Circuits and Electronic Laboratory

Experiment #5

Purpose of Experiment

In this experiment we will see how RC, RL and RLC circuit works.

General Information

There are three basic, linear passive lumped analog circuit components: the resistor (R), the capacitor (C), and the inductor (L). These may be combined in the RC circuit, the RL circuit, the LC circuit, and the RLC circuit, with the acronyms indicating which components are used. These circuits, among them, exhibit a large number of important types of behaviour that are fundamental to much of analog electronics. In particular, they are able to act as passive filters.

To specify the behavior of an electrical circuit as a function of time, the equations related to the circuit must be acquired and solved. Circuit equations, in their general form, include integrals, derivatives and algebraic relations.

Circuits can be grouped as first order and second order circuits. First order circuits consist of a resistor with a capacitor or a inductor but not both. Second order circuits can be made from using both capacitor and inductor.

Let's consider circuit depicted in Figure 1. Derivation of RC circuit equations is as follows:

$$V_r = iR \tag{1}$$

$$V_c = \frac{q}{C} \tag{2}$$

$$i = \frac{d_q}{d_t} \tag{3}$$

$$V = \frac{d_q}{d_t} R + \frac{q}{c} \tag{4}$$

$$
\begin{aligned}
VC &= \frac{d_q}{d_t}RC + q && (5)\\
VC - q &= \frac{d_q}{d_t}RC && (6)\\
\frac{d_t}{RC} &= \frac{d_q}{VC - q} && (7)\\
\int_0^t \frac{d_t}{RC} &= \int_0^q \frac{d_q}{VC - q} && (8)\\
-\frac{t}{RC} &= ln(\frac{VC - q}{VC}) && (9)\\
VCe^{-\frac{t}{RC}} &= VC - q && (10)\\
VC(1 - e^{-\frac{t}{RC}}) &= q && (11)\\
\frac{V}{R}e^{-\frac{t}{RC}} &= i && (12)\\
V_c &= V(1 - e^{-\frac{t}{RC}}) && (13)\\
V_r &= Ve^{-\frac{t}{RC}} && (14)
\end{aligned}
$$

In equations (13) and (14) $\frac{t}{RC}$ is called time constant τ.
RL and RLC circuits equations can be derived similarly.

Part List

- $R = 2.2k\Omega, 300\Omega$
- $C = 100uF$
- $L = 100uH$

Preparations Before Experiment

- Revise time derivation of $ln(f(x))$ and $e^{f(x)} functions$
- What is a capacitor and how it behaves?
- What is an inductor and how it behaves?
- Construct and analyze all circuits given in this document on a simulation program.

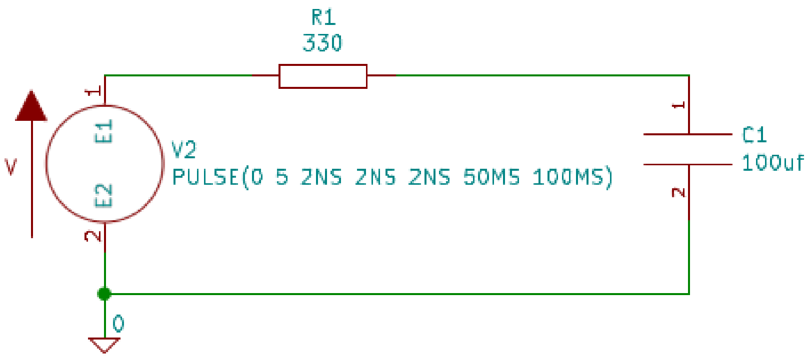
Q - What is a capacitor and how it behaves ?

A - Capacitor a passive component that stores the energy in the electric field form. When we connect voltage power source to the capacitor it will be charged up to the same voltage with source on across their plates. When we disconnect the power source it will behaves like power source.

Q - What is an inductor and how it behaves?

A - Capacitor a passive component that stores the energy in the magnetic field form. When the current is changing. It makes voltage reverse direction with magnetic field.

Figure 1: RC Circuit



Section 1

- Construct the circuit depicted in Figure 1 on the board.
- Use signal generator to generate V as 10Hz square wave.
- Connect first channel of oscillator to C_1
- Calculate time constant τ = 0.033 s
- Plot the V_c wave as seen on oscillator to Table 1.

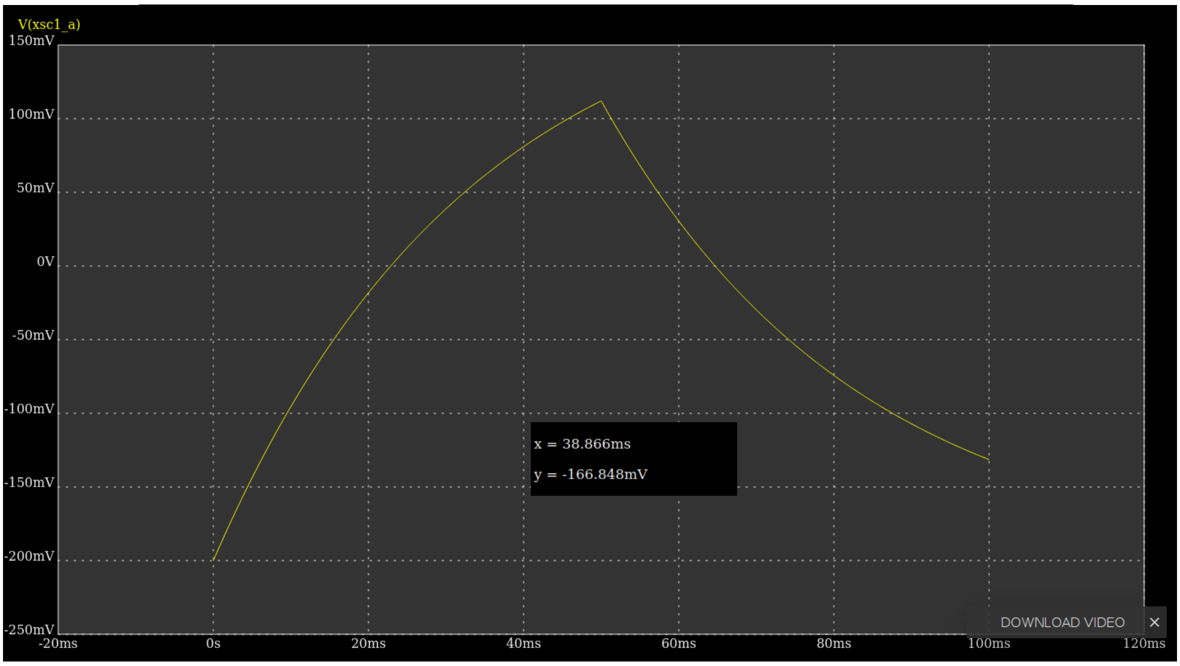
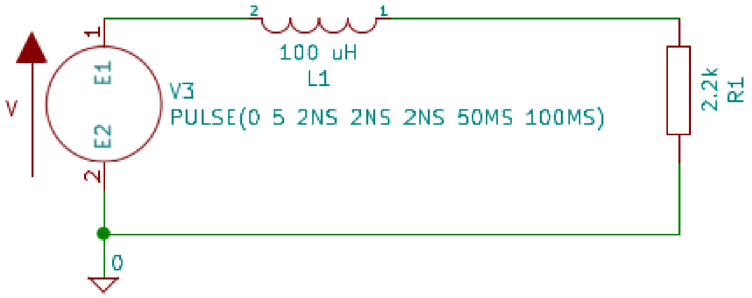


Figure 2: RL Circuit



Section 2

- Construct the circuit depicted in Figure 2 on the board.
- Use signal generator to generate V as 10Hz square wave.
- Connect first channel of oscillator to R_1
- Calculate time constant τ = 0.000000045 s
- Plot the V_r wave as seen on oscillator to Table 2.

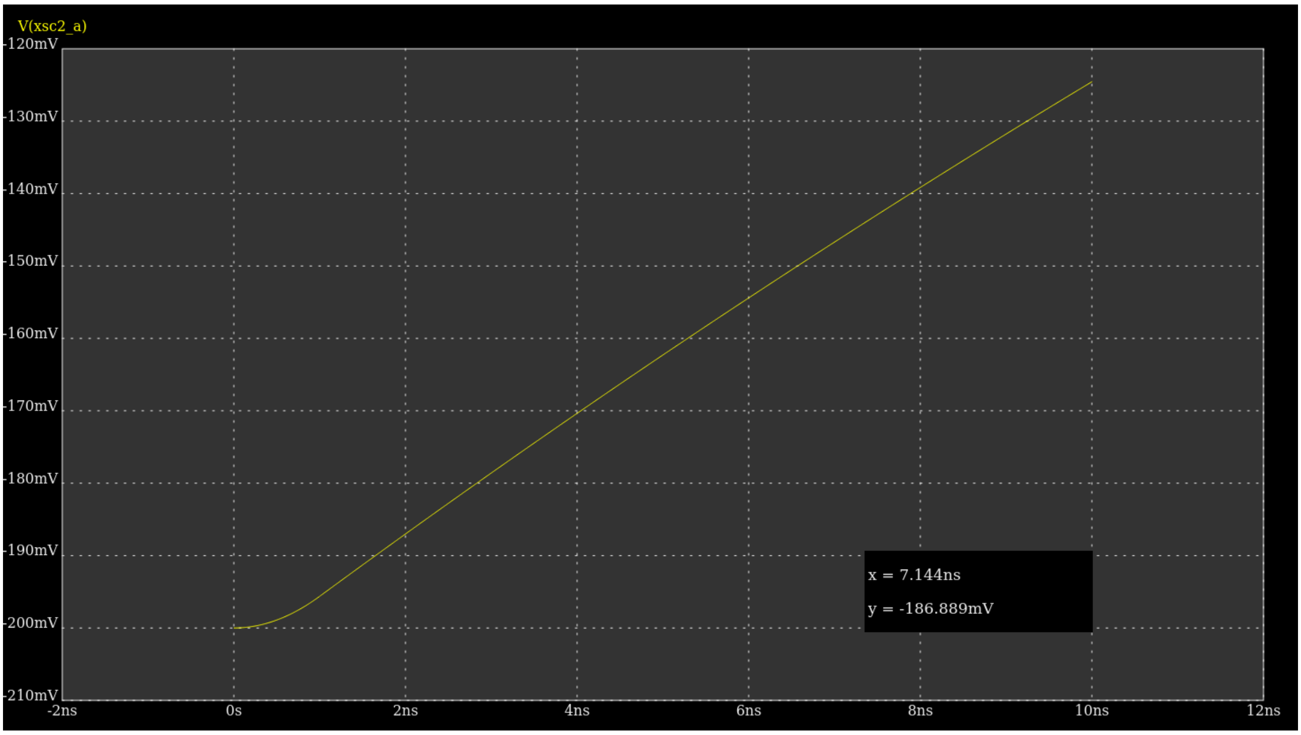
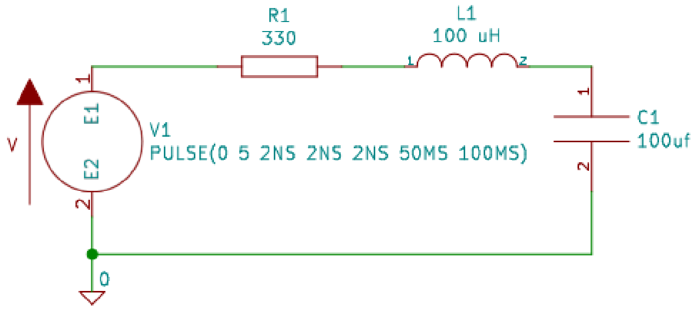
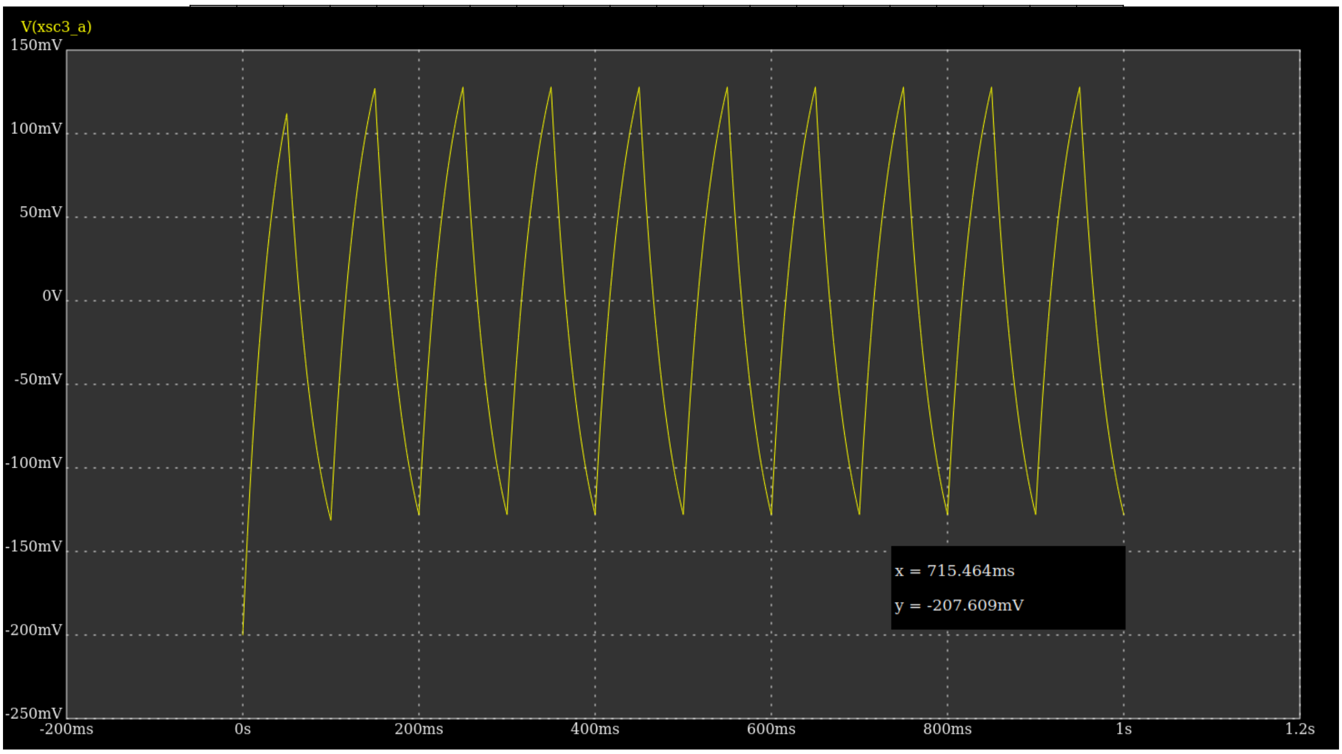


Figure 3: RLC Circuit



Section 3

- Construct the circuit depicted in Figure 3 on the board.
- Use signal generator to generate V as 10Hz square wave.
- Connect first channel of oscillator to C_1
- Plot the V_c wave as seen on oscillator to Table 3.



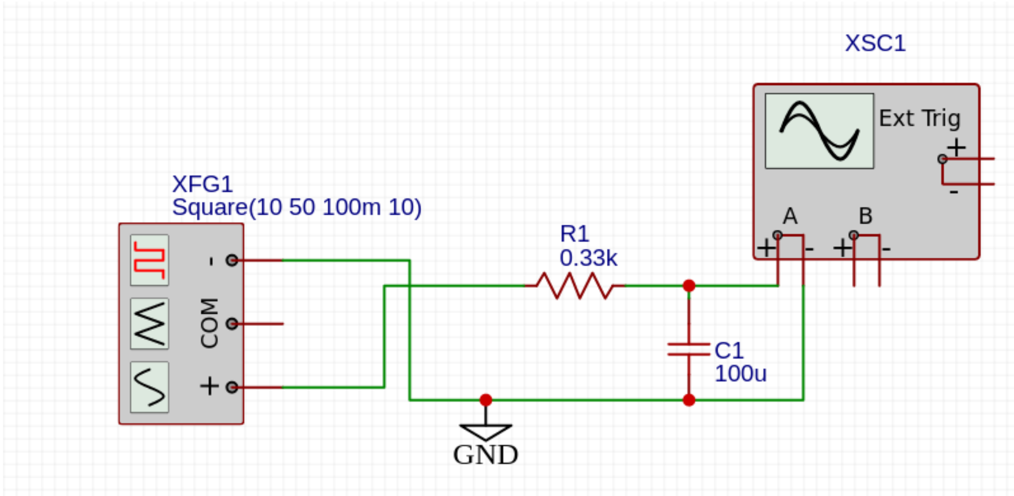


Figure 1

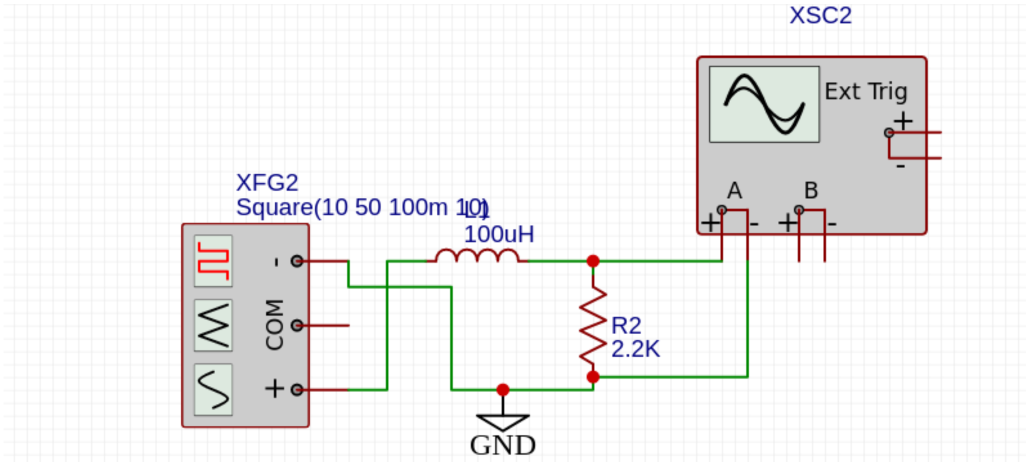


Figure 2

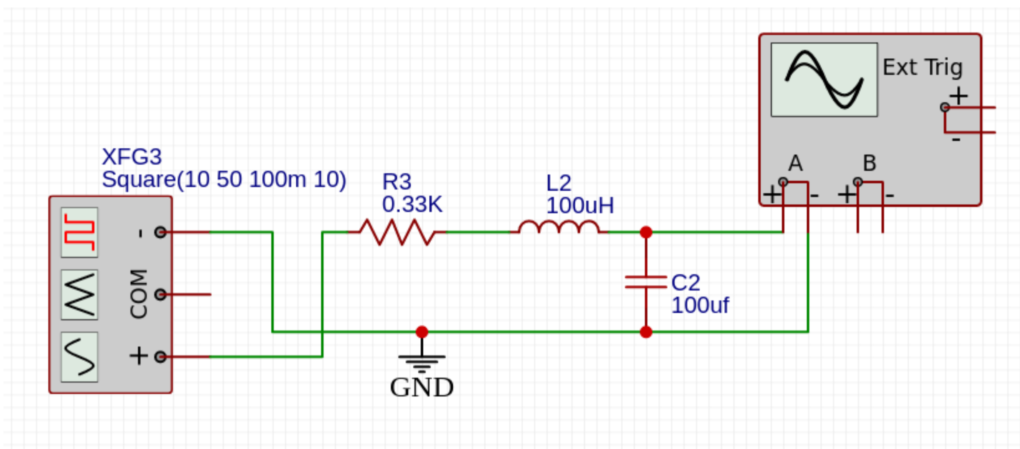


Figure 3