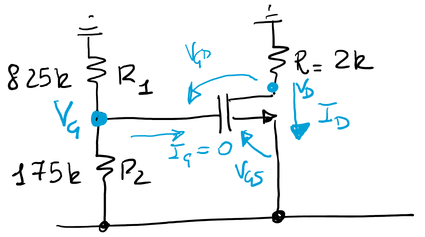
Esercizi - Polarizzazione dei MOSFET e polarizzazione e guadagno stadio Source a massa a nMOS

Wednesday, April 7, 2021 11:24 AM

ESERCIZIO



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

$V_{Tn} = 0.75V$

Hp Mos in saturazione $\quad I_D = k_n (V_{GS} - V_{Tn})^2$

$V_G = -10V - \frac{R_2}{R_1 + R_2}(-10V) = -10V \frac{R_1}{R_1+R_2} = -10V \frac{825k}{825k+175k} =$

$= -8.25V$ (1 MΩ)

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

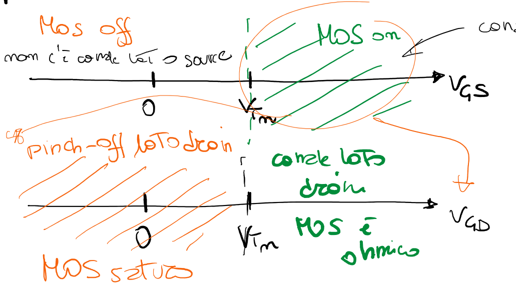
↳ nMos è acceso

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

$V_D = 0 - I_D R = -1mA * 2k = -2V$

$V_{GD} = -8.25 - (-2V) = -6.25V < V_{Tn}$ non c'è canale lato drain

↳ ok Mos saturo

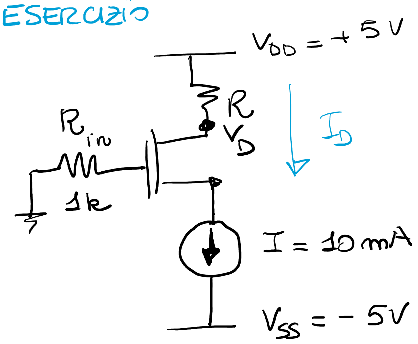


$V_{DS} > V_{GS} - V_{Tn} = V_{OV}$

$V_D - V_S > V_G - V_S - V_{Tn}$

$V_G - V_D < V_{Tn}$

ESERCIZIO



$V_{Tn} = 1.5V$

Determinare il massimo valore di R che mantenga il MOSFET saturo

$V_{GD} < V_{Tn}$ MOSFET saturo $\Rightarrow$ condiz. limite per la saturazione $V_{GD} = V_{Tn}$

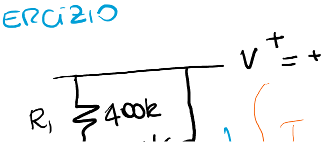
$V_G = 0V \Rightarrow \boxed{V_{GD} = V_{Tn}}$ equivale a $0 - V_D = V_{Tn}$

$V_{Dmin} = -V_{Tn} = -1.5V$

$V_D = V_{DD} - I_D R \Rightarrow R_{MAX} = \frac{V_{DD} - V_{Dmin}}{I_D} = \frac{5V - (-1.5)}{10 mA} =$

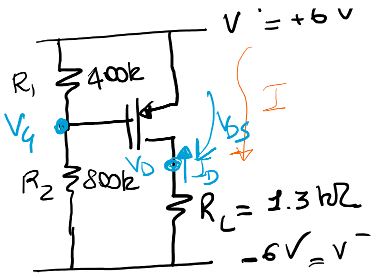
$= 650 \Omega$

ESERCIZIO



$V_{Tp} = -2V$

$\frac{1}{2} \mu_p C_{ox} W$ ... $= 2mA/V^2$



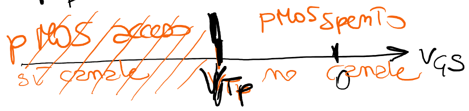
$V_{Tp} = -2V$

$k_p = -\frac{1}{2}\mu_p C_{ox}\frac{W}{L} = -2 mA/V^2$

Hp. MOS saturo

$$V_G = -6V + \frac{R_2}{R_1+R_2}(V^{+} - V^{-}) = -6V + \frac{800k}{\underbrace{800k+400k}_{1200k}} 12V = +2V$$

$$V_{GS_p} = V_G - V_S = +2V - 6V = -4V < V_{Tp}$$

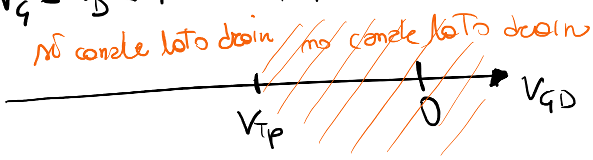


$$I_D = k_p (V_{GS_p} - V_{Tp})^2 = -2mA/V^2 \left[-4V - (-2V)\right]^2 =$$

$$= -2mA/V^2 \; 4V^2 = -8mA$$

$$V_D = V^{-} - I_D R_L = -6V - (-8mA)\,1.3k\Omega = +4.4V$$

$$V_{GD} = V_G - V_D = +2 - 4.4V = -2.4V < V_{Tp} \Rightarrow$$ **NO MOS non saturo**



Hp MOS ohmico

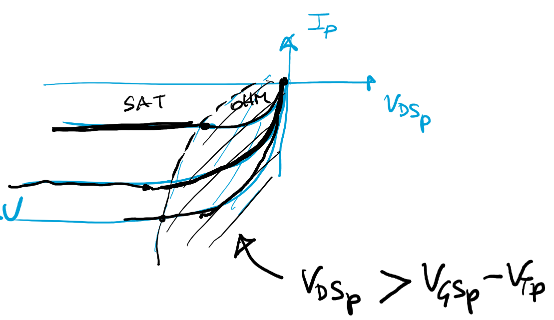
$$\begin{cases} I_D = k_p\left[2(V_{GS_p} - V_{Tp})V_{DS_p} - V_{DS_p}^2\right] \\ V_{DS} = -6V - I_D R_L - V^{+} = -12V - I_D R_L \end{cases}$$

$V_{DS} =$ $-2.63V$ / $-1.76V$ **OK**

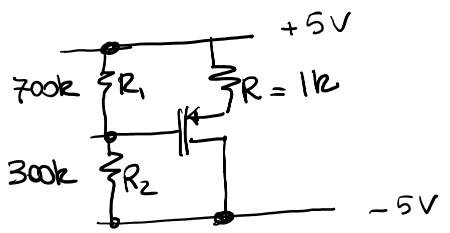
pMOS ohmico

$V_{DS_p} > V_{GS_p} - V_{Tp}$

$I_D = 7.88\ mA \Rightarrow V_D = +4.24V$



ESERCIZIO A CASA



$|V_{Tp}| = 1V$

$k_p = -1mA/V^2$

I_D? zona funzionamento

[$I_D = 4mA$, MOS ....]

ESERCIZIO STADIO AMPLIFICANTE nMOS in CONFIG. SOURCE A MASSA

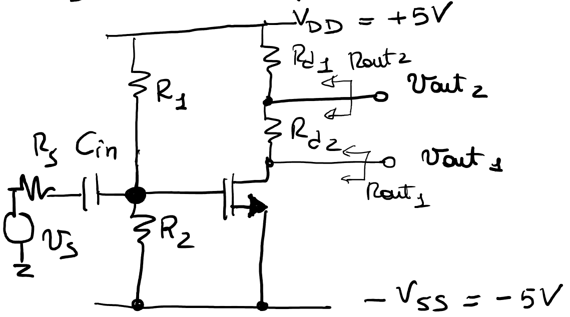
1. Polarizzazione

2. Guadagno di piccolo segnale $\frac{v_{out1}}{v_s}$ e $\frac{v_{out2}}{v_s}$ a MF (C_{in} corto circuito)

3. Dimensionare C_{in} per amplificare segnali nella banda [1kHz, 50kHz]

4. Resistenze di uscita R_{out1} e R_{out2}

5. Errore di linearità se v_s è una sinusoide di ampiezza 100 mV e frequenza 30 kHz



$V_{Tn} = 0.5V$

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

$R_1 = 850\ k\Omega$

$R_2 = 150\ k\Omega$

$R_{d1} = 2k\Omega$

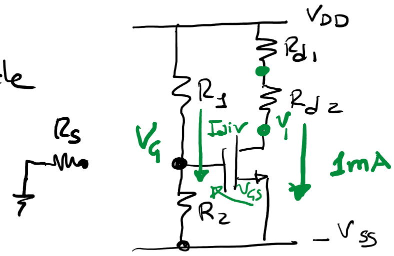
$R_{d2} = 4k$

$R_s = 200\Omega$

1. POLARIZZAZIONE

Calcolare tensioni a tutti i nodi e correnti in tutti i rami

* Capacità circuiti aperti
* Spegnere i generatori di segnale
* Hp MOS saturo



$$V_G = -V_{SS} + \frac{R_2}{R_1+R_2}\left[V_{DD} - (-V_{SS})\right] =$$

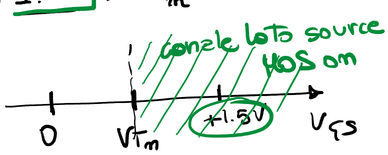
$$= -5V + \frac{150k}{150k + 850k} \cdot 10V =$$

$$= -5V + 1.5V = -3.5V \quad (150k+850k = 1M)$$

$$I_{div} = \frac{V_{DD} - (-V_{SS})}{R_1 + R_2} = \frac{10V}{1M\Omega} = 10\mu A$$

$$V_{GS} = V_G - (-V_{SS}) = -3.5V + 5V = +1.5V > V_{Tn} = 0.5V \quad \text{MOS on}$$

$$V_{GS} = \frac{R_2}{R_1+R_2}\left[V_{DD} - (-V_{SS})\right]$$



Hp MOS saturo

$$I_D = k_n (V_{GS} - V_{Tn})^2 = 1mA/V^2\,(1.5V - 0.5V)^2 = 1\ mA$$

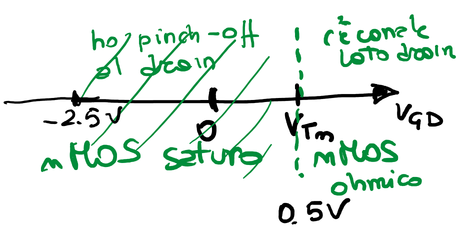
$$V_D = V_{DD} - I_D(R_{d1} + R_{d2}) = 5V - 1mA\,(2k + 4k) = -1V$$

Verifico l'hp di saturazione

$$V_{GD} = V_G - V_D = -3.5V - (-1V) =$$

$$= -2.5V < V_{Tn}$$

↳ ok MOS saturo



alternativamente

↳ cioè MOS saturo

alternativamente

$V_{DS} = V_D - V_S = -1V - (-5V) = +4V$

$V_{GS} - V_{Tn} = +1.5V - 0.5V = +1V$

$4V > 1V$ cioè $V_{DS} > V_{GS} - V_{Tn}$ cioè nMOS saturo

nMOS saturo ; nMOS ohmico

0.5V

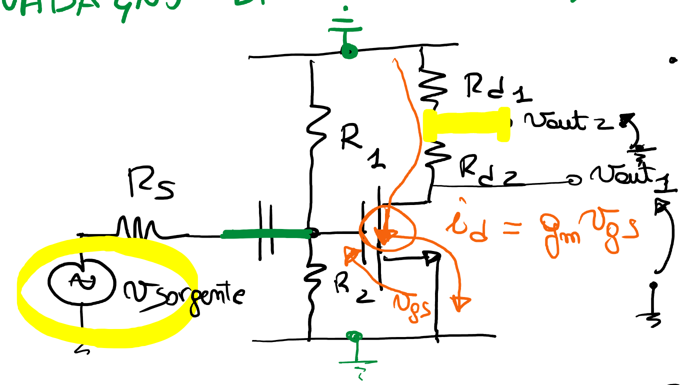
- Transconduttanza

$g_m = 2k_n (V_{GS} - V_{Tn}) = 2 * 1mA/V^2 (1.5V - 0.5V) = 2mS$

$1/g_m = 500\ \Omega$

2. GUADAGNO DI PICCOLO SEGNALE

v_{out1}/v_s e v_{out2}/v_s



- corrente di piccolo segnale

$i_d = g_m v_{gs}$

$$v_{gs} = v_g = \frac{R_1 // R_2}{R_1 // R_2 + R_s} v_{sorgente}$$

$$v_{out1} = -i_d (R_{d1} + R_{d2}) = -g_m \frac{R_{//}}{R_{//} + R_s} (R_{d1} + R_{d2}) v_{sorgente}$$

$$G_1 \triangleq \frac{v_{out1}}{v_{sorgente}} = -g_m (R_{d1} + R_{d2}) \frac{R_{//}}{R_{//} + R_s} = -2mA/V (2k + 4k) \cdot \frac{127.5k}{(127.5 + 0.2)k}$$

(0.998 → 1)

$$R_{//} = R_1 // R_2 = 850k // 150k = \frac{850k * 150k}{1000k} = 127.5\ k\Omega$$

$= -12$ [−11.98]

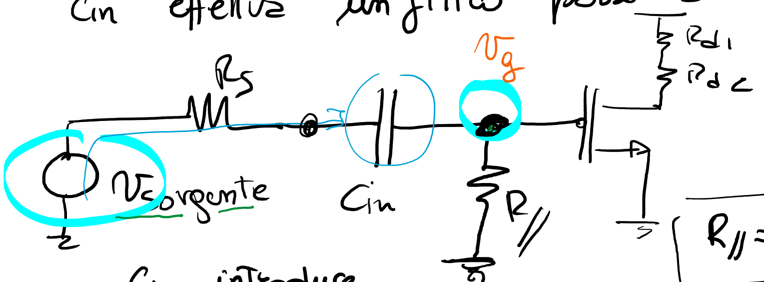
$$v_{out2} = -i_d R_{d1} = -g_m \frac{R_1 // R_2}{R_1 // R_2 + R_s} \cdot R_{d1}\ v_{sorgente}$$

$$G_2 \triangleq \frac{v_{out2}}{v_{sorgente}} = -g_m \frac{R_{//}}{R_{//} + R_s} R_{d1} \cong -2mS \cdot 1 \cdot 2k =$$

$= -4$ (−3.99)

3. DIMENSIONAMENTO Cin

Cin effettua un filtro passo alto sul segnale di ingresso



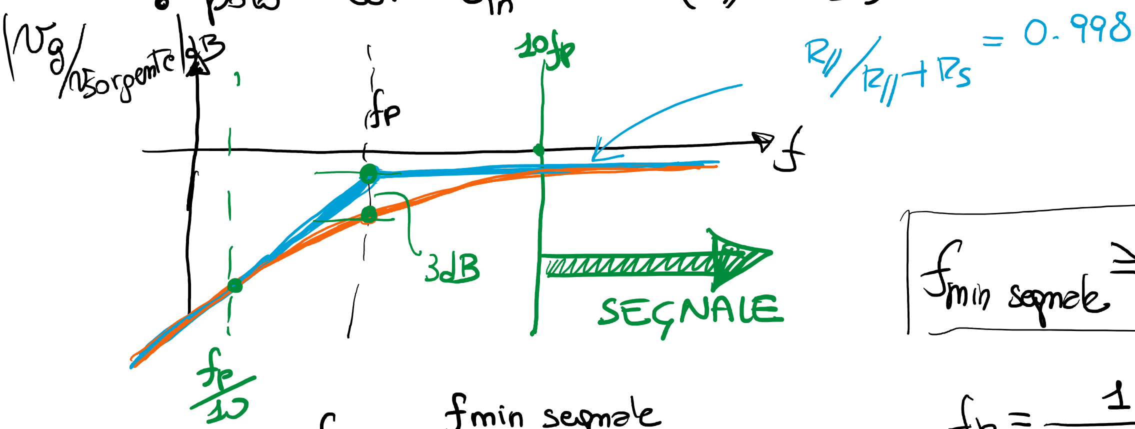
$$v_g = \frac{R_{//}}{R_s + R_{//} + 1/sC_{in}} v_{sorgente} = \frac{s C_{in} R_{//}}{1 + sC_{in}(R_s + R_{//})} v_{sorgente}$$

$R_{//} = R_1 // R_2$

Cin introduce

- zero nell'origine
- polo con $\tau_1 = C_{in} (R_{//} + R_s)$

- zero nell'origine
- polo con $\tau_{in} = C_{in}(R_{//} + R_S)$



$$f_{min\ segnale} \geq 10 f_p$$

$$f_p = \frac{f_{min\ segnale}}{10}$$

$$f_p = \frac{1}{2\pi\tau_{in}}$$

$\tau_{in} = C_{in}(R_{//} + R_S)$

$$\frac{1}{2\pi\tau_{in}} = \frac{f_{min\ segnale}}{10}$$

$$\tau_{in} = \frac{10}{f_{min\ segnale}} \cdot \frac{1}{2\pi}$$

$$C_{in} \geq \frac{\tau_{in}}{R_{in}} = \frac{10}{f_{min\ segnale}} \frac{1}{2\pi(R_{//}+R_S)} = 12.5\ mF$$

$$\boxed{C_{in\,min} = 12.5\ mF}$$

4. $R_{out_1} = (R_{d_1} + R_{d_2}) = 6\,k\Omega$

$R_{out_2} = R_{d_1} = 2k$

5. $\varepsilon = 5\%$