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EEE 102 Digital System Design - Lab 1 Report

1. Oscilloscope Probe Compensating

Aim:

This experiment allows us to see how an uncompensated probe behaves and helps us to compensate our probes correctly. This experiment also helps us get more accurate readings and measurements in the future.

Reasoning & Methods:

The compensation of the probe quickly calibrates the probe to the current oscilloscope. The compensation of the probe should be properly adjusted every time we use the probe. A poorly compensated probe may lead to mismeasurements or deformations in the signal's figure. Below are some photos featuring examples of over-compensated, under-compensated, or well-compensated probes. The compensation is adjusted by turning an adjustable capacitor in the probes. You can also see how the compensation is adjusted in the pictures.

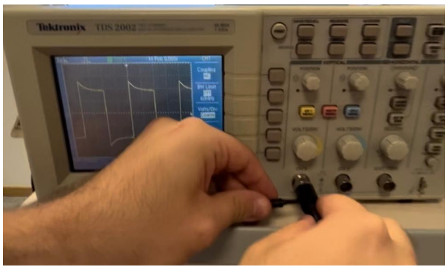

Figure 1.1: Over-Compensated Probe

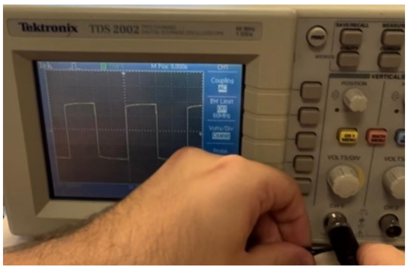

Figure 1.2: Under-Compensated Probe

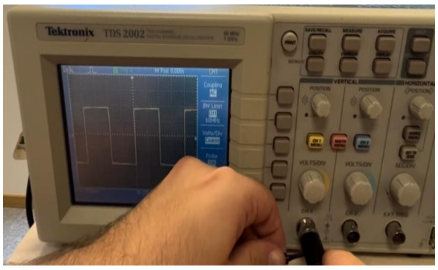

Figure 1.3: Well-Compensated Probe

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2. Negative and Positive Edge Triggering

Aim:

The aim of this experiment is to understand the difference between positive triggering and negative triggering.

Reasoning & Methods:

Changing the Trigger from positive to negative determines which side of the signal the oscilloscope will Trigger on. Signals have two sides a falling edge and a rising edge. The rising edge is the side of the wave that "rises" from the minimum voltage value to the maximum and the falling edge is the side that "falls" from the maximum voltage value to the minimum.

Note: Because of the properties of both oscilloscopes and signal generators also because oscilloscopes are required to be connected in parallel the voltage reading will be two times the desired value. This is a result of the inner workings of the signal generator. It assumes a resistance of 50Ω is connected and it assumes that it will act as a current divider circuit between two resistances. However, since the oscilloscope measures the direct voltage and is assumed to have infinite resistance the oscilloscope reads the direct value.

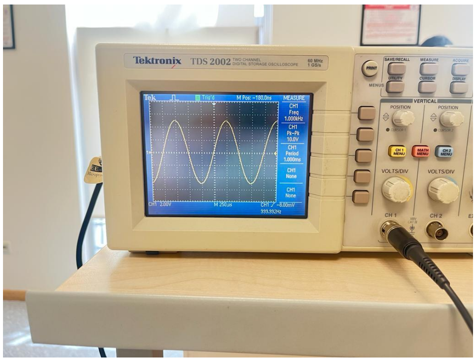

Figure 2.1: A Positively Triggered Sinusoidal Wave

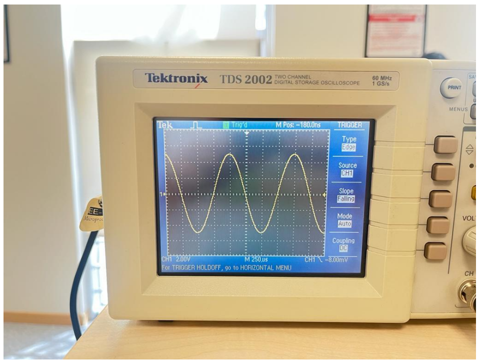

Figure 2.2: A Negatively Triggered Sinusoidal Wave

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3. Trigger Levels and Triggering

Aim:

The purpose of this experiment is to understand how triggering occurs what it actually is and how it behaves.

Reasoning & Methods:

Triggering determines when the wave starts being plotted on the screen. The wave starts being plotted from a point where the wave's voltage intersects with the voltage value determined by the triggering level. If we lower the triggering level the wave will start being projected at a lower voltage point. However, if the wave never reaches the voltage level determined by the trigger level triggering will not occur and our wave will not have a stable image.

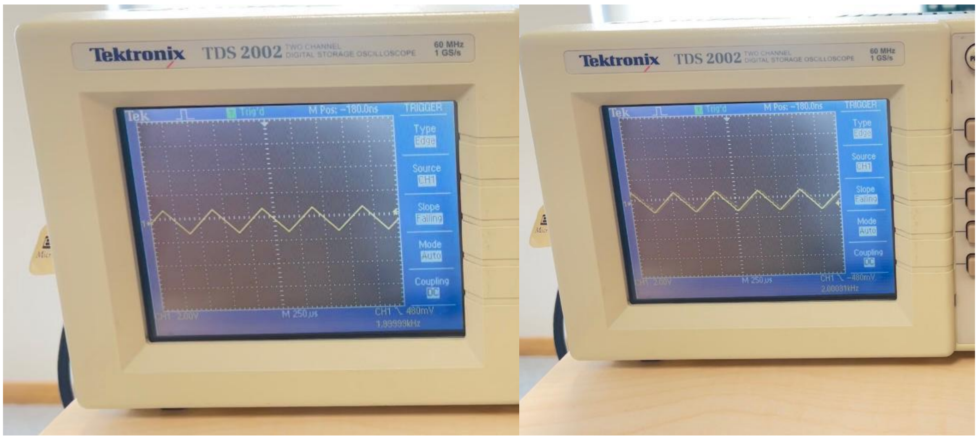

Figure 3.1: The trigger level is lower in the image on the right indicated by the little yellow arrow on the right side of the wave. The start point is taken as the y-axis in the middle of the screen. Since the triggering level is lowered the wave starts from a lower point.

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4. Digital and Analog Conversion and Different Acquisition Modes

Aim:

This experiment allows us to better understand the relationship between analog and digital data and how they interact with each other. This experiment also demonstrates the different settings of the oscilloscopes that can be used to acquire the wave signals and plot them accordingly.

Explanation of Digital and Analog Conversions:

The signal generator provides an AC signal that can have different voltages anywhere in its range. However digital devices can only function with 0 or 1 as a signal. Therefore, we need to convert the signal from analog to digital or from digital to analog. We have ADCs(Analog to digital) or DACs(digital to analog) to convert the signal accordingly. And since the oscilloscope has digital components it also has an ADC to convert the analog signal from the signal generator to binary data for the oscilloscope.

Explanations of Different Acquisition Modes:

Most oscilloscopes have three different acquisition modes.
1- Sample: This is for capturing the wave as it is without processing.
2-Peak Detection: This setting captures the peak voltage value at a given time. This setting is particularly useful when capturing high-frequency signals where the sampling rate may not be enough.

3- Average: This setting displays the average of the last “n” iterations of the signal where “n” can be selected by the user. The average setting is very useful when working with noisy or distorted signals.

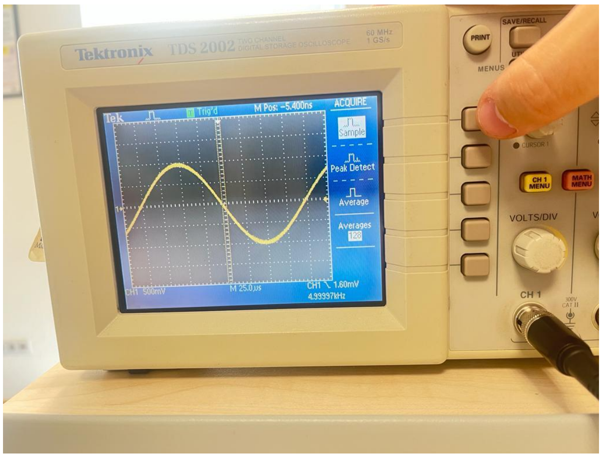

Figure 4.1: A sinusoidal wave on sample acquiring

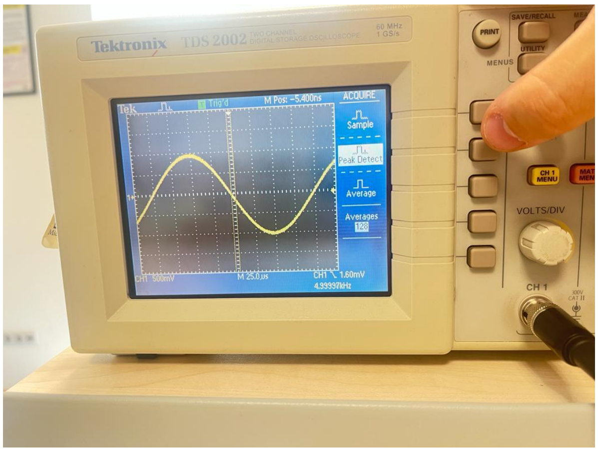

Figure 4.2: A sinusoidal wave on peak detection acquiring

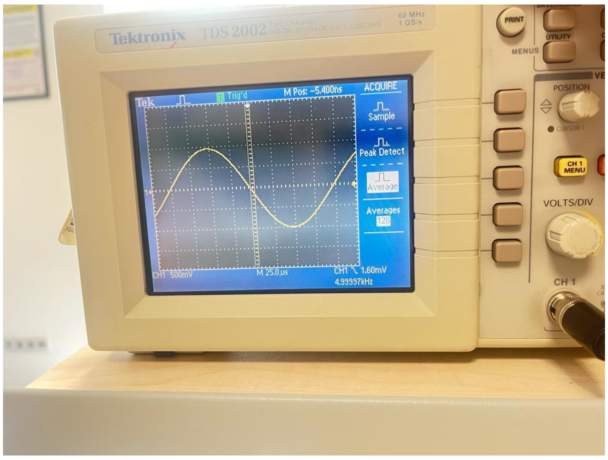

Figure 4.3: A sinusoidal wave on 128 average acquiring

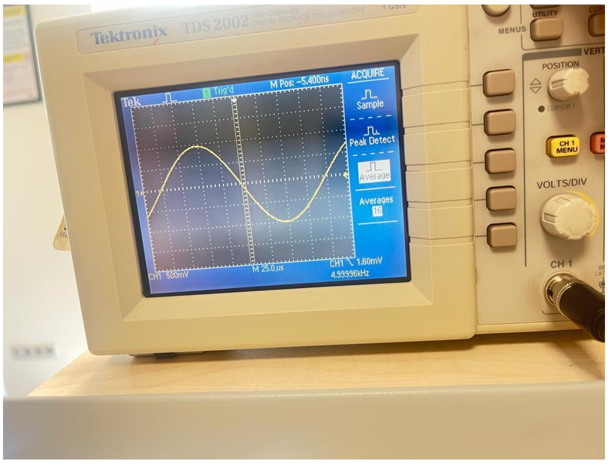

Figure 4.4: A sinusoidal wave on 16 average acquiring

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5. AC and DC Components of a Signal

Aim:

This experiment demonstrates how the AC and the DC components of a signal behave and how they can be properly measured.

Reasoning & Methods:

Since the AC component must be a sinusoidal expression it must always be centered around 0 volts. Therefore, if a signal is not centered around 0 but instead a non-zero number that must be the DC component of the signal. Selecting the DC coupling in the oscillator displays the voltage as it is. However, selecting the AC coupling in the oscillator only displays the AC component of the signal centered around 0 volts. The oscilloscope filters the DC component using a capacitor since DC cannot pass through a capacitor.

Note: The note in the 2. chapter also applies here. While the signal generator is set to 1Vp-p and 1V offset the oscilloscope picks up a 2Vp-p and 2V offset signal. If we wanted to set the oscilloscope to the desired values, simply entering half the desired values on the signal generator would be enough.

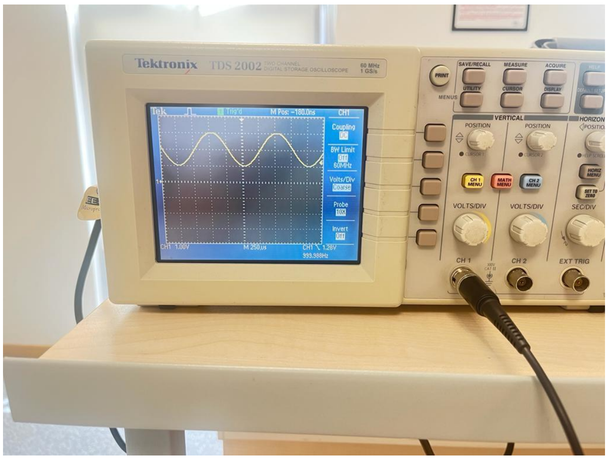

Figure 5.1: A sinusoidal wave with 2Vp-p and 2V offset under DC coupling

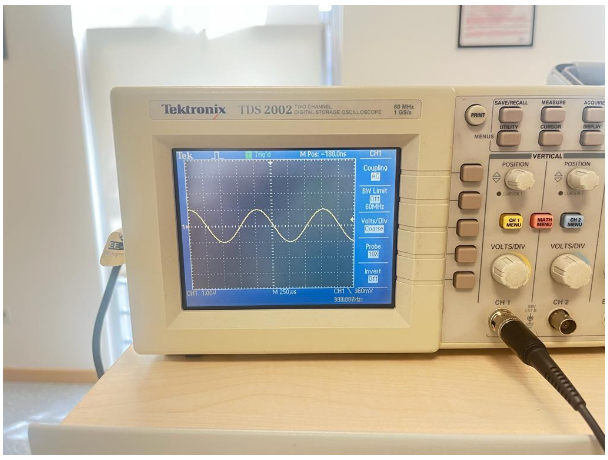

Figure 5.2: A sinusoidal wave with 2Vp-p and 2V offset under AC coupling

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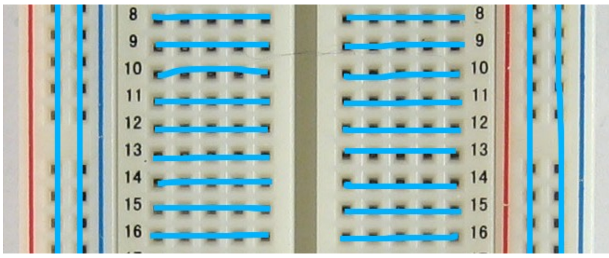
6. Breadboard Connections and Phase Differences in RC Circuits

Aim:

This experiment makes us more comfortable working with breadboards. Also, this experiment familiarises us with the cursor and measure functions of oscilloscopes.

Breadboard Inner Workings:

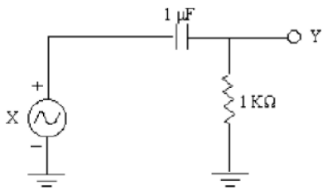
A breadboard acts as an easy way of connecting different circuit components without soldering them and making them reusable and reconfigurable.



the wirings of the breadboard are as they are shown in the image. Conventionally, the + lane is connected to the positive terminal and vice versa. The potential difference along the blue lines is 0. Therefore making everything along them connected.

Figure 6.1.1: Breadboard Connections.
Date of Access: 25/9/2023
https://os.mbed.com/handbook/Breadboard.

Reasoning & Methods Regarding Phase Difference and Calculations:



The circuit on the image provided on the right is an AC RC circuit. Therefore, it is expected to have some amount of phase difference between the voltage of the resistor(Y) and the voltage of the signal generator(X).

Figure 6.2.1: Circuit Schematic

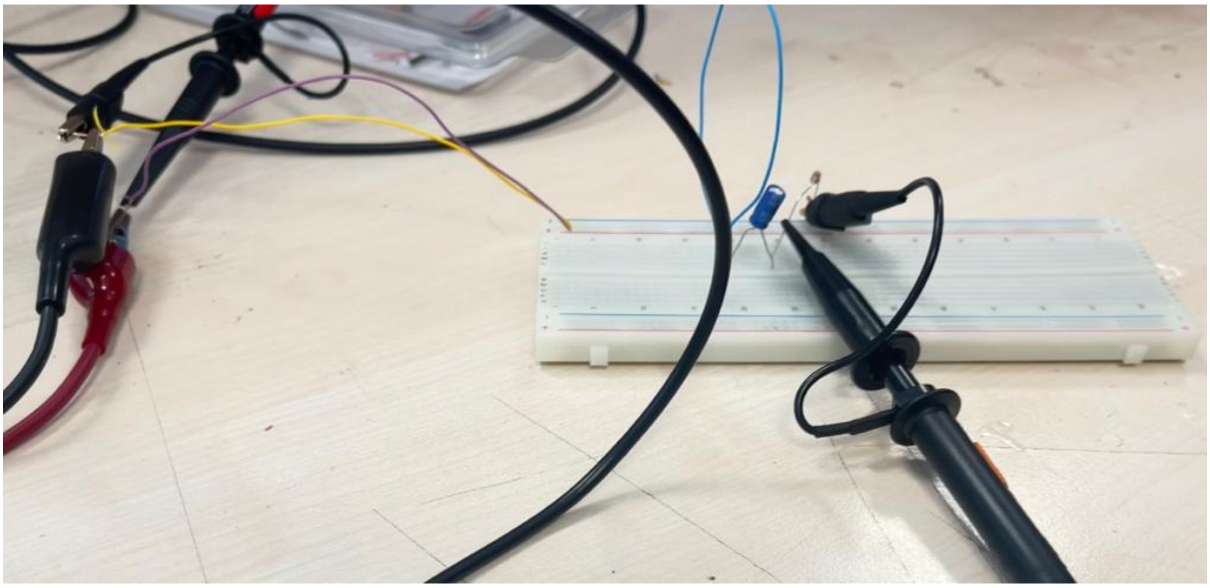
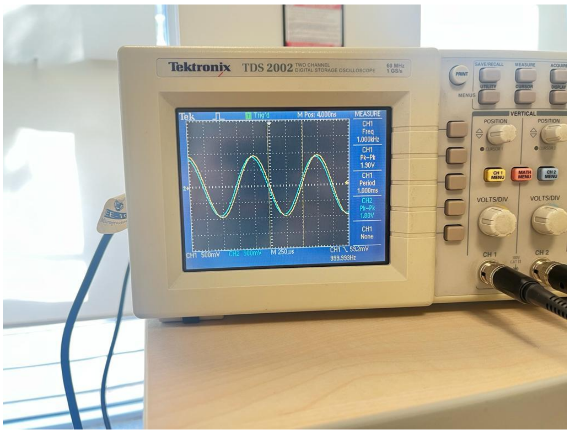


Figure 6.2.2: The physical equivalent to the circuit in Figure 6.2.1



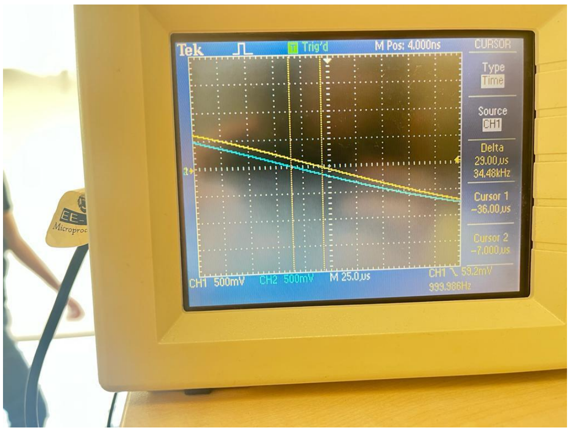


Figure 6.2.3: The graphs of X(yellow) and Y(blue) under 1kHz

Figure 6.2.4: The delay between X(yellow) and Y(blue) under 1kHz

The period under 1kHz can be seen in Figure 6.2.3 as 1 ms and the time delay between the two waves can be seen in Figure 6.2.4 as 29 μs. Using both of those magnitudes we can calculate the phase difference in radians.

The mathematical operation “(29 μs / 1 ms) 2π” gives the phase difference “φ” as 0.18221... radians or 10.44° which is similar to the theoretical value that is calculated to be 0.157... radians using phasor diagrams.

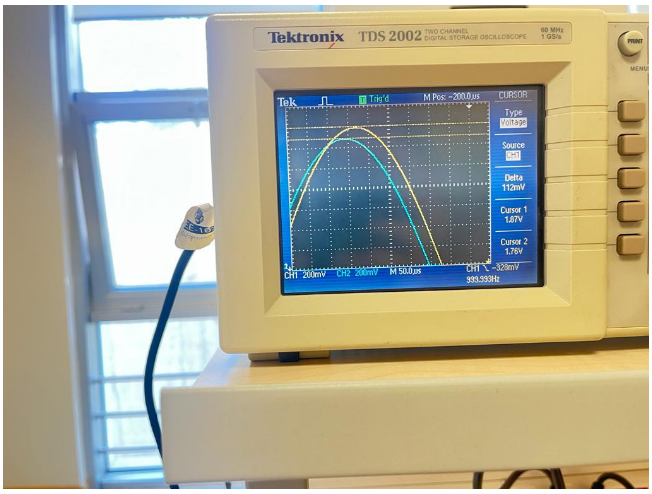


Figure 6.2.5: The voltage difference between X(yellow) and Y(blue) under 1kHz

Since X measures the voltage of the whole circuit, it measures the voltage of the current passing through both ohmic resistance and capacitive reactance therefore recording a higher voltage value. However, Y only measures the ohmic resistor’s voltage so it is expected to be lower than X.

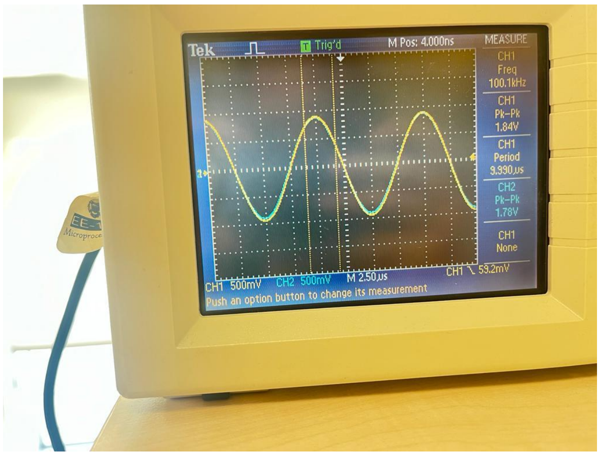


Figure 6.2.6: The graphs of X(yellow) and Y(blue) under 100kHz

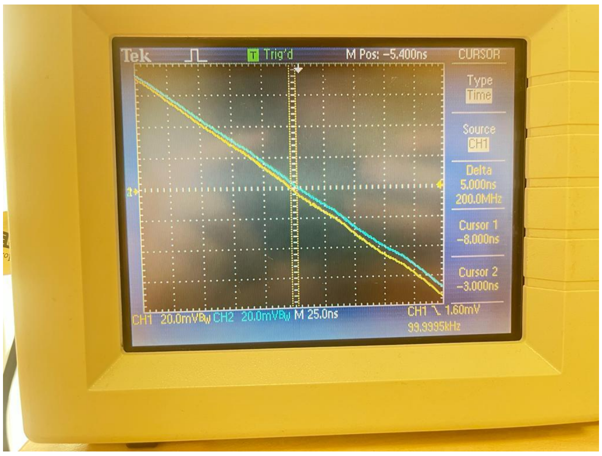
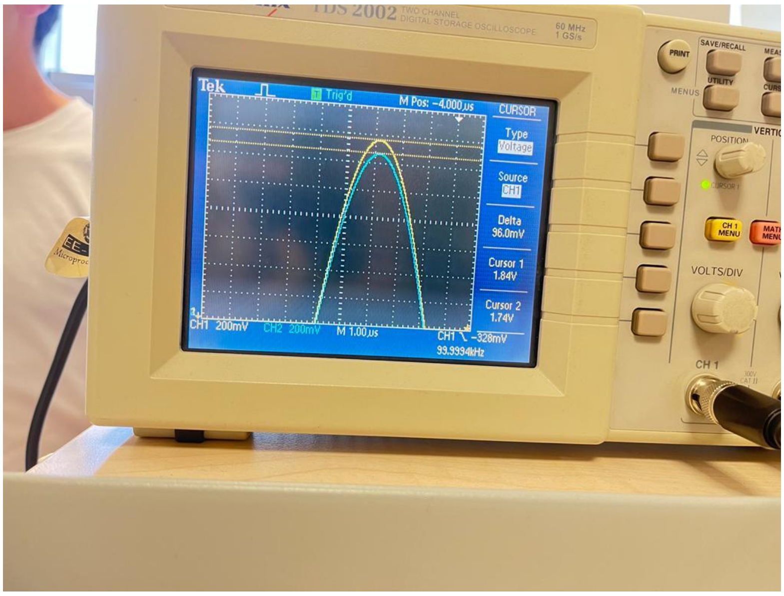


Figure 6.2.7: The delay between X(yellow) and Y(blue) under 100kHz

We will again apply the same mathematical formula we applied while calculating phase difference under 1kHz. The period is 9.99 μs and the delay is 5 ns. Under very high frequencies the resistance of the capacitor is nearly 0 because the capacitive reactance is inversely correlated with frequency. Therefore, both the phase difference and the voltage difference is very small.

The mathematical operation "(5 ns/ 9.99 μs) 2π" gives the phase difference "φ" as 0.003141... radians or 0.18° which is again similar to the theoretical value that is calculated to be 0.000159... radians using phasor diagrams.



The voltage difference can be seen in Figure 6.2.8 as 96mV. The reason for this difference is the same as the reason for the voltage difference in Figure 6.2.5.

Figure 6.2.8: The voltage difference between X(yellow) and Y(blue) under 100kHz