

# *Experiment 0: Introduction to the ADALM2000 (M2K) and Scopy Software*

*Don't plug the ADALM2000 into your computer yet!*

## **Introduction**

The Analog Devices Active Learning Module 2000 (ADALM2000 or M2K) is a mid-level classroom module that provides the high-performance functionality of several types of analog and digital electronic lab equipment in a single pocket-sized device connected to a desktop or laptop computer. With 12-bit ADCs and DACs running at 100 MS/s (mega samples per second), it features:

- Two-channel digital oscilloscope with differential inputs (30 MHz)
- Two-channel arbitrary function generator (30 MHz)
- 16-channel digital logic analyzer (3.3V CMOS and 1.8V or 5V tolerant, 100 MS/s)
- 16-channel pattern generator (3.3V CMOS, 100 MS/s)
- 16-channel virtual digital I/O
- Two input/output digital trigger signals for linking multiple instruments (3.3V CMOS)
- Two-channel voltmeter (AC, DC,  $\pm 20$  V)
- Network analyzer – Bode, Nyquist, Nichols transfer diagrams of a circuit. Range: 1 Hz to 10 MHz
- Spectrum Analyzer – power spectrum and spectral measurements (noise floor, SFDR, SNR, THD, etc.) (50 MHz)
- Digital Bus Analyzers (SPI, I<sup>2</sup>C, UART, Parallel)
- Two programmable power supplies (0...+5V, 0...-5V)

The M2K is entirely self-contained and USB powered. It interfaces with the host computer via ‘Scopy’ application software and is Mac, Linux, and (x86) Windows compatible. Advanced users can interact with real-world analog signals via MATLAB (<https://www.mathworks.com/hardware-support/adalm2000.html>), Simulink, GNU Radio or a custom C, C++, C#, or Python environment on the host platform over USB. The present discussion is limited to basic measurements with the Windows version.

## **Objectives**

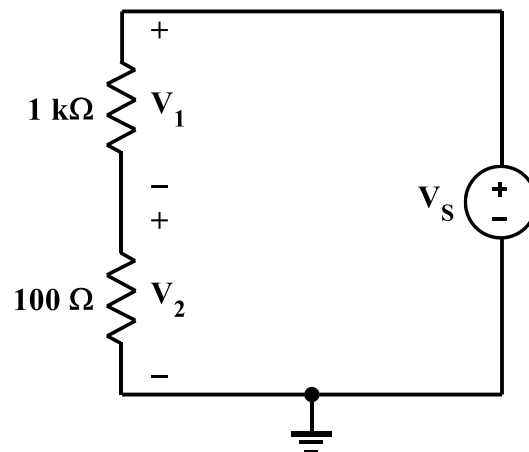
To become familiar with the Scopy Voltmeter, Oscilloscope, and Power Supply modules.

## Equipment You'll Need for this Experiment

1. ADALM2000 with Analog Probe Set and USB Cable
2. Computer with USB port, M2K driver and Scopy software
3. Breadboard
4. Wires
5. Two 6-pin headers
6. 9 V battery
7. 9 V Battery Clip
8. 100  $\Omega$  Resistor
9. 1 k $\Omega$  Resistor

## Preliminary Theoretical Analysis

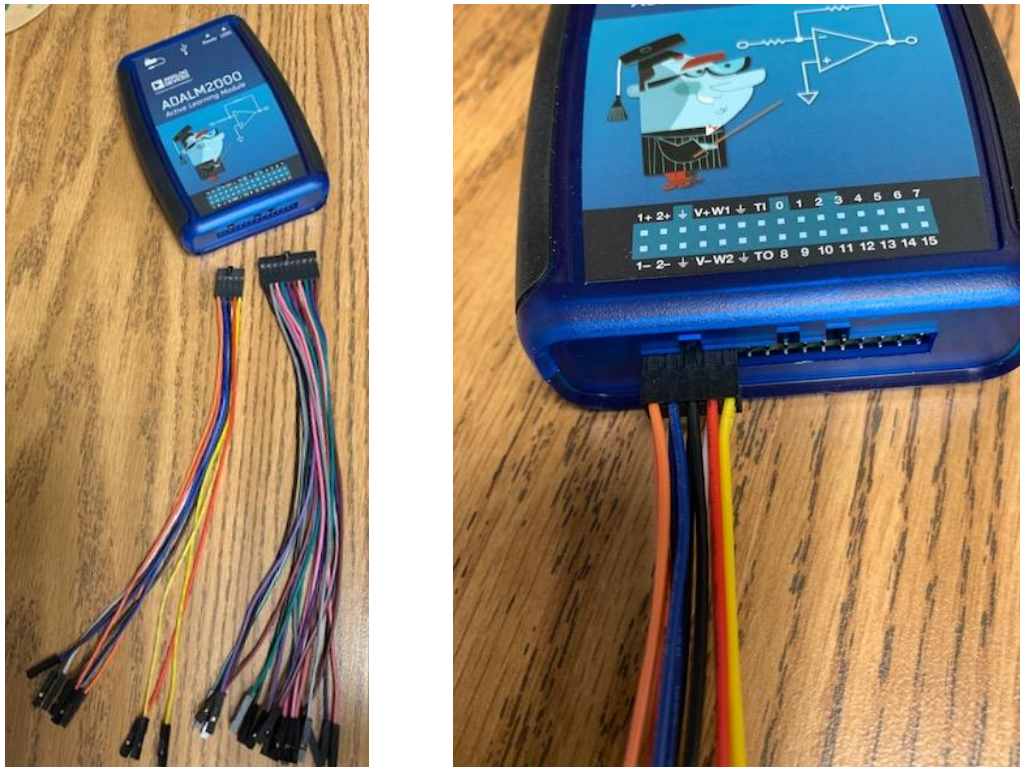
For the voltage divider circuit shown, determine the relationship between  $V_1$  and  $V_s$  and the relationship between  $V_2$  and  $V_s$ .



*Figure 0: Schematic Diagram of the Voltage Divider.*

## Initial Setup and Software Installation

There are two sets of probes provided for connecting the M2K to your experimental circuit. One has 10 wires that are used for analog applications and measurements; the other has 20 wires that are used for digital projects. Note that their plugs are keyed so that one cannot accidentally insert them into the wrong place or upside down. The analog group plugs into the left-hand side of the connector in the bottom edge of the M2K, and the digital group plugs into the right side. We will need only the analog group for this experiment, so it is not necessary to connect the digital group. Full insertion of the plug into the socket requires a strong push; it's a tight fit (unlikely to accidentally fall out in the middle of a project). Install that set of probes now.



*Figure 1: Installing the measurement probes.*

Use of the M2K requires driver software to make Windows recognize it properly and additional application software to provide the various instrumentation functions. To install the USB driver software, go to <https://github.com/analogdevicesinc/plutosdr-m2k-drivers-win/releases/tag/v0.7>, download the file [PlutoSDR-M2k-USB-Drivers.exe](#), and run it. Accept the license agreement and use the defaults for all other installation options.

Your computer is now ready for you to connect the ADALM2000 to a USB port. To do so, plug the small end of the USB cable (micro USB) into the matching port on the ADALM2000. (The port is in the middle of the top edge of the module. DO NOT plug the cable into the power port which is on the same end, and looks similar.)



*Figure 2: Connecting the USB cable to the M2K.*

Next, plug the large end of the USB cable into a USB 2.0 port on your computer. (The port is often labeled with the symbol shown at right.) Your computer should recognize the device and play a short “jingle” when it has done so. The blue “Ready” light should now be constantly on, and “LED1” should be flashing.



Now go to <https://github.com/analogdevicesinc/scopy/releases/tag/v1.2.0>, download the file [scopy-v1.2.0-Windows-setup.exe](#), and run it to install the Scopy software. Accept the license agreement and use the defaults for all other installation options. You will be asked to restart your computer when installation is complete. When the computer boots back up, a new “Scopy” icon should be on your desktop. (See the image at right.).



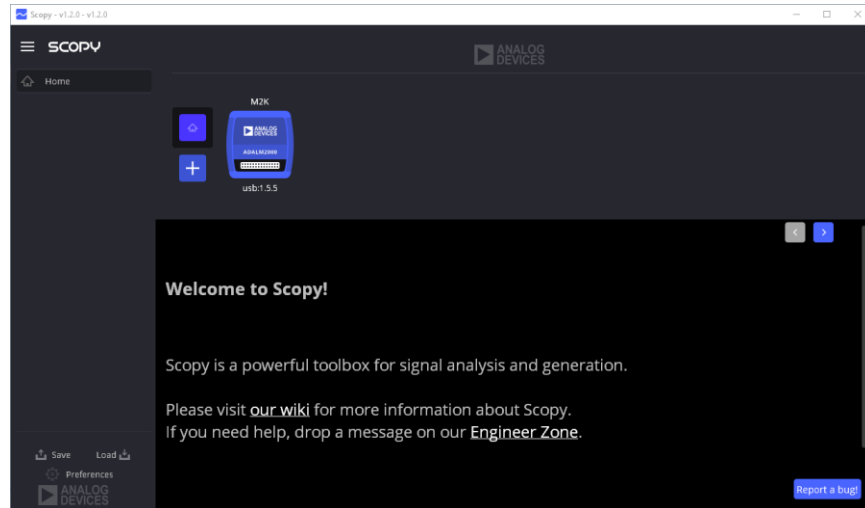
*Now you're ready to go!*



***If you ever need to disconnect the ADALM2000, be sure to “Eject” it. DO NOT just unplug it; irreparable damage can be caused by such careless handling.***

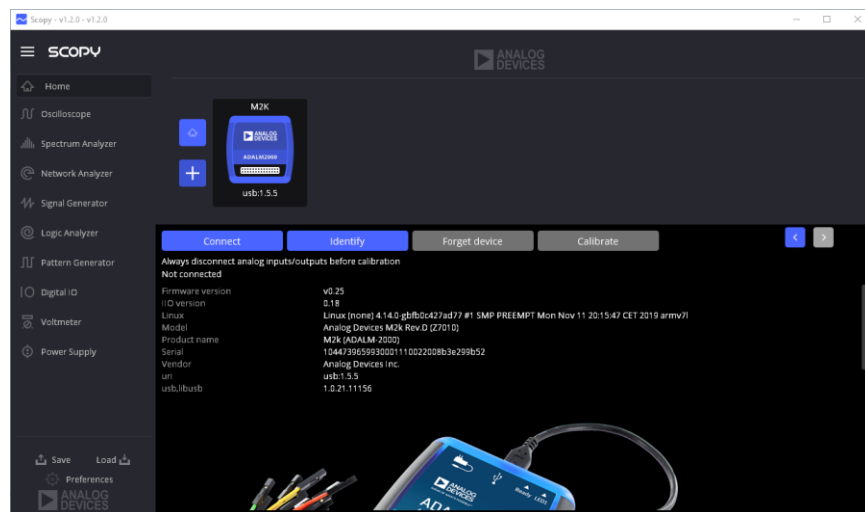
## Startup

Double-click on the Scopy icon and you'll see the startup screen shown below:



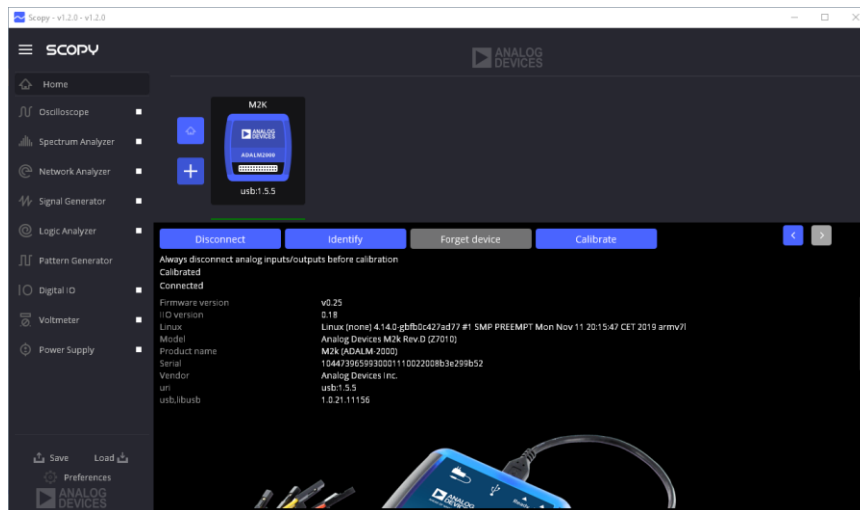
*Figure 3: Scopy Startup Screen.*

Left-click on the M2K icon, and the screen changes to:



*Figure 4: Ready to make the connection to the computer.*

Now click on the Connect button to make the software recognize the M2K. The words “Connecting...” and “Calibrating...” will be displayed on that button while recognition is taking place. When done, the display changes to the following:



*Figure 5: All set up and ready to go.*

Now you're ready to begin using the instruments. Note the menu list on the left-hand side of the window – nine different lab instruments are listed there.

## The Scopy Voltmeter

Left-click on the Voltmeter button in the instrument menu to display the voltmeter panel on the screen.



*Figure 6: The Scopy Voltmeter.*

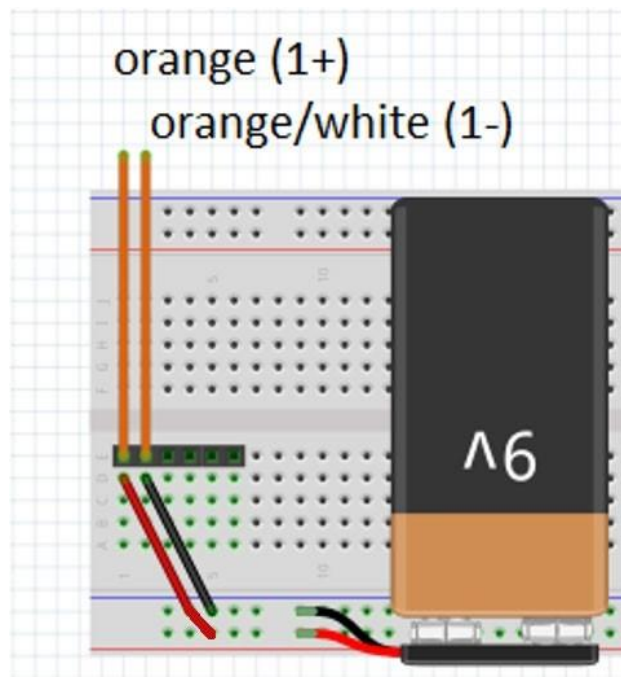
The Scopy voltmeter has two sets of probes, one pair labeled **1+** and **1-**, and the other labeled **2+** and **2-**, that can be used to measure voltages within a circuit. A brief introduction can be found at <https://wiki.analog.com/university/tools/m2k/scopy/voltmeter>.

Let's begin by building a simple voltage divider and taking some voltage measurements to confirm its operation. First, connect the **1-** probe to the negative power rail of your breadboard and the **1+** probe to the positive rail. To do this, insert a six-pin header into the breadboard as shown in Figure 8. Make sure it is seated firmly into the breadboard. In this example, the header is inserted into breadboard hole locations E1 through E6.




*Figure 7: Six-Pin Header.*

Connect the orange  $\boxed{1+}$  wire to E1 and the orange/white  $\boxed{1-}$  wire to E2. Use a short red wire from your parts kit to jump from D1 to the red power rail and a black wire to jump from D2 to the black power rail. **Do not attach your battery to the power rails yet.**



*Figure 8: Using header pins to connect Channel 1 to the battery.*

In Scopy, choose the voltmeter function on the left-side toolbar. Select  to enable the voltmeter. Carefully check your connections and then attach the battery to the power rail. If the voltmeter does not immediately report a value in the range from 8-10 volts, you should disconnect power and search for an error in your construction.

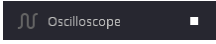

**Troubleshooting:** A voltage less than 1 volt is likely a short circuit - a direct connection between the two terminals of your battery - and will drain your battery rather quickly. A voltage between 7 and 8.5 volts is likely an indication that your battery has already expended much of its energy, likely due to being left plugged in for a long period of time or having been shorted during previous experiments. Other values may require more investigation. Detect any problems and correct them.

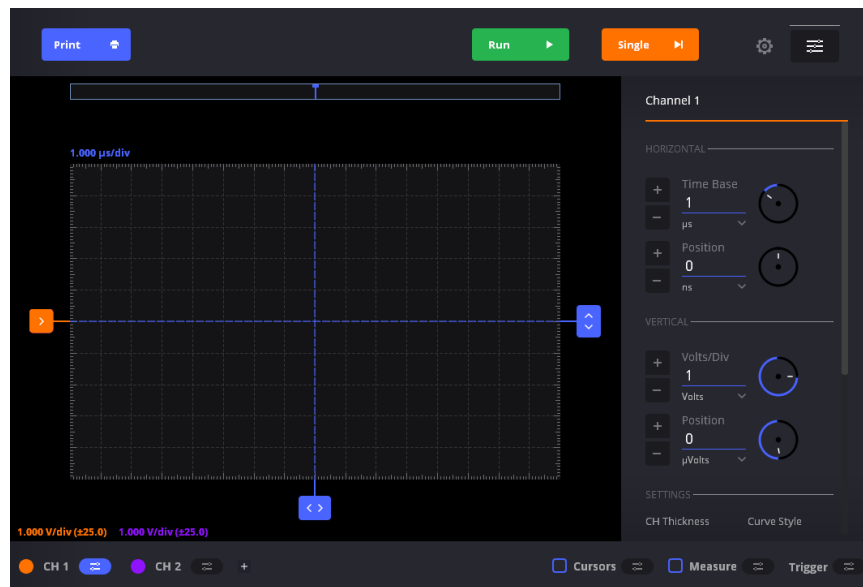
**Question 1:** Record your voltage reading.



## The Scopy Oscilloscope

You may have noticed that the Scopy voltmeter not only displayed the voltage of your device, but also presented a brief time history of those voltage values. This is not typical of a low-cost handheld multimeter, but comes about here as a convenience of having a more-sophisticated device (a computer) involved. However, plotting time-vs-voltage is typically the task performed by an oscilloscope. Scopy has an oscilloscope tool that we'll investigate next.


With your battery still connected, click on the  button and then press the  button.



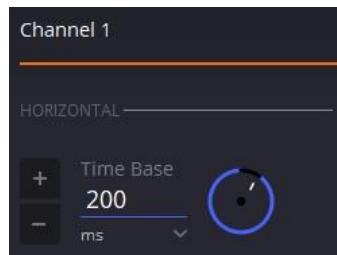
*Figure 9: The Scopy Oscilloscope.*

The voltmeter will cease to operate as you have moved control of voltage measurements over to the oscilloscope. Channel 1 of the oscilloscope will be displaying the voltage of your battery vs. time. To see this better, you can disconnect the positive side of your battery from the power rail and then reconnect it while watching the display. You should see the voltage fall to zero and then return.


Read the General section of <https://wiki.analog.com/university/tools/m2k/scopy/oscilloscope>, but stop there (unless you want a challenge). We will cover much of the latter material later.

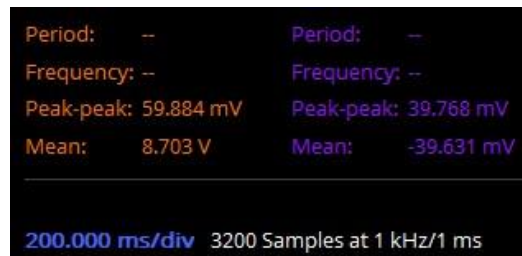
Change the Time Base (Figure 10) by pressing the “+” button until it reads 200 ms per time division. Now, press the  option (single sweep) and you will have  $(200 \text{ ms/time division}) \times (16 \text{ time divisions total screen width}) = (3.2 \text{ s total screen width})$  of data displayed on the screen at a time. Each time your scope has collected 3.2 seconds of data, it will display (or plot) that data on the oscilloscope screen. Rapidly disconnect and re-connect the red

wire several times as the oscilloscope sweeps through that 3.2 s interval. Can you see the recorded voltage change between 9 V and 0 V as you connect and disconnect it? If not, try again.



**Figure 10:** Changing the Time Base.

Now, let's use the oscilloscope's mean (average) function to again record the battery's voltage. With the time base still set to 200 ms/div (acquiring 3200 Samples at 1000 Samples/second), press  and, in Question 2, record ten consecutive values of the mean voltage. The value is determined every 3.2 seconds and you will know when a new result has been displayed because the scope will change from "Waiting" to "Triggered" at each interval.



**Figure 11:** Reading the Mean Value.

**Question 2:** Record 10 consecutive values of your oscilloscope's mean measurement.

**Question 3:** What single value should be reported utilizing your 10 values? Be careful with the number of significant digits.

**Question 4:** Repeat with the time base set to 50 ms/div (8000 Samples at 10,000 Samples/second). Record 10 consecutive mean values.

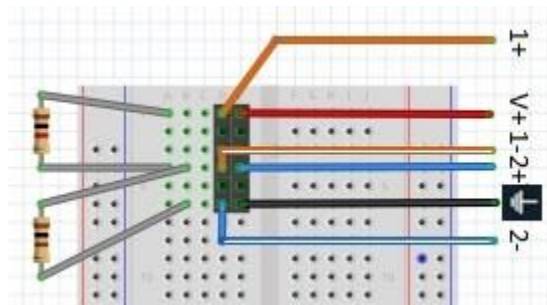
**Question 5:** From your 10 values, again report a single “best” value. Be careful with the number of significant digits.

Think about it... Why might this value be different than before? Remember that the amount of time the signal was observed as well as the number of samples observed in that time range was different for the two measurements.

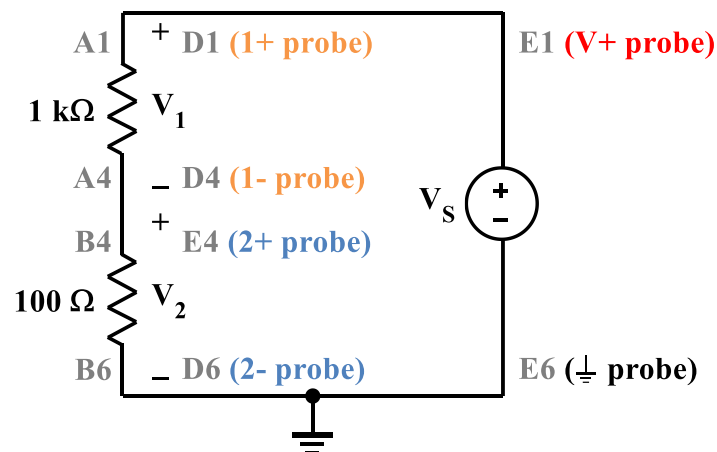
There is much more to learn about the oscilloscope, but we will save that for another day!

## The Scopy Power Supply

Remove the battery and all the wires of the M2k from your breadboard, but leave the header pins in E1 through E6. Place another set in D1 through D6 (Figure 12). Connect the red V+ wire to E1 and either one of the black ground wires  $\perp$  to E6. Attach a 1 k $\Omega$  resistor (brown, black, red, gold) between A1 and A4. Attach a 100  $\Omega$  resistor (brown, black, brown, gold) between B4 and B6. You have now created a “voltage divider” across the power supply of your M2K using these two resistors (See Figure 13). Monitor the voltage across the 1 k $\Omega$  resistor by placing the orange  $1+$  probe at D1 and the orange/white  $1-$  probe at D4. Monitor the voltage across the 100  $\Omega$  resistor by placing the blue  $2+$  probe at E4 and the blue/white  $2-$  probe at D6.

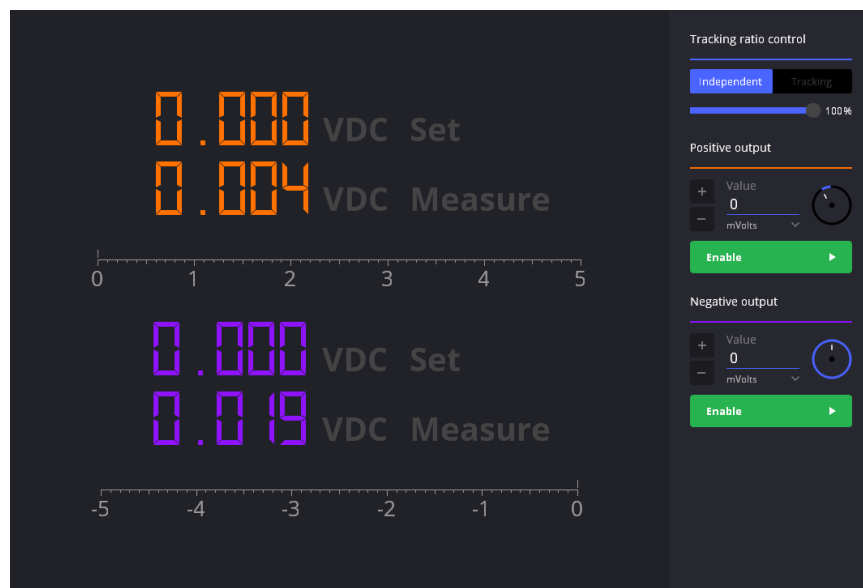


**Figure 12:** Taking two channels of voltage measurements.





**Figure 13:** Schematic Diagram of the Voltage Divider.

In the voltmeter, press Run ▶ and turn on both channels. Now, click on the Power Supply button to display the Power Supply panel on the screen.



*Figure 14: The Scopy Power Supply.*

Enable Channel 1 with a 5 V DC signal. The green  button will change to a red  button when the power supply is active.

**Question 6:** Return to the voltmeter and record the measurements from both channels.

**Question 7:** Verify that the sum of the two voltages is equal to the voltage supplied.

**Question 8:** Using Ohm's Law, verify using Ohm's law that both (series) resistors carry the same current.

**Question 9:** Calculate theoretical results for Questions 6-8 (See Figure 13 and the Preliminary Theoretical Analysis). Do your measurements match the theoretical expectation? If not, why not?

## References

ADALM2000 Overview: <https://wiki.analog.com/university/tools/m2k>

Scopy: <https://wiki.analog.com/university/tools/m2k/scopy>

Scopy Voltmeter: <https://wiki.analog.com/university/tools/m2k/scopy/voltmeter>

Scopy Oscilloscope: <https://wiki.analog.com/university/tools/m2k/scopy/oscilloscope>

Scopy Power Supply: <https://wiki.analog.com/university/tools/m2k/scopy/power-supply>

Scopy Signal Generator: <https://wiki.analog.com/university/tools/m2k/scopy/siggen>

M2K Support from MATLAB: <https://www.mathworks.com/hardware-support/adalm2000.html>