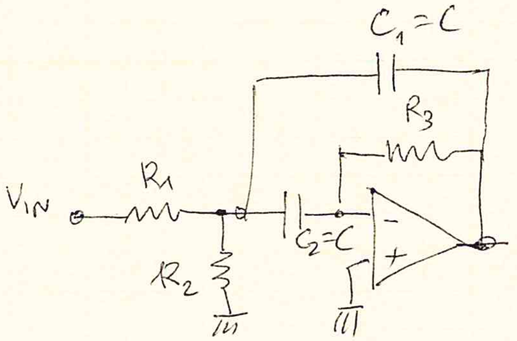
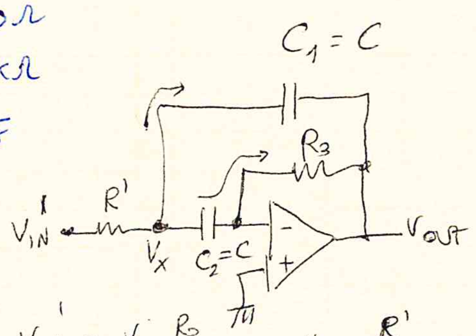
Passa bande

$R_1 = 2.7\,k\Omega$
$R_2 = 120\,\Omega$
$R_3 = 47\,k\Omega$
$C = 10\,nF$



V_{out} $=$



$$V_{IN}' = V_{IN}\frac{R_2}{R_1+R_2} = V_{IN}\frac{R'}{R_1}$$

$$R' = R_1 /\!/ R_2 = \frac{R_1R_2}{R_1+R_2}$$

$V_- = V_+ = 0$

- $I(R_3) = -\frac{V_{OUT}}{R_3} = I(C_2) = V_x \cdot sC$ $\qquad V_x = -\frac{V_{OUT}}{sCR_3}$
- $I(R') = \frac{V_{IN}' - V_x}{R'} = I(C_1) + I(C_2) = -(V_{OUT} - V_x)sC + V_x sC$

$$\frac{V_{IN}'}{R'} = \frac{V_{IN}}{R_1} = \frac{V_x}{R'} + 2V_x sC - V_{OUT}sC = -V_{OUT}\left[+\frac{1}{sCR_3R'} + \frac{2}{R_3} + sC\right]$$

$$= -V_{OUT}\left[\frac{1 + 2sCR' + s^2C^2R'R_3}{sCR_3R'}\right]$$

$$V_{OUT} = -\frac{V_{IN}}{R_1}\cdot\frac{sCR_3R'}{1 + 2sCR' + s^2C^2R'R_3} =$$

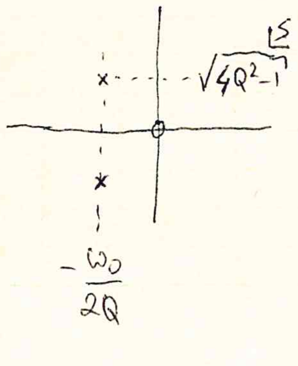
$$\omega_0^2 = \frac{1}{C^2R'R_3}$$

$$\frac{\omega_0}{Q} = \frac{2}{R_3C} = \Delta\omega$$

$$= -\frac{V_{IN}}{R_1C}\cdot\frac{s}{s^2 + \frac{2}{R_3C}s + \frac{1}{C^2R'R_3}} = -\frac{V_{IN}}{R_1C}\,\frac{s}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

$$\Delta = \frac{\omega_0^2}{Q^2} - 4\omega_0^2 = \frac{4}{R_3^2C^2} - \frac{4}{C^2R_3R'} = \frac{4}{R_3C^2}\left[\frac{1}{R_3} - \frac{1}{R'}\right] < 0 \text{ per } Q > 1/2$$

poli $\quad s = -\frac{\omega_0}{2Q}\left[1 \pm \sqrt{1-4Q^2}\right] = -\frac{\omega_0}{2Q}\left[1 \pm j\sqrt{4Q^2-1}\right] = -\omega_R \pm j\omega_I$



$$|g(\omega)|^2 = \left(\frac{1}{R_1C}\right)^2\frac{\omega^2}{(\omega^2-\omega_0^2)^2 + \frac{\omega_0^2\omega^2}{Q^2}}$$

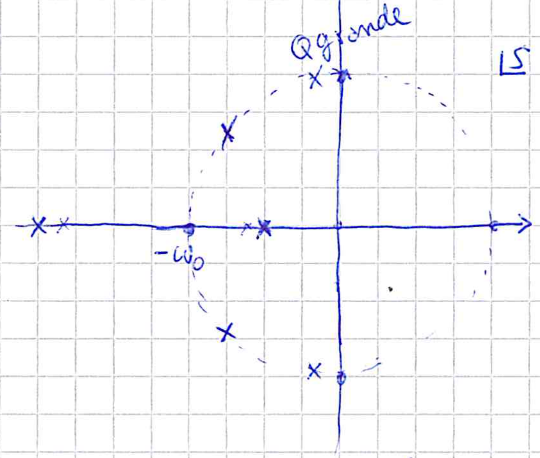
$s = j\omega$

$=$

Denominatore

$$s^2 + \frac{\omega_0}{Q} s + \omega_0^2 = (s - s_1)(s - s_2)$$

$$\Delta^2 = \omega_0^2 \left(\frac{1}{Q^2} - 4 \right) \qquad Q < \frac{1}{2} \rightarrow \text{soluzioni reali}$$



per $Q = \frac{1}{2}$ $\quad s = -\omega_0$

$Q > \frac{1}{2} \rightarrow$ soluzioni complesse

$$\begin{cases} s_1 \cdot s_2 = \omega_0^2 \\ (s_1 + s_2)^* = -\dfrac{\omega_0}{Q} \end{cases}$$

$Q < 1/2$ $\qquad s_{1,2} = -\omega_0 \left(\frac{1}{2Q} \pm \sqrt{\frac{1}{4Q^2} - 1} \right) = -\frac{\omega_0}{2Q} \left(1 \pm \sqrt{1 - 4Q^2} \right)$

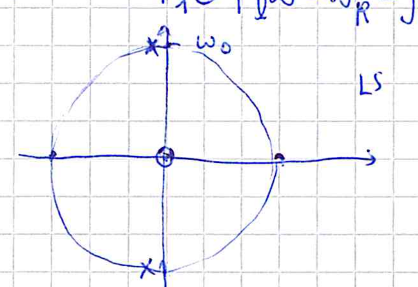
$Q > 1/2$ $\qquad s_1 = s_2^* \qquad s_1 s_2^* = |s_1|^2 = \omega_0^2$

$$s_{1,2} = -\omega_R \pm j\omega_I = -\frac{\omega_0}{2Q} \left(1 \pm j\sqrt{4Q^2 - 1} \right)$$

$$\omega_R = -\frac{\omega_0}{2Q} \qquad \omega_I = \frac{\omega_0}{2Q}\sqrt{4Q^2 - 1}$$

Guardiamo se $Q \gg 1$

$$|g(\omega)| = \frac{1}{R_1 C} \left| \frac{j\omega}{(j\omega - \omega_R - j\omega_I)(j\omega - \omega_R + j\omega_I)} \right| = \frac{1}{R_1 C} \frac{\omega}{|j(\omega - \omega_I) - \omega_R|\,|j(\omega + \omega_I) - \omega_R|}$$



$$\omega_R = -\frac{\omega_0}{2Q} = -\frac{\Delta\omega}{2}$$

$$\omega_I = \frac{\omega_0}{2Q}\sqrt{4Q^2 - 1} \simeq \omega_0$$

Se $\omega \approx \omega_0$ $\qquad |g(\omega)| \approx \frac{1}{R_1 C} \frac{\omega_0}{\left[(\omega - \omega_0)^2 + (\Delta\omega/2)^2\right]^{1/2} \cdot \left[(\omega + \omega_0)^2 + \left(\frac{\Delta\omega}{2}\right)^2\right]^{1/2}}$

$$= \frac{1}{R_1 C} \frac{\omega_0}{2\omega_0 \cdot \frac{\Delta\omega}{2}} \cdot \frac{1}{\left[1 + \left[\frac{\omega - \omega_0}{(\Delta\omega/2)}\right]^2\right]^{1/2}}$$

$=$

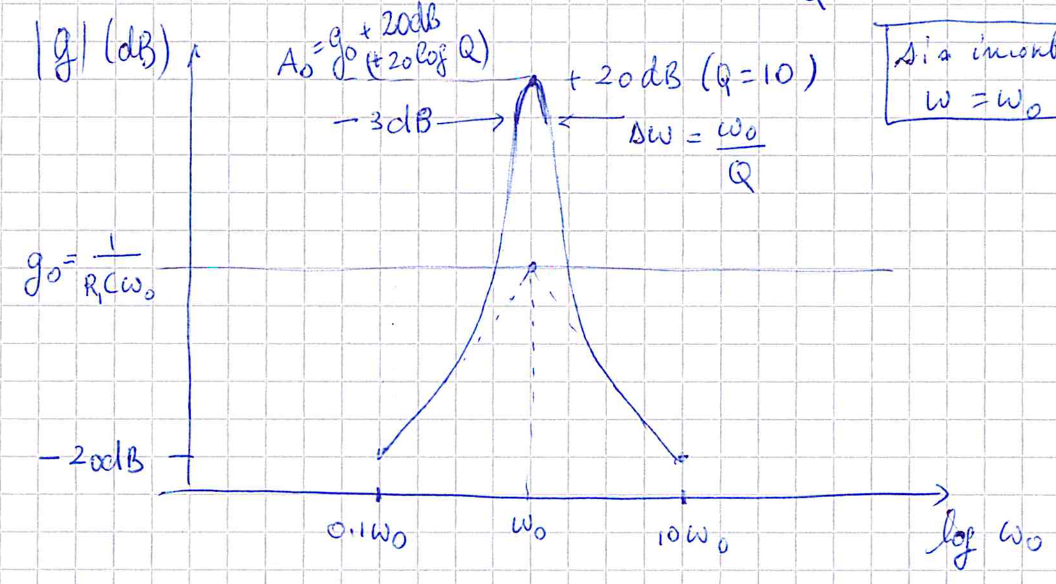
per $\omega \approx \omega_0$ $\quad |g(\omega)| = \dfrac{1}{R_1 C \Delta\omega} \dfrac{1}{\sqrt{1+\left(\frac{\omega-\omega_0}{\Delta\omega/2}\right)^2}}$

frequenze a $-3dB$ $\quad \omega = \omega_0 \pm \Delta\omega/2$

per $\omega >> \omega_0$ $\quad |g(\omega)| \cong \dfrac{1}{R_1 C} \sqrt{\dfrac{\omega^2}{\omega^4 - \frac{\omega_0 \omega^2}{Q^2}}} \cong \dfrac{1}{R_1 C \omega}$

per $\omega << \omega_0$ $\quad |g(\omega)| \cong \dfrac{1}{R_1 C} \sqrt{\dfrac{\omega^2}{\omega_0^4 - \frac{\omega_0^2 \omega^2}{Q^2}}} \cong \dfrac{\omega}{R_1 C \omega_0^2}$

$\boxed{\text{Si incontrano in } \omega = \omega_0}$



$A_0 = \dfrac{1}{R_1 C \Delta\omega} = \dfrac{Q}{g_0}$ aumenta guadagno $\quad \Delta\omega = \dfrac{\omega_0}{Q}$ ← riduce banda

$A_0 = \dfrac{1}{R_1 C \cdot \frac{2}{R_3 C}} = \dfrac{R_3}{2 R_1}$; $\quad \omega_0 = \dfrac{1}{C}\sqrt{\dfrac{1}{R' R_3}}$

$Q = \dfrac{\omega_0}{\Delta\omega} = \dfrac{1}{C}\sqrt{\dfrac{1}{R' R_3}} \cdot \dfrac{R_3 C}{2} = \dfrac{1}{2}\sqrt{\dfrac{R_3}{R'}}$

BANDA EQUIVALENTE DI RUMORE $\quad \Delta f = \dfrac{\Delta\omega}{2\pi}$

$$ENB = \frac{1}{|g_0|^2}\int_0^\infty |g(f)|^2 df = \int \frac{df}{\left[1+\left(\frac{f-f_0}{\Delta f/2}\right)^2\right]} \cong \frac{\Delta f}{2}\int_{-\infty}^{+\infty} \frac{dx}{(1+x^2)} =$$

$$= \frac{\Delta f}{2} \operatorname{arctg}(x)\Big|_{-\infty}^{+\infty} = \frac{\pi}{2}\Delta f$$