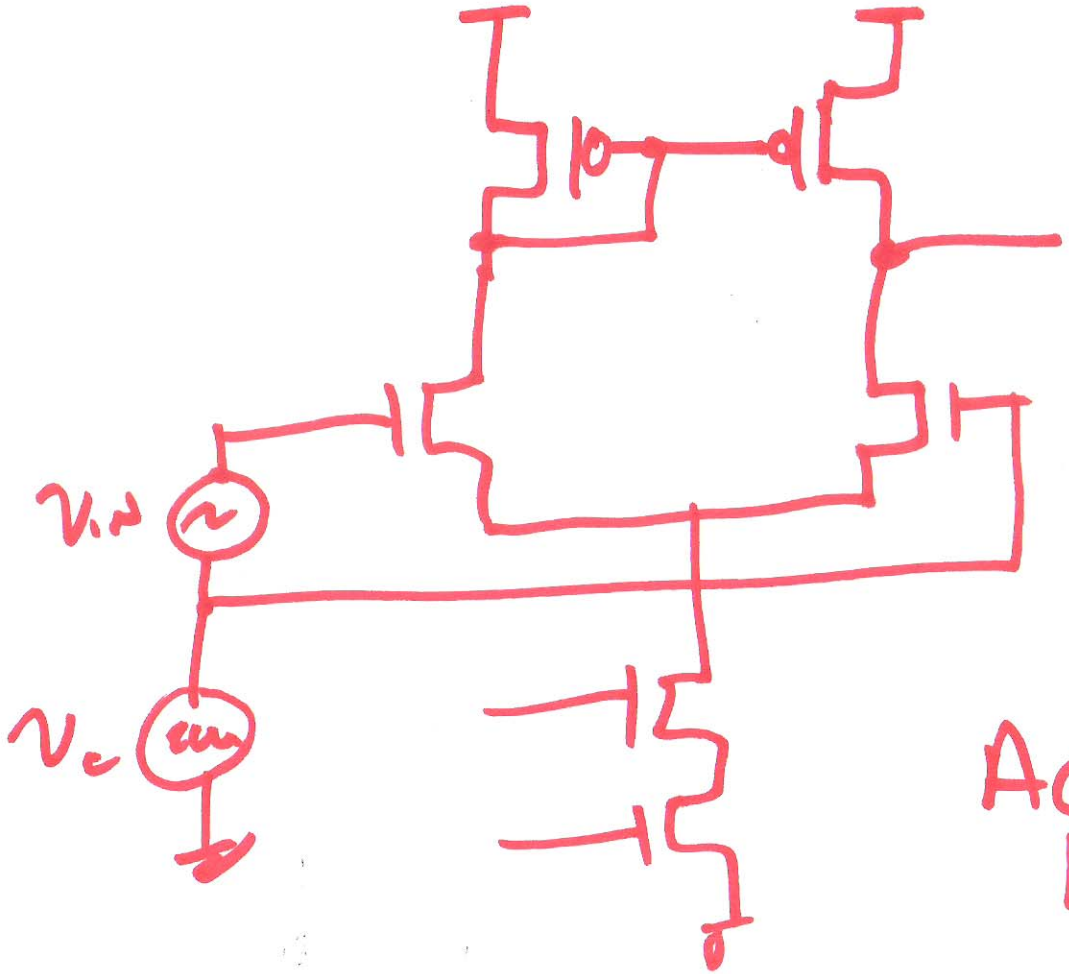
Sec. 22.1.3 CMRR



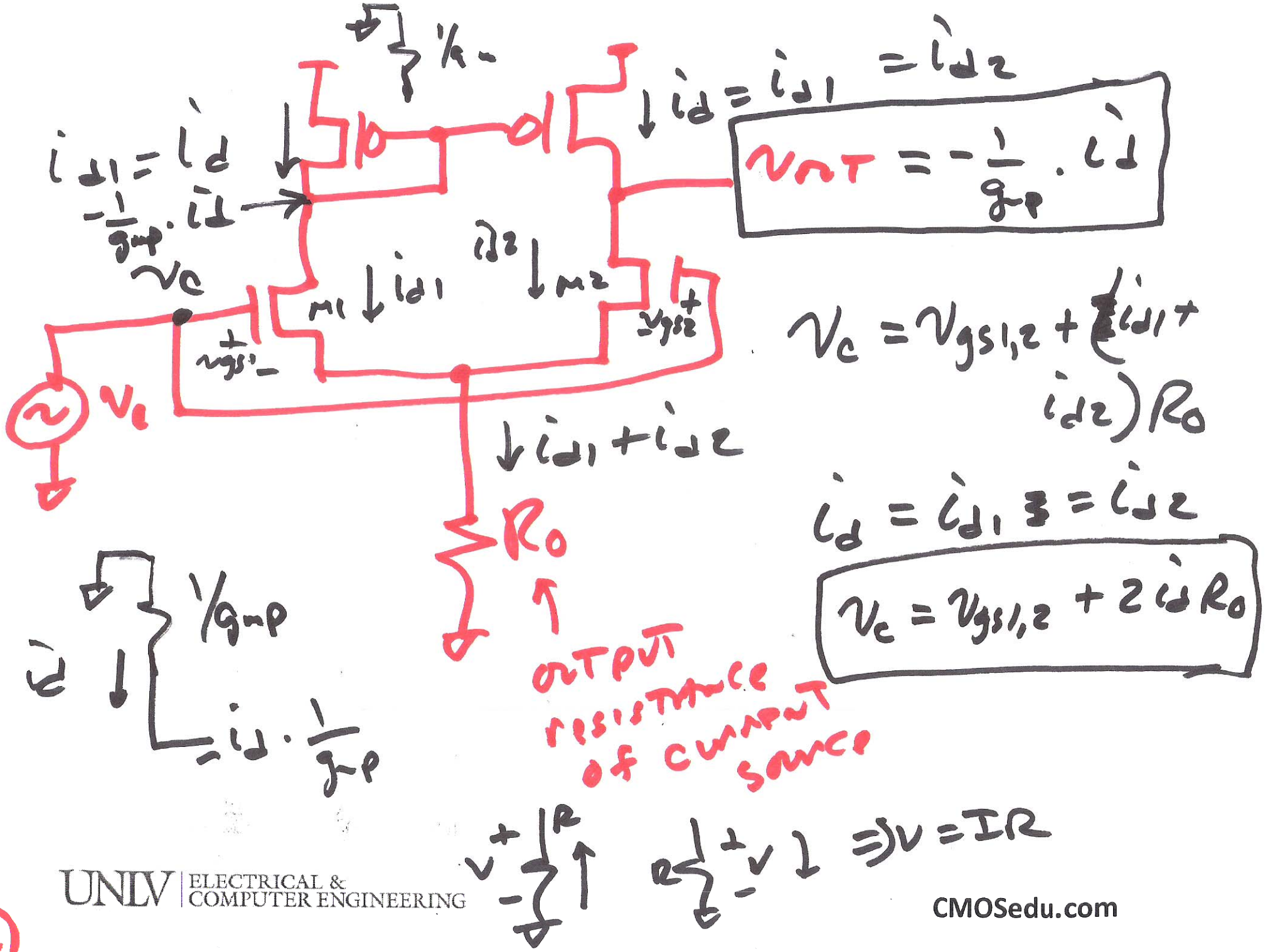
$v_{out} = A_d$

$\frac{v_{out}}{v_{in}} = g_m (r_{o1} \| r_{op})$

ideally

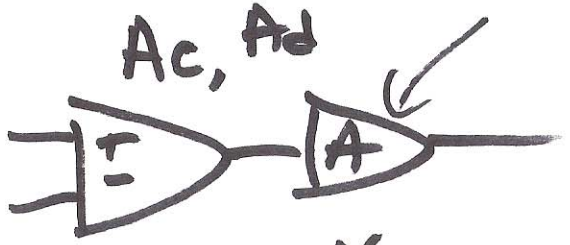
$A_C = \frac{v_{out}}{v_c} = 0$

↖ common-mode gain


∞
$i_{d1} = i_d$
$-\frac{1}{g_{mp}} \cdot i_d$
v_c
v_i
M1
M2
i_{d1}
i_{d2}
v_{gs1}
v_{gs2}
$i_d = i_{d1} = i_{d2}$
$v_{out} = -\frac{1}{g_{mp}} \cdot i_d$
$i_{d1} + i_{d2}$
R_o
OUTPUT RESISTANCE OF CURRENT SOURCE
$v_c = v_{gs1,2} + (i_{d1} + i_{d2}) R_o$
$i_d = i_{d1,3} = i_{d2}$
$v_c = v_{gs1,2} + 2 i_d R_o$
i_d
∞
$1/g_{mp}$
$-i_d \cdot \frac{1}{g_{mp}}$
$v = IR$

$$|A_c| = \left|\frac{v_{out}}{v_c}\right| = \frac{\frac{1}{g_{mp}} \cdot i_d}{v_{gs1,2} + 2 i_d R_o}$$

$$v_{gs} = \frac{i_c}{g_{mN}}$$

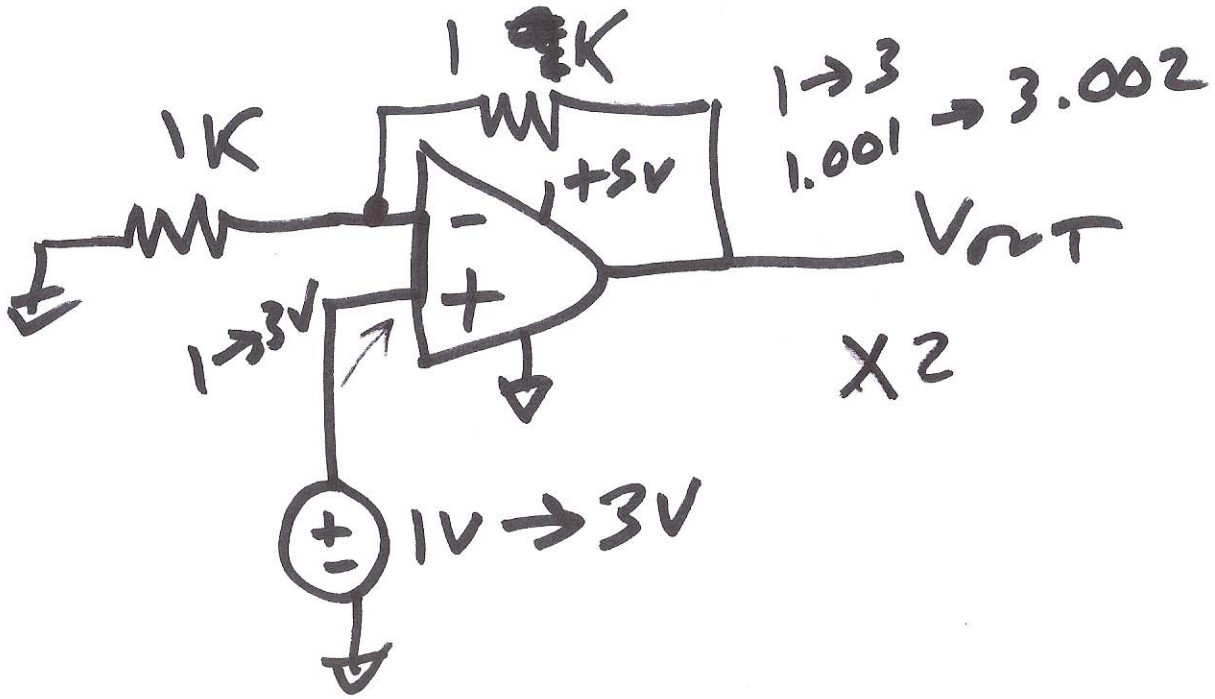


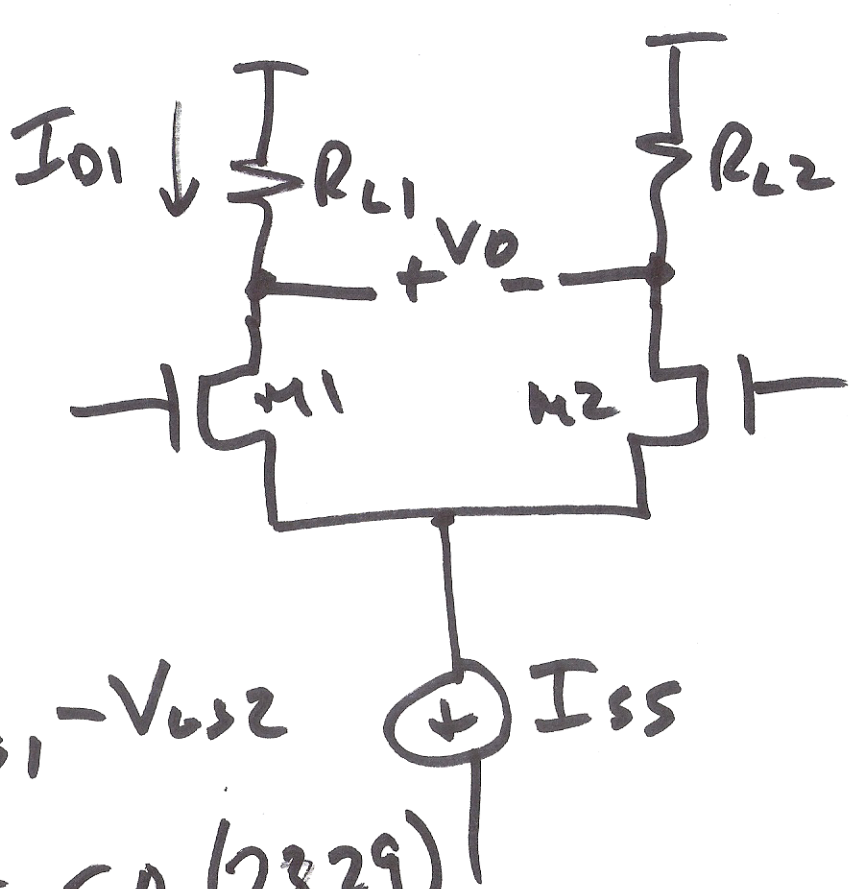
$$\frac{A_d \cdot \cancel{A}}{A_c \cdot \cancel{A}}$$

$$|A_c| = \frac{\frac{1}{g_{mp}}}{\frac{1}{g_{mN}} + 2R_o} \approx \frac{1}{2 g_{mp} \cdot R_o}$$

$$CMRR = 20 \log \frac{A_d}{A_c}$$

$$= 20 \log g_{mN} \frac{r_{ds} \| r_{dsp}}{\frac{1}{2 g_{mp} R_o}}$$


1K
1K
+5V
1→3
1.001→3.002
V_{OUT}
X2
1→3V
1V→3V



$$\Delta R_L = R_{L1} - R_{L2}$$

$$R_L = \frac{R_{L1} + R_{L2}}{2}$$

$$\Delta V_{THN} = V_{THN1} - V_{THN2}$$

$$V_{THN} = \frac{V_{THN1} + V_{THN2}}{2}$$

$$\Delta \frac{W}{L} = \frac{W}{L}_1 - \frac{W}{L}_2$$

$$\frac{W}{L} = \frac{\frac{W}{L}_1 + \frac{W}{L}_2}{2}$$

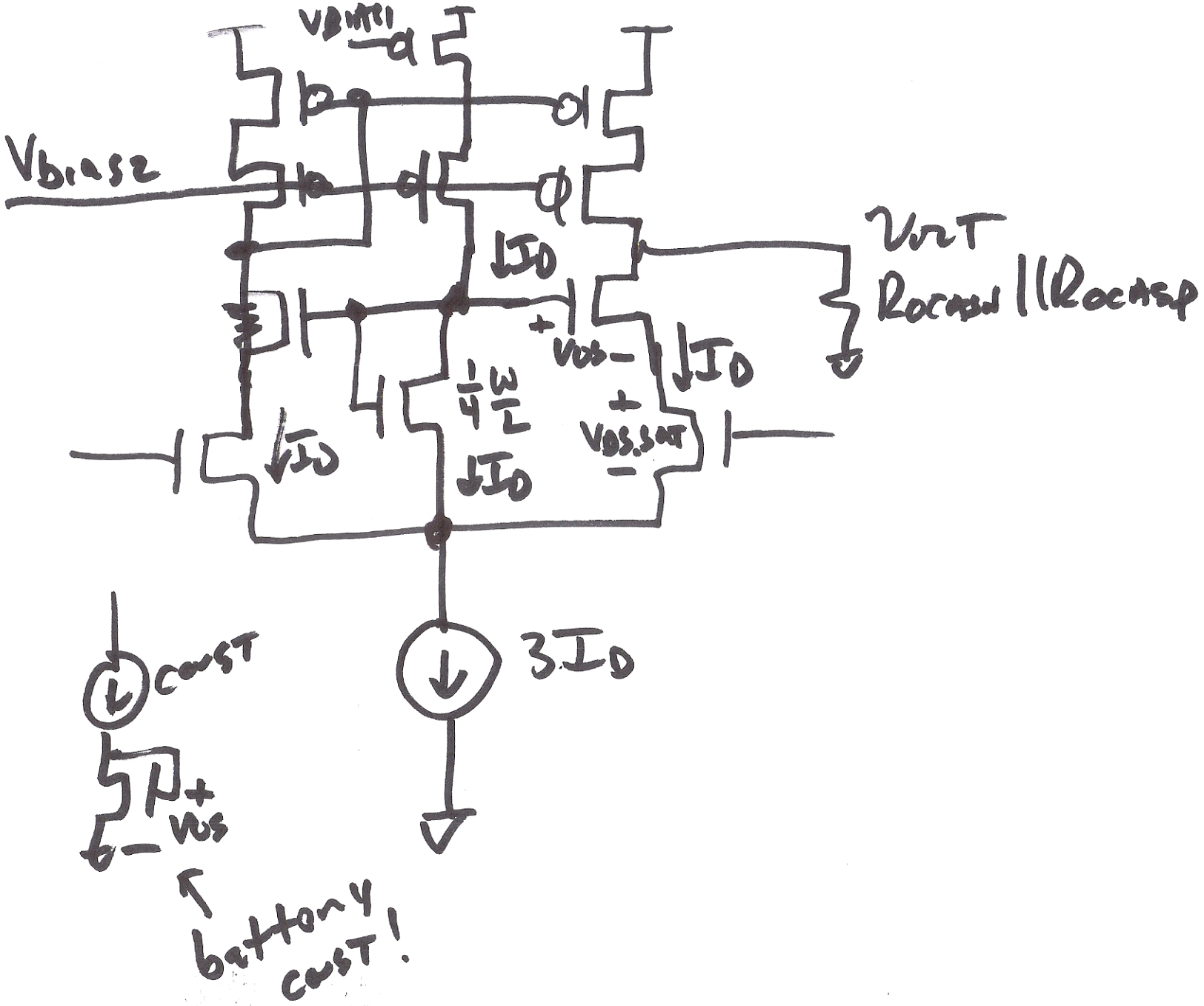
$$V_{OS} = V_{GS1} - V_{GS2}$$

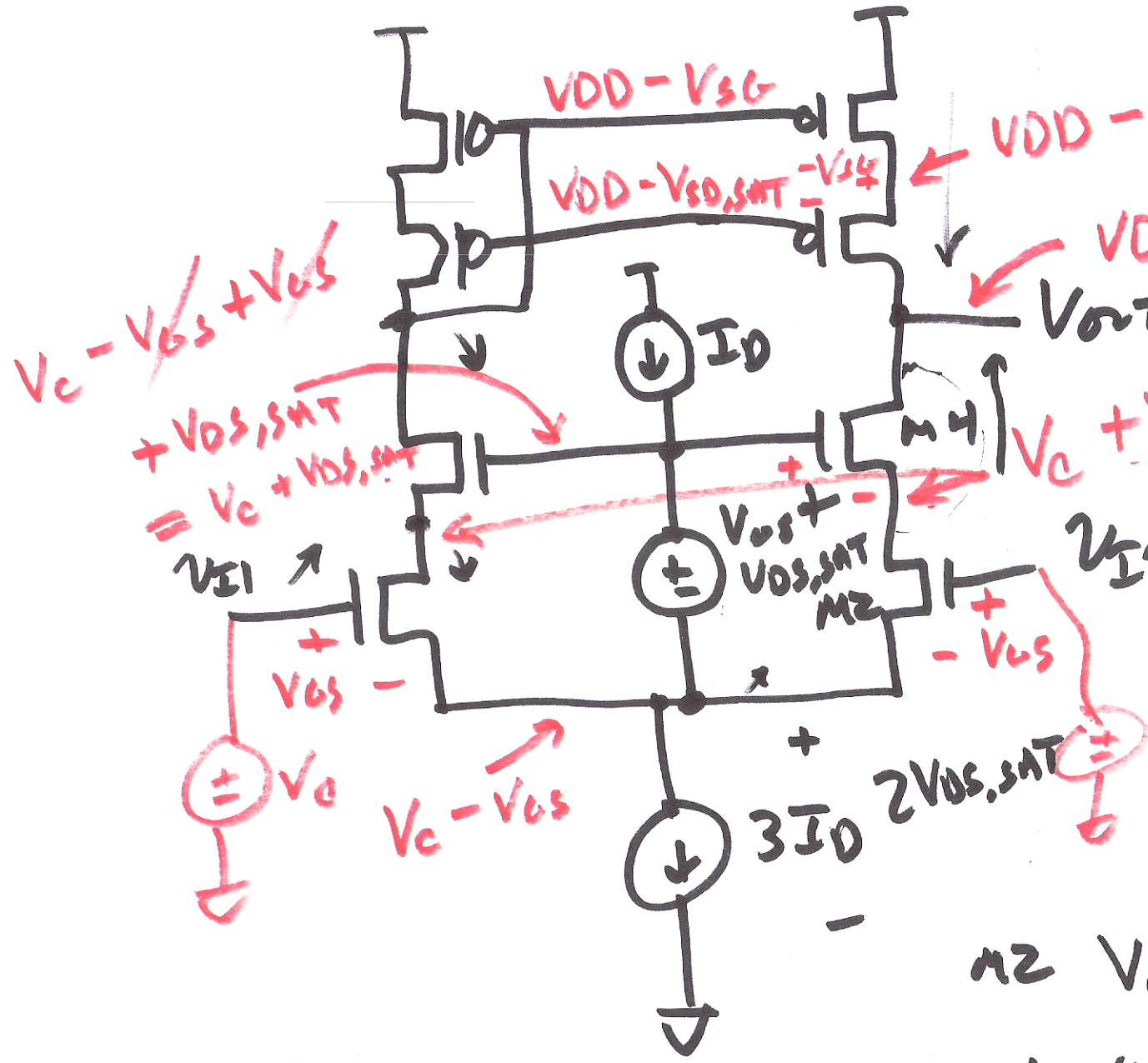
GET EQ. (28.29)

$$V_O = V_{DD} - I_{D1} \cdot R_{L1} - \left(V_{DD} - I_{D2} R_{L2}\right)$$

$$I_{D1} = \frac{KP_N}{2} \frac{W}{L}_1 \left(V_{GS1} - V_{THN1}\right)^2$$

$$I_{D2} = \frac{KP_N}{2} \frac{W}{L}_2 \left(V_{GS2} - V_{THN2}\right)$$


Vbias1
Vbias2
ID
VOUT
ROUT||RLOAD
+
VDS
−
ID
1/4 W/L
4ID
+
VDS,SAT
−
ID
3ID
IConst
+
VDS
−
battery cost!



Input CM R

neg. $V_{GS} + 2V_{DS,SAT}$

pos. input CM R

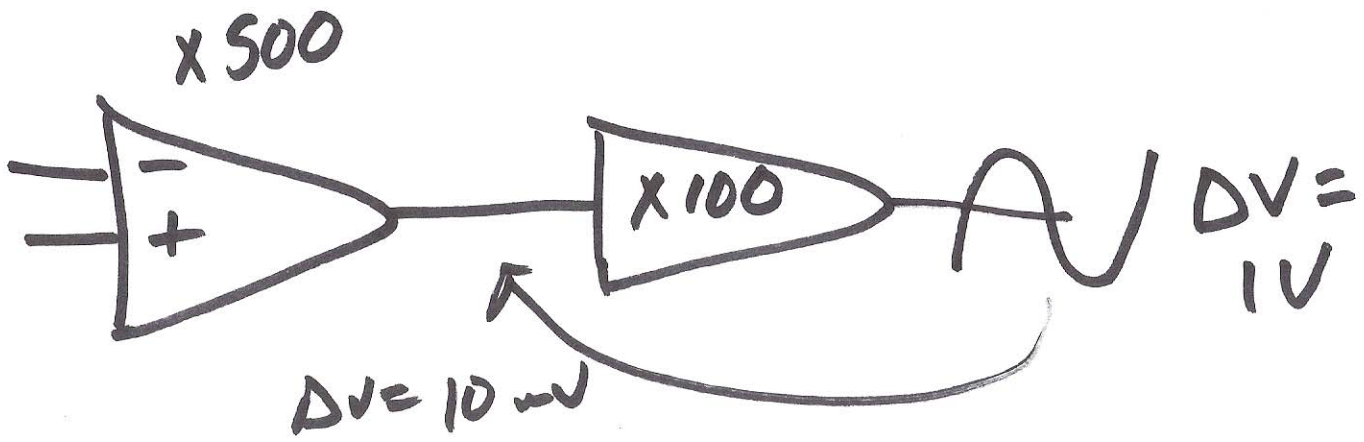
$V_D > V_G - V_{THN}$

M2 $V_C - V_{THN} \geq V_C - V_{THN}$ OK!

M4 $V_{DD} - V_{SG} > V_C - V_{THN} - V_{THN}$

$V_C < V_{DD} - V_{SG} + 2V_{THN}$

$V_C < 4.65$

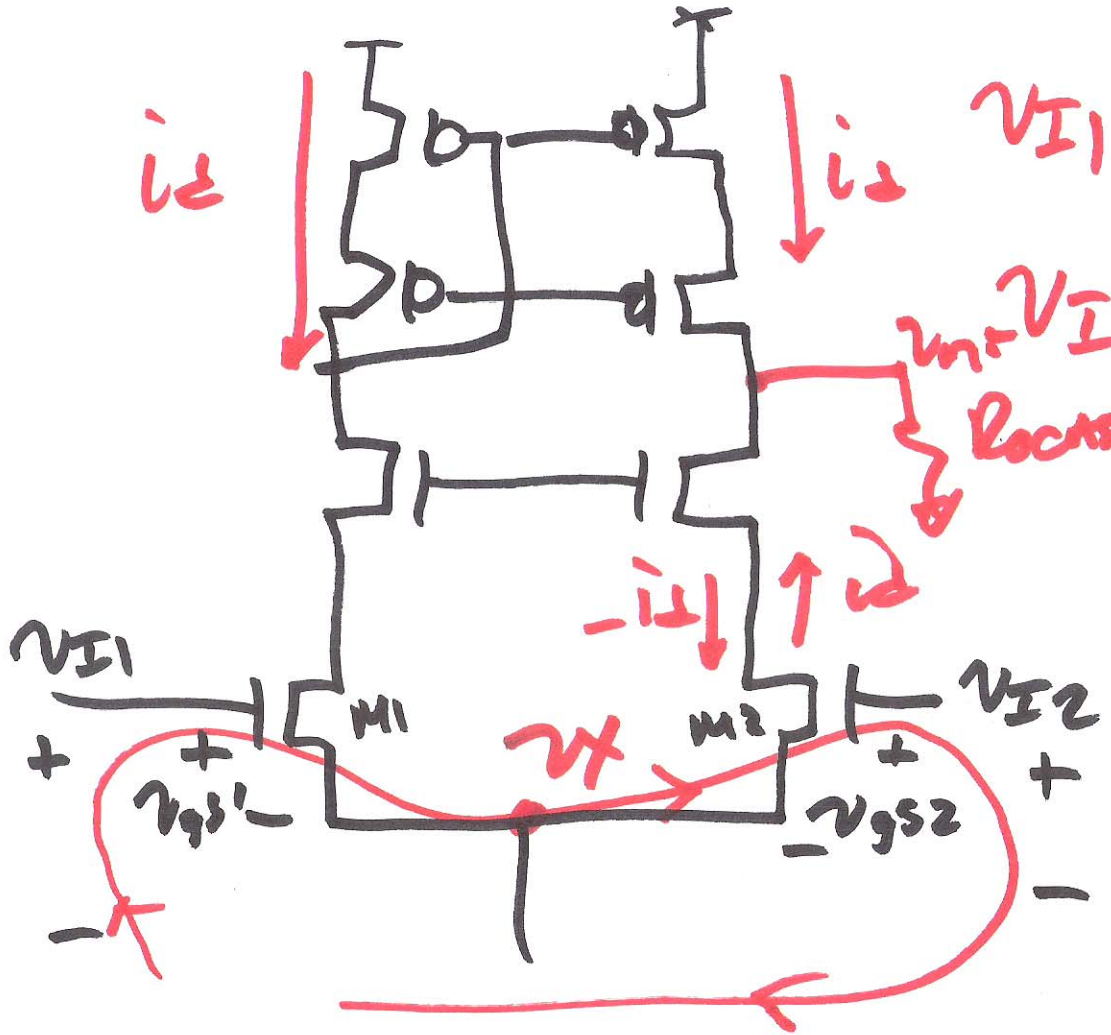


output max

$V_{DD} - 2V_{SD,SAT}$

output min

$V_c - V_{THN} + V_{DS,SAT}$



$$v_{I1} - v_{gs1} + v_{gs2} - v_{I2} = 0$$

$$v_{gs1} - v_{gs2} = v_{I1} - v_{I2}$$

$$R_{OCASCN} \| R_{OCASCP} = \frac{i_{d1}}{g_{m1}} - \frac{i_{d2}}{g_{m2}}$$

$$i_{d1} = -i_{d2} = i_d$$

$$v_{I1} - v_{I2} = \frac{2}{g_m} \cdot i_d$$

$$i_d = \frac{g_m}{2}\left(v_{I1} - v_{I2}\right)$$

$$v_{OUT} = 2 i_d \cdot R_{OCASCN} \| R_{OCASCP}$$

$$v_{OUT}/v_{IN} = g_m R_{OCASCN} \| R_{OCASCP}$$

$v_{I1} = 1\,mV$

$v_{I2} = 0$

$v_x = \frac{1}{2}\,mV$

$v_{gs1} = \frac{1}{2}\,mV$

$v_{gs2} = \frac{-1}{2}\,mV$