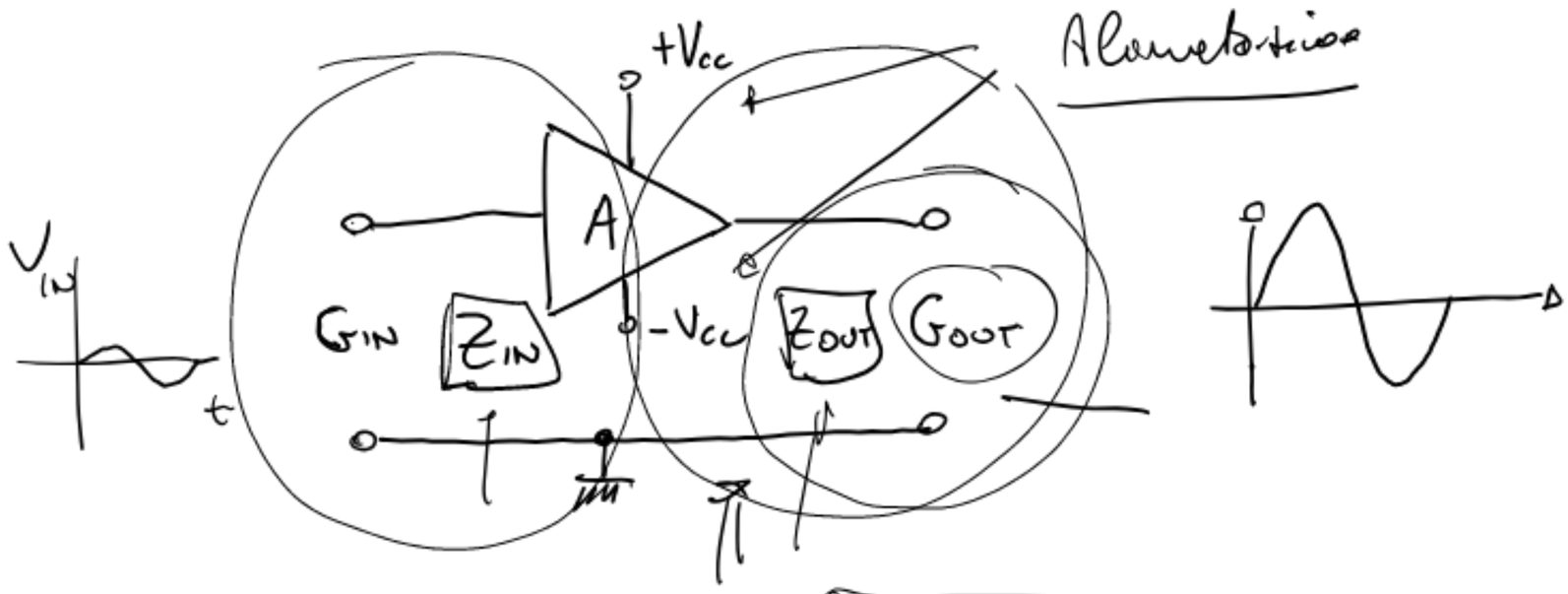
AMPLIFICATORI



DISPOSITIVI ATTIVI

$G_{out} = A \cdot G_{IN}$

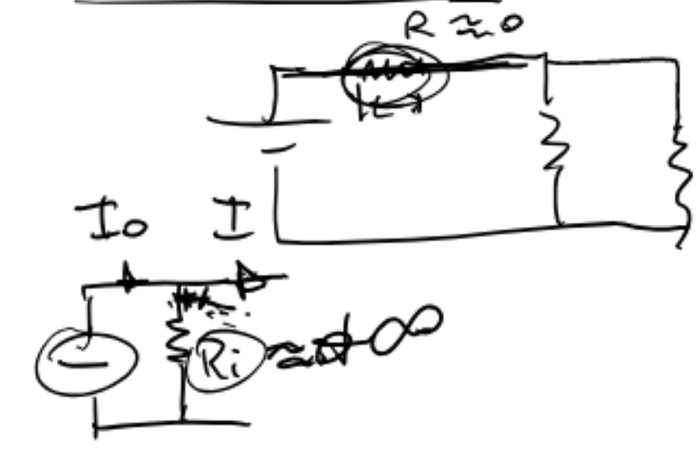
$A > 1$

GUADAGNO

* INGRESSO

MISURA V_{IN}

GENERA V_{OUT}



G_{IN} / V_{IN}	V_{IN}	I_{in}
G_{out} / V_{OUT}	TENSIONE * $[A] = \frac{V_{out}}{V_{in}}$ = adimensionale $Z_{IN} = +\infty$; $Z_{out} = \emptyset$	TRANS-IMPEDENZA $[A] = \frac{V_{out}}{I_{IN}} = \Omega$ $Z_{IN} = \emptyset$; $Z_{out} = \emptyset$
I_{OUT}	TRANS-CONDUTTANZA $[A] = \frac{I_{out}}{V_{in}} = \Omega^{-1}$ $Z_{IN} = +\infty$; $Z_{out} = \emptyset$	CORRENTE $[A] = \frac{I_{out}}{I_{in}}$ $Z_{in} = 0$; $Z_{out} = +\infty$

INGRESSO — MISURA.

- V in parallelo: $Z_{IN} = +\infty$

- I in serie $Z_{IN} = 0$

USCITA — GENERATORE

- V

$Z_{out} = 0$.

- I

$Z_{out} = +\infty$

Ampli. Tensione. ⟶ Ampli diff. ⟶ Ampli operazionale

PARAMETRI AMPLIFICATORI

1) BANDA PASSANTE : risposta in frequenza.

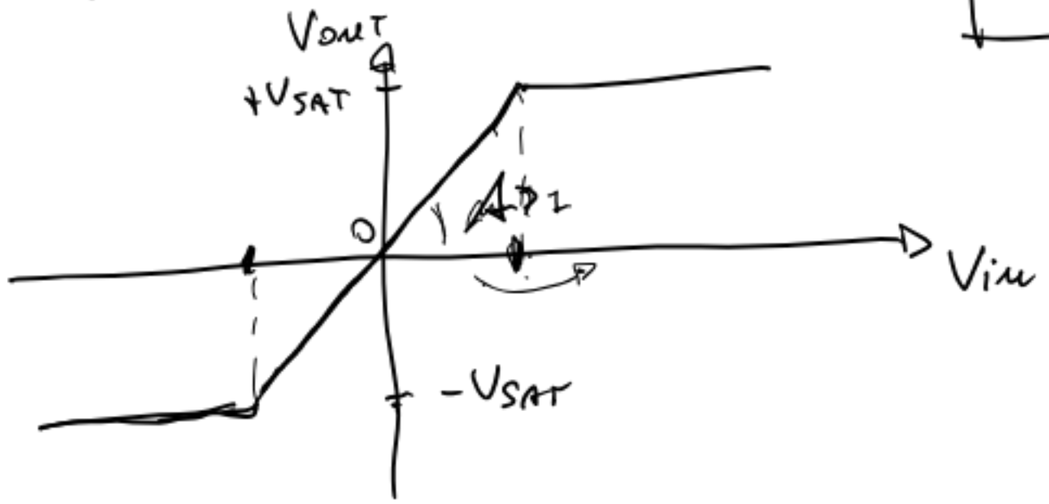
range frequenze entro il quale A cost. 3 dB

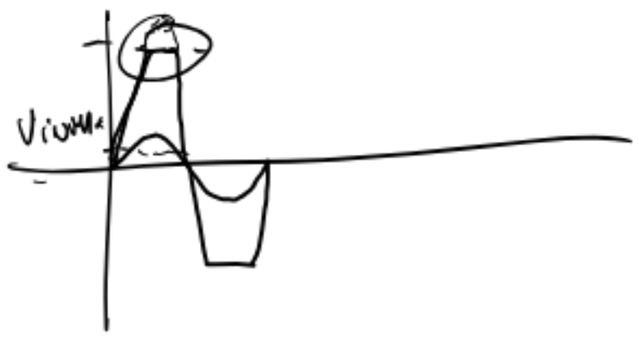
$dB = 20 \log_{10}\left(\frac{V_{out}}{V_{in}}\right)$

2) Range Vout = ~~±~~ $-V_{SAT} \leq V_{out} \leq +V_{SAT}$ ~ $V_{SAT} = V_{CC}$

$V_{out} = A V_{in} \leq V_{SAT}$

$V_{in} \leq \frac{V_{SAT}}{A}$





3) THD : Total Harmonic Distortion

SIN → ▷

$\sin A + f V_o$ → 

Sovrapp. Forme

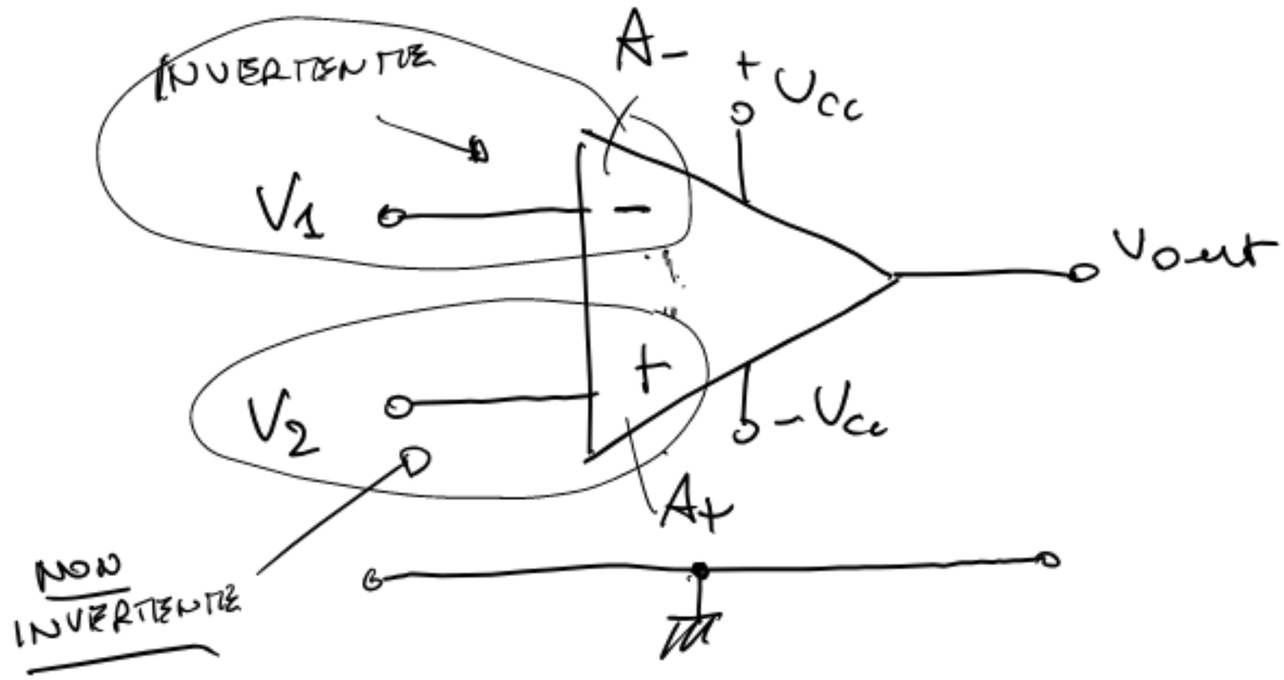
$$THD = \sqrt{\sum_{i=1}^{2} \left(\frac{V_i}{V_o}\right)^2}$$

= 0 IDEALE

4) ZONA LINEARE : range V_{in} $V_{in} \leq \frac{V_{SAT}}{A}$

5) SLEW RATE : Risposta temporale a variazioni di V_{in}

AMPLIFICATORI DIFFERENZIALI (→ operazionale)



IDEALE

$$A_+ = A_- = A$$

$$V_{out} = A\cdot(V_2 - V_1) = A_+ \cdot V_2 - A_- \cdot V_1$$

REALE $A_+ \approx A_-$

Guadagno di MODO COMUNE A_{CM}

Guadagno DIFFERENZIALE A_d

$$A_+ = A_d + \frac{A_{CM}}{2}$$

$$A_- = A_d - \frac{A_{CM}}{2}$$

$$V_{out} = A_+ V_2 - A_- V_1$$

$$A_+ = A_d + \frac{A_{CM}}{2}$$

$$A_- = A_d - \frac{A_{CM}}{2}$$

$$= A_d V_2 + \frac{A_{CM}}{2} V_2 - A_d V_1 + \frac{A_{CM}}{2} \cdot V_1 =$$

$$\boxed{V_{out} = A_d (V_2 - V_1) + A_{CM} \left(\frac{V_1 + V_2}{2} \right)}$$

Diff $V_2 - V_1$

Def Ampli Diff.

Valor medio V_1 e V_2

V_{in}

$V_2 = V_1$

$$\boxed{V_{out}} = A_{CM} \frac{V_1 + V_2}{2} = A_{CM} \cdot V_{IM}$$

MODO COMUNE

$V_1 = -V_2$

$$V_{out} = 2 A_d V_2$$

DIFFERENZIALE

$$CMRR = \frac{|A_d|}{|A_{CM}|} \longrightarrow +\infty$$

IDEALE

$A_{CM} = 0$

$$= 60\text{-}80 \text{ dB}$$

REALE

$A_d > 1$

AMPLIFICATORE OPERAZIONALE

	IDEALE	REALE
Z_i	∞	$> 1\ M\Omega$
Z_{out}	0	$< 10\ \Omega$
Banda Passante	infinita	Limitata
V_{out}^{MAX}	∞	$V_{SAT} = V_{CC}$
CMRR	∞	60 - 80 dB
Slew-Rate	∞	$\sim 10\ V/\mu s$

} Comune ampio di fasce

A	$+\infty$	10^5

Δ Ampli. operazionale.

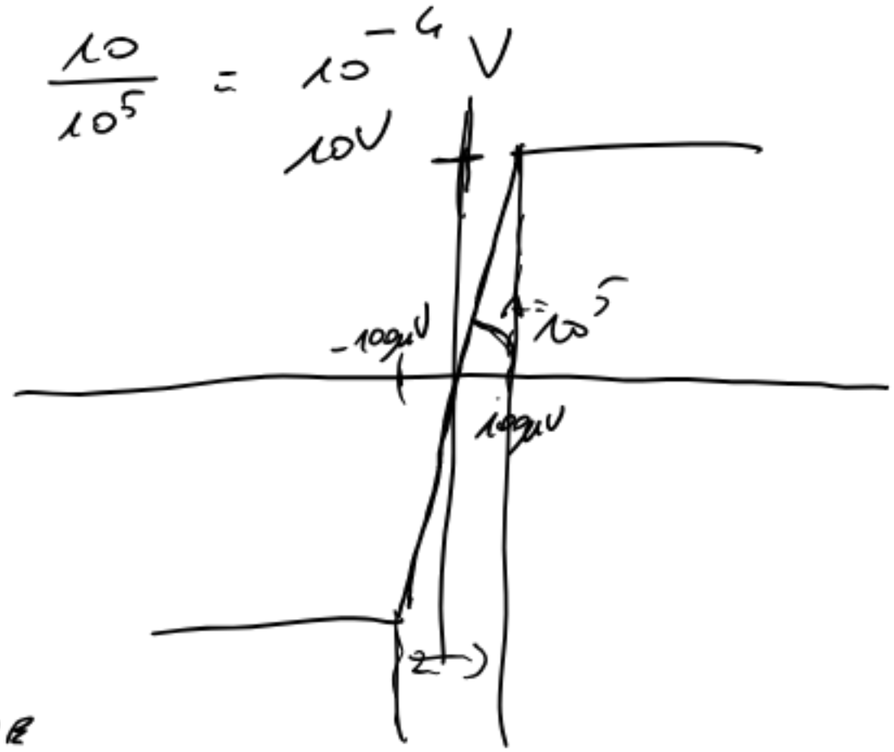
Amplificatore Operazionale

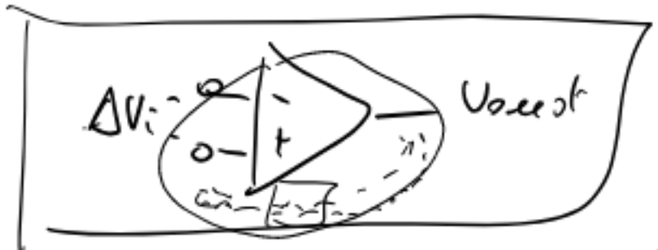
$A = 10^5$

$V_{cc} = V_{SAT} = 10\,V$

$\Delta V_i \gtrsim \frac{V_{SAT}}{A} = \frac{10}{10^5} = 10^{-4}\,V$

$\Delta V_i = V_2 - V_1 \lesssim 100\,\mu V \Rightarrow$ SAT





ANELLO APERTO:

$V_{out} \geq 10V$.

$\Delta V_i \ll V_{SAT}$

≈ 0

$V_2 \approx V_1$

SENZA RETROAZIONE

$V_2 = 10{,}000\,05\,V$

$V_1 = 10{,}000\,01\,V$

STESSO POTENZIALE

(−) (+)

è un corto circuito.

PRINCIPIO DEL CORTO CIRCUITO VIRTUALE

~~Z_i (reale) ≈ 0~~

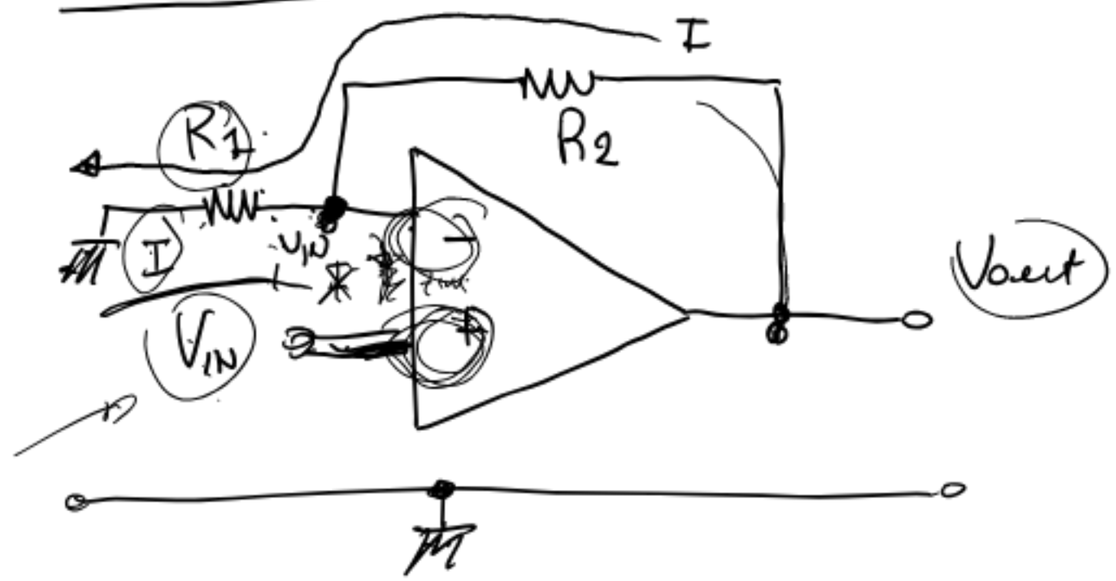
$Z_i = 10^6\,\Omega$

AMP. OP. CONNESSIONE NON INVERTENTE

ANELLO CHIUSO (10)
"RETROAZIONE"

$A_0 = 10^5$

A ?



$$A = \frac{V_{out}}{V_{in}} = \frac{(R_1 + R_2)\, I}{R_1 \cdot I} = \frac{R_1 + R_2}{R_1} \Rightarrow \boxed{A = 1 + \frac{R_2}{R_1}}$$

$V_{out} = (R_1 + R_2) I$

V_{out}) $\boxed{Z_{IN} = +\infty} \Rightarrow$ I circola in R_2 e R_1 $\Rightarrow$

V_{IN}) $\boxed{\text{Principio Corto Circ. Virt.}} \Rightarrow V_+ \approx V_- \Rightarrow V_{IN} = R_1 \cdot I$

$V_+ = V_{in}$

$\Rightarrow$ NON SATURO $\Rightarrow$ stando la regione lineare

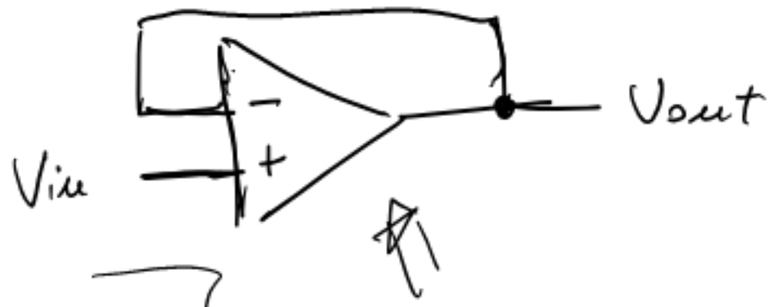
INSEGUITORE DI TENSIONE

"ADATTATORE D'IMPEDENZA"

$$A = 1 + \frac{R_2}{R_1}$$

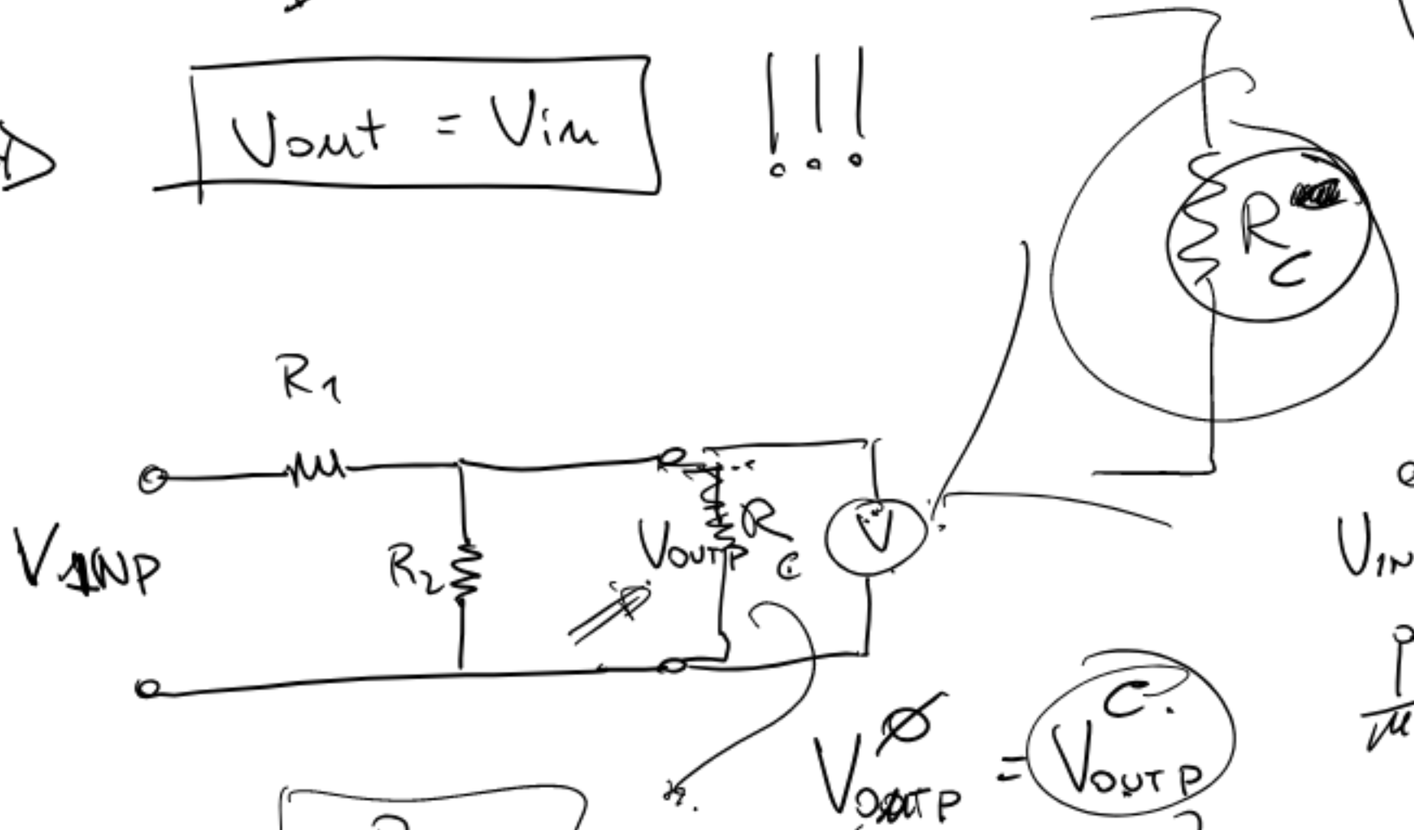
$R_2 = 0$

$R_1 = +\infty$



$A = 1$

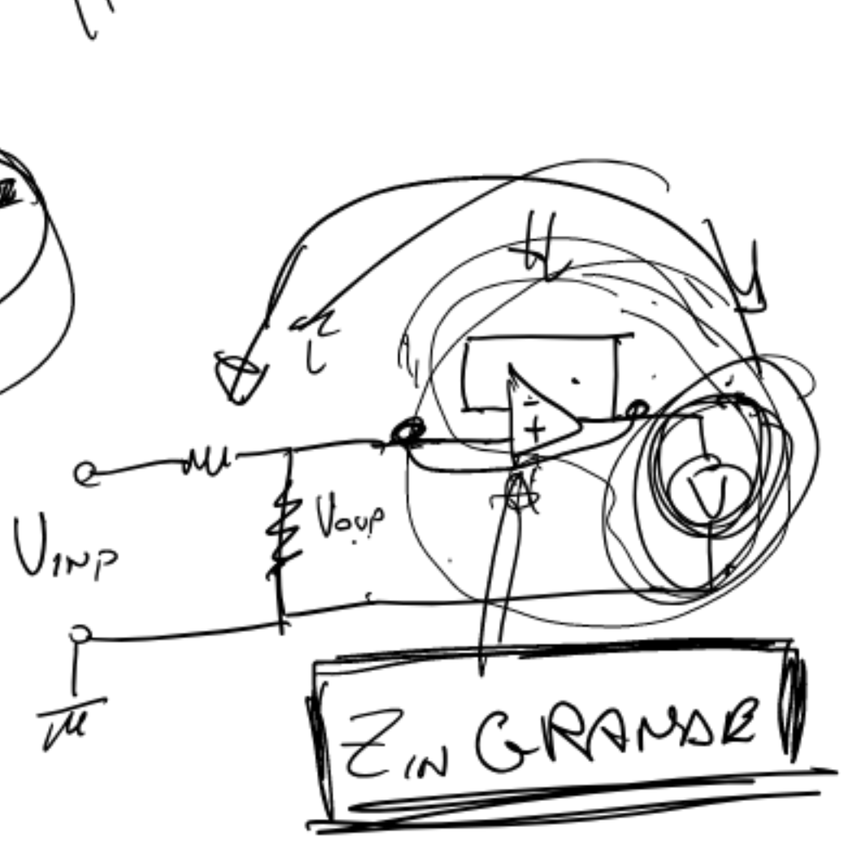
$$\Rightarrow \boxed{V_{out} = V_{in}} \quad !!!$$



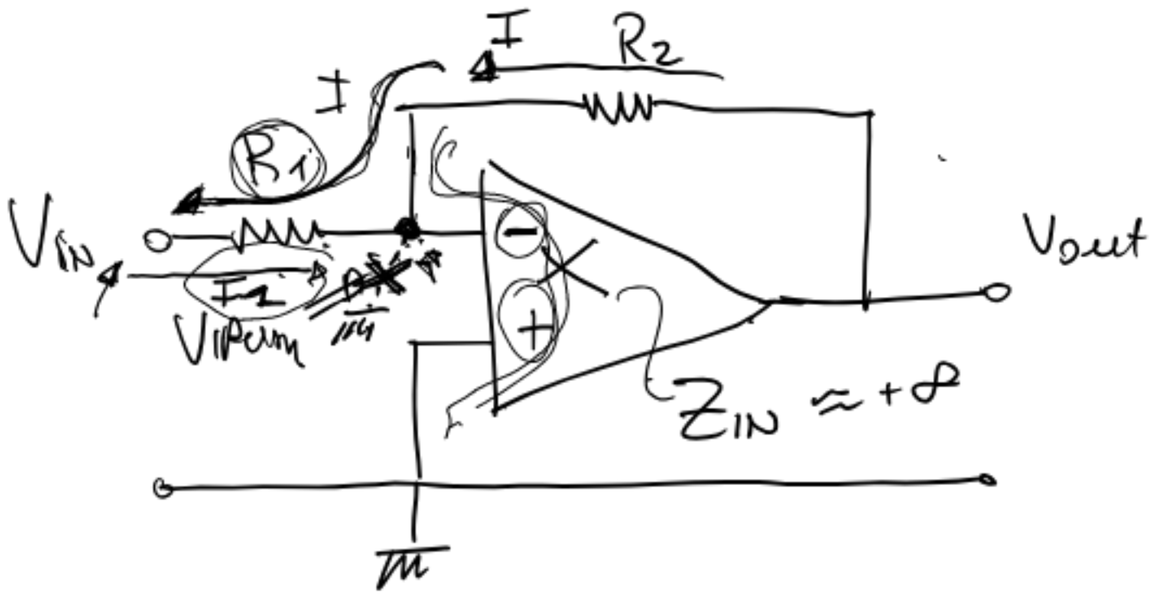
$$V_{OUTP} = \frac{R_2}{R_1 + R_2} V_{INP}$$

A vuoto.

$V_{OUTP} \approx V_{OUTP}$



AMP. OP. CONNESSIONE INVERTENTE



$$A = \frac{V_{out}}{V_{in}}$$

1) P.C.C.V $\quad V_{out} = R_2 \cdot I$

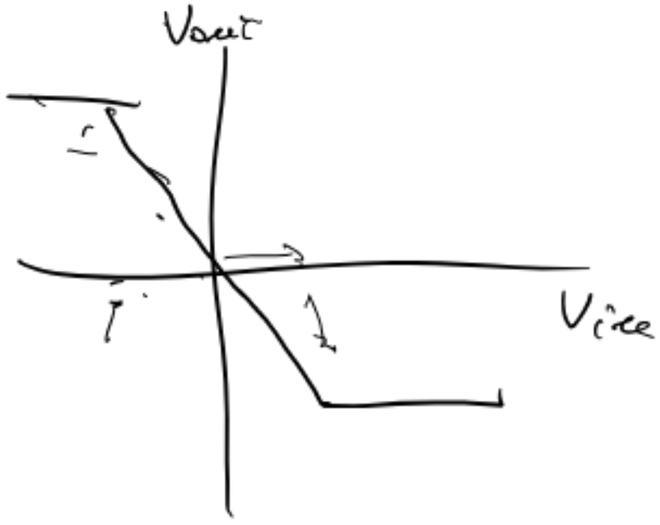
2) $Z_{IN} = +\infty \Rightarrow$ I circuito $R_2, R_1 \Rightarrow \quad V_{IN} = R_1 \cdot I_1 \qquad I_1 = -I$

$\Rightarrow \quad V_{IN} = -R_1 \cdot I$

$$A = \frac{R_2 \cdot I}{-R_1 \cdot I} = -\frac{R_2}{R_1} \Rightarrow$$

$$\boxed{A = -\frac{R_2}{R_1}}$$

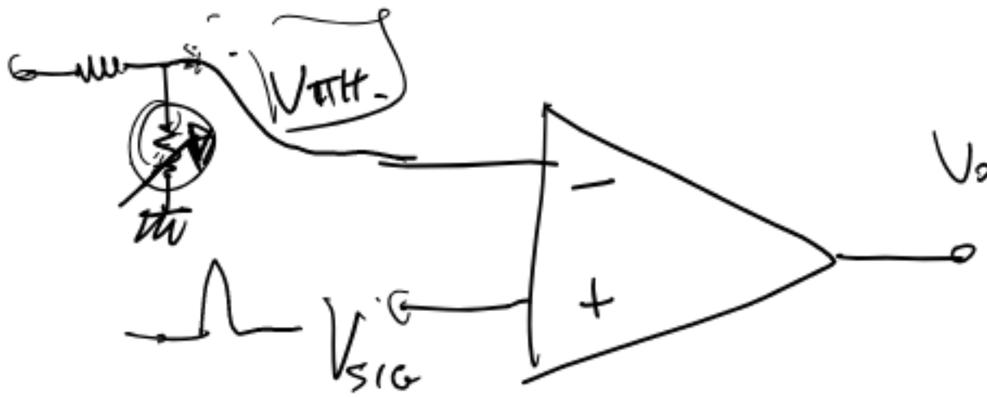
$\Rightarrow \quad \boxed{A = -1}$



APP. OP. SAT : DISCRIMINATORE

SETUP

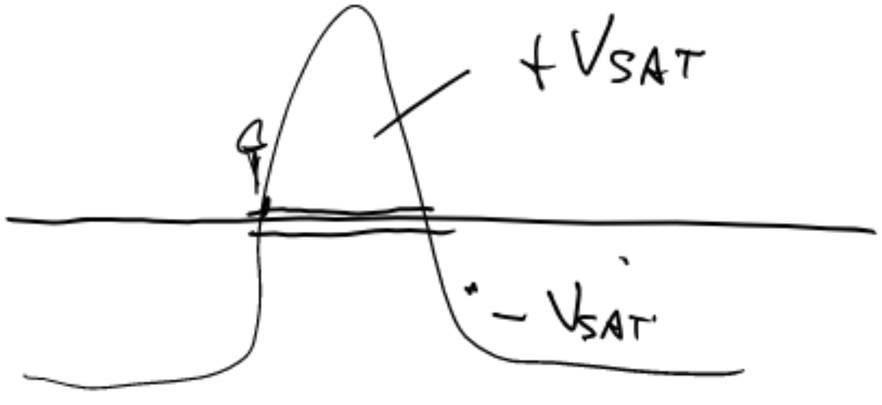
=D



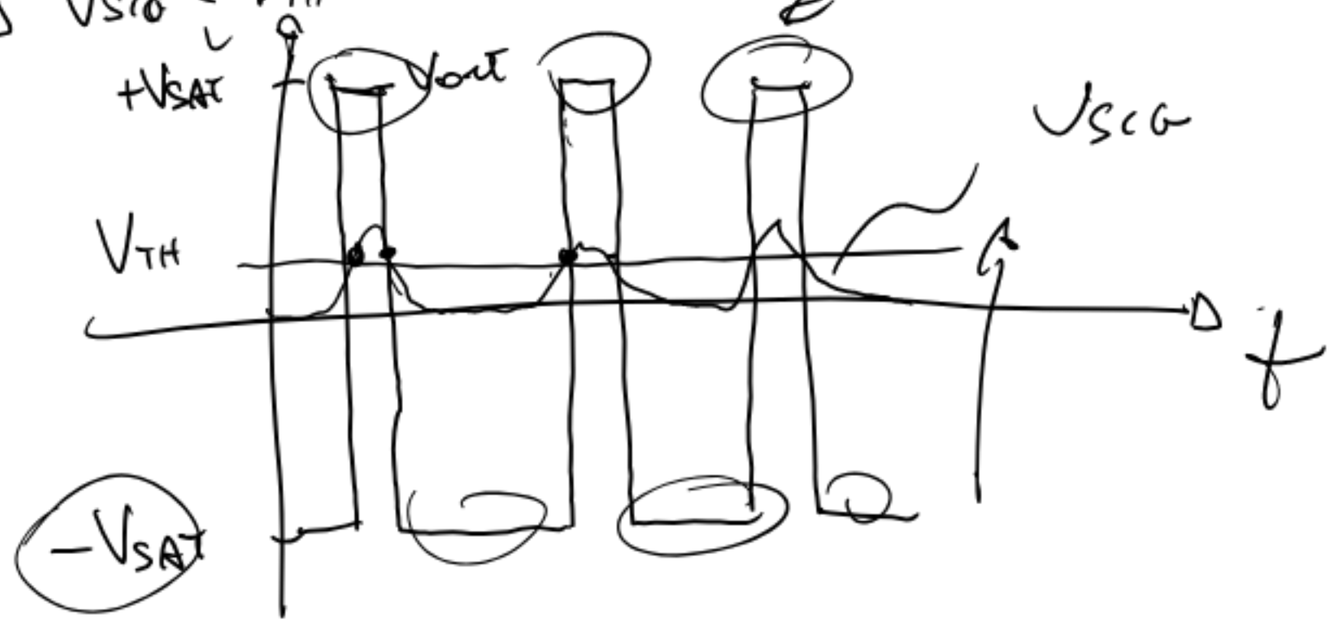
$V_{SIG} > V_{TH} \Rightarrow V_{out} = +V_{SAT}$

$V_{SIG} < V_{TH} \Rightarrow V_{out} = -V_{SAT}$

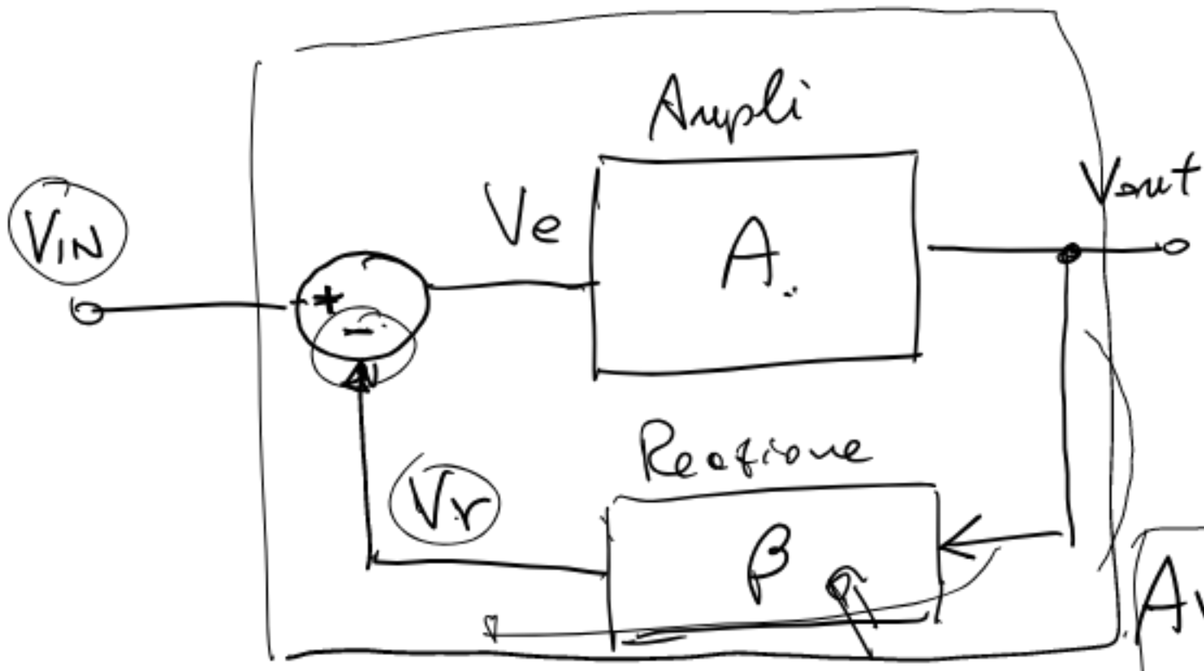
$V_{out} = A\,(V_{SIG} - V_{TH})$



segnale DIGITALE



REAZIONE (/RETROAZIONE) AMPLI



$$V_e = V_{IN} - V_r$$

$$V_{IN} = V_e + V_r$$

$$A = \frac{V_{out}}{V_e}$$

$$A_r = \frac{V_{out}}{V_{in}}$$

$$\beta = \frac{V_r}{V_{out}}$$

$$A_r = \frac{V_{out}}{V_{in}} = \frac{V_{out}}{V_e + V_r} = \frac{V_{out}/V_e}{1 + \frac{V_r}{V_e}} = \frac{A}{1 + \frac{V_r}{V_{out}} \cdot \frac{V_{out}}{V_e}} = \frac{A}{1 + \beta A}$$

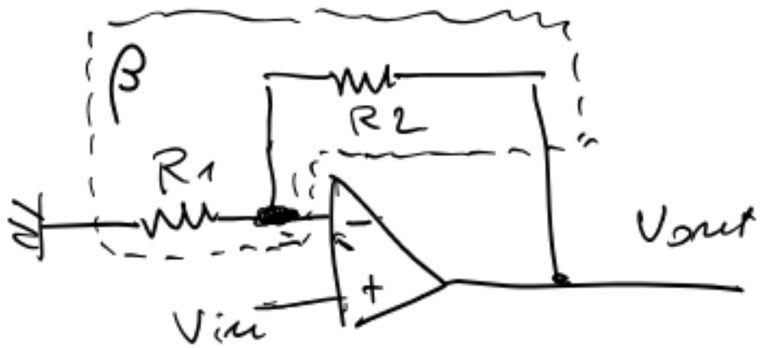
$$\boxed{A_r = \frac{A}{1 + \beta A}}$$

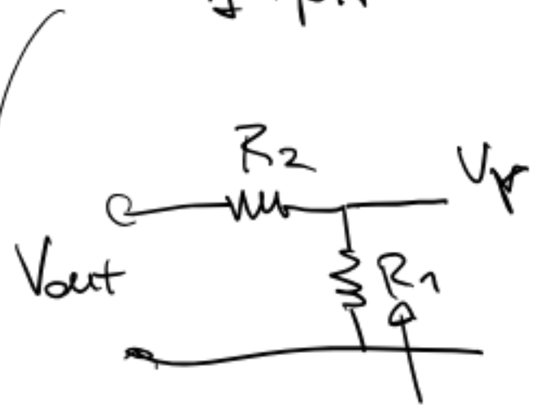
$1 + \beta A > 1 \Rightarrow A_r < A$

$1 + \beta A < 1 \Rightarrow A_r > A$

$\beta A = -1 \Rightarrow A_r = +\infty$ OSCILLATORE

$$A_r = \frac{A}{1+\beta A}$$





$$\beta = \frac{V_r}{V_{out}} = \frac{R_1}{R_1 + R_2}$$

$$A_r = \frac{1}{\frac{1}{A} + \beta} \simeq \frac{1}{\beta} = \frac{R_1 + R_2}{R_1} = \boxed{1 + \frac{R_2}{R_1}}$$

$\frac{1}{A} \simeq 0$

$A \gg 10^5$

Ampl. Op.

Stesso risultato ottenuto con P.C.C.V. + $Z_{IN} = +\infty$