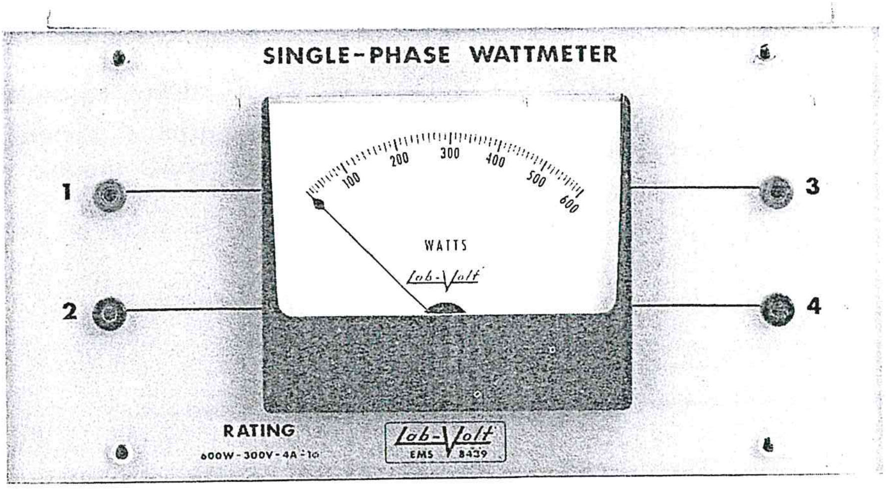
LABORATORY
EXPERIMENT
NO. 15

THE WATTMETER



OBJECT

1. To learn how to use a wattmeter.
2. To become familiar with *real and apparent* power in ac circuits.

DISCUSSION

In direct current circuits the power *(in watts)* supplied to a resistive load is always equal to the product of the voltage and the current. In alternating current circuits the product of the voltage and the current does not always give an answer which can be stated in watts. For this reason, wattmeters are essential in ac circuits, so that the **real power** *(in watts)* may be measured.

Apparent power *(in voltamperes)* is defined as the product of the ac voltage and the ac current. Apparent power is only equal to real power when the load circuit is entirely resistive. This was the case in the previous **Laboratory Experiment.** When the load circuit is not entirely resistive, the apparent power *(VA)* can be quite different from the real power *(W)*. It is a little early to explain why this is so, but we will shortly explain the phenomenon. At present we will perform some experiments to show what we mean by *real* and *apparent power*, and how these powers can be measured.

INSTRUMENTS AND COMPONENTS

Power Supply Module *(0-220 Vac)*	*EMS 8829*
Resistance Module	*EMS 8319*
Inductance Module	*EMS 8328*
Capacitance Module	*EMS 8338*
AC Metering Module *(1.5A)*	*EMS 8428*
AC Metering Module *(250V)*	*EMS 8429*
Single-Phase Wattmeter Module *(600W)*	*EMS 8439*
Connection Leads	*EMS 8941*

PROCEDURE

Caution: High voltages are present in this Laboratory Experiment! Do not make any connections with the power on! The power should be turned off after completing each individual measurement!

☐ **1.** Examine the construction of the **Single-Phase Wattmeter Module EMS 8439** paying particular attention to the meter, connection terminals and the wiring. The module wiring shcematic is shown in *Fig. 15-1.*

The internal meter current coil connections are brought out to meter terminals *A* and *B*. The internal meter voltage coil connections are brought out to meter terminals *C* and *D*. The current coil (protected by the diodes) is connected in series with the line (module terminals *1* and *3*). The voltmeter coil is connected in parallel across the load side of the line (module terminals *3* and *4*). The power supply should always be connected to terminals *1* and *2* (the input to the wattmeter module).

The load should always be connected to terminals *3* and *4* (the output of the wattmeter module). **The behind-the-panel module wiring must never be changed!**

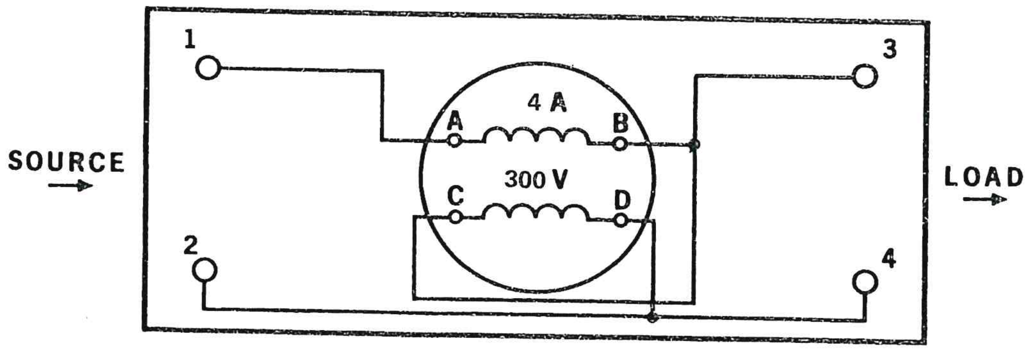


Fig. 15-1

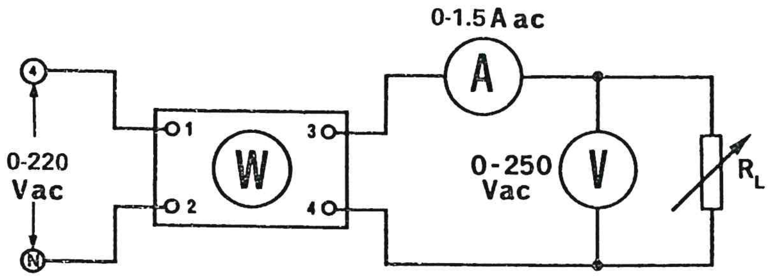


Fig. 15-2

☐ 2. Using your **EMS Resistance, Wattmeter, AC Metering and Power Supply Modules,** connect the circuit shown in *Fig. 15-2.* Set the load resistance to *210Ω* (all switches closed, all sections in parallel).

☐ 3. a) Turn on the power supply and adjust for *220 Vac* as indicated by the ac voltmeter across R_L. Measure and record the load current I_L.

I_L = ______________ *Aac*

☐ b) Measure and record the input power as indicated by the wattmeter.

P_{in} = ______________ *W*

☐ c) Calculate the input power by using the equation $P = EI$.

P_{in} = ______________ *W*

☐ d) Does the power (**b**) equal (neglecting the meter accuracies) the power (**c**) for a resistive load?

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☐ e) Remove the load by opening all of the resistance switches. Note that the wattmeter indicates zero power even if it has *220 Vac* across the voltage coil.

☐ f) Return the voltage to zero and turn off the power supply.

☐ 4. Connect the circuit shown in *Fig. 15-3.* Notice that this circuit is identical to the one used in *Procedures 2 and 3* except that now the input and output terminals of the wattmeter have been interchanged.

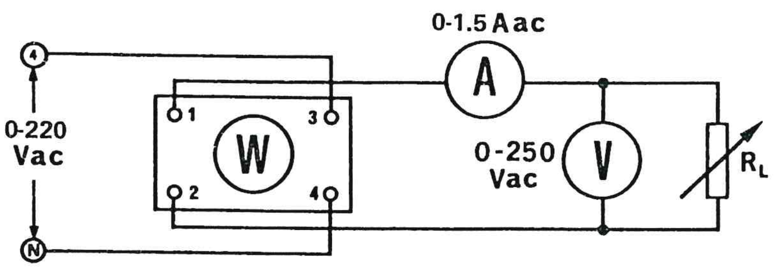

Fig. 15-3

☐ 5. a) Set the load resistance to 210Ω. Turn on the power supply and adjust for *220 Vac* as indicated by the ac voltmeter across R_L.

☐ b) Note that the wattmeter pointer deflects to the left. This does not harm the instrument, but makes a meter reading impossible.

☐ c) Return the voltage to zero and turn off the power supply.

☐ 6. a) Reconnect your circuit as shown in *Fig. 15-2.*

☐ b) Repeat *Procedures 2 and 3*, but this time take your measurements for *0V, 80V, 160V and 220V*. Record your measurements in *Table 15-1.*

	0V	80V	160V	220V
E =				
I =				
W =				
E x I =				

Table 15-1

☐ 7. Is there good agreement between your measured values of power *W* and the products of *E x I?*

NOTE 1: Procedure 6 has shown that the wattmeter can correctly multiply the quantities E and I. The wattmeter can then be trusted to indicate the real power (in watts) under various voltage and current conditions.

NOTE 2: In Procedure 6, we would call the product E x I, the apparent power supplied to the load, while the wattmeter indication would be called the real power. For resistive loads these two powers are identical.

☐ 8. a) Examine the construction of the **Capacitance Module EMS 8338**. Notice that it is similar to the resistance module in that it contains nine capacitors arranged into three identical sections. (The **Capacitance Module EMS 8338** will be explained in greater detail in a later **Laboratory Experiment**).

☐ b) Connect the circuit shown in *Fig. 15-4.* Connect each of the three capacitor sections in parallel and close *("up" position)* all of the switches. This will provide the maximum capacitance available from the module. Note that this circuit is identical to the circuit of *Fig. 15-2* except that the resistance load has now been replaced by a capacitance load.

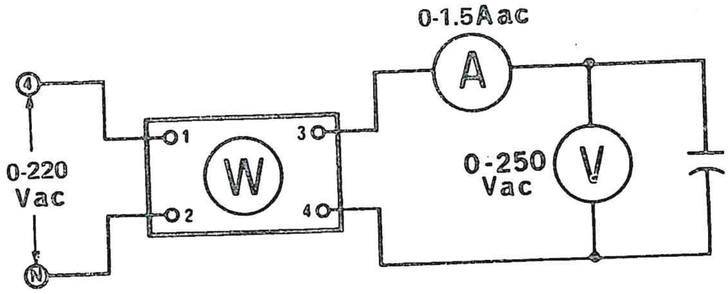

Fig. 15-4

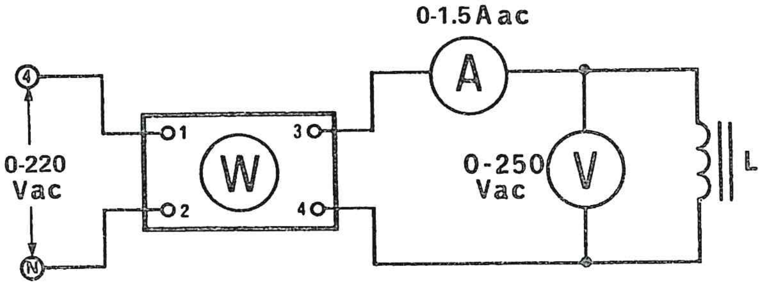

Fig. 15-5

☐ 9. a) Turn on the power supply and adjust for *220 Vac* as indicated by the ac voltmeter across the capacitance load. Measure and record the load current I_L.

I_L = ________________ *Aac*

☐ b) Measure and record the *real* input power as indicated by the wattmeter.

P_{in} = ________________ *W*

☐ c) Calculate and record the *apparent* input power.

$E \times I$ = ______________ *VA*

Note that the *apparent power (expressed in voltamperes VA)* is appreciably larger than the *real power (expressed in watts W).*

☐ d) Return the voltage to zero and turn off the power supply.

☐ 10. a) Examine the construction of the **Inductance Module EMS 8328**. Notice that it is similar to the resistance and capacitance modules in that it contains nine inductors arranged into three identical sections. (The **Inductance Module EMS 8328** will be explained in greater detail in a later **Laboratory Experiment**).

☐ b) Connect the circuit shown in *Fig. 15-5*. Connect each of the three inductor sections in parallel and close *("up" position)* all of the switches. This will provide the minimum inductance available from the module. Note that the circuit is identical to the circuit of *Fig. 15-2* except that the resistance load has now been replaced by an inductance load.

☐ 11. a) Turn on the power supply and adjust for *220 Vac* as indicated by the ac voltmeter across the inductance load. Measure and record the load current I_L.

I_L = ________________ *Aac*

☐ b) Measure and record the *real* input power as indicated by the wattmeter.

P_{in} = ________________ *W*

☐ c) Calculate and record the *apparent* input power.

$E \times I$ = ______________ *VA*

Note that the *apparent power (expressed in voltamperes VA)* is appreciably larger than the *real power (expressed in watts W).*

☐ d) Return the voltage to zero and turn off the power supply.

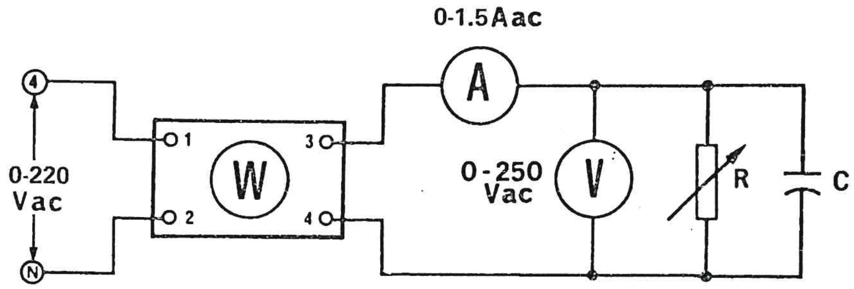

Fig. 15-6

☐ 12. Repeat *Procedure 9* using the resistance and capacitance modules in parallel as shown in *Fig. 15-6*. Connect all sections in parallel and close all switches.

I = ______________*A*

Real Power = ______________*W*

Apparent Power = ______________*VA*

TEST YOUR KNOWLEDGE

1. Is a wattmeter required to measure the real power delivered to a resistive load?

______________Explain. ________________________

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2. Name two types of circuit loads in which the apparent power is greater than the real power.

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3. In what units do you express:

a) *Apparent power?*____________________

b) *Real power?*____________________

4. The ratio of *(Real Power/Apparent Power)* is called the *power factor (PF)* of an ac circuit. Calculate the *power factor* for *Procedures 3, 9, 11 and 12.*

Procedure 3) PF = ____________________

Procedure 9) PF = ____________________

Procedure 11) PF = ____________________

Procedure 12) PF = ____________________

5. Name two household appliances that have a high power factor (nearly unity).

1.__________________________________

2.__________________________________

6. Can you suggest one domestic appliance which might have a low power factor ?

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7. Under what conditions will a wattmeter indicate a negative power (less than zero)?

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