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EE 102-2

EE-102 Introduction to Digital Circuit Design

Lab 1: Introduction to Digital Oscilloscopes

Date: 26/09/2022

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Section: 102-02

Purpose: The purpose of the experiments in this lab is to get accustomed to lab equipment and learn the principles of an oscilloscope.

Experiment-1: Signal Compensation

Essentially an oscilloscope probes electrical properties needs to balance the oscilloscope. To balance it, an adjustment tool should be used.

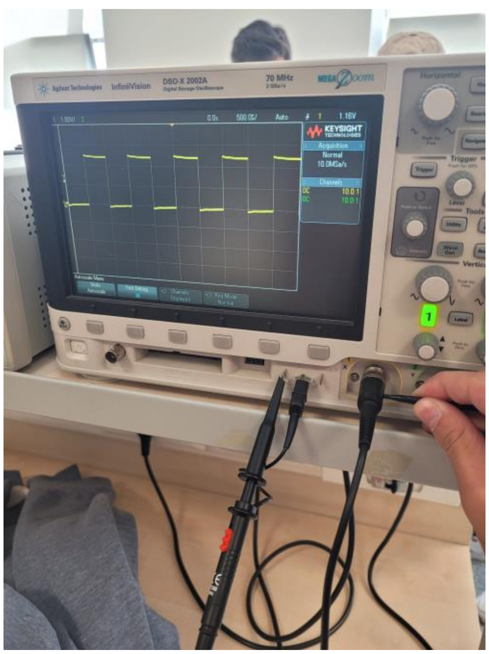

Figure 1. Over compensated wave

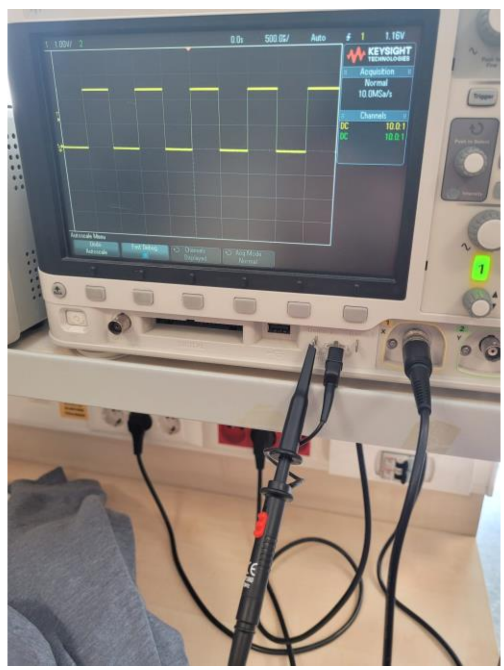

Figure 2: Adjusted wave

In this experiment, I need to create a square wave signal first so that it could be observed. According to the observation, it can be seen in figure 1 that the signal was overcompensated as

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some points in the signal are pointing outwards. Seeing this result, I used the adjustment tool to make the square waves compensation balance as it can be seen in figure 2.

Experiment 2: Edge triggering

A 5Vpp (peak to peak) sinusoidal signal with 1kHz frequency's shape in the monitor is observed when edge triggering is used in this part.

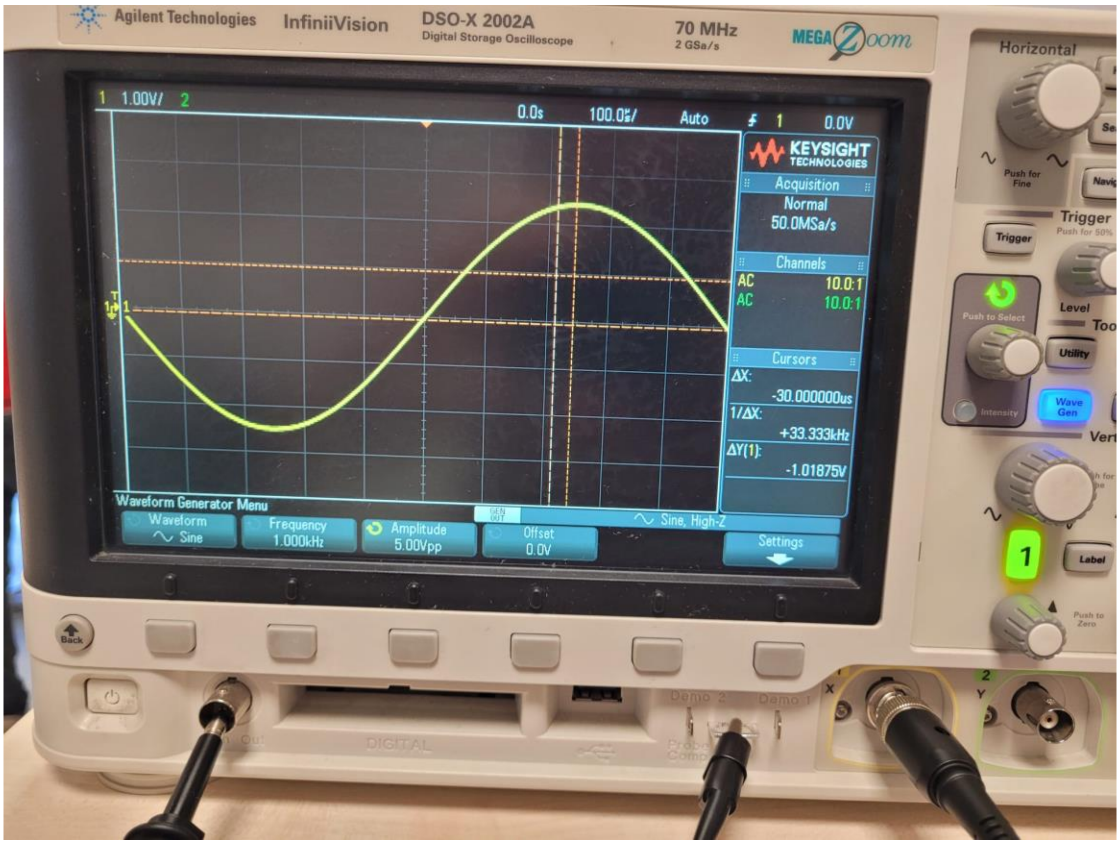

Figure 3: Wave Before Triggering

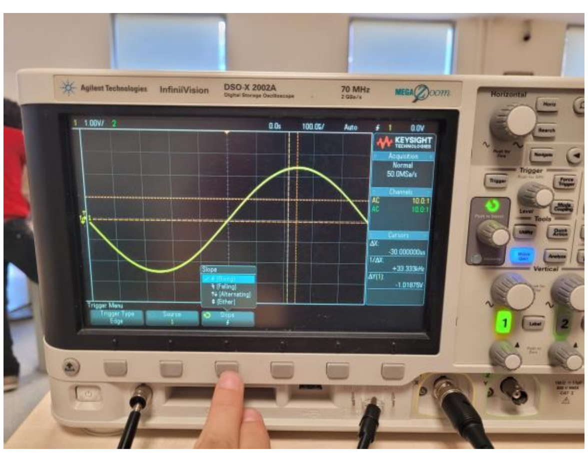

Figure 4: Positive Edge Triggering

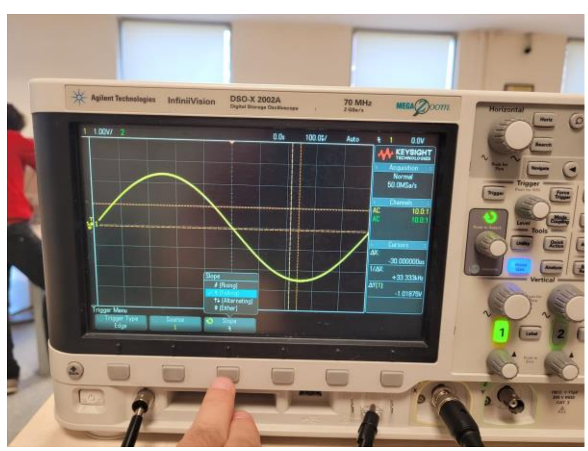

Figure 5: Negative Edge Triggering

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After adjusting signal to the required specifications as it can be seen in figure 3, I opened the triggering and applied positive and negative edge triggering to the signal. According to my observations, the main difference between the triggers were the starting slope of the signals. While positive edge trigger started off by a positive slope as seen in figure 4, negative edge trigger started off with a negative slope as seen in figure 5. In other words, the signals were symmetrical to each other.

Experiment 3: Triggering Knob

A 1 Vpp triangular wave with frequency 2kHz is created on the oscilloscope and then the trigger knob is used to observe its' behavior.

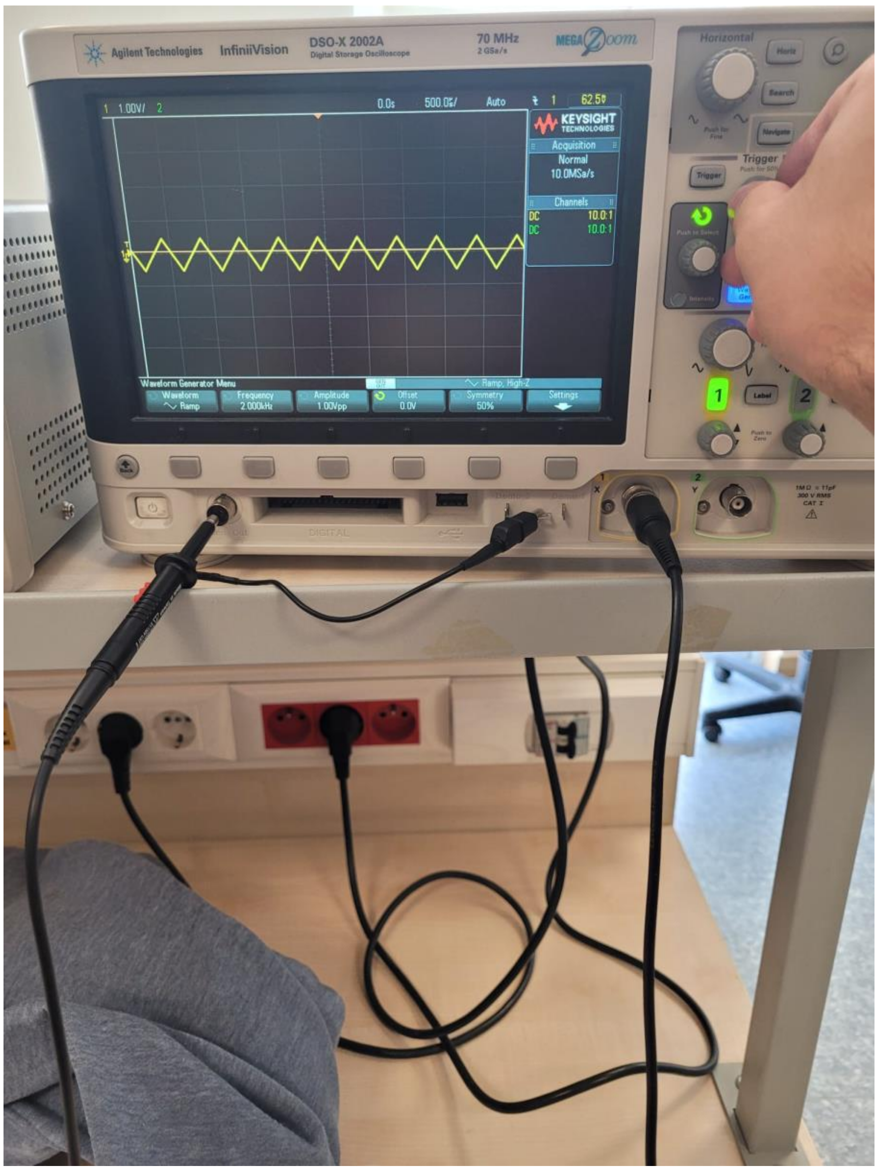

Figure 6: Triangular wave with trigger level 0

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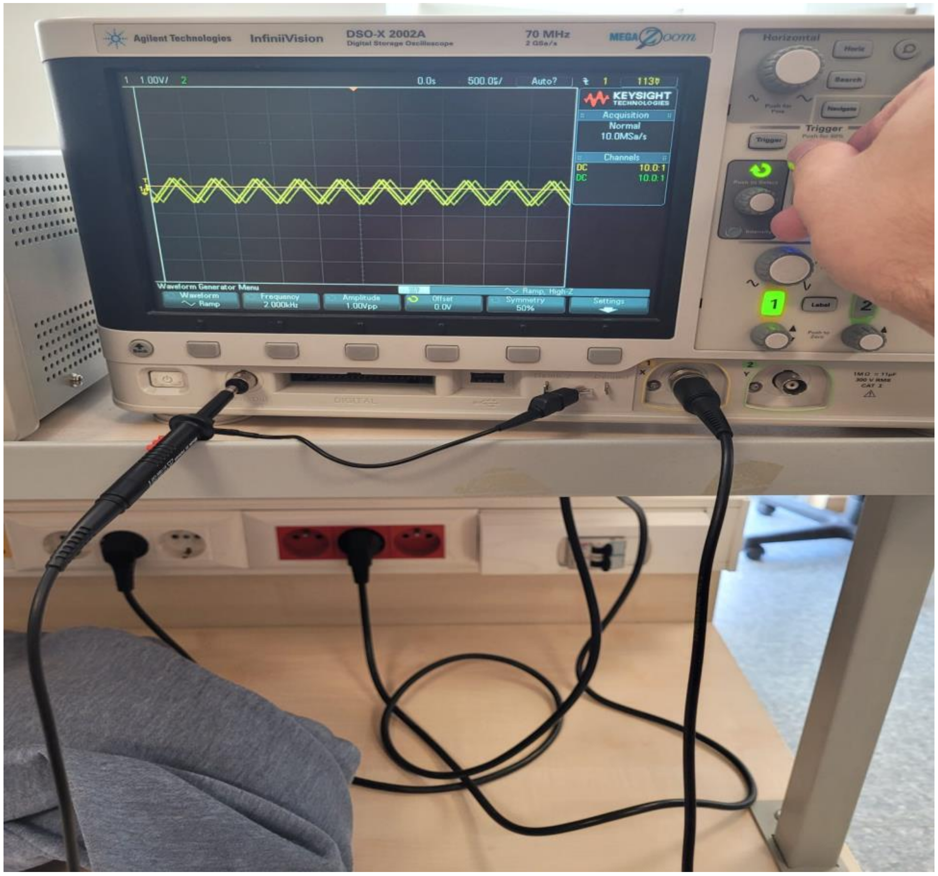

Figure 7: Triangular wave with trigger level 113mV

In this part, after creating the triangular wave, which can be seen in figure 6, I started to increase the trigger voltage by turning the knob. As I increased the trigger level the triangle images started to get distorted which is illustrated in figure 7. The concept of triggering makes repetitive waveforms appear static on display. When trigger level exceeds some certain voltage the display tends get distorted.

Experiment 4: Acquisition

Digital to Analog Converter(DAC) essentially converts a digital signal to an analog one such as where as an Analog to Digital Converter(ADC) essentially converts an analog signal to a digital signal.

Some examples of DAC would be devices that converts digital audio signals to analog signals such as CD players and games consoles. An example of ADC would be cell phones which can record our voices as digital signals.

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In an oscilloscope, ADC is used to convert voltage measured into digital information. This digital information is then converted by a DAC in digital display system so that it can be displayed.

In this part I applied a 1Vpp square wave with frequency 5kHz and observed the displays as I changed the acquisition modes differing from sample(normal) to peak detect and then peak detect to average.

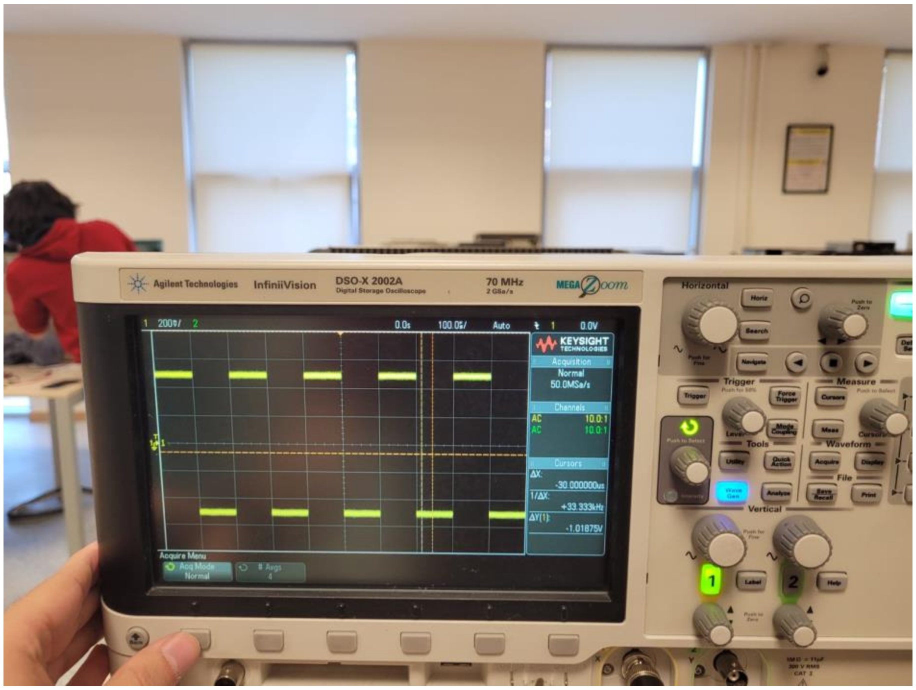

Figure 8 : Normal Acquisition Mode

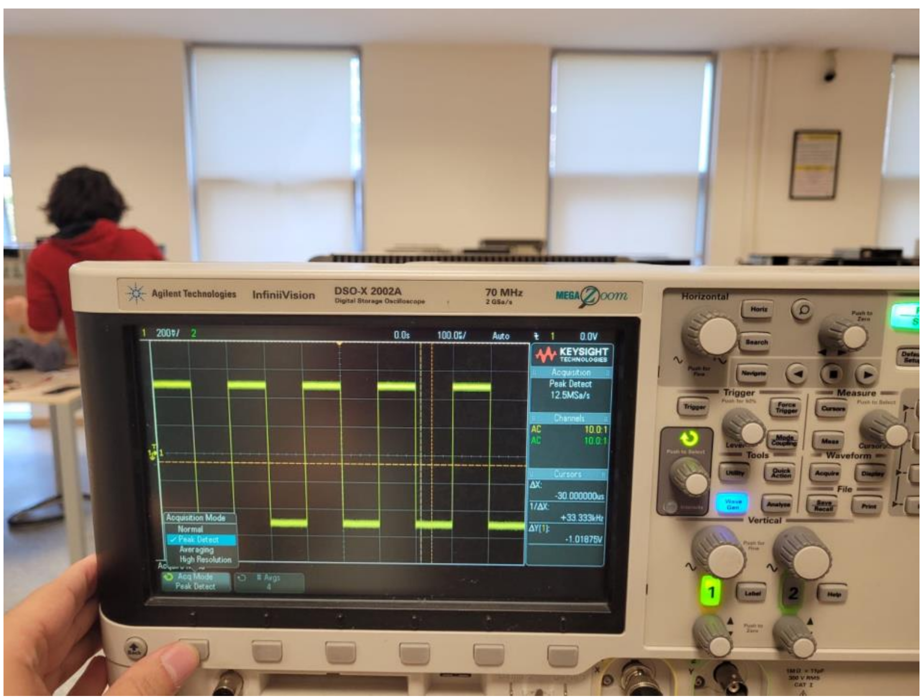

Figure 9: Peak Detect Acquisition Mode

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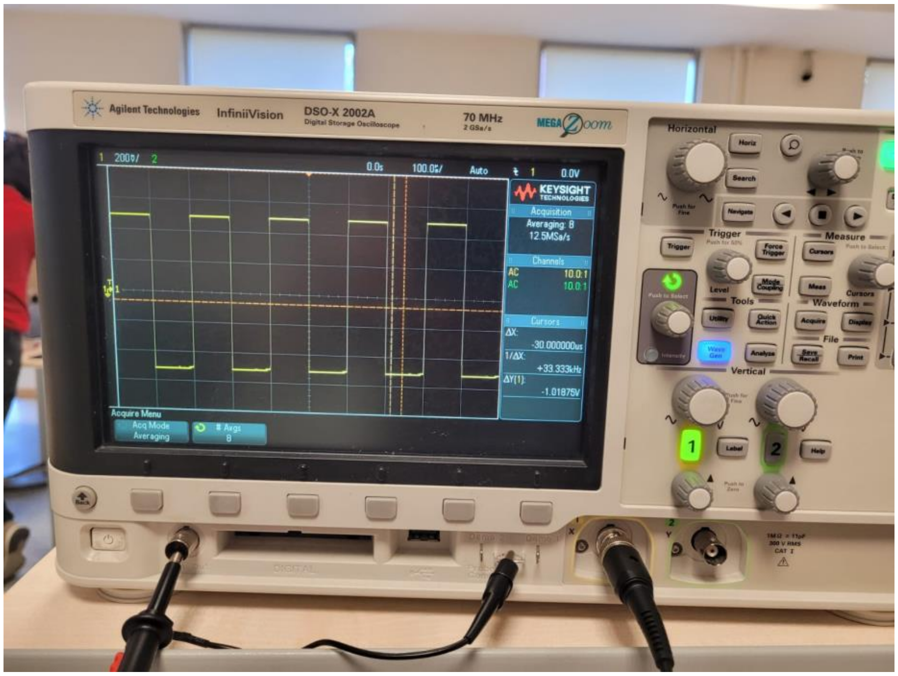

Figure 10: Average Acquisition Mode

From the sample mode, figure 8, to peak detect mode, which is illustrated in figure 9 the connection between minimum and maximum is clearer as peak detection mode saves minimum and maximum value sample points.

From peak detect mode, figure 9, to average mode, illustrated in figure 10, the lines are thinner as it averages the waves from several acquisitions.

Experiment-5: Offset and Coupling

In this part of experiment, I generated a sinusoidal signal with 2Vpp amplitude and 1kHz frequency and applied a DC offset of 1V. Afterwards I observed difference between AC coupling and DC coupling.

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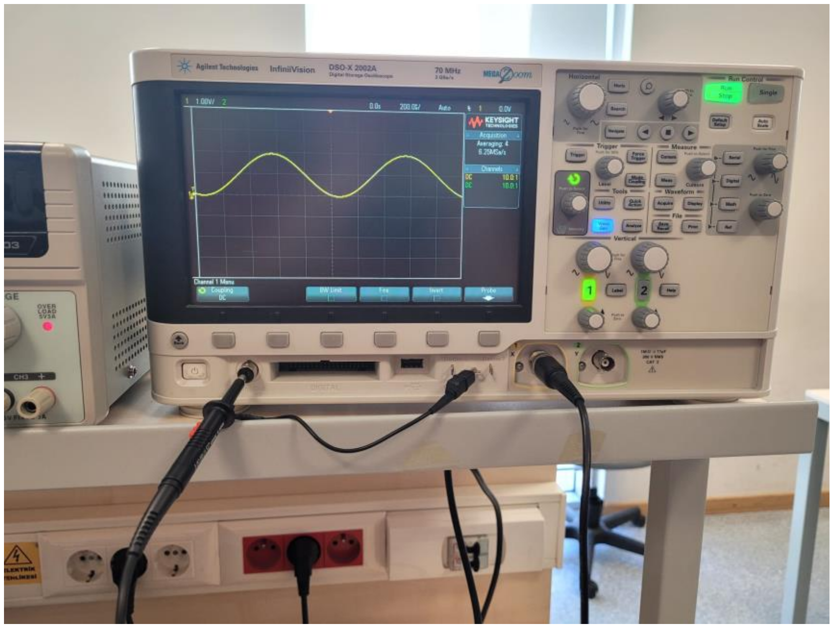

Figure 11: DC Coupling

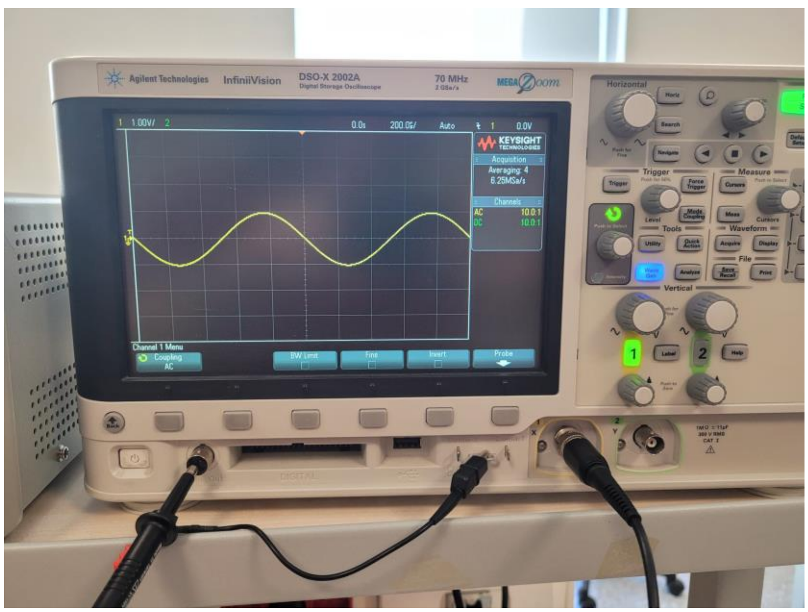

Figure 12: AC Coupling

Comparing Figure 11, where the DC coupling is applied, to figure 12, where the AC coupling is applied, the first figure is impacted by the DC offset and is 1V higher than the latter figure as a result.

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Experiment 6: Phase Difference on a Circuit

Breadboard is a device that doesn't need a solder. It has holes and columns that has positive and negative sign are connected internally. Through breadboard circuits that consists of different elements can be created.

In this part, the phase differences between probe X and probe Y is compared on a 2Vpp sinusoidal signal when the frequency is 1kHz and 100kHz.

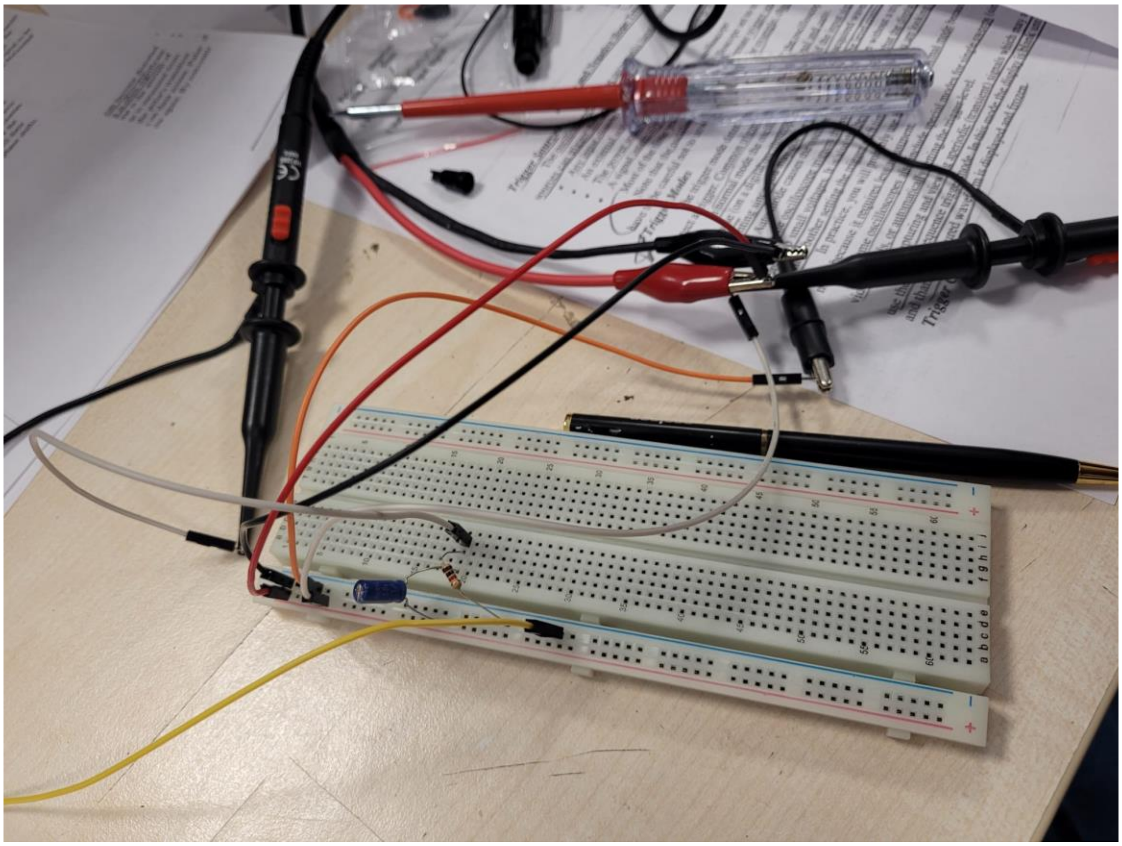

Figure 13: Breadboard Circuit with 2 probes

Firstly, I created the breadboard circuit as it's instructed without skipping on grounding and how positive and negative signs should be placed on the breadboard as it's illustrated in figure 13.

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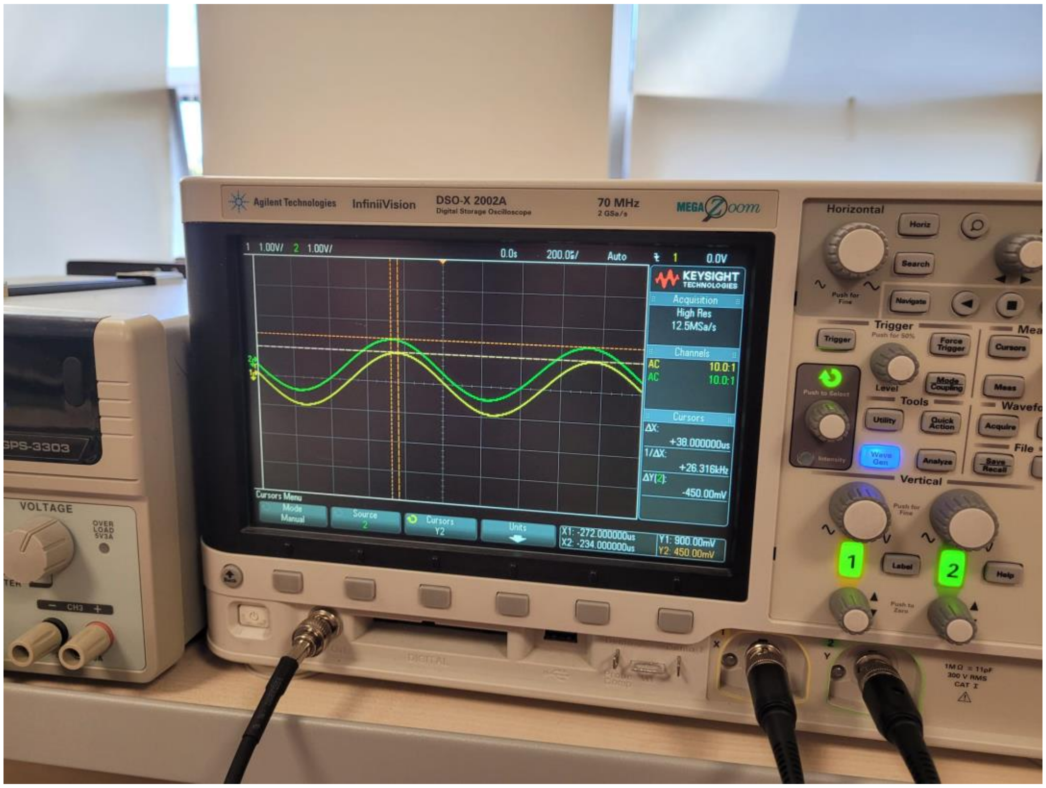

Figure 14: Phase Difference in 1kHZ sinusoidal signal

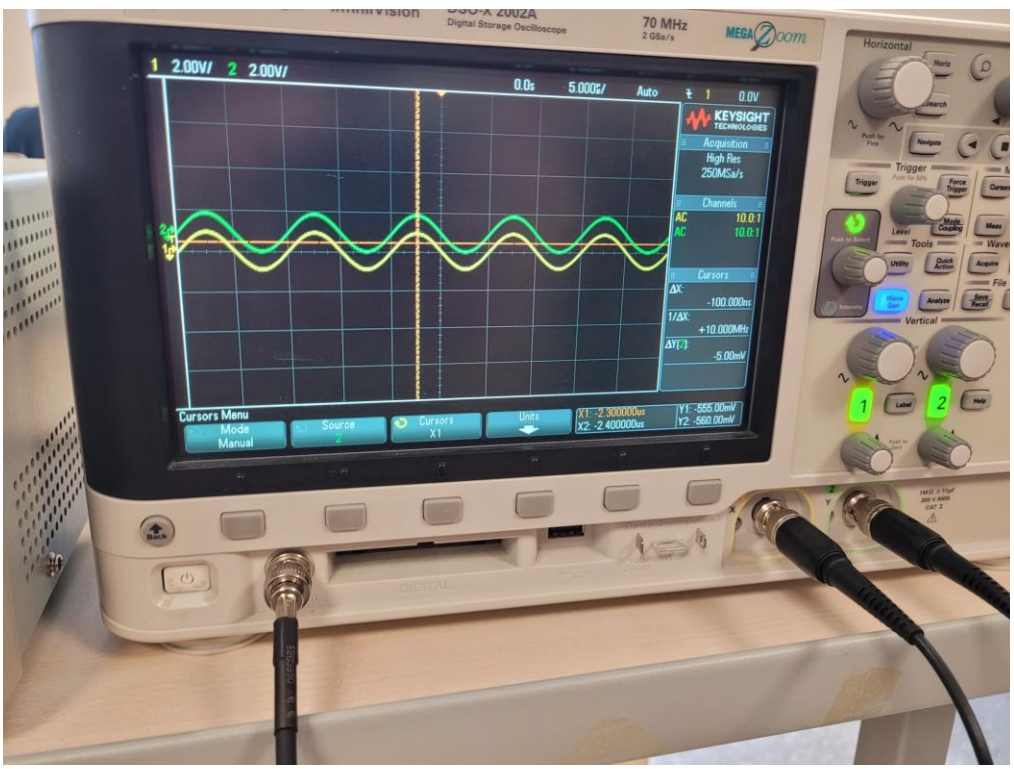

Figure 15: Phase Difference in 100kHZ sinusoidal signal

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The main difference between 1kHz signal and 100kHz signal was the phase difference. While on 1kHz signal the time difference was 38 microseconds which can be seen in figure 14, it was 100 nanoseconds on 100kHz signals which is illustrated in figure 15. In other words, the phase difference on 1kHz was $2.4*10^{-1}$ radians whereas it was $6.3*10^{-3}$ radians for 100kHz. The calculation can basically be made through multiplication of 2π radians, frequency in hertz, phase difference in seconds.

The phase difference was less noticeable as frequency increased since the capacitor charges up and discharges causing the impedance of the capacitor to decrease, which will decrease the phase difference between two signals.

Conclusion:

In this lab, I became familiar with oscilloscope and observed the changes between different types of wave signal. Through this lab I understood how an oscilloscope probe works and how it can be used with a breadboard. The experiments I made during this lab was generally successful although there could be some minor errors due to some physical faults on oscilloscope probes.