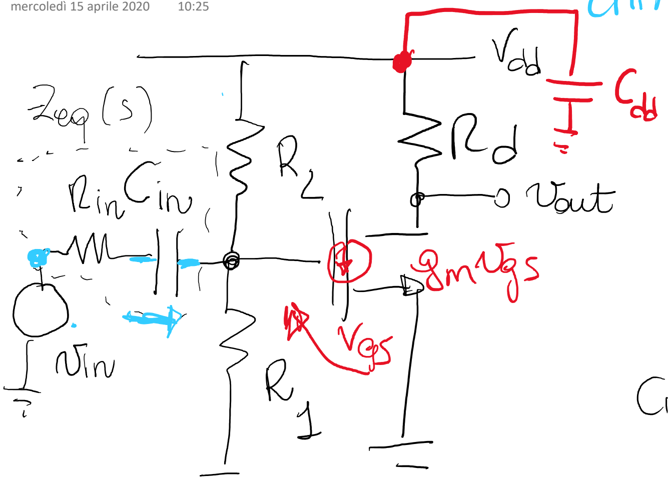
Lezione 9c: dimensionamento capacita' di disaccoppiamento di ingresso e uscita

mercoledì 15 aprile 2020 10:25

CAPACITÀ DI DISACCOPPIAMENTO IN INGRESSO



Stadio polarizzato

$$Z_{eq}(s) = R_{in} + \frac{1}{sC_{in}} = \frac{1 + sC_{in}R_{in}}{sC_{in}}$$

$$C_{in} \rightarrow Z_{C_{in}}(s) = \frac{1}{sC_{in}}$$

$$\tau = C_{in}\left[R_{in} + R_1 \| R_2\right]$$

FUNZIONE DI TRASFERIMENTO (dominio di Laplace)

$$\boxed{T(s) \triangleq \frac{V_{out}(s)}{V_{in}(s)} = -\frac{sC_{in}R_1\|R_2}{1+sC_{in}\left[R_{in}+R_1\|R_2\right]}\, g_m R_d}$$

ZERO

POLO

$1+s\tau$

$$V_g(s) = \frac{R_2 \| R_1}{Z_{eq}(s) + R_1\|R_2} \qquad V_{in}(s) = V_{gs}(s)$$

$$V_{out}(s) = -g_m V_{gs}(s) R_d =$$

$$= -g_m R_d \frac{R_2\|R_1}{Z_{eq}(s) + R_1\|R_2} V_{in}(s) =$$

$$= -g_m R_d \frac{R_1\|R_2}{\frac{1+sC_{in}R_{in}}{sC_{in}} + R_1\|R_2} V_{in}(s) =$$

$$= -g_m R_d \frac{sC_{in}R_1\|R_2}{1 + sC_{in}\left(R_{in}+R_1\|R_2\right)} V_{in}(s)$$

* ZERO DI UNA FUNZIONE DI TRASFERIMENTO

$\exists\, \bar{s}$ t.c. $\forall\, V_{in}(\bar{s}) \neq 0 \quad V_{out}(\bar{s}) = 0$

* POLO DI UNA FUNZIONE DI TRASFERIMENTO

$\exists\, \bar{s}$ t.c. $\forall\, V_{in}(\bar{s}) \neq \infty \quad V_{out}(\bar{s}) = \infty$

$\exists\, \bar{s}$ t.c. $\forall\, V_{in}(\bar{s}) \neq \infty \quad V_{out}(s) = \infty$

$$\boxed{s = j\omega}$$

$$T(j\omega) = -g_m R_d \frac{j\omega\, C_{in}\, R_1\|R_2}{1 + j\omega C_{in}(R_{in} + R_1\|R_2)}$$

MODULO della FUNZIONE DI TRASFERIMENTO

$$|T(j\omega)| = g_m R_d \frac{\omega C_{in}\, R_1\|R_2}{\sqrt{1+\omega^2 C_{in}^2 (R_{in}+R_1\|R_2)^2}}$$

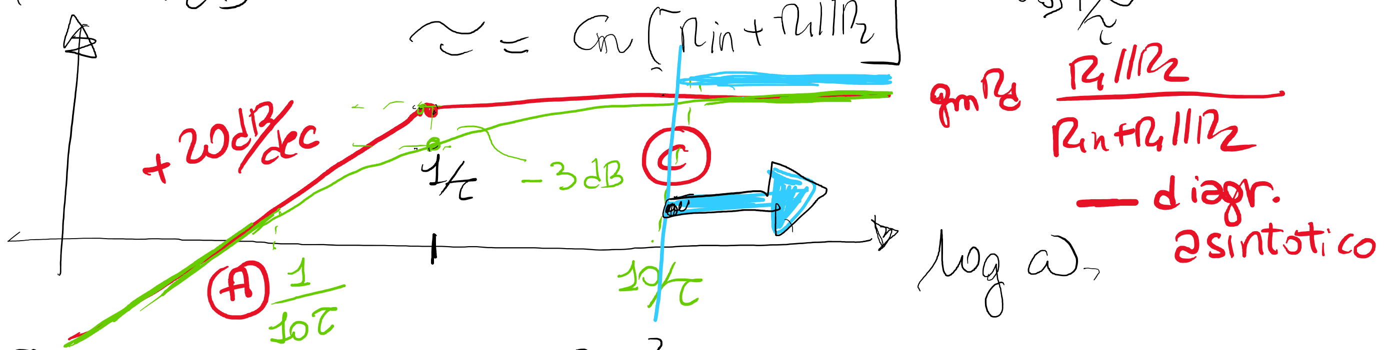
$\omega \ll 1/\tau$ (A)

$\omega = 1/\tau$ (B)

$\omega \gg 1/\tau$ (C)

$|T(j\omega)|_{dB}$

$\simeq = C_{in}\left[R_{in} + R_1\|R_2\right]$



(A) $\omega \ll 1/\tau \qquad \underbrace{1+\omega^2\tau^2}_{} \cong 1$

$$|T(j\omega)| \cong g_m R_d\, \omega\, C_{in}\, R_1\|R_2$$

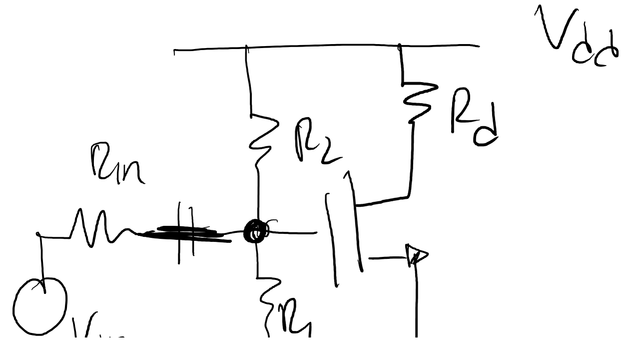
(B) $\omega = 1/\tau$ POLO

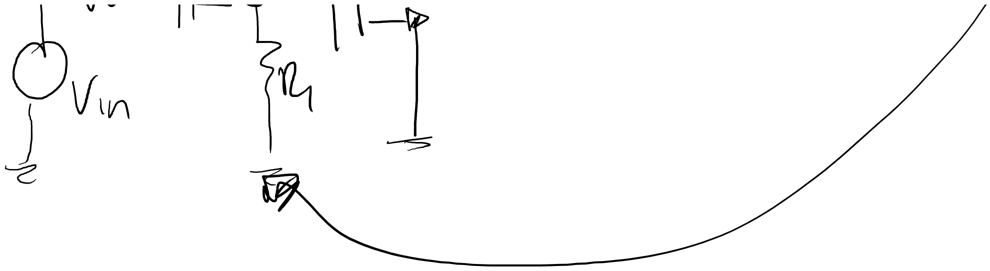
$$|T(j\omega)| = g_m R_d \frac{\frac{1}{C_{in}(R_{in}+R_1\|R_2)} \cdot C_{in} R_1\|R_2}{\sqrt{2}} =$$

$$= g_m R_d \frac{R_1\|R_2}{R_{in}+R_1\|R_2} \cdot \frac{1}{\sqrt{2}}$$

(C) $\omega \gg 1/\tau$

$$|T(j\omega)|_{MF} = g_m R_d \frac{\cancel{\omega}\, \cancel{C_{in}}\, R_1\|R_2}{\underbrace{\cancel{\omega}\, \cancel{C_{in}}\, (R_{in}+R_1\|R_2)}}$$

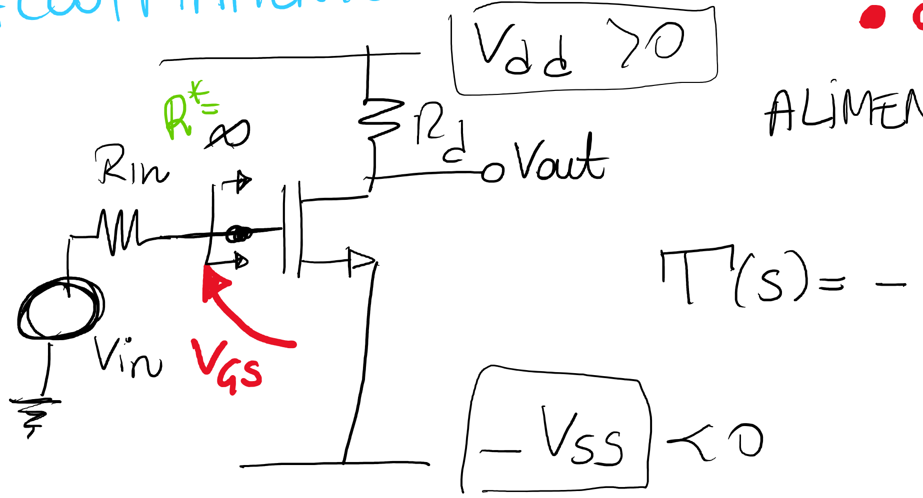




BANDA AUDIO = [20 Hz, 20 kHz]

ACCOPPIAMENTO IN CONTINUA

- amplifico anche DC
- resist. ingresso $R^* = \infty$
- due alimentazioni, una positiva e una negativa



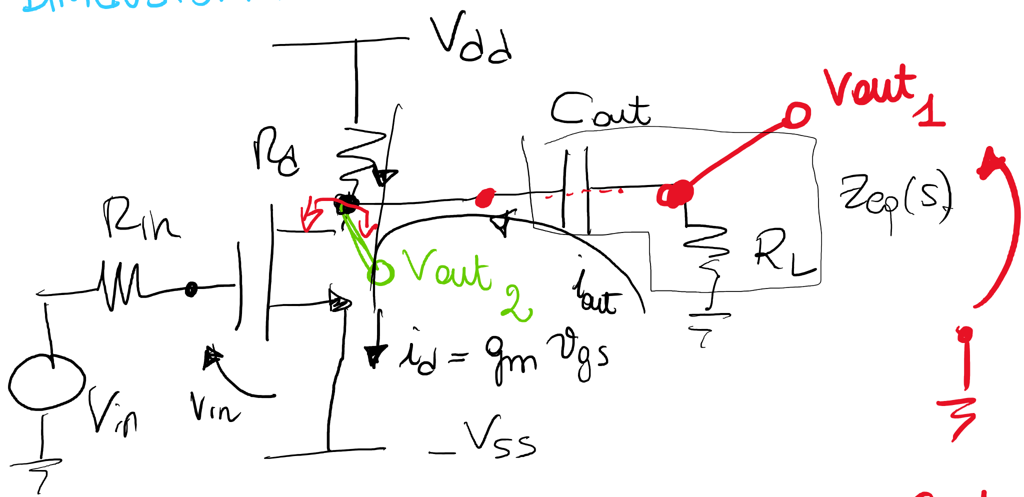
ALIMENTAZIONE DUALE

$$T(s) = -g_m R_d$$

POLARIZZ.

$$V_{GS} = V_G - V_S = 0 - (-V_{SS}) = V_{SS} > 0 \quad (> V_{Tn})$$

DIMENSIONAMENTO DELLA CAPACITÀ DI DISACCOPPIAMENTO DI USCITA



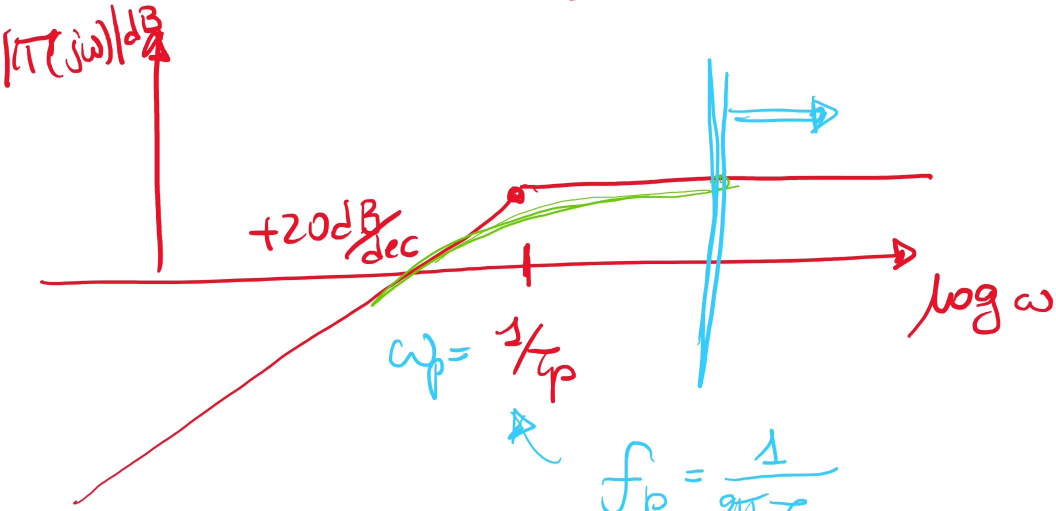
$$T(s) \triangleq \frac{V_{out\,1}(s)}{V_{in}(s)} = -g_m \frac{s C_{out} R_d R_L}{1 + s C_{out}(R_d + R_L)}$$

$$i_{out} = g_m v_{gs} \frac{R_d}{\ldots}$$

$$i_{out} = g_m v_{gs} \frac{R_d}{R_d + \underbrace{1/sC_{out} + R_L}_{Z_{eq}(s)}}$$

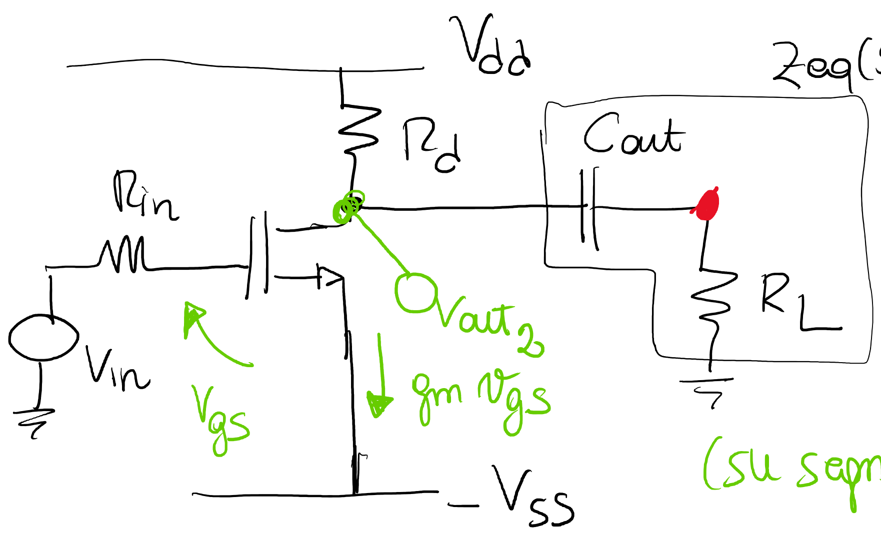
$$V_{out_1} = -i_{out} R_L = -g_m v_{gs} \frac{R_d R_L s C_{out}}{1 + sC_{out}(R_d + R_L)}$$

- zero nell'origine
- polo $\tau_p = C_{out}(R_d + R_L)$
- $|T(j\omega)|_{HF} = g_m \frac{R_d R_L}{R_d + R_L} = g_m (R_d // R_L)$



$\omega_p = 1/\tau_p$

$$f_p = \frac{1}{2\pi \tau_p}$$



$$Z_{eq}(s) = \frac{1}{sC_{out}} + R_L$$

(su segnale)

$$V_{out_2}(s) = -g_m V_{in}(s)\; R_d \,//\, Z_{eq}(s) =$$

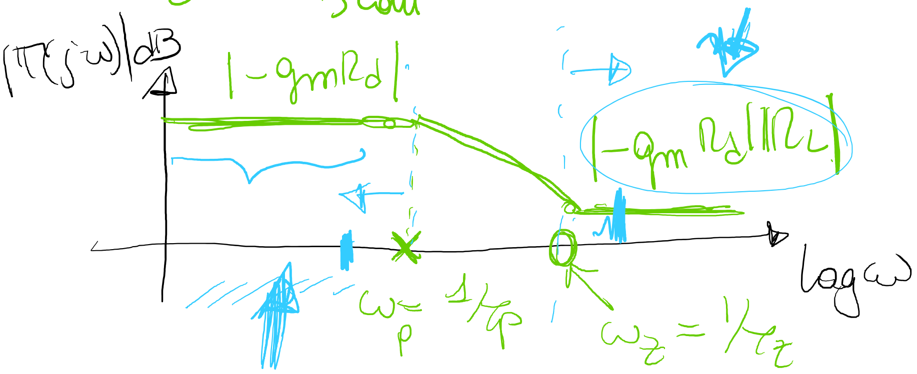
$$= -g_m V_{in}(s)\, \frac{R_d\,(1+sC_{out}R_L)}{1+sC_{out}(R_d+R_L)}$$

ZERO $s_z = -\frac{1}{C_{out}R_L}$

$\tau_z = C_{out}R_L$

polo UGUALE A PRIMA!

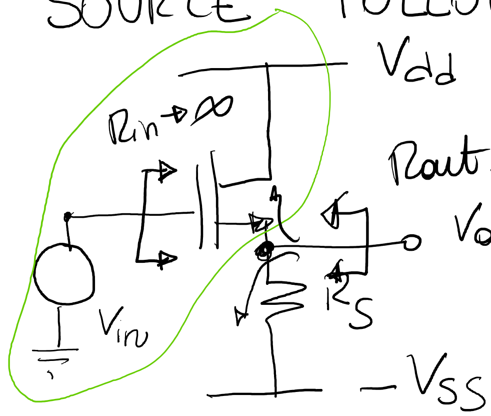
$$\frac{R_d\left(1/sC_{out}+R_L\right)}{R_d + 1/sC_{out} + R_L} = \frac{R_d\,(1+sC_{out}R_L)}{1+sC_{out}(R_d+R_L)}$$



$\tau_p = C_{out}(R_d+R_L)$

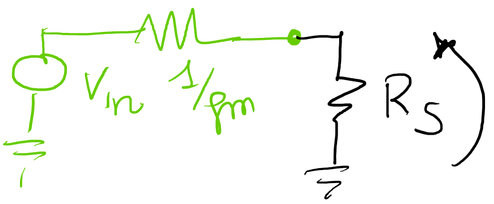
$\tau_z = C_{out}R_L$

SOURCE FOLLOWER (inseguitore di source)



$R_{out} = R_S \,//\, 1/g_m \simeq 1/g_m$

Eq. Thevenin



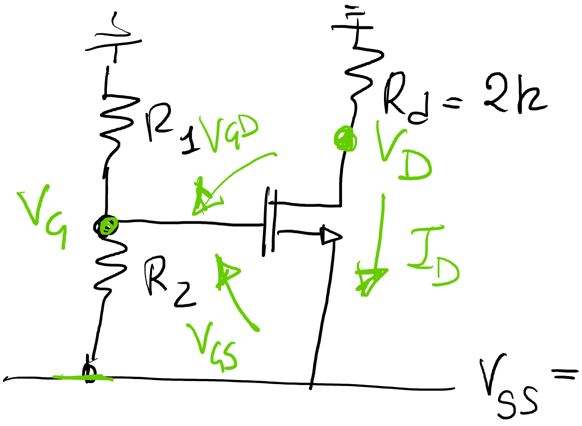
$$v_{out} = \frac{R_S}{R_S + 1/g_m}\, v_{in}$$

$$G \triangleq \frac{v_{out}}{v_{in}} = \frac{R_S}{R_S + 1/g_m} = \frac{g_m R_S}{1+g_m R_S} < 1$$

- STADIO NON INVERTENTE
- BUFFER DI TENSIONE
  - resist. in ingresso → ∞
  - resist. di uscita bassa
  - guadagno circa unitario

• BUFFER DI TENSIONE { - resist. ... ; - guadagno circa unitario

ESERCIZIO POLARIZZAZIONE



$$k_n = \frac{1}{2}\mu_n C_{ox}\frac{W}{L} = 1\,mA/V^2$$

$$V_{Tn} = 0.75V$$

$$R_1 = 825k$$

$$R_2 = 175k$$

$$V_{SS} = -10V$$

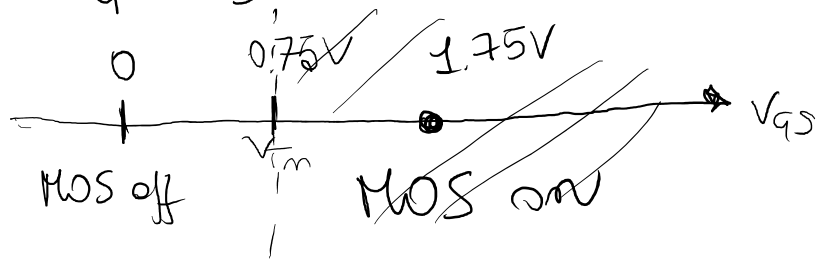
$$I_G = 0 \Rightarrow V_G = V_{SS} + \frac{R_2}{R_1+R_2}(-10V) =$$

$$= -10V\left[\frac{(R_1+R_2)}{R_1+R_2} + \frac{R_2}{R_1+R_2}\right] = -10V\frac{R_1}{R_1+R_2} =$$

$$= -8.25V$$

$$V_{GS} = V_G - V_S = -8.25V - (-10V) = +1.75V > V_{Tn}$$

MOS on



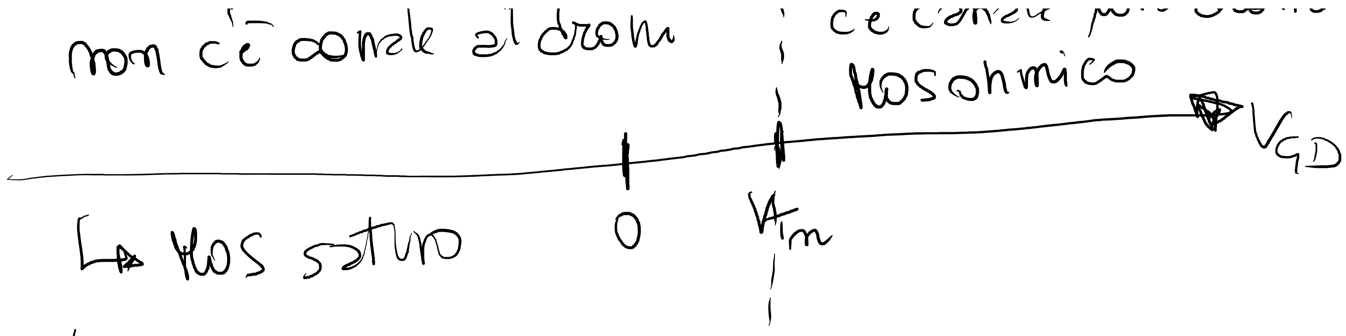
Hp saturazione nMOS

$$I_D = k_n(V_{GS} - V_{Tn})^2 = 1\,mA/V^2\,(1.75V - 0.75V)^2 = 1mA$$

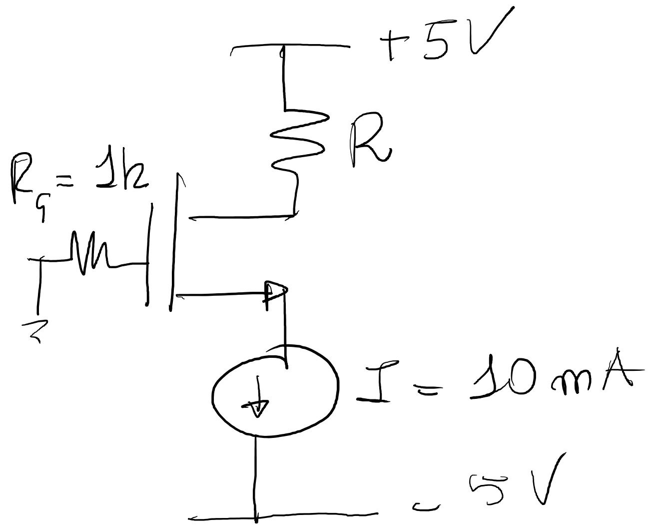
$$V_D = -I_D R_d = -1mA * 2k\Omega = -2V$$

$$\hookrightarrow V_{GD} = -8.25V - (-2V) = -6.25V$$

non c'è canale al drain | c'è canale lato drain MOS ohmico



⇓ ok MOS saturo



$V_T = 1.5\,V$

Determinare il massimo valore possibile per R per mantenere il MOS saturo?