ECE 332 Lab 3v

RC Circuit

Lab 2s was a simulation of the time-domain response of a simple RC circuit. In that lab, you used Multisim to simulate the operation of the circuit and from that simulation, you measured the time constant. In this lab, you will build the circuit and measure the time constant that the actual circuit elements provide.

This lab requires your laptop, just like the previous one did. Although you'll be testing a circuit made with actual circuit elements-a resistor and a capacitor-you'll be doing this with virtual instruments rather than instruments in boxes on your lab table. These virtual instruments will be displayed on your laptop computer via the National Instruments' myDAQ interface. The myDAQ box will provide the electrical signal to test the circuit and receive electrical data from that circuit to display on your laptop.

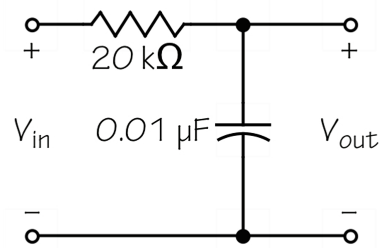

Figure 1: RC Circuit

This lab is also your introduction to the virtual instruments of myDAQ that will be displayed on your laptop.

Goals

This lab has two goals that are very similar to the previous lab:

- Observe the actual response of an RC circuit made up out of real circuit elements.
- Learn to use two of the virtual instruments provided by the myDAQ interface.

Introduction

The circuit for this lab is the RC circuit of Figure 1, the same circuit you built by simulation in Lab 2s. As before, our interest is in the time-domain response of this circuit. We will be measuring just one parameter, the time constant of the RC circuit.

Procedure

There are six steps in in this lab:

- Build an RC circuit on a protoboard, which you will sometimes hear called a breadboard.
- Connect the terminals of myDAQ to your circuit.
- Set up a virtual Function Generator to provide the input voltage for your RC circuit.
- Set up a virtual Oscilloscope to observe the time response of your RC circuit.
- Adjust the Oscilloscope to display a good exponential and measure your RC circuit's time constant.
- Calculate the actual value of the capacitance.

A. Build the RC Circuit

Figure 2 shows the construction of the actual circuit. The breadboard shown is a way of easily connecting circuit elements. There are two important facts to remember about these breadboards:

- The five holes in any vertical column are all connected together as shown by the red box of Figure 2. These five are not connected to any other holes in the board. Therefore, each group can represent one node of a circuit.

- All of the holes in one line along an edge of the board are all connected. There are four such strings that are completely independent.

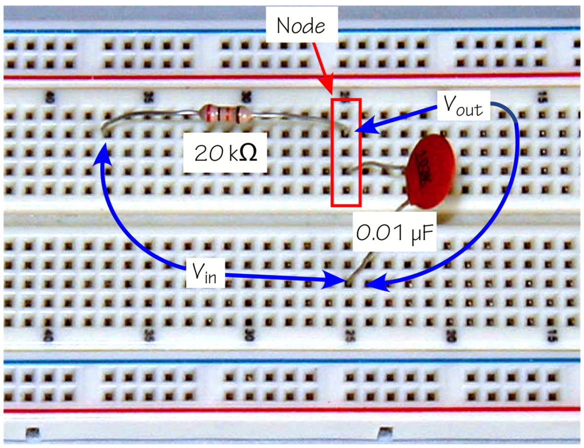

Figure 2: Breadboard Layout

Proceed as follows:

1. Located a 20-kΩ resistor (red-black-orange). Be sure it is really 20 kΩ by checking with an ohmmeter.

2. Stake it into your breadboard between two separate nodes as shown in Figure 2.

3. Locate a 0.01 μF capacitor, which should be be labeled '103'. Capacitors are labeled in an odd fashion. 103 means *10 times ten-to-the-three picofarads* which is 10,000 pF or 0.01 μF.

4. Stake the capacitor into the board with one end in the same node as one end of the resistor and the other end in a node below the gutter of the board as shown in Figure 2.

Your circuit should look like the circuit in Figure 2 and should have the same physical layout as the circuit diagram of Figure 1.

B. Connect myDAQ to Your Circuit

myDAQ will provide the input voltage V_{in} to your circuit via a pair of terminals labeled $AO0$ and $AGND$. It will observe the output voltage V_{out} via terminals $AI0+$ and $AI0-$. Note these terminal labels are designed to confuse mortals with combinations of zeros and ohs and eyes and ones. Look carefully at what you are doing. Figure 3 shows the completed connections.

1. Connect V_{in} from myDAQ by clipping $AO0$ (a yellow lead) to the left end of the resistor and $AGND$ (black) to the bottom end of the capacitor.

2. Connect V_{out} to myDAQ by clipping $AI0+$ (red) to the node where the resistor and the capacitor join, and the $AI0-$ (yellow) to the bottom end of the capacitor.

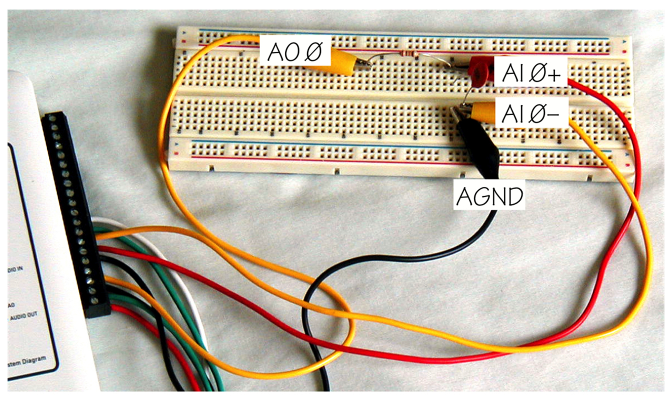

Figure 3: myDAQ Connections

3. Connect myDAQ to your computer with a USB cable. If you have installed *Elvis* correctly, you should see a strip of virtual instruments appear on your screen in approximately 10 seconds. The blue LED on myDAQ should light. If the light is on but the instrument strip is missing or inactive, reference the course website. The Laboratory Exercises document library has a file called Problems with myDAQvs.doc. This should help. If not, seek assistance.

   On some machines, the instrument stripe will not appear. To get it, go to the start menu and click All programs. In the National Instruments folder is a subfolder called NI Elvismx for NI Elvis & NI myDAQ. In this subfolder is an icon called NI Elvis Instrument Launcher. Click on this.

4. Check your work against the picture in Figure 3.

C. Collect Data and Calculate R and C

The Function Generator will provide a square wave to drive your RC circuit just as you did using Multisim. It needs a lot of settings as shown in Figure 4.

1. Click FGEN in the **instruments** stripe and position the Function Generator to the left of your screen.
2. Click the square-wave button.
3. Frequency = 250 Hz.
4. Amplitude = 5 V_{pp}.
5. DC Offset = 0 V (should already be).
6. Duty Cycle = 50% (default value).
7. Ignore Sweep Settings
8. Signal Route is $AO0$ by default.
9. Your setup should look like Figure 4. Click Run (green arrow) to start.

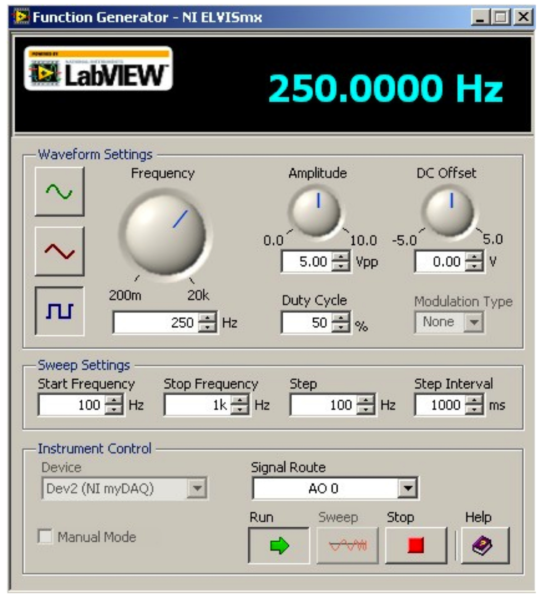

Figure 4: Function Generator Setup

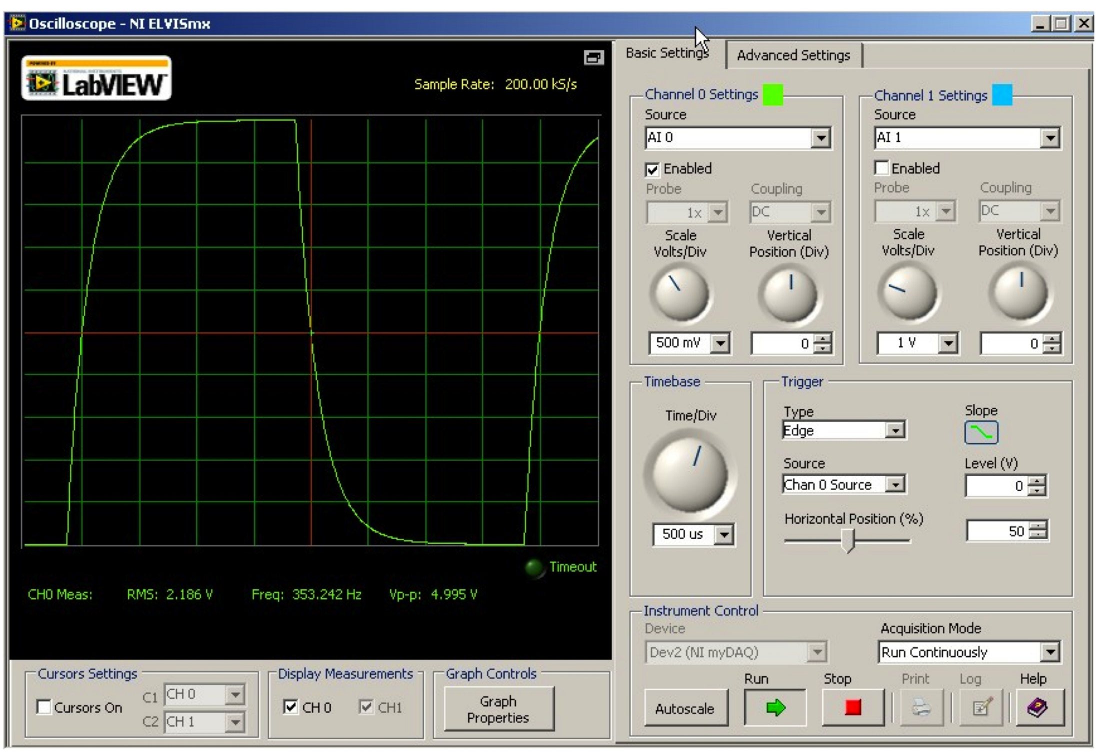

Figure 5: Scope Initial Setup

D. Set Up the Oscilloscope

The Oscilloscope will do the same job as the simulated scope did in the last lab. It needs a lot of adjusting, as shown in Figure 5.

1. Click Scope in your virtual instrument list.
2. For Channel 0 Settings:
   a. Source = $AI0$.
   b. Check Enable.
   c. Scale Volts/Div = 500 mV.
   d. Vertical Position = 0 (default).
3. Time/Div = 500 μs (note micro).
4. For Trigger:
   a. Type = Edge.
   b. Click the Slope button for downward-going.
   c. Source = Chan 0 Source.
   d. Level = 0 V.
   e. Horizontal Position (%) = 50.
5. Click run. The scope should look like Figure 5.

E. Measure the Time Constant of your Circuit

Before we begin measuring, we need to get a better scope picture for measuring. It's a general rule, when using a scope for measurement, that you make the important part of the trace occupy as much of the screen as you can. You do this to get the best precision for your data. Before we measure the time constant, we are going to adjust the scope for a better trace. Don't get concerned if the scope seems to misbehave while you are doing this–it should all work out correctly in the end.

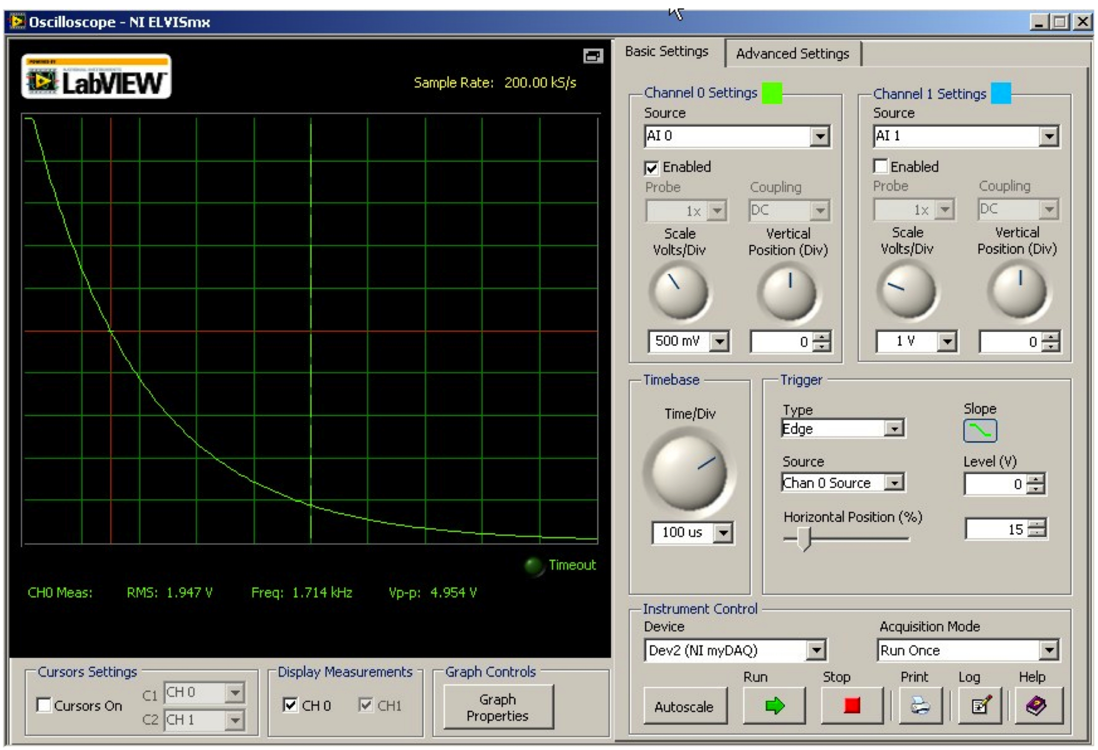

Figure 6: Scope Setup for Time Constant (τ)

1. Change Time/Div = 100 μs, which will make the scope flicker.
2. Adjust Horizontal Position (%) to get a clean exponential that starts at the upper left. 15% will be right. The result should look like Figure 6 and will probably be

flickering.

3. Change **Acquisition Mode** from **Run Continuously** to **Run Once**.

4. If the trace vanishes, click Run until you get a trace like that in Figure 6.

5. Turn **Cursors On** (bottom left corner).

6. Set both C1 and C2 to CH 0.

7. The cursors are both hiding on the left edge of the screen. Drag them out where you can get hold of them.

8. Postion C1 at the start of the downward slope of the exponential. Figure 7 shows the cursors properly positioned.

9. Position C2 at the landing level of the exponential on the far right edge.

10. Read and record on the hand-in page the two cursor voltages shown at the bottom of the screen:

    a. C1 yields $V_{initial}$.

    b. C2 yields V_{final}.

11. The equation for this exponential is:

$$V_{out} = V_{final} + (V_{initial} - V_{final})e^{-t/\tau}$$

12. Recall the time constant is the time it takes for the exponential's level to reach 1/e of its starting value. Calculate V_{tc} by substituting $t = \tau$ into the equation for the exponential.

13. Move cursor C2 so the voltage shown for it is as close to V_{tc} as you can get, as shown in Figure 8.

14. At the bottom of the screen, the value labeled DT is the time difference between C1 and the C2 cursors. Record it–this is your time constant.

F. Calculate C

Recall the time constant $\tau = RC$. Knowing τ and R enables us to calculate the capacitance.

1. Disconnect myDAQ from your RC circuit.

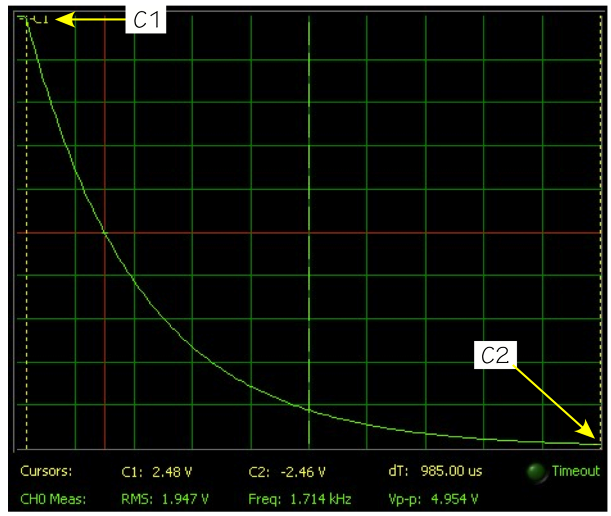

Figure 7: Cursor Initial Positions

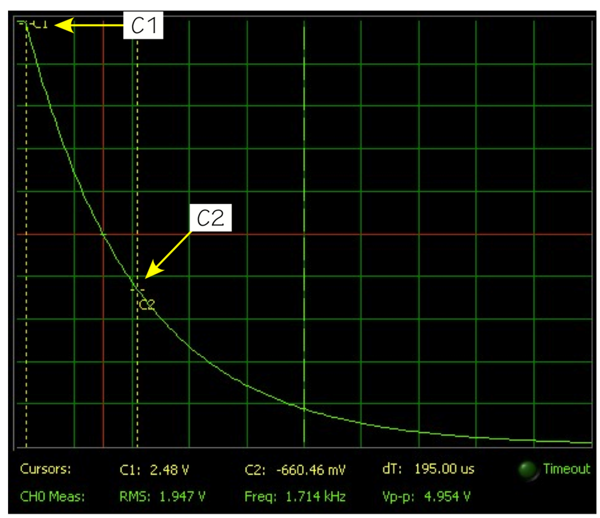

Figure 8: Measuring τ

2. Use the digital multimeter (DMM) on your bench to measure and record the actual resistance of the 20 kΩ resistor.

3. From the measured values of τ and R, calcualte and record C.

The End

Let's look at the goals and see if we met them. We've learned to use two of the virtual instruments available through myDAQ and we've used them to measure the time-constant of the RC circuit from Lab 2s. That's what we set out to do.

In future labs in this course, you'll be using Multisim to simulate a circuit and myDAQ to test what you've simulated. These are two rather standard steps in the design of a new circuit. First, simulate to check out the design to find major problems. Then build and test the circuit under laboratory conditions where the circuit elements are now real. The next step would be to build the production prototype to prove the design before making lots of them.

Report of Lab 3v Results

Name ___________________________________

Show Calculations! Show Units!

Measurement of Time Constant:

$V_{initial}$ __________________ V_{final}__________________ Calculated V_{tc}__________________

Measured τ __________________

Calculated of Capacitance

R = __________________ Calculated capacitance = __________________