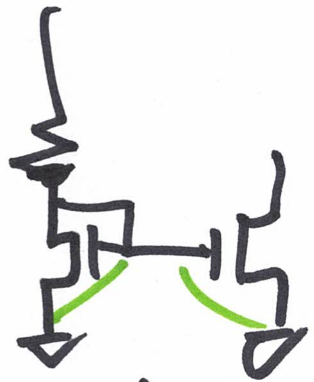
# EE 420/ECG 620

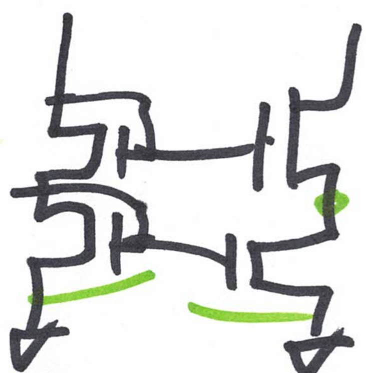
# Analog IC Design

## Lecture 11

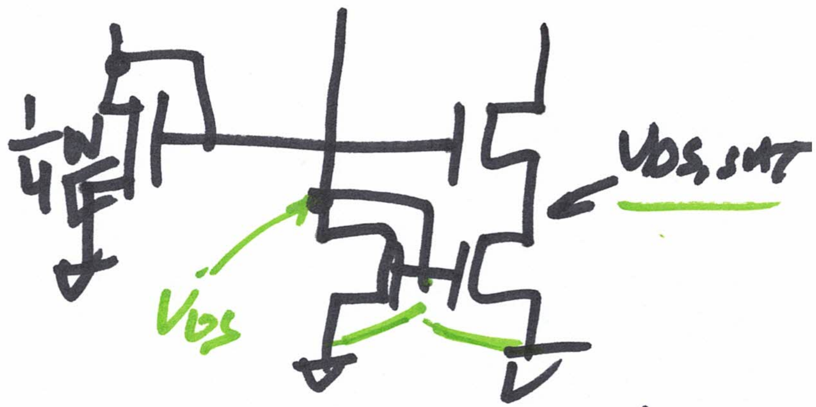
MARCH 2, 2020



BASIC current mirror



CASCODE



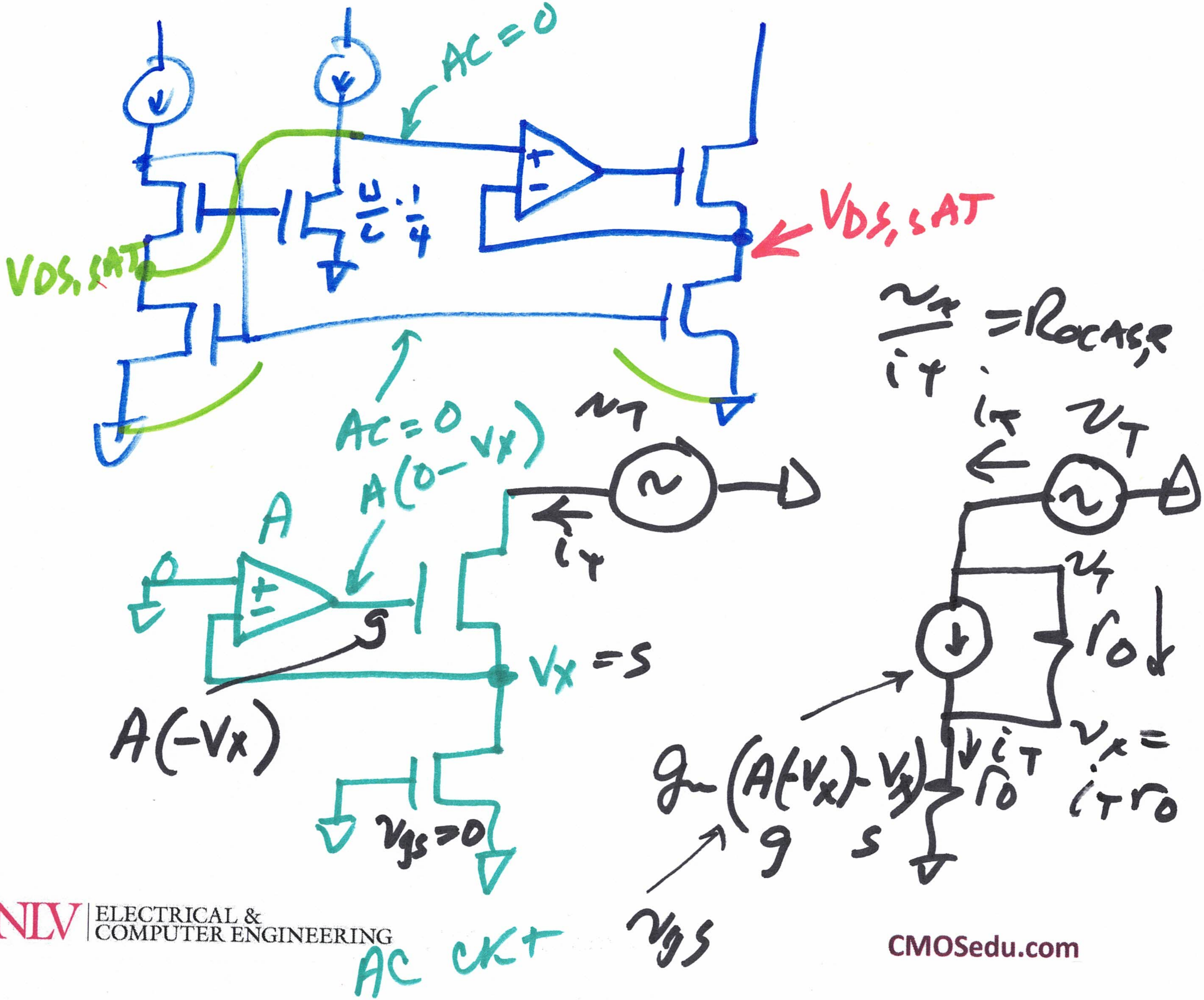

wide-swing

Vds + Vds,sat

1/10 1/5 1/4 W/L




1) wide-swing better matching

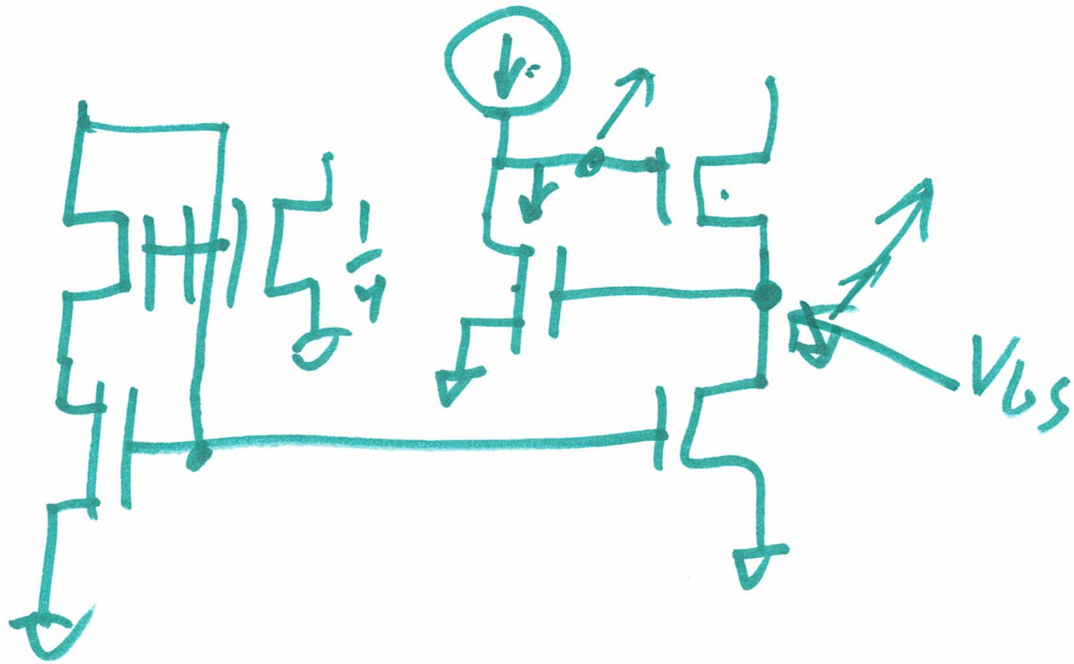

AC=0
W/L = 1/4
VDS,SAT
VDS,SAT
AC=0
A(0−Vx)
A
0
vT
iT
Vx = S
A(−Vx)
vgs=0
AC ckt
vgs
vx/iT = Rocasc
iT
vT
vx
ro
gm(A(−Vx)−Vx)
g
s
iT
ro
vx = iT ro

$$i_T = -g_m \cdot v_x (A+1) + \frac{v_T - v_x}{r_o}$$

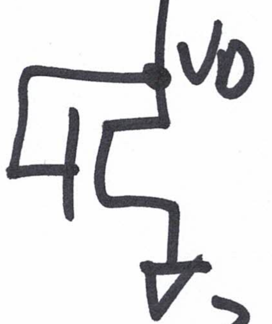
$$v_x = i_T r_o$$

$$i_T \left( r_o + g_m r_o^2 (A+1) + r_o \right) = v_T$$

$$\frac{v_T}{i_T} = R_{ocas,e} \approx g_m r_o^2 \cdot (A+1)$$


VGS

# Amplifiers



$V_D = V_G$

$V_{DS} \overset{?}{\geq} V_{GS} - V_{THN}$

$V_D - \cancel{V_S} \geq V_G - \cancel{V_S} - V_{THN}$

$V_D \overset{?}{\geq} V_G - V_{THN}$

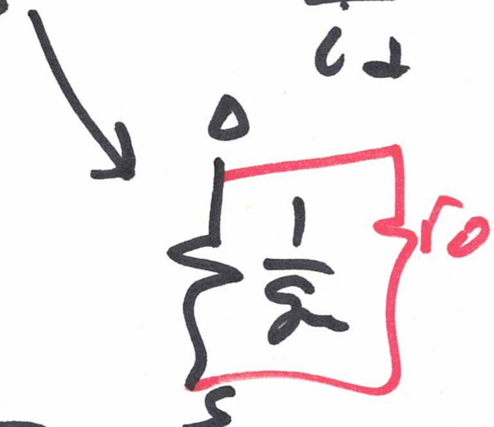
$0 \geq -V_{THN}$ yes!

in SAT!

$\downarrow i_d = g_m v_{gs}$

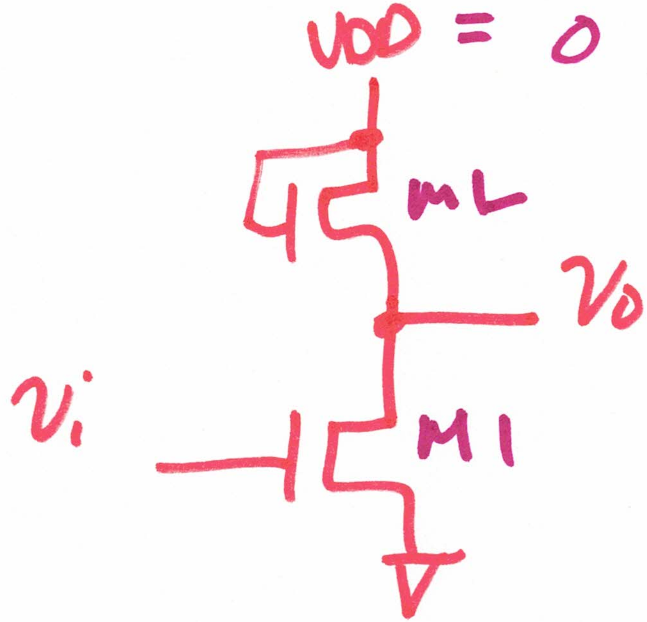
$+$ $v_{gs}$ $-$

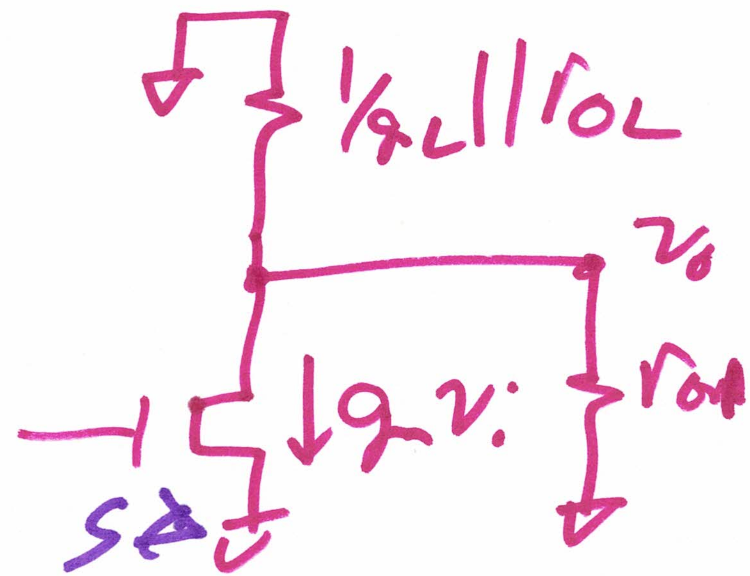
$\frac{v_{gs}}{i_d} = \frac{1}{g_m}$

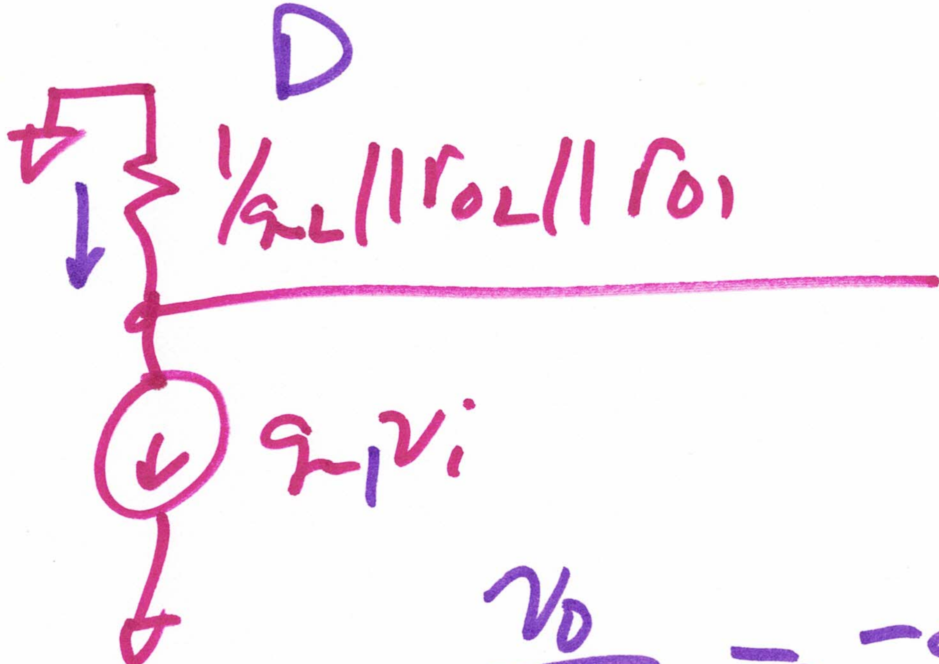




$\approx 1/g_m$



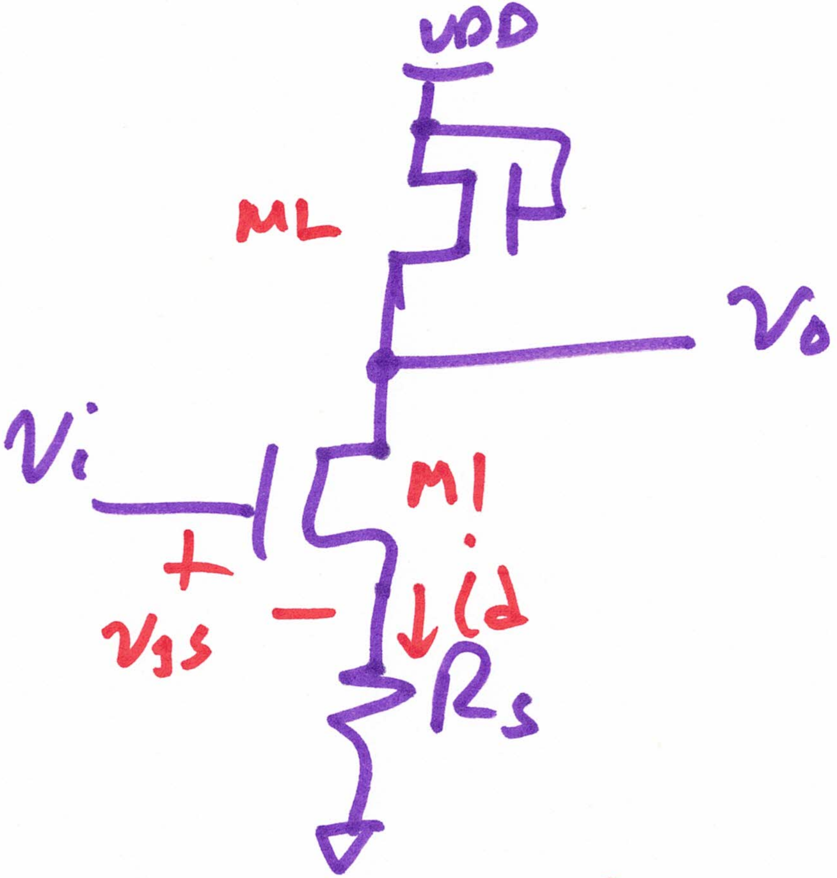

$$v_o = -g_m v_i \cdot \left(\frac{1}{g_{mL}} \| r_{oL} \| r_{o1}\right)$$

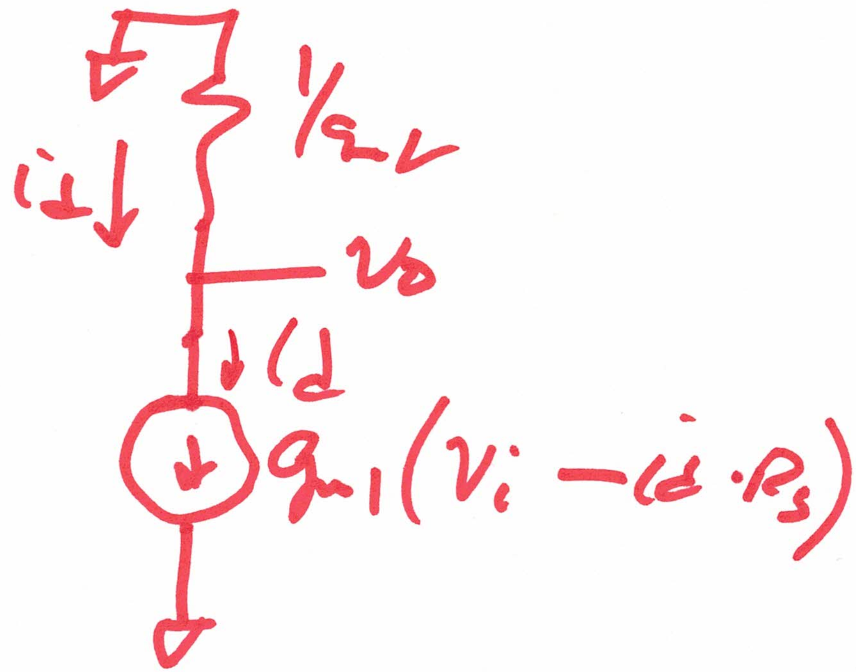
$$\frac{v_o}{v_i} = -g_{m1} \cdot \left(\frac{1}{g_{mL}} \| r_{oL} \| r_{o1}\right)$$

$$\approx -\frac{1/g_{mL}}{1/g_{m1}}$$

D

S




$$v_o = -i_d \cdot 1/g_{mL}$$

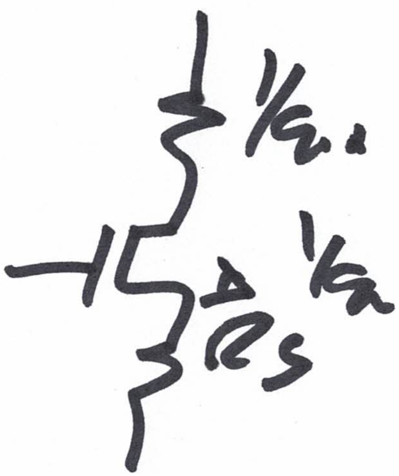
$$i_d = g_{m1}(v_i - i_d R_s)$$

$$i_d(1 + g_{m1} R_s) = v_i \cdot g_{m1}$$

$$\frac{v_o}{v_i} = \frac{-\cancel{i_d} \cdot 1/g_{mL}}{\frac{\cancel{i_d}}{g_{m1}} \cdot (1 + g_{m1} \cdot R_s)}$$

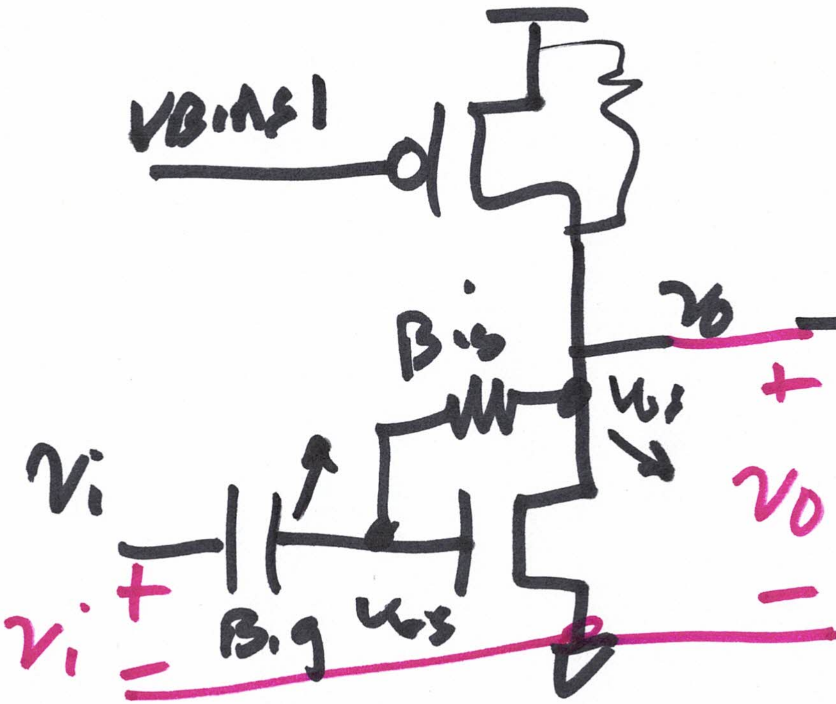
$$\frac{v_o}{v_i} = \frac{-1/g_{mL}}{1/g_{m1} + R_s}$$

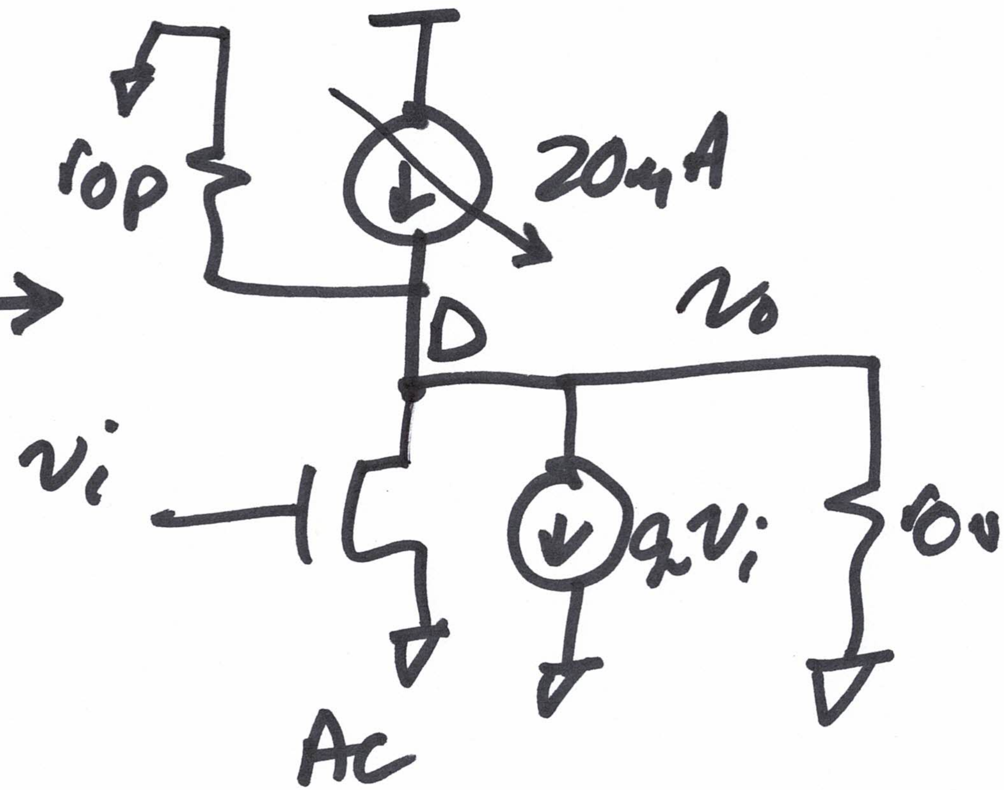
C.S.




$$= \frac{\text{Res. in Drain}}{\text{Res. in Src}}$$

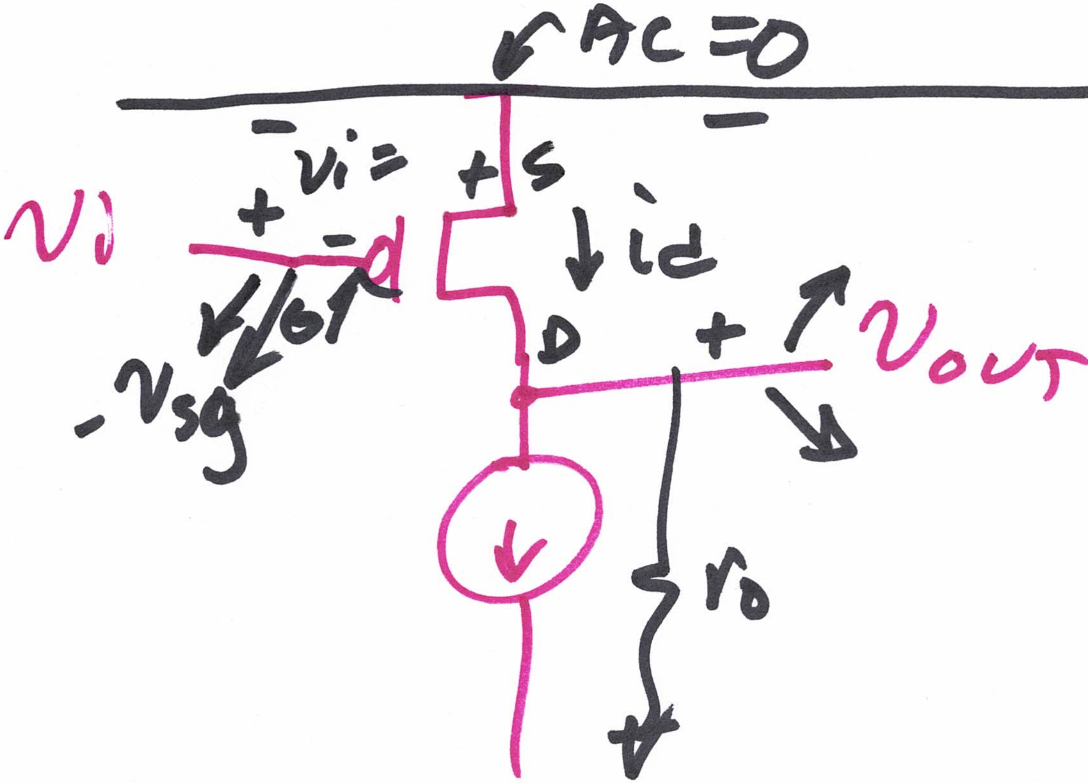
# Common-Source Amplifier




$$v_o = -g_m v_i \cdot r_{on} \| r_{op}$$

$$\frac{v_o}{v_i} = \frac{-r_{on} \| r_{op}}{1/g_m}$$




$$v_{out} = i_d \cdot r_o$$

$$i_d = g_{mp}(-v_i) = g_{mp}(v_{sg})$$