

ECE-205 Lab 2

Introduction to Mobile Studio

Throughout this lab we will focus on the use of the Mobile Studio board for measuring the response of first and second order circuits. Our goal is to become familiar with some of the features of this board and how to use it. We will also continue to introduce some Matlab programming.

The end result of this Lab will be a memo written to me that includes the figures you generated using either Mobile Studio or Matlab. Each figure needs to have a figure number and a caption. The body of the memo should be fairly short (less than one paragraph). Do not reiterate what you did in the lab, but tell me what parts of the lab were confusing, what you liked and what you didn't like.

PART 1

1) Obtain a $1 \mu\text{f}$ capacitor and a $1 \text{ k}\Omega$ resistor from you lab kit. Using an R/L/C meter measure the actual values for the resistor and the capacitor and record them in your memo. Your estimated time constant for your circuit should be $\tau = RC$ and you should use this value in the result of the lab. This value should be near 1 ms, but it may be up to 20% off.

2) Using a bread board construct the circuit shown in Figure 1 using your $1 \mu\text{f}$ capacitor and a $1 \text{ k}\Omega$ resistor. These components should be available in your lab kit. We will measure the output of the circuit as the voltage across the capacitor. We will be trying to estimate the time constants for this circuit as we vary the resistance. The time constant for this circuit is $\tau = RC$, and we will measure the time constant by determining the 10%-90% rise time, t_r , and using the formula

$$\tau = \frac{t_r}{\ln(9)}$$

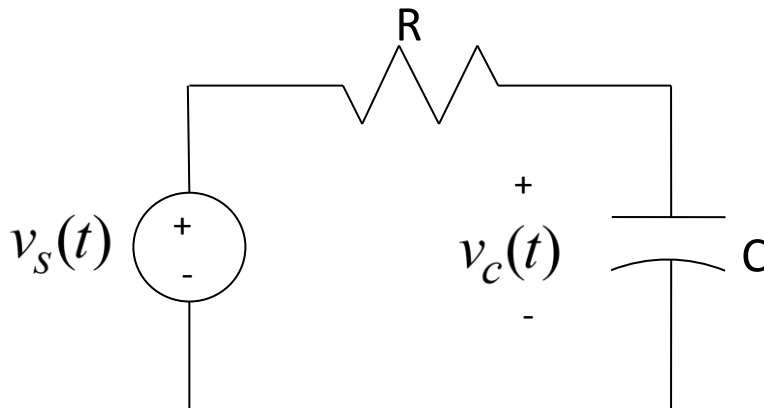


Figure 1. Circuit for PART 1.

3) The connection pins for the Mobile Studio boards are shown in Figure 2, below:

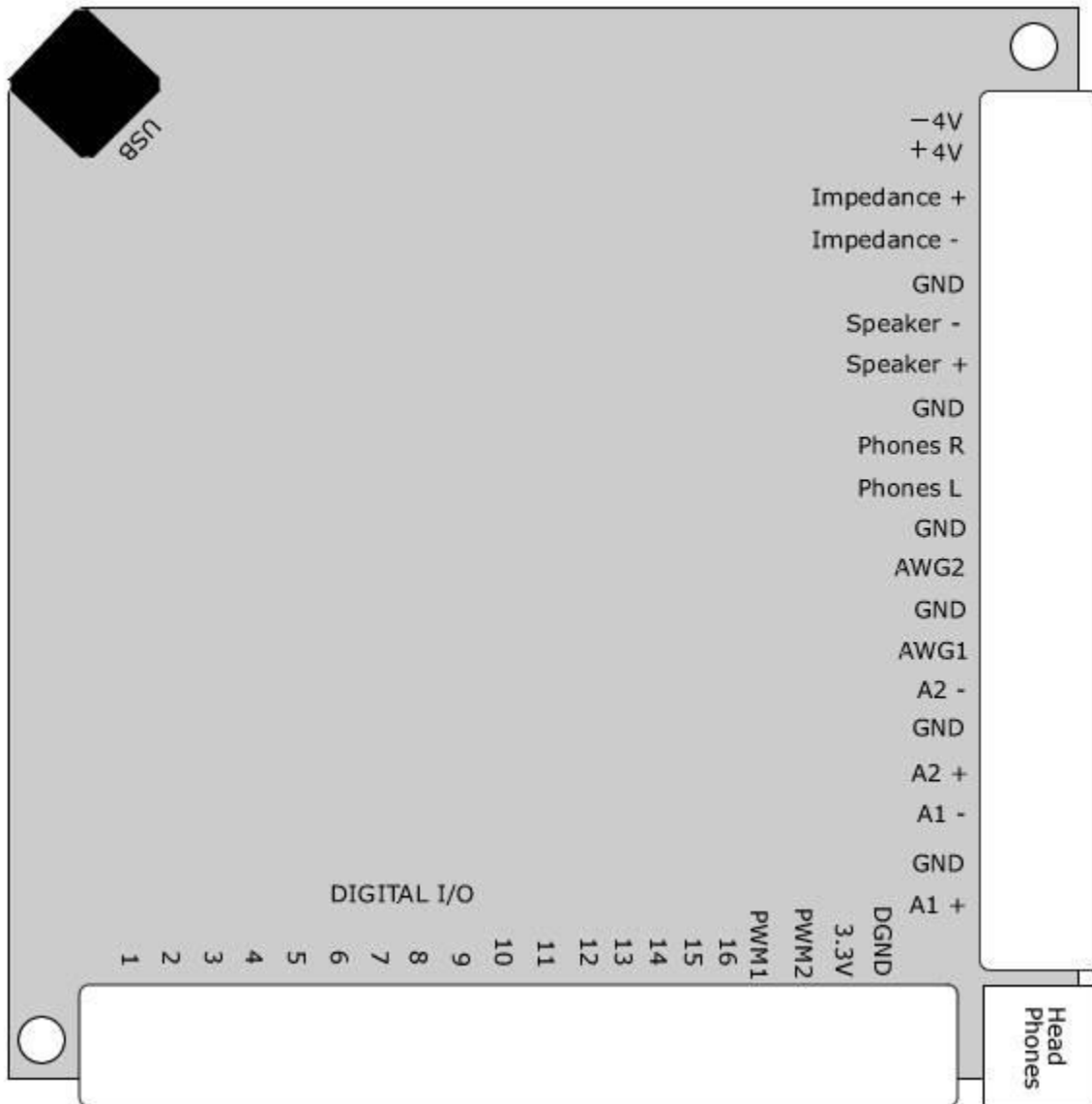


Figure 2. Mobile Studio Pinouts.

Connect the source (**AWG1**) and ground (**GND**) as the input to your circuit, and connect **A1+** to the positive end of the capacitor (where you think it will be positive) and connect **A1-** to the negative end of the capacitor. If you get these reversed you will just get an output that is the negative of what you expect.

4) Start Mobile Studio. If you cannot find the icon, use

Start → All Programs → Rensselaer → Mobil Studio Desktop → Mobil Studio Desktop

5) Start the **Function Generator**. Set channel 1 to a 50 Hz square wave, with a 0 DC offset and peak to peak value of 2.0 volts. Set channel 2 to a zero output (we will not be using it). Use the push pin to minimize the function generator once it is set.

- 6) Start the **Oscilloscope**. Set channels 1 and 2 to 500 mV/div and to **DC** coupling. Set the input on channel 1 to **A1-Diff** (this measures the voltage across the capacitor, or the difference between **A1+** and **A1-**), and the input on channel 2 to **AWG1** (the signal being generated). Be sure to **Enable** both of the channels.
- 7) Locate the right hand panel with the word **Trigger** at the top. Set the **Mode** to **Normal** and the **Source** to **Ch2**. On the left edge of the oscilloscope you will see a short segment of a red line. Hover the cursor over the line until you see a line across the screen, this is the triggering threshold. It needs to be in the middle of a well defined signal (such as channel 2). If your oscilloscope does not seem to be able to lock onto a signal, be sure to check your triggering level. (You may also want to play with changing the trigger to the Falling or Rising edge of a signal).
- 8) Lower down in the same column you will find controls for the **Horizontal** scaling. In this panel set the **Time/Div** to 2.00 ms and the **Mode** to Y-T.
- 9) Start the system, by clicking on the **Start/Stop** button in the lower left of the screen. You should get a scope that looks more or less like Figure 4: a capacitor charging and then discharging repeatedly. Note that your screen may not look exactly like this, depending on where the triggering occurs. For example, your signal may start high and then go low.

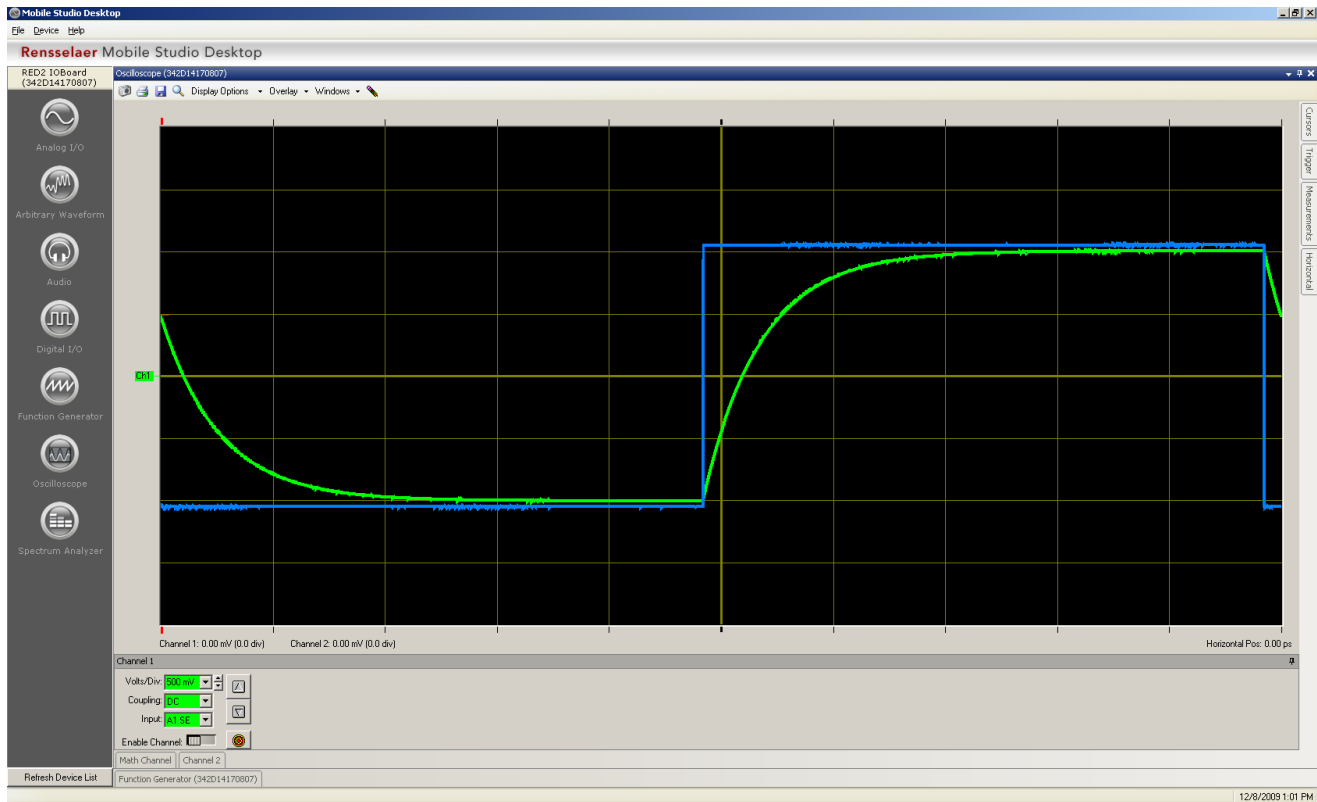


Figure 4. Typical trace for part 9.

- 10) Next we want to make measurements on our signal. On the right panel, **Enable** the cursors. We will be making measurements on channel 1, so you will need to find the **green** cursors. You may find them in the middle of the screen, or lurking just at the edges. *The measurements are taken from the location of the special symbols on the cursors.* See the bottom of the cursor panel for the shape of these symbols.

11) Align one of the cursors at the top of your output signal, and the other at the bottom of your output signal. The difference of these two cursors will be displayed in the **Cursors** panel (under **Delta**). The output signal should be around 2 volts peak to peak. Let's assume you measured the peak to peak value as Δ , so we have $ch1_high - ch1_low = \Delta$. Then align one of the cursors at an amplitude of $ch1_low + 0.1 \Delta$, and the other at an amplitude of $ch1_high - 0.1 \Delta$, this will give us a measure from 10% to 90% of the signal. Now look again at the Delta for this signal, but look at the absolute value of the time difference. This should be the rise time, t_r . Using this rise time, compute the time constant using the formula

$$\tau = \frac{t_r}{\ln(9)}$$

Your time constant should be very close to the time constant you computed in step 1 for this circuit. Compute your percent error, and if it is more than 15% off ask for help. Record your work computing your error and include it in your memo.

12) Next we want to capture a screen shot to put into your memo. Near the top left corner of the oscilloscope is a **camera icon**. Click on the camera icon to save a screen shot to a file. Then (***right now!***) include this screen shot in your memo for this lab. Do not wait to see if it all worked out! Put in a figure number and an appropriate caption.

Part 2

We are now going to repeat the above procedures for two different time constants. Hopefully you will get more of a feel for what a time constant means by doing this. In what follows, *be sure your signal has reached steady state*. This means it is not changing and is basically **flat**. It should start and end flat (the slope of the signal is zero)

- 1)** Replace the 1 k Ω resistor with the variable resistor in your lab kit. One of the outside legs should not be connected to anything.
- 2)** Adjust the resistor so the time constant is **significantly smaller** than our original 1 ms time constant. Change the **Time/Div** (x-axis) so you get a reasonably good graph. You may also need to change the **frequency** of the signal generator. *You should not have more than three periods of the output waveform on the graph.*
- 3)** Go through the above steps to use the cursors to estimate the time constant, then include a screen capture in your memo. Be sure to show your work estimating these time constants in your memo.
- 4)** Adjust the resistor so the time constant is **significantly larger** than our original time constant. Change the **Time/Div** (x-axis) so you get a reasonably good graph. You may also have to change the **frequency** of the signal generator. *You should not have more than three periods of the output waveform on the graph.*
- 5)** Go through the above steps to use the cursors to estimate the time constant, then include a screen capture in your memo. Be sure to show your work estimating these time constants in your memo.

At this point you should have three graphs in your memo from the screen captures, and three time-constant estimates.

PART 3

In this part, we will look at the response of a second order circuit and how changing the damping ratio changes the characteristic of the output. The Figure 5 shows some of the important characteristics we usually measure for the step response for an underdamped second order systems. These include the Percent Overshoot (PO), the steady state value ($y(\infty)$), the Time to Peak (T_p), and the Settling Time (T_s). In this part of the lab we are mostly interested in the percent overshoot.

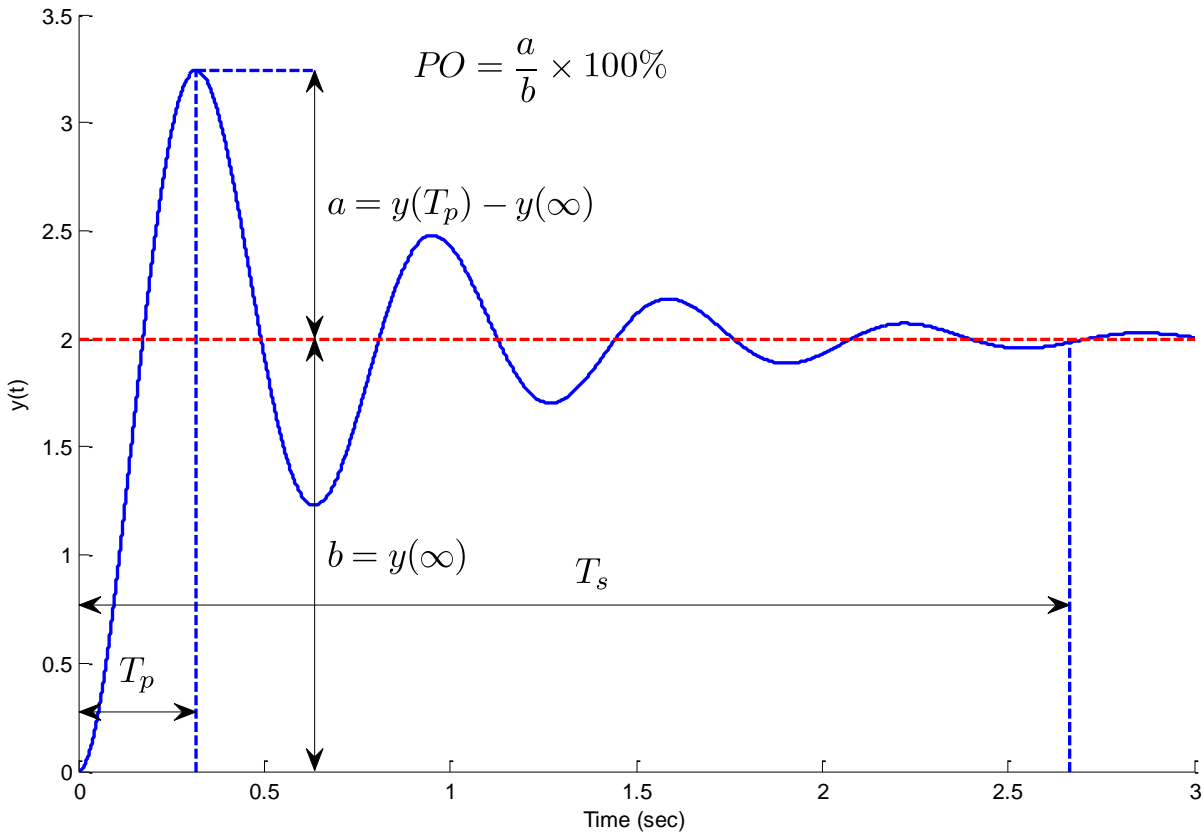


Figure 5. Important characteristics of the step response of an underdamped second order system.

1) Construct the second order circuit shown in Figure 6. For this circuit, use your variable resistor for R, use a $0.01 \mu\text{f}$ capacitor, and a 33 mH inductor.

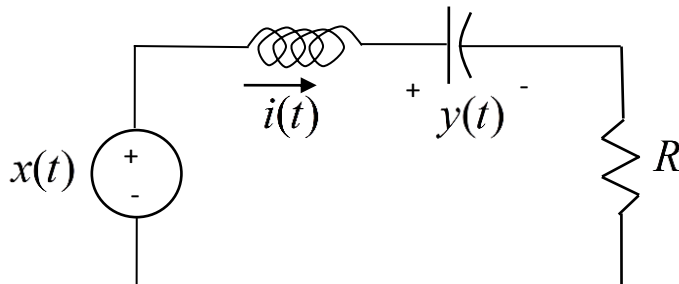


Figure 6. Second order circuit for PART 3

- 2) Set up Mobile Studio to provide the input and measure the output. The input should be a 1.2 kHz square wave with a 0.5 volt offset and 1 volt peak to peak. The output is the voltage across the capacitor.
- 3) You will need to vary the **Time/Div** to get a good view of what is going on. Start off with the potentiometer somewhere in the middle of its range.
- 4) The parameters for this problem are $\omega_n = \frac{1}{\sqrt{LC}}$ and $\zeta = \frac{R}{2} \sqrt{\frac{C}{L}}$, so by varying the resistor we can directly vary the damping ratio but not change the natural frequency.
- 5) Choose a resistance to provide no overshoot. Try to get as close to an overshoot as you can though. Get a snapshot of your waveform, and put it in your memo. Be sure to number your figure, and give it a good caption.
- 6) Choose a resistance to provide an overshoot between 40 and 50%. Use the cursors to verify the overshoot. Get a snapshot of your waveform and put it in your memo. Be sure to number your figure, and give it a good caption. Include your calculation of the overshoot in your memo.

PART 4

Now we want to measure the time constant for an unknown first order system. This is what you will be doing for part of your Lab Practical, so pay attention!! Get a numbered black box from your instructor and write the number down. Place the circuit so you can read the numbers. The red connectors are the positive terminals and should be on top, and the black connectors are the ground terminals and should be on the bottom. The instructions below are a bit vague, since you should have an idea of how to do this and each system is different.

- 1) Connect **AGW1** to the left side of the box, and **A1+** and **A1-** to the right side. The output voltage is the voltage difference between **A1+** and **A1-** and the input voltage is the voltage from the signal generator.
- 2) Set the input signal to a square wave with an offset of 0.5 volts and 1.0 volt amplitude (1 volt peak to peak, with the lowest value 0 and the highest value 1.0)
- 3) Set the input signal to a frequency between 50 and 150 Hz
- 4) Adjust the **Volts/Div** so the signal fills up as much screen as possible
- 5) Adjust the **Time/Div** scale so you clearly see one or two instances of the signal rising or falling
- 6) Use the cursors to determine the 10% and 90% times, and then determine the time constant
- 7) Check with your instructor to determine if your value is acceptable
- 8) Record the number on your black box and your estimated time constant in your memo

All Done! Your memo should have 5 snapshots, a few calculations, and the black box number and estimated time constant. Be sure the figures are large enough an old guy can see them. Finally, the body of your memo should indicate anything you found confusing or cool about this lab. It should be short.