ME 3300 Lab-04: Static and Dynamic Data Acquisition

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Contents

1 Learning objective

The objectives of this experiment are to provide the student with an opportunity to:

- Gain additional experience with Matlab.
- Create a simple program for data acquisition using toolbox and National Instrument's NI-MyDAQ.
- Become familiar with breadboards, wiring, digital multi-meters, oscilloscopes, function generators, and other basic laboratory equipment and skills.

2 Required Equipment

1. USB Data Acquisition Device (NI-MyDAQ)
2. Breadboard (MyDigital protoboard)
3. Digital Multimeter (both handheld and table-top)
4. DC Power Supply
5. Function Generator
6. Oscilloscope
7. Needle-nose pliers & wire strippers
8. Small flathead screwdriver
9. Digital multimeter (DMM)
10. Power supply and wire kit
11. BNC T-Connectors

3 Introduction

In this experiment, you will compare the measured signals from multiple sources including: an oscilloscope, a digital multimeter, a table-top digital multi-meter, and the NI-MyDAQ data acquisition device to view both DC and AC signals through the voltage divider circuit.

A typical component of the AC signal is shown in figure 1. As observed in the figure, the DC offset component is the offset of the reference signal (that is, zero volts) and V_{pp} is the difference between the maximum and minimum voltage in the AC signal. In the provided example, the offset and V_{pp} would be 2 volts and 6 volts, respectively.

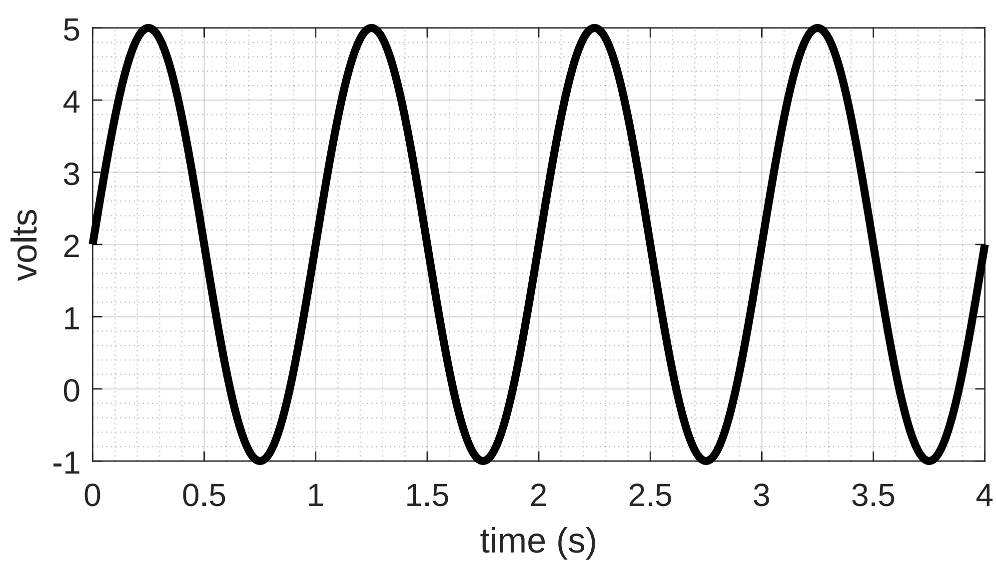

Figure 1: V_{pp} and DC offset in a typical AC signal.

4 Laboratory instruction

4.1 Part 1: Prepare MATLAB for data acquisition

Update the MATLAB code, **MATLAB_Data_Acquisition.m**, with the instructions provided in this section.

1. Collect the single-channel voltage output from ("AI1").

- Duration: 5 seconds
- Sample rate: 1000 samples per second

a. Run your program:
   - Save a data file using this naming convention: **Volt_XX.csv** where
     - `XX` indicates voltage.
   - Update the file name before each run to avoid overwriting data.

b. Compute the Average Voltage:
   - Write a MATLAB script to calculate the mean voltage from each data file.
   - Record the result with at least two decimal places.

4.2 Part 2: Set up the breadboard

Connect one "source" (power supply) to four measurement instrument NI My-DAQ, oscilloscope, hand-held DMM, and table-top DMM

1. Connect the output of the digital power supply to the breadboard.
   - Use the breadboard to distribute the source signal to the various measurement devices.
   - The required cables are located on the center column of the lab.
2. From the breadboard, connect the output (source and ground) of the digital power supply to the handheld DMM, table-top DMM, NI-MyDAQ, and oscilloscope. See figure 2.

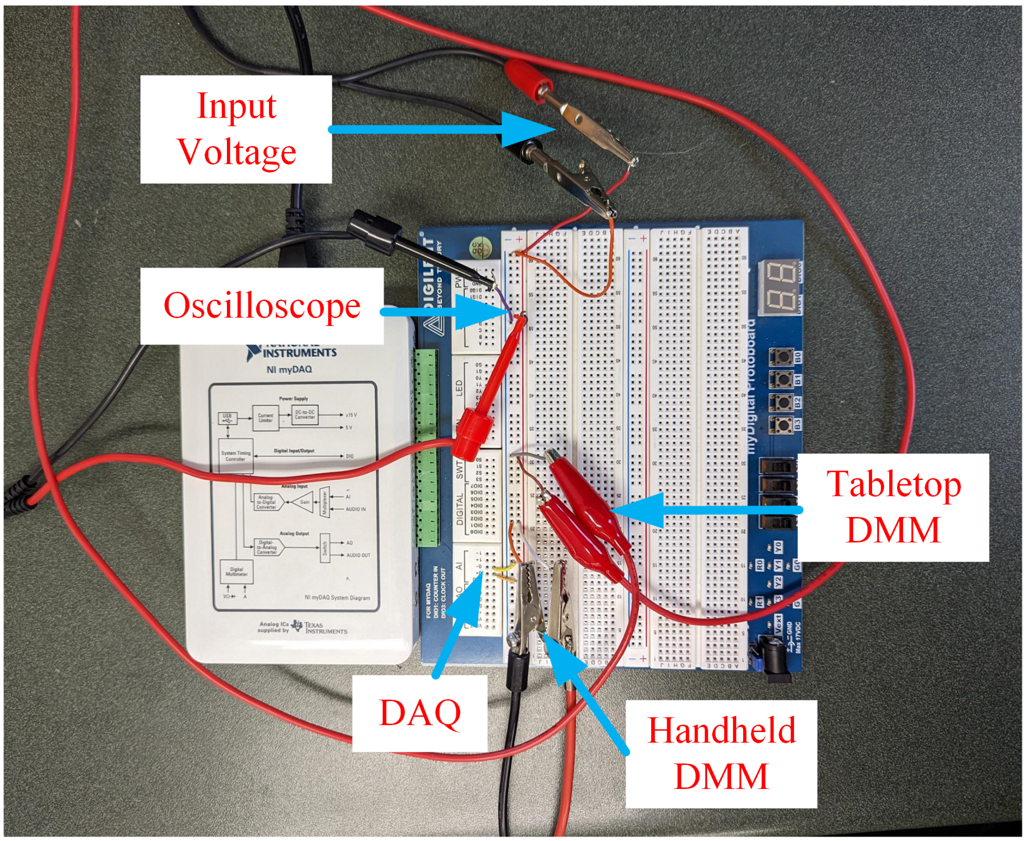

Figure 2: Sample connection from breadboard to four different measurement instrument.

4.3 Part 3: Measure static voltages with four different methods

1. Vary the power supply voltage from 0 to 5 volts in 1 volt increments.
2. Begin data collection:

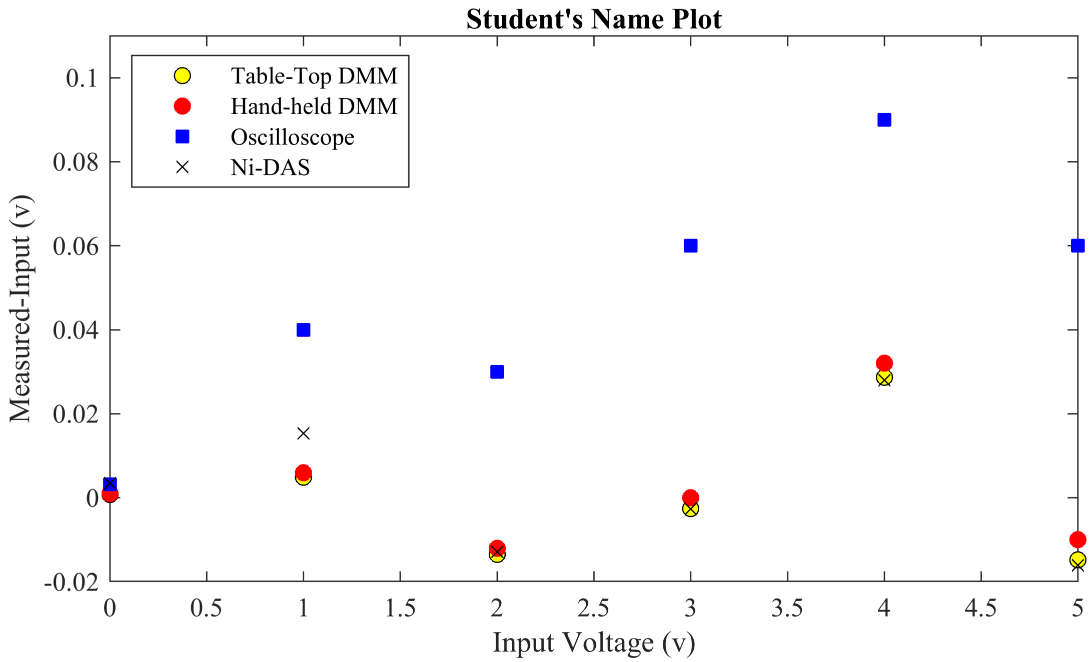

Figure 3: Sample plot of static signal post lab.

- Record the voltage, as accurately and precisely as possible with each instrument, using four methods:
  (a) Table-top DMM.
  (b) Hand-held DMM. Pay attention to the input range of the DMM.
  (c) Oscilloscope. There is a function for reporting "average voltage".
  (d) NI data acquisition system. Make sure to display average value to 8 decimal place in the acquisition program

3. In your lab notebook, record all four values for each input voltage, using the most **accurate** and **accurate**precise method for each instrument.
4. **For your post-lab submission**, create a plot of voltage error (measured input) vs. input (from the digital power supply) for all four methods in the same figure. Use different markers for your points.
5. Change the time range on the oscilloscope to a very small value. Is there a dynamic component in the digital source? What is it from? Could it be from aliasing?

Q: What are the steps to set up the oscilloscope to report "average voltage"?
Q: What is the resolution for each measurement intrument?

4.4 Part 4: Dynamic Signal Measurements

Connect one source function generator to two 1) NI My-DAQ, and, 2)oscilloscope.

1. Disconnect the power supply from the breadboard.
2. Disconnect DMM from the breadboard.
3. Connect the output of the function generator to the NI My-DAQ and the oscilloscope. You will need the BNC T-Adapter (T connector located in the resistor kit). See figure 4 .

4.5 Part 5: Measure dynamic signals with two different methods.

1. Dial in the following AC signal on the function generator: $y(t) = 2.5 + 2sin(2\pi 0.5t)$
2. Collect the single-channel voltage output from ("AI1").
   - Duration: 5 times the time period of the function $y(t)$
     - **Do not sample below 0.2 seconds.**

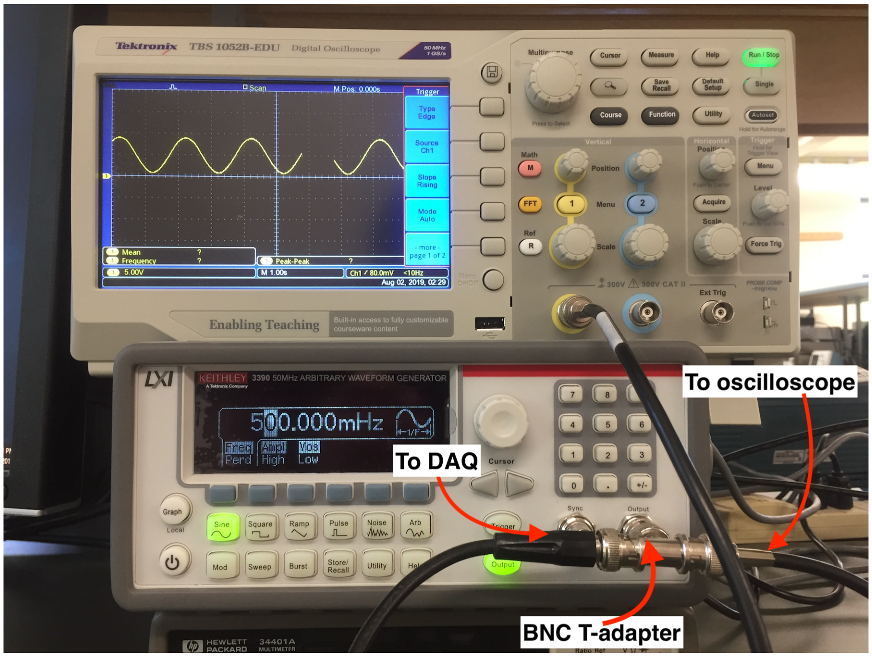

Figure 4: Figure showing connection for acquiring dynamic signal.

- Sample rate: 1000 samples per second.
  - **NOTE: this sample rate will remain constant but the frequency in function generator will be varied.**

3. Use the zoom X-axis button on the **oscilloscope** to zoom until 2-5 waves are visible. (You may have to modify this for every new signal)
4. **Practice changing the function generator**: increase the input frequency, the frequency of the function generator $y(t)$, incrementally starting from 0.5 Hz to 1,125 Hz.
5. **For your post-lab**, save the acquired data for the following five frequencies of the $y(t)$:
   - A frequency 0.2 times of the Nyquist frequency the signal begins to "look" discretized (below the Nyquist frequency).
   - A frequency 0.9 times of the Nyquist frequency the signal begins to "look" discretized (below the Nyquist frequency).
   - A frequency 1.0 times of the Nyquist frequency the signal begins to "look" discretized or Aliased.
   - A frequency 1.10 times the Nyquist frequency. What is the predicted Alias frequency? What is the actual?
   - A frequency 2.25 times the Nyquist frequency. What is the predicted Alias frequency? What is the actual?
6. Show your results to TA and make sure you have the all the required data for post-lab.
7. Modify sample code sample code: **MATLAB_Dynamic_plot.m**

Q: What are the maximum sample rate for the MyDAQ and oscilliscope? Which is better for high-frequency measurements?

5 Part 6: Return Lab Space to Prior Condition

1. Remove all breadboard wires and place them back in the wire kit in an organized fashion.
2. Remove the pendulum wires from the breadboard and set them aside.
3. Confirm your data files are saved to OneDrive.
   a. Check that files are available online using your phone or personal laptop to confirm.
   b. Make sure that all team members have access to experiment files, including data and scripts.

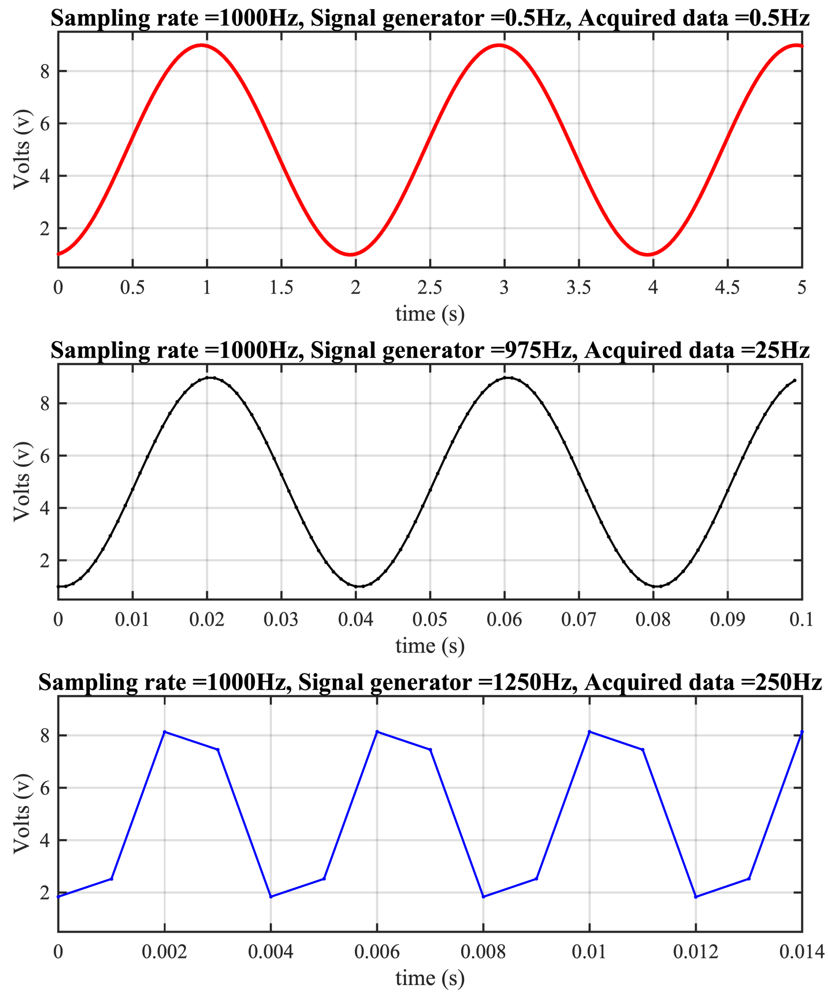

Figure 5: Sample plot dynamic signal post lab.

4. Log off the computer.

6 Post-Laboratory Assignment

For this experiment, submit the following items on Canvas for your post-laboratory assessment.

1. **Static Voltage Measurement Plot**
   - The calibration plot should include:
     - Using "scatter" plot function, raw data points should be with `MarkerSize = 90`.
     - Unique markers and colors should be used for each sampling type.
   - The plot should be 5" tall and 6.5" wide.
   - Properly annotate your plot: axis labels, title, legend, etc.
   - Include legend of all different sampling types.
     - Use title: "FirstName LastName's Static Voltage Measurements".
   - Set axis grid lines on, box off, and figure background color to white.
2. **Aliasing Figure**

- Use Subplot to create a single figure with 5 plots (5 rows, 1 column).
- Make sure the plot shows only first 3 to 4 peaks.
- Make sure to annotate each Subplot with the measured frequency (the actual frequency from the function generator) and the Alias frequency (the frequency recorded).
- See the sample plot and code. See sample plot in appendix 5 (Note that example shows three signals only.
- Make sure to change the title on each figure to show correct values of sampling frequency, signal generator frequency, and Acquired data frequency.
- The plot should be 5" tall and 6.5" wide.

3. **Answer All Questions in the Post-Lab Canvas Assignment**
   - Compare your plots to the example plots shown in Figure **??** and **??** to confirm that you have completed the assignment correctly. Note that your values will differ, but your formatting and annotation should match.

7 Appendix

7.1 Keithley Function Generator

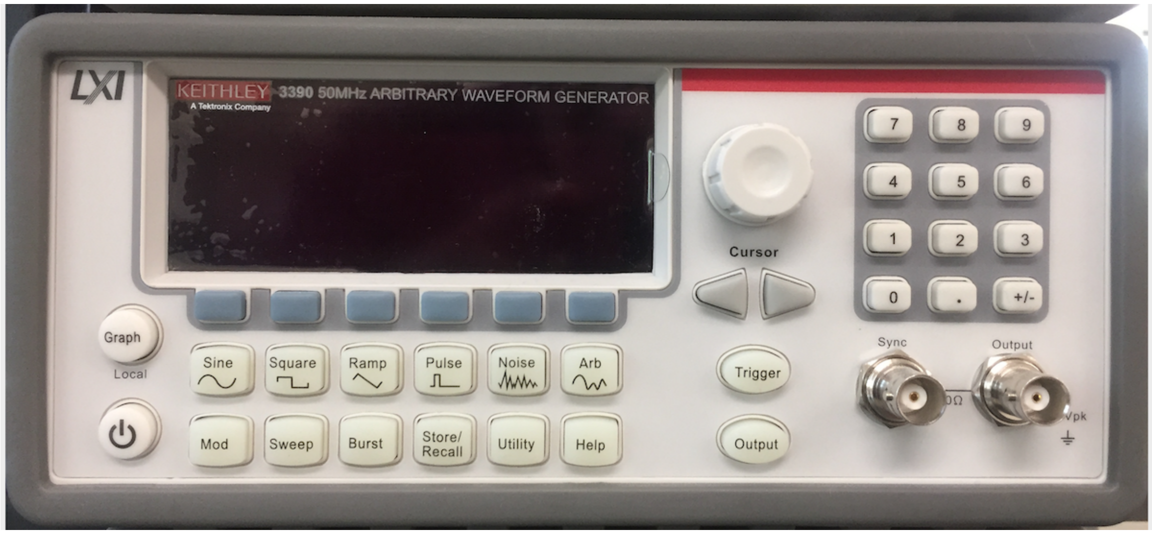

Figure 6: Keithley function generator

FREQUENCY: To set the frequency to the required frequency press the first gray button on the left-hand side on the function generator.
PEAK-TO-PEAK: In order to set the peak-to-peak voltage to the required peak-to-peak voltage press the second button starting from the left and turn the knob until we get the desired peak-to-peak voltage.
DC OFFSET:To set the DC offset to the desired offset press the third button starting from left and turn the knob until you get the desired value as required by the experiment being performed.

7.2 Tektronix Function Generator

Figure 7: Tektronics function generator

FREQUENCY: To set the frequency to the desired frequency press the frequency button and use the knob to adjust the frequency to the desired value.
PEAK-TO-PEAK: In order to set the DC offset to the required offset press the offset button and use the knob to adjust the offset to the desired value.
DC OFFSET: To set the peak-to-peak voltage to the required value press the amplitude button and use the knob to set it to the desired value.

7.3 Oscilloscope

There are two oscilloscope brands that will be used in the lab: the Agilent and the Hewlett Packard oscilloscopes. They have the same general functionality but the buttons are in different places. The following are basic instructions for each. To setup for a measurement, turn the appropriate channel(s) on (if only using one channel, turn the other off). Press the

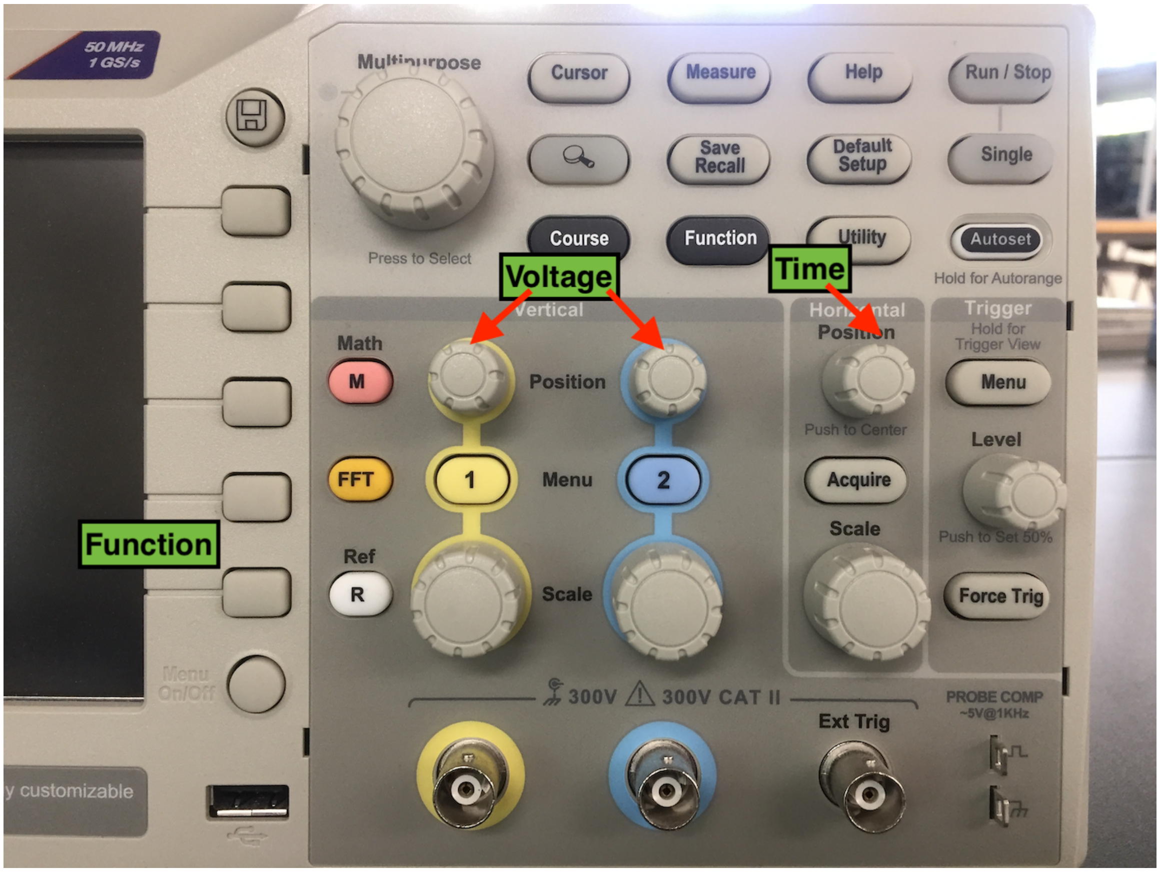

Figure 8: Oscilloscope keypad layout

corresponding Channel Button to access the options for that channel. The channel is on when the button is green. Press the button once to turn it on, press it again to turn it off. The Function Buttons change their function based on the current operation. Their current function is displayed on the side of the screen next to the corresponding button. For example, when you press one of the Channel Buttons, the function buttons will change to the options available for that particular channel.

To manually set the scale the display, use the corresponding **Voltage Scale** and the **Time Scale** adjustments. They are labeled Volts/div and Time/div respectively. The voltage is displayed on the y-axis and the time is displayed on the x-axis. The current voltage scale is listed in the top left corner of the screen, and the current time scale is listed in the top center of the screen. The display area is split into a grid for both axes. The number displayed for each scale corresponds to the amount of voltage or time represented by each grid space. Adjust each scale to a value that makes sense for the signal being measured (remember that frequency = 1/time). The voltage scale must be set for each channel independently.

The **Ground Shift** adjustment controls where the incoming signal ground is referenced to. It is labeled Position, and is adjusted independently for each channel. This acts as a voltage offset for the display, and allows a signal to be viewed even if that signal has voltages that would be out of the range of the display when ground is referenced to 0V. For most measurements, start by bringing the ground to 0V. A number on the side of the screen indicates where the ground currently is.

The **Time Shift** does the same thing for time that the ground shift does for voltage. For most measurements, bring it to 0. A number at the top of the screen indicates the current position.

For more display options, press the Main/Delayed button and adjust the settings using the Function Buttons (see function button note). The Main option (selected by default) keeps the signal stationary and traces its path across the screen. The

Roll option keeps the trace stationary and scrolls the signal across the screen. Sometimes it is easier to use Roll to verify that the scope is still updating, when Main seems to be unchanging.