EE303
02/08/06

4007 transistor Spice models

```
.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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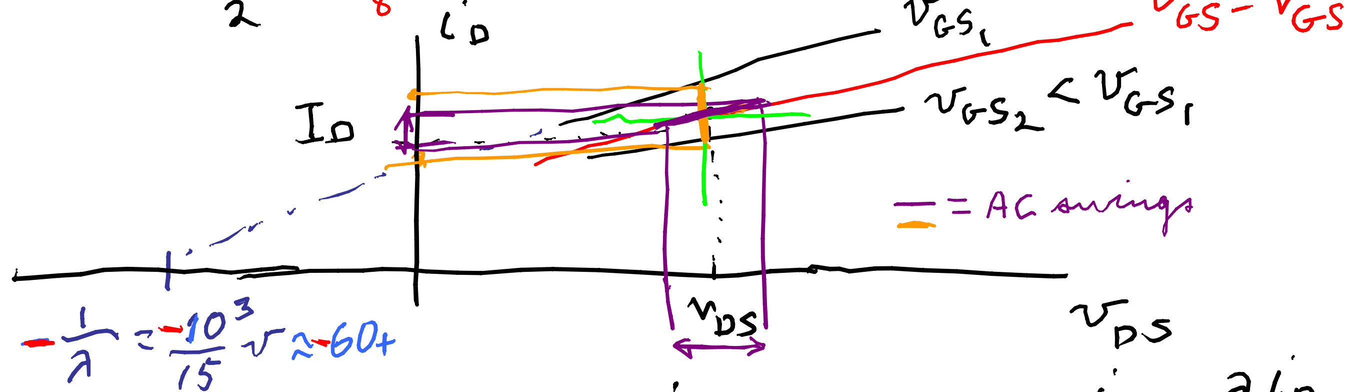
note differences in KP & W between N & P devices

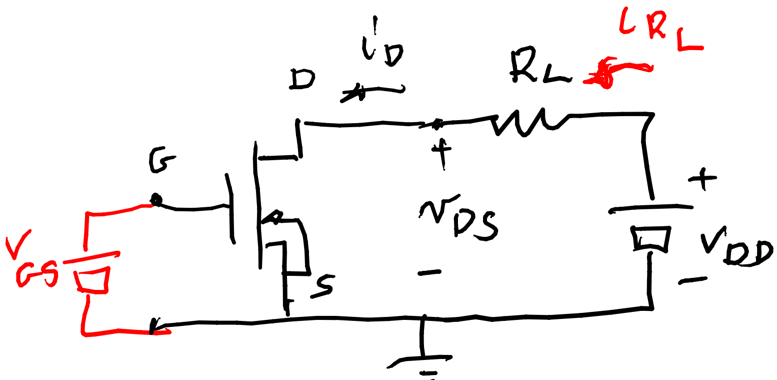
for the 4007 NMOS

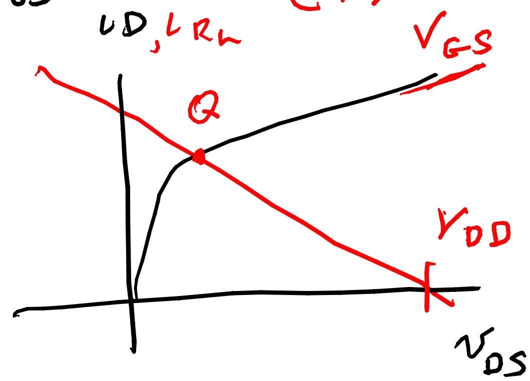
$$i_D = \frac{20.54\times10^{-6}}{2} \times \frac{144}{8}(v_{GS}-1.3)^2(1+15\times10^{-3}v_{DS}) \text{ in saturation}$$



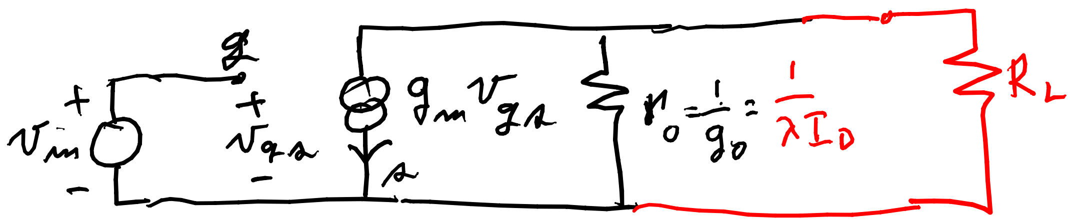
$$g_m = \frac{i_d}{v_{gs}} = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_{\substack{v_{DS}=V_{DS}\\ v_{GS}=V_{GS}}}$$

$$g_o = \frac{i_d}{v_{ds}} = \left.\frac{\partial i_D}{\partial v_{DS}}\right|_{Q\text{ point}} \approx \frac{I_D}{(1/\lambda)}$$





small signal

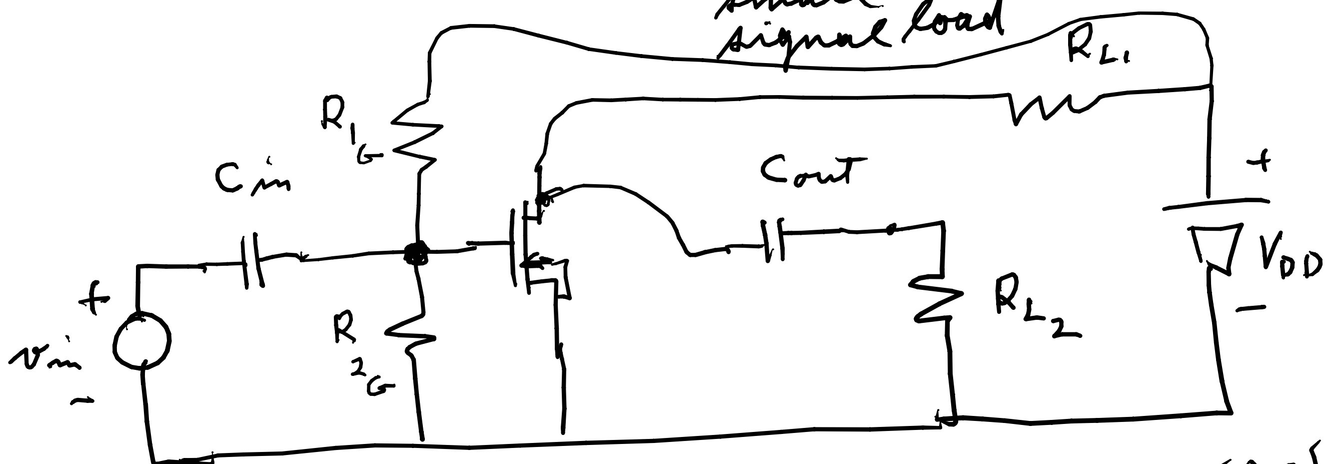


ss

$$\frac{v_{out}}{v_{in}} = \frac{-g_m R_L v_{gs}}{v_{gs}}$$

$$= -g_m R_L$$

small signal load



open @ DC

$z_{C_{out}} = \frac{1}{sC_{out}}$ @ $s = 0$ (DC)

$\approx \infty$ = open circuit @ DC

choose C_{in} & C_{out} very large

so @ freq. of $v_{in}(t) = V_{in}\sin(\omega t)$

$\omega = 2\pi f$

has $|Z_C(j\omega)| << 1 \Rightarrow$ short @ AC

now for $g_m R_L = g_m \left[\left(\frac{R_{L_1} R_{L_2}}{R_{L_1} + R_{L_2}} \right) \| (R_{1G} + R_{2G}) \right] \approx g_m \cdot R_{L_{\|}}$

$\left(\frac{R_{L_1} R_{L_2}}{R_{L_1} + R_{L_2}} \right) = R_{L_{\|}}$

$$V_{GS} = \left(\frac{R_{2G}}{R_{1G}+R_{2G}}\right) V_{DD}$$

choose R_{1G} & R_{2G} very large

(note the transistor gate looks like a capacitor at DC ⇒ open circuit for bias, so no DC gate current ⇒ R_{1G} & R_{2G} act as a voltage divider for bias)