Ministry of Higher Education and Scientific Research

Salahaddin University-Erbil

College of Education

Department of Physics

1st Stage

Laboratory of Electricity and Magnetism

Group (   )

Full Name:

Experiment Number: (1)

Name of Experiment: The Oscilloscope

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Experiment No (1)

The Oscilloscope

Aim of experiment (Objectives):

The aim of this experiment is to learn how to operate an oscilloscope by measuring the frequency of different waves.

Theory:

An oscilloscope is an electronic test instrument that displays the value of an electric signal over time. The display of the oscilloscope shows the amplitude (usually voltage) of a signal on the Y-axis, and time along the X-axis.

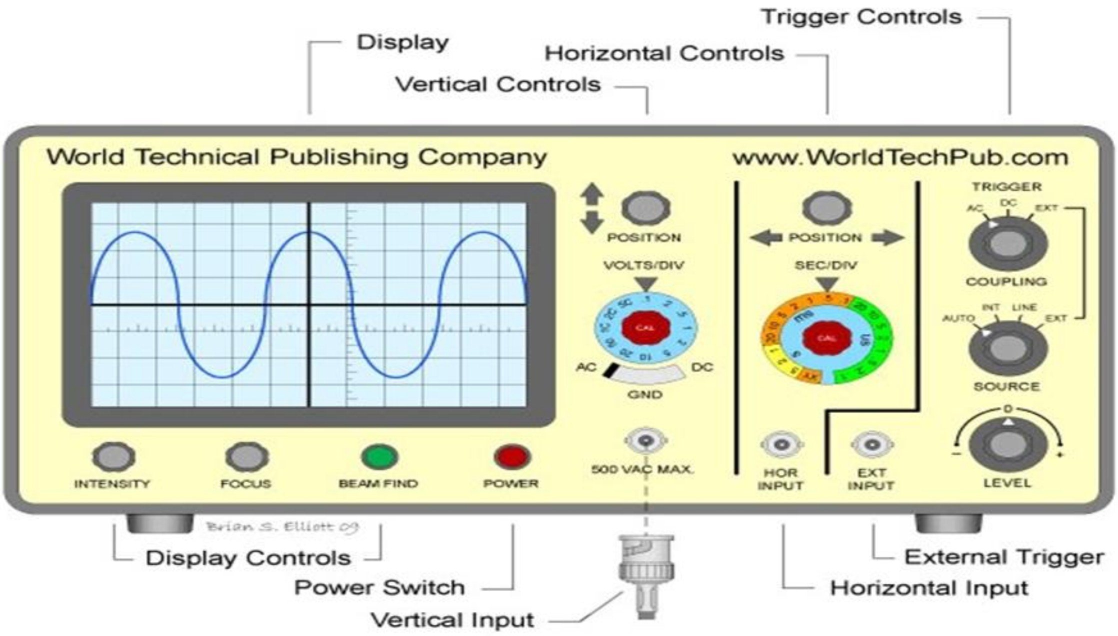
Oscilloscopes are commonly used to:

measure shape of a waveform (a graph of voltage over time),

measure amplitude and frequency of a signal,

and detect glitches and noise in a signal.

An Oscilloscope is essentially a Cathode Ray Tube (CRT) combined with appropriate circuitry so that it may be used as a voltmeter. From your lab on the CRT you may remember that a voltage applied to the horizontal plates of the CRT caused a vertical deflection of the electron beam. This deflection was proportional to the applied voltage. Therefore, the CRT can be used as a voltmeter to measure an unknown voltage applied to the horizontal plates. Calibration of the instrument is achieved by a grid of lines on the screen and by amplifying or attenuating the input signal so it fits the grid on the screen properly. An oscilloscope also contains a sweep generator that produces a time-varying voltage on the vertical plates of the CRT. This causes the electron beam to sweep horizontally across the screen. If the beam sweeps across the screen fast enough the sweeping dot on the screen appears as a line.



Display: The display on the oscilloscope shows the current status of the signal.

Analog Input Channels: The input channels are located on the front of the unit. The input channels are the industry standard Bayonet Neill Conceal man (BNC) connectors. The inner conductor carries the signal, and the outer shielding connects common ground. It is important to always have the oscilloscope connected to ground.

Analog Probes The scopes probes have a BNC connection on one end, and both ground and probe tip on the other end. Probes can be connected to any of the input channels on the front of the scope. The analog probes can be connected to any of the analog input channels. This allows different parts of a circuit to be simultaneously captured and analyzed.

Horizontal Scale Controls This knob on the oscilloscope adjusts the time per division. Turning the horizontal knob to the counterclockwise increases the time per division, and clockwise decreases the timer per division. The absolute minimum and maximum are determined by the properties of the oscilloscope. Generally, as the horizontal scale decreases more of the instantaneous details of the signal are visible but then less of the signal's period will be visible. If the scope has 12 horizontal graticules, and the time base is set for 1ms / division, then 12ms of the signal will be displayed at a given time.

Vertical Scale Controls The vertical scale on the scope adjusts the volts per division. Turning the knob counterclockwise increases the volts per division, and clockwise decreases it. As the voltage decreases, less peak to peak amplitude will be visible, but the signal will also show increased *sensitivity* (smaller changes to amplitude). If the scope has 8 vertical graticules and the voltage scale is set for 1V / division, then 8V of amplitude (peak to peak) can be displayed, which could be 4V to 4V, or 0 to 8V, or even 5V to 13V.

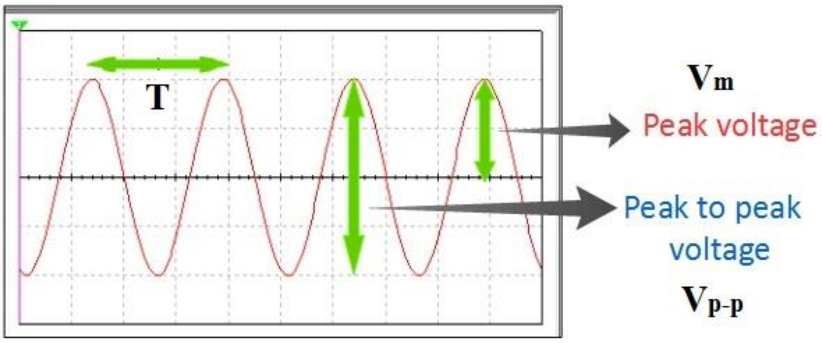
Horizontal Position Control This knob will change the displayed horizontal position. The scope captures more data that can be displayed on a screen. Change the horizontal position will allow different parts of the signal to be displayed

Vertical Position Control This knob will translate the drawn signal up and down on the screen. This is especially useful when there are multiple channels active or when the voltage has a *DC bias*. For example, if the capture signal has a peaktopeak amplitude of 5V to 13V, using the vertical control could bring the "top" of the signal down to the center of the screen, allowing a full range of display.

Trigger Control Most oscilloscopes have one or more different triggers. The trigger controls allow the selection and configuration of the trigger and the associated display options. For example, a common trigger mode is called *edge triggering* which can detect when a signal crosses a threshold. When this happens, the scope will display signal right before and right after the event.

We will be analyzing AC sinusoidal voltage signals in this lab. Such a voltage signal is characterized by voltage amplitude (V_m), a peak-to-peak voltage ($V_{P\text{-}P}$) which is twice the amplitude, a period (T) which is the time for one complete cycle, and a frequency (f) which is the number of cycles per second measured in Hertz. Period and frequency are reciprocals of one another, i.e. $f = \frac{1}{T}$. Figure (1) shows such a voltage signal versus time.

Figure (1)



Apparatus:

1. DC power supply.
2. AC power supply.
3. Voltmeter (V)
4. Resistor
5. Set of wires.

Experimental Method (Procedure):

1: Setup

Look at all the knobs and switches. There are two or three kinds of oscilloscopes, so we cannot tell you exactly where the particular knob or switch that you need will be. Please ask the instructor if you cannot find what you are looking for.

a) Set the sweep generator (Time/Division knob) to H IN or X-Y. Or push in the X-Y button.
b) Set the Volt/Division knob to 2 Volts per division.
c) Select to display ground (GND).
d) Turn on the O-scope. Focus the dot and turn the intensity down so that the dot on the screen is comfortably visible but not too bright (it may damage the screen otherwise).
e) Turn the VARIABLE knobs on the Time/Div and Volts/Div clockwise until you hear them click into position. This means that the O-scope is now calibrated.
f) Turn the POSITION knobs (VERTICAL and HORIZONTAL) to understand their function. Then adjust these controls to position the dot at the center of the screen.

Graph 1: $\boldsymbol{f_{th}} =$ ...., $\boldsymbol{V_{DMM}} =$ ....

$\boldsymbol{T} =$ .... $\boldsymbol{f} =$ ....

$\boldsymbol{V_{P-P}} =$ .... $\boldsymbol{V_m} =$

....

$\boldsymbol{V_{rms}} =$ ....

$Error_f = \varepsilon_f =$	$= \frac{\lvert f_{th} - f_{exp} \rvert}{f_{th}} \times 100\%$ $= \frac{\lvert \quad \rvert}{\quad} \times 100\%$ $=$

$Error_V = \varepsilon_V =$	$= \frac{\lvert V_{DMM_{th}} - V_{rms_{exp}} \rvert}{V_{DMM_{th_{th}}}} \times 100\%$ $= \frac{\lvert \quad \rvert}{\quad} \times 100\%$

2: Measurement of an AC voltage

a) Locate the Sine-Square Wave Generator (SSG) but do not turn it on. Connect the OUTPUT terminals of the SSG to the DMM and the VOLTAGE input terminals of the O-scope as shown in Figure 2. Make sure that the negative side of the SSG is connected to the ground terminal of the O-scope. Set the SINE/SQUARE selector switch on the SSG to SINE. Select the highest possible LEVEL range. Turn the OUTPUT VOLTAGE all the way down to zero. Using the FREQUENCY MULTIPLIER (or FREQUENCY RANGE selector) and the FREQUENCY dial, set the frequency to 100 Hz. Select AC for both the DMM and the O-scope.

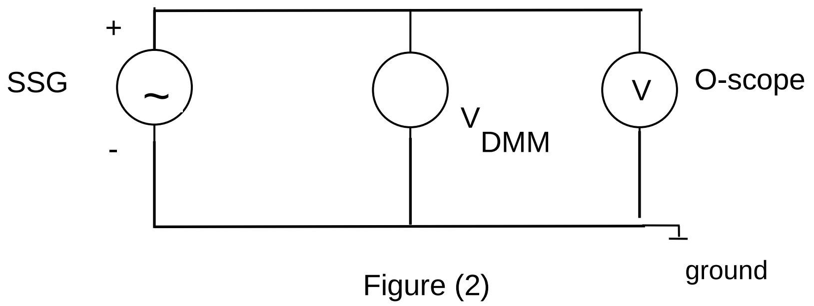


Figure (2)

b) Now turn on the SSG and increase the OUTPUT VOLTAGE to some value. You should see a vertical line on the O-scope. Why?

c) Measure the peak to peak voltage ($V_{P\text{-}P}$) of the voltage signal using the O-scope.

d) Divide this value by two to get the amplitude of the voltage (V_m).

e) Record the voltage measured by the DMM. This should be the rms voltage which is related to the voltage amplitude by $V_{rms} = \frac{V_m}{\sqrt{2}}$. Calculate the rms voltage and compare to the value from the DMM.

f) Now take the sweep generator off of H IN or X-Y and start to increase the Time/Div knob. You should see a sine wave signal displayed. Why? Obtain a stable sine wave with at least one period displayed. You may have to adjust the TRIGGER LEVEL to stabilize the signal.

g) Measure the period of the signal. Recall that the period is the time required for one cycle as illustrated in Fig. 1. Using this value of *T*, calculate the frequency *f* of the signal. Is this value close to 100 Hz? It may not agree exactly since the frequency knob of the SSG may not be calibrated perfectly.

Data and Calculate:

Table 1:

$V_{DMM}\ (V)$ $V_{DMM} = V_{rms}$	$V_{P-P}\ (V)$	$V_m\ (V)$ $V_m = \frac{V_{P-P}}{2}$

$V_{rms} = \frac{V_m}{\sqrt{2}}$ **(By using Calculate)**	$\frac{V_m}{V_{rms}} = \ldots\ldots\ldots$
$\frac{V_m}{V_{rms}}$ $(\boldsymbol{experiment})$: **(By using slope)**	$Slope = \frac{V_m}{V_{rms}} = \ldots\ldots\ldots$
$Error_{\frac{V_m}{V_{rms}}} = \varepsilon_{\frac{V_m}{V_{rms}}} =$	$= \frac{\left\lvert \frac{V_m}{V_{rms_{th}}} - \frac{V_m}{V_{rms_{exp}}} \right\rvert}{\frac{V_m}{V_{rms_{th}}}} \times 100\%$ $= \frac{\lvert\quad\quad\rvert}{\quad\quad} \times 100\%$ $=$

Graph 2:

$$\textbf{Slope} = \frac{\Delta V_m}{\Delta V_{rms}}$$

$$\textbf{Slope} = \frac{\qquad\qquad}{}$$

$$= \frac{\qquad\qquad}{}$$

$$=$$

3: Measurement of a DC Voltage

Set up the simple circuit shown in Figure (3) below using the PS (DC Power Supply) and the 10 Ohm resistor. Set the voltage of the PS at about 4 volts.

a) Measure the voltage across *R* using first the DMM.

b) On the O-scope, deselect GND and select DC and measure the voltage across *R*. Compare the two measured values.

c) Reverse the polarity of the voltage across *R* and observe what happens to the signal on the DMM and the O-scope.

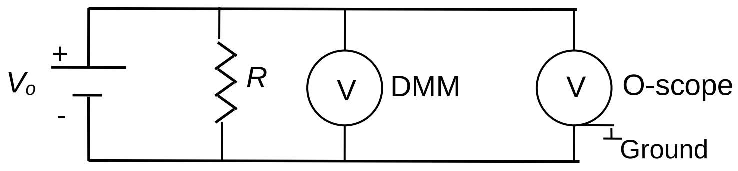


Figure (3)

Data and Calculate:

Table 2:

$V_{DMM}\ (V)$ $V_{DMM} = V_{DC}\ (V)$	$V_{CRO}\ (V)$

$V_{DC} = V_{CRO}$ **(By using Calculate)**	$\frac{V_{CRO}}{V_{DC}} =$ ………
$\frac{V_{CRO}}{V_{DC}}$ ($\boldsymbol{experiment}$): **(By using slope)**	$Slope = \frac{V_{CRO}}{V_{DC}} =$ …… …

$Error_{\frac{V_{CRO}}{V_{DC}}} = \varepsilon_{\frac{V_{CRO}}{V_{DC}}} =$	$= \frac{\left\lvert \frac{V_{CRO}}{V_{DC\ th}} - \frac{V_{CRO}}{V_{DC\ exp}} \right\rvert}{\frac{V_{CRO}}{V_{DC\ th}}} \times 100\%$ $= \frac{\lvert \qquad\qquad \rvert}{\qquad\qquad} \times 100\%$ $=$

Graph 3:

$$\boldsymbol{Slope} = \frac{\Delta V_{CRO}}{\Delta V_{DC}}$$

$$\boldsymbol{Slope} = \underline{\qquad\qquad\qquad}$$

Result and Discussion: