Notes on Lab 1

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About this Lab

This lab introduces basic equipment functions in the circuit lab, and fundamental concepts about signals and spectral response.

You will explore the following topics:

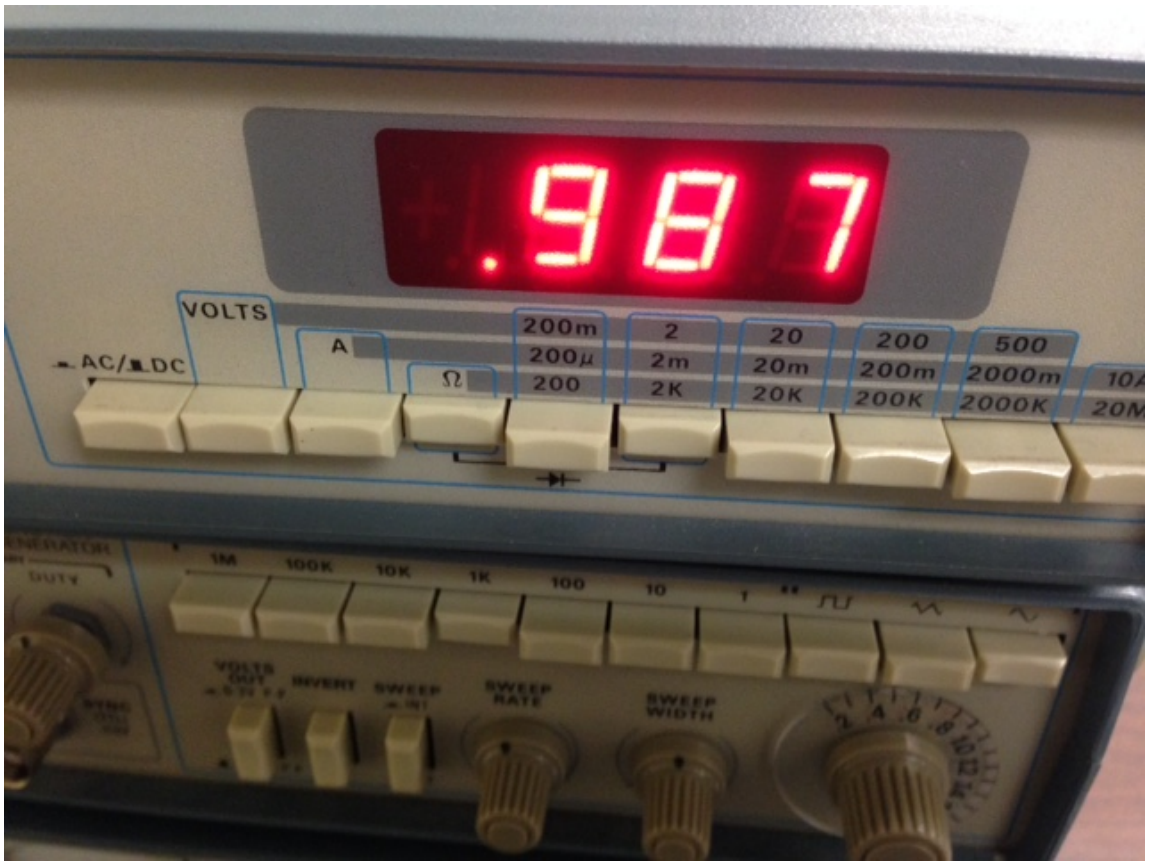
- Measuring voltage and resistance with the Digital Multi-Meter (DMM).
- Using the Function Generator as a signal source.
- Configuring the oscilloscope and probes to properly display a signal.
- Synchronizing the oscilloscope with the function generator.
- Use the scope's FFT display to measure spectral characteristics like the 3dB bandwidth.

Using the DMM

To make voltage or resistance measurements, use a red/black pair of banana cables and connect them to the corresponding colors on the DMM. (The white colored ports are for current measurements).

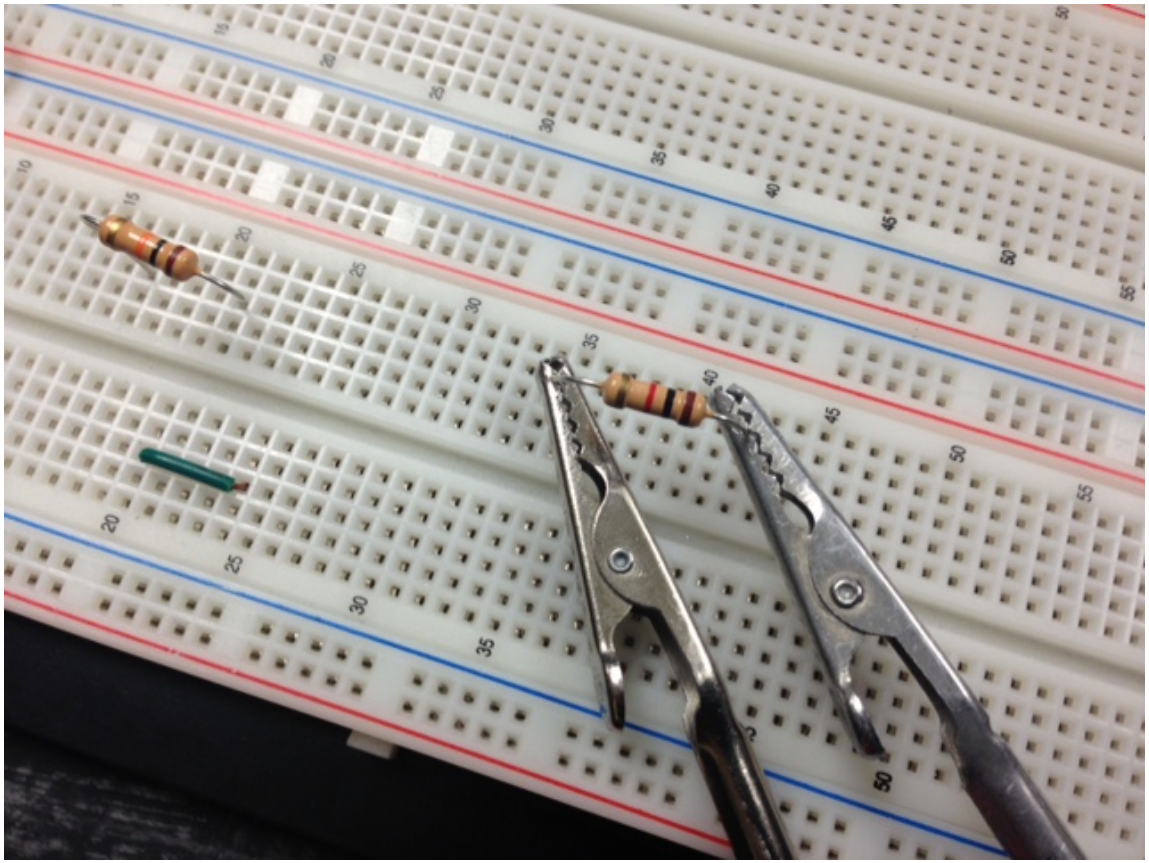
Using the DMM

To measure resistance, select the Ω button and choose the appropriate range (for the 1kΩ resistor select the 2kΩ range button). Since the resistor's actual value will vary from its stated value, you should measure all resistors used in the lab.



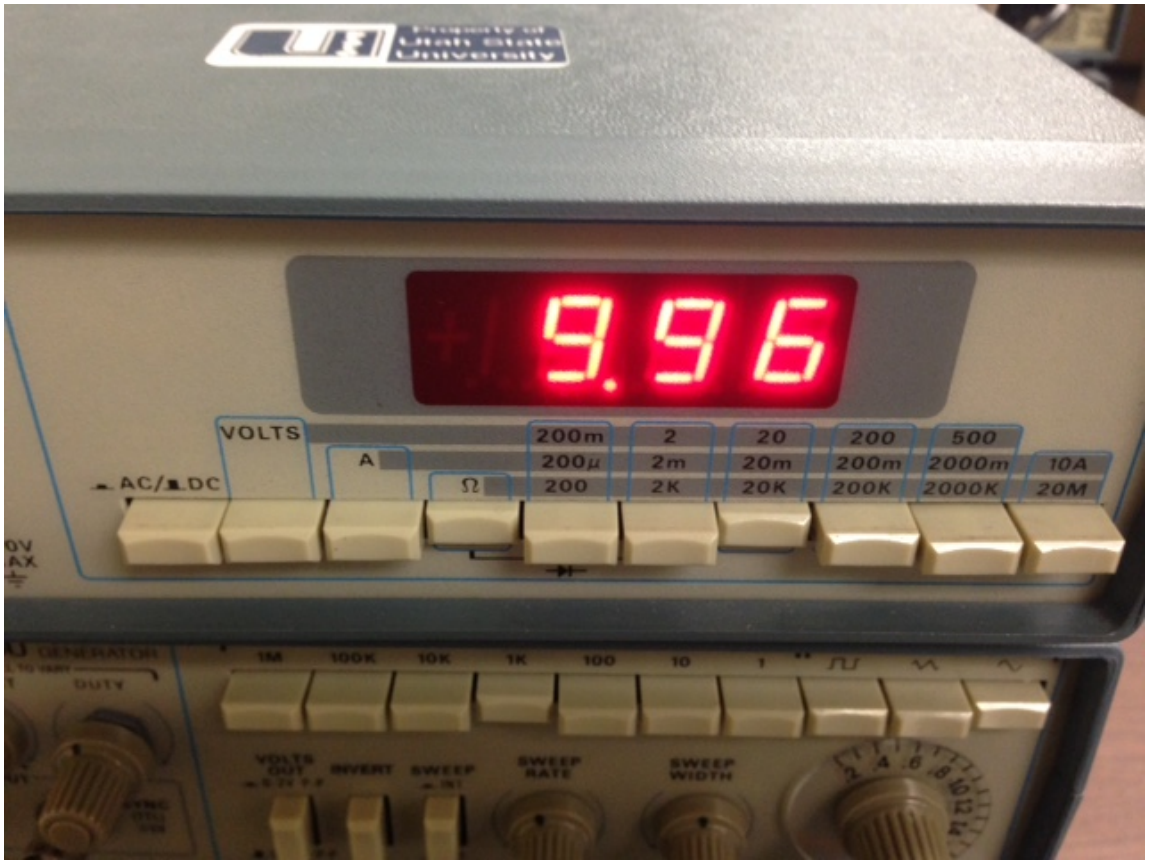
Using the DMM

Connect the resistor to the cables using alligator clips as shown. Make sure the resistor is not connected to any circuit or power source as these may affect the measurement.



Using the DMM

When measuring the larger 10kΩ resistor, adjust the range setting as shown.



Configuring the Function Generator

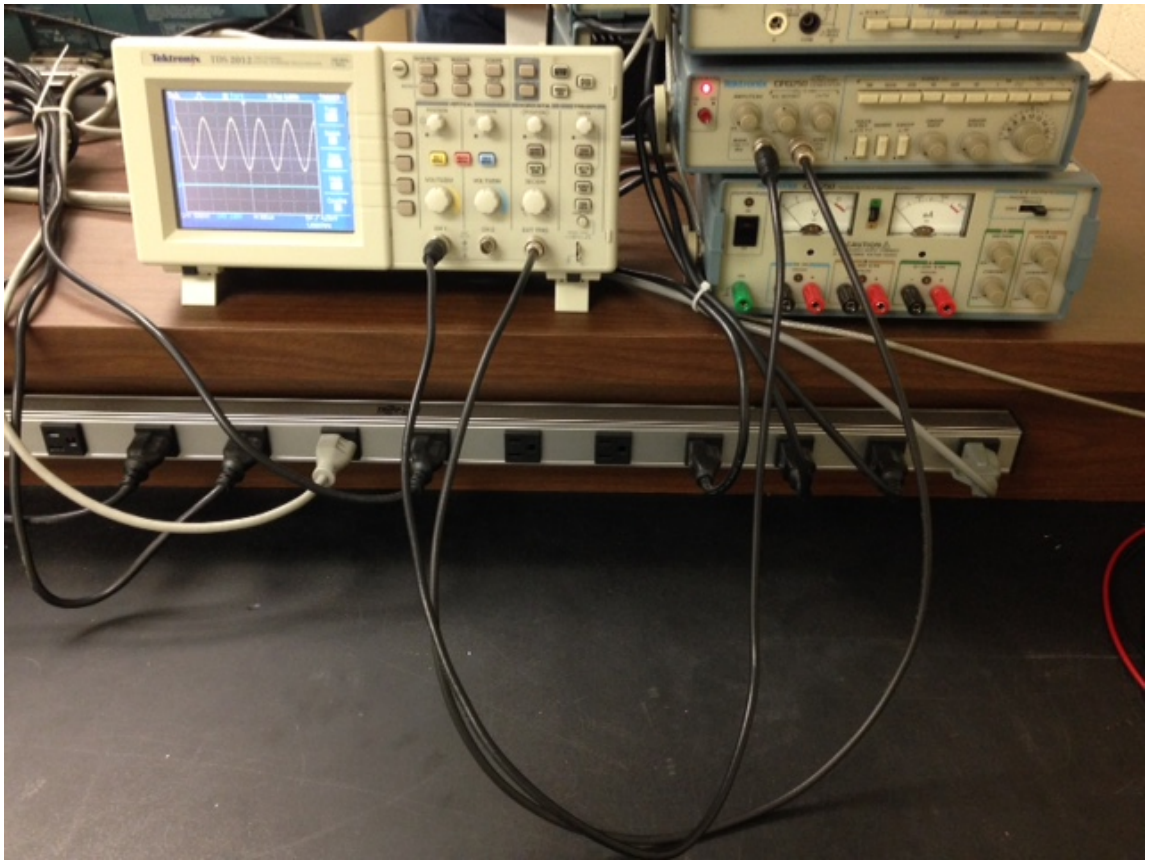
Connect the function generator using a BNC cable. For this lab, you will need to pull out the offset adjust knob in order to have a non-zero offset voltage.

Configuring the Function Generator

You will also need to set the Volts Out button to the larger range, since your offset settings will push the output higher than 2V. Also make sure the function type is sinusoid (upper left buttons), and the signal range is 1kHz (upper middle buttons).

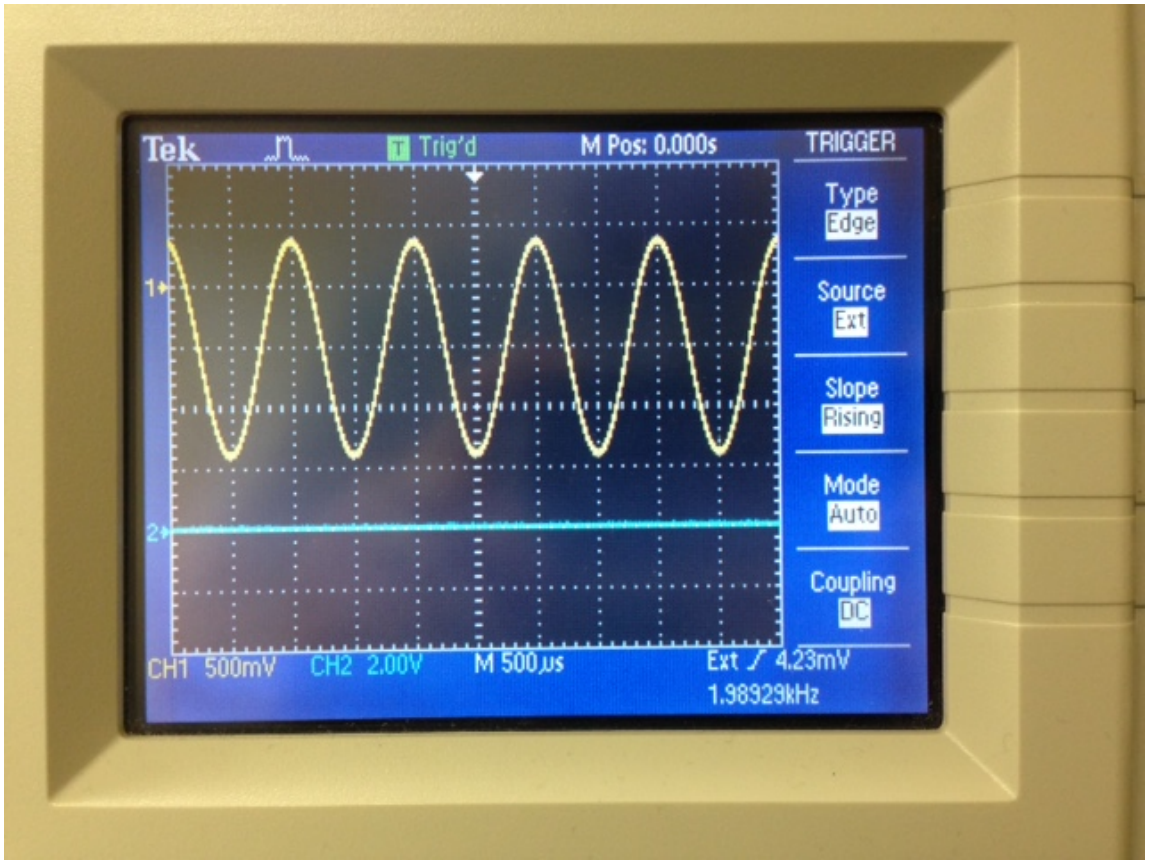
Syncing the Generator and Scope

The FG's `SYNC` output should connect to the scope's `EXT TRIG` input, like this:



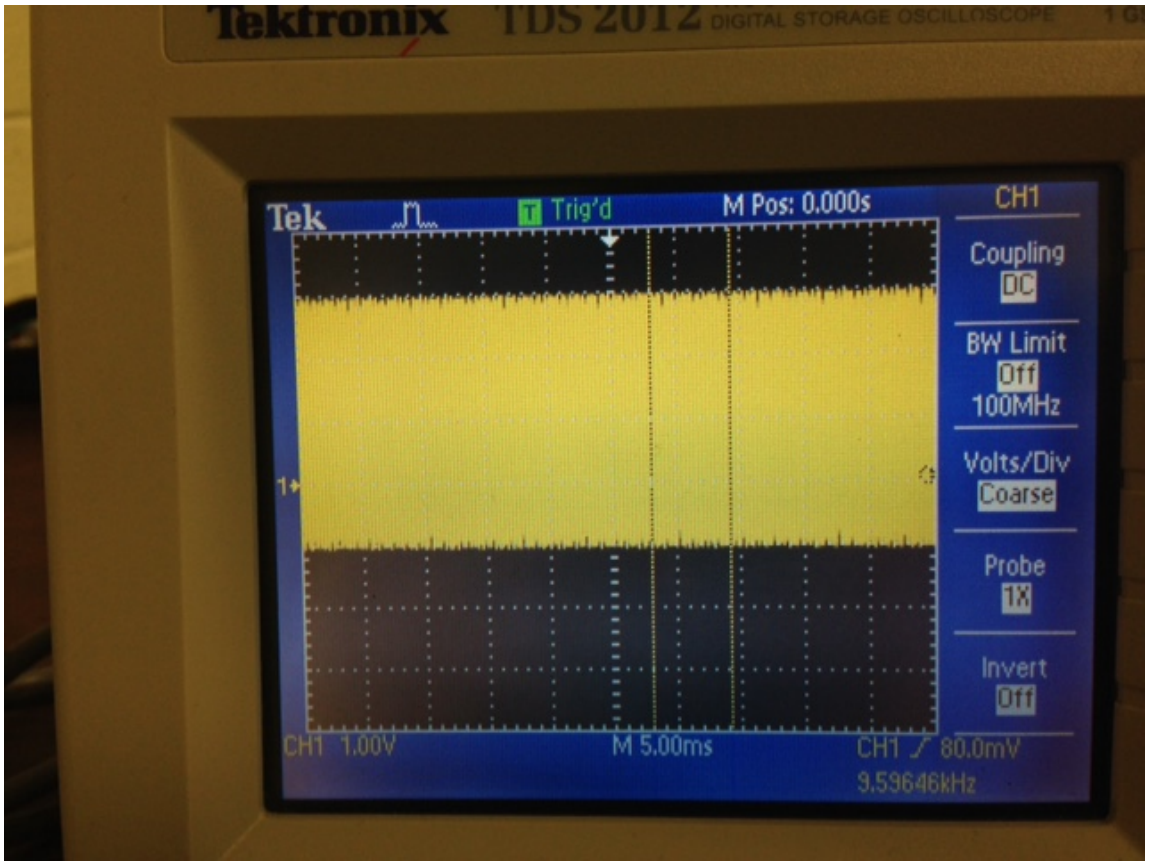
Configuring the Trigger

To keep the scope synchronized with the signal, access the `TRIGGER` menu and select `SOURCE EXT`.



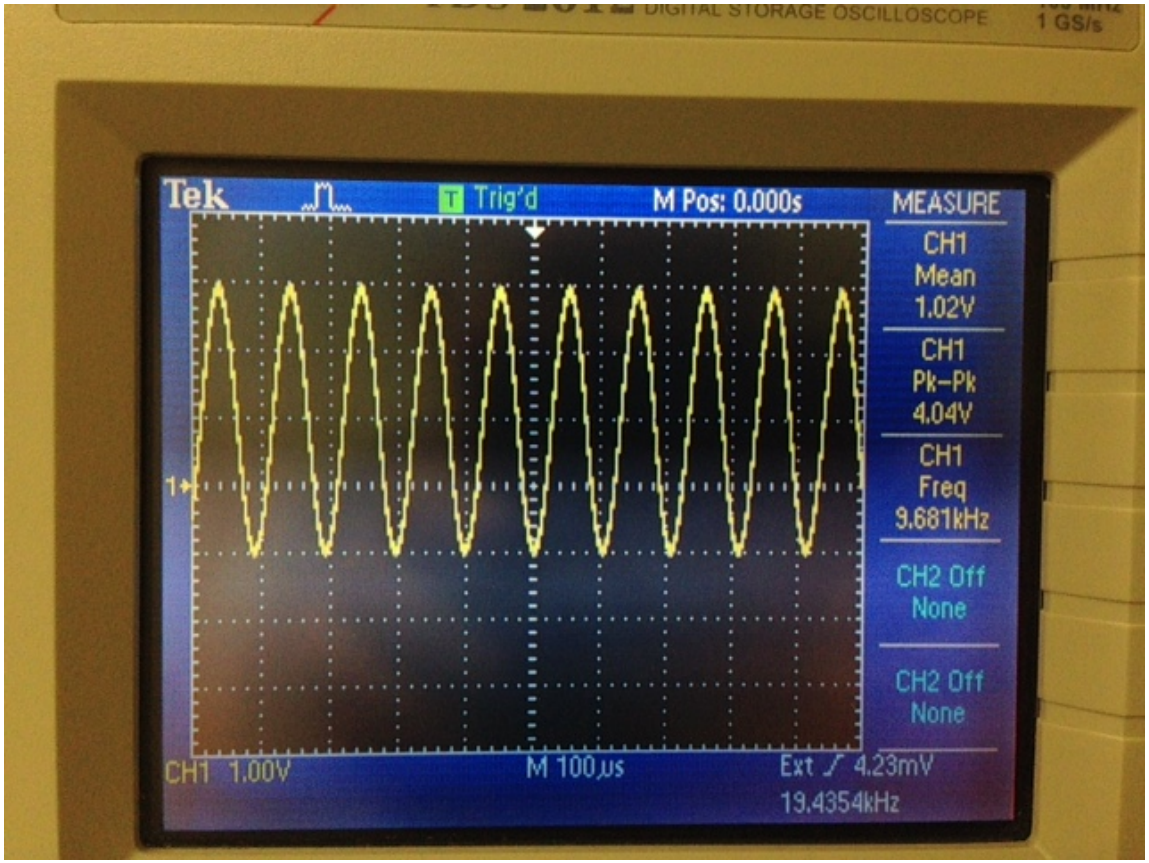
Configuring the Channel Display

On the oscilloscope, configure the channel settings by pressing the Channel 1 button. The settings are shown along the right side of the scope display. Each setting is adjusted by pressing a button to the right of the display. Make sure the probe is set to 1X and the scope is also set to 1X.



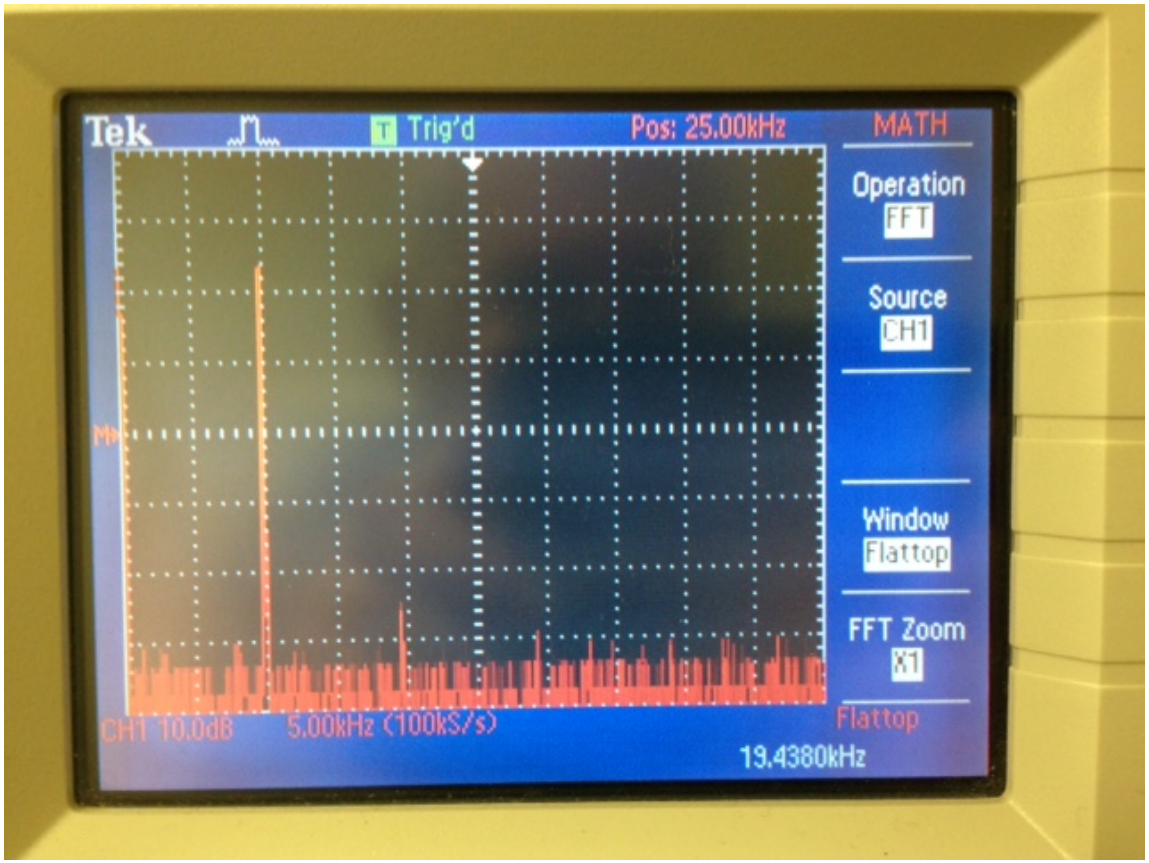
Using the Measure Menu

Access the scope's measurements by pressing the `Measure` button. The scope provides a variety of measurements, shown on the right of the display. The individual measurements are selected and configered by pressing the buttons just to the right of the display. Adjust your settings to display the frequency, peak-to-peak and mean for Channel 1.



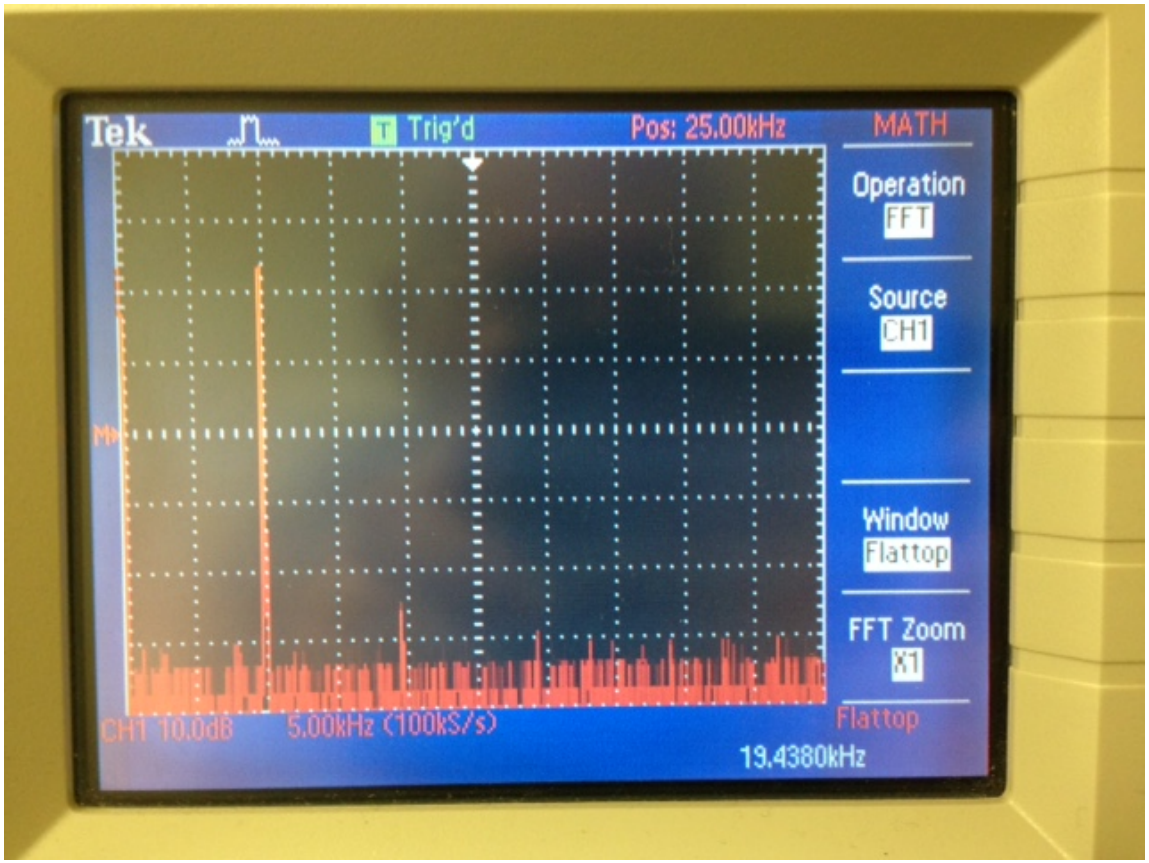
The FFT Display

FFT reveals the signal's magnitude spectrum. A pure sinusoid should have a single frequency lobe. In FFT mode, SEC/DIV sets the sampling rate (shown here as $f_S = 100kS/s$). It's important to pay attention to the Sampling Theorem: the sampling rate must be greater than twice the signal's maximum frequency component.



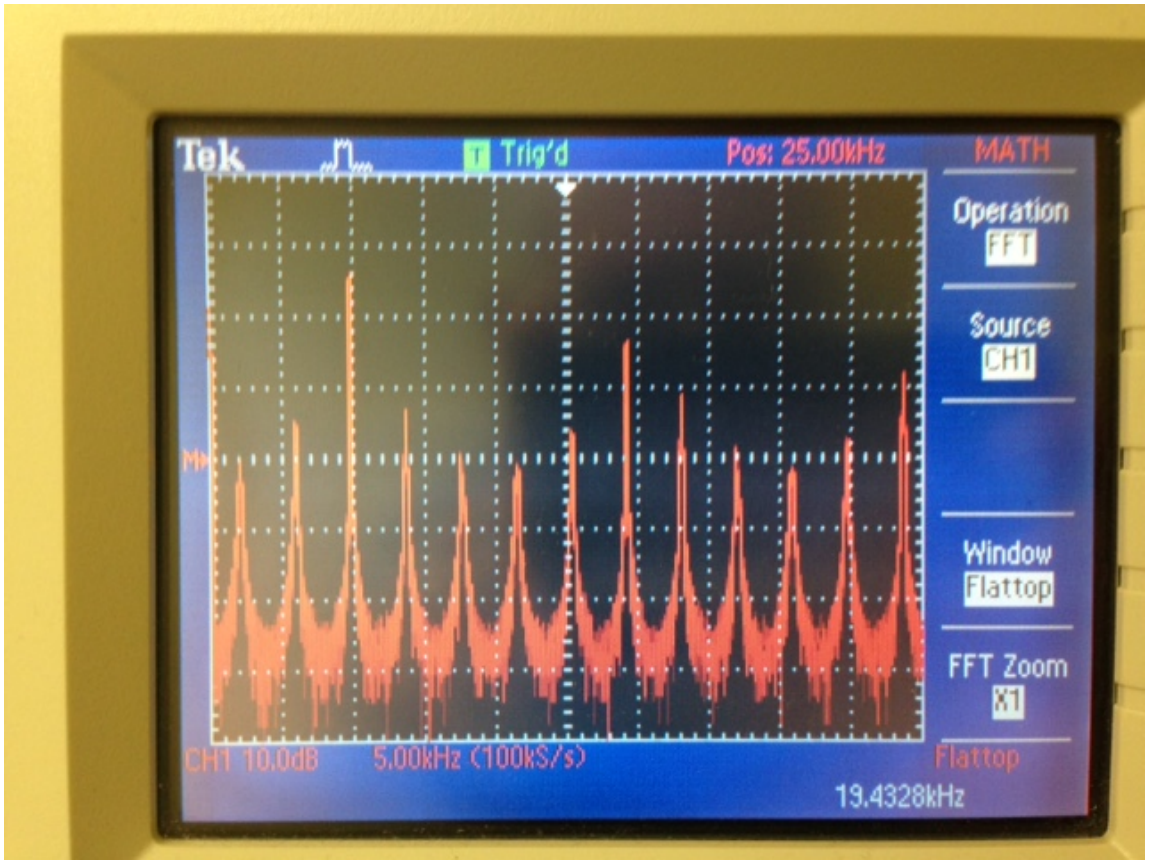
The FFT Display

The magnitude display is in decibels. `VOLTS/DIV` sets the number of dB per division.



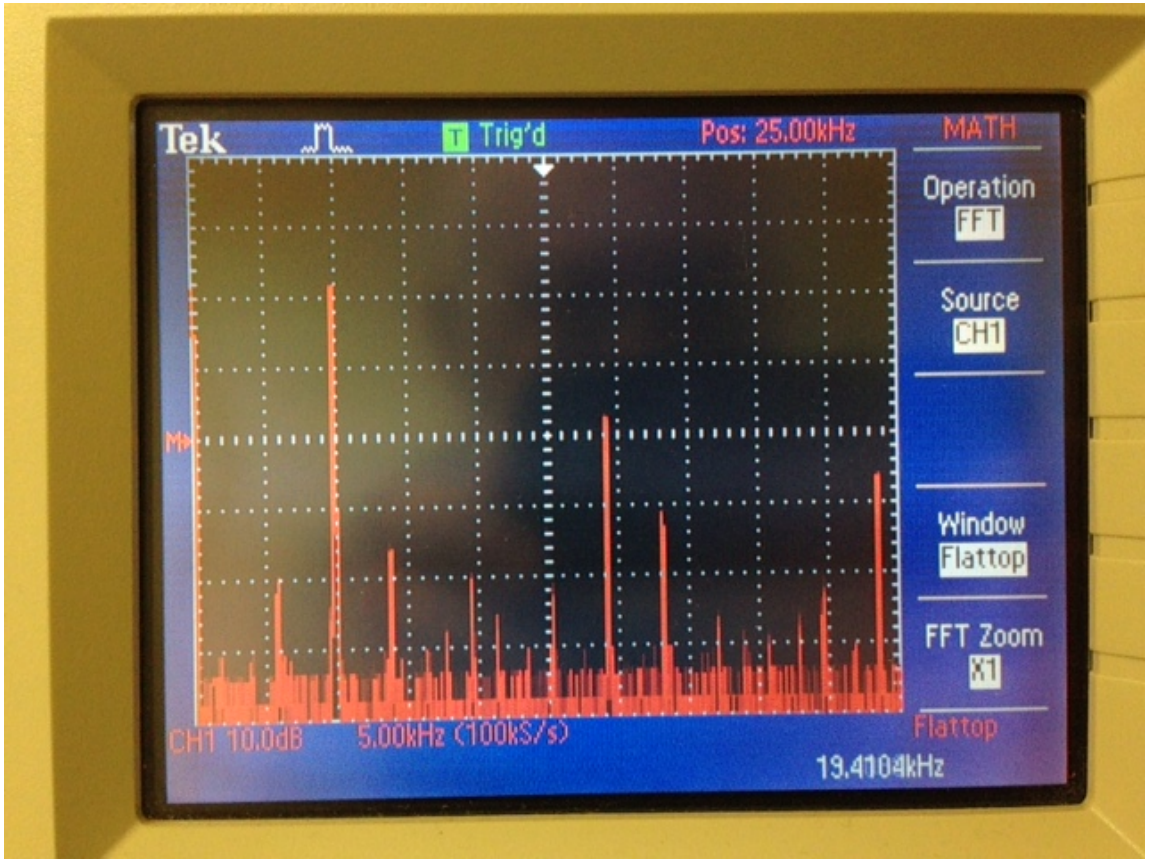
FFT of a Square Wave

Unlike a sinusoid, a square wave has many frequency components. In this example, the square wave has frequency components extending far beyond 50kHz, so aliasing occurs: the higher-frequency components are reflected back into the displayed portion of the spectrum, creating lots of spurious signals.



FFT of a Triangle Wave

A triangle wave also has many high-frequency components. Aliasing is occuring in this display as well. The frequency components should occur at integer multiples of the fundamental, but aliased components are visible in unexpected locations.



Getting a Clean FFT Display

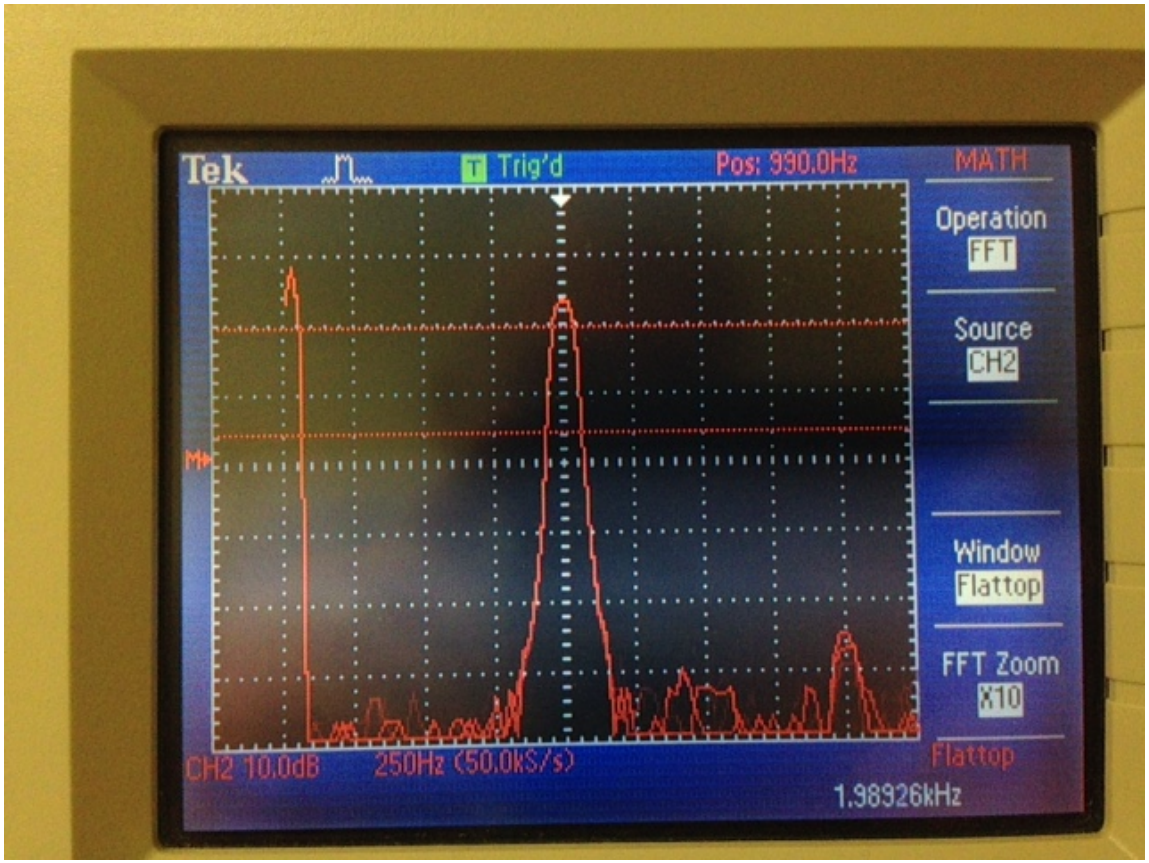
In order to properly view the FFT of a non-sinusoidal waveform, you need to use an anti-aliasing filter.

Since our circuit has no filter, we can get improved results by adjusting the SEC/DIV knob until a very high sampling rate is obtained. Try doing this with the triangle and square waves.

To get a closer look at the individual components, use the FFT Zoom feature. Do not use SEC/DIV as a horizontal zoom!.

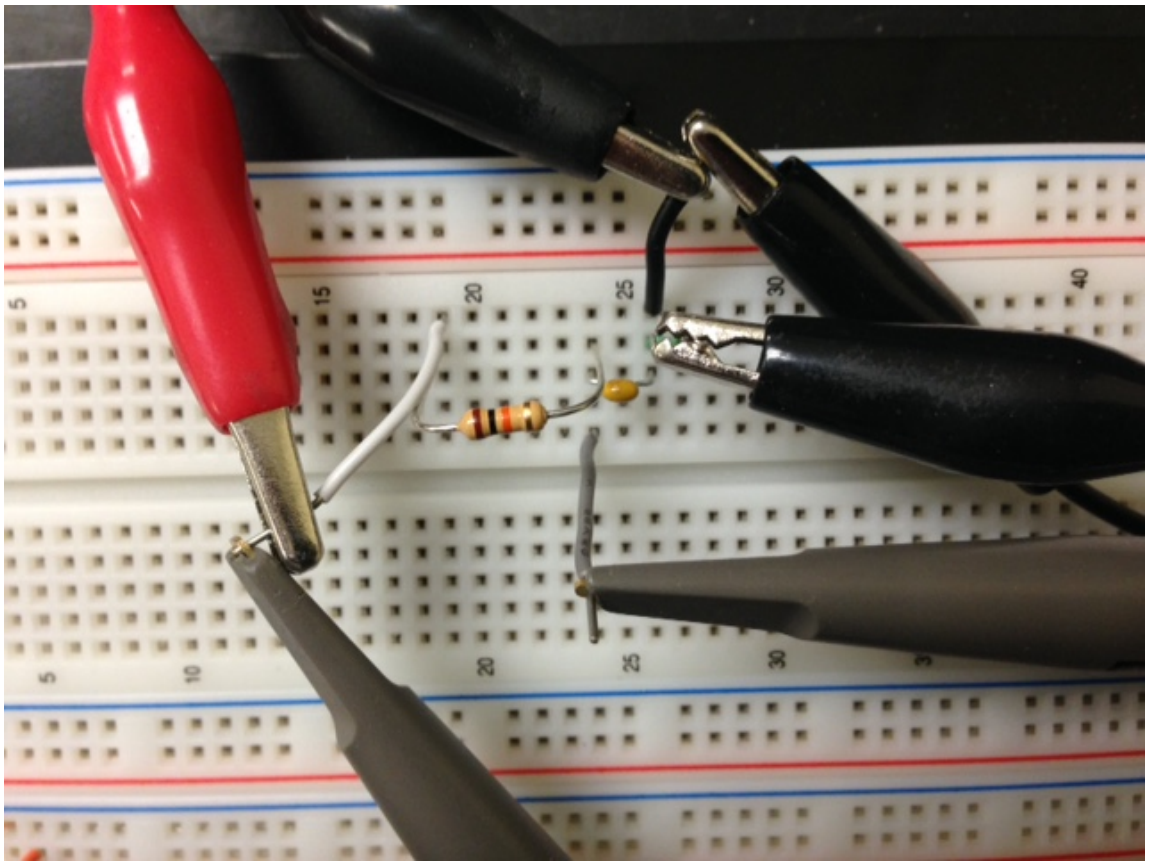
Using FFT Zoom

The `FFT Zoom` button allows you to perform a horizontal zoom without affecting the sampling rate. This is the safe way to get a closer look at the spectrum.



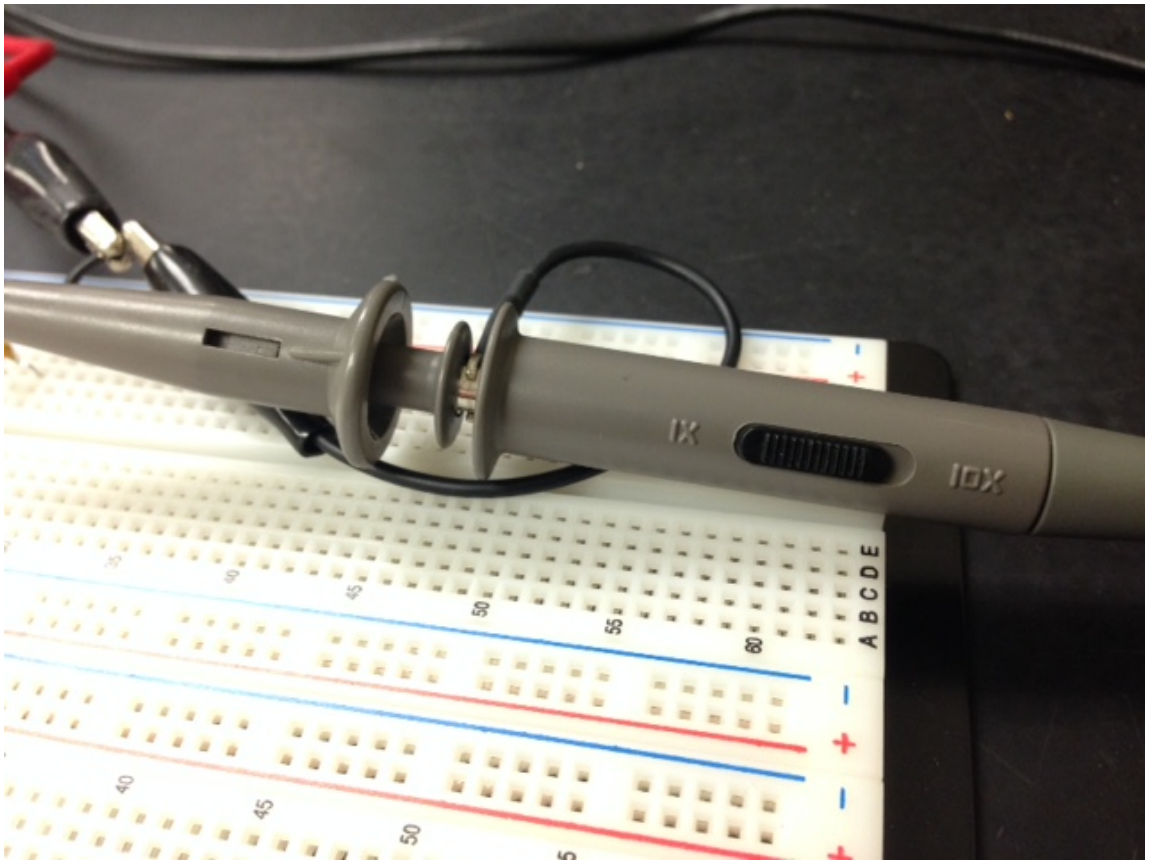
Circuit Connections

For the next part of the lab, construct the circuit on your breadboard. Use the alligator clips for the input signal. Use the oscilliscope probes to connect to the output signal. Never connect the oscilloscope probes to the function generator.



Set the Probe to 1X

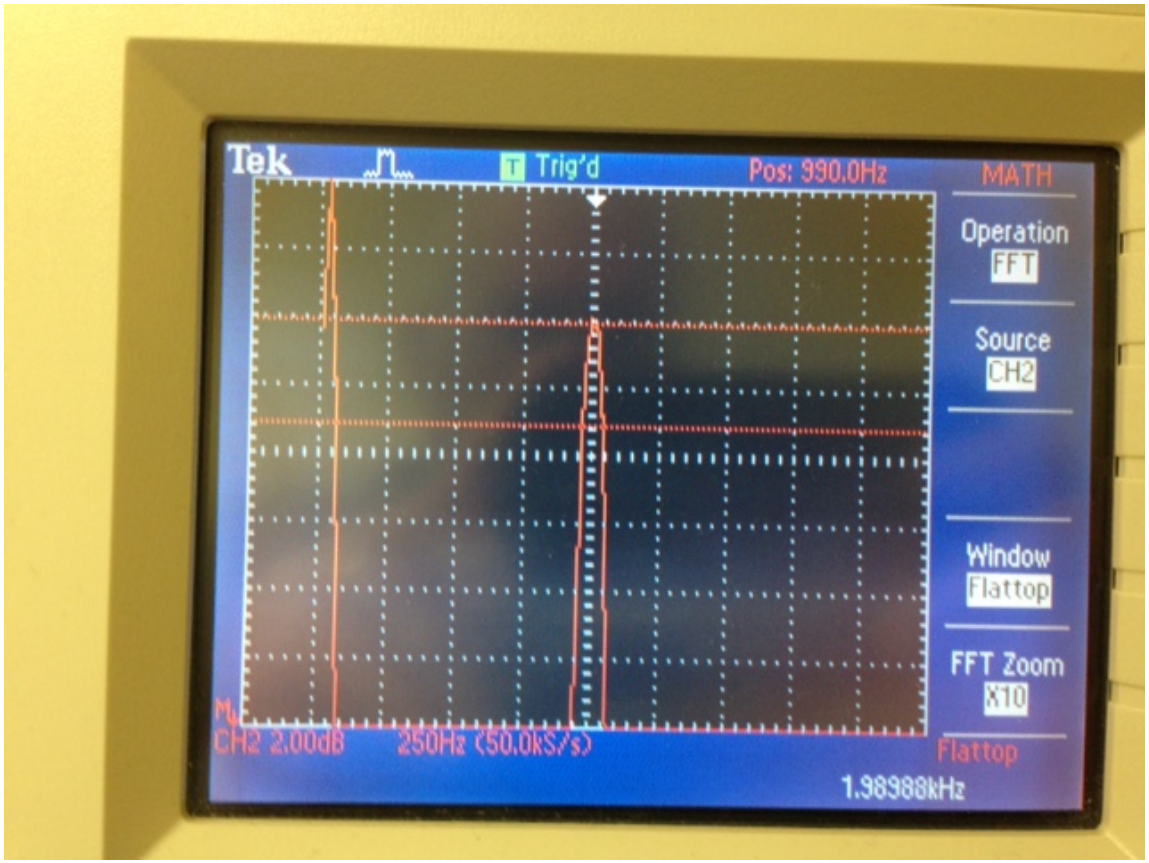
Make sure the switch on the probe matches the setting in the Channel setup menu on the scope.



Precise Magnitude Measurement

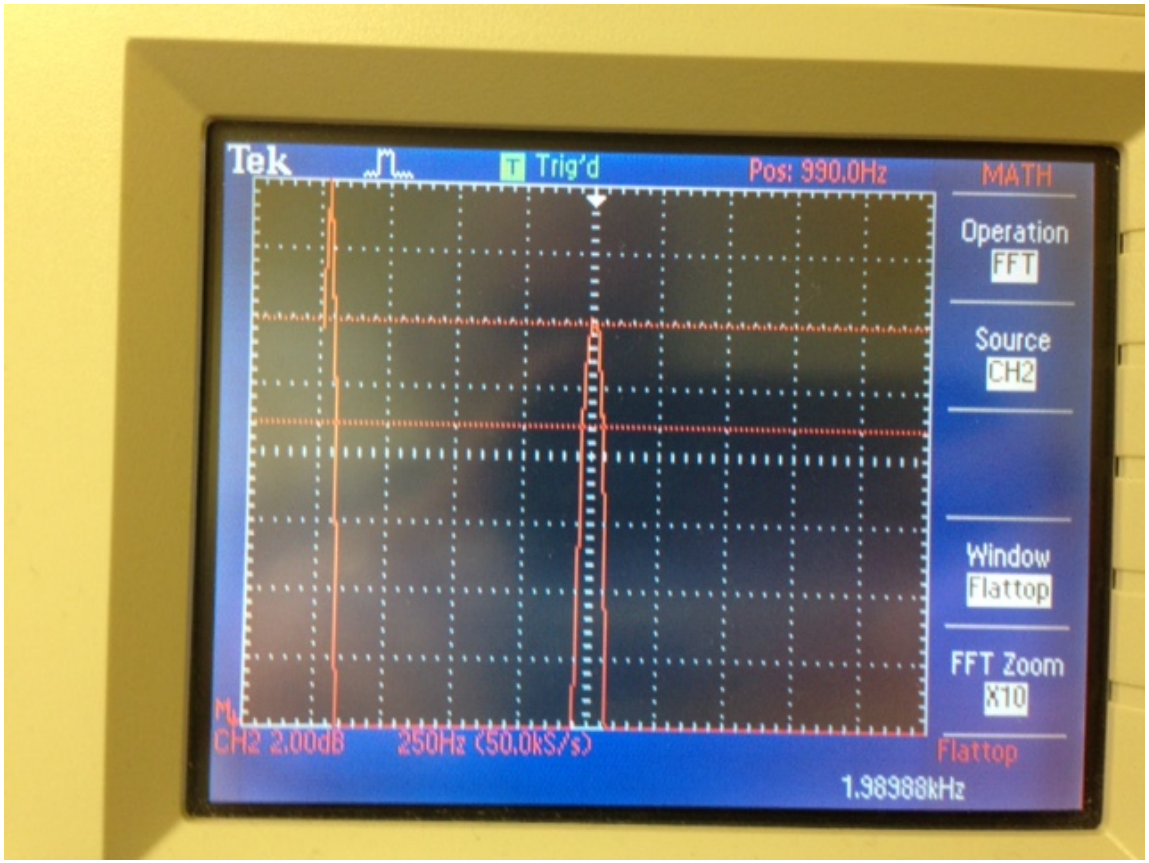
Use the FFT Zoom centered on the fundamental component.

You can freely adjust the `VOLTS/DIV` knob to zoom the vertical display.



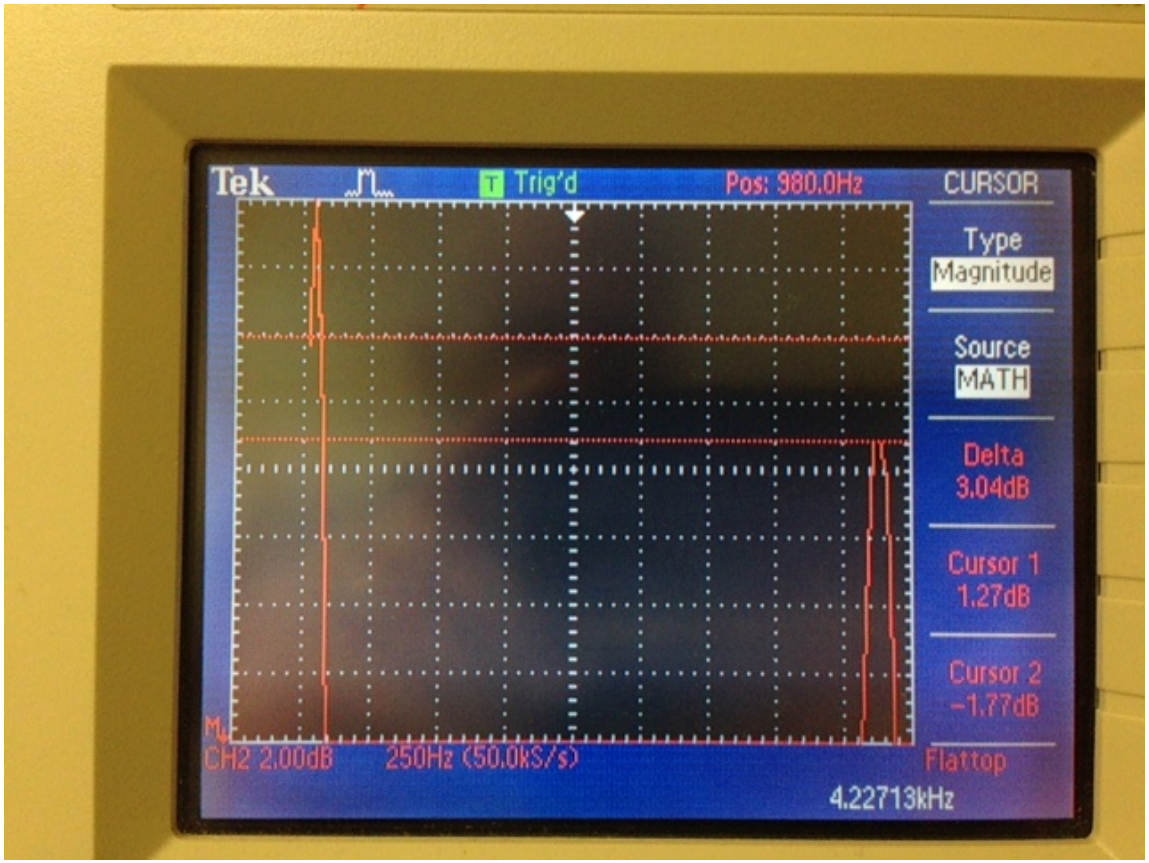
Precise Magnitude Measurement

Press the CURSOR button, and set type to MAGNITUDE, then position the cursors 3dB apart like this:



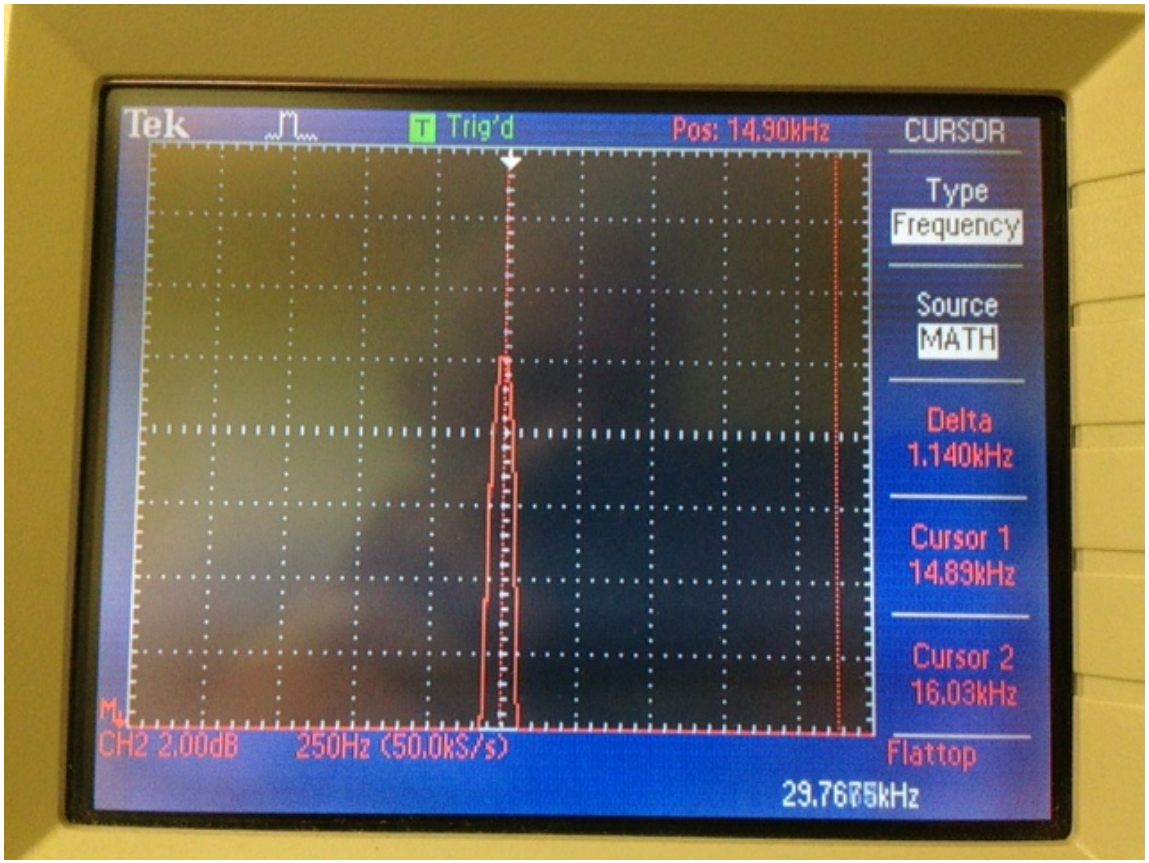
Finding the -3dB Frequency

When you adjust the frequency, watch for when the fundamental component crosses the lower cursor, like this (you may need to reduce the FFT Zoom amount):



Precise Frequency Measurement

To measure the exact frequency, switch the cursors to `Frequency` mode and use them to measure the center of the fundamental component.



That's All

Repeat the procedures described in this lab to complete the assignment.