Bilkent University Electrical and Electronics Department

EEE-102-02 Lab 1 Report

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Purpose:

The purpose of this experiment is to learn how to use a signal generator and oscilloscope. Besides teaching the basics of signal generator and oscilloscope this experiment also teaches how to create circuits by using simple circuit components like capacitor, breadboard and resistors.

Equipments:

- A digital oscilloscope (Tektronik TDS 2002)
- A signal generator (Stanford Research Systems)
- Oscilloscope probe
- Resistance(1kΩ)
- Capacitor (1µF)
- Breadboard
- Jumper cable

Methodology:

In this experiment there are multiple parts. The first part is about compensating the oscilloscope probe according to instructions. In Step 2, a 5 Vpp sinusoidal wave with frequency 1 kHz is generated. Different triggering methods (positive and negative edge triggering) have been tested. In step 3, this time a 1 Vpp (voltage peek to peek) triangular wave with frequency 2 kHz is generated and we observed the effect of turning the trigger knob on oscilloscope. In step 4, a 1 Vpp square wave with 5 kHz is created and I tried the all acquisition modes. In Step 5, I generated a 2 Vpp (voltage peek to peek) sinusoidal wave with frequency 1 kHz and applied DC offset of 1.0 V then I saw DC coupling and AC coupling. As a final step, circuit with 1µF capacitor and 1 KΩ resistor is created by using breadboard. A 2 Vpp 1 kHz wave with no DC offset is applied to circuit and the wave from two different points are observed. Possible error sources and interpretations will be discussed in the conclusion part.

Results:

Results, observations and interpretations will be discussed step-by-step in this section of this report.

Step 1

Compensation process is essential when signals are involved since if the compensation step is skipped or not done properly, observations and measurements will be incorrect as can be seen in Figure 1.1 and figure 1.2. The figure should include flat and proper square waves (Figure 1.3). When compensating the oscilloscope probe, we need an adjustment tool (Figure 1.4) to make arrangements. We connected the probe to an input connector and the probe tip was attached to the compensation signal while ground clip was connected to ground.

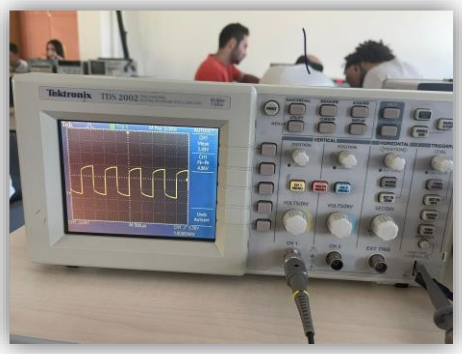

Figure 1.1 (undercompensated)

Figure 1.2(overcompensated)

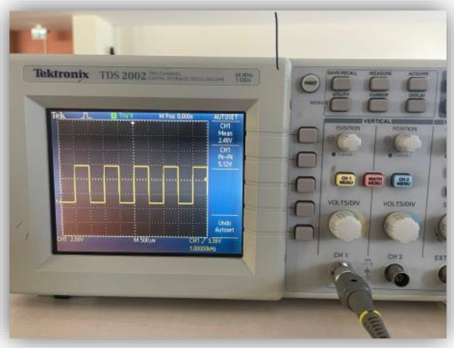

Figure 1.3 (proper)

Figure 1.4

Step 2

As I mentioned in methodology 5 Vpp (voltage peek to peek) with 1kHz is created. At the first part of step 2, positive edge triggering is used which process centers the wave's rising part which means slope is positive at this trigger level (Figure 2.2). At the second part, negative edge triggering is used in order to start the wave with falling (negative slope) on the screen Figure (2.1). This feature may be useful when we need comparison.

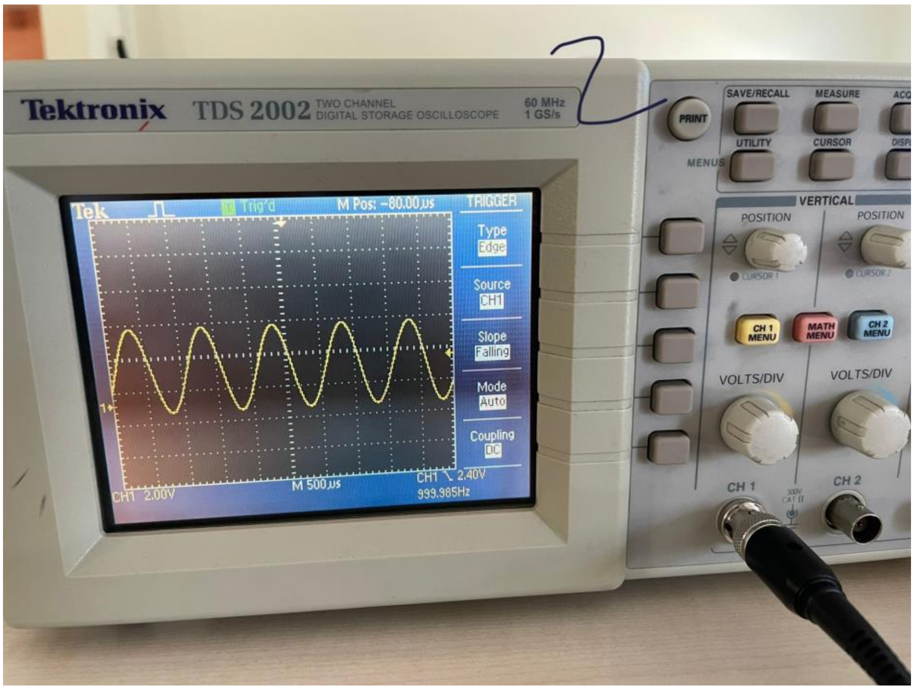

Figure 2.1

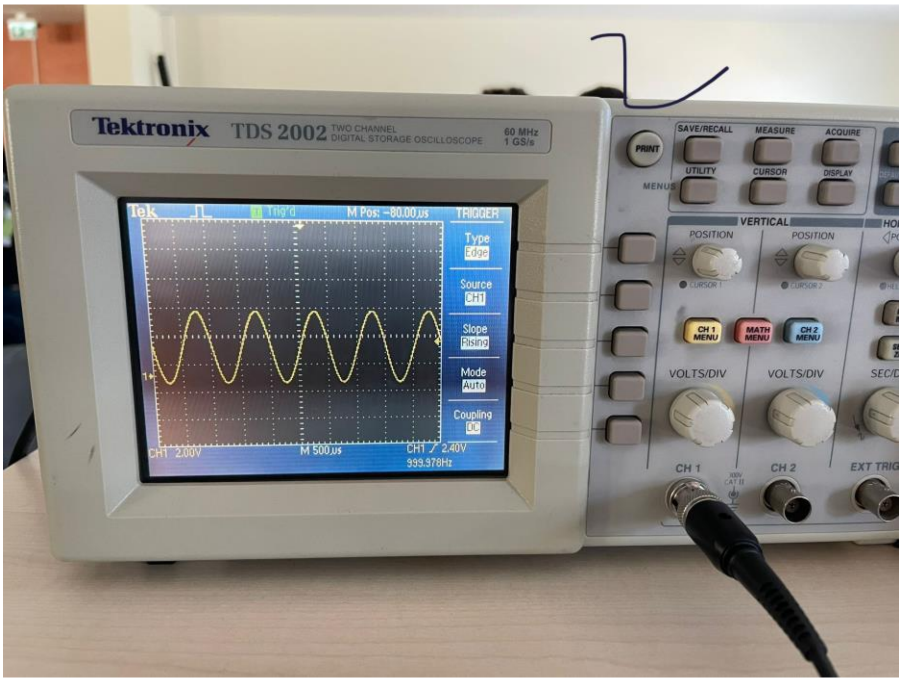

Figure 2.2

Step 3

We concentrate on trigger options in this step. The trigger controls let us stabilize repeating waveforms and capture single-shot waveforms. The trigger makes repeating waveforms appear static on the oscilloscope display. After reading the manual I generated a 1Vpp triangular wave with frequency 2kHz (Figure 3.1). Since the trigger changes the starting point of the wave little adjustments on the trigger level moves the wave. When the trigger knob is turned much, and trigger is out of borders wave becomes unstable and distorted (Figure 3.2).

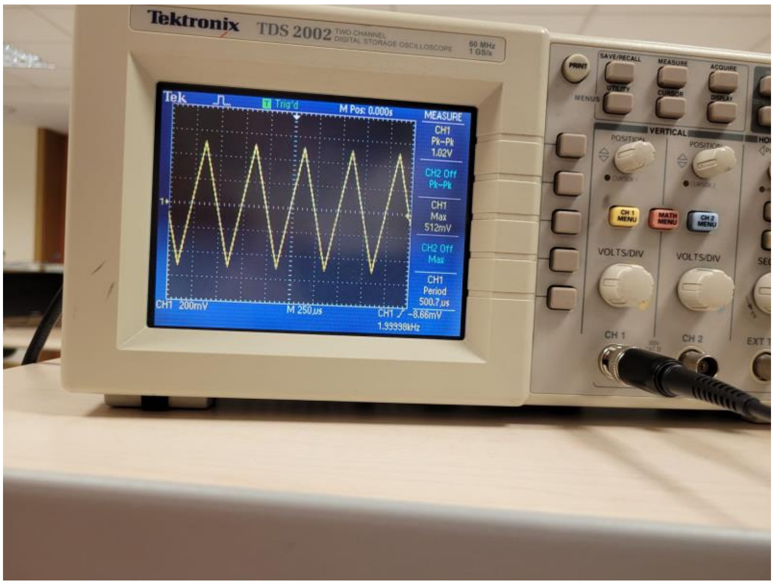

Figure 3.1

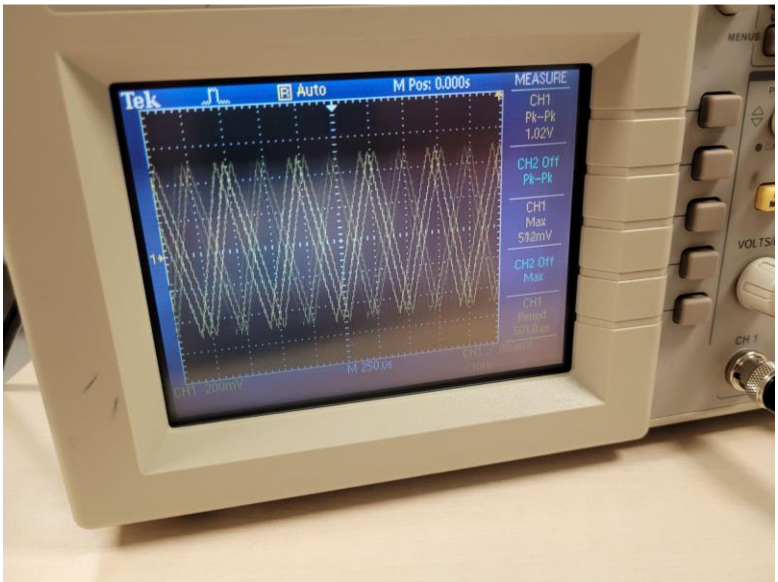

Figure 3.2

Step 4

Analog to digital converter (ADC) is a device which converts analog (physical) data into digital data. For instance, microphones use ADC to convert sound waves into digital signals and digital to analog (DAC) converter does the opposite. The oscilloscope that we have used uses ADC. It takes analog samples and converts them into digital samples. By using these samples oscilloscope creates an image of signal. We generate a 1Vpp square wave with the frequency of 5kHz. We changed the acquisition modes (sample, average, peak detect) and made a comparison. In the sample mode, the most basic type of acquisition, the oscilloscope automatically creates a wave by determining one sample point during each waveform interval. In peak detect mode oscilloscope chooses the highest and draws according to these points. Average mode averages the associated data points on a point-by-point basis using data from two or more collections. Average mode is useful when the signal is periodic, and the trigger is stable otherwise signal won't show proper data. Although the wave in average mode seems a bit proper since the signal is periodic, difference between these modes is barely noticeable since our signal is regular and we are seeing the wave minimized.

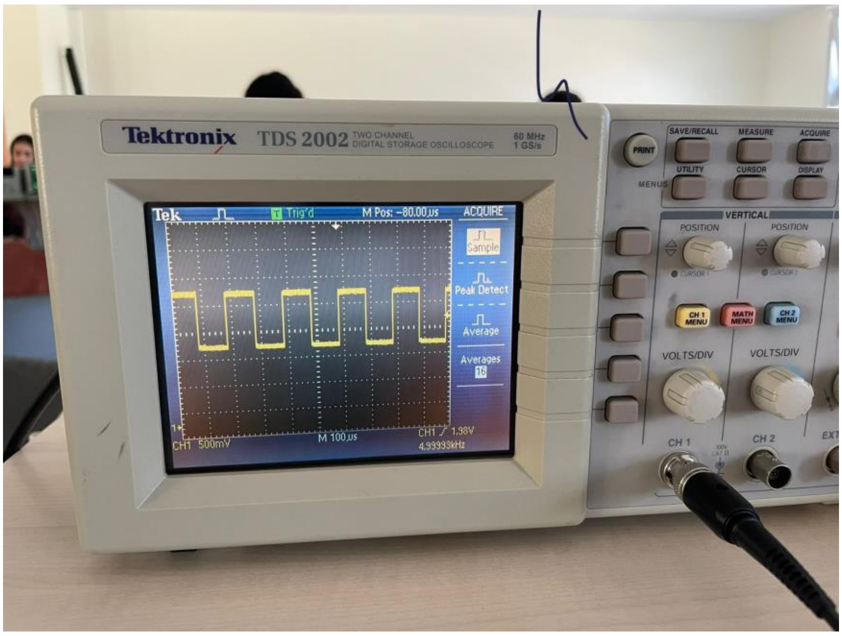

Figure 4.1

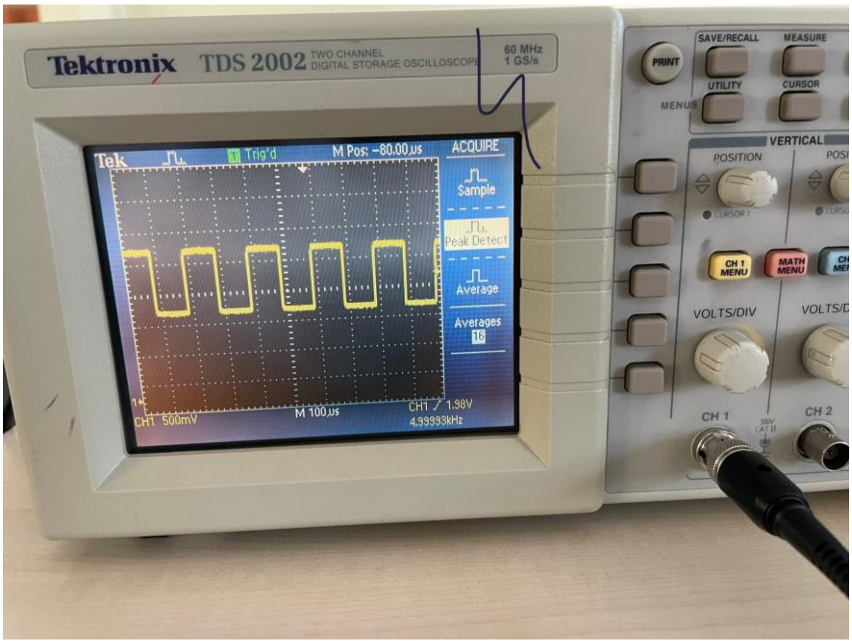

Figure 4.2

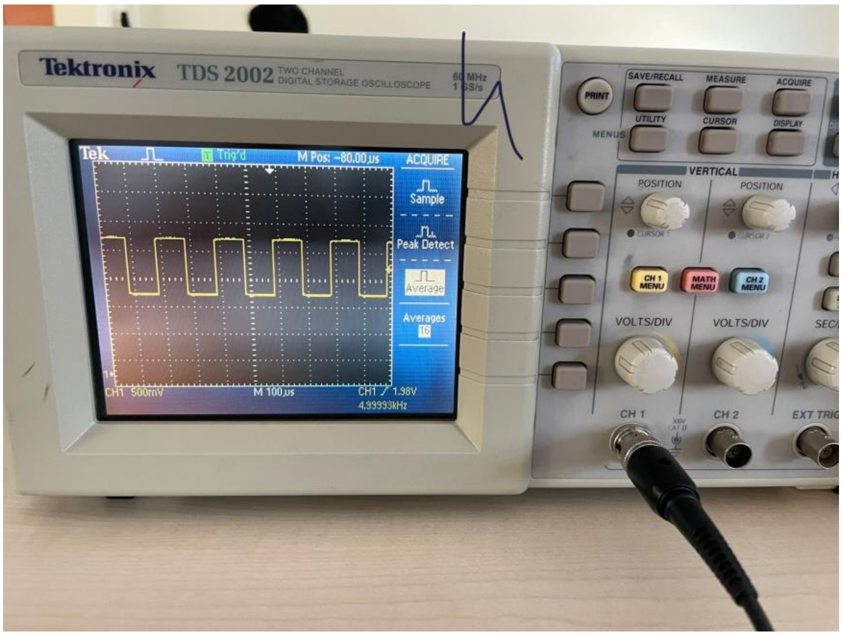

Figure 4.3

Step 5

In this step we generate a 2Vpp sinusoidal wave with frequency 1 kHz, but this time with a DC offset of 1V. At first, I used DC coupling (Figure5.1) and then AC coupling (Figure 5.2). I observed a difference in the position of the wave. When DC coupling is used the wave shifts 1 V up more than AC coupling. The reason behind this incident is that applying a DC offset adds a DC voltage to the input signal. It is useful when measuring small signals since it increases vertical resolution. However, AC coupling is not shifted up since this mode eliminates outer DC properties.

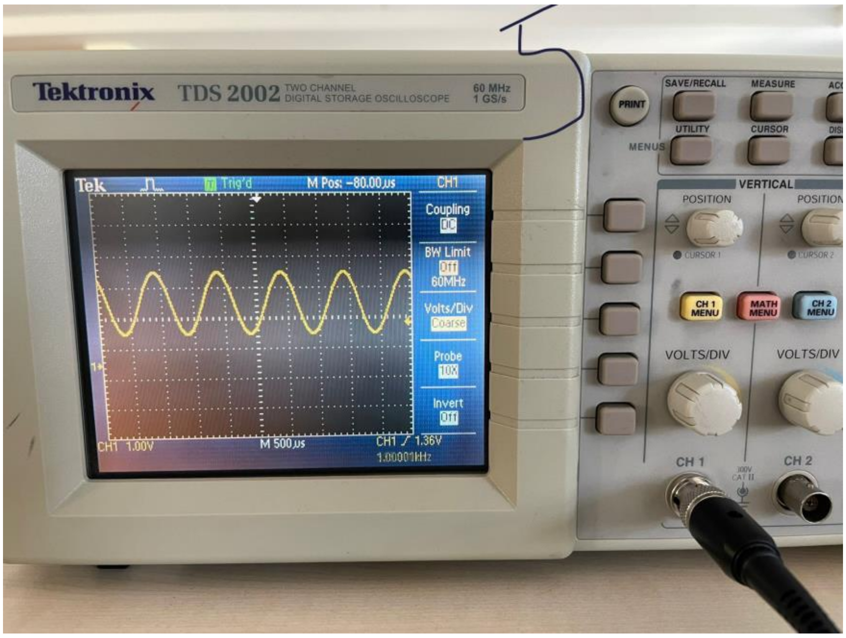

Figure 5.1

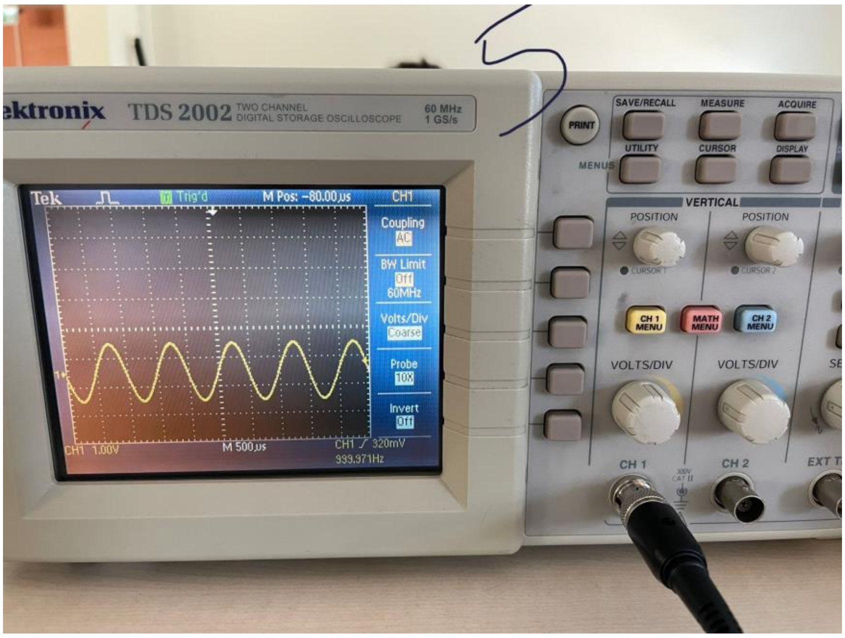

Figure 5.2

Step 6

A breadboard is utilized at this stage. A breadboard is a useful array that allows users to build circuits. In order to avoid accidents, it contains a grounding component. To create parallel and series circuits, the user may put male wires and components like capacitors and resistances into the holes on it. The connection of holes is shown in Figure 6.1

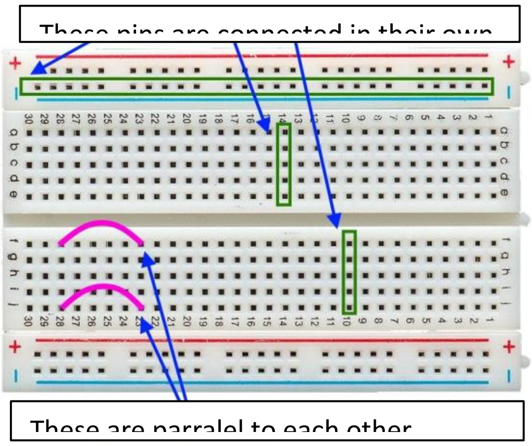

Figure 6.1

In the last part, circuit shown in the Figure 6.2 setted by using a capacitor with 1µF capacitance and a resistance with 1kΩ. Constructed circuit can be seen in Figure 6.3

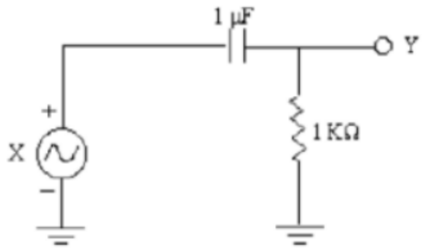

Figure 6.2

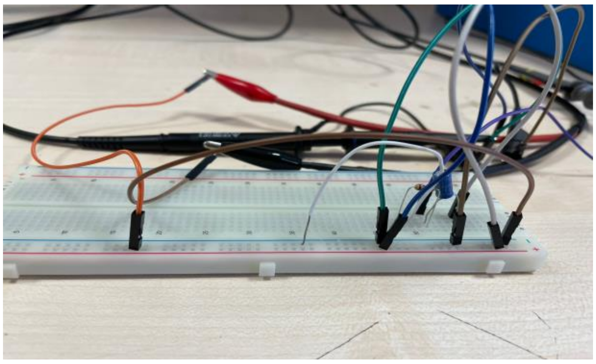

Figure 6.3

After constructing the circuit we can connect it to the signal generator. Since we need two oscilloscopes to measure signal X and signal Y we have worked with my friend to construct this part. Channel 1 in oscilloscope is used for X and channel 2 for Y. We tried to observe phase difference between two signals and how phase difference is affected by frequency. To see the difference, we tried to determine a peek point on both waves by arranging the cursors. After proper arrangements we have observed a small difference as it can be seen in Figure 6.4. Although the delay at 1 KHz is small (70µs) the delay at 100 KHz is even smaller. In Fact, the difference is barely visible when the waves are diminished on the screen (Figure 6.5). The reason behind is related to the period which is 1/f. When frequency is increased the period decreases proportionally. So the delay time is also divided by 100.

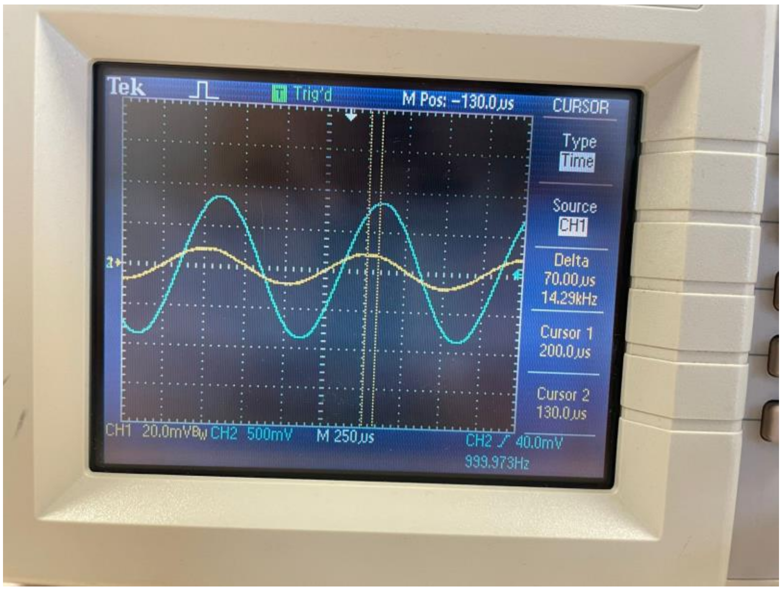

Figure 6.4

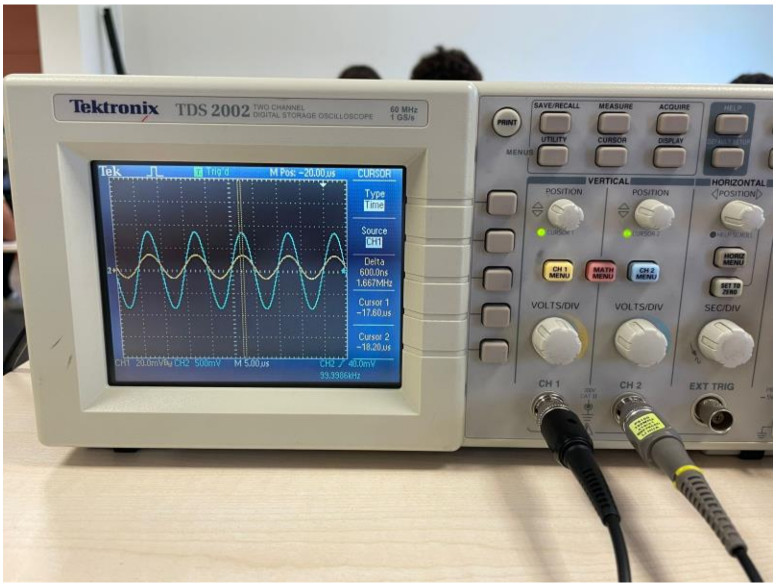

Figure 6.5

Conclusion

The aim of these experiments is to get used to complex lab machines like oscilloscopes, signal generators, and some basic circuit components such as breadboards, capacitors, and resistors. All of them are essential for this course and signal-related fields. The first step, which is about compensating the probe, is essential to get proper measurements. Adjusting the signal generator to emit a range of pulses at various frequencies and amplitudes, as well as how to attach it to an oscilloscope to track radiating signals, were discovered. Vital oscilloscope features include positive and negative edge triggering, employing triggers to keep the signal stable and acquisition modes to view waveforms from adding a DC offset, altering the peak-to-peak and average time intervals, and understanding the impacts of DC components, coupling to DC from AC was employed. A simple RC circuit was put up on a breadboard using an oscilloscope to view and compare the signals at different frequencies. Measure the delays at various circuit nodes. Each phase had mistakes, yet the percentage of mistakes was negligible. Possible error sources are listed below:

- There is a impedance difference between oscilloscope and signal generator this may affect the results since there can be mistakes during auto adjustments.
- Conductor of the experiment can make mistakes easily, especially in the last part since finding the phase difference requires manual adjustments.
- Probe’s tip can get loose in time and that may affect the outcomes
- Every component has ideal working conditions such as temperature, humidity, pressure. It is not possible to provide all of these ideal conditions

References

Figure 6.2: Moodle-EE102 Page. ‘Lab 1 Assignment’ . 25.09.2023 . https://moodle.bilkent.edu.tr/2023-2024-fall/pluginfile.php/56616/mod_resource/content/0/lab1.pdf.

Figure 1.4: Amazon. ‘Automotive Probe, HT307A Oscilloscope Acupuncture Probe Pins Tools Use for Diagnosis Test Repair’. 25.09.2023 . https://www.amazon.com/Automotive-HT307A-Oscilloscope-Acupuncture-Diagnosis/dp/B07RDQS882.