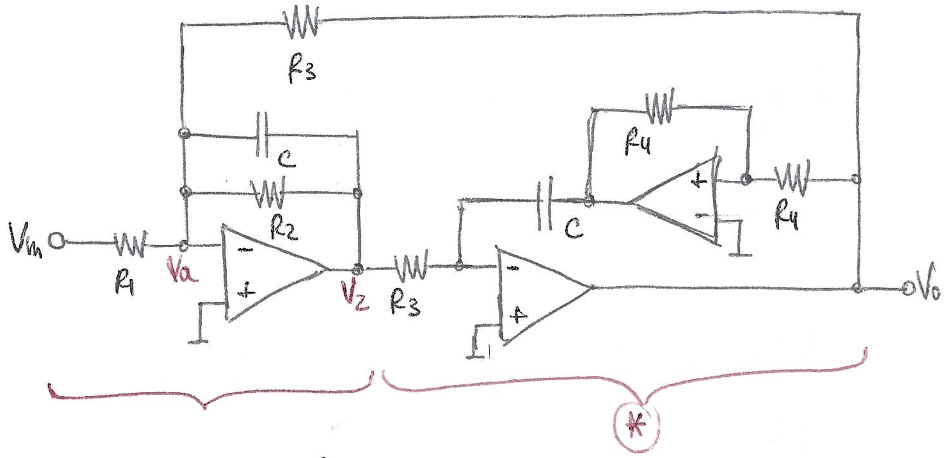
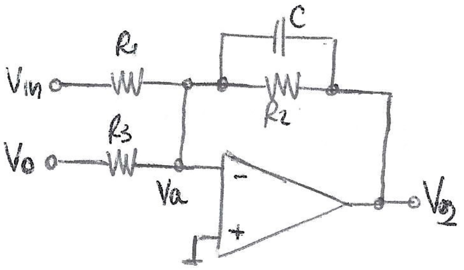
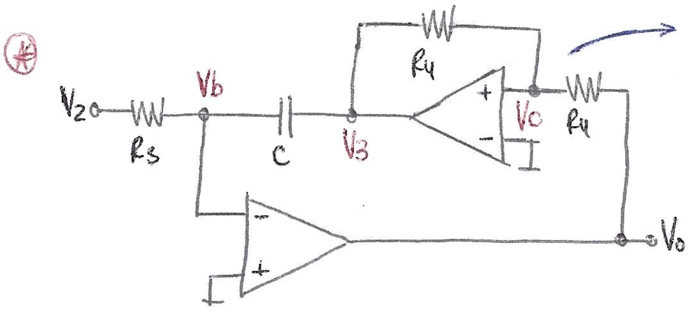



$$V_a(G_1+G_3+G_2+\$C)=V_{in}G_1+V_0G_3+V_2(G_2+\$C)$$ $V_a=0$ por T.V. (sólo realim. neg.)

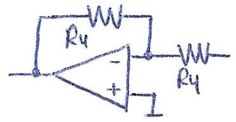
$$\hookrightarrow V_2(G_2+\$C)=-V_{in}\cdot G_1-V_0\cdot G_3$$

$$\left\{V_2=-V_{in}\cdot\frac{G_1}{G_2+\$C}-V_0\cdot\frac{G_3}{G_2+\$C}\right\}$$




→ Este opamp tiene realim. 100% positiva ⇒ es inestable

⇒ Invierto el orden de las entradas




$V_b=0 \wedge V_c=0$ por T.V.

$$\cancel{V_b}(G_3+\$C)-V_2G_3-V_3\$C=0 \rightarrow V_2G_3=-V_3\$C \rightarrow \{V_3=-V_2G_3/\$C\}$$

$$\cancel{V_c}\cdot 2G_4-V_3G_4-V_0G_4=0 \rightarrow V_0\cancel{G_4}=-V_3\cancel{G_4} \rightarrow \{V_0=V_2G_3/\$C\}$$

⇒ Combinando la transferencia de ambas etapas:

$$V_0=V_2\cdot\frac{G_3}{\$C}=\frac{G_3}{\$C}\left\{-V_{in}\cdot\frac{G_1}{G_2+\$C}-V_0\frac{G_3}{G_2+\$C}\right\}\longrightarrow V_0\left\{\frac{\$C}{G_3}+\frac{G_3}{G_2+\$C}\right\}=-V_{in}\cdot\frac{G_1}{G_2+\$C}$$

$$V_0\left\{\$C(G_2+\$C)+G_3^2\right\}=-V_{in}\cdot G_1G_3 \Rightarrow \left\{T(\$)=\frac{V_0}{V_i}=-\frac{G_1G_3}{\$C(G_2+\$C)+G_3^2}=\frac{-G_1G_3}{(\$C)^2+\$CG_2+G_3^2}\right\}$$

$$T(\$)=\frac{-G_1G_3/C^2}{\$^2+\$\frac{G_2}{C}+\left(\frac{G_3}{C}\right)^2}=-\frac{G_1}{G_3}\cdot\frac{(G_3/C)^2}{\$^2+\$\frac{G_2}{C}+\left(\frac{G_3}{C}\right)^2}=K\cdot\frac{\omega_0^2}{\$^2+\$\frac{\omega_0}{Q}+\omega_0^2}$$

$$\left\{\omega_0=\frac{G_3}{C} \qquad \frac{\omega_0}{Q}=\frac{G_2}{C}\rightarrow Q=\omega_0\cdot\frac{C}{G_2}=\frac{G_3}{C}\cdot\frac{C}{G_2}=\frac{G_3}{G_2} \qquad K=-\frac{G_1}{G_3}\right\}$$

$$T(\$) = k \cdot \frac{\omega_0^2}{\$^2 + \$\frac{\omega_0}{Q} + \omega_0^2} \quad \text{con} \left\{ \omega_0 = \frac{G_3}{C} \quad Q = \frac{G_3}{G_2} \quad k = -\frac{G_1}{G_3} \right\}$$

Todos los parámetros dependen de $\overset{R}{\cancel{G}}_3$ → fijo $\overset{R}{\cancel{G}}_3$ a 1 y modifico C para ajustar $\omega_0$, $R\cancel{G}_2$ para Q y $\overset{R}{\cancel{G}}_1$ para k.
$R\cancel{G}_4$ no afecta a la transferencia → también lo fijo a 1

Para lograr $\{\omega_0 = 1 \ ; \ Q = 3\} \to 1 = \frac{\overset{1}{\cancel{R_3}}}{CR_3} \to C = \frac{\cancel{R_3}}{1/R_3} = 1 \qquad 3 = \frac{R_2}{R_3} \to R_2 = 3R_3 = 3$

↳ $\{R_1 = 1 \ ; \ R_2 = 3 \ ; \ R_3 = 1 \ ; \ R_4 = 1 \ ; \ C = 1\}$

↳ Para mantener $|T(0)| = 1$

Para lograr $|T(0)|_{dB} = 20dB \to 20 = 20\log\left|-\frac{R_3}{R_1}\right| \to 1 = \log\left(\frac{R_3}{R_1}\right) \to \frac{\overset{1}{R_3}}{R_1} = 10 \to R_1 = \frac{1}{10} = 0{,}1$

↳ $\{R_1 = 0{,}1 \ ; \ R_2 = 3 \ ; \ R_3 = 1 \ ; \ R_4 = 1 , \ C = 1\}$

Normalización $\Omega_z$ → elijo $R_3$ ya que ~~afecta~~ está directamente relacionada a todos los parámetros

$$\Omega_\omega = \omega_0 = \frac{1}{CR_3}$$

$\Rightarrow \{R_3 = \Omega_z \ ; \ R_4 = \Omega_z\}$ → elijo arbitrariamente.

$K = -\frac{R_3}{R_1} \to \left\{R_1 = -\frac{R_3}{K} = \frac{\Omega_z}{(-K)}\right\} \qquad Q = \frac{R_2}{R_3} \to \{R_2 = QR_3 = Q \cdot \Omega_z\} \qquad \omega_0 = \frac{1}{CR_3} \to \left\{C = \frac{1}{\omega_0 R_3} = \frac{1}{\Omega_\omega \Omega_z}\right\}$

Sensibilidad $\left\{S^{\omega_0}_C = \frac{C}{\omega_0} \cdot \frac{\partial \omega_0}{\partial C} = \frac{C}{\omega_0}\left[-\frac{1}{C^2 R_3}\right] = -\frac{1}{\omega_0 C R_3} = -1\right\}$

$\left\{S^Q_{R_2} = \frac{R_2}{Q} \cdot \frac{\partial Q}{\partial R_2} = \frac{R_2}{Q} \cdot \frac{1}{R_3} = 1\right\} \qquad \left\{S^Q_{R_3} = \frac{R_3}{Q} \cdot \frac{\partial Q}{\partial R_3} = \frac{R_3}{Q}\left[-\frac{R_2}{R_3^2}\right] = -\frac{R_2}{QR_3} = -1\right\}$

Butterworth Dado que se trata de una transf. de orden 2, debe contar con 2 polos comp. conjugados, con apertura $\psi = \frac{\pi}{2n} = \frac{\pi}{4}$ respecto del eje $\sigma$

$$2\cos\psi = \frac{1}{Q} \to \cancel{2} \cdot \frac{\sqrt{2}}{\cancel{2}} = \frac{R_3}{R_2} \to \{R_2 = R_3\sqrt{2}\}$$

Transf. P.Banda → Según Schaumann. 4.6, tomo ~~la~~ como salida la tensión que denominé $V_2$
Calculo la transf. como $T_{BP} = V_2/V_i$

$\left\{V_2 = -V_i \cdot \frac{G_1}{G_2 + \$C} - V_0 \frac{G_3}{G_2 + \$C}\right\} \to V_0 \frac{G_3}{G_2 + \$C} = -V_i \frac{G_1}{G_2 + \$C} - V_2 \to V_0 = -V_i \cdot \frac{G_1}{G_3} - V_2 \cdot \frac{(G_2 + \$C)}{G_3}$

$\left\{V_0 = V_2 \cdot \frac{G_3}{\$C}\right\} \to V_2 \frac{G_3}{\$C} = -V_i \frac{G_1}{G_3} - V_2 \frac{(G_2 + \$C)}{G_3} \to V_2\left(\frac{G_3}{\$C} + \frac{G_2 + \$C}{G_3}\right) = -V_i \frac{G_1}{G_3} \to V_2\left(G_3^2 + \$C(G_2 + \$C)\right) = -V_i G_1 \$C$

Se mantienen $\omega_0$ y Q, cambia k

$$\left\{T_{BP}(\$) = \frac{V_2}{V_i} = -\frac{\$CG_1}{(\$C)^2 + \$CG_2 + G_3^2} = \frac{-\$G_1/C}{\$^2 + \$G_2/C + (G_3/C)^2} = -\frac{G_1}{G_2} \cdot \frac{\$G_2/C}{\$^2 + \$G_2/C + (G_3/C)^2}\right\} \to \left\{\omega_0 = \frac{G_3}{C} \quad Q = \frac{G_3}{G_2} \quad k = -\frac{G_1}{G_2}\right\}$$