Exp (7)
Oscilloscope

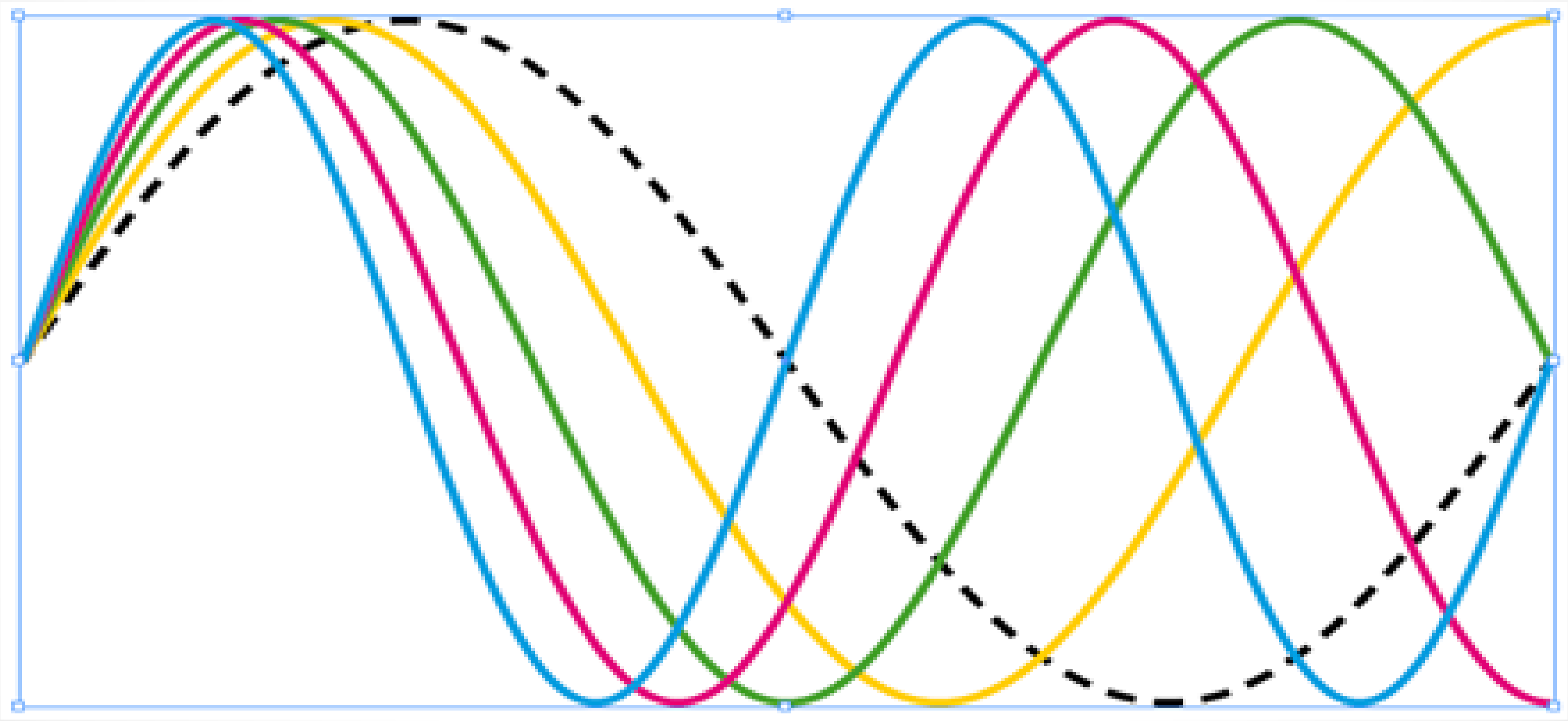
Main Objective

- In this experiment you are going to study two important lab instruments

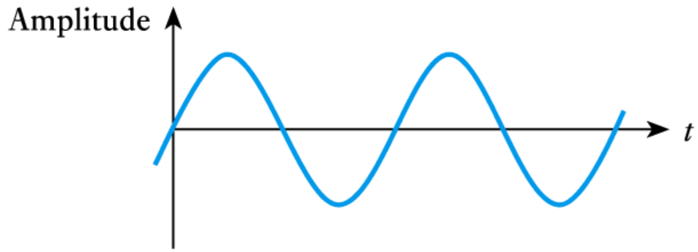
Oscilloscope & Function Generator

Introduction (Waves)

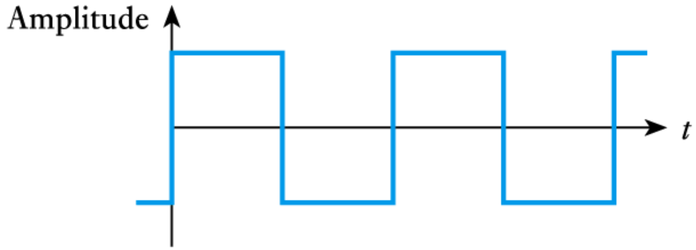
- A **wave** is an oscillation that travels from one place to another.



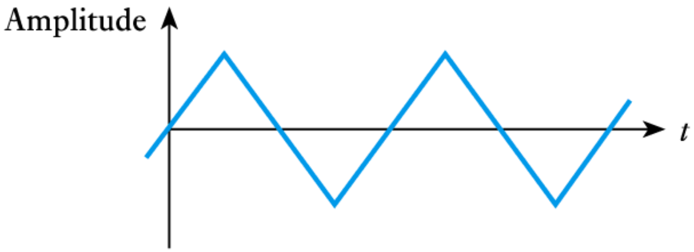
Types of Waves



(a) A sinusoidal wave



(b) A square wave



(c) A triangular wave

Sine waves

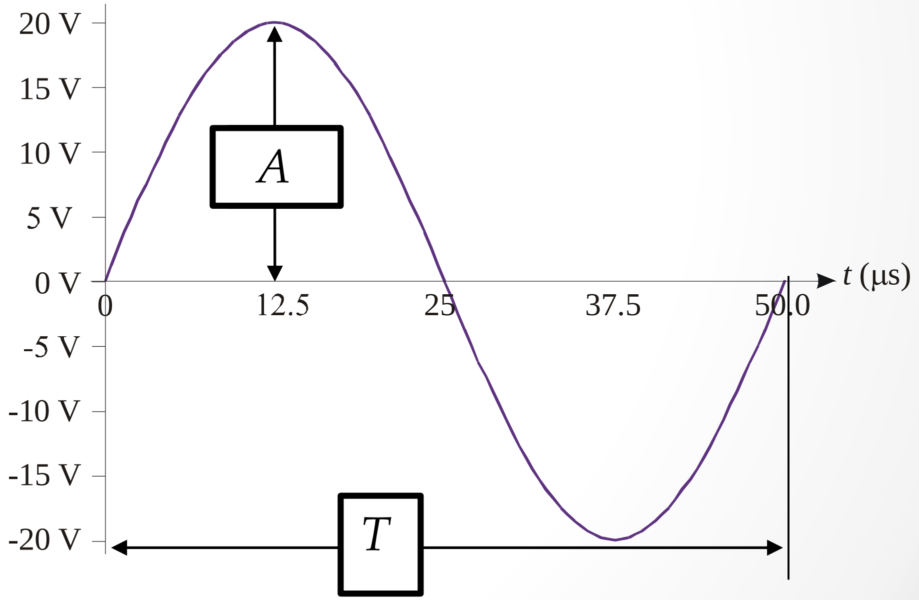
- Sine waves are characterized by the **amplitude** and **period**.
- The **amplitude** is the maximum value of a voltage or current.
- the **period** is the time interval for one complete cycle.

Example

- The amplitude (A) of this sine wave is

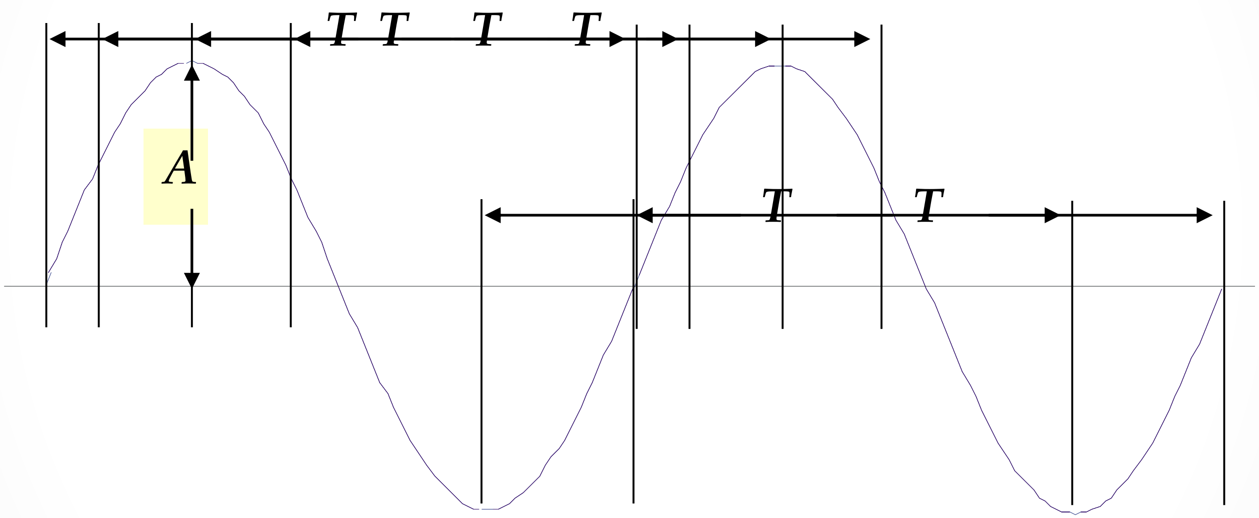
  20 V

- The period is 50.0 μs



Sine waves

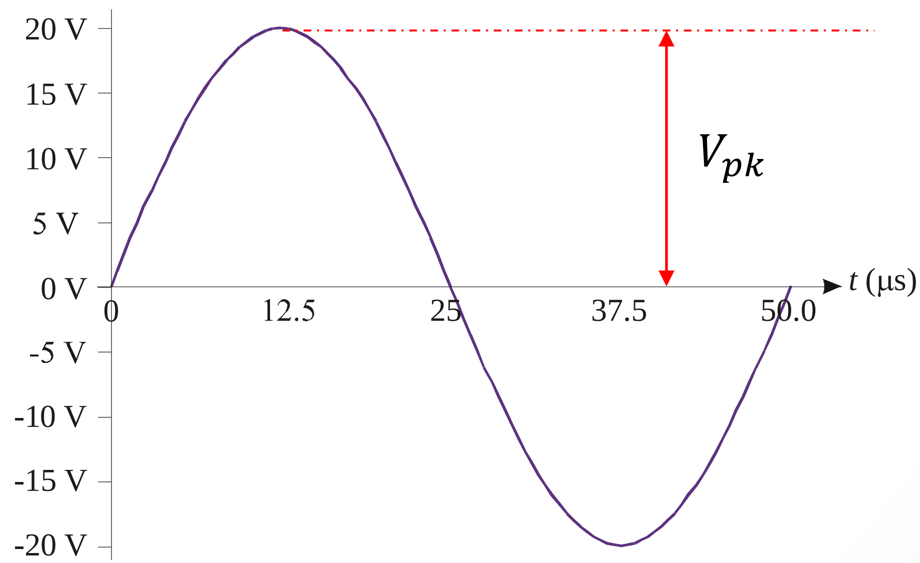
- The period of a sine wave can be measured between any two corresponding points on the waveform.



- By contrast, the amplitude of a sine wave is only measured from the center to the maximum point.

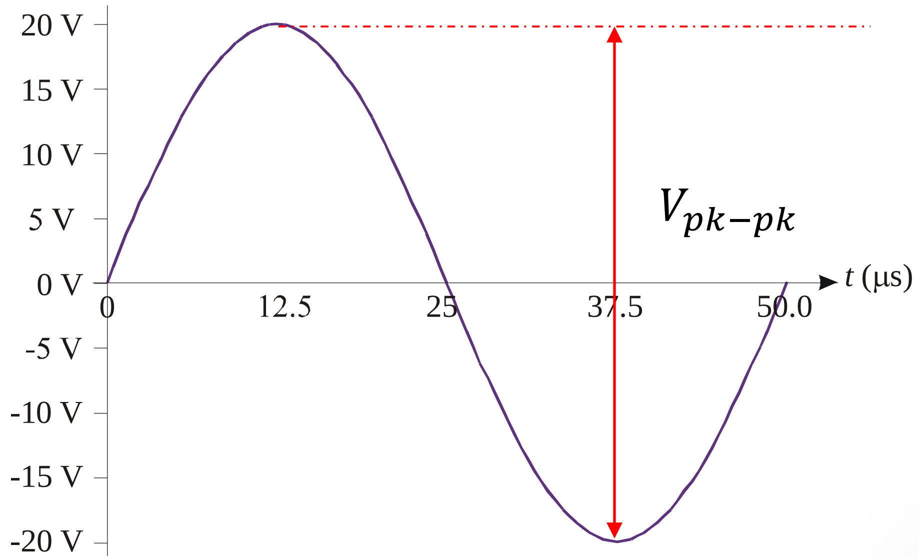
Sine waves

- ***Peak value:*** The value of the voltage at its maximum positive or negative points.



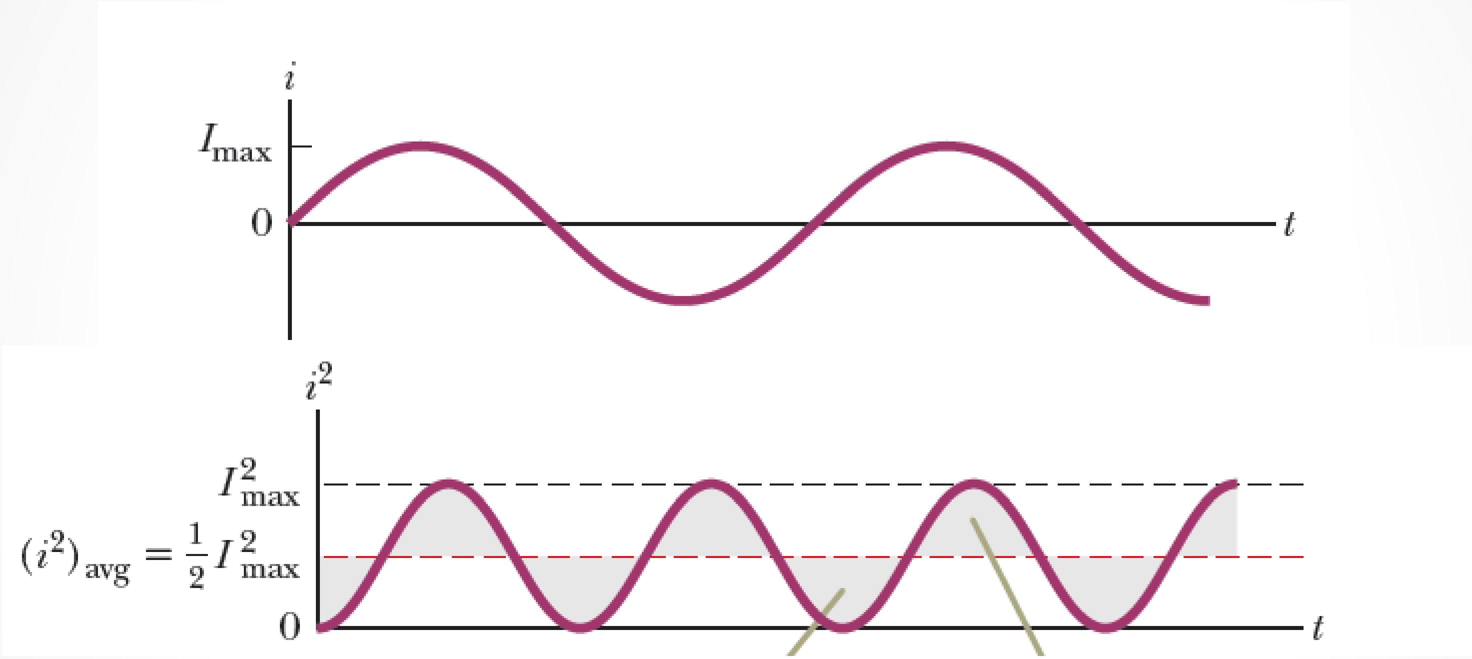
Sine waves

- ***Peak-to-peak value:*** The value of the voltage measured from its minimum to its maximum points.



Sine waves

- ***root-mean-square (rms)***: refers to the square root of the average value of the square voltage or current



$$I_{rms} = \frac{1}{\sqrt{2}} I_{max} \qquad V_{rms} = \frac{1}{\sqrt{2}} V_{pk}$$

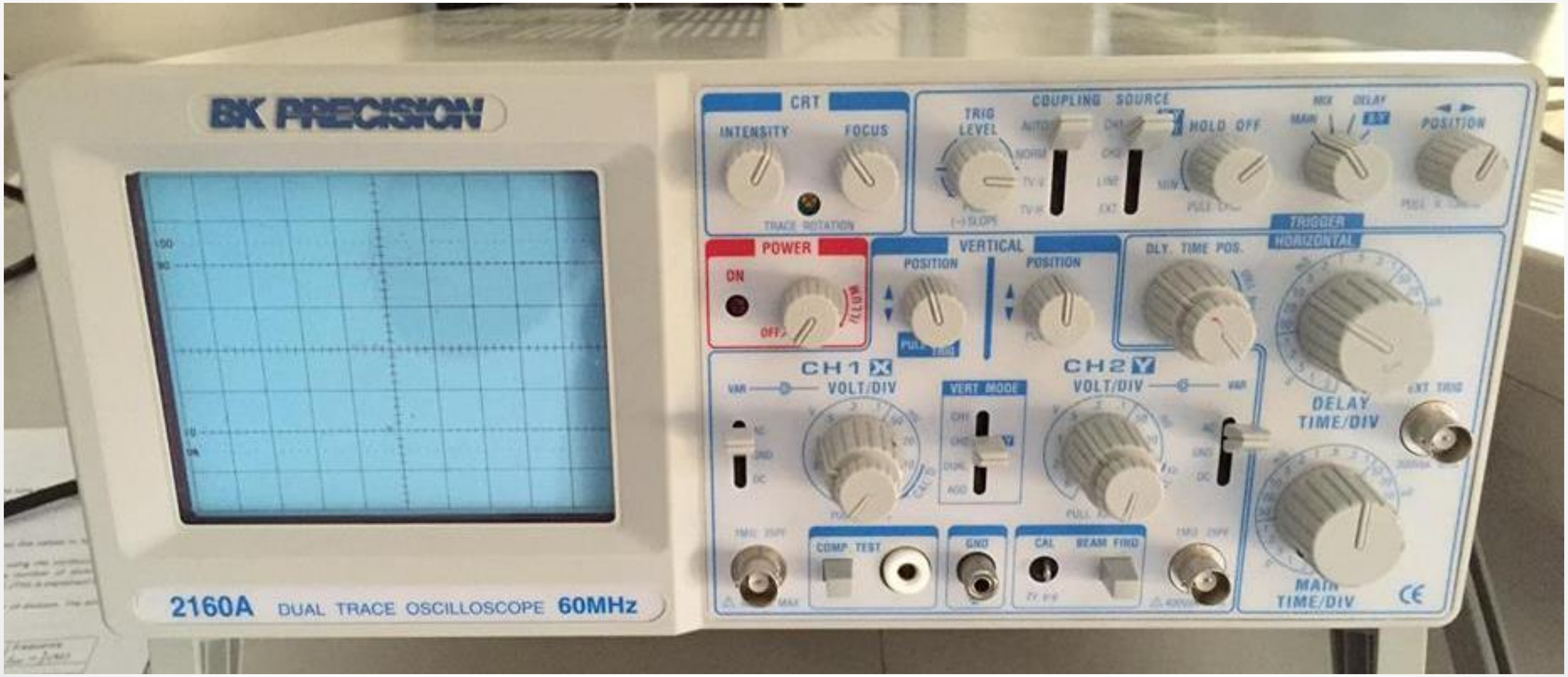
Sine waves

- ***rms Value***: can be defined as the "effective value"
- ***Vrms*** can be defined as the value indicated by the vast majority of AC voltmeters.

$$V_{pk-pk} = 2\,V_{pk} \qquad V_{pk} = \sqrt{2}\,V_{rms} \qquad V_{rms} = \frac{1}{\sqrt{2}}\,V_{pk}$$

Oscilloscope

- The oscilloscope is an instrument used to measure the voltage change with time and show it in a graphical format.

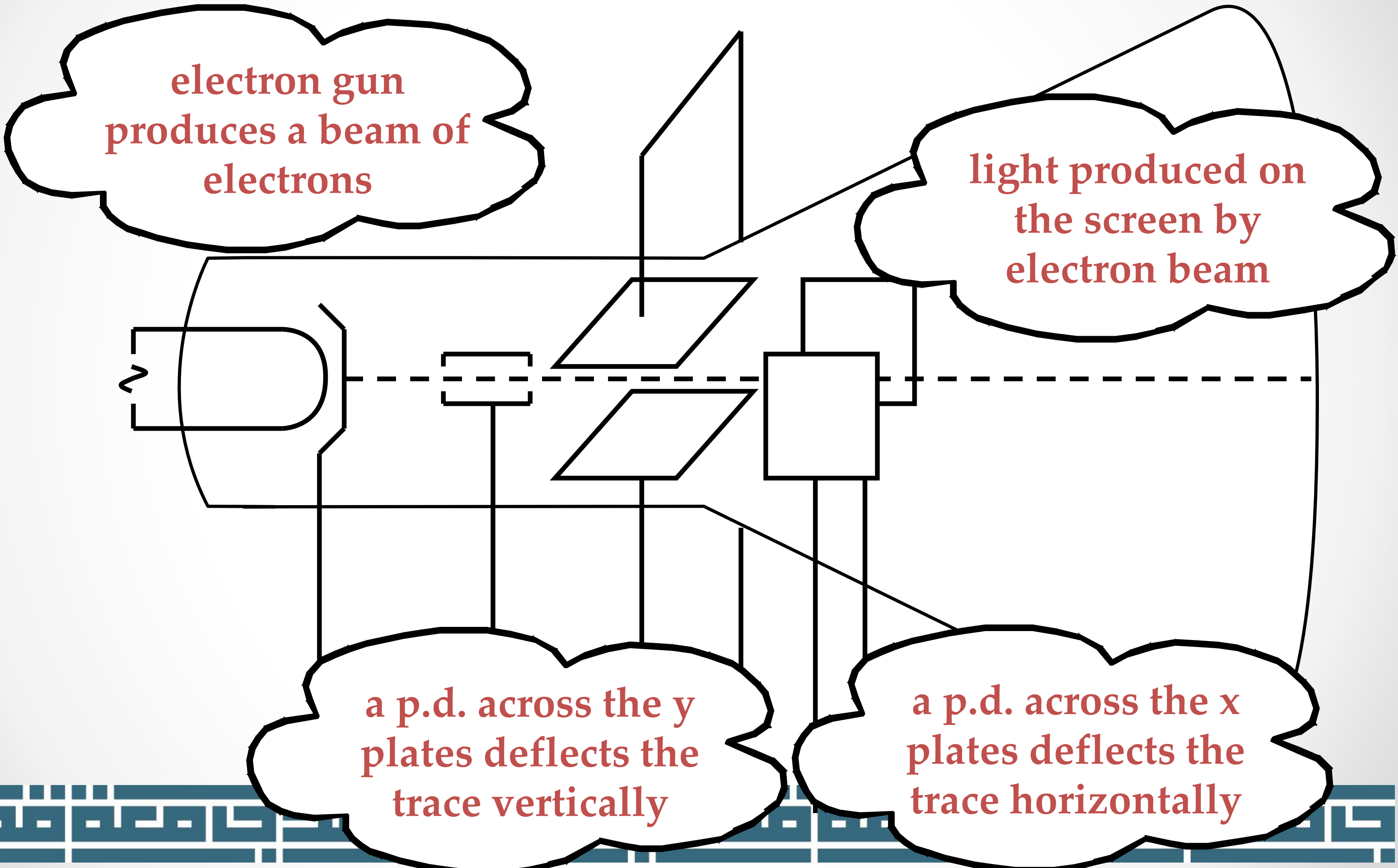


Composition of Oscilloscope

- The main component of an Oscilloscope is the Cathode Ray Tube (CRT).
- The CRT can be divided in three basic sections:

1) The electron gun which produces a focused electrons beam.
2) The deflection part where the beam is deflected in horizontal and vertical direction. The vertical deflection, usually, represents the measured voltage and the horizontal deflection represents time.
3) The screen which visualizes the position of the beam (beam spot). The screen has also a grid allowing the reading of the beam spot position (representing voltage versus time for example).

Composition of Oscilloscope



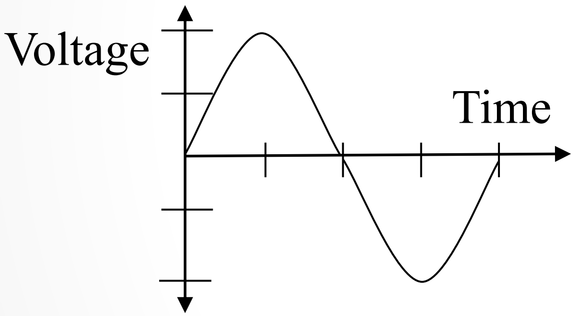
The main components

Display Screen
Displays an input signal with respect to time.

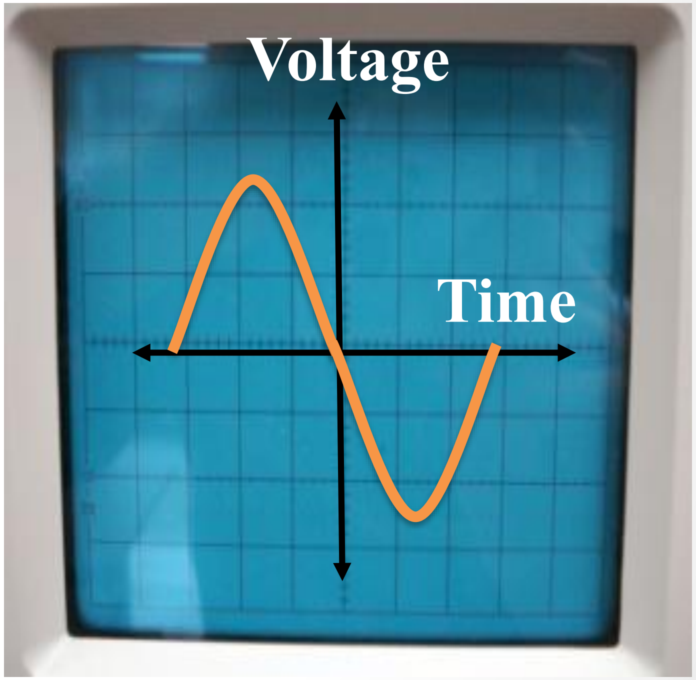
Control Panel
Adjusts how the input signal is displayed.

Oscilloscope: Screen

- **Display Screen:** Displays an input signal with respect to time.
- Here is the form of the alternating voltage signal.



- If we measure our signal with the oscilloscope, it would look like this

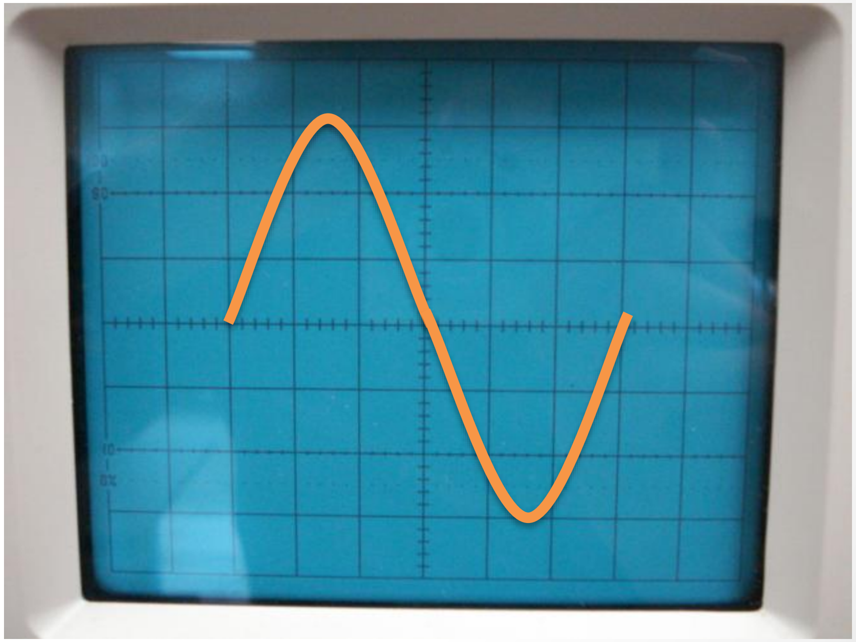


Oscilloscope: Screen

- The screen has ruled divisions both horizontally and vertically.

- If each vertical line represents 2 s, what is the period of this wave?

- If each horizontal line represents 3 volt. What is the peak value and the peak to peak value and the rms value of the voltage?



Oscilloscope: Control Panel

Oscilloscope: Control Panel

- POWER dial: Used to switch on/off the oscilloscope

Oscilloscope: Control Panel

Volts/Division Dial does not change the voltage.

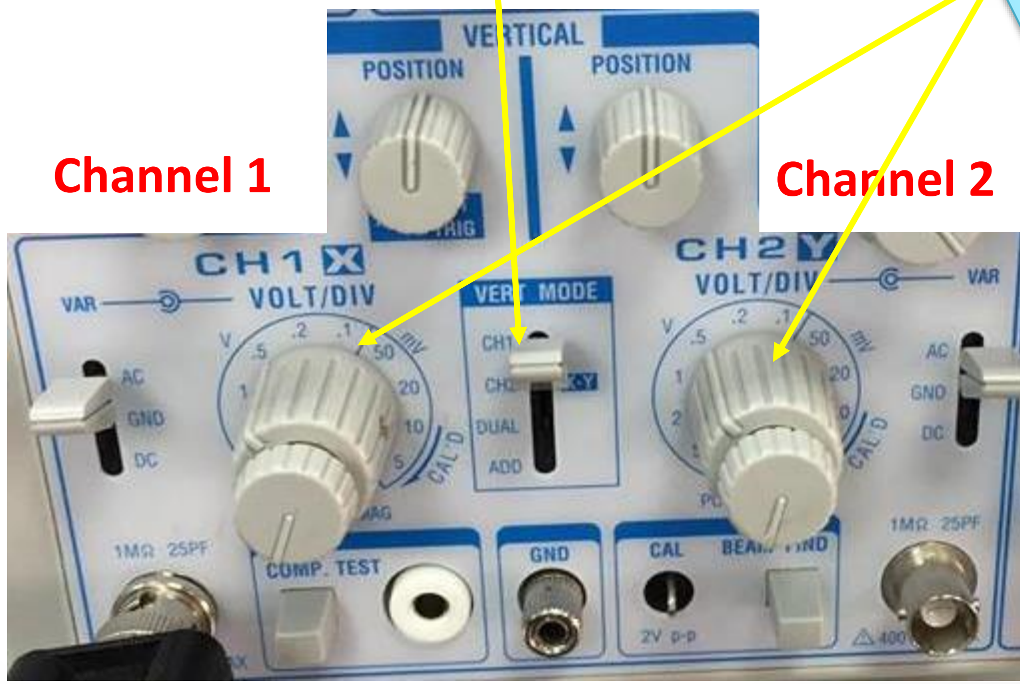
It is a sensitivity dial that allows us to measure a wide range of voltages by indicating how many volts are represented by each division.

In the center is a switch that determines which channel will serve as the input.

VOLT/Div dial. This dial controls the amount of voltage per centimeter division.

Channel 1

Channel 2



Oscilloscope: Control Panel

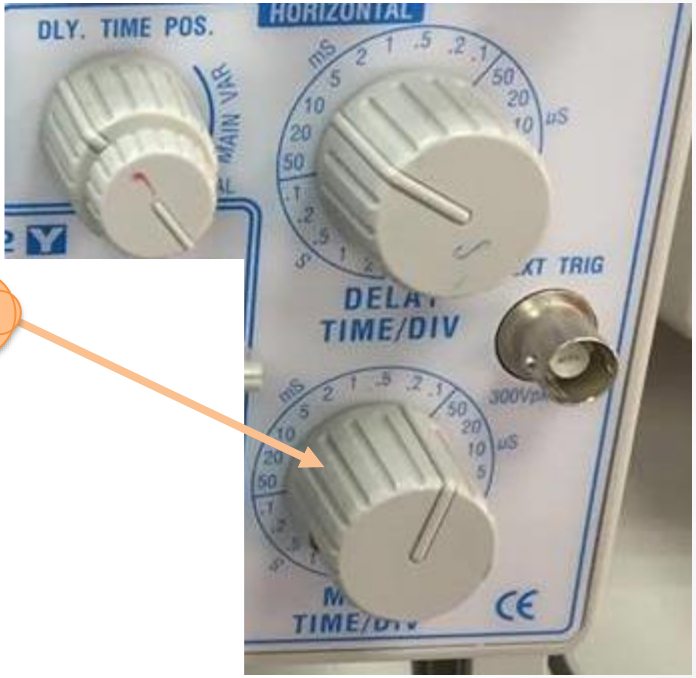
Horizontal Position

- This dial allows us to change the position of the displayed wave to the horizontally to the right or the left.

Oscilloscope: Control Panel

Time Per Division Dial

This dial allows us to controls the amount of time per centimeter division.



Oscilloscope: Control Panel

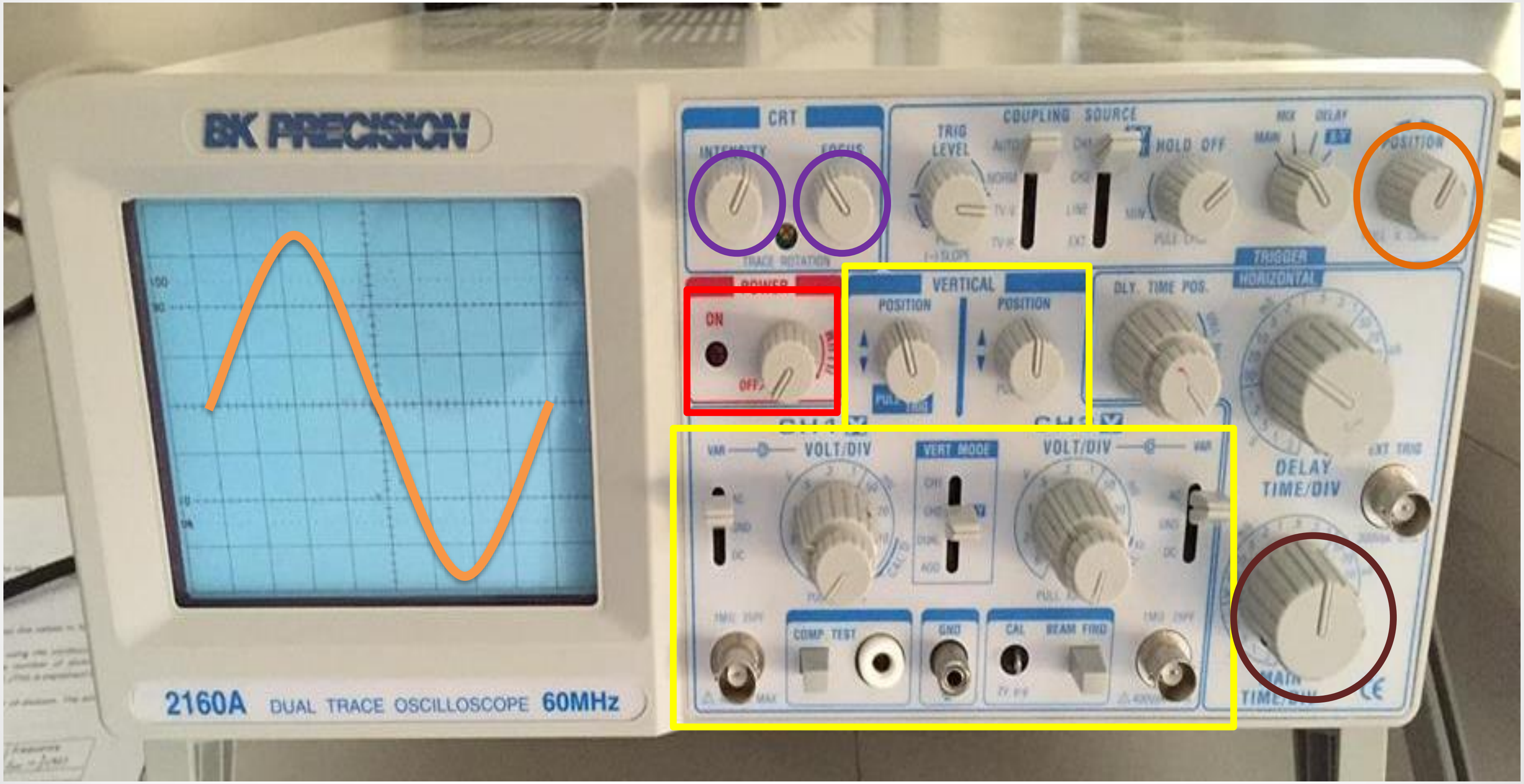
Adjusting the Display

- If the display is difficult or out of focus, the Intensity and Focus dials can be used to adjust it.

- The INTENSITY dial controls the brightness of the line.

- The FOCUS dial controls the sharpness of the line.

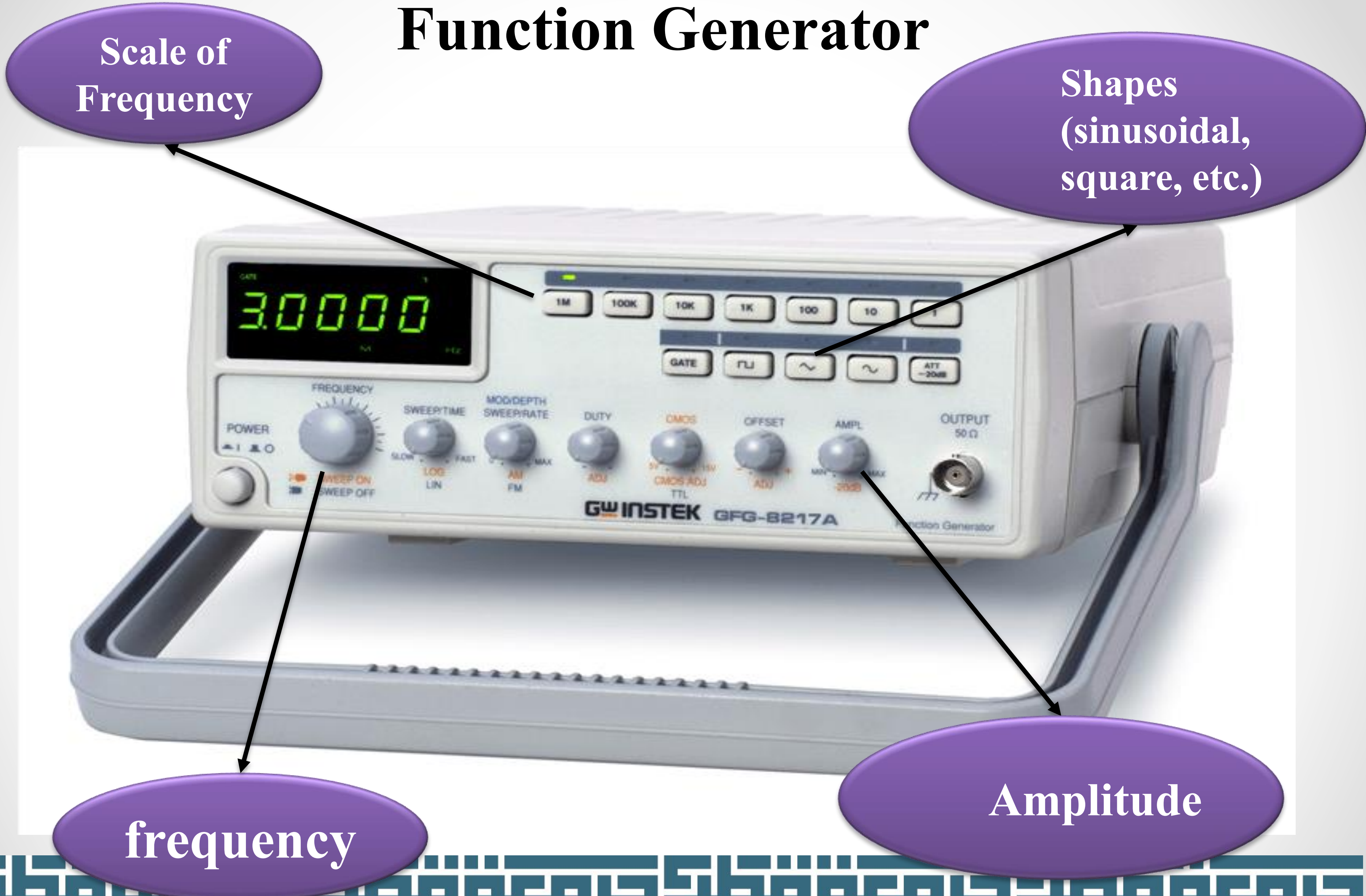
Oscilloscope



Function Generator

1) Function generators is an instrument that provide a variety of output waveforms over a wide frequency range.
2) The most common output waveforms are sine, square, and triangular.
3) The frequency range generally extends from a fraction of a hertz to several hundred kilohertz.

Function Generator



Equipment needed

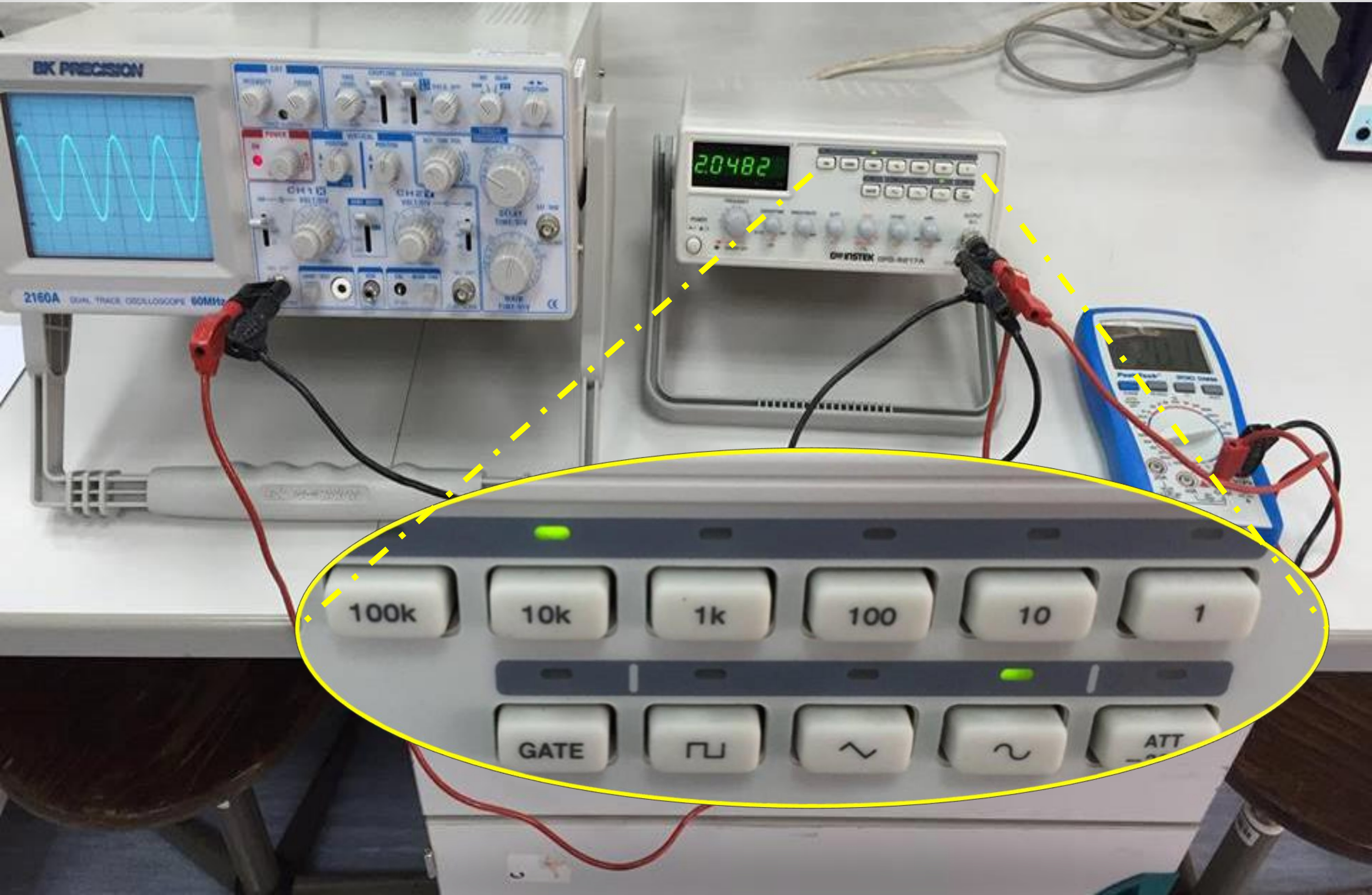
1. Oscilloscope.
2. Function generator.
3. Multimeter.
4. BNC connectors.

Experimental procedure

Part 1: Measurement of the frequency

1) Select the sinusoidal signal on the generator.
2) Vary the frequency on the function generator to take on the values in the following table. The amplitude should be fixed in this part.
3) For each frequency, on the function generator, measure using the oscilloscope the corresponding period T. You can do that by reading the number of divisions D spanned by **one full period** and multiply it by the time scale S.
4) Estimate the error on the generator frequency and the number of division. The error of the scale is 5%.
5) Calculate the frequency $f = 1/T$ and fill in the following table.

Experimental procedure



Experimental procedure

Part 1: Measurement of the frequency

Generator frequency f_{gen}	Number of division D (div)	Time scale S (s/div)	Period $T = D.S$ (s)	Frequency $f_{osc} = \frac{1}{T}$ (hz)
1000				
3000				
5000				
7000				
9000				

Data analysis

1) Plot, using Excel, f_{osc} versus f_{gen} and draw the error bars. Do not forget the units and titles.
2) Fit linearly your data and get the slope and the intercept.
3) Using the Excel function **linest** get the errors on the slope and intercept.
4) What are the expected values of the slope and intercept?

Experimental procedure

Part 2: Measurement of the amplitude

1) Select the sinusoidal signal on the generator.
2) Set the generator frequency to about 2 kHz.
3) Vary the amplitude on the generator so that you read, on the multimeter, the voltage values listed in the following table.
4) For each value read the corresponding amplitude on the Oscilloscope.
5) Do not forget to estimate the errors on your measurements.

Experimental procedure

Part 2: Measurement of the amplitude

Voltage RMS value on voltmeter V_{RMS} (volts)	Voltage Amplitude value on Oscilloscope V_{pk}(volts)
1	
2	
3	
4	
5	
6	

Data analysis

1) Plot, using Excel, V_{pk} versus V_{RMS} and draw the error bars. Do not forget the units and titles.
2) Fit linearly your data and get the slope and the intercept.
3) Using the Excel function **linest** get the errors on the slope and intercept.
4) The theory tells us that for a sine wave we do have $V_{pk} = \sqrt{2}\, V_{RMS}$. How do your measurements compare with the theory?

References

1) lab manual
2) Physics for Scientists and Engineers with modern Physics, tenth edition.

Thank you