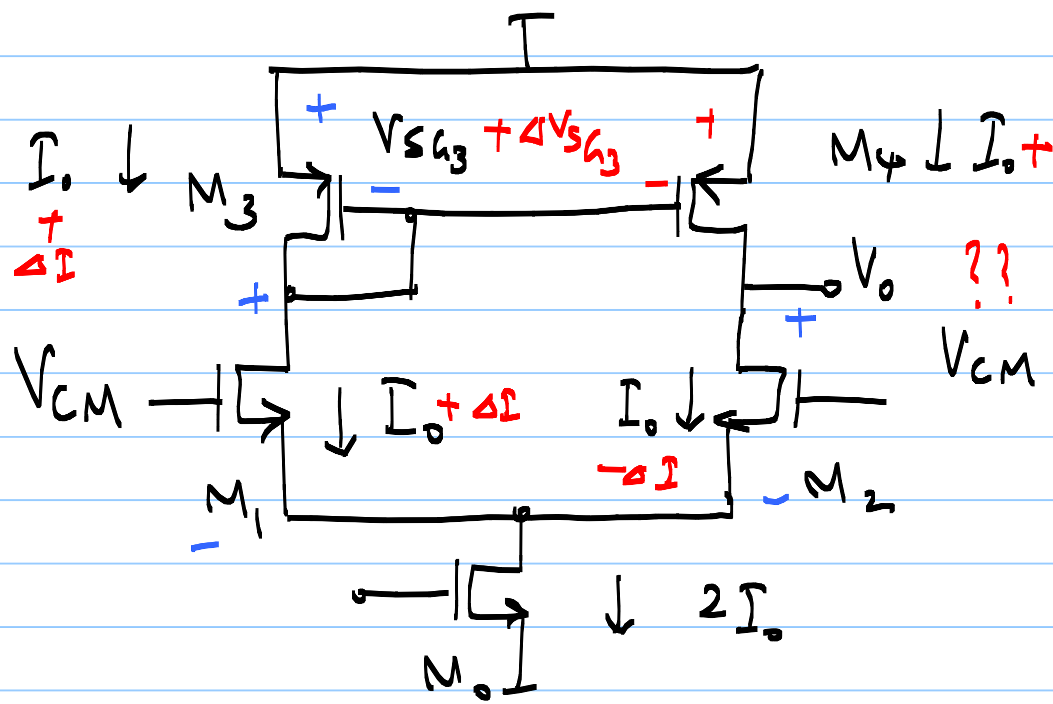
7/10/20

Lecture 34



$M_1 \equiv M_2$

$M_3 \equiv M_4$

$$V_{SG_3} = V_{T_3} + \sqrt{\frac{2I_0}{\mu_p C_{ox} \left(\frac{W}{L}\right)_3}}$$

$$= V_{SG_4}$$

?? = 0

$$V_{D_1} = V_{DD} - V_{SG_3} - \Delta V_{SG_3}$$

$\Delta I = 0$; $V_{o_{CM}} = V_{DD} - V_{SG_3}$

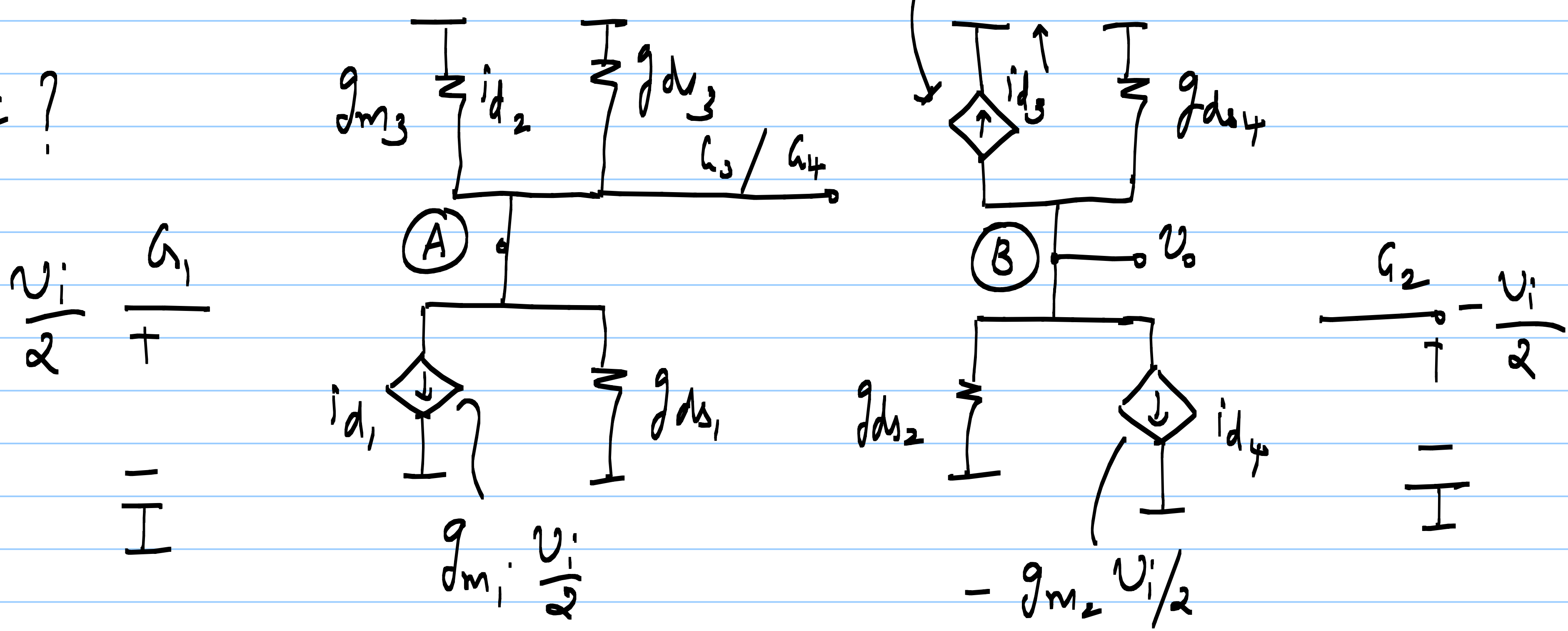
Case 2: λ's are non-zero

$$I_{D_1} = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right)_1 \left(V_{GS_1} - V_{T_n}\right)^2 \left(1 + \lambda V_{DS_1}\right)$$

$$I_{D_2} = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right)_2 \left(V_{GS_2} - V_{T_n}\right)^2 \left(1 + \lambda V_{DS_2}\right)$$

DM SS analysis

$\frac{v_o}{v_i} = ?$



$$v_A = -\frac{g_{m_1}}{g_{m_3} + g_{ds_1} + g_{ds_3}} \cdot \frac{v_i}{2}$$

$$i_{d_3} = g_{m_4} \cdot v_A = -\frac{g_{m_4}}{g_{m_3} + g_{ds_1} + g_{ds_3}} \cdot g_{m_1} \frac{v_i}{2}$$

$$\approx -g_{m_1}\frac{v_i}{2} \quad \text{if} \quad g_{m_3} \gg g_{ds_1} \ \& \ g_{ds_3}$$

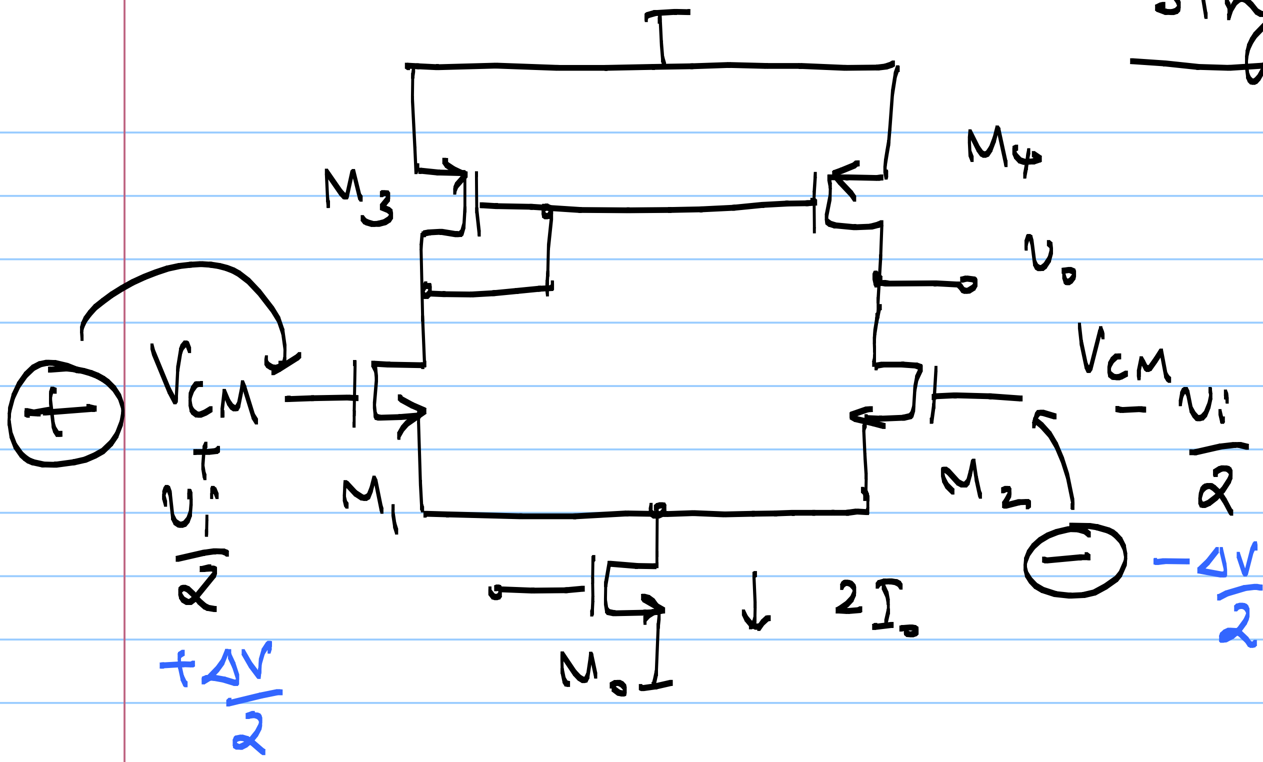
$$v_o = -\left(i_{d_3} + i_{d_4}\right)\cdot\frac{1}{g_{ds_2}+g_{ds_4}}$$

$$= -\left(-g_{m_1}\frac{v_i}{2} - g_{m_2}\frac{v_i}{2}\right)\cdot\frac{1}{g_{ds_2}+g_{ds_4}}$$

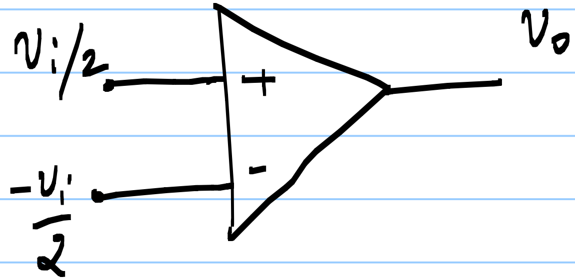
$$= \frac{g_{m_1}}{g_{ds_2}+g_{ds_4}}\cdot v_i$$

$$\frac{v_o}{v_i} = \frac{g_{m_1}}{g_{ds_2}+g_{ds_4}} = g_{m_1}\left(r_{ds_2} \,||\, r_{ds_4}\right)$$

"Single-Stage Opamp"



≡



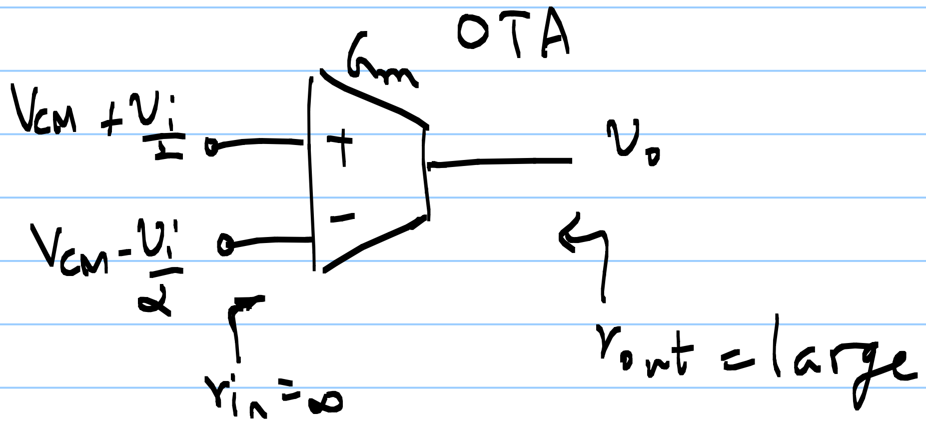
DM gain = $g_{m_1}(r_{ds_2} \| r_{ds_4})$

$r_{in} = \infty$

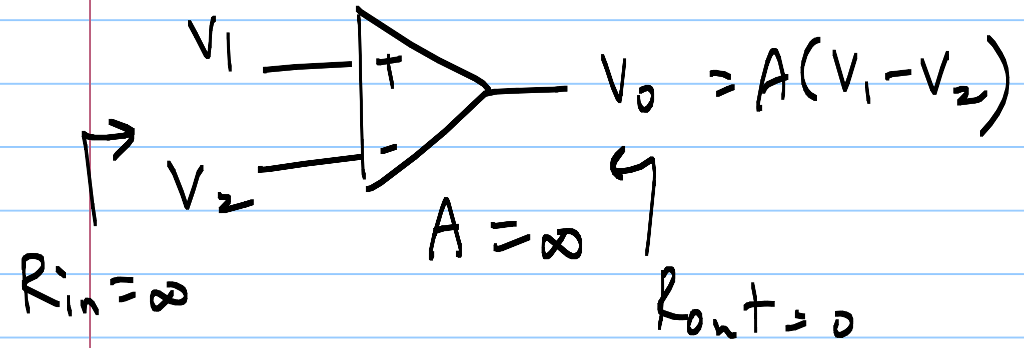
$r_{out} = r_{ds_2} \| r_{ds_4}$ (large)

$G_m = g_{m_1}$

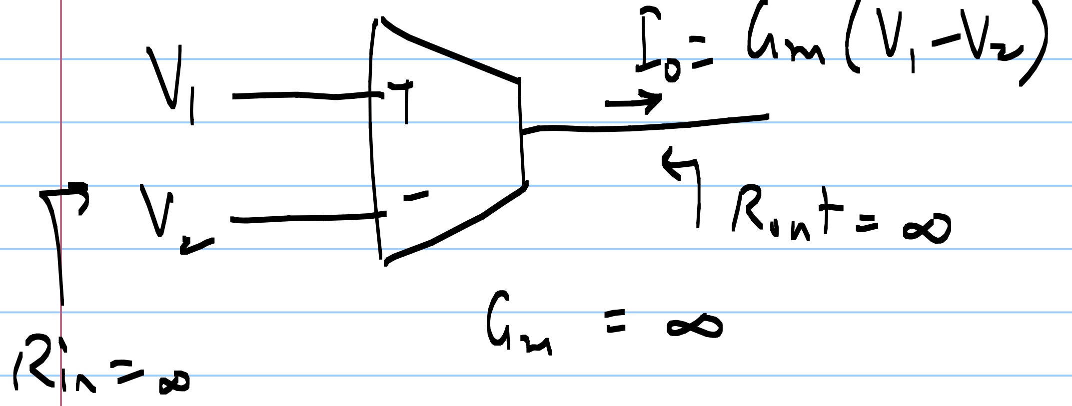
≡



OTA ≡ Operational Transconductance Amplifier



≡ ideal opamp



≡ ideal OTA

$$\text{gain} = \frac{V_o}{V_1 - V_2} = G_m R_{out} = \text{large}$$