Lab 1 - Using the ADALM2000

Objectives

To familiarize yourself with the ADALM2000 device. To learn how to measure, store, manipulate, and characterize analog signals. Learn how to make electrical connections using a solderless breadboard.

Laboratory Equipment

You will use the ADALM2000 Learning Module, connected via the provided USB connection to your computer, using the Scopy software. You will use a solderless breadboard.

Background

A DC power supply is an electrical device that produces a prescribed constant voltage between two terminals. Portable electronic devices typically use batteries to provide this voltage, while other devices use rectifying or regulating devices to produce a DC voltage from an AC-connected power plug. The ADALM2000 has two programmable DC output voltages, with opposite polarity (i.e., one of them is positive, relative to ground, while the other is negative.) The maximum output voltage is +/- 5V.

A voltmeter is a basic instrument for measuring the electrical voltage in circuits. Voltmeters can measure constant (DC) voltages, or AC voltages. The ADALM2000 can be used as a two-channel digital voltmeter.

A Digital Oscilloscope is a piece of measurement equipment used to acquire, record, and display time-varying analog signals. They are usually designed for the table-top but some are hand held. The input analog signal sampled at regular time intervals and the resulting sequence of voltages is displayed on a screen. The capabilities in terms of frequency response and measurement features vary considerably (as do the prices). Most of them store data in memory, can transfer data to flash drives or computers, add or multiply signals, and can perform various statistical functions on the data (e.g., maximum, average, etc.). The ADALM2000 functions as a two-channel oscilloscope.

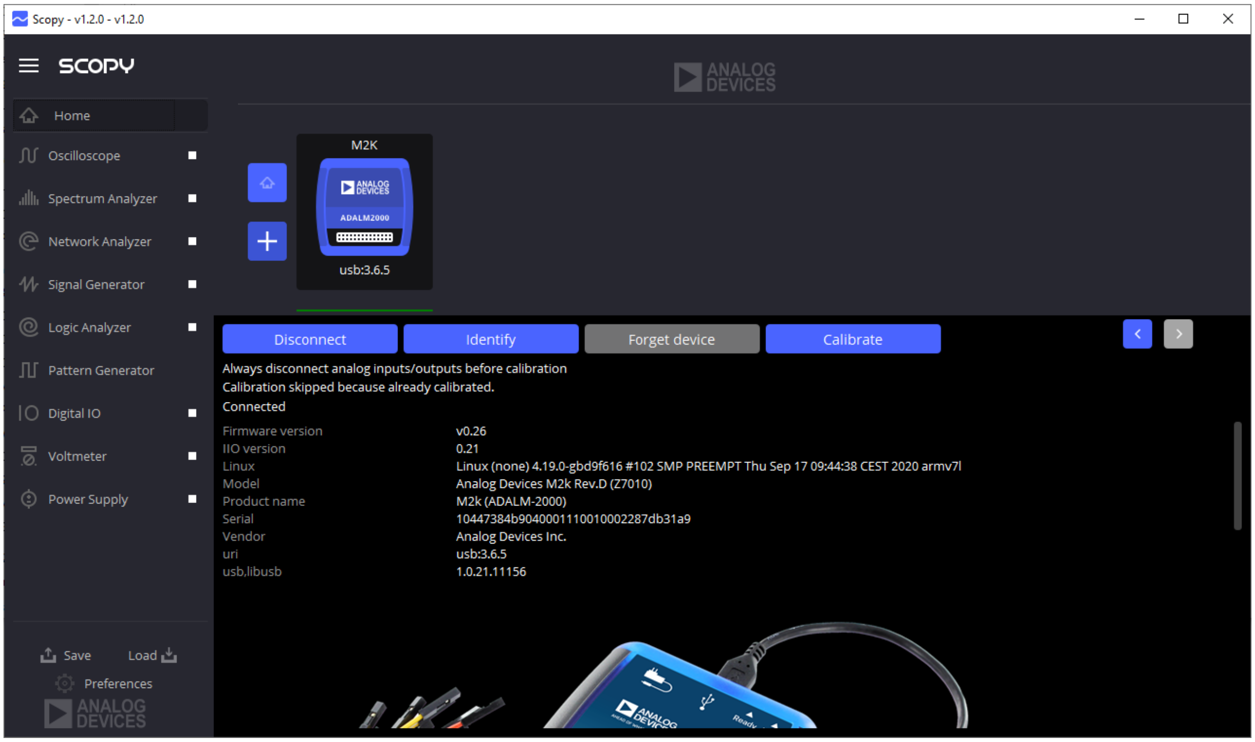
Function (Signal) Generators are used to generate periodic voltage signals. Basic signal generators can produce sinusoidal, square, or triangular (saw-tooth) waves over a range in amplitudes and frequencies. The output signal can typically be either repetitive (continuous) or single shot (one pulse). The available current supplied by function generators is usually low. The ADALM2000 has two programmable function generator outputs.

Pre-lab Preparation

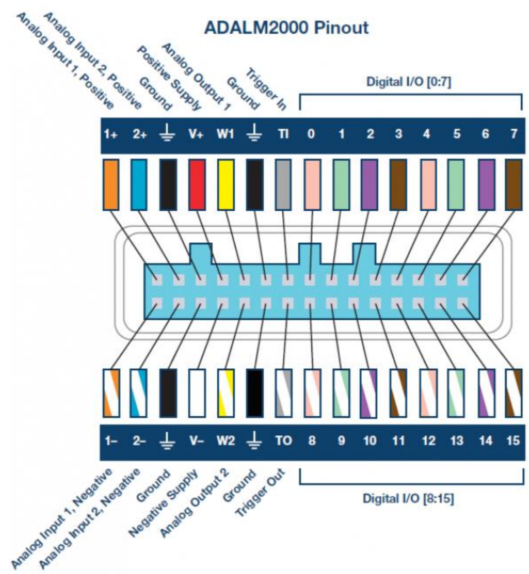
There are no circuits that need to be analyzed or assembled prior to this lab.

Instructions

Here is how the Scopy main menu works, after connecting the ADALM2000. In this lab, we are going to introduce the following features: Power Supply, Voltmeter, Signal Generator and Oscilloscope.



The ADALM2000 analog pin connections



The ADALM2000 connector, which has the wires we will connect to our circuits, is shown in the figure to the right. The analog pins that we will use are the ten wires on the left side of the connector (5 on top and five on the bottom row). We will describe the wire functions from left to right in pairs. The first two on the left are the connections for the first oscilloscope channel. On top, the solid orange wire is the positive terminal for the probe and on the bottom, the orange/white wire is the negative terminal. These connections are “floating”, which means that they can be connected anywhere in a circuit. HOWEVER, normally the negative terminal is connected to the circuit ground, which is the node we consider to be at zero volts. The next pair of wires connect to the second oscilloscope channel. The blue wire on top is the positive connection and the blue/white wire on the bottom is the negative connection. The next two wires are black. They are connected to each other and to the internal ground of the ADALM2000, hence representing the circuit ground. The next two wires are connected to the internal power supplies. The red wire on the top goes to the variable positive supply and the white wire on the bottom goes to the variable negative power supply. The final two wires that we will use are yellow and yellow/white. The yellow wire on top connects to the first signal generator. Only one wire is needed to connect a signal generator as the second terminal of each signal generator is ground. The yellow/white wire is connected to the second signal generator.

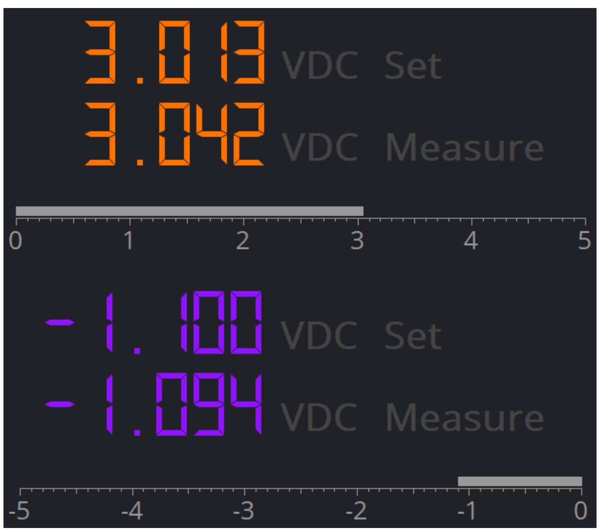
1. Power Supply

Connect Scopy to your ADALM2000. Once connected, use the Power Supply tab to access the two-channel programmable power supply. The power supply has two modes: tracking (in which the two supplies are constrained to be equal and opposite) and independent, in which you can separately adjust the positive and negative voltage.

Set the positive power supply voltage to match the last three digits of your telephone number times 5. For example: (301) 314-5111 = 0.555 V (720) 423-2344 = 1.72 V.

Set the negative power supply voltage to match your birth date (d.dmm), so if you were born March 12th, use -1.203 V, January 1st would use -0.101 V and December 31st would use -3.112 V

Enable the output voltages, and then take a screenshot showing your programmed and measured voltages. Below is an example:



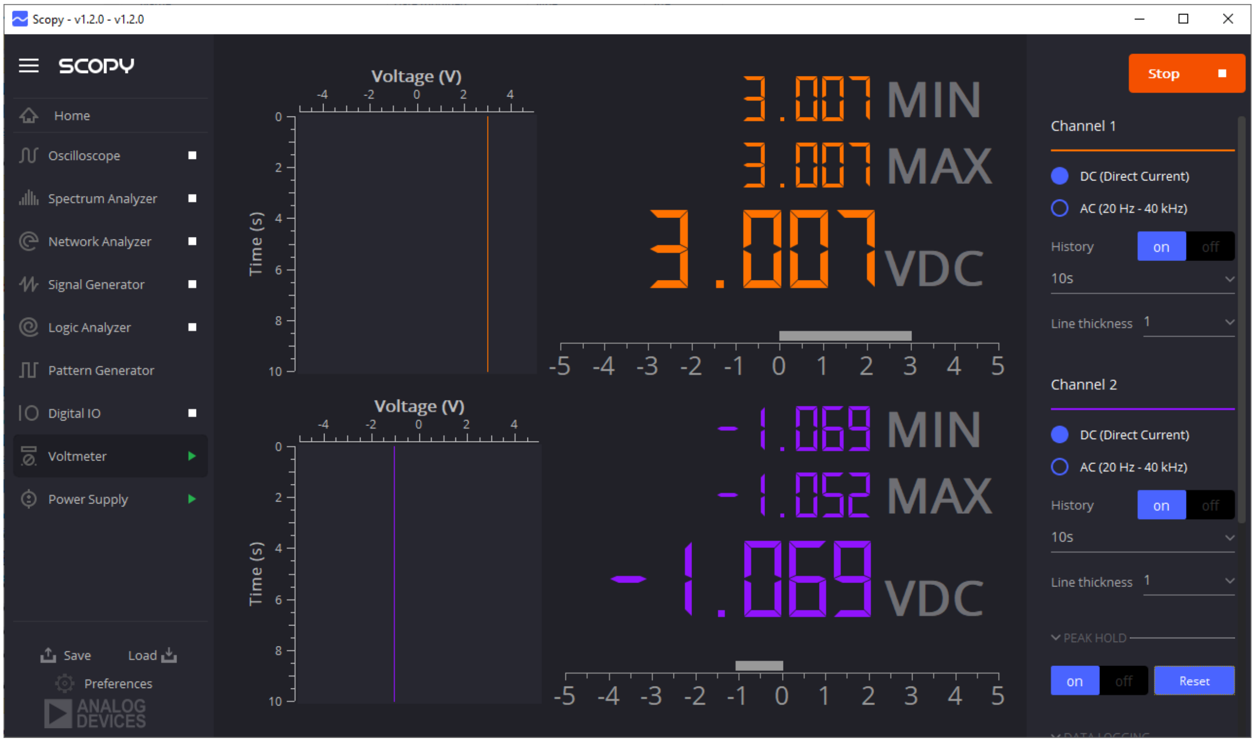
2. Voltmeter

The DC voltages provided by the ADALM2000 are produced on the RED and WHITE output leads (corresponding to V+ and V–, respectively.) In addition to producing programmable DC output voltages, the ADALM2000 can measure DC input voltages. The input voltages are measured using the ORANGE and BLUE wires.

Use the solderless breadboard, and jumper wires provided to connect the ORANGE wire (Channel 1 input) to measure the V+ terminal, and the BLUE wire (Channel 2 input) to measure the V– terminal.

Take a clear photograph of your breadboard, showing the connections made. You do not need to show the entire ADALM2000 -- just enough to clearly document which wires are connected and how the ground pins and negative terminals are connected.

Turn on both channels of the voltmeter, and record the voltages produced by the power supply. You will find that they do not exactly match what you programmed -- that is normal. See if you can get the output measurements to match your target values by making small adjustments to the power supply voltages.



3. Signal Generator

The ADALM2000 can also produce waveforms, by using the SIgnal Generator menu. You are offered a variety of choices, including sine waves, sawtooth, ramp (ascending) and ramp (descending), and you can separately provide the parameters for two independent output channels, on the YELLOW and YELLOW/WHITE leads.

Adjust the settings so that Channel 1 with the following properties:

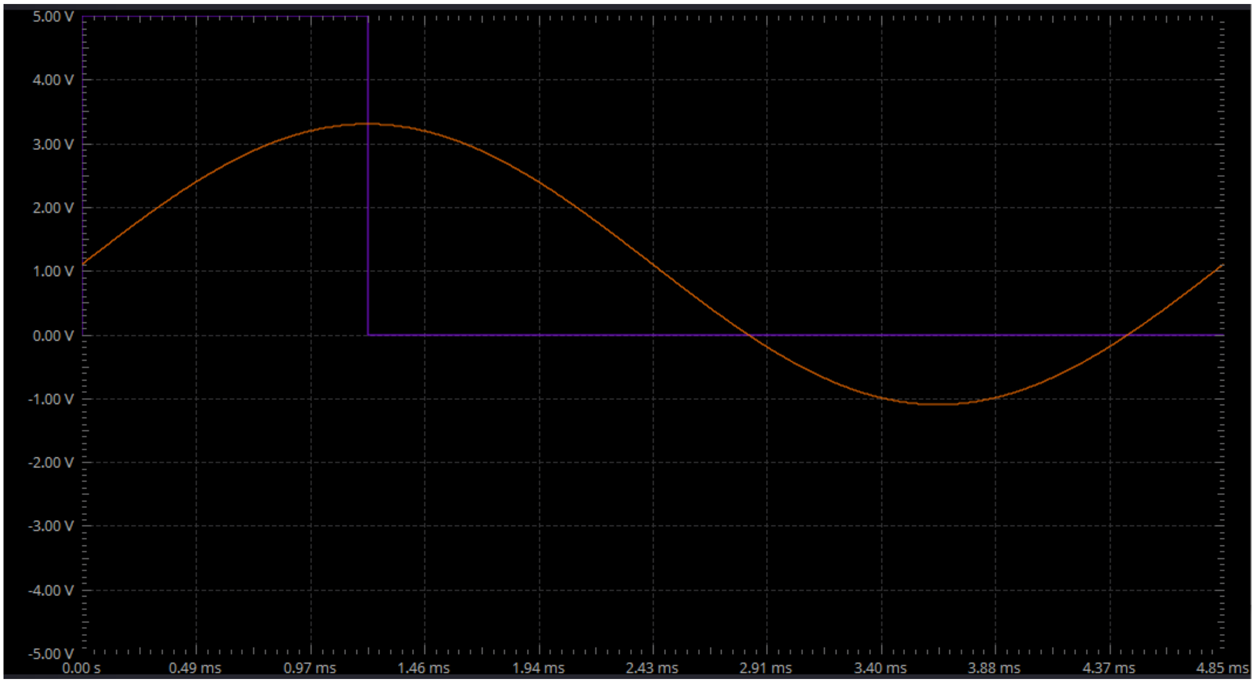
- Waveform: Sine
- Max voltage = [obtained from leading digits of phone number] (ex:. 3.013 V)
- Min voltage = [obtained from start-time of your discussion] (ex: –1.100 V)
- Frequency = your section number (ex: section 0206 = 206 Hz)

Adjust the settings so that Channel 2 is a square wave with the following properties:

- Waveform: Square

- Max voltage = 5 V
- Min voltage = 0 V
- Duty cycle = 25%
- Frequency = SAME AS FOR CHANNEL 1

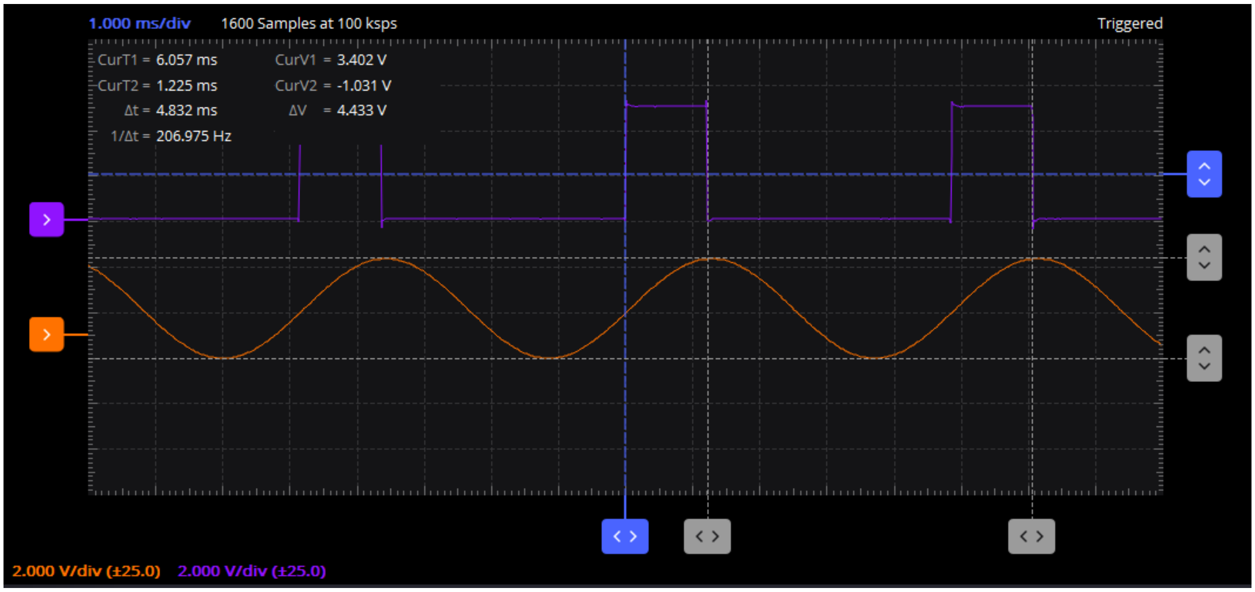
You will need to do a little math to determine the peak to peak amplitude and offset needed to achieve the desired minimum and maximum voltages. Scopy will provide you with a graphical depiction of the two programmed waveforms channels. Although the numbers and values will be a little different for each student, it should look something like this:



Enable the two outputs and take a screenshot clearly showing the settings that you used.

4. Oscilloscope

Use the same configuration with the breadboard as in step 2, but use the orange and blue oscilloscope probes to measure the two outputs from the signal generators. Make sure that the orange/white and blue/white wires are both connected to a black ground wire. On the oscilloscope tab, push the "Run" button and then push the "Autoset" button. Make a copy of the oscilloscope results, which will look similar to the figure below.



If the oscilloscope traces seem to drift with time, either slowly or rapidly, it is most likely because the oscilloscope trigger is not set correctly. The trigger system is needed because the oscilloscope is continuously sampling data and needs to be told what sample should be considered as t=0. The trigger system has several adjustments that can be used to stabilize the traces; we will talk only about four key adjustments. The first is the trigger voltage level and is shown by the level dashed blue line on the trace above. The trigger level can be adjusted by typing a voltage on the trigger settings panel (729.927 mV in the figure to the right) or by simply dragging the blue up/down marker on the right end of the trigger line. If the trigger level is lower than the lowest voltage or higher than the highest voltage level, then the signal is not triggered and will drift. The trigger can be “tied” to either the channel 1 signal or the channel 2 signal and can be changed via the source drop-down menu (set to Channel 1 in figure). Finally, one can adjust the “condition” for the trigger. The two most typically used conditions are rising edge and falling edge (set to rising edge in the figure). For periodic signals, for any trigger level, there will always be two times in a single period where the signal equals the trigger level. The condition is used to pick only one of those points so that the trace doesn’t jump around between the two points. The final trigger adjustment is the trigger mode, which is set to “auto” in the figure. The other option is “normal”. In auto mode, you will always see the signal on the oscilloscope whether it is triggered or not. In normal mode, you will only see the signal if triggered, and the screen will be blank if not triggered. Perhaps it is best to leave it in “auto” mode normally.

Timebase, Voltage Scale, and Cursors

The oscilloscope screen is separated into horizontal and vertical divisions, which are used to mark the time axes and the voltage axes, respectively. A benchtop oscilloscope has knobs that are used to change the time-base and voltage scales, which allows you to "zoom in" or "zoom out" to view different portions of the waveform. The horizontal scale is always indicated on the oscilloscope display, for example, in the above figure the label in the top left indicates that each horizontal division represents 1 millisecond. The vertical scale (Volts per division) is also clearly marked, and can be separately adjusted for each of the channels. Additionally, it is possible to shift the position of the v=0 axis independently for the two channels, which is useful if you would like to separate the two waveforms with an offset.

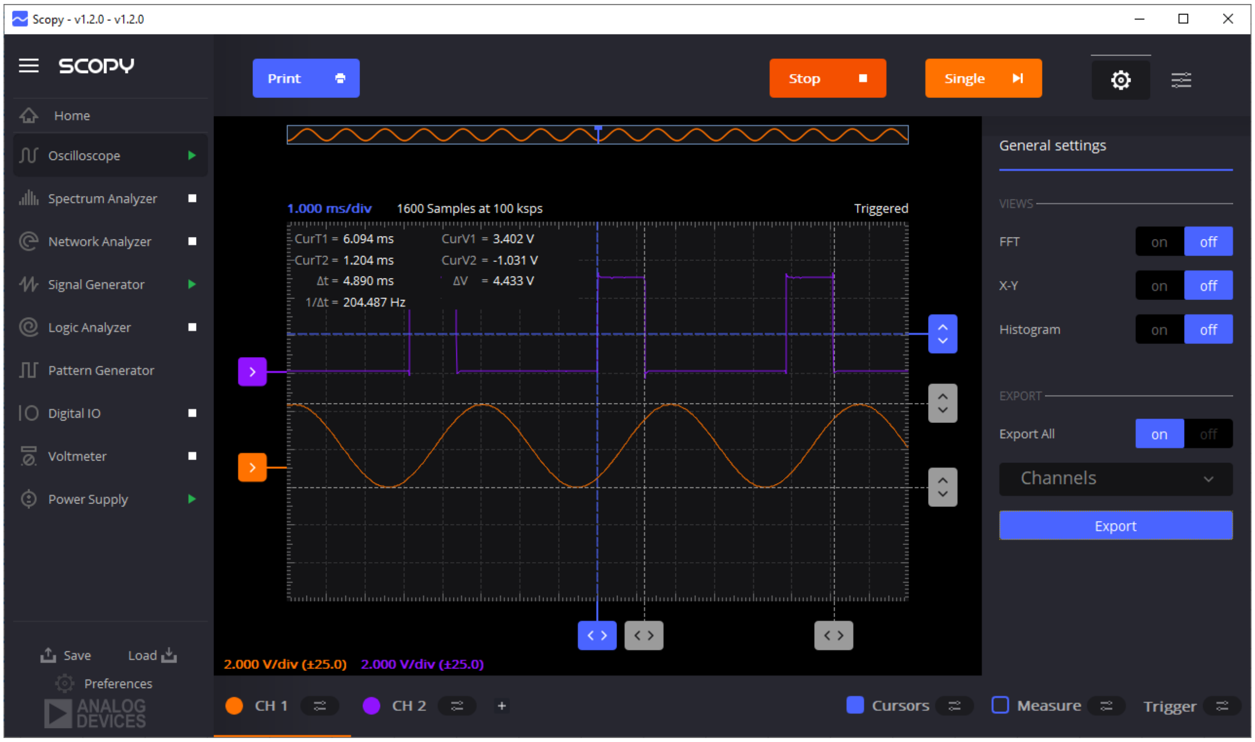
It is common to use an oscilloscope to measure voltages and time intervals, and nearly all digital oscilloscopes offer convenient cursors that can be manually positioned over your waveforms to assist with measurements.

Use the vertical (time) cursors on Channel 2 to measure the period of the square wave that you have generated. Then use the horizontal (voltage) cursors on Channel 1 to measure the minimum and maximum voltage levels of the sinusoid.

Storing Waveforms

One of the benefits of a digital oscilloscope is that the measured waveforms are stored as digital information before they are plotted on the screen. Digital oscilloscopes offer you the ability to save these captured waveforms to a file or storage device, allowing you to plot, analyze, or process the data using external software (such as Matlab, Excel, Python or others.)

Use the Export All feature of Scopy to save a copy of the two waveforms (Channels 1 and 2) to a comma-separated value (CSV) file.



5. Free Discovery

Experiment with the ADALM2000. Use different waveforms. Make one of the frequencies twice the other. Then make one frequency 0.1 Hz higher than the other. Play around with the time base. Play with all the symbols at the bottom of the oscilloscope screen (CH1, CH2, +, cursors, measure, trigger). Make a note of how each control can modify what is displayed on the screen. Remember to use the “Autoset” button if you ever make changes that you otherwise cannot recover from.

6. Post-lab Analysis

Your post-lab analysis task for lab one is to describe in reasonable detail what you learned about the operation of the ADALM. Have three sections in your analysis. In the first section, write your observations regarding the first four steps of the lab. In the second section, write about your actions and observations during the “Free Discovery” section of the lab (Part 5). Finally, in the last section, write about any questions you would like to have answered regarding the operation of the ADALM2000 or anything you would like to know about its capabilities and limitations.

Your lab report, to be uploaded to ELMS by the due date, should have the following sections:

(1) Lab title / Name(s) / Date / block

(2) Description of Test and Measurement Equipment used (for this lab only the ADALM2000 plus Scopy on your computer)
(3) List of any hardware used (for this lab only wires and breadboard)
(4) Procedure followed (what you actually did rather than what this document said to do)
(5) Laboratory data with description (for example, figures need to be captioned)
(6) Post-lab Analysis