Experiment 1: Introduction to Digital Oscilloscopes

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Section: 2

Purpose of the experiment:

The purpose of this experiment is to teach us how to use a signal generator, and a digital oscilloscope work. We also obtained information about how a breadboard works and created a simple circuit on it by using a 1 uF capacitor and a 1 kΩ resistance.

Methodology:

Before coming to the lab, we were asked to read the document *Digital Oscilloscope Principles* on Moodle to gain familiarity with the lab equipment. In this document, there was the theory behind how an oscilloscope worked and showed different types of waveforms in a more understandable fashion. The oscilloscopes have ADC built in them so that they can convert the voltage being measured into digital information. Then they use this digital information to represent the waveform on the screen. An ADC changes an analog signal that's continuous to a digital signal that's discrete. On the other hand, a DAC changes a digital signal (digital information) that's discrete to an analog signal that's continuous. Both ADC and DAC are commonly used in electronics, such as telephones, computers, etc. to convert data into the wanted type.

At the beginning of the experiment, we compensated our oscilloscope probes to be as accurate as possible in our readings. This step should be done every time before using an oscilloscope. In this step, we used our adjustment pins in our probe kits to properly compensate them (Figure.1). For this experiment, 10x attenuation factor was more beneficial, therefore preferable. After the compensation, the waveform on the screen is shown in Figure.2.

In the second step, we monitored a sinusoidal signal generated by the signal generator and had amplitude Vpp 5V and frequency 1kHz. Then by changing the trigger slopes, we obtained different waves on the screen. A RISING edge is a positive slope and a FALLING edge is a negative slope. In order to have positive edge triggering, we used the RISING slope setting (Figure.3) and to have negative edge triggering, we used FALLING slope setting (Figure.4). The difference between them is just phase difference, one of them can be obtained by mirroring the other with respect to x-axis. Since the signal generator was not terminated by an impedance of 50 Ω, but instead by a higher impedance, the magnitude of the output was twice the input value (in our case approximately 10V).

In the third step, we monitored a triangular signal generated by the signal generator and had amplitude Vpp 1V and frequency 2kHz. When the trigger level was inside the bounds (the positive and negative voltage values we set earlier), the oscilloscope successfully represented the signal (Figure.5). When we started to turn the trigger knob, the trigger level started to go out of bounds, thus making the oscilloscope unable to show the signal's waveform on the screen. This is because in order for an oscilloscope to work properly, there should be enough data (sample) points on the trigger level (coinciding with the trigger level). In fact, just before exiting the set bounds, the oscilloscope starts showing a distorted image (Figure.6), and when the trigger level completely exits, the wave starts to move very fast, thus making capturing a proper image impossible (Figure.7).

In the fourth step, we monitored a square wave generated by the signal generator and had amplitude Vpp 1V and frequency 5kHz. Then we tried all the acquisition modes. In sample (normal) mode, the oscilloscope creates a waveform point by saving one sample point during each waveform interval (Figure.8). In peak detect mode, the oscilloscope saves the minimum and maximum valued sample points taken during two waveform intervals and uses these samples as the two corresponding waveform points (Figure.9). In averaging mode, the oscilloscope saves one sample point during each waveform interval, then these sample points are averaged together to show a single waveform (Figure.10). These images may not be enough to study the behavior of modes but in general, averaging mode gives a waveform with less noise and the peak detect leaves a singular line above the peaks when it is used to show a square or rectangular wave (where this line sits is dependent on the trigger slope).

In the fifth step, we monitored a sinusoidal signal generated by the signal generator and had amplitude Vpp 2V and frequency 1kHz. We also set DC offset to 1V. Then we observed the differences between DC (Figure.11) and AC (Figure.12) coupling. The difference between them is that DC coupling shows all of the input signal whereas AC coupling blocks the DC component of a signal so that you see a waveform centered at 0 volts.

In the last step, we used a breadboard to set up a simple circuit (Figure.13). A breadboard allows us to place components on the board to make circuits/prototypes without soldering so that it is easier to remove a component or change its position. We applied a sinusoidal signal generated by the signal generator and had amplitude Vpp 2V and frequency 1kHz as the X signal. Since we had a capacitor in our circuit, we observed a phase difference of 8.24 degrees (Figure.14). The delay between the waves was 25 us. The period of this wave was 2 ms. The voltage difference was 0.1V. Then we changed the frequency to 100 kHz. This time we observed a phase difference of 0.65 degrees (Figure.15) and the delay between the waves was 5 ns. The period of this wave was 8 ms. The voltage difference was 0.1V.

Results:

Figure.1 Compensating by the adjustment pin

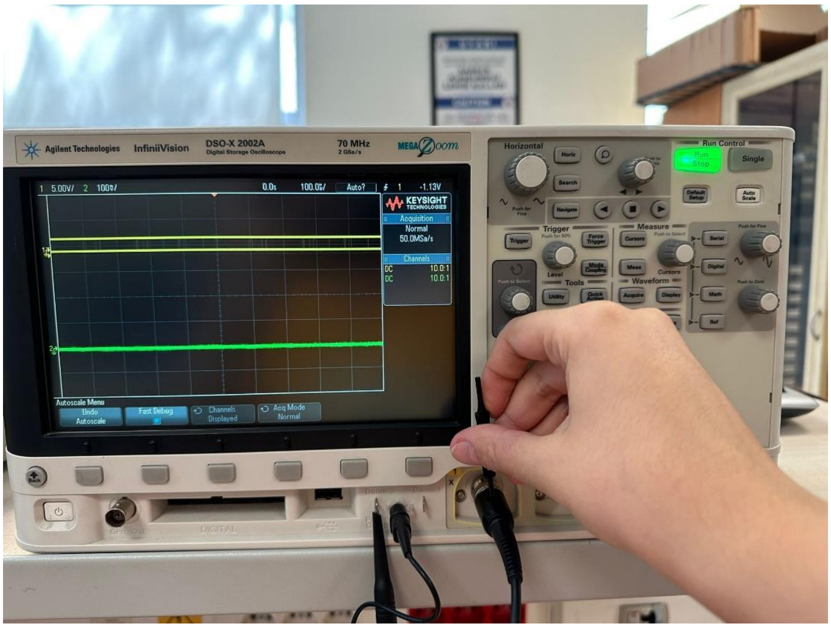


Figure.2 Waveform of the compensated probe

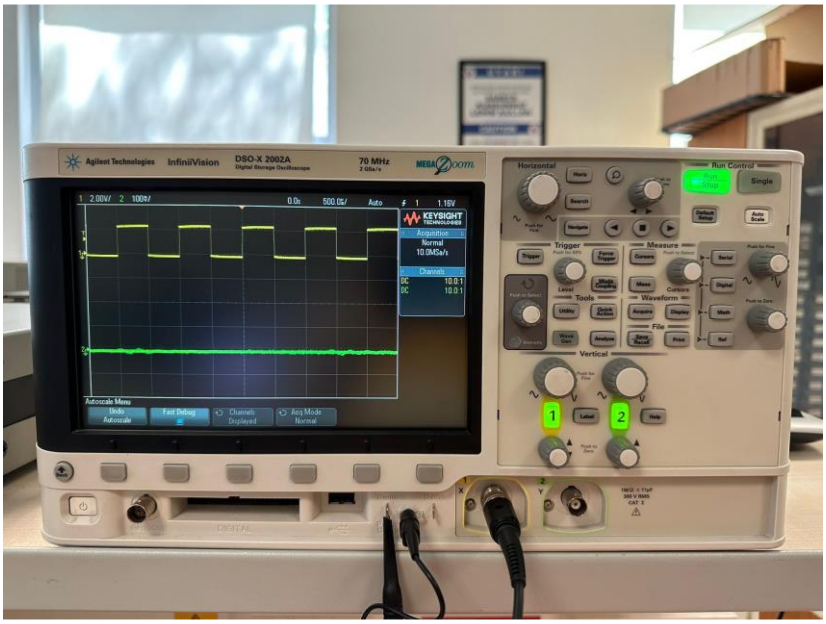


Figure.3 Positive edge triggering

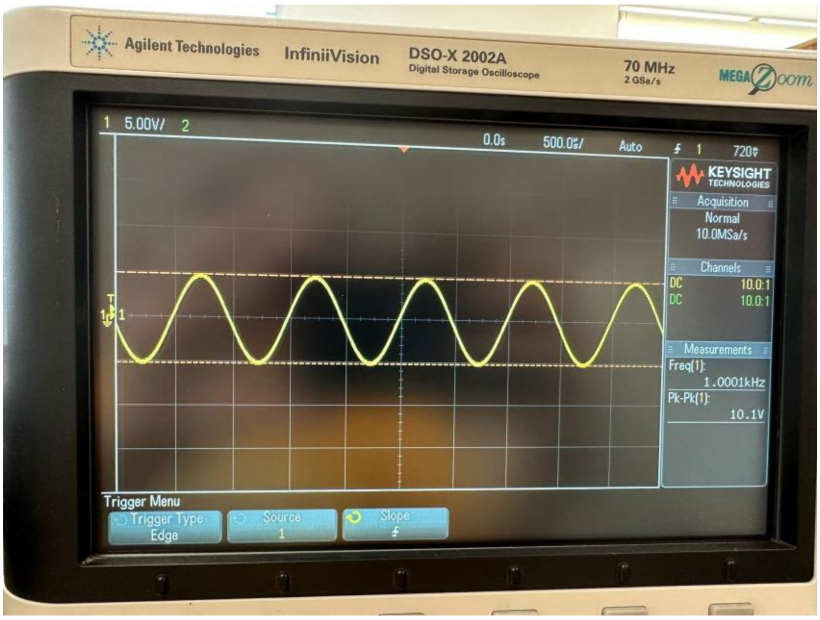


Figure.4 Negative edge triggering

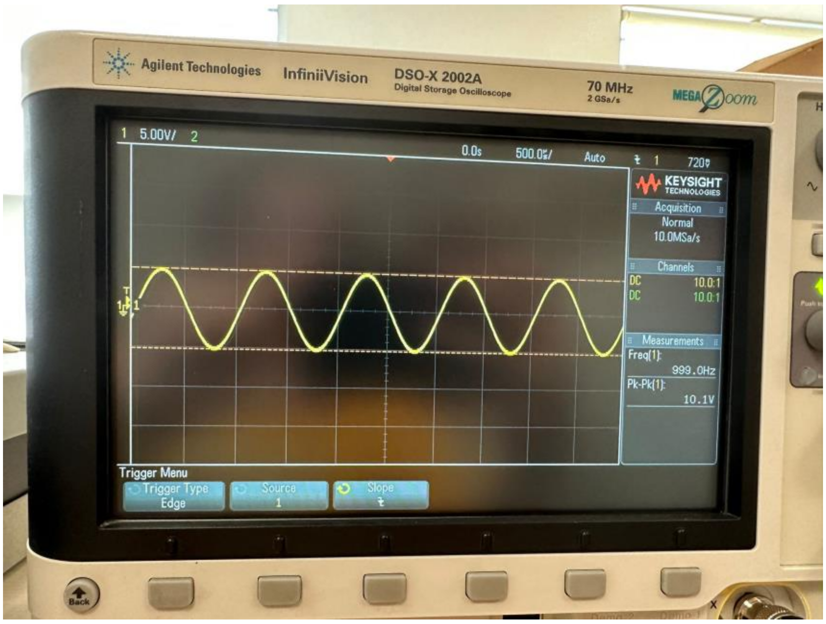


Figure.5 Trigger level inside the bounds

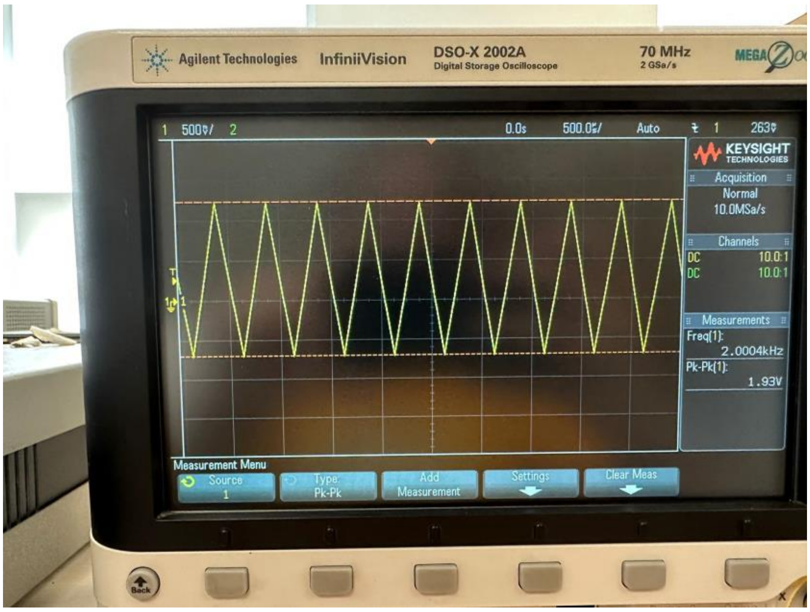


Figure.6 Trigger level just about to leave the upper bound

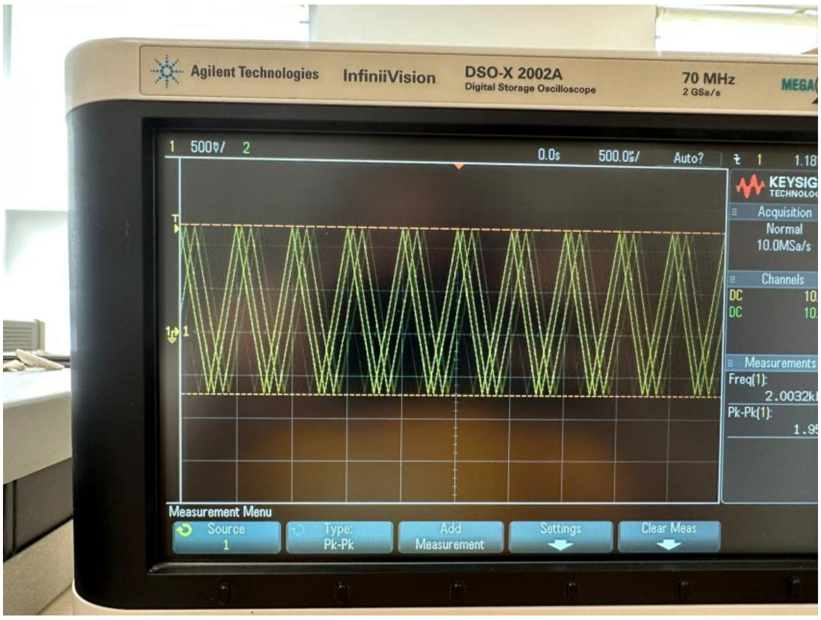


Figure.7 Trigger level outside the bounds

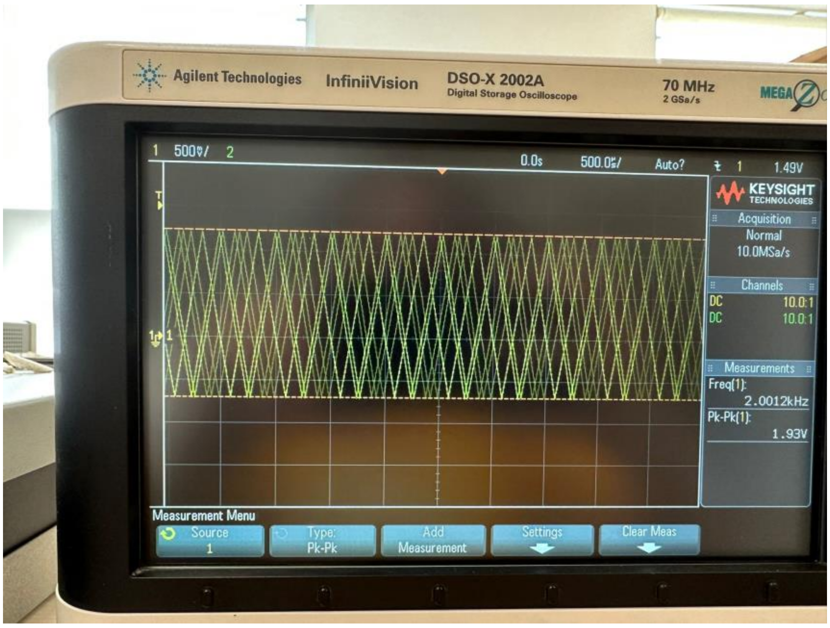


Figure.8 Normal mode

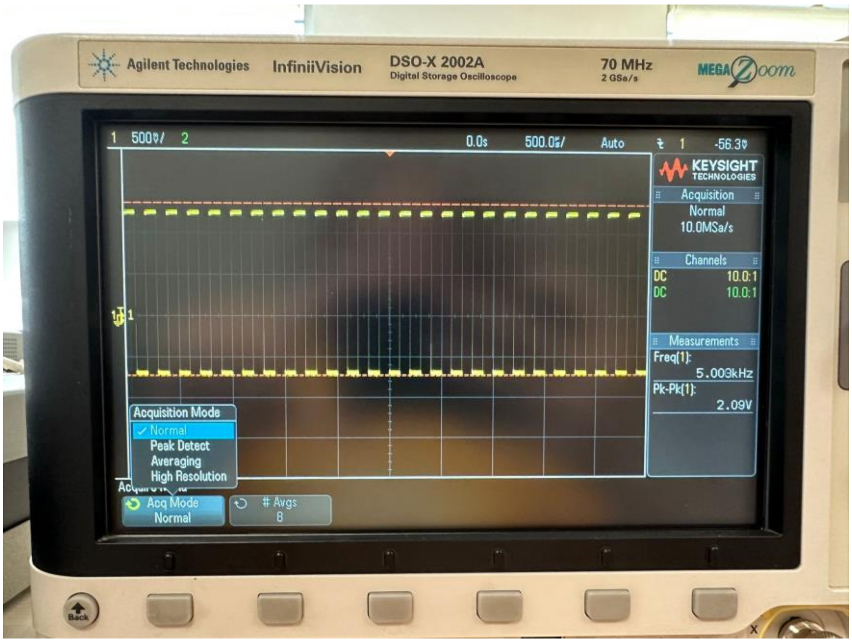


Figure.9 Peak detect mode

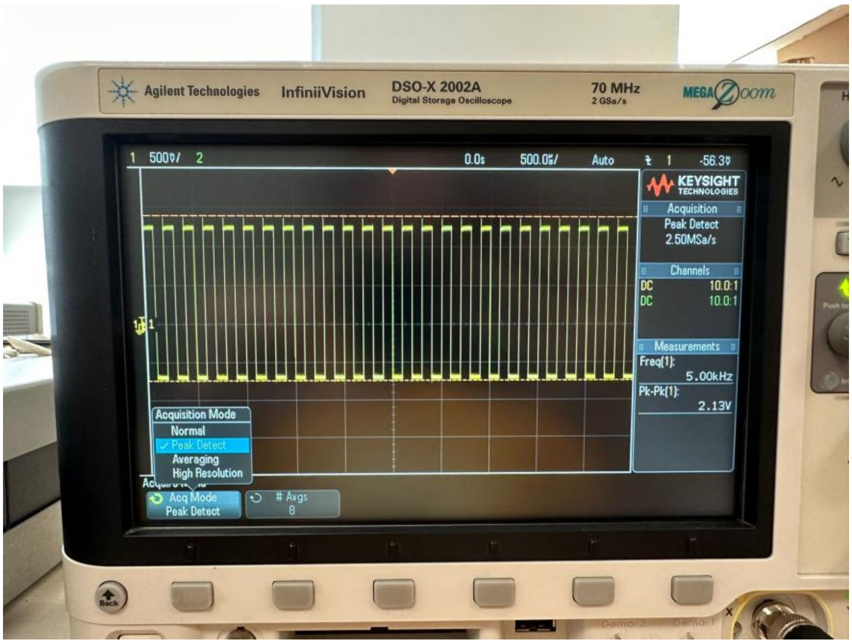


Figure.10 Averaging mode

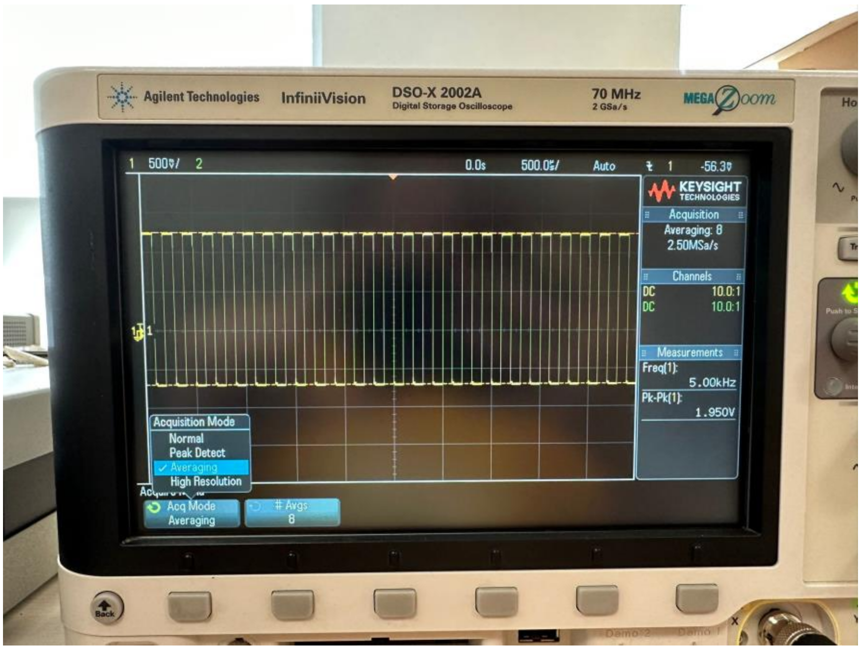


Figure.11 DC coupling

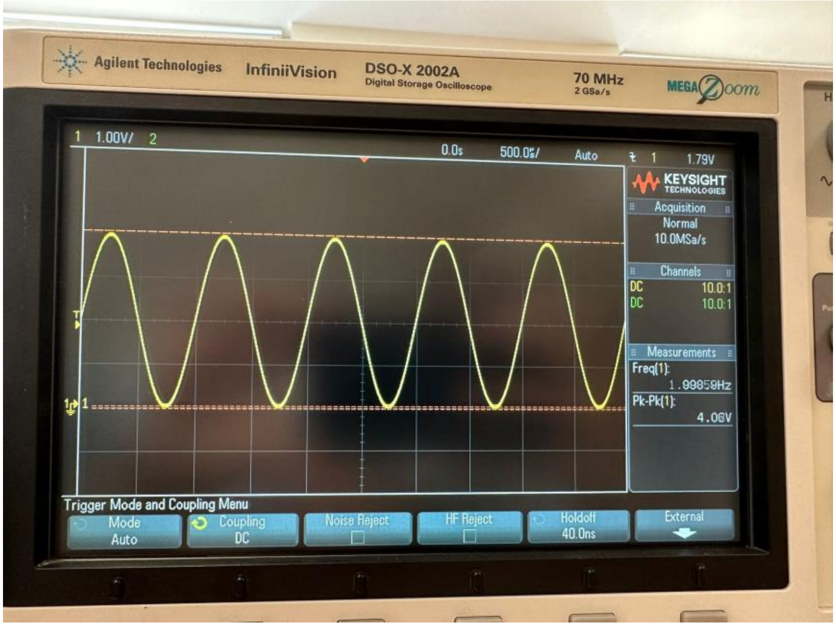


Figure.12 AC coupling

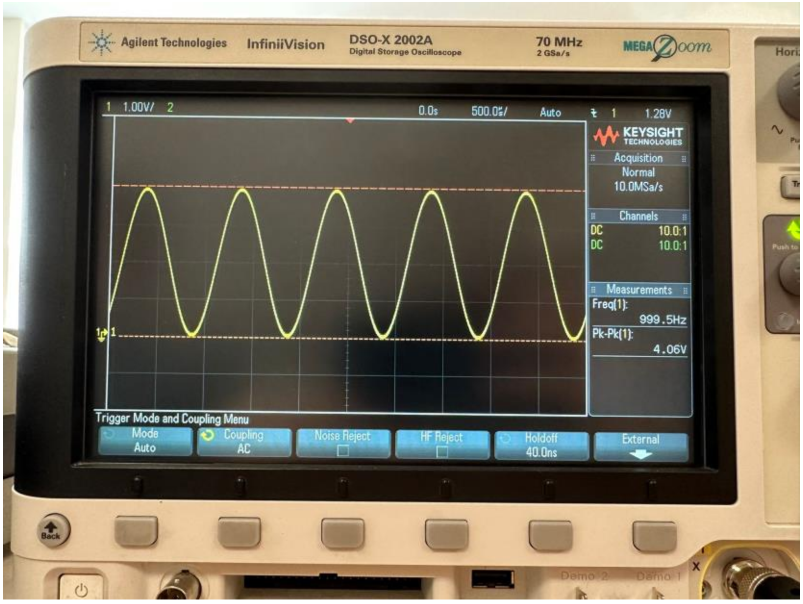


Figure.13 Circuit on the breadboard

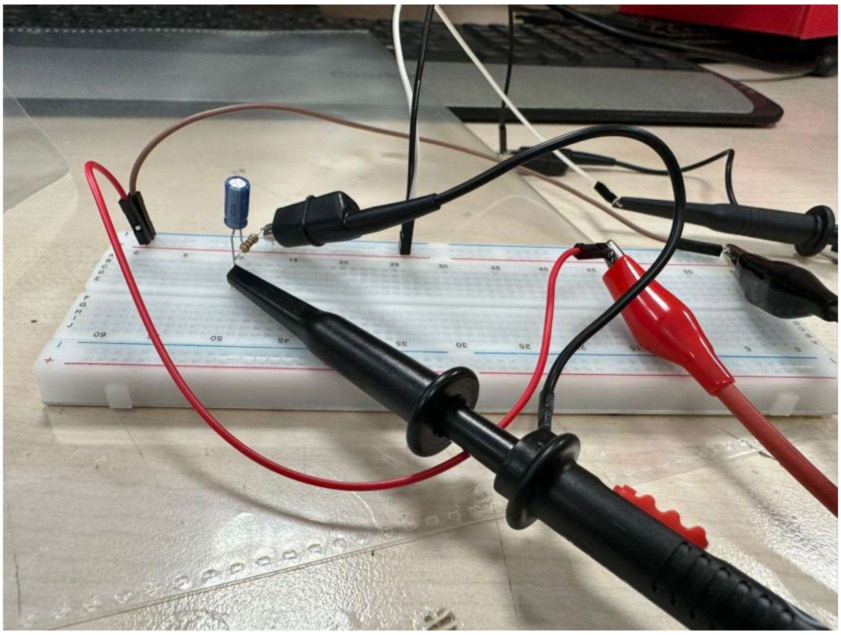


Figure.14 Wave with frequency 1 kHz

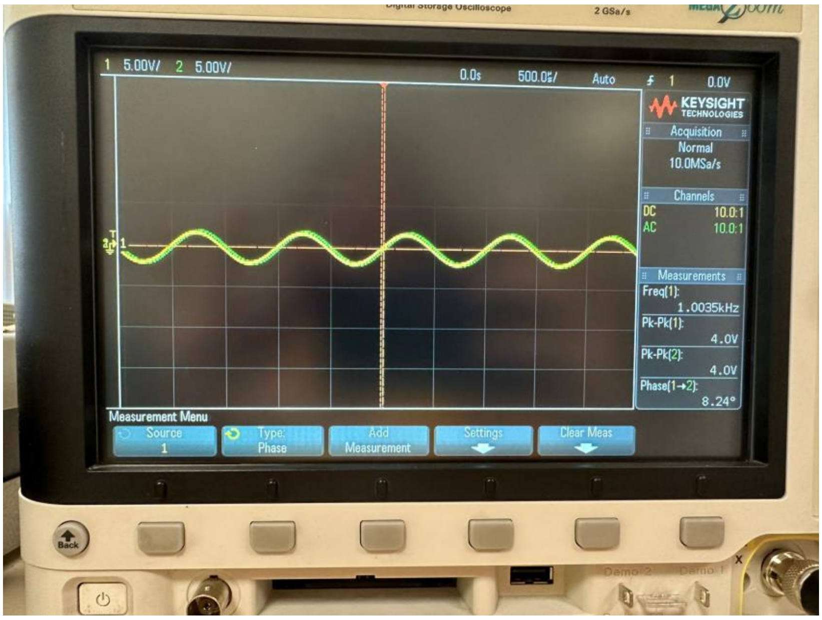
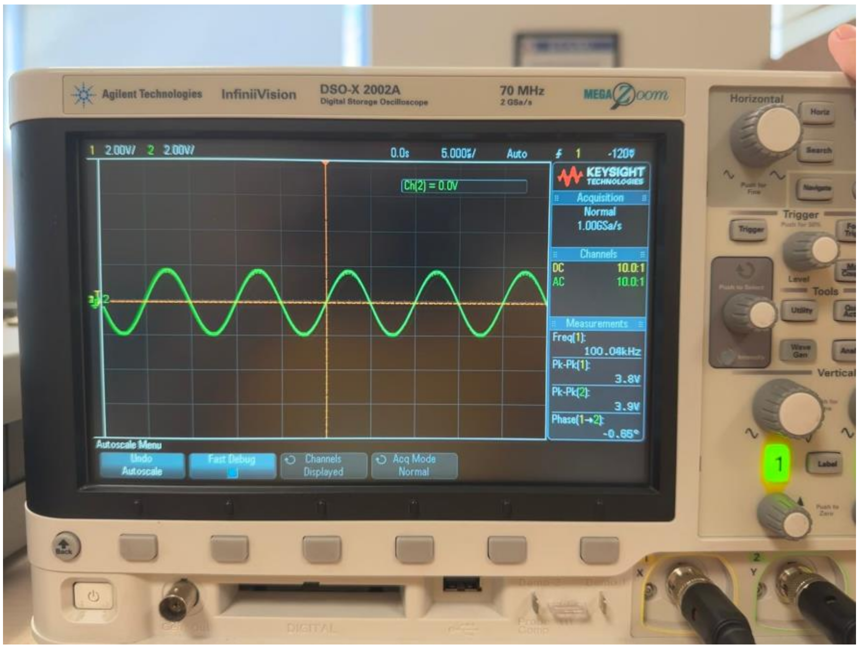


Figure.15 Wave with frequency 100 kHz



Conclusion:

The purpose of this experiment was to teach us how to use an oscilloscope the correct way and it was very beneficial for us. The results of the steps showed us the difference between trigger modes, coupling modes, etc. In the last step, my classmates showed me how to ground my breadboard in the correct way so that the circuit started working. Also, throughout the experiment my signal generator had a 0.01V offset value as default because the generator was not working properly when the offset was 0. Ergin Atalar was at the lab during the beginning and he advised me to continue using it this way in order to obtain correct results.