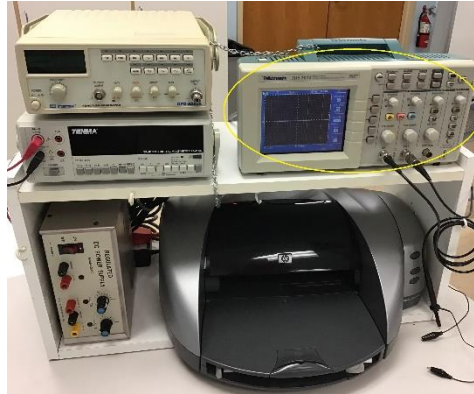


How to use our oscilloscopes

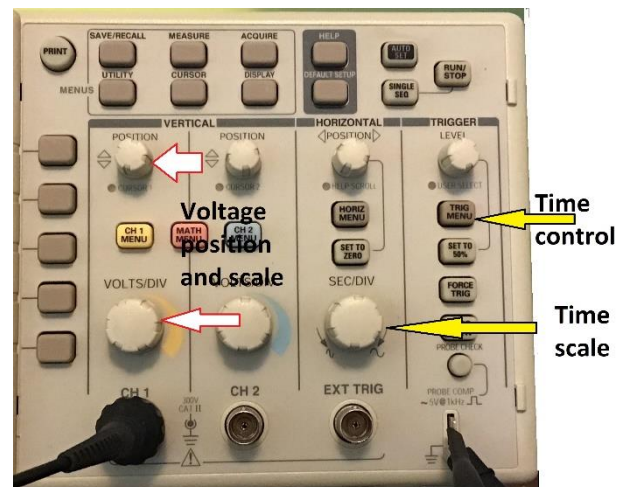
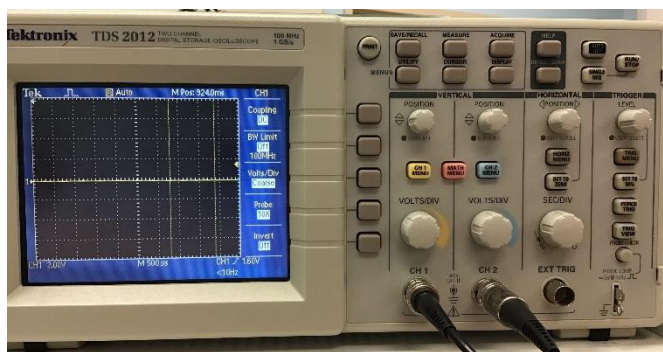
What is an oscilloscope?

An oscilloscope (typically just called a *scope*) is a marvelous instrument to measure voltage. It has a *probe* that you attach to whatever voltage you wish to measure. The scope measures the voltage and records it on a screen, thus giving you a graph of voltage vs. time. The wonderful thing is that you can easily choose the scale of voltage and time (i.e., how many volts or seconds each square on the screen represents), and also be very flexible about when the graphs turn on and off. Here's where the scope is in our lab:



The main controls

Here is a picture of the scope, showing some of the main controls we'll use. Some of them control the voltage scale, some control the time scale, and others control the overall operation.

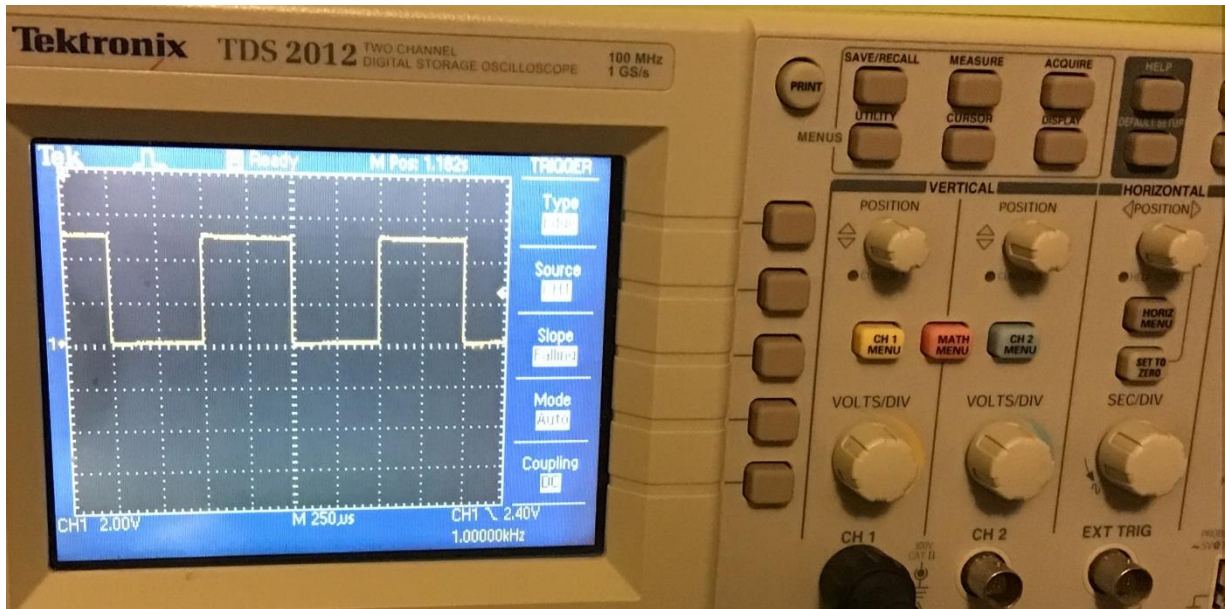


We'll talk about each category in turn. But first...

Triggering vs. scanning

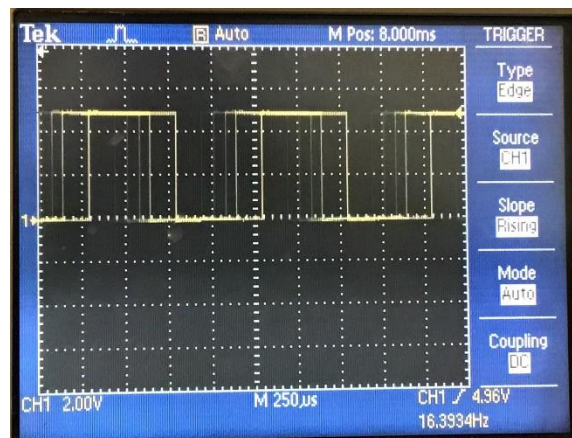
The scope screen is a grand total of about 3.5 inches wide. Here's a picture of a *square wave*. It has a frequency of 1kHz; i.e., it bounces up and down 1000 times per second. You'll note that the scope time scale is set to 250us (i.e., 250×10^{-6} seconds) per division, which is *very* fast! At 8 squares wide, it thus takes only $8 \times 250 \times 10^{-6} = 2 \times 10^{-3}$ seconds to sweep across the

entire screen. So why does the picture look like a stable image rather than somehow flashing on and off?



The scope, in fact, is playing a trick; it's drawing from left to right. When it gets to the right edge of the screen it waits a small amount of time and then starts from the left again. This happens so fast that your eye sees a steady trace. Furthermore, it's cleverly synchronized so that each sweep across the screen draws in exactly the same location. Here's a picture of what happens with that clever synchronization turned off:

You can see multiple traces at any given time – the most recent traces are the brightest, but you can still see the past few as well.



The clever synchronization is called *triggering*; essentially each sweep across the screen is triggered by the input crossing a particular voltage threshold. We won't use triggering very much (if at all) for this class, so this short mention is all you get. But feel free to ask any of us for more details.

Scanning

Controlling the scope via triggering is the chief way of viewing signals that change at 100Hz or higher. Most of the signals we will use in this class are much slower than that, and so we will rarely if ever use triggering. Instead, we will use the scope in *scan* mode.

To enter scan mode, you must

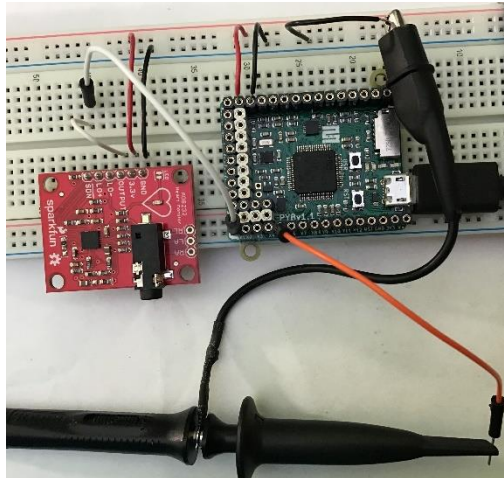
- Use the “SEC/DIV” knob to set the time scale to 100ms/division or slower.
- Use the configuration buttons to set the triggering mode to “Auto” rather than “Normal.”

Once you do this, the mode indicator on the top of the screen will read “Scan.”

Let’s view a signal in scan mode. Perhaps the easiest way to do this is to use the PyBoard to generate a signal for you (in our Music Day lab, we’ll use this same PyBoard capability to generate an audio signal).

First, using Thonny, run the program `2_scope_sEMG_DAC.py` or `2_scope_ECG_DAC.py`. They’re both in the folder Q → en1EIY → 2021f → public_html → labs → code. You won’t be modifying the program at all, so feel free to just run it straight from the course directory. Or you can copy it to your own folder if you prefer. The first program generates an sEMG-like signal, and the second one an ECG-like signal.

Second, hook up the scope probe to the PyBoard’s X5 output pin. This is the same pin that drove audio output in our Music-Day lab, since we are using the same DAC to generate our scope input as we previously use to generate an audio signal. Here’s a picture of that:



Once the scope is hooked up, click on Thonny's green Run arrow, and your signal should appear on the screen. It should look like one of these two pictures, depending which file you ran:

Now play with the controls! Get used to the vertical (i.e., voltage) controls – POSITION and VOLTS/DIV. Note the little “1” on the scope, which indicates the 0V line. It will move as you move the POSITION knob.

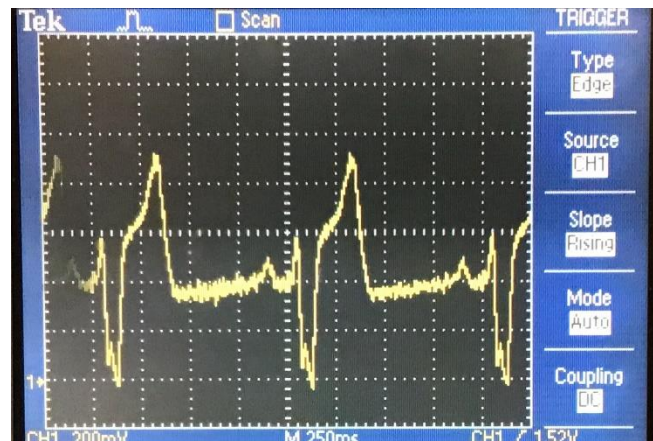
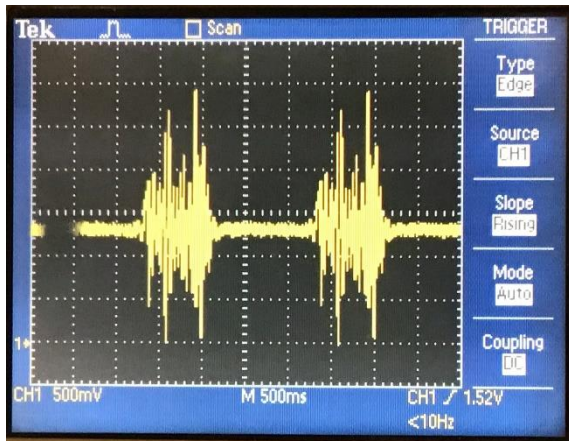
Next play with the horizontal (time) controls. You can make the sweep rate faster or slower (though if you make it faster than 100ms/division, the scope will exit from Scan mode).

Finally, try pressing the Run/Stop button. What does it do? What happens if you adjust the voltage or time scale while you're in “Stop” mode, *after* you've captured a waveform?

Things that can go wrong and how to fix them

Here are the quick solutions to a few common issues:

- Channel 2: the scopes have two channels (channel #1 and #2); i.e., they can display two signals on the screen at the same time. Sometimes you'll inadvertently turn on the channel-2 display. To turn it off, just press the “Ch2 menu” button. Each time you



press the button, the display will toggle between turning channel 2 on vs. off. You don't have to use any of the menu items – just pressing the main “Ch2 menu” button is enough!

- To get into Scan mode, you set the Sec/Div control to 100 ms/div or slower, *and* set the trigger mode to Auto
- Occasionally, somebody might change the Volts/Div item in the “ch1 menu” from coarse to fine; then the volts/div knob no longer does its usual 1/2/5 ratios.
- To reset the scope, just power it off and back on. If that's not enough, press the “Default setup” button in the second row from the top.