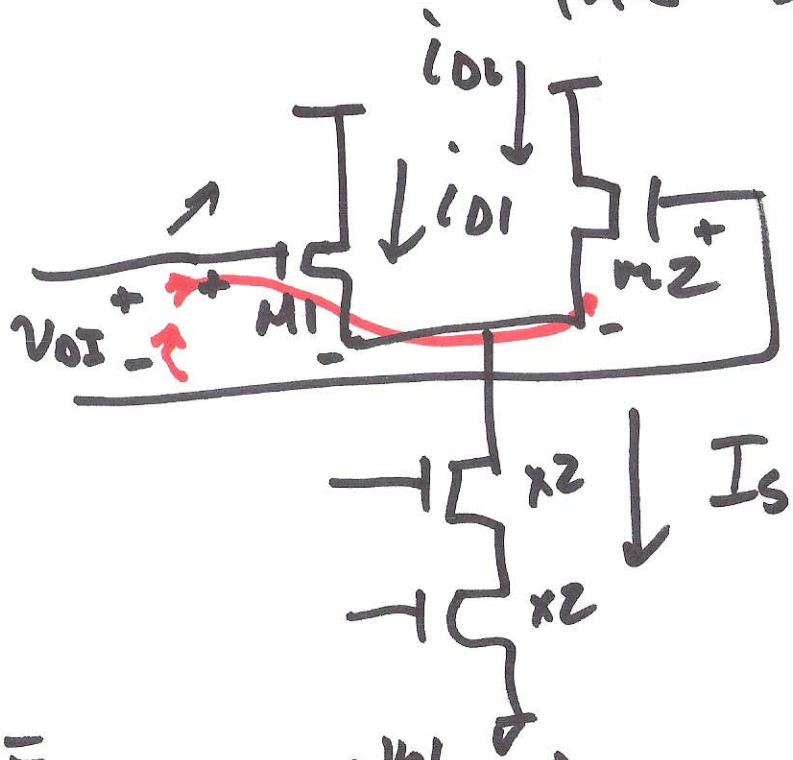
Sec. 22.1

Diff-Amps

the Source-coupled pair



$$v_{OI} = v_{GS1} - v_{GS2}$$

$$= \sqrt{\frac{2i_{D1}}{\beta_N}} + V_{TH} - \sqrt{\frac{2i_{D2}}{\beta_N}} - V_{TH}$$

$$I_{SS} = i_{D1} + i_{D2}$$

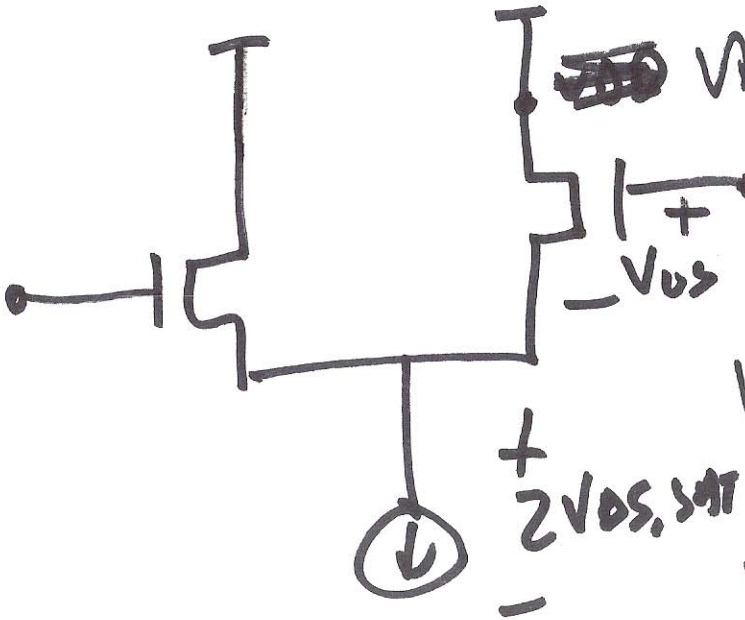
$$I_{D1} + i_{d1}$$

$$\sqrt{i_D} = \sqrt{\frac{\beta_N}{2}}\left(\underbrace{V_{GS} - V_{TH}}_{v_{GS}}\right)$$

$$v_{OI} = \sqrt{\frac{2}{\beta_N}}\left(\sqrt{i_{D1}} - \sqrt{i_{D2}}\right)$$

$$v_{OI,MAX} = ? \sqrt{\frac{2I_{SS}}{\beta_N}}$$

MAX CMR



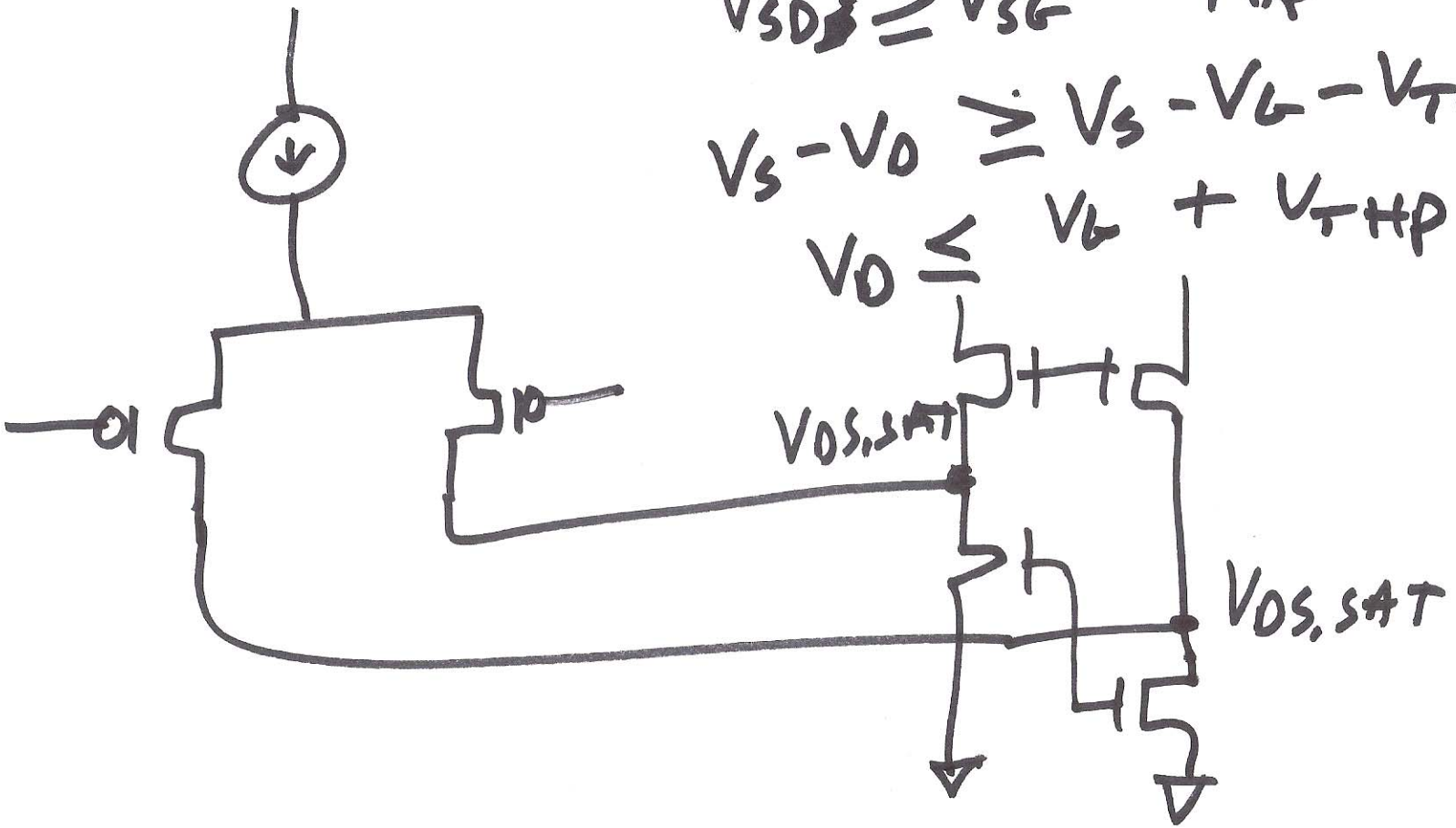
$$V_{DS} \geq V_{GS} - V_{THN}$$

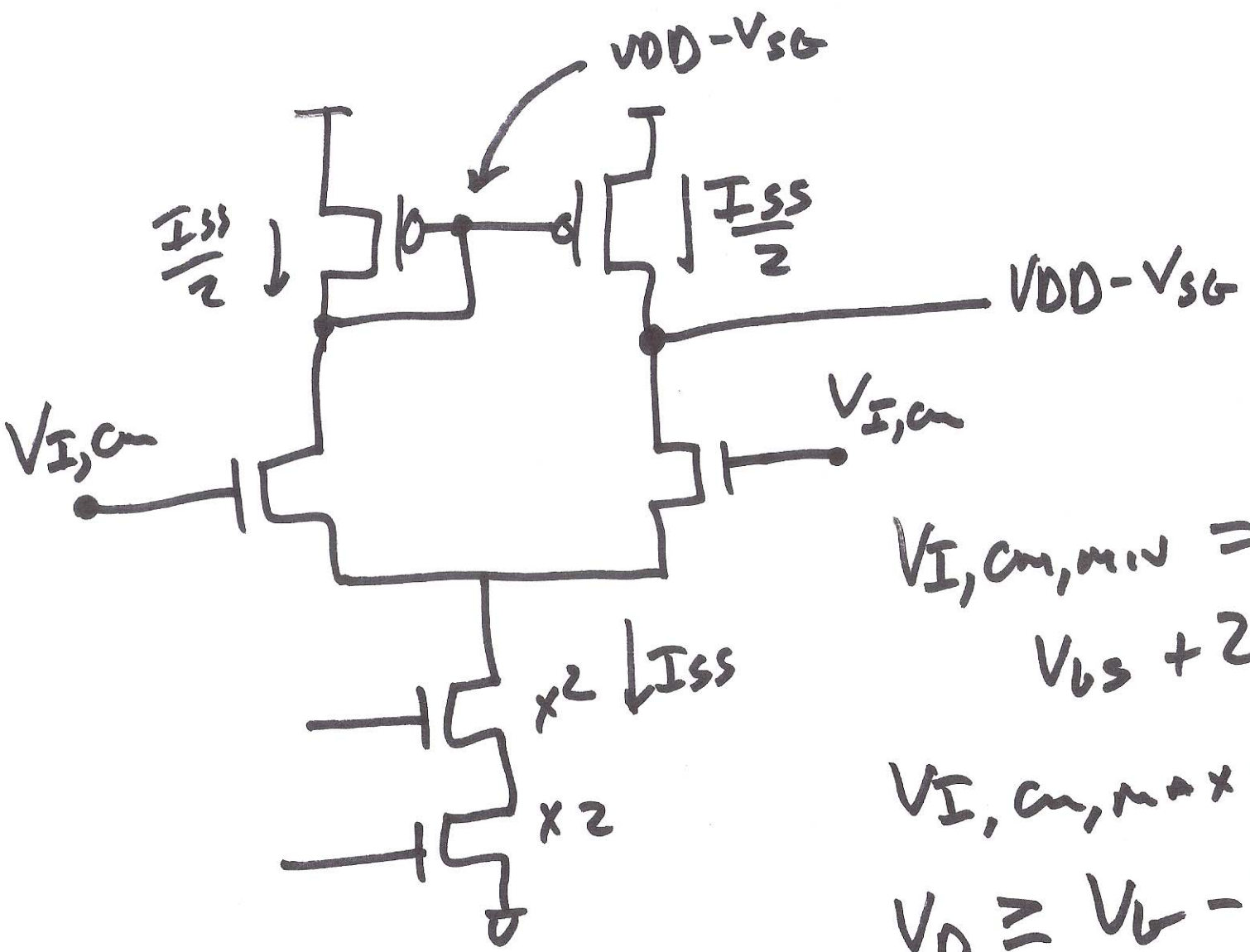
$$V_D \geq V_G - V_{THN}$$

$$V_{DD} \geq V_{CM,IMAX} - V_{THN}$$

$$V_{CM,IMAX} \leq V_{DD} + V_{THN}$$

$$V_{CM,IMAX} \leq V_{DD} - V_{SD,SAT} + V_{THN}$$


$V_{SD3} \geq V_{SG} - V_{THP}$
$V_S - V_D \geq V_S - V_G - V_{THP}$
$V_D \leq V_G + V_{THP}$
01
10
$V_{DS,SAT}$
$V_{DS,SAT}$
$V_{DS,SAT} \leq V_{ICM,MIN} + V_{THP}$
$V_{ICM,MIN} \geq V_{DS,SAT} - V_{THP}$



$V_{I,cm,min} = V_{GS} + 2V_{OS,SAT}$

$V_{I,cm,max} \rightarrow$

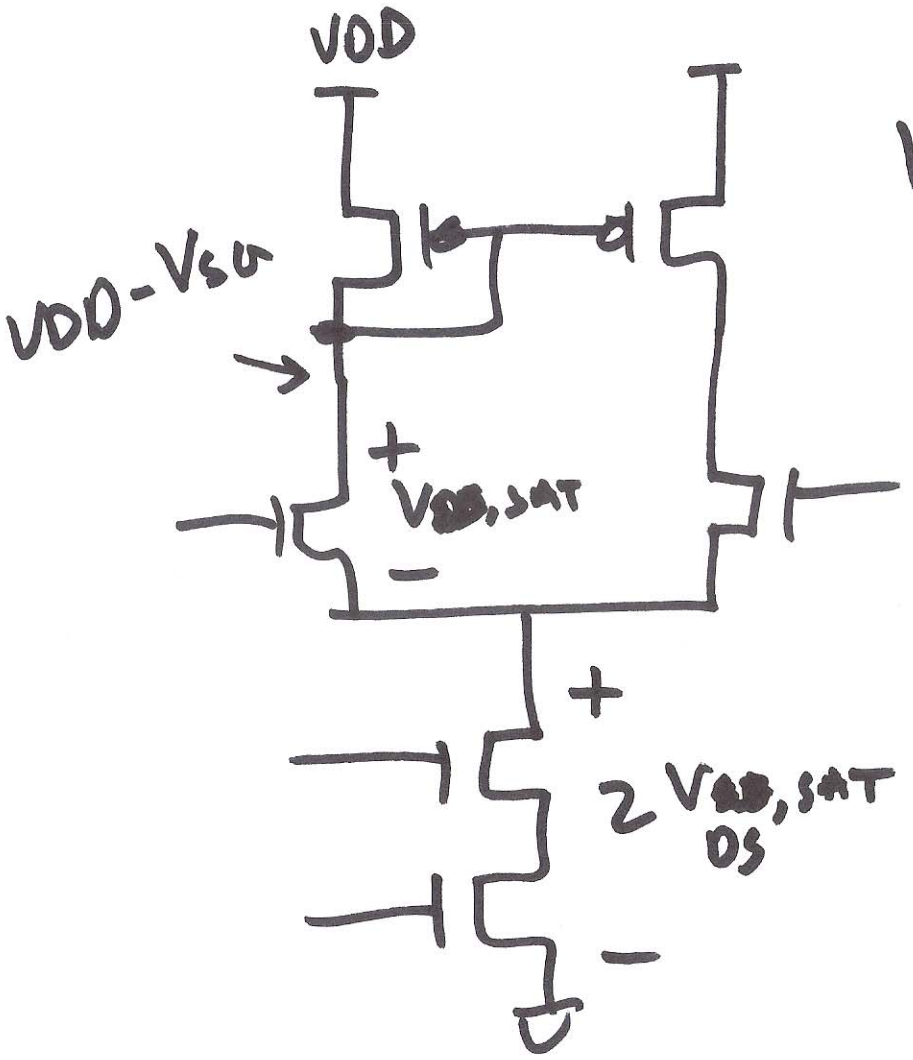
$V_D \geq V_G - V_{THN}$

$V_{Icmmax} \leq VDD - V_{SG} + V_{THP}$

$VDD - V_{SG} \geq V_{I,cm,max} - V_{THN}$

$= VDD - V_{SD,SAT} - V_{THN} + V_{THP}$

Main Supply Voltage

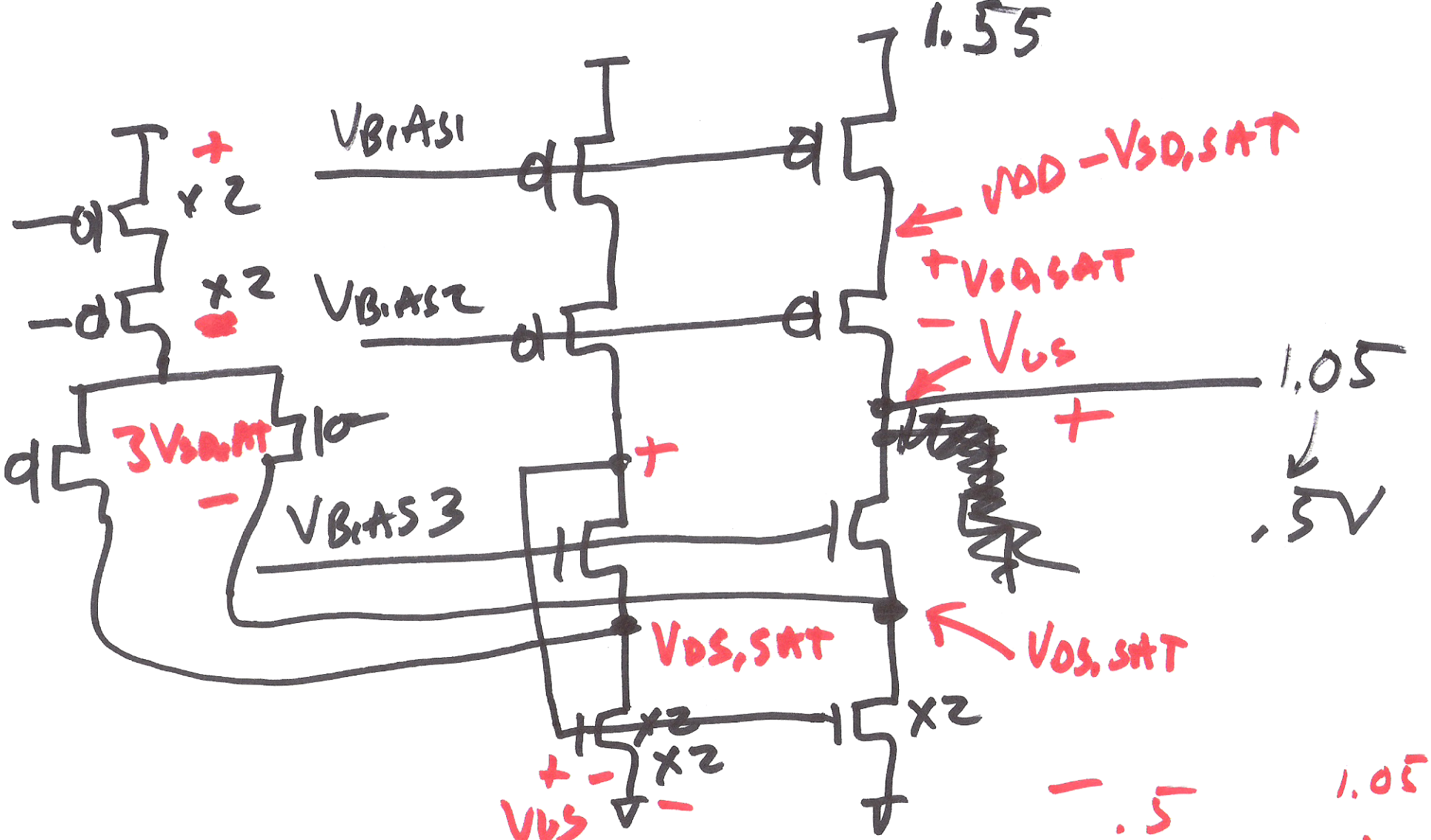


$VDD_{MN} = V_{SG}$

$+ 3\, V_{DS,SAT}$

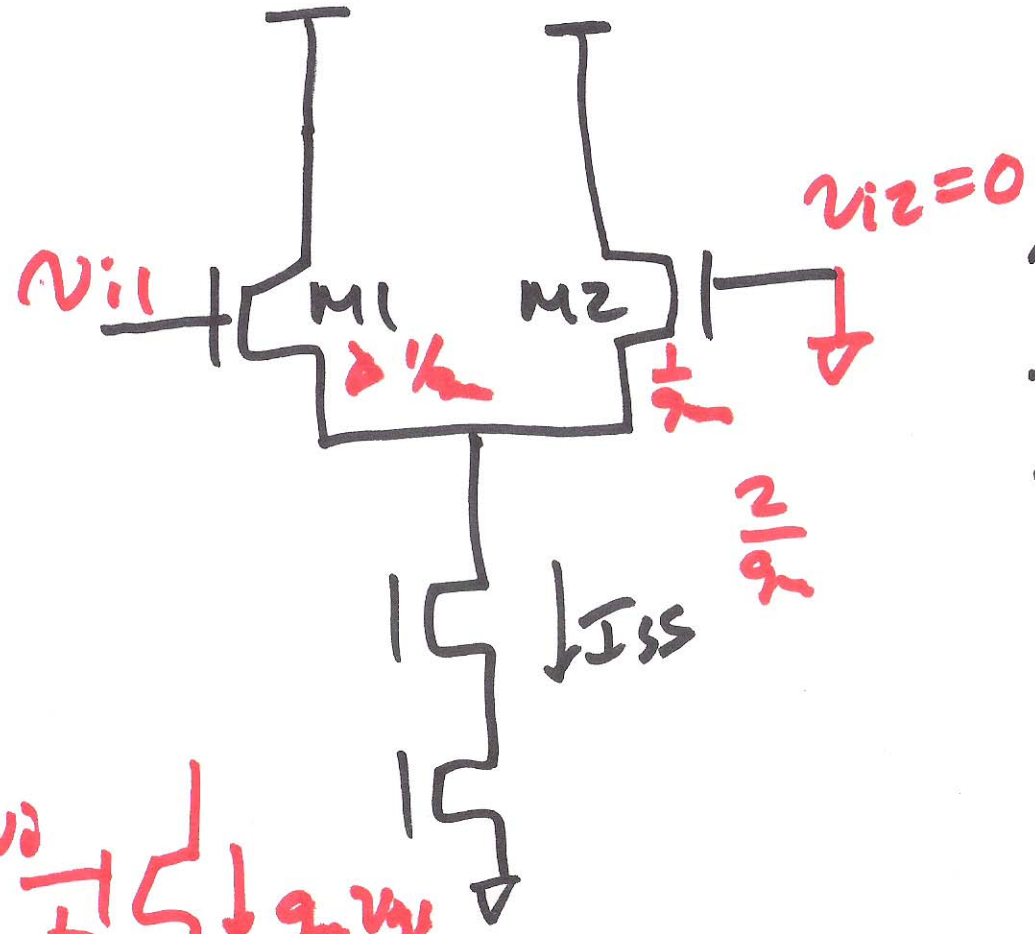
$1.15 + .75$

$1.9V$

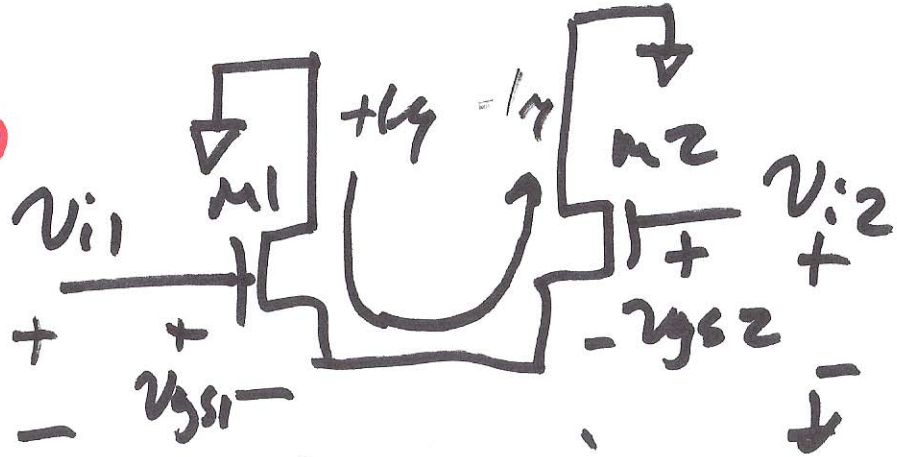


$$\rightarrow V_{DD_{min}} = 2V_{SD,SAT} + V_{GS}$$

$$= 1.55$$



AC CKT



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

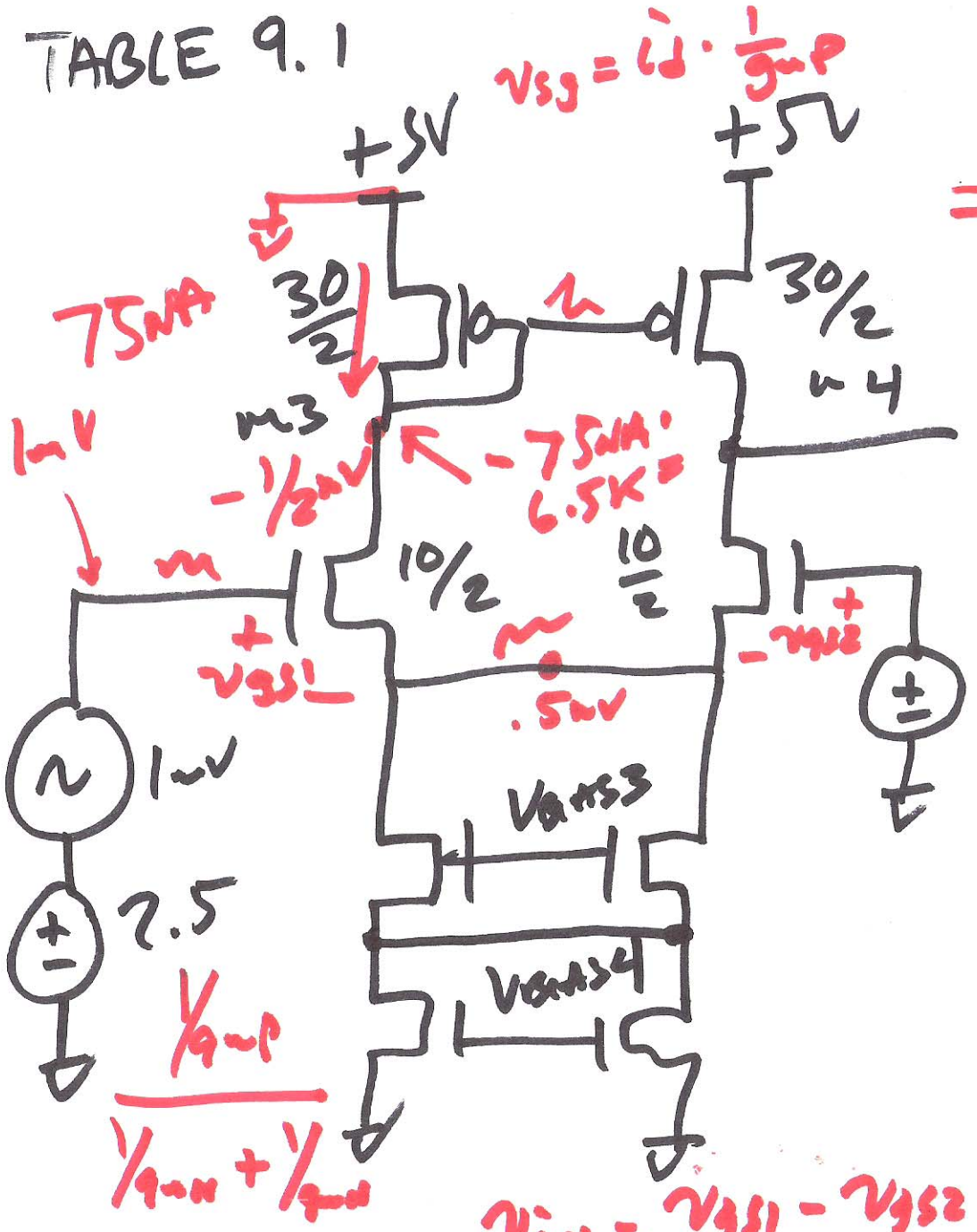
$$v_{i1} - v_{gs1} + v_{gs2} - v_{i2} = 0$$

$$v_{di} = v_{i1} - v_{i2} = v_{gs1} - v_{gs2}$$

$$i_{d1} = \frac{g_m}{2} \cdot v_{di} = \left(\frac{i_{d1}}{g_m} - \frac{i_{d2}}{g_m}\right)$$

$$i_{d1} = \frac{g_m}{2} \cdot v_{i1}$$

TABLE 9.1



$v_{SG} = i_D \cdot \frac{1}{g_{mP}}$

$r_{op} = 54\,M\Omega$

$r_{ON} = 5\,M\Omega$

$r_{op} \| r_{ON} = 2.22$

$g_{mN} = 150\,\mu A/V$

$\frac{1}{g_{mP}} = \frac{1}{150\,\frac{\mu A}{V}} = 6.5K$

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

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

$i_{D1} = -i_{D2} = 150\,\mu A/V \cdot \frac{1}{2}\,V = 75\,\mu A$

$v_{IN} = v_{gs1} - v_{gs2}$

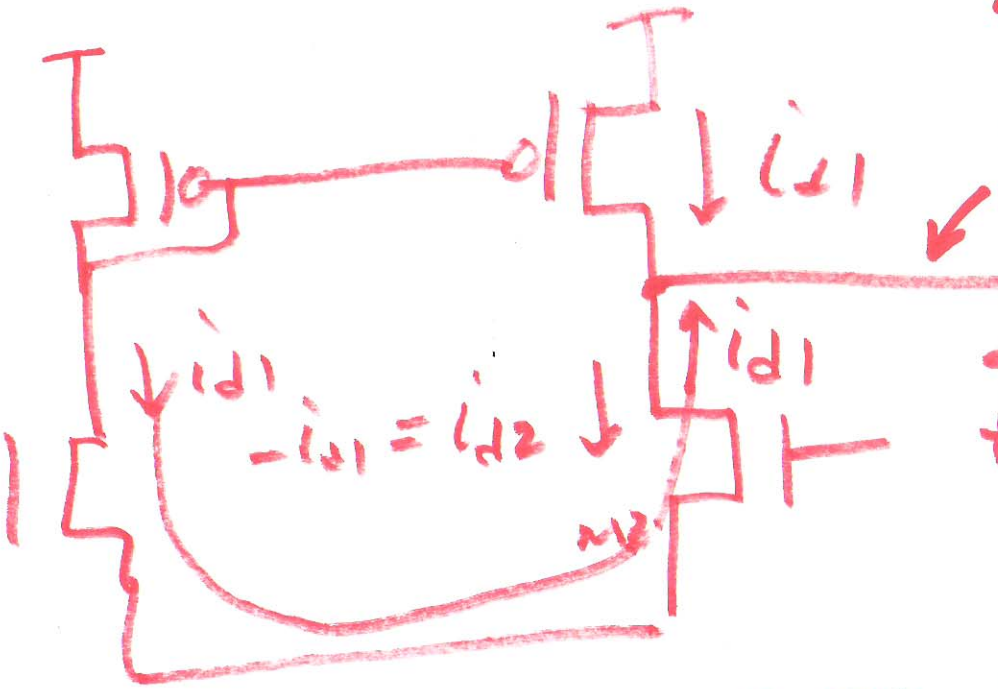
$= i_{D1}\left(\frac{1}{g_{mN}} + \frac{1}{g_{mP}}\right)$

$\frac{1/g_{mP}}{1/g_{mN} + 1/g_{mP}}$

$$\frac{v_{out}}{v_{in}} = \frac{r_{op} \| r_{on} \cdot 2i_{d1}}{\frac{2}{g_m} \cdot i_{d1}} = \frac{r_{op} \| r_{on}}{1/g_m}$$

$g_m r_{on} \| r_{op}$

$v_{out} = 2i_{d1} \cdot r_{on} \| r_{op}$



$150\mu \cdot 2.22k\Omega$

$\frac{v_{out}}{v_{in}} = 330$

$1mV \quad v_{out} = 330mV$