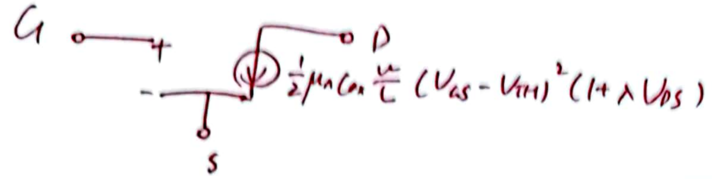
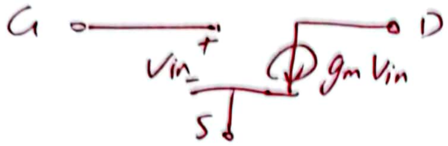
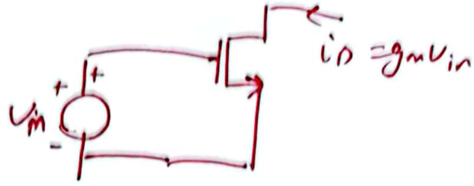
Large-Signal & Small-Signal Models (in Sat)

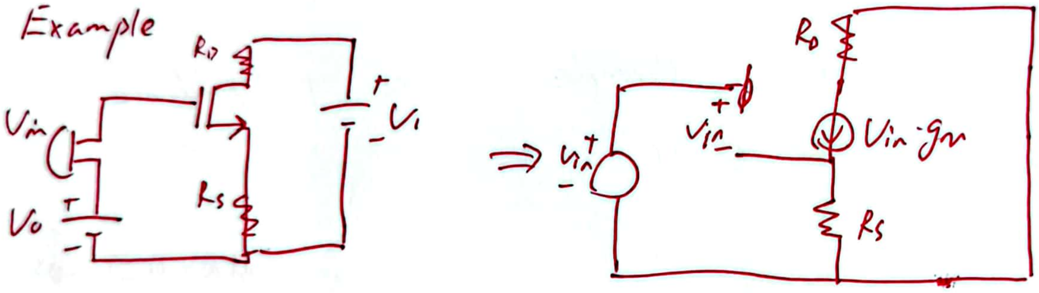






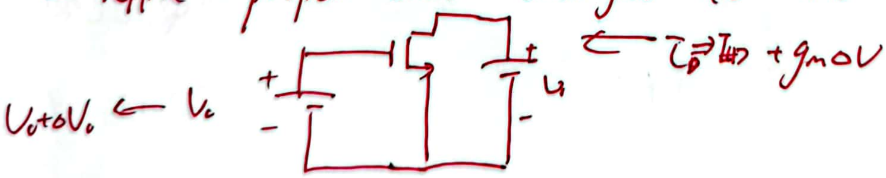
Small-Signal Models of Const Sources

Example



General Procedure of Constructing a Small-Signal Model

① Apple proper bias voltages to the device

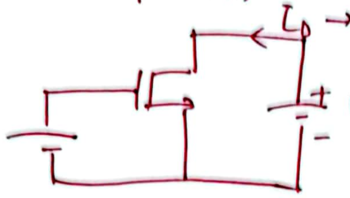


② Increament the voltage difference between two terminals

③ Measure all current increments

④ Model the change by a proper electrical device.

Increament of V_{DS}



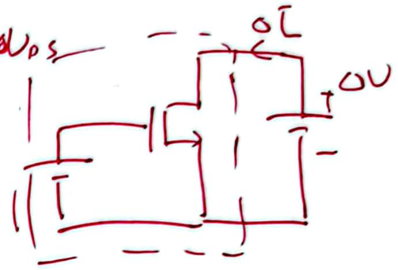
because of the Chanel-Length Modulation

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1+\lambda V_{DS})$$

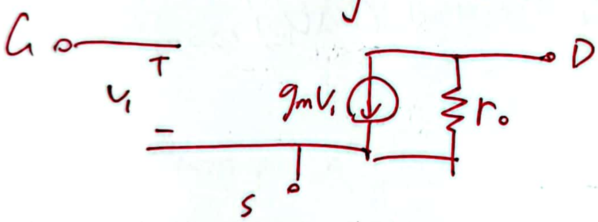
$$I_D + \Delta I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1+\lambda V_{DS}+\lambda\Delta V_{DS})$$

$$\cancel{I_D} + \Delta I_D = \cancel{I_D} + \underbrace{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2}_{\approx I_D}\lambda\Delta V_{DS}$$

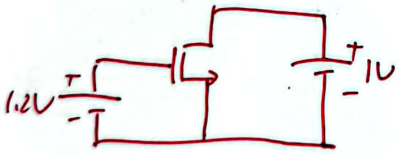
$$\frac{\Delta V_{DS}}{\Delta I_D} \approx \frac{1}{\lambda I_D} = r_o$$



We neglect the effect of Channel-length modulation on the g_m expressions



Example



$\mu_n C_{ox} = 100\,\mu A/V^2$ $\quad \frac{W}{L} = 10$

$V_{TH} = 0.5V$

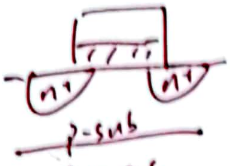
$\lambda = 0.2V^{-1}$

$V_{GS} - V_{TH} \leq V_{DS} \Rightarrow$ sat.

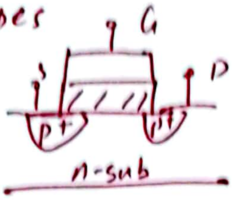
$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2 \Rightarrow r_o = \frac{1}{\lambda I_D} \Rightarrow r_o = 20.4k\Omega$

$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH}) = \frac{1}{1.43k\Omega}$

MOS Device Types



NMOS

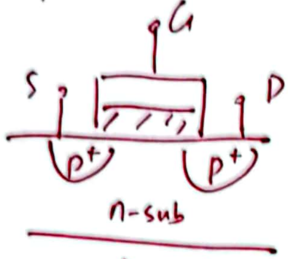


PMOS

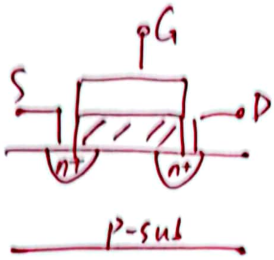
$V_G < V_S$

$V_{TH} < 0$

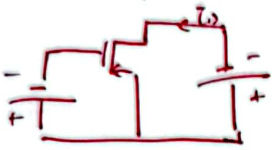
$V_D < V_S$

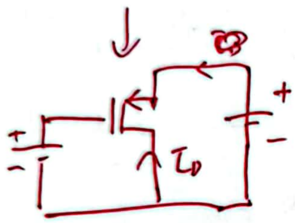


PMOS



NMOS

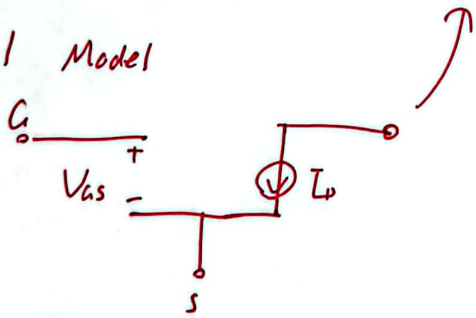


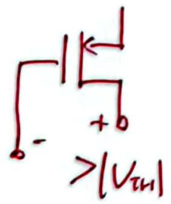


In Sat.

$$I_D = -\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1-\lambda V_{DS}) \quad (\lambda>0)$$

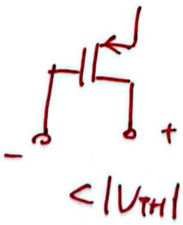
Large-Signal Model





Triode

Edge



Sat.

Small-Signal Model