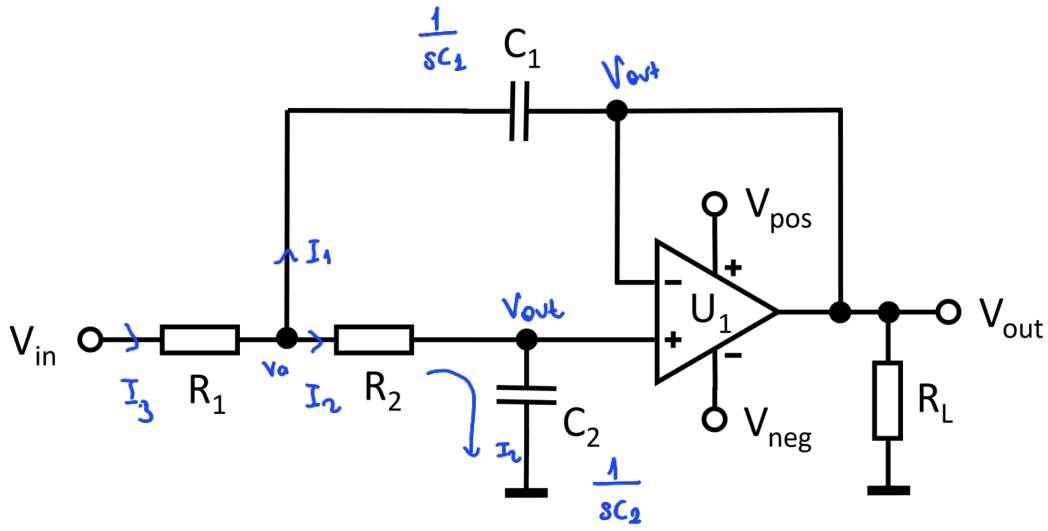
19/10/22

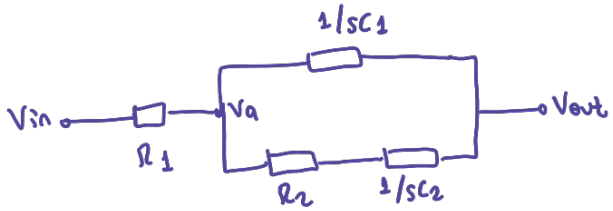
# Exercise set #5

## Exercise 1:

We want to analyze the following circuit using *LTspice*:




a) Draw the circuit and use the following values for the components:






$$\frac{V_{in}-V_a}{R_1} = \frac{V_a-V_{out}}{1/sC_1} + \frac{V_a-V_{out}}{R_2+1/sC_2}$$

| | |
|---|---|
| $R_1$ | $15\ k\Omega$ ✓ |
| $R_2$ | $15\ k\Omega$ ✓ |
| $R_L$ | $50\ \Omega$ ✓ |
| $C_1$ | $225\ pF$ ✓ |
| $C_2$ | $115\ pF$ ✓ |
| $U1$ | $UniversalOpamp2$ ✓ |
| $V_{pos}$ | $5\ V$ ✓ |
| $V_{neg}$ | $-5\ V$ ✓ |

✓b) Simulate the circuit and plot $V_{out}$ as a function of time, when $V_{in}$ is a sinusoidal signal with an amplitude of $1\ V$, a DC offset of $0\ V$ and frequency $f = 10\ kHz$. → $T = \frac{1}{10k} = \frac{1}{10^4} = 10^{-4}\ sec = 10^{-1} \times 10^{-3} = 0.1\ msec$

✓c) Repeat the simulation for $f = 5\ kHz$, $f = 50\ kHz$, $f = 100\ kHz$ and $f = 500\ kHz$. What does the circuit do?

✓ d) Find $f_C$ for which the amplitude of $V_{out}$ is $3\ dB$ lower than $V_{in}$.

✓ e) Repeat d) for $C_2 = 65\ pF$, $C_2 = 200\ pF$ and $C_2 = 250\ pF$.

✓ f) Find a value for $C_2$ such that $f_C = 30\ kHz$.

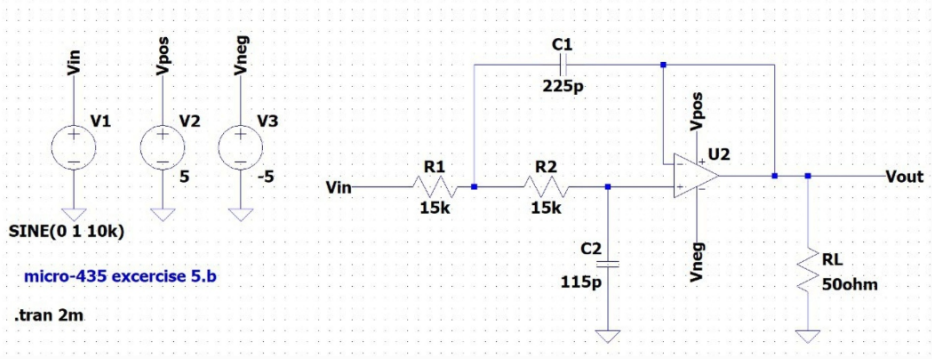
✓ g) Simulate the circuit and plot $V_{out}$ as a function of time, when $V_{in}$ is a rectangular signal with an amplitude of $1\ V$, a DC offset of $0\ V$ and frequency $f = 20\ kHz$. What do you observe? $\frac{1}{20k} = \frac{1}{20} \times 10^{-3}\ msec = 0.05\ msec = 50\ \mu sec$

h) Plot the spectrum of $V_{out}$.

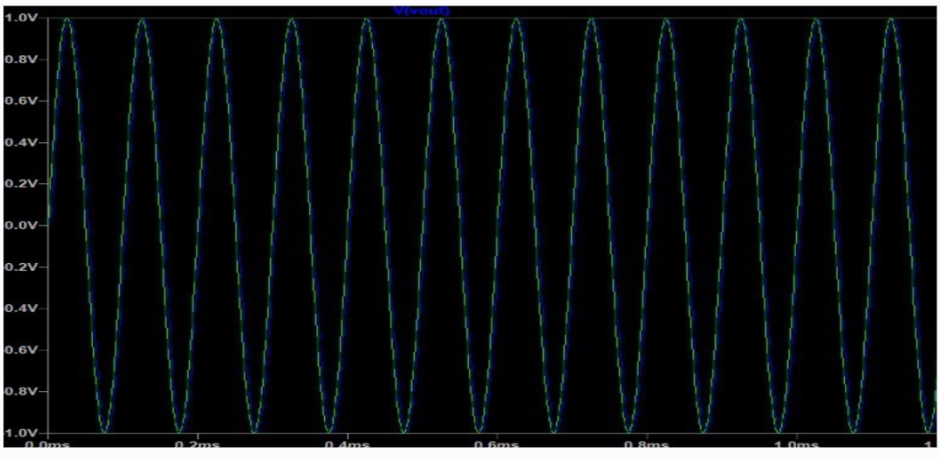
i) Measure the average power required at $V_{pos}$.

j) What will happen to $V_{out}$ if $V_{in}$ is a sum of two sinusoidal signals with amplitudes of $1\ V$, DC offsets of $0\ V$ and frequencies $f_1 = 10\ kHz$ and $f_2 = 100\ kHz$? What about $f_1 = 10\ kHz$ and $f_2 = 40\ kHz$?

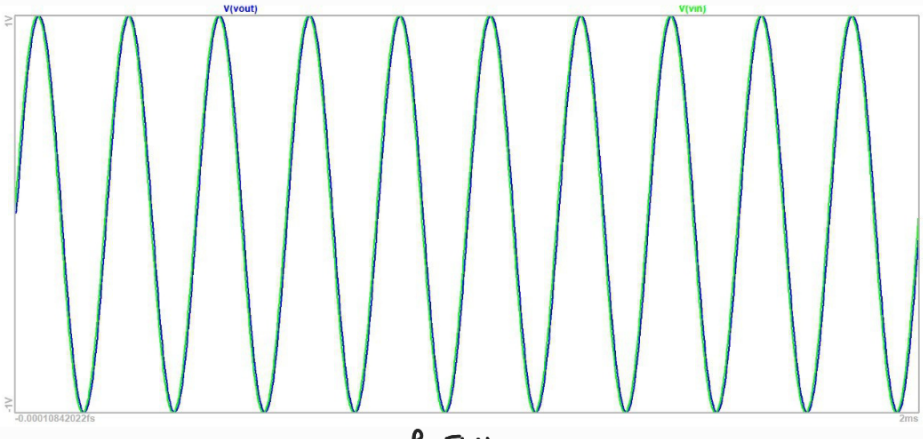
a)



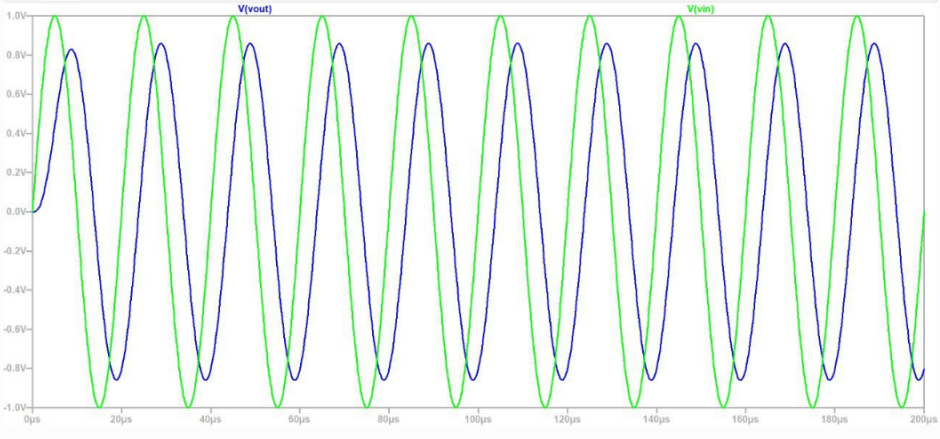

b)



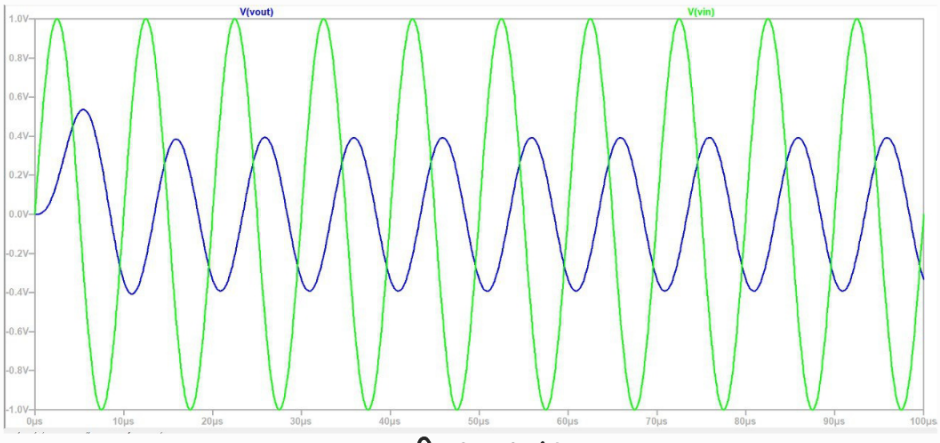

c)




f= 5kHz




f= 50k

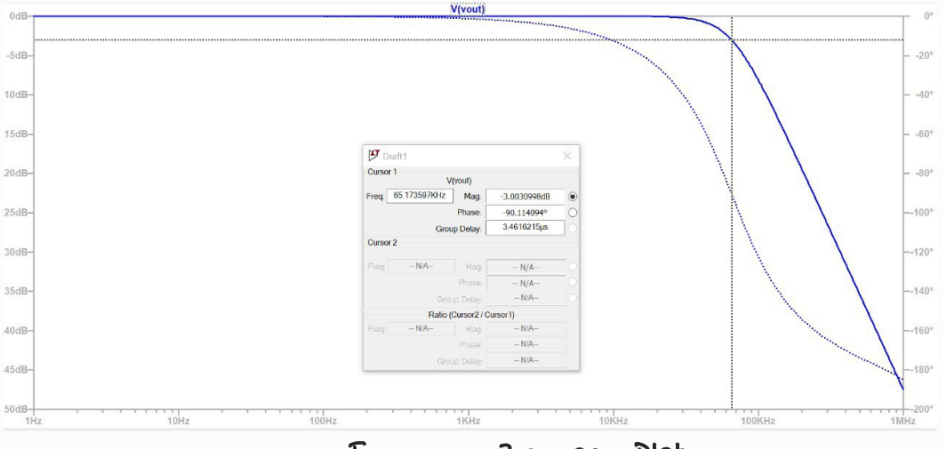



f = 100kHz


f = 500 kHz

Increasing frequency yields decrease in voltage.

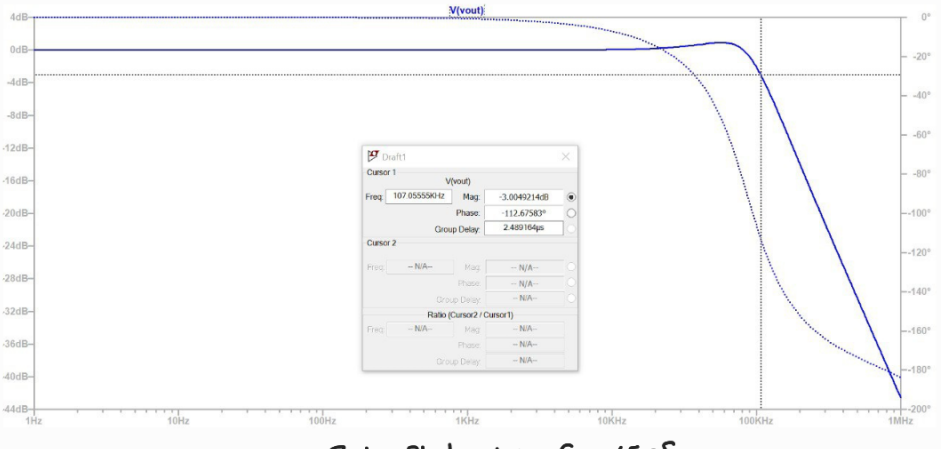
d)




→ $f_c \simeq 65$ kHz

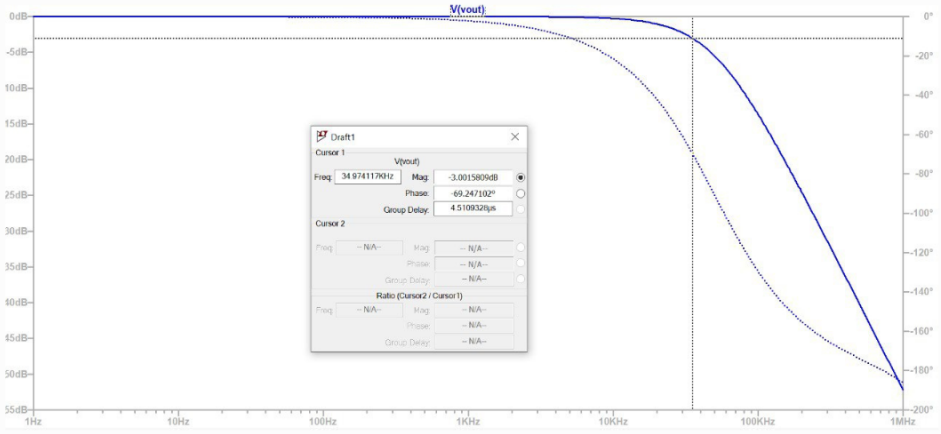
Frequency Response Plot

e)



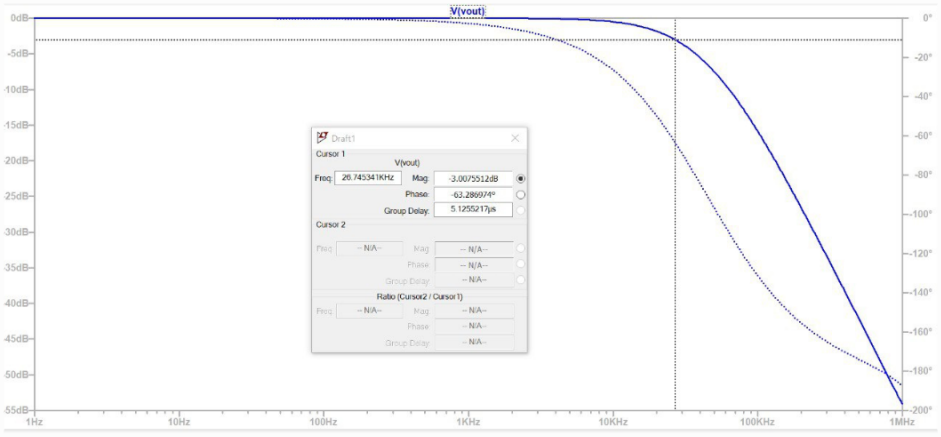

$f_c \simeq 107$ kHz

Bode Plot when $C_L = 65$ pF




$f_c \simeq 35$ kHz

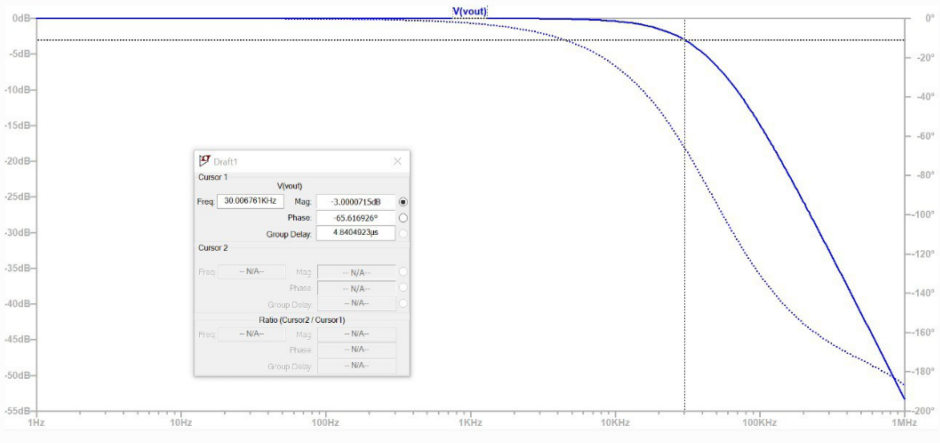
Bode Plot when $C_2 = 200pF$



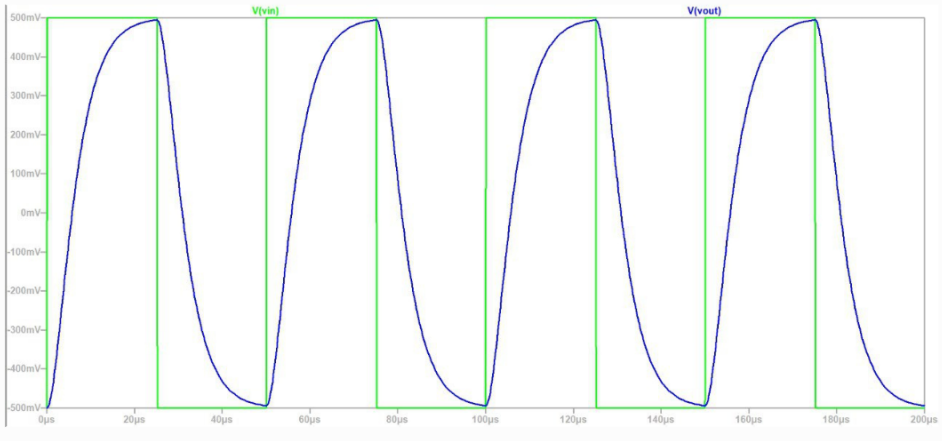

$f_c \simeq 27$ kHz

Bode Plot when $C_2 = 250pF$

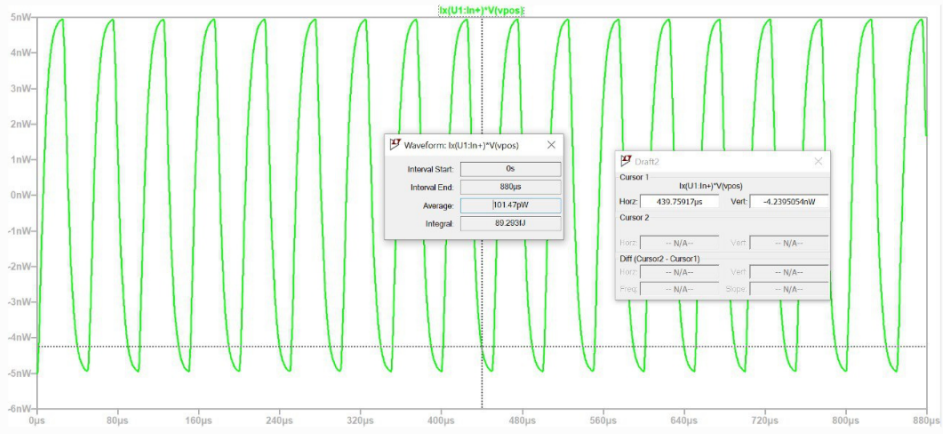
f) From my intuition if $C_2 = 200pF \rightarrow f_c = 35kHz$ & $C_2 = 250pF \rightarrow f_c = 27kHz$, $C \simeq 227\ pF \rightarrow f_c = 30$ kHz




g)

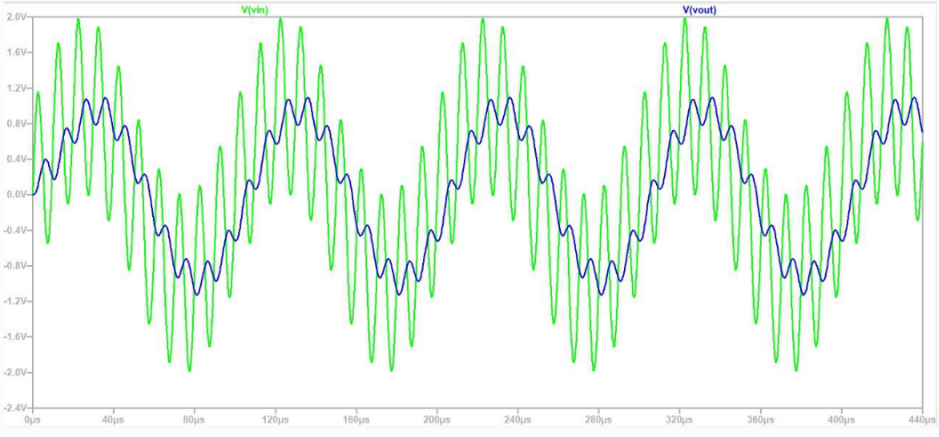


i)

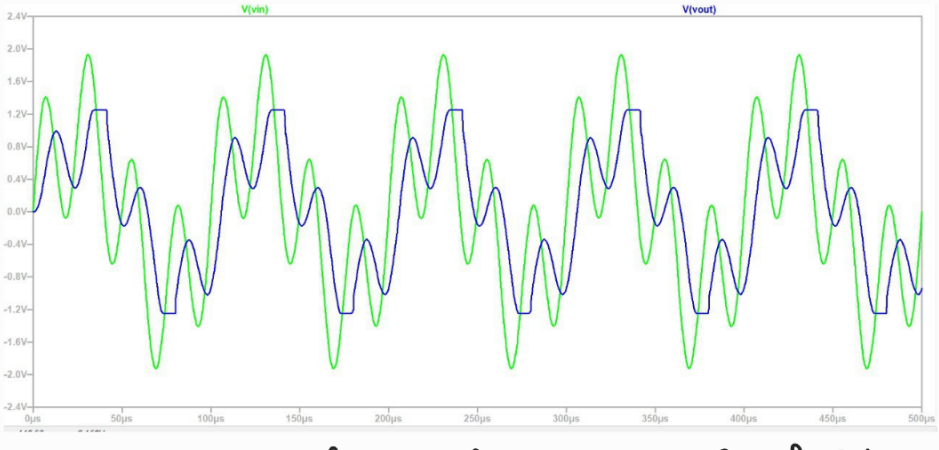



Avg. power @ Vpos

j)




$f_1$=10k , $f_2$= 100k , $C_2$= 227p $f_c$= 30k




$f_1$= 10k $f_2$=40k , $C_2$= 227p $f_c$= 30k