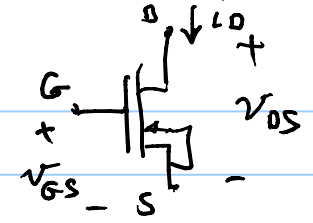
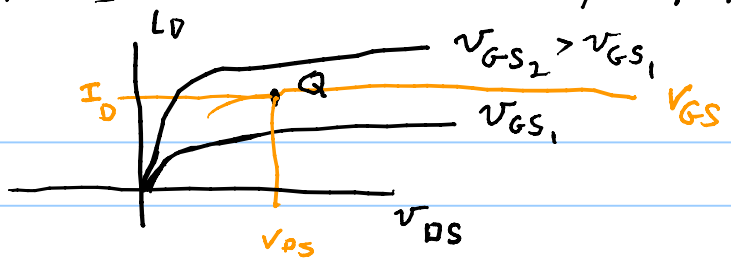
EE 303
02/05/07

small signal for NMOS



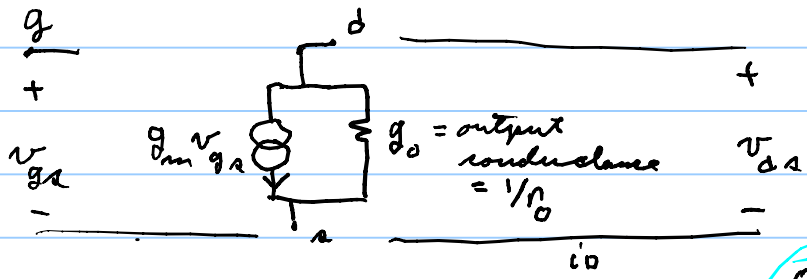


$$i_D = f(v_{GS}, v_{DS}) = f(V_{GS}, V_{DS}) + \left.\frac{\partial f}{\partial v_{GS}}\right|_Q (v_{GS} - V_{GS}) + \frac{\partial f}{\partial v_{DS}} (v_{DS} - V_{DS})$$

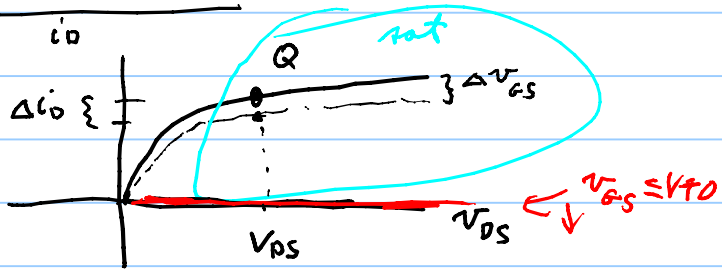
$$= I_D + \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q (v_{gs}) + \left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q (v_{ds}) + \frac{\partial^2}{\cdots} \cdots$$

$$i_D - I_D = i_d = g_m \cdot v_{gs} + g_o \cdot v_{ds}$$

(+ ... which ignore if small enough v_{gs}, & v_{ds})



$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q$$



If in saturation : $i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - VTO)^2(1 + \lambda v_{DS})$

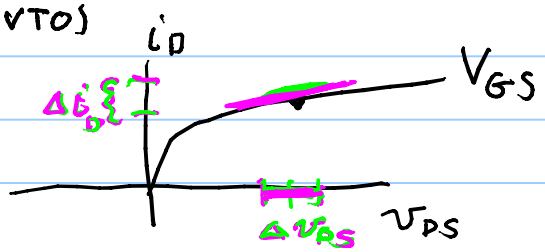
small

$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q = 2\left(\frac{KP}{2}\frac{W}{L}\right)(v_{GS} - VTO)(1 + \lambda v_{DS})\Big|_{\substack{v_{GS} = V_{GS} \\ v_{DS} = V_{DS}}}$$

$$= 2\frac{\left[\frac{KP}{2}\frac{W}{L}(V_{GS} - VTO)^2(1 + \lambda V_{DS})\right]}{(V_{GS} - VTO)}$$

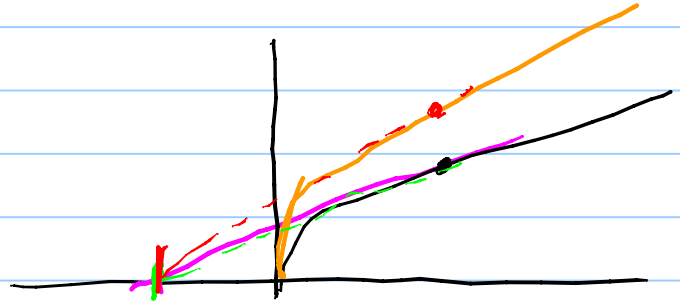
$$= 2\frac{I_D}{(V_{GS} - VTO)}$$

$$g_o = \left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q = \text{slope of curve @ Q}$$



$$\left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q = \left.\frac{KP}{2}\frac{W}{L}(v_{GS}-VTO)^2 \cdot \lambda\right|_Q = \left.\frac{\lambda i_D}{(1+\lambda v_{DS})}\right|_Q = g_o = \frac{\lambda I_D}{1+\frac{V_{DS}}{V_A}}$$

to find λ



$$-1/\lambda = -V_{Early} = -V_A$$

$$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS}-VTO)^2(1+\lambda v_{DS})$$