RC & RLC Circuit Experiment

In this experiment the students are supposed to conduct a series of RC and RLC circuit experiments and record the results. Considering the source, resistor, capacitor and inductor the students will solve analytically and numerically the response of the circuit. Afterwards, the result of the experiment can be compared with the theoretically calculated response.

The experiment videos are available online in English/Turkish. (click the link).

Part I: The circuit elements

1) The resistor:

$$R = \dots \Omega$$

2) The capacitor:

$$C = \dots F$$

3) The inductor:

$$L = \dots H$$

Part II

First experiment is the RC experiment, the resistor and capacitor are connected serially and a voltage source is connected to this circuit. The input is the voltage applied to the circuit, the output is the voltage difference on the capacitor.

In the second experiment; resistor, capacitor and inductor are connected serially and a voltage source is connected to this circuit, the input-output relation is the same as RC experiment. The instructions below should be followed for each experiment.

Record the voltage response of the capacitor based on the readings on voltmeter, and voltage divider circuit on MATLAB Simulink.

Experimental Results:

1) The voltage divider circuit seen in Figure 1 and Figure 2 will help to reduce the voltage of the capacitor between 0-5 Volts. This signal is recorded as a 10-bit digital signal. The readings are between 0 and 1023, 0 means zero volt, 1023 will mean 5 volts. The

readings are calibrated on Simulink, the source voltage and the voltage on the capacitor are recorded as a .mat file.

2) What is the settling time based on readings?
3) In order to increase the settling time, which component of the circuit must be changed? Should it be increased or decreased?
4) What is the final voltage of the capacitance?

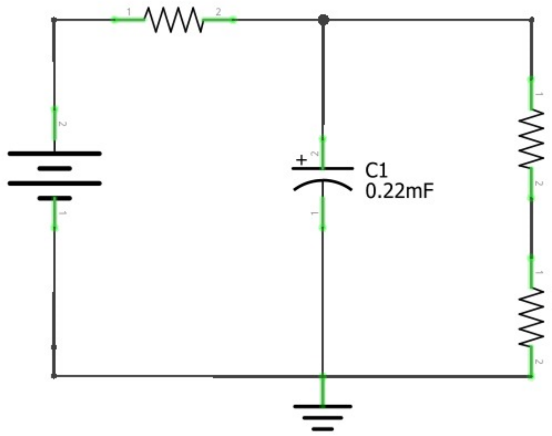

Figure 1: Circuit Schematics

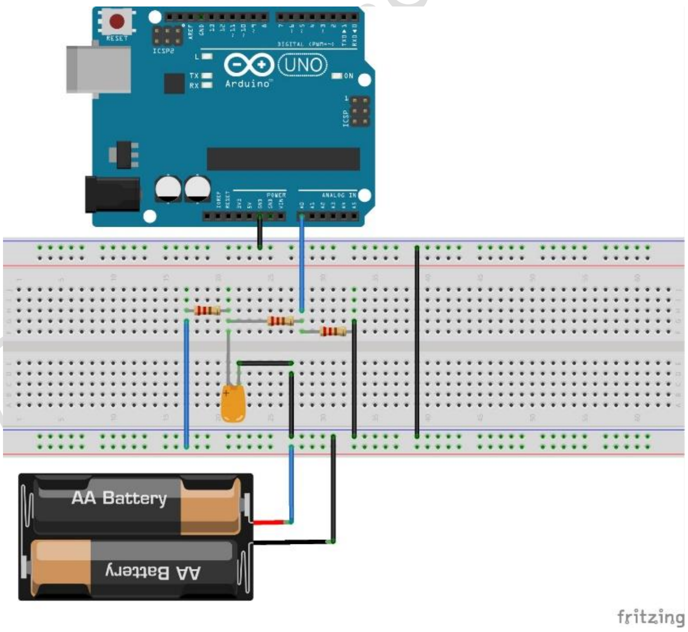

Figure 2: RC Circuit with Voltage Divider and Arduino

Numerical Calculations:

1) What is the differential equation representing the system? Classify the equation.
2) Solve the differential equation analytically using the values of the circuit elements (V, R, C) in the previous section.

3) Solve the differential equation numerically (You can use MATLAB or other tools).
4) What is the calculated time constant of the system?
5) What is the calculated settling time of the system?

Comparison:

1) Do the responses (numerical, analytical, experimental) match? Show your results graphically. Please plot all the data in one plot and add legend to the numerical, analytical and experimental data and for the voltage source, like in Figure 4.
2) Is there any difference between the settling times? What is the amount of the difference?

Additional Information on the RC Circuit Analysis:

The serially connected RC circuit can be represented as a first order ODE. The corresponding ODE is:

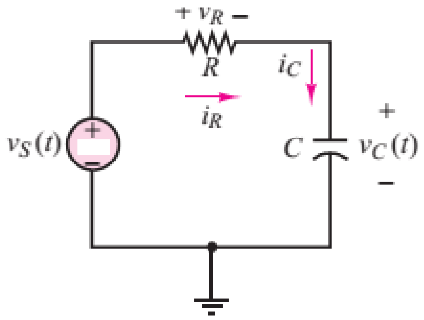

Figure 3: RC Circuit Representation.

$$\frac{dv_c}{dt} + \frac{1}{RC} v_c = \frac{1}{RC} v_S$$

Possible outcome of a RC circuit can be found in the Figure 4.

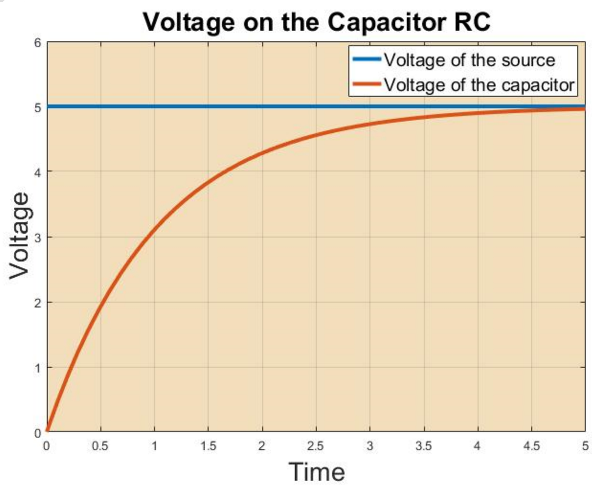

Figure 4: Voltage on the Capacitor of a RC Circuit.

However, the response of the system may change with the values of R and C.

Additional Information on the RLC Circuit Analysis:

Serially connected RLC circuits are represented by a second order ODE

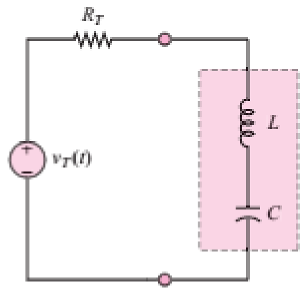

Figure 5: RLC Circuit Representation

The ODE representing the system is as follows:

$$\frac{d^2 v_c(t)}{dt^2} + \frac{R_T}{L}\frac{dv_c(t)}{dt} + \frac{1}{LC}v_c(t) = \frac{1}{LC}v_T(t)$$

Possible outcome of RLC circuit can be seen in Figure 6.

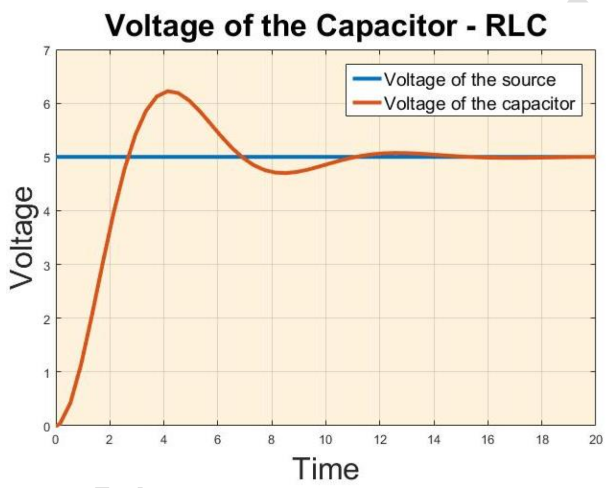

Figure 6: Voltage on the Capacitor in a RLC Circuit.

However, the response of the system may change with the values of R, L and C.

In the scope of this set of experiments the students are expected to graphically present the measurements and the calculated response (analytical, numerical solutions) of the system to verify the mathematical model.

Please follow the instructions below.

- Read this document in detail.
- Watch these video series, in English/Turkish. (click the link)
- The data related to the experiment will be uploaded to the Ninova, after the experiment. (Each group should use the data corresponding to the number of their group. In data folder, you can find README.txt file which contains the numerical values of the circuit elements.)
- Solve the circuit by using circuit analysis laws. Find the response of the capacitor, both analytically and numerically.
- Plot all the data in one figure, experimental data and numerical/analytical solutions.
- Explain about the lab setup and the devices, instruments that are used, briefly.
- Answer all the questions asked in this document. (For example; What is the calculated time constant of the system?)
- In your report please include the names and student numbers of the students in the group, the name of the lecturer in the cover page. **Only one member** of the group should upload the report to Ninova.

The lab TAs are:

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