1) Si me pide $D(\omega=0)=1$ seg pasabajo

con Bessel

$$\bullet \text{ si } n=2 \rightarrow \frac{\cosh(s)}{\operatorname{senh}(s)} = \frac{1}{s} + \frac{1}{\underbrace{\frac{3}{s}+0}_{\frac{s}{3}}} = \frac{s^2+3}{3.s}$$

$s^2+3 \rightarrow \cosh(s)$

$3.s \rightarrow \operatorname{senh}(s)$

$$\text{si } T(s) = \frac{1}{\cosh(s)+\operatorname{senh}(s)} \rightarrow T(s) = \frac{1}{s^2+3+s.3}$$

$$T(s) = \frac{1}{s^2+3s+3}$$

$s^2+3s+3 = B(s)$

~~para normalizar $|T(0)|=1$~~

$-\omega^2 + j\omega 3 + 3$

$(3-\omega^2)+j\omega.3$

$$\text{si } \boxed{\measuredangle T(\omega) = -\operatorname{arctg}\left(\frac{3\omega}{3-\omega^2}\right)}$$

$$D(\omega) = -\frac{\partial \measuredangle T(\omega)}{\partial \omega} = \frac{\partial \operatorname{arctg}\left(\frac{3\omega}{3-\omega^2}\right)}{\partial \omega} \rightarrow \text{si } \boxed{\operatorname{arctg}(x)' = \frac{1}{1+x^2} \cdot x'}$$

$$\left(\frac{3\omega}{3-\omega^2}\right)' = \frac{3(\omega)'.(3-\omega^2) - (3\omega).(3-\omega^2)'}{(3-\omega^2)^2} = \frac{\overbrace{3.(3-\omega^2)}^{9-3\omega^2} \pm \overbrace{(\omega 3).(-2\omega)}^{6\omega^2}}{(3-\omega^2)^2}$$

$$\rightarrow = \boxed{\frac{9+3\omega^2}{(3-\omega^2)^2}}$$

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$$\boxed{D(\omega) = \frac{1}{1+\frac{(3\omega)^2}{(3-\omega^2)^2}} \cdot \frac{9+3\omega^2}{(3-\omega^2)^2}}$$ → para $n=2$

$\therefore \boxed{D(0)=1}$ → ya está normalizado para $D(\omega=0)=1$ ✓

$$\therefore \boxed{T(s) = \frac{3}{s^2+s.3+3}}$$ → lo pongo para tener $|T(0)|=1$, no influye en $D(\omega)$

• si $n=3$ → $\frac{\cosh(s)}{\sinh(s)} = \frac{1}{s} + \cfrac{1}{\frac{3}{s}+\cfrac{1}{\frac{5}{s}+0}}$ → $\frac{3}{s}+\frac{s}{5} = \frac{15+s^2}{s.5}$

$\frac{5}{s}+0 = \frac{5}{s}$

$$= \frac{1}{s} + \frac{s.5}{15+s^2} = \frac{15+s^2+s^2 5}{s.15+s^3} = \frac{s^2.6+15}{s^3+s.15}$$ → $\cosh(s)$ / → $\sinh(s)$

si $T(s) = \frac{1}{\cosh(s)+\sinh(s)}$ → $T(s) = \frac{1}{s^2.6+15+s^3+s.15}$

$$\boxed{T(s) = \frac{1.15}{s^3+s^2.6+s.15+15}}$$

$$T(j\omega) = \frac{1}{-j\omega^3-\omega^2.6+j\omega.15+15} = \frac{1}{(15-\omega^2.6)+j.(\omega.15-\omega^3)}$$

$$\boxed{\measuredangle T(\omega) = -\operatorname{arctg}\left(\frac{\omega.15-\omega^3}{15-\omega^2.6}\right)}$$

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si $\operatorname{artg}(x)' = \frac{1}{1+x^2} \cdot x'$

$D(w) = -\frac{\delta \measuredangle T(w)}{\delta w} \to \left(\frac{w.15 - w^3}{15 - w^2.6}\right)' = \frac{(w.15-w^3)'.(15-w^2.6) - (w.15-w^3).(15-w^2.6)'}{(15-w^2.6)^2}$

$= \frac{(15-3w^2).(15-w^2.6) - (w.15-w^3).(-12.w)}{(15-w^2.6)^2}$

$$\boxed{D(w) = \left[\frac{1}{1+\left(\frac{w.15-w^3}{15-w^2.6}\right)^2}\right] \cdot \frac{(15-3w^2).(15-w^2.6)-(w.15-w^3).(-12.w)}{(15-w^2.6)^2}}$$

si $\boxed{D(w=0) = 1}$ ✓ para $n=3$

• si $n=4 \to \frac{\cosh(s)}{\operatorname{senh}(s)} = \frac{1}{s} + \cfrac{1}{\cfrac{3}{s} + \cfrac{1}{\cfrac{5}{s} + \cfrac{1}{\cfrac{7}{s}+0}}}$

$\frac{7}{s}+0 \Rightarrow \frac{s}{7}$

$\to \left(\frac{5}{s} + \frac{s}{7}\right)^{-1} = \left(\frac{35+s^2}{s.7}\right)^{-1} = \frac{s.7}{s^2+35}$

$\to \left(\frac{3}{s} + \frac{s.7}{s^2+35}\right)^{-1} = \left(\frac{s^2.3+105+s^2.7}{s^3+s.35}\right)^{-1}$

$\frac{s^3+s.35}{s^2.10+105}$

$= \frac{1}{s} + \frac{s^3+s.35}{s^2.10+105} = \frac{(s^2.10+105)+(s^4+s^2.35)}{s^3 10+s.105} = \frac{s^4+s^2.45+105}{s^3.10+s.105}$

$\cosh(s)$: $s^4+s^2.45+105$

$\operatorname{senh}(s)$: $s^3.10+s.105$

si $T(s) = \frac{1}{\cosh(s)+\operatorname{senh}(s)} = \frac{1}{(s^4+s^2.45+105)+(s^3.10+s.105)}$

$$T(s) = \frac{1 \cdot 105}{s^4 + s^3 \cdot 10 + s^2 \cdot 45 + s \cdot 105 + 105}$$

$$T(j\omega) = \frac{1}{\omega^4 - j\omega^3 \cdot 10 - \omega^2 \cdot 45 + j\omega \cdot 105 + 105}$$

$$T(\omega) = \frac{1}{(\omega^4 - \omega^2 45 + 105) + j(\omega \cdot 105 - \omega^3 10)}$$

$$\sphericalangle T(\omega) = -\operatorname{arctg}\left(\frac{\omega \cdot 105 - \omega^3 \cdot 10}{\omega^4 - \omega^2 \cdot 45 + 105}\right)$$

si $\operatorname{arctg}(x)' = \frac{1}{1+x^2} \cdot x'$

$$D(\omega) = -\frac{\partial \sphericalangle T(\omega)}{\partial \omega}$$

$$\left(\frac{\omega \cdot 105 - \omega^3 \cdot 10}{\omega^4 - \omega^2 \cdot 45 + 105}\right)' = \frac{\underbrace{(\omega \cdot 105 - \omega^3 \cdot 10)'}_{=(105 - \omega^2 \cdot 30)} \cdot (\omega^4 - \omega^2 \cdot 45 + 105) - (\omega \cdot 105 - \omega^3 \cdot 10) \cdot \underbrace{(\omega^4 - \omega^2 \cdot 45 + 105)'}_{=(4 \cdot \omega^3 - \omega \cdot 90)}}{(\omega^4 - \omega^2 \cdot 45 + 105)^2}$$

$$\boxed{D(\omega) = \left[\frac{1}{1 + \left(\frac{\omega \cdot 105 - \omega^3 \cdot 10}{\omega^4 - \omega^2 \cdot 45 + 105}\right)^2}\right] \cdot \frac{(105 - \omega^2 \cdot 30) \cdot (\omega^4 - \omega^2 \cdot 45 + 105) - (\omega \cdot 105 - \omega^3 \cdot 10) \cdot (4 \cdot \omega^3 - \omega \cdot 90)}{(\omega^4 - \omega^2 \cdot 45 + 105)^2}}$$

$n = 4$

$$\boxed{D(\omega = 0) = 1}$$ ✓

2) si $\boxed{\left|T(\omega_p)\right|\Big|_{n=2} = 0{,}832 = \cancel{} -1{,}597\,dB}$ → si para tension $V_{dB} = 20 \cdot \log_{10}(V)$

$\boxed{\left|T(\omega_p)\right|\Big|_{n=3} = 0{,}901 = \cancel{} -0{,}9\,dB}$

$\boxed{\left|T(\omega_p)\right|\Big|_{n=4} = 0{,}93 = \cancel{} -0{,}63\,dB}$ → ambos cumplen con tener menos $\alpha_{max} = 1\,dB$

elijo $n=3$ por ser el mínimo orden de cumplimiento

$$\boxed{\left|T(s)\right|\Big|_{n=3} = \frac{15}{S^3 + S^2 \cdot 6 + S \cdot 15 + 15}}$$

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3) si $\boxed{\left|D(w=2{,}5)\right|_{n=3} = 0{,}75}$

si $\boxed{\left|D(w=0)\right|_{n=3} = 1}$

y $\text{Error Porcentual respecto } D(w=0) = \left|\dfrac{D(w=2{,}5) - D(w=0)}{D(w=0)}\right| \cdot 100$

$\boxed{\text{Error Porcentual respecto } D(w=0) = 25\%}$

4) si estoy en orden $n=3$ y quiero un Sallen-Key de $K=1$

$$T(s) = \frac{15}{(s^2+a_1 . s+a_0).(s+b)}$$

$$T(s) = \frac{15}{s^3 + s^2.(a_1+b) + s.(a_0+a_1.b) + a_0.b}$$

igualo a $T(s)|_{n=3}$

$$\begin{cases} a_1 + b = 6 \\ a_0 + a_1.b = 15 \\ a_0.b = 15 \end{cases}$$

$$\boxed{a_0 = \frac{15}{b}}$$

$$\text{si } a_0 + a_1 . b = 15 \rightarrow \frac{15}{b} + a_1 . b = 15 \xrightarrow{\times b} 15 + a_1 . b^2 = 15b$$

$$a_1 = \frac{15b - 15}{b^2} \rightarrow \text{si } a_1 + b = 6 \rightarrow \boxed{a_1 = 6 - b}$$

$$(6-b) . b^2 = 15b - 15 \rightarrow 6b^2 - b^3 = 15b - 15$$

$$b^3 - 6b^2 + 15b - 15 = 0 \rightarrow \boxed{b = 2{,}32}$$

$$\boxed{a_0 = 6{,}46}$$

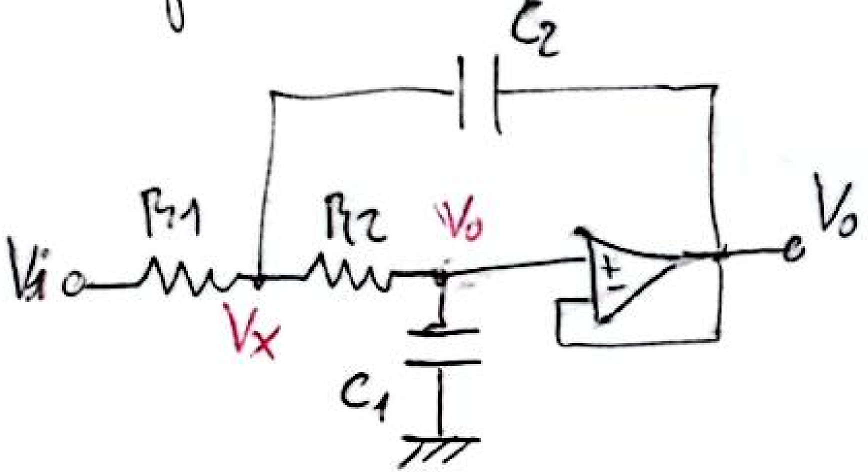
$$\boxed{a_1 = 3{,}68}$$

$$\therefore \boxed{T(s) = \frac{15}{(s^2 + s . 3{,}68 + 6{,}46) . (s + 2{,}32)}}$$

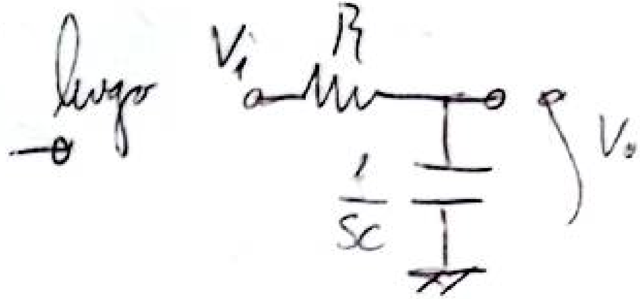
$$T(s) = \underbrace{\left(\frac{6{,}46}{s^2 + s . 3{,}68 + 6{,}46}\right)}_{\text{etapa 1}} \cdot \underbrace{\left(\frac{2{,}32}{s + 2{,}32}\right)}_{\text{etapa 2}} \rightarrow K = 1$$

en ambas

veo el Sallen Key de $K=1$



luego



$$V_x \cdot (G_1 + G_2 + sC_2) - V_i \cdot (G_1) - V_o \cdot (G_2 + sC_2) = 0$$

$$V_o = V_x \cdot \frac{\cancel{sC_1}\ \frac{1}{sC_1}}{R_2 + \frac{1}{sC_1}} \rightarrow V_o = V_x \cdot \frac{1}{s\frac{C_1}{G_2} + 1} \rightarrow \boxed{V_x = \left(s\frac{C_1}{G_2} + 1\right) \cdot V_o}$$

$$\frac{sC_1 \cdot R_2 + 1}{sC_1}$$

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$$V_0 \cdot \left(\frac{SC_1}{G_2}+1\right)\cdot\left(G_1+G_2+SC_2\right) - V_0\cdot\left(G_2+SC_2\right) = V_i\cdot(G_1)$$

$$V_0\left[\left(\frac{SC_1\cdot G_1}{G_2}+SC_1+S^2\frac{C_1C_2}{G_2}+G_1+\cancel{G_2}+\cancel{SC_2}\right)-\left(\cancel{G_2}+\cancel{SC_2}\right)\right] = V_i\cdot(G_1)$$

$$V_0\cdot\left[S^2\cdot\frac{C_1C_2}{G_2\cdot G_1}+S\cdot\left(\overset{C_1\cdot\left(\frac{G_1+G_2}{G_1\cdot G_2}\right)}{C_1\cdot\left(\frac{1}{G_1}+\frac{1}{G_2}\right)}\right)+1\right] = V_i$$

$$T(S) = \frac{V_0}{V_i} = \frac{\frac{G_2\cdot G_1}{C_1C_2}}{S^2+S\cdot\left(\frac{G_2\cdot G_1}{\cancel{C_1}\cdot C_2}\right)\cdot\cancel{C_1}\cdot\left(\frac{G_1+G_2}{G_1\cdot G_2}\right)+\frac{G_2G_1}{C_1C_2}}$$

$$\boxed{T_1(S) = \frac{\frac{G_2G_1}{C_1C_2}}{S^2+S\cdot\left(\frac{G_1+G_2}{C_2}\right)+\frac{G_1G_2}{C_1G_2}}}$$

$\leftarrow K=1$

Busco $T_2(s)$ → si $V_0 = V_i \cdot \dfrac{\frac{1}{\cancel{sC}}}{\dfrac{SCR+1}{\cancel{sC}}}$ → $\dfrac{V_0}{V_i} = T_2(s) = \dfrac{1}{SCR+1}$

$R + \dfrac{1}{sC}$

$$\boxed{T_2(s) = \frac{\frac{1}{CR}}{s + \frac{1}{CR}}}$$

veo la etapa 2 y la igualo

$\dfrac{1}{CR} = 2{,}32$ → $C = \dfrac{1}{2{,}32} \cdot \dfrac{1}{R}$ → si $\boxed{\Omega_Z = \dfrac{1}{R}}$ → $\boxed{R' = 1}$

$\boxed{C' = \dfrac{1}{2{,}32}}$

veo la etapa 1 y la igualo

$$6{,}46 = \frac{1}{R_1 R_2 C_1 C_2} = \omega_0^2$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{1}{C_2} = 3{,}68 = \frac{\omega_0}{Q}$$

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Si $R_2 = R_1 \rightarrow$ y $R_1 = R_2 \rightarrow \boxed{R_1' = R_2' = 1}$

~~$6{,}46 = \ldots$~~

$6{,}46 = \dfrac{1}{C_1 C_2} \rightarrow \boxed{C_1 = 0{,}2853}$

$\dfrac{2}{C_2} = 3{,}68 \rightarrow \boxed{C_2' = 0{,}5433}$