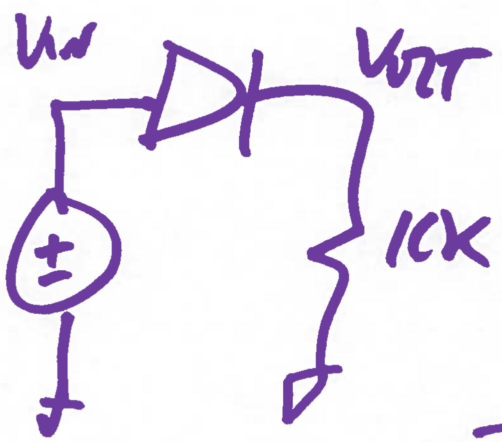
EE 420/ECG 620

Analog IC Design

Lecture 3

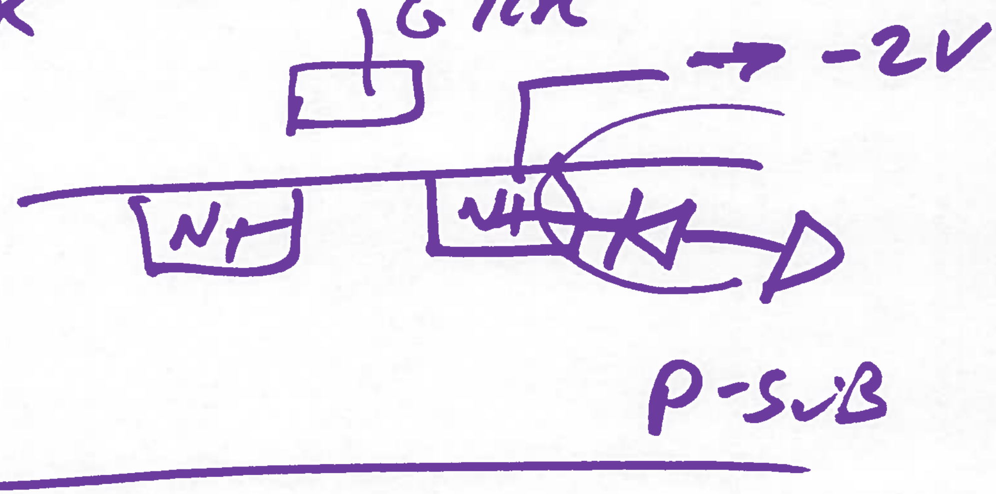
Jan. 30, 2019

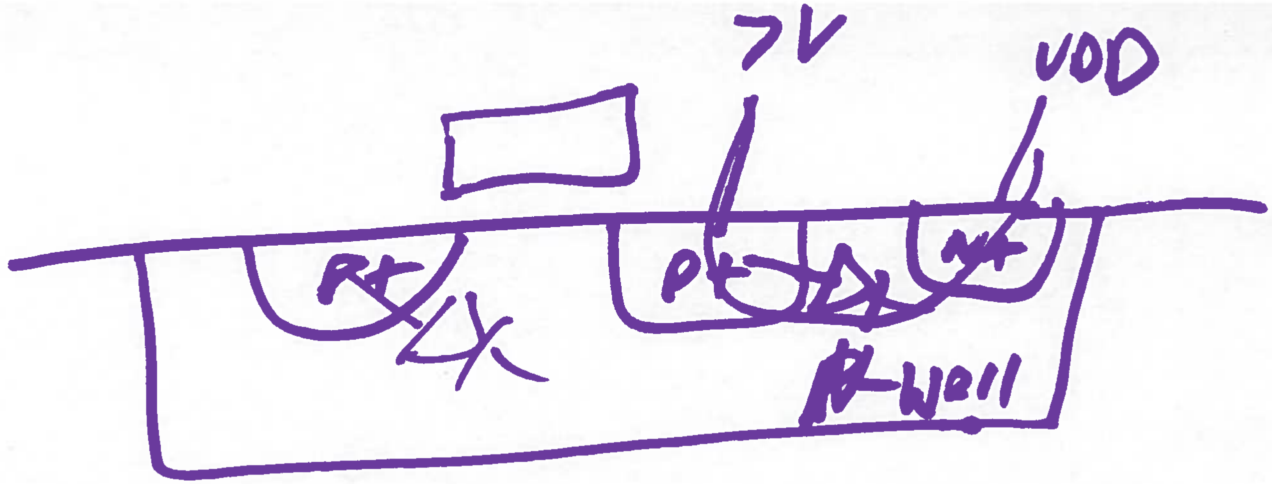


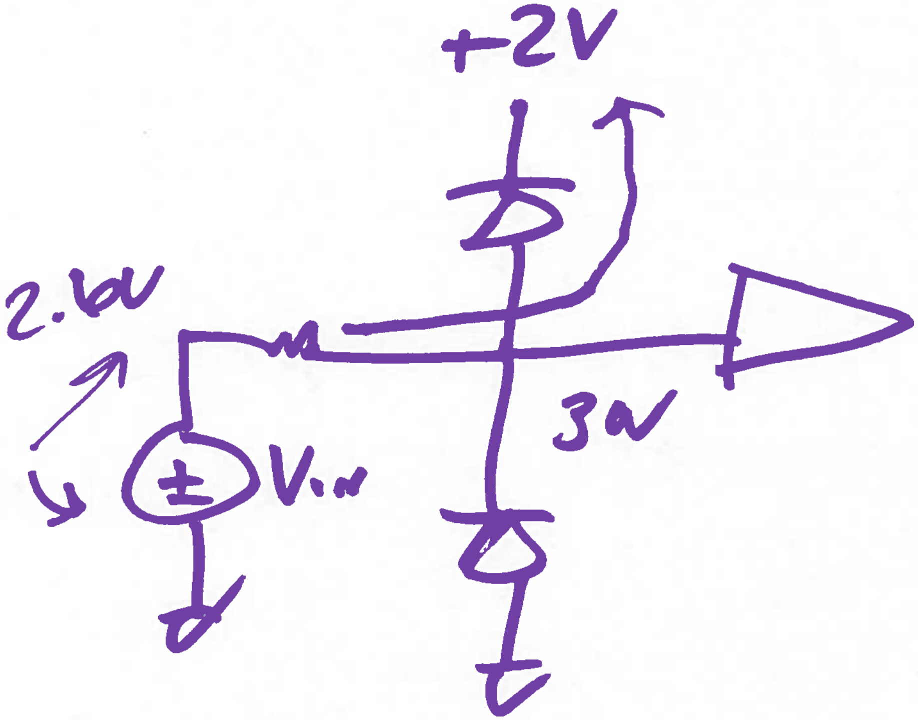
$V_{OUT} = V_{IN} - .7$

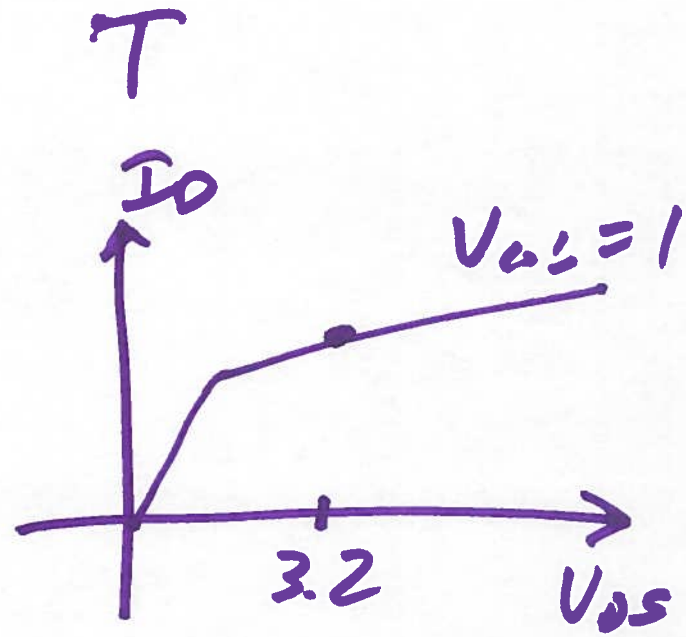
$V_D > 0.6$

$I = \frac{V_{IN} - .7}{10K}$









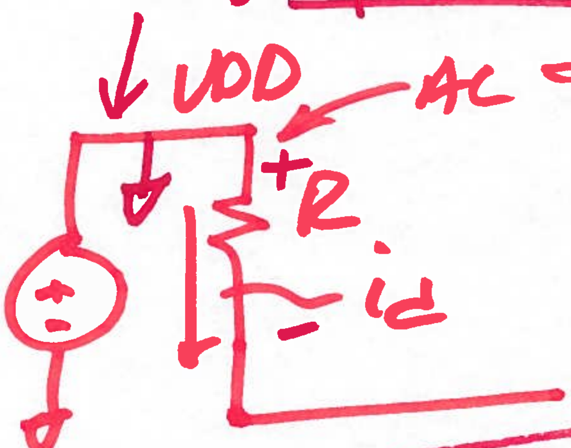
2)

$$I_D = \frac{KP_n}{2} \cdot \frac{W}{L} \left(V_{GS} - V_{THN} \right)^2$$

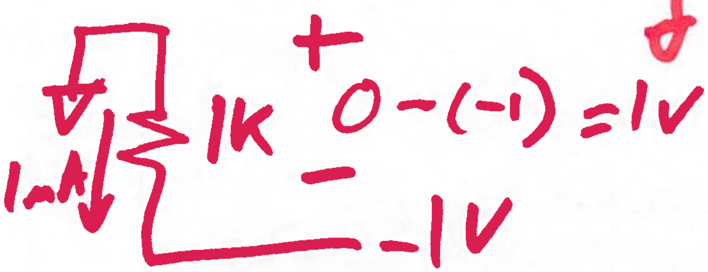
$$V_{DS} = VDD - I_D \cdot R$$

$$i_d = g_m v_{gs}$$

AC ground

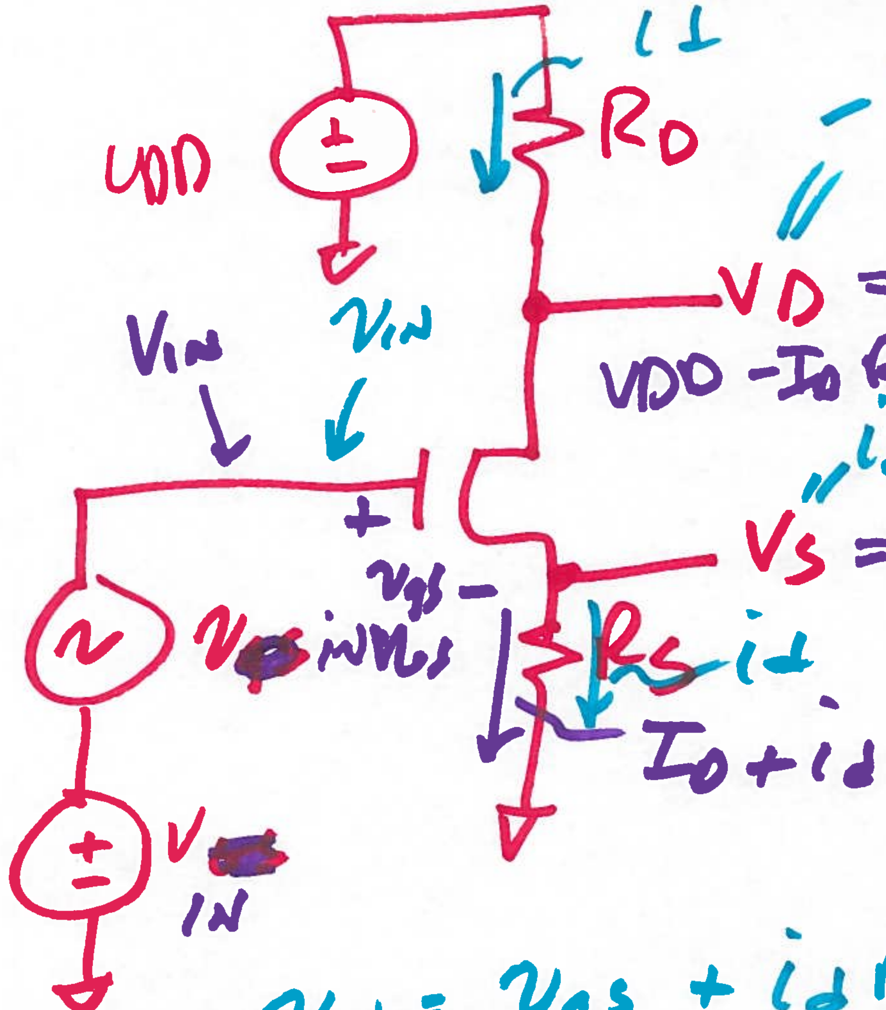


$$v_{out} = v_d$$



$$v_{out} = -i_d \cdot R$$

$-i_d \cdot R_D = v_{out}$



$V_{IN} = V_{GS} + I_D \cdot R_S$

$V_{GS} = \sqrt{\frac{2I_D}{KP \cdot \frac{W}{L}}} + V_{THN}$

$V_{IN} - V_{THN} = \sqrt{\frac{2I_D}{KP\frac{W}{L}}} + I_D R_S$

let $\sqrt{I_D} = x$

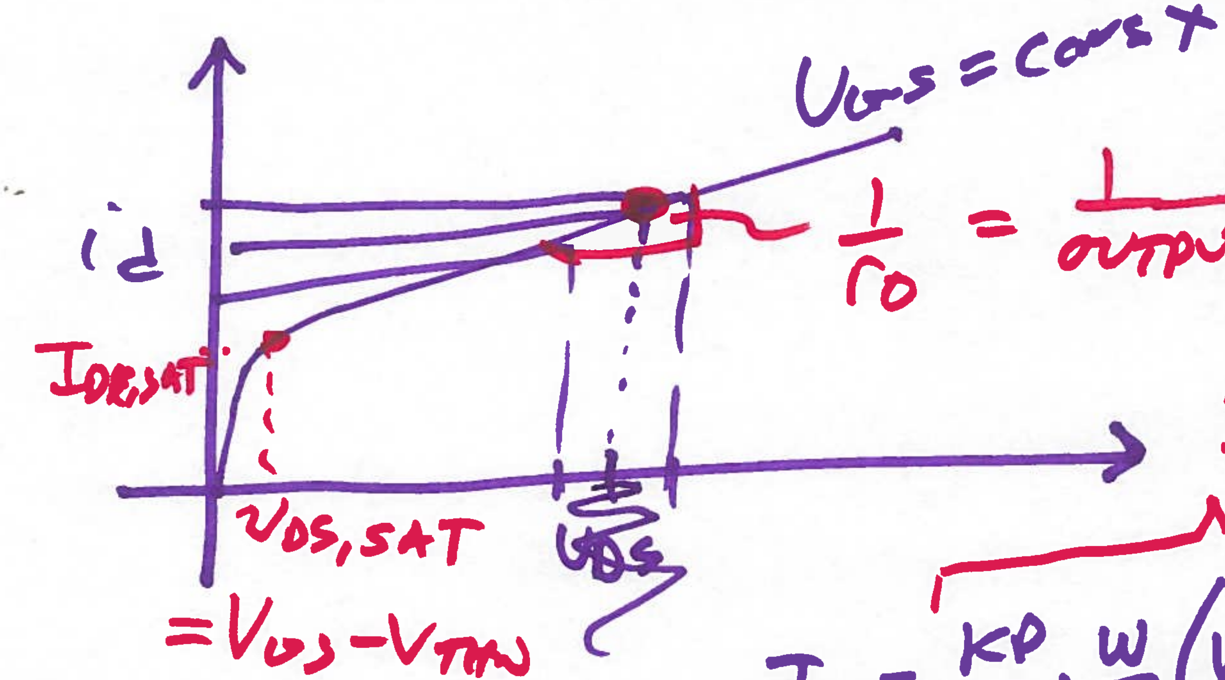
$x^2 \cdot R_S + \sqrt{\frac{2}{KP\frac{W}{L}}} \cdot x + V_{THN} - V_{IN} =$

$v_{in} = v_{gs} + i_d R_s$

$v_{gs} = \frac{i_d}{g_m}$

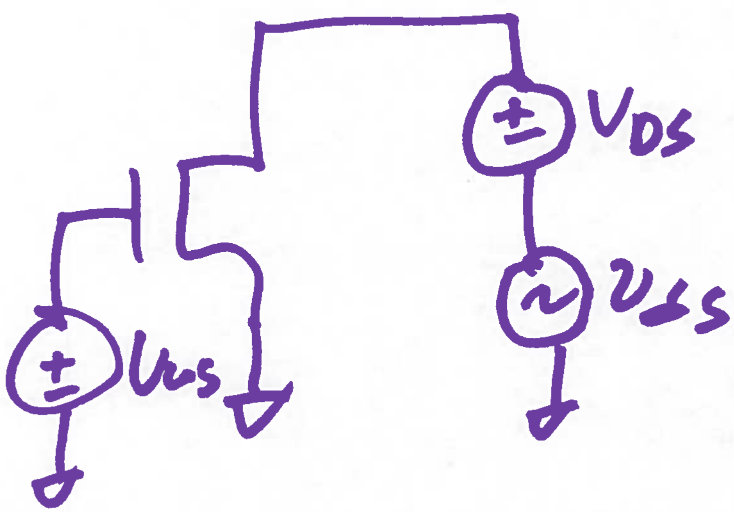
$v_{in} = i_d \cdot \left(\frac{1}{g_m} + R_s\right)$

$\frac{v_{out}}{v_{in}} = -\frac{i_d \cdot R_D}{i_d\left(\frac{1}{g_m} + R_s\right)}$



$$\frac{1}{r_o} = \frac{1}{\text{output resistance}}$$

$$I_D = \overbrace{\frac{KP}{2}\cdot\frac{W}{L}\left(V_{GS}-V_{THN}\right)^2}^{I_{D,SAT}} \cdot \left(1+\lambda\left(\underbrace{V_{DS}+v_{ds}}_{v_{DS}\ \text{AC+DC}}-V_{DS,sat}\right)\right)$$

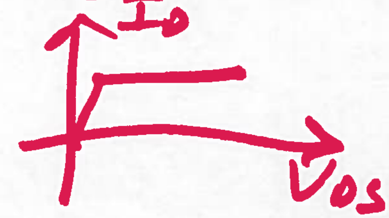


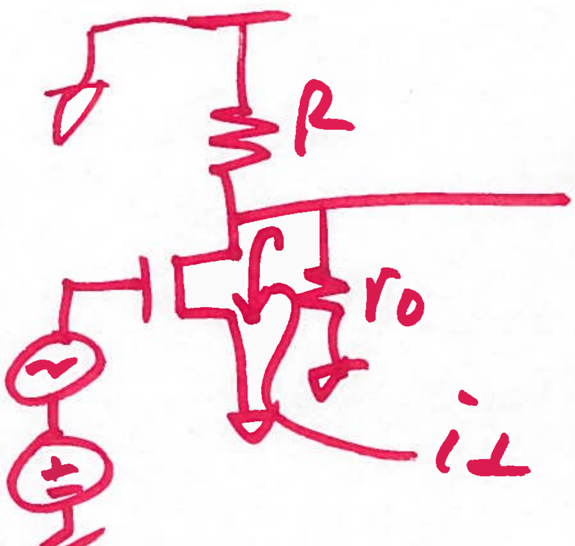
$$r_o^{-1} = \frac{\delta}{\delta v_{DS}} \Bigg|_{\substack{I_D = \text{const} \\ V_{GS} = \text{const}}} I_{D,SAT}\cdot\left(1+\lambda\left(\ \uparrow\ \right)\right)$$

$$r_o^{-1} = \frac{\delta}{\delta v_{DS}} I_{D,SAT}\left(1 + \lambda\left(\underbrace{V_{DS} + v_{ds}}_{v_{DS}} - V_{DS,sat}\right)\right)$$

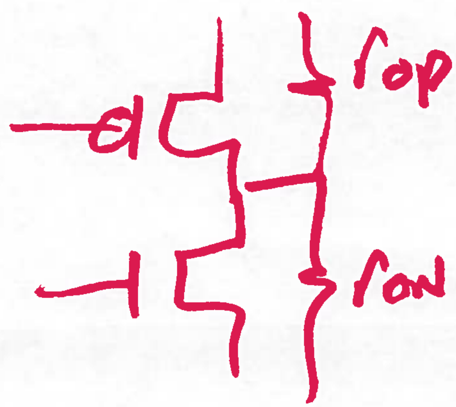
$$= 0 + \lambda \cdot I_{D,SAT} + 0$$

$$\boxed{r_o = \frac{1}{\lambda I_{D,SAT}}} = \frac{1}{0.1 \cdot 1\mu A} = 10 M\Omega$$





$$v_{out} = -i_d \cdot (R \| r_o)$$



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