Bilkent University
EE102-02 Lab 1 Report:
Introduction to Digital Oscilloscopes

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Purpose:

This lab's goal is to explore and comprehend the fundamental capabilities of a digital oscilloscope and a signal generator. By utilizing breadboards and basic circuit components, we also practice building simple circuits.

Methodology:

For Task 1, we set up and compensated the probes with an adjusting rod. In Task 2, we generated 5V Pk-Pk 1kHz sinusoidal signal and observed the different edge triggering of the signal. In Task 3, we generated 1V Pk-Pk 2kHz triangular signal and we changed the settings of the trigger knob. In Task 4, we created a 1V 5kHz square signal and observed different acquisition modes. In Task 5, a 1V we generated a 2V Pk-Pk 1kHz sinusoidal signal and added 1V offset, and observed the effects of AC and DC coupling modes. For Task 6, we set up an RC circuit with a 1μF capacitor and 1kΩ resistor on a breadboard. After applying a 2V Pk-Pk 1kHz voltage as input, we observed the voltage signal from Point X and Point Y.

Results:

Task 1: Set up and compensate the Probes

We compensated probes by turning the screw on the probe with an adjusting rod (Figure 1.1). If the compensation is not appropriately adjusted, there are 2 possible displays: under-compensation (Figure 1.3) and over-compensation (Figure 1.2) and these cause erroneous measurements.

Task 2: Observing the Trigger Function of the Oscilloscope

We apply a 5 V peak-to-peak sinusoidal signal with a frequency of 1kHz. The display can be seen in Figure 2.1. Then we changed the triggering slope between “Rising” and “Falling”. When the option is “Falling”, the signal passes from the origin with a negative slope (Figure 2.2). When the option is chosen as “Rising”, the signal passes from the origin with a positive slope (Figure 2.3).

Task 3: Altering the Trigger Knob

We apply a 1V peak-to-peak triangular signal with a frequency of 2kHz. A stable form is seen when the trigger threshold is within the signal's amplitude range (Figure 3.1). The oscilloscope signal becomes unstable and begins to vary if the trigger point is outside the range of the amplitude (Figure 3.2). Thus, triggering is just the act of capturing a signal in accordance with the guidelines we offer. Repeating waveforms are captured by the trigger, which makes them appear static on an oscilloscope.

Task 4: Converter Types (DAC & ADC) and Acquisition Modes

Digital-to-Analog Converter (DAC) turns digital input samples into an analog signal. Analog-to-Digital Converter (ADC) converts an analog input into a digital signal. Digital to Analog Converters (DAC) and Analog to Digital Converters (ADC) are crucial parts of electronic equipment. Since the majority of signals in the actual world are analog, these two conversion interfaces are required to let digital electronic devices process analog signals. Oscilloscopes use DAC. We generated a 1peak-to-peak square signal with 5kHz frequency (Figure 4.1) The “Sample” mode (Figure 4.2), The “Peak-Detect” (Figure 4.3) mode, and The “Average” (Figure 4.4) mode are the acquisition modes of oscilloscopes.

Task 5: Adding Offset to the Signal

We generated a sinusoidal signal with 2V peak-to-peak amplitude and 1kHz frequency (Figure 5.1). From the function generator, we added a 1V DC offset to the signal wave. The signal is moved 1V upward from the horizontal axis when the signal is studied with DC coupling (Figure 5.2). while choosing AC coupling (Figure 5.3), the signal is back to its original state. Both the AC and DC components of the input signal are present in the DC coupling mode, but the AC coupling cancels the DC component of the wave, therefore the offset is not depicted on the displayed graph.

Task 6: Breadboard and Circuit Analysis

A breadboard can be thought of as a collection of linked circuit lines. On the breadboard, the female input pins are made of spring-loaded metal plates that attach to the male pin. Voltage and ground lines, which are the female pins on the board's left and right sides, are conventionally represented as red and blue lines, respectively. Each column has attached voltage and ground connections. There is no connection between any of the center rows of lines, which are joined row by row. We create a 2V peak-to-peak 1kHz sinusoidal signal X to the constructed circuit (Figure 6.1). The input signal was measured at X and Y, and the time and voltage differences were examined. The variation in voltage and frequency was very negligible. (Figure 6.2). Point X measured 1.96V and 999.0Hz, Point Y measured 1.96V and 999.0Hz. The oscilloscope's lack of accuracy or precision may be at fault for the error. We built an RC circuit, therefore a phase difference between X and Y was predicted. There was a 44μs time difference between the 2 points (Figure 6.3). Since 1 period corresponds to 2π, the phase difference is calculated as 88π *10^-9. When the frequency is increased to 100kHz, Point X measured 1.96V and 100.5kHz, Point Y measured 2.00V and 100.5kHz (Figure 6.4). There was a 20ns time difference and thus phase difference was 40π * 10^-12. Since the voltage amplitude is unaffected by frequency, there was no difference between the results when frequencies were 1kHz and 100kHz. However, the frequency had an impact on the phase and time differential. The phase difference correspondingly decreases as frequency increases and period decreases.

Conclusion:

This experiment was designed to familiarize participants with the common functions of an oscilloscope and a function generator. The experiment's outcomes mostly matched the outputs that were predicted, and the output results' error percentages were predictable. The resolution of the function generator and oscilloscope may be to blame for the error. Also, the error might potentially have been caused by the oscilloscope probe and the function generator's cable. Additionally, there were instances where the amplitudes measured by the oscilloscope and those provided by the function generator did not match, generally, there was a ½ ratio in between them. The signal generator's high impedance may have contributed to this behavior. We modified the function generator's output signal to provide the required output on the oscilloscope screen to correct this problem.

Appendices:

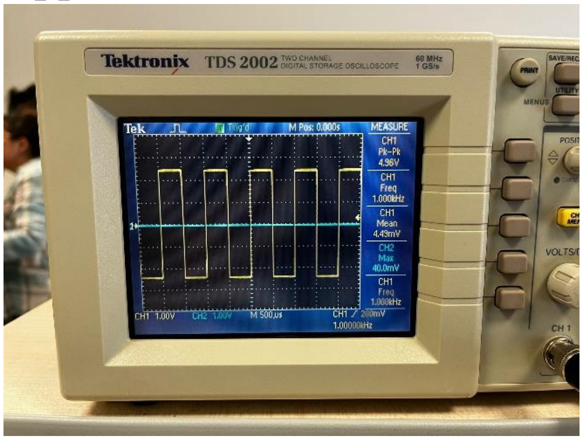


Figure 1.1 The compensated probe

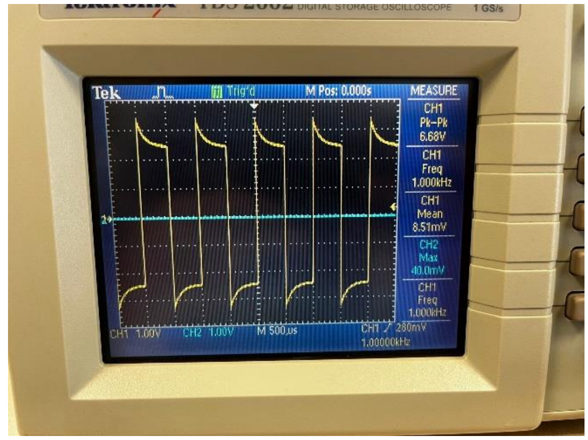


Figure1.2 Overcompensated signal

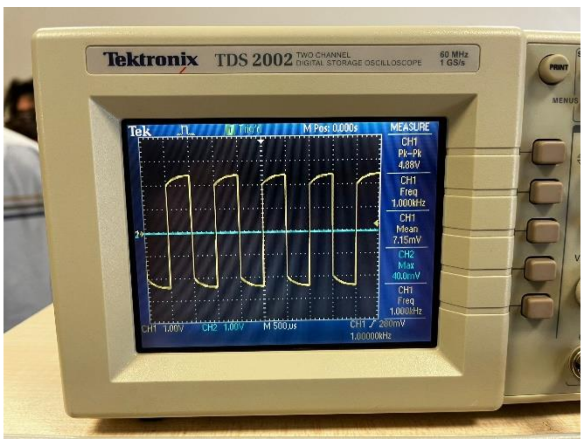


Figure 1.3 Undercompensated signal

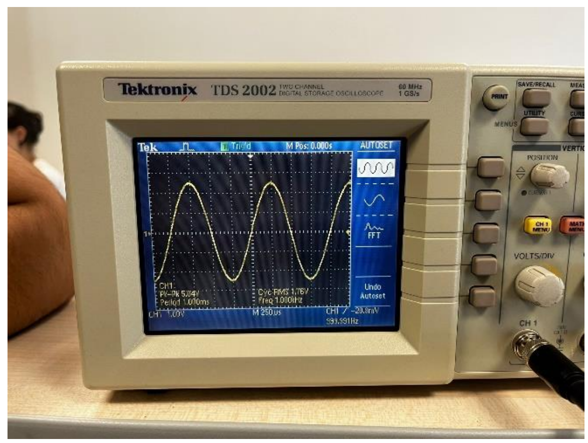


Figure 2.1 5V Pk-Pk 1kHz sinusoidal signal

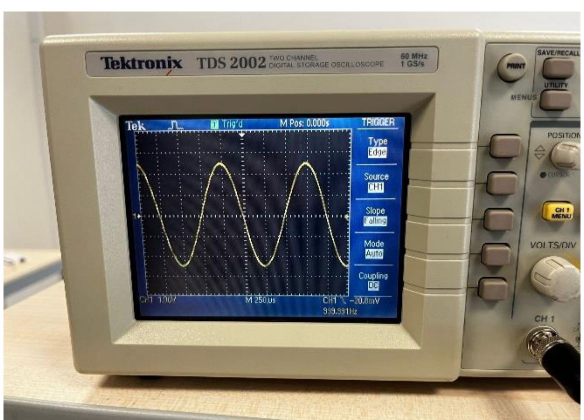


Figure 2.2 "Falling" Slope Trigger

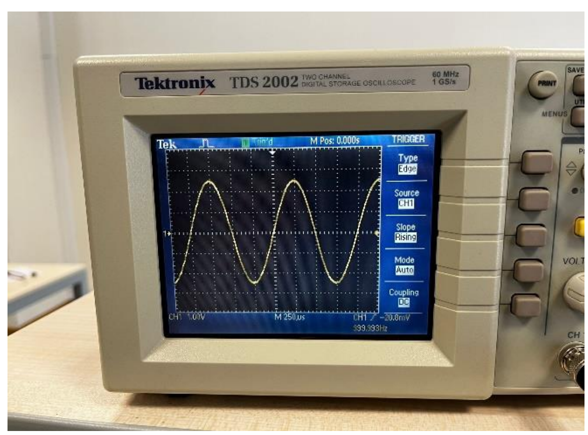


Figure 2.3 "Rising" Slope Trigger

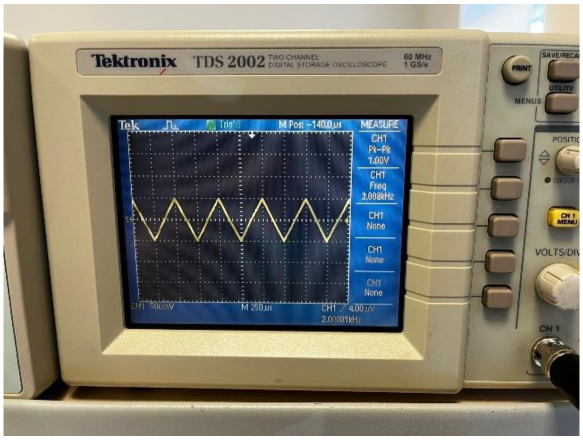


Figure 3.1 1V Pk-Pk 2kHz stable triangular signal

Figure 1.2 Unstable signal

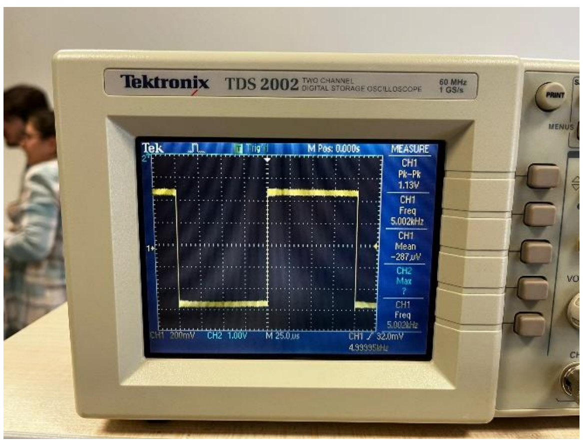


Figure 4.1 1V Pk-Pk 5kHz stable square signal

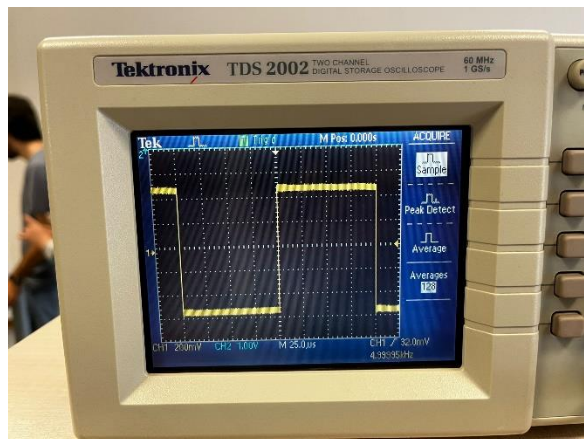


Figure 4.2 Acquisition mode "Sample"

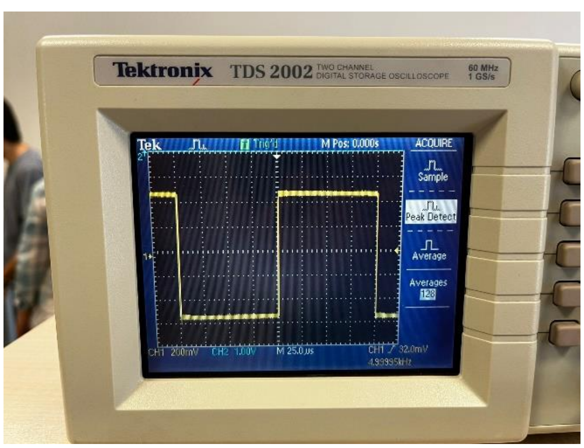


Figure 4.3 Acquisition mode "Peak Detect"

Figure 4.4 Acquisition mode "Average"

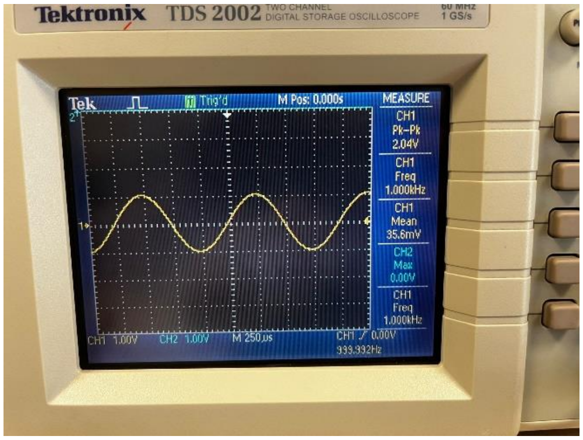


Figure 5.1 2V Pk-Pk 1kHz with 1V offset

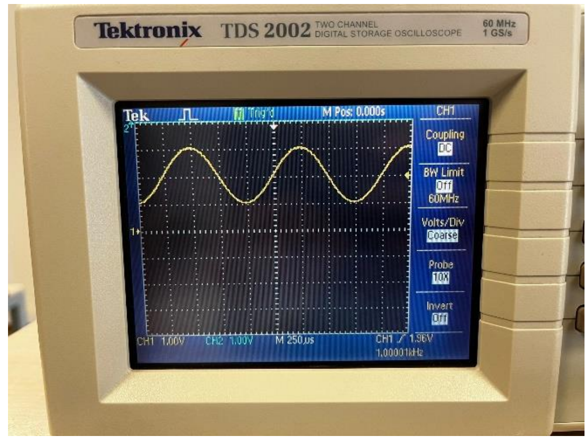


Figure 5.2 DC Coupling

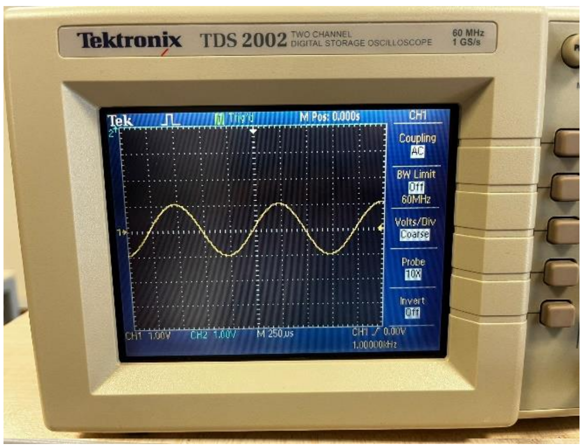


Figure 5.3 AC Coupling

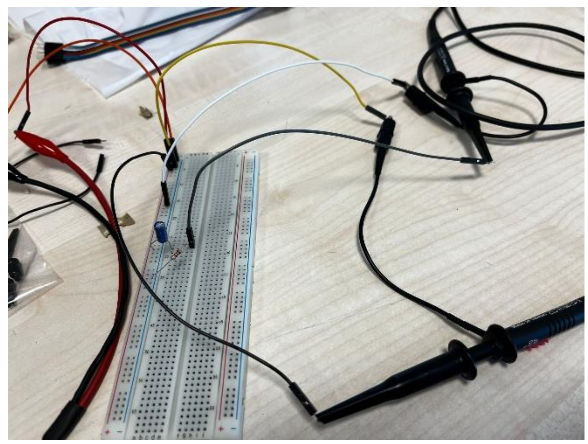


Figure 6.1 RC circuit

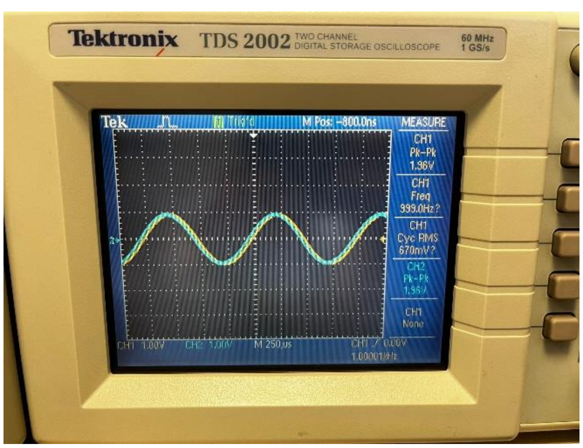


Figure 6.2 2V Pk-Pk 1kHz signal from point X and Y

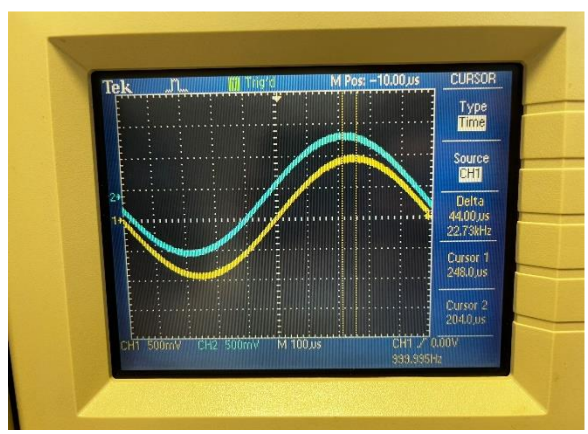
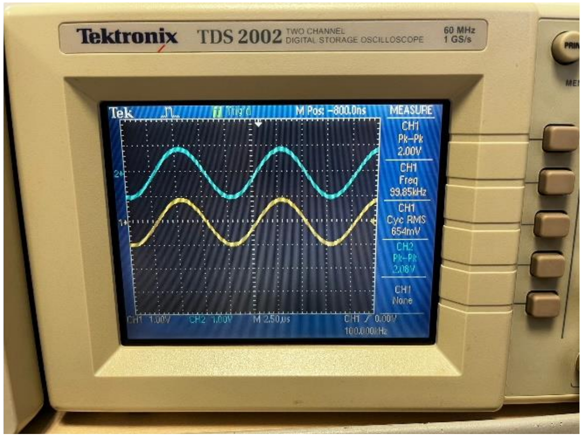


Figure 6.3 Time difference between signals from point X and Y with 1kHz



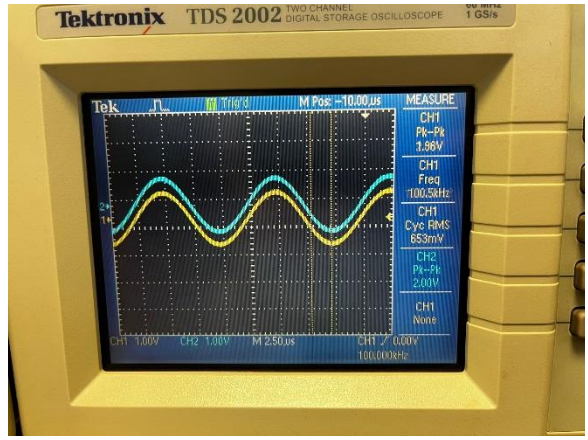


Figure 6.4 2V Pk-Pk 100kHz signal from points X and Y

Figure 6.5 Time difference between signals from point X and Y with 100kHz

References:

http://www.cmm.gov.mo/eng/exhibition/secondfloor/MoreInfo/ADConverter.html#:~:text=Analog%20to%20Digital%20Converter%20(ADC,to%20process%20the%20analog%20signals.