EE102 Lab1: Introduction to Digital Oscilloscopes

2nd February 2024

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Purpose:

The purpose of this lab is to understand how the lab equipment such as an oscilloscope, breadboard, or a signal generator works and learn how to use them. In the lab, we used the signal generator and the oscilloscope to generate and evaluate certain kinds of signals.

Methodology:

Task 1:

I properly compensated the probe with the screwdriver that came with it so that the signal doesn't overcompensate or undercompensate.

Task 2:

A 5 Vpp sinusoidal signal with 1 kHz frequency is produced by the signal generator without any DC components. Then I used positive and negative edge triggering to the signal then observed what happened.

Task 3:

In an oscilloscope, the trigger effect is the function that helps it capture and display repeating waves consistently. A 1 Vpp triangular wave with 2 kHz frequency is produced by the signal generator. Then I observed the effect of turning the trigger knob of the oscilloscope on the signal.

Task 4:

A 1 Vpp square wave with 5 kHz frequency is produced by the signal generator. Then I tried three acquisition methods which are sample, peak detect, and average, and observed their difference.

Task 5:

A sinusoidal signal with 2 Vpp amplitude, 1 kHz frequency, and a DC offset of 1 V is produced by the signal generator. Then I change the coupling from DC to AC and observe the effect of this change.

Task 6:

I construct the circuit given in the lab manual. Then I apply a 2 Vpp 1 kHz sinusoidal signal with 0 DC offset as the X signal. Then I measure the time difference between signals X and Y and use this difference to calculate the phase difference. Lastly, I change the frequency to 100 kHz and repeat the same process.

Results:

Task 1:

In order to get accurate results from an oscilloscope, I need to compensate my probe which balances the electrical properties of my probe to the specific oscilloscope I am using. Firstly, I checked that I used the probe with the appropriate attenuation factor which is 10x. Then I connected the probe to the oscilloscope. The initial probe adjustment signal looked like Figure1 which means that my probe is overcompensated. This signal indicates that my probe and oscilloscope are not balanced and the oscilloscope will give me inaccurate measurements. I used the screwdriver that came with my probe to compensate my probe until the wave looked like Figure 2.

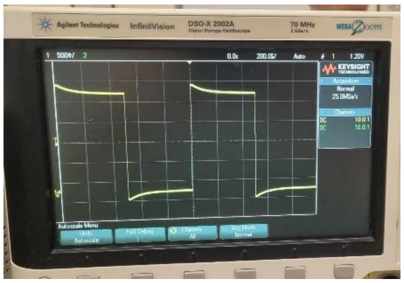

Figure 1: Overcompensated Probe

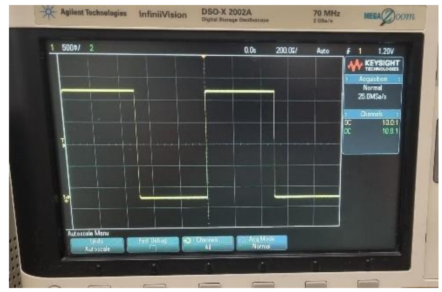

Figure 2: Properly Compensated Probe

Task 2:

By using the signal generator, I created a 5 Vpp sinusoidal signal with frequency 1 kHz and no DC component and observed this signal with the oscilloscope (Figure 3). Using the positive edge triggering resulted with the trigger point being on the rising edge of the wave which can be seen in Figure 4. However, using the negative edge triggering resulted with the trigger point being on the falling edge of the wave.

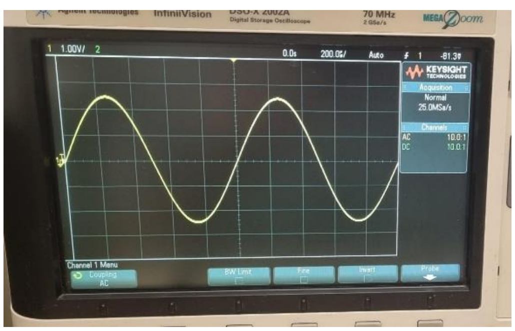

Figure 3: Positive Edge Triggering

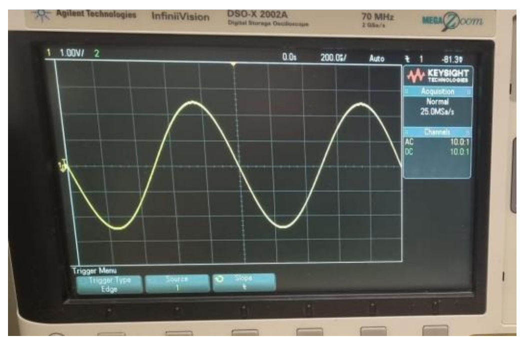

Figure 4: Negative Edge Triggering

Task 3:

By using the signal generator, I created a 1 Vpp triangular wave with 2 kHz frequency. Then I observed this wave in the oscilloscope (Figure 5). When I turned the trigger knob in a clockwise direction my trigger point moved to the right which made my wave look like it shifted to the left as you can see in Figure 6. When I turned the trigger knob in an anticlockwise direction, my trigger point moved to the left which made my wave look like it shifted to the right as you can see in Figure 7. If the trigger point is out of the amplitude of my wave, an unstable and meaningless wave appears at the oscilloscope. The triggering concept is basically specifying some conditions to determine when the oscilloscope captures and displays a wave. The trigger is especially useful for making repeating signals appear static on the screen of the oscilloscope. Adjusting the trigger point allows me to focus on different properties of the signal and helps me analyze the measurements better.

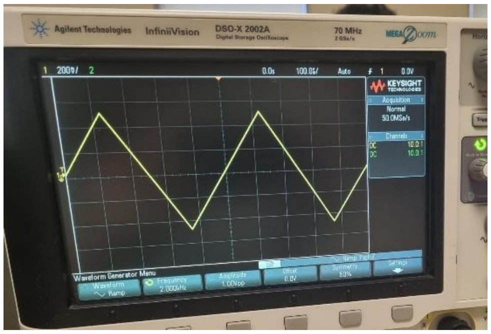

Figure 5: Triangular Wave

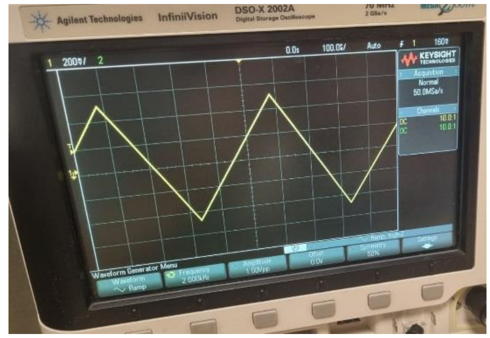

Figure 6: Trigger knob moved by clockwise direction

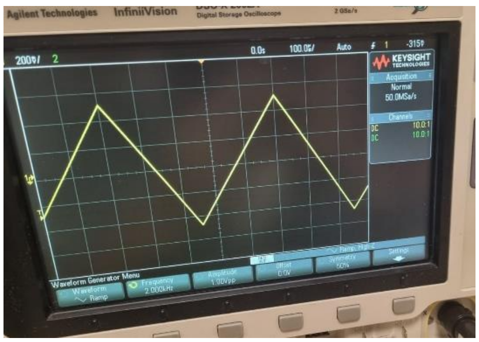

Figure 7: Trigger knob moved to anticlockwise direction

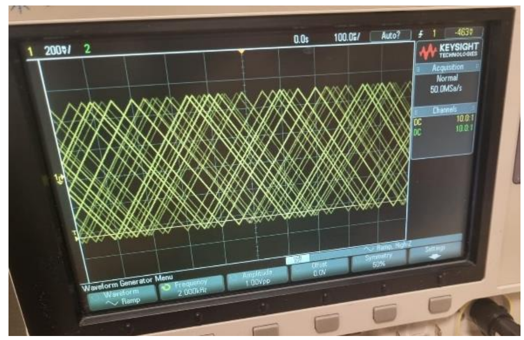

Figure 8: Trigger point out of the wave amplitude

Task 4:

A digital-to-analog converter (DAC) is a device that can take binary digital input and give a continuous analog output as a product. One example use of a DAC is in audio systems where digital audio data is converted into continuous analog signals that can be used by speakers to play the audio.

An analog-to-digital converter (ADC) is a device that converts continuous analog signals into binary digital representations. One example use of an ADC is temperature sensing systems where an analog signal that varies with temperature is converted into a digital representation that can be processed by the microcontroller.

In digital oscilloscopes, ADC is used since a digital oscilloscope needs to display the analog signal of voltage over time as a digital data. This conversion of analog data that cannot be displayed by the oscilloscope to digital data that can be displayed by the oscilloscope is done by an ADC.

In this task, I produced a 1 Vpp square wave with 5 kHz frequency with the signal generator (Figure 9). Then I tried acquisition modes sample, peak detect, and average. In the sampling acquisition mode, which appeared as normal in my oscilloscope, (Figure 10), the oscilloscope acquires the wave data by selecting sample points in equal intervals of the continuous input data. In the peak detect acquisition mode (Figure 11), the oscilloscope records the highest and the lowest voltage values between the samples and then, displays these peak voltage values on the screen. In averaging acquisition mode (Figure 12), the oscilloscope takes multiple input data and averages them together which helps the user to get rid of unwanted noise in the display.

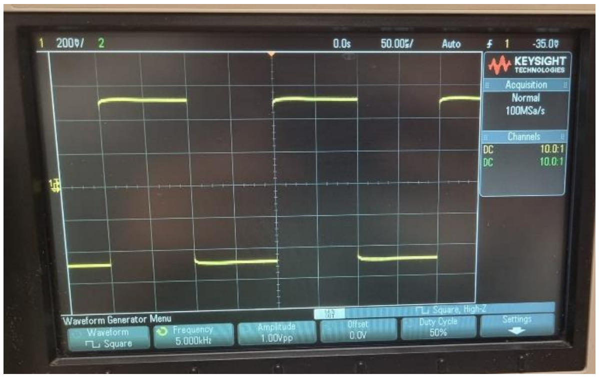

Figure 9: Square wave

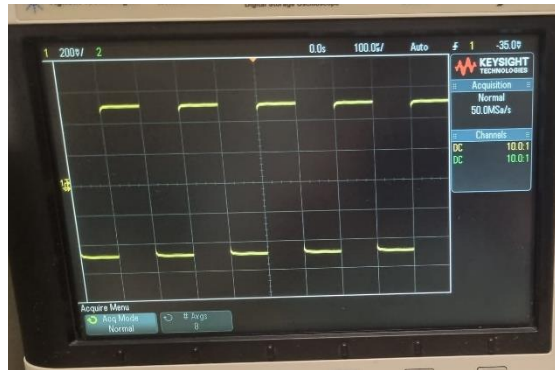

Figure 10: Sampling acquisition mode

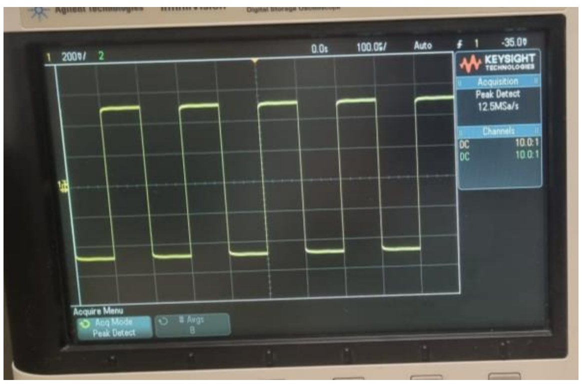

Figure 11: Peak detect acquisition mode

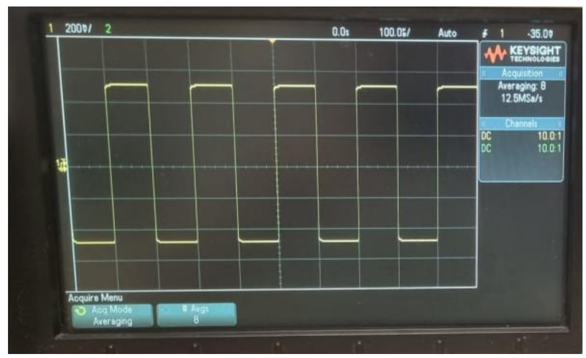

Figure 12: Averaging acquisition mode

Task 5:

I produced a 2 Vpp and 1 kHz sinusoidal signal with a DC offset of 1 V with the signal generator. When I use DC coupling, the signal is placed on 1 V above the horizontal axis as you can see in Figure 13: When I use AC coupling, the offset of 1 V is not visible on the screen (Figure 14) since AC coupling eliminates the DC component of the wave which results with the offset of 1 V not appearing on the oscilloscope.

Figure 13: sinusoidal signal with DC coupling

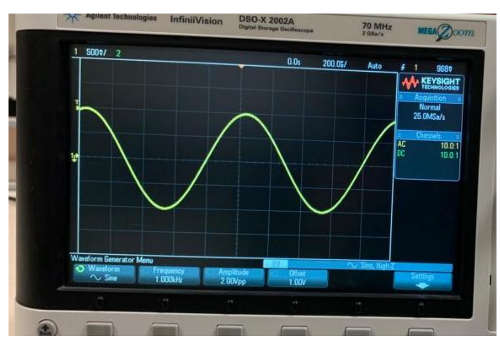

Figure 14: Sinusoidal signal with AC coupling

Task 6:

A breadboard is simply a collection of metal plates connected in a grid-like way. In the surface of the breadboard, there are metal sockets that provide a connection point for electronic circuit elements such as resistors, LEDs, and capacitors. In a regular breadboard, there are two lines at the left and right sides which are shown with blue and red colors. The red line is conventionally used as the voltage line and the blue line is conventionally used as a ground line. Between these lines, the grids are connected to each other row wise which makes designing circuits easier.

We designed the circuit given in the lab manual as you can see in Figure 15 and applied a 2 Vpp 1 kHz signal with 0 DC offset as the X signal in the circuit. By connecting two probes to the oscilloscope, we observed both the signals X and Y. As you can see from Figure 16, I measured 1.95 V and 999.48 Hz at point X and 1.89 V and 999.52 Hz at point Y. According to Figure 17, there is a 34.3 µs time difference between the two points. We can use the phase difference formula mentioned below to calculate the phase difference:

$$\Delta\phi = 2\pi f \, \Delta t$$

Using this formula gives us approximately a 0.216 radians of phase difference.If we increase the frequency to 100 khz we can see that the time difference between X and Y will be 44ns as you can see in Figure 18. I used the same formula once again to calculate the phase difference which turned out to be 0.0276 radians. This result showed that the frequency has an effect on the phase difference between the signals. Since capacitive reactance is inversely proportional to the frequency, an increase in the frequency, just like my experiment, would decrease the capacitive reactance of the capacitor and result with less phase and voltage difference.

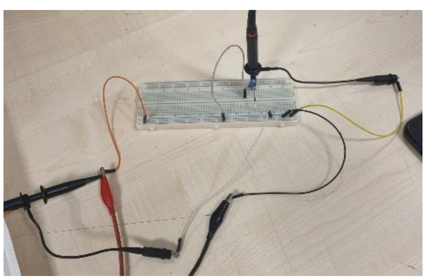

Figure 15: Circuit given on the lab manual

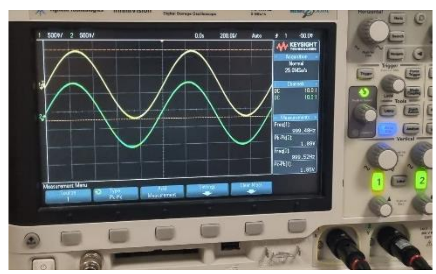

Figure 16: Measurements of X and Y signals

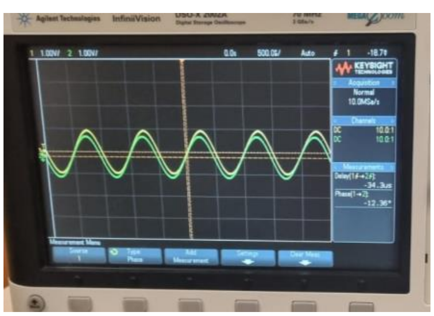

Figure 17: Time delay between X and Y (1kHz)

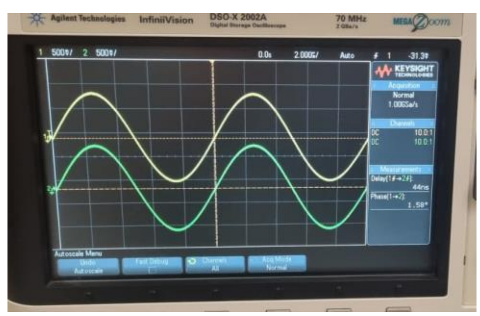

Figure 18: Time delay between X and Y (100 kHz)

Conclusion:

In the end, I learned how to use an oscilloscope and a signal generator and used my knowledge of them to design a simple circuit and observed the phase difference created by a capacitor. There were a small amount of errors in my measurements due to problems in the equipment such as the probe or the oscilloscope or human error. However, I managed to successfully complete the tasks and the experiments.

References:

1- https://www.electronicdesign.com/technologies/test-measurement/article/21801317/why-you-should-care-about-oscilloscope-acquisition-modes
2- https://thimble.io/how-to-use-a-breadboard-an-in-depth-guide/
3- https://www.keysight.com/blogs/en/tech/bench/2018/10/18/when-to-use-ac-coupling-on-your-oscilloscope