# AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

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

**Assignment No:** 07 **Date of Submission:** November 13, 2022

**Course Title:** Introduction to Electrical Circuits Laboratory

**Course Code:** COE2102 **Section:** T

**Semester:** FALL 2022-23 **Course Teacher:** BISHWAJIT BANIK PATHIK

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## Abstract:

The experiment was conducted to investigate the operations of an oscilloscope and measuring corresponding AC quantities from the waveforms obtained from the oscilloscope. The objectives of this experiment are to become familiar with the function genetor and oscilloscope also measure peak value, peak-to-peak value, average value, rms value, time period, frequency and phase difference by using oscilloscope. In this experiment, some basic tools like function generator, oscilloscope, probs and connecting wires etc. are used. By completing this experiment, we are able to develop the understanding of the function generator and 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.

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 screen 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 amplitude of voltage waveform along Y axis and time along X axis.

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.

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 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.

Time base 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, a high intensity is desirable for fast traces, and for 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:**

**Wave shape:** 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 $2\pi$ or 3600 [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 cycle 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 wave form [2]. For a voltage waveform it is denoted by $V_{P-P} = |V_m| + |-V_m| = 2V_m$.

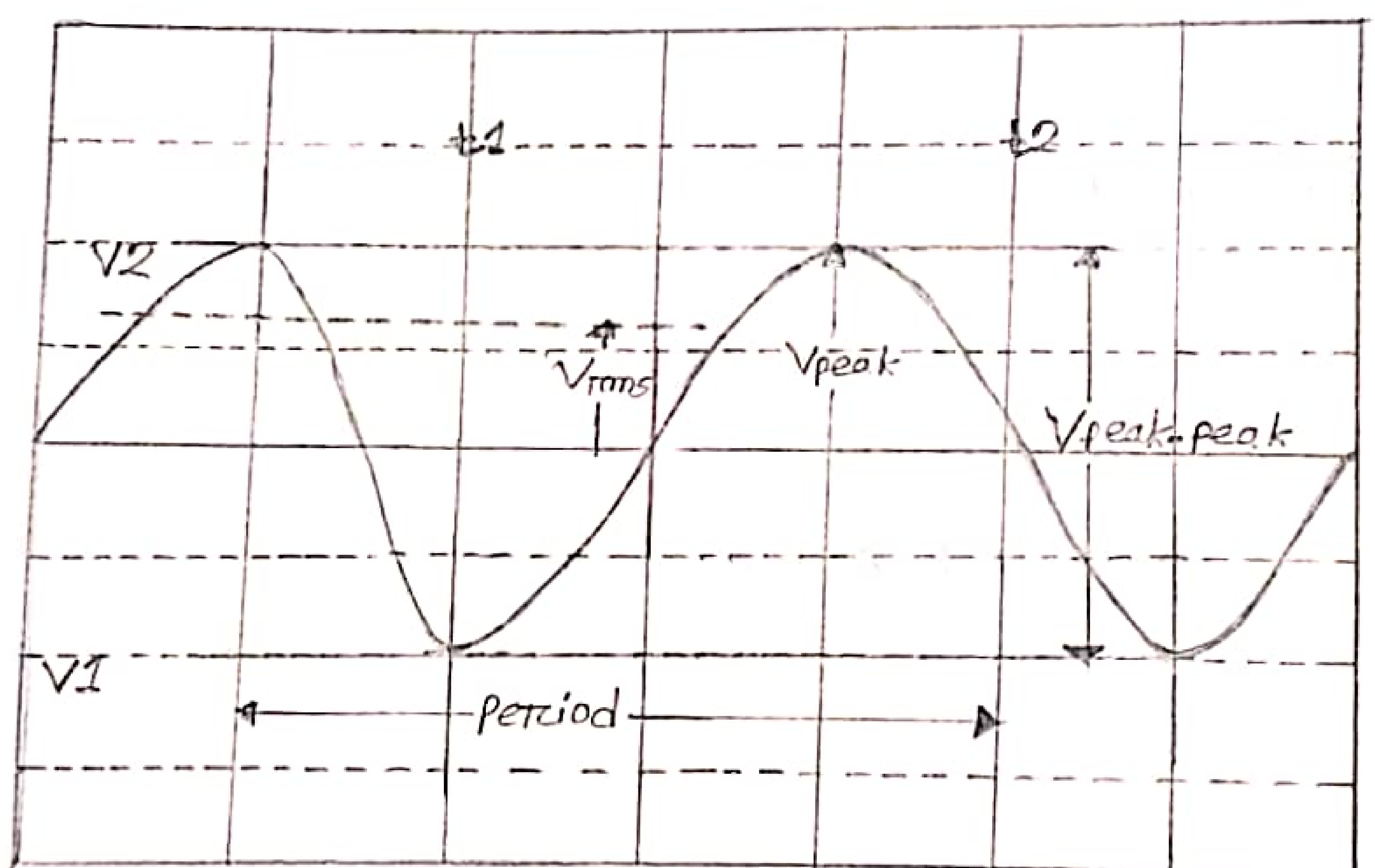



Figure-6: Characterization of sinusoidal time varying signal

**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]. $V_{avg} = 0.636 V_m$, 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].

$V_{rms} = 0.707 V_m$, 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 similar point of two alternating wave (provided that frequency of both waves must be 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 $\alpha$ or Wave $I_2$ Lags Waves $I_1$ by angle $\alpha$.

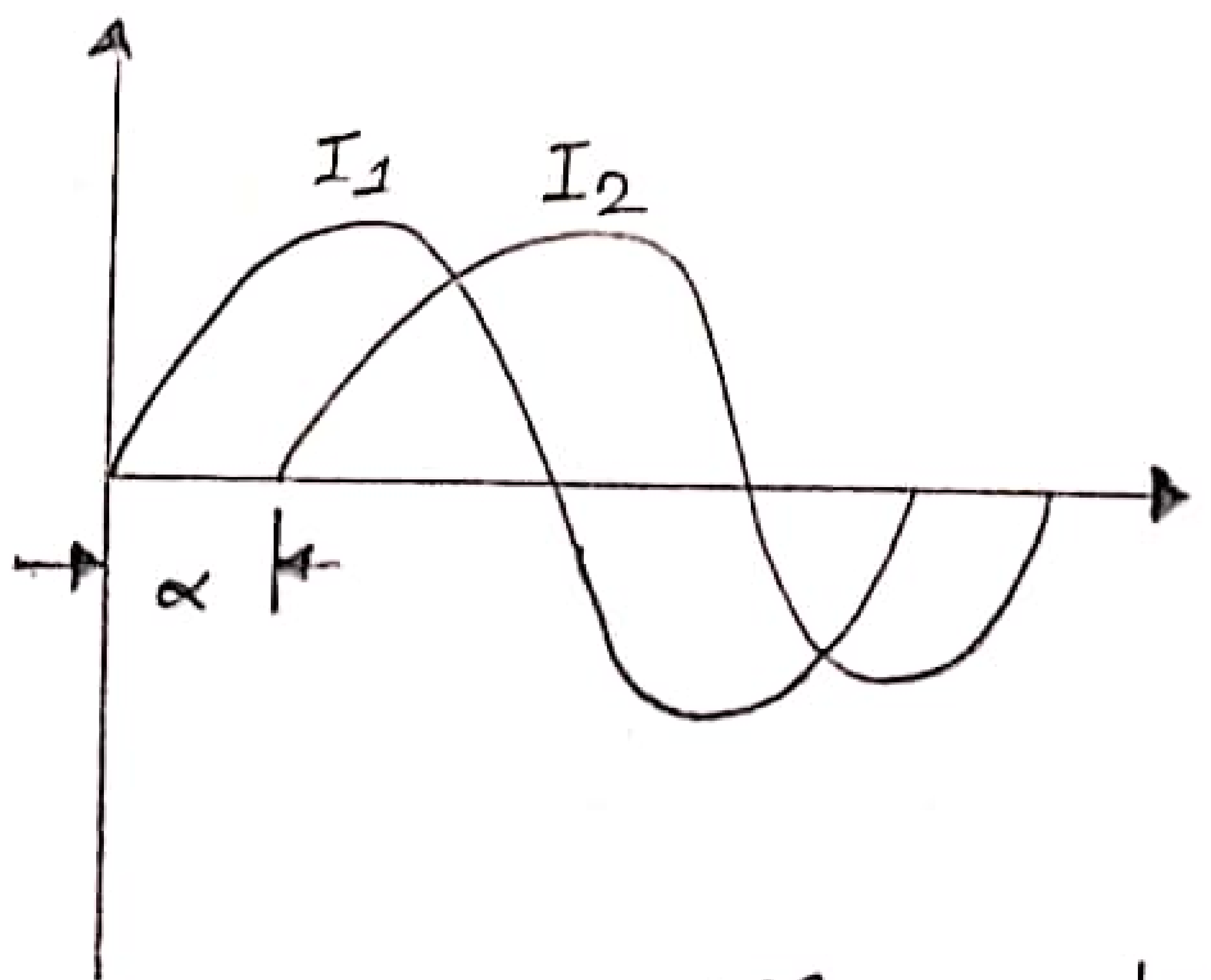



Figure-7: The phase difference between two waves

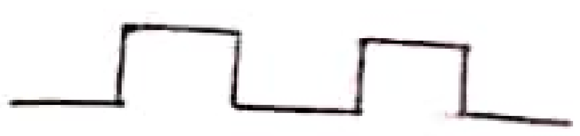
Sine Waveform:

Sine: $V_{p-p} = 2V_p = 2\sqrt{2}\, V_{rms}$ or $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{V_p}{\sqrt{2}} = \frac{V_{pp}}{2\sqrt{2}}$

Triangular Waveform:

Triangle: $V_{p-p} = 2V_p = 2\sqrt{3}\, V_{rms}$ or $V_{rms} = \frac{V_m}{\sqrt{3}} = \frac{V_p}{\sqrt{3}} = \frac{V_{pp}}{2\sqrt{3}}$

Square Waveform:



Square: $V_{p-p} = 2V_p = 2V_{rms}$ or $V_{rms} = V_m = V_p = \frac{V_{pp}}{2}$

Necessary diagram:

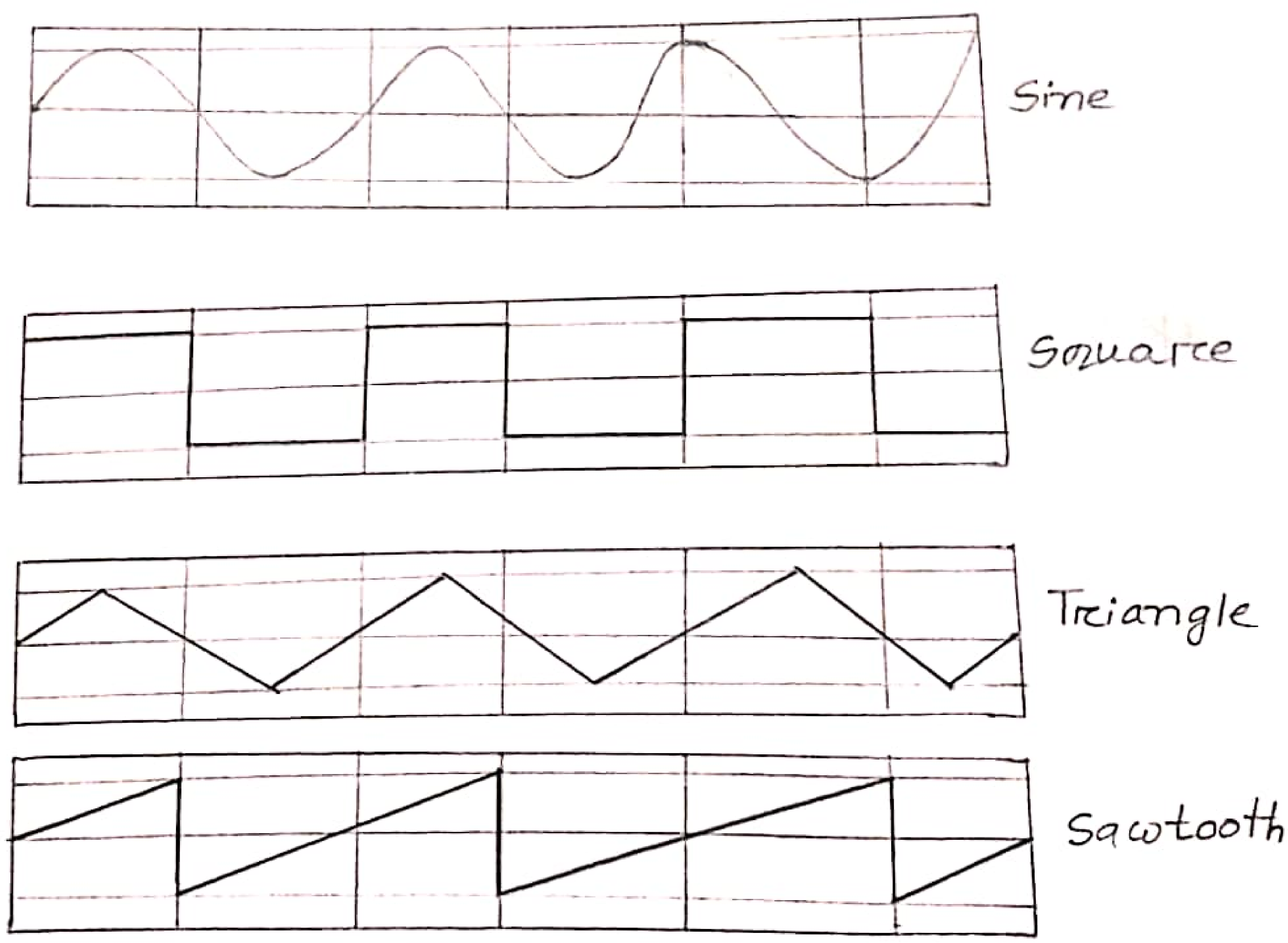



Figure-1: Typical Function Generator's different wave shapes

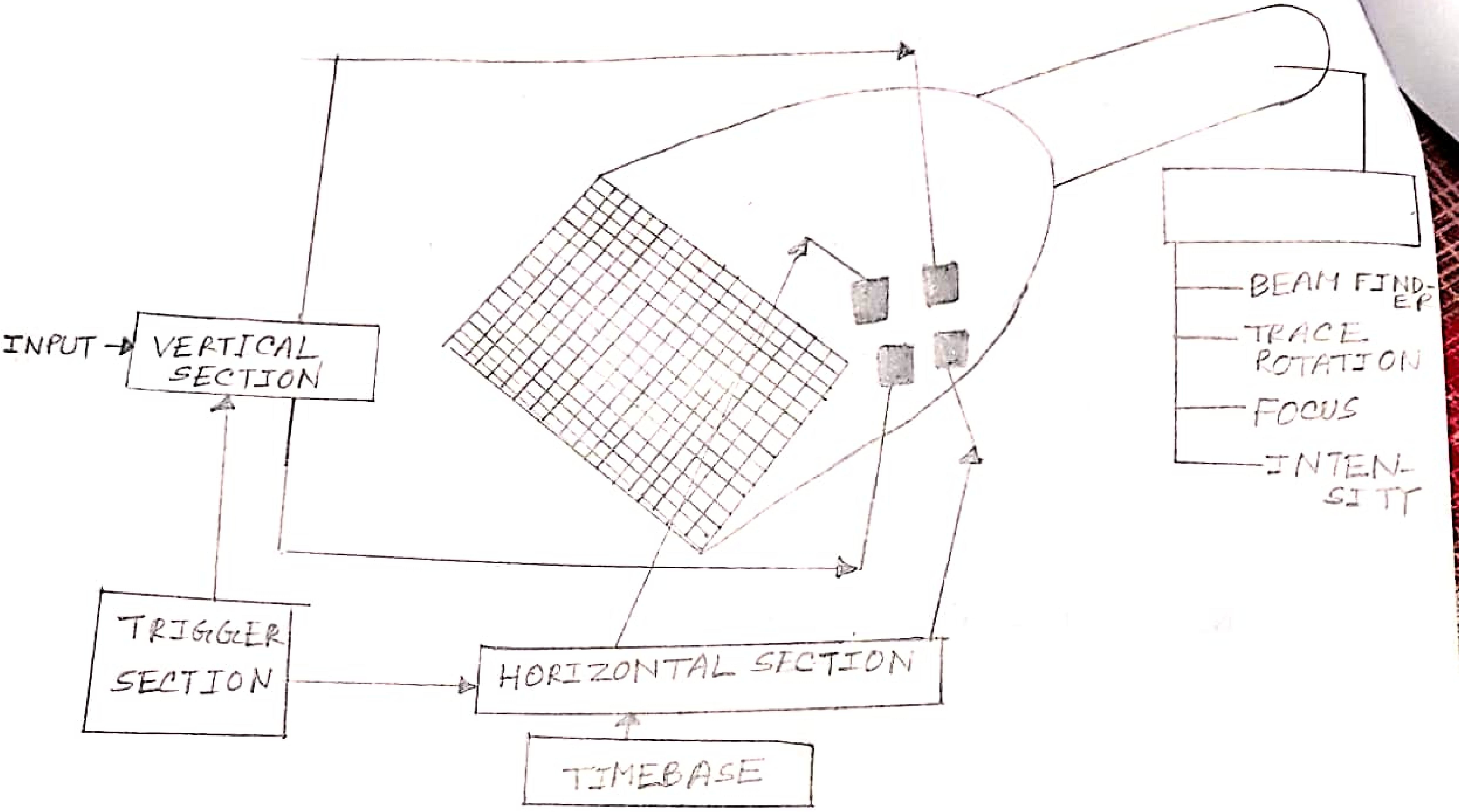



Figure-4: Functional Diagram of Oscilloscope

Apparatus:

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

Calculation:

| Frequency (KHz) | Time Period (ms) | Vp-p (Volts) | Vp (Volts) | Vavg (volts) | Vrms (Volts |
|---|---|---|---|---|---|
| 13 | 0.076 | 2.04 | 1.02 | 0.649 | 0.721 |
| 48 | 0.020 | 2.02 | 1.01 | 0.643 | 0.714 |
| 45 | 0.022 | 1.5 | 0.756 | 0.477 | 0.530 |
| 24 | 0.041 | 1.01 | 0.505 | 0.321 | 0.357 |
| 2 | 0.5 | 1.002 | 0.501 | 0.319 | 0354 |

When,
Frequency, $f = 13$ khz and
Peak value, $V_p = 1.02$ V

113 = 0.076 ms

1.02 = 2.04V

1.02 = 0.649 V

1.02 = 0.721 V

When,
Frequency, $f = 48$ khz and
Peak value; $V_p = 1.01$ V

148 = 0.020 ms

1.01 = 2.02 V

1.01 = 0.643V

1.01 = 0.714 V

When,

Frequency, $f = 45khz$ and

Peak value, $V_P = 0.750\,V$

$145 = 0.022ms$

$0.750 = 1.5V$

$0.750 = 0.477V$

$0.750 = 0.530\,V$

When,

Frequency, $f = 24khz$ and

Peak value, $V_P = 0.505\,V$

$124 = 0.0416ms$

$0.505 = 1.01\,V$

$0.505 = 0.321\,V$

$0.505 = 0.357V$

When,

Frequency, $f = 2khz$ and

Peak value, $V_P = 0.501\,V$

$12 = 0.5ms$

$0.501 = 1.002V$

$0.501 = 0.319\,V$

$0.501 = 0.354V$

Experimental Procedure:

1. We have connected the output of the function generator directly to the channel 1 of the oscilloscope. Then we have set the amplitude of the wave 10V peak to peak and the frequency at 1kHz. After that the sinusoidal wave shape is being selected.
2. We have sketched the wave shape observed in the oscilloscope. The time period of the wave and calculate the frequency is to be determined.
3. The frequency to 2.5kHz in changed and what happens to the display of the wave is noted. Then when frequency is increased 10kHz, it is repeated. The wave shapes for both cases in drawn.
4. We have measured the peak value, peak-to peak value, average value, rms value for all the five frequencies. Finally, we have filled the following table with necessary calculations.

Discussion:

In this experiment the output determined by using different steps like connecting function generator to the channel 1 of the oscilloscope. It had been learnt that how to select input signal by giving amplitude and frequency on the function generator. The output shape has changed with the frequency change of the function generator.

## Conclusion:

By completing this experiment we had become fimiliar with the function generator and oscilloscope. Measuring peak value, peak-to-peak value, average value, rms value, time period, frequency from factor and peak factor. Using oscilloscope had been learnt clearly.

## 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).