_{min}} = V_{B_2} - V_{T_2}$

$V_{B_{2_{min}}} = V_{T_2} + V_{DSAT_2} + V_{DSAT_1}$

$V_{x_{min}} = 2V_{DSAT}$




$V_B \neq V_S$

$$V_T = V_{T_0} + \gamma\left[\sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F}\right]$$

* $V_T > V_{T_0}$
* Small-signal behaviour

24/1/14

# Lec 5

$$g_m = \left.\frac{\partial I_D}{\partial V_{GS}}\right|_{\substack{V_{DS}=\text{const.} \\ V_{SB}=\text{const}}}$$

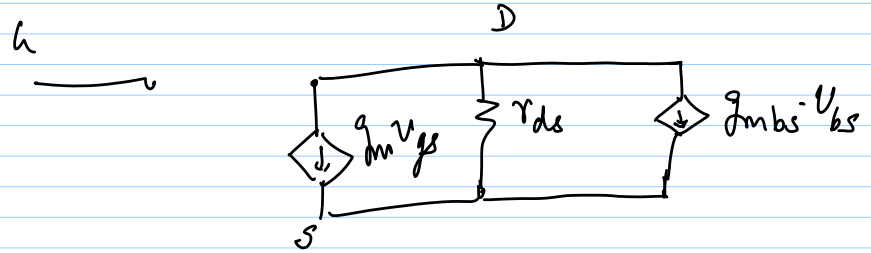
$$g_{m_{bs}} = \frac{\partial I_D}{\partial V_{BS}} = \frac{\partial I_D}{\partial V_T}\cdot\frac{\partial V_T}{\partial V_{BS}}$$

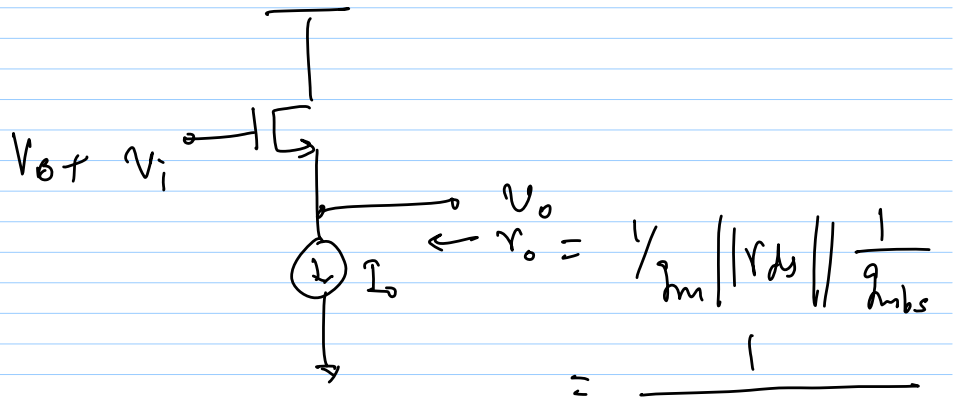
$$= -g_m \cdot \frac{\partial V_T}{\partial V_{BS}}$$

$$g_{mbs} = -g_m \cdot \frac{-\gamma/2}{\sqrt{2\phi_F + V_{SB}}}$$

$$= k \cdot g_m$$

$k < 0.2$

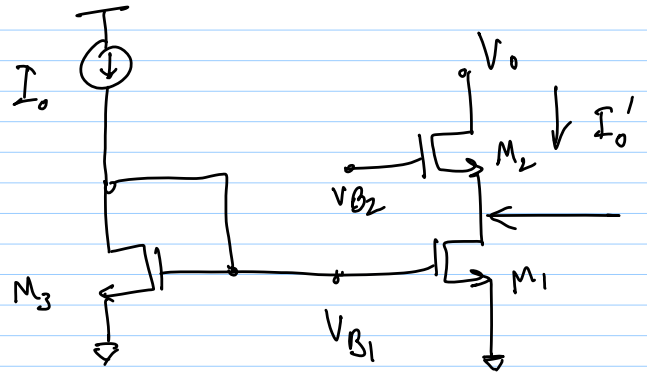


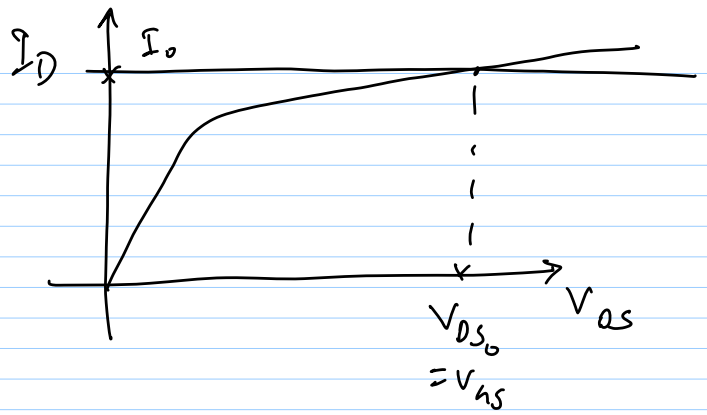




$$r_o = 1/g_m \,||\, r_{ds} \,||\, \frac{1}{g_{mbs}}$$

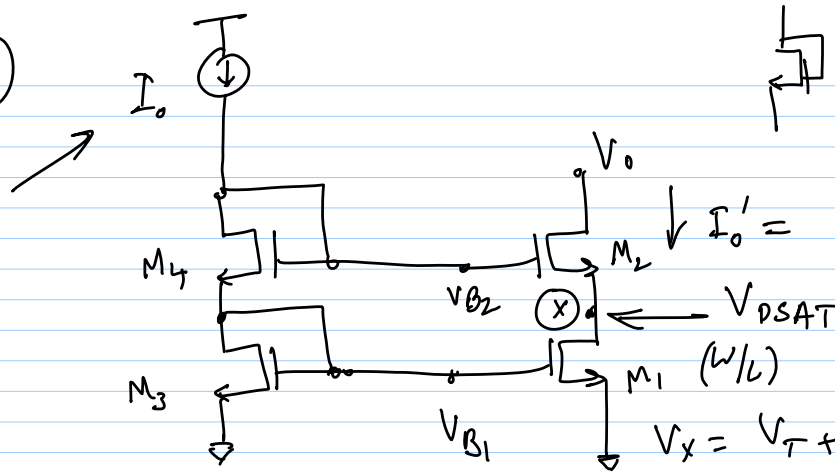
$$= \frac{1}{g_m + g_{mbs} + g_{ds}}$$

(A)



(B)



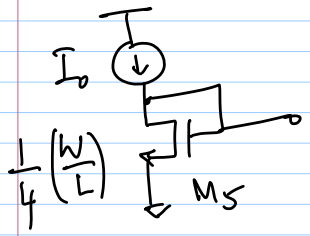

$V_{B1} = V_T + V_{DSAT} = V_{GS1}$

$V_{B2} = 2V_T + 2V_{DSAT} = V_{GS3} + V_{GS4}$

$V_{O,min} = V_T + 2V_{DSAT}$

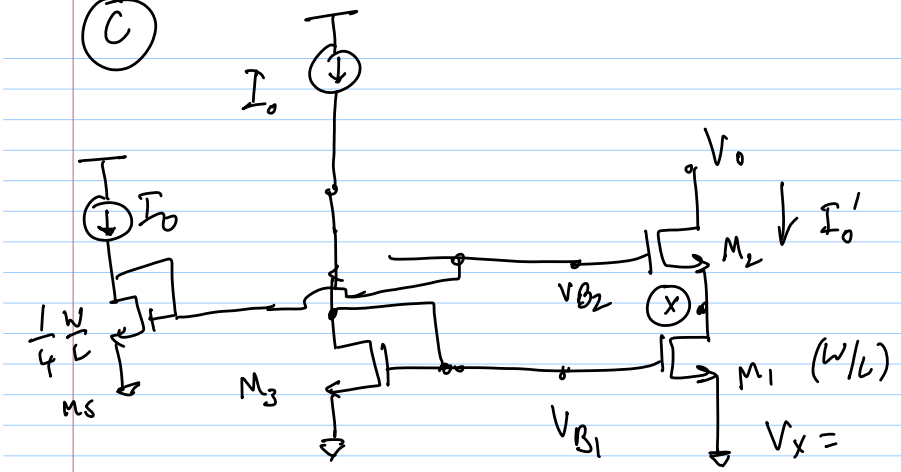
$0.4 - 0.7\,V$ $\quad$ $\rightarrow 100\,mV$

We want $V_{B2} = V_T + 2V_{DSAT}$




$V_T + 2V_{DSAT} = V_{B2}$

(C)




(D)

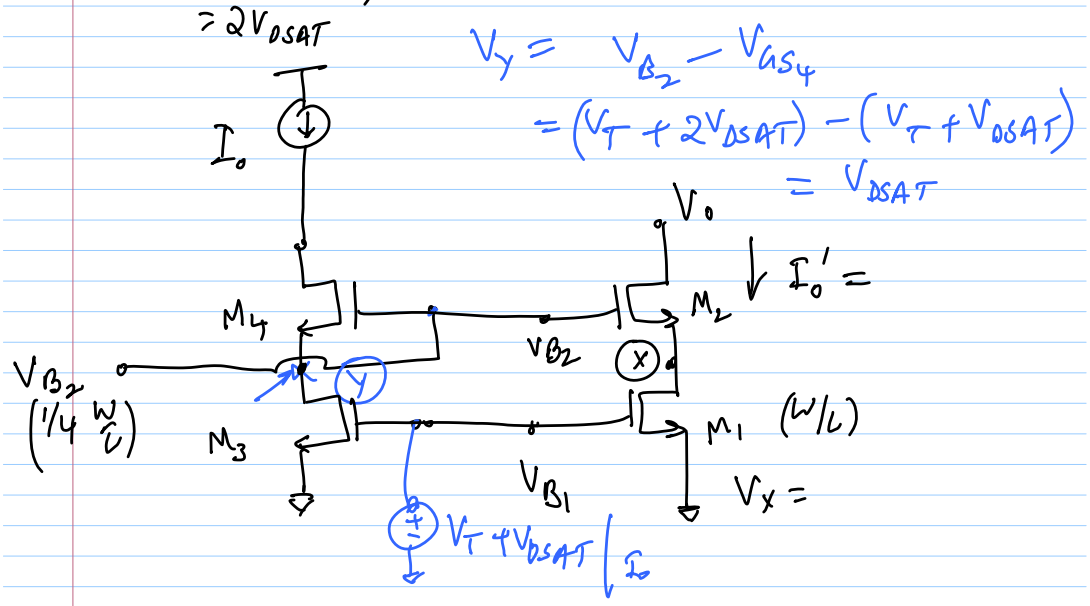
$V_{O,min}$, $I' = I_o \Rightarrow V_{DS3} = V_{DSAT}$

$= 2V_{DSAT}$

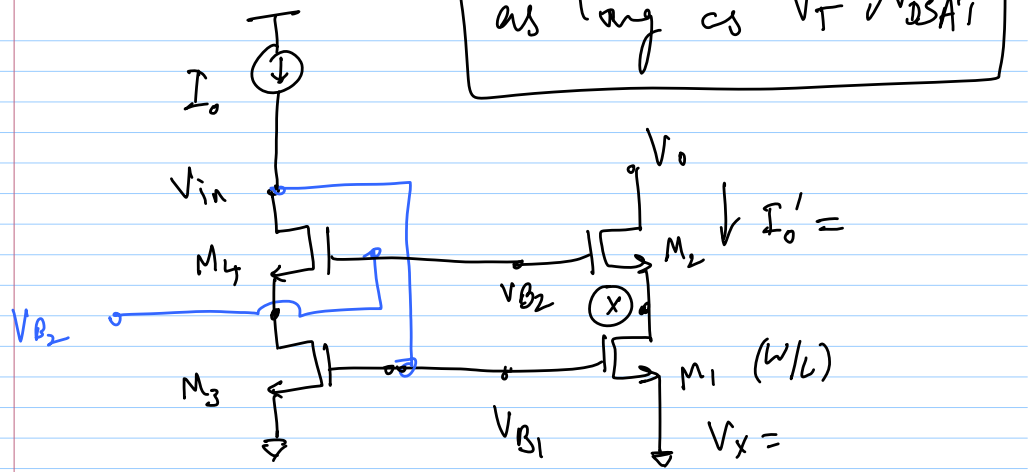
$V_y = V_{B2} - V_{GS4}$

$= (V_T + 2V_{DSAT}) - (V_T + V_{DSAT})$

$= V_{DSAT}$



as long as $V_T > V_{DSAT}$




$V_{DS4} < V_{DSAT}$ ⟸ $M_4$ triode

$V_{O4} = V_T + V_{DSAT}$ ; $V_{S3} = V_{DSAT}$