ESE 150 – Lab 0: Detkin Lab Equipment

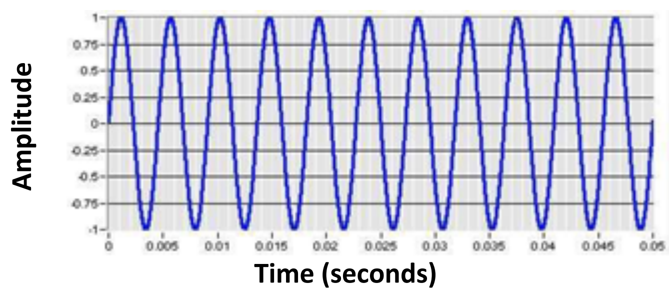
LAB 0

In this lab we will do the following:

1. Listen to pure audio tones produced by a function generator
2. View and capture pure audio tones using an oscilloscope

Background:

In lecture, you are learning that sound is a vibration of particles in the air. If we play a pure tone into a microphone and plot the output of the microphone with time, we'd see a sinusoidal pattern as shown in the figure below. We note the amplitude of the voltage is changing as time progresses. We recall that this voltage is continuous with time.



An oscilloscope is an instrument that allows us to capture and plot how voltage varies with time for a signal. This is useful in understanding the dynamic properties of circuits and of phenomena we can convert to voltage, like sound waves. One challenge is that the signal we want to observe may be changing faster than we could observe with our eyes. For example, we want to observe sound waveforms that change thousands of times per second, and we may want to understand how they change over periods that are only microseconds long (and we will want to observe circuits that change over periods of nanoseconds). For repetitive waveforms (like sine waves), we can do this by synchronizing the start of the waveform, displaying a small time window, and allowing it to redraw the waveform over and over again on a time scale that allows us to view the signal. This is the basic function of an oscilloscope.

To drive circuits, it is also useful to create waveforms that provide changing inputs to circuits. For this lab, that will give us something to observe on the oscilloscope before we turn to audio signals. We use a function generator for this purpose.

As we go to lab, you will do things you've never done before. This is a necessary part of learning. Not everything you do will work perfectly on the first try. This is expected. Included here is an excerpt from Henry Petroski's *Success through Failure: The Paradox of Design* that highlights how we should not fear failure but embrace it and learn from it in design and in our educational experiences. As he quotes Mason, you should "learn to disassociate failures resulting from their [your] attempt to succeed from being failures themselves [yourselves]."

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Prototyping can be viewed as a "sort of three-dimensional sketchpad," with the prototype enabling potential backers and users to see the invention as a tangible thing. Dennis Boyle, a studio leader at the design firm IDEO, further sees the construction of "rapid and rough prototypes" as a means of identifying problems early in the design process, when they are less costly to correct. According to Boyle, if a "project is not generating masses of prototypes, including many that clearly won't fly, something is seriously wrong." The creed at IDEO is thus "Fail early, fail often."[28]

The sentiment is not new, nor is it unique to design. According to Samuel Smiles, the Victorian biographer of engineers who wrote about their overcoming great personal and technical challenges, "We learn wisdom from failure much more than from success. We often discover what will do by finding out what will not do; and probably he who never made a mistake never made a discovery."[29] The American poet James Russell Lowell conveyed a cognate idea by means of a simile: "Mishaps are like knives, that either serve us or cut us, as we grasp them by the blade or the handle."[30] What was true for engineers and poets—and everyone—in the nineteenth century remains true for everyone today. As the design critic Ralph Caplan has written, "The more things change, the more we stay the same."[31]

How individuals react to failure separates leaders from followers, true designers from mere users of things. Professor Jack Matson of Pennsylvania State University believes so strongly in the role of failure in design that he expects students in his Innovative Engineering Design course to fail in order to pass. The course, nicknamed "Failure 101," requires students "to

build and attempt to sell outlandish and frequently useless products," like a hand-held barbecue pit. The most successful students in the course are those who take the most risks and so fail the most. Matson hopes to get them to the point "where students learn to disassociate failures resulting from their attempts to succeed from being failures themselves." He believes that, "Innovation requires that you go beyond the known into the unknown, where there might be trap doors and blind alleys. You've got to map the unknown. You map it by making mistakes." It is not unlike being blindfolded in a labyrinth. Smacking into walls may signal a misstep, but the sum of those missteps defines an outline of the maze. The quicker more mistakes are made, the quicker the maze is mapped. Matson is an advocate of "fast failure."[32]

Whether fast or slow, failure and its avoidance have always been central to the development of designs and their far-reaching influence. Though often considered apocryphal, the familiar story of the standard railroad gauge of 4 feet 8½ inches serves as an example. This odd distance between rails is believed to be rooted in ancient times, when all Roman war chariots came to have that same wheel spacing, which is said to have been established to be no wider than the rear ends of the two horses that pulled a chariot. This width, which prevailed throughout the Roman Empire, ensured that the horses would not pull a too-wide wagon through an opening only wide enough for them. As the standardized chariots ranged throughout the empire, they wore deeper and deeper ruts in the Roman roads, including those in England. So, the development of English wagons incorporated the same wheel width, lest their wheels not ride in the ruts, the path of least resistance and least

Lab Procedure:

Lab – Section 0:

(This will normally be a prelab. Since this is the first day of classes and the lab is light, you can do this during the first 15-30 minutes of the lab section. For subsequent labs, please complete the prelab before coming to lab.)

1. Watch the following videos.
    a. Triple Output Power Supply https://youtu.be/5ZxPFVS-muI
    b. Arbitrary waveform Generator and Oscilloscope https://youtu.be/4iZLt0PcRCQ
    c. Screen and Data Capture in Excel Oscilloscope https://youtu.be/YoXMoZSuXpU
2. Answer the following questions based on the videos.
    a. How would you obtain a voltage of 30V with the Triple Output Power Supply? What settings would you have to set and where would you put the positive and negative probe?
    b. What is graphed on the X and Y axis of the oscilloscope?
    c. When do you need to reset statistics on the oscilloscope?
    d. Describe the difference between capturing the screen and capturing data from the oscilloscope.

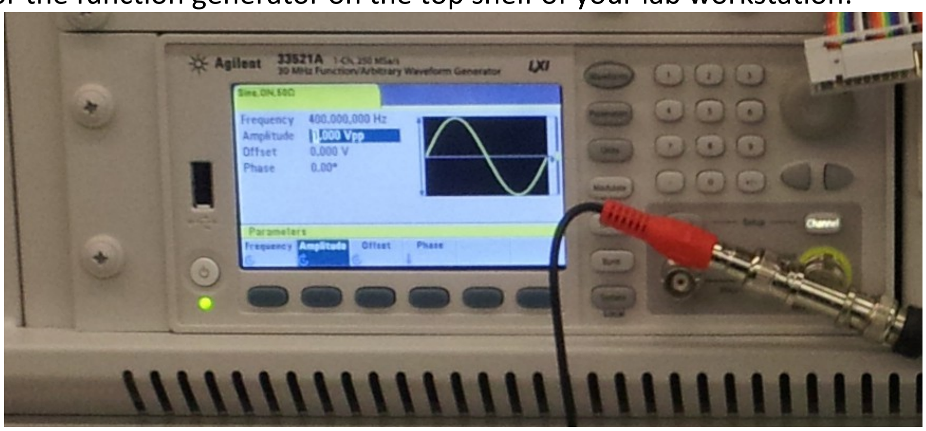
When you are ready, have a TA check you off on these questions.

Lab – Section 1: Measuring pure tones with an oscilloscope

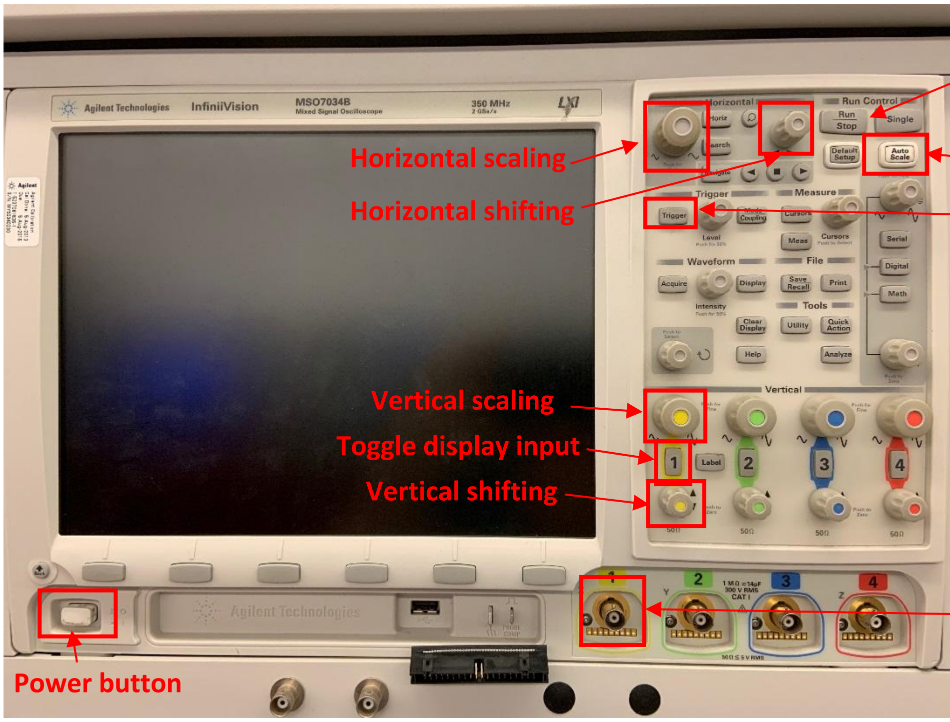
- A function generator can generate signals whose voltage varies with time, much like the output of our microphone.
- We'll have the function generator generate a few sine waves for us, with an exact amplitude and frequency, so we can measure them with the oscilloscope.
- An oscilloscope is a piece of lab equipment that can measure voltage vs. time.
- The various pre-manufactured wires are identified by their connector ends: BNC, banana, and grabber/alligator, as shown below:

BNC Splitter Banana BNC Alligator/Grabber

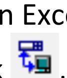
1. Look for the function generator on the top shelf of your lab workstation:



2. Obtain a "BNC to BNC" connector wire from your lab bin, connect the yellow output from the function generator to CH1 on your oscilloscope.



3. The oscilloscope is shown above, look for the "yellow" BNC connector on it labeled "1" – attach your cable there.
4. Turn on the oscilloscope with the power button in lower left corner.
5. How does the scope work?
    a. There is a horizontal knob that you can use to stretch out the x-axis.
    b. There is a vertical knob that you can use to stretch out the y-axis.
    c. The cursors button and knob can be used to turn on and move the X and Y axis cursors on the screen to find exact values in the waveform.
6. Configure the function generator as follows:
    a. On the function generator, press the "**Channel**" button right above the output:
        i. A menu will be displayed along the bottom of the screen; you can select the options using the blue buttons beneath each one.
        ii. Now set the output to High Z.
            1. Select "**Output Load**".
            2. Select "**Set to High Z**".
    b. Press the "**Waveforms**" button. You can set the type of wave (square, sine, etc.).
    c. Options will be displayed on the bottom of the screen: select "***sine***".
    d. Now you can set the frequency, amplitude, etc. for the sine wave:
        i. Press the button below **frequency**.
        ii. The field with the value of the frequency should now be highlighted.
        iii. Enter 400.
        iv. After you enter 400, a list of units appears at the bottom of the screen.
        v. Select Hz.
    e. Next, adjust the amplitude and offset the same way that you adjusted frequency:
        i. Set the amplitude to 2 VPP (2 Volt – peak to peak).

        ii. Set offset to 1.0V.
    f. Turn the output on by:
        i. Press the channel button: in the menu that appears at the bottom of the screen, select the leftmost button to switch the **output on**.
7. Measure this on the oscilloscope
    a. On the scope, press “autoscale” and you should see your 400 Hz 2VPP (2V peak-to-peak) sine wave.
    b. Measure the period of the wave using the vertical lines on the screen
        i. Convert it to frequency, is it 400 Hz?
    c. Measure the voltage range of the wave using the horizontal lines on the screen.
        i. Is it indeed 2 Volt Peak-to-peak?
    d. Once you’re sure it’s correct, take a screenshot of the waveform to save to Excel, using the following instructions. You’ll need to turn this in.
        i. The run/stop button can be used to (un) freeze the screen, allowing for accurate screen captures.
        ii. Open Excel on the lab computer and go to the Add-ins tab.
        iii. Click , and select the Address and Identified Instruments that show up, before clicking OK.
        iv. To capture the oscilloscope screen, click  and uncheck the greyscale box before clicking OK.
        v. The screenshot should now be in your Excel workbook.
    e. Adjust the function generator to 1kHz.
        i. Scale your scope and repeat the previous steps to measure the period (verifying that it is now 1kHz) and take a picture of the waveform. You’ll need to turn this in.
8. Make sure both partners have a copy of the oscilloscope screen shots. We recommend you set up a google drive that both partners can access and upload the screenshots before leaving lab.
9. Show your screenshots to a TA. This is your exit ticket for this lab.

HOW TO TURN IN ANSWER TO THE LAB:

- Answer the Part 0 questions, assemble the data requested, and answer the questions in the lab.
- Upload a word document or PDF containing your informal lab report including:
    - Partner's name
    - Prelab answers
    - Oscilloscope screen shots (1.7.d, 1.7.e.i) (highlighted)
- Each lab writeup is individual.
- You can see the grading rubric we are using for the lab on Canvas. Review that to make sure there will be no surprises when your lab is graded.
- Due by next Wednesday 3pm. (typically, these will be due on Monday before the next lab.)