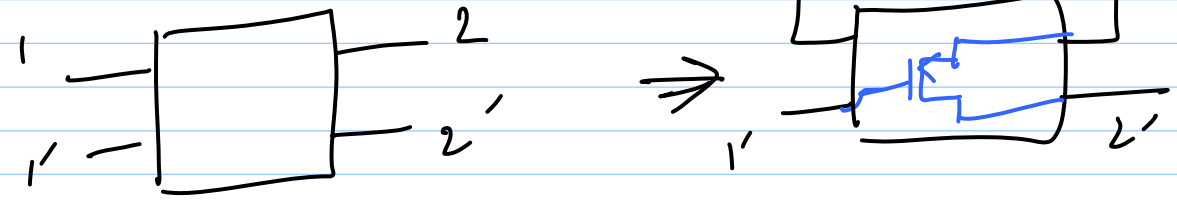
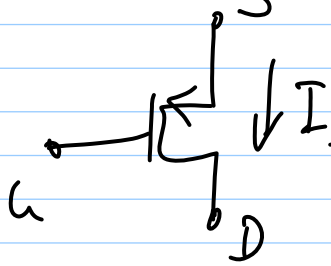
10-10-12

Lec 29

PMOS transistor



o.p. X

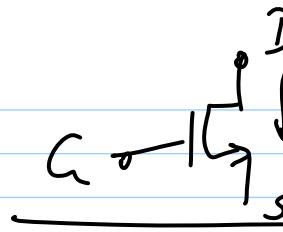


Sat.

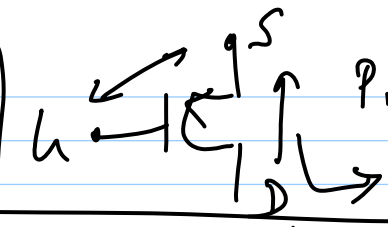
$$I_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(V_{SG}-V_{T_p})^2(1+\lambda_p V_{SD})$$

non-sat. (triode)

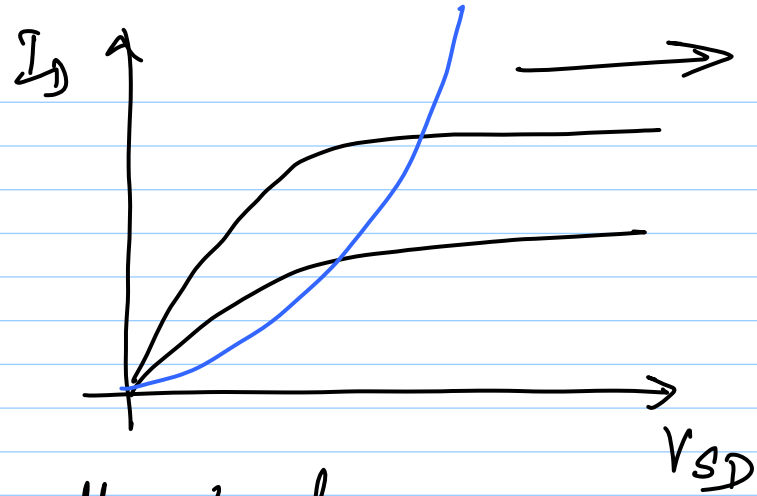
$$I_D = \mu_p C_{ox}\frac{W}{L}\left\{(V_{SG}-V_{T_p})V_{SD}-\frac{V_{SD}^2}{2}\right\}$$



* I_D flows into (D)
* For sat. $V_D >> V_S$
  $\Rightarrow$ V_D can go on V_T below V_G
* $V_{GS} \geq V_{TN}$ for $I_D > 0$
* $V_{T_n} > 0$ for enhancement mode device



* I_D flows out of (D)
* For sat. $V_D << V_S$
  $\Rightarrow$ V_D can go V_T above V_G $(V_D \leq V_G + V_T)$
* $V_{SG} \geq V_{T_p}$ for $I_D > 0$
* $V_{T_p} > 0$ for enh. mode PMOS

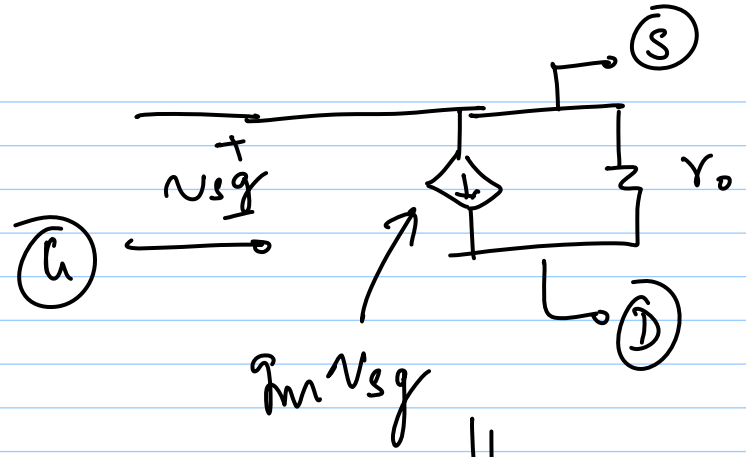


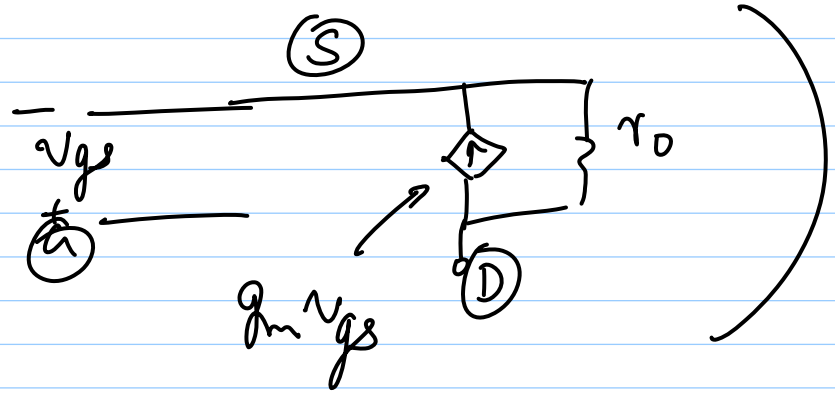
Small-signal eqv.

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

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

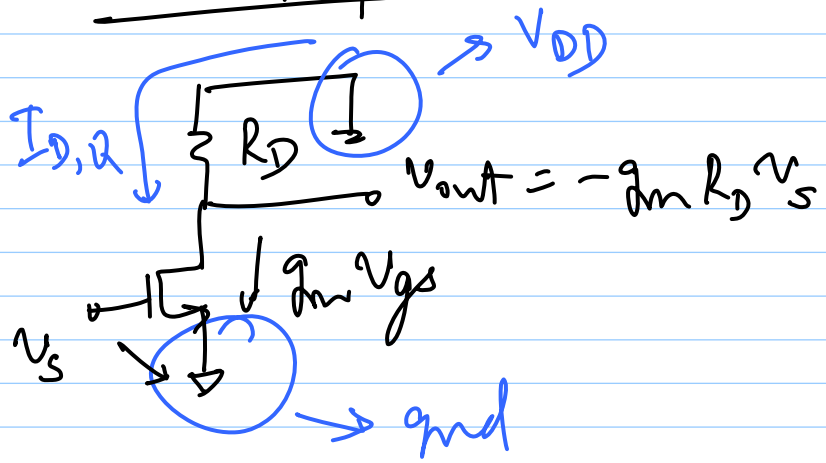
$y_{22} = \frac{1}{r_o} = \lambda I_D = g_o$

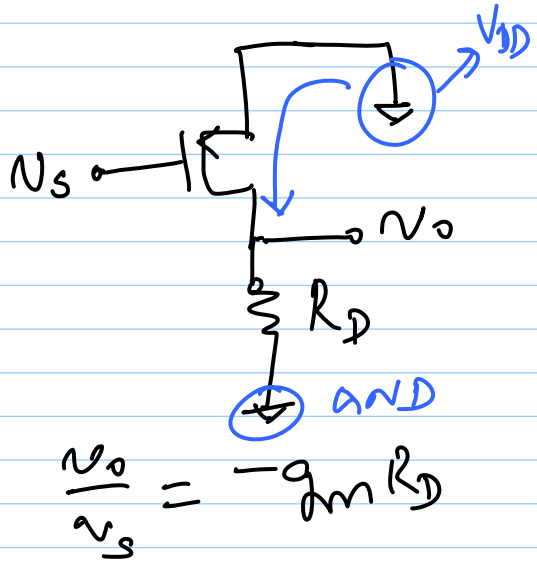


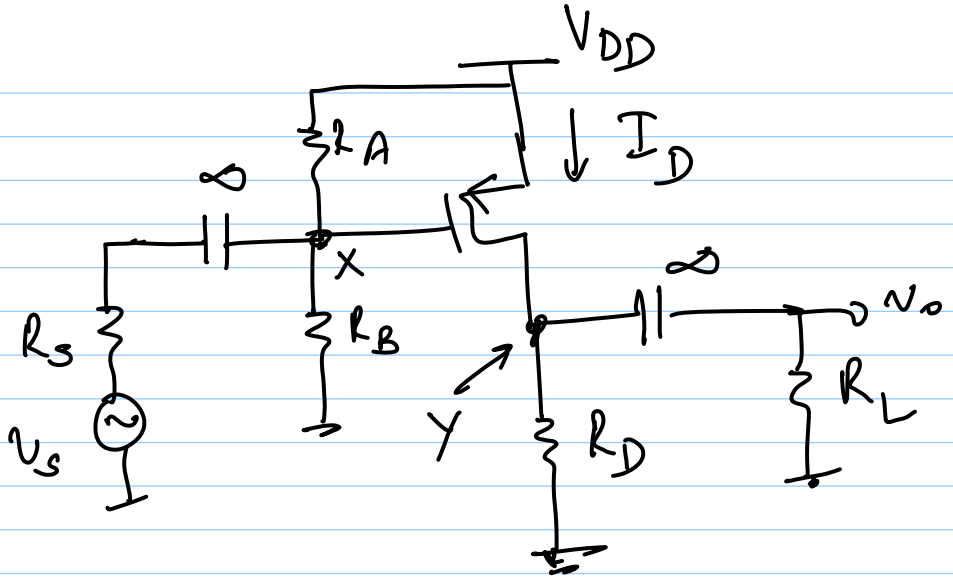


same as NMOS device

C.S. Amp







* $v_x \simeq v_s \Rightarrow R_A \| R_B \gg R_S$

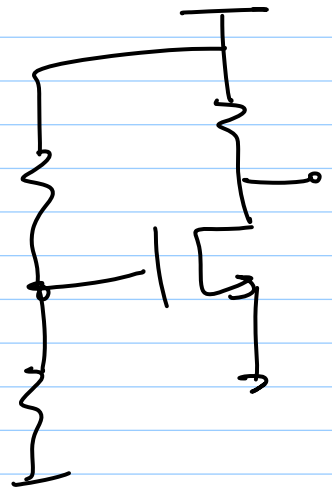
$V_{Y,Q} = I_D \cdot R_D$

$V_{X,Q} = \frac{R_B}{R_A + R_B} \cdot V_{DD}$

for sat.,

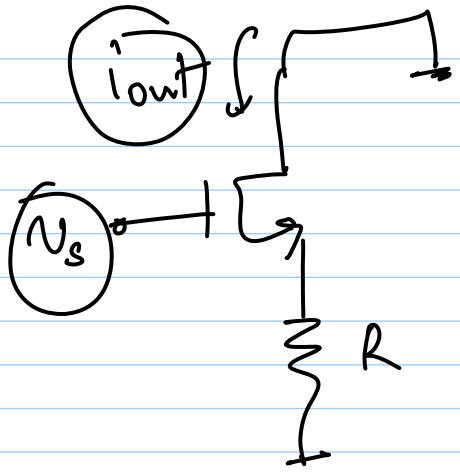
$V_{Y,Q} \leq V_{X,Q} + V_{TP}$

$I_D \cdot R_D \leq (\quad) V_{DD} + V_{TP}$



$$V_{O,Q} = V_{DD} - I_D R_D$$

$$V_{DD} - I_D R_D \geq V_{G,Q} - V_{T_n}$$



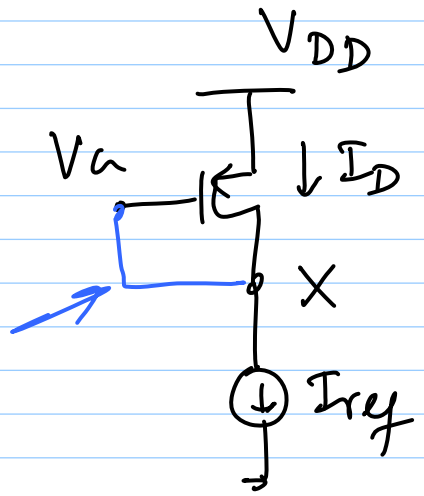
$$i_{out} = \frac{g_m}{1 + g_m R} \cdot v_{in}$$

$g_m \gg 1/R$

$$\Rightarrow \boxed{i_{out} = \frac{v_{in}}{R}}$$

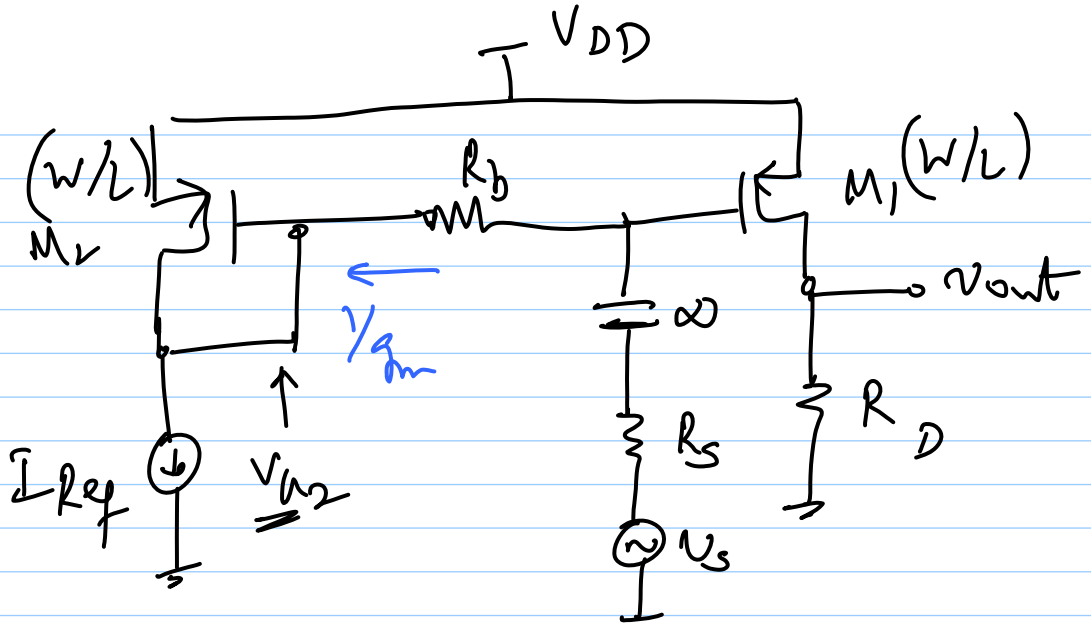
Bias Stabilisation

(I)



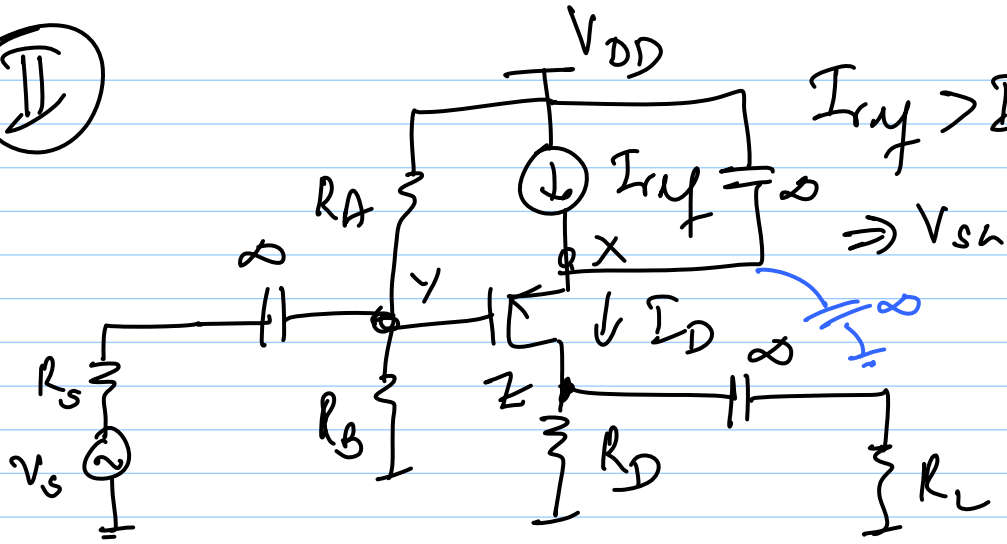
$I_D > I_{ref} \Rightarrow V_X \uparrow$

$\Rightarrow$ need to $\uparrow V_A$



Current mirror

II



$I_{ref} > I_D \Rightarrow V_x \uparrow$

$\Rightarrow V_{SG_p} \uparrow \Rightarrow I_D \uparrow$

$$V_{Z,Q} = I_{ref} \cdot R_D$$

$$V_{Y,Q} = \frac{R_B}{R_A + R_B} \cdot V_{DD}$$

$$V_{X,Q} = V_{Y,Q} + V_{SG}$$

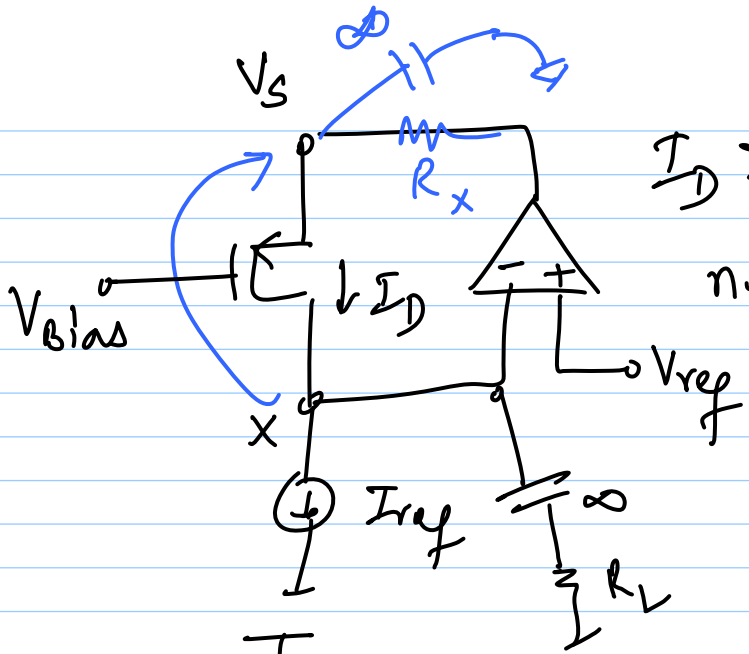
cut off

$I_{tot.} = I_D + i_d$

triode

$V_D = V_G + V_T$

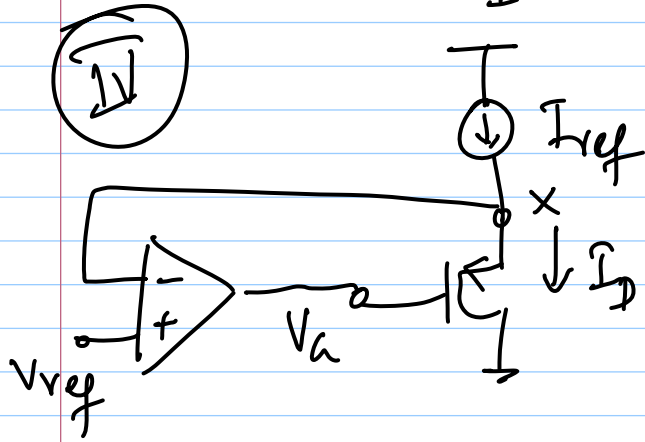
III



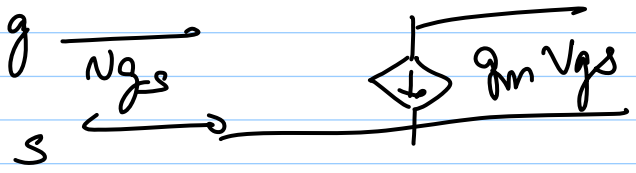
$I_D > I_{ref} \Rightarrow V_x \uparrow$

need to $\downarrow V_S$

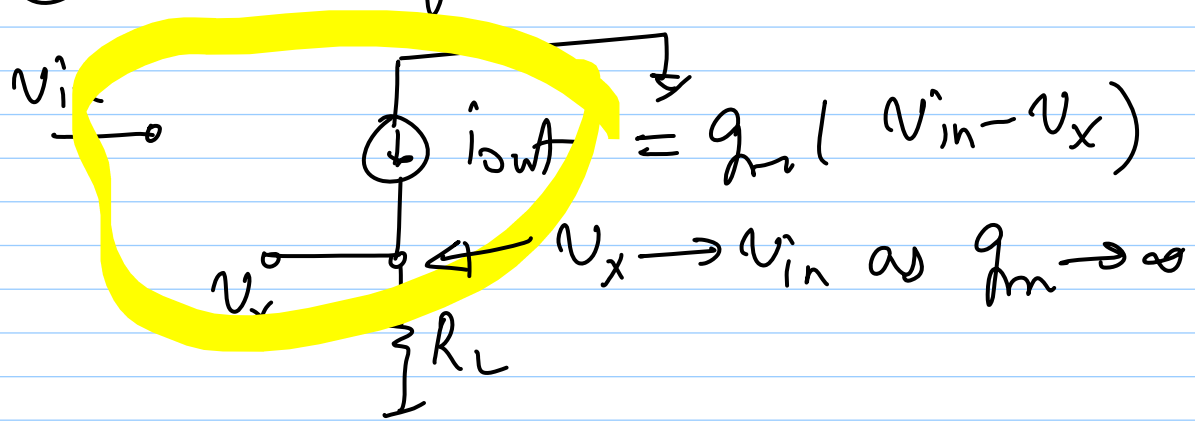
IV

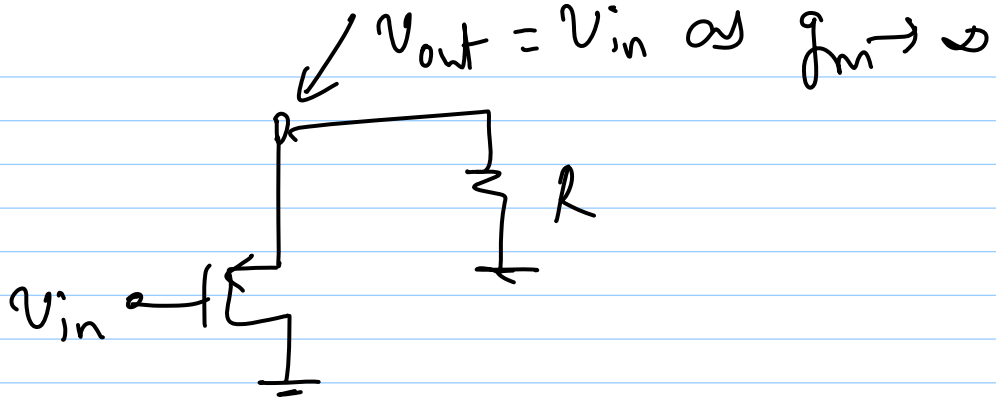


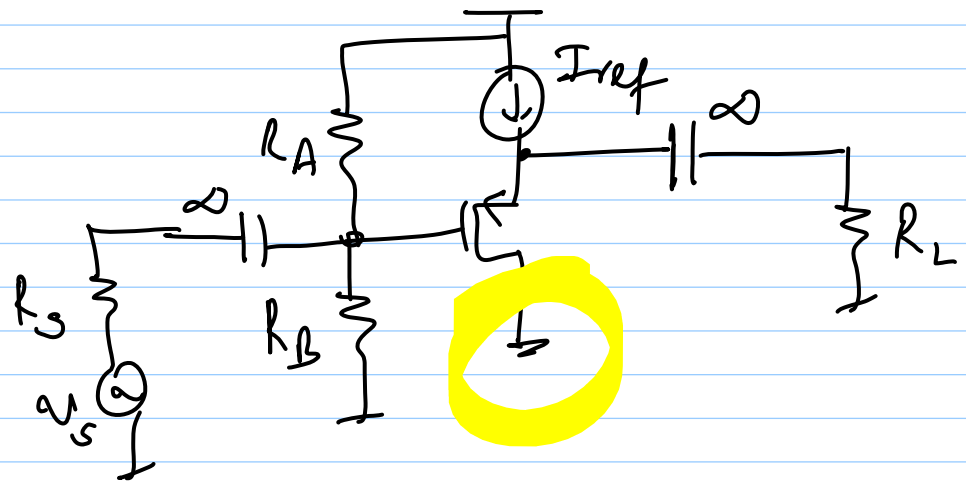
Controlled Sources



① VCVS gain = 1







Common Drain Amp. (PMOS)