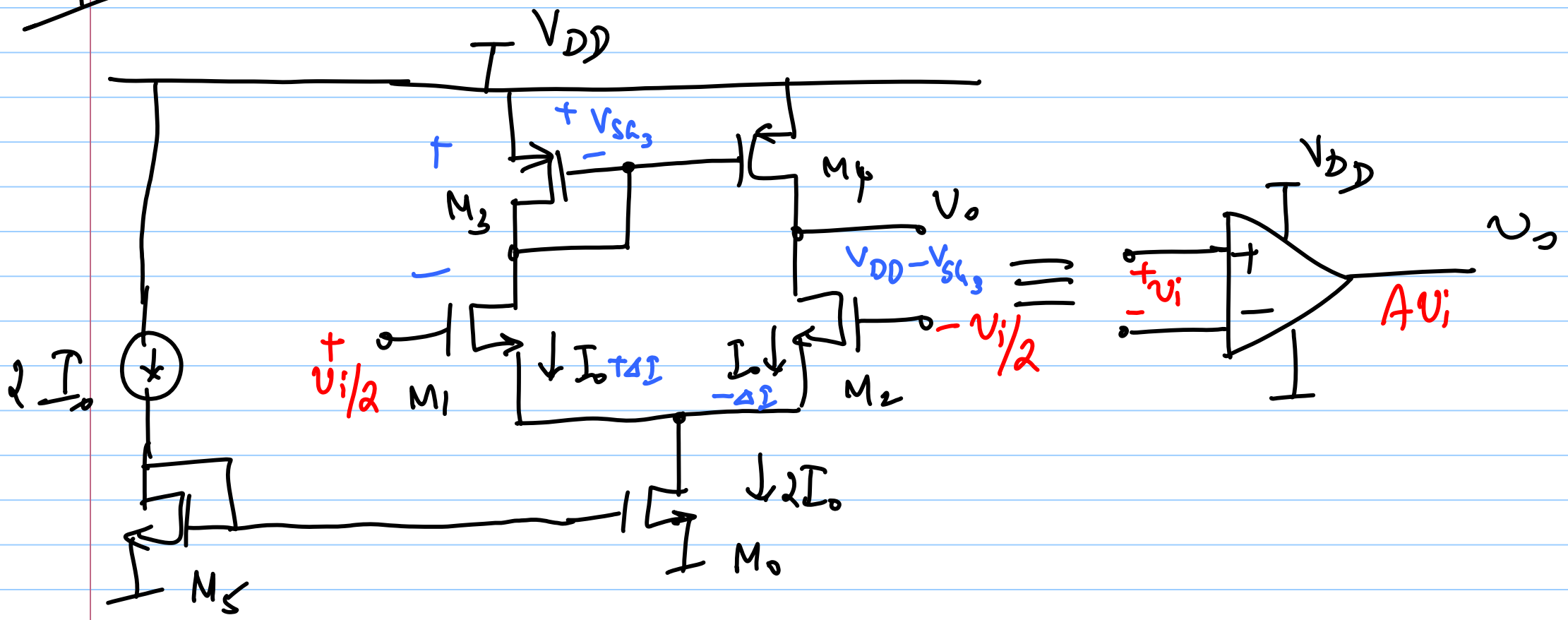
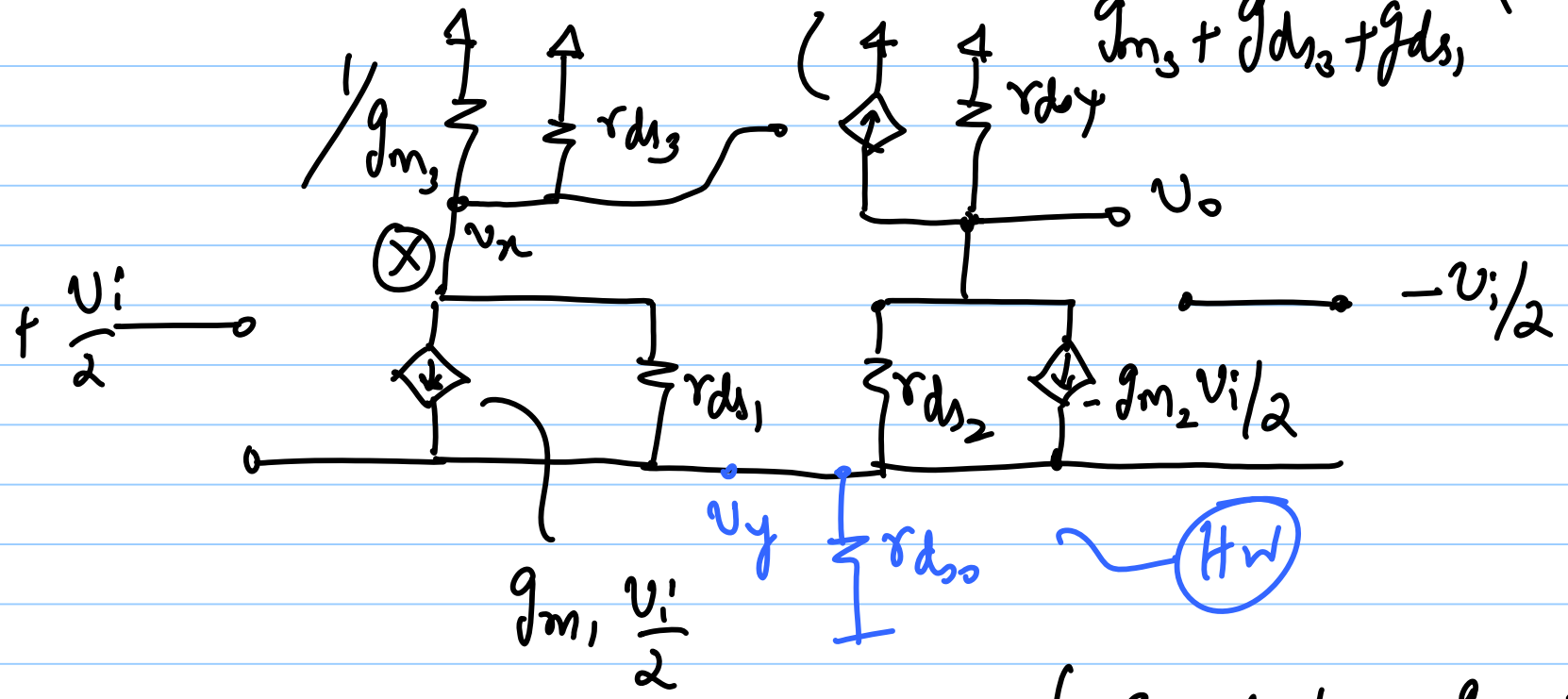
21/9/2019

Note Title 21-Sep-19

Lec 24

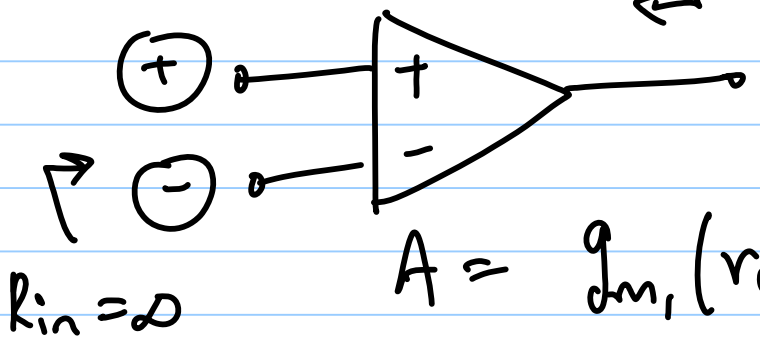




$$v_x = \frac{-g_{m1} \cdot (v_i/2)}{g_{m3} + g_{ds3} + g_{ds1}} \quad ; \quad v_o = \frac{\left(+g_{m2} v_i/2 - g_{m4} v_x\right)}{g_{ds2} + g_{ds4}}$$

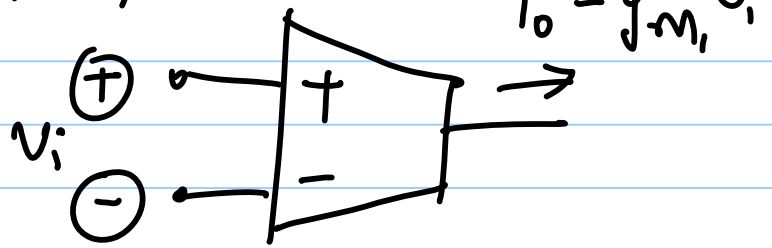
$$v_o = \frac{v_i}{2} \cdot \frac{1}{(g_{ds2} + g_{ds4})} \cdot \left\{ g_{m2} + \underbrace{\frac{g_{m4} \cdot g_{m1}}{g_{m3} + g_{ds3} + g_{ds1}}}_{\simeq 1} \right\}$$

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



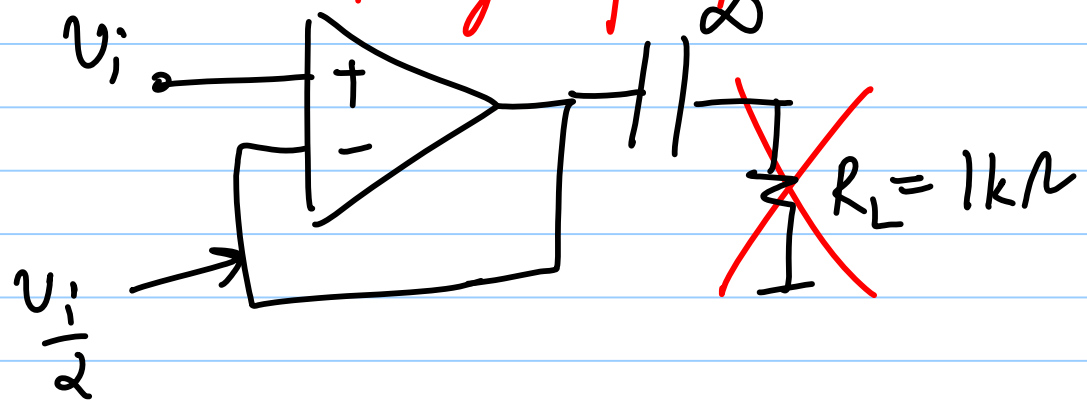
$R_o = r_{ds_2} \| r_{ds_4}$

$A = g_{m_1}\left(r_{ds_1} \| r_{ds_4}\right)$



OTA

1-stage opamp

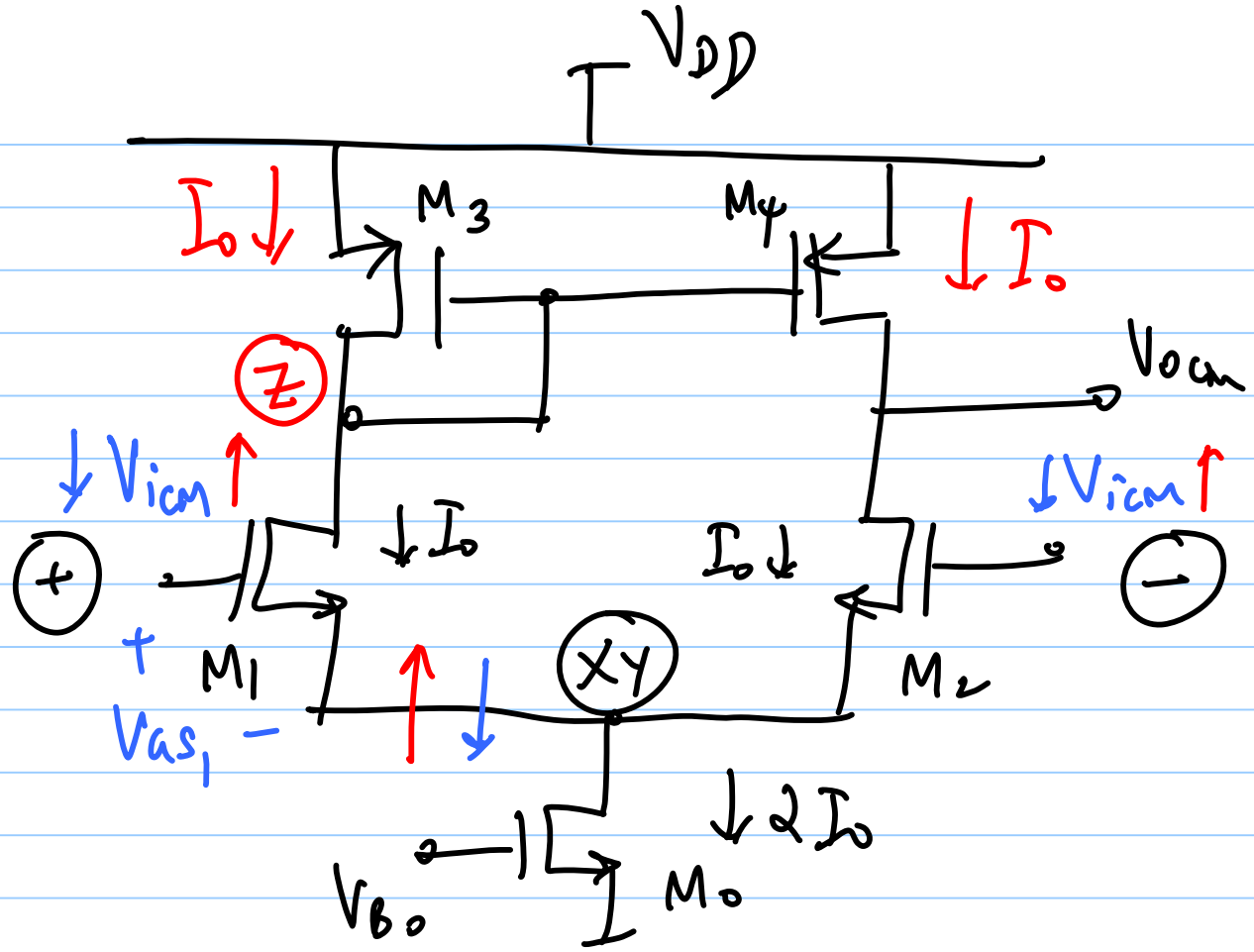


$r_{ds_2} \| r_{ds_4} = 100k\Omega$

$g_{m_1} = 1mS$

$A = 100$

$\hookrightarrow A \to 1$



@ $V_{XY} = V_{B_o} - V_{T_o}$,

M_o goes into triode

$V_{GS,2}$ — stays the same as long as M_0 is in sat.

V_{xy} — follows V_{ICM}

$V_{xy} = V_{ICM} - V_{GS_1}$

@ edge of M_0 triode:

$$\text{min. } V_{ICM} = |V_{GS_1}|_{I_0} + |V_{DSat_0}|_{2I_0}$$

$V_{DSat} = V_{GS} - V_T$

$$V_Z = V_{DD} - V_{SG_3}\Big|_{I_o}$$

as $V_{ICM} \uparrow \Rightarrow M_1$ goes closer to triode

$V_{ICM_{max}}$:

$$V_{DS} = V_{GS} - V_T$$

$$V_D - V_S = V_G - V_S - V_T$$

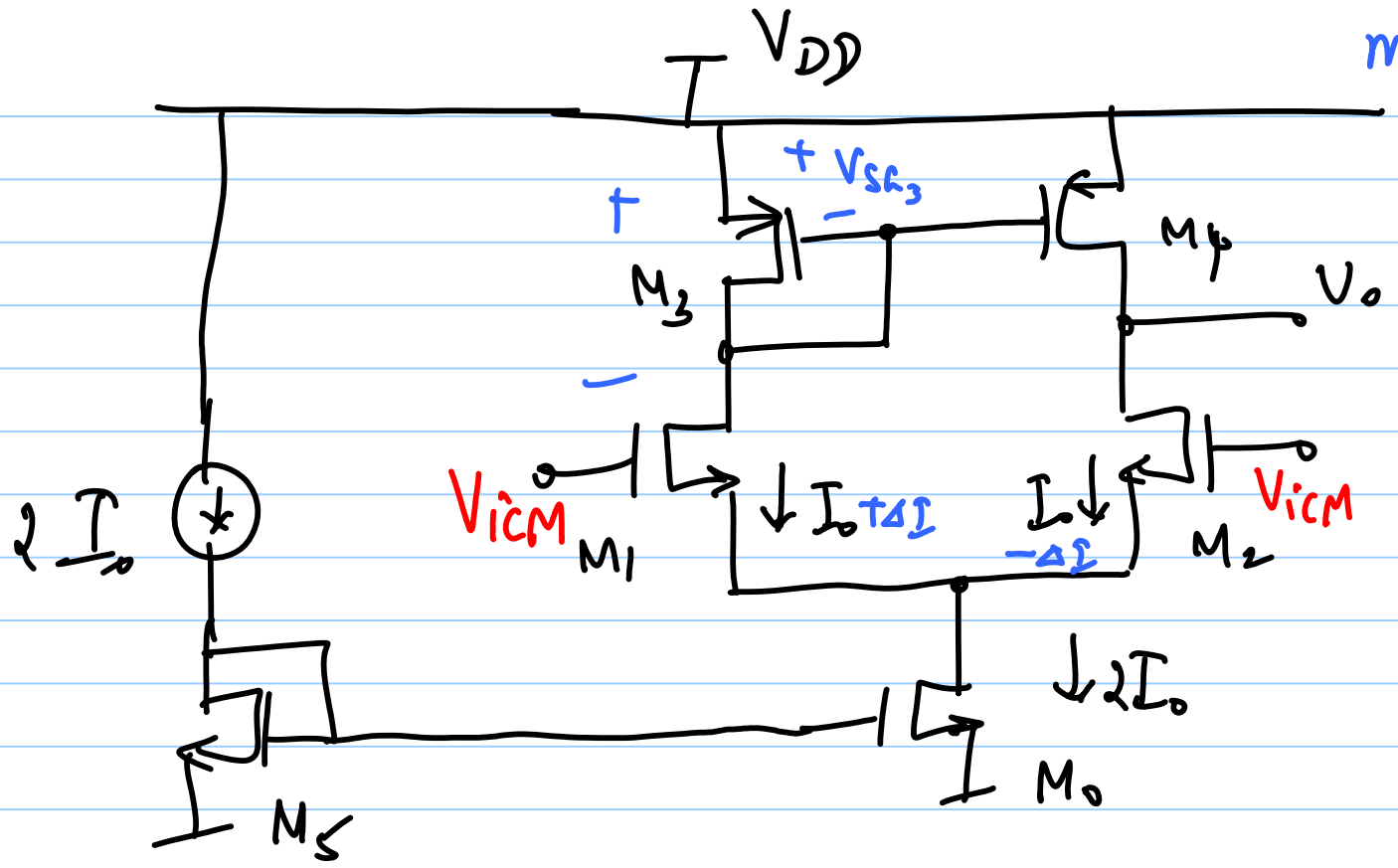
$$V_{D_1} = V_{G_1} - V_{T_1}$$

$$V_{DD} - V_{SG_3}\Big|_{I_o} = V_{ICM} - V_{T_1}$$

$$\max V_{ICM} = V_{DD} - V_{SG_3}\Big|_{I_o} + V_{T_1}$$

$$ICMR = \{V_{icm_{min}}, V_{icm_{max}}\}$$

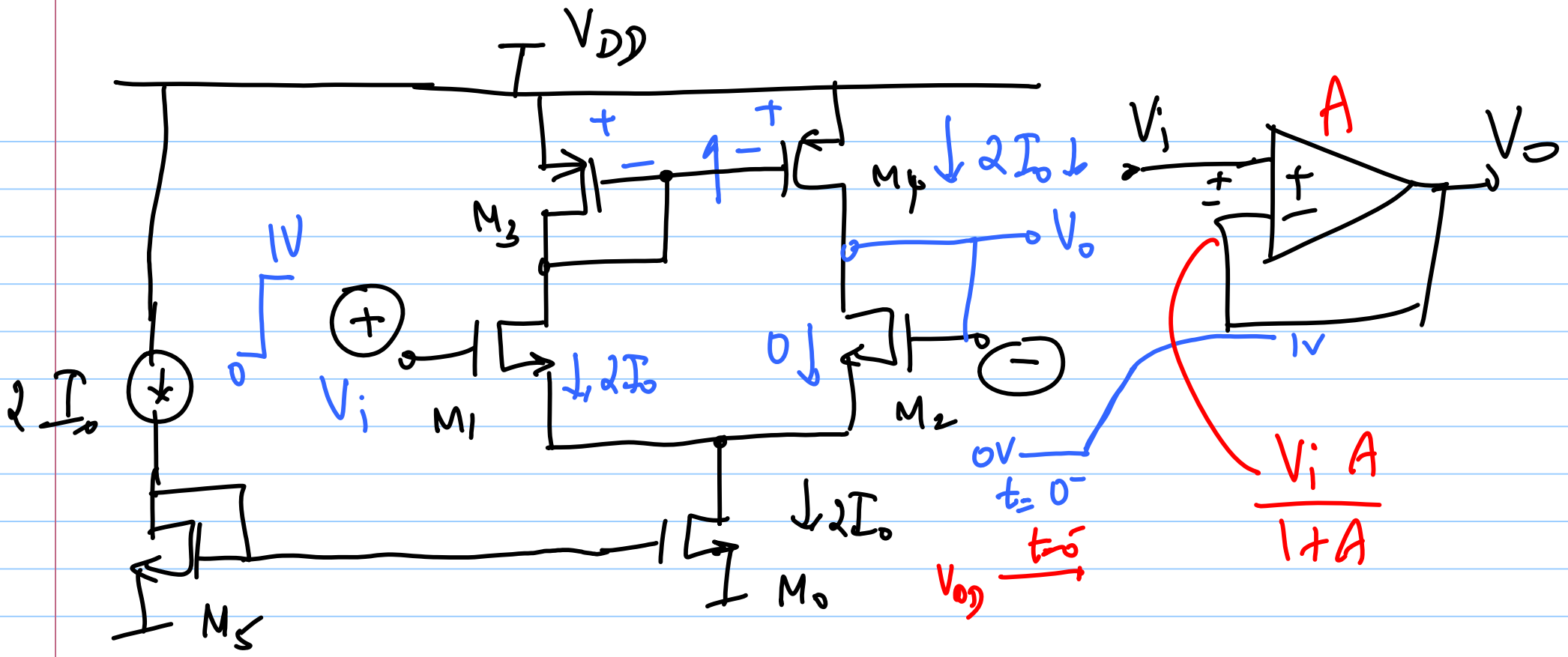
input common-mode range

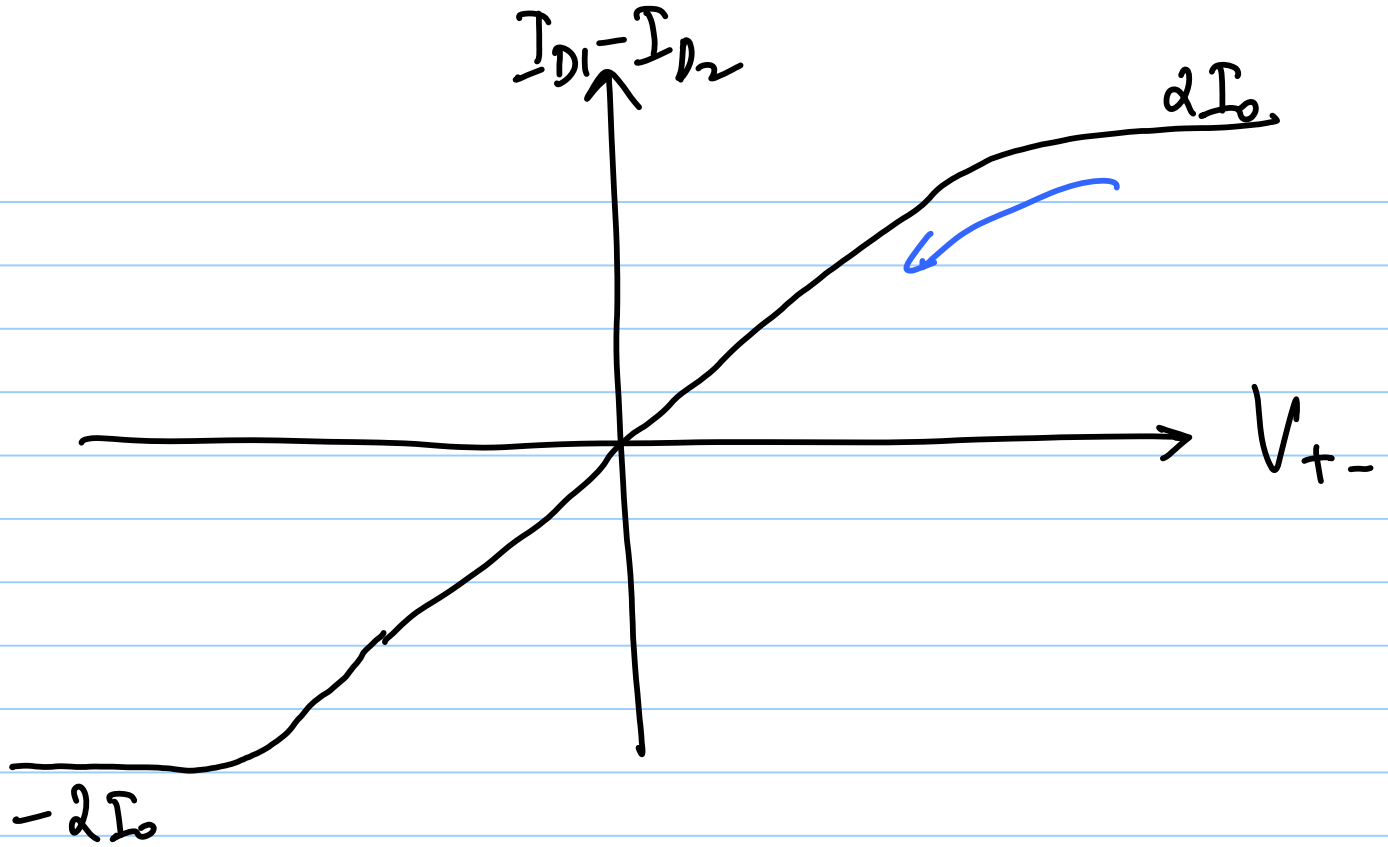


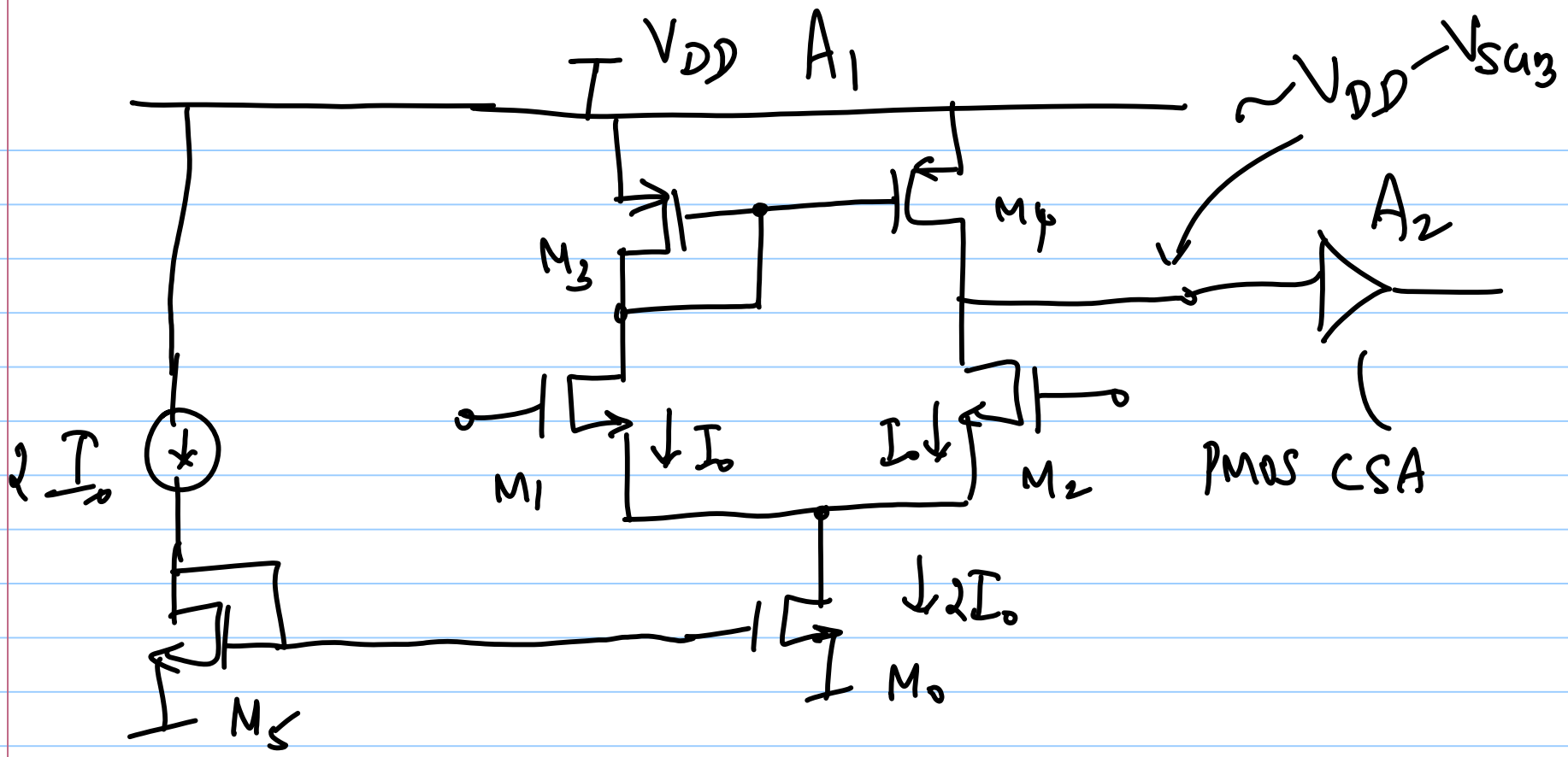
max $V_{OCM} = V_{DD} - V_{SG_4}$

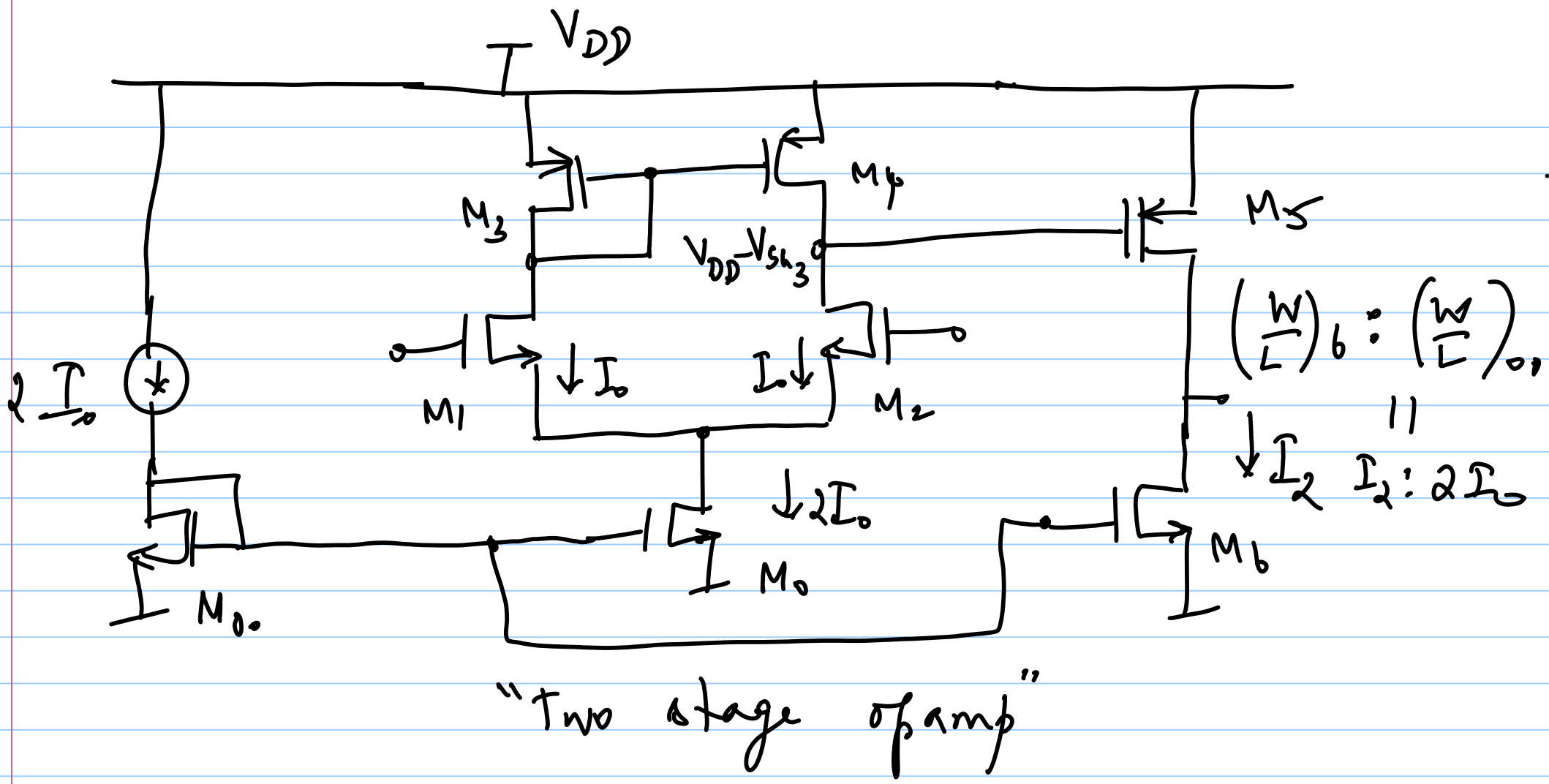
$+V_{T_4}$

min V_{OCM} $= V_{ICM} - V_{T_2}$


V_{DD}
M_3
M_4
$\downarrow 2I_0 \downarrow$
V_o
1V
0
$2I_0$
V_i
M_1
$\downarrow 2I_0$
0
M_2
$\downarrow 2I_0$
M_0
M_5
V_i
A
V_o
1V
0V
$t = 0^-$
$t=0$
V_{DD}
$\frac{V_i A}{1+A}$


$I_{D1} - I_{D2}$
$2I_o$
V_{+-}
$-2I_o$


V_{DD}
A_1
$\sim V_{DD} - V_{SG3}$
M_3
M_4
A_2
$2I_o$
I_o
I_o
M_1
M_2
PMOS CSA
$2I_o$
M_0
M_5



"Two stage opamp"

$$V_{DD} - V_{SG_3}\Big|_{I_1} \equiv V_{DD} - V_{SG_5}\Big|_{I_2}$$

$$V_{SG_3}\Big|_{I_0} = V_{SG_5}\Big|_{I_2}$$

$$\boxed{\frac{I_0}{(W/L)_3} = \frac{I_2}{(W/L)_5}}$$

M_3, M_4, M_5 have same "current densities"