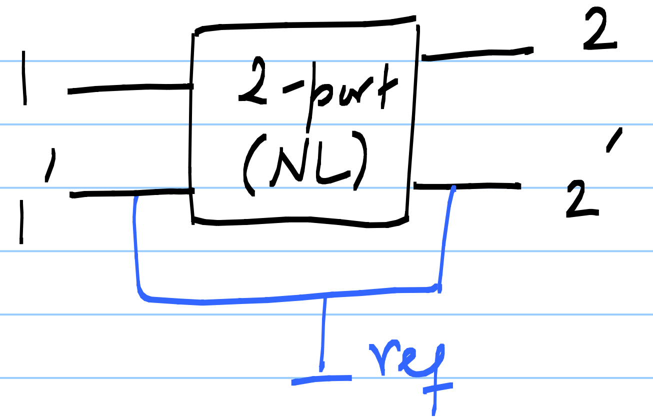
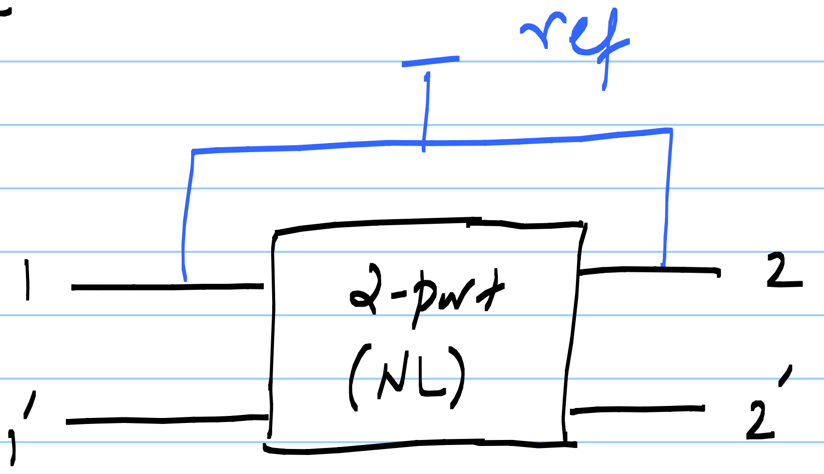
15/9/20

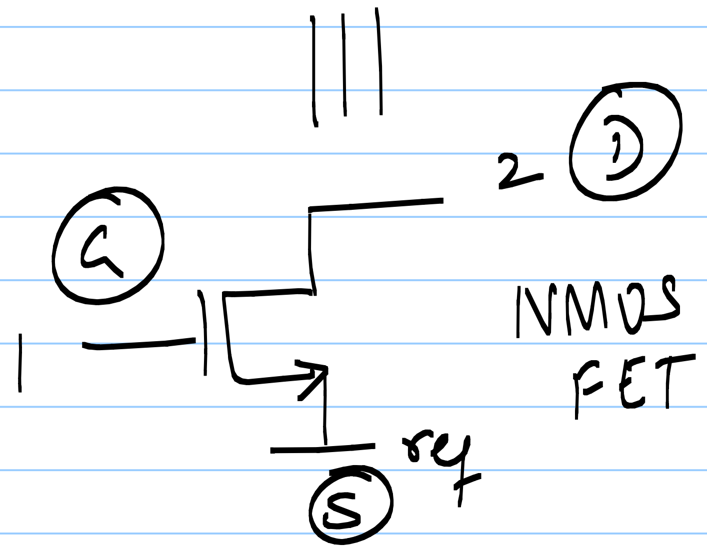
Lecture 24

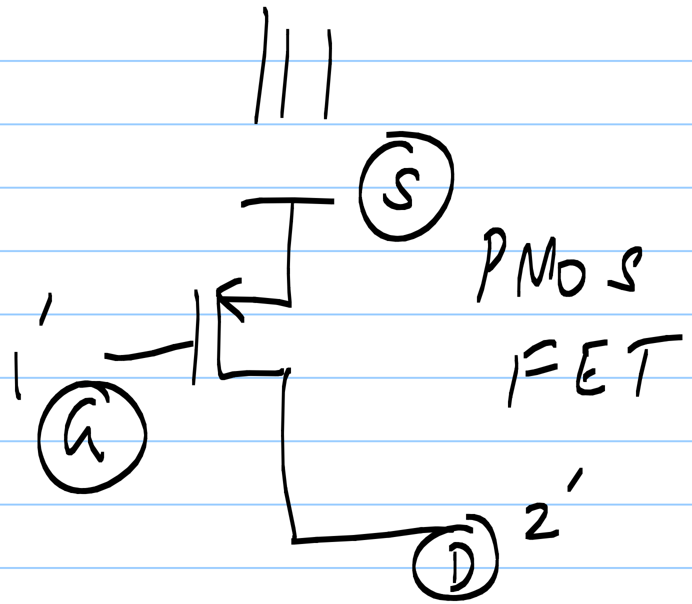


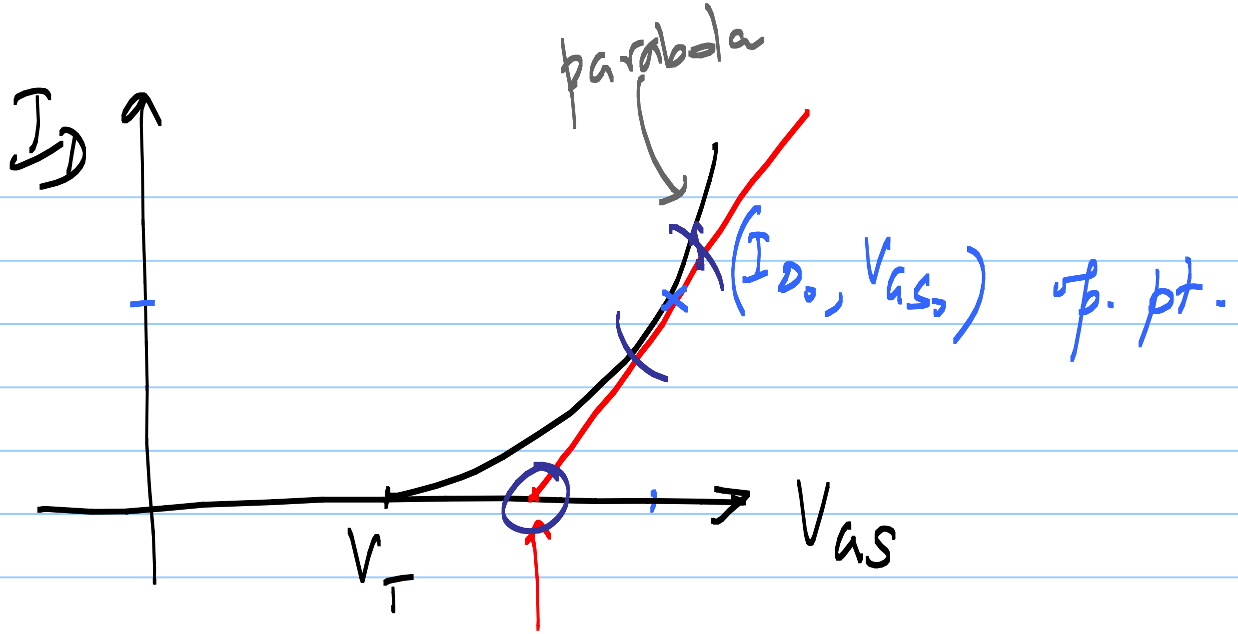


3T 2-port #1

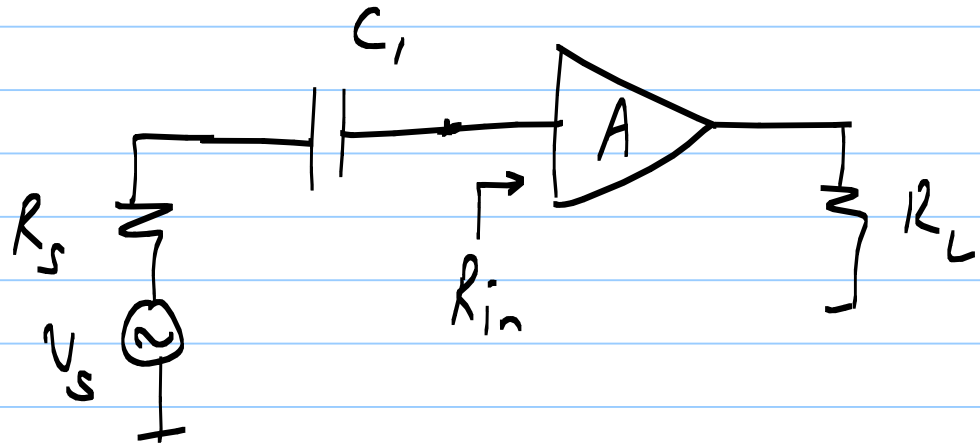
3T 2-port #2

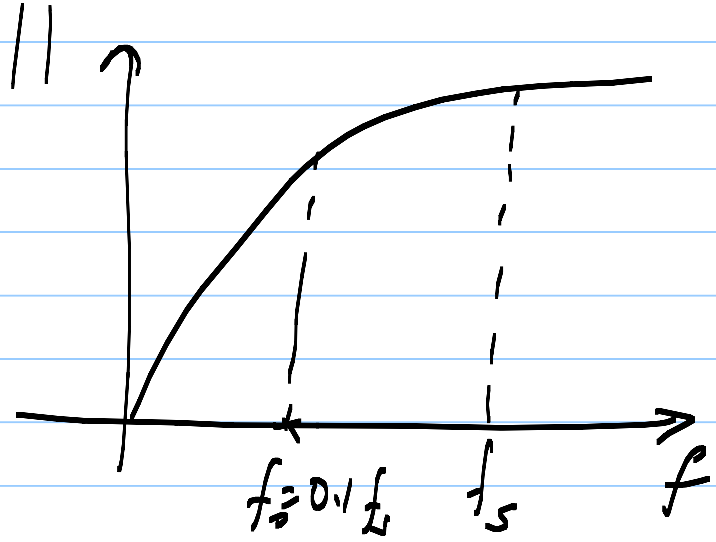


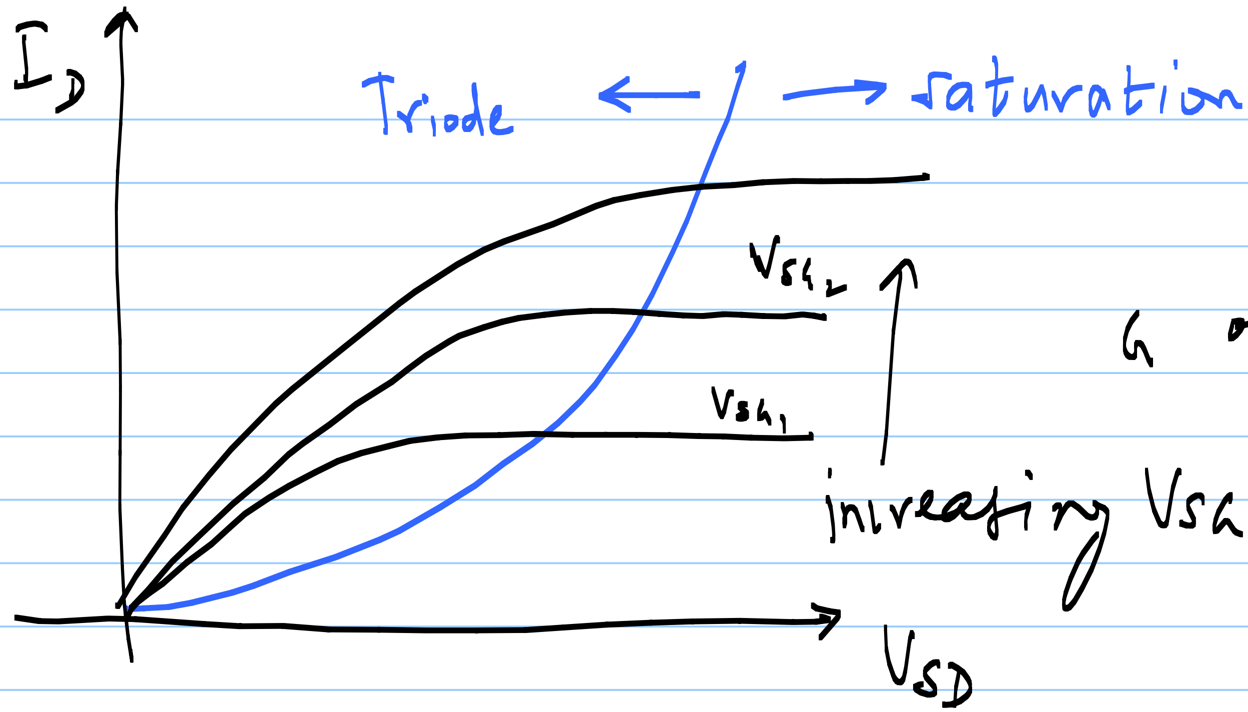




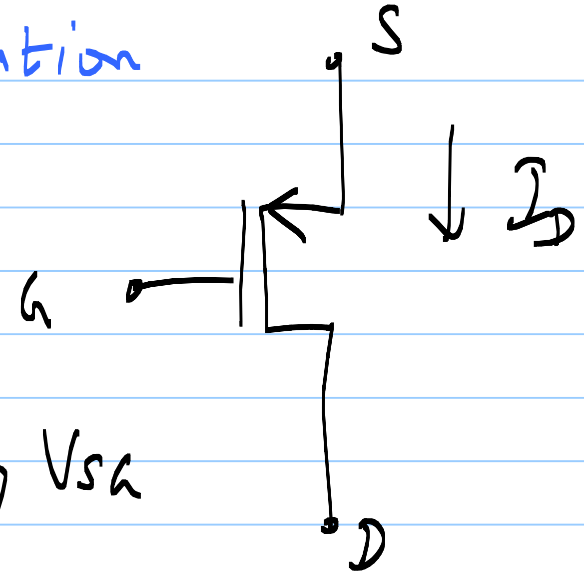
$I_D = 0$ point assuming linear approx.





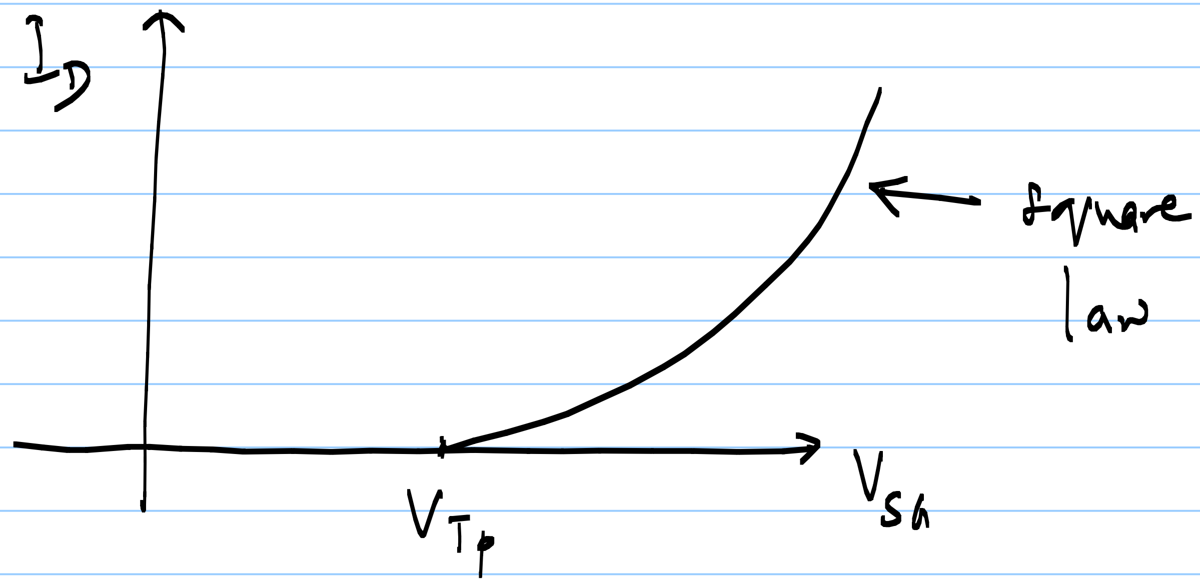


I_D
Triode
saturation
V_SG2
V_SG1
increasing V_SG
V_SD



S
I_D
G
D

$I_G = 0$



I_D
square law
V_Tp
V_SG

$$I_D = 0 \quad \text{if} \quad V_{SG} < V_{Tp} \qquad \text{(OFF)}$$

$$= \frac{1}{2}\mu_p C_{ox}\left(\frac{W}{L}\right)\left[V_{SG} - V_{Tp}\right]^2 \cdot (1+\lambda_p V_{SD}) \qquad \text{(SAT)}$$

if $V_{SG} > V_{Tp}$ and $V_{SD} \geq V_{SG} - V_{Tp}$

i.e. $V_D \leq V_G + V_{Tp}$

$$= \mu_p C_{ox}\left(\frac{W}{L}\right)\left[(V_{SG}-V_{Tp})V_{SD} - \frac{V_{SD}^2}{2}\right] \qquad \text{(TRIODE)}$$

if $V_{SG} > V_{Tp}$ and $V_D > V_G + V_{Tp}$

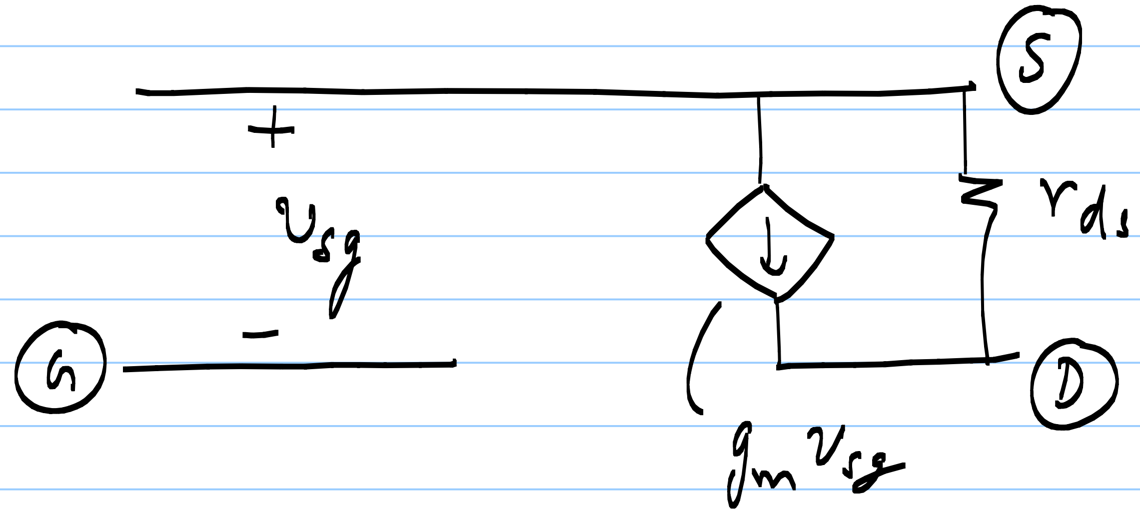
Small-signal

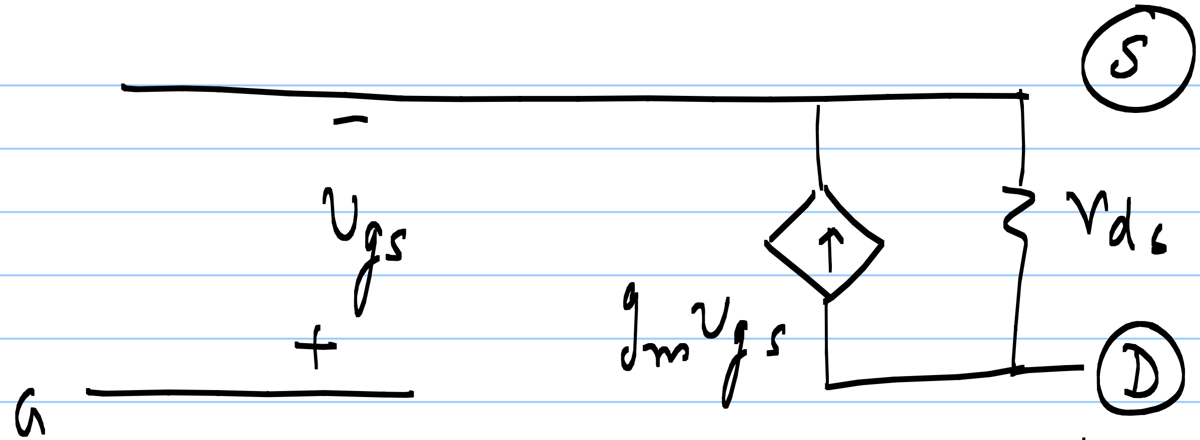
$y_{11} = 0$; $y_{12} = 0$

$$y_{21} = g_m = \mu_p C_{ox} \left(\frac{W}{L}\right)(V_{SG} - V_{Tp})$$

HW 10 : 2 other expressions for g_m

$$y_{22} = g_{ds} = \frac{1}{r_{ds}} = \lambda_p \cdot I_D$$



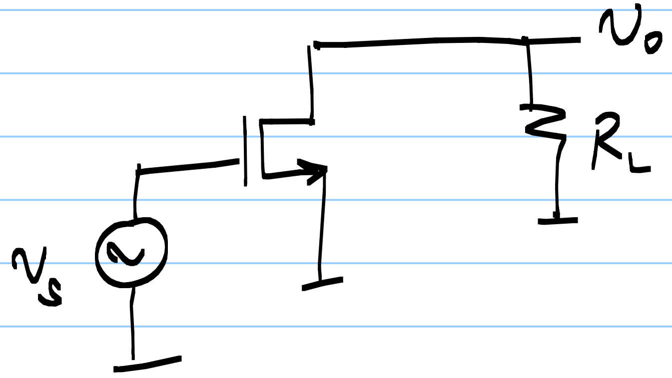


Exactly same ss model as for NMOS

NMOS	PMOS
* DC I_D flows into D	DC I_D flows out of D
* For sat., $V_D >> V_S$ $V_D \geq V_G - V_{Tn}$	For sat.: $V_D << V_S$ $V_D \leq V_G + V_{Tp}$
* $V_{GS} \geq V_{Tn}$ for $I_D > 0$	$V_{SG} \geq V_{Tp}$ for $I_D > 0$
* $V_{Tn} > 0$ for enhancement mode device	$V_{Tp} > 0$ for enhancement mode device

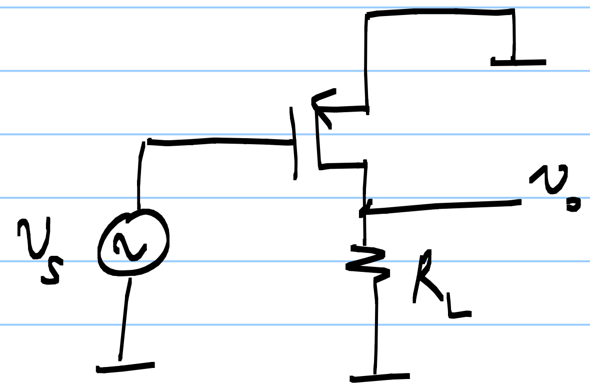
Common Source Amplifier

NMOS

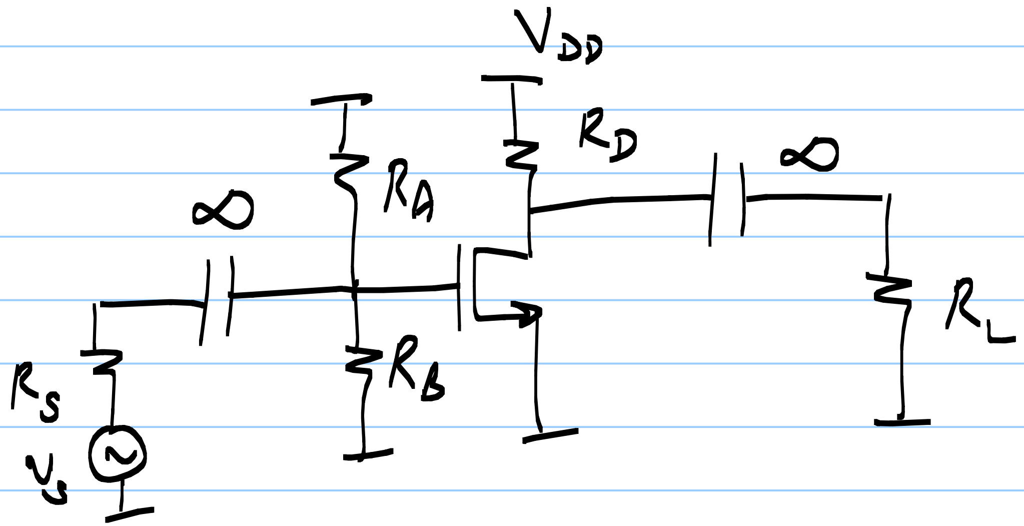


$$\frac{v_o}{v_s} = -g_{m_n} R_L$$

PMOS



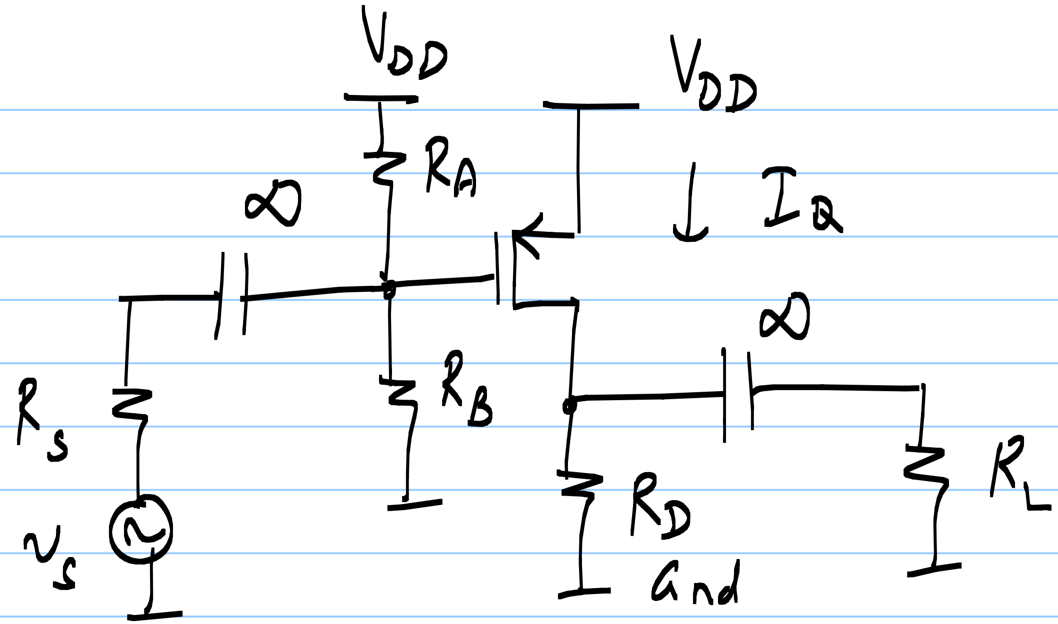
$$\frac{v_o}{v_s} = -g_{m_p} R_L$$



NMOS

CSA

$$V_{GS_n} = \frac{R_B}{R_A + R_B} V_{DD}$$



PMOS Common-source amplifier

$$I_Q = \frac{1}{2} \mu_p C_{ox} \left(\frac{W}{L}\right) \left(V_{SG_Q} - V_{T_p}\right)^2$$

$$V_{SG_Q} = \frac{R_A}{R_A + R_B} \cdot V_{DD} \quad ; \quad V_{SD_Q} = V_{DD} - I_Q \cdot R_D$$

$$V_{S,Q} = V_{DD} \quad ; \quad V_{G,Q} = \frac{R_B}{R_A + R_B} \cdot V_{DD}$$

$$V_{D,Q} = I_Q \cdot R_D$$