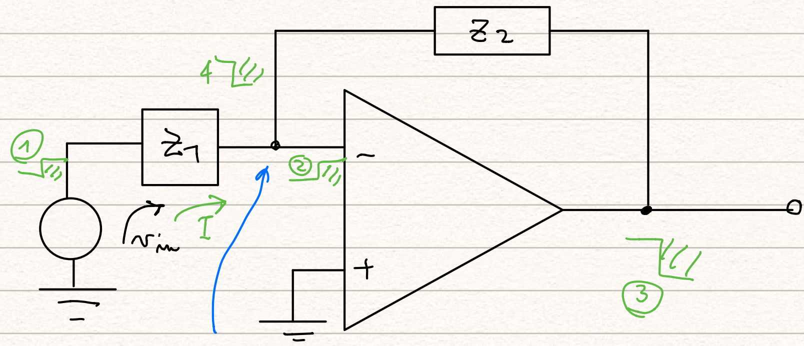
CONFIGURAZIONE INVERTENTE CON IMPEDENZE GENERALIZZATE, FILTRI, DIAGRAMMI DI BODE

Configurazione invertente con impedenze generalizzate

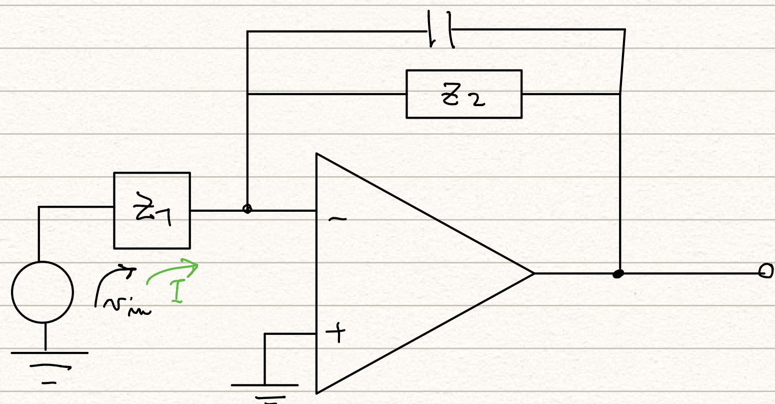


nodo di terra virtuale

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

$$V_{OUT}(s) = -I\, Z_2(s) = -V_{IN}\frac{Z_2(s)}{Z_1(s)}$$

$$T(s) \triangleq \frac{V_{OUT}(s)}{V_{IN}(s)} = \frac{-Z_2(s)}{Z_1(s)}$$



$$Z_1(s) = R_1$$

$$Z_2(s) = \frac{R_2}{1 + sC_2R_2}$$

$$T(s) = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2}{R_1}\,\frac{1}{1+sC_2R_2}$$

funzione di trasferimento

- numero complesso

* GUADAGNO IN CONTINUA $T(0) = -\frac{R_2}{R_1}$

* POLO CON $\tau_P = C_2R_2$ $\qquad s_p = -\frac{1}{R_2C_2}$

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

* FASE $\qquad \arg[T(j\omega)] = \operatorname{arctg}\left[\frac{-R_2}{R_1}\,\frac{1}{1+j\omega R_2C_2}\right] = -180° + \operatorname{arctg}(-\omega R_2C_2)$

(*) $|T(j\omega)|_{dB} = 20\log_{10}|T(j\omega)| = 20\log_{10}\frac{R_2}{R_1} + 20\log_{10}\frac{1}{\quad} =$

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

$$\bullet = \begin{cases} w \ll 1/R_2C_2 & 20\log_{10}\frac{R_2}{R_1} \\ w = 1/R_2C_2 & 20\log_{10}\frac{R_2}{R_1} - 20\log_{10}\sqrt{2} \cong 20\log_{10}\frac{R_2}{R_1} - 3\,dB \\ w \gg \frac{1}{R_2C_2} & 20\log_{10}\frac{R_2}{R_1} - 20\log_{10} wR_2C_2 \end{cases}$$

$$\sqrt{w^2R_2^2C_2^2} = wR_2C_2$$

DIAGRAMMA DI BODE DEL MODULO:

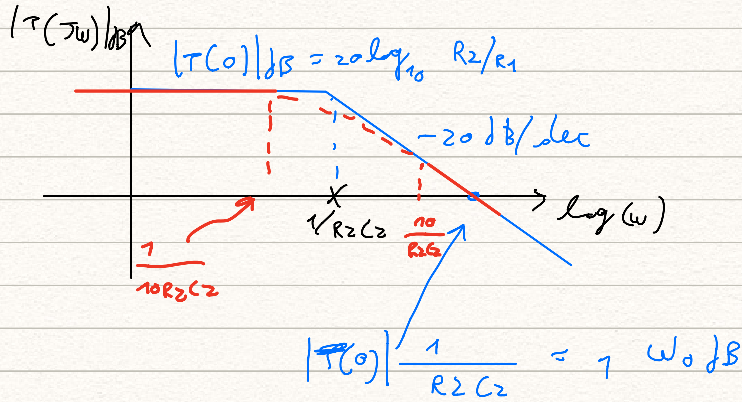
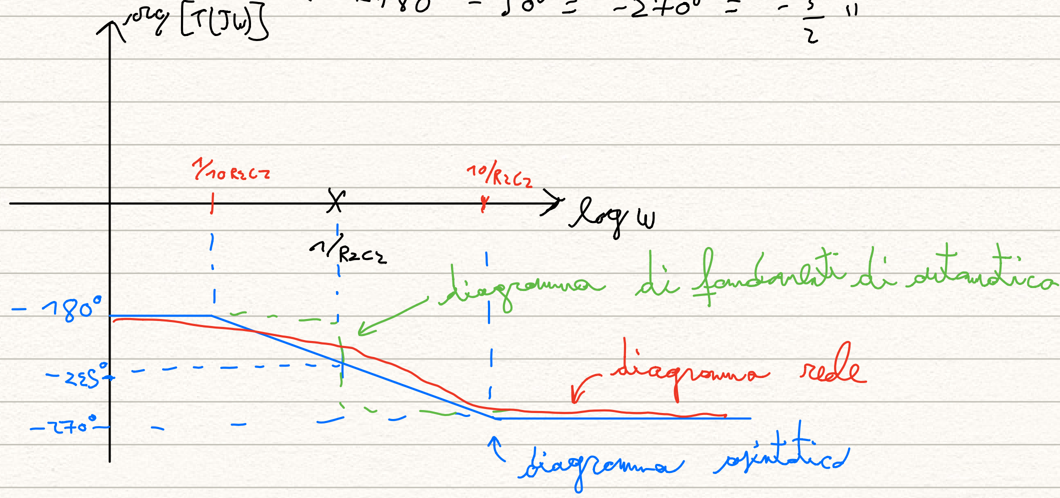


DIAGRAMMA DI BODE DELLA FASE:

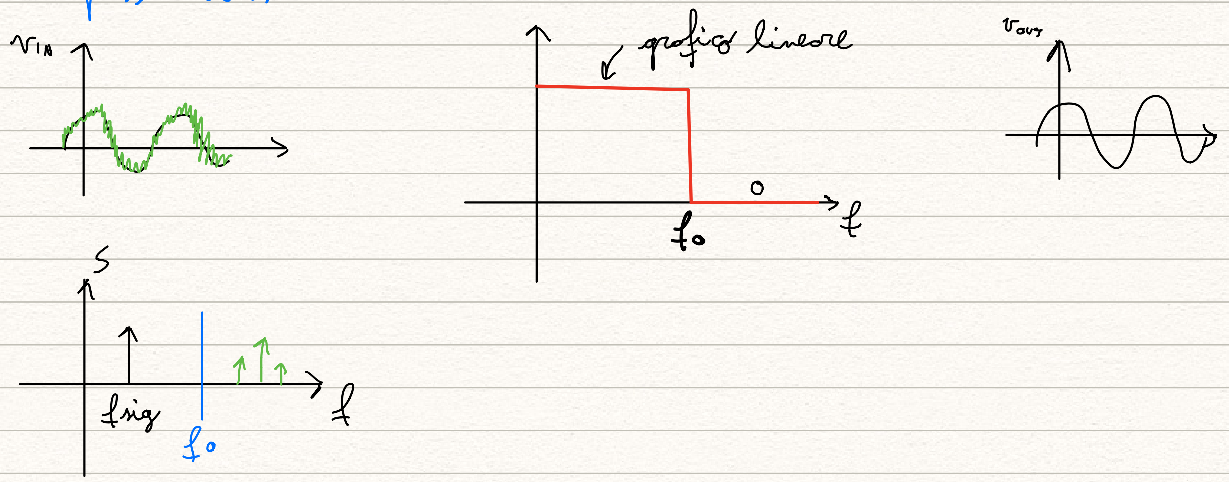
$$\arg[T(jw)] = -180° - \arctan wR_2C_2 = \blacksquare$$

$$\blacksquare = \begin{cases} w \ll 1/R_2C_2 & -180° = -\pi \\ w = 1/R_2C_2 & -180° - \arctan 1 = -225° = -\frac{5}{4}\pi \\ w \gg 1/R_2C_2 & -180° - 90° = -270° = -\frac{3}{2}\pi \end{cases}$$

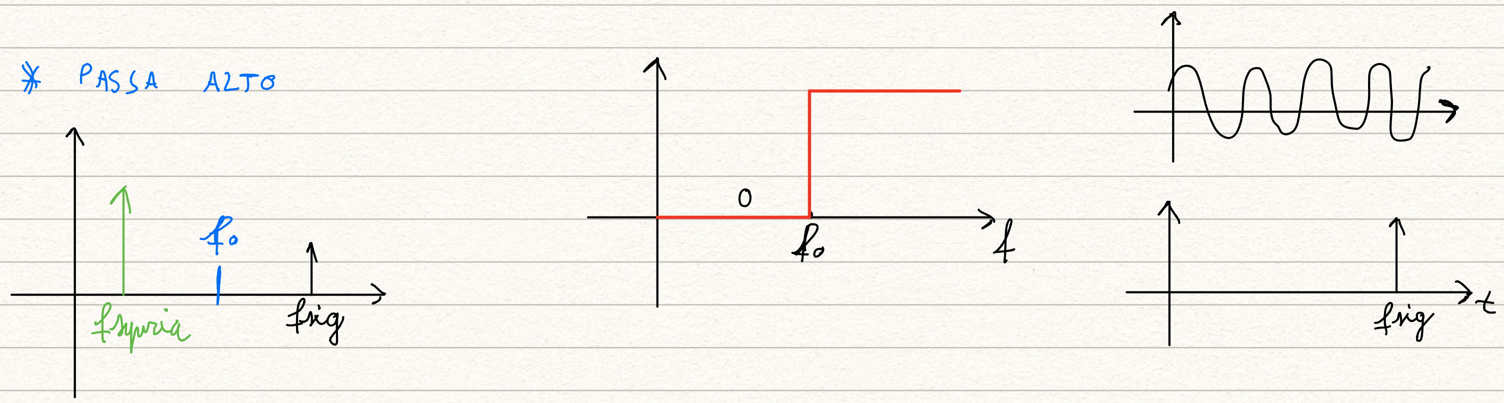


FILTRI ATTIVI DEL 1° ORDINE

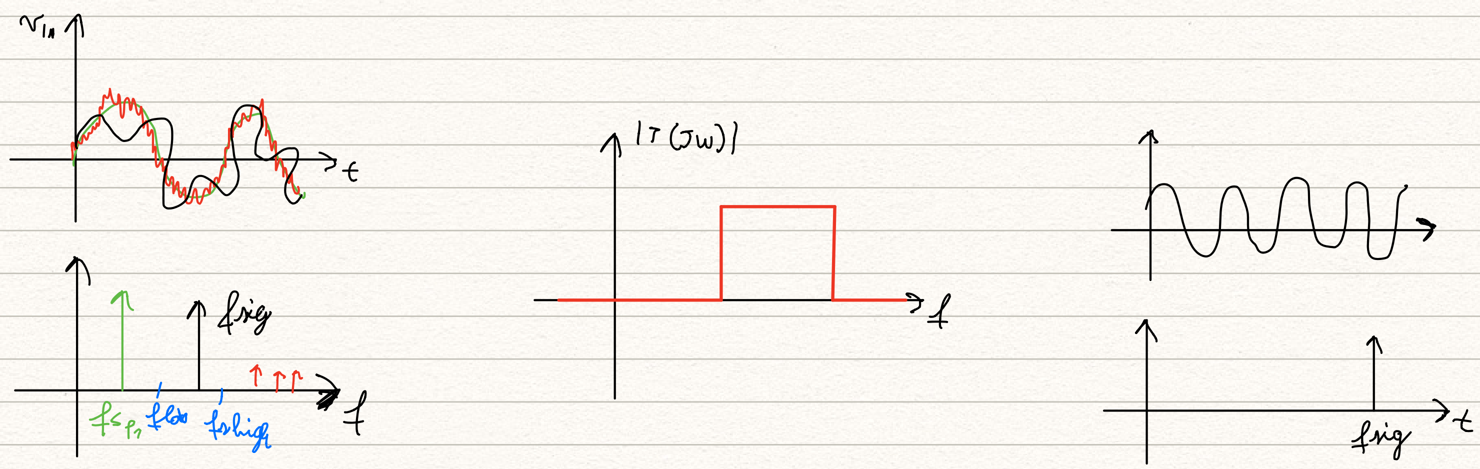
* passa basso



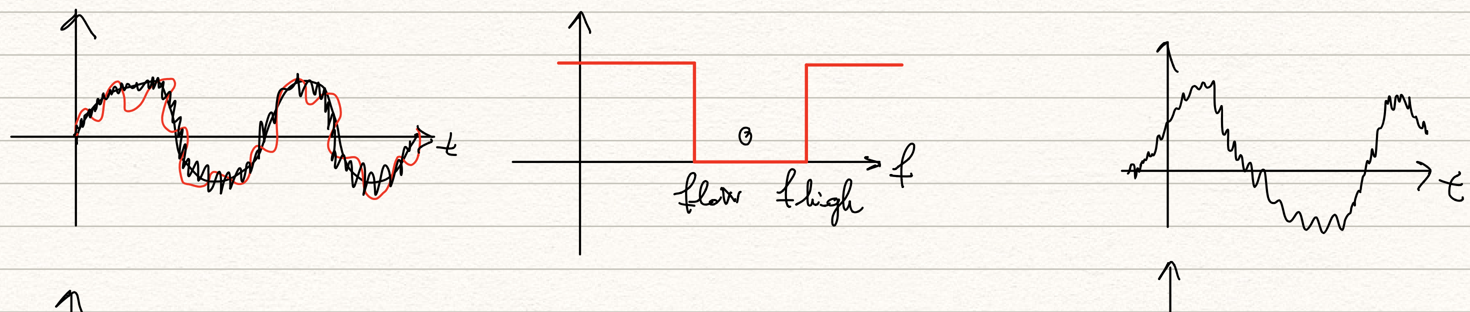
* PASSA ALTO

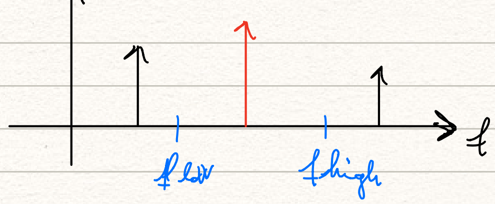


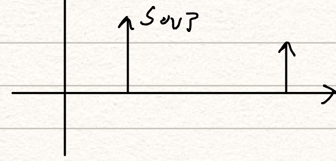
* FILTRO PASSA-BANDA



* FILTRO ARRESTA-BANDA

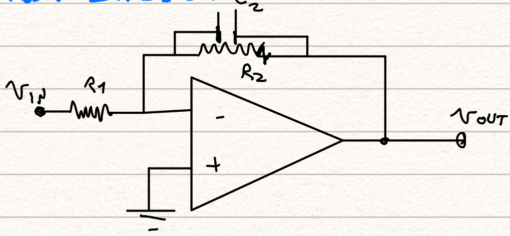






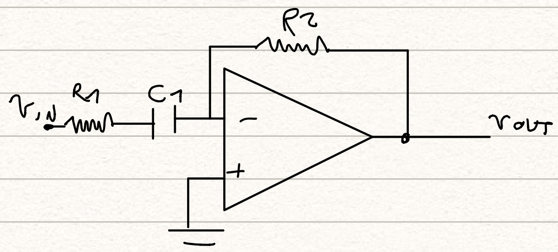
IMPLEMENTAZIONI CIRCUITALI FILTRI DEL 1° ORDINE:

→ **PASSA BASSO:**



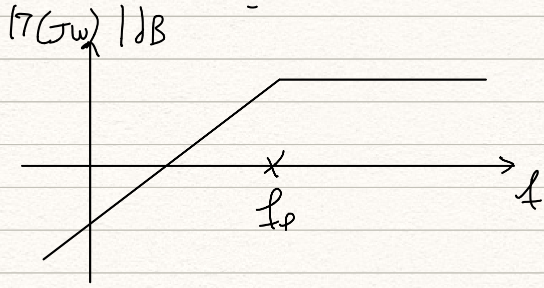
$-80\ \frac{dB}{dec}$ se fosse filtro del 4° ordine!

→ **PASSA ALTO:**



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

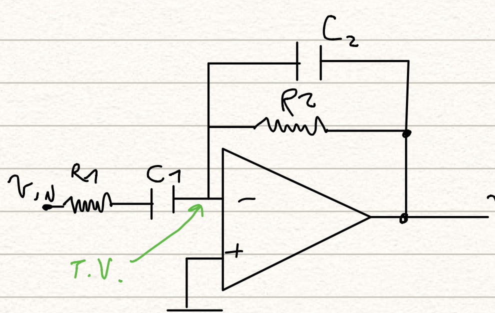
$$= -\frac{sC_1 R_2}{1 + sC_1 R_1}$$

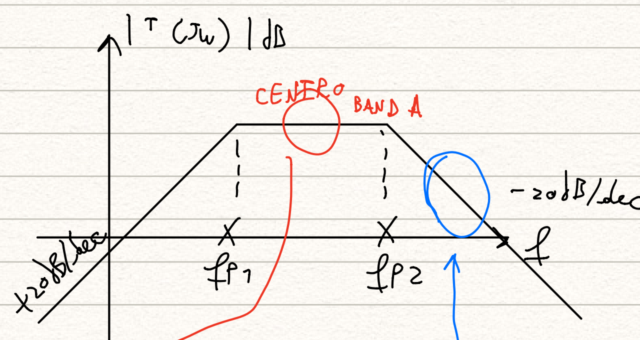


- $\tau_p = C_1 R_1$
- zero nell'origine

$f_p = 1/2\pi\tau_p$

→ **PASSA BANDA:**





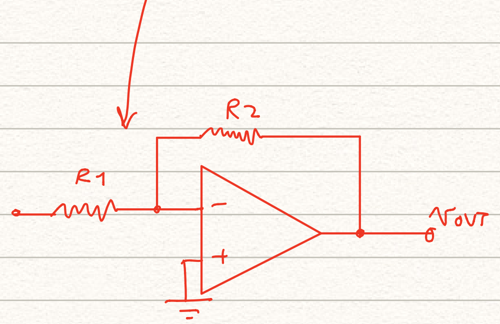
ALTA FREQUENZA
$s \to \infty$ $|T(j\omega)| \to 0$

$$f_{P1} = \frac{1}{2\pi\tau_{P1}}$$

$$f_{P2} = \frac{1}{2\pi\tau_{P2}}$$

$C_1 \begin{cases} \tau_{P1} = C_1 R_1 \\ \text{zero nell'origine} \end{cases}$

$C_2 \begin{cases} \tau_{P2} = C_2 R_2 \end{cases}$

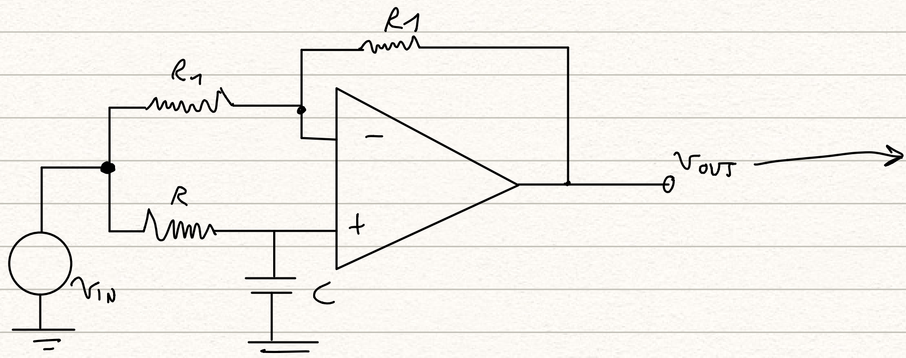


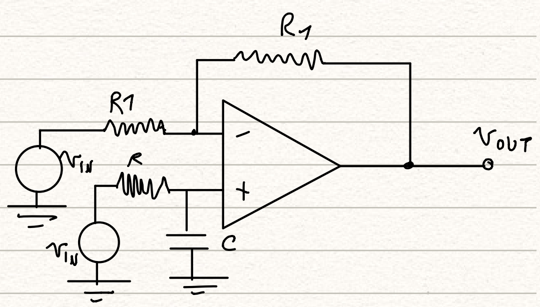
$$Z_1 = R_1 + \frac{1}{sC_1}$$

$$Z_2(s) = \frac{R_2}{1+sC_2R_2}$$

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

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





applico princ. sovrapp. effetti

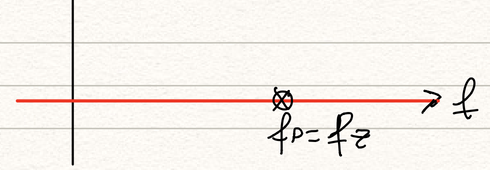
$$V_{OUT} = \frac{1/sC}{R + 1/sC} \cdot \left(1 + \frac{R_1}{R_1}\right) V_{IN} - \underbrace{\frac{R_1}{R_1}}_{1} V_{IN}$$

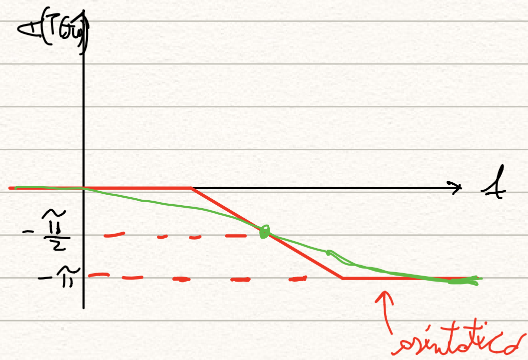
$$T(s) = \frac{1/sC}{R + 1/sC} \qquad 2-1 = 2\,\frac{1}{1+sCR} - 1 = \frac{2-1-sCR}{1+sCR} = \frac{1-sCR}{1+sCR}$$

* POLO $\quad s_P = -1/RC \quad \tau_P = RC$ (sx)
* ZERO $\quad s_Z = +1/RC \quad \tau_Z = RC$ (dx)

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

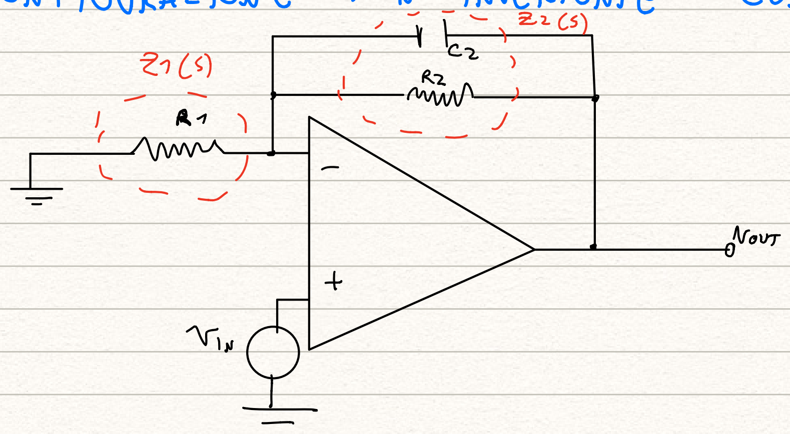
$\uparrow |T(j\omega)|_{dB}$





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



$$Z_2(s) = \frac{R_2}{1+sC_2R_2}$$

$$Z_1 = R_1$$

$$T(s) = 1 + \frac{Z_2(s)}{Z_1(s)} = 1 + \frac{\frac{R_2}{1+sC_2R_2}}{R_1} = 1 + \frac{R_2}{R_1(1+sC_2R_2)} =$$

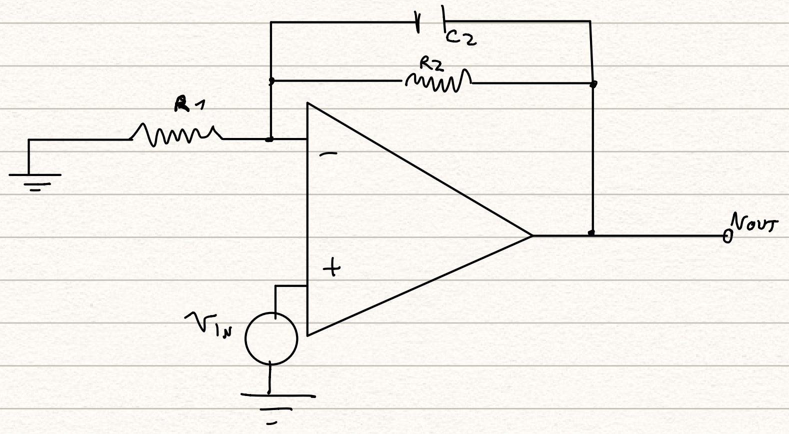
$$= \frac{R_1 + sC_2R_2R_1 + R_2}{R_1(1+sC_2R_2)} = \frac{(R_1+R_2)}{R_1} \; \frac{1 + sC_2 \frac{R_2R_1}{R_1+R_2}}{1+sC_2R_2} = \left(1 + \frac{R_2}{R_1}\right) \frac{1+sC_2(R_1//R_2)}{1+sC_2R_2}$$

$R_1//R_2$

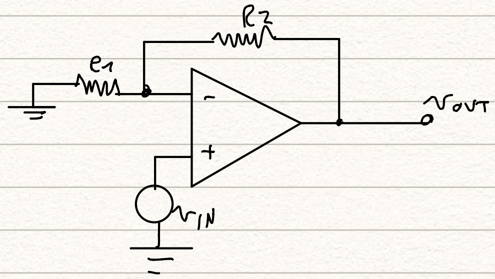
GUADAGNO IN CONTINUA $T(0)$

ZERO $\tau_Z = C_2(R_1//R_2)$

POLO $\tau_P = C_2R_2$

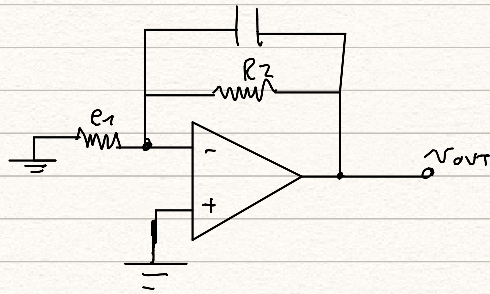


• guadagno in continua ($f=0 \rightarrow$ capacità circuiti aperti)



$T(0) = 1 + \frac{R_2}{R_1}$

• polo $\tau_p = C_2 R_2$



• ZERO?

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

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

$Z_{eq}(s) = 0$ dove $Z_{eq}(s) = R_1 + \frac{R_2}{1+sC_2R_2}$

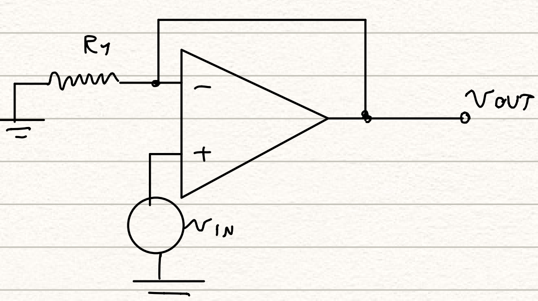
$Z_{eq}(s) = R_1 + \frac{R_2}{1+sC_2R_2} = R_1 + sC_1R_2R_1 + R_2 = (R_1+R_2)\left[\frac{1+sC_2R_1R_2}{R_1+R_2}\right] =$

$= (R_1+R_2)\left[1 + sC_2(R_1//R_2)\right]$

$s_z = -\frac{1}{C_2(R_1//R_2)}$

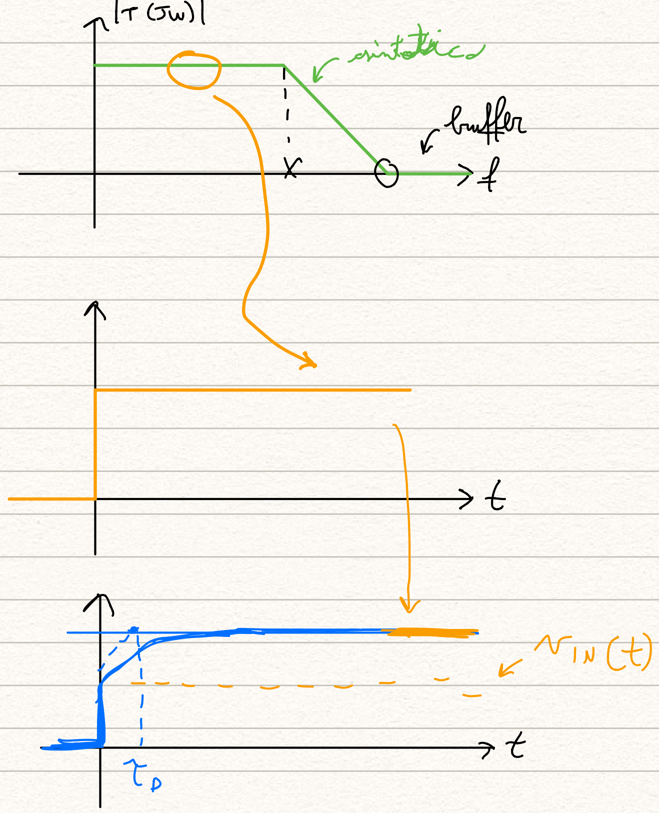
$\tau_z = C_2(R_1//R_2)$

in alta freq. C_2 è assimilabile a un corto circuito



È UN BUFFER

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



$$\tau_P = C_2 R_2$$
$$\tau_Z = C_2 \; R_1 // R_2$$
$$\tau_Z < \tau_P$$
$$\downarrow$$
$$f_Z > f_P$$