PW n° 04: ***Phase Shift Measurement***

Duration: 1^h30.

Date of the experiment: ……. /……../…….. .

Report prepared by:

Last Name	First Name	Group	S/Group	Final Note
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

Instructions :

- **Internal laboratory regulations must be observed.**
- **You must wear a lab coat.**
- **Attendance is compulsory and will be monitored. Any unjustified absence or failure to hand in a report will result in a mark of 0/20.**
- **Have your assemblies checked before connecting the voltage source.**
- **It is strictly forbidden to move equipment from one station to another. In the event of a breakdown or faulty equipment, contact the teacher.**
- **The report must be written by a maximum of four students.**
- **The report must be handed in at the beginning of the next session.**
- **The report must include the following sections:**
  - **TP cover page.**
  - **The date of the practical session.**
  - **Last Name and first name of the main writer.**
  - **Last Names and first names of the WP participants.**
  - **Preparation and work in manuscript.**

Person in charge of practical work: Dr. Abderrzak Laib

PW n° 04: ***Phase Shift Measurement***

1. Objectives of the experiment

The objectives of this experiment are:

- Familiarization with an oscilloscope: preliminary settings, start-up, signal visualization, and measurements on alternating signals (amplitude, frequency, and phase shift).
- Familiarization with a Function Generator (GBF) and a stabilized power supply.
- Familiarization with a multimeter: various measurements (voltage, current, resistance), and different tests (diode, transistor).

2. Theoretical reminders

2.1 Introduction

The oscilloscope is a measuring device that allows the visualization of voltage variations over time or in relation to another voltage. It is particularly well-suited for studying alternating voltages (which are the most common in electricity and electronics). The oscilloscope has two input channels, making it possible to observe two distinct electrical signals on the same screen—allowing comparisons of amplitudes, periods, and phase shifts.

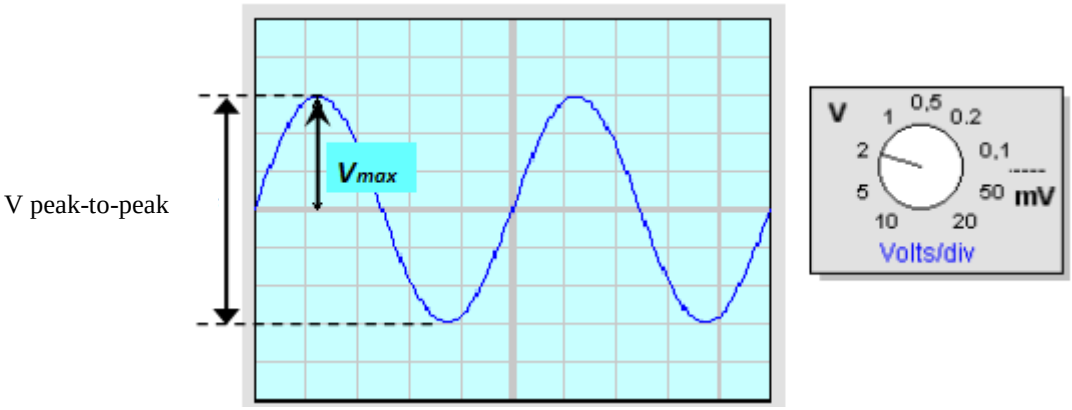
2.2 Measurement Procedures Using an Oscilloscope:

2.2.1 Voltage Measurement:

To measure a voltage (V) with an oscilloscope, the vertical scale (sensitivity) should be selected so that the peak-to-peak amplitude of the signal occupies most of the screen height without exceeding it. This ensures more accurate readings by minimizing measurement errors.

Person in charge of practical work: Dr. Abderrzak Laib

PW n° 04: ***Phase Shift Measurement***



We have:

V peak-to-peak = Number of divisions × Vertical scale (Volts/div)

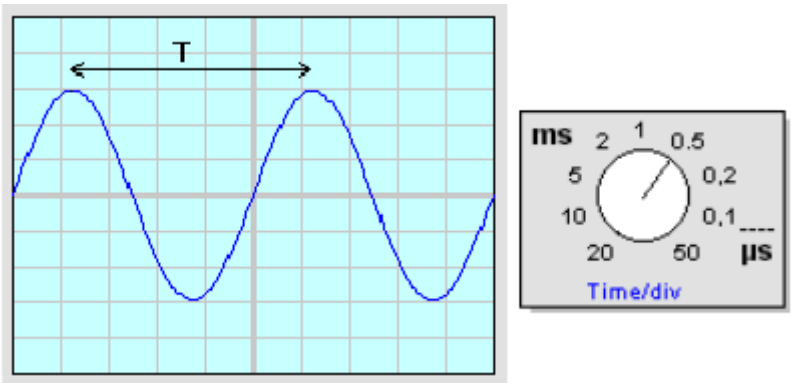
Vmax = Vpeak-to-peak / 2

V_{RMS}= Vmax$\sqrt{2}$

The RMS value ($\mathbf{V_{RMS}}$) is the value displayed by the multimeter when measuring an alternating voltage.

2.2.2 Frequency Measurement:

To measure the frequency of a signal using an oscilloscope, the time base setting should be adjusted so that the signal's period spans most of the screen's horizontal length. This helps minimize reading errors and improves measurement accuracy.



We have:

T = Number of divisions × Time base (Seconds/div)

f = 1 / T .

Where T is the period of the signal, and f is its frequency.

PW n° 04: ***Phase Shift Measurement***

2.2.3 Phase Shift Measurement:

To measure the phase shift between two signals, they must be observed simultaneously. For this, both voltages need to be measured with respect to a common reference point, which is ground. Two methods can be used to measure the phase shift with an oscilloscope: the **direct method** and the **Lissajous method**.

A) Direct Method:

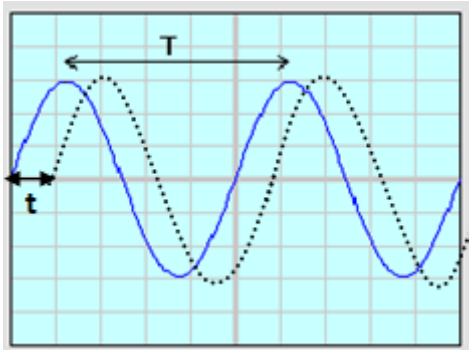
This method is used when the two signals have the same frequency. Consider two periodic signals where one is phase-shifted relative to the other (either leading or lagging), as illustrated in Figure 4 below.

To calculate the phase shift φ (in degrees), we use the formula:

$$\varphi = \frac{t}{T} * 360^0$$

Where:

- t is the time difference between corresponding points of the two signals (e.g., peaks),
- T is the period of the signals.



B) Lissajous Method:

B.1) Case of Two Signals with the Same Frequency:

This method involves generating curves in a plane by tracking the movement of a point whose coordinates are functions of the same parameter. To use this method, the oscilloscope must be set to horizontal sweep mode by pressing the **HOR. EXT / X-Y** button.

e(t) = A sin wt

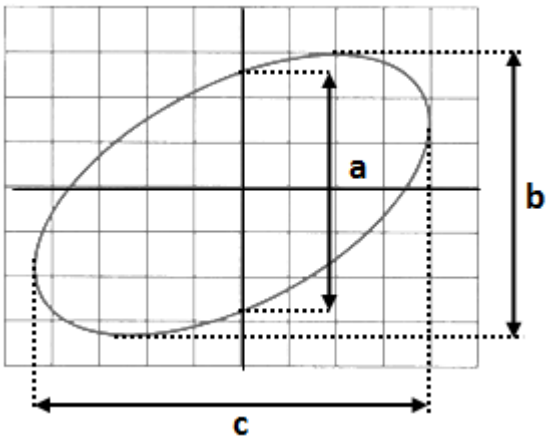
s(t) = B sin (wt + φ)

with :

$b = 2B$ **et** $c = 2A$

$a = 2B \sin wt$

sin $\varphi = a/b \Rightarrow \varphi =$ **arcsin(** $a/b)(radians)$**.**



B.2) Case of Two Signals with Different Frequencies:

This method is used to verify the frequency fx of a function generator (GBF) relative to another reference function generator with frequency fo.

- Apply the two signals with frequencies fx and fo to channel I and channel II of the oscilloscope, respectively.
- Set the oscilloscope to horizontal sweep mode by pressing the HOR. EXT / X-Y button.
- Adjust the frequency fx until a stable closed curve appears on the screen.
- Record Nx (the number of points where the curve touches the horizontal axis) and Ny (the number of points where the curve touches the vertical axis).

We have :

$$fx = \frac{Nx}{Ny}$$

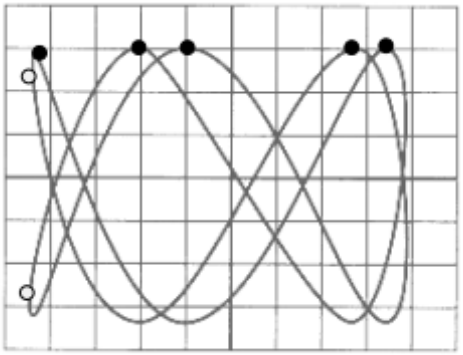
Example :

In the adjacent figure:

Ny=2

Nx=5

Therefore: : $\boldsymbol{fx}$ = $\boldsymbol{f}$o*5/2



3. Experimental procedures:

3.1 Preliminary Settings and Starting Up the Oscilloscope:

a) Before turning on the oscilloscope, the following adjustments are recommended:

- Make sure all buttons positions (turned fully to the right).
- Confirm that the HOLD OFF control is in its calibrated position (turned fully to the left).
- Set the position controls (X-POS, Y-POS I, and Y-POS II) to the center position (indicator pointing upwards).
- The trigger selector (TRIG.) should be set to the highest position (AC).
- The GD buttons for both channels should be pressed (input signal grounded).
- are released.
- Ensure that the rotary knobs for the time base (TIME/DIV) and the variable attenuators (VOLTS/DIV) are set to their calibrated

b) Once the oscilloscope is turned on by pressing the red POWER button:

- The LED will light up, and after a few seconds, a trace representing the baseline will appear on channel I (or channel II).
- To display a signal on channel I (or channel II), press the CH I/II button.
- To display signals on both channels simultaneously, press the DUAL button.
- Center the trace on the screen using the X-POS and Y-POS I / Y-POS II controls.
- Adjust beam brightness and sharpness using the INTENSITY and FOCUS controls to obtain a moderately bright and finely focused trace.
- If no trace appears, check the position of other controls, especially the AT/NORM button, which should be released.

3.2 Calibration of an Oscilloscope:

Before performing any measurement with an oscilloscope, like with any measuring instrument, it is essential to carry out a calibration as follows:

- The oscilloscope is equipped with a built-in reference signal (calibration signal), which is a square wave with an amplitude of either 0.2 V or 2 V and a frequency of either 1 MHz or 1 kHz. Set the calibration signal to 0.2 V amplitude and 1 kHz frequency.
- Apply this calibration signal to the input of Channel I of the oscilloscope, using a vertical scale of 0.1 V/div. The signal displayed on the screen should have a peak-to-peak amplitude of 2 cm.
- Repeat the same procedure for Channel II of the oscilloscope.

3.3 Measurements of Voltage, Frequency, and Phase Shift:

3.3.1 Voltage Measurements:

Using a function generator (GBF), apply a sinusoidal voltage to the input of Channel I of the oscilloscope and select the appropriate vertical scale for a clear visualization of the signal.

- Measure the peak-to-peak amplitude of the signal using the oscilloscope.
- Measure the same voltage using a multimeter.
- Record these values in Table 1, then repeat the procedure for a triangular signal and a square signal.

Table 1: Voltage Measurement Results

	Sinusoidal	Square	Triangular
Oscilloscope Scale (V/cm)			
No. of Divisions (Peak-to-Peak)			
Vpeak-to-peak (V)			
Vmax (V)			
V (Multimeter)			
V_{RMS} (V)			

3.3.2 Frequency Measurements:

Using a function generator (FG), apply a sinusoidal signal with a frequency higher than 100 Hz to the input of **channel I** of the oscilloscope and select the appropriate settings (scales) for correct signal visualization.

- Measure the **period** of this signal and record the values in **Table No. 2**.
- Repeat the same procedure for a **triangular signal** and a **square signal**.

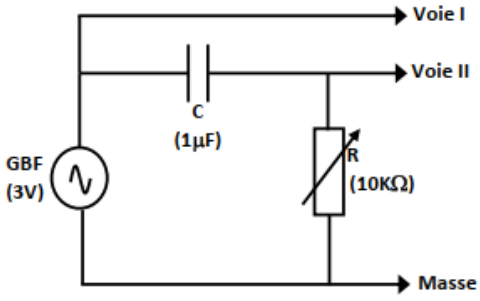
Table 2: Frequency Measurement Results

	Sinusoidal	Square	Triangular
GBF Frequency (Hz)			
Time Base Setting (ms/cm)			
No. of Divisions (for T)			
T (s)			
f = 1/T (Hz			

PW n° 04: ***Phase Shift Measurement***

3.3.3 Phase Shift Measurements:

A) Direct Method:



Build the following circuit:

- Make sure the **GD buttons** are pressed (the input signal is grounded), then **adjust the two traces** on the oscilloscope so that they are perfectly **superimposed on the x-axis**.
- Vary the **resistance R** and **determine the phase shift** for each value of R.
- Record these values in **Table No. 3**.

R (KΩ)	**1**	**2**	**4**	**8**	**10**
t (cm)					
T (cm)					
$\boldsymbol{\varphi = \frac{t}{T} * 360^0}$					

B) Lissajous Method:

B.1) Two signals with the same frequency:

1. Set the oscilloscope to **horizontal sweep mode** by pressing the **X-Y button**.
2. Press the **GD buttons** for both channels and **center the spot** at the intersection of the axes (in the middle of the screen).
3. Using the same setup, **determine the phase shift** for each value of **R**.
4. Record these values in **Table No. 4**.

R (KΩ)	**1**	**2**	**4**	**8**	**10**
a (cm)					
b (cm)					
a/b					
sin φ = a/b					
φ = arcsin a/b (rd)					
φ (degré °)					

B.2) Two signals with different frequencies:

1. Set the oscilloscope to **horizontal sweep mode** by pressing the **External Horizontal (Hor. ext.)** button.
2. Press the **GD buttons** for both channels and **center the spot** at the intersection of the axes (center of the screen).
3. Apply the signal from **FG1 (Function Generator 1)** to **Channel I** and the signal from **FG2** to **Channel II**.
4. Vary the frequency of **FG2** according to **Table No. 5** until a **stable figure** appears on the oscilloscope screen.
5. Record **Nx** and **Ny**, and enter these values into **Table No. 5**.

Fréq. GBF(Hz)	**75**	**100**	**150**	**200**
Nx				
Ny				
Nx / Ny				
Fx = Fo . Nx / Ny				

4. Conclusion