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Lab 1: Introduction to Digital Oscilloscopes

The purpose of this lab is to get yourself used to the lab equipment.

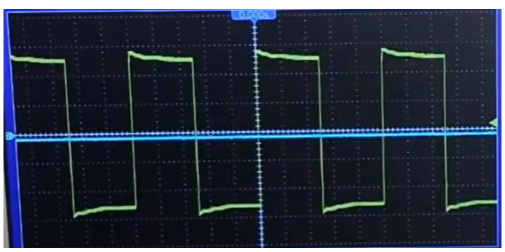
Read the document *Digital Oscilloscope Principles* on Moodle before the Lab.

Lab Work:

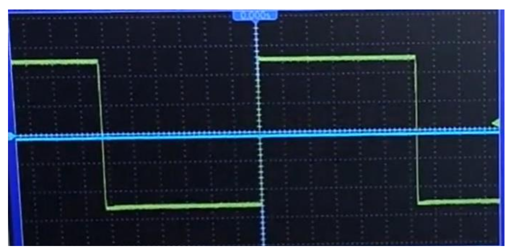
In the lab, please do each task in order. At each step take photographs of your results to put them in your reports. After each step, you need to get the approval of your TA, so do not move on if you will lose the results until your TA sees them.

1. **Use the compensation signal of the oscilloscope and compensate your probes as explained in the above-mentioned document. Explain in your report (with photos) how you compensated your probes. (Make sure that you use your probe with appropriate attenuation factor).**

Before



After



While Compensating:

2. **Using a signal generator, apply a 5 Vpp (peak-to-peak) sinusoidal signal with frequency 1 kHz (Note that this signal should not have a DC component). Use the oscilloscope to monitor this signal. First, use positive edge triggering and report (with photos) what you see on the screen. Then, apply negative edge triggering and report the result.**

   For positive edge, the wave starts from above the x axis. For negative edge, the wave starts from below the x axis. This is the only difference that i could observe.

   To have a DC free signal, I had to set 0V to DC offset:

Postive-Rising Edge:

Negative-Falling Edge:

3. **Apply a 1 Vpp triangular wave with 2 kHz frequency to the oscilloscope. Observe and report the effect of turning the trigger knob on the oscilloscope. Comment in your report on what the triggering concept is.**

Knob is off:

Knob is on:

When the probe is off, there are many moving lines and it's hard to catch every of them. This means there is no triggering. However, when i turn on the probe, I can observe fixed triangular waves and this means that there is a triggering.

Triggering is the process of controlling when the oscilloscope starts capturing a signal. It's like setting a gate that only opens when a specific condition is met, allowing you to see a specific portion of the signal instead of the entire continuous waveform. This is important to analyze and understand the signal's behavior.

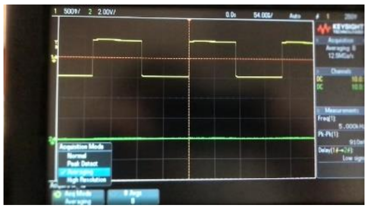
4. **What is digital to analog converter (DAC)? What is an analog to digital converter (ADC)? What are they used for? Which one is used in oscilloscopes and how? Answer in your report. Apply a 1 Vpp square wave with 5 kHz frequency to the oscilloscope. Then try all the acquisition modes (sample, peak detect, average) and report (with photos) your observations.**

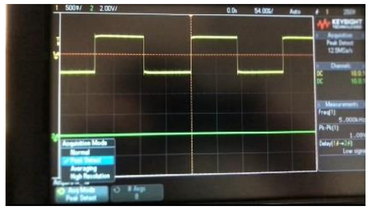
DAC (Digital-to-Analog Converter):
Transforms digital information (0s and 1s) into smooth, continuous analog signals (like sound or voltage). It's like connecting dots on paper (digital) to create a smooth picture (analog). It is used for creating sound from music files, robot control signals, smooth voltage outputs.
ADC (Analog-to-Digital Converter):
Converts continuous analog signals into digital data (series of points). It converts a smooth curve on a graph (analog) into individual points (digital). It is used for digitizing sensor data (temperature, pressure), capturing audio/video, converting microphone signals.

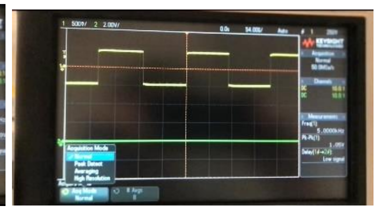
In Oscilloscopes: Analog to digital convertor is being used.

- **ADC:** Converts incoming analog signal (f.i, from the circuit including resistor and capacitor, question 6) into digital data for processing.

Average Mode: Peak Detect: Normal:







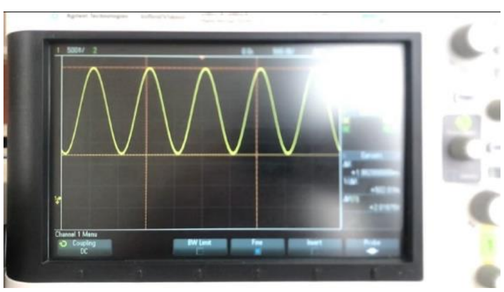
I think there is a slight difference between three of them, but here is much detailed explanation:

- Sample mode: "staircase" steps representing the discrete samples.
- Peak detect mode: The waveform might appear thicker, highlighting the peaks and valleys.
- Average mode: The waveform is smoother and noiseless.

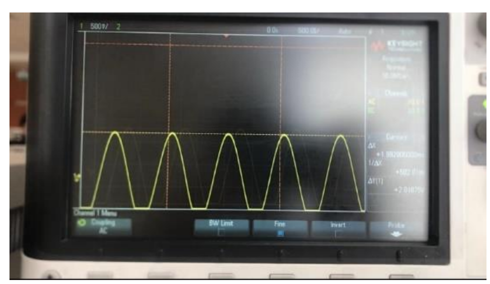
5. **Question: Generate a sinusoidal signal with 2 Vpp amplitude and 1 kHz frequency. Also apply a DC offset of 1 V. First, use DC coupling on the oscilloscope and report (with photos) what you see. Then use AC coupling and report the result. Comment on the difference.**

   Answer: When the oscilloscope was set to AC coupling, waves were between +1V and -1V, this means that we couldnot see the effect of DC offset, it's eliminating. However, when we are in DC copuling, waves were oscillating +1V and +3V. The point is, peak to peak voltage is still 2V.

   DC coupling: **AC coupling:**



DC coupling, waves are between +1V and +3V

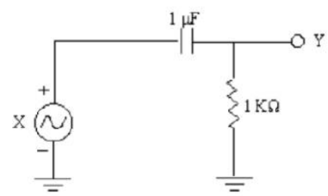


AC coupling, waves are between -1V and +1V

It can be clearly seen that when we switch DC coupling to AC coupling, wave moved down.

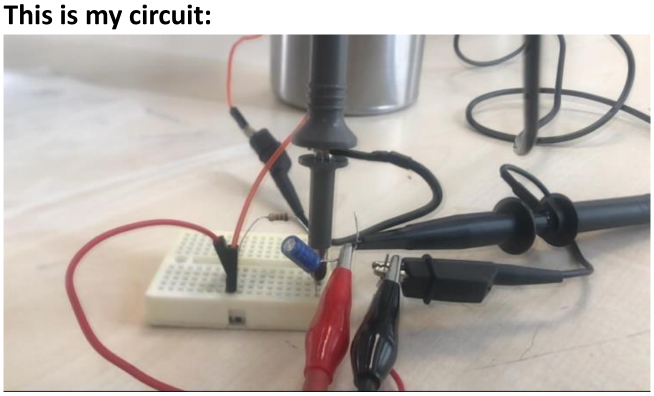
6. **Question: Check how a breadboard works. Very briefly explain it in your report. Set up the following circuit on your breadboard. Do not forget to connect the grounds. It is common practice to use the long blue lines on your breadboard for ground and red lines for voltage sources as they connect to most other components. Notice that on some breadboards, these lines may be disconnected at the middle of the board.**

   Answer: A breadboard acts like a temporary workbench for electronic circuits. Instead of soldering, you insert components like LEDs and resistors into its springy holes, which connect them electrically based on specific patterns. Power rails run along the sides, and jumper wires bridge connections across rows or columns, letting you easily build and test your circuit before making it permanent.



Question: Apply a 2 Vpp 1 kHz sinusoidal signal (with 0 DC offset) as the X signal. Borrow a friend's probe and display both X and Y signals on the oscilloscope. Make sure you connect the grounds of both channels to the common ground; oscilloscopes measure voltage *differences*. Use channel 1 for X and channel 2 for Y. You should be using channel 1 as the trigger source. Learn how to measure time and voltage differences on an oscilloscope. Measure the delay between signals X and Y. Calculate the phase difference (note that a full period corresponds to a phase of 2π). Then, change the frequency to 100 kHz and repeat. Report (with photos) the results. Try to comment on the difference between different frequencies.

This is my circuit:



Answer:
There is a clear difference between 1kHz and 100kHz version of the circuit.

For 1kHz, delay (in seconds) is 19.16 x 10^{-6}
For 100kHz, delay (in seconds) is 39 x 10^{-9}

Delay times more or less explains 1kHz frequency and 100kHz frequency difference.

Phase Difference (θ) = (2 **π** * Δt) / T

For the 1 kHz:
Phase difference:
6.90°

For the 100kHz:
Phase difference:
1.40°