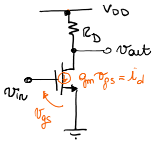
Effetto della resistenza di uscita, carichi attivi, stadio Source a Massa con carico attivo, specchi di corrente

Wednesday, April 7, 2021 10:19 AM



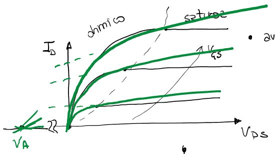
MOS in saturazione

$$G \triangleq \frac{v_{out}}{v_{in}} = -g_m R_D$$

- aumentare g_m

$$g_m = 2 k_n (V_{GS} - V_{Tn}) =$$

$$= 2\left(\frac{1}{2}\mu_n C_{ox} \underset{\uparrow}{\boxed{\frac{W}{L}}}\right) \underbrace{(V_{GS} - V_{Tn})}_{\uparrow}$$

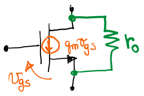


- aumentare R_D

$$I_D = k_n (V_{GS} - V_{Tn})^2 \underset{\uparrow}{(1 + \lambda V_{DS})}$$

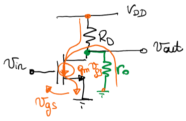
effetto di moduloz. della lunghezza di canale

$$\lambda = \frac{1}{|V_A|}$$



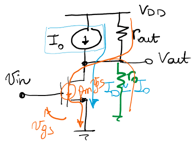
$$r_o = \left[\frac{\partial I_D}{\partial V_{DS}}\right]^{-1}_{saturaz} = \frac{|V_A|}{I_D}$$

$$r_o \simeq 50k\Omega \div 100k\Omega$$



$$G \triangleq \frac{v_{out}}{v_{in}} = -\underset{1mS \uparrow}{g_m}(R_D \,//\, \underset{\uparrow 100k\Omega}{r_o})$$

STADIO SOURCE A MASSA CON CARICO ATTIVO



- in assenza di r_o

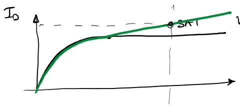
$$v_{out} = -g_m v_{in} r_{out} \Rightarrow G = -g_m r_{out}$$

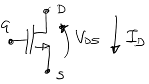
- tenendo conto di r_o

$$v_{out} = -g_m v_{in} (r_{out} // r_o)$$

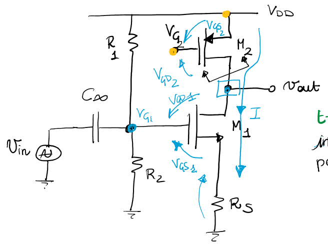
$$\hookrightarrow G = -g_m (r_{out} // r_o)$$

GEN. DI CORRENTE A MOSFET





STADIO SOURCE DEGENERATO CON CARICO ATTIVO



$$I = |k_p| (V_{GS_2} - V_{Tp})^2$$

trascurando r_{o1}

intervallo di Tensioni possibili per il nodo v_{out}

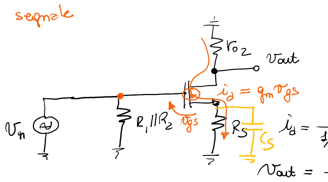
$$\begin{cases} V_{GD_2} > V_{Tp} \\ V_{GD_1} < V_{Tn} \end{cases}$$

$$\begin{cases} V_{G2} - V_{out} > V_{Tp} \\ V_{G1} - V_{out} < V_{Tn} \end{cases}$$

$$\begin{cases} V_{out} < V_{G2} - V_{Tp} \\ V_{out} > V_{G1} - V_{Tn} \end{cases}$$

$$\boxed{(V_{G1} - V_{Tn}) < V_{out} < V_{G2} - V_{Tp}}$$

su segnale



$$i_d = \frac{v_{in}}{1/g_{m1} + R_S}$$

$$v_{out} = -i_d r_{o2} =$$

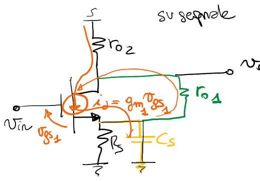
$$= -\frac{r_{o2}}{1/g_{m1} + R_S} v_{in}$$

$$\hookrightarrow G \triangleq \frac{v_{out}}{v_{in}} = -\frac{r_{o2}}{1/g_{m1} + R_S} = -\frac{g_{m1} r_{o2}}{1 + g_{m1} R_S}$$

$$G_{HF} \triangleq -g_m r_{o2}$$

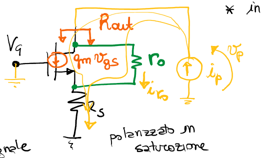
Circuito in HF Tenendo conto di entrambe le r_o

su segnale



$$v_{out} = -g_{m1} (r_{o2} // r_{o1}) v_{in}$$

GEN. DI CORRENTE CON MOSFET CON DEGENERAZIONE DI SOURCE



circuito di piccolo segnale

polarizzato in saturazione

* in assenza di r_o $R_{out} = \infty$

$$R_{out} \triangleq \frac{v_p}{i_p}$$

$$i_p = g_m v_{gs} + i_{r_o}$$

$$v_s = i_p R_S \Rightarrow v_{gs} = -i_p R_S$$

$$i_{r_o} = \frac{v_p - v_s}{r_o}$$

$$i_p = -i_p g_m R_S + \frac{v_p}{r_o} - i_p \frac{R_S}{r_o}$$

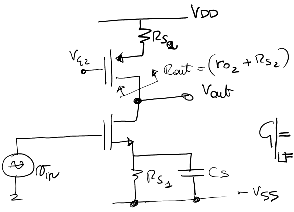
$$i_p\left[1 + g_m R_S + \frac{R_S}{r_o}\right] = \frac{v_p}{r_o}$$

$$i_p = -i_p\, g_m R_S + \frac{v_p}{r_o} - \cdots \frac{}{r_o}$$

$$i_p\left[1 + g_m R_S + \frac{R_S}{r_o}\right] = \frac{v_p}{r_o}$$

$$v_p = r_o\left[1 + g_m R_S + \frac{R_S}{r_o}\right] i_p$$

$$R_{out} \triangleq \frac{v_p}{i_p} = r_o + R_S + g_m R_S r_o = (r_o + R_S)\left[1 + g_m\, r_o \| R_S\right]$$



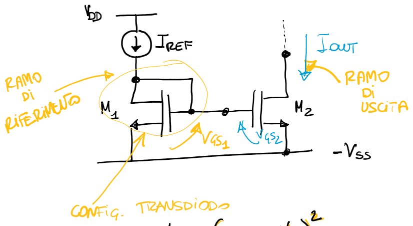
$$R_{out} = (r_{o_2} + R_{S_2})\left[1 + g_{m_2}(r_{o_2} \| R_{S_2})\right]$$

$$G\Big|_{LF} = -\frac{R_{out}}{1/g_{m_1} + R_{S_1}} = -\frac{(r_{o_2}+R_{S_2})\left[1+g_{m_2} r_{o_2} \| R_{S_2}\right]}{1/g_{m_1} + R_{S_1}}$$

$$G_{HF} = -g_{m_1} R_{out} = -g_{m_1}\left[(r_{o_2}+R_{S_2})\,(1+g_{m_2} r_{o_2} \| R_{S_2})\right]$$

FINE ARGOMENTI PRIMA PROVA IN ITINERE

SPECCHIO DI CORRENTE (CURRENT MIRROR)



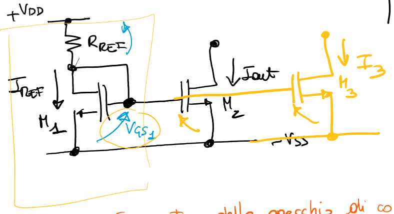
$$I_{out} = \frac{k_{m2}}{k_{m1}} I_{REF} = \frac{\cancel{1/2\, \mu_n C_{ox}}(W/L)_2}{\cancel{1/2\, \mu_n C_{ox}}(W/L)_1} I_{REF} = \frac{(W/L)_2}{(W/L)_1} I_{REF}$$

- $I_{REF} = k_{m_1}(V_{GS_1} - V_{Tn})^2$

$V_{GS_2} = V_{GS_1}$

- $I_{out} = k_{m_2}(V_{GS_2} - V_{Tn})^2 = k_{m2}\underbrace{(V_{GS_1} - V_{Tn})^2}_{I_{REF}/k_{m_1}} = \frac{k_{m2}}{k_{m1}} I_{REF}$

a patto che ciò che è connesso al drain di M_2 lo mantenga saturo

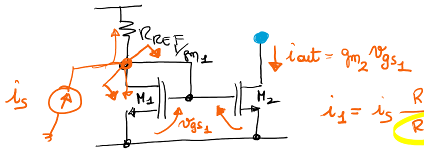


$$\begin{cases} I_{REF} = k_m (V_{GS_1} - V_{Tn})^2 \\ \left[V_{DD} - (-V_{SS})\right] = I_{REF} R_{REF} + V_{GS_1} \end{cases}$$

$$\Downarrow$$

$$(V_{GS_1},\ I_{REF})$$

Comportamento dello specchio di corrente su piccolo segnale

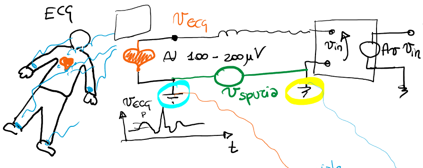


$$i_{out} = g_{m_2} v_{gs_1}$$

$$i_1 = i_s \frac{R_{REF}}{R_{REF} + 1/g_{m_1}} = g_{m_1} v_{gs_1}$$

$$i_{out} = g_{m_2} v_{gs_1} = \frac{i_1}{g_{m_1}} g_{m2} = i_1 \frac{\cancel{2} k_{m2}\cancel{(V_{GS_2} - V_{Tn_2})}}{\cancel{2} k_{m_1}\cancel{(V_{GS_1} - V_{Tn_1})}} = i_1 \frac{(W/L)_2}{(W/L)_1}.$$

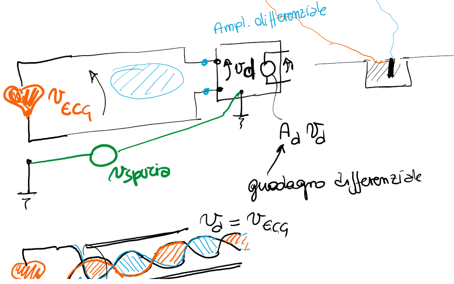
STADIO DIFFERENZIALE

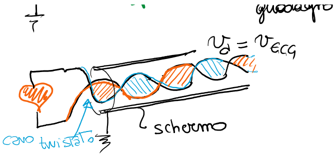


$$v_{out} = \overset{1000}{A_v}\, \underset{100-200\mu V}{v_{in}} = A_v\, v_{ECG} = 100mV$$

0.1mV

$$v_{out} = A_v v_{in} = A_v(v_{ECG} + \underset{100\,mV}{v_{spuria}}) = \underline{\underline{1000V}}\ !!!\ 1\,V$$




$v_d = v_{ECG}$
schermo
cavo twistato