Lab 1: Introduction to Digital Oscilloscopes

Date: 26.09.2022

Name: Orkun İbrahim Kök

Section: EE102-01

Purpose

The aim of this experiment is to understand how a digital oscilloscope works, comparing two different signals, understanding how a breadboard works and, learning how to measure time and voltage differences on the digital oscilloscope.

Methodology

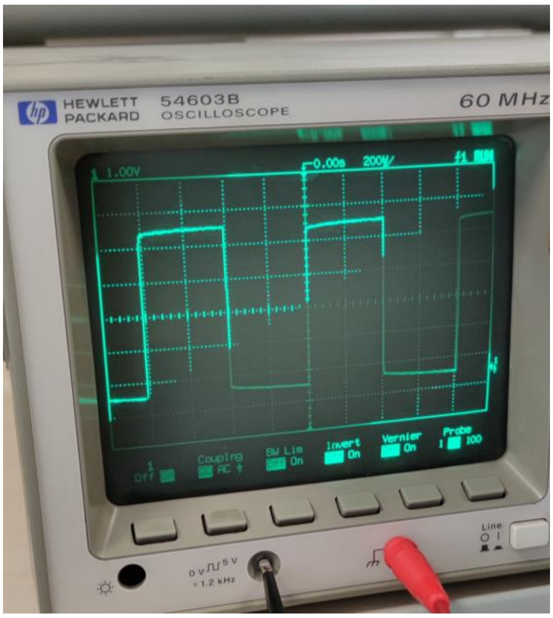
1) I attached the oscilloscope probe to the digital oscilloscope, then grounded it. Looking at the compensation signal on the oscilloscope, with the screwdriver, I adjusted the signal thus it seems similar to a rectangular waveform.
2) I used a signal generator and applied 5 Vpp sinusoidal signal with frequency 1 kHz, then checked whether the signal has a DC component or not. Finally, I observed the changes between the positive edge triggering and negative edge triggering.
3) I applied a 1 Vpp triangular wave with 2 kHz frequency, then turned the trigger knob of the oscilloscope in order to observe the affect it makes on the signal.
4) I applied 1 Vpp square wave with 5 kHz frequency to the oscilloscope. Then one-by-one tried all of the acquisition modes (sample, peak detect, average) on the waveform.
5) I generated a sinusoidal signal with 2 Vpp amplitude and 1 kHz frequency and set the DC offset to 0 from the signal generator. After that, from the coupling menu of the oscilloscope, first selected Dc coupling and observed the results, then selected AC coupling and observed the results.
6) I made the circuit that is shown at the sixth question on my breadboard. I used a capacitor (1µF), a 1kΩ resistance and 2 oscilloscope probes. After making the circuit, I applied a 2 Vpp 1 kHz sinusoidal signal with setting DC offset to 0. After doing these, 2 different signals appear on the oscilloscope screen. I measured the time and voltage delay between them and repeated the same steps again with the frequency 100 kHz.

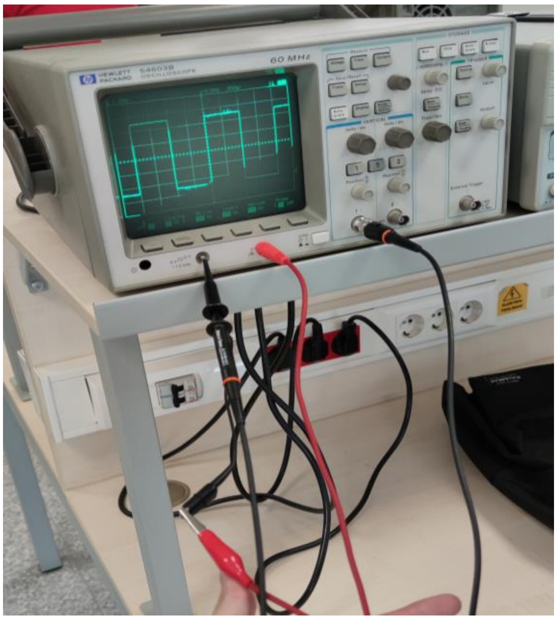
Results

1) Before compensating the oscilloscope probe, the compensation signals are not in the rectangular form, the horizontal wavesare not in a linear direction, so I used a screwdriver and compensated the oscilloscope probe, and the signals become more like a rectangular waveform.

Figure 1: uncompensated oscilloscope probe signals

Figure 2: Compensated oscilloscope probe signals





2) In the second question, using a signal generator, I applied 5 Vpp sinusoidal signal with frequency 1 kHz. From the slope menu in the oscilloscope I can choose either positive edge triggering or negative edge triggering. When I used the positive edge triggering, signals look like a sine function, however, when I changed the edge triggering from positive to negative, the whole signal replaced with its symmetry with respect to the time axis.

Figure 3: 5 Vpp and 1kHz applied to signal generator

Figure 4: Positive edge triggering signal

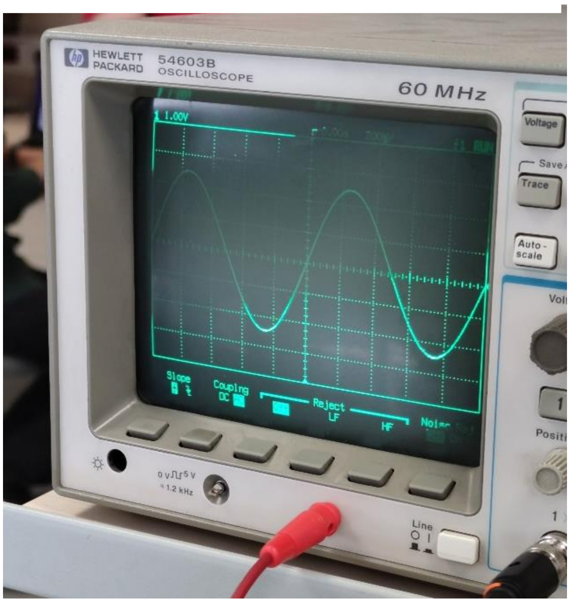
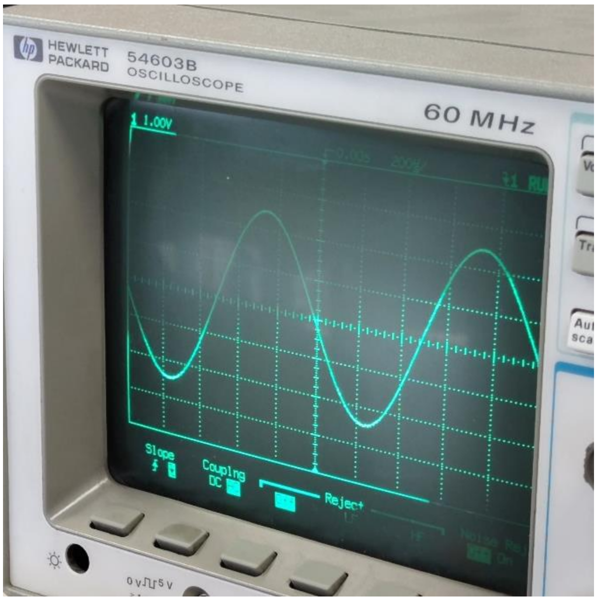


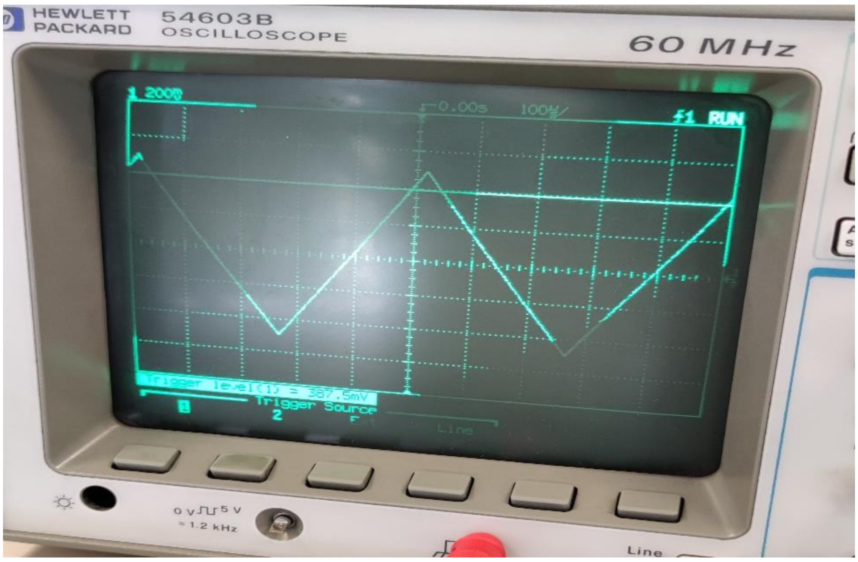
Figure 5: Negative edge triggering signal



3) In the third question, I applied 1 Vpp triangular wave with 2kHz frequency. Then I turned the trigger level knob in order to observe the affect of it on the wave. When I turned it, horizontal line appeared in the oscilloscope screen, when this horizontal line is intersecting the wave, wave becomes more stabilized because the trigger synchorizes the starting point of the sweep to the same point on the signal, thus waveform becomes stable. However, on the other hand, when the horizontal line does not intersects with the signal, the more unstable waveform gets. The triggering concept can be explained as, when the waveform voltage reaches a required level, then the timebase synchronises with the already displayed waveform, thus it remains stable.

Figure 6: 1 Vpp and 2kHz frequency applied to signal generator

Figure 7: Effect of triggering knob on the triangular waveform



4) Analog-to-digital converter (ADC) can be explained as converting the voltage measured by the oscilloscope to the digital information, ADC converts the continuous form of signal to discrete form signal, for example, converting an analog signal such as voltage to a digital form thus it can be processed. Digital-to-analog converter (DAC) converts a digital signal into voltage, which can be used to drive electrical equipment. For example, DAC converts digital information into analog sound. Oscilloscopes have ADC inside them because oscilloscope is a kind of a computer, thus with the help of ADC's, oscilloscopes can provide high sample rates and perfect time resolution.

Using a signal generator, I applied 1 Vpp square wave with 5 kHz frequency then observed different acquisition modes. The sample mode is pure waveform. The peak detect mode made the horizontal lines of the signal more thick than it is, and the average mode made the horizontal lines of the signals more thinner compared to sample mode signal.

Figure 8: 1 Vpp and 5 kHz frequency applied to signal generator

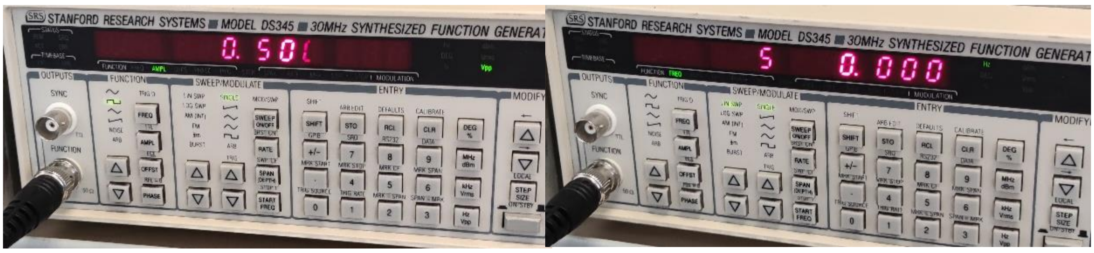


Figure 9: Sample mode of the oscilloscope

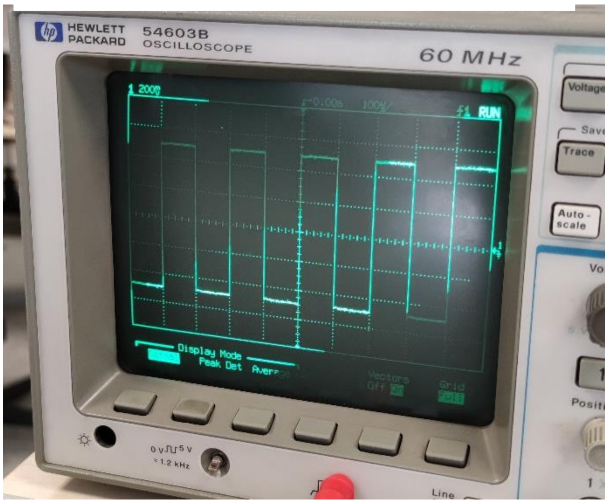


Figure 10: Peak detect mode of the oscilloscope

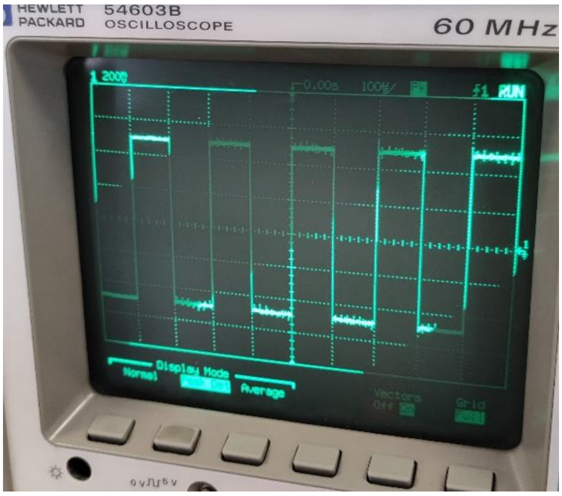
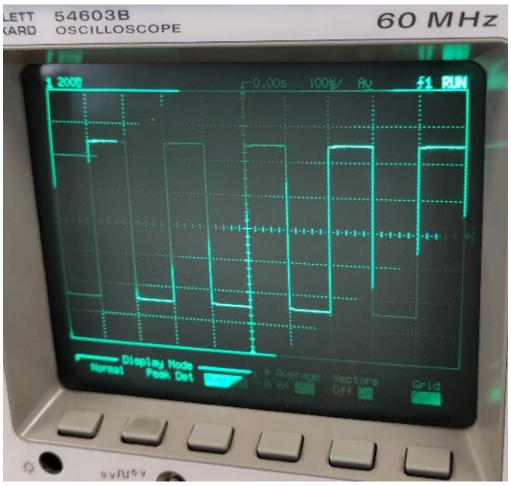


Figure 11: Average mode of the oscilloscope



5) In the fourth question, I generated a sinusoidal signal with 2 Vpp amplitude and 1 kHz frequency. After setting DC offset to 0, observed coupling options both DC and AC. While the coupling is at DC, the signal is a normal sinusoidal signal, well arranged according to the both voltage axis and time axis, however, when I selected the AC coupling option, whole signal slided down under the time axis. To summarise, the difference between DC coupling and AC coupling is the displacement of the signal in the negative y direction.

Figure 12: DC coupling on a sinusoidal signal

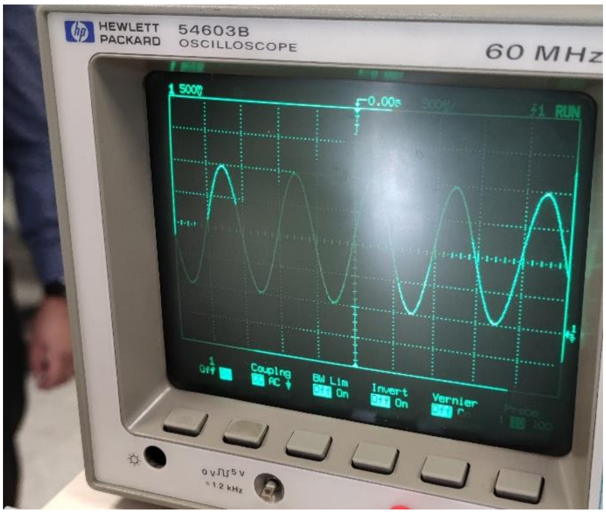
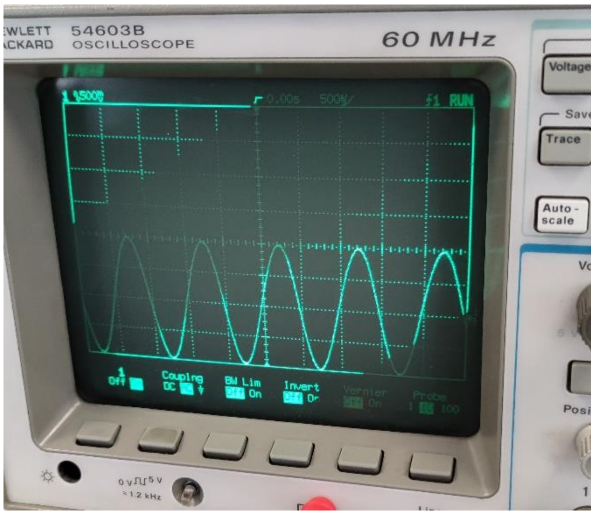


Figure 13: AC coupling on a sinusoidal signal



6) Breadboard can be explained as small solderless devices for prototypes and test circuit designs. Each set of 5 holes (half of a row) is electrically connected. At the sides of the breadboard, there are 2 columns, each column is electrically conencted. One of them is positive and the other one is negative. Positive one is used for power and negative one is used for grounding. I made the circuit and grounded it. By using 2 oscilloscope probes, I end up with 2 different signals on the oscilloscope screen. Firstly I measure the time and voltage differences between two signals at 1 kHz. Then repeating the same process with 100kHz, I come up with a conclusion that as the frequency gets bigger and bigger, the voltage difference between the two signals are becoming smaller, and also, time difference between these two signals become more smaller. Then I calculated the phase difference for both frequency values according to the formula (Phase difference = 2*π*td/p) where td is the time difference between the waves and p is the wave period. Using this formula, at 1 kHz, the result is $2*\pi*6*10^{-8}*10^{-3}$, at 100 kHz, the result is $2*\pi*(15.98)*10^{-6}*10^{-5}$.

Figure 14: Circuit on the breadboard with capacitor and resistance

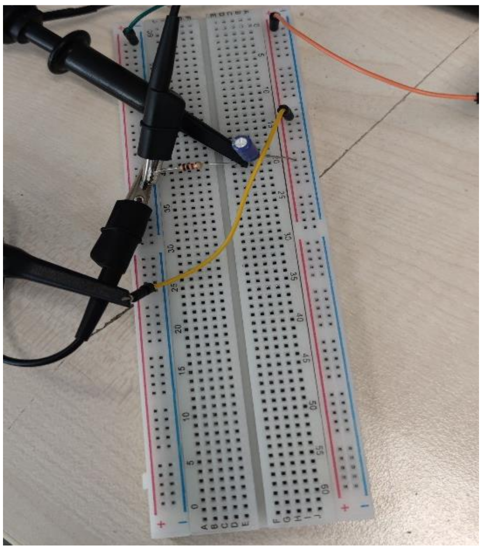


Figure 15: At 1 kHz, the measured voltage difference between 2 waves is 71.87 mV

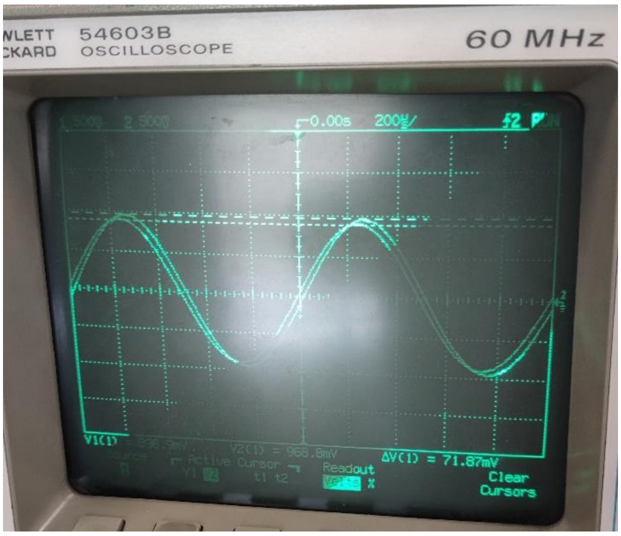


Figure 16: At 1 kHz, the measured voltage difference between 2 waves is 40.62 mV

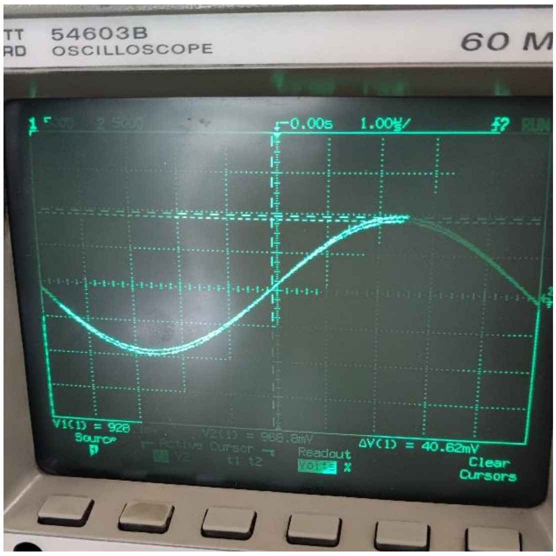


Figure 17: At 1 kHz, the measured time difference between 2 waves is 15.98 µs

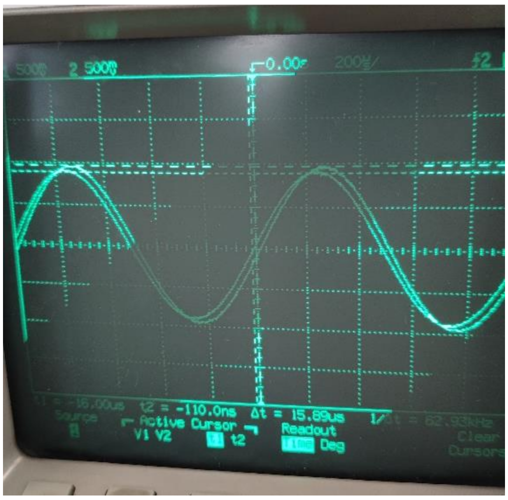
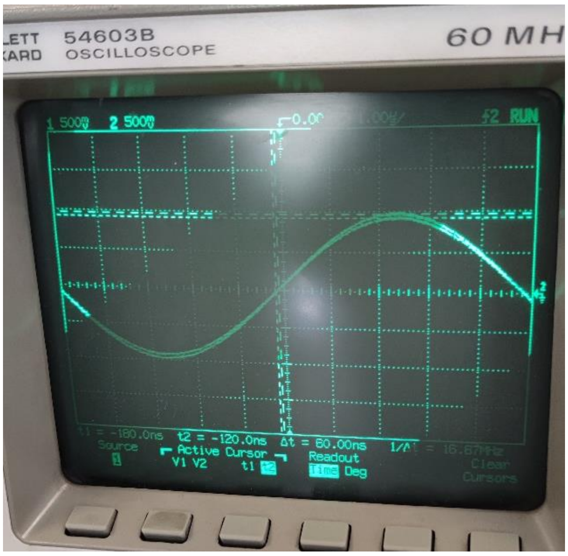


Figure 18: At 100 kHz, the measured time difference between 2 waves is 60 ns



Conclusion

Throughout the experiment, I learned how to use a digital oscilloscope and use its features, and I learned how a breadboard is working. While doing the experiments, I used half of the Vpp values that is written on the questions because my signal generator is not terminated by an impedance of 50 Ohms but instead by high impedance.