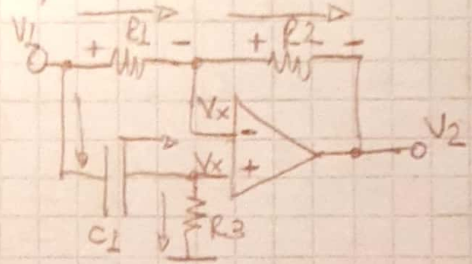
Trabajo semanal 1:



1) F. Trans. V_2/V_1 (Módulo, Fase, diagrama polos y ceros)
2) Norma de impedancia y frecuencia para llegar a transferencia normalizada.
3) Simule en Python
4) Simule la red normalizada en LTspice y obtenga respuesta en frecuencia
5) ¿Qué tipo de filtro es? ¿Qué utilidad podría tener este tipo de circuitos?

1) $\dfrac{V_1 - V_x}{R_1} = \dfrac{V_x - V_2}{R_2}$;

$V_x = V_{R3} = i_{R3} \cdot R_3$; $i_{R3} = \dfrac{V_1}{R_T} = \dfrac{V_1}{R_3 + \frac{1}{sC}} = \dfrac{V_1}{\frac{sCR_3+1}{sC}}$

$\Rightarrow i_{R3} = V_1 \cdot \dfrac{sC}{sCR_3+1}$

$V_x = i_{R3} \cdot R_3 = V_1 \cdot \dfrac{sC}{sCR_3+1} \cdot R_3$

$\Rightarrow \dfrac{V_1}{R_1} - \dfrac{V_x}{R_1} = \dfrac{V_x}{R_2} - \dfrac{V_2}{R_2}$;

$\dfrac{V_1}{R_1} = \dfrac{V_x}{R_2} + \dfrac{V_x}{R_1} - \dfrac{V_2}{R_2}$;

$\dfrac{V_1}{R_1} = V_x \left(\dfrac{1}{R_2} + \dfrac{1}{R_1}\right) - \dfrac{V_2}{R_2}$;

$\dfrac{V_1}{R_1} = \dfrac{V_1 \cdot sCR_3}{sCR_3+1} \cdot \left(\dfrac{R_1+R_2}{R_2R_1}\right) - \dfrac{V_2}{R_2}$;

$V_1 \left(\dfrac{1}{R_1} - \dfrac{sCR_3}{sCR_3+1} \cdot \dfrac{R_1+R_2}{R_2R_1}\right) = -\dfrac{V_2}{R_2}$;

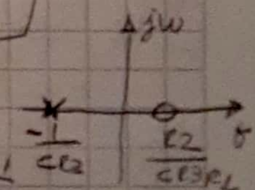
$-R_2 \cdot \left(\dfrac{1}{R_1} - \dfrac{sCR_3}{sCR_3+1} \cdot \dfrac{R_1+R_2}{R_2 \cdot R_1}\right) = \dfrac{V_2}{V_1} = -\dfrac{R_2}{R_1} + \dfrac{sCR_3\cancel{R_2} \cdot (R_2+R_1)}{(sCR_3+1) \cdot \cancel{R_2} \cdot R_1}$;

$\dfrac{V_2}{V_1} = \dfrac{sCR_3\cancel{R_2} \cdot (R_2+R_1) - R_2 \cdot (sCR_3+1)}{R_1 \cdot \cancel{R_2} \cdot (sCR_3+1)} = \dfrac{\cancel{sCR_3R_2} + sCR_3R_1 - \cancel{sCR_3R_2} - R_2}{sCR_3R_1 + R_1}$;

$\dfrac{V_2}{V_1} = \dfrac{sCR_3R_1 - R_2}{sCR_3R_1 + R_1} = \dfrac{(s - R_2/CR_3R_1) \cdot \cancel{CR_3R_1}}{(s + R_1/CR_3R_1) \cdot \cancel{CR_3R_1}} = \boxed{\dfrac{s - \frac{R_2}{C \cdot R_3 \cdot R_1}}{s + \frac{1}{CR_3}}} = H(s)$

Si: $R_2 = R_1$

$\Rightarrow \dfrac{s - \frac{1}{CR_3} \cdot \frac{R_2}{R_1}}{s + \frac{1}{CR_3}} = \dfrac{s - \frac{1}{CR_3}}{s + \frac{1}{CR_3}}$ = PASA TODO? CAMBIA FASE?



$H(\omega) = H(s)\big|_{s=j\omega} \Rightarrow \left[H(\omega) = \dfrac{j\omega - \frac{1}{CR_3} \cdot \frac{R_2}{R_1}}{j\omega + \frac{1}{CR_3}}\right.$; $\Rightarrow$ * otra página

$H(\omega) = \dfrac{\left(j\omega - \frac{1}{CR_3} \cdot \frac{R_2}{R_1}\right)}{\left(j\omega + \frac{1}{CR_3}\right)} \cdot \dfrac{\left(-j\omega + \frac{1}{CR_3}\right)}{\left(-j\omega + \frac{1}{CR_3}\right)} = \dfrac{\omega^2 + \frac{j\omega}{CR_3} + \frac{j\omega}{CR_3}\frac{R_2}{R_1} - \left(\frac{1}{CR_3}\right)^2 \frac{R_2}{R_1}}{\omega^2 + \cancel{\frac{j\omega}{CR_3}} - \cancel{\frac{j\omega}{CR_3}} + \left(\frac{1}{CR_3}\right)^2}$;

si $\dfrac{1}{CR_3} = \omega_p \Rightarrow \left[H(\omega) = \dfrac{\omega^2 + j\omega\left(\frac{1}{CR_3} + \frac{1}{CR_3} \cdot \frac{R_2}{R_1}\right) - \omega_p^2 \cdot \frac{R_2}{R_1}}{\omega^2 + \omega_p^2}\right]$; $\Rightarrow H(\omega) = |H(\omega)| \cdot e^{j\theta(\omega)}$

$\Rightarrow \boxed{|H(\omega)| = \dfrac{\sqrt{\left(\omega^2 - \omega_p^2 \cdot \frac{R_2}{R_1}\right)^2 + \left[\omega_p \cdot \omega \left(\cancel{1} + \cancel{\omega_p} \cdot \frac{R_2}{R_1}\right)\right]^2}}{\omega^2 + \omega_p^2}}$

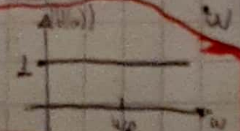
$\Rightarrow \omega = 0$: $\dfrac{\sqrt{\omega_p^4 \cdot \left(\frac{R_2}{R_1}\right)^2 + 0}}{(\ldots)} = \dfrac{\omega_p^2 \cdot \frac{R_2}{R_1}}{\omega_p^2} \Rightarrow \dfrac{R_2}{R_1}$

$\Rightarrow = \dfrac{R_2}{R_1}$;

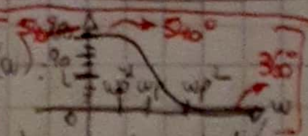
$\omega = \omega_p$: $\dfrac{\sqrt{\left[\omega_p^2\left(1 - \frac{R_2}{R_1}\right)\right]^2 + \left[\omega_p^2\left(1 + \frac{R_2}{R_1}\right)\right]^2}}{2\omega_p^2} \Rightarrow = \dfrac{\sqrt{\omega_p^4\left[\left(1 - \frac{R_2}{R_1}\right)^2 + \left(1 + \frac{R_2}{R_1}\right)^2\right]}}{2\omega_p^2}$

$\omega = \infty$: $\Rightarrow |H(\omega)| = 1$

$|H(\omega)|\big|_{R_2 = R_1} =$



$\theta(\omega)$:



$H(\omega) = |H(\omega)| \cdot e^{j\,tg^{-1}\left(\frac{\omega_p \cdot \omega\left(1 + \frac{R_2}{R_1}\right)}{\omega^2 - \omega_p^2 \cdot \frac{R_2}{R_1}}\right)} \Rightarrow \theta(\omega) = tg^{-1}\left(\dfrac{\omega \cdot \omega_p\left(1 + R_2/R_1\right)}{\omega^2 - \omega_p^2 \cdot \frac{R_2}{R_1}}\right)$

$\Rightarrow$ ignorar

$\theta(\omega)$: $\omega = 0 \rightarrow = 180^0$

$\theta(\omega)$: $\omega = \omega_p \rightarrow \Rightarrow R_2 = R_1 \Rightarrow 90^0$

$\theta(\omega)$: $\omega = \infty \rightarrow = 0^0$

$\sqrt{1 + \left(\frac{R_2}{R_1}\right)^2} \cdot \dfrac{\sqrt{2}}{2} = \sqrt{2 \cdot \left[1 + \left(\frac{R_2}{R_1}\right)^2\right]} \cdot \dfrac{1}{2} = \underset{R_2 = R_1}{1} = \dfrac{1}{2} \cdot \sqrt{\left(1 - \frac{R_2}{R_1}\right)^2 + \left(1 + \frac{R_2}{R_1}\right)^2}$

Normalizar : $\$^* \cdot \Omega_W = \$ \Rightarrow T(\$^*) = T(\$)\Big|_{\$ = \$^* \cdot \Omega_W} \rightarrow \Omega_W = \omega_p \; ; \; T(\$) = \dfrac{\$ - \omega_p \cdot \frac{R2}{R1}}{\$ + \omega_p}$

$$T(\$^*) = \frac{\$^* \cdot \omega_p - \omega_p \cdot R2/R1}{\$^* \cdot \omega_p + \omega_p} = \frac{\cancel{\omega_p}\,(\$^* - R2/R1)}{\cancel{\omega_p}\,(\$^* + 1)} = \frac{\$^* - R2/R1}{\$^* + 1}$$

→ Normalizado en W,

$$T(\$) = \frac{\$ C R3 R1 - R2}{\$ C R3 R1 + R1} \Rightarrow \underbrace{Z_T}_{\text{ignorar}} = R1 + \$ C R3 R1 \rightarrow Z_T = R1 + \$^* \cdot \Omega_W \cdot C \cdot R3 \cdot R1 \rightarrow \text{si } \Omega_Z = R1 : \frac{1}{R3} \; \frac{1}{R3\,C} = \omega_p^* = 1$$

$R3 = \dfrac{1}{C}$

$R1 \cdot \Omega_W \cdot C = C^*$

$$\frac{Z_T}{\Omega_Z} = \frac{\$^* \cdot \Omega_W \cdot C \cdot R1 \cdot R3}{\Omega_Z} + \frac{R1}{\Omega_Z} = \$^* \cdot C \cdot \frac{\Omega_W \cdot R1 \cdot R3}{\Omega_Z} + \frac{R1}{\Omega_Z} = j\omega\,(\;) + \mathrm{Re} = \frac{R1}{\Omega_Z} = 1 \text{ si } \Omega_Z = R3$$

$C = \dfrac{1}{\Omega_Z} = \dfrac{1}{R3}$; $1 = \dfrac{1}{C\,\Omega_Z}$

$$\boxed{\omega_p \cdot \frac{R2}{R1} = \omega_o}$$

$$|H(\omega)| = \frac{\sqrt{(\omega^2 - \omega_o \cdot \omega_p)^2 + (\omega \cdot (\omega_p + \omega_o))^2}}{\omega^2 + \omega_p^2}$$

$$* \; H(\omega) = \frac{-j\omega + \omega_p \cdot R2/R1}{j\omega + \omega_p} = |H(\omega)| \cdot \frac{e^{tg^{-1}\left(\frac{\omega}{+\omega_p R2/R1}\right)} \cdot e^{180°}}{e^{tg^{-1}\left(\frac{\omega}{\omega_p}\right)}}$$

$$\theta(\omega) = 180° + tg^{-1}\left(\frac{-\omega}{+\omega_p R2/R1}\right) - tg^{-1}\left(\frac{\omega}{\omega_p}\right) = -2 \cdot tg^{-1}\left(\frac{\omega}{\omega_p}\right) + 180°$$

$\theta(0) = 180° + 360° - 0 = 540°$; $\theta(\infty) = 180° + 270° - 90° = 360$

Condición pasa todo : $R2/R1 = 1$; → Si cumple

(corrección) T7 también

$\omega_o > \omega_p$:

$\omega_p > \omega_o$: Picos invertidos