EEE 117L Laboratory – Network Analysis

Lab #4: Oscilloscope and Function Generator (Week I)

Lab Day and Time: Wednesday, 1:30PM - 4:10PM

Group Number: # 03

Group Members: (Last Name, First Name)

Member #1: Trinh, Bon

Member #2: Chan, Casey

Member #3: Algador, Vigomar Kim

General Instructions:

Theoretical analyses and making predictions regarding the behavior of circuits is one of the most crucial, yet underrated and often ignored, jobs among young engineers. This includes the ability to carry out hand calculations in the abstract and running circuit simulations. You may use any technique of circuit analysis in order to obtain the solutions, but you must clearly state which technique of analysis you are using. You must show all work to receive credit. No credit will be given for answers with no justification. Your work should be neat and organized. If I can't follow your work or read your writing, then you will not get full credit. You may attach extra sheets if you need more space to show all your work. Remember that the ability to clearly explain what you are doing to other engineers is one of the most important skills you need to develop.

Total Score: /100

Work Breakdown Structure: It is important that every group member do their share of the work in these labs. Remember that you will receive no credit for the lab worksheet if you did not contribute. Write in the Table provided below, which group member(s) contributed to the solution of each problem in the lab worksheet. Also remember that only one lab worksheet per group will be turned in at the beginning of next week's lab. If there was any group member that did not contribute, then write their name in the space provided below.

Problem Number	Group member(s) that worked on the problem.
Part I.1.a	Trinh, Bon Chan, Casey Algador, Vigomar Kim
Part I.1.b	Trinh, Bon Chan, Casey Algador, Vigomar Kim
Part I.2.a	Trinh, Bon Chan, Casey Algador, Vigomar Kim
Part I.2.b	Trinh, Bon Chan, Casey Algador, Vigomar Kim
Part I.3	Trinh, Bon Chan, Casey Algador, Vigomar Kim
Part I.4	Trinh, Bon Chan, Casey Algador, Vigomar Kim

Absent member(s):____

General Theory:

Out of all the measurement tools in the electrical engineers arsenal, the oscilloscope is one of the most versatile and powerful. This is due to many factors, among which include (1) the ability of the oscilloscope to graphically display multiple time evolving voltages on its screen simultaneously and (2) the ability to automatically compute and display mathematical properties of the voltage waveforms being measured.

When describing different oscilloscopes and their capabilities, it is possible to draw an analogy with cars. Every car has certain component requirements that are needed in order to perform properly. With a few odd exceptions, all cars have an engine, a gas and brake pedal, four wheels, and a steering wheel, all of which are necessary to function properly. Some cars, however, depending on their construction and cost will have more advanced features that other cars may not. For example, some cars have heated seats, back-up cameras, power windows and locks, etcetera. The same is true of oscilloscopes. Every oscilloscope will be able to display voltages as functions of time, within a particular range, and will be able to carry out measurements of interest. These are basic functions of an oscilloscope. However, oscilloscopes of different costs and manufactures will differ in many ways. These lab experiments will be modified from the original EEE 117L lab manual experiments in order to illustrate all of the important concepts that must be learned to have a well-rounded education. Although this lab is now adapted to how the Analog Discovery 2 works, keep in mind many of the experiments, observations, and results will apply directly to how almost any oscilloscope works.

Some of the major purposes of this lab is for students to learn (a) how to use the “function generator” to generate voltage waveforms with particular properties, (b) how to use the oscilloscope in order to display data and calculate electrical parameters of interest.

Part I: Horizontal and Vertical Controls Total Score: /90

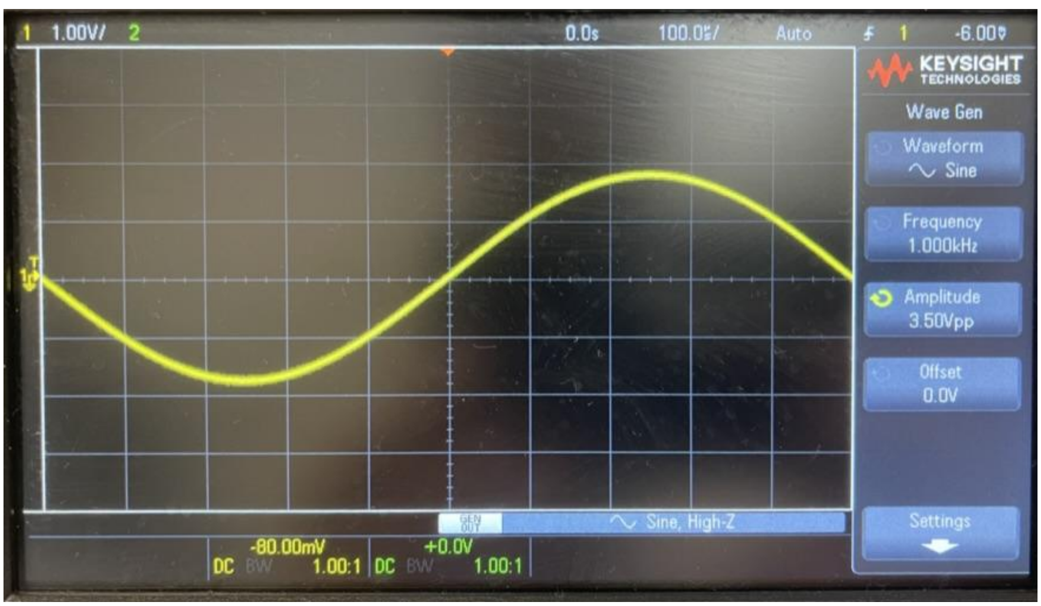
1) Waveform Generator Controls Total Score: /30

Connect the waveform generator, W1, directly to the first channel of the oscilloscope, Ch1. Press the "Default Setup" button on the oscilloscope to reset (almost) all of the settings. Ensure that the switch on the oscilloscope probe is placed in the X1 setting, and not in the X10 setting. Using the oscilloscope controls, make sure that the ratio has been set to 1:1. Test this setting by inputting a **known signal** and using the oscilloscope to measure the input voltage. The measured value of the voltage should match the input value.

a) Sine waves Score: /15

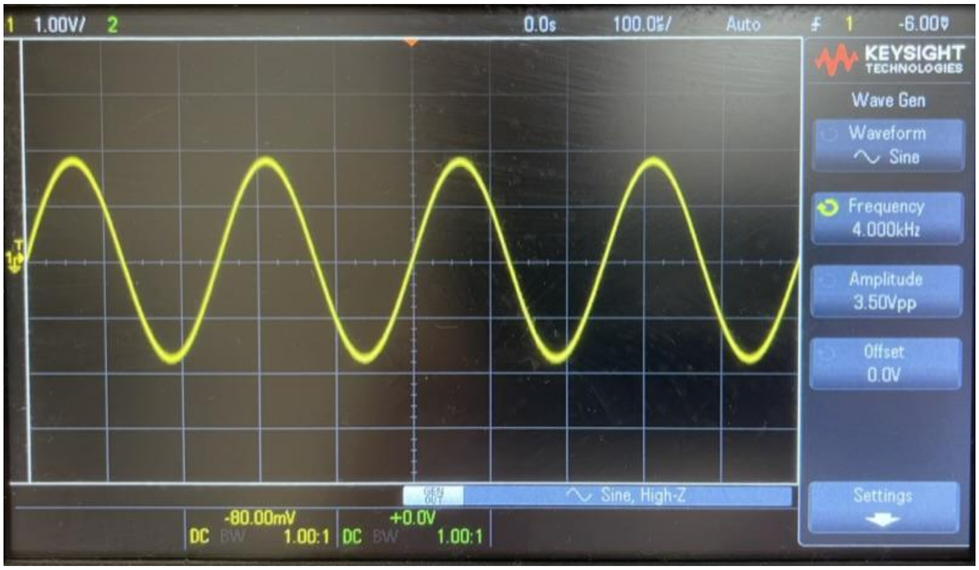
Turn on the waveform generator on the oscilloscope. Choosing the "Sine" waveform from the drop down menu and keeping the rest of the controls on the oscilloscope in the default settings, describe how the waveform changes (as seen in the oscilloscope window) as the rest of the settings are changed in the menu. In particular explore the frequency, amplitude, and offset. Be specific and use pictures to help with your explanations. Every picture must have a descriptive title and its corresponding explanation. Use more pages as needed.

<u>Normal:</u>



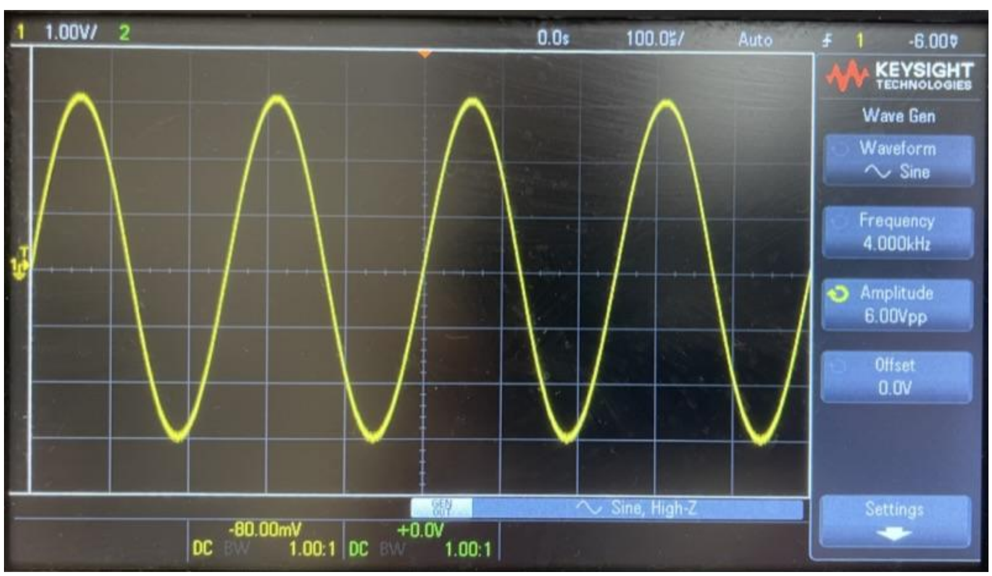
- The above picture illustrates a default sine waveform shown on the oscilloscope.

Frequency change:



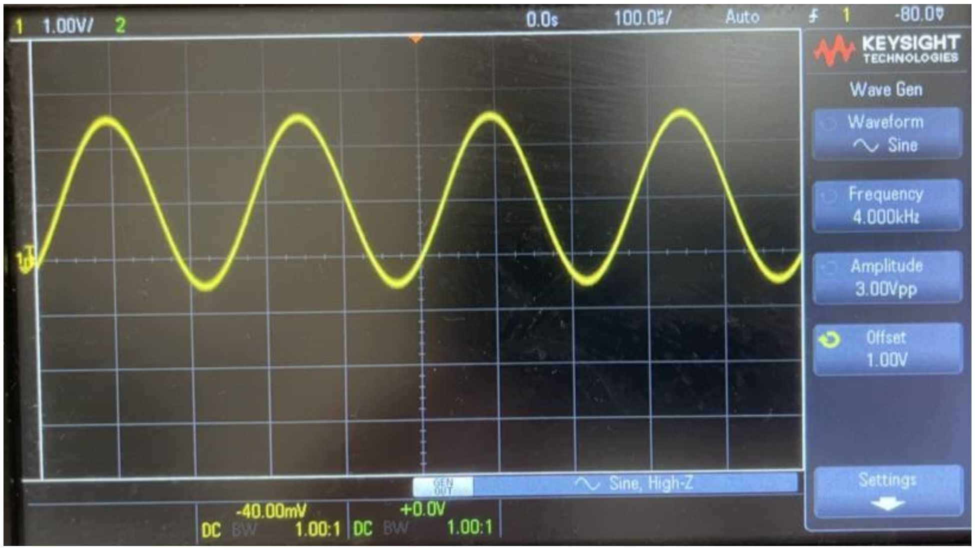
- We changed the frequency from 1.000 kHz to 4.000 kHz. The number of cycles changes when you change the frequency.

Amplitude change:



- We changed the amplitude from 3.50 Vpp to 6.00 Vpp. Changing the amplitude adjusted the peak-to-peak voltage.

Offset change:

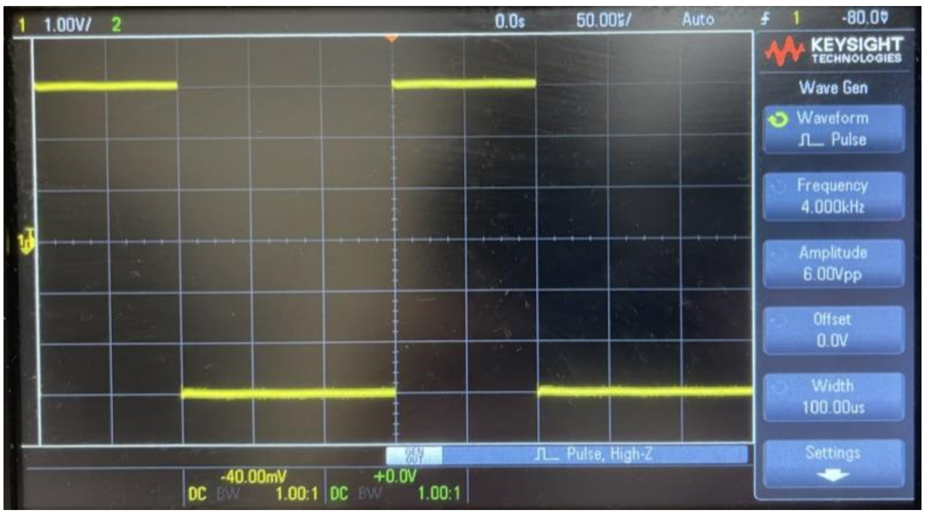


- We changed the offset from 0.00 V to 1.00 V. Adjusting the offset shifted the position of the waveform by 1 volt.

b) Pulses Score: /15

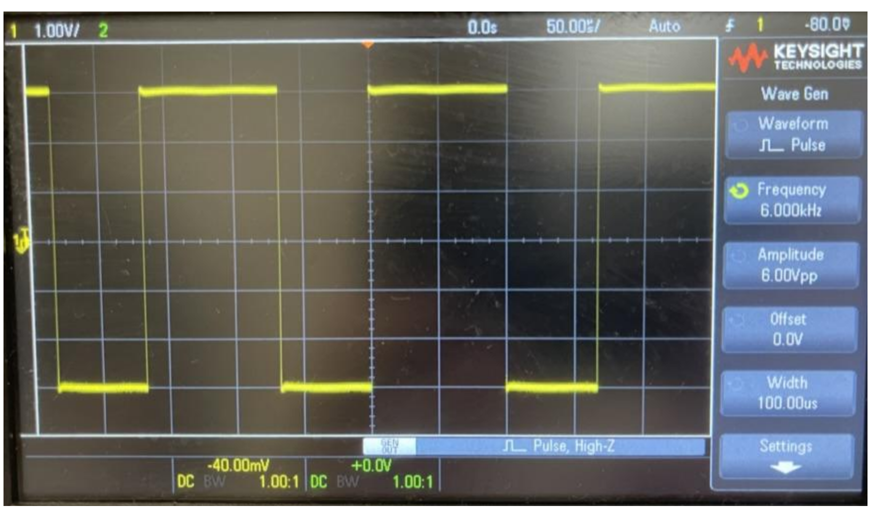
Choosing the “Pulse” waveform from the drop down menu and keeping the rest of the controls on the oscilloscope in the default settings, describe how the waveform changes (as seen in the oscilloscope window) as the rest of the settings are changed in the menu. Explore all the settings under the “Pulse” waveform. Be specific and use pictures to help with your explanations. Every picture must have a descriptive title and its corresponding explanation. Use more pages as needed.

Normal:



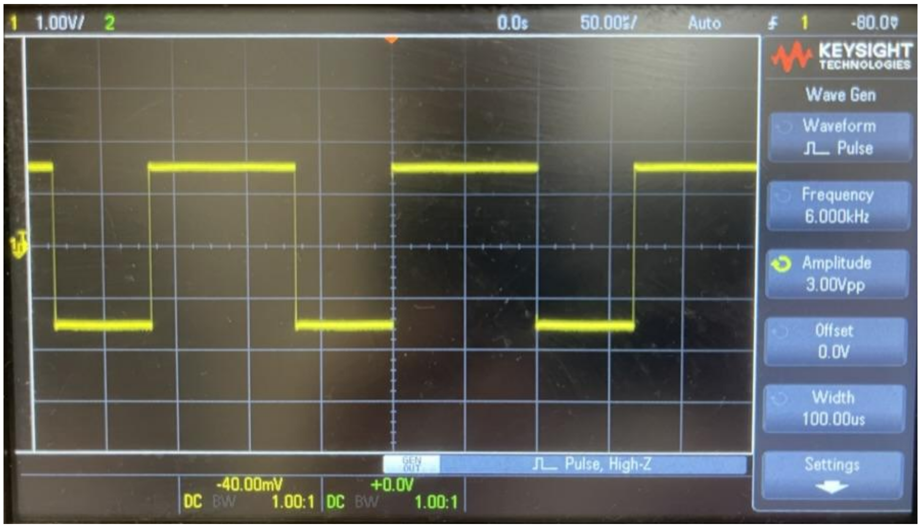
- The above picture illustrates a default pulse waveform shown on the oscilloscope

Frequency:



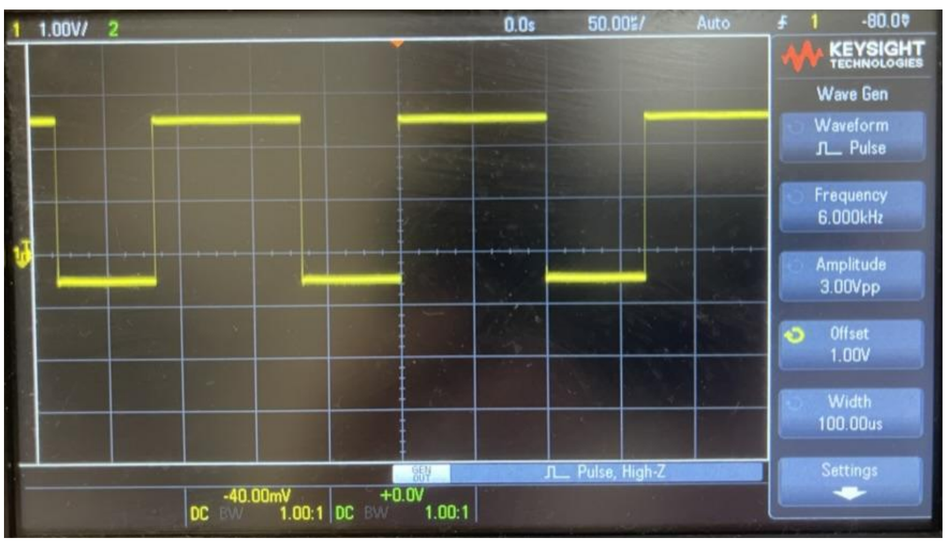
- We changed the frequency from 4 kHz to 6 kHz. The number of cycles changes when adjusting the frequency.

Amplitude change:



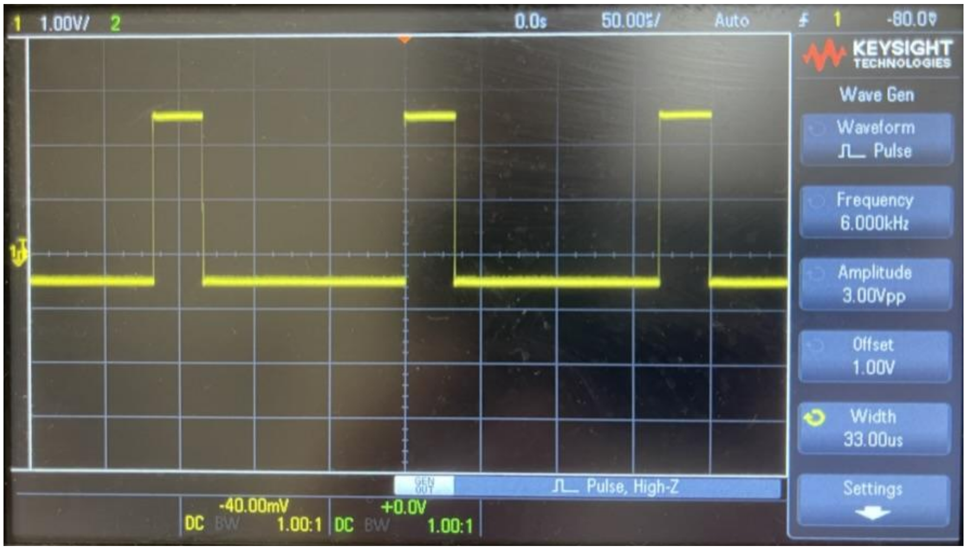
- We changed the amplitude from 6.00 Vpp to 3.00 Vpp. Changing the amplitude changed the peak-to-peak of the pulse waveform.

Offset change:



- We changed the offset from 0.00 V to 1.00V. When increasing the offset to 1 volt, our pulse waveform goes up on the Y-axis by 1 volt.

Width change:

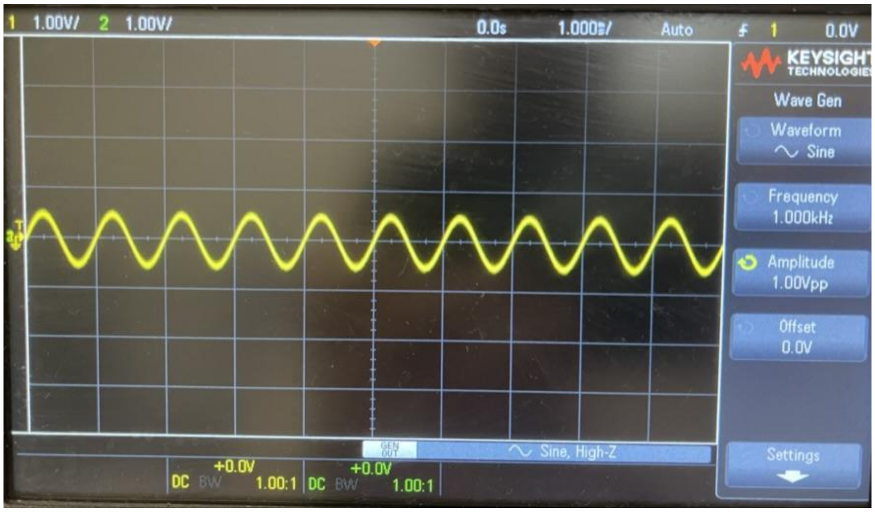


- We changed the width from 100 µs to 33 µs. Changing the width changes the amount of time for the pulse to go from low to high and back to low again.

2) Oscilloscope Controls Total Score: /30

Connect the waveform generator, W1, directly to the first channel AND the second channel, Ch1 and Ch2, of the oscilloscope. Make sure that all the settings are the same for both channels. Using the controls on the waveform generator, set up a sine wave with the following properties: (a) Frequency = 1 kHz, (b) Amplitude = 1 V, (d) Offset = 0 V. The settings for Ch2 will not be changed and will serve as a reference for you to make comparisons.

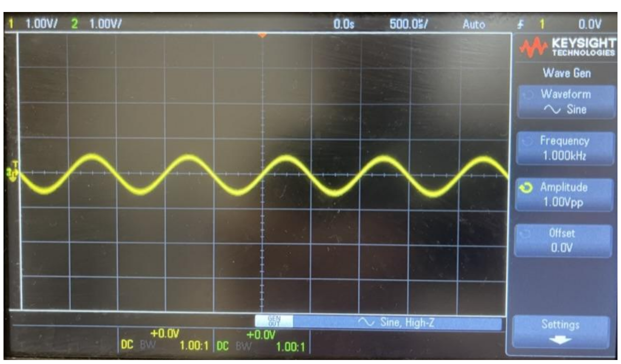
Normal

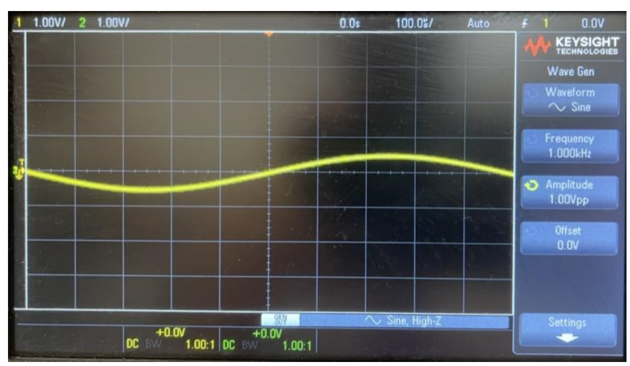


- This is the default waveform that we are basing for our horizontal and vertical control settings on.

a) Horizontal Controls Score: /15

Describe how the waveform displayed on Ch1 of the oscilloscope changes as the position and base settings under the "”Horizontal” controls on the right hand side of the oscilloscope are changed. There are two dials on the oscilloscope that allow you to change these settings. Take a close look and focus on the units along the vertical axis. Be specific and use pictures to help with your explanations. Every picture must have a descriptive title and its corresponding explanation. Use more pages as needed.

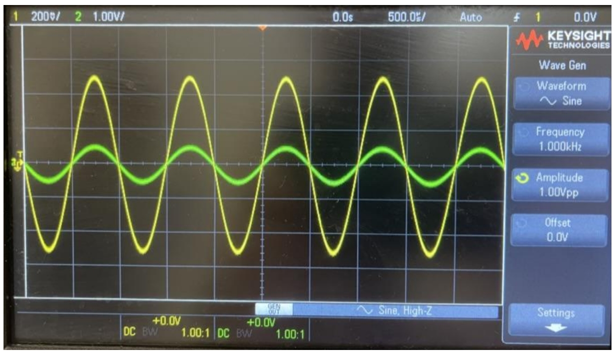


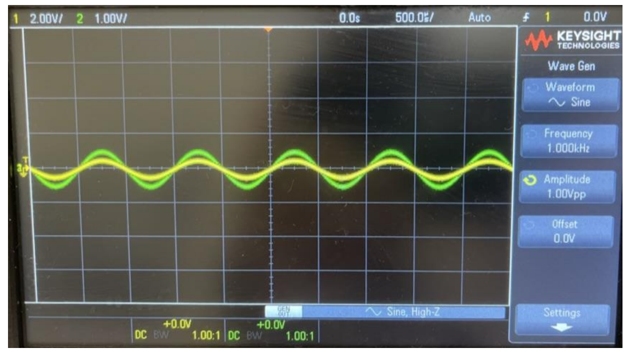


From the figures above, the Ch2 (green wave) and Ch1 (yellow wave) were both changing when switching the horizontal control. Compared to the normal state, both figures shrink. Visually, it seems that the period decreases in the oscilloscope.

b) Vertical Controls Score: /15

Describe how the waveform displayed on Ch1 of the oscilloscope changes as the offset and range settings under the “Vertical” controls on the right hand side of the oscilloscope are changed. There are two dials on the oscilloscope that allow you to change these settings. Take a close look and focus on the units along the horizontal axis. Be specific and use pictures to help with your explanations. Every picture must have a descriptive title and its corresponding explanation. Use more pages as needed.

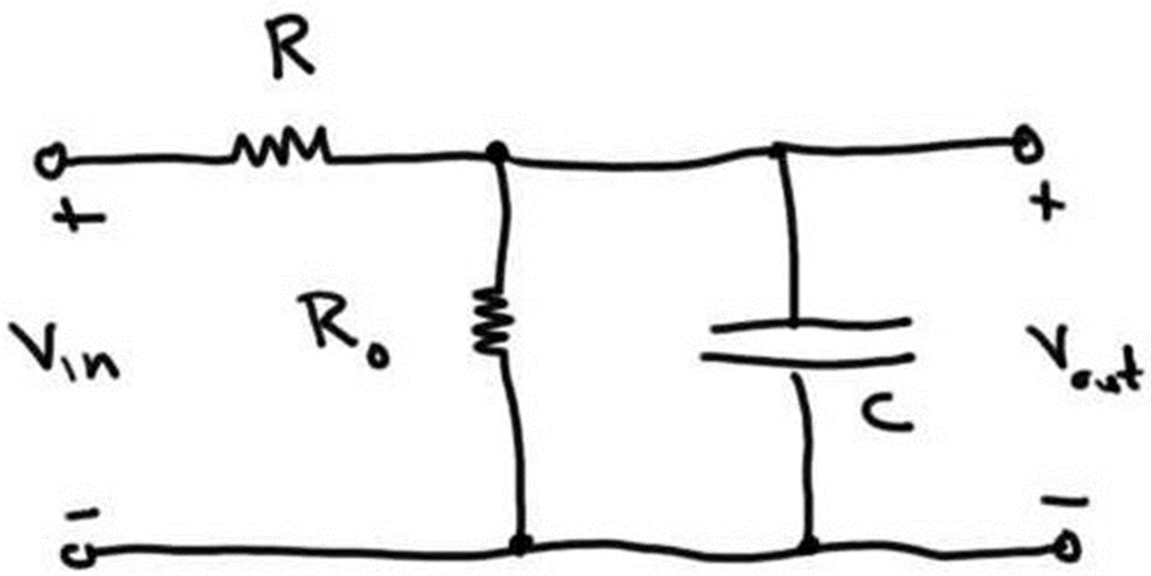




From the figures above, we can see the green wave as the original wave and the changes in vertical control would be the yellow one. The vertical setting controls the volts per division along the y-axis. The figure from the left shows that decreasing the vault will expand the yellow wave visually from the oscilloscope with a settings of 200 mv. On the other hand, the figure from the right shows the yellow wave that shrinked when the control set up to 2V. Visually, we can see that the amplitude changes.

3) RC Circuit Total Score: /30

Figure 1. RC Circuit



Connect the circuit shown in Figure 1 above. Choose the value of R from your lab kit so that there is about a 45° phase shift from V_{in} to V_{out} for a 1 kHz sine wave. Use the calculation from the prelab to help with your choice of R. Connect V_{in} to the function generator (set for 1 volt p-p 1 kHz and 0 volts DC offset). Connect Channel #1 of the oscilloscope to V_{in} and Channel #2 to V_{out}. You should now observe the relative time position of the circuit input and the circuit output on the oscilloscope. Include a picture of the waveforms below. **Make sure that both Ch1 and Ch2 have the same settings**. Otherwise you cannot significantly compare the two waveforms.

	Theoretical Value	Experimental Value
R	1.6 kΩ	1.584 kΩ
R_0	100 kΩ	100.30 kΩ
C	100 nF	98.2 nF

Table 1. RC Circuit Data

Theoretical Solution:

$$f = 1\,kHz = 1000\,Hz$$

$$\omega = 2\pi f = 2\pi(1000\,Hz)$$

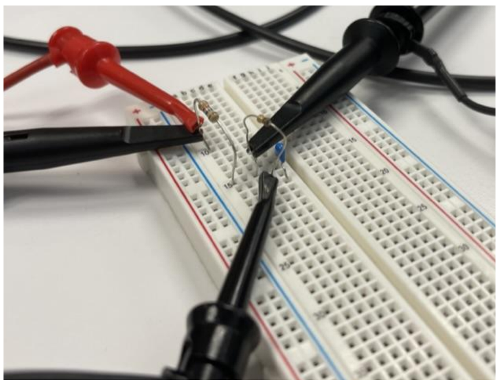
$$= 2000\pi$$

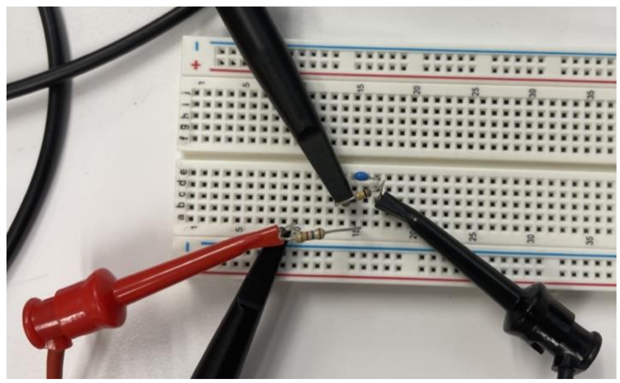
$$R = \frac{R_o}{R_o j\omega C - 1}$$

$$= \frac{100\,k\Omega}{(100\,k\Omega)\,(j)\,(2000\pi)(100\,nF) - 1}$$

$$= -\,25.32 - j1591.14$$

$$= 1591.34 \simeq 1.6\,k\Omega$$





The yellow line represent V_{in} and the green line represents V_{out}. With the 1600 Ω resistor we chose, there is a 45° phase shift from V_{in} to V_{out}.

4) Conclusion Total Score: /10

Explain in a few paragraphs the purpose of the lab, the experimental set up and methodology, and central results of the lab and these experiments. **You should be quantitative** in this summary. Include any important equations used and explain their significance. Write the conclusion as if you were writing an English essay. This is an important portion of the lab, so make sure to do a good and thorough job.

The purpose of this lab is to get us familiar with using an oscilloscope. We learned the different functions and capabilities of what an oscilloscope can do. To calibrate the oscilloscope, we set the oscilloscope probe to X1 and the ratio to 1:1. We tested to see if we set it up correctly by setting it to a known signal. We set the signal to 1 V and it matched with what the oscilloscope was showing. By doing so, we knew the oscilloscope was properly calibrated. The next part is getting us familiar with how to use the waveform generator. Using the same 1 V signal, we turned the signal into a sine wave, and after that, into a pulse waveform. The waveform generator has different settings such as frequency, amplitude, offset and width. These all control how the waveforms are displayed. The next part was observing what the waveforms looked like when adjusted vertically and horizontally. Ch1 and Ch2 are both connected to the oscilloscope. We only adjusted the Ch1 and observed how it affected the waveform compared to Ch2.

The last part was connecting a RC circuit to an oscilloscope. We had to choose a resistor that would cause a 45° phase shift from V_{in} to V_{out}. The resistor we chose was 1600 Ω. When the circuit was connected to the oscilloscope, we were able to observe a 45° phase shift.