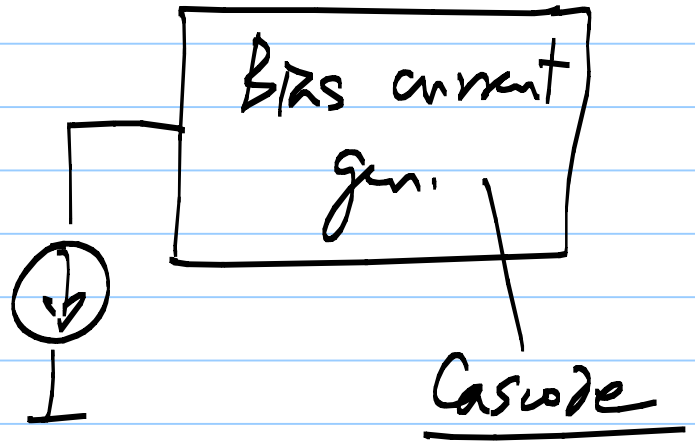
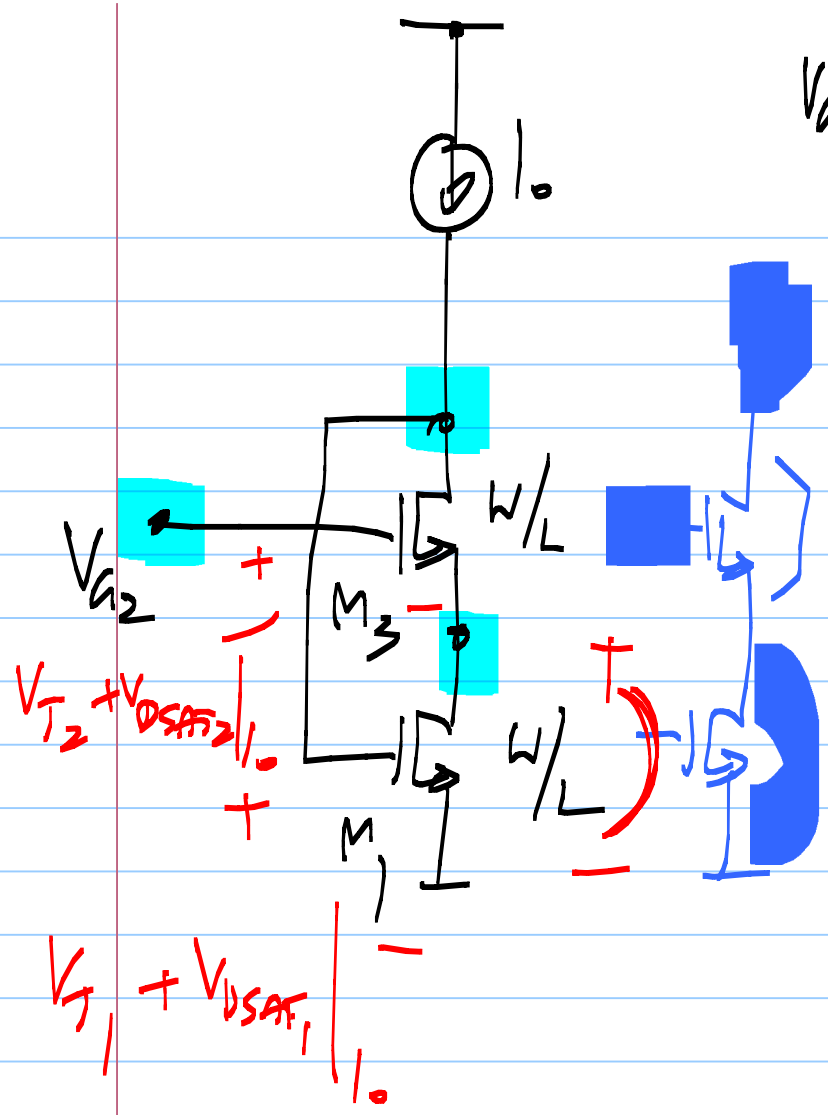
Lecture 19 29/2/2016

Cascode – Improves the output resistance

$$r_{ds} = \frac{1}{\lambda I_D} \; ; \; \lambda = \frac{k_\lambda}{L}$$

$L \uparrow$ to increase r_{ds}





V_{G_2} : both M_1, M_3 are in −ve feedback

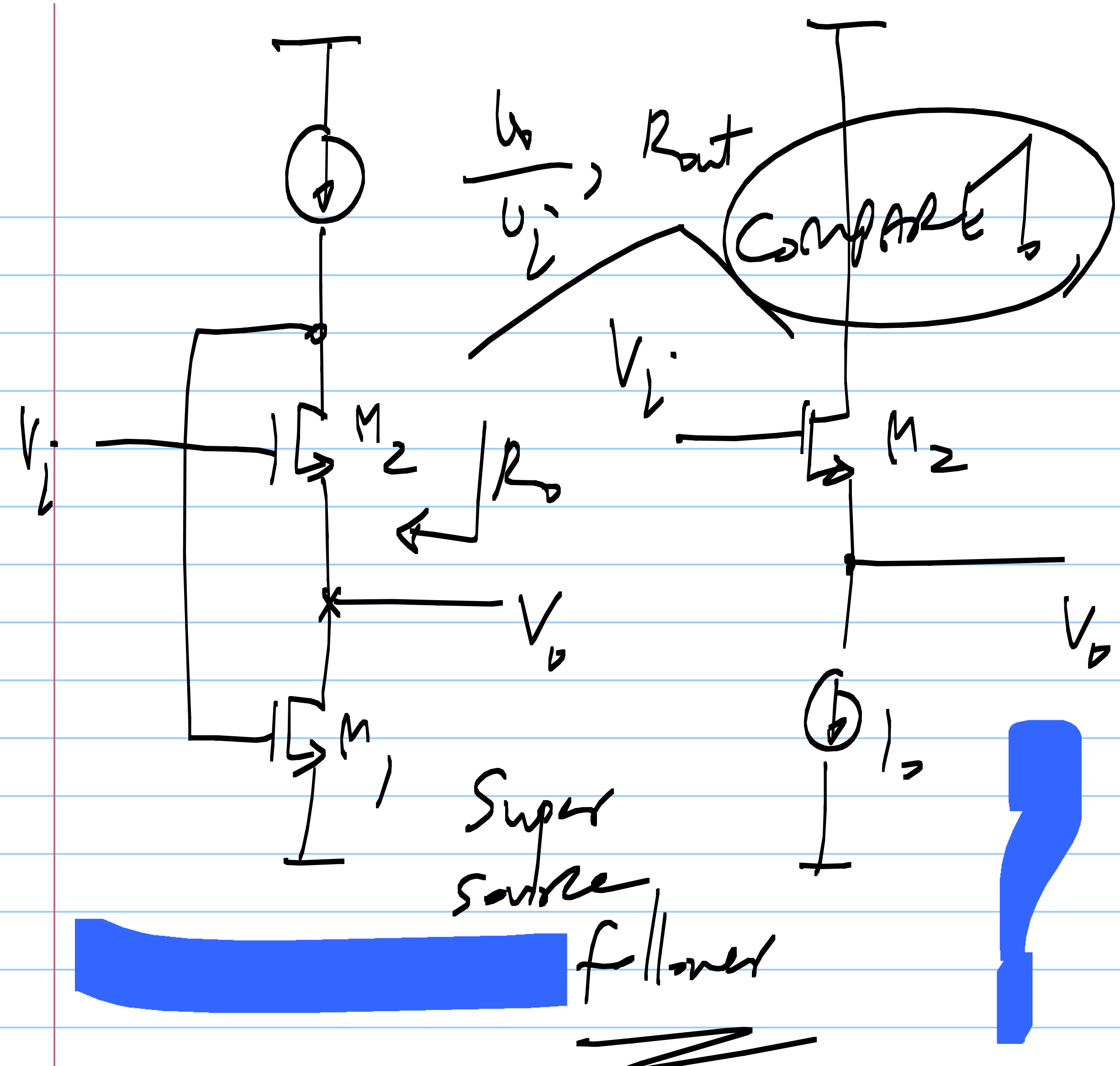
I_0, W, L, $\mu_n C_{ox}$

$2V_T + V_{DSAT}$

$$V_{G_2} < V_{T_1} + V_{DSAT_1}\big|_{I_0} + V_{T_2}$$

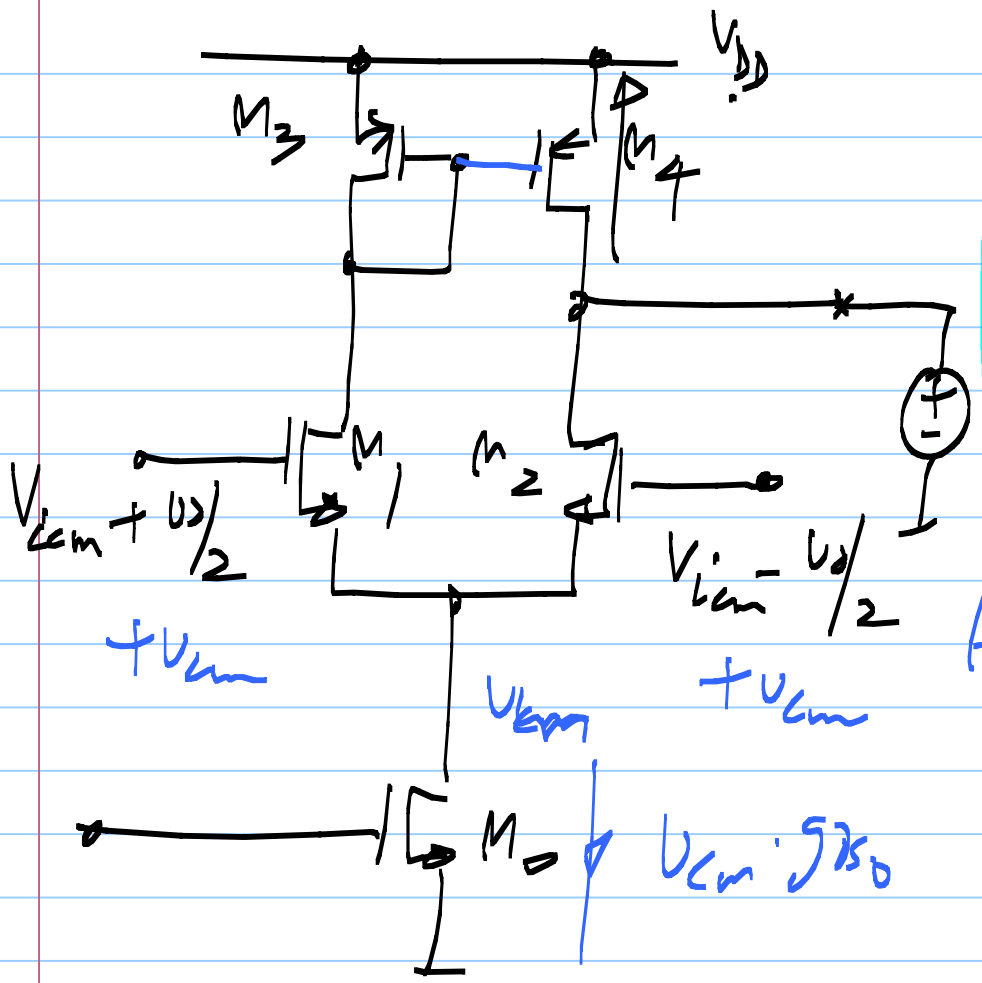
$$V_{G_2} > V_{DSAT_1}\big|_{I_0} + V_{T_2} + V_{DSAT_2}\big|_{I_0}$$

$V_T + 2V_{DSAT}$



$\frac{v_o}{v_i}$, R_{out}
COMPARE
V_i
M_2
M_1
R_o
V_o
I_o
Super source follower

Single stage opamp:

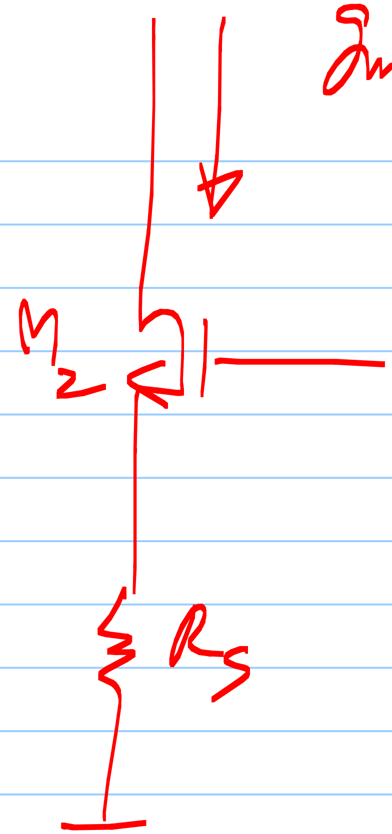


$$G_m = g_{m_1}$$

$$G_{out} = g_{ds_1} + g_{ds_2}$$

$$A_0 = \frac{g_{m_1}}{g_{ds_1} + g_{ds_2}}$$

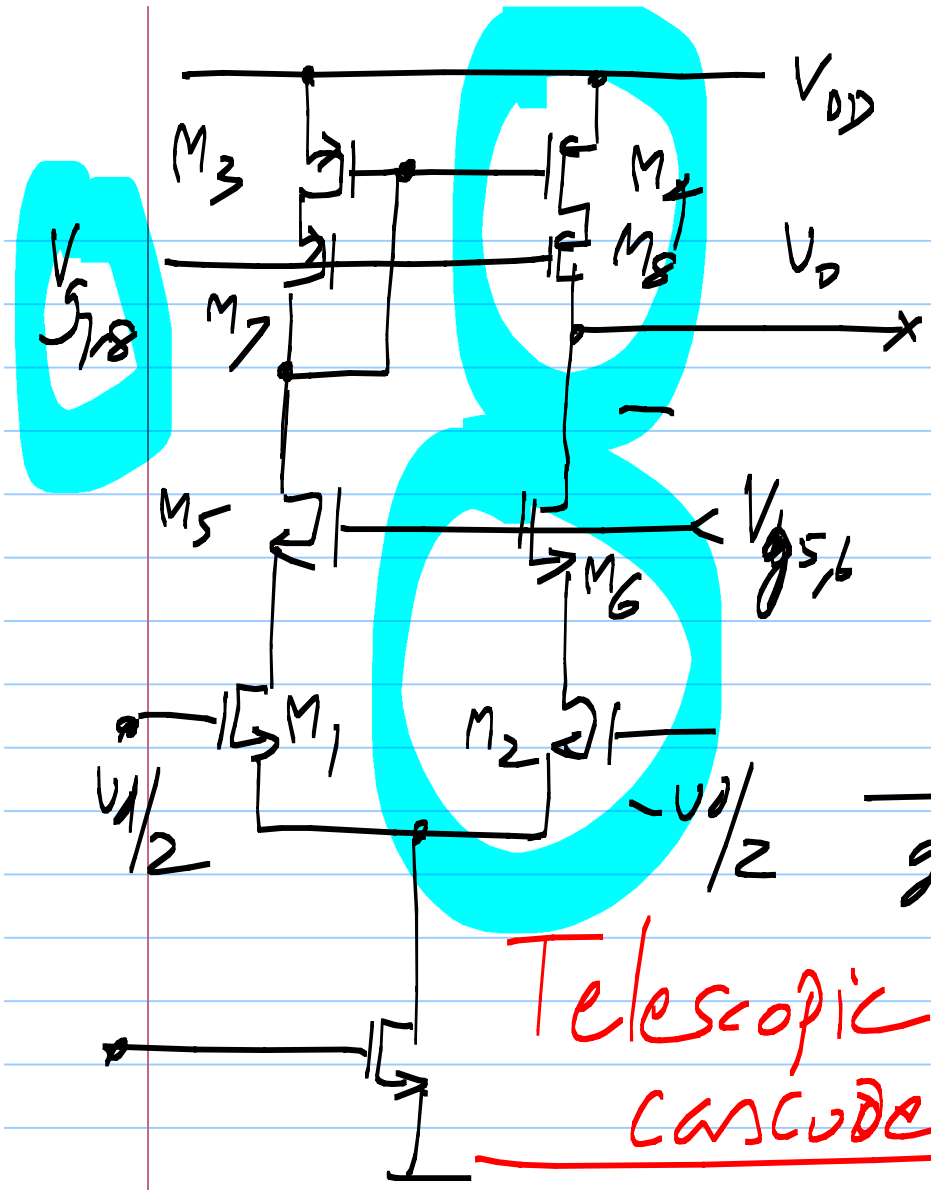
$$A_{cm} = \frac{g_{ds_0}/2}{g_{m_3}}$$



$g_{m_2} r_{ds_2} R_S + r_{ds_2} + R_S$

$R_S = 1/g_{m_1}$

$2 r_{ds_2} + ~~1/g_{m_1}~~$



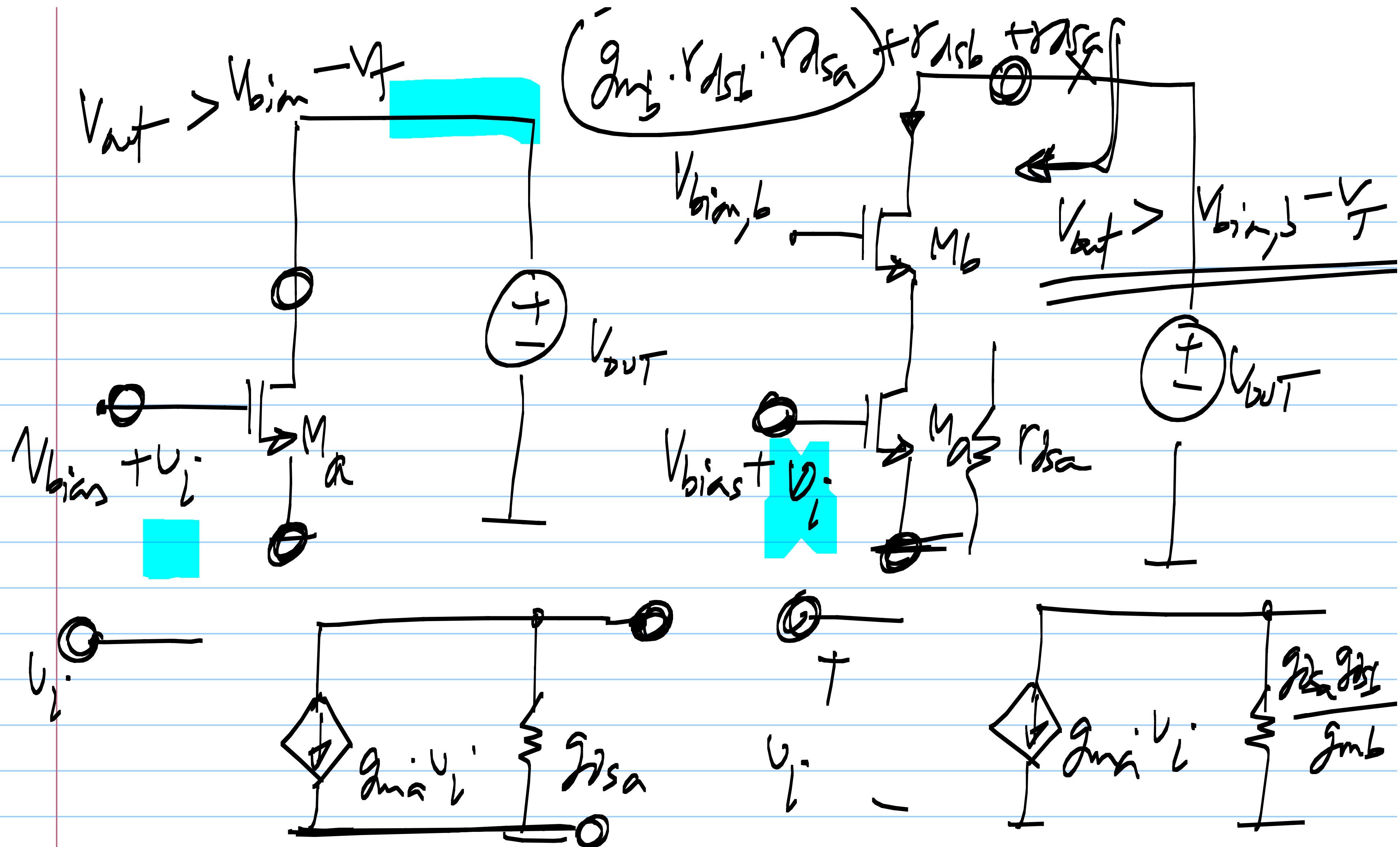
Telescopic cascode

$$A_D = \frac{V_o}{V_d} = \frac{g_{m1}}{\frac{g_{ds1}\,g_{ds5}}{g_{m5}} + \frac{g_{ds3}\,g_{ds7}}{g_{m7}}}$$

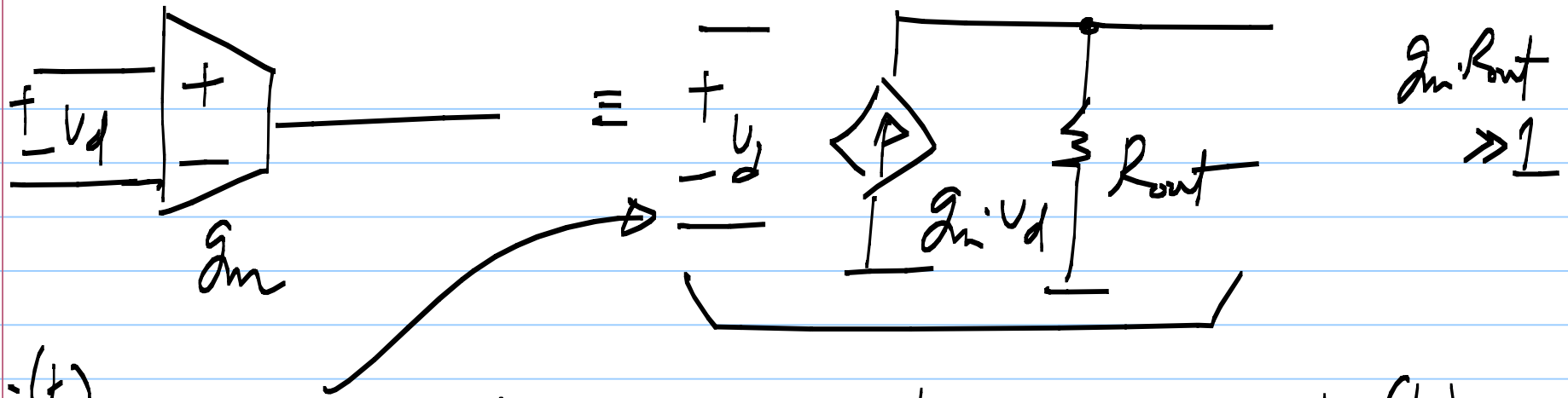
$$g_{ds3} \rightarrow \frac{g_{ds3}\cdot g_{ds7}}{g_{m7}}$$

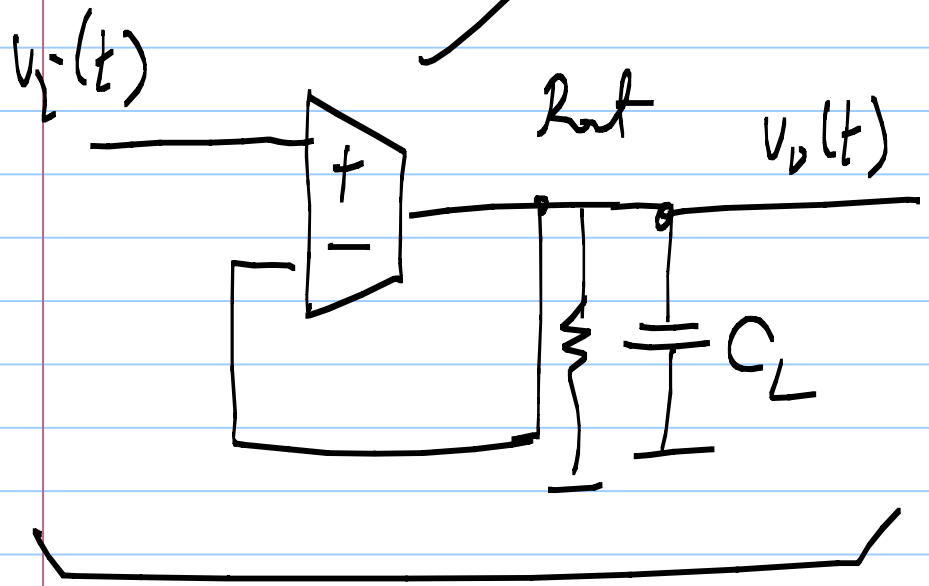
$$\frac{g_{m1}}{g_{ds1} + g_{ds3}} \sim \frac{g_m}{g_{ds}}$$

$$\left(\frac{g_m}{g_{ds}}\right)^2$$



$V_{out} > V_{bias} - V_T$
$V_{bias} + v_i$
M_a
V_{OUT}
v_i
$g_{ma} \cdot v_i$
g_{dsa}
$(g_{mb} \cdot r_{dsb} \cdot r_{dsa}) + r_{dsb} + r_{dsa}$
$V_{bias,b}$
M_b
$V_{out} > V_{bias,b} - V_T$
$V_{bias} + v_i$
M_a
r_{dsa}
V_{OUT}
$+$
v_i
$-$
$g_{ma} \cdot v_i$
$\frac{g_{dsa} g_{dsb}}{g_{mb}}$





step response $v_o(t)$

$\frac{V_o(s)}{V_i(s)}$ — Bode mag. phase plot