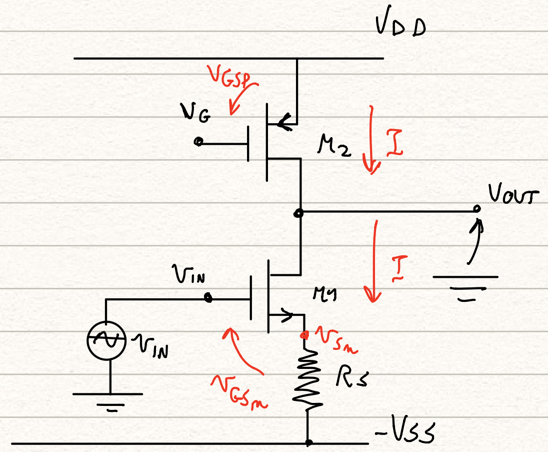
STADIO SOURCE A MASSA CON CARICO ATTIVO E STADI DIFFERENZIALI



(A) POLARIZZAZIONE

$$V_{GSP} = V_G - V_{DD} \rightarrow I = -I_D = -K_p \left(V_{GS_p} - V_{Tp}\right)^2$$

$$V_{S_n} = -V_{SS} + I R_S$$

$$V_{GS} = 0 - V_{SN} \rightarrow I_{D_n} = K_n \left(V_{GS_n} - V_{Tn}\right)^2 = I$$

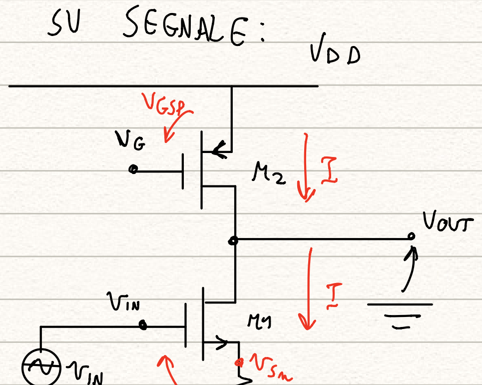
Saturazione di M_1 $\quad V_{GD_n} < V_{Tn}$

Saturazione di M_2 $\quad V_{GD_p} > V_{Tp}$

$$V_{GD_n} = V_{G_n} - V_{D_n} = V_{G_n} - V_{OUT} = 0 - V_{OUT}$$
$$V_{GD_p} = V_{G_p} - V_{D_p} = V_G - V_{OUT} > V_{Tp}$$

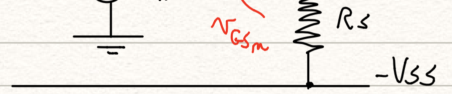
$$\left.\begin{array}{l} (1)\ V_{OUT} > -V_{Tn} \\ (2)\ V_{OUT} < V_G - V_{Tp} \end{array}\right\} \quad \boxed{-V_{Tn} < V_{OUT} < V_G - V_{Tp}}$$

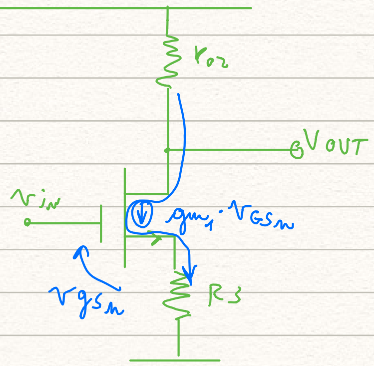
(B) ANALISI SU SEGNALE:



r_{o_2} finita

$r_{o_1} = \infty$



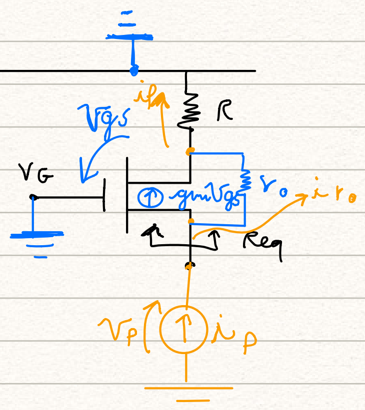


$$V_{OUT} = -g_{m1} v_{gsm} r_{o2}$$

$$v_{gsm} = \frac{1/g_{m1}}{1/g_{m1} + R_s} V_{IN}$$

$$V_{OUT} = \frac{-g_{m1} r_{o2}}{1 + g_{m1} R_s} V_{IN}$$

$$G \triangleq \frac{V_{OUT}}{V_{IN}} = -\frac{g_{m1} r_{o2}}{1 + g_{m1} R_3}$$



RESISTENZA EQUIVALENTE VISTA DAL DRAIN IN PRESENZA DI Ro

$$R_{eq} \triangleq \frac{v_P}{i_P}$$

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

$$v_S = -v_{gs} = i_P R$$

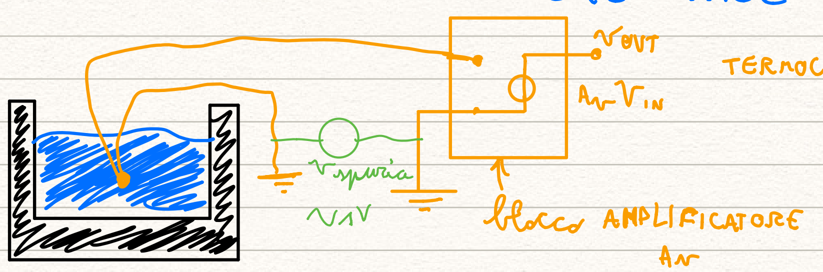
$$i_{r_o} = \frac{v_P - v_S}{r_o} = \frac{v_P - i_P R_s}{r_o}$$

$$i_P = g_m(-i_P R) + \frac{v_P}{r_o} - \frac{i_P R_s}{r_o}$$

$$v_P = r_o i_P \left[1 + g_m R + \frac{R_s}{r_o}\right]$$

$$R_{eq} = \frac{v_P}{I_P} = r_o + g_m R r_o + R_s = (r_o + R_s)\left[1 + g_m \underbrace{\frac{r_o R}{r_o + R}}_{r_o // R}\right] = (r_o + R)\left[1 + g_m \, r_o // R\right]$$

LO STADIO DIFFERENZIALE



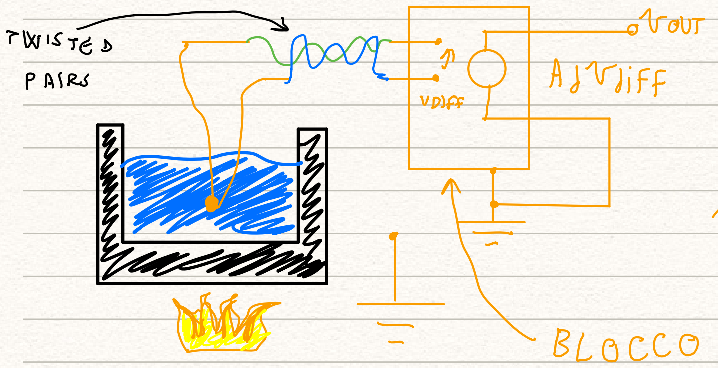
TERMOCOPPIA $\simeq 50\ \mu V/°C$

$V_{OUT} = A_V V_{IN} = A_V \cdot V_{sig}$

$A_V = 10^3 \longrightarrow V_{sig} = 100\mu V \longrightarrow V_{OUT}$

$V_{IN} = V_{sig} + V_{SPURIA}$

$V_{OUT} = A_V V_{IN} = A_V (V_{sig} + V_{spuria})$



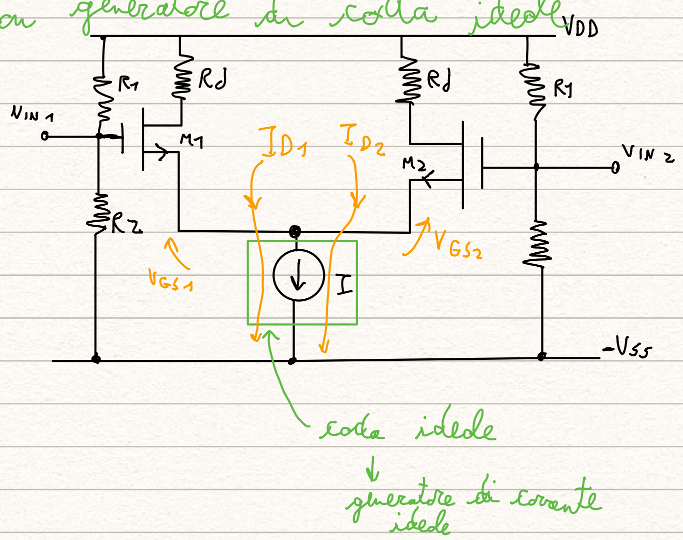
$V_{OUT} = A_d V_{diff}$

$V_{diff} = V_{sig}$

$V_{OUT} = A_d V_{diff} = A_d V_{sig}$

STADIO DIFFERENZIALE A MOSFET

A) con generatore di coda ideale



A) POLARIZZAZIONE

Se lo stadio è simmetrico

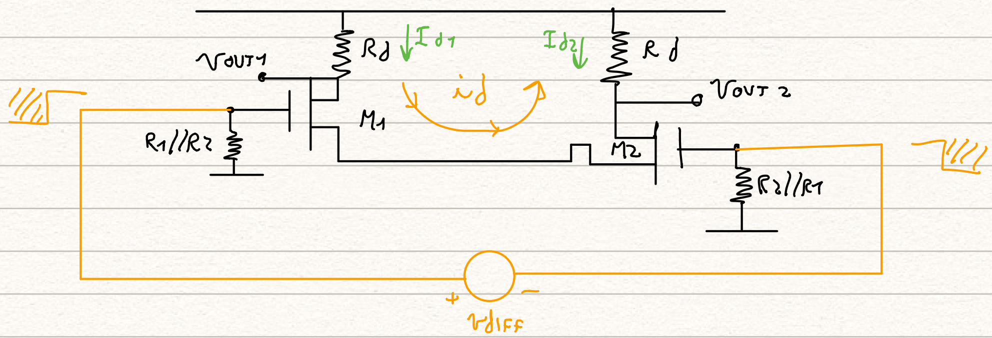
$V_{GS_1} = V_{GS_2} \longrightarrow I_{D_1} = I_{D_2} = \frac{I}{2}$

HP: MOS saturi

$I_D = K_n (V_{GS} - V_{Tn})^2$

(B) COMPORTAMENTO SU SEGNALE DIFFERENZIALE

Segnale differenziale di ingresso va a sbilanciare i gate (segnale applicato tra i gate)



$i_{d1} = g_m v_{gs1}$
$i_{d2} = g_m v_{GS2}$
$v_{GS1} = +v_{diff}/2$
$v_{GS2} = -v_{diff}/2$

$$i_d = \frac{v_{diff}}{1/g_{m1} + 1/g_{m2}}$$

$g_{m1} = g_{m2} = g_m$ (stadio simmetrico)

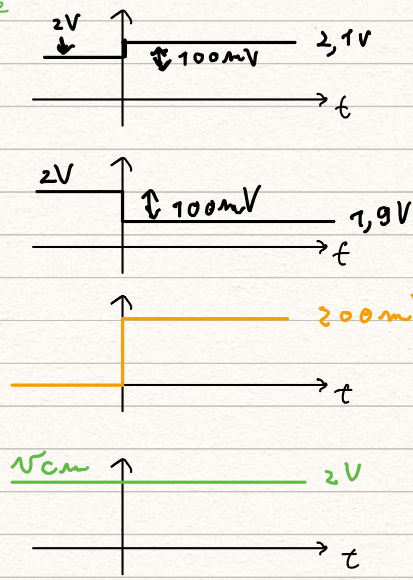
v_{diff} segnale differenziale in ingresso $\quad v_{diff} = V_{IN_1} - V_{IN_2}$

$v_{diff} = V_{IN_1} - V_{IN_2}$

v_{cm} segnale di modo comune $\quad v_{cm} \triangleq \frac{V_{IN_1} + V_{IN_2}}{2}$

$v_{IN_1} = 2V + 100\,mV \cdot 1(t)$

$v_{IN_2} = 2V - 100\,mV \cdot 1(t)$



$V_{OUTdiff} \triangleq V_{O1} - V_{O2}$ (preleva un uscita balle-ended)

V_{OUT} single ended

V_{d1}, V_{d2} riferita a massa

$$V_{OUT_{cm}} \triangleq \frac{V_{OUT1} + V_{OUT2}}{2}$$

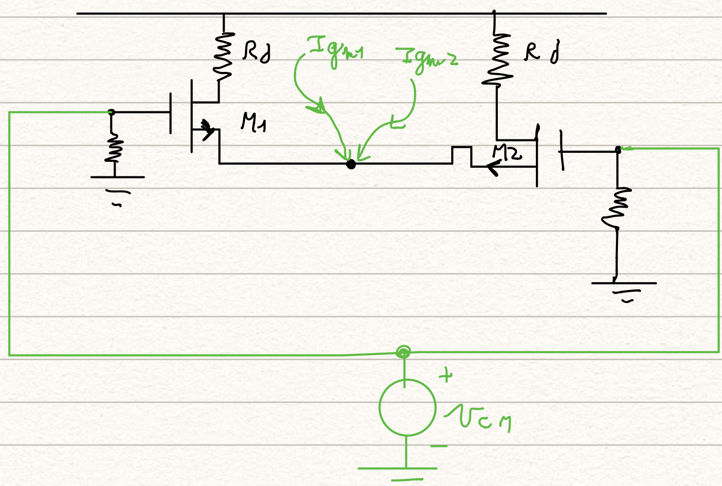
tensione di uscita di modo comune

$$V_{OUT\,DIFF} \triangleq V_{OUT1} - V_{OUT2} = -(i_d R_d) - (i_d R_d) = -2 i_d R_d = -2 \frac{R_d}{1/g_{m1} + 1/g_{m2}} v_{diff}$$

* in doubleended

$$G_{diff} = -g_m R_d$$

Ⓒ Comportamento su segnale di modo comune



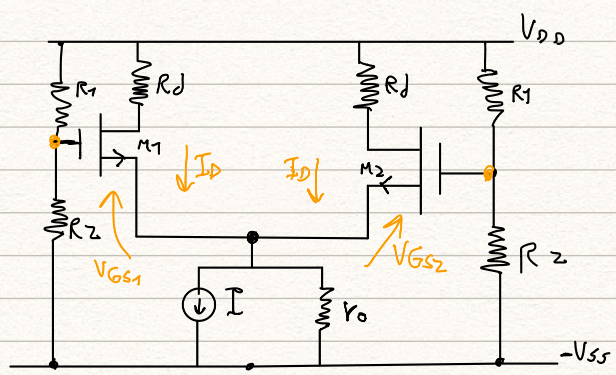
$$\begin{cases} i_{cm1} + i_{cm2} = 0 \\ i_{cm1} = i_{cm2} \end{cases} \longrightarrow \boxed{i_{cm} = 0}$$

$$G_{cm} \triangleq \frac{v_{out\,cm}}{v_{cm}} = \frac{\frac{V_{OUT1} + V_{OUT2}}{2}}{v_{cm}} = 0$$

$$C.M.R.R. \triangleq \left| \frac{G_{DIFF}}{G_{CM}} \right|$$

COMMON MODE REJECTION RATIO

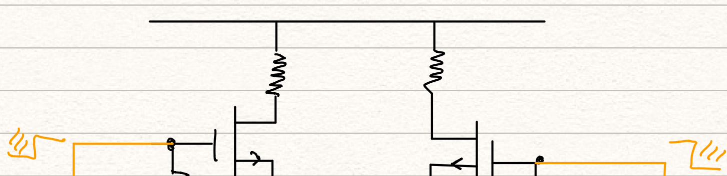
Ⓑ CON GENERATORE DI CODA REALE (NON IDEALE)

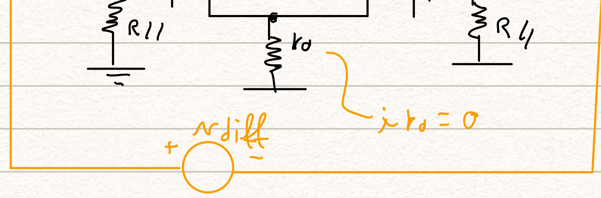


$$V_{GS1} = V_{GS2} = V_{GSN}$$

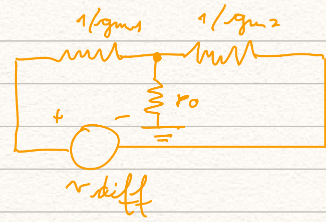
$$\begin{cases} I_D = K_n (V_{GSn} - V_{Tn})^2 \\ V_{GS} + I_{r_o} \cdot r_o = V_G - (-V_{SS}) \end{cases}$$

Se stadio simmetrico su segnale differenziale non cambia nulla

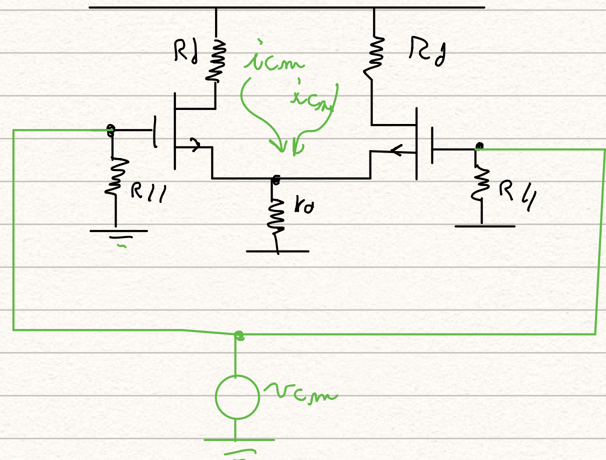




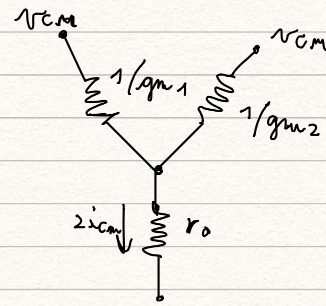
su segnale differenziale



SU SEGNALE DI MODO COMUNE



$$i_{r_0} = i_{cm1} + i_{cm2} \overset{i_{cm1} = i_{cm2}}{=} 2 i_{cm}$$



$$2 i_{cm} = \frac{v_{cm}}{\underbrace{\frac{1}{2g_m}}_{1/g_{m1},\ 1/g_{m2}} + r_o}$$

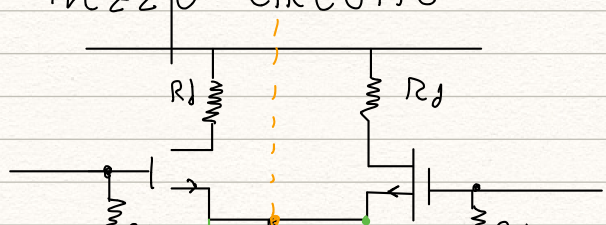
$$i_{cm} = v_{cm} \frac{1}{\frac{1}{g_m} + 2 r_o}$$

$V_{OUT\,1} =$

$$G_{cm} \triangleq \frac{\frac{V_{OUT\,1} + V_{OUT\,2}}{2}}{V_{CM}} = \frac{-R_d}{1/g_m + 2 r_o}$$ DOUBLE ENDED

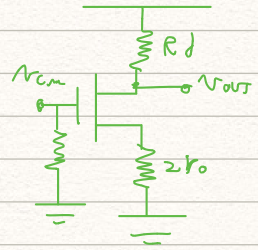
$$G_{cm} \triangleq \frac{V_{OUT\,1}}{V_{cm}} = -\frac{R_d}{1/g_m + 2 r_o}$$ SINGLE ENDED

MEZZO CIRCUITO



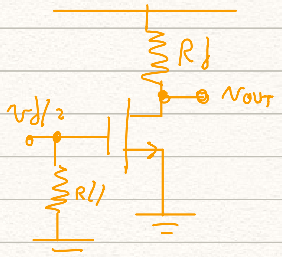
MODO COMUNE

r_o è vista come $2r_o // 2r_o$

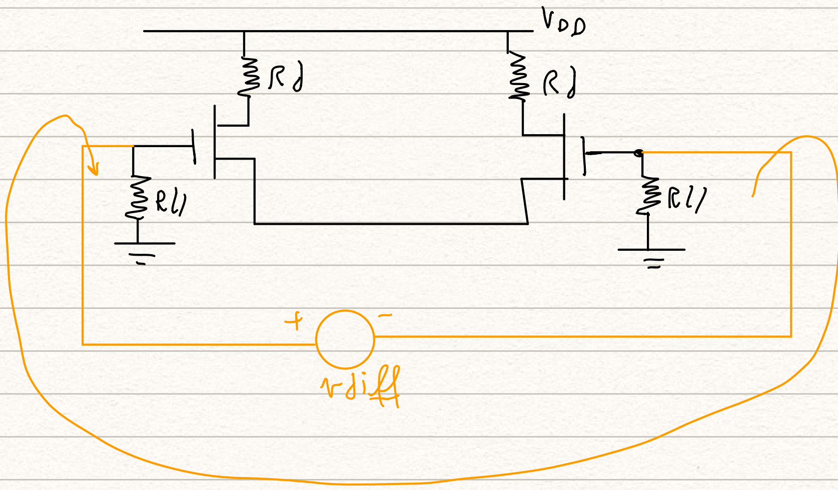


SEGNALE DIFFERENZIALE

Vsource fissa in tensione

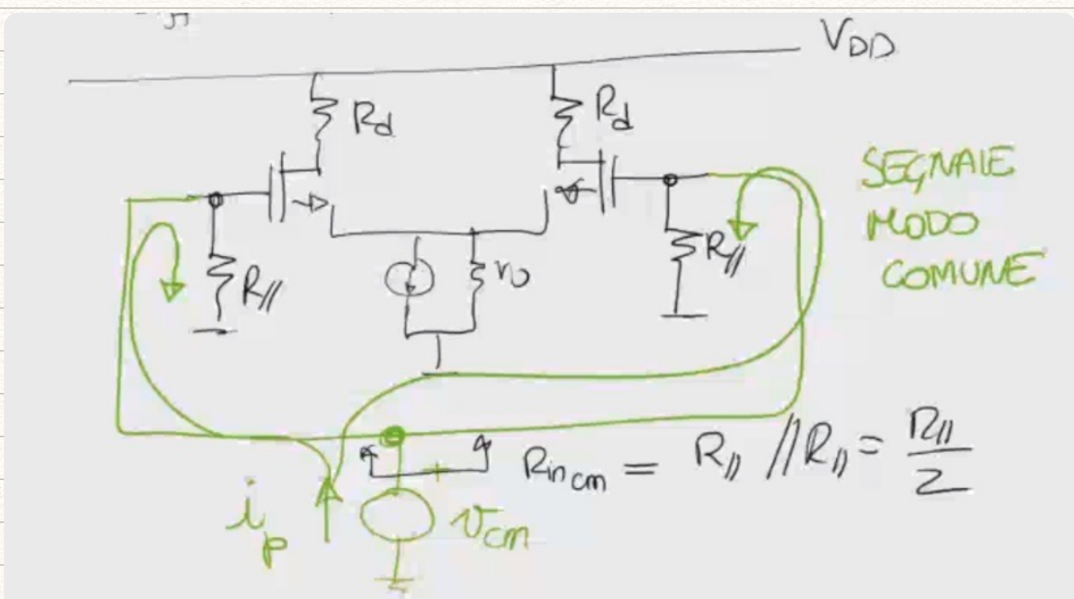


RESISTENZA DI INGRESSO



SEGNALE DIFFERENZIALE

$R_{IN\,diff} = R// + R// = 2R//$



$R_{in\,cm} = R_{//} // R_{//} = \frac{R_{//}}{2}$