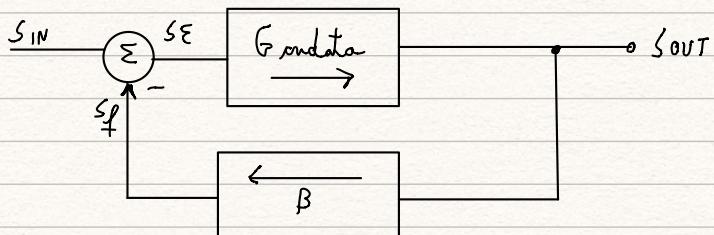


# RETROAZIONE NEGATIVA E CALCOLO DEL GUADAGNO

## D'ANELLO; ANALISI DI CONFIGURAZIONI CON OPAMP



$S_E$ : segnale errore

$S_E = S_{IN} - S_f$

$S_f$ : segnale di retroazione

$$S_f = S_{OUT} \beta$$

$$S_{OUT} = Guadato \quad S_E = Guadato \quad (S_{IN} - S_f) = Guadato \quad (S_{IN} - \beta S_{OUT})$$

$$S_{OUT} = \frac{Guadato}{1 + Guadato \beta} S_{IN}$$

$$G_{redle} \stackrel{\Delta}{=} \frac{S_{OUT}}{S_{IN}} \Big|_{redle} = \frac{Guadato}{1 + Guadato \beta} = \frac{Guadato}{1 - G_{loop}}$$

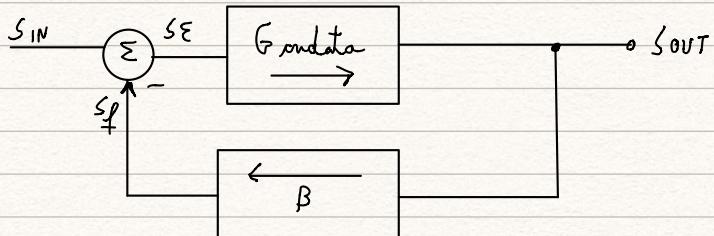
↑  
guadagno redle

$$G_{loop} = - Guadato \beta$$

↑  
guadagno loop

$G_{loop}^{(co)} < 0 \rightarrow$  retroazione negativa  
 $G_{loop}^{(co)} > 0 \rightarrow$  retroazione positiva

## PROPRIETÀ DEI CIRCUITI RETROAZIONATI NEGATIVAMENTE:



$$G_{redle} = \frac{S_{OUT}}{S_{IN}} = \frac{Guadato}{1 + Guadato} \xrightarrow{Guadato \rightarrow \infty} \frac{1}{\beta}$$

GUADAGNO IDEALE

(1)  $Guadato \rightarrow \infty \implies G_{loop} \rightarrow \infty$

$$G_{\text{real}} \rightarrow G_{\text{ideal}} = 1/\beta$$

$$\textcircled{2} \quad \frac{S_f}{S_{IN}} = \frac{G_{\text{on data}} \beta}{1 + G_{\text{on data}} \beta} \xrightarrow{G_{\text{on data}} \rightarrow \infty} 1$$

$$S_f = \beta S_{IN}$$

$$S_{OUT} = G_{\text{on data}} S_E = G_{\text{on data}} (S_{IN} - S_f)$$

$$\frac{S_f}{\beta} = G_{\text{on data}} S_{IN} - G_{\text{on data}} S_f$$

$$\textcircled{3} \quad \frac{S_E}{S_{IN}} = \frac{1}{1 + G_{\text{on data}} \beta} \xrightarrow{G_{\text{on data}} \rightarrow \infty} 0$$

→ segnale errore idealmente è 0

→ segnale di retroazione è poi al segnale di ingresso

$$\textcircled{4} \quad \frac{\delta G_{\text{real}}}{G_{\text{real}}} = \frac{\delta G_{\text{on data}}}{G_{\text{on data}}} \cdot \frac{1}{1 + G_{\text{on data}} \beta} = \frac{\delta G_{\text{on data}}}{G_{\text{on data}}} \frac{1}{1 - G_{\text{loop}}}$$

$$\delta [G_{\text{real}}] = \delta \left[ \frac{G_{\text{on data}}}{1 + G_{\text{on data}} \beta} \right] = \frac{\delta G_{\text{on data}} (1 + G_{\text{on data}} \beta) - G_{\text{on data}} \beta \delta G_{\text{on data}}}{(1 + G_{\text{on data}} \beta)^2}$$

$$= \frac{\delta G_{\text{on data}}}{(1 + G_{\text{on data}} \beta)} = \frac{G_{\text{on data}}}{G_{\text{on data}}} \cdot \frac{1}{(1 + G_{\text{on data}} \beta)}$$

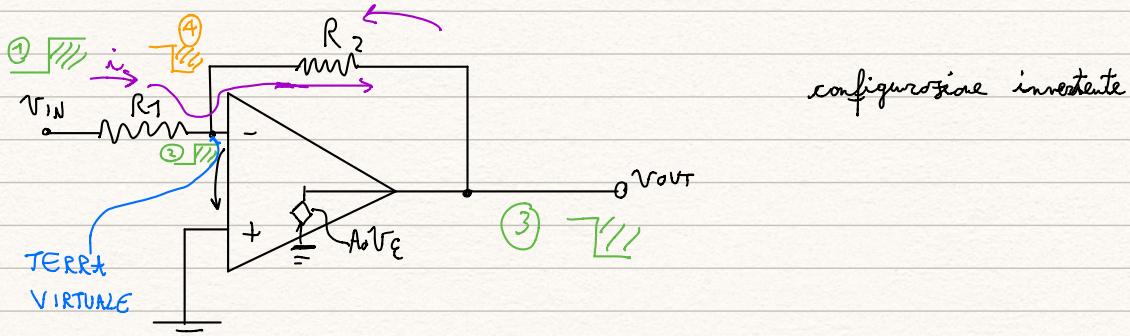
$\uparrow$   
 $G_{\text{real}}$

$$G_{\text{real}} = \frac{G_{\text{on data}}}{1 + G_{\text{on data}} \beta} = \frac{G_{\text{on data}}}{1 - G_{\text{loop}}} = \frac{G_{\text{on data}}}{1 + G_{\text{on data}} \beta} \cdot \frac{1}{\beta} = G_{\text{ideal}} - \frac{G_{\text{loop}}}{1 - G_{\text{loop}}} =$$

$$G_{\text{real}} = G_{\text{ideal}} \frac{1}{1 - 1/G_{\text{loop}}}$$

# ANALISI DELLA CONFIGURAZIONE INVERTE NTE

ALLA LUCE DELLA TEORIA DELLA RETROAZIONE:

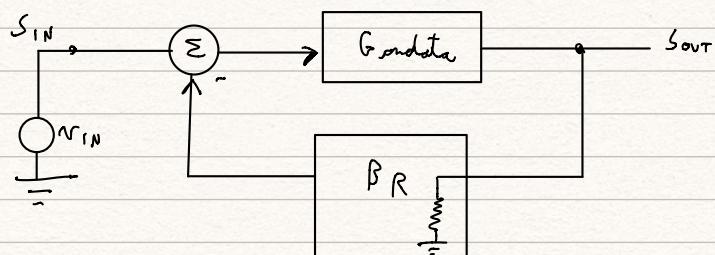


$$i = \frac{V_{IN}}{R_1} \quad \text{proie alla terra virtuale}$$

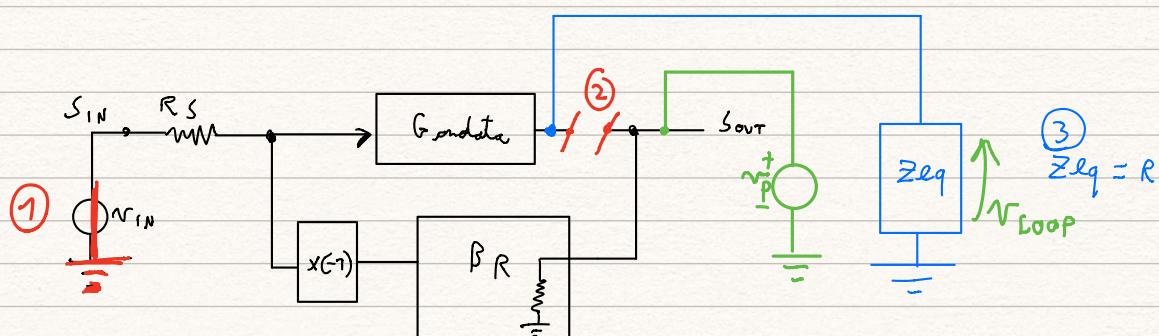
$$V_{OUT} = -I \cdot R_2 = -\frac{V_{IN}}{R_1} \cdot R_2$$

$\hookrightarrow$  Gidede  $= -\frac{R_2}{R_1}$

CONCETTO DI GUADAGNO AD ANELLO E RELATIVO  
CALCOLO:

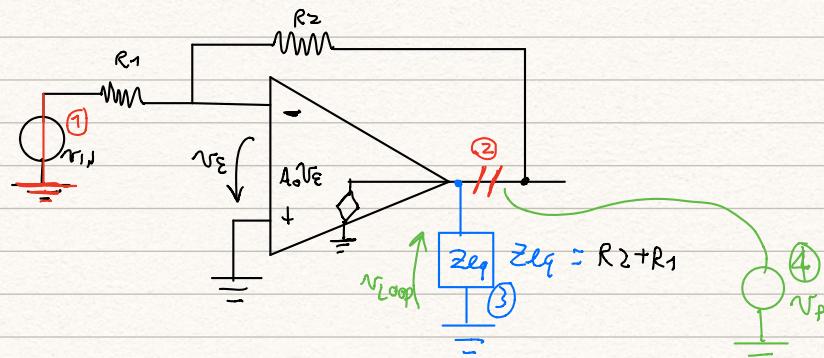


METODO DI CALCOLO DEL GUADAGNO D'ANELLO:



- 1) Spengo i generatori fornienti
  - 2) Taglio l'anello (in un punto comodo!)
  - 3) RI COSTRUISCO A MONTE DEL TAGLIO L'IMPEDENZA VISTA A VALLE  
di tensione (corrente)
  - 4) Applico un generatore di prova  $V_p$  a valle del taglio e valuto la tensione (corrente)  
una volta percorso l'anello (tensione ai capi di  $Z_{eq}$  o corrente in  $Z_{eq}$ )
- $\hookrightarrow G_{Loop} \triangleq \frac{V_{Loop}}{V_p}$

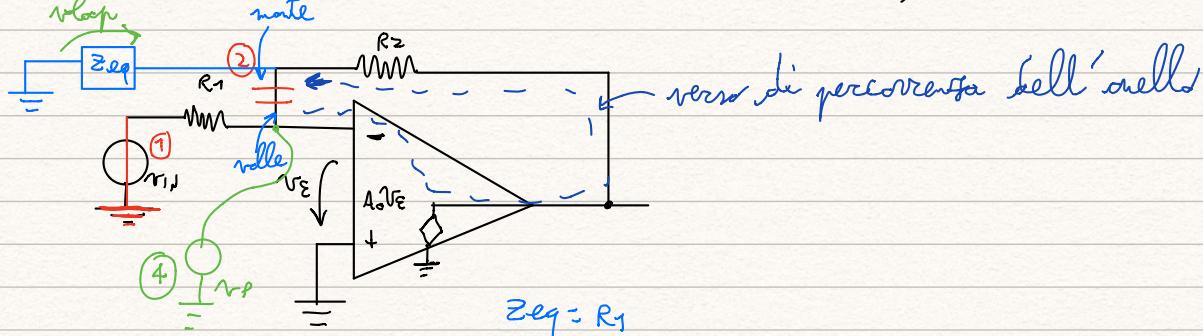
## CALCOLO DEL GUADAGNO D'ANELLO IN UNA CONFIGURAZIONE INVERTENTE :



$$V_{Loop} = A_0 V_E = A_0 (V^+ - V^-) = -A_0 V^- = -A_0 \frac{R_1}{R_1 + R_2} V_p$$

$$G_{Loop} \triangleq \frac{V_{Loop}}{V_p} = -A_0 \frac{R_1}{R_1 + R_2}$$

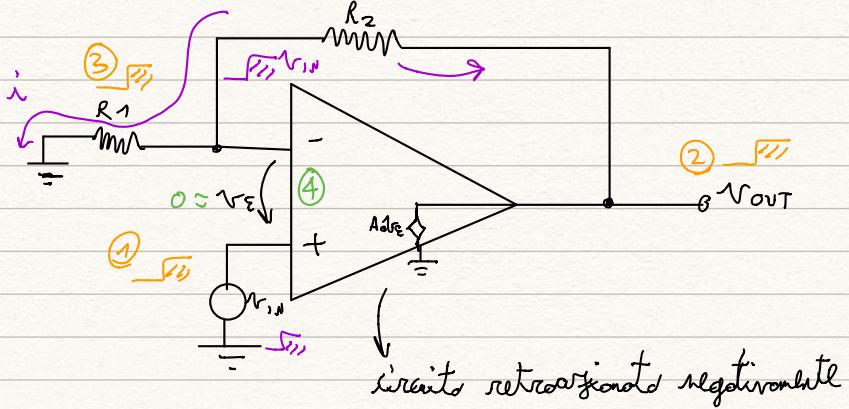
TAGLIO IN UN ALTRO PUNTO (menoscando)



$$V_{Loop} = -A_0 V_p \frac{Z_{eq}}{Z_{eq} + R_2}$$

$$G_{Loop} \triangleq \frac{V_{Loop}}{V_p} = -A_0 \frac{Z_{eq}}{Z_{eq} + R_2} = -A_0 \frac{R_1}{R_1 + R_2}$$

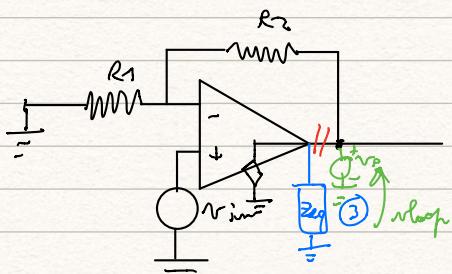
## CONFIGURAZIONE NON INVERTENTE:



- dipende solo da un rapporto di R
- uscita in fase con l'ingresso
- resistenza in ingresso tendente all'  $\infty$

$$G_{\text{REAL}} = \frac{G_{\text{IDEALE}}}{1 - 1/g_{\text{loop}}}$$

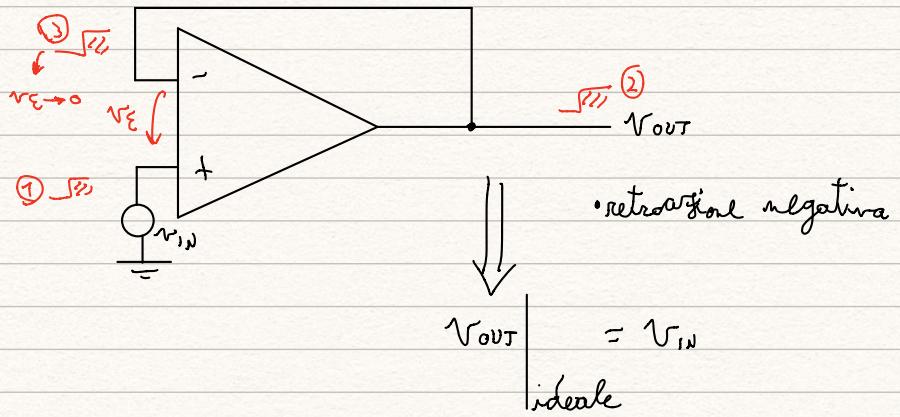
CALCOLO GLOOP DELLA CONFIG NON INVERTENTE:



## ERRORE STATICO DI GUADAGNO:

$$\varepsilon = \left| \frac{G_{\text{real}}(\omega) - G_{\text{ideale}}(\omega)}{G_{\text{real}}(\omega)} \right| = \left| \frac{\frac{G_{\text{ideale}}}{1 - G_{\text{loop}}} - G_{\text{ideale}}}{\frac{G_{\text{ideale}}}{1 - G_{\text{loop}}}} \right| = \frac{1}{|G_{\text{loop}}(\omega)|}$$

# BUFFER DI TENSIONE:



$$G_{ideale} \triangleq \frac{v_{out}}{v_{in}} = 1$$

$$G_{loop} = -A_o$$

$$Grado = \frac{G_{ideale}}{1 + G_{loop}} =$$

$$= \frac{1}{1 + A_o} = \frac{10^5 \div 10^6}{1 + A_o} \approx 1$$

