Electric Circuits I
Laboratory 5: RC Circuits

Objective:

- In this laboratory you will learn the meaning of the time constant of a simple RC circuit and measure the output of the same circuit in each of two different configurations.

Introduction

A circuit with a resistor and a capacitor in series is more popularly known as a first-order resistor-capacitor circuit (RC circuit). Such circuit is driven by a voltage or current source. The circuit's response to a step function is defined by the RC time constant:

$$\tau = RC \tag{1}$$

Laboratory Procedure

Part A

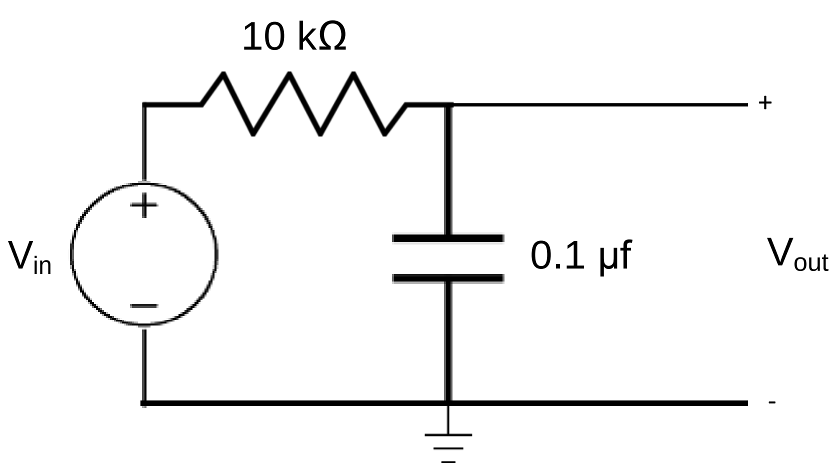

Fig. 1. RC circuit

1. Build the circuit on the ELVIS breadboard using a resistance box for the resistor.

2. Set V_{in} = 1V.

3. Measure the voltage and current across the capacitor using the DMM. Save results.

4. Set V_{in} as a periodic step function with the following settings:
   a. Wave type: Square Wave
   b. Frequency: 50 Hz
   c. Amplitude: 1 V

5. Measure the voltage output across the capacitor using the oscilloscope. Save the output.

6. Measure the time constant by determining the time at where the voltage across the capacitor increases to ~63% of its maximum value. Compare with theoretical time constant.

7. Repeat steps 5 and 6 with a resistor value of 100 kΩ instead of 10 kΩ, and change frequency to 5 Hz. Save the output. Compare the time constant of the circuit with the 10 kΩ resistor with the time constant of the circuit with the 100 kΩ resistor. Note the ratio of the two time constants.

8. Change the resistor value back to 10 kΩ and frequency back to 50 Hz. Change the V_{in} wave type to a sinusoidal wave, and vary slowly the frequency from 50 Hz to 1 kHz. Observe the output across the capacitor while varying the frequency. Save the output at 1 kHz.

Part B

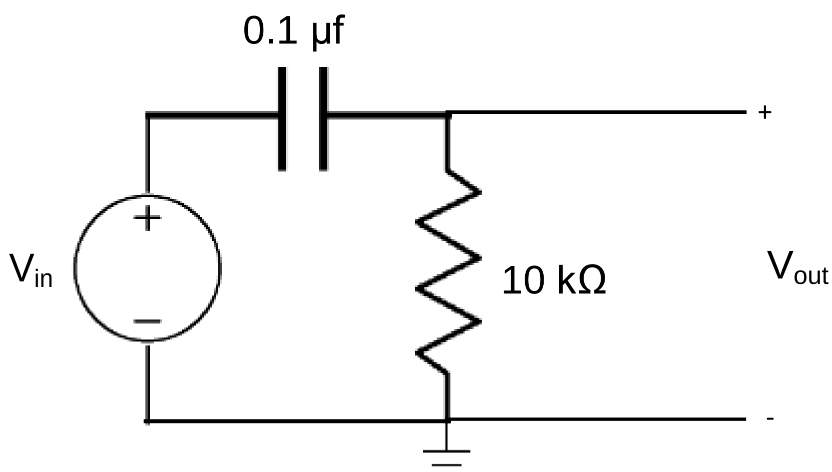

Fig. 2. RC circuit.

1. Repeat steps 4-6 from **part A** for this circuit for a V_{in} frequency equal to 50 Hz, but measure the voltage across the resistor instead of the capacitor.

**For measuring the time constant, observe the time it takes for the voltage drop across the resistor to go to 37% of its initial value.

4. Change the resistor value from 10 kΩ to 100 kΩ, and change the frequency to 5 Hz. Observe the output across the resistor. Save the output. Measure the time constant of the circuit by

determining the time at where the voltage across the resistor drops to ~37% of its original value. Compare this time constant with the previous time constant. Note the ratio of the two.

5. Change the resistor value back to 10 kΩ and frequency back to 50 Hz. Change the V_{in} wave type to a sinusoidal wave, and vary the frequency from 50 Hz to 1 Hz. Observe the output across the resistor. Save the output at 1 Hz.

Pre-Lab

1. Calculate the RC time constant of the circuit in **Fig. 1** using equation (1).
2. Derive expressions of $V_{out}(t)$ for circuits in **Figs. 1 and 2**.
3. Sketch your derived results for $V_{out}(t)$, clearly labeling your initial voltages and time constants.

Laboratory Report

1. Include all measurements, computations, and answers to questions from the laboratory procedure. Clearly label all steps

2. Make a table showing the theoretical and measured time constants of the first circuit with respect to the different resistor values. Also include the percentage error.

$$\%error = \frac{\tau_{measured} - \tau_{theoretical}}{\tau_{theoretical}} \text{ x } 100\%$$

3. Include all voltage and output graphs.

4. A high-pass filter is a filter that only passes signals with a high enough frequency, while a low-pass filter is a filter that only passes signals with a low enough frequency. With respect to how V_{out} is defined in the two circuits, determine which one is a high-pass filter and which one is a low-pass filter.