ECE 541: Electric Circuits

Laboratory Exercise #4
Introduction to RC Circuits
Weeks of 11/7 (Group A) and 11/14 (Group B)

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Objectives

In this lab, we will experimentally validate the natural and step responses of the RC circuit. We will also investigate the phase shift of the RC circuit.

Procedure

1.1. Resistor-Capacitor (RC) Circuit

- Set up the circuit shown in Figure 1.
- Adjust the signal generator to produce a square wave of 0 V to 1 V at 1 kHz. Connect the output of the signal generator to V_1.
- Connect the channel 1 and 2 probes of the oscilloscope to the input (V_1) and output (V_2), respectively.
- Based on the oscilloscope, sketch at least 1 period of the waveforms of V_1 and V_2 on the same graph. Label each waveform.

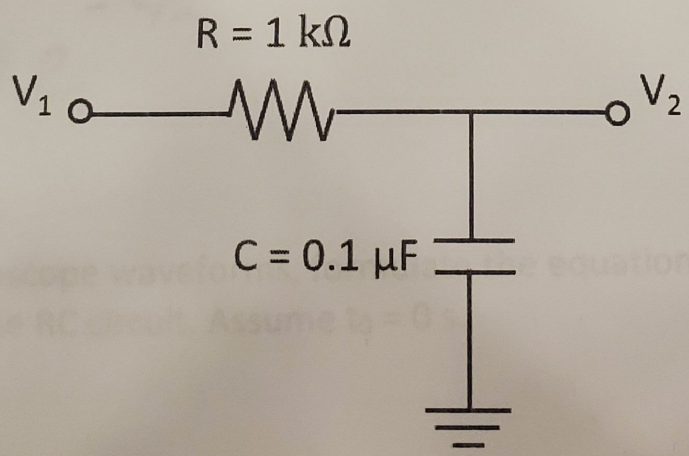
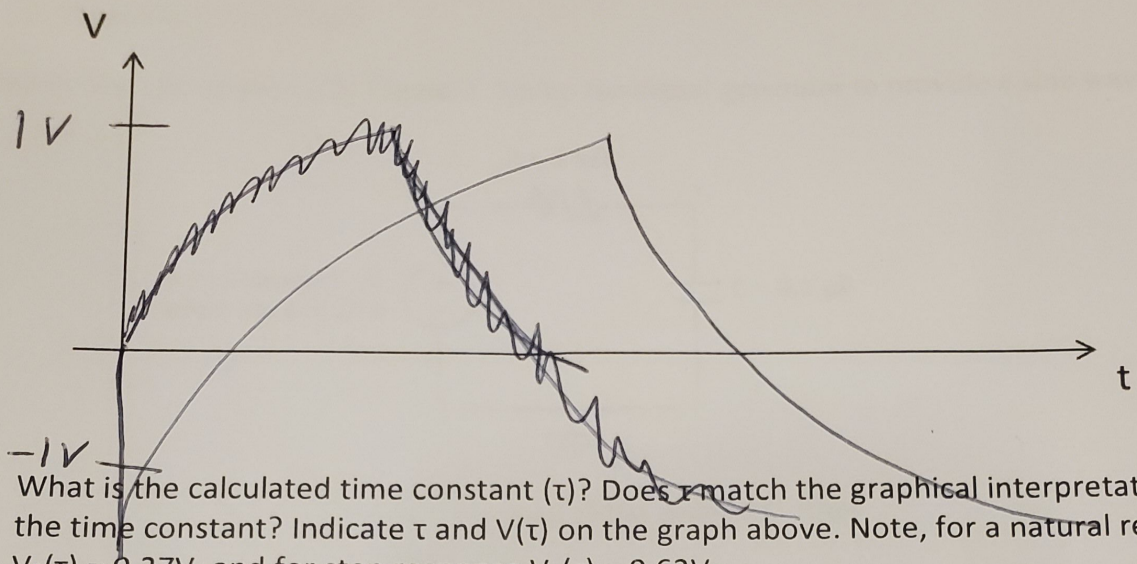


Figure 1: An RC Circuit



- What is the calculated time constant (τ)? Does τ match the graphical interpretation of the time constant? Indicate τ and V(τ) on the graph above. Note, for a natural response, $V_2(\tau) = 0.37V_0$ and for step response $V_2(\tau) = 0.63V_0$.

$\tau = 0.0001$ seconds $= 1k \times 0.1\mu F = 0.1 \times 10^{-3} S = 100\mu S$

$\Delta V(\tau) = (1.96)(0.37) = 0.7252$

- Based on the oscilloscope waveforms, formulate the equation for $V_2(t)$ describing the Natural Response of the RC circuit. Assume $t_0 = 0$ s.

$-1.04e^{-t/2}$

- Based on the oscilloscope waveforms, formulate the equation for $V_2(t)$ describing the Step Response of the RC circuit. Assume $t_0 = 0$ s.

$1.96 + (-1.04 - 1.96)e^{-t/2}$

TA's Signature: _____

1.2. Measuring Phase Shift

- Set up the circuit shown in Figure 2. Set up the signal generator to provide a sine wave.

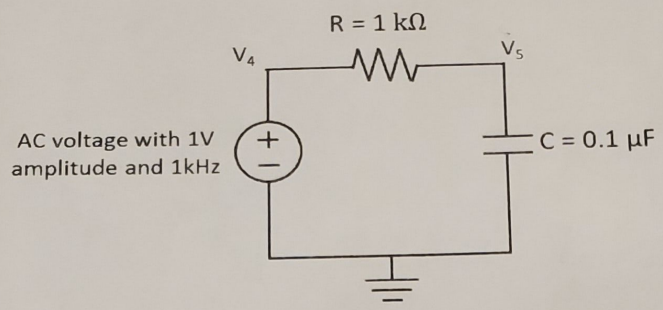
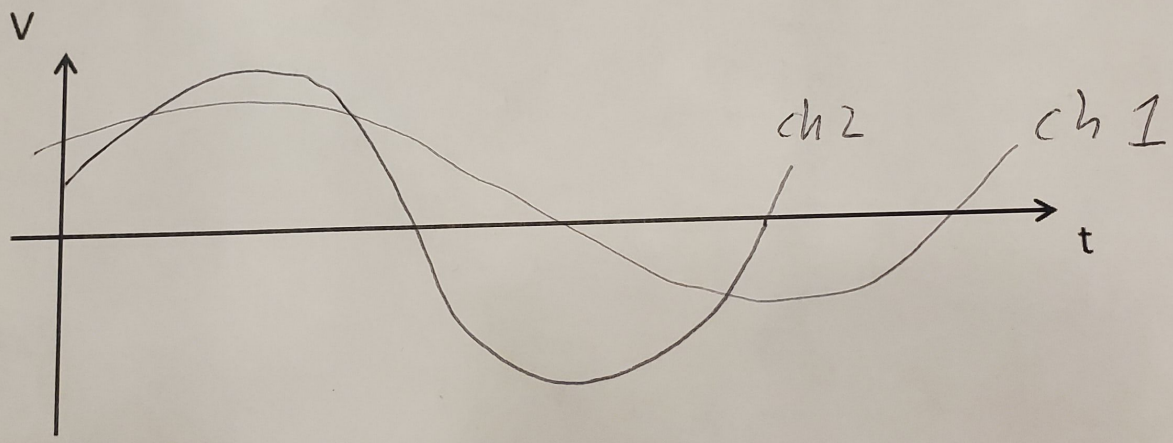


Figure 2: First order RC filter

- Connect channel 1 of the oscilloscope to node V4 and channel 2 to node V5. Set up the oscilloscope to display both channels 1 and 2.
- Draw both waveforms on the axis below. Clearly indicate which waveform is V4 and V5. Indicate time scale on x-axis and voltage magnitude on y-axis.



- Find the phase difference between the input signal (channel 1) and the voltage at node V5 (channel 2).

Phase shift at node V5 relative to node V4: -34.2°

Note: Phase Shift (degrees) = $\frac{\Delta t}{Period} \times 360°$

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