POWER AND ENERGY MEASUREMENT IN A SINGLE PHASE SYSTEM

1) Preparation Questions

Before starting the experiment, answer the following questions and add answers to the beginning of your report.

a) Explain the operation of a single-phase alternating current meter with the necessary circuit diagram.

b) Describe the operation of the analog Wattmeter and show the circuit connections.

c) Describe the operation of a digital Wattmeter and show the circuit connections.

d) Describe the operation of a phase meter.

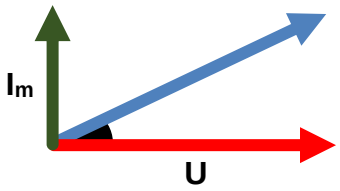
2) Power and Energy Measurement in Single Phase System

a) Purpose of the Experiment

The purpose of this experiment is to provide the student with information on how to calculate power and energy.

b) Theoretical background for Power Calculation

In alternating current circuits, we know that the angle (φ), between the voltage applied to the circuit and the circuit current, varies depending on the ohmic or reactive resistances in the circuit.



In the vector diagram in Figure 1 , the current is behind voltage (φ).
Let's divide the current I into vertical components. I_w component is in phase with voltage (U) and I_m component is perpendicular to voltage (U). The product of the I_w current, which is in phase with the voltage, and the voltage (U) gives the **real (active) power** in Watts.

$$P = I_w U \quad (1)$$

$$I_w = I\cos\varphi \quad (2)$$

$$P = UI\cos\varphi \quad (3)$$

The unit of active power is (Watt) and shown as W.

In this expression, which gives the real power in alternating current circuits, its component (I_w) is called watt current or active current.
The reactive power is also found as follows:

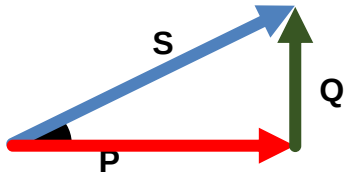
$$Q = UI_m \tag{4}$$

$$Q = UIsin\varphi \tag{5}$$

The unit of reactive power is (Volt - Amper - Reactive) and it is denoted as VAR. The current (I_m) component perpendicular to the voltage is the reactive current or called as Wattless current or magnetizing current.

The product of the voltage (U) and the current (I) is called **apperant power**. Th eunit of the Apperant Power is Volt Amper (VA) and denoted as S.

$$S = UI \tag{6}$$



The relationship between reactive, active and apperant power can be written from the power triangle (Figure 2).

$$S = \sqrt{P^2 + Q^2} \tag{7}$$

As an example, 120V 50Hz and 8A source delivers 720W (active) power. So the apperant power is:

$$S = 120V.8A = 960VA \tag{8}$$

Active power is:

$$P = 720W \tag{9}$$

$$P = UIcos\varphi \tag{10}$$

From the equation, we can extract $cos\varphi$ to find the power factor:

$$cos\varphi = \frac{720}{960} = 0.75 \Longrightarrow \varphi = 41{,}4 \tag{11}$$

We can find the reactive power by plugging the values in Eqn.5:

$$Q = 120.8.sin\ sin\ (41{,}4)\ = 633.6VAR \tag{12}$$

The accuracy of the K coefficient given on the electricmeters (tour / kWh) should be checked. This is important for the active power taken from the grid. Therefore, the following equation is important.

W=Pt=n/K (n=1)

P= Active power
t= One electricmeter tour time
n= 1 tour
K = Electicmeter coefficient

3) Experiment Procedure

The circuit you need for the experiment is shown in Figure 3 and detailed explanation for constructing the circuit is given in Section 4. For the purpose of this experiment, you are asked to setup the circuit and reconfigure it by turning different switches ON/OFF. At each configuration, you are asked to find certain values below Exp.1-7.

4) Experimental Setup

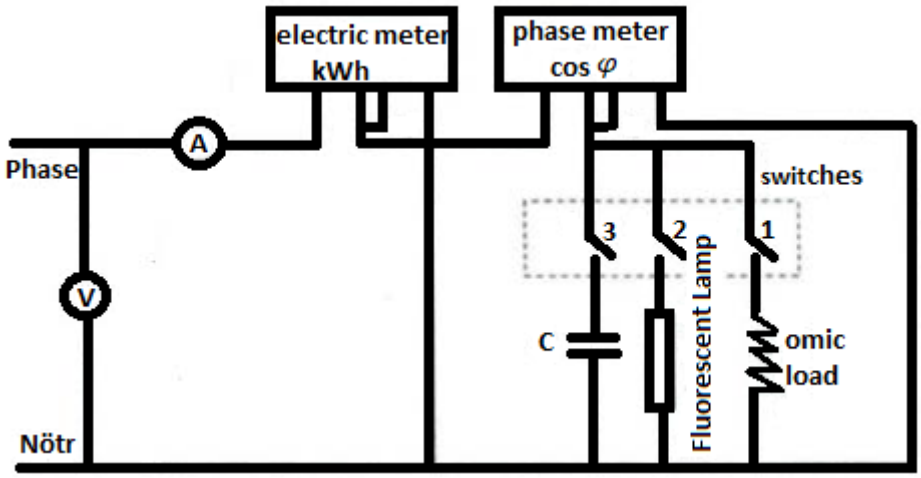


Figure. 3 Circuit schematic

1. Setup the circuit as in Figure 3.
2. Take the bulb as ohmic load.
3. Take fluorescent lamp for inductive load.
4. Take any capacitor for capacitive load,
5. To find the voltage across the load and the current flowing through use multimeter.

Experiment 1. Omic Load Test

Activate the ohmic load by closing only switch 1 in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 2. Inductive Load Test

Activate the inductor load (fluorescent lamp) by closing only switch 2 in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 3. Capacitive Load Test

Activate the capacitor load by closing only switch 3 in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 4. Parallel Connected Omic Inductive Load Test

Activate only resistive-inductive load in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 5. Parallel Connected Omic Capacitive Load Test

Activate only resistive-capacitive load in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 6. Parallel Connected Inductive Capacitive Load Test

Activate only capacitive-inductive load in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.

Experiment 7 . Parallel Connected Omic Inductive Capacitive Load Test

Activate only resistive-inductive-capacitive load in Figure 3.
Read current from ampermeter and voltage from voltmeter.
Phase meter shows phase difference as cosφ. Please note down these values
Please calculate the active power from P=VIcosφ.
Please find the time of one electricmeter tour from timer.
Please confirm the electicmeter coefficient (K) according to the equation W=Pt=n/K (n=1)
Draw the phasor diagram of the circuit.