EE 256: POWER AND ENERGY

Experiment: Power & Energy Measurements

(3 hours)

DATE:..................................

CAUTION: High voltages are present in this Laboratory Experiment! Do not make any connections when the power is on. The power should be turned off after completing each set of measurements.

INTRODUCTION

This experiment covers power and energy measurement of a single-phase system. The power measurements are condcuted using a Wattmeter. Students are given the practical exposure to measure single phase power based on following loads; a resistive load, a capacitive load, an inductive load, a resistive load in parallel with an inductive load & a resistive load in parallel with an inductive load and Capacitive load.

LEARNING OUTCOMES:

- LO 2: Discuss and demonstrate different methods of power measurements (covering attributes of WA1 and WA2)

OBJECTIVES:

- Discuss and demonstrate single phase power measurements using one wattmeter (LO 2).

a) Measurement of Power and Power Factor of a Resistive Load

APPARATUS

- Single Phase Wattmeter: 1A, 240V (YOKOGAWA)
- Single Phase Energy meter: meter constant - ....
- AC Ammeter: 0~2A (YOKOGAWA)
- AC Voltmeter: 0~300V (YOKOGAWA)
- Variable resistor: 330Ω/2A or 500Ω/2A
- Variable AC Supply

PROCEDURE

Step 1 – Examine the construction of the single-phase wattmeter module shown in Figure 1, paying particular attention to its terminals and wiring.

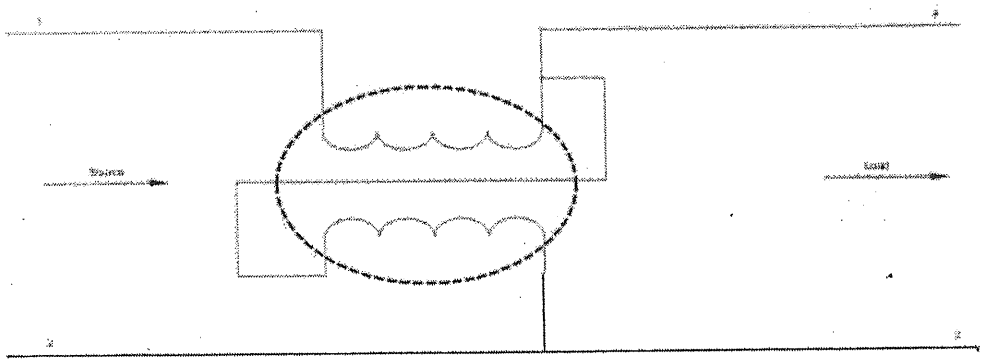

Figure 1: The wiring schematic of the single-phase wattmeter

Step 2 – Connect the circuit as shown in Figure 2.

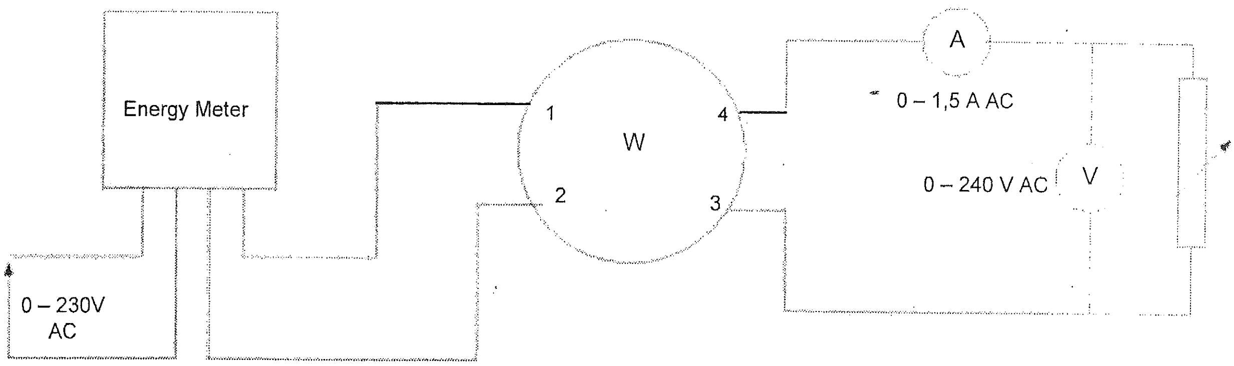

Figure 2: Power measurements with a resistive load

Step 3 – Turn on the power supply and increase the voltage from 0 to 200V in steps as mentioned below. Take the ammeter and the wattmeter readings and record in Table 1.

Step 4 – Find the number of rotations of the energy meter for 2mins, when the voltmeter reading is 160V (Suggest your own method).

Step 5 – After taking the readings, set the voltage to zero and turn off the power supply

OBSERVATIONS

Table 1: Meter readings for the test shown in Figure 2

Voltmeter reading, V/(V)	0	80	160	200
Ammeter reading, I/(A)				
Wattmeter reading, P/(W)				

Energy meter reading (Number of rotations): ....

RESULTS AND DISCUSSION

Step 6 – Calculate active power, reactive power, apparent power and power factor for the above voltage levels.

Step 7 – Calculate the energy acquired by the circuit using the energy meter.

Is there a good agreement between your measured values of power P and the product of E I? (Yes or No)

Step 8 – Interchange the terminals of either the current coil or the voltage coil. Turn on the power. Adjust the voltage to 200V. Is there a reading on the wattmeter? (Yes or No)

If "Yes" what is the reading? If "No" Why?

Table 2: Results of the experiment

Voltmeter reading, E/(V)	0	80	160	200
Active Power, P(W)				
Reactive Power, Q(Var)				
Apparent Power, S(VA)				
Power Factor, Cos (ϕ)				

Energy acquired by the circuit using the energy meter = ...

b) Measurement of Power and Power Factor of a Capacitive Load

APPARATUS

- Single Phase Wattmeter: 1A, 240V (YOKOGAWA)
- Single Phase Energy meter: meter constant - ....
- AC Ammeter: 0~5A (YOKOGAWA)
- AC Voltmeter: 0~300V (YOKOGAWA)
- Variable capacitor (Terco MV1102) – maximum position value = ...
- Variable AC Supply

PROCEDURE

Step 1 – Connect the circuit shown in Figure 3. Select the **maximum** capacitance available from the capacitor module as the capacitor. Note that this circuit is identical to the circuit of Figure 2 except that the resistive load has been replaced by a capacitive load.

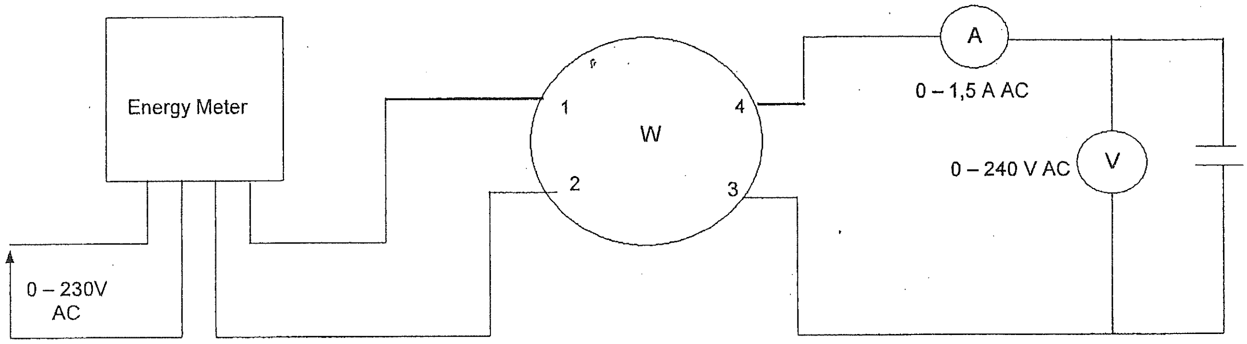

Figure 3: Power measurement on a capacitive load

Step 2 – Turn on the power supply and adjust the voltage for 200V as indicated by the voltmeter. Measure and record the load current I_L.

Step 3 – Measure and record the active input power as indicated by the wattmeter.

Step 4 – Find the number of rotations of the energy meter for 2mins, for the given load condition.

Step 5 – Set the voltage to zero and turn off the power supply.

OBSERVATIONS

- I_L = ... A
- P = ... W
- Number of rotations: ....

CALCULATION

Step 6 – Calculate and record reactive power, apparent power and power factor.

Step 7 – Calculate the energy acquired by the circuit using the energy meter.

Note that the apparent power (in VA) is appreciably larger than the active power (in W)

RESULTS

- Reactive power, Q(Var) = ...
- Apparent power, S(VA) = ...
- Power Factor, Cos (φ) = ...
- Energy acquired by the circuit using the energy meter = ...

c) Measurement of Power and Power Factor of an Inductive Load

APPARATUS

- Single Phase Wattmeter: 1A, 240V (YOKOGAWA)
- Single Phase Energy meter: meter constant - ....
- AC Ammeter: 0~5A (YOKOGAWA)
- AC Voltmeter: 0~300V (YOKOGAWA)
- Variable inductor (Cosford) – 2A position value = ...
- Variable AC Supply

PROCEDURE

Step 1 – Connect the circuit as shown in Figure 4. Switch on appropriate inductance so that 2 A of current flows through it which is measured by the ammeter. Note that this circuit is identical to the circuit of Figure 2, except that the resistive load has been replaced by an inductive load.

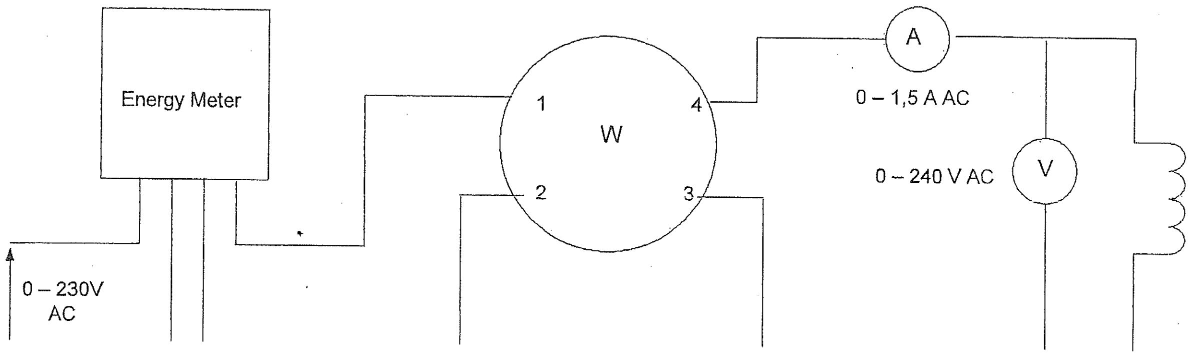

Figure 4: Power measurement on an inductive load

Step 2 – Turn on the power supply and adjust the voltage for 240V as indicated by the voltmeter. Measure and record the load current I_L.

Step 3 – Measure and record active power as indicated by the wattmeter.

Step 4 – Find the number of rotations of the energy meter for 2mins for the given load condition.

Step 5 – Set the voltage to zero and turn off the power supply.

OBSERVATIONS

- I_L = ... A
- P = ... W
- Number of rotations: ....

CALCULATIONS

Step 6 – Calculate and record reactive power, apparent power and power factor.

Step 7 – Calculate the energy acquired by the circuit using the energy meter.

Note that the apparent power (in VA) is appreciably larger than the active power (in W).

RESULTS

- Reactive Power, Q(Var) = ...
- Apparent Power, S(VA) = ...
- Power Factor, Cos (φ) = ...
- Energy acquired by the circuit using the energy meter = ...

d) Measurement of power and power factor of a resistive load connected in parallel with an inductor

APPARATUS

- Single Phase Wattmeter: 1A, 240V (YOKOGAWA)
- Single Phase Energy meter: meter constant - ....
- AC Ammeter: 0~5A (YOKOGAWA)
- AC Voltmeter: 0~300V (YOKOGAWA)
- Variable resistor: 330Ω/2A or 500Ω/2A
- Variable inductor (Cosford) – 2A position value = ...
- Variable AC Supply

PROCEDURE

Step 1 – Connect the circuit as shown in Figure 5. Increase the variable resistor position to its maximum value. Turn on the power and set the input voltage to 200V.

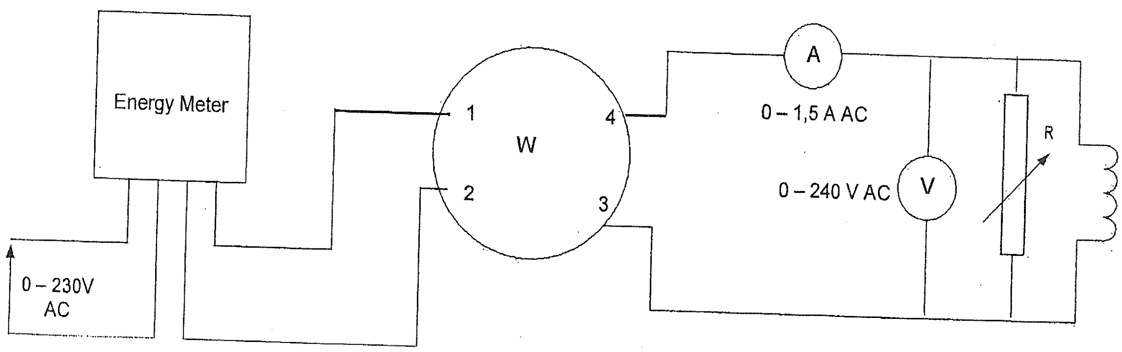

Figure 5: Power measurement on a parallel RL circuit

Step 2 – Measure and record the load current I_L.

Step 3 – Measure and record active power as indicated by the wattmeter.

Step 4 – Find the number of rotations of the energy meter for 2mins for the given load condition.

Step 5 – Set the input voltage to zero & turn off the power supply.

OBSERVATIONS

- Current (I_L) = ... A
- Active Power (P) = ... W
- Number of rotations: ....

CALCULATIONS

Step 6 – Calculate and record reactive power, apparent power and power factor.

Step 7 - Calculate the energy acquired by the circuit using the energy meter.

RESULTS

- Reactive Power, Q (Var) = ...
- Apparent Power, S (VA) = ...
- Power Factor, Cos (φ) = ...
- Energy acquired by the circuit using the energy meter = ...

e) Measurement of Power and Power Factor of a Resistive Load connected in parallel with Inductor and Capacitor

APPARATUS

- Single Phase Wattmeter: 1A, 240V (YOKOGAWA)
- Single Phase Energy meter: meter constant - ....
- AC Ammeter: 0~5A (YOKOGAWA)
- AC Voltmeter: 0~300V (YOKOGAWA)
- Variable resistor: 330Ω/2A or 500Ω/2A
- Variable capacitor (Terco MV1102)
- Variable inductor (Cosford) – 2A position value = ...
- Variable AC Supply

PROCEDURE

Step 1 – Connect the capacitor module in parallel to R & L (Keep the values of the R & L unchanged) as shown in Figure 6. Turn on the power and set the voltage to 200V.

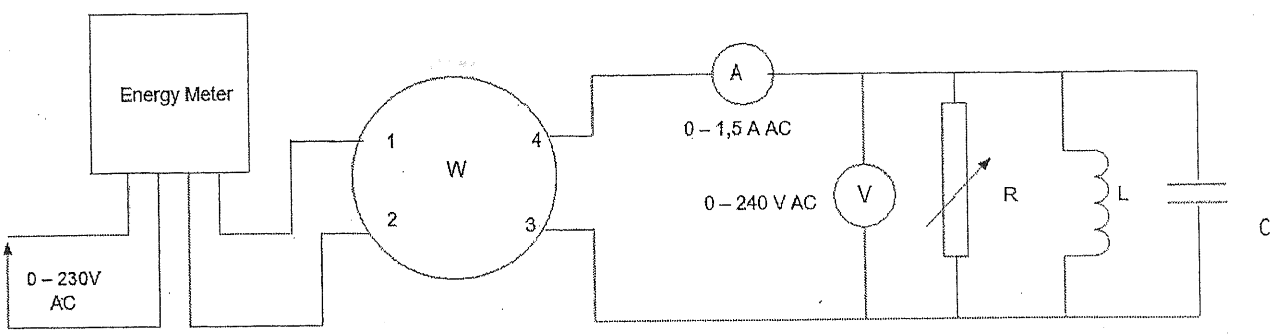

Figure 6: Power measurement on a parallel RLC circuit

Is there any change in the Wattmeter reading as the capacitance is increased? (Yes or No)
Explain your observations.

Step 2 – Adjust the capacitance for minimum line current. Measure the Ammeter reading, Wattmeter reading and the Capacitance for minimum current.

Step 3 – Find the number of rotations of the energy meter for 2mins for the given load condition.

Step 4 – Set the input voltage to zero & turn off the power supply.

OBSERVATIONS

- Current (I_L) = ... A
- Active Power (P) = ... W
- Capacitance for minimum current (C) = ... μF
- Number of rotations: ....

CALCULATIONS

Step 5 – Calculate and record reactive power, apparent power & power factor.

Step 6 – Calculate the energy acquired by the circuit using the energy meter.

RESULTS

- Reactive Power, Q (Var) = ...
- Apparent Power, S (VA) = ...
- Power Factor, Cos (φ) = ...
- Energy acquired by the circuit using the energy meter = ...

COMPARISON OF RESULTS

Step 1: Fill in the blanks in the Table 3

Table 3: Results

Part	Power (W)		Q (Var)	S (VA)	Power factor	
	Wattmeter	Energy meter			Impedance	Meter reading
a						
b						
c						
d						
e						

Note: Specimen Calculations should be attached for each part separately. Power factor should be calculated using both impedance values and meter reading values.

REPORT

1. Is there a difference between the power values from Wattmeter and Energy meter? Comment
2. Is there a difference between the power factor values from impedance values and meter readings? Comment
3. Name two household appliances that have a high-power factor (nearly unity).
4. Can you suggest one domestic appliance, which might have a low power factor?

WATT METER DIAGRAM