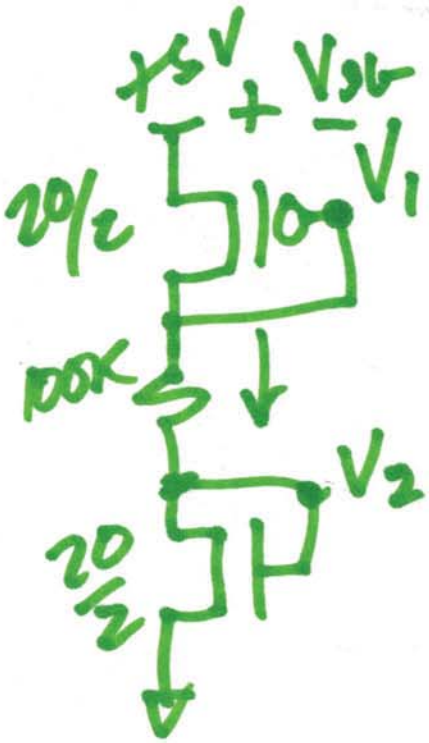
Lecture 11

EE 420 /ECG 620

Feb. 23, 2016



$$V_{SG} = 5 - V_1$$

$$V_{DS} = V_2$$

$$I_D = \frac{V_1 - V_2}{100K}, \quad V_1 - V_2 = 10^5 I_D$$

$V_{DD} - V_1$ V_2

$$VDD - V_{SG} - I_D \cdot 100K - V_{DS} = 0$$

$$V_2 = \sqrt{\frac{2I_D}{k_n' \cdot \frac{20}{2}}} + V_{THN}$$

$$V_{SG} = VDD - V_1 = \sqrt{\frac{2I_D}{k_p' \cdot \frac{20}{2}}} + V_{THP}$$

$$I_D \cdot 10^5 = -\sqrt{\frac{2I_D}{K_P \cdot \frac{20}{2}}} - V_{THP} + V_{DD}$$

$$- \sqrt{\frac{2I_D}{K_n \cdot \frac{20}{2}}} - V_{THN} \qquad \sqrt{\frac{1}{20 \cdot 4}} = \frac{1}{14} \cdot 10^{-3}$$

$$I_D \cdot 10^5 = 3.3 - \sqrt{\frac{2I_D}{40 \cdot 10}} \left(1 + \frac{1}{\sqrt{3}}\right)$$

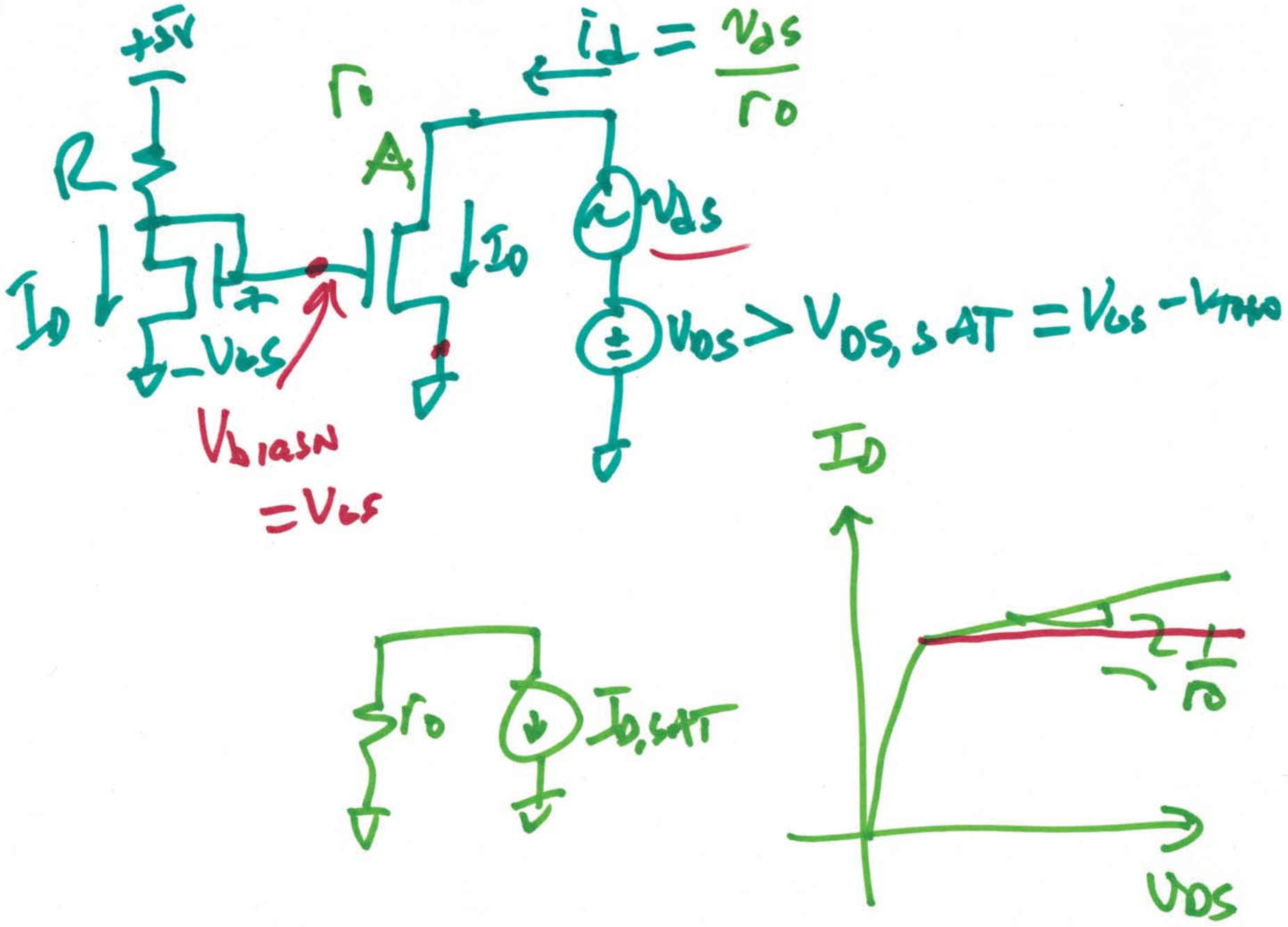
let $x = \sqrt{I_D}$, $x^2 = I_D$

$$x^2 \cdot 10^5 + x \cdot \frac{10^3\left(1+\frac{1}{1.7}\right)}{14} - 3.3 = 0$$

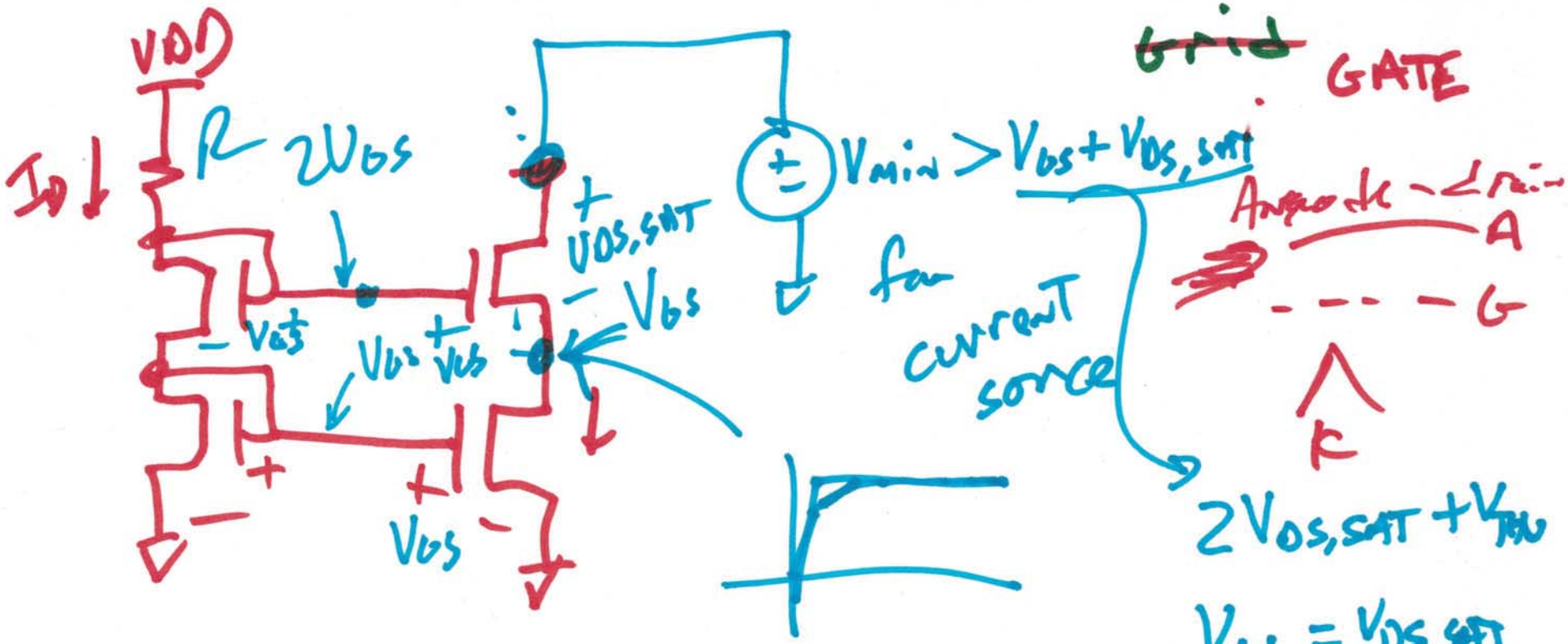
$$x = \frac{-10^{-3} \pm \sqrt{10^{-6} + 4(3.3)10^{-5}}}{2}$$

$$x^2 + x \cdot \frac{10^{-2}\left(1+\frac{1}{1.7}\right)}{14} - 3.3 \cdot 10^{-5} = 0$$

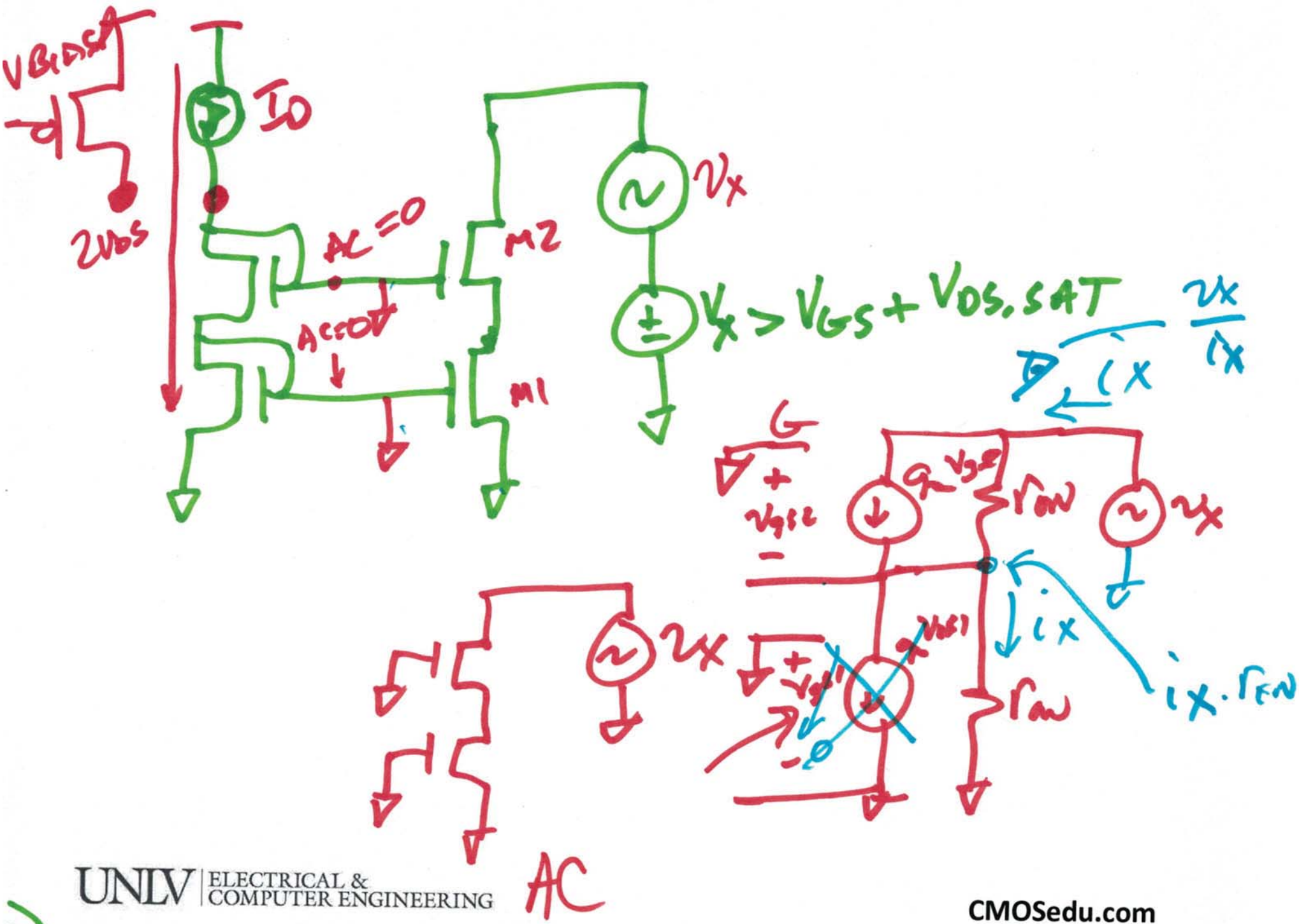
$$x = \sqrt{I_D}$$

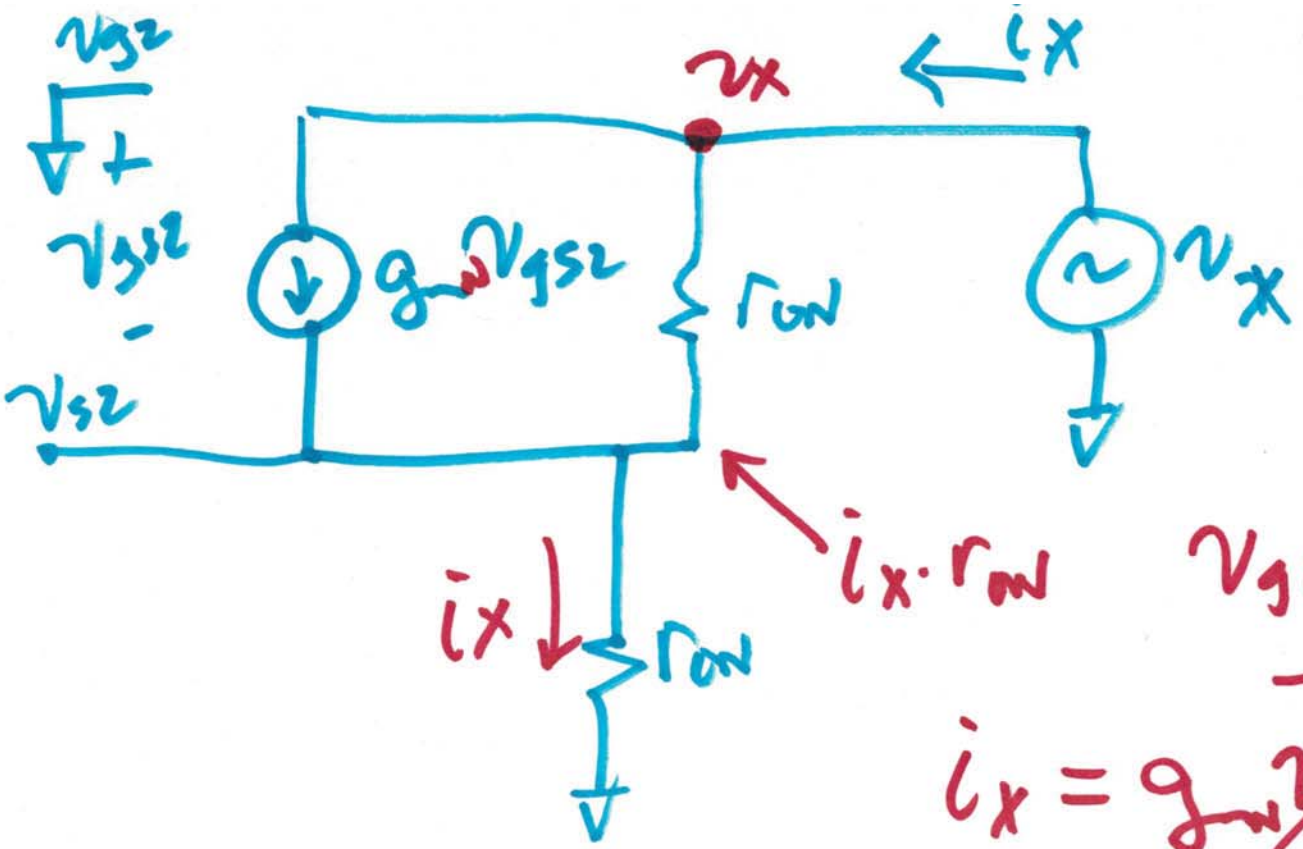

+5V
R
I_D
V_{GS}
V_{BIASN}
$= V_{GS}$
r_o
A
I_D
$i_1 = \frac{v_{ds}}{r_o}$
v_{ds}
$V_{DS} > V_{DS,SAT} = V_{GS} - V_{THN}$
r_o
$I_{D,SAT}$
I_D
$\frac{1}{r_o}$
V_{DS}

CASCODE → Common-~~Cathode~~ source driving a common-~~grid~~ GATE



$$I_D = \frac{V_{DD} - 2V_{GS}}{R}, \quad V_{GS} = \sqrt{\frac{2I_D}{\beta_N}} + V_{THN}$$


VBIAS
ID
2VDS
AC=0
M2
M1
Vx
Vx > VGS + VDS,SAT
2x/Ix
Ix
G
+
VGS
-
gmVGS
rON
2x
ix
ix·rEN
rON
2x
AC



$$R_{ON} = \frac{v_x}{i_x}$$

$$v_{gs2} = -i_x \cdot r_{ON}$$

$$i_x = g_m \cancel{v_{gs2}} + \frac{v_x - i_x r_{ON}}{r_{ON}}$$

$-i_x \cdot r_{ON}$

r_o C.M.

$g_m r_o \cdot r_o$ cascode

$v_{open-ckt}$

$$i_x\left(1 + r_{ON} g_m + 1\right) = v_x \cdot \frac{1}{r_{ON}}$$

$$\frac{v_x}{i_x} = 2r_{ON} + g_m r_{ON}^2 \simeq g_m r_{ON}^2$$

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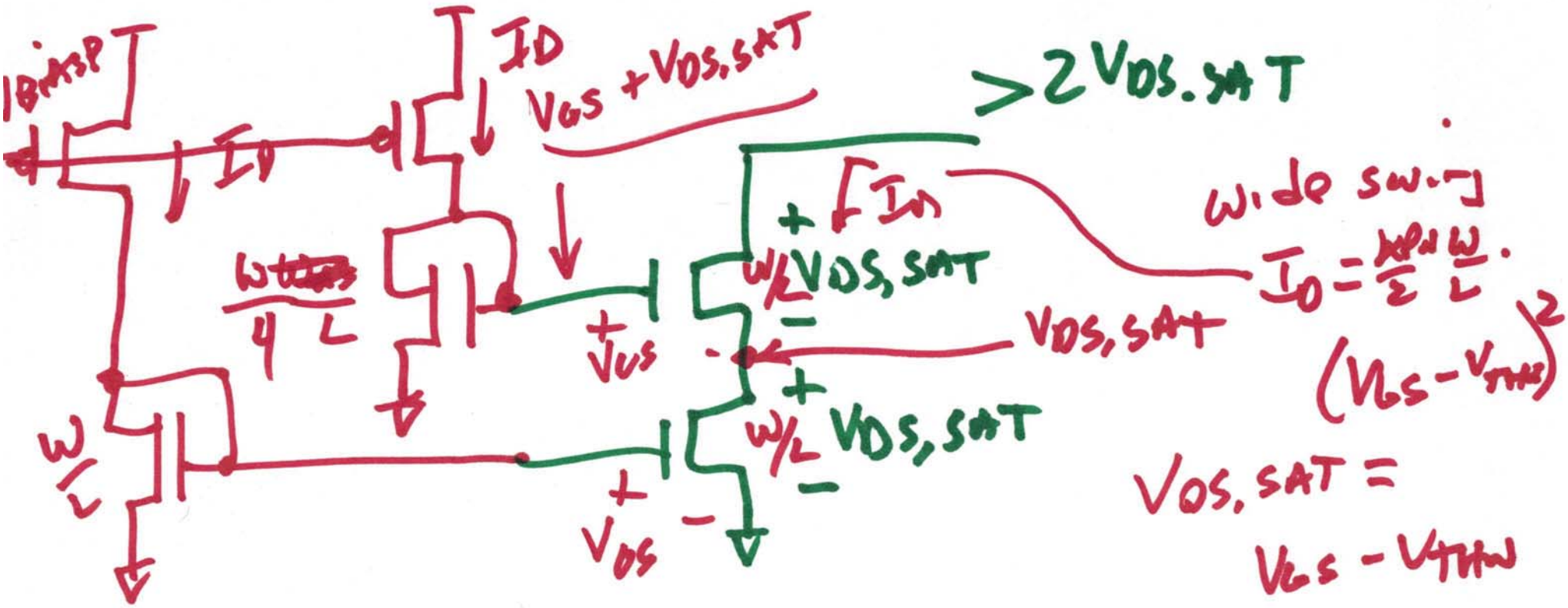

$$V_{GS,WS} = V_{GS} + V_{DS,SAT}$$

$$= 2V_{GS} - V_{THN}$$

$$W = W_{WS} \cdot 4$$

$$\boxed{W_{WS} = \frac{1}{4} \cdot W}$$

$$I_D = \frac{K_{PN}}{2} \cdot \frac{W_{WS}}{L} \left(2V_{GS} - V_{THN} - V_{THN}\right)^2$$

$$= \frac{K_{PN}}{2} \cdot \frac{W_{WS} \cdot 4}{L} \left(V_{GS} - V_{THN}\right)^2$$