Instructions :

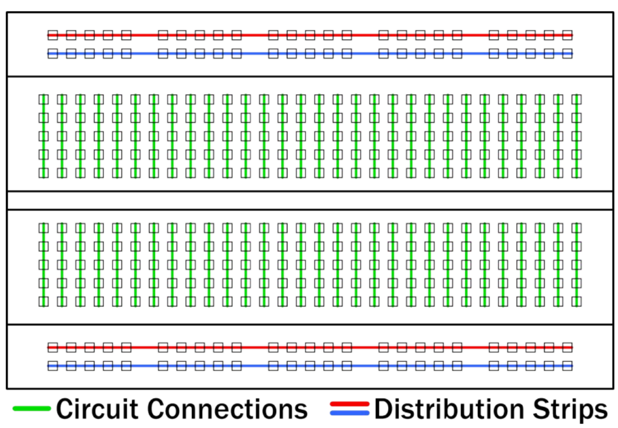
- Duration : 2 Hours
- The goal of this working lab is to build the electronic circuits studied in the courses and understand the concepts behind them with practical circuits.

---

1 Materials

- 1 oscilloscope
- 1 Low Frequency Generator (LFG)
- 1 breadboard
- 2 BNC connectors
- 4 banana connectors and probes to connect to the breadboard
- Various resistors, capacitors and inductors. Note that if the components are not available, take the closest value available.

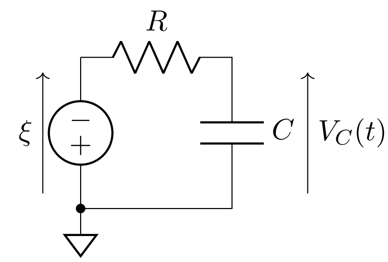
For the next two working lab, you will use breadboard. Review here how slots and strips are connected into a single breadboard :



2 Experiment 1: Study of a RC circuit

2.1 Preparation

Consider the following circuit : $R = 1.8\ k\Omega$ and $C = 100\ nF$



1. Determine the expression of the voltage $V_C(t)$ for the charge of the capacitor :
   (a) First write the voltage Kirschhoff's law.
   (b) Use Ohm's law to express the current that flows into the resistor.
   (c) Express the current as function of the capacitor voltage.
   (d) For the differential equation, use the time constant $\tau = RC$
2. Show with calculations that for $t = \tau$:
   (a) $V_C = 0.63 V_{C_{\max}}$ for the charging
   (b) $V_C = 0.37 V_{C_{\max}}$ for the discharging
3. Show that if at t_1, $V_C(t_1) = 0.1\xi$ et à t_2, $V_C(t_2) = 0.9\xi$, then $\tau = \frac{t_2 - t_1}{ln(9)}$
4. show that for $t = 5\tau$, the capacitor is charged at 99%.

2.2 Manipulations

1. Set the Low Frequency Generator (LFG) to have a *square* signal with a frequency $f = 1\ kHz$ and a peak-peak voltage of $V_{cc} = 5\ V$, and a DC component $V_{dc} = 2.5\ V$.
2. Adjust the oscilloscope trigger to successfully observe the charging of the capacitor.
3. Visualize the voltage of the capacitor during the charging. Deduce the time constant on the oscilloscope.
4. Visualize the voltage of the resistor and reproduce the oscillogram. Deduce the evolution of the charge current of the capacitor. **Note : In order to obtain the voltage of the resistor, you need to use a differential measure because it is not possible to obtain it with only one probe. For that, you need an additionnal BNC connector and probes.**

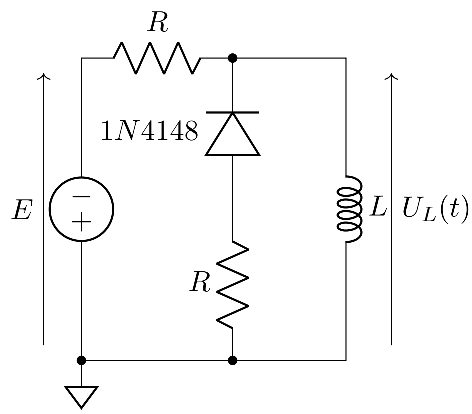
3 Experiment 2 : Study of a *RL* circuit

3.1 Preparation

Give the expression of $i(t)$ for an RL circuit with a step voltage as an input and for a RL circuit when the generator is off.

3.2 Manipulations

Build the following circuit with $L = 471$ µH. The *1N4148* component is a diode:



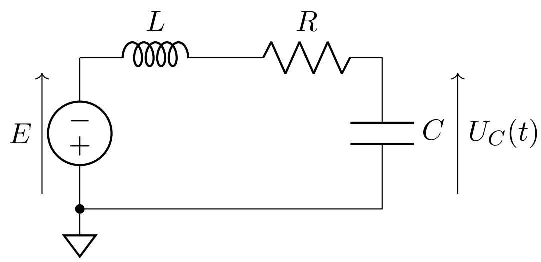
1. Determine R in order to have a time constant of 30 μs when the diode is blocking the current (reverse mode). The time constant $\tau = \frac{R}{L}$.
2. Adjust the LFG to have a *square* signal with a frequency of $f = 1\ kHz$, and a peak-peak voltage of $V_{cc} = 5\ V$, and a DC component $V_{dc} = 2.5\ V$.
3. Adjust the oscilloscope in order to observe the voltage of the inductor and the resistor. Reproduce the oscillogram.
4. What would happen if the inductor is charged, and we replace the generator by an open circuit? Explain the utility of the diode called '*Freewheeling diode*' or '*Flyback diode*'.

4 Experiment 3 : Study of the RLC circuit

4.1 Preparation

1. Give the expression of the voltage of the capacitor in a series RLC circuit and the quality factor Q.
2. Explain briefly the different possible regimes as function as the value of the Q factor. Explain with a curve the behavior in each case.

4.2 Study of the aperiodic regime



1. Determine the value for R to obtain $Q = 0.1$.
2. Build the circuit above with an inductor $L = 471\ H$ and $C = 1\ nF$ and the closest value of resistor calculated before. Use the LFG to deliver a square wave voltage of $5\ V$ peak-peak and an offset of $2.5\ V$. Set the frequency so that the permanent regime is obtained for each half-period.
3. With the model of exponential decay ($Q \ll 1$), we can consider that the permanent regime is obtained after $\Delta t = \frac{T_0}{Q}$ with $T_0 = 2\pi\sqrt{LC}$. Deduce graphically Δt and the value of Q.

4.3 Study of the critical regime

1. Calculate the value of the critical resistor.
2. In order to visualize the different regimes, use a potentiometer to vary the resistor around the critical value. Visualize the voltage of the capacitor C. Is the behavior of the circuit expected?

4.4 Study of the pseudo-periodic regime

1. Determine the value of R to obtain $Q = 8$.
2. Set the frequency of the LFG in order to have the permanent regime after each half-period.
3. Visualize with the oscilloscope the voltage of the LFG and of the capacitor.
4. Reproduce the oscillogram and deduce the angular frequency of the pseudo-oscillations. Compare it to the natural angular frequency.