جامعة محمد بوضياف- المسيلة -
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كلية التكنولوجيا
Faculty of Technology
قسم الهندسة الكهربائية و قسم الإلكترونيك
Department of Electrical Engineering and Department of Electronics
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University year: 2024/2025 — السنة الجامعية: 2024 /2025
2nd year Electrical Engineering and Electronics — السنة الثانية هندسة كهربائية و إلكترونيك
Applied Work in Fundamentals of Electrotechnics 1 — أعمال تطبيقية في الكهروتقني الأساسية 1
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PW n°02 : Measuring Voltage, Current and Power in Three Phases

Duration : 1^h30.

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

Report prepared by:

Last Name	**First Name**	**Group**	**S/Group**	**Final Note**
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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 ROUABHI.R

***PW n°02* : Measuring Voltage, Current and Power in Three Phases**

I- Aim of the manipulation:

The aim of this experiment is to measure the voltage, current and active and reactive power in a three-phase circuit.

II- Equipment used :

- Three-phase voltage sources (AC).
- Electrical loads (resistors, inductors and capacitors).
- Instruments (multimeters, power meters).

III- Theoretical reminder :

Note:

i, u: instantaneous values.

U: the effective composite voltage between two phases.

V: the effective simple voltage between phase and neutral.

IV- Three-phase electrical power

01) The active power

The active power, P, is the average value of the instantaneous power. It is equal to the arithmetic sum of the active powers of the three single-phase receivers. In other words, three times the single-phase active power when the system is balanced.

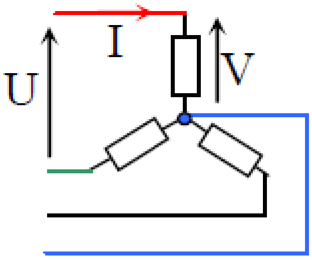
$$\boldsymbol{P_{\text{three-phase}} = P_1 + P_2 + P_3 = 3 * P_{\text{single-phase}}}$$

- Case of a balanced star-coupled system

$$\boldsymbol{P = 3.V.I.Cos\varphi}$$

With $\boldsymbol{V = U/\sqrt{3}}$

V : is the effective value of the phase-to-neutral voltage
I : is the effective value of the line current.
φ : is the phase shift of I relative to V.

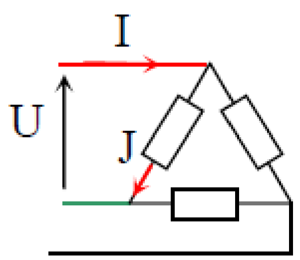


- Case of a balanced delta-coupled system

$$\boldsymbol{P = 3.U.J.Cos\varphi}$$

With $\boldsymbol{J = I/\sqrt{3}}$

U : is the effective value of the phase-to-phase voltage
J : is the effective value of the current of a receiver
φ: is the phase shift of J relative to U



Whatever the coupling for a balanced three-phase system

The active power is given by: $\boldsymbol{P = \sqrt{3}.U.I.Cos\varphi}$

02) The reactive power

The reactive power noted Q is the power brought into play in the reactive dipoles. It is due to the reactance and is expressed in Var (Volt Ampere reactive). It is equal to the arithmetic sum of the reactive powers of the three single-phase receivers. That is to say three times the single-phase reactive power when the system is balanced.

$$Q_{\text{three-phase}} = Q_1 + Q_2 + Q_3 = 3 * Q_{\text{single-phase}}$$

Whatever the coupling for a balanced three-phase system
The reactive power is given by: $Q = \sqrt{3}.U.I.Sin\varphi$

03) The apparent power

The apparent power noted S is the power that characterises the generator of the voltage and alternating current sources. When a source of alternating current is made available, we do not know how it will be used by the user and therefore we do not know the phase difference between the current and the voltage. However, it is necessary to know the voltage and current available.
This is equal to the vectorial sum of the apparent powers of the three single-phase sources. In other words, three times the apparent single-phase power when the system is balanced.

$$S_{\text{three-phase}} = S_1 + S_2 + S_3 = 3 * S_{\text{single-phase}}$$

Whatever the coupling for a balanced three-phase system, the apparent power is given by:

$S = \sqrt{3}.U.I$ Or by: $S = \sqrt{P^2 + Q^2}$

The three-phase power factor is: $Cos\varphi = P/S$

V- Three-phase power measurement methods

01) Single wattmeter method :

This method is valid when the three-phase system is balanced and the neutral is connected (balanced 4-wire system).

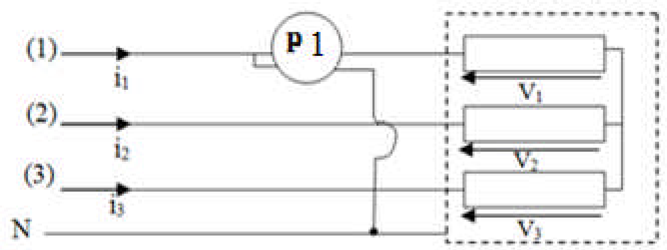


Figure 1

- The current coil is connected to line (1), so the current I_1 flows through it. The voltage coil of the same power meter is connected between the lines (1) and the neutral, so it measures the simple voltage V_1. The indication on the power meter is therefore :

$P_1 = V_1.I_1.Cos\varphi_1$ and $Q_1 = V_1.I_1.Sin\varphi_1$

We can therefore deduce that the active power of this system is: $P = 3.V_1.I_1.Cos\varphi_1 = 3.P_1$

The reactive power is: $Q = 3.V_1.I_1.Sin\varphi_1 = 3.Q_1$

The apparent power is: $$S = 3.V_1.I_1 = \sqrt{P^2 + Q^2}$$

02) Two wattmeter method:

This measurement method is used for three-phase systems without neutral. It allows the measurement of active and reactive powers. The assembly corresponding to the method is as follows:

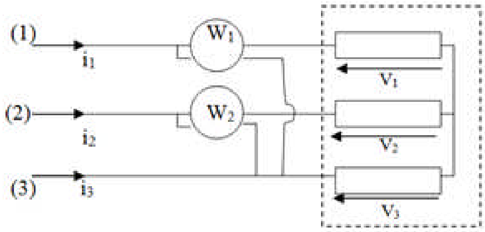


Figure 2

- The current coil of the first wattmeter is connected to line (1), so the current I_1 flows through it. The voltage coil of the same wattmeter is connected between lines (1) and (3), so it measures the composite voltage $U_{13}=V_1-V_3$. The indication on the 1st wattmeter is therefore :

$$W_1 = (U_{13}\, I_1)_{moy} = U\,I\cos(\varphi - \frac{\pi}{6}) = U\,I\,(\frac{\sqrt{3}}{2}\cos\varphi + \frac{1}{2}\sin\varphi):$$

- The current coil of the second wattmeter is connected to line (2), so that current I2 flows through it. The voltage coil of the same wattmeter is connected between lines (2) and (3), so it measures the voltage U23=V2-V3, so the indication of the second wattmeter is therefore :

$$W_2 = (U_{23}\, I_2)_{moy} = U\,I\cos(\varphi + \frac{\pi}{6}) = U\,I(\frac{\sqrt{3}}{2}\cos\varphi - \frac{1}{2}\sin\varphi)$$

We show that the active power of this three-phase system is the sum of the readings of the two wattmetes:

$$\boxed{P = (W_1 + W_2)}$$

The same applies to reactive power: $W_1 - W_2 = UI\sin\varphi = Q/\sqrt{3}$, therefore : $\boxed{Q = \sqrt{3}(W_1 - W_2)}$

The apparent power is: $\boxed{S = \sqrt{P^2 + Q^2}}$

03) Three wattmeter method:

If the three-phase system is unbalanced and with the neutral connected (unbalanced 4-wire system), three power meters must be used to measure the total power.

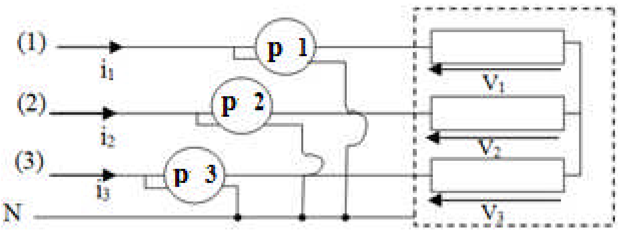


Figure 3

In this case, the active power is: $\boxed{P = P_1 + P_2 + P_3}$

The reactive power is: $\boxed{Q = Q_1 + Q_2 + Q_3}$

The apparent power is: $\boxed{S = \sqrt{P^2 + Q^2}}$

VI- Practical part:

1. Single wattmeter method :

Purely resistive load: The three-phase system is balanced and with neutral connected (4-wire balanced system).

1) Carry out the assembly shown in Figure 4:

$U=U_{12}=U_{23}=U_{31}= 50V$

R= ……..Ω

V_1= …………………………………..V

Z= ……………………………………

………………………………………..Ω

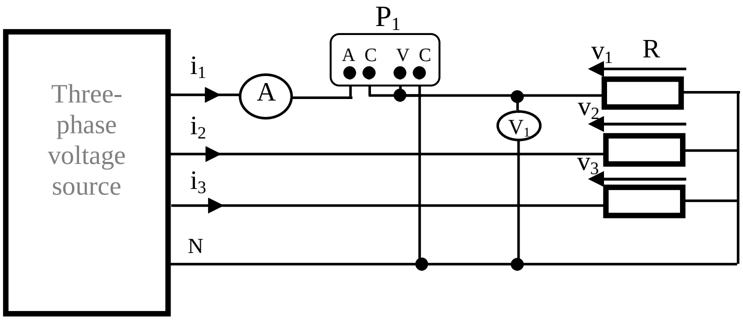


Figure 4

2) Complete the table below:

Greatness	V_1(V)	I_1(A)	P_1(Watt)	Q_1(Var)	S_1(VA)	$Cos(\varphi_1)$
Formula						
Calculation						
Measurement						

Table 1

3) Calculate the total power and the power factor.

Calculations	Measurement
P_{T_C}=…………………………………………………	P_{T_M} =…………………………………………
Q_{T_C}=…………………………………………………	Q_{T_M} =…………………………………………
S_{T_C} = …………………………………………………	S_{T_M} = …………………………………………
$Cos(\varphi)$ =………………………………………………	$Cos(\varphi)$ =……………………………………

4) What can we conclude ?

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2. Three wattmeter method:

Purely capacitive load: The three-phase system is unbalanced with the neutral connected (4-wire system) and the load is connected in star configuration.

1) Carry out the assembly shown in 5:

U_{12}=U_{23}=U_{31}=U=50 V
f= 50 Hz.
C_1= …………µF.
C_2= …………µF.
C_3= …………µF.

Z= …………………………
……………………….…..Ω

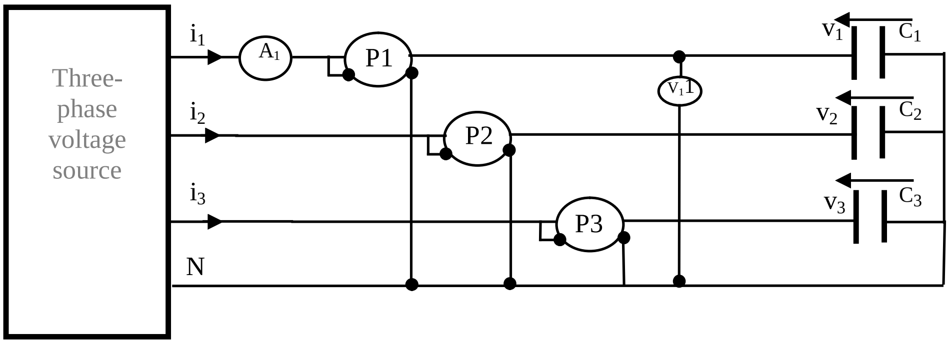

Figure 5

2) Complete the table below: Tab2 et Tab3

Greatness	V_1(V)	I_1(A)	P_1(Watt)	Q_1(Var)	S_1(VA)	Cos(φ_1)
Formula						
Calculation						
Measurement						

Table 2

Greatness	P_2(Watt)	Q_2(Var)	S_2(VA)	P_3(Watt)	Q_3(Var)	S_3(VA)
Measurement						

Table 3

3) Calculate the total power and the power factor.

P_T=…………………………………………………………………………………………………
Q_T=…………………………………………………………………………………………………
S_T= …………………………………………………………………………………………………
Cos(φ) =……………………………………………………………………………………………….

4) What can we conclude?

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3. Two wattmeter method :

Inductive load: The three-phase system is balanced and has no neutral (balanced 3-wire system).

U= 50 V.
f= 50 Hz.
R= ……....Ω.
L= ………..H.
r= ………..Ω.
Z= ……………………..…
……………….………..Ω

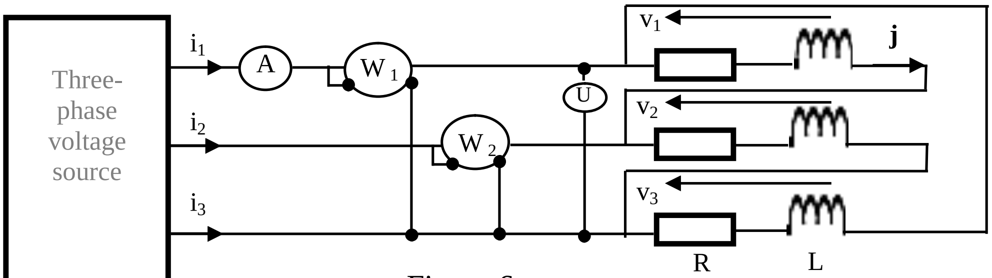

Figure 6

1) Complete the following tables: Table 4 et Table 5

Greatness	J (A)	P_{ph1}(Watt)	Q_{ph1}(VAR)	P_T(Watt)	Q_T (VAR)	S_T (VA)	Cos(φ)
Formula							
Calculation							

Table 4

Values to be measured				Values to be calculated			
U(V)	I(A)	W_1	W_2	P_T(Watt)	Q_T(VAR)	S_T(VA)	Cos(φ)
.	.	.	.	.	.	.	.

Table 5

2) What can we conclude?

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VII- Conclusion.

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