Instructions :

- Duration : 2 Hours
- The goal of this working lab is to build the electronic circuits studied in the courses and understand the concepts behind them with practical circuits.

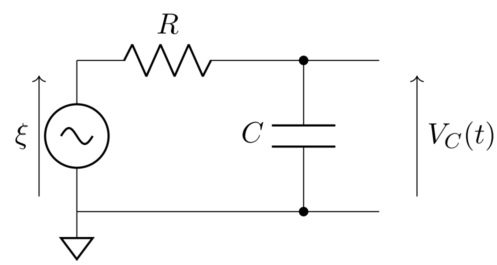
---

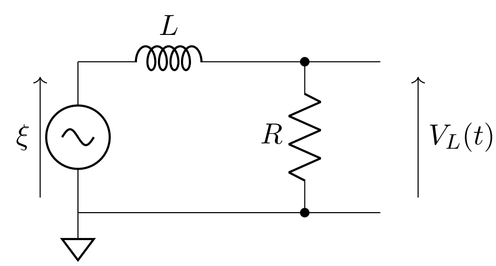
1 Materials

2 Experiment 1: Study of low-pass filters

2.1 Preparation

Consider the following circuits :





1. Build the first circuit and connect it the LFG. Set a sine wave of 30 kHz with an amplitude of 5 V. Select the value of $R = 1$ kΩ and $C = 1$ nF.

2.2 Manipulations

1. Sweep the frequency from 30 kHz to 300 kHz, and look at the output $V_C(t)$, what do you observe?
2. Note down then plot the amplitude of the output voltage read on the oscilloscope as function of the frequency f. (Take more than 10 points of measurements)
3. Try to find experimentally the value of the cut-off frequency f_c.
4. Compare it the theoretical value $f_c = \frac{1}{2\pi RC}$.
5. Consider the transfer function of the circuit $H(s) = \frac{\omega_c}{s+\omega_c}$, where $\omega_c = \frac{1}{RC}$ and $s = j\omega$ is the complex frequency. Explain why this circuit is a low-pass filter.

6. Select now values for R and C to reach a cut-off frequency $f_c = 2$ MHz. If the values are not avaiable, take the components close to those values.

2.3 Preparation

1. Build the second circuit and connect it the LFG. Set a sine wave of 100 kHz with an amplitude of 5 V. Select the value of $R = 75\ \Omega$ and $L = 471\ \mu$H.

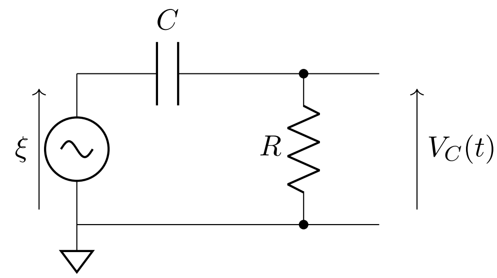
2.4 Manipulations

1. Sweep the frequency from 100 Hz to 200 kHz, and look at the output $V_L(t)$, what do you observe?
2. Find the correct values of R to find a cut-off frequency of $f_c = 3$ MHz, in that second case $\omega_c = \frac{R}{L}$. If the values are not avaiable, take the components close to those values.

3 Experiment 2 : Study of high-pass filters

3.1 Preparation

Exchange the position of the resistor and the capacitor and build the following filter :



3.2 Manipulations

1. The transfert function is now $H(s) = \frac{s}{s+\omega_c}$, with $\omega_c = \frac{1}{RC}$. Explain with this equation the type of filter that you have.

2. Take the same R and C as experiment 1. Visualize the voltage of the resistor as function of the frequency and reproduce the oscillogram. Sweep the frequency with values coherent with the f_c cut-off frequency. (Take more than 10 points of measurements)

3. By using the same principle with the second circuit, build the high-pass filter with a resistor and an inductor.

4. Do the same procedure than the question 2 and reproduce the oscillogram to prove that you indeed have a high-pass filter.

4 Experiment 3 : Study of second-order filters

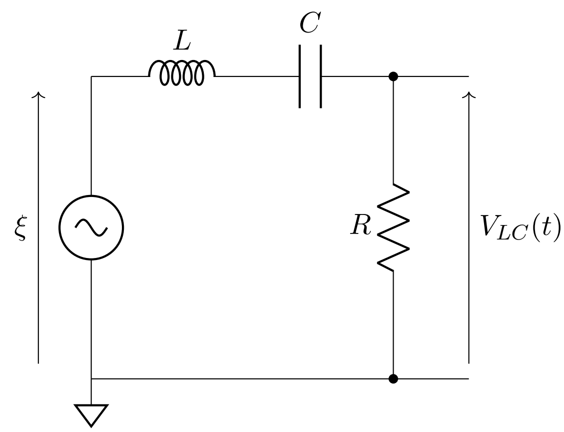
4.1 Manipulation

1. By combining now a resistor R, a capacitor C and an inductor L, find the circuit for a second-order low-pass filter. Use combinations of previous filters to build the circuit.
2. With the LFG, sweep the frequency and record the value of the output voltage. What do you observe compared to the low-pass filter of the exercise 1?
3. Consider the transfert function $H(s) = \frac{1}{1+sRC-s^2LC}$. Why this filter is considered a second-order low-pass filter?

5 Experiment 4 : Study of an unkown filter

5.1 Manipulation

Build the following circuit, with a value of $R = 75\ \Omega$, $L = 471\ \mu$H and $C = 220$ nF. If the components are not available, take something close in value.



1. Sweep the frequency from 1 kHz to 100 kHz and measure the voltage amplitude at different frequency points.
2. Deduce what kind of filter do you have. Draw the equivalent circuit for low frequencies, high frequencies and at resonance.
3. Estimate experimentally the resonance and cut-off frequencies and the bandwidth (BW). The high and low cut-off frequencies are chosen when the output amplitude is 70% of the maximum value.