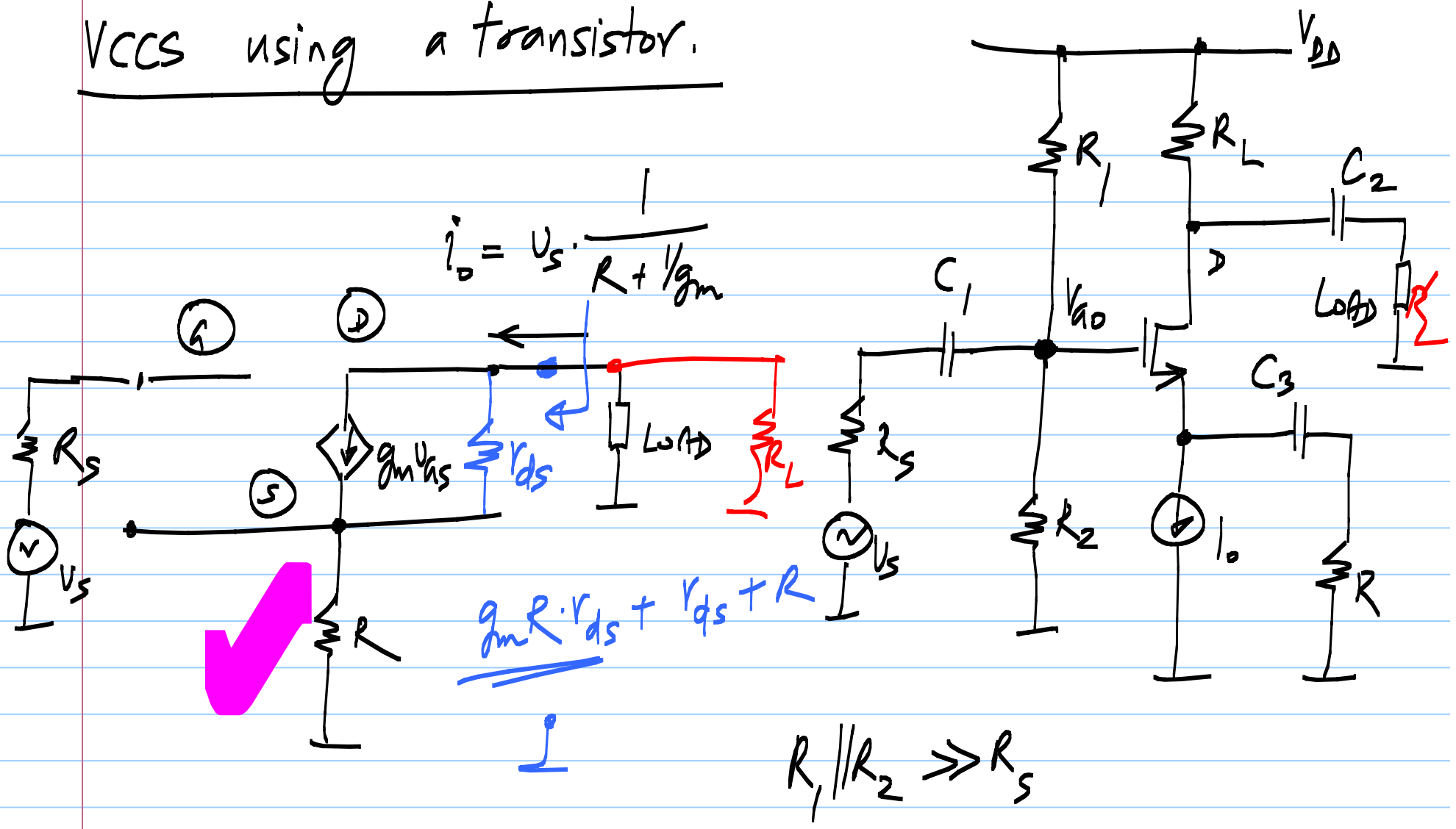
VCCS using a transistor.



$$\frac{1}{\omega C_1} \ll R_s + R_1 \| R_2$$

$$\frac{1}{\omega C_2} \ll R_L + R_L'$$

$$\frac{1}{\omega C_3} \ll R + \frac{1}{g_m} \simeq R$$

	Quiescent	increment
V_G :	$V_{DD} \cdot \frac{R_2}{R_1 + R_2}$	$v_s \cdot \frac{R_1 \| R_2}{R_s + R_1 \| R_2} \simeq v_s$
V_D :	$V_{DD} - I_o R_L$	$-\frac{g_m}{1 + g_m R} v_s \cdot (R_L \| R_L') \simeq -\frac{v_s}{R}(R_L \| R_L')$
I_D :	I_o	$\frac{v_s}{R + 1/g_m} \simeq \frac{v_s}{R}$

$$V_{DD} - I_o R_L - \frac{v_s}{R}(R_L \| R_L') > V_{DD} \cdot \frac{R_2}{R_1 + R_2} + v_s - V_t$$

$$-I_0 R \;<\; U_S \;<\; \frac{V_{DD}\cdot\frac{R_1}{R_1+R_2} - I_0 R_L + V_T}{1+\frac{R_L \| R_L'}{R}}$$

$$-I_0\left(R+\frac{1}{g_m}\right)$$

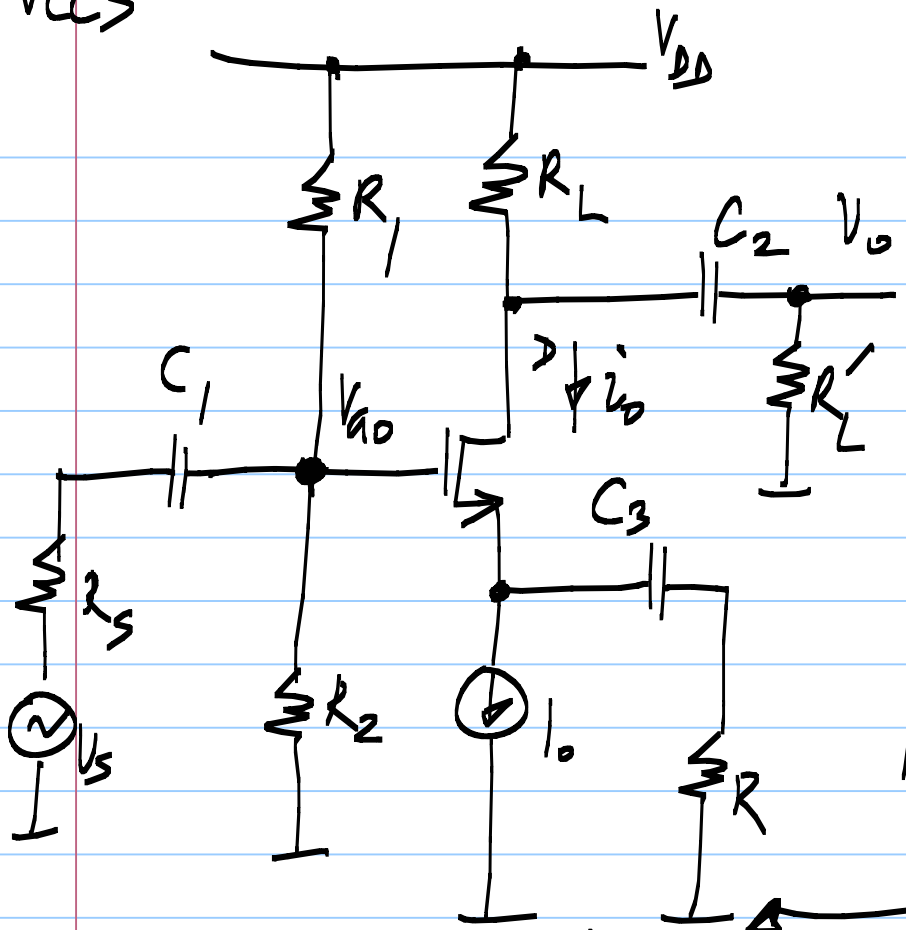
(cutoff)

(Triode)

$$g_m R_L \| R_L'$$

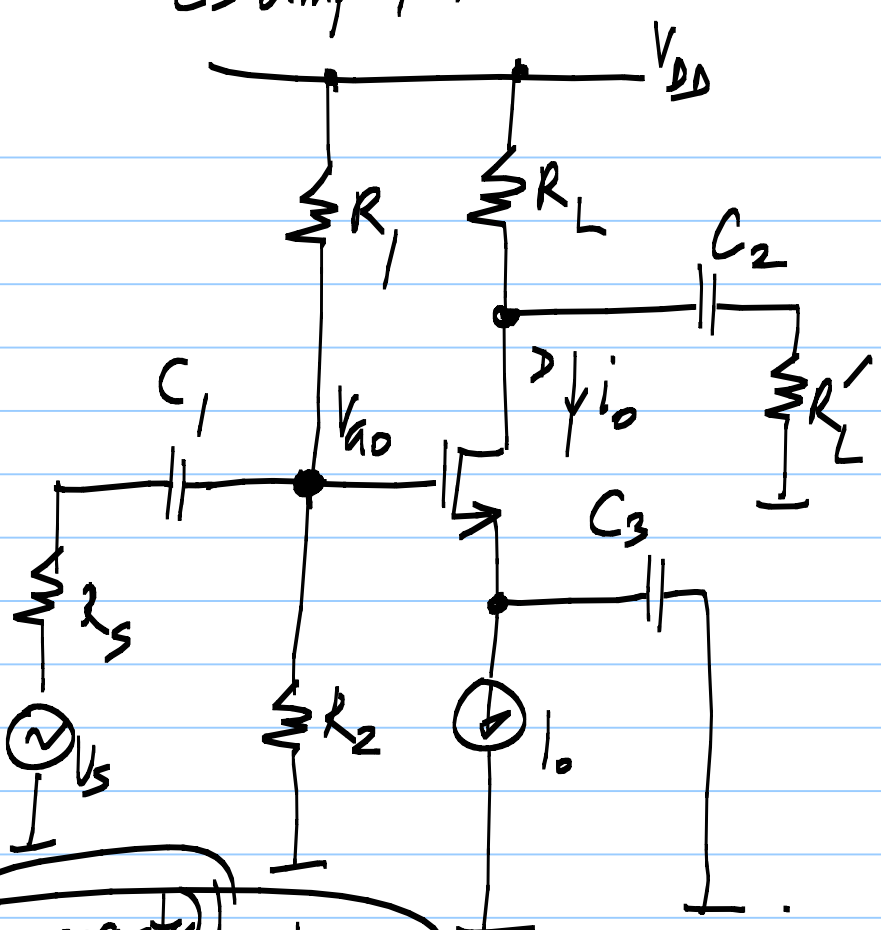
$$\frac{1}{R+1/g_m}$$

VCCS



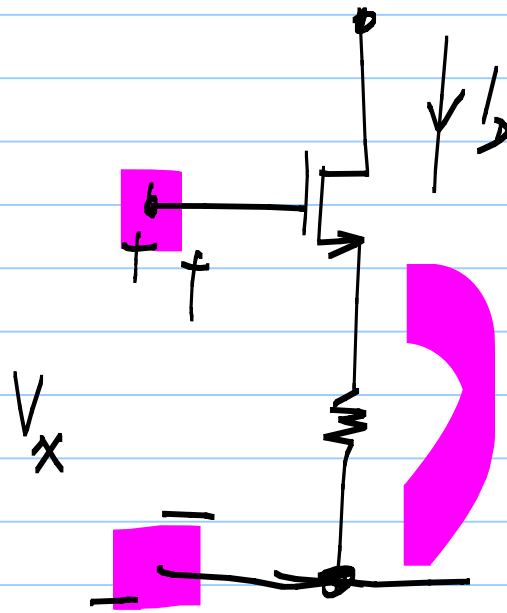
$$\frac{i_o}{V_s} = \frac{1}{R + 1/g_m} \simeq \frac{1}{R}$$

CS amplifier



degenerated

$$\frac{i_o}{V_s} = g_m$$

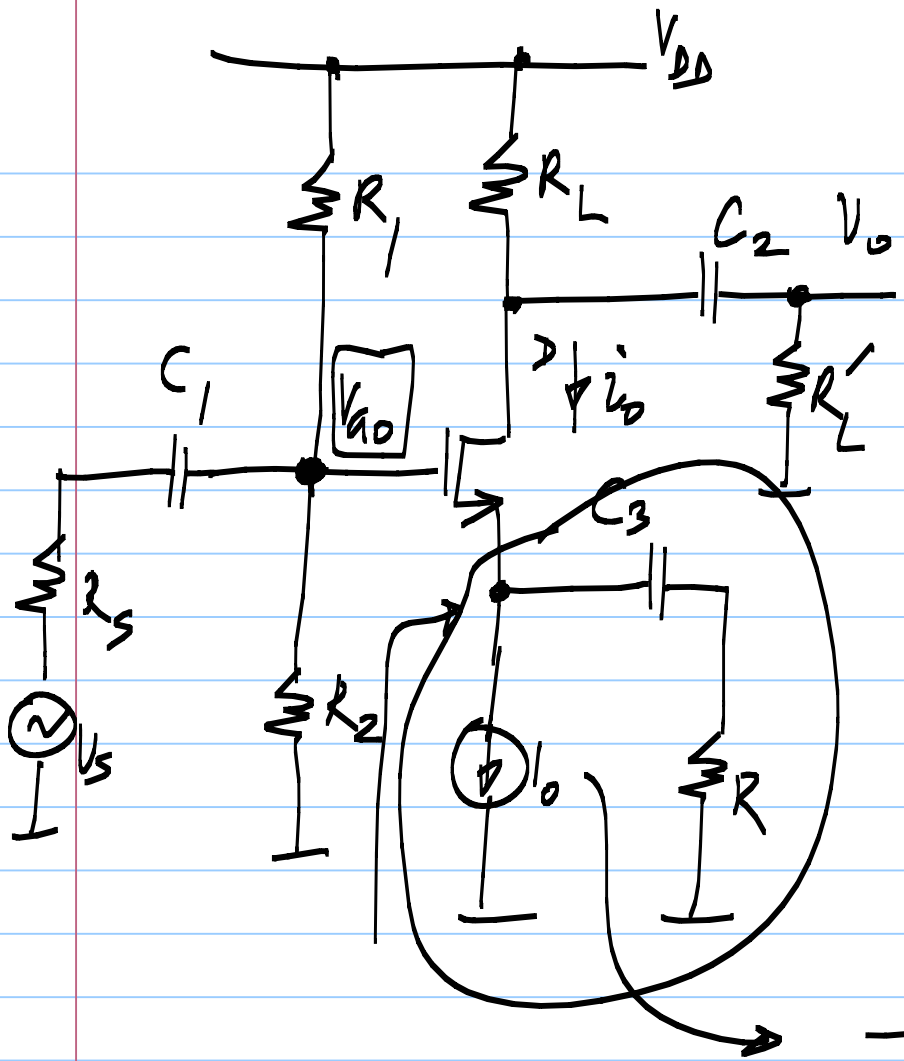


$$\frac{\partial I_D}{\partial V_x} = \frac{g_m}{1+g_m R}$$

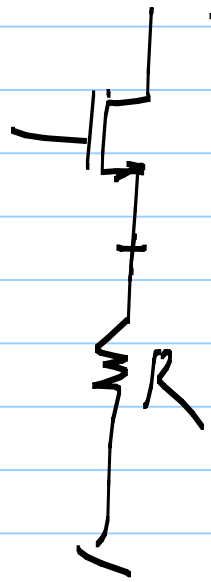
Degenerated transistor

$$\frac{v_o}{v_s} = -\frac{g_m}{1+g_m R} R_L \| R_L' \simeq -\frac{R_L \| R_L'}{R}$$

$$= -\frac{R_L}{R} \Bigg|_{R_L' = \infty}$$

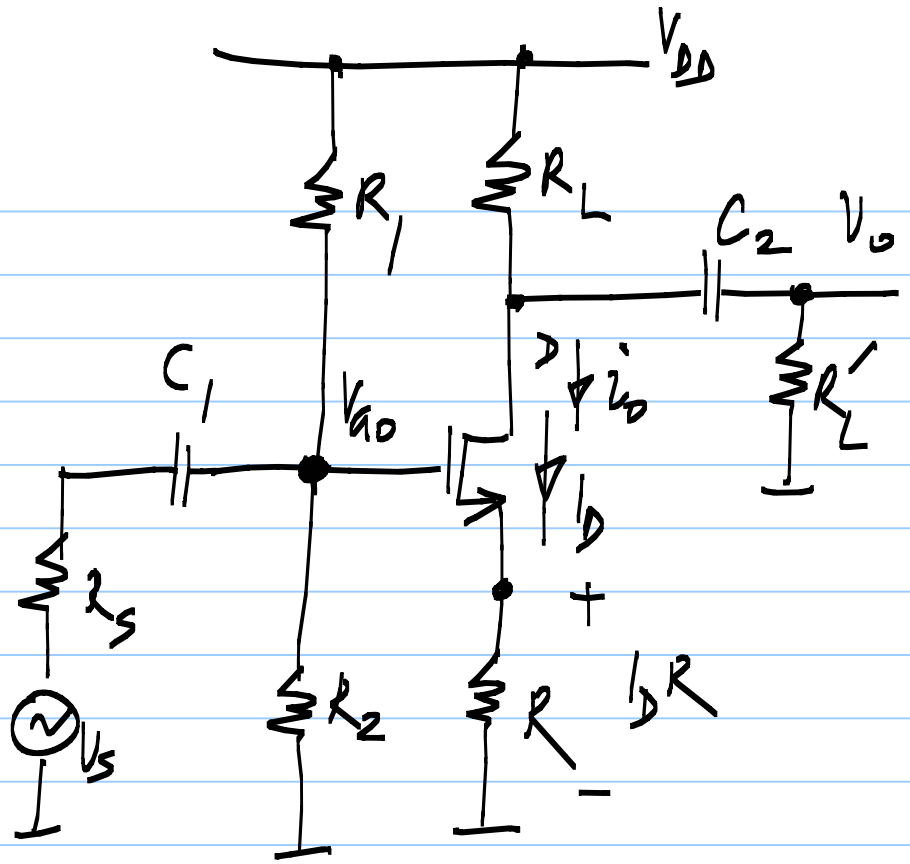


$$\frac{i_o}{V_s} \simeq \frac{1}{R \parallel R_o} = \frac{1}{R}$$



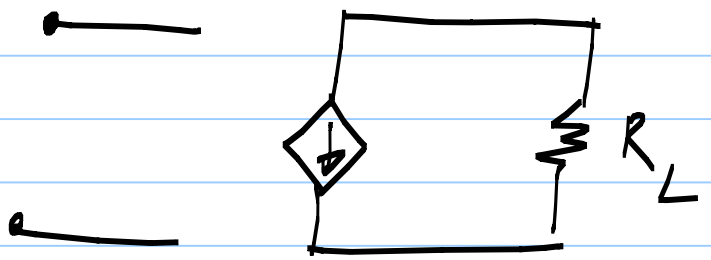
$$\frac{V_{SD}}{I_o} < R$$

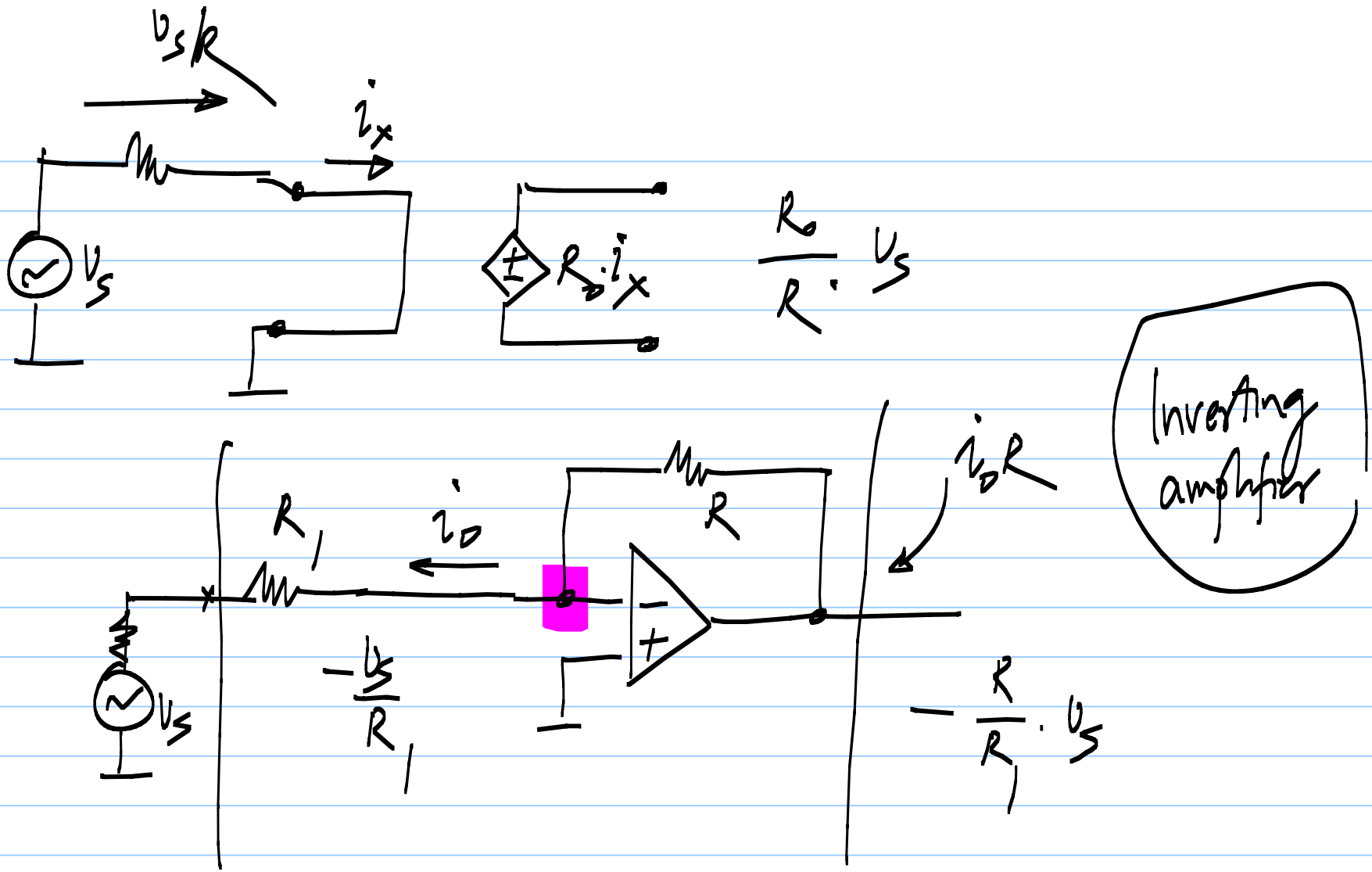
$$\frac{V_{SD}}{I_o} = R$$



$$\frac{\mu C_{ox}}{2} \frac{W}{L} \left(V_{GD} - I_D R - V_T \right)^2$$

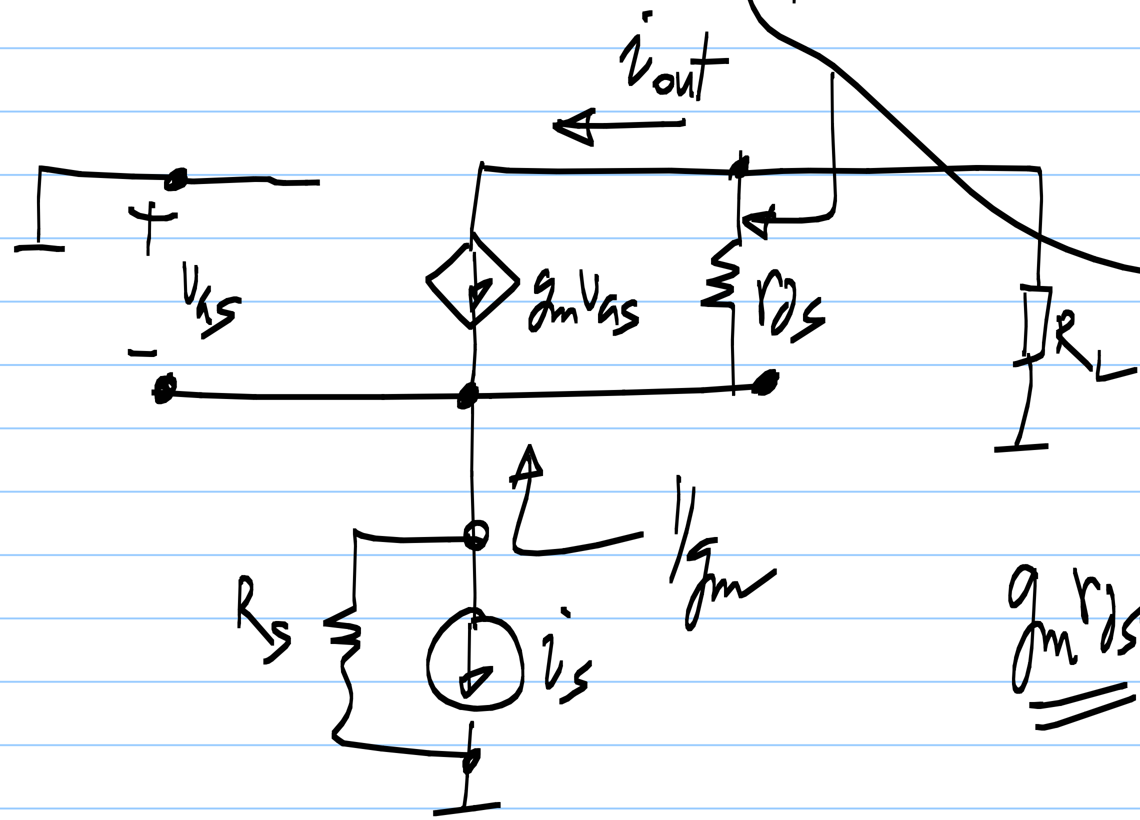
$$= I_D$$




v_s/R
i_x
v_s
$R_o i_x$
$\frac{R_o}{R} \cdot v_s$
Inverting amplifier
R_1
i_D
R
$i_D R$
v_s
$-\frac{v_s}{R_1}$
$-\frac{R}{R_1} \cdot v_s$

CCCS: $i_{out} = i_s$ $i_o - i_s = 0$

If $i_o - i_s > 0$ v_{gs} : must decrease



$g_m r_{ds} R_s + r_{ds} + R_s$

$\gg R_s$