EECE 2150 - Circuits and Signals: Biomedical Applications

Lab 9

Introduction to RC Circuits in the Time and Frequency-Domains

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Part 1. Transient Signals with an RC Circuit with Square Waves

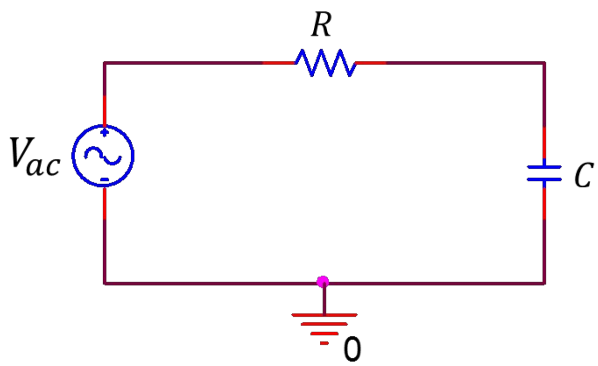

Figure 1. Simple RC circuit for Part 1.

1.1 Connect your function generator to a $20\,k\Omega$ resistor in series with a $0.1\,\mu F$ capacitor as in figure 1. Set your function generator to produce a $1\,V$ amplitude square wave to charge and discharge the capacitor through the resistor. Using the function generator, add a DC offset of 1V so that the square wave switches between $2\,V$ and $0\,V$. Make sure the function generator is set to high Z.

1.2 What frequency should you use to observe the exponential decay behavior discussed in class? Hint: consider your ***R and C*** values, and the exponential ***decay constant*** **τ**. You will want at least 10-times this τ value between on-off cycles so that you can see the capacitor fully charge and discharge. Set up your function generator to produce this ***square wave***.

1.3 Use the oscilloscope to measure the voltage across the capacitor. Be sure to use the correct time-axis (horizontal control) to observe the decay effect, i.e. to “zoom” into the decay part of your square wave.

1.4 Calculate the time constant τ from your waveform. Think about it, recall that $V_c(t)=V_0 e^{\frac{-t}{\tau}}$. If you find a time and a voltage, you can calculate τ. Hint - the x and y cursors are useful for this measurement. **Q1**: What is τ, and is this consistent with what you expect from your circuit and what we discussed in class?

Part 2. A Simple RC Circuit with Sine Waves

2.1 Use the same circuit and set your function generator to produce an input signal of $1\,V$ amplitude sine wave with a frequency of $80\,Hz$. Verify that you have the correct signal by measuring it on your oscilloscope (using a BNC-BNC cable). Set the function generator to High Z.

2.2 Measure the output voltage across the capacitor using the other channel of the oscilloscope. Compare the input and output sine waves at 80 Hz. **Q2:** How do they compare in magnitude? **Q3:** How do they compare in phase (remember that the phase is an angle, in either radians or degrees, and that a whole cycle of the sine wave is 2π radians)? Work your way up in frequency from 80 Hz and record results for 100, 1000, and 10000 Hz. Then work down to 10, 1, and 0.1 Hz. (Hint – be careful about using auto scale at the lowest frequencies – you may get unexpected results.) Record your results in a table. We will study phasor-domain analysis in the coming weeks that will allow us to explain these results. **Q4**: For now, what happens to the phase and amplitude as you go up in frequency? Down in frequency? Figure 2 shows an illustration of how the phase difference is related to the time difference between two identical points on the waveforms.

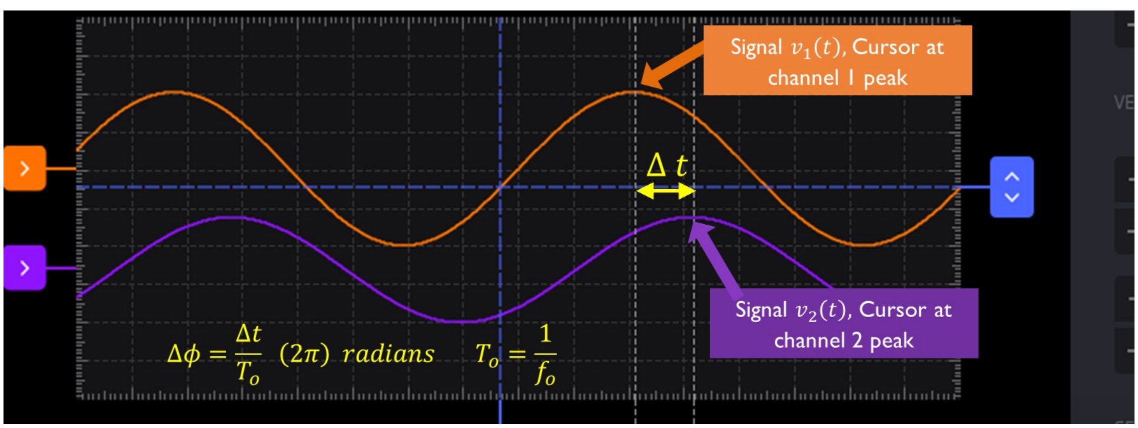

Figure 2 Illustration of the relationship between the phase difference and the time difference between the peak values on the two wave forms. The input signal is displayed on channel 1 and the output signal on channel 2. f_o is the fundamental frequency of the input signal. The figure shows the output on channel 2 to be lagging the input which results in a negative phase difference

Part 3 - For the Write-Up.

Please follow instructions for writing lab reports available on Canvas

IMPORTANT: BEFORE YOU LEAVE THE LAB:

- **a.** Place all the components that your removed from the red toolbox back in that box and return it to the cabinet that houses them
- **b.** Collect all used components and wires from your bench and place them in your group's reusable plastic container. If you are not going to use these components or wires again, please discard them in the trash bin located in your lab room.
- **c.** Turn off all the equipment you have used on your workbench.
- **d.** Make sure you return your protoboard, the equipment wires and your reusable container to the front window.
- **e.** Make sure to have your notebook signed by an instructor or TA before you leave the lab.

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Last modified: I. Salama, 8/23/2021 N. McGruer, 2/16/16; M.Niedre 8/10/15,