Lab Report 1: Introduction to Digital Oscilloscopes

EE102

Section 02

Bilkent University

February 14th, 2024

Doğa Zeynep Tarman

22303157

Purpose of the Experiment

The main goal of this first laboratory experiment was to get acquainted with the equipment such as oscilloscopes, oscilloscope probes, signal generator and breadboards. Using the equipment, we were expected to complete six different tasks according to the manual and observe the results of each of these experiments.

Methodology

During the laboratory session, I tried to conduct the experiments correctly by carefully reading the laboratory manual in each step. For the first experiment, we were asked to insert our probe to the oscilloscope and compensate them using a compensation signal. I compensated my probe using the screw and was ready to move on to the second task. On the second task, we were asked to use the signal generator to apply 5 V_{pp} in order to generate a sinusoidal signal with a frequency of 1 kHz. We were also warned to make sure that the signal we have generated does not have a DC component. I generated a sinusoidal wave according to the instructions provided and made sure there was no DC component. For the third task, we were asked to observe the effect of the trigger knob of the oscilloscope when applied an amplitude of 1 V_{pp} triangular wave with 2 kHz frequency. I observed the effect by adjusting the knob to different values after I set up the signal that was asked on my oscilloscope. For task four, I generated a square wave by applying 1 V_{pp} with 5 kHz on the oscilloscope. I also tried out all the acquisition modes on the oscilloscope I was using which were normal, peak detection and average. On the fifth task, we were asked to use a DC offset of 1 V. I generated a sinusoidal wave by applying 2 V_{pp} of amplitude and a frequency of 1 kHz, then applied an DC offset of 1 V and observed the changes on the oscilloscope. Lastly, on the sixth experiment, we were asked to use the breadboard and set up a circuit, then apply a 2 V_{pp} and 1 kHz sinusoidal signal with no DC offset. To complete this task, we also needed to use a second probe, which I was able to borrow from a friend. I completed the setup and tried measuring the difference between the two signals generated, while also changing the frequency to 100 kHz.

Results

Task 1:

I started by connecting my probe to the oscilloscope. I made sure that I made connected the ground to the right place and started the compensation process. The signal I received was neither too overcompensated nor undercompensated. Still, I made the necessary adjustments using the screw as seen in Figure 1.2. Overall, the process went smoothly and I did not face any problems. I still wanted to double-check my result so I tried changing the signal as seen in Figure 1.3.

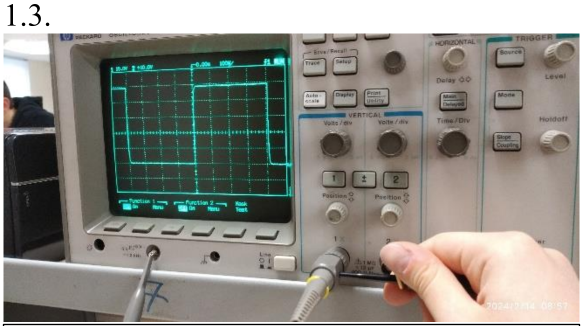

Figure 1.2 Compensating the Probe

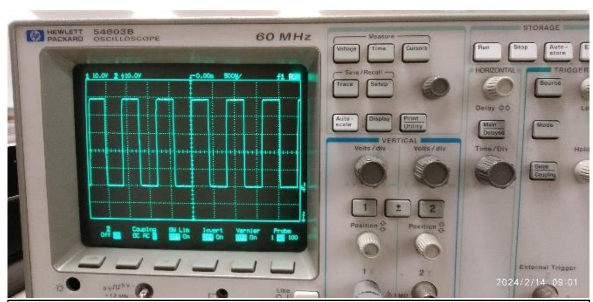

Figure 1.3 Double-checking the Results

Task 2:

For this task I used the signal generator to generate a sinusoidal signal with 5 V_{pp} and 1 kHz. I generated the sine wave without any DC component. First, I observed the one which was positive edge triggered as seen in Figure 2.1. Afterwards, I applied the negative edge trigger as in Figure 2.2 and realized the wave's slope has changed. On the positive edge triggered one and the negative edge triggered one, the waves were “flipped” in comparison to each other and their slopes were the opposite. In other words, the positive edge triggered one had a positive slope whereas the negative edge triggered one had a negative slope.

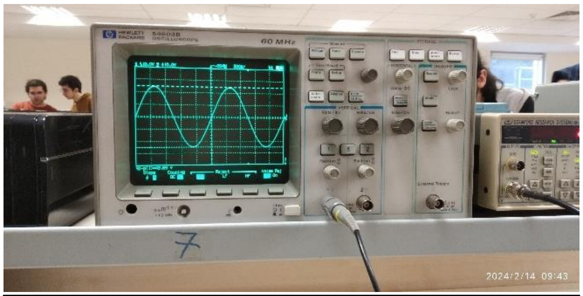

Figure 2.1 Positive Edge Triggered Sinusoidal Wave

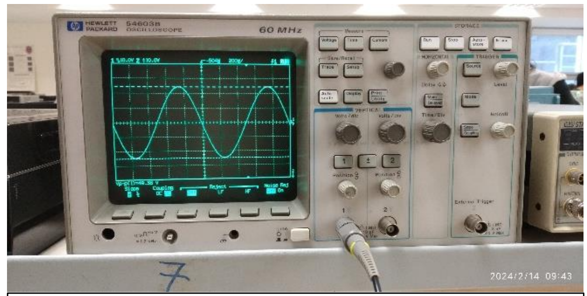

Figure 2.1 Negative Edge Triggered Sinusoidal Wave

Task 3:

On this task, I set the frequency to 2 kHz and applied a 1 V_{pp} triangular wave as seen in Figure 3.1. I started adjusting the triggering knob and observed the results. When I adjusted the knob, it changed the way the signal was displayed. This was because of the amplitude we applied at the beginning. The wave started moving accordingly when I adjusted the trigger knob’s amplitude. From this, we can conclude that the triggering knob helps adjust the wave and it makes the signal more stable.

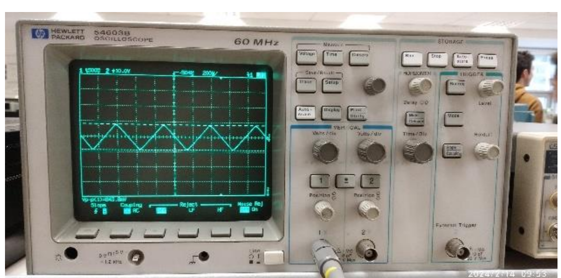

Figure 3.1 1 V_{pp} and 2 kHz Triangular Wave

Task 4:

A digital to analog converter (DAC) is a kind of circuit which acts as a converter between digital signals and analog signals. For example, it converts a digital signal such as binary signal into an analog signal such as current or voltage (*Digital to analog converter (DAC) - types, working & applications*). An analog to digital converter (ADC) is basically the same concept working in reverse. In other words, it converts analog signals into digital signals, so this is the one used inside oscilloscopes. Such circuits are needed because analog signals could be diverse or continuously changing voltages whereas the digital circuits work with only two signals since there are two states in binary representation (*Analogue to digital converter (ADC) basics*).

I applied a 1 V_{pp} square wave with a frequency of 5 kHz. I then tried out the acquisition modes on the oscilloscope that I was using which can be seen in Figure 4.1 and Figure 4.2.

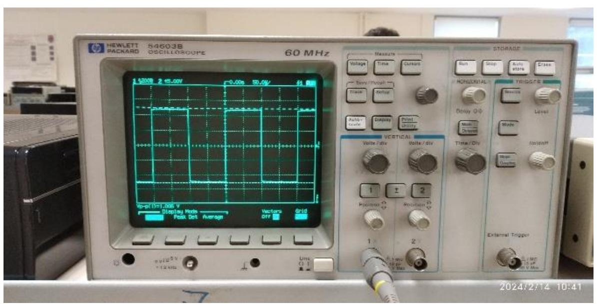

Figure 4.1 1 V_{pp} and 5 kHz Normal Wave

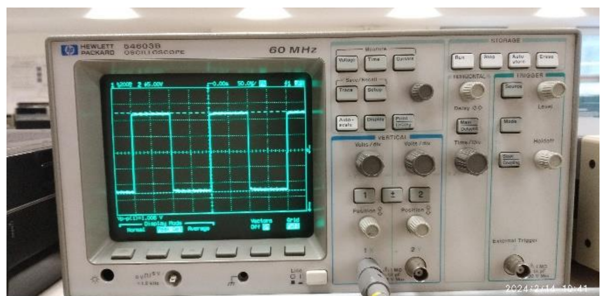

Figure 4.2 1 V_{pp} and 5 kHz Peak Detect Wave

The modes were named normal, peak detect and average respectively. The average one also had options named with numbers, which were 8, 32 and 64 which are shown in Figure 4.3, Figure 4.4 and Figure 4.5. These modes are to give the observer a better understanding of the waves. According to my observations, the normal mode just shows the waves as they are whereas peak detect highlights the peaks of the wave. Average combines different number of these to give a more clear representation of the waves. Which is why 64 was much more well defined than 8.

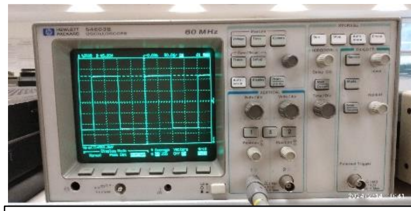

Figure 4.3 1 V_{pp} and 5 kHz Average 8 Wave

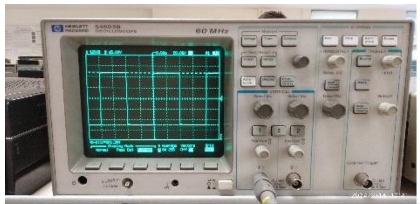

Figure 4.4 1 V_{pp} and 5 kHz Average 32 Wave

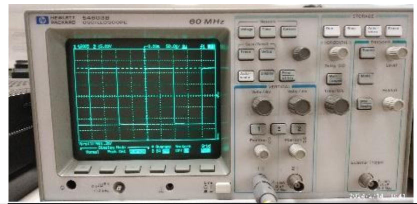

Figure 4.5 1 V_{pp} and 5 kHz Average 64 Wave

Task 5:

During this task, I generated a 2 V_{pp} sinusoidal signal with a frequency of 2 kHz. However, I also applied a DC offset of 1V this time. I tried doing it with DC coupling first, then AC coupling. I observed that the signal shifted upwards by 1V as it can be seen by comparing Figure 5.1 and 5.2. This is a result of using different coupling modes, and an indicator that the oscilloscope separates these components.

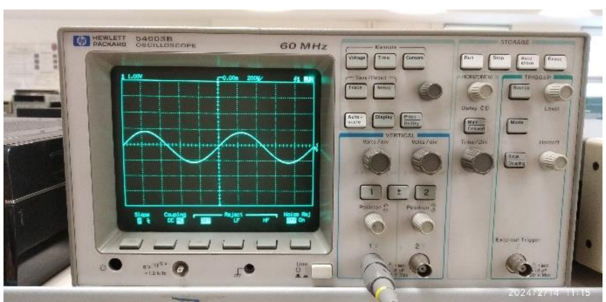

Figure 5.1 2 V_{pp} and 2 kHz Sinusoidal Wave with DC Offset of 1V (AC Coupling)

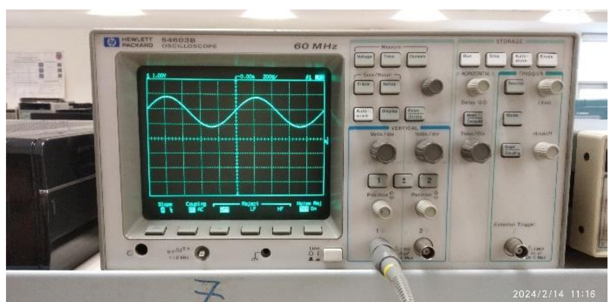

Figure 5.2 2 V_{pp} and 2 kHz Sinusoidal Wave with DC Offset of 1V (DC Coupling)

Task 6:

For this task, we were asked to use an equipment called the breadboard. A breadboard is a type of board used for building circuits on (*What is a Breadboard?*). During the task, this was exactly what we did, we built the circuit in the laboratory manual on the breadboard as seen in

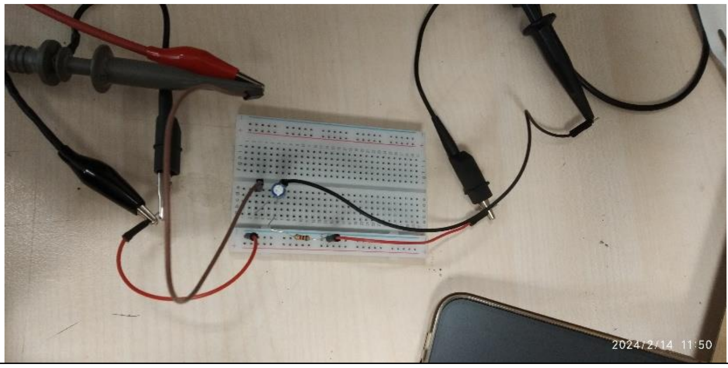

Figure 6.1 Circuit Implementation on a Breadboard

Figure 6.1. Later, using a friend's oscilloscope probe, I was able to generate the sinusoidal signal with 2 V_{pp} and 1 kHz. I made sure the signal had 0 DC offset and tried to observe the difference in voltages between the two signals that were generated as seen in Figure 6.2. Observing the difference was 26.84 ns, I changed the frequency to 100 kHz and repeated the process as seen in Figure 6.3. I observed that the difference was 3 ns. From this, I concluded that as frequency got higher, difference between two signals became smaller.

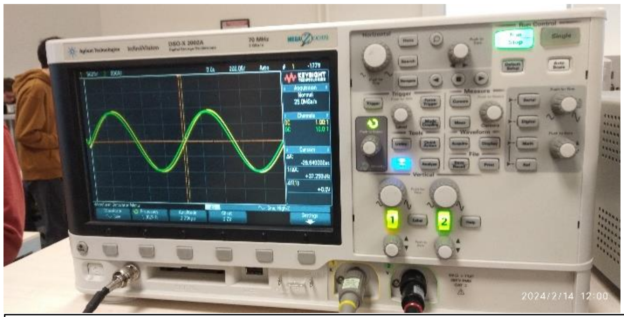

Figure 6.2 2 V_{pp} and 1 kHz Sinusoidal Wave

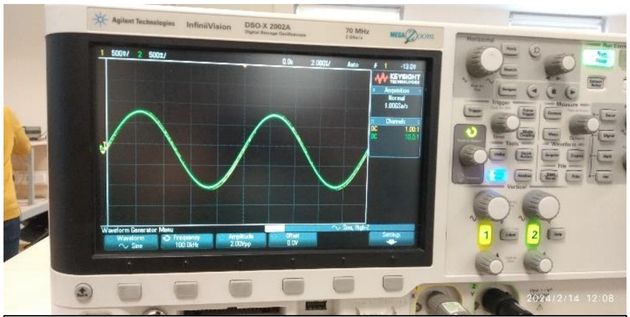

Figure 6.3 2 V_{pp} and 100 kHz Sinusoidal Wave

Conclusion

By completing each task, I was able to get more familiar with the laboratory equipment I have mentioned before such as the oscilloscope, oscilloscope probe, signal generator and breadboard. This has made it possible for me to better understand the theoretical information that we have been learning in our classes for the past weeks. Being able to put all the information I have learned into practice was an experience that has benefited me significantly. There were parts where the experiments went smoothly, but also times where I encountered unexpected signals and errors. For example, while generating a square wave, I realized the edges of my signal were not straight as they should be. I tried compensating the oscilloscope probe again, which was an unsuccessful attempt at fixing the problem. I then realized that there was a problem with the part where I inserted the probe to the oscilloscope, so I reinstalled the probe and was able to fix the problem. There were also issues during the implementation of the circuit on the breadboard. The signal generated was fuzzy and unclear during the first few tries. I believe such errors were caused by the equipment, because the values that I have set were correct and the problems were fixed after changing or adjusting the equipment.

Appendix

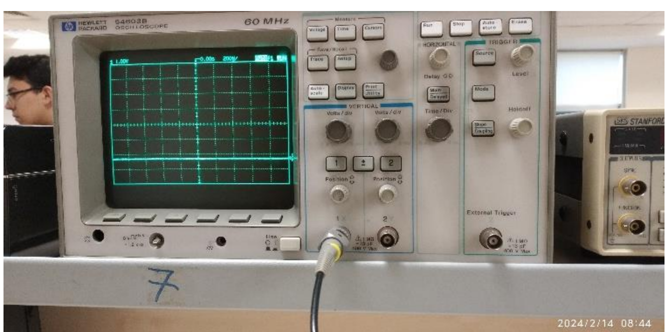

Figure 1.1 Inserting the Probe

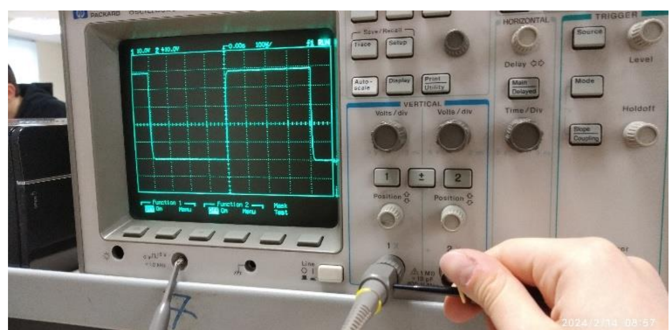

Figure 1.2 Compensating the Probe

Figure 4.1 1 V_{pp} and 5 kHz Normal Wave

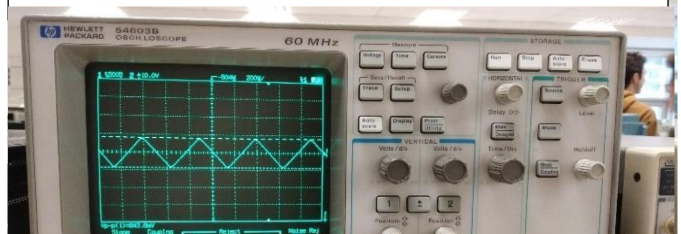

Figure 4.2 1 V_{pp} and 5 kHz Peak Detect Wave

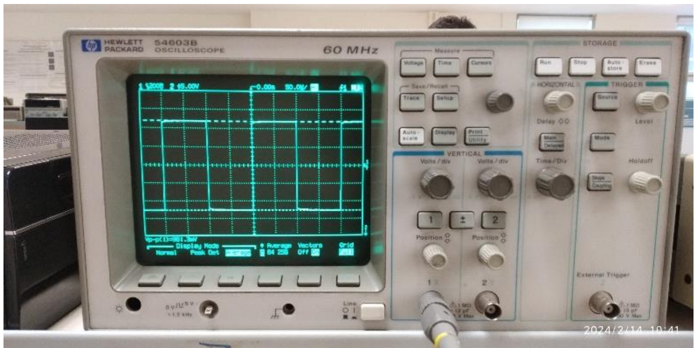

Figure 4.3 1 V_{pp} and 5 kHz Average 8 Wave

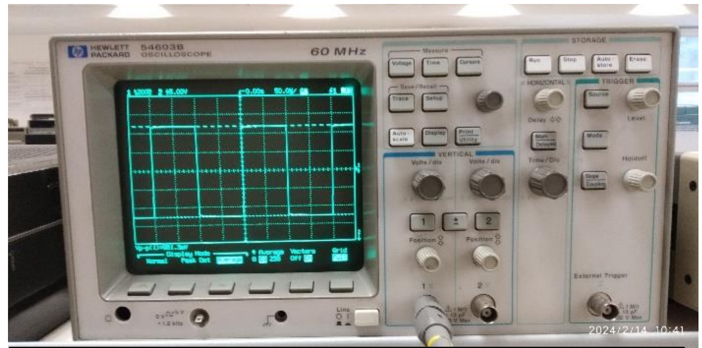

Figure 4.4 1 V_{pp} and 5 kHz Average 32 Wave

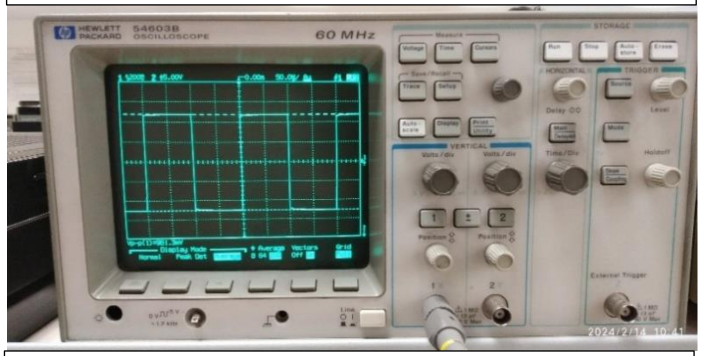

Figure 4.5 1 V_{pp} and 5 kHz Average 64 Wave

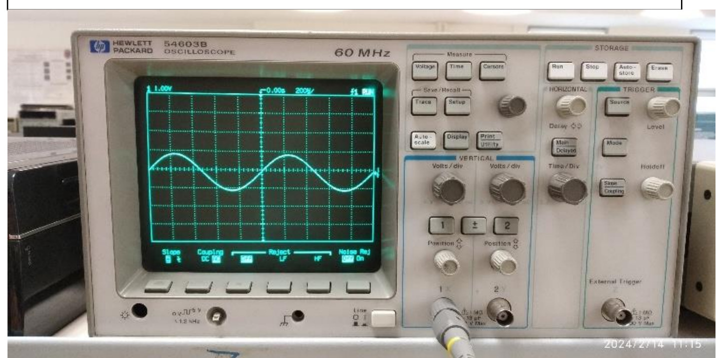

Figure 5.1 2 V_{pp} and 2 kHz Sinusoidal Wave with DC Offset of 1V (AC Coupling)

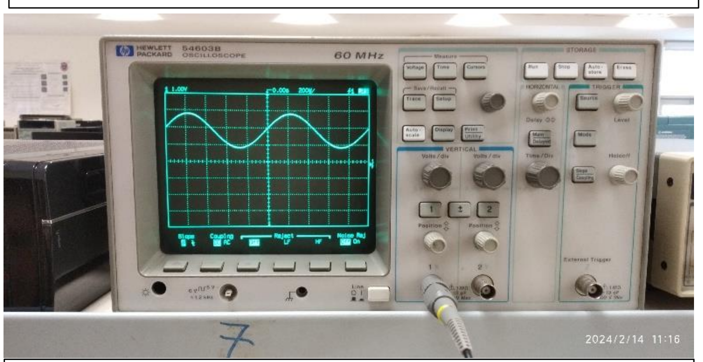

Figure 5.2 2 V_{pp} and 2 kHz Sinusoidal Wave with DC Offset of 1V (DC Coupling)

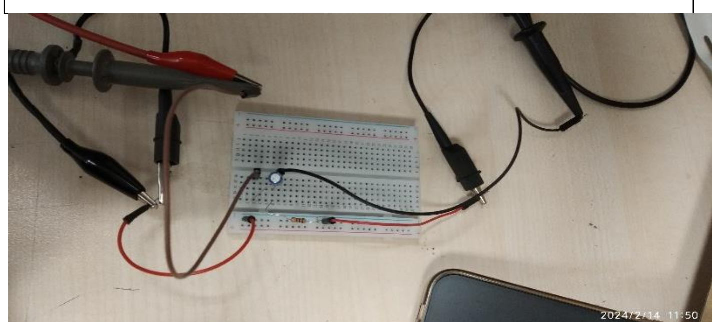

Figure 6.1 Circuit Implementation on a Breadboard

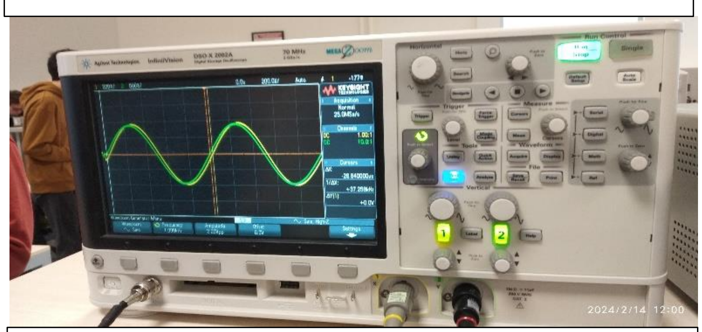

Figure 6.2 2 V_{pp} and 1 kHz Sinusoidal Wave

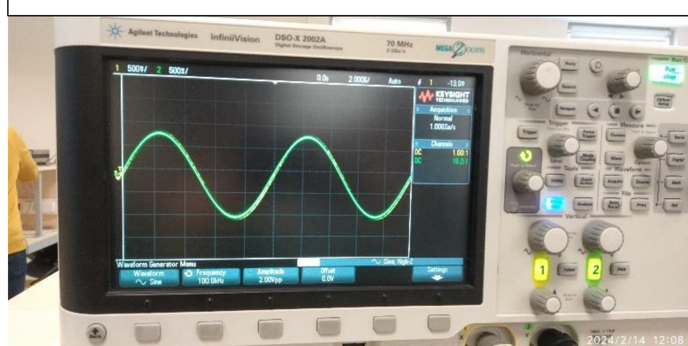

Figure 6.3 2 V_{pp} and 100 kHz Sinusoidal Wave

Works Cited

"Digital to Analog Converter (DAC) - Types, Working & Applications." *ELECTRICAL TECHNOLOGY*, 29 Apr. 2020, www.electricaltechnology.org/2020/04/digital-to-analog-converter-dac.html.

Storr, Wayne. "Analogue to Digital Converter (ADC) Basics." *Basic Electronics Tutorials*, 17 Mar. 2023, www.electronics-tutorials.ws/combination/analogue-to-digital-converter.html.

"What Is a Breadboard?" *CircuitBread*, 12 Jan. 2024, www.circuitbread.com/ee-faq/what-is-a-breadboard.