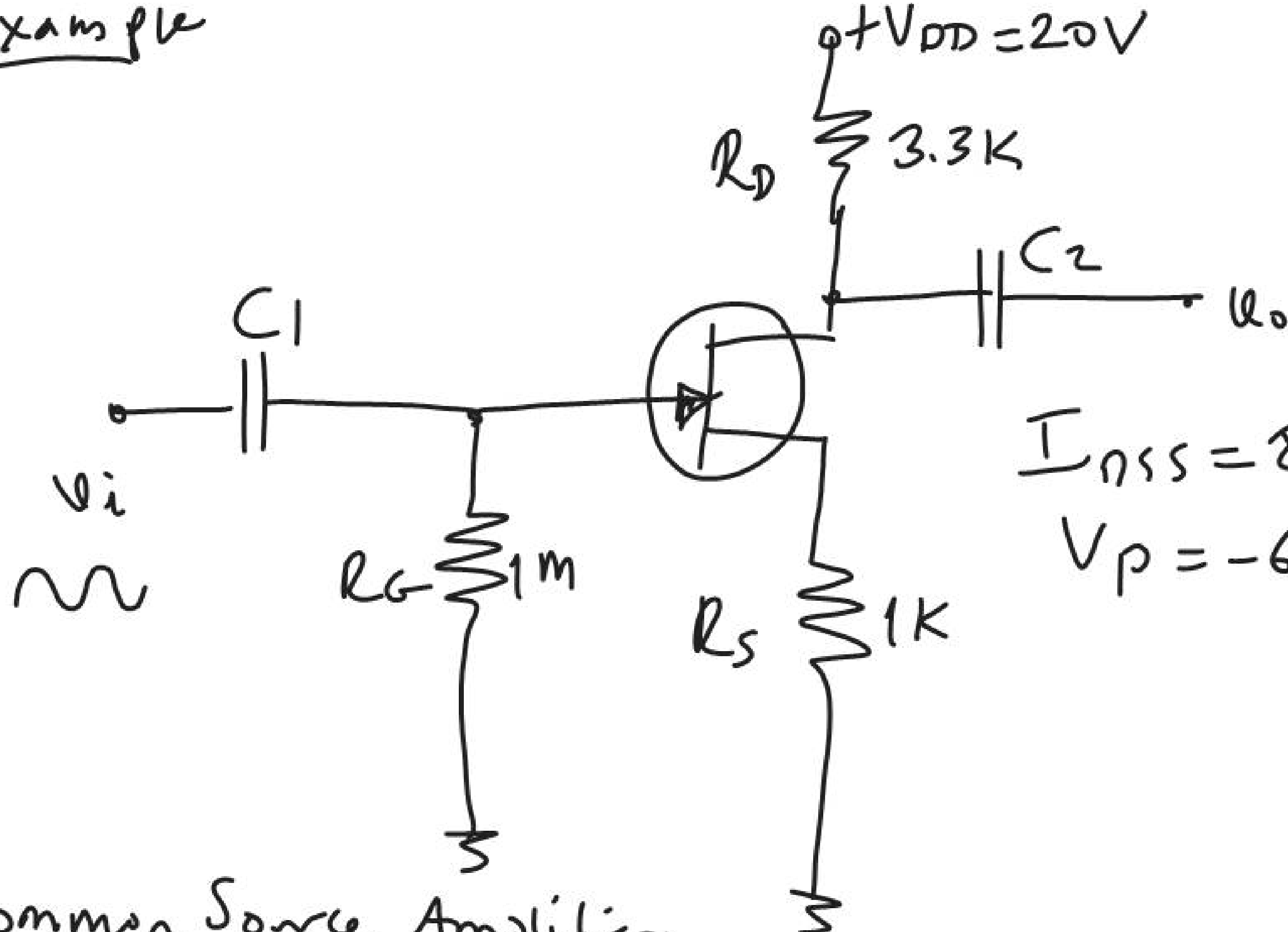
Example

10.05.2011

©



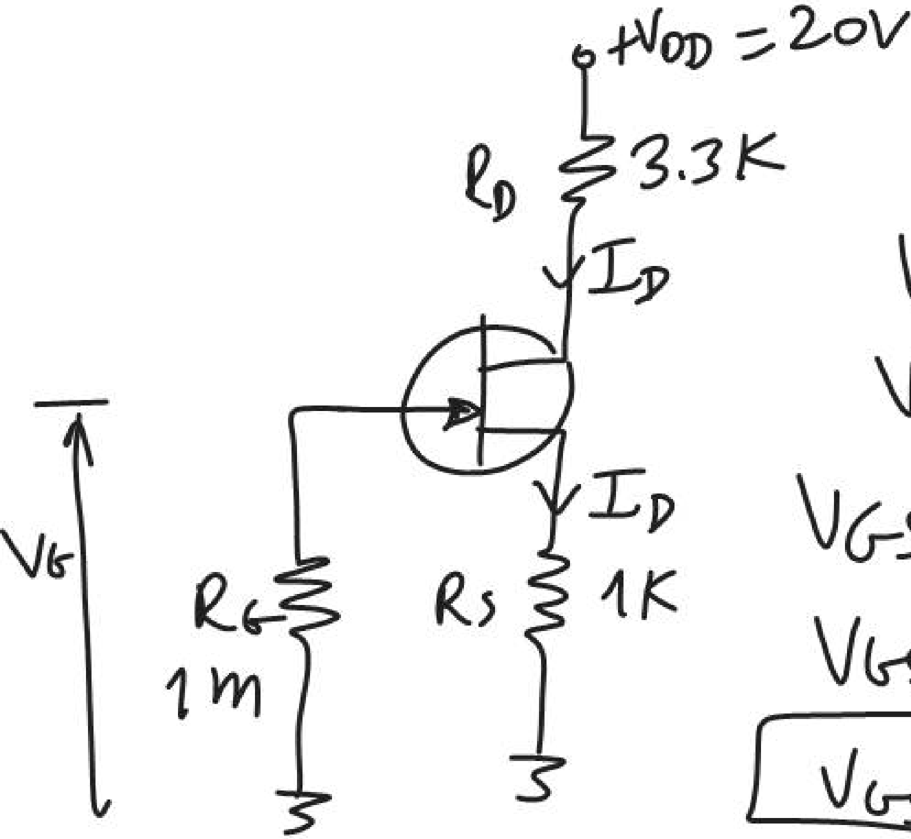
$I_{DSS} = 8mA$

$V_P = -6V$

Common Source Amplifier

JFET

a) DC analysis to calculate g_m



$V_G = 0V$.

$V_S = I_D \cdot R_S$

$V_{GS} = V_G - I_D R_S$

$V_{GS} = 0 - 10^3 I_D$

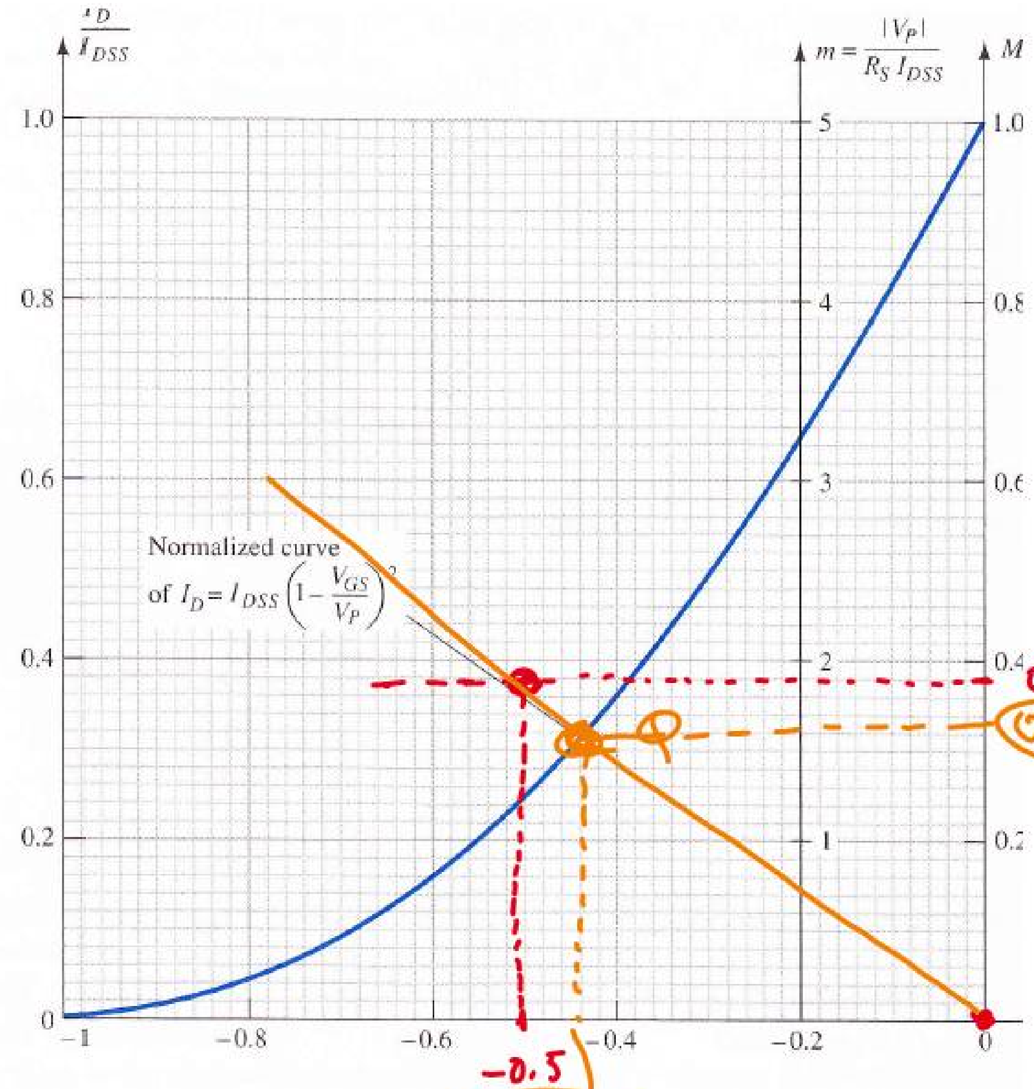
$$\boxed{V_{GS} = -10^3 I_D}$$

line eqn.

$V_{GS} = 0 \rightarrow I_D = 0$

$V_{GS} = -3V \rightarrow I_D = 3mA$

$$\begin{cases} V_{GS} = \dfrac{-3V}{|-6|} = -0.5 \\ I_D = \dfrac{3mA}{8mA} = 0.38 \end{cases}$$



$$g_m = g_{mo}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$g_m = \frac{2I_{DSS}}{|V_P|}\left(1 - \frac{-2.6}{-6}\right)$$

$$g_m = \frac{2 \times 8 \times 10^{-3}}{6}(1 - 0.4)$$

$$\boxed{g_m = 1.6\ mS}$$

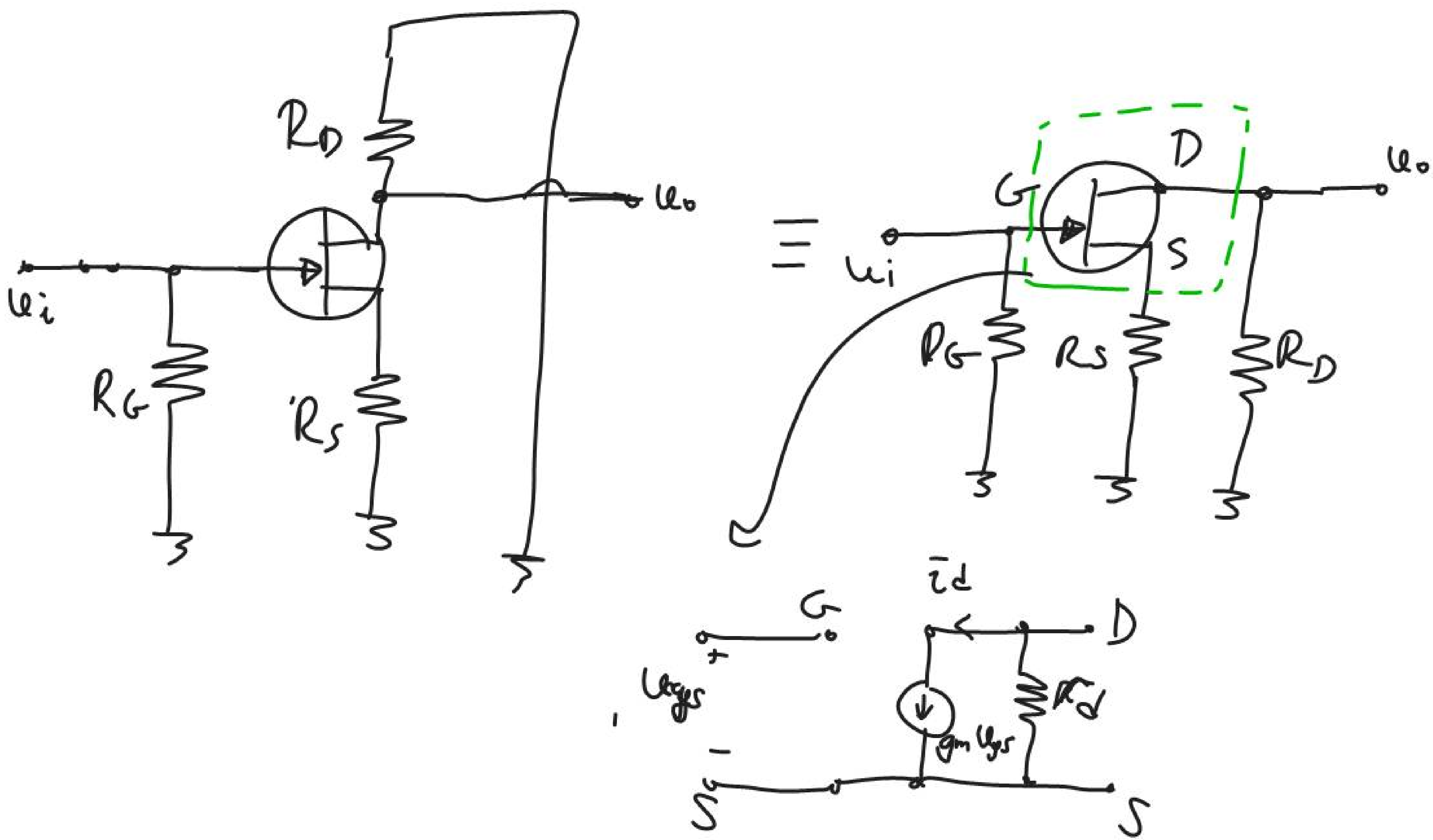
0.35 $I_{DQ} \rightarrow 0.35 \times I_{DSS} =$

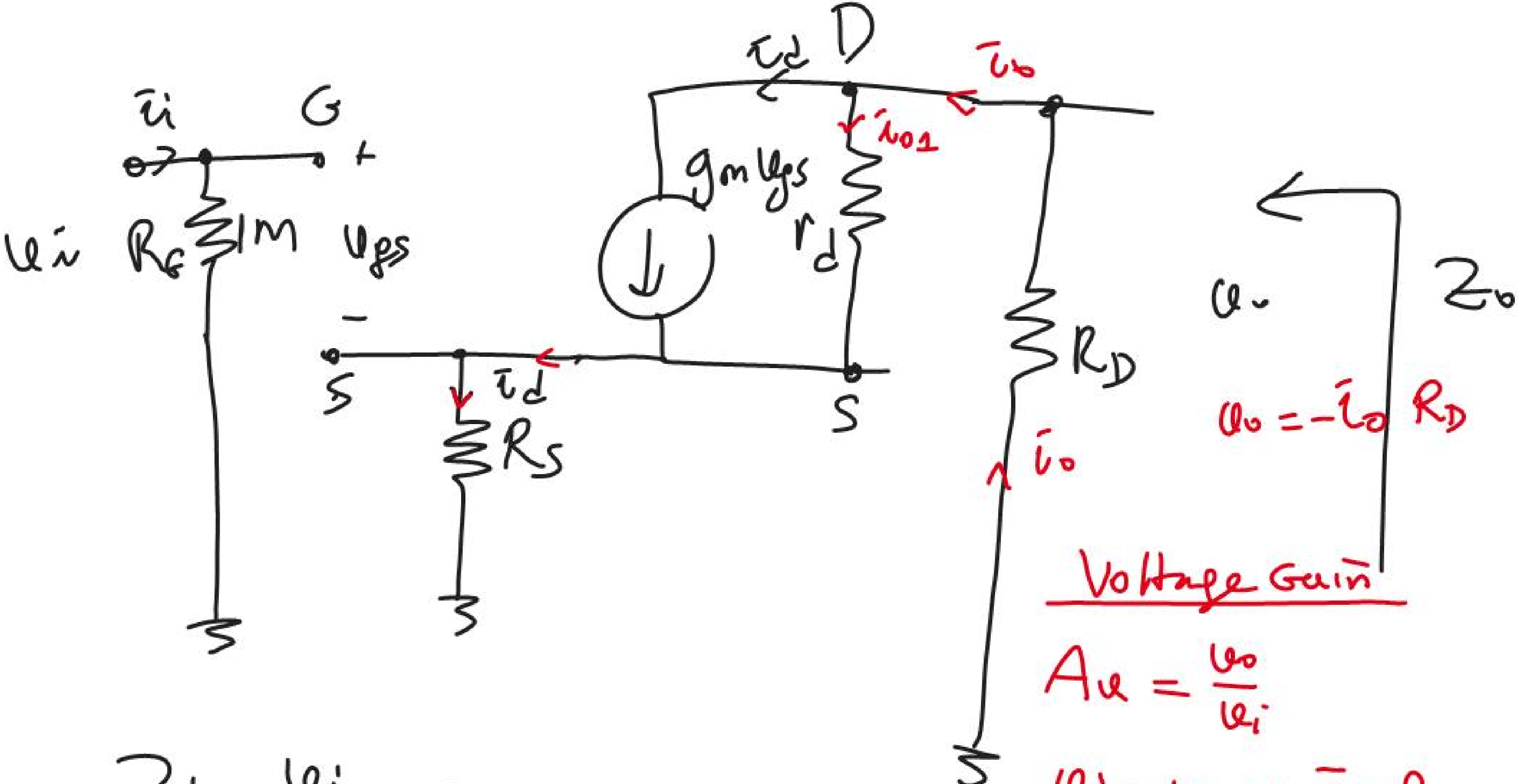
$0.35 \times 8mA = \underline{2.8mA}$

-0.44 $V_{GSQ} \rightarrow -0.44 \times 6 = -2.64 \cong \underline{-2.6V}$

$\underline{V_{GSQ}}$

b) AC behavior





Voltage Gain

$$A_v = \frac{v_o}{v_i}$$

$$v_i = v_{gs} + i_d \cdot R_S$$

$$i_d = g_m \cdot v_{gs}$$

$$v_i = v_{gs} + g_m \cdot R_S \cdot v_{gs}$$

$$Z_i = \frac{v_i}{i_i} = R_G = 1M\Omega$$

$$Z_o = R_D // \left[\left(r_d // \frac{1}{g_m} \right) + R_S \right]$$

$$Z_o \cong R_D \cong 3.3K \quad \left(\text{since } R_D << \left[\left(r_d // \frac{1}{g_m} + R_S \right) \right] \right)$$

$$v_i = \underline{\underline{v_{gs}}}(1 + g_m R_S) \longrightarrow v_{gs} = \frac{v_i}{1 + g_m R_S}$$

$$v_o = -i_o \cdot R_D$$

$i_o \approx i_d$ (if r_d is big enough)

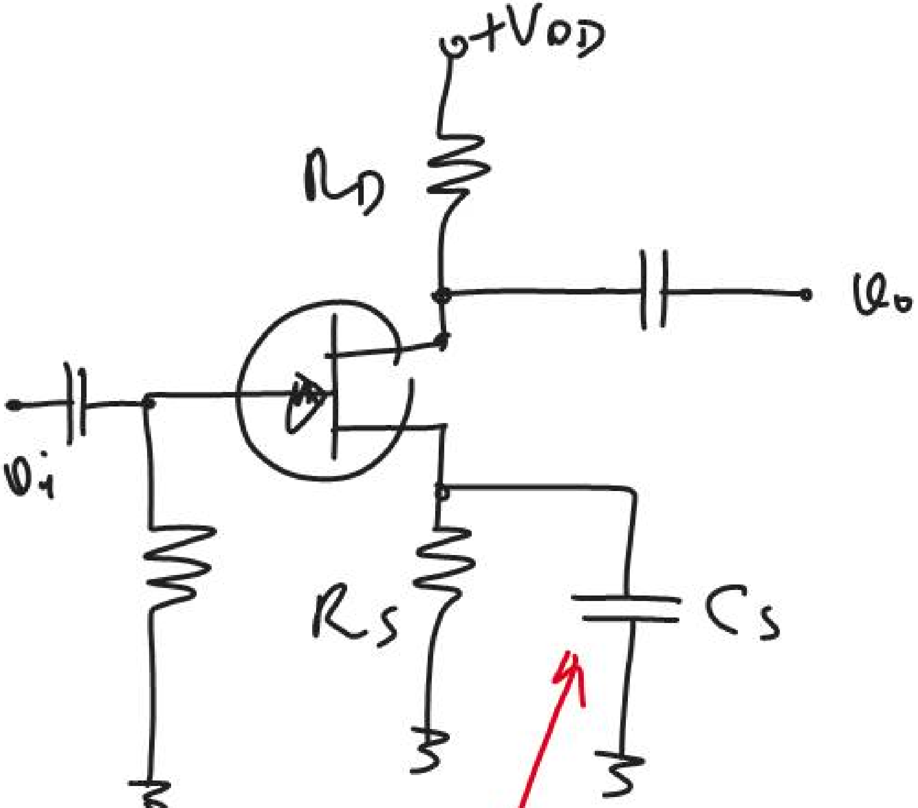
$r_d > 10 R_D$

$$v_o = -i_d \cdot R_D$$

$$v_o = -g_m \underline{\underline{v_{gs}}} \cdot R_D$$

$$v_o = -g_m R_D \cdot \frac{v_i}{1 + g_m R_S} \implies \boxed{A_v = \frac{v_o}{v_i} = -\frac{g_m R_D}{1 + g_m R_S}}$$

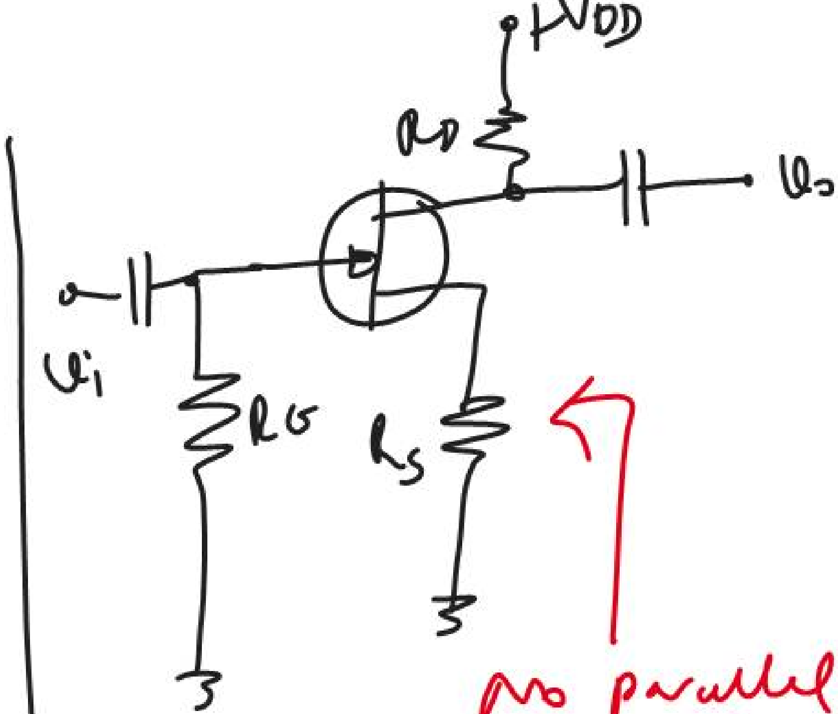
$$A_v = -\frac{1.6 \times 10^{-3} \times 3.3 \times 10^{3}}{1 + 1.6 \times 10^{-3} \times 10^{3}} = -\frac{1.6 \times 3.3}{1 + 1.6} \cong -2$$



Rs is bypassed by Cs.

$$A_u = \frac{u_o}{u_i} = -g_m R_D$$

$$A_u = -1.6\times10^{-3}\times 3.3\times10^{3} = -5.3$$



No parallel Cs!

$$A_u = \frac{u_o}{u_i} = -\frac{g_m R_D}{1+g_m R_S}$$

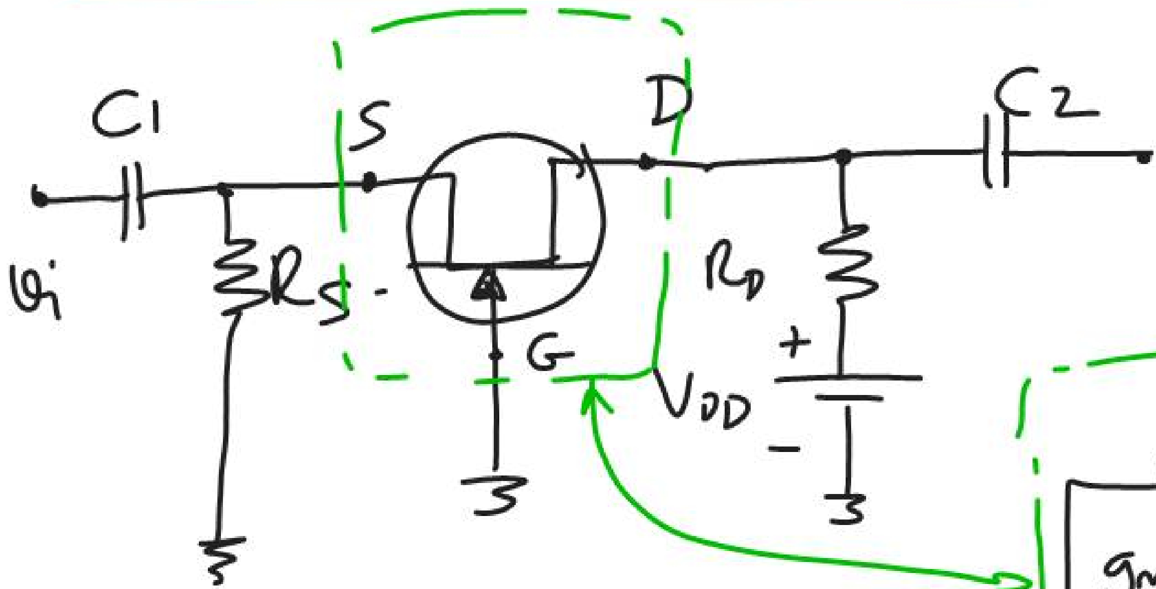
$$A_u = -2$$

Common-Gate FET amplifier

21 May 2011

2 hours extra

11:00
A319



$v_i = -v_{gs}$

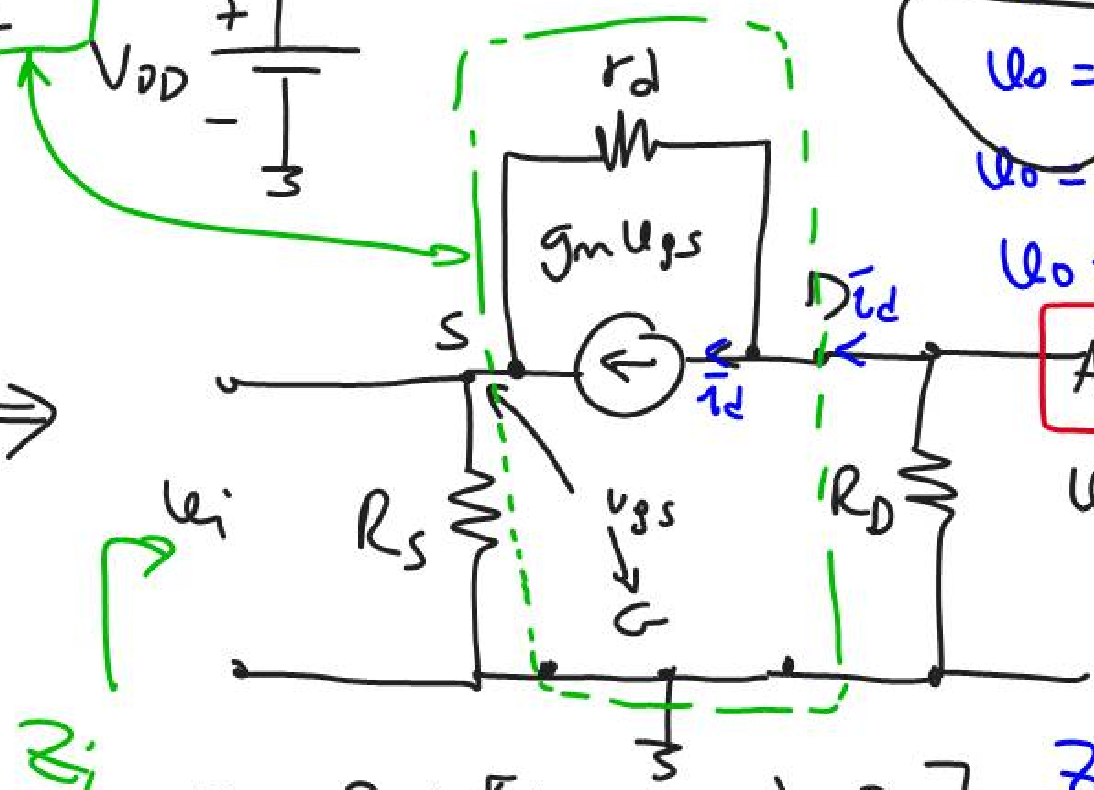
$v_o = -i_d \cdot R_D$

$v_o = -g_m v_{gs} \cdot R_D$

$v_o = g_m v_i \cdot R_D$

$$A_v = \frac{v_o}{v_i} = g_m R_D$$

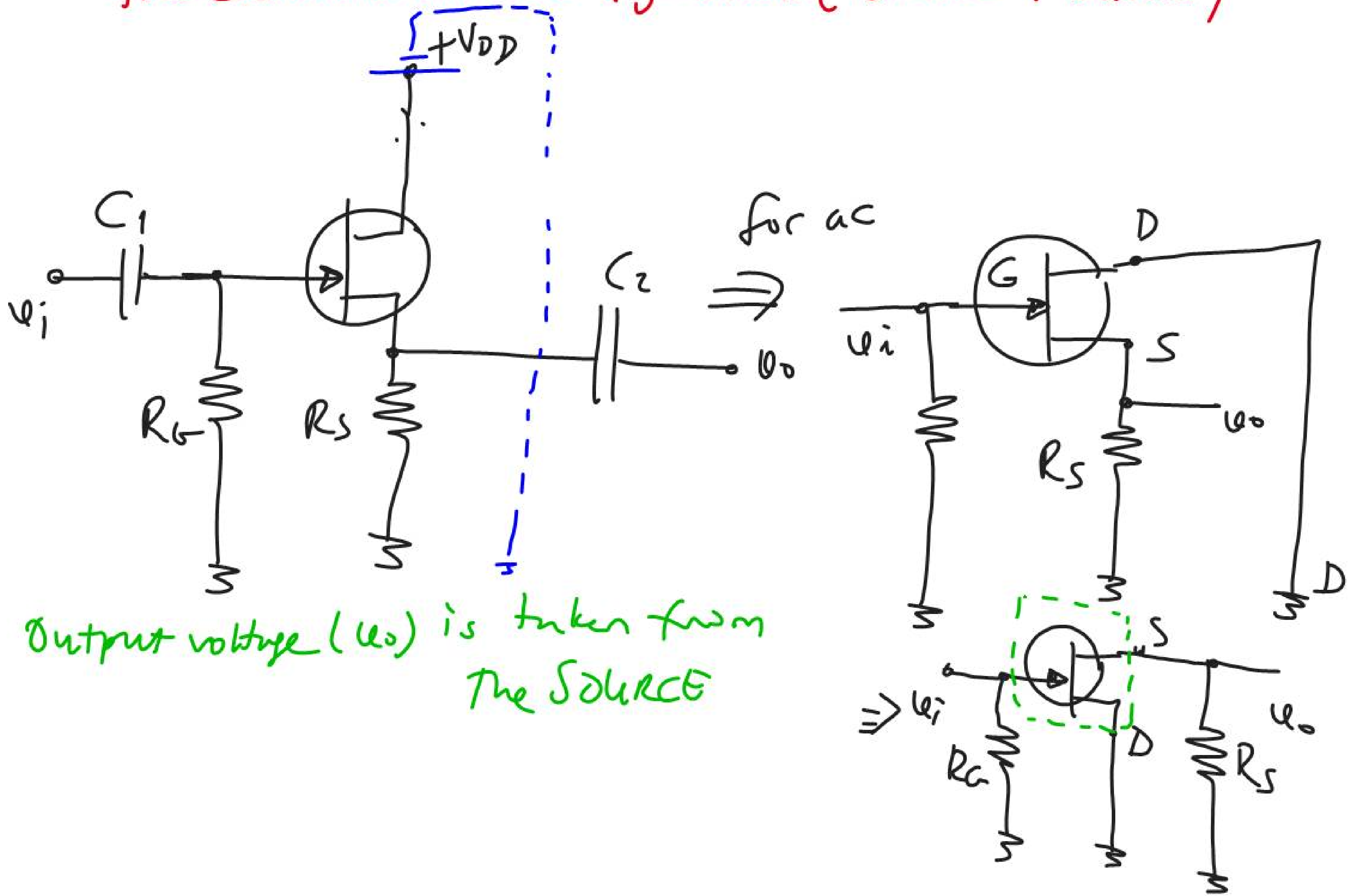
ac equivalent ⇒



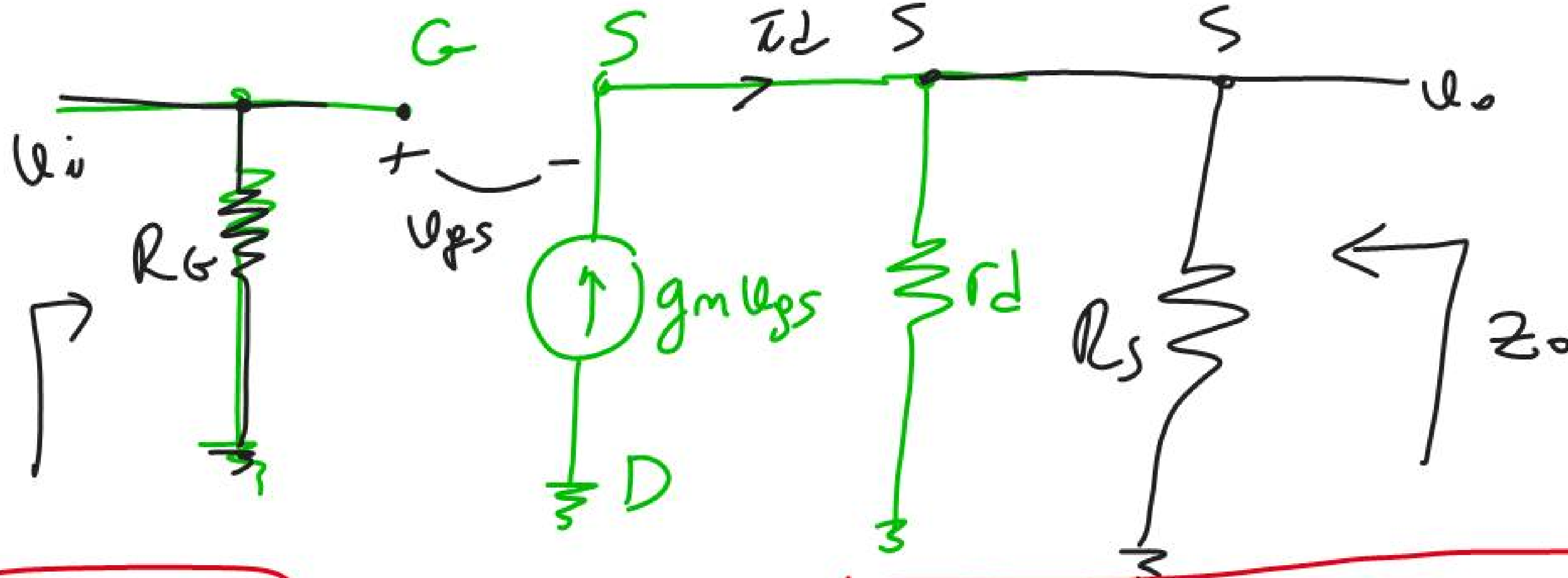
$$Z_i \cong R_S // \left[\left(1/g_m // r_d \right) + R_D \right]$$

$$Z_o \cong R_D // \left(\frac{1}{g_m} // r_d \right)$$

The Common Drain Configuration (Source Follower)



Output voltage (v_o) is taken from the SOURCE



$$Z_i \approx R_G$$

$$Z_o = R_s \,//\, r_d \,//\, \frac{1}{g_m}$$

$$A_v = \frac{v_o}{v_i}$$

$$v_i = v_{gs} + v_o \Rightarrow v_{gs} = v_i - v_o$$

$$v_o \cong i_d \cdot R_s \quad (r_d \gg R_s) \quad ; \quad i_d = g_m v_{gs}$$

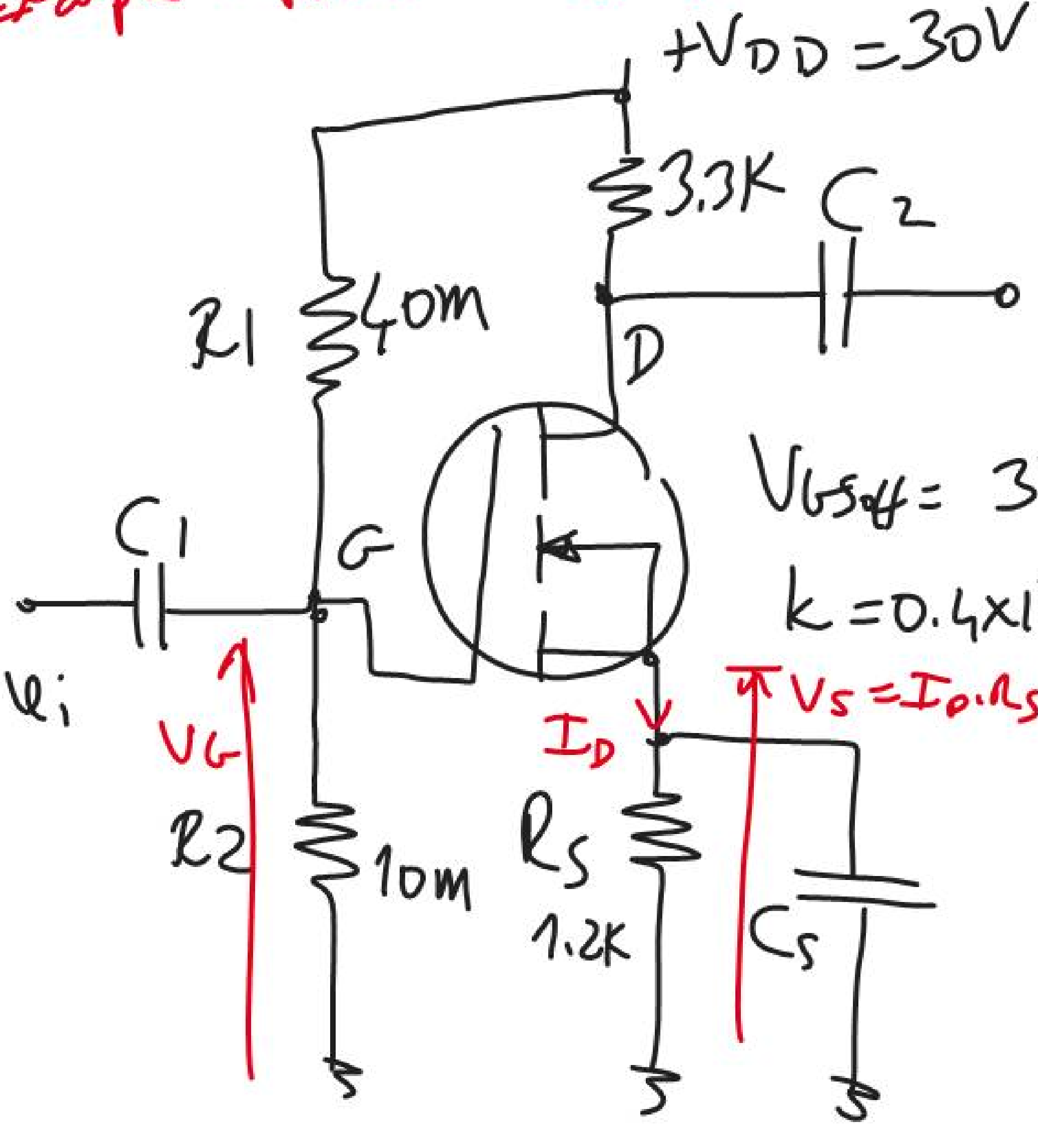
$$v_o \cong g_m v_{gs} \cdot R_s$$

$$v_o = g_m (v_i - v_o) \cdot R_s$$

$$v_o (1 + g_m R_s) = g_m R_s \cdot v_i$$

$$A_v = \frac{v_o}{v_i} = \frac{g_m R_s}{1 + g_m R_s} < 1$$

Example . Problem 8-43 :



Z_i, Z_o, A_v ?

E-MOSFET

Common-Source amplifier

$V_{GSoff} = 3V = V_T$

$k = 0.4 \times 10^{-3}\ A/V^2$

$$g_m = \frac{dI_D}{V_{GS}}$$

$$I_D = k \cdot (V_{GS} - V_T)^2$$

$$g_m = \frac{dI_D}{dV_{GS}} = 2k(V_{GS} - V_T)$$

(1) DC analysis

$$I_D = k(V_{GS} - V_T)^2 \quad (1)$$

$$V_S = I_D \cdot R_S$$

$$V_G = \frac{V_{DD}}{R_1 + R_2} \cdot R_2$$

$$V_{GS} = V_G - V_S$$

$$V_G = \frac{30}{(40+10)\times 10^6} \times 10 \times 10^6$$

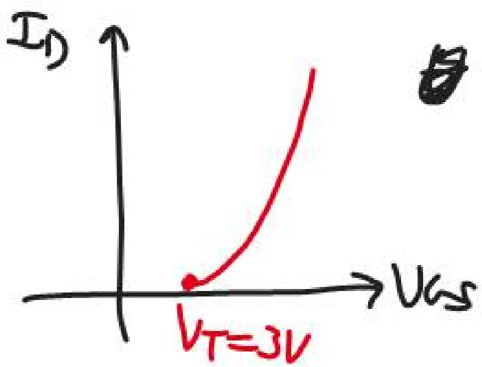
$$V_{GS} = 6 - 1.2\times10^3 \times I_D \quad (2)$$

$$I_D = 0.4\times10^{-3}(V_{GS} - 3)^2 \quad (1)$$

$$= \frac{30}{50} \cdot 10$$

$$V_G = 6V$$

$$I_D = \frac{V_{GS} - 6}{-1.2\times10^3} \qquad V_{GS} \Rightarrow x$$



$$\frac{x-6}{1.2\times10^3} = 0.4\times10^{-3}(x-3)^2$$

$$x - 6 = \left[0.4\times10^{-3}(x^2 - 6x + 9)\right](-1.2\times10^3)$$

$V_{GS} \approx 6V$

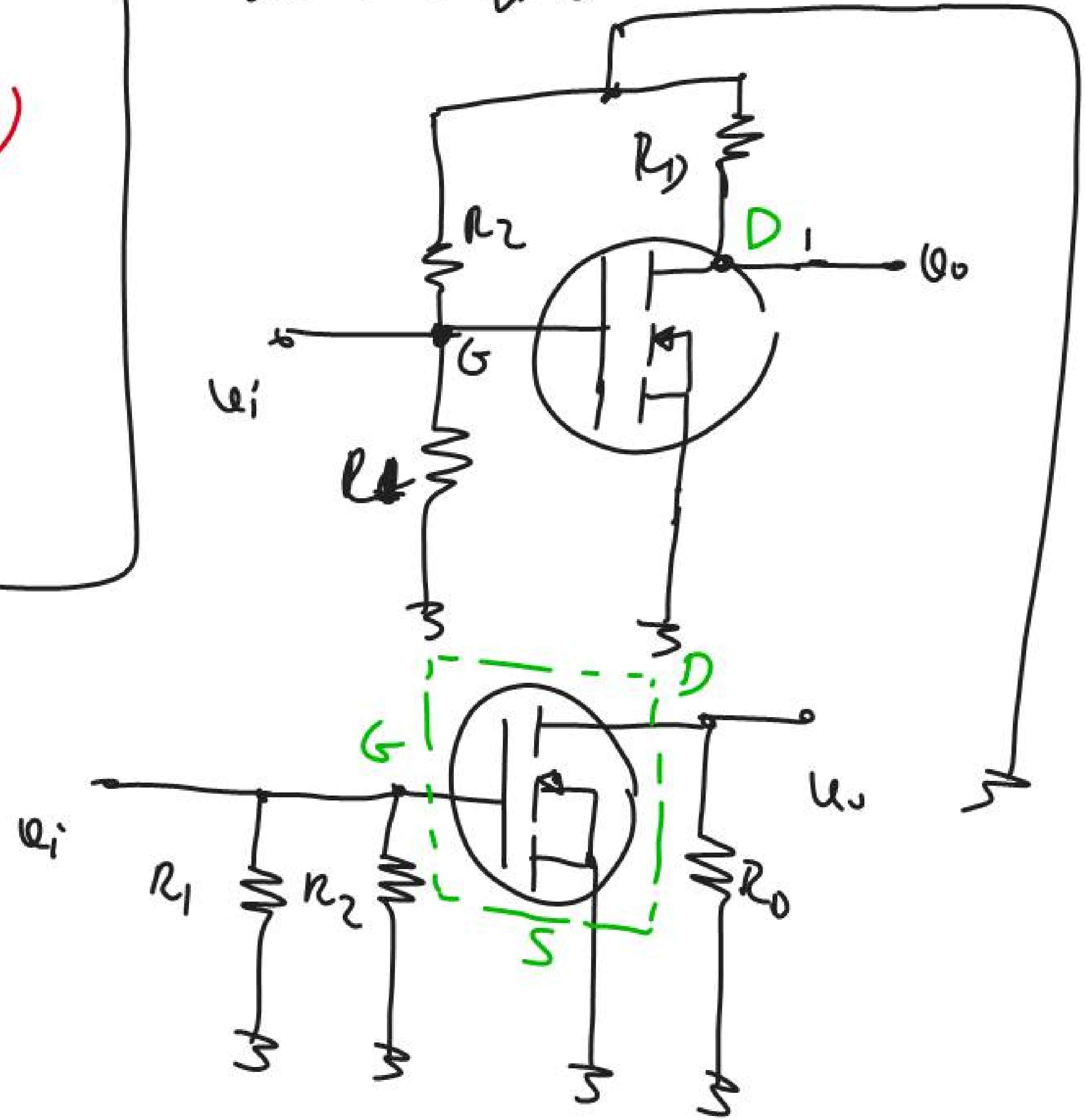
$g_m = 2k(V_{GS} - V_T)$

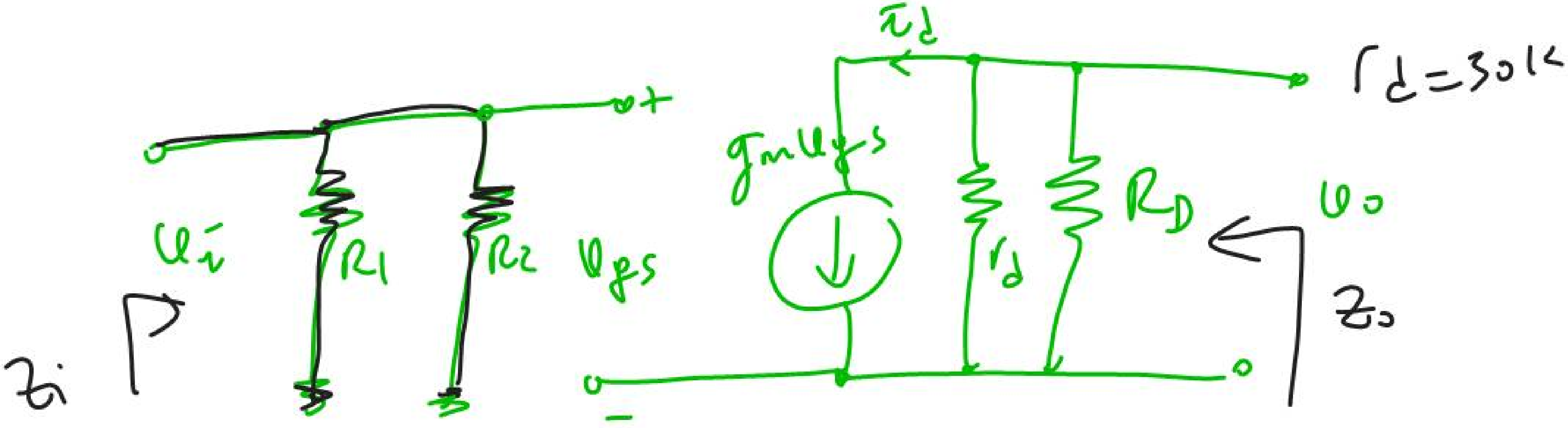
$= 2 \times 0.4 \times 10^{-3}(6-3)$

$= 0.8 \times 10^{-3} \times 3$

$g_m = 2.4\ mS$

ac analysis





$$Z_i = R_1 // R_2 = \frac{40 \times 10}{40 + 10} \times 10^6 = 8\, M\Omega$$

$$A_v = \frac{v_o}{v_i} = -g_m \cdot R_D = -2.4 \times 10^{-3} \times 3.3 \times 10^{3} \cong \underline{\underline{-8}}$$

$$Z_o = R_D // \left(r_d // \frac{1}{g_m} \right)$$

$$Z_o = \underbrace{3.3 \times 10^3}_{3.3K} // \underbrace{30 \times 10^3}_{30K} // \underbrace{\frac{1}{2.4 \times 10^{-3}}}_{416\Omega}$$

$$Z_o \cong 416\,\Omega$$