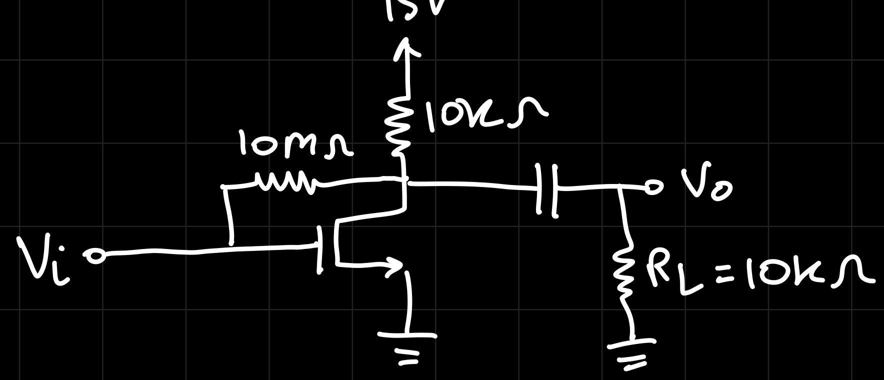
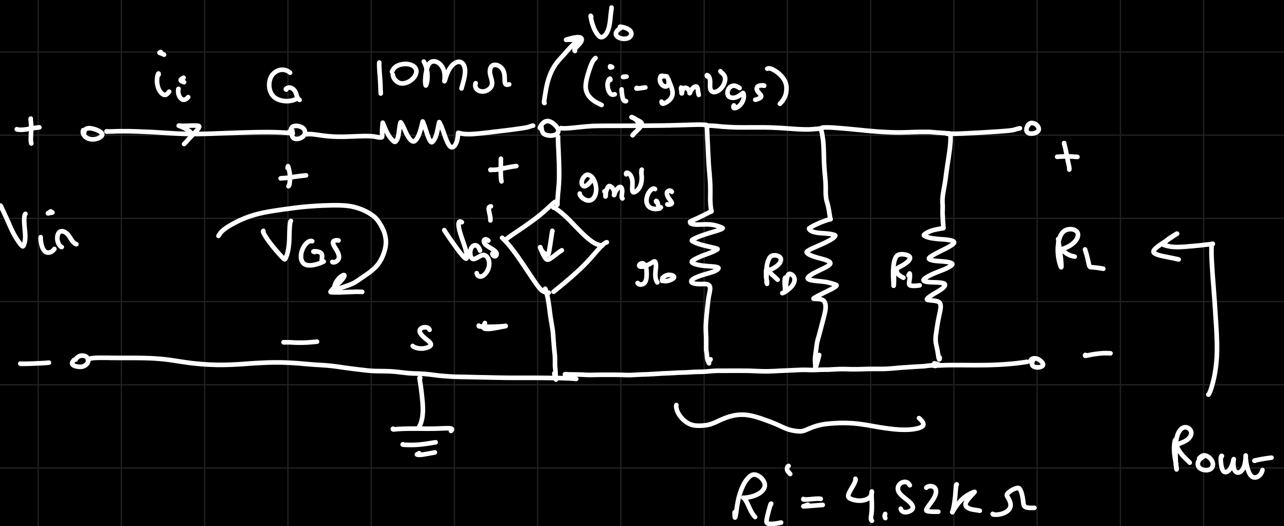
Tut (continuation)

previous Tut done on paper

g)



AC analysis → π model



$$V_o = (i_i - g_m v_{gs}) R_L' \quad \text{——} \quad ①$$

$$KVL = \quad -V_{in} + 10M(i_i) + V_o = 0$$

$$V_{in} - V_o = 10\times10^6 (i_i)$$

$$\frac{V_{in} - V_o}{R_G} = i_i \quad \text{——} \quad ②$$

$$V_o = \left(\frac{V_{in} - V_o}{R_G} - g_m v_{gs} \right) R_L'$$

$$V_o + \frac{V_o R_L'}{R_G} = \frac{V_{in} \cdot R_L'}{R_G} - g_m v_{gs} R_L'$$

$$V_o \left[1 + \frac{R_L'}{R_G} \right] = V_{in} \left(\frac{1}{R_G} - g_m \right) R_L'$$

$$\downarrow$$

$$V_{gs} = V_{in}$$

$$\frac{V_{out}}{V_{in}} = A_v = \frac{(1/R_G - g_m) R_L'}{(1 + R_L'/R_G)}$$

(overall gain)

volt/volt

mosfet gain $= \dfrac{V_o}{V_{gs}'}$ gain without R_G

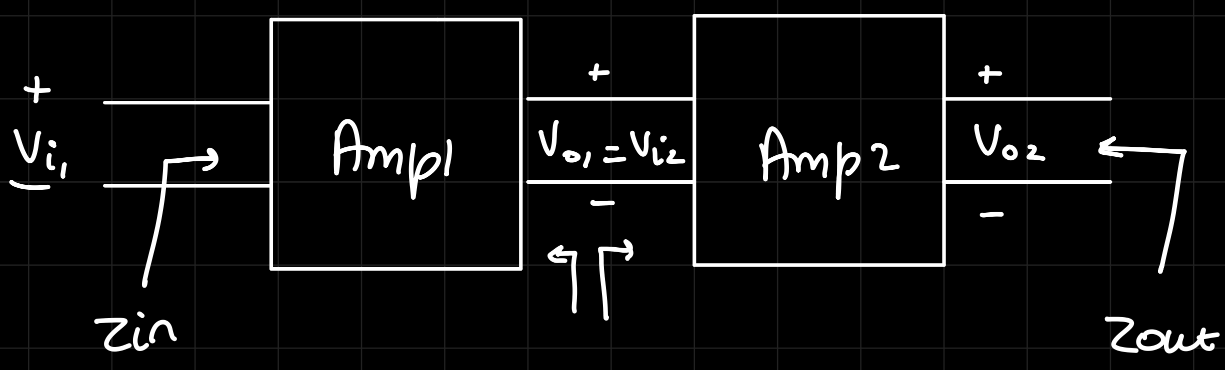
$R_L' = 4.52 k\Omega$ $\quad g_m = 0.72 m$

$A_{v_{overall}} = \underline{-3.259} \sim -3.3$

$$R_{in} = \frac{V_i}{i_i} = \frac{V_i \times R_G}{V_i - V_o} = \frac{V_i}{V_i + 3.3 V_i} \times R_G$$

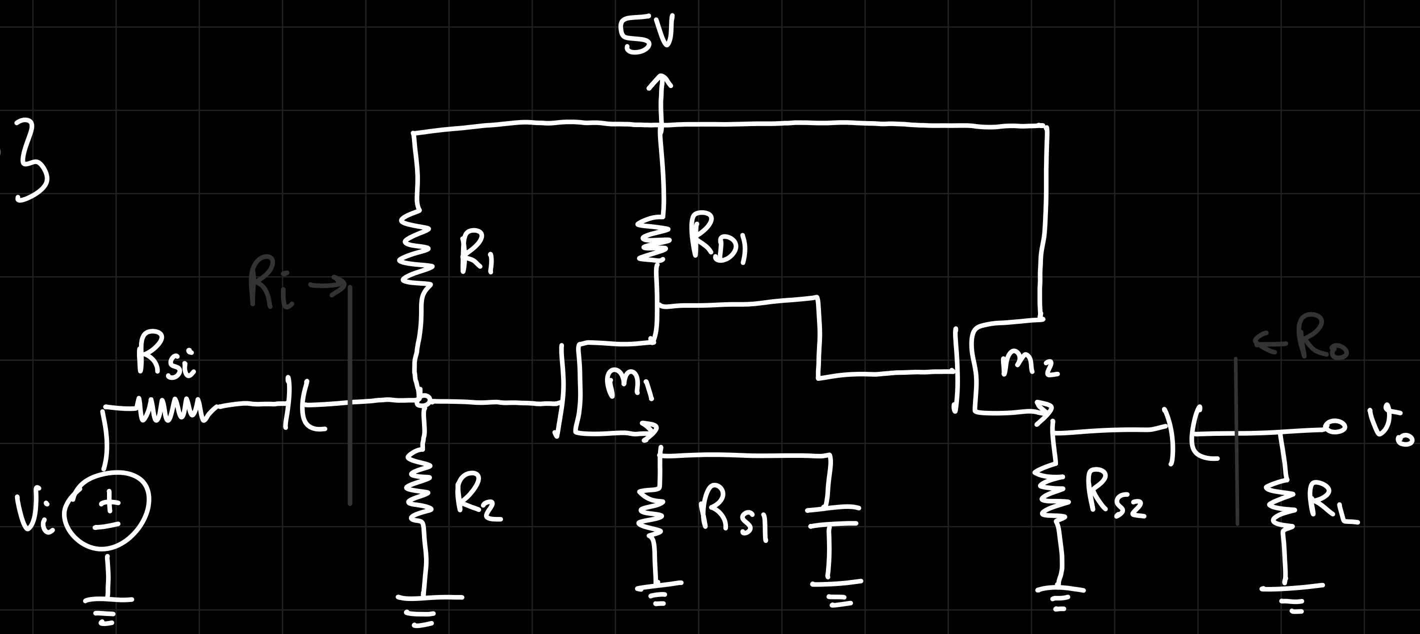
$$= \frac{R_G}{4.3} \Rightarrow 2.32 M\Omega$$

multistage / cascade amplifier



$R_{out_1} = R_{in_2}$

Q3



$K_{n_1} = 0.5\,mAV^{-2}$

$K_{n_2} = 0.2\,mAV^{-2}$

$V_{T1} = V_{T2} = 1.2V$

$I_{D1} = 0.2mA$

$I_{D2} = 0.5mA$

$V_{DS1} = V_{DS2} = 6V$

$R_i = 100k\Omega$

$R_{Si} = 4k\Omega$

assume

$K_n = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$

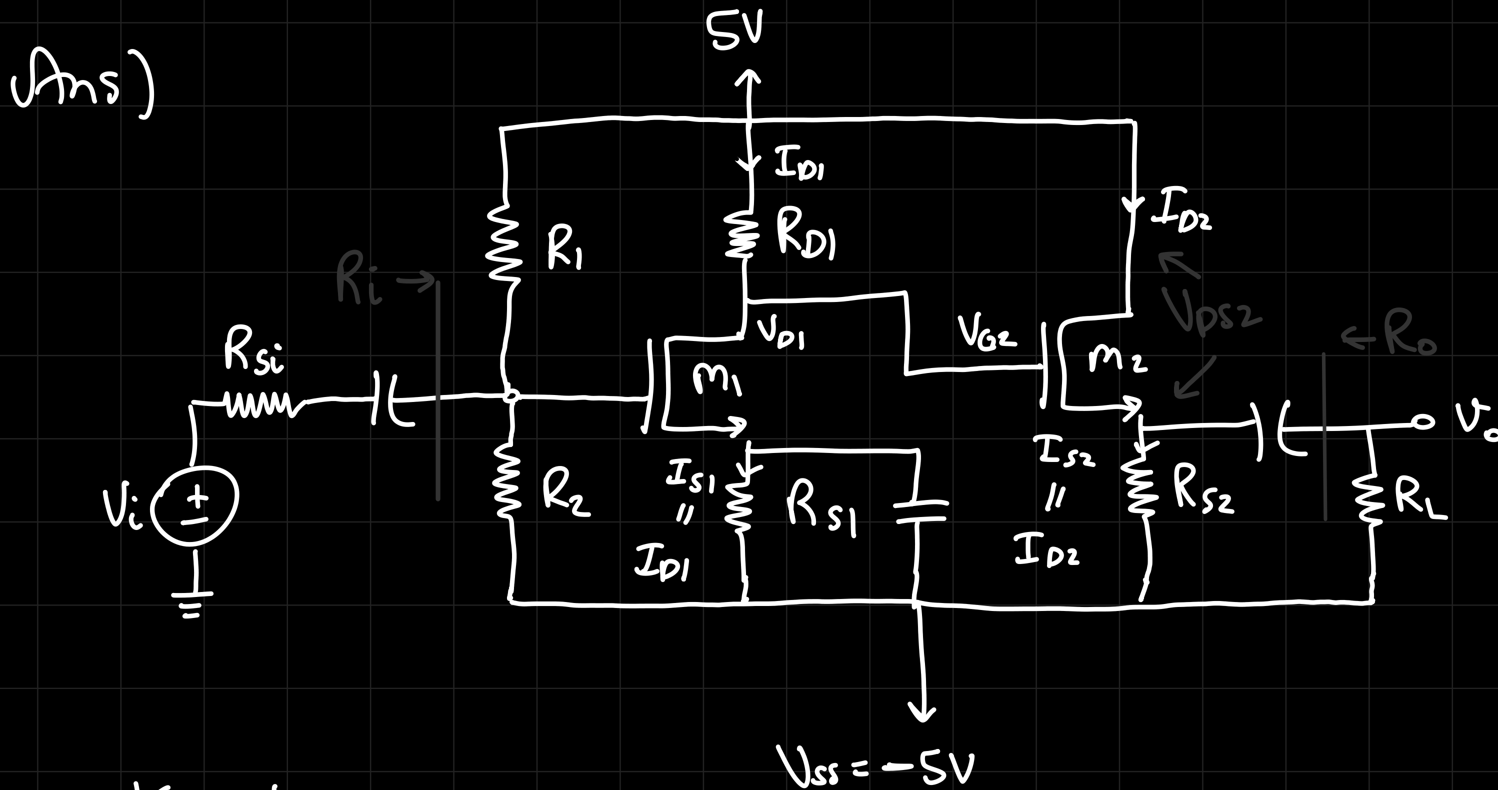
AC → BJT
DC & AC → MOSFET
Current mirror

Quiz 2 Syllabus

1st Amp → π model
2nd Amp → T model

assume that both work under saturation

Ans)



KVL (outer loop)

$$-V_{DD} + V_{DS_2} + I_{D2} R_{S2} + V_{SS} = 0$$

$$I_{D2} R_{S2} = 10 - 6 = 4V$$

$$R_{S2} = \frac{4}{0.5mA} = \underline{8k\Omega}$$

$$V_{GS2} = V_{G2} - V_{S2} = V_{G2} - (4 + V_{SS})$$
$$= V_{G2} + 1$$

$$I_{D2} = K_{n2}(V_{GS2} - V_T)^2$$

$$0.5m = 0.2 \times 10^{-3} (V_{GS2} - 1.2)^2$$

$$2.5 = (V_{GS} - 1.2)^2$$

$$V_{GS}^2 + 1.44 - 2.4V_{GS} = 2.5$$

$$V_{GS2} = \underline{2.78}$$

$$V_{G2} = \underline{1.78\,V}$$

KVL: $-5 + I_{D1}R_{D1} + V_{GS2} + I_{D2}R_{S2} - 5 = 0$

$$-5 + 0.2m\,R_{D1} + 2.78 + 4 - 5$$

$$R_{D1} = \frac{10 - 2.78 - 4}{0.2} \times k$$

$$R_{D1} = \underline{16.1\,k\Omega}$$

$$V_{G2} = V_{D1} = 1.78V$$

③ $$-V_{DD} + I_{D1}R_{D1} + V_{DS1} + R_{S1}I_{D1} - 5 = 0$$

$$4 = 0.2m(16.1k + R_{S1})$$

$$4 = 3.22 + R_{S1}(0.2m)$$

$$R_{S1} = \underline{3.9k\Omega}$$

$$I_{D1} = K_{n1} \times (V_{GS} - V_T)^2$$

$$0.2\cancel{m} = 0.5\cancel{m} \times (V_{GS} - 1.2)^2$$

$$0.4 = V_{GS}^2 + 1.44 - 2.4V_{GS}$$

$$V_{GS1} = 1.832V$$

$$V_{DS1} = V_{D1} - V_{S1}$$

$$V_{S1} = V_{D1} - 6 = V_{G2} - 6 = 1.78 - 6 = -4.22V$$

$$V_{GS1} = V_{G1} - V_{S1}$$
$$= V_{G1} - I_{D1} R_{S1}$$
$$= \frac{R_2}{R_1+R_2}\left(V_{DD} - V_{SS}\right) - I_D R_{S1}$$
$$= \frac{R_2}{R_1+R_2}(10) - 0.2 \times \cancel{10^{-3}} \times 3.9 \times \cancel{10^{3}}$$

$$\frac{1.832 + 0.78}{10} = \frac{R_2}{R_1+R_2}$$

$$2.612 = 10 \times \frac{R_2}{R_1+R_2}$$

We know $R_i = 100 k\Omega$

$$R_i = \frac{R_1 \times R_2}{R_1 + R_2} \rightarrow \frac{R_i}{R_1} = \frac{R_2}{R_1+R_2}$$

$$10 \times \frac{100k}{2.612} = R_1 \rightarrow R_1 = \underline{383 k\Omega}$$

$$R_2 = \underline{135.33 k\Omega}$$