EE303
02/10/06

```
.model nch mnmos(Level=1 Tox=300n Uo=600 Kp=20.54u W=144u L=8u Vto= 1.3
+               Lambda=15m Cbd=4p Cbs=4p Cgdo=1.7n Cgso=1.7n Rs=1 Rd=1)
.model pch pmos(Level=1 Tox=300n Uo=300 Kp=10.32u W=328u L=8u Vto=-1.5
+               Lambda=15m Cbd=8p Cbs=8p Cgdo=1.7n Cgso=1.7n Rs=1 Rd=1)
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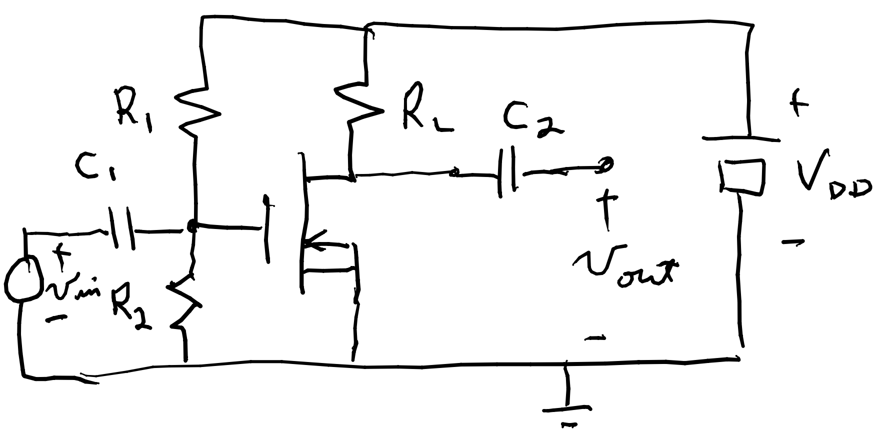
$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q = \frac{2 \cdot I_D}{(V_{GS} - VTO)}$$

$$g_o = \left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q = \frac{\lambda I_D}{(1+\lambda V_{DS})}$$

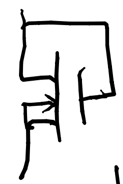
In saturation region

$$v_{GS} - VTO \le v_{DS}$$

$$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - VTO)^2$$



if $v_{DS} = v_{GS}$
are always in sat



but for

then

switch to ohmic when

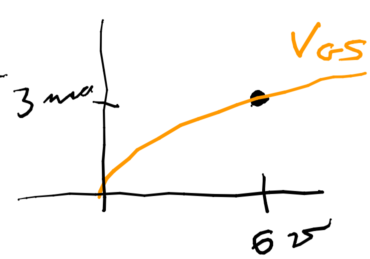
$$v_{GS} - VTO = v_{DS}$$

choose Q point, say

$V_{DS} = 6\,v$

$I_D = 3\,ma$

gives $V_{GS} \hat{=} 6\,v$



gives

$$g_m = \frac{2 \cdot I_D}{V_{GS} - V_{TO}} = \frac{2 \times 3 \times 10^{-3}}{6 - 1.3} = \frac{6}{4.7}\, m\mho = 1.28 \times 10^{-3}\, \mho$$

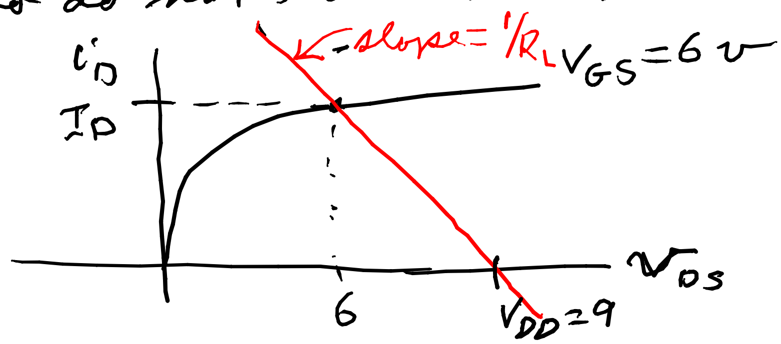
$$g_o = \frac{\lambda I_D}{1 + \lambda V_{DS}} = \frac{15 \times 10^{-3} \times 3 \times 10^{-3}}{1 + 15 \times 10^{-3} \times 6} = \frac{45 \times 10^{-6}}{1.090} \approx 45 \times 10^{-6}\, \mho$$

$$r_o = 0.02 \times 10^{6}\, \Omega = 200K\Omega$$

fix $V_{DD} = 9v$ then $V_{GS} = 6v = \frac{R_2}{R_1 + R_2} \times V_{DD} = \frac{1}{1 + \frac{R_1}{R_2}} \cdot 9$

$$3 = 6 \cdot \frac{R_1}{R_2} = \frac{1}{2} = \frac{R_1}{R_2}$$

choose R_1 & $R_2 = 2R_1$ very large so do not load $\Rightarrow$ $R_1 = 10Meg\,\Omega$, $R_2 = 20Meg\,\Omega$



$$\frac{1}{R_L} = -\text{slope of load line} = \frac{I_D - 0}{V_{DD} - V_{DS}} = \frac{3 \times 10^{-3}}{9 - 6} = 10^{-3}$$

$$R_L = 1K\Omega$$

$$\text{gain(small signal)} = -g_m R_L = -1.28 \times 10^{-3} \times 1 \times 10^{3}$$
$$= -1.28$$