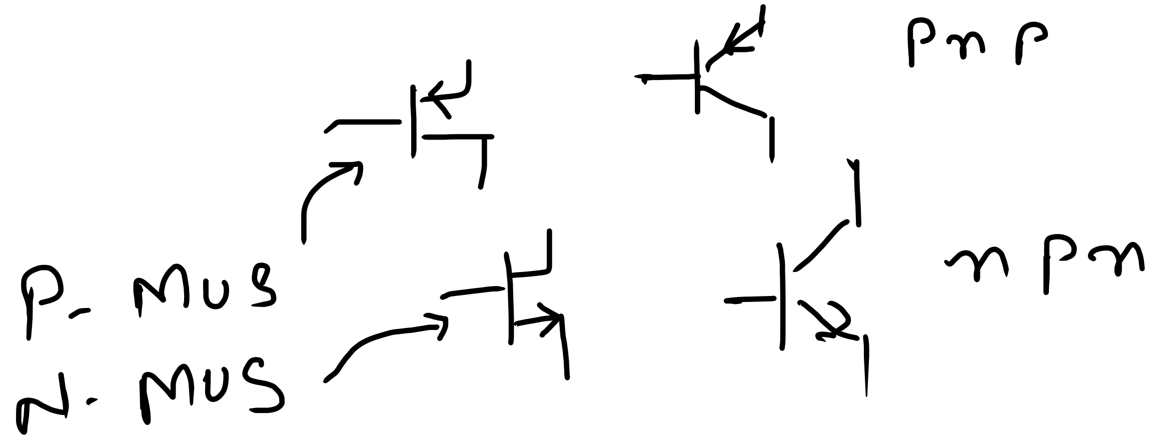
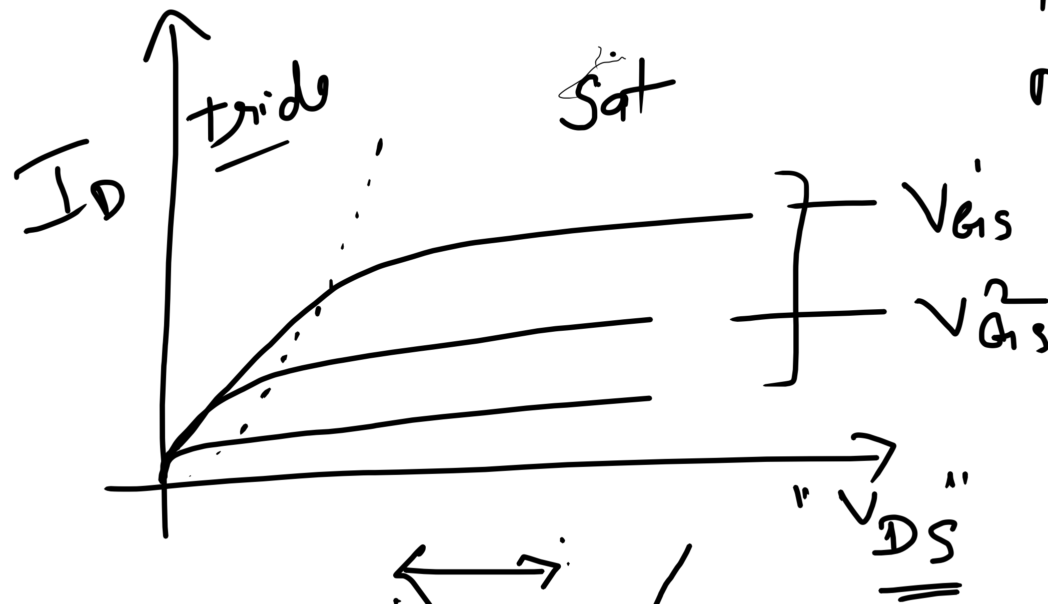
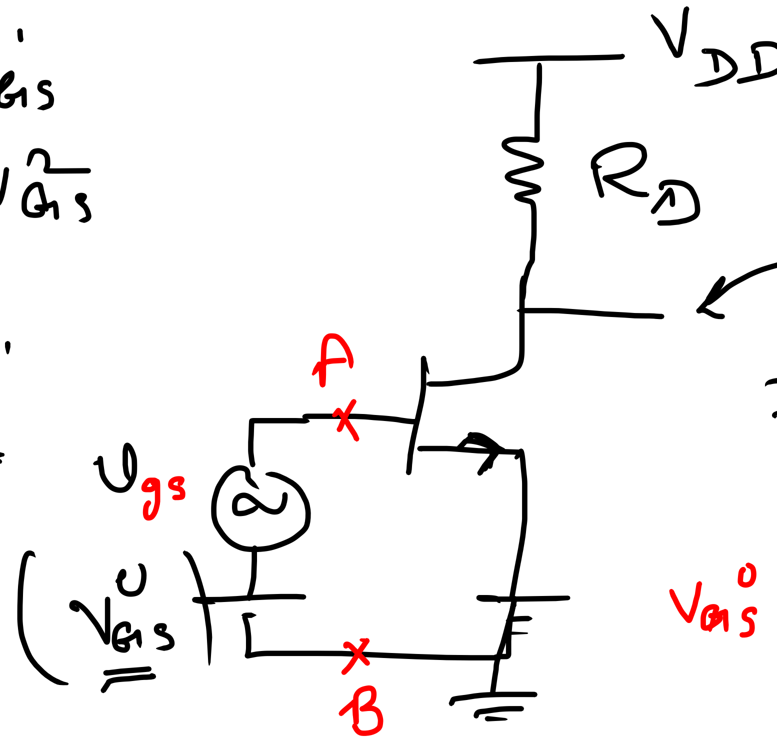
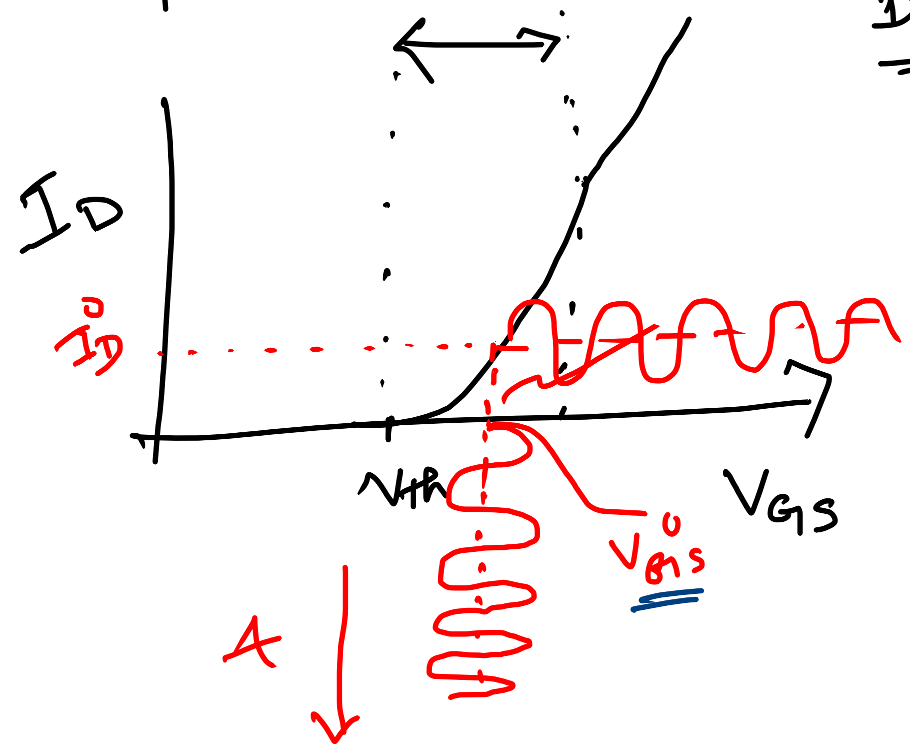
MOSFET

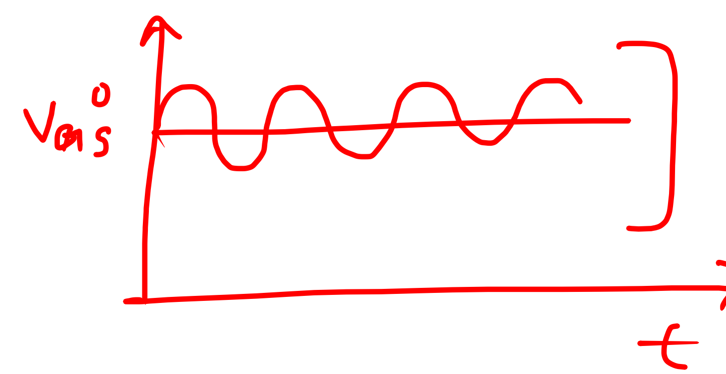






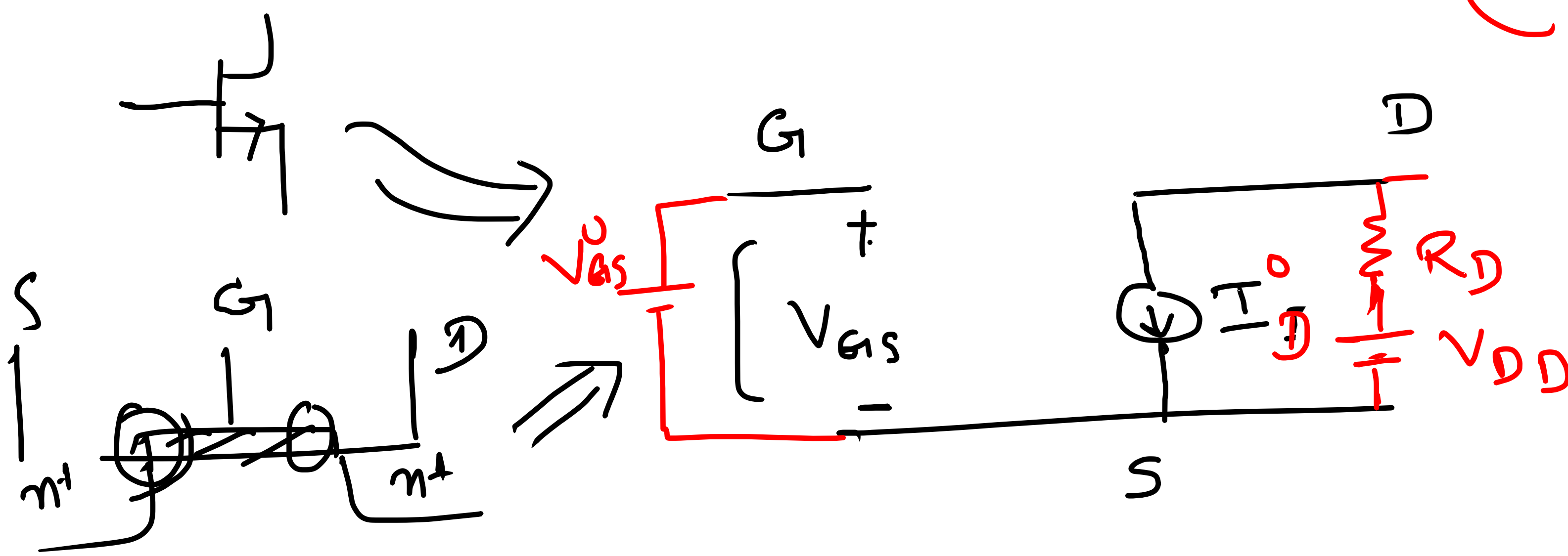
$V_{DS}^0 = V_{DD} - I_D^0 R_D$

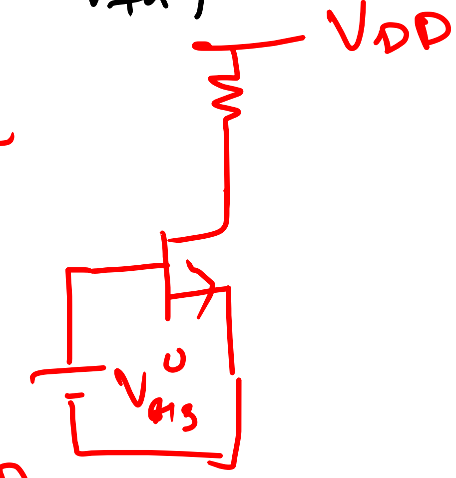




Large sig Model →

$$I_D = \frac{1}{2}\mu_n C_{ov}\frac{W}{L}\left(V_{GS} - V_{th}\right)^2 \quad (1)$$





Small sig model →

$$I_D = f(V_{GS}) \quad (V_{GS}^0, I_D^0) \quad (ii)$$

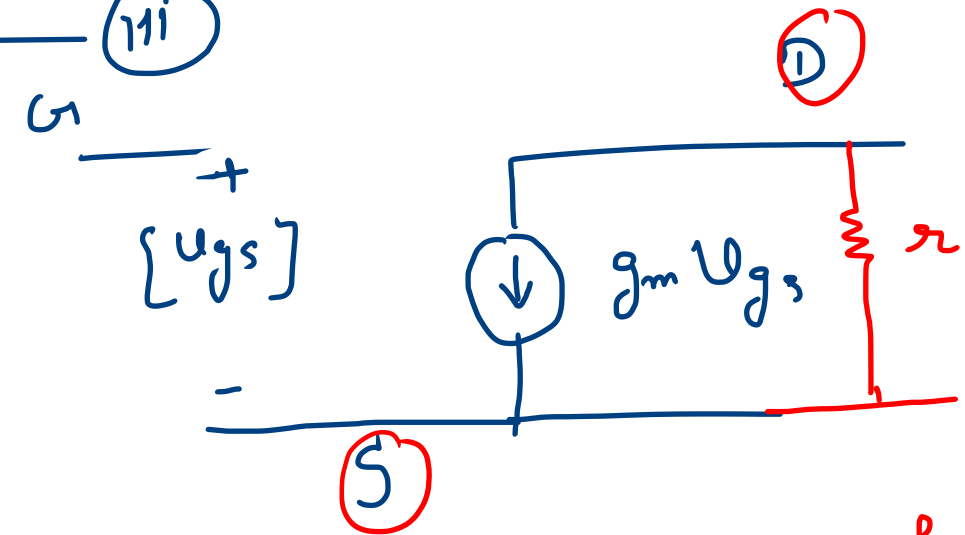
Linearize (ii) in the neighbourhood of (V_{GS}^0)

$$I_D = \underbrace{f(V_{GS}^0)}_{I_D^0} + \underbrace{\left.\frac{\partial f}{\partial V_{GS}}\right|_{V_{GS}^0}}_{g_m} \underbrace{\left(V_{GS} - V_{GS}^0\right)}_{v_{gs}} + \dots$$

$$\boxed{i_D = g_m v_{gs}} \quad \text{— (III)}$$

$$i_D = I_D - I_D^0$$

$$g_m = \left.\frac{\partial I_D}{\partial V_{GS}}\right|_{V_{GS}^0} \quad \text{— (IV)}$$



$$r_o = \frac{1}{\lambda I_D^0}$$

$$I_D = \frac{\mu C_{ox} W}{2\, L(1-\lambda V_{DS})}(V_{GS}-V_{th})^2 \simeq \underbrace{\frac{1}{2}\mu C_{ox}\frac{W}{L}(V_{GS}-V_{th})^2(1+\lambda V_{DS})}_{f(V_{GS},\, V_{DS})}$$

$$I_D = f(V_{GS}, V_{DS}) \longrightarrow (V_{GS}^0, V_{DS}^0)$$

$$I_D = \underbrace{f(V_{GS}^0, V_{DS}^0)}_{I_D^0} + \underbrace{\frac{\partial f}{\partial V_{GS}}}_{g_m} v_{gs} + \underbrace{\frac{\partial f}{\partial V_{DS}}} v_{ds}$$

$$\Rightarrow \boxed{i_D = g_m v_{gs} + r_o^{-1} v_{ds}} \quad \text{— (V)}$$

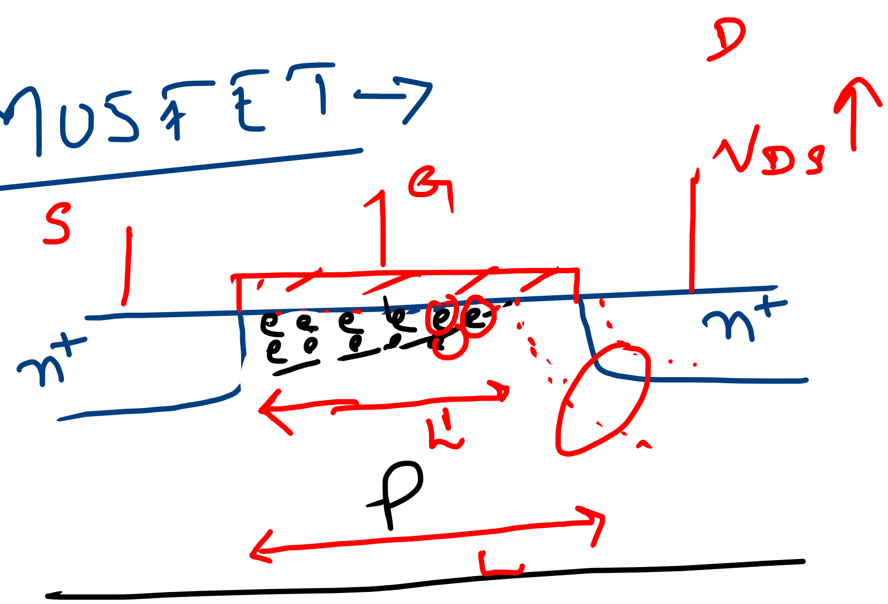
$$\frac{\partial f}{\partial V_{DS}} = \underbrace{(\ )}\lambda$$

$$\frac{\partial I_D}{\partial V_{DS}} \simeq I_D^0 \lambda$$

$$(r_o)^{-1} = I_D^0 \lambda$$

* P-MOS have same small sig

MOSFET →



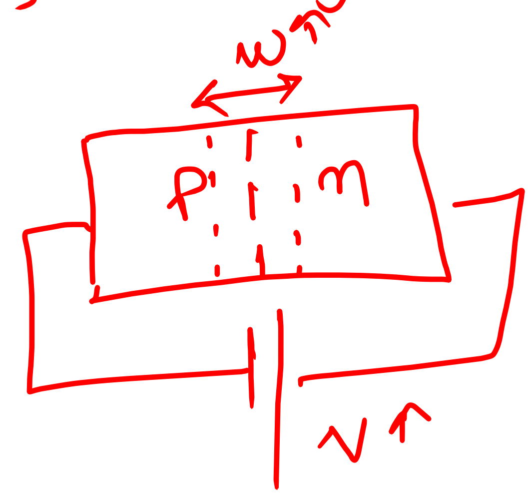
"– Minority are swept away as soon as they hit depletion region"

$V_{DS}\uparrow$, $\bigcirc$ pn depletion $\uparrow$

$L' \downarrow$ [CLM]

└→ channel length modulation

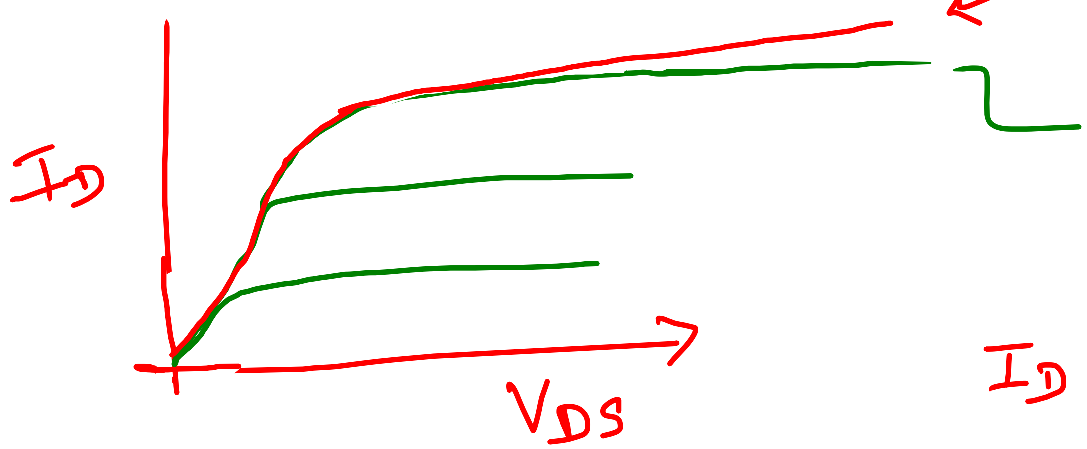
$V_{DS}\uparrow$ $\bigcirc^n$ in R.B



$L' = L(1-\lambda V_{DS})$

↓

CLM Factor

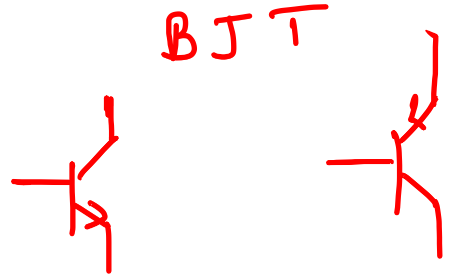


no channel length modulation

$I_D = \frac{1}{2}\mu C_{ox}\frac{W}{L'}(V_{GS}-V_{th})$

BJT & MOSFET

BJT

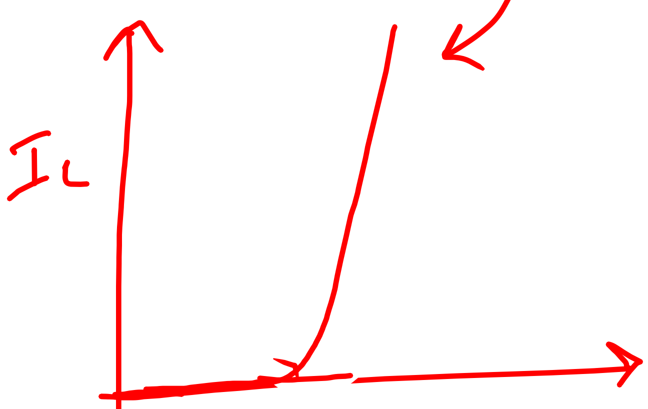


npn pnp

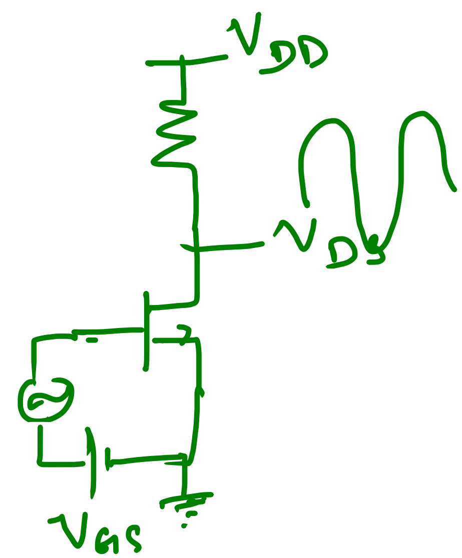
MOSFET

n-mos P-mos

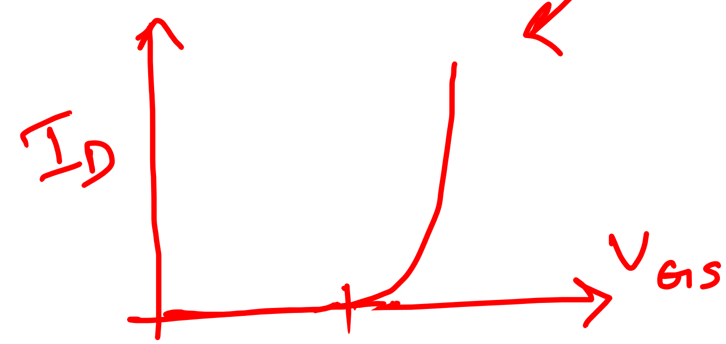
"$I_C = I_S \left(e^{\frac{V_{BE}}{V_T}} \right)$"



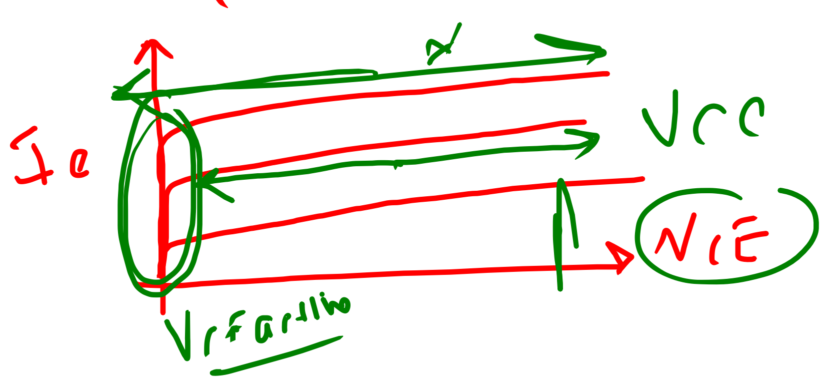
$(0.6 - 0.7\,V)$

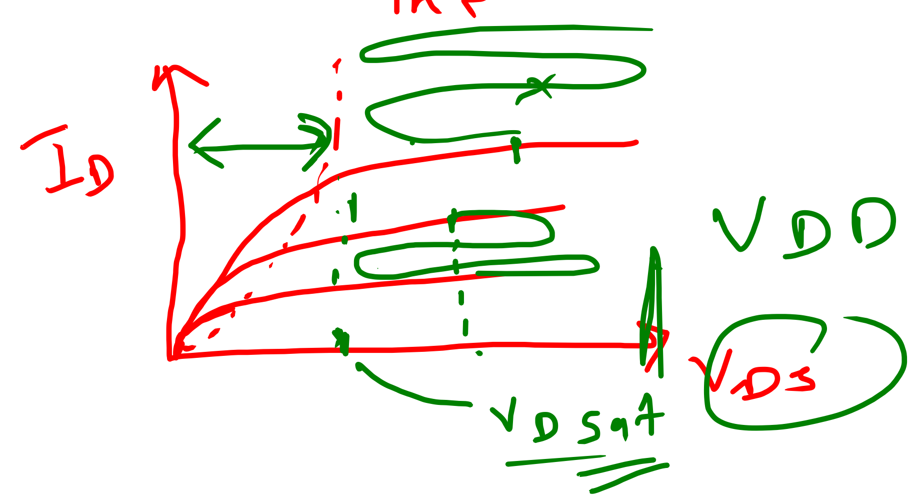


"$I_D = \frac{1}{2} \mu C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2$"

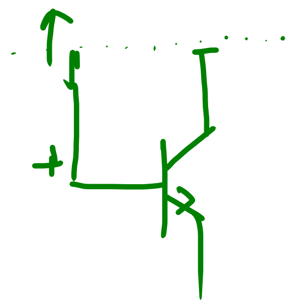


$V_{Th} \simeq 0.4 - 0.5$

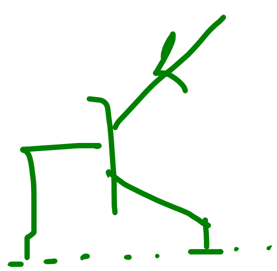




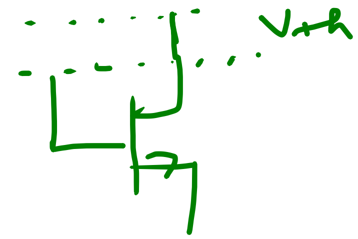
BJT



$V_B \leq V_C$



MOS



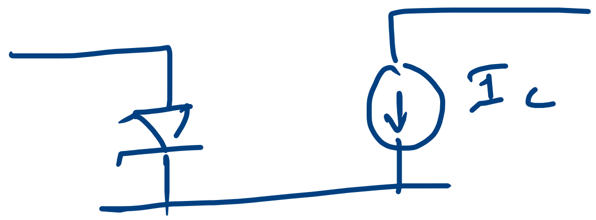
Saturation (active for amplification)

$V_{DS} > V_{GS} - V_{th}$

$V_D > V_G - V_{th}$

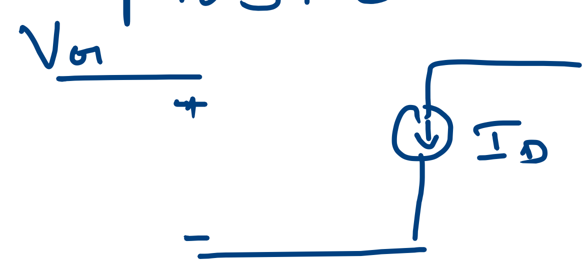
P-MOS

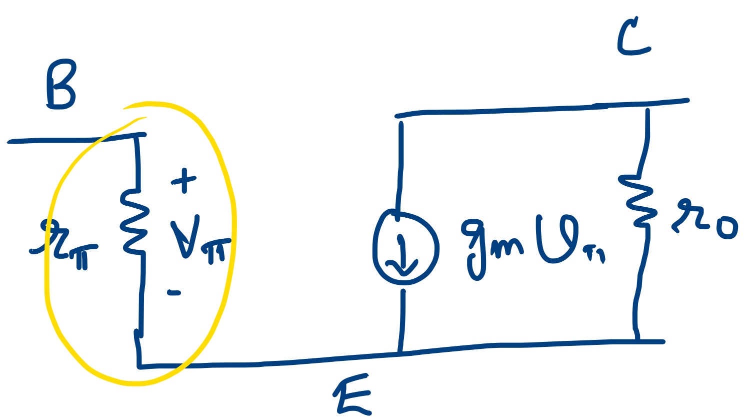
BJT

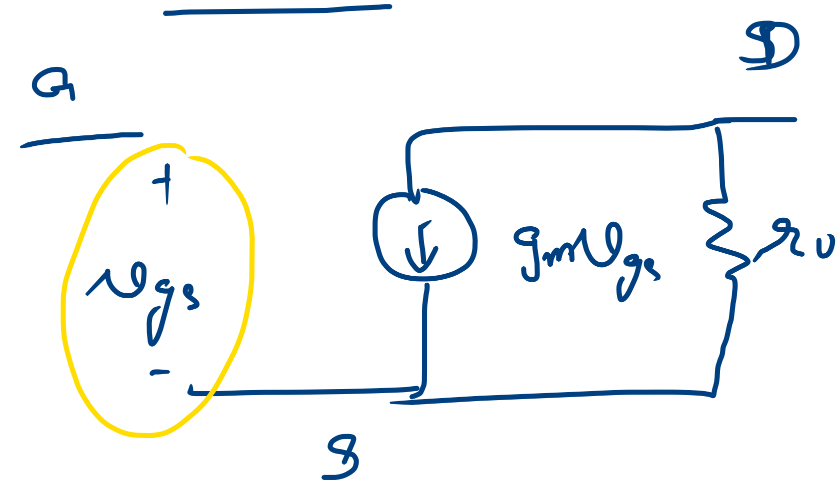


Large s/g

MOSFET







$g_m r_\pi = \beta$, $r_o = \dfrac{V_A}{I_C^0}$

$r_o = \dfrac{1}{\lambda I_D^0}$

$I_c = I_s \exp\left(\dfrac{V_{BE}}{V_T}\right)$

$g_m = \dfrac{\partial I_c}{\partial V_{BE}}\Big|_{V_{BE}^0} = \dfrac{I_c^0}{V_T}$

$g_m = \dfrac{\partial I_D}{\partial V_{GS}}$

$g_m = \mu_e C_{ox} \dfrac{W}{L} (V_{GS}^0 - V_{th})$

→ offer high g_m

→ relatively low in comp. to BJT