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وزارة التعليم العالي و البحث العلمي
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
جامعة محمد بوضياف بالمسيلة
MOHAMED BOUDIAF UNIVERSITY OF M'SILA
كلية التكنولوجيا
FACULTY OF TECHNOLOGY
قسم الهندسة الكهربائية
DEPARTMENT OF ELECTRICAL ENGINEERING
جامعة محمد بوضياف - المسيلة

رقم: 102 /ق.ه.ك /2025

المسيلة في : 29 افريل 2025

# شهادة إدارية

## بخصوص مطبوعة الدروس الخاصة بالأستاذ

## العايب عبد الرزاق

بناءً على محضر اللجنة العلمية لقسم الهندسة الكهربائية تحت رقم: 41/ق.ه.ك/2025 المنعقد بتاريخ 17 فيفري 2025 والمتضمن تعين الخبراء: الأستاذ عايب عبد الغني أستاذ محاضر-أ- بجامعة المسيلة الأستاذ حريزي عبد الغفور أستاذ محاضر –أ- بجامعة المسيلة، والأستاذ عكا علي أستاذ محاضر –أ بالمدرسة العليا للأساتذة ببوسعادة وذلك لتقييم مطبوعة الأعمال التطبيقة الخاصة بالأستاذ العايب عبد الرزاق أستاذ محاضر "أ" بقسم الهندسة الكهربائية لجامعة المسيلة تحت عنوان :

" TP_ Mesures électriques et électroniques "

مطبوعة أعمال تطبيقية مكتوبة باللغة الإنجليزية تحت عنوان:

" PW_ Electrical and Electronic measurements "

وبعد إطلاع رئيس اللجنة العلمية ورئيس القسم على التقارير الواردة و التي كانت كلها ايجابية، وعليه فإن اللجنة لا ترى مانعا أن تتخذه سندا في تدريس طلبة السنة الثانية ليسانس في الكهرميكانيك ، شعبة الكهرميكانيك ، ميدان علوم و تكنولوجيا و أن تعتمد في أي تقييم للمسار العلمي للأستاذ المعني.

رئيس اللجنة العلمية

أ .د بوقرة عبد الرحمان

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جامعة محمد بوضياف المسيلة
رئيس قسم الهندسة الكهربائية
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دفاف المبروك

**ملاحظة:** سلمت هذه الشهادة للمعني(ة) لاستعمالها في حدود ما يسمح به القانون.

People's Democratic Republic of Algeria Ministry of Higher Education and Scientific Research

Mohamed Boudiaf University at M'Sila




Faculty of

Technology Department

of Electrical Engineering

# Practical work handout

Subject: Practical work on Electrical and Electronic measurements

**Speciality: Electrotechnics, Electromechanics, Automatic, Renewable energy and environment.**

Level: 2nd year bachelor's degree

Author: Abderrzak LAIB

Academic Year: 2024-2025

***Author***

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Faculty/Institute: Faculty of Technology
Department: Electrical Engineering
Institution: Mohamed BOUDIAF University of M'sila - Algeria

Subject title: **Practical work on Electrical and Electronic measurements**

Semester: 03
Fundamental Teaching Unit Code: UEM2.1 Number of teaching hours of practical work 09.00 h
Number of hours of personal work for the student: 1.5 h Number of credits: 2; Subject coefficients: 1

## *Foreword*

With a view to applying the new university syllabuses proposed by the national educational councils as part of the overhaul of the curricula initiated by the Ministry of Higher Education and Scientific Research, this book has been written mainly as a teaching tool with the aim of facilitating and providing students in the 2nd year of a degree in Electrical Engineering, Electromechanics, Automation, Renewable energy and environment with the basic principles of electronics and electrotechnics.

## *PW n°01: MEASUREMENT OF RESISTANCES*

### *Aim*

- Measure the values of unknown resistances using the following methods:
- Ohmmeter
- Volt-Ampere (Volt-Ampere Metric) method
- Evaluate the relative accuracy of each method.

### *Equipment used*

- Resistors
- Stabilized power supply
- Voltmeter, ammeter, and multimeter

## *PW n°01: INDUCTANCE MEASUREMENT*

### *Aim*

- Measure an inductance using the volt-amperometric and series RLC methods.
- Measure Quality factor

### *Equipment used*

- Power Sources (DC).
- The Oscilloscope
- Function Generator (GBF)
- Electrical loads (resistors, inductors and capacitors).
- Measuring instruments (multimeters, ammeters, milliammeters, voltmeters, millivoltmeters).

## *PW n°03: MEASUREMENT OF CAPACITANCES*

Aim

- Measurement of capacitance using the volt-ampere (V-A) method.

***Equipment used***

- Function Generator / AC Voltage Source
- Voltmeter
- Ammeter
- Unknown Capacitor
- Connecting Wires

## PW n°04*: The Oscilloscope - Measurement of (Voltage, Frequency)*

***Aim***

- 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).

***Equipment used***

- The Oscilloscope
- Function Generator (GBF)
- Measuring instruments (multimeters, ammeters, milliammeters, voltmeters, millivoltmeters).

## *PW n°01: Measuring Voltage, Current and Power in Single Phase (Electrotechnics)*

***Aim***

- To learn about the different electrical elements (electrical charges, electrical sources, measuring instruments, etc.).
- To learn the correct way of measuring with all the measuring instruments (amperemeter, voltmeter, power meter, etc.).
- To give general help on the influence of electric charges on the power measured in alternating current circuit

***Equipment used***

- Voltage sources (AC).
- Electrical loads (resistors, inductors and capacitors).
- Measuring instruments (voltmeters, ammeters, multimeters, power meters)

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# *PW n° 01: Measurement of Resistances*

Duration: $1^h30$.

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

Report prepared by:

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

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  - **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.**

## 1. Objectives:

- Measure the values of unknown resistances using the following methods:

✓ Ohmmeter

✓ Volt-Ampere (Volt-Ampere Metric) method

- Evaluate the relative accuracy of each method.

## 2. Equipment:

- Resistors
- Stabilized power supply
- Voltmeter, ammeter, and multimeter

## 3. Method 1: Direct Measurements Using the Ohmmeter

Determine the values of resistances R1 and R2 using the multimeter in ohmmeter mode. Then calculate the absolute and relative uncertainties by applying the following formula:

$$\Delta R = R * \textbf{Precision} + \textbf{Number of digits} * \textbf{Resolution}$$

Where:

- **R**: is the measured resistance.
- **Precision:** refers to the manufacturer's specified precision of the measuring device.
- **Number of digits:** is the number of significant digits displayed by the multimeter.
- **Resolution** :is the smallest change in resistance that the multimeter can detect.

The ohmmeter manual for determining the precision of measurements provided according to the applied range is given by the following uncertainty table:

| Range | Precision + Number of Digits | Resolution | Uncertainty |
|---|---|---|---|
| 200Ω | **±(1%+3 digits)** | **0,1Ω** | **4,5Ω** |
| 2kΩ | **±(0,8%+1 digits)** | **1Ω** | **30Ω** |
| 20kΩ | **±(0 ,8%+1 digits)** | **10Ω** | **300Ω** |
| 200kΩ | **±(0,8%+1digits)** | **100Ω** | **3kΩ** |
| 2MΩ | **±(0.8%+1 digits)** | **1kΩ** | **42kΩ** |

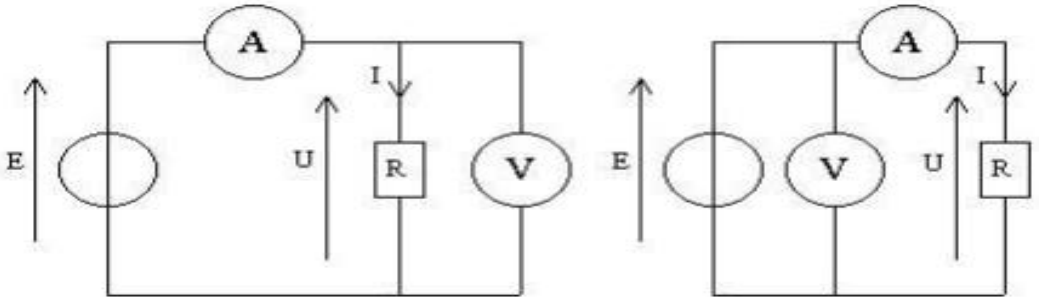
Measure the resistances, then calculate the uncertainty for each measurement, and complete the following table:

| | Measurement of R1 | Measurement of R2 |
|---|---|---|
| **Range** | | |
| **R** | | |
| $\Delta R$ | | |
| $\partial R = \Delta R/R$ | | |

## 4. Method 2: Measurements Using the Volt-Ampere method

### 4.1 Selection of the Appropriate Circuit Configuration

The task is to select the appropriate circuit configuration, either downstream or upstream, for measuring each of the resistances R1 and R2 given the imposed measuring instruments. After performing the measurements, determine the value of each resistance and its associated uncertainty for the chosen configuration.




Downstream Circuit (Short Branch) Upstream Circuit (Long Branch)

The choice of the circuit configuration will be made according to the following rule:

- If $R_{Approximated\ Resistance} \leq \sqrt{R_A * R_v}$ (Low-value resistances) The downstream circuit configuration is preferred.
- If $R_{Approximated\ Resistance} \geq \sqrt{R_A * R_v}$ (High-value resistances) The upstream circuit configuration is preferred.

### 4.2 Measurement Table

- E = 5V
- Ammeter Class = …….
- Voltmeter Class = …….

| | Measurement of R1 | Measurement of R2 |
|---|---|---|
| **Adopted Circuit Configuration** | **Downstream** | **Downstream** |
| **Range for I ($R_A$)** | | |
| **Scale for I ($S_A$)** | | |
| **Reading for I ($Re_A$)** | | |
| **$I_m=(Re_A/S_A)*R_A$** | | |
| **Range for V ($R_V$)** | | |
| **Scale for V ($S_V$)** | | |
| **Reading for V ($Re_V$)** | | |
| **$I_m=(Re_V/S_V)*R_V$** | | |
| **Rm=Um/Im** | | |
| **$\Delta Rm$** | | |

| | Measurement of R1 | Measurement of R2 |
|---|---|---|
| **Adopted Circuit Configuration** | **Upstream** | **Upstream** |
| **Range for I ($R_A$)** | | |
| **Scale for I ($S_A$)** | | |
| **Reading for I ($R_A$)** | | |
| **$I_m=(R_A/S_A)*R_A$** | | |
| **Range for V ($R_V$)** | | |
| **Scale for V ($S_V$)** | | |
| **Reading for V ($R_V$)** | | |
| **$V_m=(R_V/S_V)*R_V$** | | |
| **Rm=Um/Im** | | |
| **$\Delta Rm$** | | |

**4. Remarks:**

➢ **Absolute uncertainty $\Delta X$**: The calculation of the absolute uncertainty $\Delta X$ due to a measurement device with deviation is given by:

$$\Delta X = \frac{Class * Range}{100}$$

➢ **Relative uncertainty**: Usually expressed as a percentage (%).

$$\frac{\Delta R}{R} = \frac{\Delta I}{I} + \frac{\Delta V}{V}$$

## 5.Conclusion-

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# *PW n° 02: Inductance Measurement*

Duration: $1^h30$.

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

Report prepared by:

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

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  - **Last Names and first names of the WP participants.**
  - **Preparation and work in manuscript.**

## 1. Aim of the manipulation

- Measure an inductance using the volt-amperometric and series RLC methods.
- Measure Quality factor

## 2. Equipment used

- Power Sources (DC).
- The Oscilloscope
- Function Generator (GBF)
- Electrical loads (resistors, inductors and capacitors).
- Measuring instruments (multimeters, ammeters, milliammeters, voltmeters, millivoltmeters).

## 3. Evaluation method

- Continuous assessment: 100%.

## 4. Theoretical reminder:

A coil consists of a winding of conductive turns around an insulator. It therefore has a certain internal resistance due to the long length of wire. The coil is therefore symbolised in the receiver convention as follows:

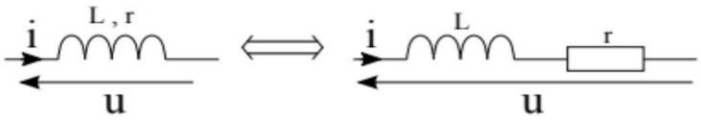



Figure 1: Symbolisation of a real coil, receiver convention.

## 5. Method n° 01: Indirect measurements using the Volt-Amperometric method

- ❖ Volt-Amperometric method with DC source
- ❖ Carry out the following assembly.

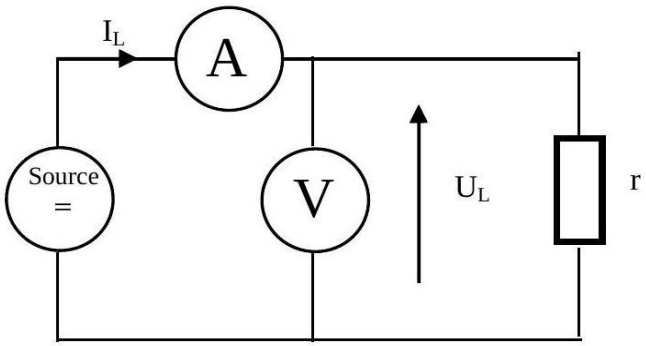



Figure 2: Volt-Amperometric method with DC source

- Find $\boldsymbol{U_L}$ and $\boldsymbol{I_L}$ by varying $\boldsymbol{U}$ from $1\boldsymbol{V}$ to $9\boldsymbol{V}$.

| $\mathbf{U(V)}$ | **1** | **3** | **5** | **7** | **9** |
|---|---|---|---|---|---|
| $\mathbf{U_L(V)}$ | | | | | |
| $\mathbf{I_L(A)}$ | | | | | |
| $\mathbf{Z = r = U_L/I_L}$ | | | | | |

Table 1

## 4.1 Volt-Amperometric method with AC source

- The coil is fed by a sinusoidal generator $\mathbf{U(t)}$ with an effective value $\mathbf{U(t) = 7V}$ and a variable frequency.
- Carry out the installation by positioning the equipment so that $\mathbf{U_L(V)}, \mathbf{I_L}$

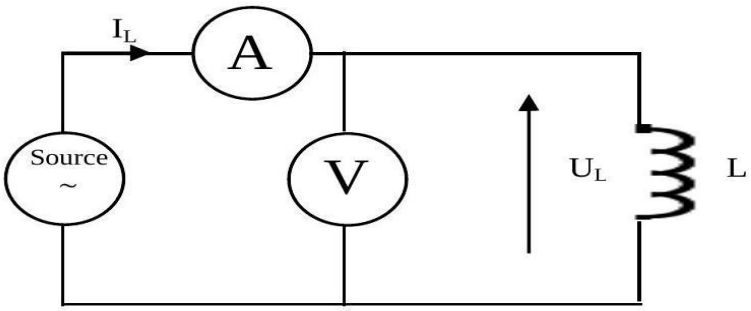



Figure 3: Volt-Amperometric method with AC source

- Find $\mathbf{U_L(V)}, \mathbf{I_L}$ by varying the frequency from $\mathbf{100\ Hz}$ to $\mathbf{250\ Hz}$
- Calculate the value of $\mathbf{Z}$ from these measurements,
- Derive $\mathbf{L}$

| $\mathbf{f(Hz)}$ | **100** | **150** | **200** | **250** |
|---|---|---|---|---|
| $\mathbf{U_L(V)}$ | | | | |
| $\mathbf{I_L(A)}$ | | | | |
| $\mathbf{Z = U_L/I_L}$ | | | | |
| **L** | | | | |

Table 2

## 6. Method $n°02$ : Indirect measurements using the Resonance of a series RLC circuit.

- The Resonance of a series RLC circuit

To study the resonance of the RLC circuit, we will make the following series circuit:

- An inductor set at **150mH**
- A capacitor set at $\mathbf{3.3\mu F}$
- A resistor set at **56 0Ω**

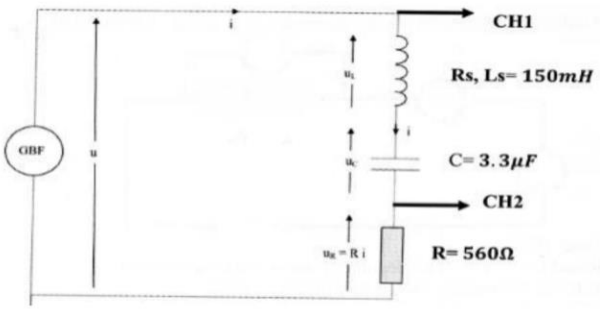



Figure 4: RLC circuit

- Look at the current and voltage curves on the oscilloscope. *
- Plot these curves on a millimetre sheet,
- Calculate the phase shift $\varphi_{\text{expérimental}}$ directly on the oscilloscope and compare it with the theoretical value.
- In general the impedance **Z** of a dipole is given by the relationship: $\mathbf{Z = U_{max}/I_{max} = U_{eff}/I_{eff} = U/I}$ through the dipole.
- Record the amplitude of the voltage across the resistor $\boldsymbol{U_R}$, the capacitor $\boldsymbol{U_C}$ and the coil $\boldsymbol{U_L}$ and the current $I$ for frequencies between **100 Hz** and 500 **Hz**.
- Plot the curves $\boldsymbol{I, U_c, U_L, U_R = G(f)}$
- Calculate the resonance frequency

- Calculate the bandwidth and the quality factor, given that $\boldsymbol{Q = f_0/\Delta f}$
- Deduce the value of $\boldsymbol{L}$ for all frequencies;
- Discuss each of the results obtained.

| $\mathbf{f(Hz)}$ | **100** | **200** | $f_0$ | **250** | 500 |
|---|---|---|---|---|---|
| $\mathbf{I(A)}$ | | | | | |
| $\mathbf{U_R(V)}$ | | | | | |
| $\mathbf{U_C(V)}$ | | | | | |
| $\mathbf{U_L(V)}$ | | | | | |
| $\mathbf{Z = U/I}$ | | | | | |
| $\mathbf{R = U_R/I}$ | | | | | |
| $\mathbf{Z_C = U_C/I}$ | | | | | |
| $\mathbf{Z_L = U_L/I}$ | | | | | |
| $\mathbf{L}$ | | | | | |

**Table 3**

## 2) Interpretation of results

## VII. Conclusion

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# *PW n° 03: Measurement of Capacitances*

Duration: $1^h30$.

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

Report prepared by:

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

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  - **Last Names and first names of the WP participants.**
  - **Preparation and work in manuscript.**

# 1. Objective of the Experiment:

Measurement of capacitance using the volt-ampere (V-A) method.

# 2. The Volt-Ampere Method:

The volt-ampere method is a fundamental technique for measuring capacitance based on the analysis of the relationship between voltage, current, and capacitive reactance in an AC circuit. This method exploits the fact that in an AC system, a capacitor behaves as a frequency-dependent impedance element, where the current leads the voltage by 90 degrees.

Principle:

For a purely capacitive circuit supplied with an alternating voltage $V(t) = V_m Cos(wt)$ the current i(t) through the capacitor of capacitance C is given by:

$$i(t) = C\frac{dV(t)}{dt} = CwV_m Sin(wt)$$

Since the RMS values of voltage and current are typically measured in practical applications, the capacitive reactance Xc is defined as:

$$X_c = \frac{1}{wC} = \frac{V}{I}$$

where:

- V is the RMS voltage across the capacitor,
- I is the RMS current through the capacitor,
-w=2*pi*f is the angular frequency of the applied AC voltage,
- C is the capacitance to be determined.

Rearranging for capacitance:

$$C = \frac{1}{wX_c} = \frac{I}{wV}$$

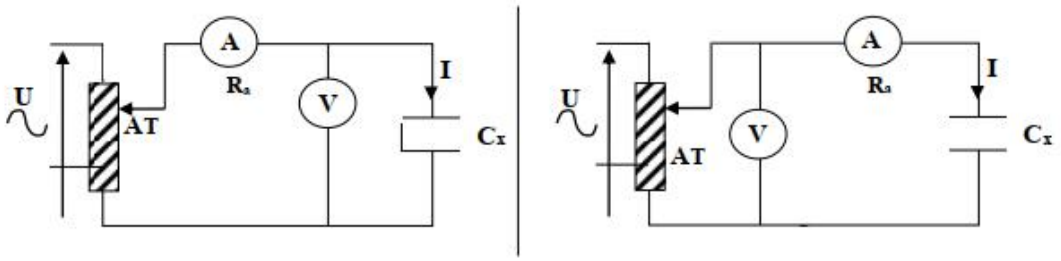



**Figure 1: Upstream and Downstream Circuit Configurations**

This figure illustrates the electrical setups for measuring capacitance using the volt-ampere method. The upstream configuration (Montage Amont) typically refers to the arrangement where the voltage measurement is taken before the capacitor, while the downstream configuration

(Montage Aval) refers to the setup where the voltage is measured after the capacitor. These configurations help analyze the behavior of the capacitor in different circuit placements, ensuring accurate capacitance estimation.

The volt-ampere (V-A) method is used only for measuring capacitance values greater than 0.1 μF

Measurement errors are minimized by using the upstream (Amont) and downstream (Aval) configurations as follows:

- **Upstream**: for capacitance values C<10 μF

- **Downstream** : for capacitance values C ≥10 μF

The impedance Z is expressed as: $Z = R + \frac{1}{JCw}$

Where R is the parasitic resistance introduced by the capacitance C and the connection wires. However, R can be neglected, considering the circuit as purely capacitive, leading to:

$$Z = \frac{1}{JCw} = Xc = \frac{Uc}{I}$$

The exact capacitance values can still be calculated for each configuration by accounting for systematic errors.

In the case of the upstream (Amont) configuration, the voltmeter measures a voltage U given by:

$$U = Ua + Uc$$

Thus:

$$C_{mea} = \frac{I}{2\Pi fU}\begin{cases} C_{calc} = \dfrac{1}{2\pi f\sqrt{\dfrac{U^2}{I^2} + R_a}} & Upstream \\ C_{calc} = \dfrac{\sqrt{I^2 - I_V^2}}{2\Pi fU} & downstream \end{cases}$$

**Mathematically demonstrate equations (1) and (2)**.

---

---

- **V**: Voltmeter, class …

- **AT**: Autotransformer

- Cx: Capacitor box containing the capacitors to be measured

**Operating Procedure:**

Before starting the experiment, several precautions must be observed:

1. The autotransformer should only be connected with its output set to the minimum value, i.e., zero.

2. The voltmeter and ammeter should be initially set to their maximum range.

3. **Important Note**: During the experiment, the appropriate measurement ranges should be selected. However, any range adjustments must be performed while the circuit is de-energized, meaning the autotransformer must be disconnected.

The autotransformer's cursor should be set to the position corresponding to **70 volts**, as indicated by the voltmeter. This voltage value remains constant throughout all measurements.

Error Calculation: The total relative error is given by: $\frac{\Delta C_{mes}}{Cmes} \approx \frac{\Delta U_{mes}}{Umes} + \frac{\Delta I_{mes}}{Imes} + \frac{\Delta f_{mes}}{fmes}$

$\frac{\Delta f_{mes}}{fmes} = 0.5\%$ ; f=50Hz, $C_{probable} \approx \Delta C_{mes} \mp C_{mes}[F]$.

$\Delta U_{mes} = \frac{Class*Range}{100}$ .Where **Class** and **Range** refer to the specifications of the voltmeter.

$\Delta I_{mes} = \frac{Class*Range}{100}$ . Where **Class** and **Range** refer to the specifications of the ammeter.

**Measure the current for the three capacitors C1, C2.**Record the measured and calculated results in the following table:

| | C1=4 micro F | | C2 =11 micro F | |
|---|---|---|---|---|
| **Adopted Circuit Configuration** | **Downstream** | **Upstream** | **Downstream** | **Upstream** |
| Range for I ($R_A$) | | | | |
| Scale for I ($S_A$) | | | | |
| Reading for I ($Re_A$) | | | | |
| Range for V ($R_V$) | | | | |
| Scale for V ($S_V$) | | | | |
| Reading for V ($Re_V$) | | | | |
| $Im=(Re_A/S_A)*R_A$ | | | | |
| $U_V=(Re_V/S_V)*R_V$ | | | | |
| Xc | | | | |
| Ra | | | | |
| Rv | | | | |
| $C_{mes[F]}$ | | | | |
| $\Delta Cmes$ [%] | | | | |
| $C_{calc[F]}$ | | | | |
| $\partial C_{mes} = \frac{\Delta Cmes}{C_{mes}}$ [%] | | | | |
| $C_{probable}$ [F] | | | | |

## 4.Conclusion

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# *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 :**

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- **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.**

# 1. Objectives of the experiment

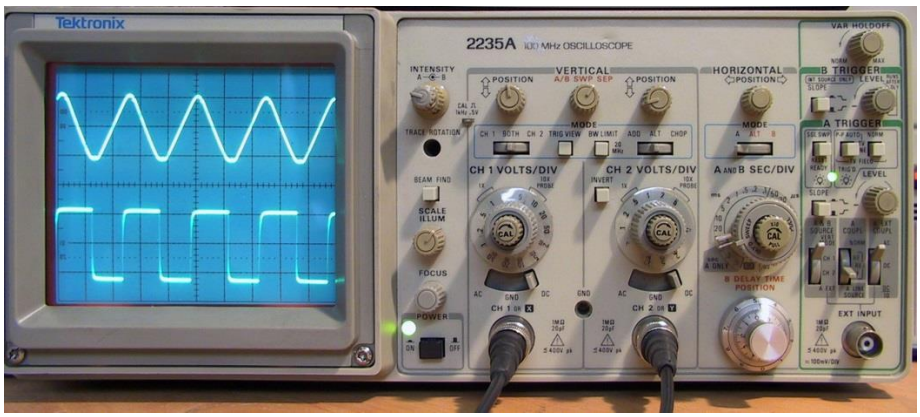
The objectives of this experiment are:

- 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.

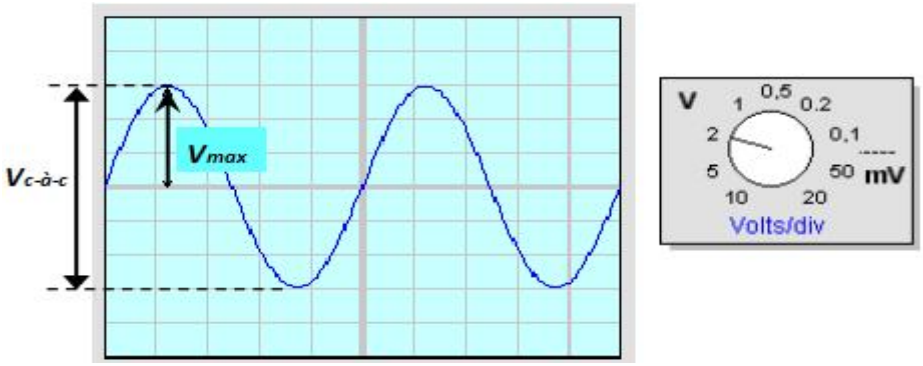



## 2.2 Measurement Procedures Using an Oscilloscope:

### 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.

V peak-to-peak




**We have:**

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

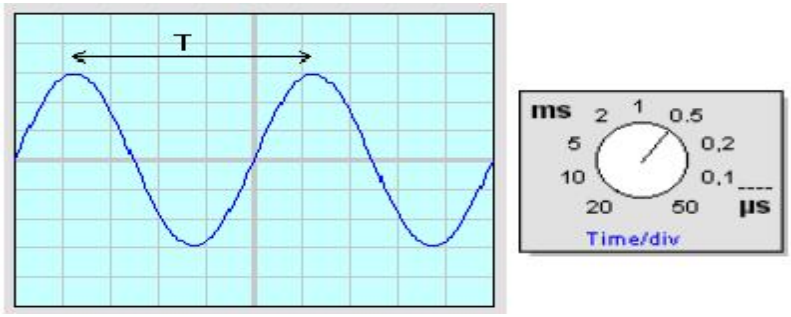
**Vmax = Vpeak-to-peak / 2**

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

The RMS value ($V_{RMS}$) 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.

## 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:**

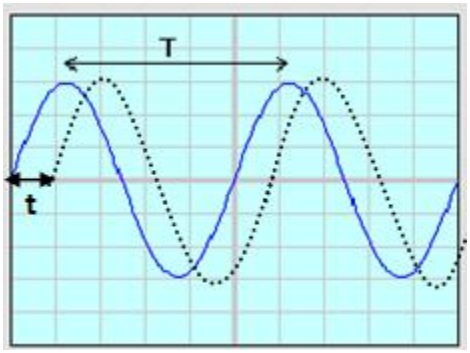
This method is used when the two signals have the same frequency. Consider two periodic signals where one is phase-shifted relative to the other (either leading or lagging), as illustrated in Figure 4 below.

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

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

Where:

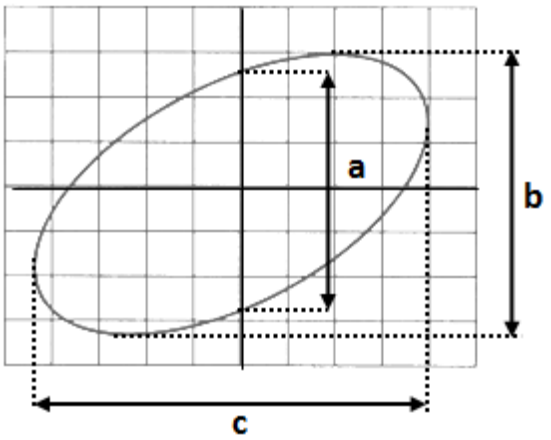
- t is the time difference between corresponding points of the two signals (e.g., peaks),
- T is the period of the signals.




**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** $\varphi = a \Rightarrow \varphi$ **= 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 :

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

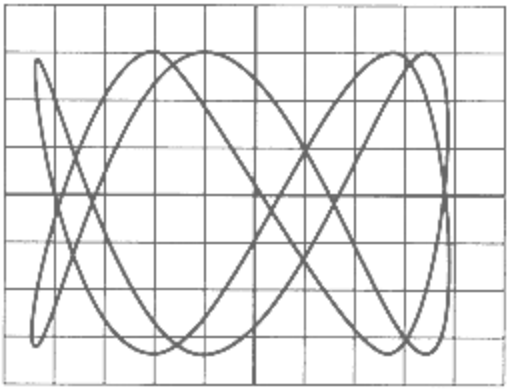
**Example** :

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**.

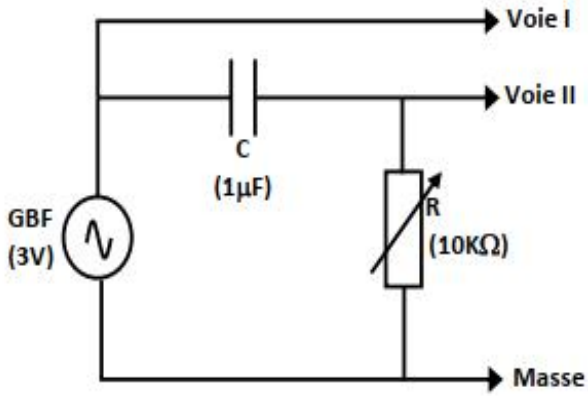
**Table 2: Frequency Measurement Results**

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

### 4.3.3 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) | | | | | |
| $\varphi = \frac{t}{T} * 360°$ | | | | | |

**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** | | | | |

**Conclusion**----------

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# *PW n° 5 : Measuring Voltage, Current and Power in Single Phase*

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

Report prepared by:

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

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- **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.**

## 1. Aim of the manipulation:

The aim of this experiment is to learn how to measure voltage, current, active and reactive power and power factor in a single-phase circuit.

## 2. Equipment used:

a. Power sources (AC).
b. Electrical loads (resistors, inductors and capacitors).
c. Instruments (multimeters, power meters).

## 3. Evaluation method:

Continuous assessment: 100%.

## 4. Theoretical reminder:

**Note :**

**i, u:** instantaneous values of current and voltage respectively.
**I, U:** effective values of current and voltage respectively.

### 4.1The electrical voltage:

It is a difference in potential (d.p) between two points, reflecting an electrical imbalance or different electrical charges, and is measured by a voltmeter.
The voltmeter is a device that is connected in parallel with the component or dipole whose terminal voltage is to be measured. There are three types of voltmeters:

1) The analogue voltmeter.
2) The digital voltmeter.
3) The multimeter.

Figure (1) shows the position of the voltmeter in a single phase circuit.

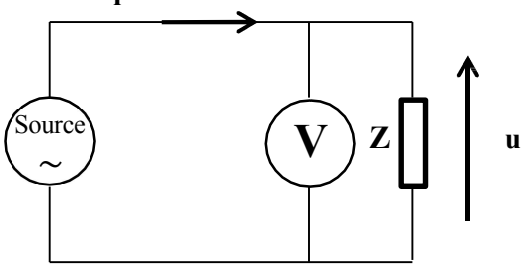



Figure 1

### 4.2The electric current:

Electric current results from the movement of electric charges between two points on a branch. Its intensity reflects the flow of moving charges and is measured by an ammeter.
An ammeter is a device connected in series with the component(s) through which the current to be measured flows. There are three types of ammeter:

4) The analogue ammeter.
5) The digital ammeter.
6) The multimeter.

Figure (2) shows the position of the ammeter in a single-phase circuit.

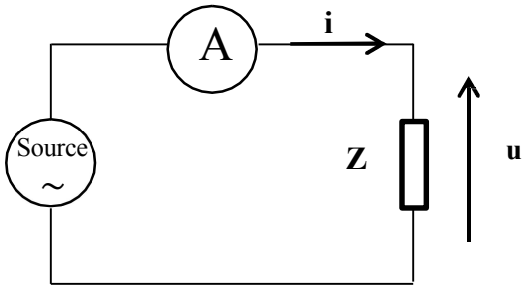



Figure 2

## 4.3 The electrical power :

Figure (3) shows the position of the power meter in a single-phase circuit.

Any electrical system that uses alternating current contains two forms of power: active and reactive.

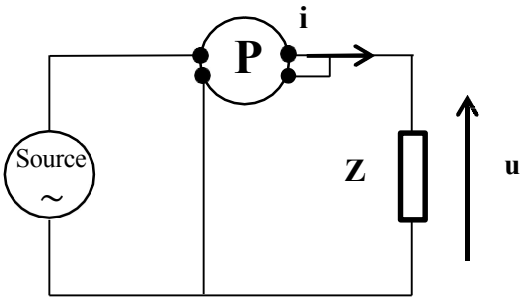



Figure 3

### 4.3.1 The active power P

It is completely converted into useful energy in the form of mechanical, thermal or light energy. The average active power is defined by the following relationship: $P = UI\cos(\varphi)$ (W)

Where φ is the phase difference between current I and voltage U.

### 4.3.2 The reactive power Q

It is used to magnetise the magnetic circuits of electrical machines (transformers and motors). The average reactive power is defined by: $Q = U\,I\sin(\varphi)$ (VAR)

### 4.2.3 Single-phase power measurement

Active power, reactive power and apparent power are measured directly by a power meter. The single- phase power meter is a device for measuring single-phase power. It consists of two coils: a current coil, which measures the current flowing through the load (equivalent to an ammeter), and a voltage coil, which measures the voltage across the load (equivalent to a voltmeter). (fig.3).

# 5. Experiment

## 5.1 Single phase voltage, current and power measurement:

Carry out the assembly shown in Figure 4:

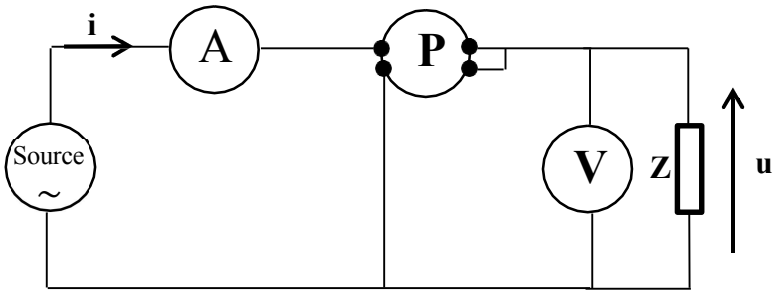



Figure 4

Load Z consists of the series connection of passive elements whose corresponding values are as follows:

5 Resistance R=100 Ω; maximum current 1A.

6 Iron core coil with inductance L = 60m H and internal resistance r = 1.2 Ω; maximum current 2.5A.

7 Capacitor C= 16μF.

**For each receiver**

7.2 Calculate the value of Z.

7.3 Complete the following tables (assembly fig.4).

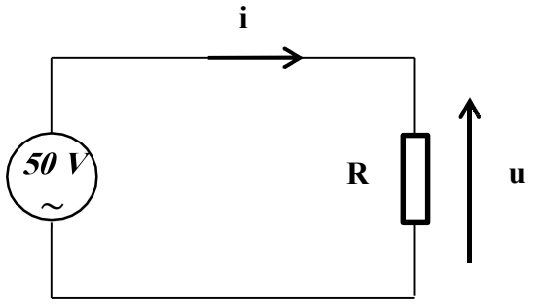



Figure 5

### 5.1.1 Load R

U=50V.
R=100ohm.

Z = .....

| Greatness | U(V) | I(A) | P(Watt) | Q(Var) | S(VA) | Cos($\varphi$) |
|---|---|---|---|---|---|---|
| Formula | | | | | | |
| Calculation | | | | | | |
| Measurement | | | | | | |

Table 1

What can we conclude?

.....

.....

.....

.....

### 5.1.2 Load L

U=50V. L=
60mH. r
=1.2 ohm.
f=50Hz.

= .....

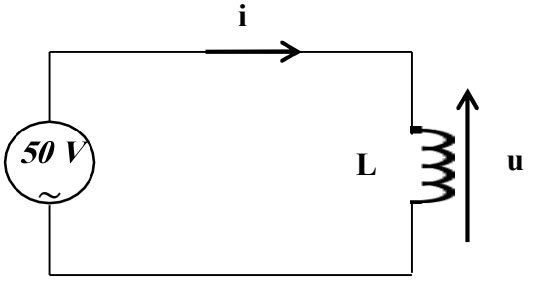



Figure 6

| Greatness | U(V) | I(A) | P(Watt) | Q(Var) | S(VA) | Cos($\varphi$) |
|---|---|---|---|---|---|---|
| Formula | | | | | | |
| Calculation | | | | | | |
| Measurement | | | | | | |

Table 2

What can we conclude?

.....

……

……

……

### 5.1.3 Load C

U=50V.
C= 16µF.
f=50Hz.

$Z$ = ……

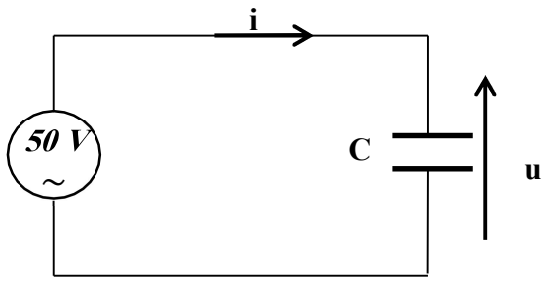



Figure 7

| Greatness | U(V) | I(A) | P(Watt) | Q(Var) | S(VA) | Cos($\varphi$) |
|---|---|---|---|---|---|---|
| Formula | | | | | | |
| Calculation | | | | | | |
| Measurement | | | | | | |

Table 3

## What can we conclude?

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### 5.1.4 Load RL

U=50V. R=100 ohm.
L= 60mH.
r=1.2ohm.
f=50Hz.

$Z$ = ……

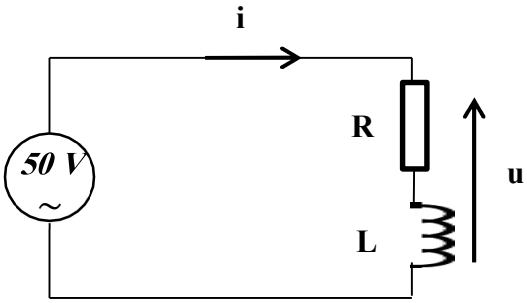



Figure 8

| Greatness | U(V) | I(A) | P(Watt) | Q(Var) | S(VA) | Cos($\varphi$) |
|---|---|---|---|---|---|---|
| Formula | | | | | | |
| Calculation | | | | | | |
| Measurement | | | | | | |

Table 4

What can we conclude?

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**5.1.6 Load RLC**

U=50V.

R=100ohm

L= 60mH.

r =1.2 ohm.

C= 16 µF.

f=50Hz.

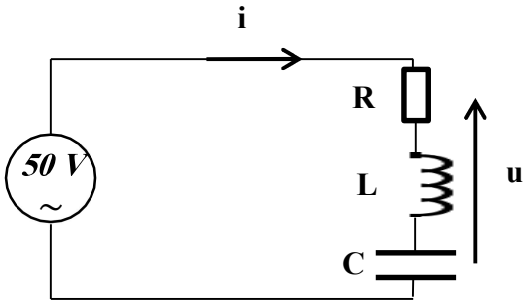



Figure 9

*Z*= ……

| Greatness | U(V) | I(A) | P(Watt) | Q(Var) | S(VA) | Cos(φ) |
|---|---|---|---|---|---|---|
| Formula | | | | | | |
| Calculation | | | | | | |
| Measurement | | | | | | |

Table 5

What can we conclude?

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## 6. Conclusion.

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