Report: Introduction to Digital Oscilloscopes

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EE102-01 Lab 1

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Purpose:

The intent of this lab was to study the essentials of the digital oscilloscope and the function generator. Additionally, to get acquainted with basic circuits and design them using breadboard and jumpers.

Methodology:

This lab work primarily practiced the digital oscilloscope and the function generator. Task 1 required the compensation of the probes with a Phillips screwdriver. In Task 2, a 5V peak-to-peak 1kHz sinusoidal signal was generated from the function generator, and altered edge trigger slopes of the signal were observed. Task 3 was expected to generate a 1V peak-to-peak 2kHz triangular wave and to experiment with the trigger knob. In Task 4, a 1V 5kHz square wave was investigated with various acquisition modes. For Task 5, a 1V DC offset has been added to a 2V peak-to-peak 1kHz sinusoidal wave, and have been observed the following effects with DC and AC coupling modes. The last task was to construct an RC circuit with a 1k resistor and 1F capacitor on a breadboard and then apply a 2V peak-to-peak 1kHz voltage as input in order to observe the voltage signal from 2 different points as Point X and Point Y.

Results & Lab Work:

Task 1:

Probe compensation can be described as atoning the capacitance between the digital oscilloscope in exchange for settling its electrical properties. By adjusting the screw on the probe calibration process may be completed. The proper calibration can be seen in Figure 1.

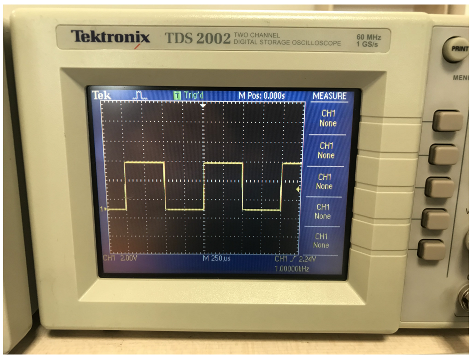
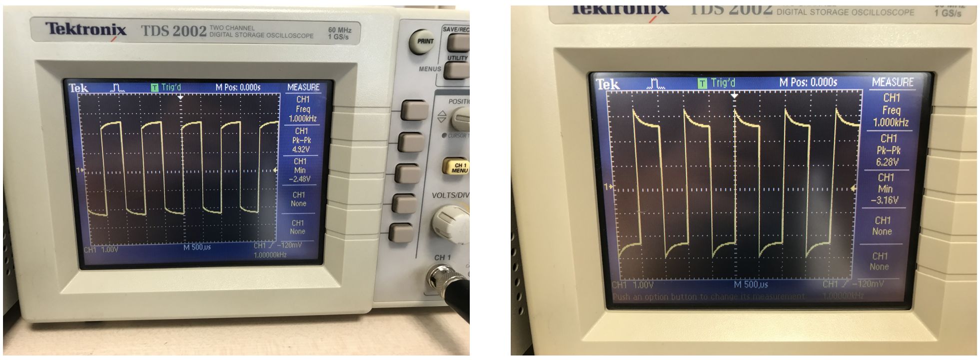


Figure 1: Compensated probe.

In the case where the compensation has not been properly corrected, the measurements would not yield accurate data. There are two possible outcomes if the calibration is not well-adjusted: under-compensation (Figure 1a) or (Figure 1b) over-compensation.



(a) Under-compensated probe.

(b) Under-compensated probe.

Figure 1: Error in compensation.

Task 2:

Task 2 required applying a 5V peak-to-peak sinusoidal signal with a frequency of 1kHz without including a DC component. Measurements of the digital oscilloscope screen can be found in Figure 2a.

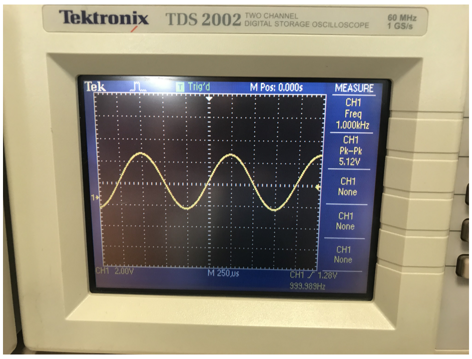
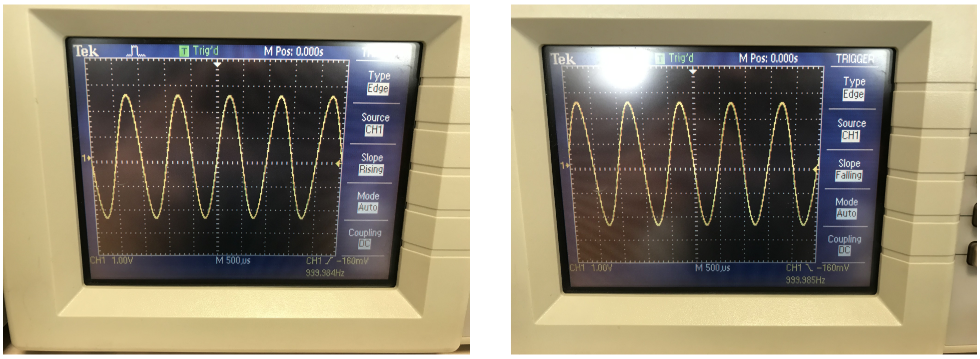


Figure 2: A 5 Vpp sinusoidal signal with frequency 1 kHz.

Then the triggering option was modified in order to exhibit the input signal with various images. To do the described operation triggering slope has been changed between “Rising” (positive) and “Falling” (negative). When the mode is selected chosen as “Rising” (Figure 2a), the positive slope of the signal coincides with the origin point. When the mode is selected “Falling” (Figure 2b), the coinciding part has a non-positive slope.



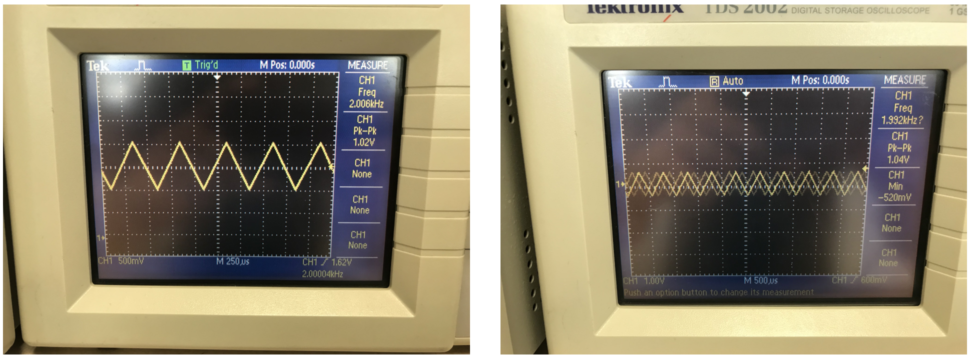
(a) Rising edge.

(b) Falling edge.

Figure 2: Trigger edges.

Task 3:

A 1V peak-to-peak triangular wave with 2kHz frequency is applied to the digital oscilloscope. When the trigger knob is turned, the digital oscilloscope is changed according to the turning direction of the coinciding point of the signal to the origin. As long as the threshold of the trigger is inside the range of the signal amplitude, a stable image can be seen (Figure 3a). Otherwise, the signal observed on the digital oscilloscope is no longer steady (Figure 3b). Therefore, the concept of triggering can be condensed as registering a signal according to designated criteria. The trigger captures the echoing waveform and makes it show fixed on the digital oscilloscope.



(a) In the range. (b) Out of range.

Figure 3: Trigger knobs effect.

Task 4:

A 1V peak-to-peak square wave with 5kHz frequency has been generated via the function generator. The difference between various acquisition modes, such as sample, peak detect, and average, has been examined through the digital oscilloscope.

The *"Sample"* mode (Figure 4a) is the most frequently used mode between other options. The analog-to-digital (ADC) converter samples the signal, then the signal is converted into the desired format of points to plot the waveform.

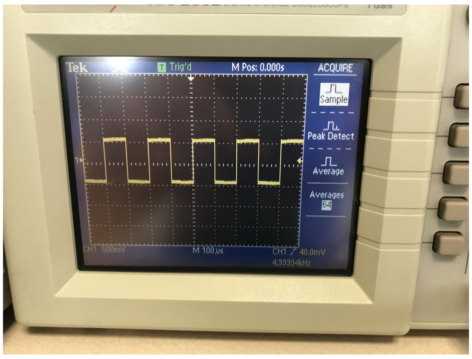


Figure 4: Sample mode.

The *"Peak-Detect"*(Figure 4b) mode collects the maximum and minimum values of every sample to project the waveform. It does this process by collecting entire values between two values.

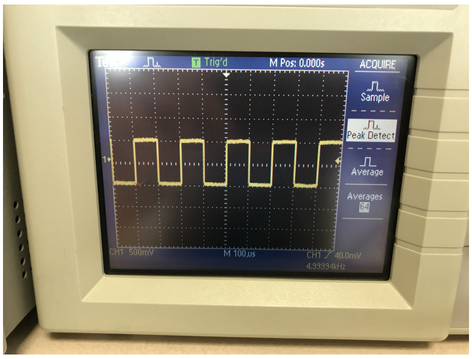


Figure 4: Peak-Detect mode.

The *"Average"* (Figure 4c) mode collects two (or power of two) input data to average the provided data, point by point. Due to this practice, this mode enables the elimination of irrelevant noise.

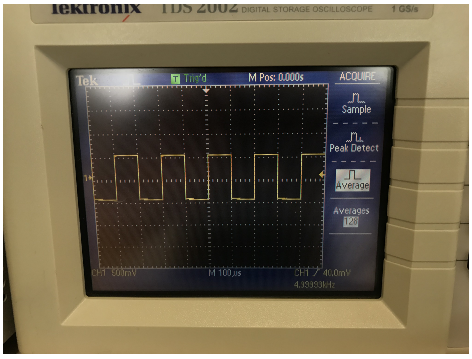


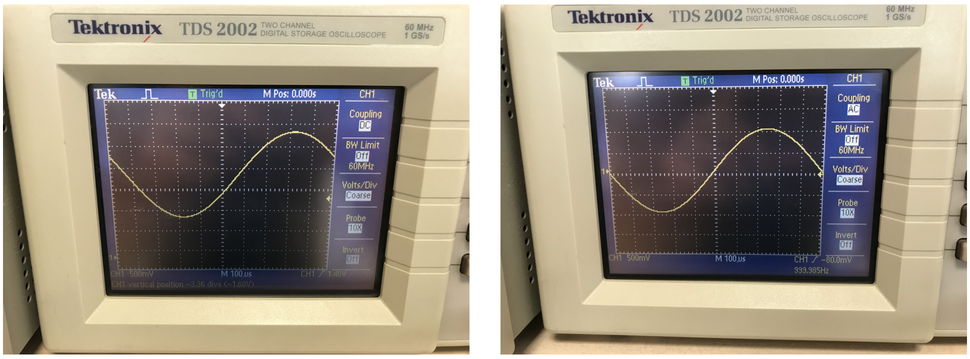
Figure 4: Average mode.

- *Digital-to-Analog Converter (DAC)* converts digitally equipped input samples into an analog signal. As an example, microphones benefit from DAC to turn the digital stream into an analog signal.

- *Analog-to-Digital Converter (ADC)* turns an analog-given input into a digitally converted signal. A traditional oscilloscope evaluates the circuit by gathering digital samples from the circuit and adapting the info into an analog signal to project to the screen.

Task 5:

A sinusoidal signal with 2V peak-to-peak amplitude and 1kHz frequency has been generated. In addition, a 1V DC offset to the signal wave has been added by the function generator. If the signal is examined with DC coupling, it can be seen that the signal is shifted 1V up from the horizontal axis (Figure 5a). In the case that AC coupling was to be selected, it cannot be observed that the offset of the input signal where is caused by DC (Figure 5b).



(a) DC coupling mode. (b) AC coupling mode.

Figure 5: Coupling modes.

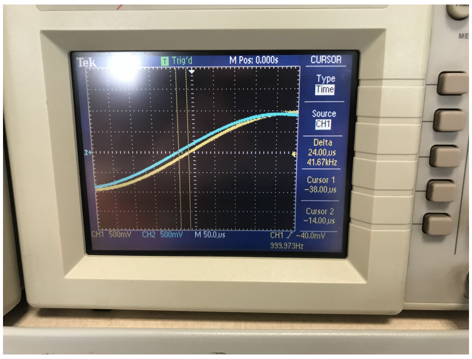
Task 6:

A breadboard can be described as an array of connected conducting metal plates. The breadboards are made of metal plates that allow users to connect wires. A conventional breadboard has two long columns, which are described as voltage and ground lines on the right and left sides of the board. The ground line and voltage line are linked over each column. In the middle, there are lines where each is connected row vise, and there is not any connection between each row of line.

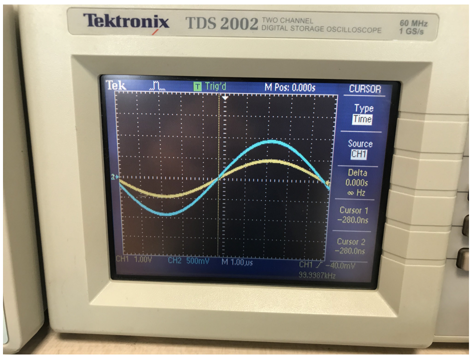
A sinusoidal signal with 2V peak-to-peak, 1kHz with zero DC offset is generated and attached to the circuit. The input signal from 2 points has been analyzed to find the time and voltage difference. At point X, 1.97V and 999.0Hz were measured, and at point Y, 2.01V and 1001.0Hz were measured. The error may have been a result of the precision and accuracy issues of the oscilloscope. As a result of constructing an RC circuit, phase shift was expected between points X and Y. There was a $24\mu s$ time difference between the two points (Figure 6a). By reason of one period corresponds to 2π, the difference among phases can be calculated as $48\pi \times 10^{-9}$. After increasing the frequency to 100kHz, point X measured 1.95V and 99.7kHz, point Y measured 1.98V and 100kHz (Figure 6b). Thus there was not any phase difference. The phase shift formula can be written as follows.

$$\Delta\phi = \frac{2\pi \times \Delta t}{T} \tag{1}$$

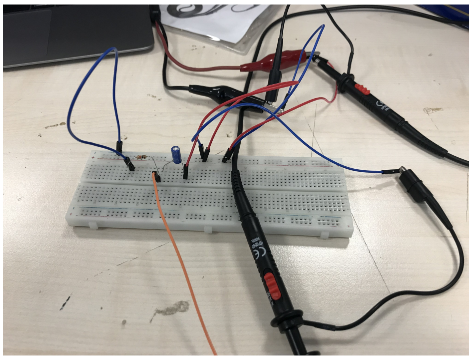
The frequency change has affected the phase difference since the frequency exists in the AC voltage formula, $V = V_0 sin(\omega t)$, $\omega = 2\pi f$, and the period is $f = \frac{1}{T}$, as a result, increase in frequency decreases the period and the phase difference decreases as a consequence.



(a) Phase shift, 1kHz is applied.



(b) Phase shift, 100kHz is applied.



(c) Circuit itself.

Figure 6: Basic circuit task.

Conclusion:

The ambition of the experiments was to get acquainted with the generally used functionalities of a digital oscilloscope and the function generator. The outcomes of the experiment were mostly consistent with the anticipated results. Even though there were foreseeable errors in the yielded results. Errors may have been a product of a function generator and oscilloscope. Additionally, the oscilloscope probe could also have added to the error.

References:

- http://www.cromptonusa.com/oscilloscope.pdf
- https://github.com/CankutBoraTuncer/Bilkent-EEE102-Labs