

ECE 204 AC CIRCUITS

Lab # 1 Introduction to Mobile Studio Desktop (MSD)

The objectives of this laboratory experiment are:

1. To install MSD on your laptop.
2. To become familiar with the basic features of MSD.
3. To use MSD to confirm predictions made using Ohm's Law and Voltage Dividers.

1.0 PRE-LAB

- 1.1 Read the complete laboratory procedure and be ready to apply it to your work. If you do not understand anything in the lab procedure, go and ask your instructor — don't wait until the lab has started; remember, the instructor has to deal with fifteen groups and you will be "waiting in line". Note that "waiting in line" is not a valid excuse for failing to finish the lab. You are expected to "budget your time" in lab and not waste it socializing.
- 1.2 Apply the voltage division techniques presented in ECE203 to predict the voltage across each resistor in figure 1. Present your results as shown in table 1 (a sample with different resistor values is shown).

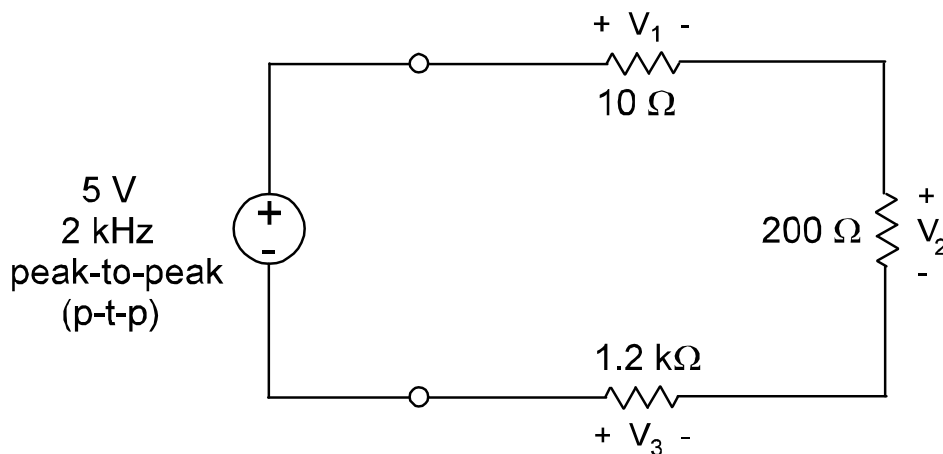


Table 1-Ideal Predictions

Nominal R (Ω)	V _R p-t-p	V _R rms
12	0.039	0.013
120	0.368	0.130
1500	-4.596	-1.625

Figure 1 - Circuit Diagram for Voltage Division

Note that $V_{\text{rms}} = \frac{V_{\text{peak}}}{\sqrt{2}}$ and $V_{\text{peak}} = \frac{V_{\text{peak-to-peak}}}{2}$ these relationships will be explained in class, later in the course.

- 1.3 Review the material in the appendix and come to lab ready to install MSD on your laptop (if you understand everything in the appendix, have a go at installing MSD.)
- 1.4 Submit a photocopy of the pre-lab at the **start of the lab period**.
- 1.5 Be sure you are familiar with the ECE Department's Writing Standards, particularly with regard to laboratory notebooks (this is on pages 15 & 16 of the following webpage: <http://ece-1.rose-hulman.edu/ece/images/stories/files/ecewritingstandards.pdf>).

2.0 LAB PROCEDURE

- 2.1 Start your laptop in the administrator mode and follow the instructions developed by Dr. Eccles in the appendix, to get MSD working on your laptop. When you have this done, make a few adjustments to the function generator and oscilloscope settings and observe the results. The objective at this stage is just to “play with MSD” and see what happens, e.g. adjust amplitude, frequency, waveshape and take measurements with the cursors. Sketch the resulting images in your lab book.
- 2.2 Select the following resistors: 10 Ω , 200 Ω , and 1.2 k Ω then measure and record their values using the digital multimeter (DMM). Connect them in series, on the breadboard, as shown in figure 1.
- 2.3 Adjust the function generator Ch. 1 to give an output of 5 V peak-to-peak, sine wave at 2 kHz, zero degrees phase and zero volts dc off-set. Connect the resistors across AWG1 and ground as shown in figure 2. Display this waveform on Ch. 1 of the oscilloscope by connecting A1+ and A1- across the supply and making selecting A1 DIF (meaning show the difference in voltage between A1+ and A1-). Display the voltage across each resistor on Ch. 2 of the oscilloscope by connecting A2+ and A2- across the resistor and selecting A2 DIF

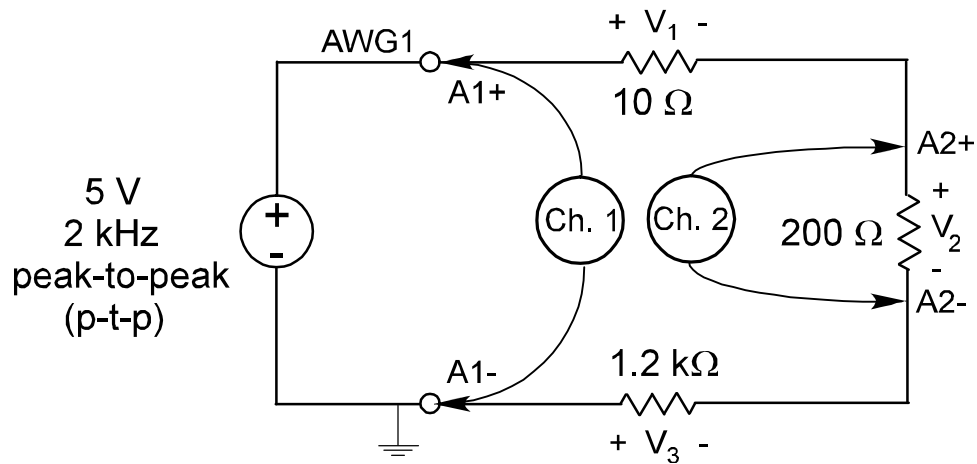


Figure 2 - Circuit Diagram for Voltage Measurement

- 2.4 Measure and record the voltage across each resistor, using the oscilloscope to measure peak-to-peak values on Ch. 2 while rms values are measured with the DMM. Call these values V_{Measured} .
- 2.5 Apply voltage division to re-calculate the results of step 1.2 in the pre-lab using the measured values for the resistors. Call these values V_{Nominal} . Compute and display the percent error from the nominal value for each resistor using the following formula:

$$\%_{\text{error}} = \frac{V_{\text{Nominal}} - V_{\text{Measured}}}{V_{\text{Measured}}} \times 100\%$$

- 2.6 The lab-work is finished now make sure your lab notebook is properly completed by following the same concluding steps as the ECE203 labs.

APPENDIX

Installation of Mobile Studio Desktop (MSD)

Purpose

Mobile Studio Desktop provides the equivalent of a number of bench-top electrical instruments in the form of software on a personal computer. The purpose of this Introduction is to tell you a little about MSD, walk you through setting it up on your laptop, and have you try a couple of its functions.

A Brief History

Mobile Studio Desktop grew out of an idea of Professor Don Millard, an idea that good electrical laboratory pedagogy could be accomplished by using computer representations of typical laboratory instruments plus computer interface boards to connect to actual electrical devices and circuits.

Professor Millard and his graduate students began to develop this idea at Rensselaer Polytechnic Institute. As the project expanded, he obtained financial support from the National Science Foundation and involved four other schools: Howard, Morgan State, Rose-Hulman, and SUNY Albany.

The concept is simple: Use a computer as the instrument, provide an interface board to connect electrical devices to the computer through the USB port, and manipulate the virtual instruments just as one would use real instruments on a lab bench—but at a much lower cost. Figure 1 shows a complete set-up with a small circuit attached to it.

Equipment

We'll use Mobile Studio Desktop in a number of the labs in this course. Here's what that takes:

- An Intel-based computer, either desktop or laptop with a USB 2.0 port, running Windows 2000, XP (except x64), Vista, or Windows 7. This includes Intel-based Macs running Windows either under OS X and Parallels or stand-alone via Boot Camp.¹
- The current version of Mobile Studio Desktop. See the next section for how to get this.
- The current Mobile Studio IOBoard™ and the appropriate USB cable.

A word of warning! The I/O board is powered by your computer's USB port. The circuits you build will be con-

¹ I have not been successful on the Mac with Fusion or VirtualBox. Parallels is slow.

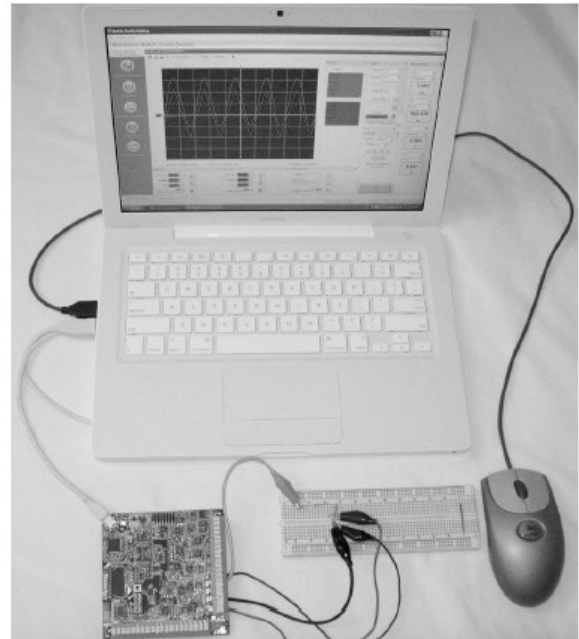


Fig. 1—Complete MSD setup

nected to the board and will derive power from it. **DON'T SHORT-CIRCUIT ANY POWER CONNECTIONS FROM THE I/O BOARD!** It is possible to destroy the board and, under the right (wrong?) conditions, your USB port.

Installing Mobile Studio Desktop

Before downloading Mobile Studio Desktop, **YOU MUST DISCONNECT ANY I/O BOARD FROM YOUR USB PORT.** Don't connect the board until you have MSD running on your computer.

You *must* be in **administrator mode**. Then go to <http://www.mobilestudioproject.com> and click on the "Software Download" button.

After downloading, go through the license and installer screens. If you get a security warning, allow installation to continue. If you are asked to allow installation of .NET or National Instrument software, allow them—they are needed for MSD to run. At the end, if you are asked to restart, do so.

Now stop here until you have an IOBoard to connect.

Connecting the I/O Board

Once installation is finished, and you are still in *administrator mode*, connect your I/O board. If you get a notice of a need for drivers, follow the Add New Hardware instructions, choosing "No" on the first screen and then accepting

all defaults. You also may get a request to update the board's firmware before the board will work properly. Go to the Device menu and follow instructions.

You will probably get a message that this board is not "calibrated." What this is really saying is that your computer does not know the settings for reading data precisely from the board you've connected. If you don't get the message about calibration, skip over the *Calibration* section to *Now Let's Play!*

Calibration

Choose to calibrate now. Someone has probably already generated the calibration file for this board (a .ioc file):

1. Go to <http://ece-1.rose-hulman.edu>
2. Then ECE Downloads → Mobile Studio
3. Look for your board (R2nnn.ioc).
4. If it's there, download the file to your desktop—if it isn't, skip to *Manual Calibration*.
5. In Mobile Studio, Device → Analog Calibration, click "load from file," locate the newly-downloaded file, and load it.
6. Your computer now knows about (and will remember) this particular board. Discard the .ioc file and skip to *Now Let's Play!*

Manual Calibration

If you didn't find a calibration file, your board needs calibration. It's not hard to do but it requires close attention to detail. The only instrument you'll need is your digital multimeter.

Please calibration carefully! Your file will be available to other MSD users.

Figure 2 is the arrangement of the connections on the IOBoard. Calibration requires measuring and adjusting voltages at some of the terminals and then using these output ports to automatically calibrate the input ports.

The initial calibration sets the Gain and the Offset of AWG1 and then repeats the procedure for AWG2:

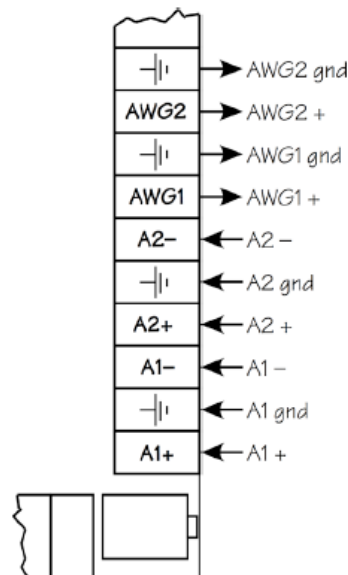


Fig. 2—Red2 terminals

1. Close any instruments that are on your screen.
2. Launch Analog I/O.
3. Connect your digital multimeter to the AWG1 terminal (yellow) and its ground (white). See Fig. 2.
4. Set Analog I/O's Analog Out Ch1 to 3.000 V.
5. Select DEVICE → ANALOG CALIBRATION.
6. In "calibration settings," select "channel 1." (It probably is already.)
7. On the "AWG output" line, adjust "Gain" to get the DMM to read 3.000.
8. In Analog I/O, change Analog Out Ch1 to -3.000 V.
9. Note the DMM's reading. Calculate the mean between this number and -3.000. For example, if the reading is -3.227, the mean value is -3.114 V.
10. On the "AWG Output" line, adjust "Offset (SE)" to get the DMM to read the value just calculated.
11. On the "AWG output" line, adjust "Gain" to get the DMM to read -3.000 V.
12. Change Analog Out Ch1 to +3.000 V.
13. Check the DMM, which should read 3.000 V. If it doesn't, split the difference and return to Step 7.
14. Repeat Steps 3 through 13 for AWG2 with the following differences:
 - a. Connect the DMM to AWG2 (yellow) and its ground (white).
 - b. Set Analog I/O's Analog Out Ch2 as directed.
 - c. Make all calibration adjustments on "channel 2."

This completes manual calibration. Now we'll have Mobile Studio automatically calibrate the inputs A1+/- and A2 +/-.

1. Close Analog I/O.
2. Connect AWG1 (yellow) to A1+ (red) and AWG1's ground (white) to A1- (green). (See Fig. 2.)
3. Connect AWG2 (yellow) to A2+ (red) and AWG2's ground (white) to A2- (green).
4. Near the bottom of the Analog Calibration screen, click the "auto-calibrate A1" button. Calibration could take as long as a minute.
5. Similarly, click the "auto-calibrate A2" button.

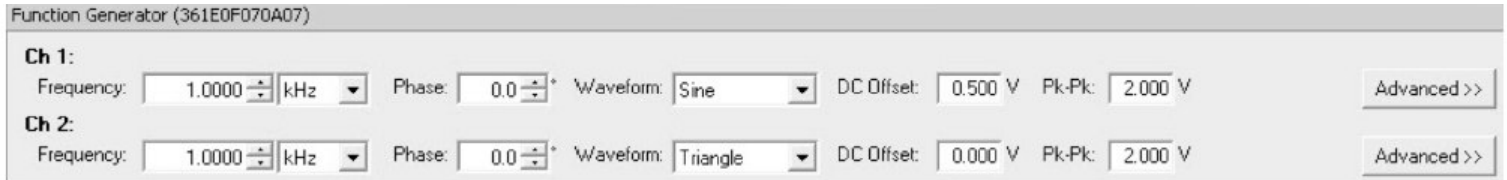


Fig. 3—Function generator screen

That finishes calibrating everything. Now make it available to others. Click “save to file” and save the calibration file on your desktop with your IOBoard’s name: R2nnn.ioc. Then e-mail it to crosby@rose-hulman.edu to have it included on the ECE web site.

It’s time to try Mobile Studio Desktop.

Now Let’s Play!

You’ve installed your software, connected your I/O board, and calibrated it so that your computer knows how to precisely display data from the board. It’s time to play with a couple of instruments without connecting anything to the I/O Board.

I’m going to walk you through some simple exercises to try out the instruments. I’ll use a few screen shots, but don’t be surprised if your screen differs a bit from mine. The MSD software is continually being updated and screens change from time to time.

I’ll assume that you have MSD running, an I/O board connected and calibrated, and a display of icons for several instruments on the left. (For the record, the Mobile Studio folks call these *devices*, not instruments.) Let’s start with the Function Generator device.

Function Generator

1. Click on the FUNCTION GENERATOR icon.
2. Change the settings for Ch 1 and Ch 2 to match those shown in Fig. 3 above.
3. Note that Ch 1 has a d-c offset of 0.5 V and Ch 2 is a triangle waveform.

4. Locate the small pushpin icon in the upper right corner and click on it to get the Function Generator to become a tab near the bottom of the screen.
5. Mouse over the Function Generator tab at the bottom of the working area and note that the settings pop up. Moving the mouse out of the Function Generator sinks it from sight.

Oscilloscope

1. Click on the OSCILLOSCOPE icon.
2. Set Channel 1 to 500 mV, DC coupling, and AWG1 input. (AWG1 is both the Arbitrary Waveform Generator and the Function Generator.) See Fig. 4 below.
3. Enable the channel by clicking the switch to the left.
4. Set up and enable Channel 2 the same way, except that the input is to be AWG2.
5. Set up Trigger (upper right) for Auto, Ch1, Rising, 500 μ s/div, Y-T.
6. Click on the green Start button near the bottom right of the screen

Your MSD screen should look like Fig. 5 on the next page.

The End

Now Mobile Studio Desktop is set up and calibrated and you are ready to begin using it. Figure 6 on the next page shows the cliplead connections for the various terminals.

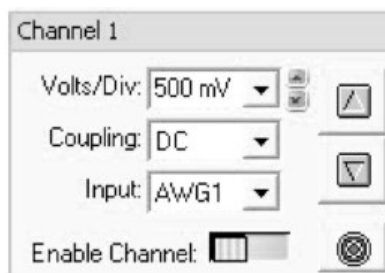


Fig. 4—Scope channel screen

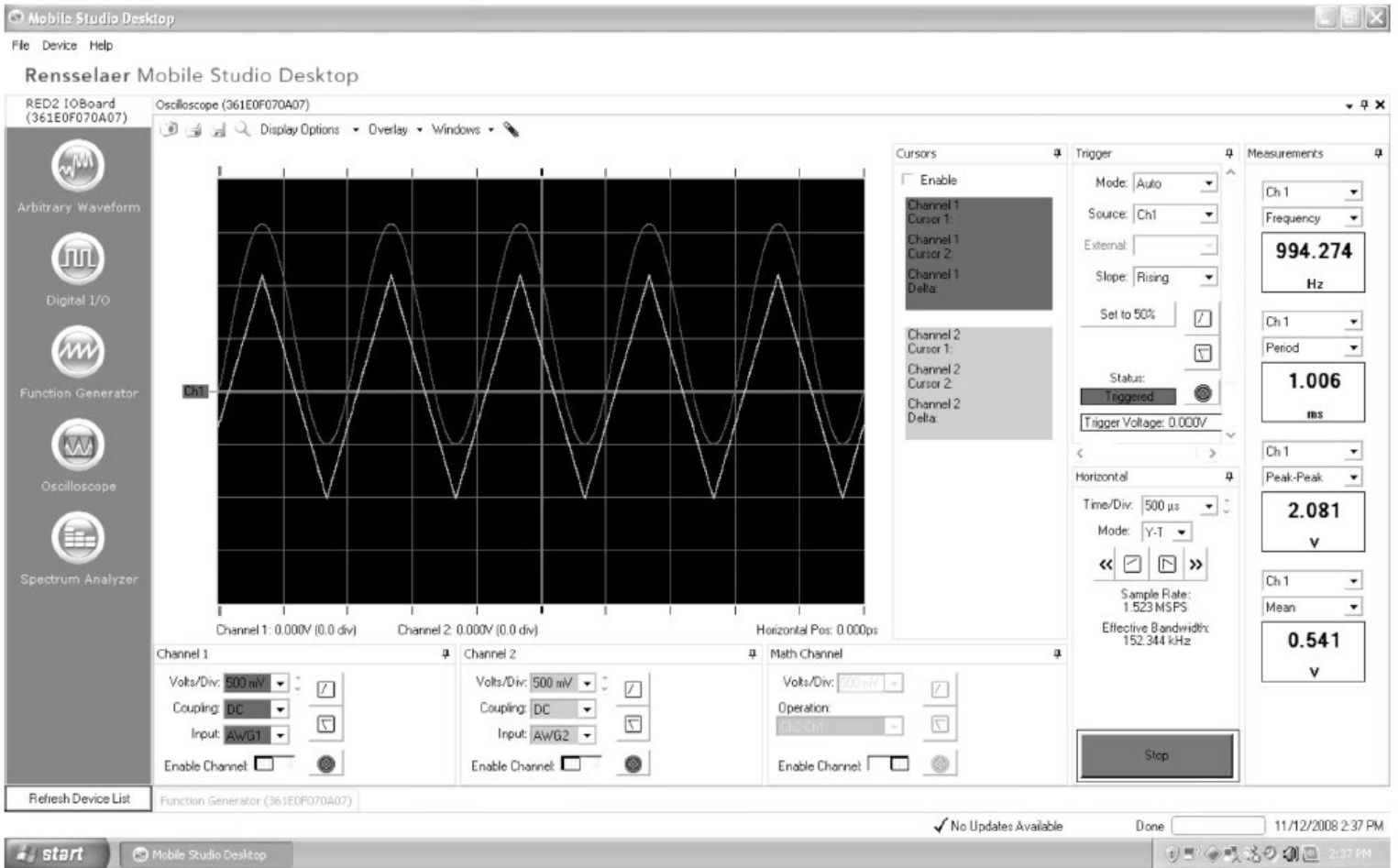


Fig. 5—Overall MSD screen