18-100: Intro to Electrical and Computer Engineering
Oscilloscope Guide

In Lab 4, you will be using the ADALM2000. This device can serve many functions, including serving an oscilloscope, signal generator, network analyzer, spectrum analyzer, etc. This guide will walk you through some of the basics of getting started with the ADALM2000 and using Scopy's oscilloscope tool.

Guide Contents

Setting Up Your ADALM2000

To begin using the oscilloscope functionality of the ADALM2000, we must first connect it to our computer. This can be done by connecting the provided micro-USB to USB-A cable to the port shown in 1. *Be careful, as the USB port is upside-down from what you may expect, so if it does not work try flipping it around.*

Figure 1: The micro-USB port on the ADALM2000

Next, plug in the BNC breakout board making sure that the Ch1 and Ch2 jumpers are properly switched to "DC" as shown in the BNC breakout board guide.

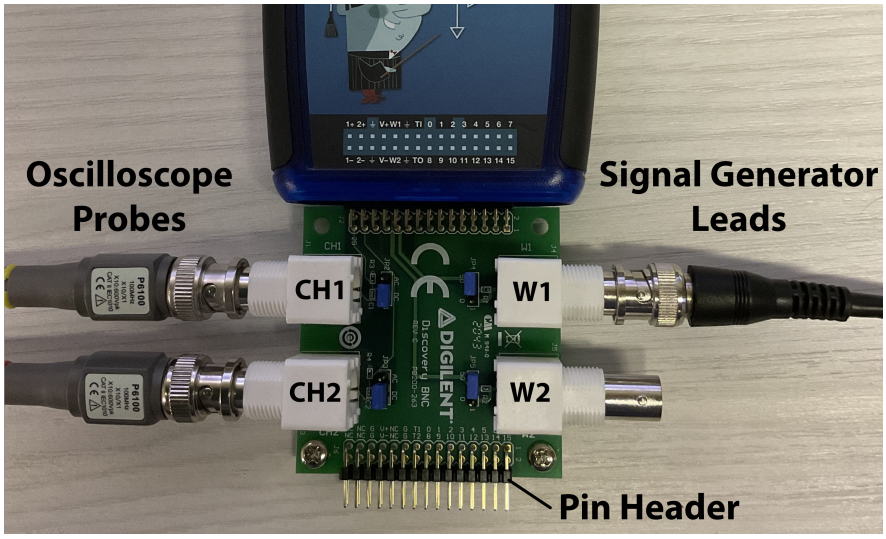

Figure 2: The BNC breakout connected to the ADALM2000

Using the Oscilloscope Probes

As is shown in 2, you can connect your oscilloscope probes to the BNC breakout board's Ch1 and Ch2 ports.

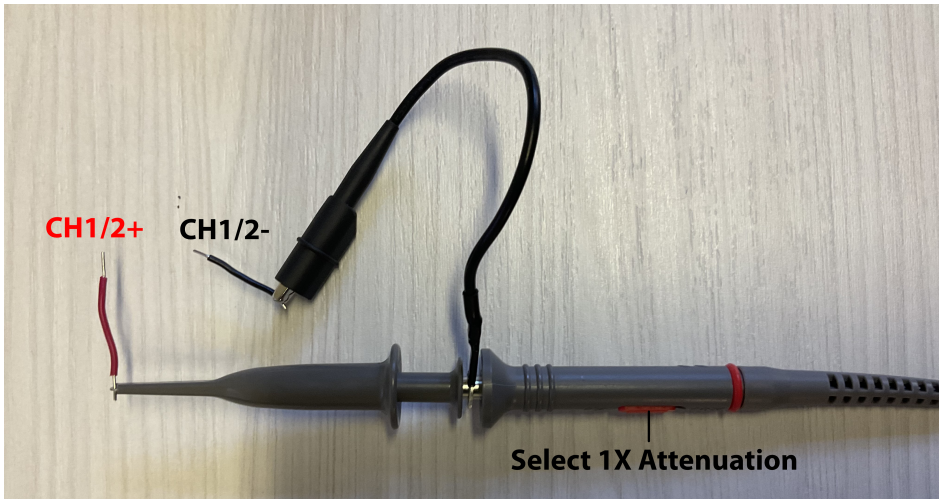

Figure 3: Oscilloscope probes

To use the oscilloscope probe, first connect the black alligator clip to a ground in your circuit. Then pull back on the housing of the probe to reveal the + contact. Connect this to the point in the circuit you wish to measure, either by directly hooking it onto exposed metal or by connecting it to a short jumper wire.

Note that unlike your multimeter, when connecting your oscilloscope probes using the BNC breakout board, they are not what are known as *differential probes*. This means that all your probes will share their - contact with the ADALM's ground, including your signal generator. This means that the - contacts *must* be connected to ground and not some other voltage in your circuit.

Downloading Scopy

The ADALM2000 will connect to your computer using a software called *Scopy*. Scopy can be downloaded here.

Windows

No additional setup should be needed. Allow a short amount of time for the ADALM to automatically set itself up on your computer.

Mac

When trying to launch Scopy, you may be prompted with a message about running apps from unknown developers. To resolve this issue, try following either this tutorial or this tutorial.

Connecting the ADALM2000 to Scopy

After launching Scopy, you will be prompted with a screen like what is shown in 4. The ADALM2000 should show up when plugged in.

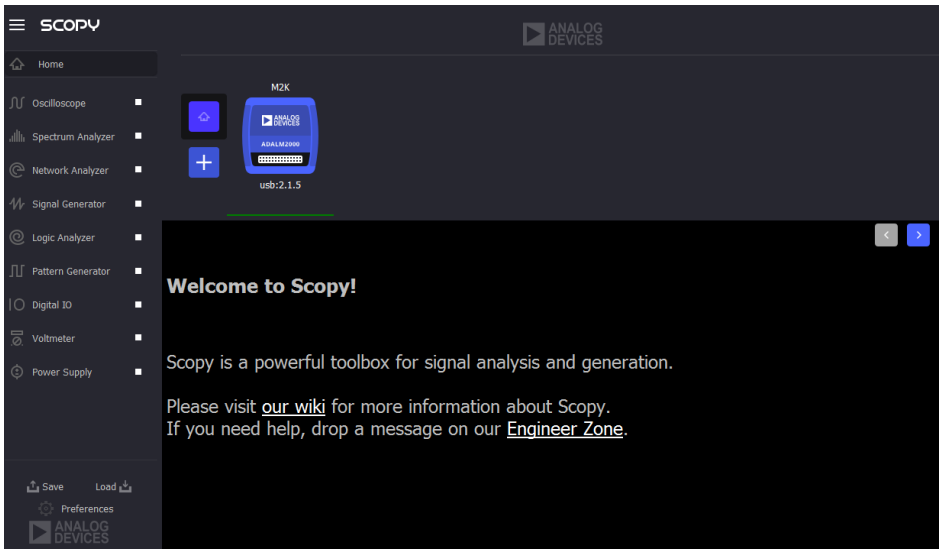

Figure 4: Scopy home screen

Click on the image of the ADALM2000. This will give you a button that says "Connect." Clicking on this button will connect the ADALM2000 to your computer. In the event that Scopy says "Calibration failed," try disconnecting the BNC breakout board and trying again.

To verify that you have successfully connected to the ADALM, you can click on the "Oscilloscope" tab on the left side and verify that you are brought to the oscilloscope page.

Oscilloscope Controls

What is an Oscilloscope?

An oscilloscope is like the voltmeter setting on your multimeter, as they both measure voltages. However, unlike your multimeter, which measures the average voltage over time, an oscilloscope allows you to plot the voltage of a signal with respect to time.

This is a powerful tool that can help you better understand and debug your circuits, so it is important to understand how to use the oscilloscope functionality of your ADALM2000.

As a supplement to this guide, Analog Devices has a very thorough guide on the oscilloscope tool here.

Oscilloscope Buttons

1. **Start/Stop:** This will start and stop the ADALM performing continuous measurement of a signal.
2. **Single:** Found in the top right corner, this will perform a single capture of the signal and then pause.
3. **Settings:** Controls some of the oscilloscope settings. Not used often.
4. **Channel Settings:** Opens the settings for the currently selected item.
5. **Time Base:** Indicates the time between vertical divisions on the plot.
6. **Parameters:** This is where you can change the parameters for the settings you currently have open.

7. **Vertical Offset:** Changes where 0V is defined vertically on the plot for each channel. This is the same as setting 'd.'
8. **Trigger Voltage:** The voltage level such that when the signal crosses this voltage, the oscilloscope will plot the signal. Therefore this should be somewhere in the voltage range of your signal.
9. **Vertical Scale:** Indicates the voltage difference between adjacent horizontal divisions on the plot for each channel.
10. **Horizontal Offset:** Changes the horizontal offset of the signal. This is the same as setting 'b.'
11. **Channels:** You can show/hide each channel by clicking on its corresponding colored circle. You can also access the settings for that channel here.
12. **Cursors:** Draggable lines that allow you to more accurately measure the min/max voltages of a signal
13. **Measurements:** This will show measurements at the top of the screen. This should always be enabled and you should go into the settings and select "All measurements."
14. **Trigger:** Controls the settings for the trigger.

Channel Parameters

a **Time Base:** Controls the horizontal 'compression' of the signal.

b **Position:** Controls the horizontal position of the signal.

c **Volts/Div:** Controls the vertical 'compression' of the signal.

d **Position:** Controls the vertical position of the signal.

Measuring a Signal

Once you have a signal to measure (note that oscilloscopes are not the tool to use for a DC voltage, you should use your multimeter for that), we measure it with the oscilloscope. Begin by connecting your probe + to the voltage you want to measure and the probe - to ground. Also make sure you connect the probe to the BNC board on either Ch1 or Ch2 (typically Ch1 unless you have two signals).

Press the Run button to begin measuring your signal. You should see it appear on the screen, although it may not look very nice yet. If it does not appear, verify that you actually have a signal that your are measuring and that your trigger is at a voltage that your signal will hit.

Making the Signal Look Nice

An oscilloscope is an invaluable tool when it comes to debugging circuits and understanding how to properly view a signal is essential.

We will almost always be measuring periodic signals. When measuring a periodic signal, we will want to see the entire waveform, so it is important to capture at least one period. However, capturing too many periods will make the graph cluttered and your signal impossible to see. **Therefore you should often aim for around 5 periods of your signal being visible. This can be accomplished by pressing the +/- buttons on the 'Time Base' parameter.**

Additionally, it is important to have your signal take up a significant vertical fraction of the plot so you can clearly see it. **Use the +/- minus buttons for the 'Volts/Div' parameter to make the signal take up the majority of the graph.**

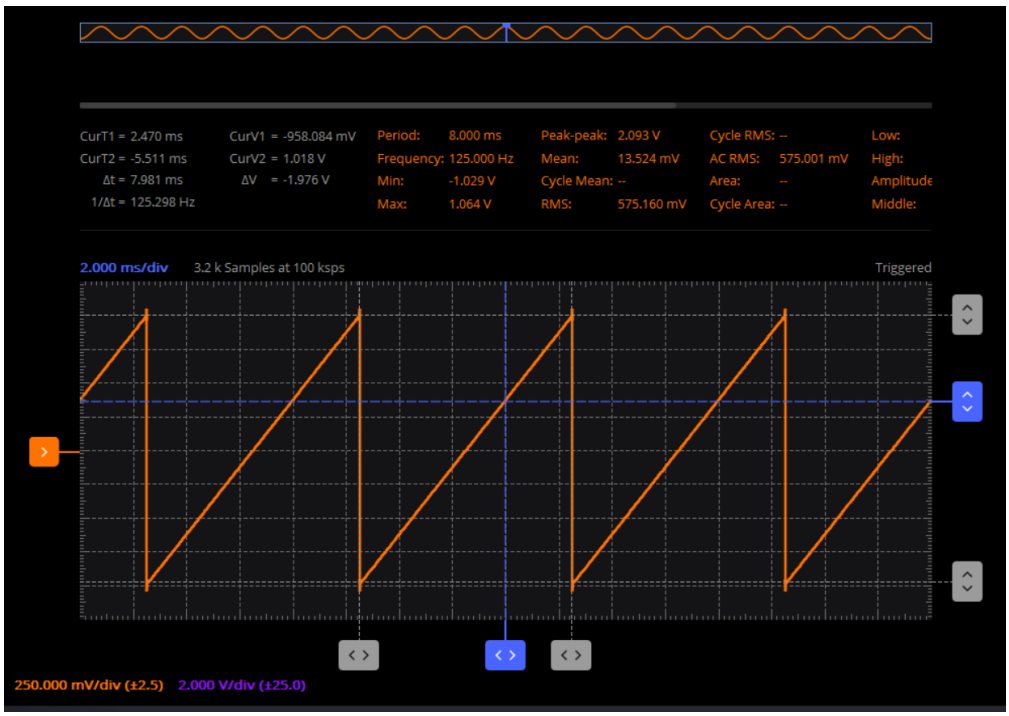

Figure 5: An example of an appropriately measured signal

Using the Cursors

Cursors are a very useful oscilloscope tool for measuring time periods and voltages. To use the cursors, click the 'Cursor' button in the bottom right corner of the oscilloscope page.

Once enabled, you will see a set of draggable vertical lines and a set of draggable horizontal lines. You will also see some new values being displayed in gray, as can be seen in 5.

To use the cursors, drag the desired cursor and observe that one of the values displayed will change. This will indicate what cursor you currently have. Once you move the cursor to the desired location, you can read off the value displayed for either the voltage or time the cursor is located at.

Additionally, you will see some additional parameters such as ΔV and Δt. These are calculated by subtracting the values of the corresponding cursors to find the difference between them. ΔV is useful for measuring the peak-to-peak voltage of a signal, as can be seen in 5. Δt is useful for finding the period or duty cycle of a signal. $1/\Delta t$ is also calculated.

Triggering

Triggering is what allows the oscilloscope to know where a given period of the signal begins. Without proper triggering, your oscilloscope signal may jump around and be hard to see. Your measurements will also often not show up without proper triggering.

The main trigger setting you will be adjusting is 'level.' This sets the voltage at which when your signal crosses this point, the oscilloscope will set the the time equal to zero (the vertical blue line) and will begin measuring the signal.

Settings your triggering to 'Auto' and with a 'level' in between the min and max of your signal (typically 1-2V will work in this class for most signals) will typically provide decent results. However, if you are confident that your trigger level is set to an adequate value, switching from 'Auto' to 'Normal' can provide better results.

You should not change the trigger hysteresis or what channel you are triggering on unless you are confident you know what these settings are for.

Below is an example of good triggering. The horizontal blue line is set to a level that the signal crosses, and therefore the signal stays in the same spot on the screen and measurements for the signal are accurate.

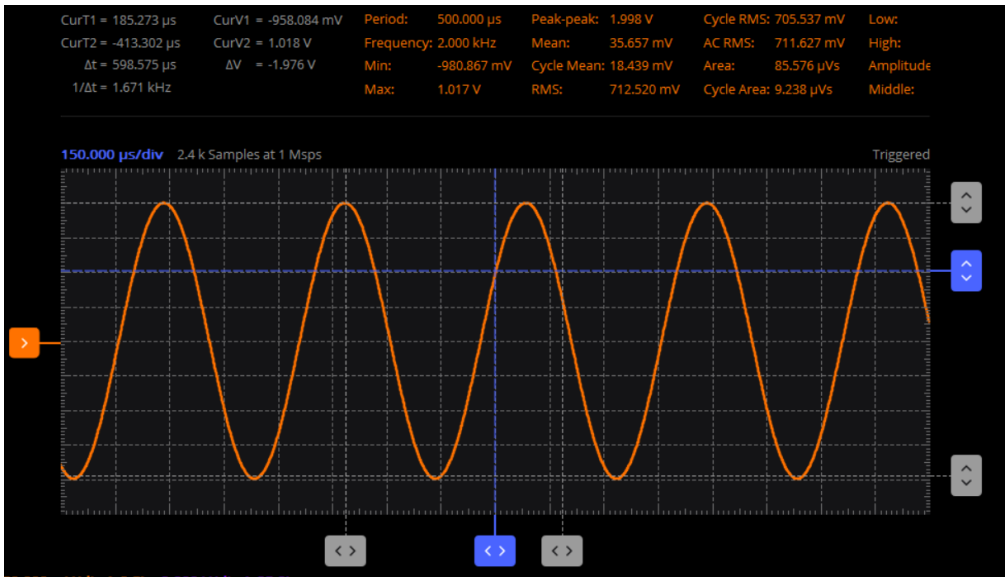

Figure 6: An example of good triggering

On the other hand, if the triggering level is not properly set, the signal will jump around on your screen and the measurements will not accurately display. In the image below, the triggering level is set too high, so the signal never crosses this triggering threshold.

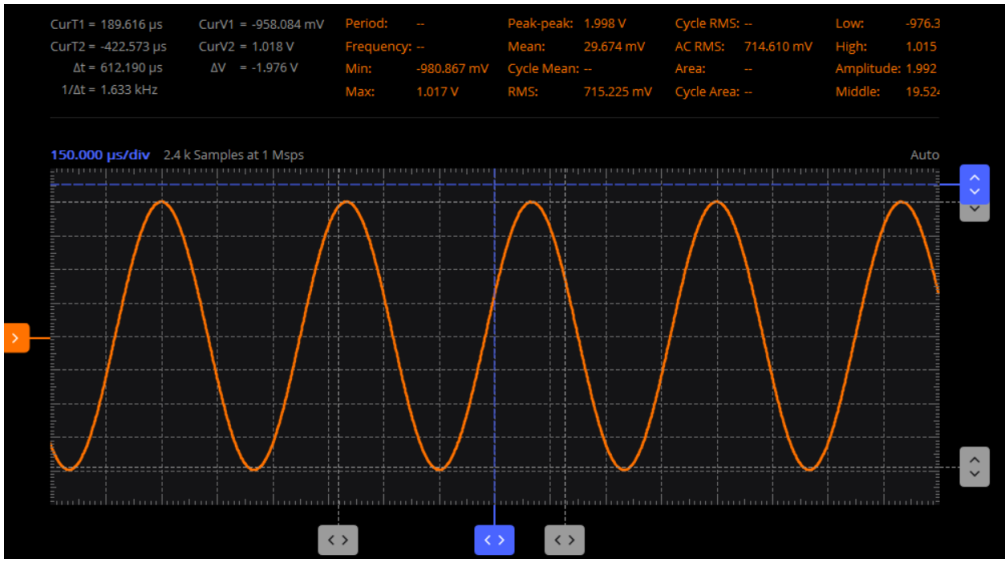

Figure 7: An example of bad triggering, since the trigger voltage is above the maximum signal voltage

Screenshot Standards

For your labs you will need to turn in screenshots of the signals you measure for credit. Unless a question specifies otherwise, you should follow the following standards to ensure getting fell credit.

1. **Measurements:** Measurements should be visible in all screenshots. In particular, the frequency should be listed. If your frequency reads '-,' refer to the 'Triggering' section for information on how to resolve this.
2. **Horizontal Time Base:** Your signal should have around 5 periods visible. If less than 1 period is visible or the signal cannot be discerned due to too many periods, credit will likely be lost.
3. **Volts/Div:** The signal should span most of the vertical range of the plot, but should not be cut off. In the case of measuring multiple signals, it is often best to keep the vertical scales the same for the two signals, so it is okay if the smaller of the two signals does not span the whole plot.
4. **Originality:** Screenshots are obviously expected to be your own. We understand that things may sometimes not work as expected, but we are more than happy to provide debugging assistance at office hours. Additionally, it is better to submit nothing than to submit someone else's work, as this is an academic integrity violation.

Full Credit Screenshot:

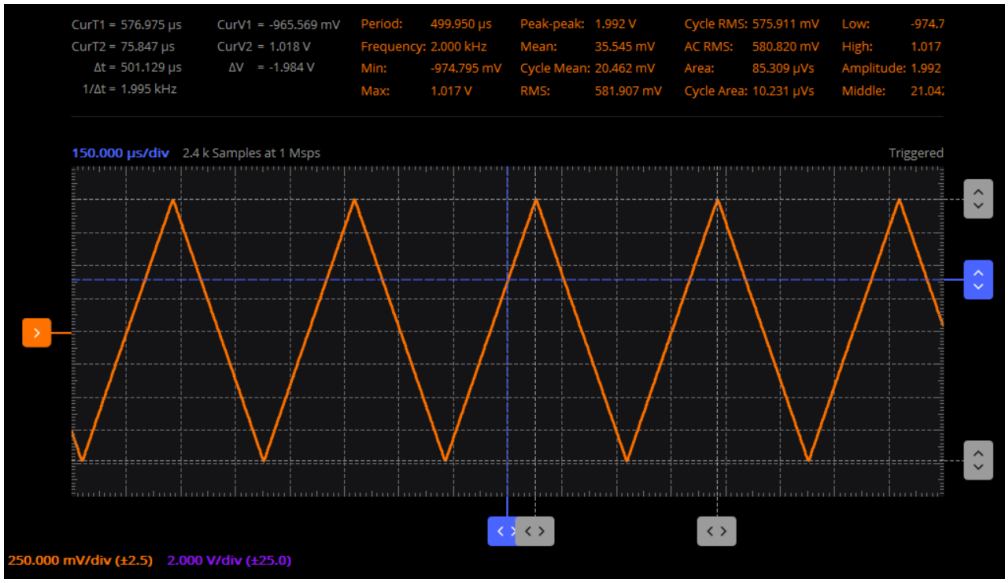

Figure 8: Measurements visible, time base and vertical scale visible

Poor Screenshots:

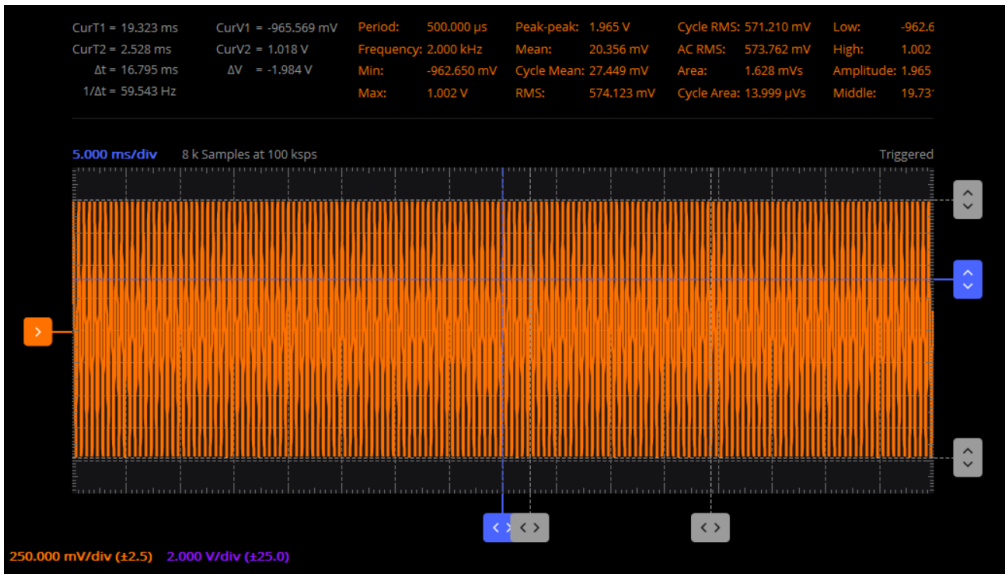

Figure 9: Far too many periods visible, the shape of the signal cannot be seen

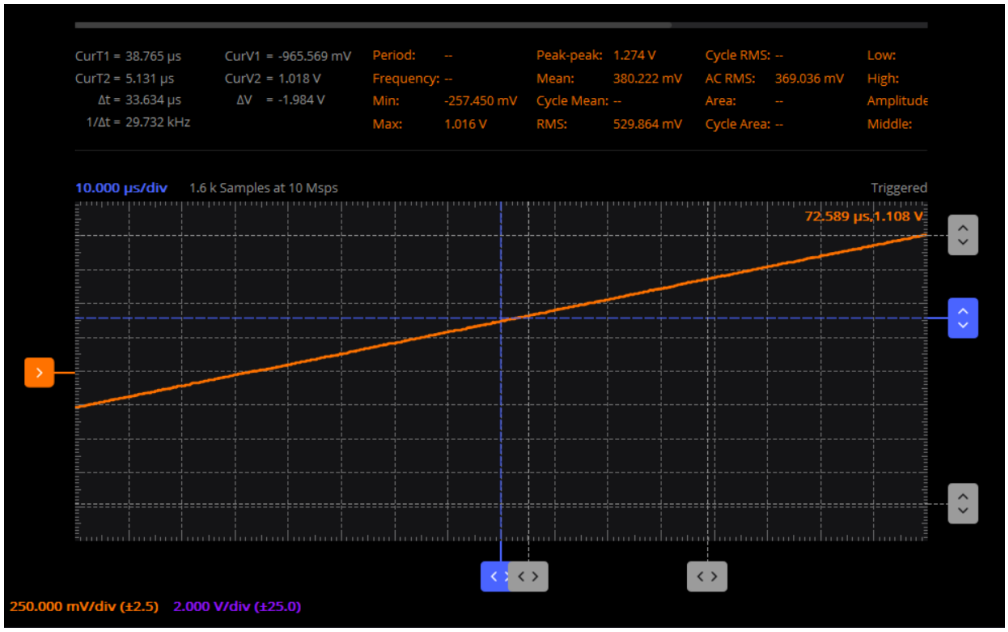

Figure 10: A full period of the signal cannot be seen

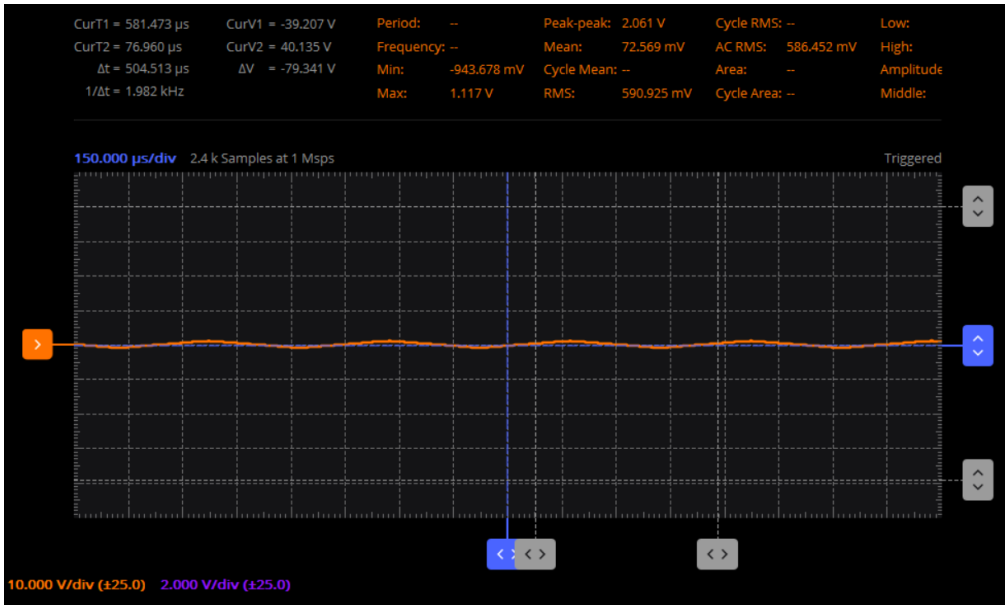

Figure 11: The vertical scale is too large

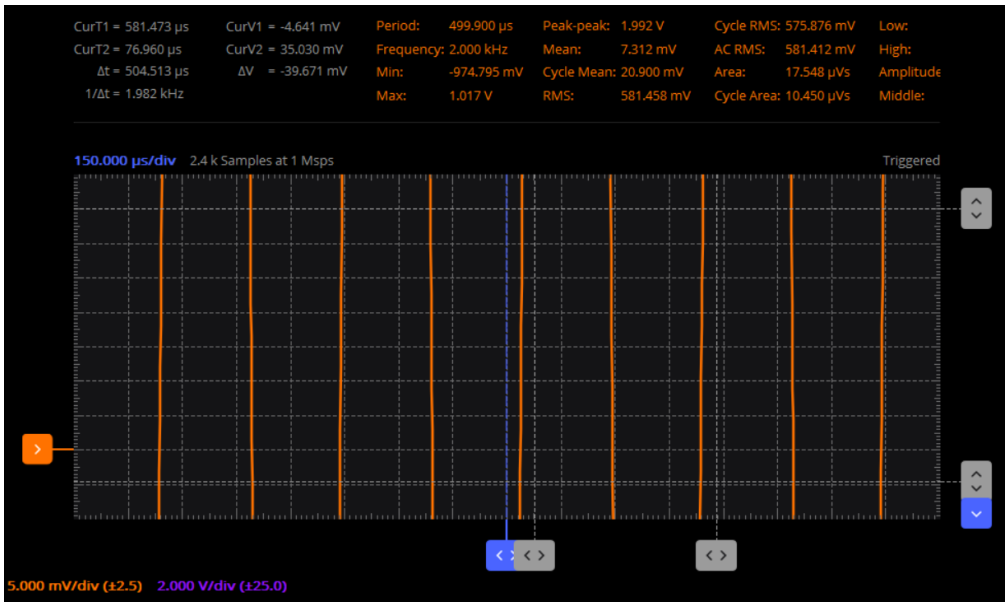

Figure 12: The vertical scale is too small

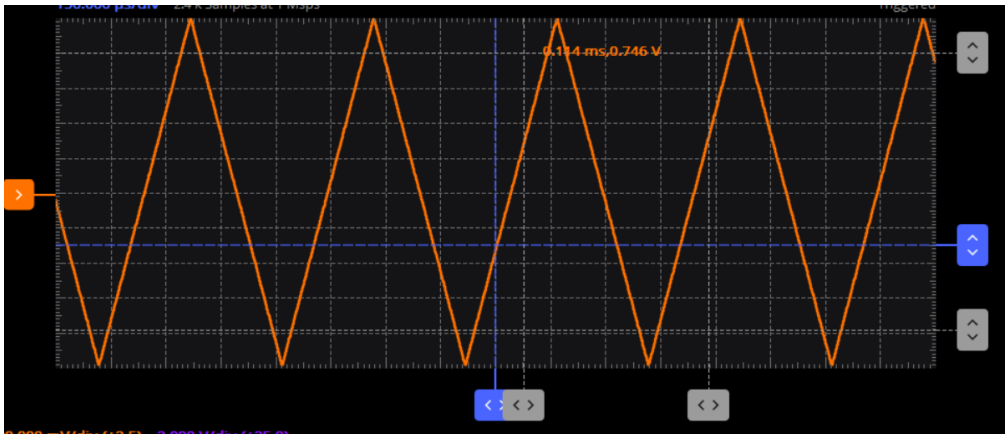

Figure 13: The screenshot does not include the time base, vertical scale, or measurements

