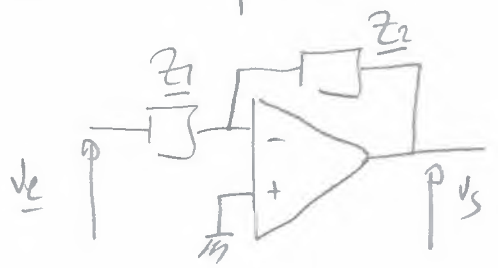
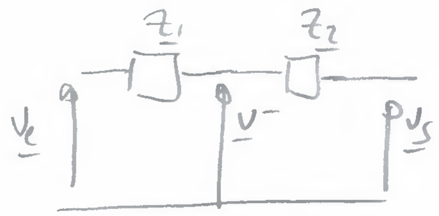
I Expression de $\underline{H}$

1 

avec $\underline{Z_1} = R_1 + \frac{1}{jC_1\omega} = \frac{1+jR_1C_1\omega}{jC_1\omega}$

$$\underline{Z_2} = R_2 // \frac{1}{jC_2\omega} = \frac{\frac{R_2}{jC_2\omega}}{\frac{R_2 jC_2\omega + 1}{jC_2\omega}}$$

$$\underline{Z_2} = \frac{R_2}{1+jR_2C_2\omega}$$

Millman en ⊖ : 

$$\underline{V}^- = \frac{\frac{\underline{V_e}}{\underline{Z_1}} + \frac{\underline{V_s}}{\underline{Z_2}}}{\frac{1}{\underline{Z_1}} + \frac{1}{\underline{Z_2}}}$$

Inutile de développer car.

$\Downarrow$

$$V^- = \frac{N}{D}$$

2 $V^+ = 0 \Rightarrow V^- = 0$ car $V^+ = V^-$

$\Rightarrow \frac{N}{D} = 0 \Rightarrow N = 0$!

$$\frac{\underline{V_e}}{\underline{Z_1}} + \frac{\underline{V_s}}{\underline{Z_2}} = 0 \Rightarrow \frac{\underline{V_s}}{\underline{V_e}} = -\frac{\underline{Z_2}}{\underline{Z_1}}$$

on retrouve l'ampli inverseur

$$\underline{H} = \frac{\underline{V_s}}{\underline{V_e}} = -\underbrace{\frac{R_2}{1+jR_2C_2\omega}}_{\underline{Z_2}} \times \underbrace{\frac{jC_1\omega}{1+jR_1C_1\omega}}_{\frac{1}{\underline{Z_1}}}$$

3. $$\underline{H} = -R_2 \frac{jC_1\omega}{\left(1+j\frac{\omega}{\omega_1}\right)\left(1+j\frac{\omega}{\omega_2}\right)} \rightarrow \text{avec } \omega_1 = \frac{1}{R_1C_1}, \quad \omega_2 = \frac{1}{R_2C_2}$$

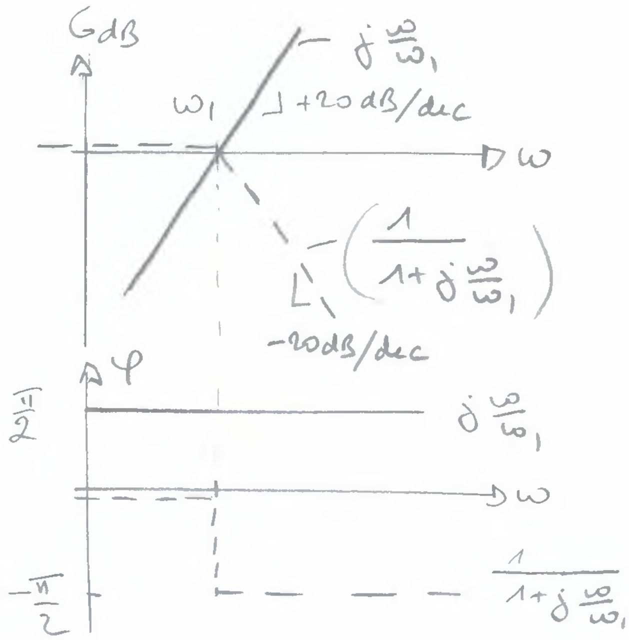
$$= -\frac{R_2}{R_1} \times \frac{jR_1C_1\omega}{\left(1+j\frac{\omega}{\omega_1}\right)\left(1+j\frac{\omega}{\omega_2}\right)}$$

$$= A \times \frac{j\frac{\omega}{\omega_1}}{\left(1+j\frac{\omega}{\omega_1}\right)\left(1+j\frac{\omega}{\omega_2}\right)} \quad \text{avec } A = -\frac{R_2}{R_1}$$

$$\underline{H} = \underbrace{\underline{H_0}}_{-\frac{R_2}{R}} \times \underbrace{\underline{H_{11}}}_{j\frac{\omega}{\omega_1}} \times \underbrace{\underline{H_{12}}}_{\frac{1}{\left(1+j\frac{\omega}{\omega_1}\right)}} \times \underbrace{\underline{H_2}}_{\frac{1}{\left(1+j\frac{\omega}{\omega_2}\right)}}$$

4 – Etude de $\underline{H_1}$

$$\underline{H_1}(j\omega) = \frac{j\frac{\omega}{\omega_1}}{\left(1+j\frac{\omega}{\omega_1}\right)}$$



5 – $\arg \underline{H_1}(j\omega) = \mathrm{Arg}(\underline{H_{11}}) + \mathrm{Arg}(\underline{H_{12}})$

$$= \mathrm{Arg}\left(j\frac{\omega}{\omega_1}\right) + \underbrace{\mathrm{Arg}\left(\frac{1}{1+j\frac{\omega}{\omega_1}}\right)}_{= -\mathrm{Arg}\left(1+j\frac{\omega}{\omega_1}\right)}$$

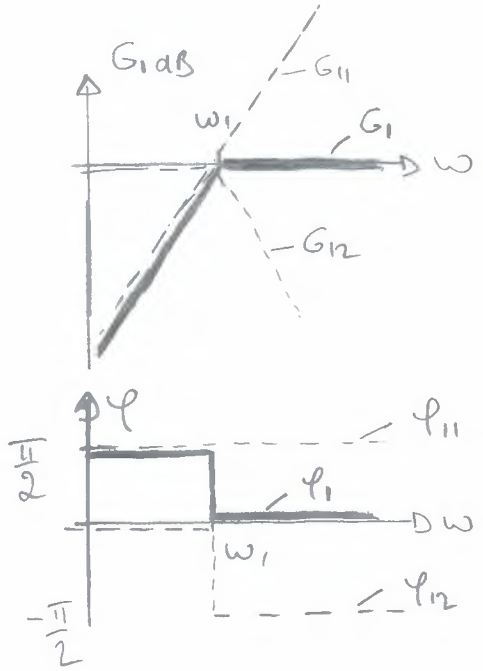
6 – $G_{H_1 dB} = 20\log|\underline{H_1}| = 20\log\left(|\underline{H_{11}}| \times |\underline{H_{12}}|\right)$

$$= 20\log|H_{11}| + 20\log|H_{12}|$$

$$= G_{11}dB + G_{12}dB$$

cl. On trace les formes canoniques et on ajoute les gains puis les phases !

7.



8. Résultat vu pour le filtre passe haut ! On atténue les basses fréquences et on amplifie les hautes fréquences.

ω_1 = fréquence de coupure

Etude de $\underline{H}$ total.

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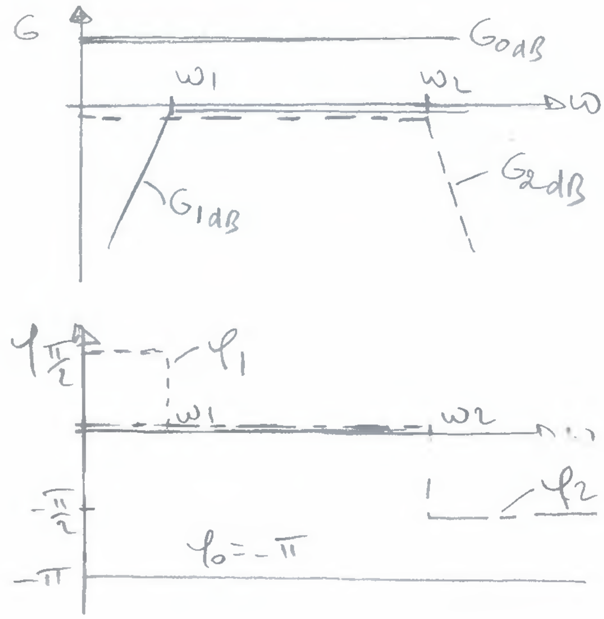

10 – $\underline{H_0}$ gain pur. (ici on suppose $R_2 > R_1$)

$\underline{H_1}$ filtre passe haut.

$\underline{H_2}$ filtre passe bas

$\varphi_0 = -\pi$ car $\underline{H_0} = -\frac{R_2}{R_1}$

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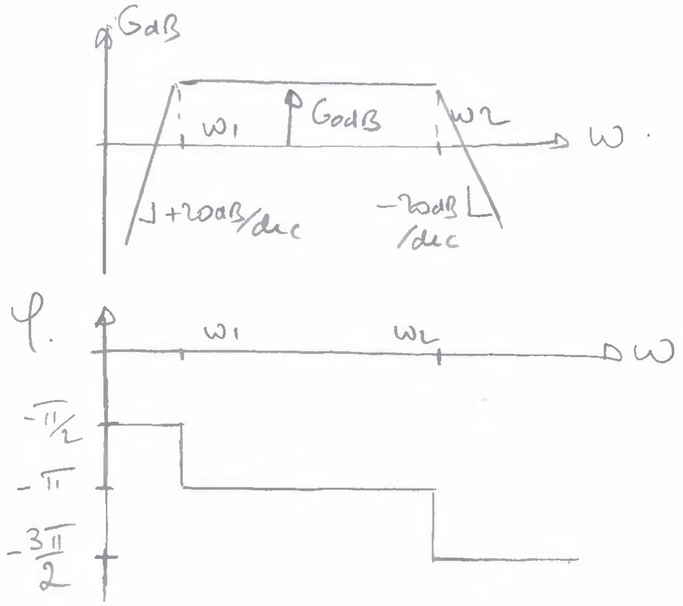

$G_{0dB} = 20 \log \frac{R_2}{R_1}$

combinaison d'un passe bas et d'un passe haut = filtre passe bande

Calcul Gain réel en un point

12 - $|H| = |H_0| \times |H_1| \times |H_2|$

$$= \frac{R_2}{R_1} \times \frac{\omega/\omega_1}{\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}} \times \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_2}\right)^2}}$$

$$\mathrm{Arg}\,\underline{H} = \mathrm{Arg}\,H_0 + \mathrm{Arg}\,\underline{H_1} + \mathrm{Arg}\,\underline{H_2}$$

$$= -\pi + \mathrm{Arg}\left[\frac{j\,\omega/\omega_1}{1+j\frac{\omega}{\omega_1}}\right] + \mathrm{Arg}\left(\frac{1}{1+j\frac{\omega}{\omega_2}}\right)$$

$$= -\pi + \mathrm{Arg}\left(j\frac{\omega}{\omega_2}\right) - \mathrm{Arg}\left(1+j\frac{\omega}{\omega_1}\right) - \mathrm{Arg}\left(1+j\frac{\omega}{\omega_2}\right)$$

$$= -\pi + \frac{\pi}{2} - \mathrm{Arctan}\left(\frac{\omega}{\omega_1}\right) - \mathrm{Arctan}\left(\frac{\omega}{\omega_2}\right)$$

13 Rappel $\omega_1 << \omega_2$ au minimum 1 décade.

$$\omega_1 < \frac{\omega_2}{10}$$

$$|H(j\omega_1)| = \frac{R_2}{R_1}\left|\frac{\frac{\omega_1}{\omega_1}}{\sqrt{1+\left(\frac{\omega_1}{\omega_2}\right)^2}}\right| + \left|\frac{1}{\sqrt{1+\left(\frac{\omega_1}{\omega_2}\right)^2}}\right|$$

$= \frac{1}{\sqrt{2}}$

↳ $\simeq 1$ car $\left(\frac{\omega_1}{\omega_2}\right)^2 << 1$

$$|H(j\omega_1)| \simeq \frac{R_2}{R_1} \times \frac{1}{\sqrt{2}} \simeq \frac{|A|}{\sqrt{2}}$$

en dB : $G_{dB} = 20\log\frac{R_2}{R_1} - 20\log\sqrt{2}$

$$= G_{0dB} - 3\text{ dB}.$$

ω_1 = fréquence de coupure à -3 dB !

$\Delta\omega = \omega_2 - \omega_1$ = bande passante du filtre

voir TD semilog.