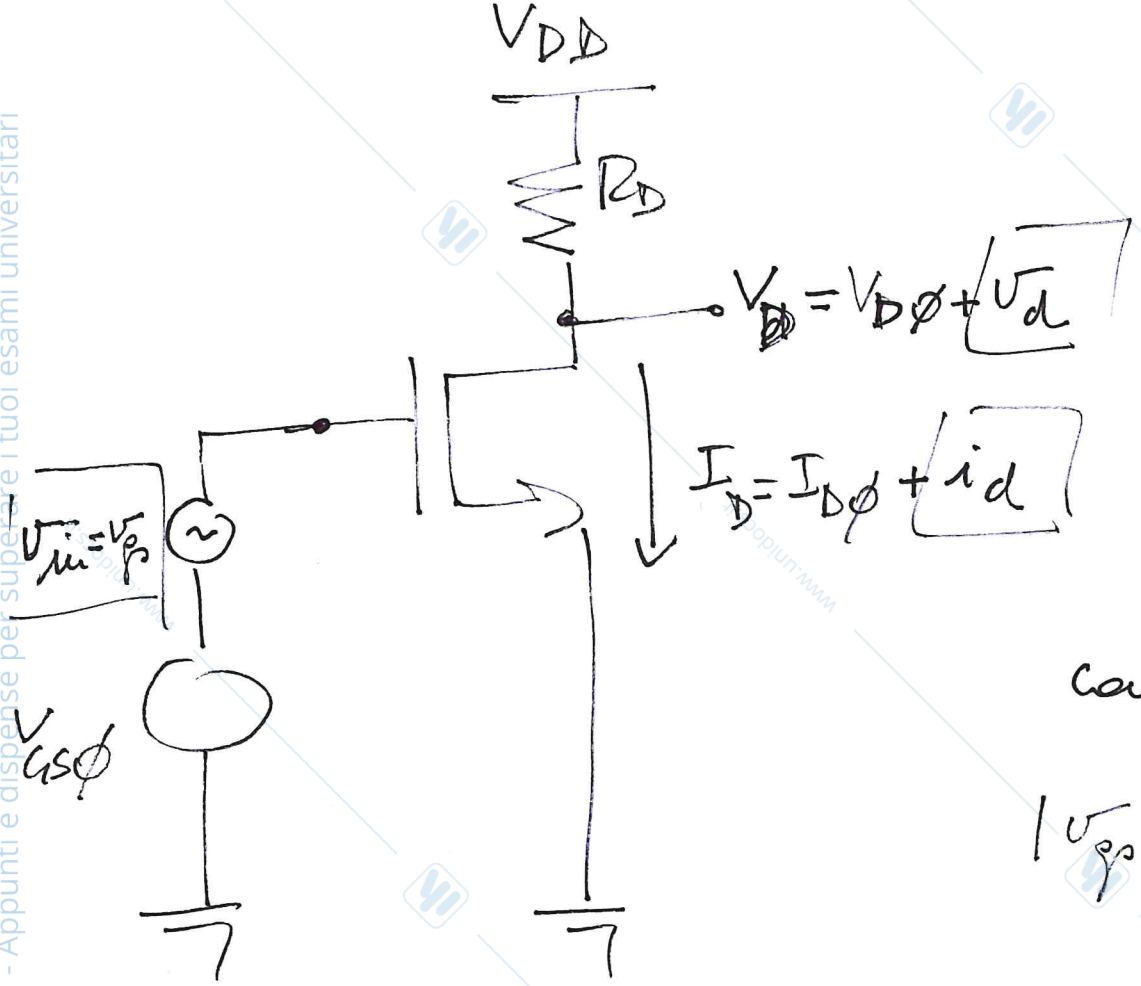
STADIO SOURCE A MASSA - sintesi



$$v_d = (-g_m R_D) \cdot v_{gs}$$

(v_d → v_o; v_{gs} → v_{in})

$$A_v \triangleq \frac{v_d}{v_{gs}} = -g_m R_D$$

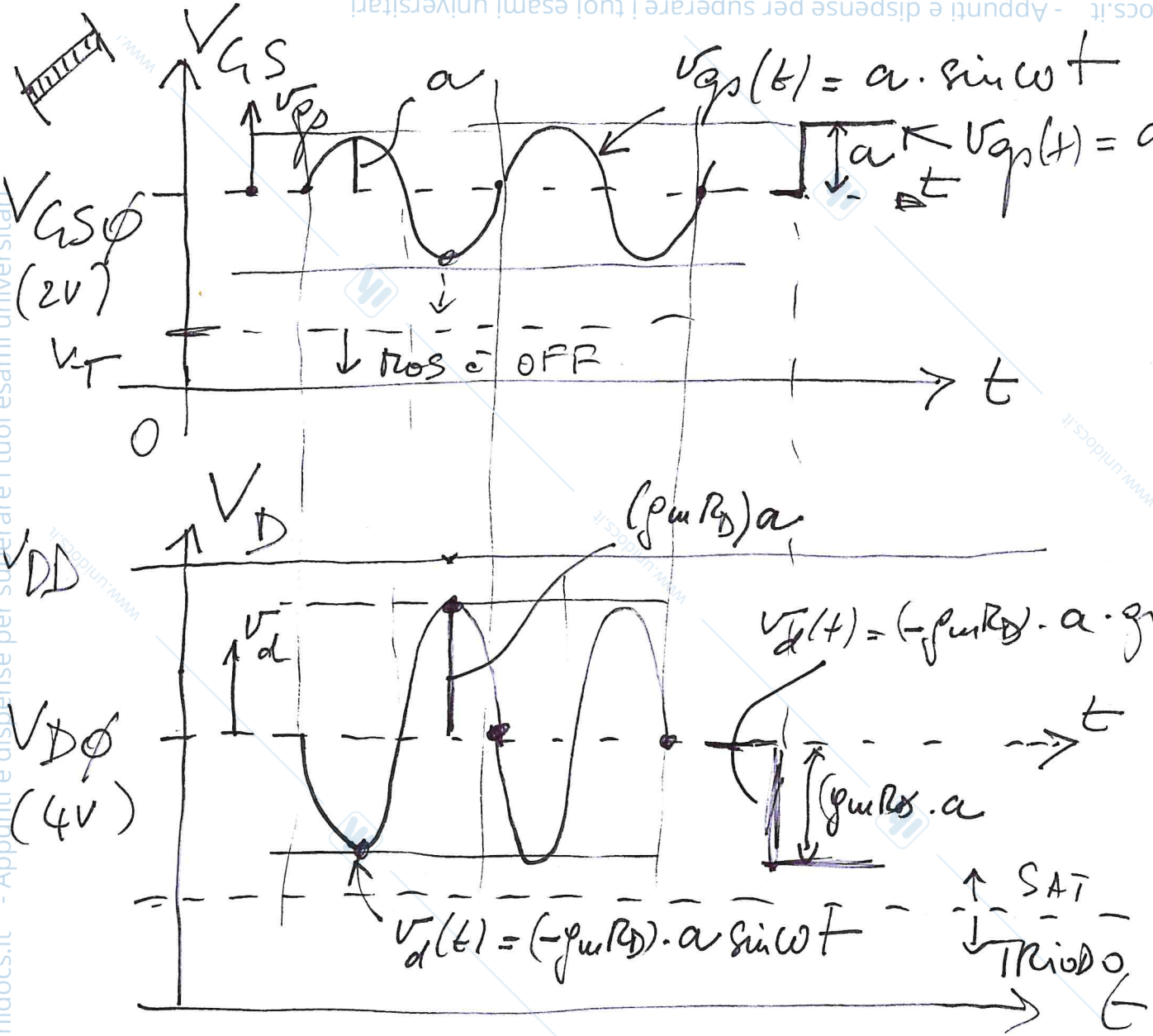
TRANSCONDUTT.

$$g_m = 2k(V_{GS\phi} - V_T)$$ MOS SATURO

↑ TENSIONI DI POLARIZZAZIONE

cond. "piccolo segnale"

$$|v_{gs}| \ll 2(V_{GS\phi} - V_T)$$



v_{gs} NEGATIVA

v_d POSITIVO

$\rightarrow V_D = V_{D\phi} + v_d$ CRESCE

$V_{GS} = V_{GS\phi} + v_{gs} \geq V_T$ (1)

↑

MOS OFF.

CONDIZIONE LIMITE

Per $v_{gs} = -(V_{GS\phi} - V_T)$

Limiti: v_{gs} POSITIVA $\rightarrow v_d$ NEG $\rightarrow V_D = V_{D\phi} + v_d$ DECRESCE

$\cong (-g_m R_D) v_{gs}$

$V_{DS} = V_D \geq V_{GS} - V_T \Rightarrow V_{D\phi} + v_d \geq V_{GS0} + v_{gs} - V_T \Rightarrow v_{gs}|_{MAX}$ (1)

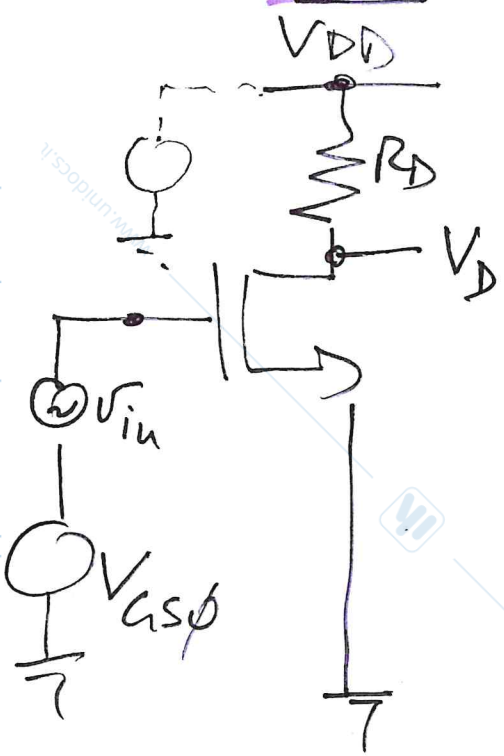
↑ CONDIZIONE LIMITE

L7 SEPARIAMO ANALISI DC E ANALISI SEGNALE

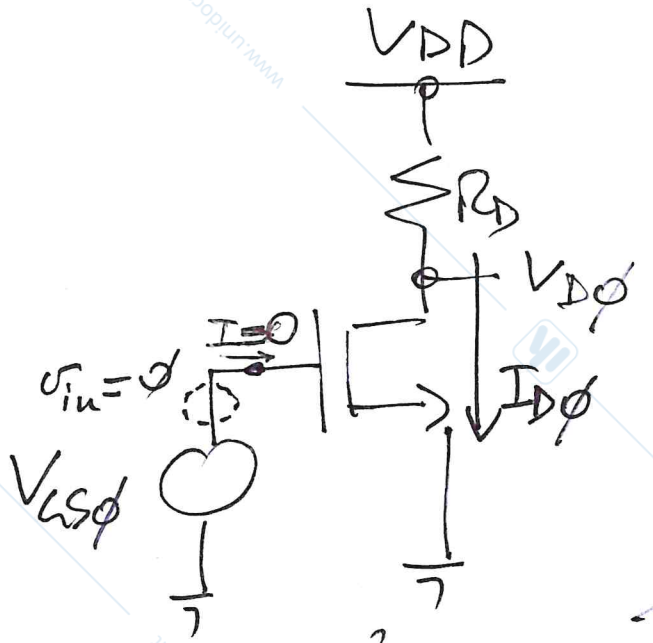
CIRCUITO N.L.
SEGNALI = Ø
ω = Ø

CIRCUITO EQ. "PICCOLI" SEGNALI
→ MOSFET LINEARIZZATO
→ CIRCUITO LINEARE

CIRCUITO REALE

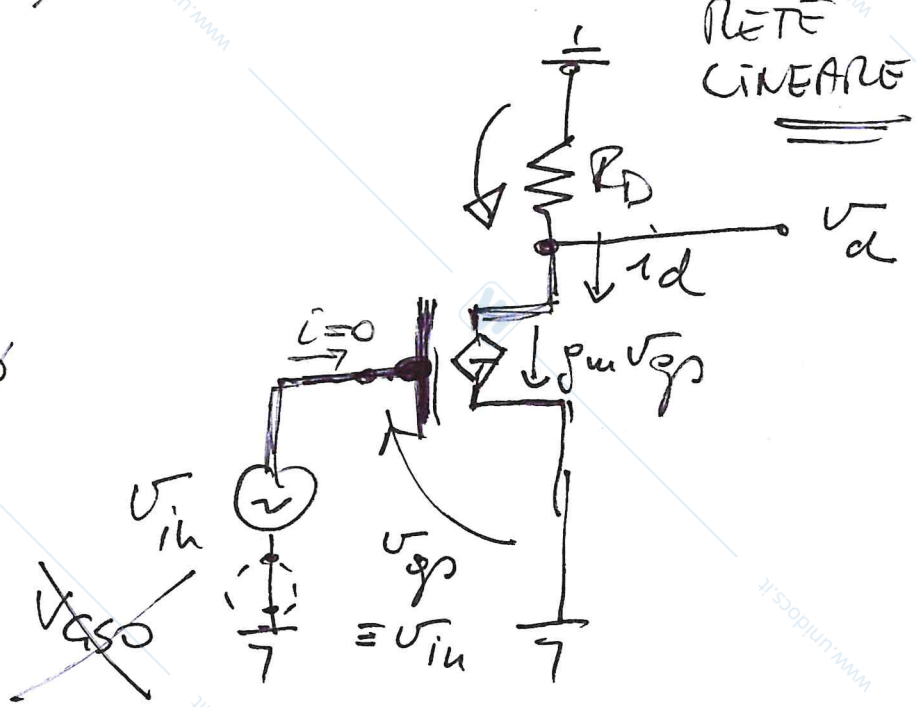


ANALISI DC (POLARIZZ., BIAS)



ANALISI SEGNALE "PICCOLO" CONDIZ.

RETE LINEARE!!!



tip. $I_D = k(V_{GS\emptyset} - V_T)^2$

$V_{D\emptyset} = V_{DD} - R_D I_{D\emptyset}$

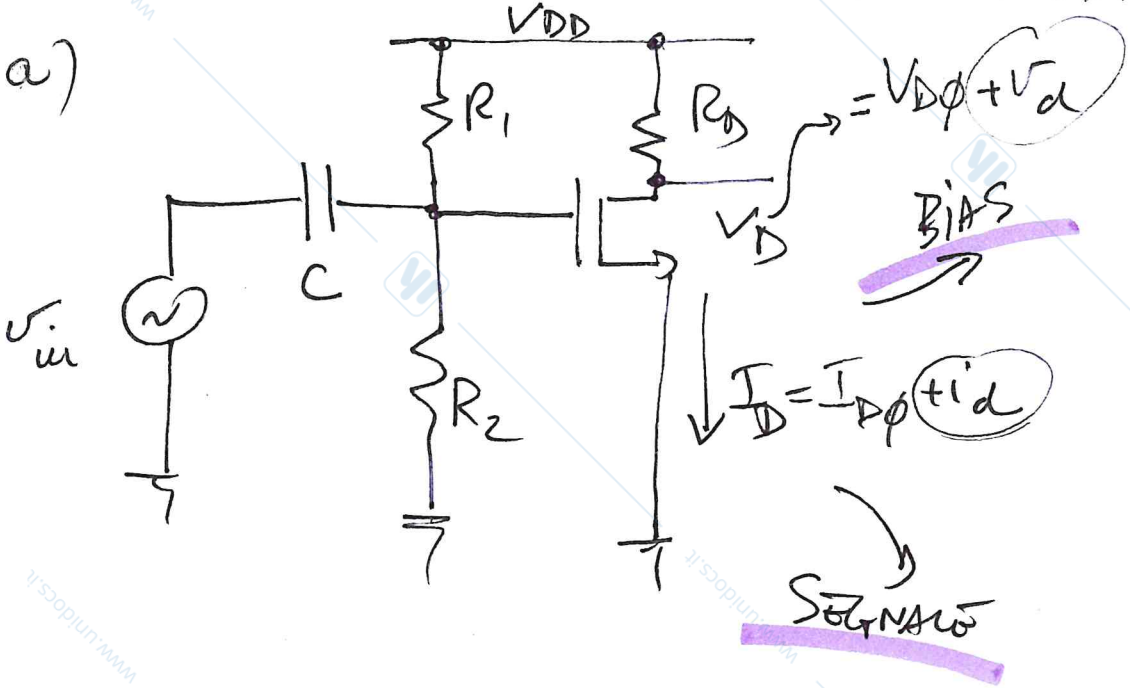
→ VERIFICA SAT.

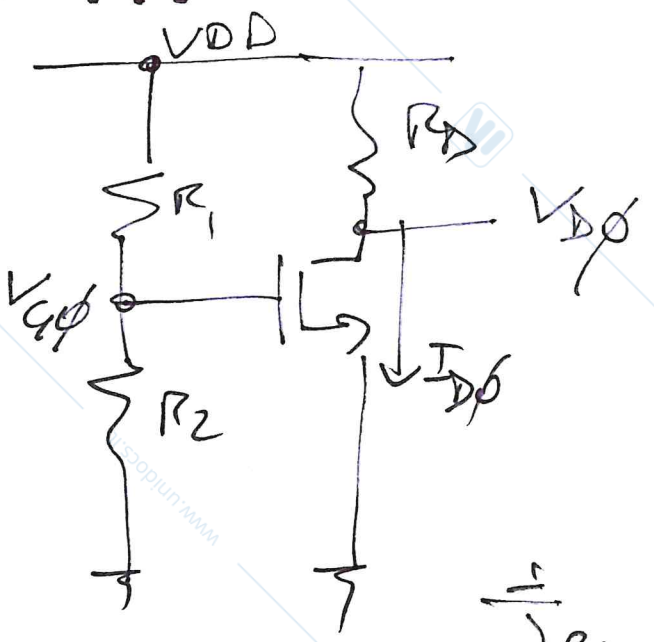
$v_d = -g_m v_{gs} R_D = (-g_m R_D) \cdot v_{in}$

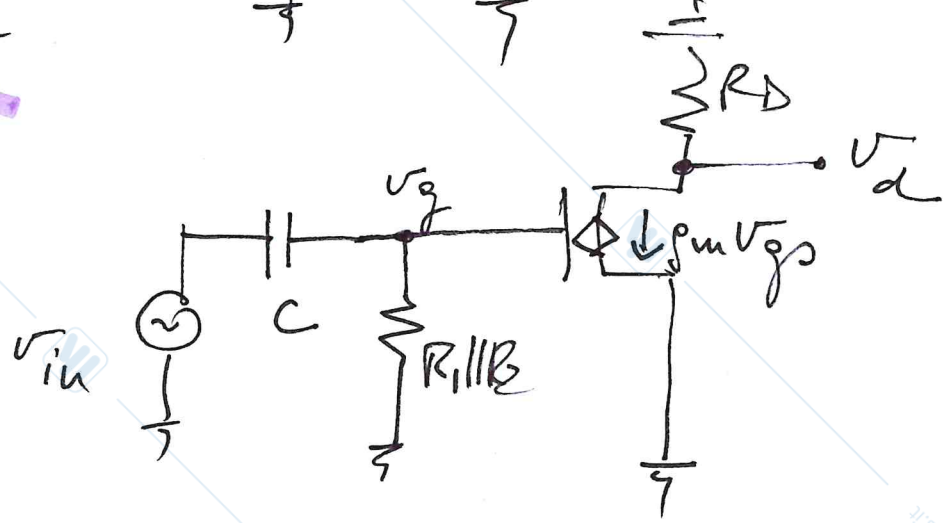
$\Rightarrow A_v \triangleq \frac{v_d}{v_{in}} = -g_m R_D$

☐ ALTRI STADI "SOURCE A MASSA" ...

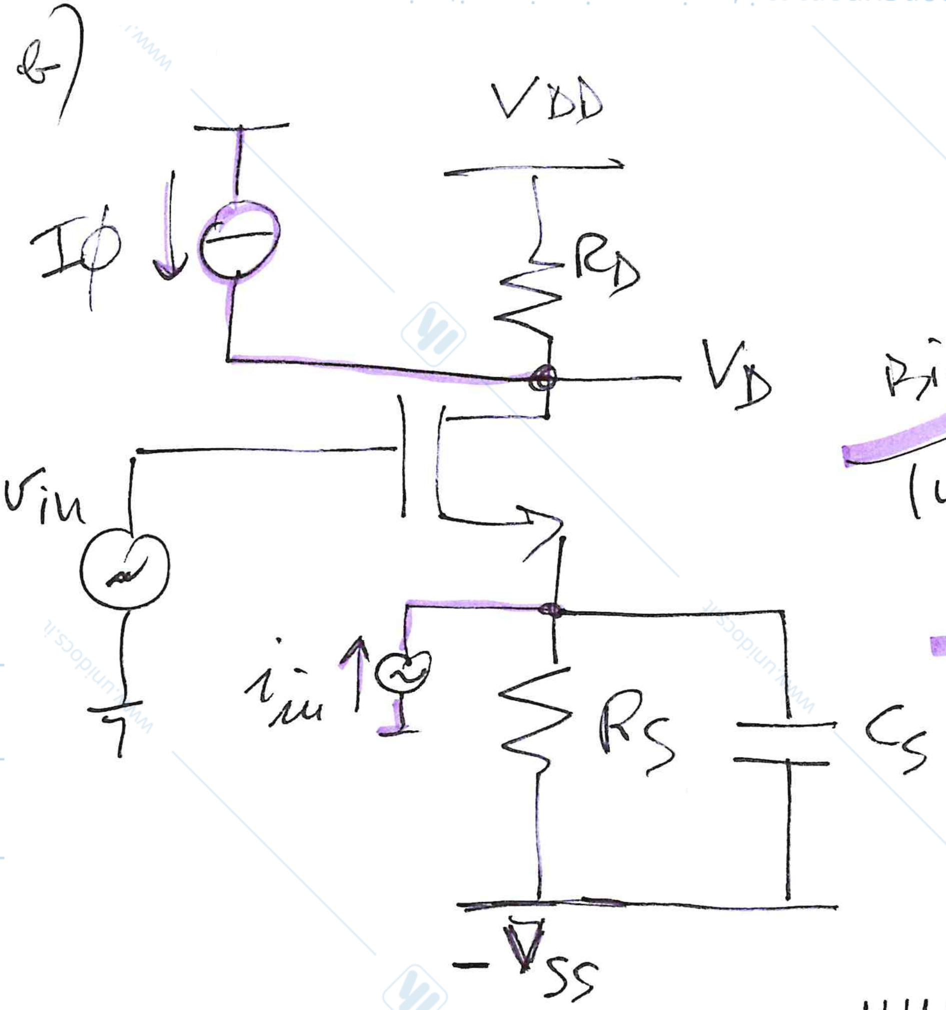
a)

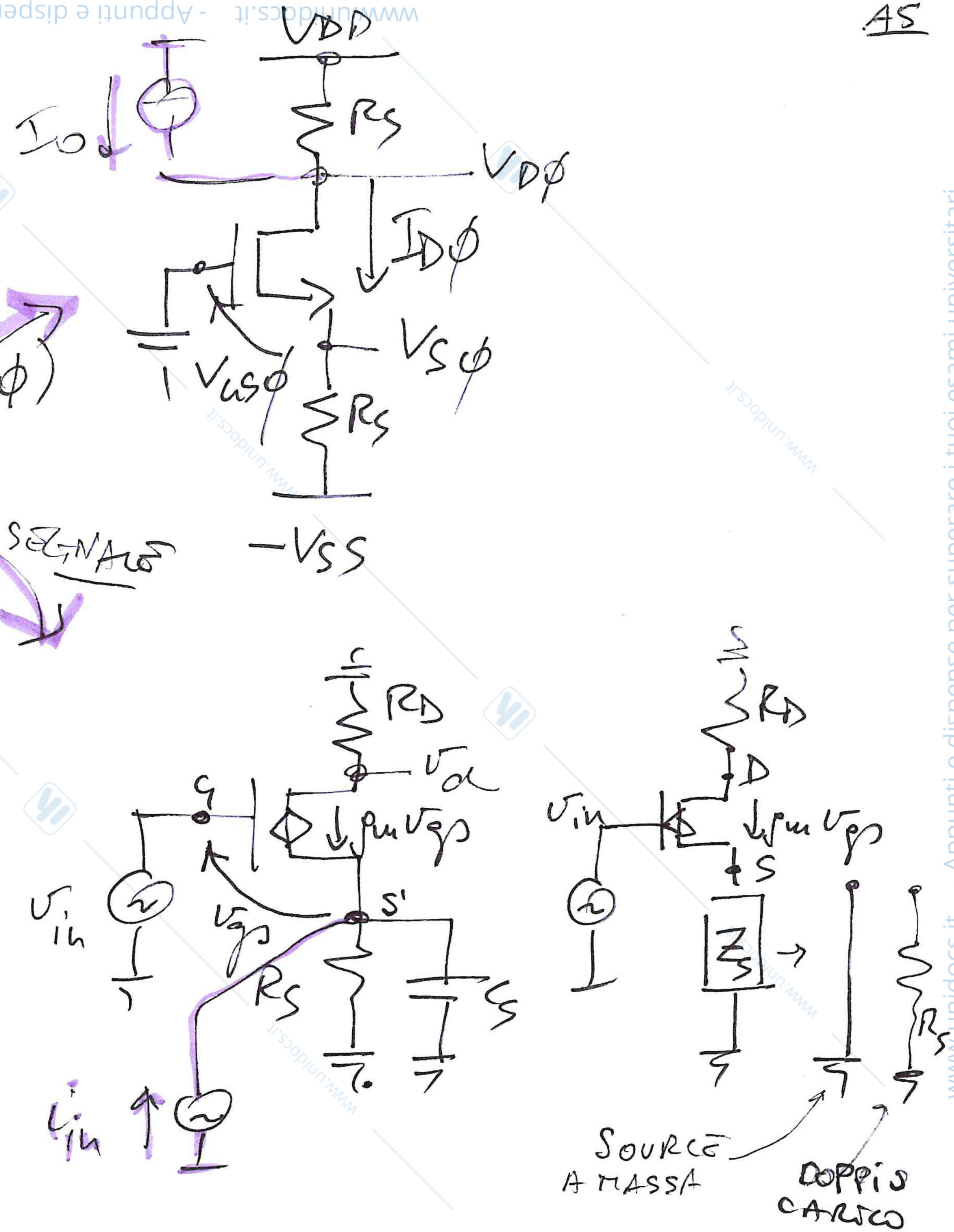






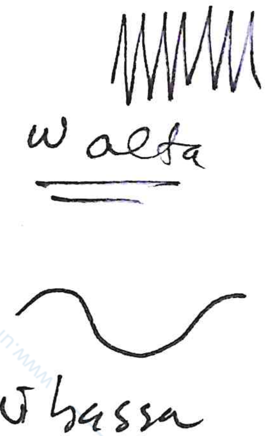
b)



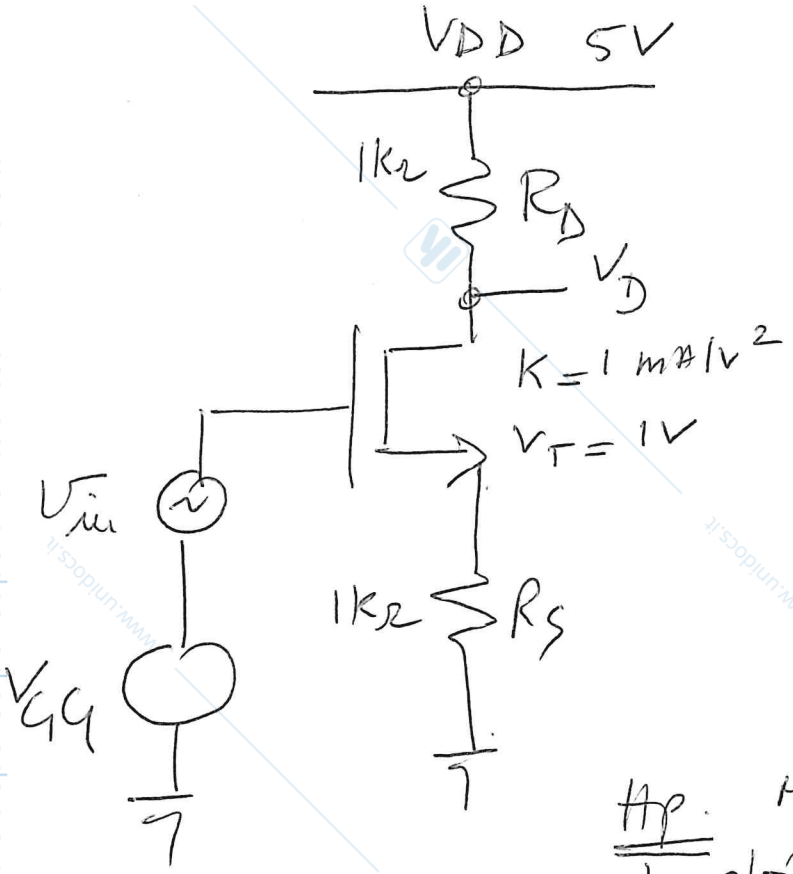


$$A_v \triangleq \frac{v_d}{v_{in}} = H(j\omega)$$

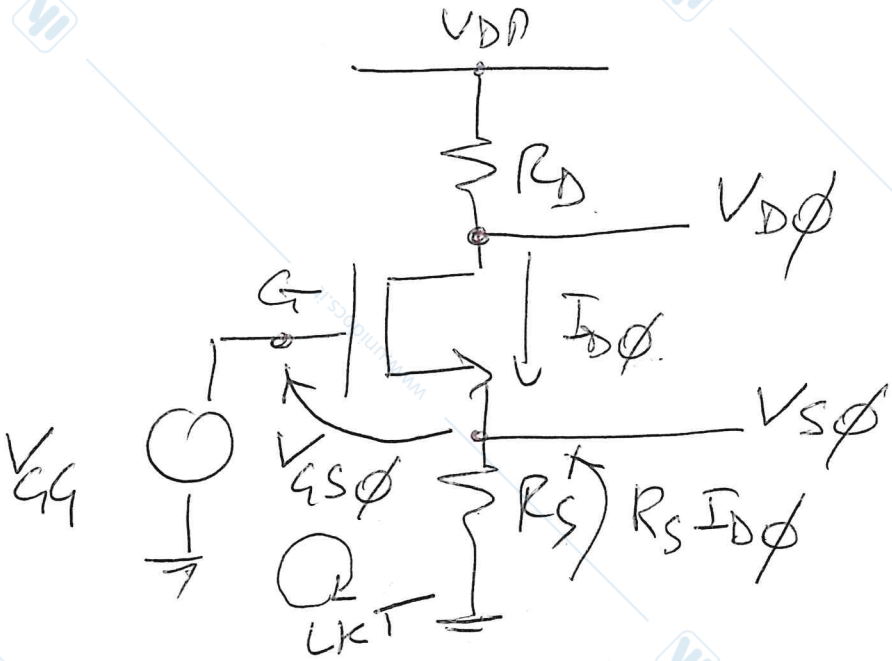
$$H(s)$$



☐ STADIO "DOPPIO" CARICO (R_D, R_S)



POLARIZZAZIONE



Hp. MOSFET SATURO

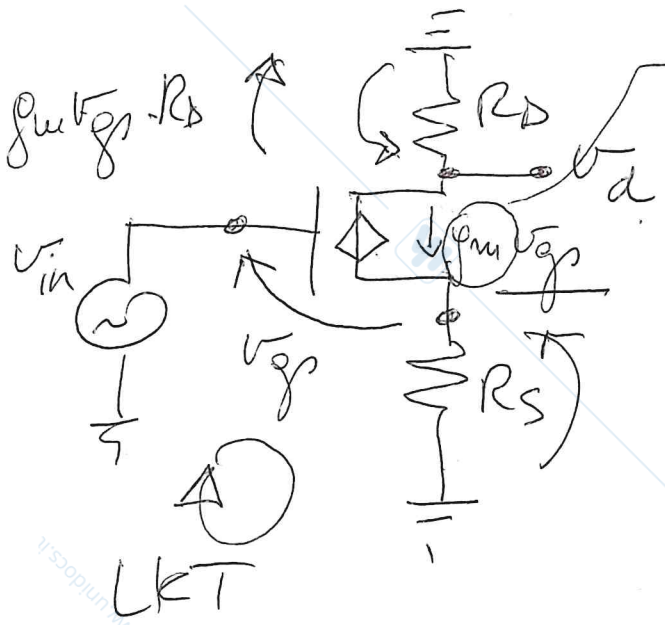
$$\begin{cases} I_D = K (V_{GS} - V_T)^2 \\ V_{GG} = V_{GS} + R_S I_D \end{cases} \Rightarrow V_{GG} = V_{GS} + R_S K (V_{GS} - V_T)^2$$

$\hookrightarrow V_{GS1,2} \rightarrow \boxed{V_{GS\phi}}$ Acc.

Verifica: $V_{DS\phi} = V_{D\phi} - V_{S\phi} \geq (V_{GS\phi} - V_T)$

$$\left[V_{GS\phi} = 2V,\ I_{D\phi} = 1mA,\ V_{D\phi} = 4V,\ V_{S\phi} = 1V \right]$$

SEGNALE



$$g_m = 2K(V_{GS} - V_T)$$

V_{GS} ↑ POLARIZZABILE

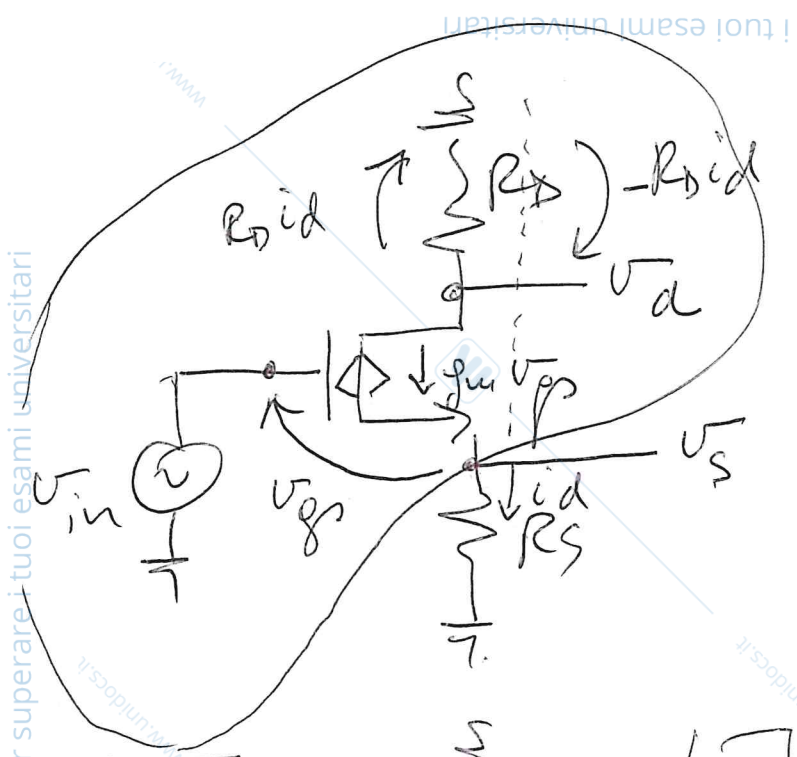
(1°) LKT alla maglia di ingresso

$$v_{in} = v_{gs} + g_m v_{gs} \cdot R_S = v_{gs}(1 + g_m R_S)$$

$$\rightarrow \boxed{v_{gs} = \frac{v_{in}}{1 + g_m R_S}}$$

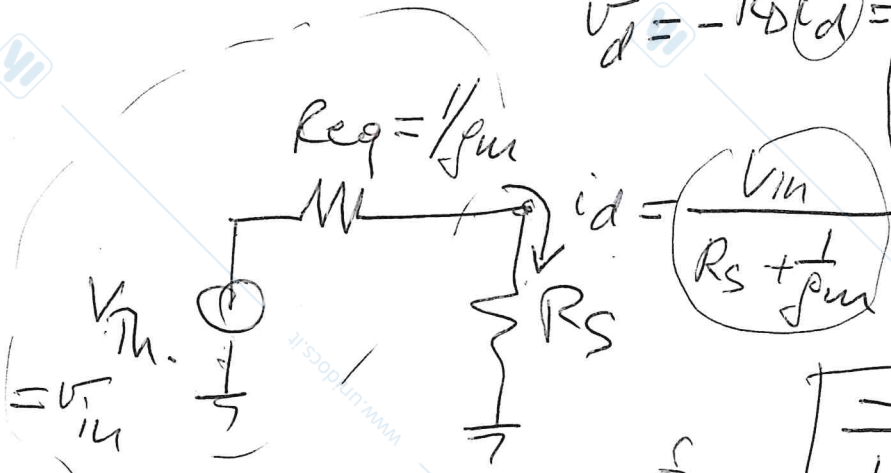
$$\rightarrow v_d = -g_m v_{gs} R_D = \boxed{-\frac{g_m R_D}{1 + g_m R_S}} \cdot v_{in}$$

$$\rightarrow A_v \triangleq \frac{v_d}{v_{in}} = -\frac{g_m R_D}{(1 + g_m R_S)}$$



$\rightarrow$

(2°) circuito eq. Thevenin

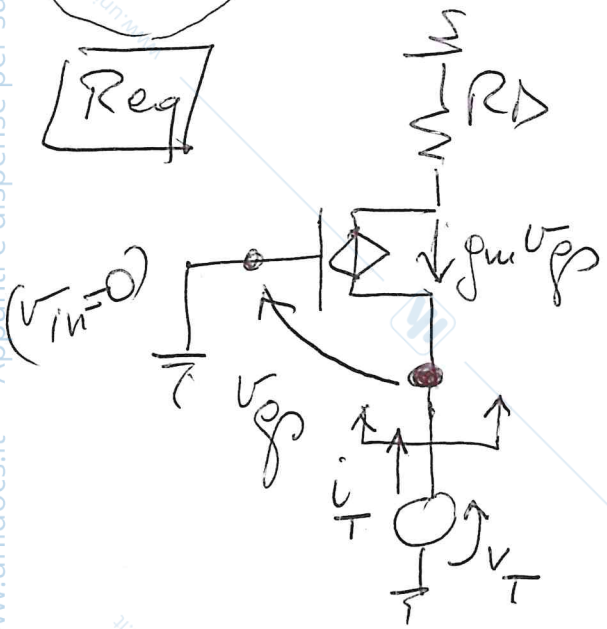


$v_d = -R_D i_d = -\dfrac{R_D}{R_S + \frac{1}{g_m}} v_{in}$

$\dfrac{-g_m R_D}{1 + g_m R_S}$

COME PRIMA!

R_{eq}

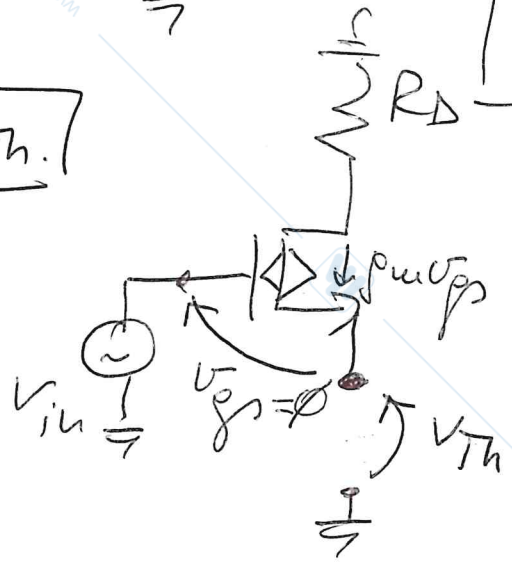


$v_{gs} = 0 - v_T = -v_T$

$i_T = -g_m v_{gs} = g_m v_T$

$R_{eq} = \dfrac{v_T}{i_T} = \dfrac{1}{g_m}$

V_{Th}

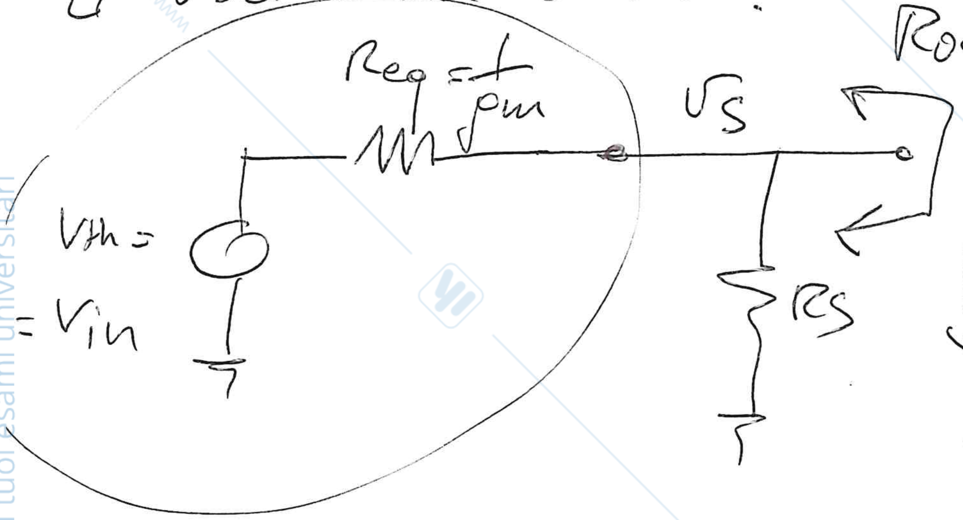


$g_m v_{gs} = 0 \quad (g_m \neq 0)$

$\rightarrow v_{gs} = 0$

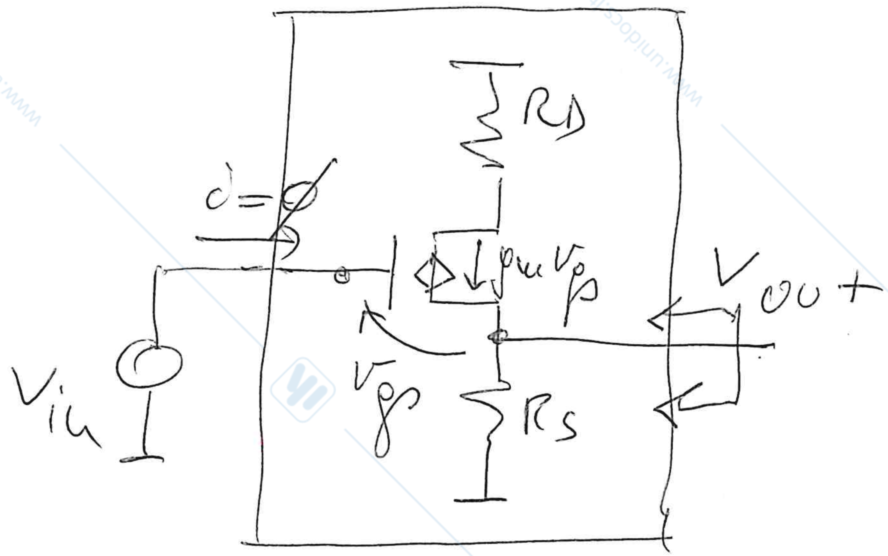
$\rightarrow V_{Th} = v_{in}$

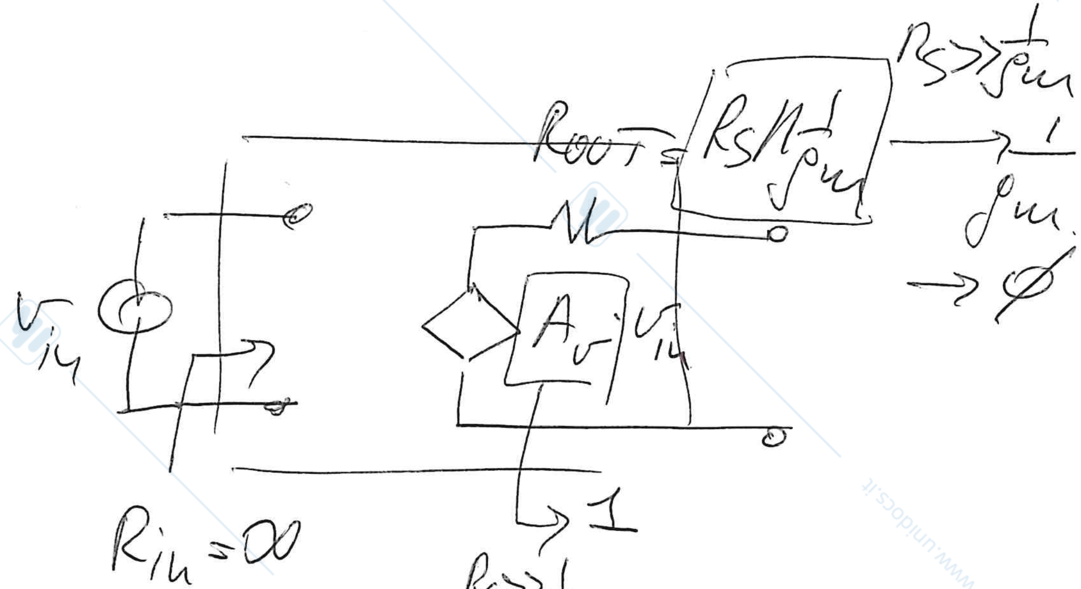
□ Uscita sul source:



$$v_S = V_{in} \frac{R_S}{R_S + \frac{1}{g_m}} = V_{in} \frac{g_m R_S}{1 + g_m R_S}$$

$$A_v \triangleq \frac{v_S}{v_{in}} = \frac{R_S}{R_S + \frac{1}{g_m}} \xrightarrow[(g_m R_S \gg 1)]{R_S \gg \frac{1}{g_m}} \boxed{1}$$





AL LIMITE $R_S \gg \frac{1}{g_m}$ BUFFER DI TENSIONE

AMPLIFICATORI = DOPPIO BIPOLO

PER SEMPLICITÀ ↓

UNIDIREZIONALE

- ALL'INGRESSO:

$$V_{in} = V_S \frac{R_{in}}{R_{in} + R_S} \rightarrow 1$$

$V_{in} \sim V_S$ sse $R_{in} >> R_S$

- $V_{OUT} = (A V_{in}) \left(\frac{R_L}{R_{OUT} + R_L} \right) \rightarrow 1$ se $R_{OUT} \ll R_L$

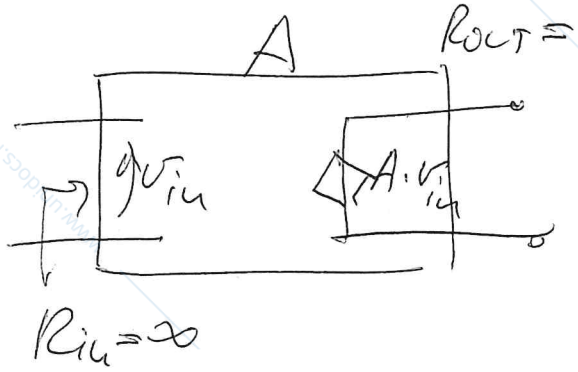
  ↑ Effetto CARICO in uscita

- COMPLESSIVAMENTE:

$$V_{OUT} = V_S \times \frac{R_{in}}{R_{in} + R_S} \times A \times \frac{R_L}{R_{OUT} + R_L}$$

$R_{in} = \infty \rightarrow 1 \ \forall R_S$

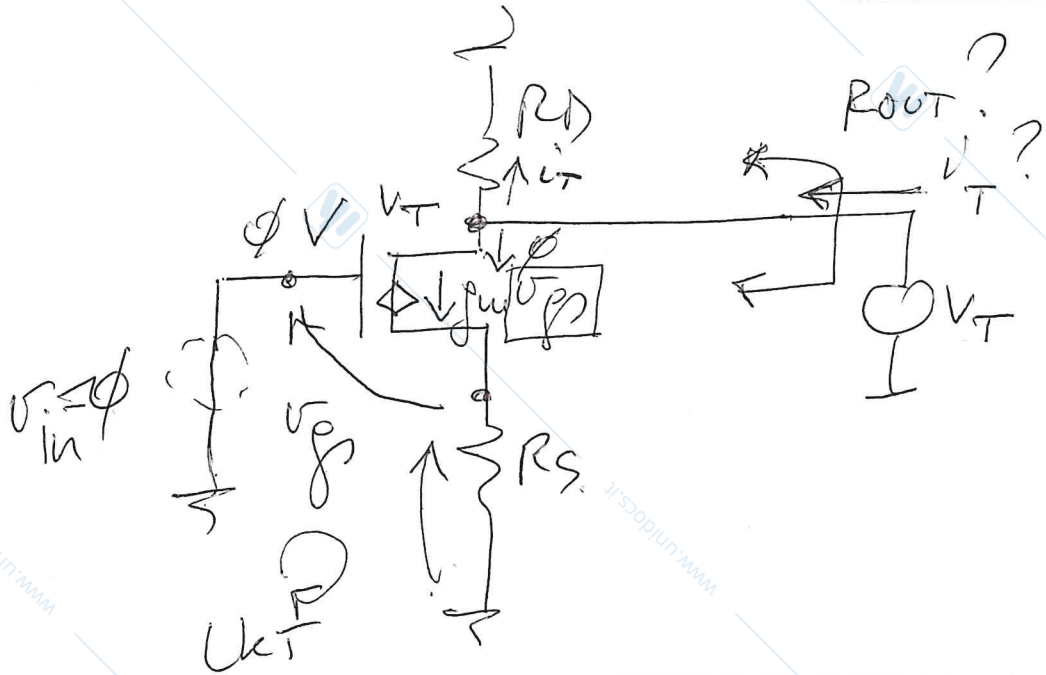
$R_{OUT} = 0 \rightarrow 1 \ \forall R_L$



$A = 1$

BUFFER IDEALE DI TENSIONE

☐ RESISTENZA DI USCITA SUL DRAIN ?



Ckt ingresso:

$$\phi = v_{gs} + R_S g_m v_{gs}$$

$$\phi = v_{gs}(1 + g_m R_S)$$

$$\neq 0$$

$$\rightarrow v_{gs} = \phi$$

$$\rightarrow i'_T = \frac{V_T}{R_D}$$

$$\rightarrow R_{eq} \triangleq \frac{V_T}{i'_T} = R_D$$

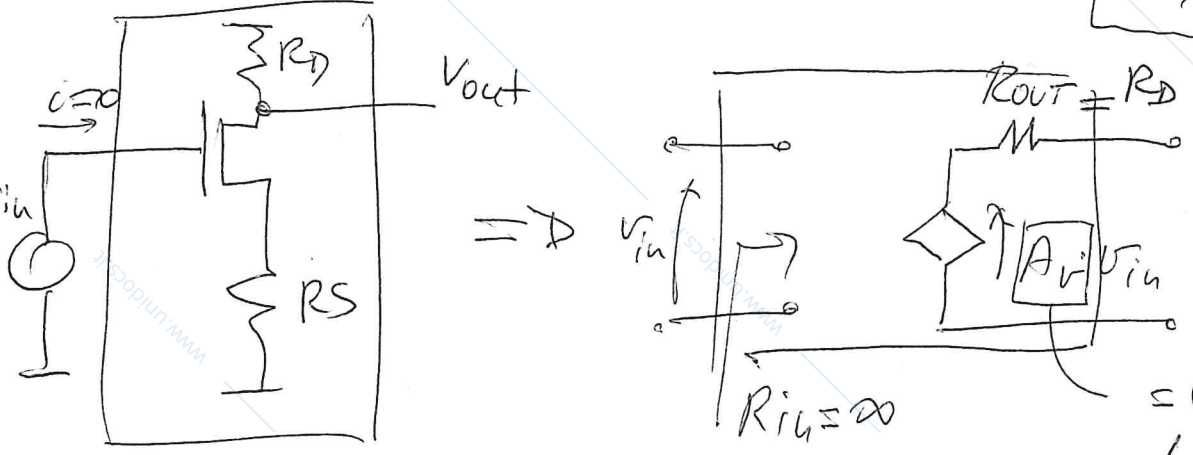
← GENERALMENTE DI VALORE MEDIO-GRANDE DATO CHE CONTRIBUISCE AL GUADAGNO:

$$|A_V| = \left|\frac{v_o}{v_{in}}\right| = g_m \cdot R_D$$

→ FORTE EFFETTO DI CARICO SE DEVE PILOTARE UN CARICO $R_L \sim R_D$ OPPURE $R_L < R_D$ –

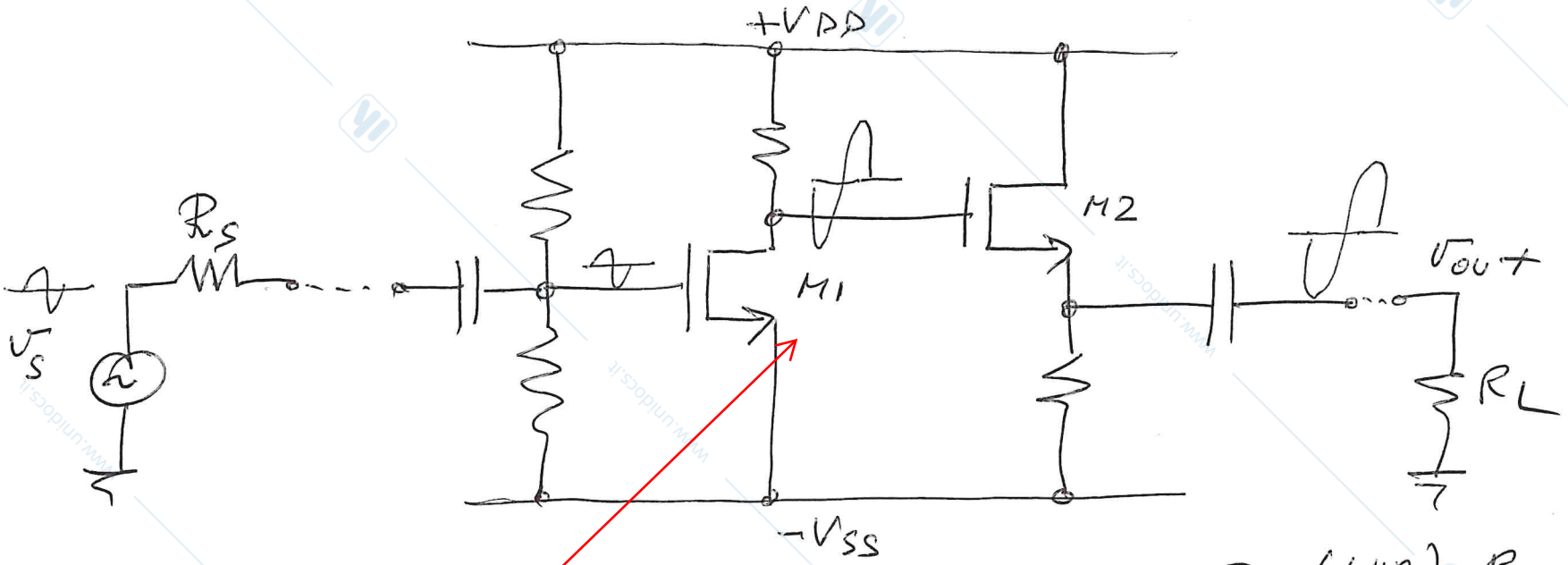
→ SOLUZIONE: STADIO CON USCITA SUL DRAIN + BUFFER IDEALE DI TENSIONE –

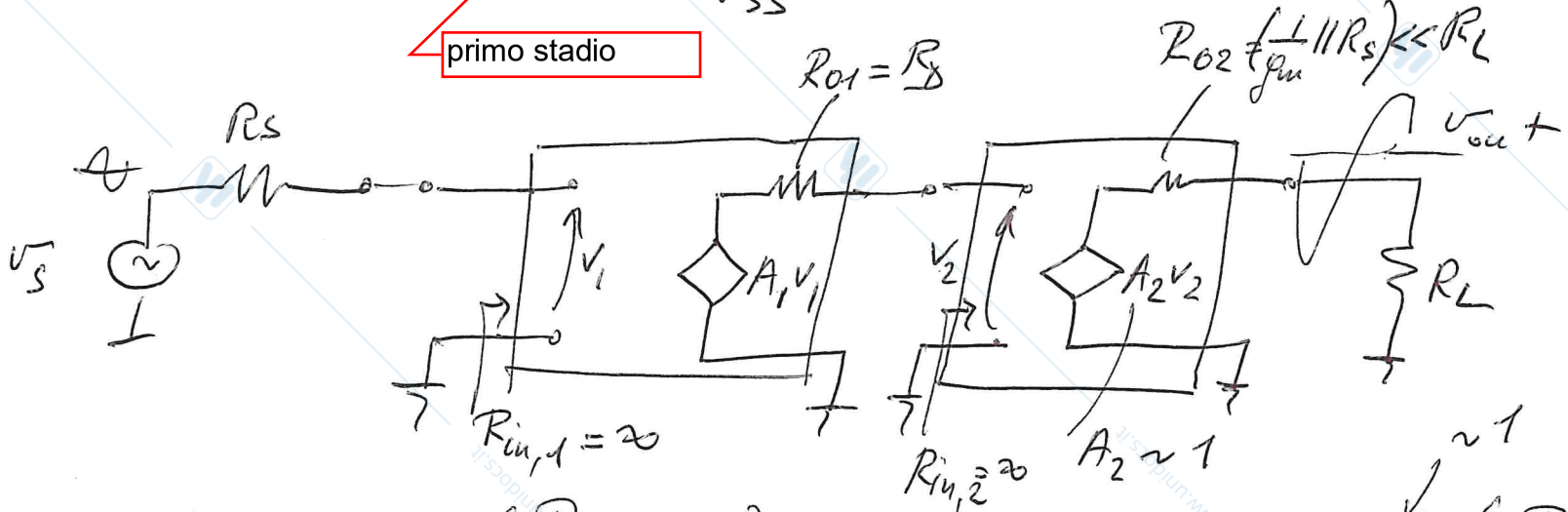
☐ RAPPRESENTAZIONE DOPPIO BIPOLO EQUIVALENTE AMPLIFICATORE MOSFET CON USCITA SUL DRAIN:



$$= \frac{(-g_m R_D)}{(1 + g_m R_S)}$$

ESEMPIO: USO DELLO STADIO CON USCITA SU SOURCE COME BUFFER DI TENSIONE PER RENDERE IL GUADAGNO INSENSIBILE AL CARICO





$$v_{out} = v_s \times \left(\frac{R_{in,1}}{R_{in,1}+R_S}\right) \times A_1 \times \left(\frac{R_{in,2}}{R_{in,2}+R_{o,1}}\right) \times A_2 \times \left(\frac{R_L}{R_L+R_{o2}}\right) \rightarrow A_1 v_s$$

$\frac{R_{in,1}}{R_{in,1}+R_S} \approx 1$ $\quad \frac{R_{in,2}}{R_{in,2}+R_{o,1}} \approx 1$ $\quad A_2 \approx 1$ $\quad \frac{R_L}{R_L+R_{o2}} \approx 1$