ELE 292 Lab 1

Lab Basic Skills

Overview

In Lab 1, we will learn the following:

- ☐ Writing a report using Jupyter Notebook
- ☐ Generating, Measuring, and Logging signals in Analog Discovery
- ☐ Data analysis using Python pandas

Prelab

There is no prelab for Lab 1.

This lab requires you to use Jupyter Notebook to write individual lab reports.

So, before you start your lab work, open a new notebook in Jupyter Lab. Write down the following info in the header of your notebook:

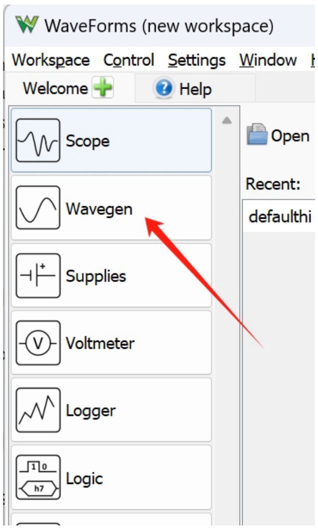
- # Lab 1 Report: Lab Basic Skills
- ### Yue Cao. Group member: Nandan Sriranga
- ### Lab completed on: Jan 22, 2025

Task 1 – Generate Signals

For every group, get one work station and one Micro USB Cable.

Connect the cable to your laptop. Make sure that you select the an available serial number and the green light is blinking.

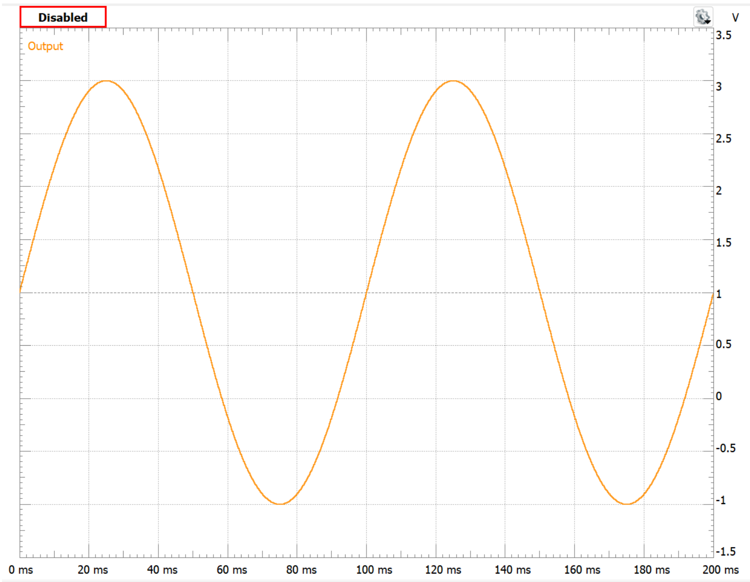
Open the WaveForms software in your laptop. Then on the left panel, open the "Wavegen". **This Wavegen will serve as the source in your circuit.**



By default, you will see a sine wave displayed. The left panel is where you can configure the signal, and the right plot shows how the signal looks like.

In the left panel, the "frenquncy" and "period" are associated. If you change one of them, the other one will automatically adjust as, frenquency = 1/period.
The "offset" adjusts the signal's position along the Y-axis.

Now, explore the left-panel settings and try to find appropriate settings to generate such plot:



Report Item 1-a

Record these Wavegen settings in your Jupyter notebook.

To do so,

In the notebook, use Table format. Also use a Horizontal Rule and sub-Header to separate it in a section named "Report Item 1-a". For details Markdown typing (Table, Horizontal Rule, Header), you may refer to:
https://github.com/adam-p/markdown-here/wiki/markdown-cheatsheet

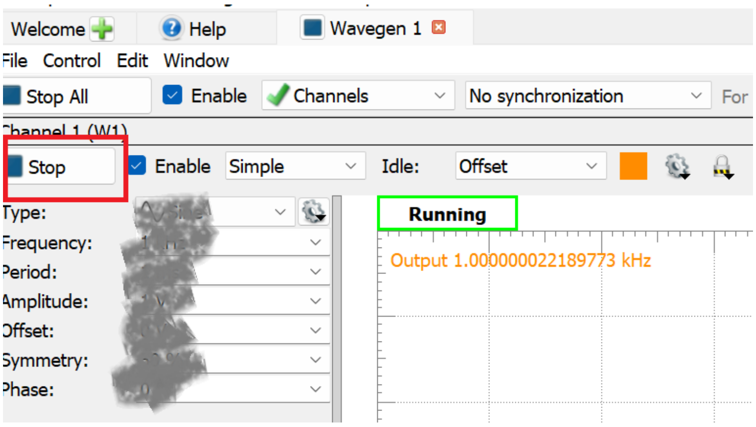
or Google any "Markdown Cheatsheet"

Frequency	
Amplitude	
Offset	
Symmetry	

Don't forget the units

After setting up your signal, then we need to actually activate the signal.

To do so, in the GUI, click the “Run” in a red box position, then you should see “Running“ on your screen. The device is now sending out signal via W1 port.



Note on Check Point

Although there is no Check Point in this task, you are free to check anything unsure with lab staff at any step.
And you are free to check with lab staff for any lab this semester.

Task 2 – Acquire Signals

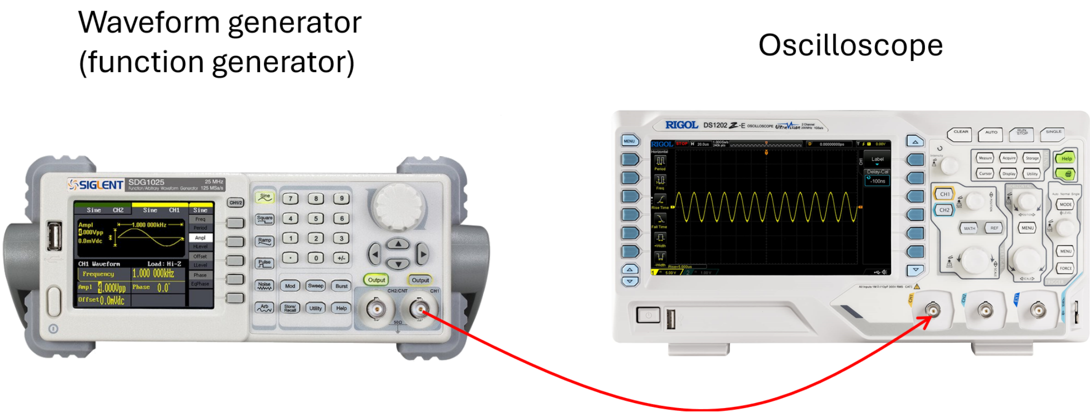
In this task, we will directly measure the signals in the scope.

To make things simple, we will call the "oscilloscope" as "scope" in class.

Task 2.1 Connect wires

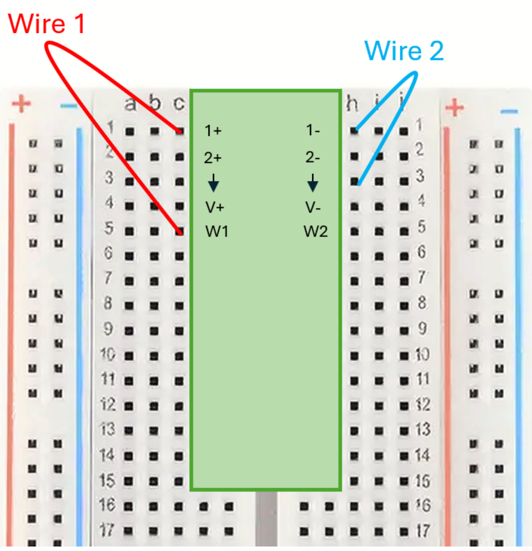
Firstly, we want to establish the connection between the waveform generator and the scope.

In a traditional electrical lab, the connection will look like this:



Since the Analog Discovery in our lab contains the functions of both a waveform generator and a scope, we only need to make a "self-connection" within the Analog Discovery.

Get 2 wires, connect as follows:



These pins used here are:

$1+$: Scope Channel 1 Positive

$1-$: Scope Channel 1 Negative

$W1$: Waveform Generator 1

$\downarrow$: Ground

The scope needs to use two pins, $1+$ and $1-$, to determinate the final measurement as,

$$\text{Final Measurement} = \text{Signal}(1+) - \text{Signal}(1-)$$

Here in circuit, we pair $1+$ to the waveform generator output $W1$, and pair $1-$ with the ground. This way, the final measurement will match the waveform generator output exactly:

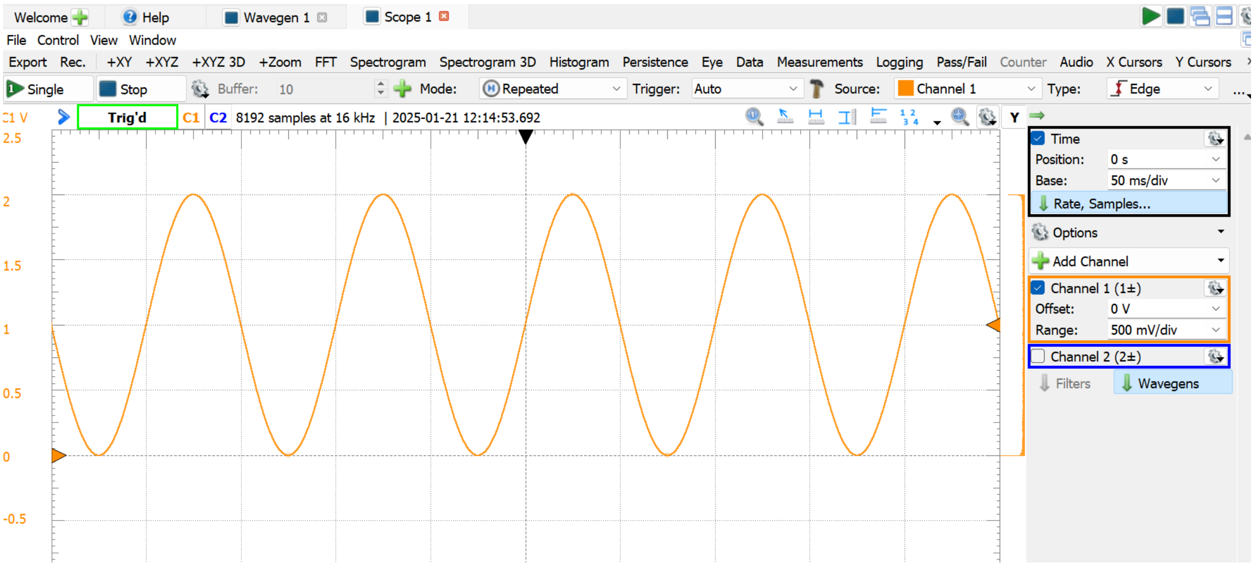
$$\begin{aligned}\text{Final Measurement} &= \text{Signal}(1+) - \text{Signal}(1-)\\ &= \text{Signal}(\text{W1}) - \text{Signal}(\text{Ground}) = \text{Signal}(\text{W1}) - 0\\ &= \text{Signal}(\text{W1})\end{aligned}$$

Task 2.2 Open Scope

Let's go back to the WaveForms software. First make sure your previsou signal in Wavegen is still running.

Then in the Welcom page, open "Scope".

On the opened scope, click the green arrow "Run" to receive the signal.



Since we only connect the $W1$ pin, which corresponds to Channel 1. The $W2$ pin is unconnected, so we un-tick Channel 2 on the right-side panel.

Now, you will obtain the Channel 1 signal on the scope.

Task 2.3 Set the X-Y axis

The current signal on the scope may appear to be not well scaled. We can adjust the X-Y axis to make it look better. There are 4 settings to adjust the X-Y axis, all located on the right-side panel:

- Adjust X-axis
  - Position = ... (never adjust this one)
  - Base = ... (if your time axis (X-axis) is not scaled)
- Adjust Y-axis
  - Offset = ... (if your voltage axis (Y-axis) is out of screen)
  - Range = ... (if your voltage axis (Y-axis) is too large/small)

Keep the X-axis Position set to 0 s and adjust the other three settings to achieve a better-scaled display.

For example, display around 3-5 cycles of the signal, and make the amplitude occupies more than 50% of the Y-axis.

Note that the X-axis Position = ... is associated with the triggering. We typically keep it as 0. We will introduce triggering next.

Task 2.4 Understand the triggering

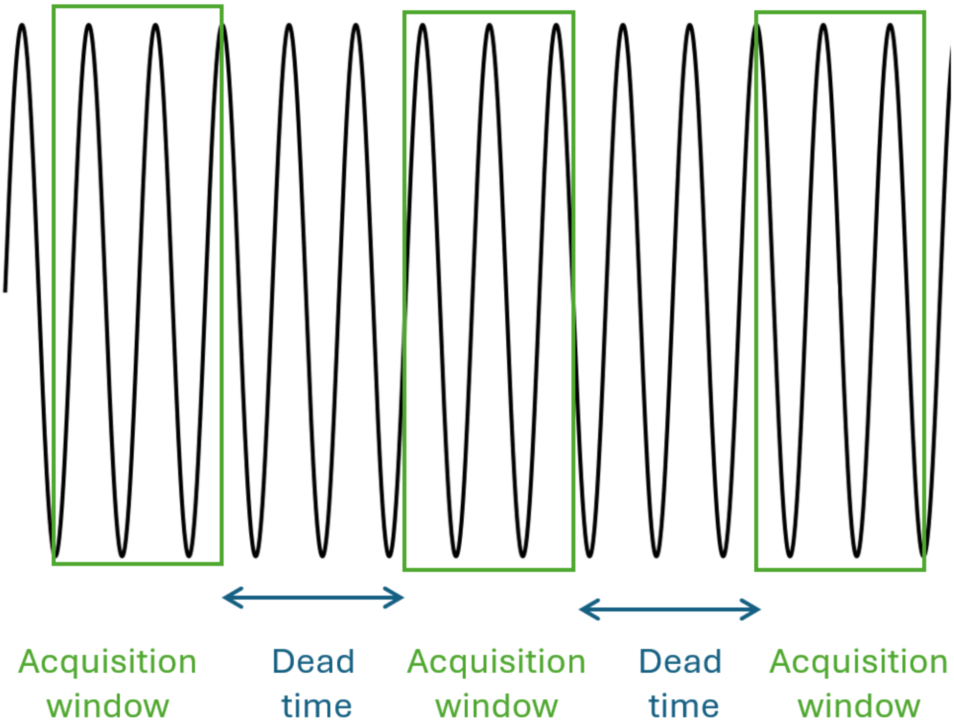
Even though we have properly adjust the X-Y axis, it may be constantly scrolling, making it hard to measure. Next, we will use triggering to correctly adjust the signal display.

We might wonder what causes a scrolling signal on the scope display. This effect actually results from the scope's acquisition process.

In fact, the scope captures small fragments of the signal (acquisition window) each time and then displays them on the screen.

For periodic signals, the oscilloscope may place its acquisition window at any point in the signal. And when signals from different acquisition window are displayed on scope, it looks like in scrolling.

To prevent a scrolling display, it is crucial to place the acquisition window at a specific location in the waveform.



The way to configure such acquisition window is called **triggering**.

The triggering defines an condition-based event on the signal: when a specified condition is met, the scope places the acquisition window.

The commonly used triggering for sine waves is "Edge" type with "Rising" condition. In this setting, if a signal is rising and reaches a threshold voltage (called "Level"), the window will be placed.

Now, go to your scope, adjust these 3 triggering settings as:

Type = Edge Condition = Rising Level = 1 V

This setting means: **When the signal is rising, and it just crosses the 1 V, this is the exact moment to place acquisition window.** Now, does your signal look stable?

To check if a signal is successfully triggered, look for a green-boxed "Trig'd" indicator in the top-left corner of the scope display.

The triggering position is marked by the intersection of two indicators: a black arrow on the top of the screen and an orange arrow on the right.

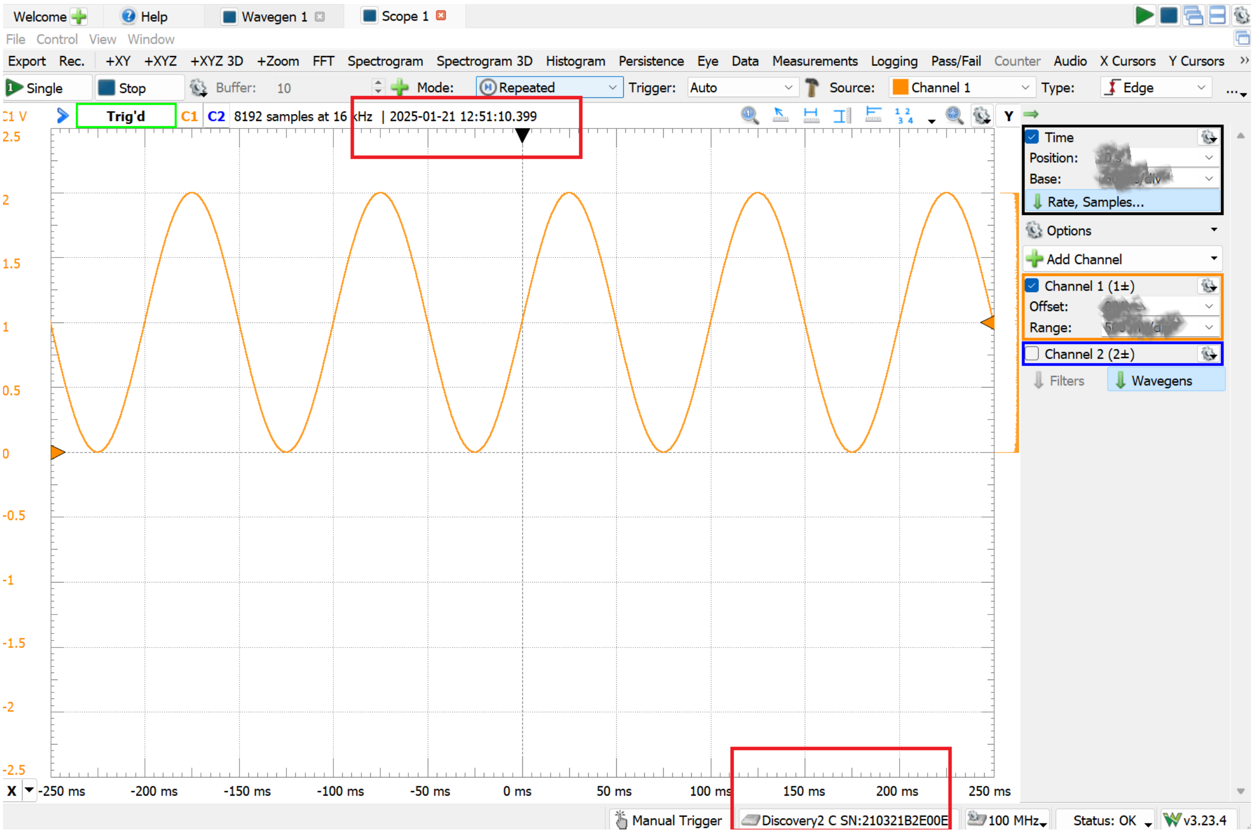
Report Item 2-a

Provide the screenshot of the final display. Include the local time and device Serial Number (Discovery 2 C SN: ..) in the screenshot.

To do so, Start a new section named "Report Item 2-a" using horizontal Rule and sub-Header.

Use computer-built-in app to screenshot. Not use your phone camera to take pictures.

Copy the screenshot image from your folder in computer, and then directly paste it (ctrl+V) into a Markdown cell in Jupyter Notebook.



Inside red boxes are your local time and device Serial Number.

In the backend of the notebook, it uses a format called "Base64" to encode the image to a permanent string. In such way, your image in the notebook can be then decoded in other computers.

There is no way to directly adjust the width and height of a base64-encoded image in the notebook. If you feel like your image is too large or small in width and height. You need to use other apps in your computer to resize it and then re-paste to the notebook.

Also better keep your image size under 500 kB. Otherwise Base64 encoding will result to a very long string in the backend.

Next, manually adjust the “Level” setting, find out and record:
the range of level where the scope can be successfully triggered for the given signal.

Report Item 2-b

Provide the range of level that you found.

Back to your notebook, write a separate section name “Report Item 2-b”. Write the answer in Markdown.

(Include text description, ont only numbers.)

Check Point 1

Check your results with lab staff.

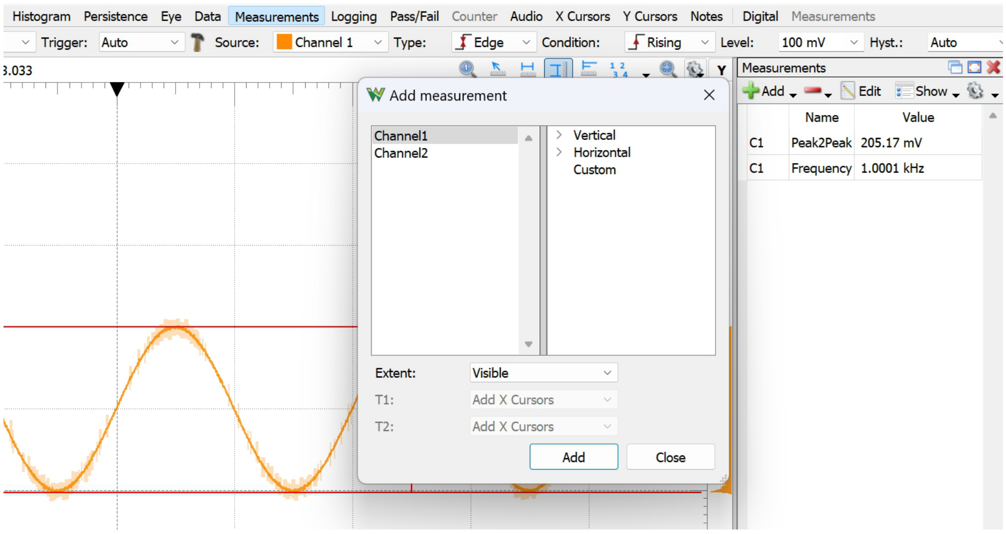
Task 3 – Measure Signals

You can measure signals in Scope.

There are 3 tools that we can use to measure signals.

First, go to the top-right corner of the scope screen, where you will find “Quick Measure” tools. Use the “Horizontal” to measure the time of the signal and the “Vertical” tool to measure the voltage.

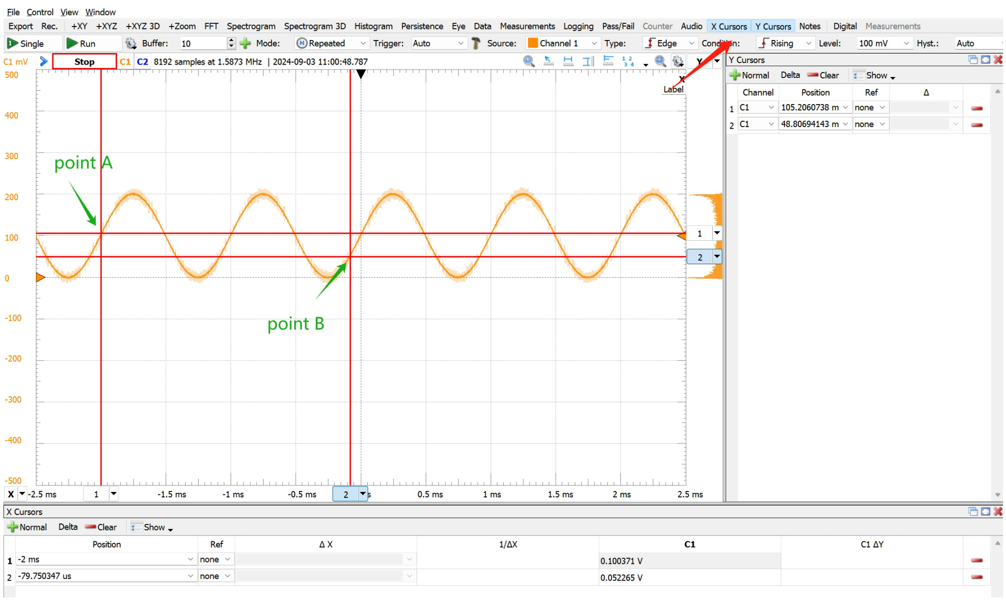
Second, we will try to use the pre-defined measure tools. From the top bar, click "Measurements". Then click green plus "Add" → "Define Measurement". It will show a panel like this:



In the "Vertical", select "Peak2Peak". Then in the "Horizontal", select "Frequency". Once set up, you can see the measurement in real time.

Third, we can use cursors to perform customized measurements. From the top bar, click "X Cursors" and "Y Curcors". Then add two "Normal" cursors for both. For the cursor displayed on screen, you can select cursor 2 on the axis, set cursor 1 as its reference. Then we can obtain the horizontal and vertical distances between two arbitrary points.

You can stop the scope to get a steady reading.



Report Item 3-a

Provide the measurement of your signal .

Max voltage	
Min voltage	
Period	

Don't forget the units

Again, in notebook, use a separate section and table format to show the results.

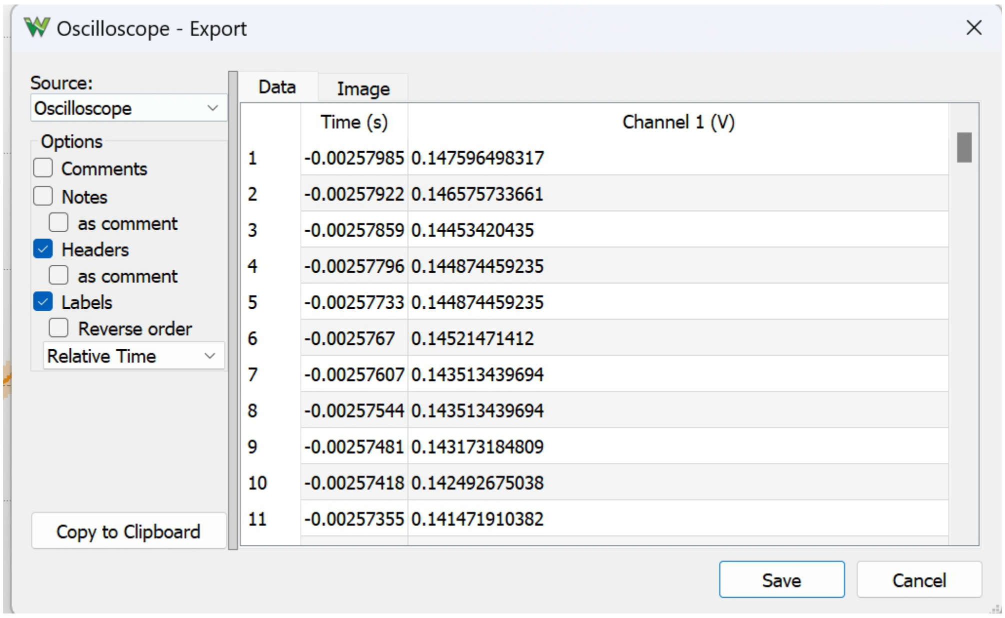
Task 4 – Log Signals

Task 4.1 Export and Plot

In the Scope window, from the top bar, go to "File" → "Export". In the pop-out window, we recommend to un-tick the "Comment" since it may cause some difficulties in processing.

Scroll down to the end of the table and ensure that there are 8,192 data instances, which is the maximum capacity the Analog Discovery can log.

Click "Save". **Save as a .csv file** in your computer. Save to the same folder where your notebook file is.



Report Item 4-a

Plot your saved signal in the notebook.

To do so, start a new section in your notebook. Now we do Python code cell.

(Please type code in your notebook, not direct copy-paste. Some computers display .pdf with strange indent/space, which may cause issues when direct copy-paste Python.)

Python code

```
import pandas as pd
import matplotlib.pyplot as plt

# Read the CSV file while skipping metadata lines that start with '#'
file_path = 'my_saved_data.csv'
my_lab_data = pd.read_csv(file_path, sep=',', comment='#',
    skip_blank_lines=True)

# Plot the data
plt.figure(figsize=(10, 6))
plt.plot(my_lab_data['Time (s)'], my_lab_data['Channel 1 (V)'])
plt.xlabel('Time (s)')
plt.ylabel('Voltage (V)')
plt.title('Signal over Time')
plt.grid(True)
```

Task 4.2 Python Pandas

This previous code uses a library called Pandas. This is a popular library to handle tabular data.

The code `pd.read_csv` creates a Pandas DataFrame object. (object in Object-oriented programming). Then you can use all its methods to perform data analysis. (method in Object-oriented programming)

Report Item 4-b

Use Python Pandas to analyze the max and min voltages of your save signal.

You can search the cheatsheet online or direct ask ChatGPT which methond to use.

Check Point 2

Check your results with lab staff.

Task 5 – Write Conclusion

At the end of the lab report, you need to write a conclusion. This is the requirement from your program.

If you go to your official program requirement, (for example, this is EE program: https://courses.syracuse.edu/preview_program.php?catoid=38&poid=19223&returnto=4781&redirect) you can always find such sentence:

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

For this course, we ask you to write a conclusion for every lab report.

- You are not allowed to copy the conclusion from anyone else, including your lab teammate.
- The conclusion must be longer than 100 words.

The conclusion can cover:

- Purpose, hardware/software, and brief experimental procedures.
- Overall assessment of the experimental results.
- Challenges Encountered and how you resolved them. (If any)

Here we provide 2 samples:

Sample 1:

The purpose of Lab 6 is to study a first-order linear system using a resistor-based heating setup. The system is modeled with power as the input and Celsius temperature as the output. With PWM-controlled input power, we used Analog Discovery 2 and Arduino to measure the corresponding temperature output.

In the experiment, we observed the expected proportional relationship between the power input and the temperature output. This observation aligns with the scalability of the linear systems. Also, we calculated the time constant to be 60 seconds, which we believe is reasonably long for this heating system.

During the experiment, it took a long time to wait for the cooling down, which makes the lab duration to be long. In addition, we also had difficulty to figure out how to align the voltage divider with the Arduino sensor readings.

Sample 2:

The purpose of Lab 3 is to study the step response of a first-order linear system. In this experiment, the system is an RC series circuit. In Task 2, we measured the time constant using known RC values and compared it with theoretical values. In Task 3, we first measured the time constant experimentally and then used it to determine the unknown value in the circuit.

The percent errors for both experimental tasks were reasonably low, with the first one at 0.564% and the second one at 2.13%. Overall, we consider the experiment to be successful.

In the experiment, we had challenges in using the cursors on Scope to take measurements. However, after multiple attempts, we were able to figure out how to use them.

Lab Report

Please complete the report individually.

Write the report in Jupyter Notebook. Then export it as .html. Finally convert .html to .pdf. The submission in BlackBoard must be in .pdf.

The total score for the report is 20 points.

- Format. (5 points)
- Item 1-a (2 point)
- Item 2-a, 2-b (2x2 point)
- Item 3-a (2 points)
- Item 4-a, 4-b (2x2 point)
- Conclusion. (3 points)

Lab 1 Report will be graded but will not be counted into final grade.