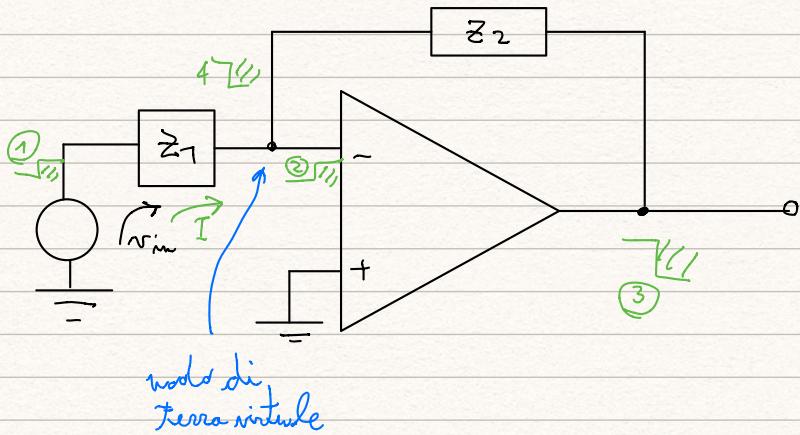


CONFIGURAZIONE INVERTENTE CON IMPEDENZE GENERALIZZATE,

FILTRI, DIAGRAMMI DI BODE

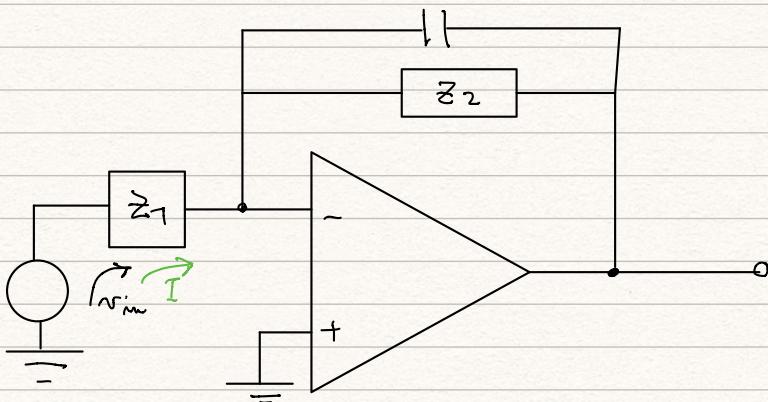
Configurazione invertente con impedenze generalizzate



$$I = \frac{V_{in}(s)}{Z_1(s)}$$

$$V_{out}(s) = -I Z_2(s) = -V_{in} \frac{Z_2(s)}{Z_1(s)}$$

$$T(s) \stackrel{\Delta}{=} \frac{V_{out}(s)}{V_{in}(s)} = -\frac{Z_2(s)}{Z_1(s)}$$



$$Z_1(s) = R_1$$

$$Z_2(s) = \frac{R_2}{1 + sC_2 R_2}$$

$$T(s) = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2}{R_1} \frac{1}{1 + sC_2 R_2}$$

funzione di trasferimento

• numero complesso

* GUADAGNO IN CONTINUA $T(0) = -R_2$

* POLO CON $\tau_p = C_2 R_2$ $s_p = \frac{R_1}{R_2 C_2} - \frac{1}{R_2 C_2}$

$$* \text{MODULO} \quad |T(j\omega)| = \frac{R_2}{R_1} \frac{1}{\sqrt{1 + \omega^2 R_2^2 C_2^2}}$$

$$* \text{FASE} \quad \arg[T(j\omega)] = \arctg \left[\frac{-R_2}{R_1} \frac{1}{1 + j\omega R_2 C_2} \right] = -180^\circ + \arctg(-\omega R_2 C_2)$$

$$(*) |T(j\omega)|_0 = 20 \log_{10} \left| \frac{R_2}{R_1} \right| + 20 \log_{10} \frac{1}{\sqrt{1 + \omega^2 R_2^2 C_2^2}} =$$

$$= 20 \log_{10} \frac{R_2}{R_1} - 20 \log_{10} \left(\sqrt{1 + w^2 R_2^2 C_2^2} \right) = \square$$

$$\textcircled{1} = \frac{\cancel{w \ll 1/R_2 C_2}}{\cancel{w = 1/R_2 C_2}} 20 \log_{10} \frac{R_2}{R_1} - 20 \log_{10} \sqrt{2} \approx 20 \log_{10} \frac{R_2}{R_1} - 3 \beta$$

$20 \log_{10} \frac{R_2}{R_1} - 20 \log_{10} w R_2 C_2 \quad \sqrt{w^2 R_2^2 C_2^2} = w R_2 C_2$

DIAGRAMMA DI BODE DEL MODULO:

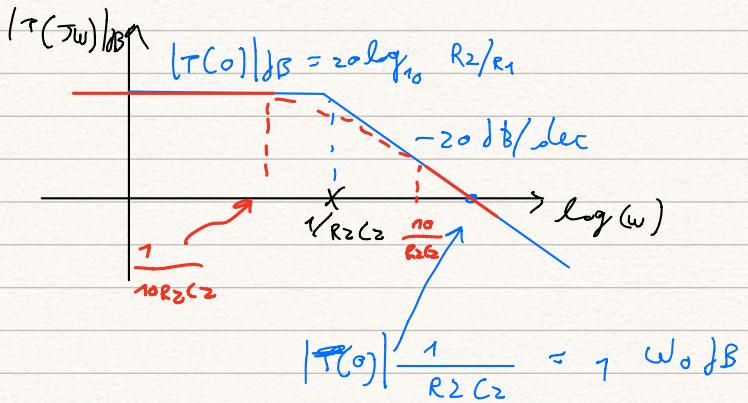
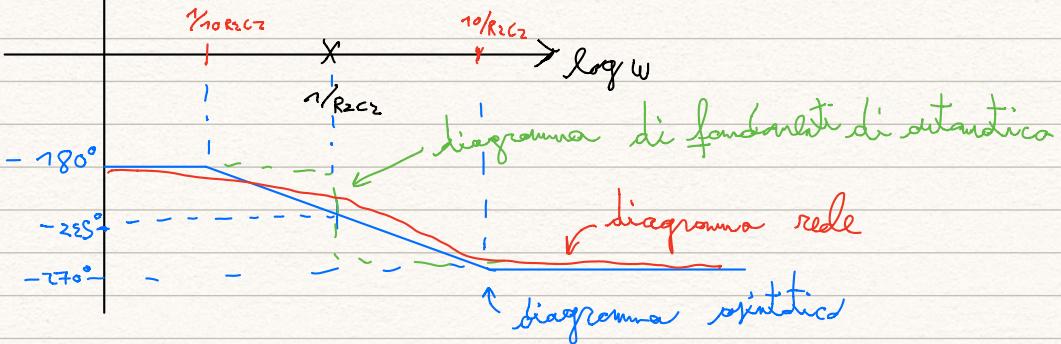


DIAGRAMMA DI BODE DELLA FASE:

$$\arg [T(jw)] = -180^\circ - \arctg w R_2 C_2 = \square$$

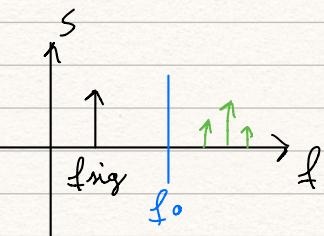
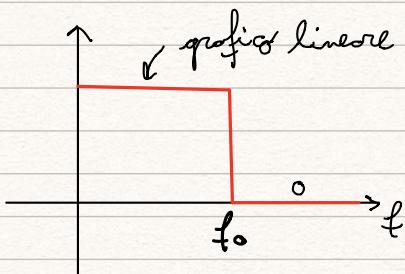
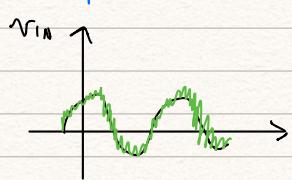
$$\textcircled{2} = \frac{\cancel{w \ll 1/R_2 C_2}}{\cancel{w = 1/R_2 C_2}} -180^\circ - \arctg 1 = -225^\circ = -\frac{5}{4} \pi$$

$-180^\circ - 90^\circ = -270^\circ = -\frac{3}{2} \pi$

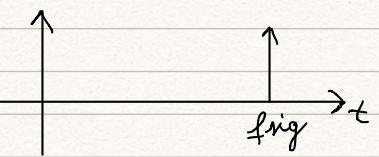
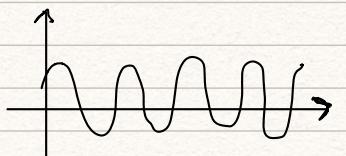
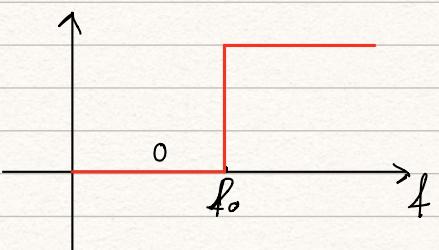
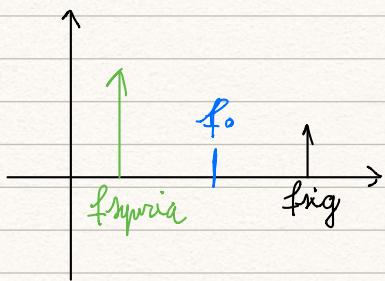


FILTRO APTIVI DEL 1^o ORDINE

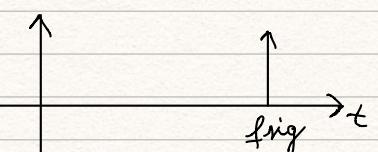
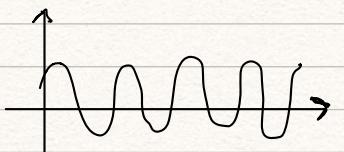
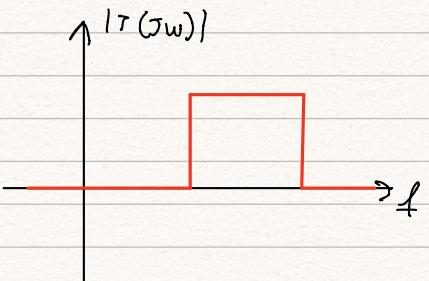
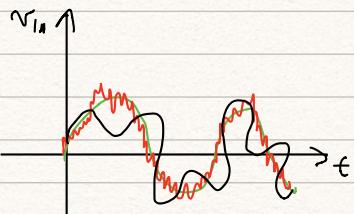
* PASSA BASSO



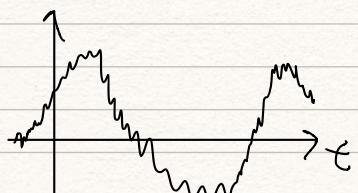
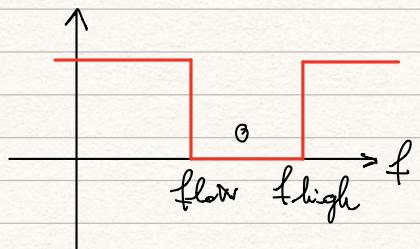
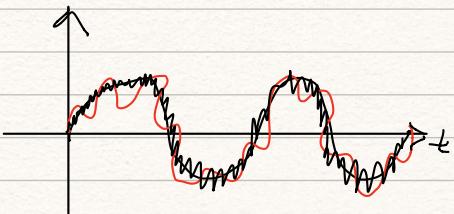
* PASSA ALTO



* FILTRO PASSA-BANDA



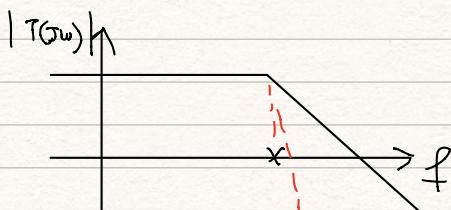
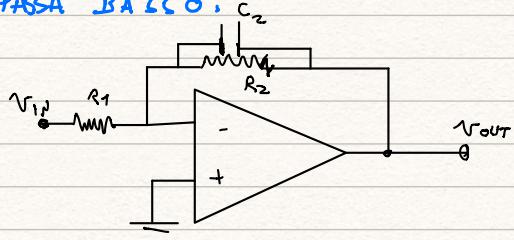
* FILTRO ARRESTA-BANDA





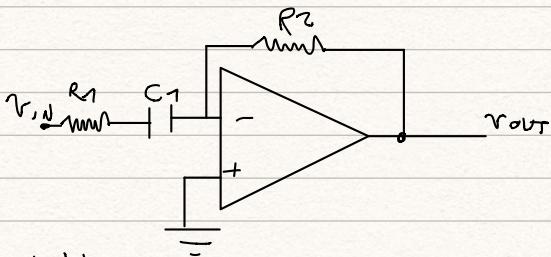
IMPLEMENTAZIONI CIRCUITALI FILTRI DEL 1° ORDINE:

→ PASSA BALLO:

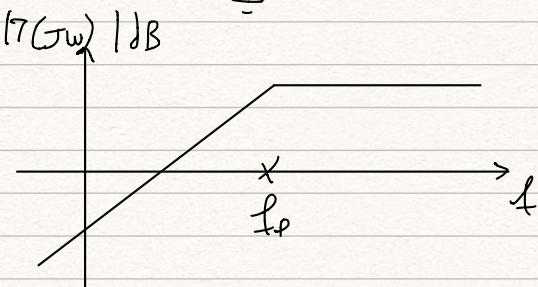


$-20 \frac{dB}{dec}$ se fosse filtro del 4° ordine!

→ PASSA ALTO:

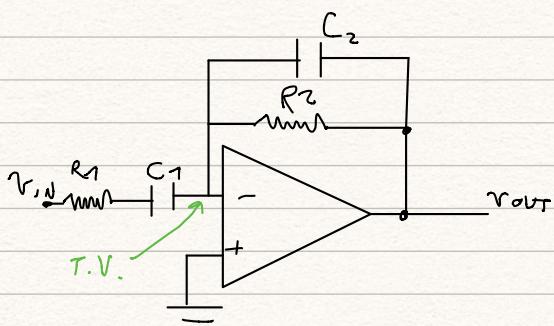


$$|T(s)| \triangleq \frac{V_{out}(s)}{V_{in}(s)} = -\frac{R_2}{R_1 + 1/sC_1} = -\frac{sC_1 R_2}{s + sC_1 R_1}$$



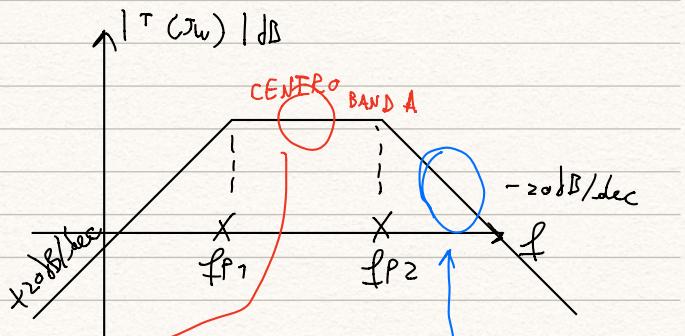
- $\zeta_p = C_1 R_1$
- zero nell'origine
- $f_p = 1/(2\pi\zeta_p)$

→ PASSA BANDA:



$$G_1 \left\{ \begin{array}{l} \zeta_{p_1} = C_1 R_1 \\ \text{zero nell'origine} \end{array} \right.$$

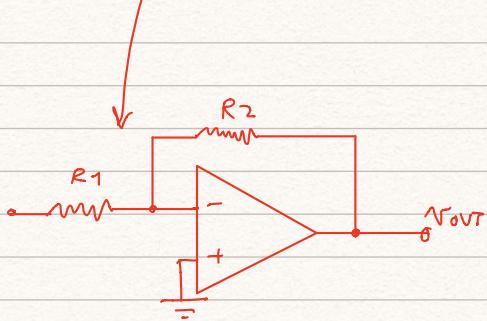
$$G_2 \left\{ \begin{array}{l} \zeta_{p_2} = C_2 R_2 \\ \text{zero nell'origine} \end{array} \right.$$



$$f_{p_1} = \frac{1}{2\pi\zeta_{p_1}}$$

$$f_{p_2} = \frac{1}{2\pi\zeta_{p_2}}$$

ALTA FREQUENZA
 $|T(jw)| \rightarrow 0$

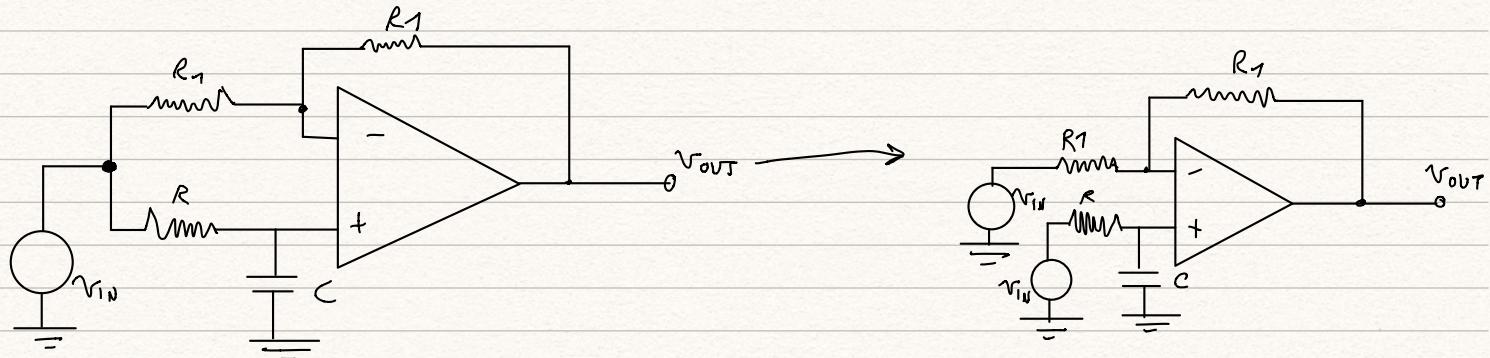


$$Z_1(s) = R_1 + \frac{1}{sC_1}$$

$$Z_2(s) = \frac{R_2}{s + sC_2R_2}$$

$$T(s) = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2}{s + sC_2R_2} \cdot \frac{1}{R_1 + \frac{1}{sC_1}} = \frac{-sC_1R_2}{(s + sC_2R_2)(s + sC_1R_1)}$$

PASSA-TUTTO (SFASATORE PURO) ("PHASE SHIFTER")



applied princ. sorpasso effetti

$$v_{out} = \frac{1/sC}{R + 1/sC} \cdot \left(1 + \frac{R_1}{R}\right) v_{in} - \underbrace{\frac{R_1}{R}}_1 v_{in}$$

$$T(s) = \frac{1/sC}{R + 1/sC} \cdot 2 - 1 = 2 \cdot \frac{1}{s + sCR} - 1 = \frac{2 - 1 - sCR}{s + sCR} = \frac{1 - sCR}{s + sCR}$$

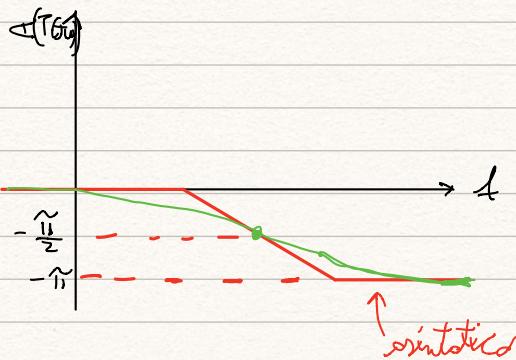
$$* \text{POZO} \quad s_p = -1/R_C \quad \tau_p = RC \quad (\text{sx})$$

$$* \text{ZERO} \quad s_z = +1/R_C \quad \tau_z = RC \quad (\text{dx})$$

$$|T(j\omega)| = \left| \frac{1 - j\omega RC}{s + j\omega RC} \right| = \frac{\sqrt{1 + \omega^2 R^2 C^2}}{\sqrt{1 + \omega^2 R^2 C^2}} = 1$$

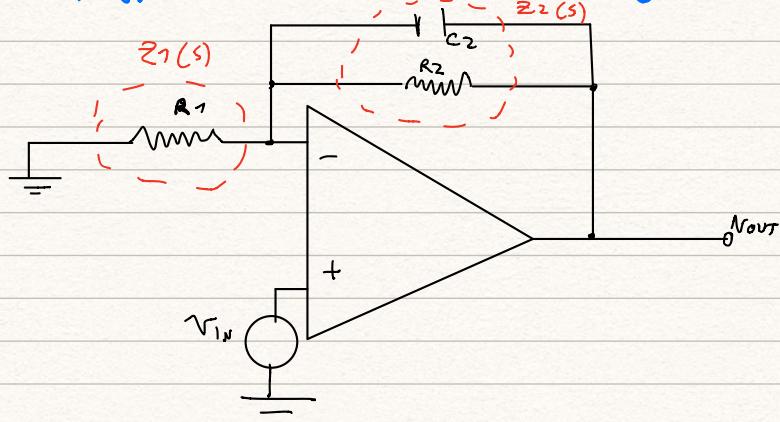
$$\uparrow |T(j\omega)| \text{dB}$$

$$f_P = f_Z \rightarrow f$$



PER COMPENSARE LE CORRENTI
DI BIAS LA RESISTENZA
AL MORSETTO + DEVE ESSERE
PARI ALLA RESISTENZA AL
MORSETTO - (in continua)

CONFIGURAZIONE NON INVERTENTE



CON IMPEDENZE GENERALIZZATE

$$Z_2(s) = \frac{R_2}{1 + sC_2 R_2}$$

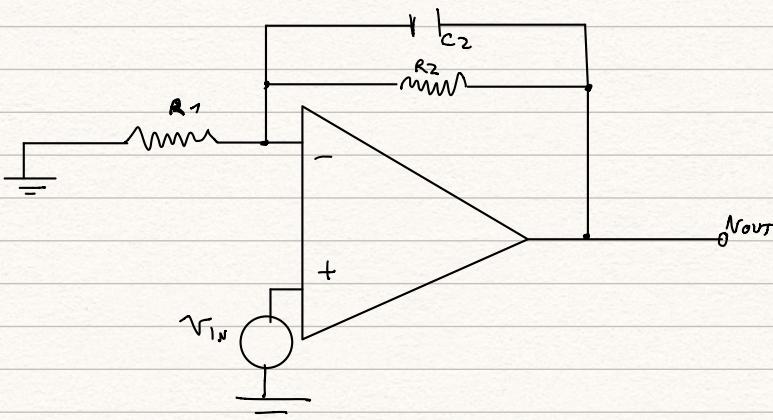
$$Z_1 = R_1$$

$$T(s) = 1 + \frac{Z_2(s)}{Z_1(s)} = 1 + \frac{\frac{R_2}{1 + sC_2 R_2}}{R_1} = 1 + \frac{R_2}{R_1(1 + sC_2 R_2)} =$$

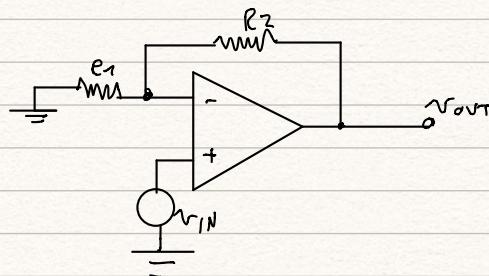
$$= \frac{R_1 + sC_2 R_2 R_1 + R_2}{R_1(1 + sC_2 R_2)} = \frac{(R_1 + R_2)}{R_1} \cdot \frac{1 + sC_2 \frac{R_2 R_1}{R_1 + R_2}}{1 + sC_2 R_2} = \left(1 + \frac{R_2}{R_1}\right) \frac{1 + sC_2 (R_1/R_2)}{1 + sC_2 R_2}$$

GUADAGNO IN
CONTINUA $T(\omega)$

ZERO $\omega_2 = C_2 (R_1/R_2)$
POLO $\omega_p = C_2 R_2$



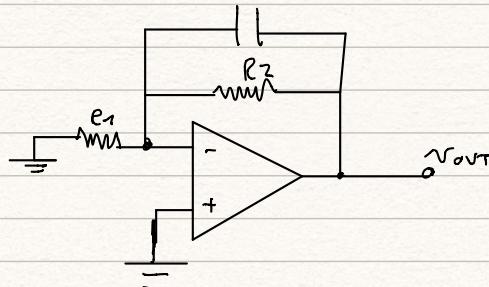
- guadagno in continua ($f=0 \rightarrow$ capacità circuiti aperti)



$$T(o) = 1 + \frac{R_2}{R_1}$$

• polo

$$\gamma_p = C_2 R_2$$



• $\omega_{ZER0}?$

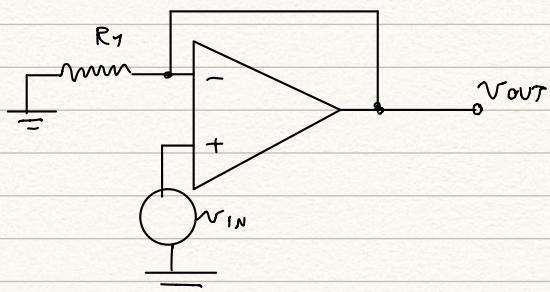
$$\exists \bar{s} \text{ t.c. } V_{IN}(\bar{s}) \neq 0$$

$$V_{OUT}(\bar{s}) = 0$$

$$Z_{eq}(s) = 0 \text{ dove } Z_{eq}(s) = R_1 + \frac{R_2}{1 + sC_2 R_2}$$

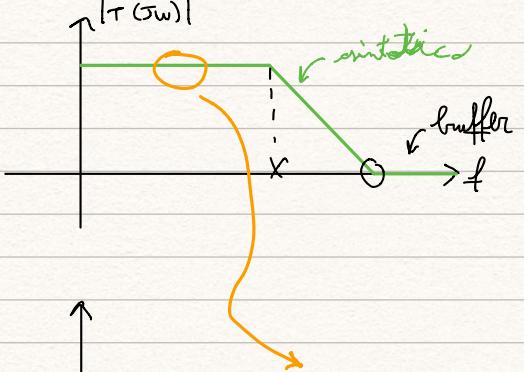
$$\begin{aligned} Z_{eq}(s) &= R_1 + \frac{R_2}{1 + sC_2 R_2} = R_1 + sC_1 R_2 R_1 + R_2 = (R_1 + R_2) \left[\frac{1 + sC_2 R_1 R_2}{R_1 + R_2} \right] = \\ &= (R_1 + R_2) \left[\frac{1 + sC_2 (R_1 / R_2)}{1 + sC_2 (R_1 / R_2)} \right] \quad \downarrow \\ s^2 &= -\frac{1}{C_2 (R_1 / R_2)} \quad \rightarrow \gamma_z = C_2 (R_1 / R_2) \end{aligned}$$

in alta freq. C_2 è assimilabile a un corto circuito



È VN BUFFER

$$|T(j\omega)|_{MF} = 1$$



$$\begin{aligned}\tilde{\tau}_p &= C_2 R_2 \\ \tilde{\tau}_z &= C_2 \cdot R_1 / R_2 \\ \tilde{\tau}_z &< \tilde{\tau}_p\end{aligned}$$

$$f_z > f_p$$

