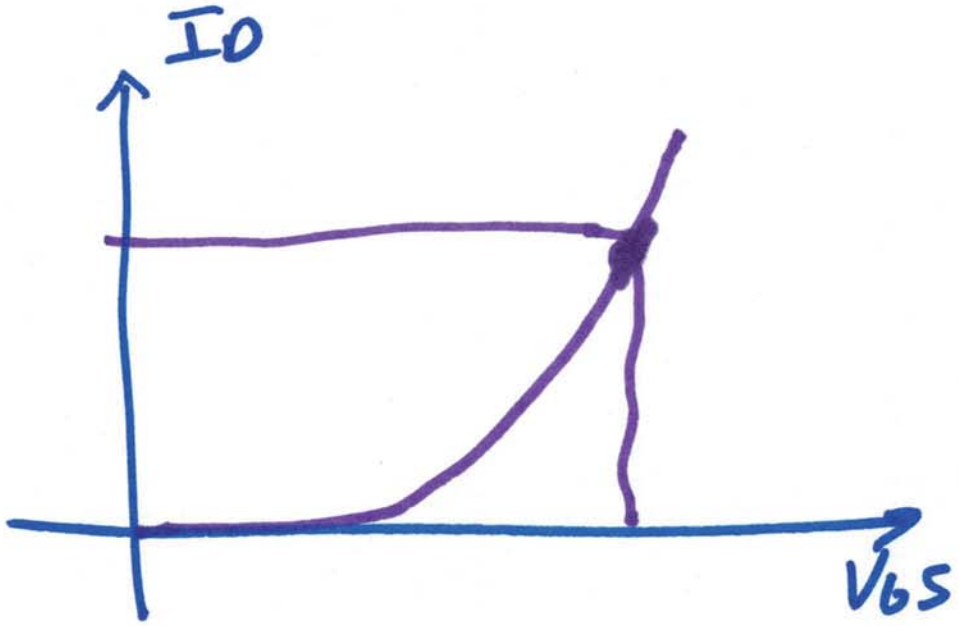
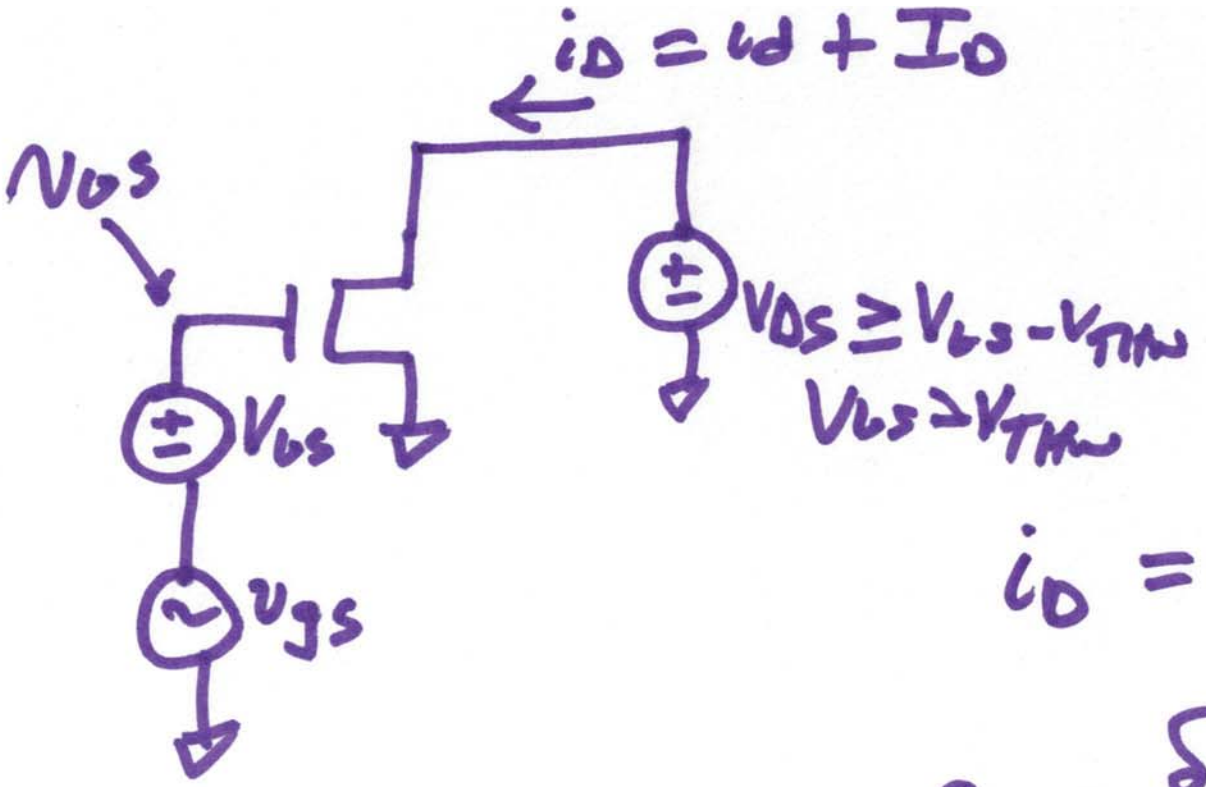
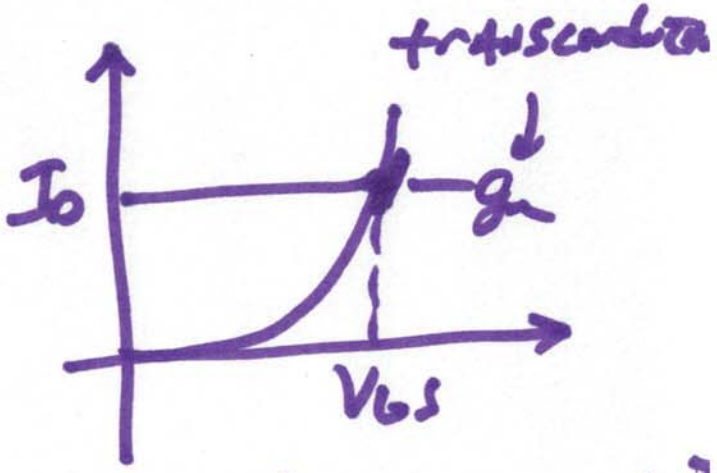
EE420/ECG620 Analog IC Design

Lecture 3

JAN. 29, 2020







$$i_D = \frac{KP}{2} \cdot \frac{W}{L} \left(v_{GS} - V_{TH} \right)^2$$

$$v_{GS} = \underset{DC}{V_{GS}} + \underset{AC}{v_{gs}}$$

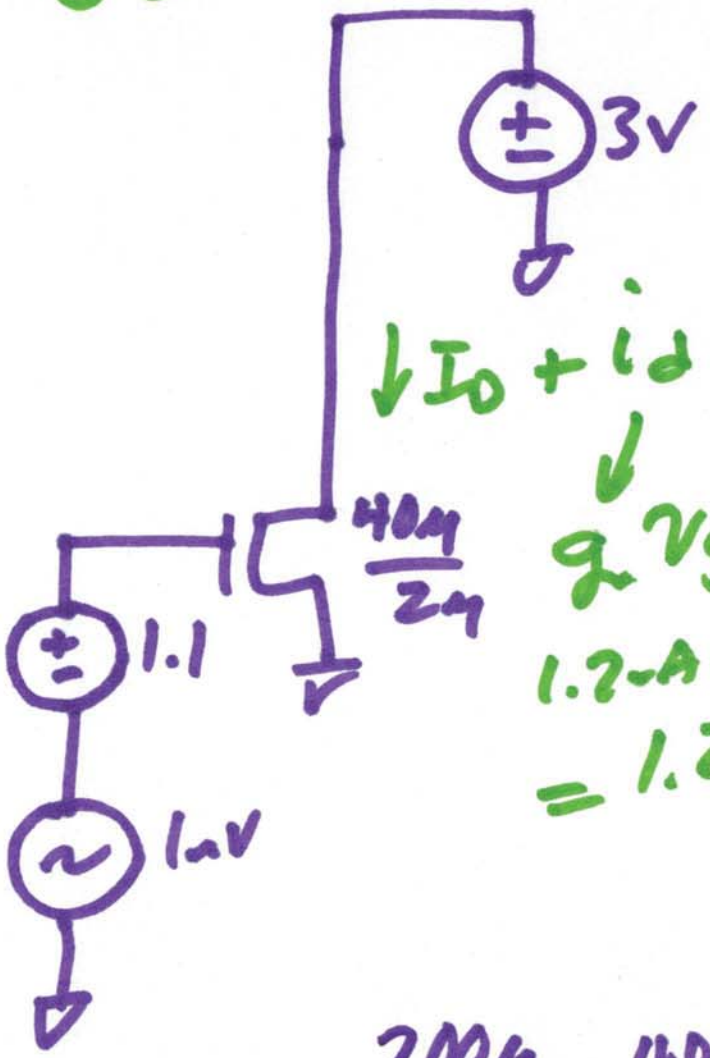
$$g_m = \left. \frac{\delta i_D}{\delta v_{DS}} \right|_{\substack{I_D = CONST \\ V_{GS} = CONST}}$$

$$\beta_N = KP_N \cdot \frac{W}{L}$$

$$g_m = \frac{2}{2} \frac{KP}{2} \frac{W}{L} \left(V_{GS} - V_{TH} \right) \frac{\delta \left(V_{GS} - V_{TH} \right)}{\delta v_{DS}}$$

$$g_m = KP \cdot \frac{W}{L} \left(V_{GS} - V_{TH} \right)$$

C5



$I_D = \frac{100u}{2} \cdot \frac{40}{2} \cdot (1.1 - .8)^2$

$= 612mA \cdot 0.09$

$= 108uA$

?

$I_D = 90uA$

$g_m v_{gs}$

$1.2mA \cdot 1mV$

$= 1.2uA$

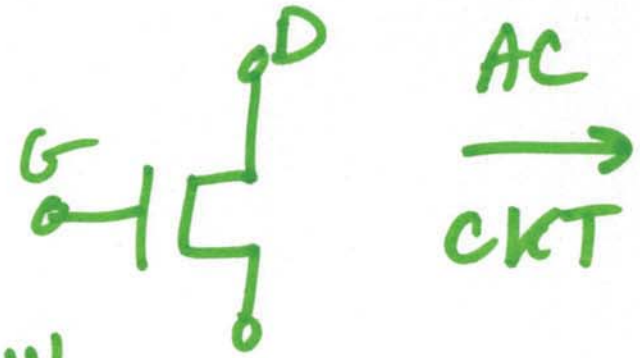
$190u = \frac{KP}{2} \cdot \frac{40}{2}(1.1 - .8)^2$

$190u = KP \cdot 0.09$

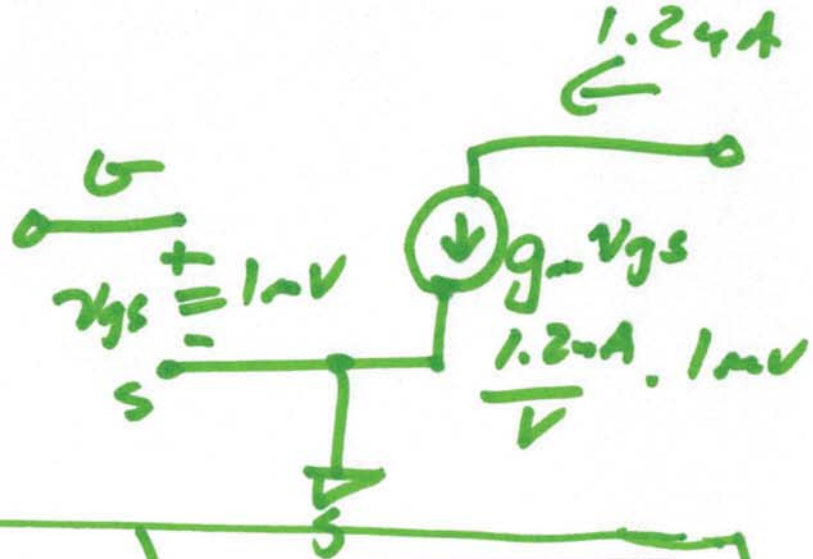
$KP = 200\frac{uA}{V^2}$

$g_m = \frac{200u}{2} \cdot \frac{40}{2}(1.1 - .8)$

$4mA \cdot .3 = \frac{1.2mA}{V}$



AC CKT



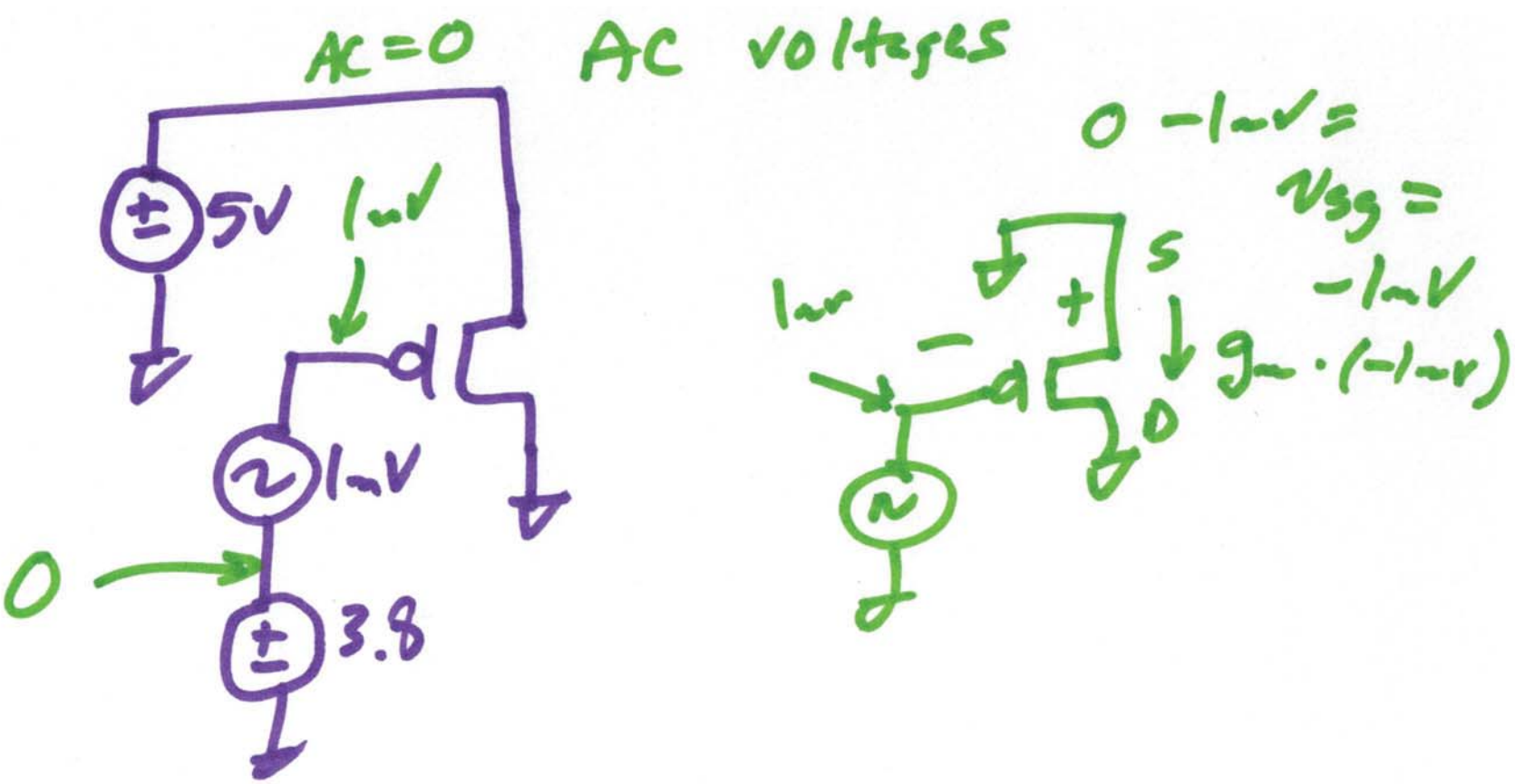
$\beta_N = K_{ON} \cdot \frac{W}{L}$

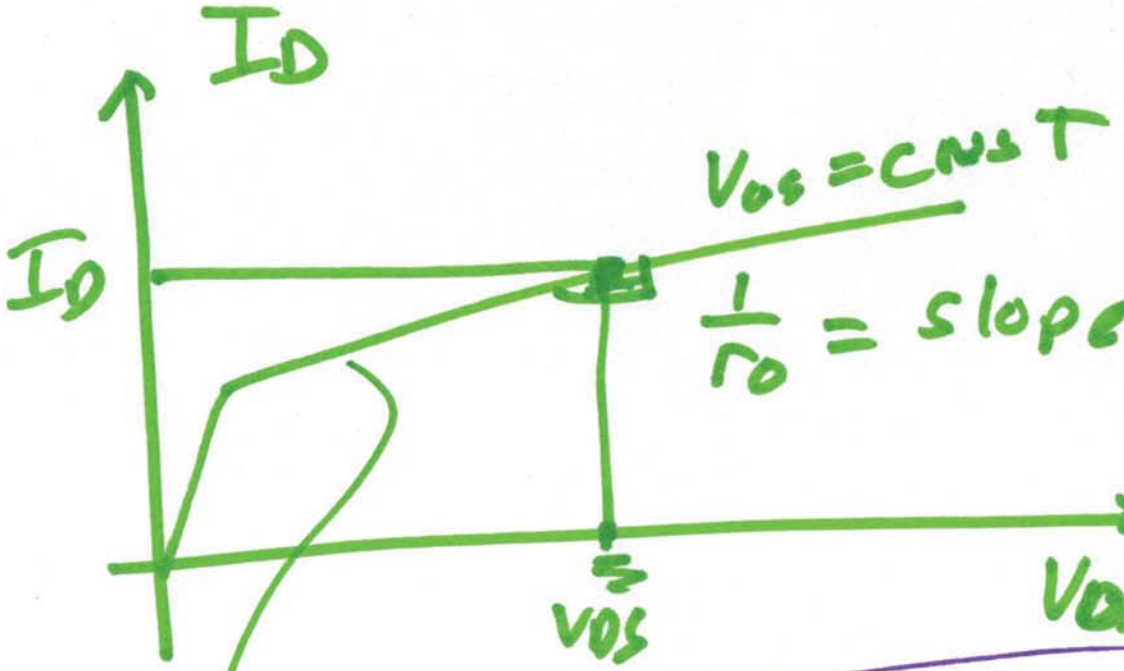
$$g_m = \beta_N (V_{GS} - V_{THN}) = \sqrt{2 I_D \cdot \beta_N}$$

$$I_D = \frac{\beta_N}{2} (V_{GS} - V_{THN})^2$$

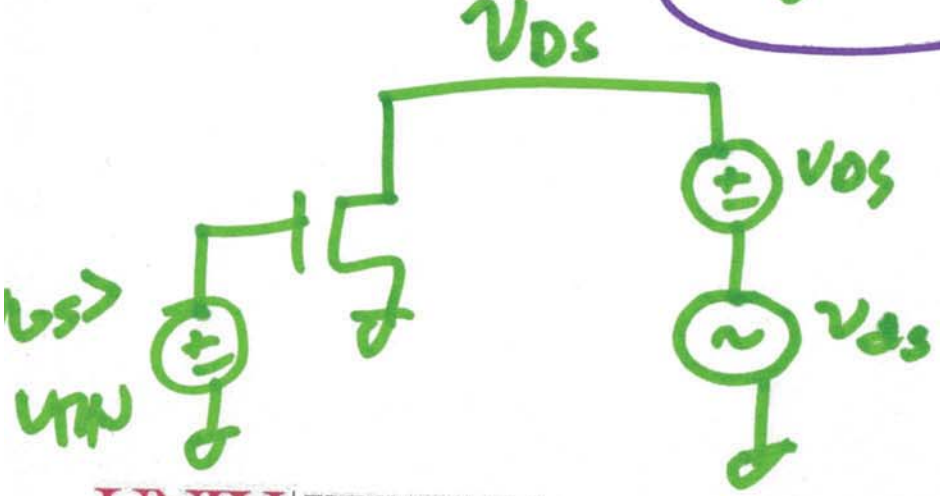
$$V_{GS} = \sqrt{\frac{2 I_D}{\beta_N}} + V_{THN}$$

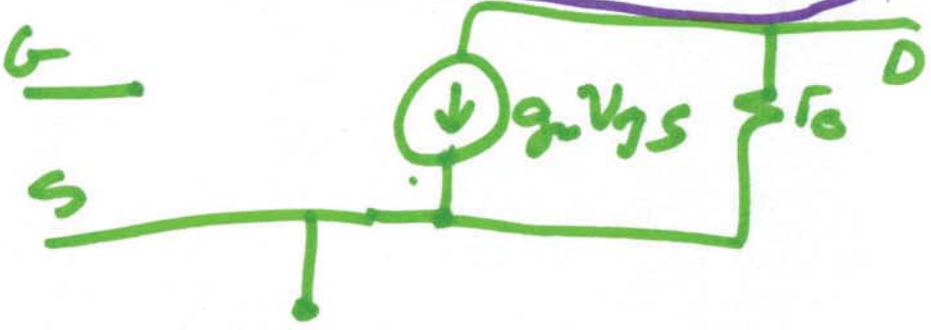
$$(V_{GS} - V_{THN}) = \sqrt{\frac{2 I_D}{\beta_N}}$$


AC=0
AC voltages
5V
1mV
d
2
1mV
0
3.8
0 -1mV=
v_{sg} =
-1mV
1mV
s
+
−
d
$g_m \cdot (-1mV)$
0
2



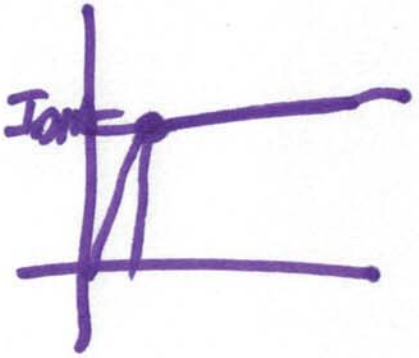
$$I_D = \frac{K_n}{2}\frac{W}{L}\left(V_{GS} - V_{TN}\right)^2 \cdot (1 + \lambda V_{DS})$$





b)

$$r_o^{-1} = \frac{\delta i_D}{\delta v_{DS}} \Bigg|_{\substack{I = CONST \\ V_{DS} = CONST}}$$

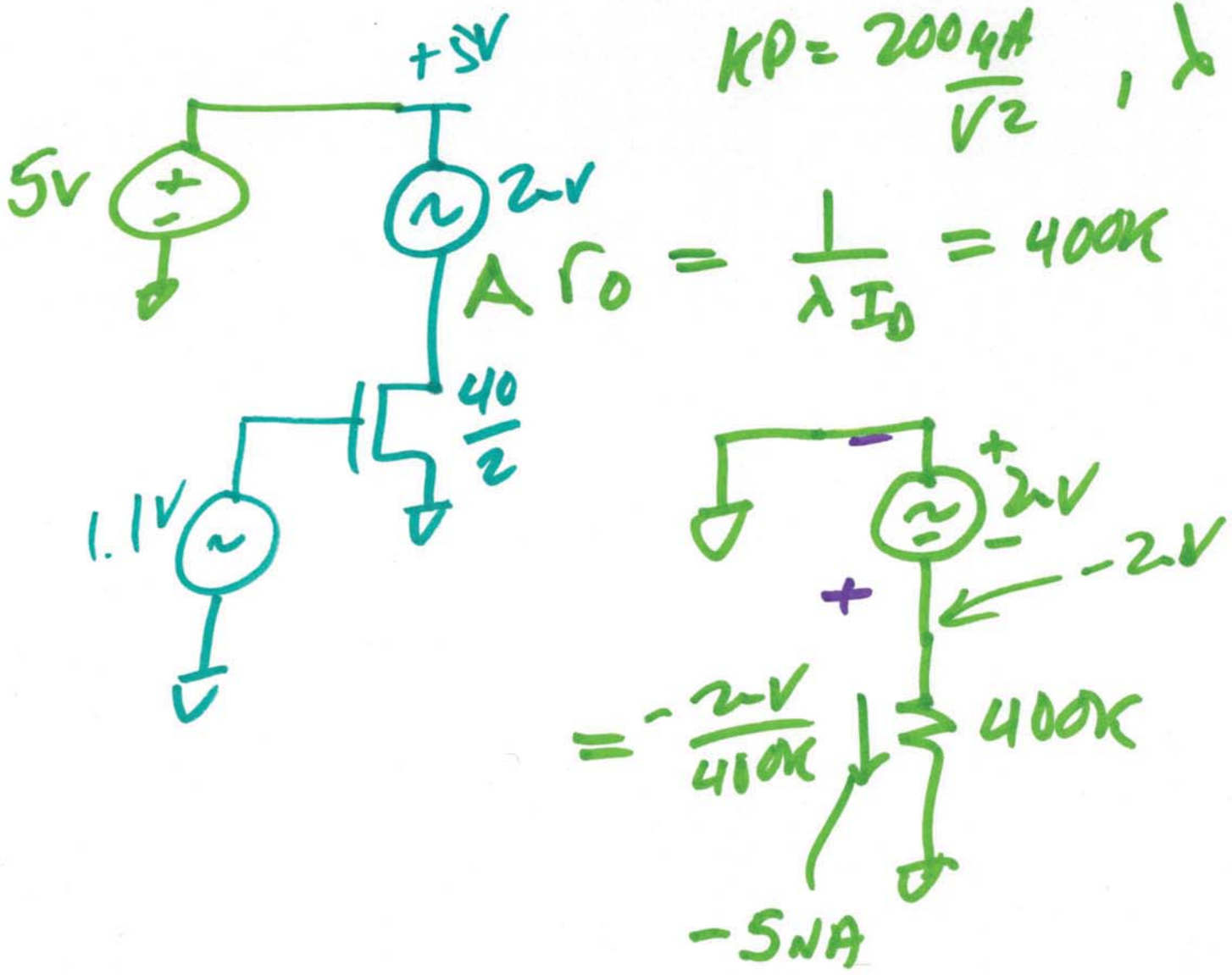


$$r_o^{-1} = \underbrace{\frac{K_P}{2}\frac{W}{L}\left(V_{GS} - V_{TH}\right)^2 \cdot \lambda}_{I_{D,SAT}}$$

$$r_o = \frac{1}{\lambda \cdot I_{D,SAT}}$$

$$r_o = \frac{v_{DS}}{\partial I} = \frac{1}{2.5\mu} \simeq 400\,K = \frac{1}{\lambda \cdot I_D} = \frac{1}{400{,}000 \cdot 1864}$$

$$\boxed{\lambda = 0.01 V^{-1}}$$


+5V
5V
2V
A
40/2
1.1V
$KP = 200\frac{\mu A}{V^2}$, $\lambda = 0.01V^{-1}$
$r_o = \frac{1}{\lambda I_D} = 400K$
2V
-2V
$= -\frac{2V}{410K}$
400K
-5μA