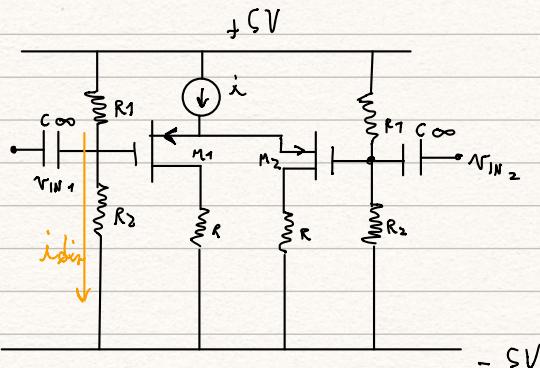


# ESECUZIONE STADIO DIFFERENZIALE

esercizio 1



## A) GEN. DI CODA IDEALE

$$|V_{TP}| \approx 1V$$

$$K_p = \frac{1}{2} \mu_p C_o x \left( \frac{W}{L} \right)_p = -50 \mu A/V^2$$

$$R_1 = R_2 = 100 K\Omega$$

$$R = 10 K\Omega$$

$$I = 40 \mu A$$

## A) POLARIZZAZIONE

- 1 spegni i generatori forzanti
- 2 capienza circuiti aperti
- 3 MOS  $\underline{\underline{MOS}}$

$$V_{G1} = V_{G2} \approx -5V + \frac{R_1}{R_1+R_2} [5V - (-5V)] = -5V + 5V = 0V \text{ a } 1/2$$

$$I_{PMOS} = -I_D = |K_p| (V_{GS} - V_{TP})^2 \rightarrow V_{GS} = -\sqrt{\frac{|I_D|}{K_p}} + V_{TP} = 3V$$

$$I_{PMOS} = \frac{I}{2} = 200 \mu A \quad \text{per la simmetria dello stadio e poiché } V_{GS1} = V_{GS2}$$

$$\Delta V_R = I_{PMOS} R = 200 \mu A \cdot 10 K\Omega = 2V$$

$$\hookrightarrow V_{D1} = V_{D2} = -5V + \Delta V_R = -5V + 2V = -3V$$

$$V_{GD1} = V_{GD2} = V_G - V_D = 0 - (-3V) = +3V$$



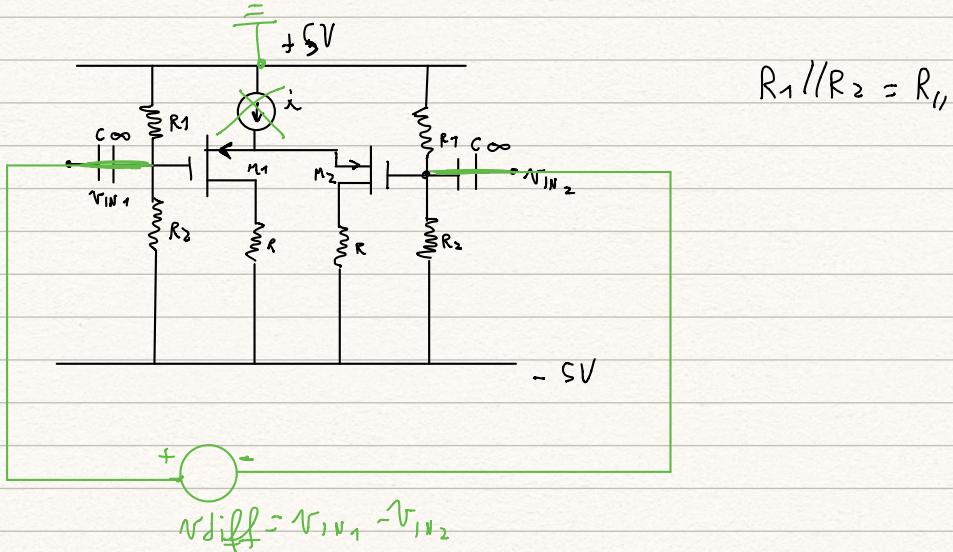
$$I_{D1} = \frac{5V - (-5V)}{R_1+R_2} = \frac{10V}{200 K\Omega} = 50 \mu A$$

$$g_m = 2K_p (V_{GSp} - V_{TP}) = \frac{2I_D}{V_{or}} = \frac{-400 \mu A}{-2V} = 200 \mu A/V = 0.2 mS$$

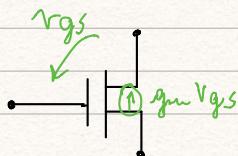
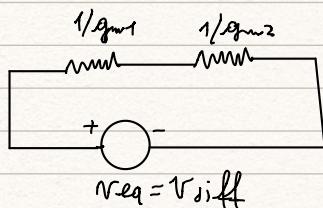
$$g_m = \frac{I_D}{V_{GS} - V_{TP}} \xrightarrow[V_{GS} - V_{TP} < 0]{< 0} > 0 !!$$

$V_{or}$  tensione di sovradrivenza

### B) COMPORTAMENTO SU SEGNALE DIFFERENZIALE



1) Eq. therenin da SOURCE



$$i = \frac{V_{req}}{1/gm_1 + 1/gm_2} \approx \frac{V_{diff}}{2/gm} = gm \frac{V_{diff}}{2} = gm_1 = gm_2$$

$$V_{o1} = -iR$$

$$V_{o2} = iR$$

USC ITA DOUBLE ENDED

$$V_{outDE} \stackrel{?}{=} V_{o2} - V_{o1} = iR - (-iR) = 2iR$$

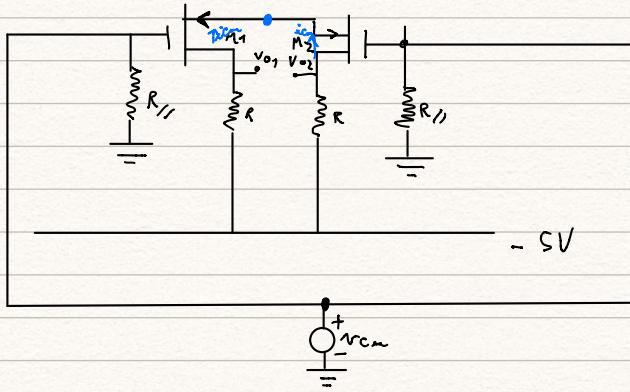
?

USC ITA SINGLE ENDED

$$V_{outSE} \stackrel{?}{=} V_{o1} = -gm R/2 = -1$$

$$\stackrel{?}{=} V_{o2} = gm R/2 = 1$$

### C) COMPORTAMENTO SU SEGNALE DI MODO COMUNE



$$\text{inc} + \text{dec} = 0 \quad 2\pi \text{cm} = 0 \rightarrow \text{inc} = 0$$

$$G_{cm}|_{DE} \stackrel{\Delta}{=} \frac{r_{01} + r_{02}}{2} \frac{1}{rcm} \quad \text{DOUBLE ENDED}$$

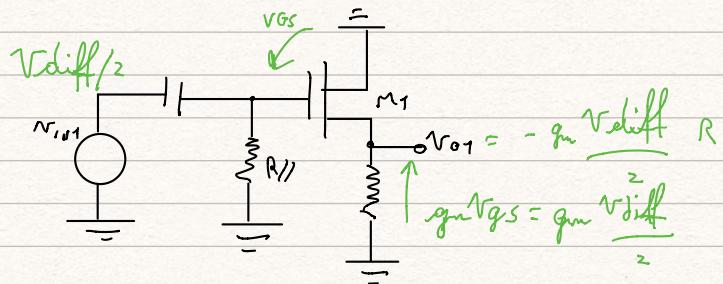
$$G_{CM|SE} \stackrel{\triangle}{=} \frac{V_{G1}}{V_{CM}} = \frac{V_{G2}}{V_{CM}}$$

SINGLE ENDED

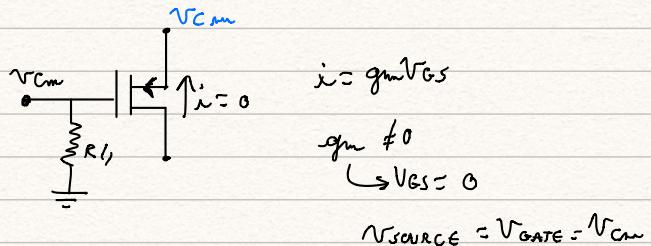
$G_{CM} = 0 !!!$

$\rightarrow CMRR \rightarrow \infty$

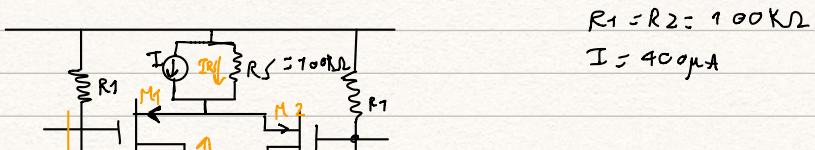
66 bis) COMPORTAMENTO DIFFERENZIALE - ANALISI CON MEZZO CIRCUITO

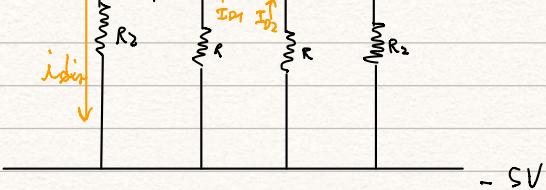


Cbis) COMPORTAMENTO SU MODO COMUNE CON MEZZO CIRCUITO



## (B) GEN. DI CODA REALE





$$I_{D1} + I_{D2} + I + I_{RS} = 0$$

$$I_{RS} = \frac{V_S - 5V}{R_S}$$

$$I_{D1} = K_P (V_{GS1} - V_{TP})$$

$$V_G = V_{GS1}$$

$$V_{S1} = V_{S2} = V_S$$

approssimando:

$$I_{D1} \approx -I_1$$

$$I_1 = I_2 \approx \frac{I}{2} + \frac{5V - V_S}{R_S} \cdot \frac{I}{2} = 200 \mu A + \frac{5V - 3V}{100 k\Omega} \cdot \frac{I}{2} = 210 \mu A$$

$$10 \mu A \ll 200 \mu A$$

OK l'approssimazione è valida

$$g_m = 200 \mu A/V$$

$$(V_{GS}) = 3,05 V$$

## SEGNALI DIFFERENZIALI:

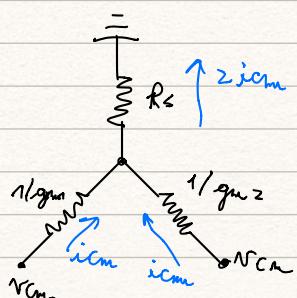
in  $R_S$  non scorre corrente se lo stadio è simmetrico

$$\hookrightarrow i = v_{diff} / (1/g_{m1} + 1/g_{m2}) = g_m v_{diff} / 2$$

NON CAMBIA NULLA

## SEGNALE DI MODO COMUNE

eq. Thevenin di source



$$z_{icm} = \frac{V_{cm}}{1/g_{m1} || 1/g_{m2} + R_S}$$

$$icm = \frac{V_{cm}}{\frac{1}{2} 1/g_m + R_S} \cdot \frac{I}{2} = \frac{V_{cm}}{1/g_m + 2R_S}$$

$$V_{o1} = V_{o2} = -i_{cm} R = -\frac{V_{cm}}{1/g_m + 2R_S} R$$

DOUBLE  
ENDED

$$G_{cm} \stackrel{\downarrow}{=} \frac{\frac{V_{o1} + V_{o2}}{2}}{V_{cm}} = -\frac{R}{1/g_m + 2R_S} = -0,05$$

SINGLE

ENDED

$$G_{cm} \stackrel{\rightarrow}{=} \frac{V_{o1,2}}{V_{cm}} = -\frac{R}{1/g_m + 2R_S} = -0,05$$

$$CMRR = \left| \frac{G_{diff}}{G_{cm}} \right| = \frac{2}{0,05} = 40 \rightarrow 32 \text{ dB}$$