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ELEN 50L – 47347
F: 2:15 - 5:00 pm
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Lab #5: RC Circuits

1. **Objectives**

a. Learn about time constant τ in RC circuit.
b. Measure the output of the same circuit in each of two different configurations.

2. **Laboratory Procedure**

Part A:

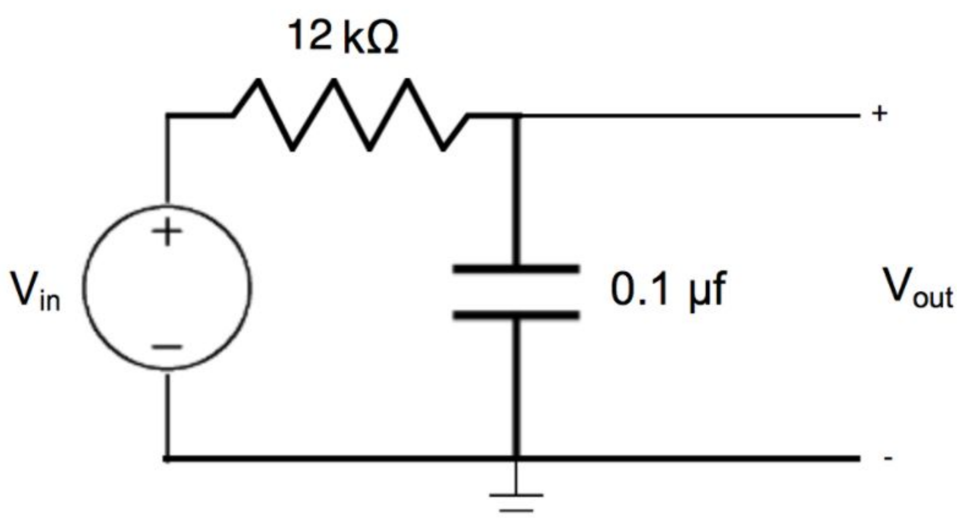
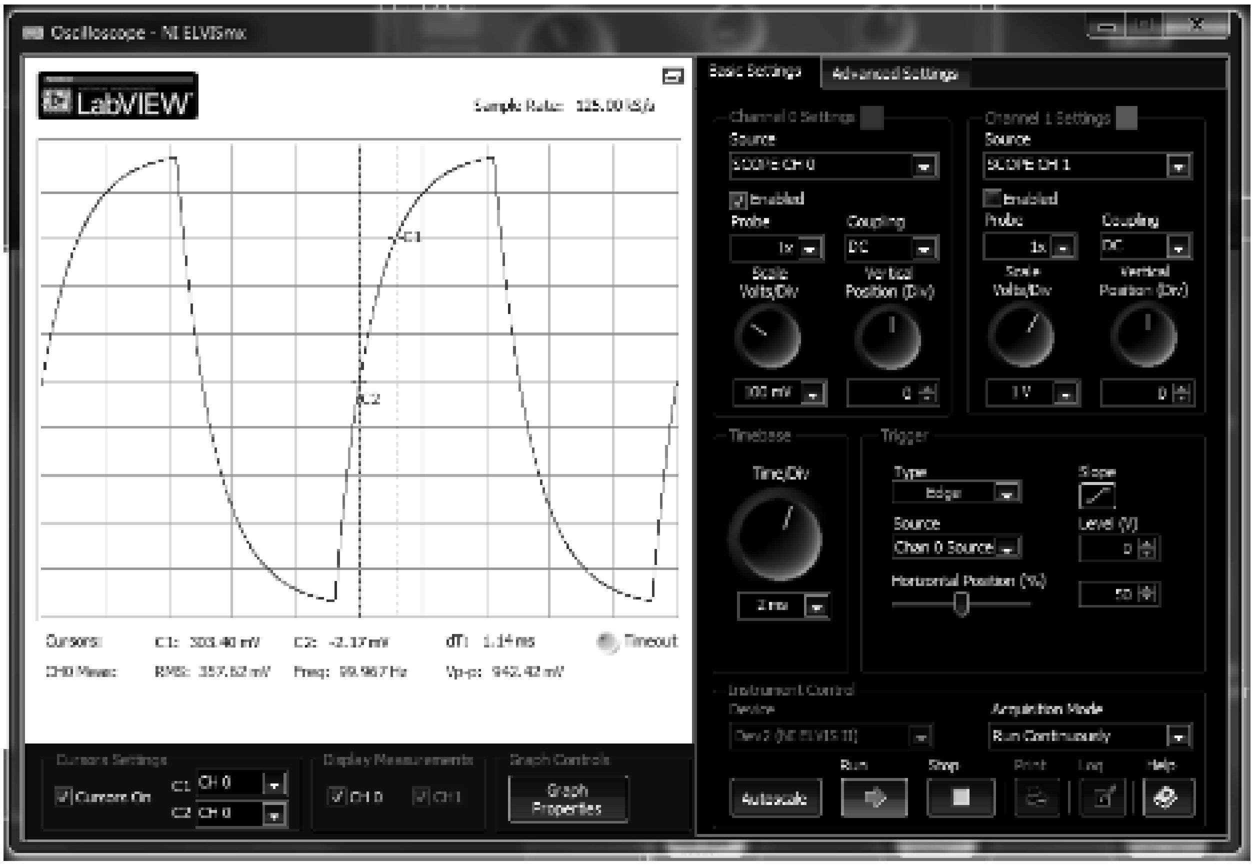


Fig. 1. RC circuit

Step 1: Build the circuit shown in Figure 1.
Step 2: Set V_{in} = 1V.
Step 3: Measure the voltage and current across the capacitor using the DMM. Save results.
V = 1.0001V
C = 0.0981μF
I = 0.03mA
Step 4: Set V_{in} as a periodic step function with the following settings:

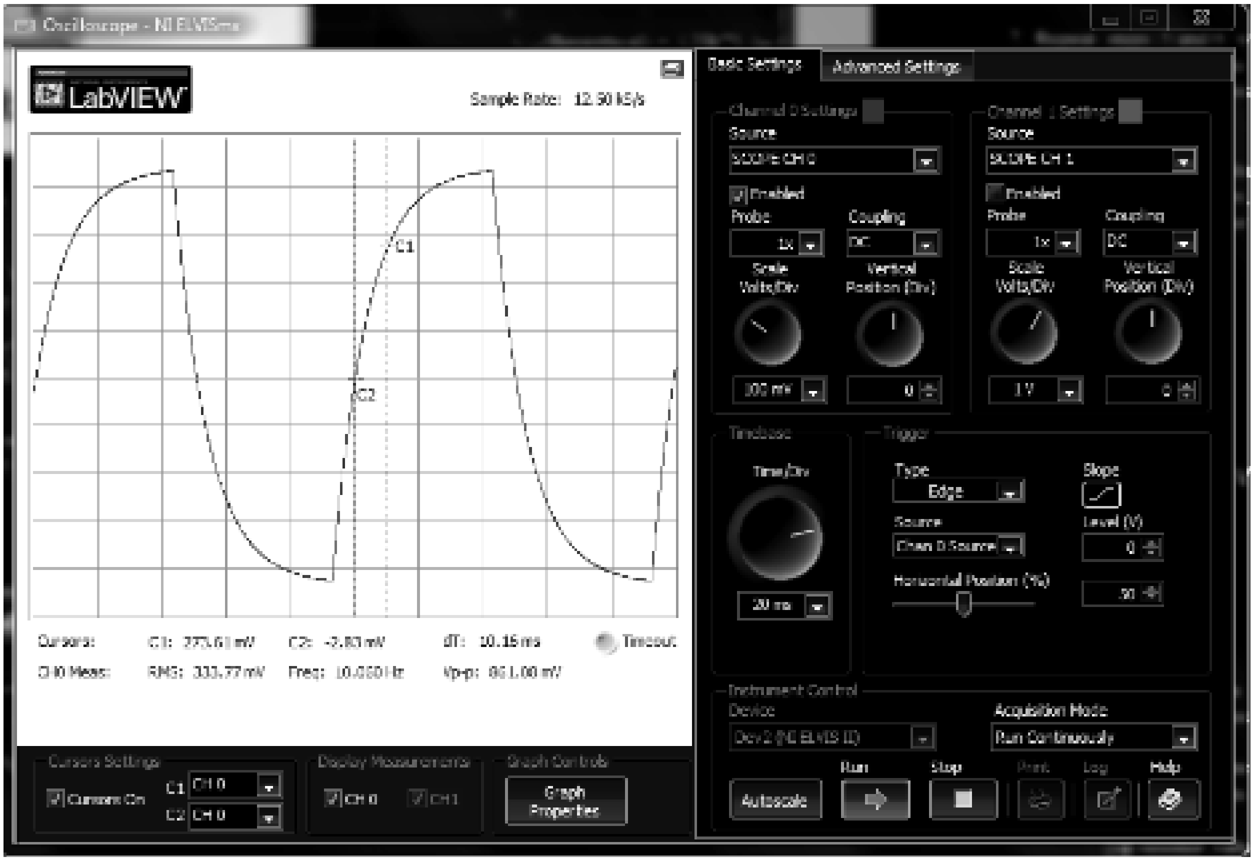
a. Wave type: square wave
b. Frequency: 100 Hz
c. Amplitude: 1V

Step 5: Measure the voltage output across the capacitor using the oscilloscope. Save the output.
V = 0.445V



Step 6: Measure τ by determining the time at where the voltage across the capacitor increases to ~63% of its maximum value.
63%V = 0.299V
τ_{12}(experimental)= $11.4*10^{-4}$s
τ_{12}(theoretical)=12k*0.1μ = $12*10^{-4}$s
The experimental value that we get is only 5% off. The results are pretty close.

<u>Step 7:</u> Repeat steps 5 and 6 with a resistor value of 120kΩ, and change the frequency to 10Hz. Compare τ_{12} with τ_{120}. Note the ratio of the two time constants.



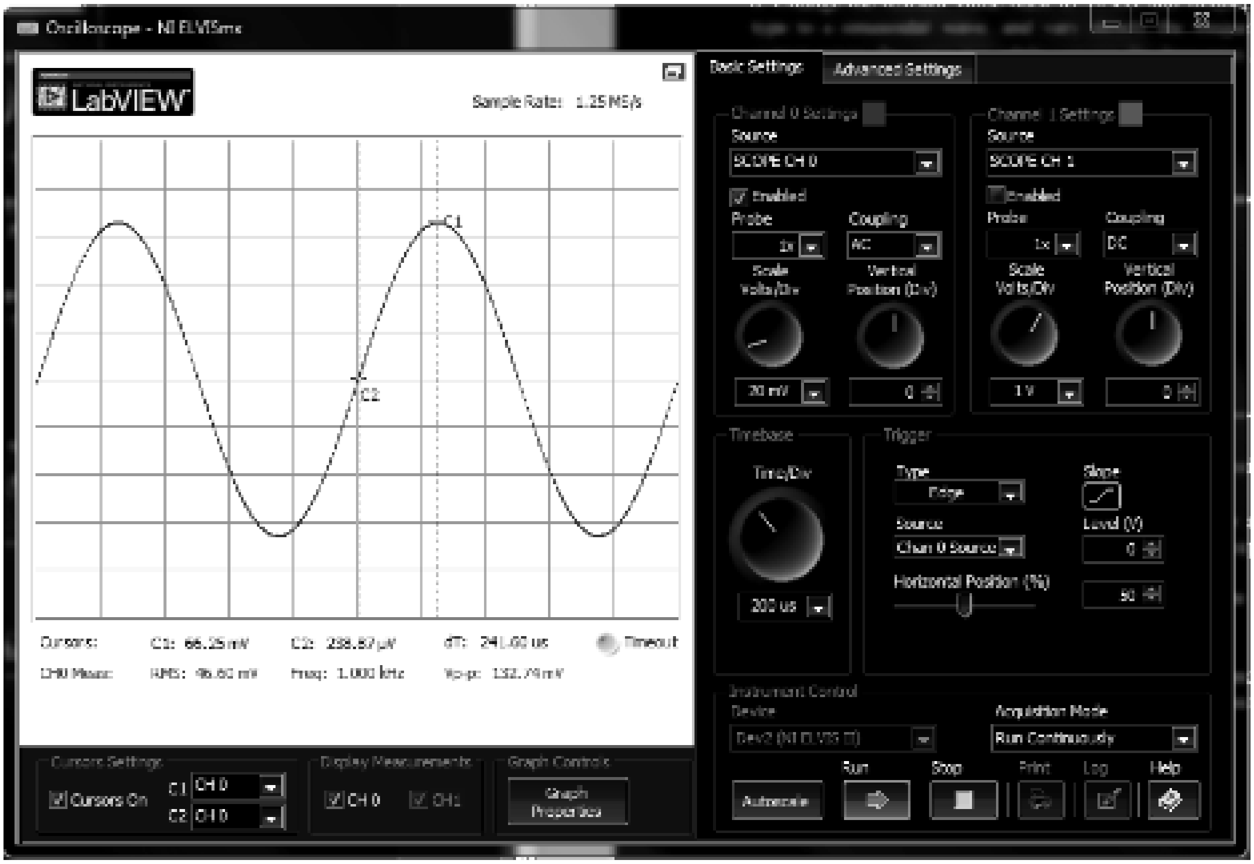
We are comparing the time constants at 63% of the maximum values.

τ_{12}(experimental)= $11.4*10^{-4}$s

τ_{120}(experimental)= $10.16*10^{-3}$s

ratio = $\tau_{120}/\tau_{12} = 8.912$

Step 8: Use 12kΩ and 100 Hz. Change the V_{in} wave type to a sinusoidal wave, and vary slowly the frequency from 100Hz to 1kz. Save the output at 1kHz.



By increasing the frequency, the graph's amplitude is decreasing and the period is decreasing, which means that it is not passing a high frequency wave. Therefore, this circuit is a low pass filter.

Part B:

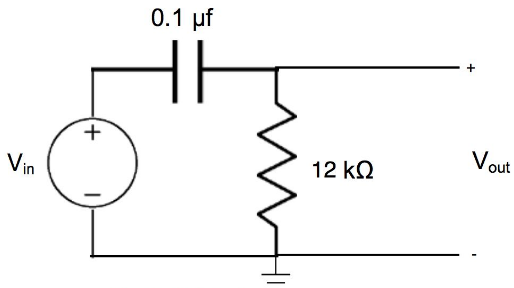


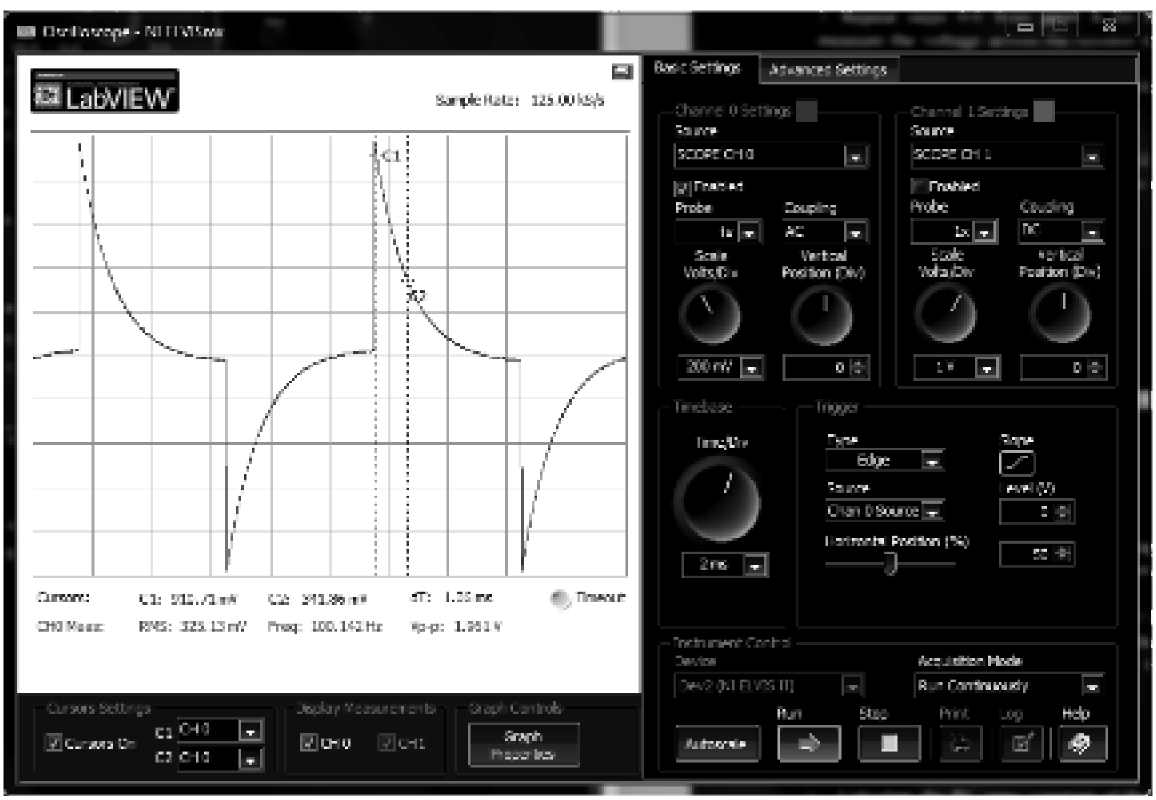
Fig. 2. RC circuit.

Step 1: Set V_{in} as a periodic step function:

a. Wave type: square wave
b. Frequency: 100Hz
c. Amplitude: 1V

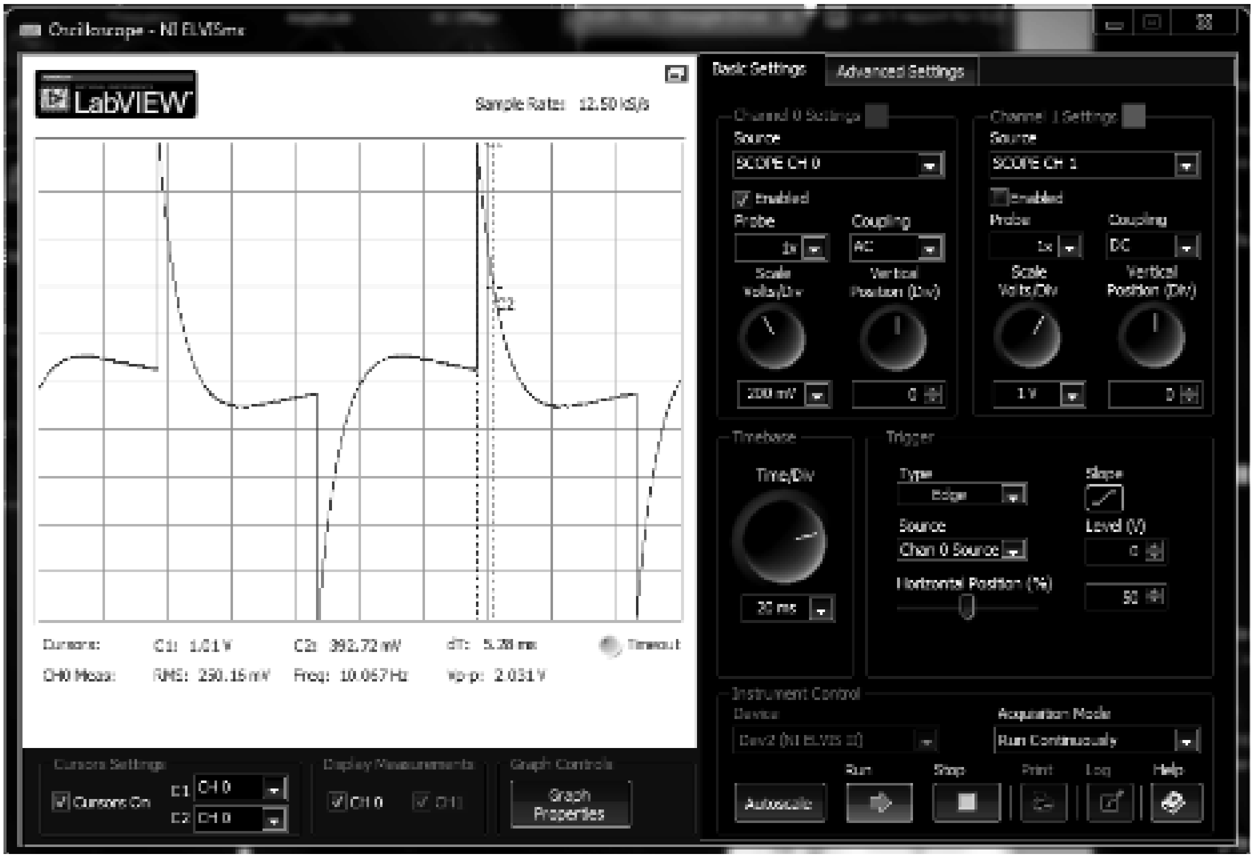
Step 2: Measure the voltage output across the resistor using the oscilloscope. Save the output.
V = 0.950V

Step 3: Measure the time constant 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.



τ_{12}(experimental)=$1.06*10^{-3}$s
ratio= 9.30

Step 4: Use 120kΩ and 10 Hz. Observe the output across the resistor. 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.

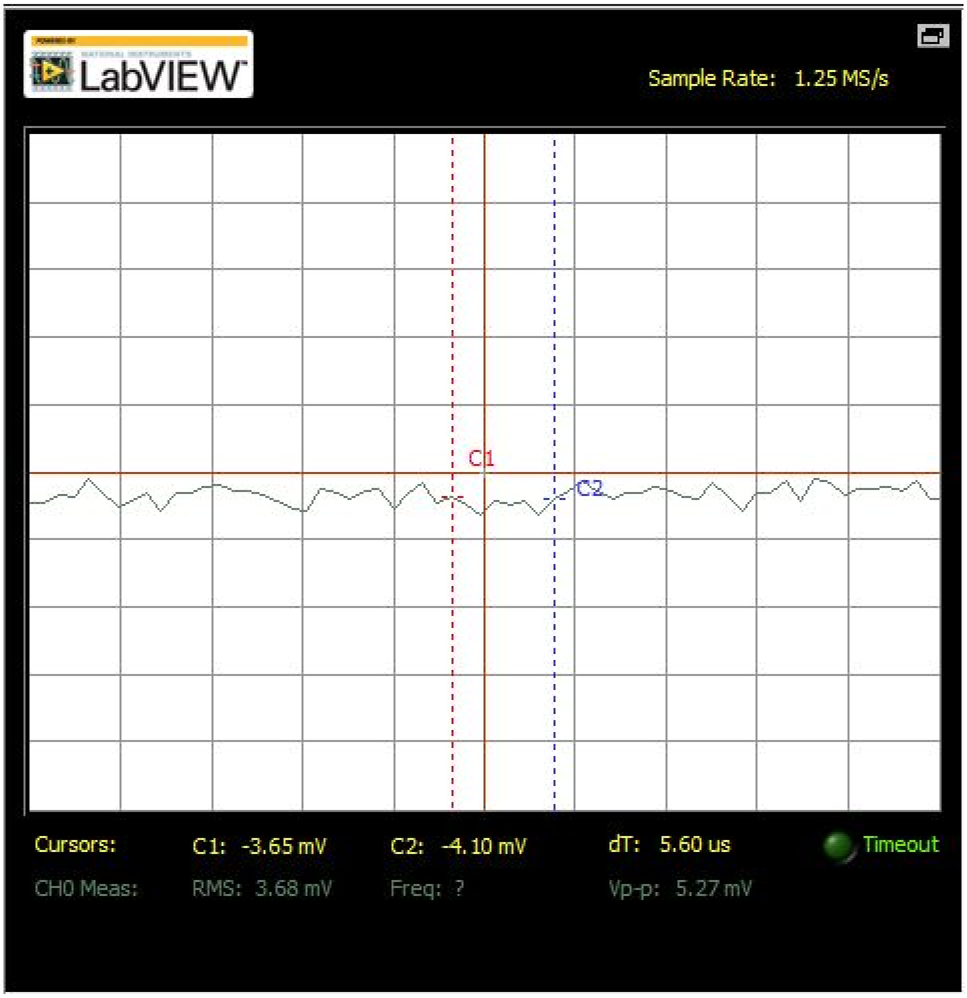


τ_{120}(experimental)= $5.28*10^{-3}$s

ratio= $\tau_{120}/\tau_{12} = 4.981$

The theoretical ratio should be about 10, yet we get only half of it. Since we have already switch to another breadboard, we guess this off may due to the capacitor.

Step 5: Use 12kΩ and 100 Hz. Change the V_{in} wave type to a sinusoidal wave, and vary the frequency from 100 Hz to 1 Hz. Observe the output across the resistor.



Amplitude slightly decreases. Period increases.This circuit is acting like a high pass filter because it attenuates low frequencies.

3. Observation and Analysis

When low-pass filter is blocking or weakening the high frequencies, high-pass filter will block/weaken the low frequencies, and only letting the high frequencies through. Going through the initial phase of finding a wave from the capacitor, we noticed that the oscilloscope did not produce the wave that we were expecting, and we had to switch our original ELVIS board for a better one. Furthermore, in Step 4, we noted a puzzling phenomenon where our time constant ratio only produced around 5, when we were expecting a ratio of 10 because the resistor value changed from 12k Ohm to 120 kOhm. We believe this is due to a defect in either the capacitor or variable resistor.

4. Questions

Questions are answered in the respective sections.

5. Conclusions

In this lab, we learn how to assemble simple low-pass filter and high-pass filter with capacitor and resistor. We also learn what the time constant of a simple RC circuit is. Furthermore, we calculated the time constants using the oscilloscope and cursors, which enhanced our knowledge of the capabilities and functionalities of the ELVIS system. Additionally, we were able to observe how voltages drop across RC circuits depending on the orientation of the resistor and capacitor.