Électronique
Oscillateur à déphaseur RC

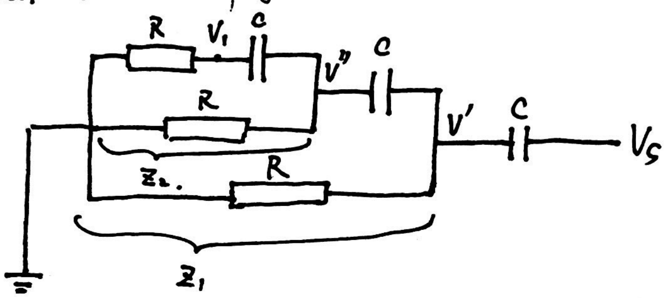
Li Chen, Robin, SY1924115

Q1

La fonction de transfert $H(j\omega) = \dfrac{A}{1 - A\beta(j\omega)}$

$A = \dfrac{R_1 + R_2}{R_1}$, $\beta(j\omega) = \dfrac{V_1}{V_s}$.

Pour calculer $\beta(j\omega)$, on utilise la chaîne de retour:



$$\frac{V'}{V_s} = \frac{Z_1}{Z_1 + \frac{1}{j\omega C}} \quad \text{avec} \quad Z_2 = \frac{1}{\frac{1}{R} + \frac{1}{R + \frac{1}{j\omega C}}} = \frac{(j\omega CR + 1)R}{2j\omega CR + 1}$$

$$\frac{V''}{V'} = \frac{Z_2}{Z_2 + \frac{1}{j\omega C}} \qquad Z_1 = \frac{1}{\frac{1}{R} + \frac{1}{Z_2 + \frac{1}{j\omega C}}} = \frac{(j\omega C Z_2 + 1)R}{j\omega C(R + Z_2) + 1}$$

$$\frac{V_1}{V''} = \frac{R}{R + \frac{1}{j\omega C}} \qquad = \frac{((j\omega CR)^2 + 3j\omega CR + 1)R}{3(j\omega CR)^2 + 4j\omega CR + 1}.$$

Donc
$$\beta(j\omega) = \frac{V_1}{V_s} = \frac{V_1}{V''} \cdot \frac{V''}{V'} \cdot \frac{V'}{V_s} = \frac{R}{R + \frac{1}{j\omega C}} \cdot \frac{Z_2}{Z_2 + \frac{1}{j\omega C}} \cdot \frac{Z_1}{Z_1 + \frac{1}{j\omega C}}.$$

$$= \frac{j\omega CR}{j\omega CR + 1} \cdot \frac{\frac{(j\omega CR)^2 + j\omega CR}{2j\omega CR + 1}}{\frac{(j\omega CR)^2 + j\omega CR}{2j\omega CR + 1} + 1} \cdot \frac{\frac{(j\omega CR)^3 + 3(j\omega CR)^2 + j\omega CR}{3(j\omega CR)^2 + 4j\omega CR + 1}}{\frac{(j\omega CR)^3 + 3(j\omega CR)^2 + j\omega CR}{3(j\omega CR)^2 + 4j\omega CR + 1} + 1}$$

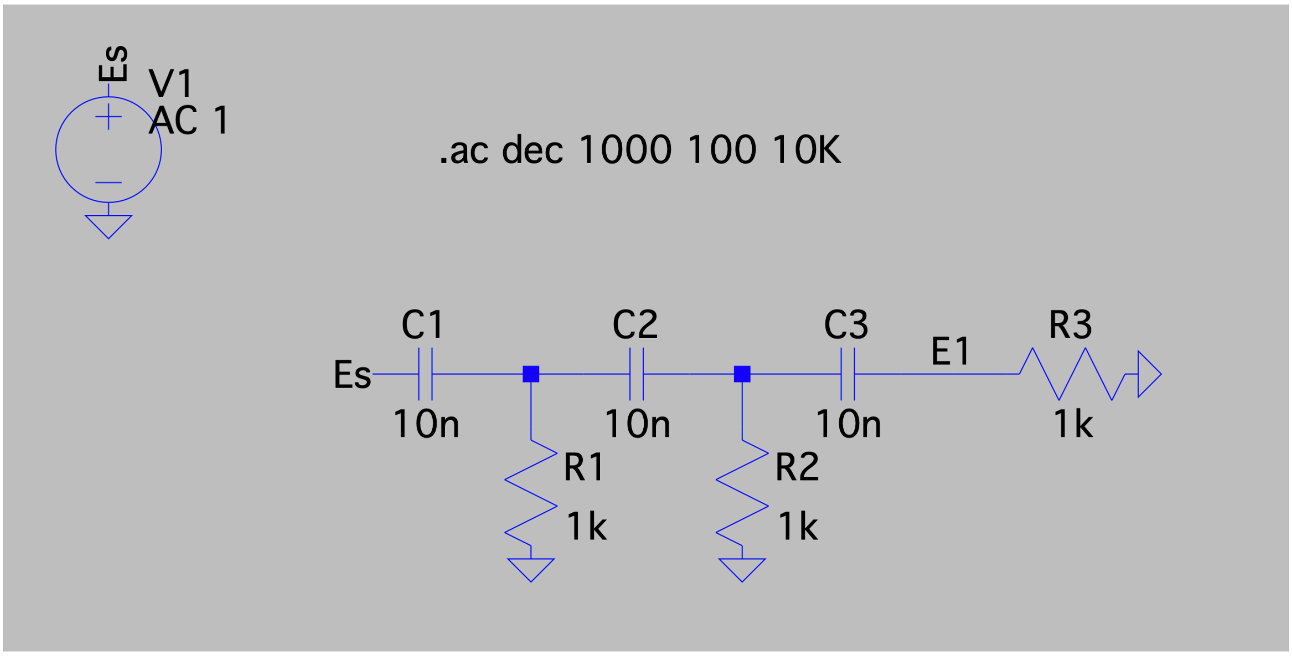
$$= \frac{j\omega CR}{j\omega CR + 1} \cdot \frac{(j\omega CR)^2 + j\omega CR}{(j\omega CR)^2 + 3j\omega CR + 1} \cdot \frac{(j\omega CR)^3 + 3(j\omega CR)^2 + j\omega CR}{(j\omega CR)^3 + 6(j\omega CR)^2 + 5j\omega CR + 1}$$

$$= \frac{(j\omega CR)^3}{(j\omega CR)^3 + 6(j\omega CR)^2 + 5(j\omega CR) + 1}$$

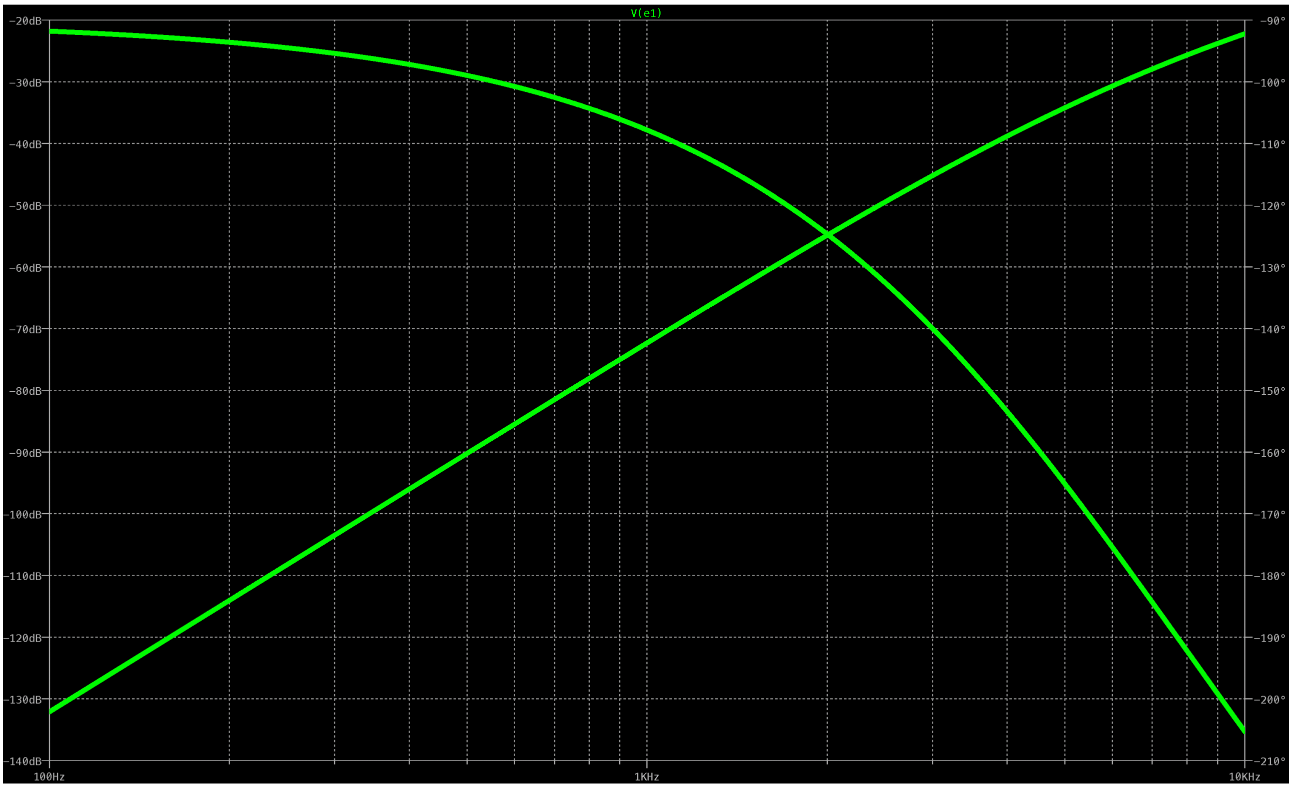
$$= \frac{1}{1 - \frac{5}{(\omega RC)^2} - j\left(\frac{6}{\omega RC} - \frac{1}{(\omega RC)^3}\right)}$$

Q2

On réalise le graphe ci-dessous:



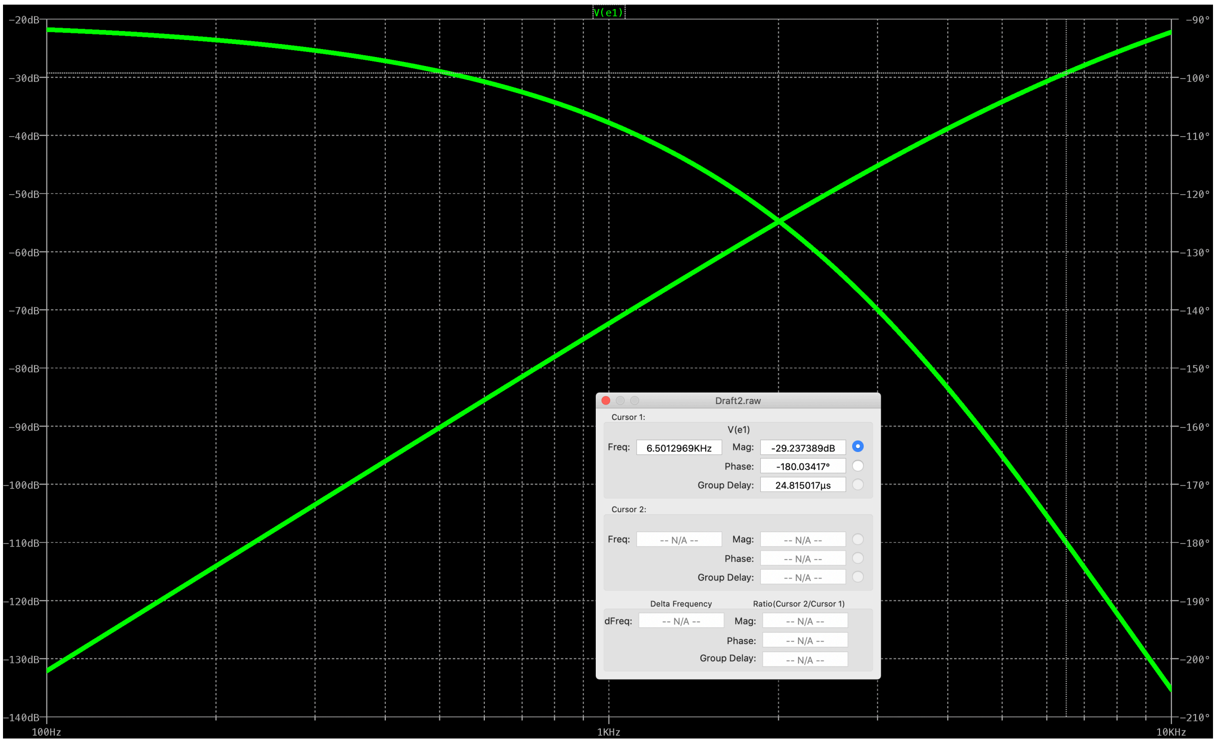
Et le résultat:



Q3

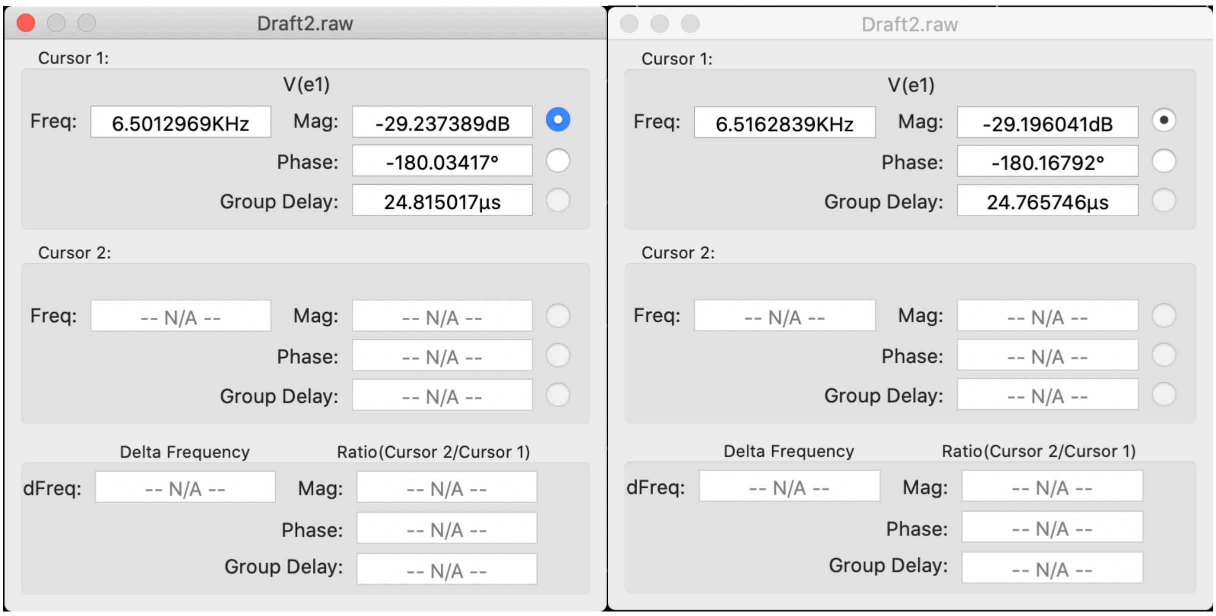
D'après calcule, on peut trouver $f_0 = \dfrac{1}{2\pi\sqrt{6}RC} = 6.50kHz$ et $A = -\dfrac{1}{|\beta(j\omega)|} = -29$.

Et dans la simulation, on peut trouver $f_0 = 6.50kHz$ et $A = -29.2$.



Q4

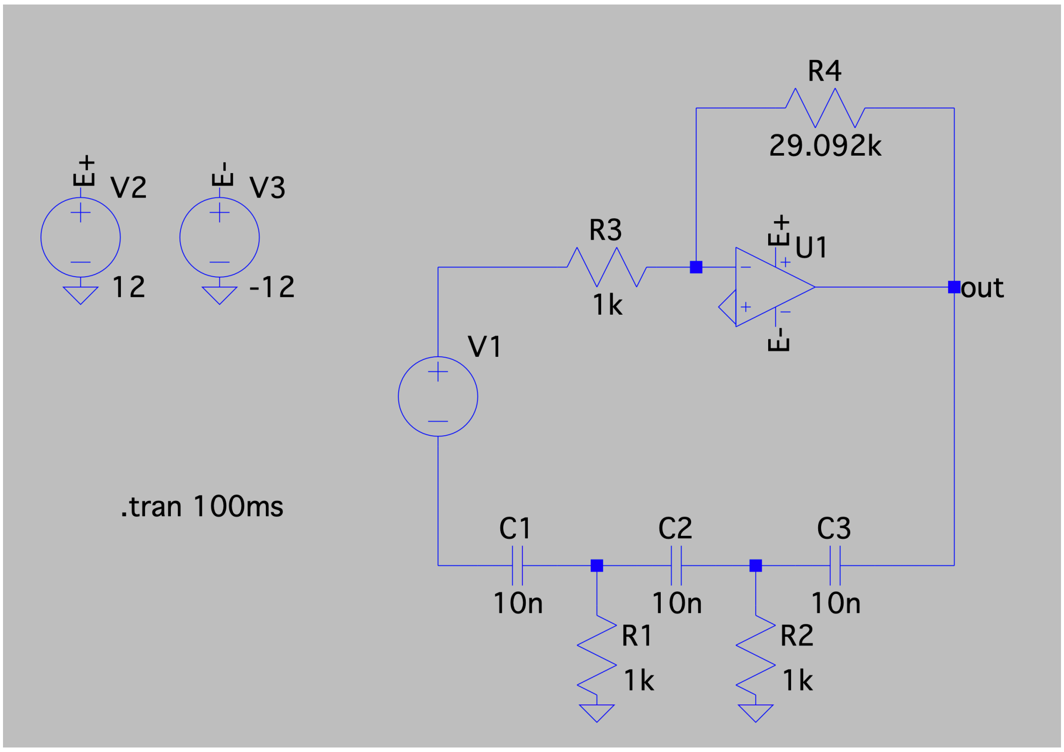
D'après le cours, on trouve $S(\omega_0) = \dfrac{12}{29}\sqrt{6} \approx 1.01$.



On prend deux points proches de f_0 pour calculer $S(\omega_0)$.

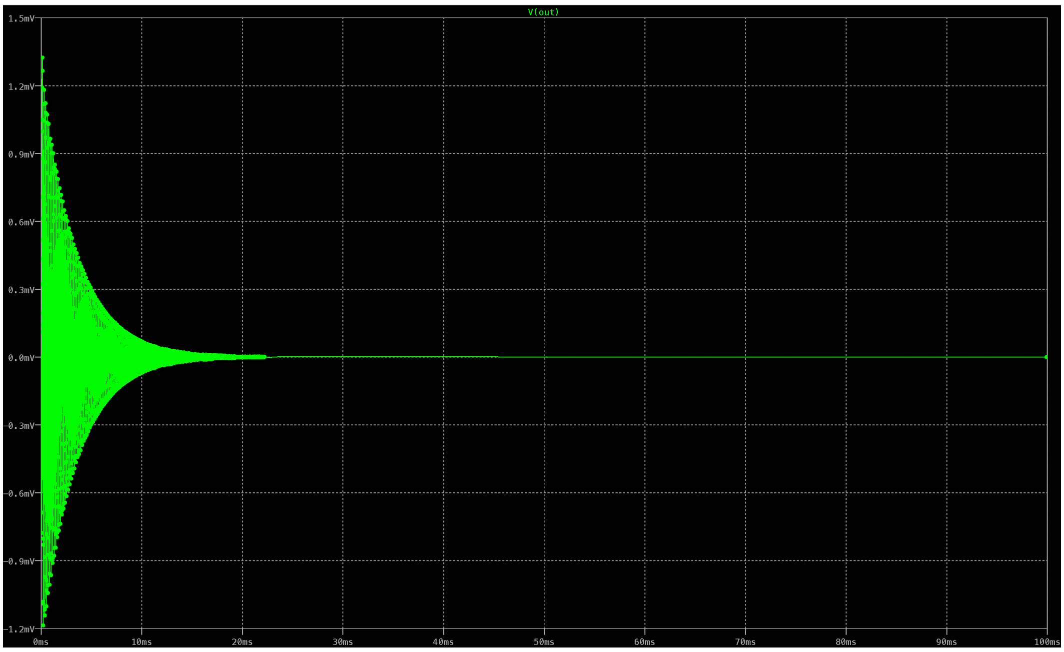
$$S(\omega_0) = \left| \frac{d\varphi(\beta(j\omega))}{d(\omega/\omega_0)} \right|_{\omega=\omega_0} = \left| \frac{\omega_0}{2\pi} \frac{d\varphi}{df} \right|_{f=f_0} = \left| \frac{\omega_0}{2\pi} \frac{-180.16 + 180.03}{6516.3 - 6501.3} \frac{\pi}{180} \right|_{f=f_0} = 0.98.$$

Q5

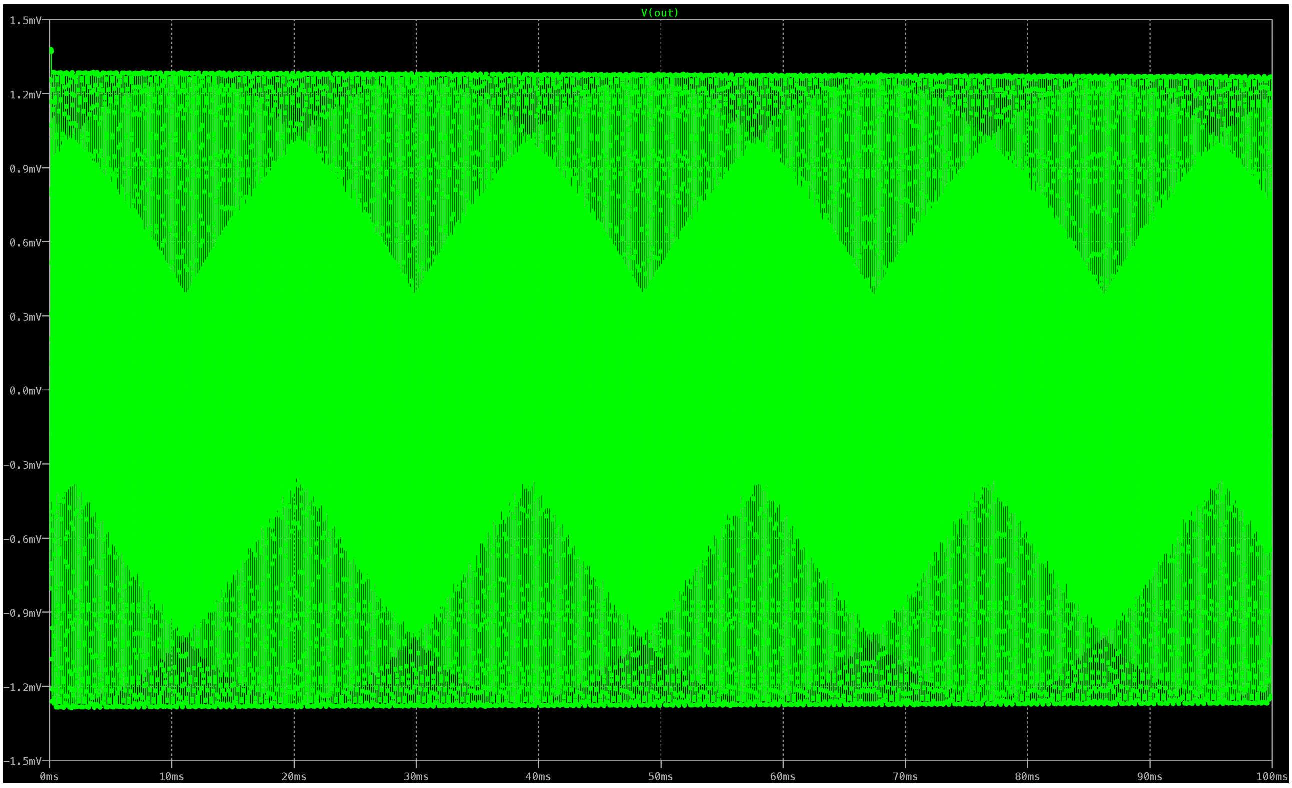


Q6

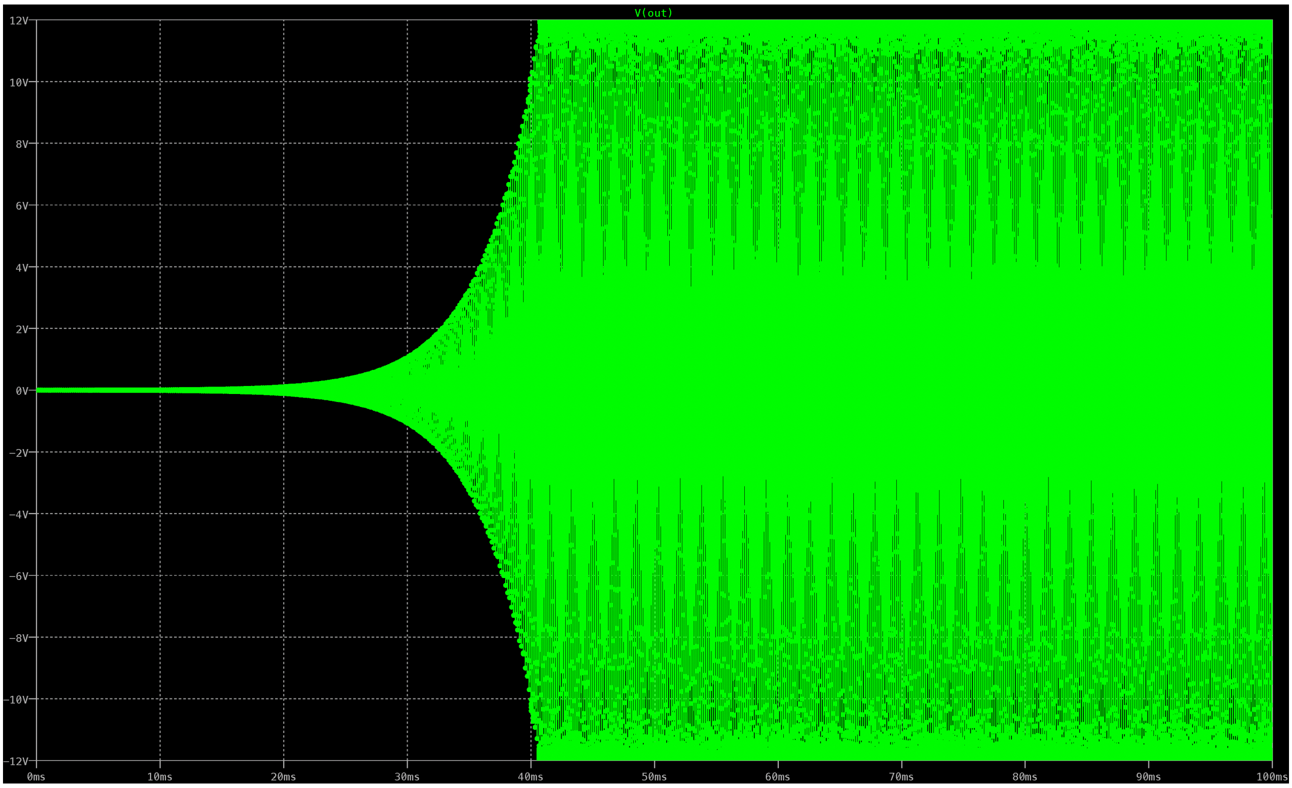
Dans le cas $A\beta(j\omega) < 1$, on choisit $R_2 = 28k\Omega$:



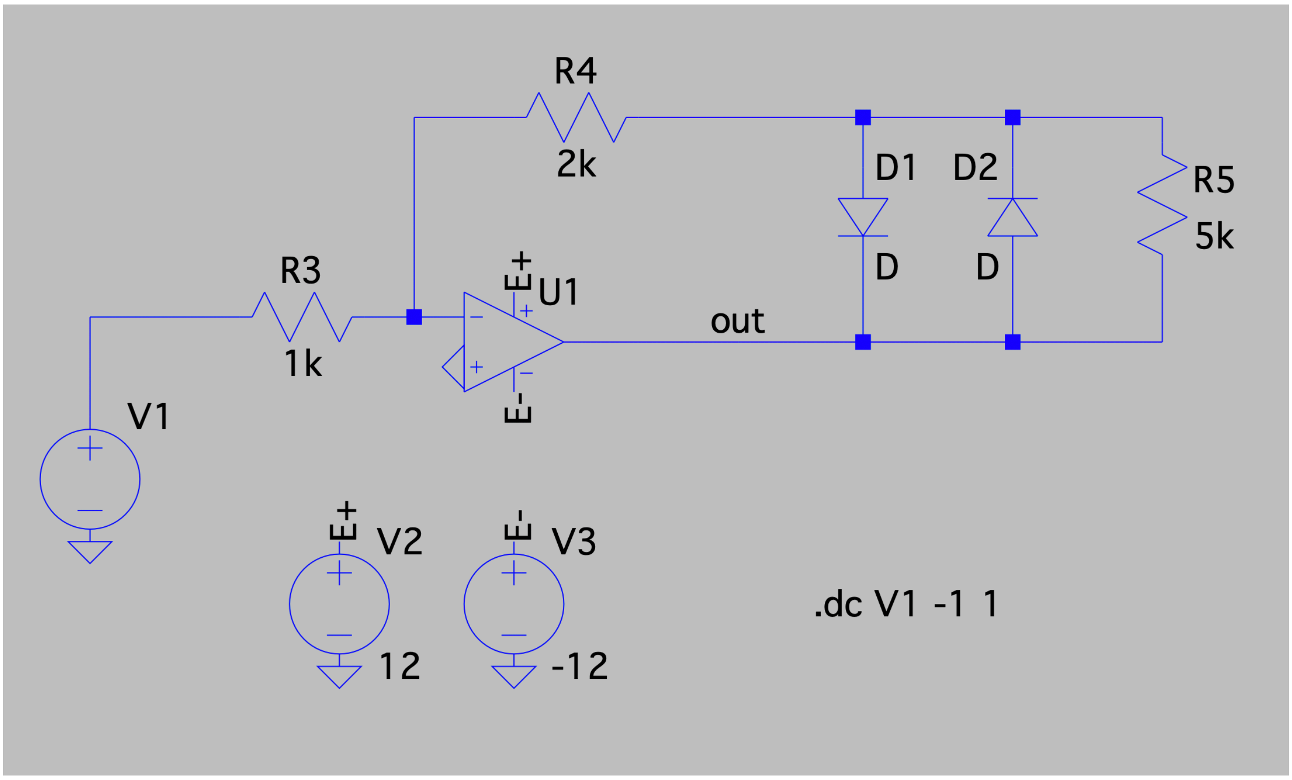
Dans le cas $A\beta(j\omega) = 1$, on choisit $R_2 = 29.092k\Omega$:



Dans le cas $A\beta(j\omega) > 1$, on choisit $R_2 = 30k\Omega$:



Q7



Q8

Quand R_2 est petit, on choisit $R_2 = 2k\Omega$, on peut voir la non-linéarité du gain.