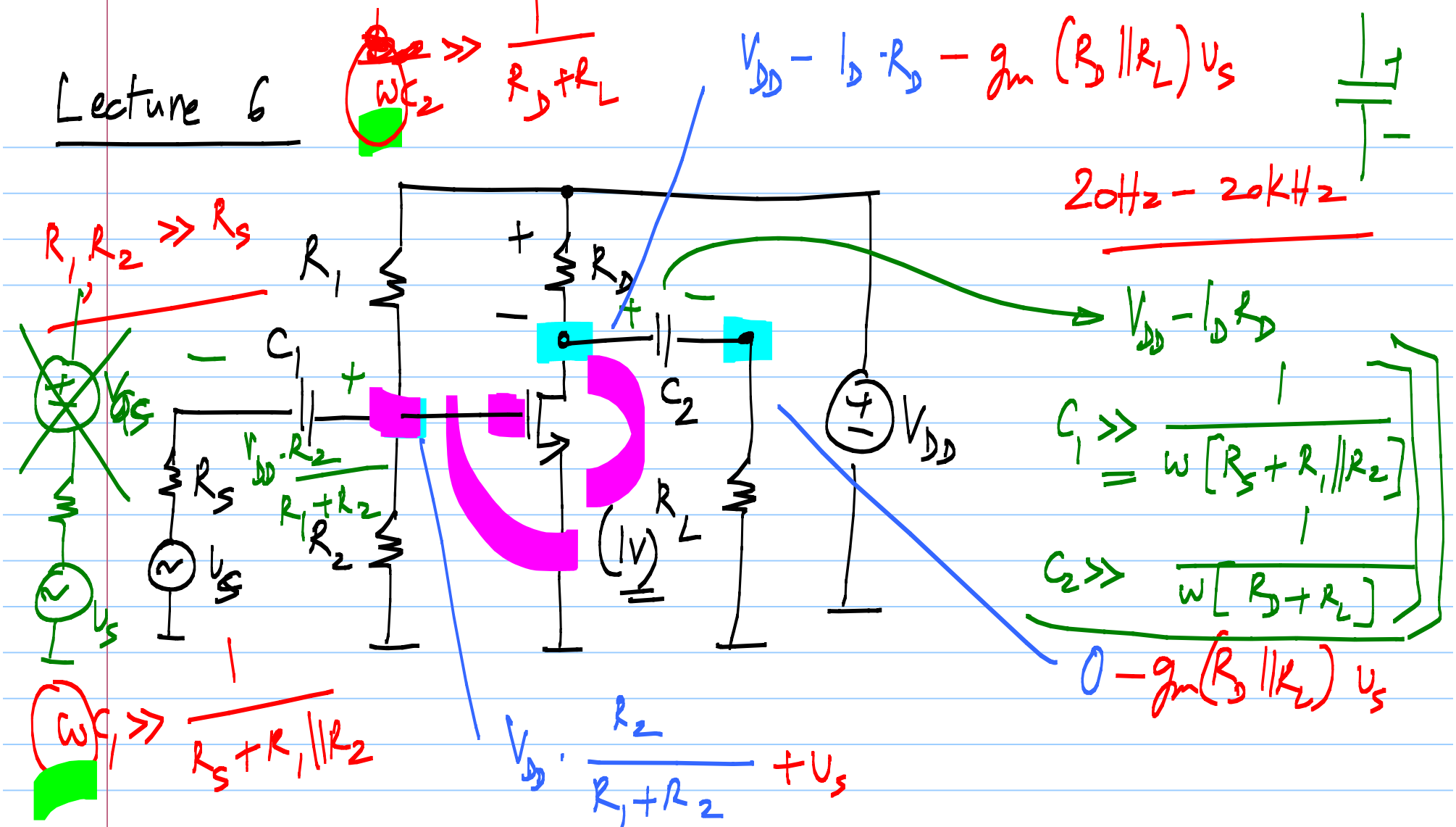
Lecture 6


$\omega C_2 \gg \frac{1}{R_D + R_L}$
$V_{DD} - I_D \cdot R_D - g_m (R_D \| R_L) v_s$
20Hz – 20kHz
$R_1, R_2 \gg R_s$
R_1
R_D
C_1
C_2
R_s
R_L
V_{DD}
v_s
$\frac{V_{DD} \cdot R_2}{R_1 + R_2}$
$V_{DD} - I_D R_D$
$C_1 \gg \frac{1}{\omega [R_s + R_1 \| R_2]}$
$C_2 \gg \frac{1}{\omega [R_D + R_L]}$
$\omega C_1 \gg \frac{1}{R_s + R_1 \| R_2}$
$V_{DD} \cdot \frac{R_2}{R_1 + R_2} + v_s$
$0 - g_m (R_D \| R_L) v_s$

$(-g_m R_L) \longrightarrow -g_m(R_D \| R_L) \simeq -g_m R_L$

$[-4]$ $\quad 200\mu S$

$R_D = 200k\Omega$

$R_D = 20k\Omega$, $R_L = 2k\Omega$ $\quad -2$ $\quad \gg 20k\Omega$

$V_{GS} = 1.5V$

$R_D \uparrow$ $40k\Omega$, $V_{DD} \longrightarrow 6V$

Gain $\simeq -g_m R_L$

$R_D = 200k\Omega$, $- V_{DD} \longrightarrow 22V$

$R_D \gg R_L$

$I_D \cdot R_D = 20V$

$100\mu A$

$R_1 : R_2 = 20.5 : 1.5$

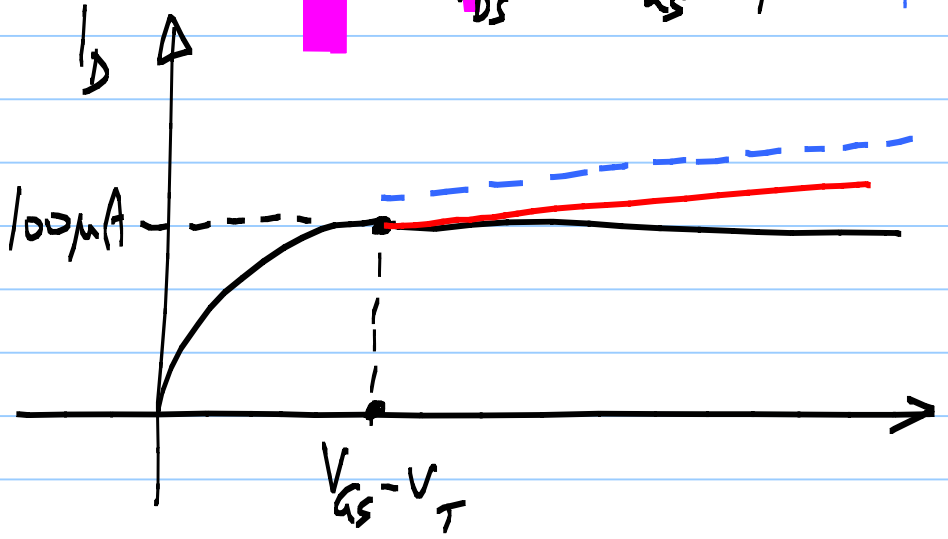
$I_D = 0$ $\quad V_{GS} \leq V_T$

$$\mu_n C_{ox} \frac{W}{L}\left[(V_{GS}-V_T)V_{DS} - \frac{V_{DS}^2}{2}\right] \quad V_{GS} > V_T,\ V_{DS} < V_{GS}-V_T$$

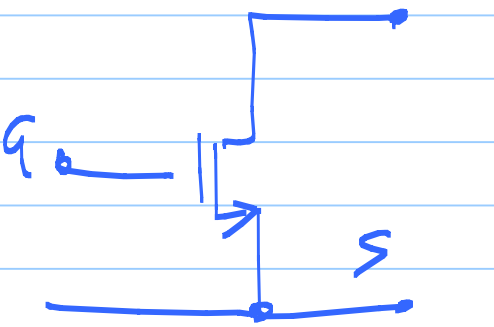
$$\mu_n C_{ox} \frac{W}{2L}(V_{GS}-V_T)^2(1+\lambda V_{DS}) \quad V_{GS} > V_T,\ V_{DS} > V_{GS}-V_T$$

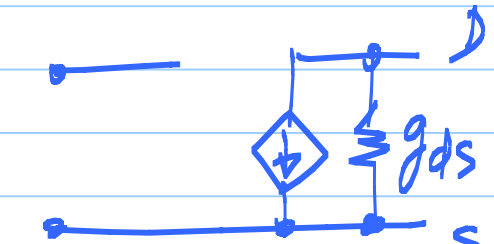
$\lambda = 0.01\ V^{-1}$

[channel length modulation]



$y_{22} \neq 0$





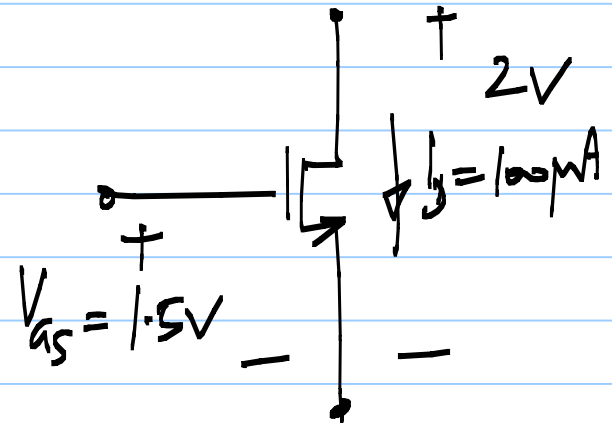
$V_{GS} = 1.5V$ $\quad g_m v_{GS}$

$$g_m = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)$$

$$\lambda = 0.01\ V^{-1}$$

usually ignored while calculating I_D, g_m

$$g_{ds} = \frac{1}{1 + 0.01 \times 2}$$

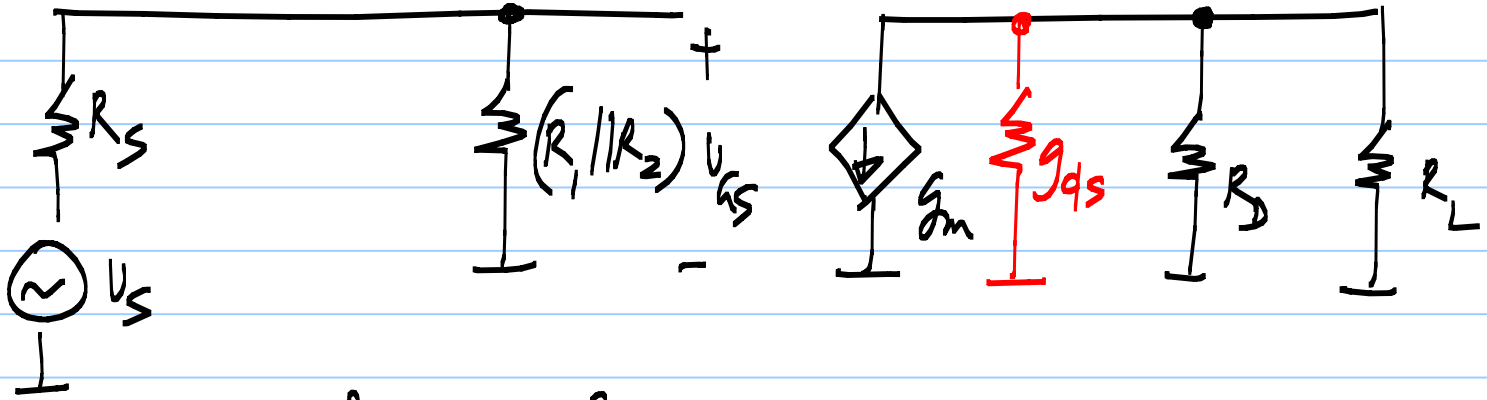


$$I_D = \mu_n C_{ox} \frac{W}{2L} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$\frac{\partial I_D}{\partial V_{DS}} = \mu_n C_{ox} \frac{W}{2L} (V_{GS} - V_T)^2 \cdot \lambda$$

$$\simeq \lambda I_D = 1\mu S$$

$r_{ds} = 1/g_{ds}$



$R_1, R_2 \gg R_S$

$R_D \gg R_L$

$R_L \to \infty$

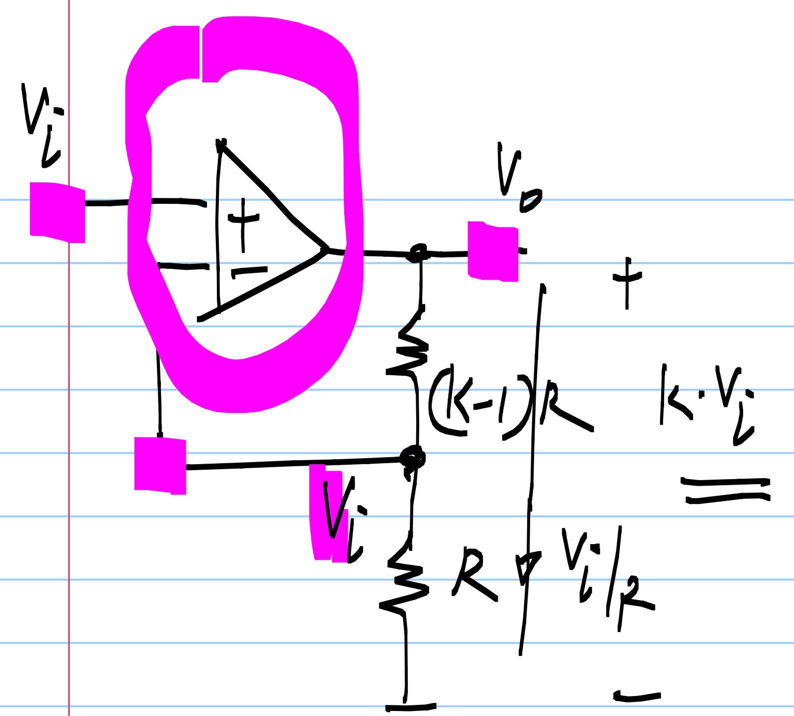
$$-g_m (r_{ds} \| R_L)$$

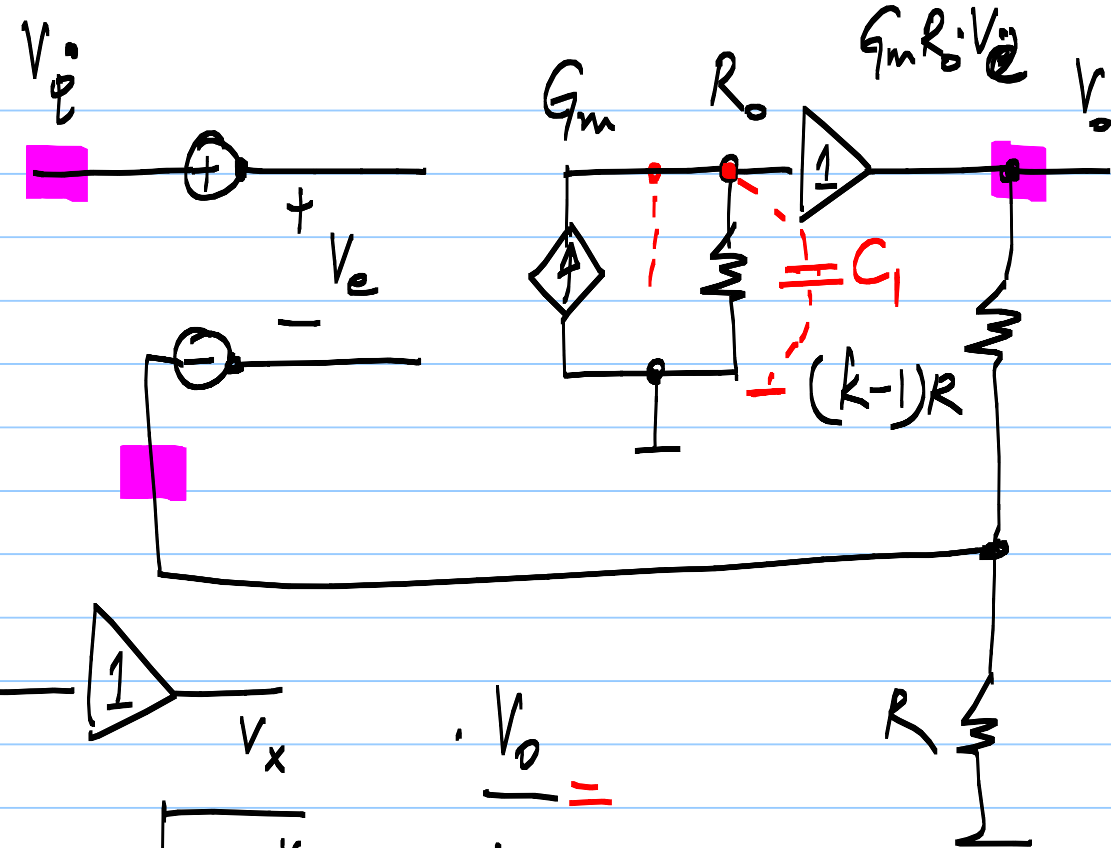
$200\mu S \cdot 1M\Omega = 200$

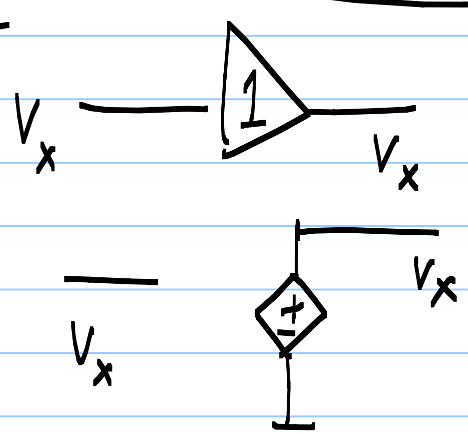
$$-g_m r_{ds}$$

* Inherent gain of the MOS transistor limited to $g_m r_{ds}$ ($\sim$ 10 in modern processes)

* Need to implement large gains (e.g opamp)







$$\frac{V_o}{V_i} = k$$

$$\frac{V_o}{V_i} =$$