American International University-Bangladesh (AIUB)

AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH (AIUB)
Faculty of Engineering
Department of EEE and CoE
Undergraduate Program

Course: **INTRODUCTION TO ELECTRICAL CIRCUITS LAB** **MID,** **Fall 2021** Group: 02

Title:- To be familiar with the operations of an oscilloscope and measuring corresponding AC quantities from the waveforms obtained from the oscilloscope.

Submitted by:-

Name	ID	Section	Email
Rahman, Sheikh Talha Jubayer	19-41468-3	**Q**	jubayertalha194@gmail.com
Shifat, Mahabub Hasan	19-41460-3	**Q**	mahabub.shifat@gmail.com
Khanom, Afrida	19-41444-3	**Q**	afridakhanomkibriaarni@gmail.com
Das, Atanu	20-42914-1	**Q**	dasatanu348@gmail.com
Md. Aftabuzzaman Dhruba	19-41506-3	**Q**	aftab.dhruba@gmail.com
Amit Podder	20-42273-1	**Q**	aprudra0011311@gmail.com
Rahman, Rahat	20-43401-1	**Q**	rahat9747@gmail.com
Asha, Nahida Akther	19-41190-2	**Q**	nahidaasha1@gmail.com

Submitted To

Md Rabiul Islam
Lecturer
Faculty of Engineering
Department of EEE
American International University-Bangladesh

Title:-

To be familiar with the operations of an oscilloscope and measuring corresponding AC quantities from the waveforms obtained from the oscilloscope.

Introduction:-

The purpose of the experiment is:

- To become familiar with the Function Generator and Oscilloscope.
- To measure peak value, peak-to-peak value, average value, rms value, time period, frequency, and phase difference using an oscilloscope.

Theory and Methodology:-

i) Function Generator: A function generator is usually a piece of electronic test equipment used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source). Integrated circuits used to generate waveforms may also be described as function generator ICs. Function generators cover both audio and RF frequencies.

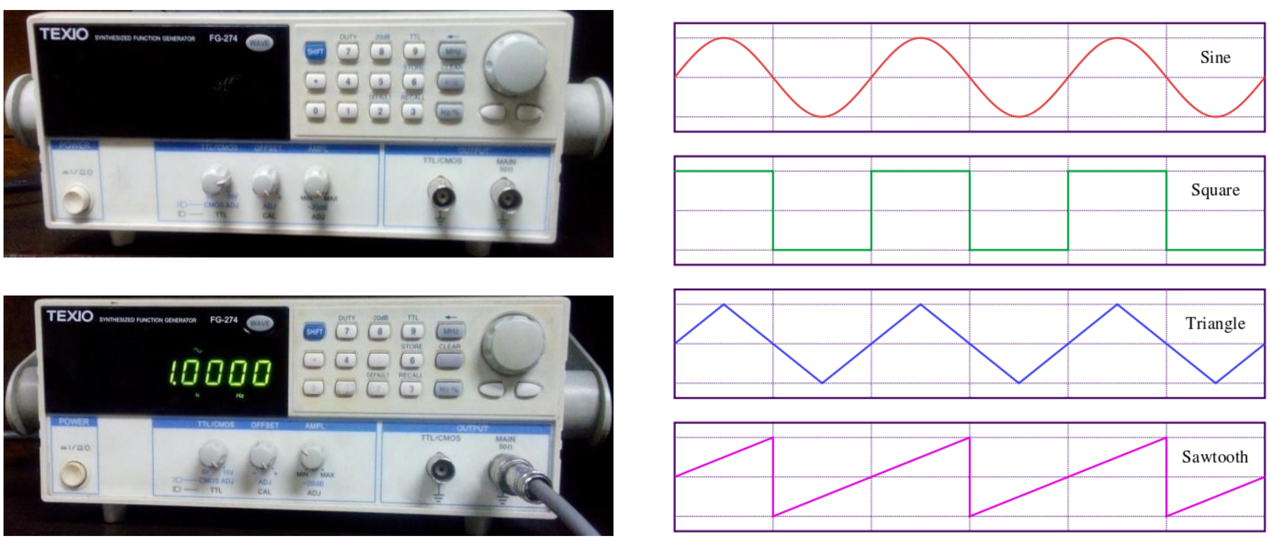
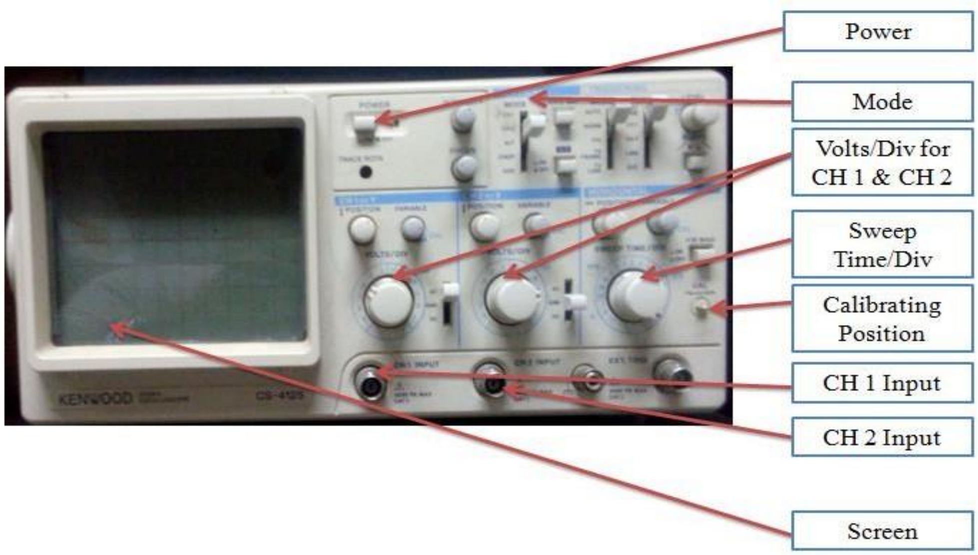


Figure-1: Typical Function Generator and Different Wave shapes

ii) Oscilloscope: The oscilloscope is a device for observing and taking measurements of electrical signals and waveforms. The analog oscilloscope consists of a cathode ray tube (CRT) which displays a graph, primarily voltage versus time. It also has one or more amplifiers to supply voltage signals to the CRT and a time base system for generating the time scale. Some of the modern digital oscilloscopes use liquid crystal display screens for the same purpose. There are three controls for the screen, which are focus, intensity, and beam finder knobs. Besides the screen, there is also a vertical section and a horizontal section.

This device allows real-time graphs of voltage versus time to be drawn on the screen. This allows studying and comparing various voltage waveforms in circuits. Usually, two waveforms can be displayed simultaneously. There are two channels for taking input voltage waveform. The oscilloscope shows the amplitude of voltage waveform along the Y-axis and time along the X-axis.

<u>Figure-2:</u> An Oscilloscope



<u>Figure-3:</u> Different Parts of an Oscilloscope

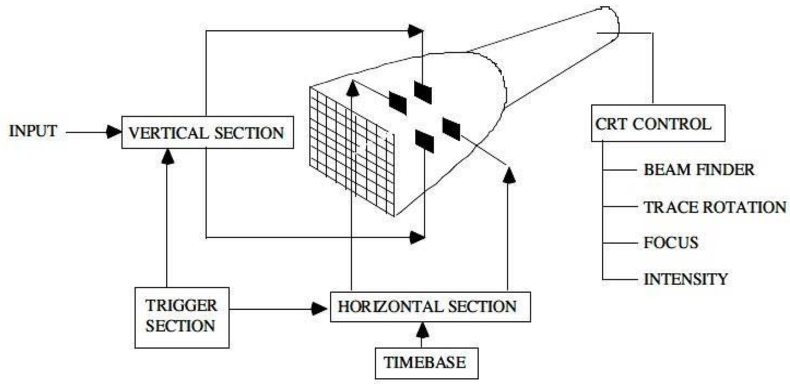


Figure-4: Functional Diagram of Oscilloscope

iii) Oscilloscope Probe: An oscilloscope probe is a high-quality connector cable that has been carefully designed not to pick up stray signals originating from radio frequency (RF) or power lines. They are especially useful when working with low voltage signals or high-frequency signals which are susceptible to noise pick up.

Figure-5: Oscilloscope Probe

iv) Basic Operations of an Oscilloscope:

The Trace: The trace is one of the most basic operations of an oscilloscope. The oscilloscope draws a trace, which is a horizontal line, across the screen. The time base control determines how quickly the trace (also called a sweep) is drawn. When the voltage becomes negative or positive, the viewer displays a correspondingly positive or negative jump in the trace on the screen.

Vertical and Horizontal Sensitivity Controls: These controls allow the user to determine manually the sensitivity, both vertically and horizontally. This allows oscilloscopes to accommodate a wide range of input amplitudes.

Focus Control: This allows users to adjust the sharpness of the trace. New flat-panel models do this automatically.

Beam Finder: This control prevents the trace from deflecting off-screen or otherwise being blocked. Because the beam finder prevents the trace from deflecting off-screen, it may temporarily distort the trace.

Timebase Control: This control determines how quickly the oscilloscope draws the trace. This control allows users to manually select the sweep speed, which is in seconds per unit on the square grids (graticule) seen on the oscilloscope display.

Intensity Control: The intensity control determines how intensely the trace is drawn. For CRT models, high intensity is desirable for fast traces, and low speed lower intensity. Speed is unimportant for LCD models.

Types of Sweeps: There are four types of sweeps: triggered, recurrent, single, and delayed. Triggered sweeps reset the screen every time the trace reaches the right end of the screen, and are useful for periodic signals like sine waves. Recurrent and single sweeps are more common on older models and are less useful for qualitatively observing signals. Delayed sweeps allow users to get a very detailed look at voltage.

AC Fundamentals:-

Waveshape: The shape of the curve is obtained by plotting the instantaneous values of voltage or current as the ordinate against time as an abscissa (X-axis value) is called waveform or wave shape [1].

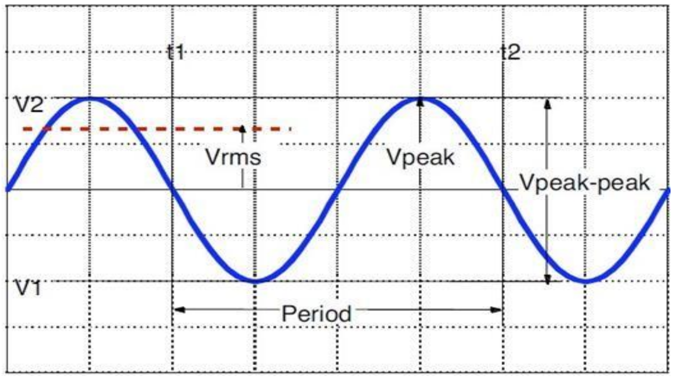
Cycle: One complete set of positive and negative values of an alternating quantity is called a cycle. One complete cycle is 2π or 360^0 [1].

Time Period: The time required to complete one cycle of the alternating quantity is called a period, expressed by the symbol T [1].

Frequency: The no. of cycles per second is called the frequency of the alternating quantity. Unit is Hertz (Hz). Frequency, $f = (1/T)$ Hz [1].

Peak Value: The maximum instantaneous value of a function or waveform is called the peak amplitude [2].

Peak to Peak Value: It is the sum of the magnitude of the positive peak and negative peak of a given waveform [2]. For a voltage waveform it is denoted by $V_{P\text{-}P} = |V_m| + |-V_m| = 2V_m$.



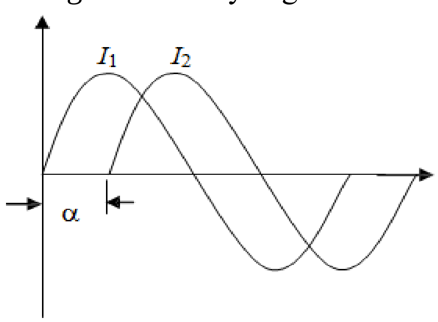
<u>Figure-6:</u> Characterization of a sinusoidal time-varying signal

Average Value: The steady current that transfers across any circuit the same charge as is transferred by that alternating current during the same time expresses the average value of a sinusoid [3]. $V_{avg} = 0.636V_m$, where V_m is the maximum value of the sinusoid.

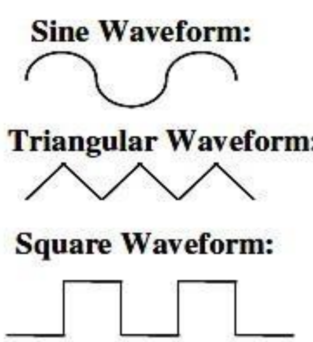
RMS Value: The Root Mean Square (RMS) value is the DC equivalent value of an alternating quantity which is given by that steady current which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current when flowing through the same circuit for the same time [3]. $V_{rms} = 0.707V_m$, where V_m is the maximum value of the sinusoid.
The digital multimeter (DMM) is used to measure DC currents and voltages. The DMM in the AC Mode can also be used to measure the RMS value of an AC waveform.

Phase Difference: Phase difference is the difference of phases corresponding to a similar point of two alternating waves (provided that the frequency of both waves must be the same).

Leading & Lagging Waves: In figure-7, there are two waves, Wave I_1 and Wave I_2. Wave I_1 leads Wave I_2 by angle α or Wave I_2 lags Wave I_1 by angle α.



<u>Figure-7:</u> The phase difference between two waves

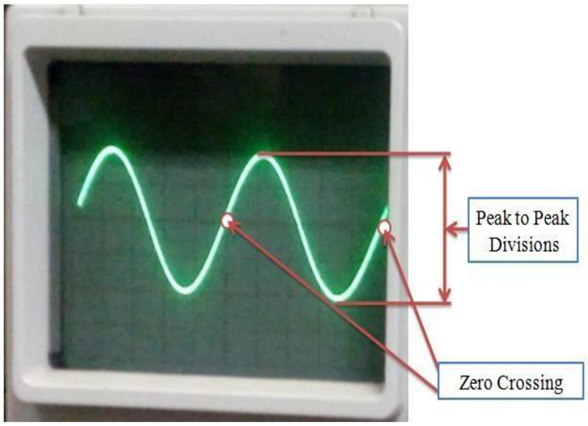


<u>Sine:</u> $V_{p\text{-}p} = 2\,V_p = 2\sqrt{2}\;V_{rms}$ or $V_{rms} = \dfrac{V_m}{\sqrt{2}} = \dfrac{V_p}{\sqrt{2}} = \dfrac{V_{pp}}{2\sqrt{2}}$

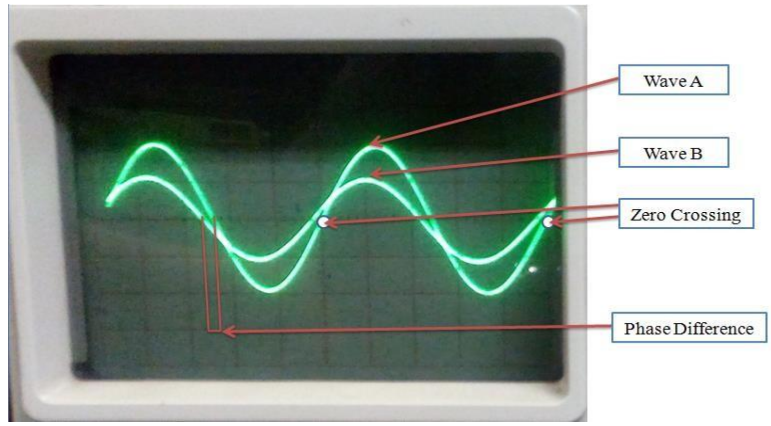
<u>Triangle:</u> $V_{p\text{-}p} = 2\,V_p = 2\sqrt{3}\;V_{rms}$ or $V_{rms} = \dfrac{V_m}{\sqrt{3}} = \dfrac{V_p}{\sqrt{3}} = \dfrac{V_{pp}}{2\sqrt{3}}$

<u>Square:</u> $V_{p\text{-}p} = 2\,V_p = 2V_{rms}$ or $V_{rms} = V_m = V_p = \dfrac{V_{pp}}{2}$

Measurements from Oscilloscope:-



(a)



(b)

Figure-8: Waveform(s) in oscilloscope in (a) single-mode and (b) dual-mode

In figure-8 (a), Vertical: 2Volts/Div and Horizontal: 0.2ms/Div. 4 divisions peak to peak times 2V/Div. Peak to Peak Value, V_{P-P} = (4Div) x (2V/Div) = 8V. Peak Value, V_P =4V. Average Value, V_{avg}= 0.636 x (4V) = 2.544V. RMS Value, V_{rms} = 0.707 x (4V) = 2.828V. 5 divisions between "zero crossing". Time Period, T = (5Div) x (0.2ms/Div) = 1ms. Frequency, f = (1/T) = (1/1ms) = 1kHz.

In figure-8 (b), there are two waves, Wave A and Wave B. The phase difference can be calculated by the equation, θ = [{Phase Shift (no. of div.)/T (no. of div.)} x 360˚].
1 division = 5 small divisions, Phase Shift = 1 small division and T = 25 small divisions.
θ = [{(1 small div.)/(25 small div.)} x 360˚] = 14.4˚. Wave B leads Wave A by 14.4˚ or Wave A lags Wave B by 14.4˚.

Apparatus:-

1. Function Generator
2. Oscilloscope
3. Probes and Connecting Wires

Precautions:-

The oscilloscope must be calibrated correctly before the start of the experiment. The frequency and waveform mode of the function generator must be set as per the requirement of the experiment.

Experimental Procedure:-

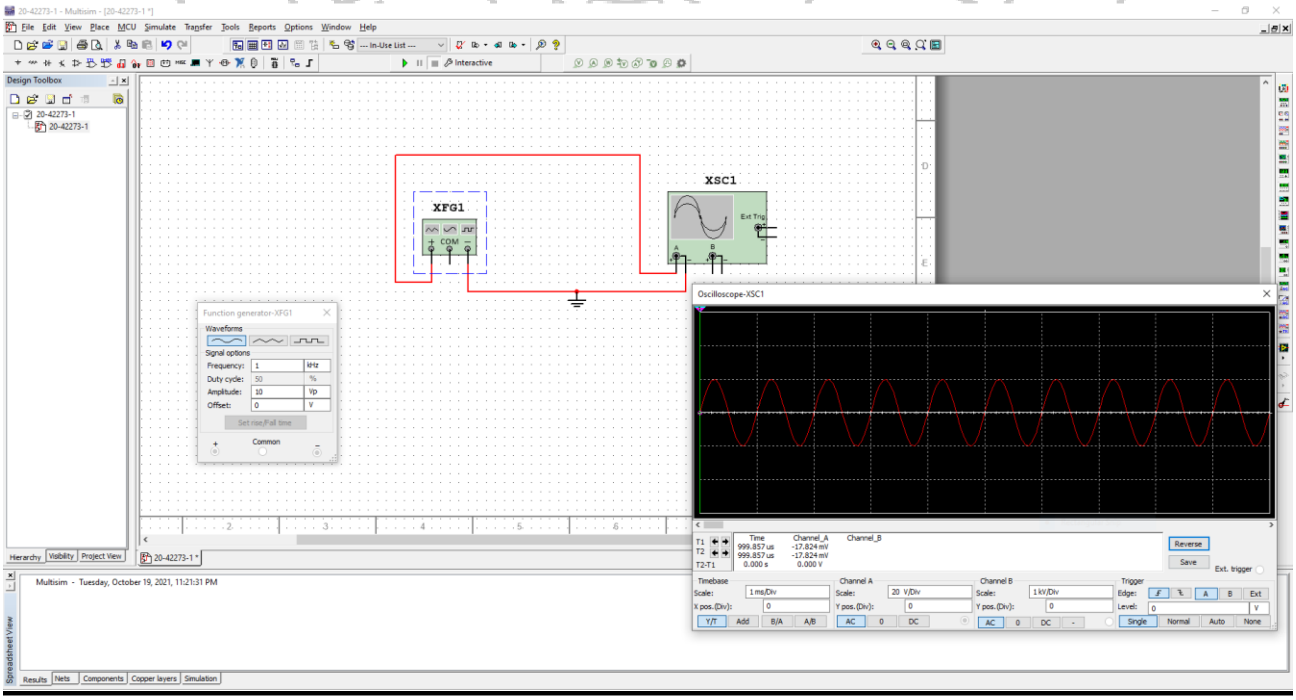
1. We have connected the output of the function generator directly to channel 1 of the oscilloscope. Then, we have set the amplitude of the wave 10V peak to peak and the frequency at 1 kHz. And, then we have selected a sinusoidal wave shape.

2. We have sketched the wave shape observed in the oscilloscope. Then, we have determined the time period of the wave and calculated the frequency.
3. We also changed the frequency to 2.5 kHz and note what happened to the display of the wave. Then, we have repeated when the frequency is increased to 5 kHz, 7.5 kHz, and 10 kHz.
4. Finally, We measured the peak value, peak-to-peak value, average value, rms value for all five frequencies.

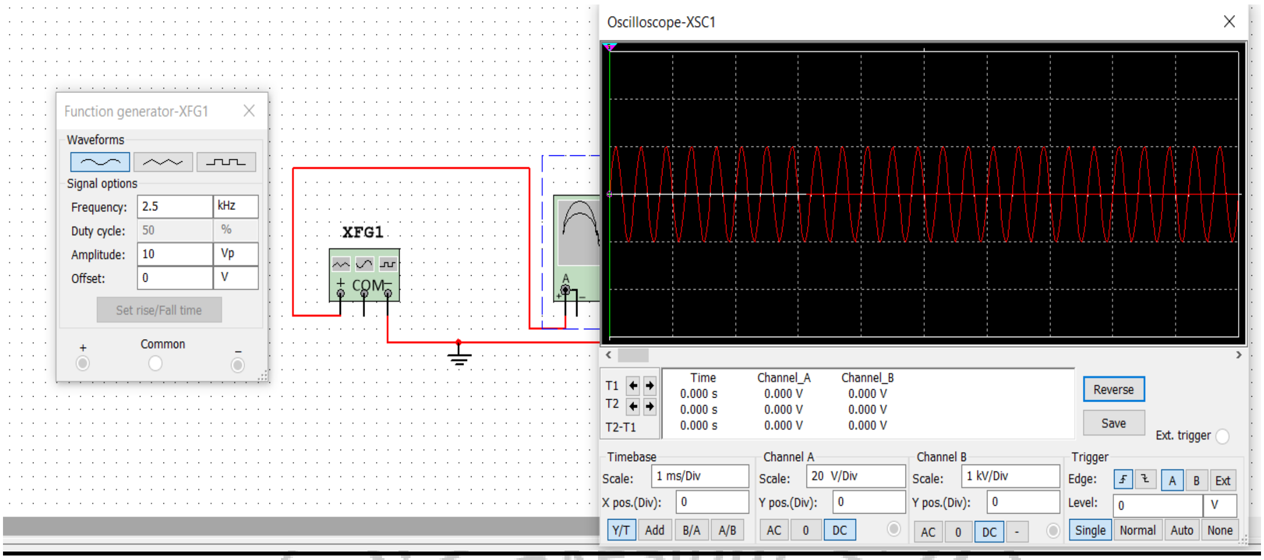
Data Table:

Table1

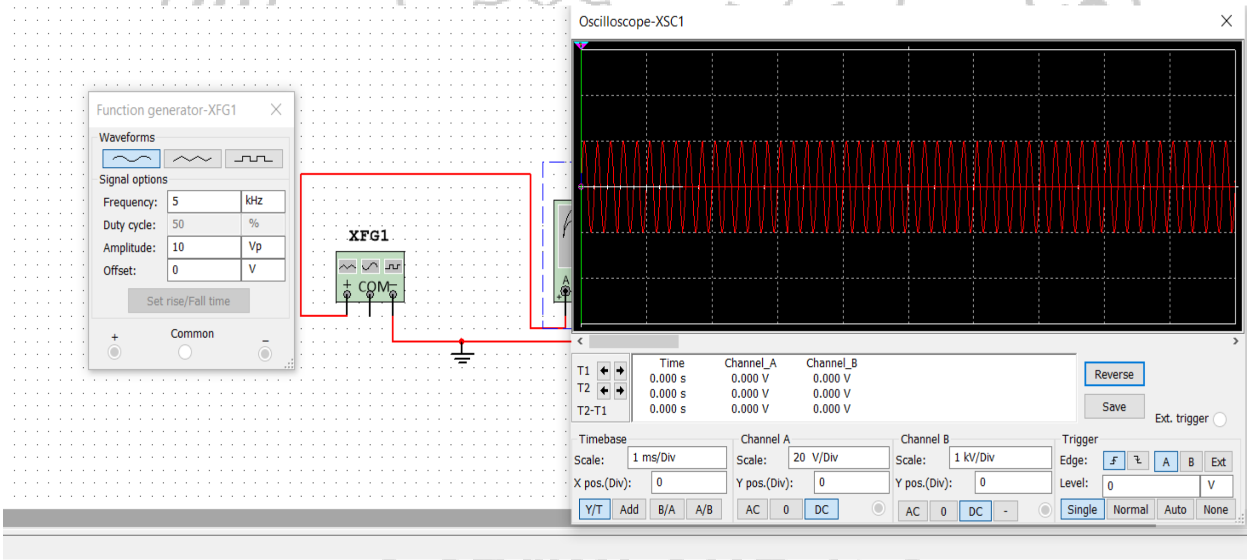
Frequency (kHz)	Time Period (ms)	*VP-P* (Volts)	*VP* (Volts)	*Vavg* (Volts)	*Vrms* (Volts)
1	1	40	20	12.72	14.14
2.5	0.4	40	20	12.72	14.14
5	0.2	40	20	12.72	14.14
7.5	0.13	40	20	12.72	14.14
10	0.1	40	20	12.72	14.14



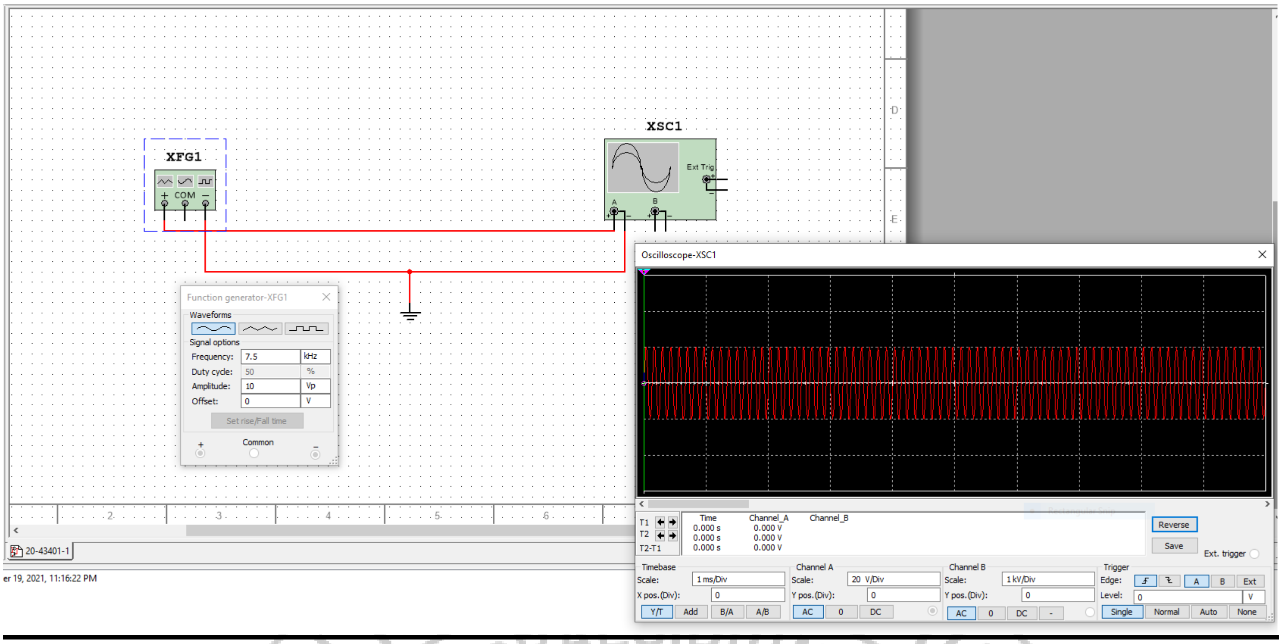
Frequency- **1 kHz**



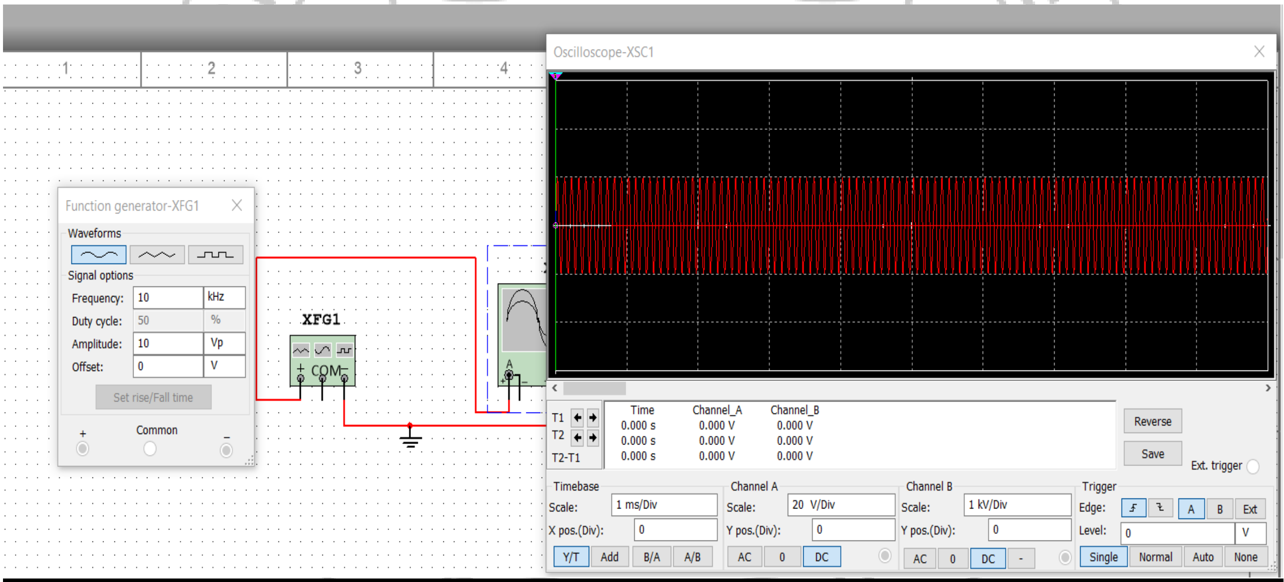
<u>Frequency-</u> 2.5 kHz



<u>Frequency-</u> 5 kHz



Frequency- 7.5 kHz



Frequency- 10 kHz

Report:-

Calculation:

Here,

f_1= 1 KHz

f_2= 2.5 KHz

f_3= 5 KHz

f_4= 7.5 KHz

f_5= 10 KHz

Now,

T_1= $1/f_1$ = 1 ms

T_2= $1/f_2$ = 0.4 ms

T_3= $1/f_3$ = 0.2 ms

T_4= $1/f_4$ = 0.133 ms

T_5= $1/f_5$ = 0.1 ms

V_p = 20 Volts

$V_{p\text{-}p}$ = 40 Volts

$V_{avg} = 0.636 * V_p = 0.636 * 20 = 12.72$ Volts

$V_{rms} = 0.707 * V_p = 0.707 * 20 = 14.14$ Volts

Conclusion:-

The data/findings from this experiment were analyzed to establish the extent to which the experiment was successful in compiling. The goal was initially established. By calculating and measuring the AC quantities from the waveforms obtained from the oscilloscope we were able to find the peak volts and peak to peak volts which were investigated and described.

Reference:-

[1] Russell M. Kerchner, George F. Corcoran, ″Alternating Current Circuits″, 4th Edition, Wiley, New York, 1960, pp. 48-50.

[2] Robert L. Boylestad, ″Introductory Circuit Analysis″, 10th Edition, Prentice-Hall, New York, 2005-2006, p. 524.

[3] Er. R.K. Rajput, ″Alternating Current Machines″, 3rd Edition, Laxmi Publications, New Delhi, 2002, p. (xi).