

## ELECTRICAL INSTRUMENT AND MEASUREMENT

Electrical measuring instruments are devices used to measure electrical quantities such as electric current, voltage, resistance, electrical power and energy.

### MULTIMETERS

Multimeter measures range of currents and voltages for both direct current and alternating current and also resistances. It is a combined Ammeter, Voltmeter and Ohmmeter and is essential test instrument in electronics.

There are two types of multimeters:

1. Analogue Multimeter.
2. Digital Multimeter.

They both indicate the magnitude of the analogue and digital quantity, the difference between the two multimeter are the readings. The analogue gives a reading where the position of a pointer on a scale indicates the quantity and the digital multimeter gives a digital read out.



Fig. 1 – Analogue Multimeter

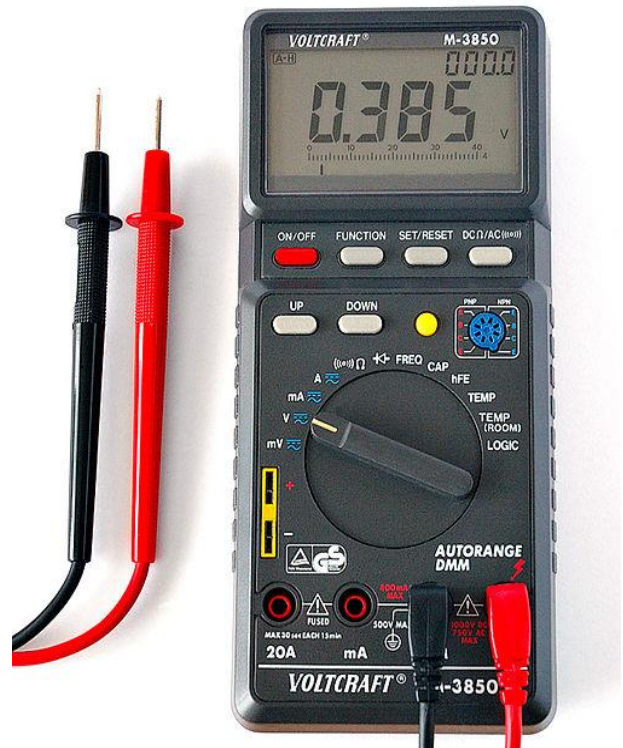


Fig.2 – Digital Multimeter

In analogue multimeter, there are three parts that is important to understand, they are;

- a. Function.
- b. Range.
- c. Scale.

**Function** – it is the types of quantity to be measured. Eg. Voltage in a.c./d.c. volts, Current in a.c./d.c. ampere and resistance in Ohm.

**Range** - it is the limited values for each function for examples the expected values of the circuit to be measured is 20V d.c, then use the range of 25V and the function of DCV.

**Scale** – It is the place where we read the values the meter produce. Scale can only be found in analogue type of meter.

### Use of Multimeter.

A multimeter incorporates a switching arrangement enabling the instrument to be used as an ohmmeter, a voltmeter and an ammeter.

### Resistance measurement

The range on the multimeter must be set to measure resistance. The multimeter now act as an Ohmmeter. When measuring resistance it is very important that the voltage supply is disconnected first from the resistor circuit. This is to prevent damage to the *Ohmmeter*. The multimeter is **connected across** the resistance to measure it.

To measure resistance, the terminal are joined and R (often labeled zero  $\Omega$ ) adjusted until the pointer gives a full-scale deflection. I.e. is on zero of the ohm scale. The ‘short circuit’ is then removed from across the terminals and the unknown resistor connected instead. The pointer falls owing to the smaller current passing through the meter and indicates the resistance on Ohms. The resistance scale is a non-linear, reverse one, i.e. the zero is on the right.

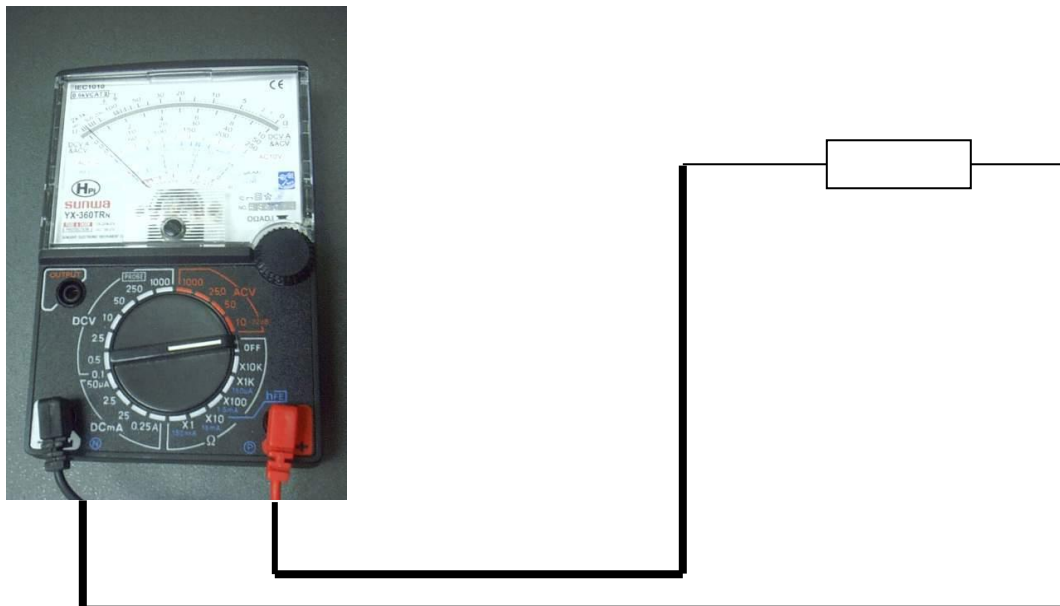


Fig.3 – shows how to measure a resistor

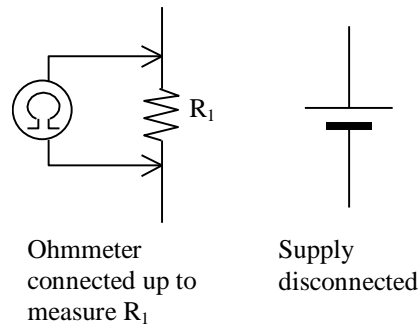


Figure 4. Measuring resistance of R<sub>1</sub>.

### Voltage measurement.

The range on the multimeter must be set to measure voltage. The multimeter now act as a Voltmeter. Always start with the highest range. When measuring voltage, the circuit should be switched on and the multimeter should be **connected in parallel** to the component (such as the resistor) that you want to measure the voltage. For AC measurement, the reading will show RMS value.

Select the V a.c. and V d.c. functions and connects the leads as shown below.

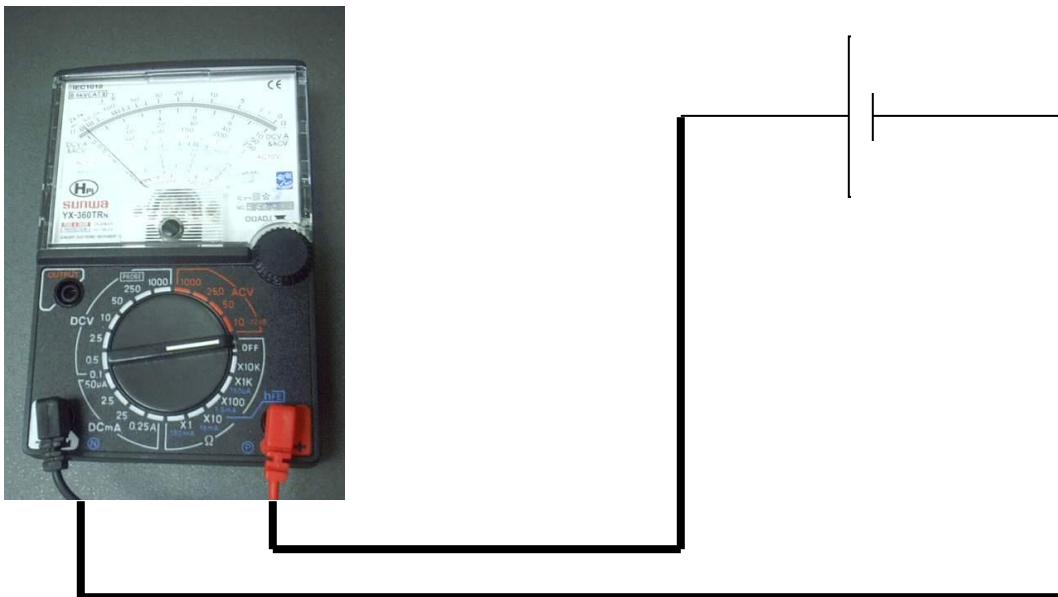


Fig.5 – shows how to measure voltage

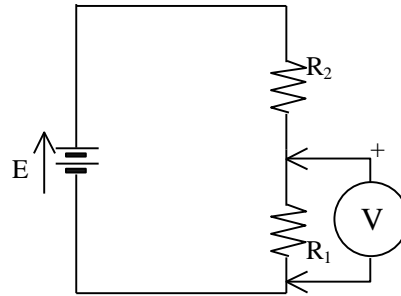


Figure 6. Measuring voltage across  $R_1$ .

### Current measurement.

For these measurements, the meter must be placed in series, then select AC and DC function.

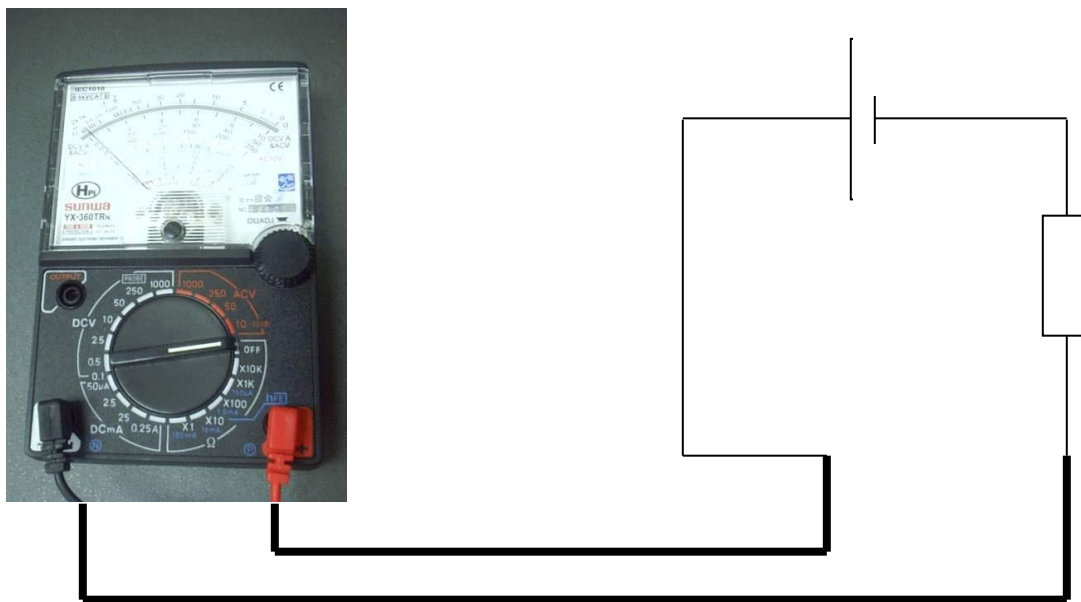


Fig.7 – shows how to measure current

The range on the multimeter must be set to measure current. The multimeter now act as an Ammeter. Always start with the highest range. When measure current, the circuit should be switched on and the multimeter should be connected in series to the component (such as the resistor) that you want to measure the current. Never connect an Ammeter in parallel with the component, or the meter will be damaged. For AC measurement, the reading will show RMS value.

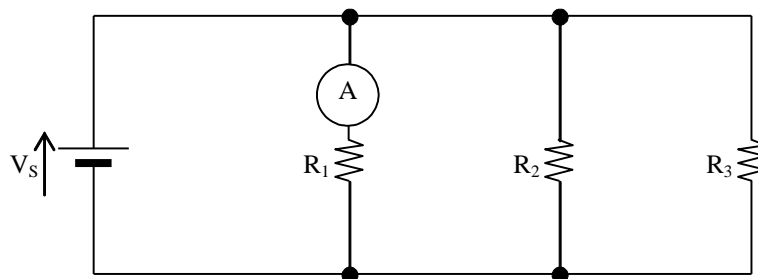


Figure 8. Measuring current flowing through  $R_1$ .

## READING THE METER

There are a number of scales on the meter. We shall consider three scales only:

1. Resistance Scale - the top scale for measurement of resistance.
2. DC Scale - the scale under the resistance scale, for measurement of DC current and voltage.
3. AC Scale - the scale below the DC scale, for measurement of AC voltage.

Take note that you may encounter different looks of scale but the principle of operation/reading is the same.

### Resistance Scale

The Zero Ohm is at the right most end. The reading should be multiplied by the multiplier setting on the meter (knob).

### How to use multimeter to read the resistance value;

Procedures:-


1. Set the Range Selector to the appropriate range position. The ranges are:
  - a. R x 1
  - b. R X 10
  - c. R x 100
  - d. R x 1K
  - e. R x 10K

If the resistance is not known, start from the highest range setting.

2. Check if the Pointer rests on the infinity mark ( $\infty$ ). If not adjust the movement of the pointer with a small screwdriver.
3. Connect the test leads (test probes) together, short circuiting them. Check if the pointer rests on  $0\Omega$ . If not, adjust the  $0\Omega$  ADJ.  
If the pointer cannot be zeroed the internal battery requires replacement.
4. To measure the resistance, connect the test leads ( test probes) across the resistor to be measured.

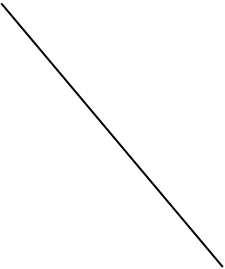
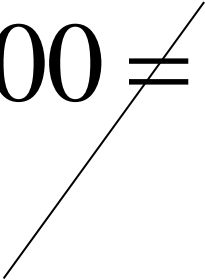
Notes:

- a. Resistor must be disconnected from the voltage supply before the Ohmmeter (Multimeter) can be connected.
  - b. Keep your fingers on the insulated part of the test leads (test probes) to avoid incorrect reading.
5. Observe the reading on the Scale Plate and multiply with the range setting E. of the scale reads 5 and the range selector set to Rx100, the actual reading will be;  
Resistance =  $500\Omega$ .
  6. If the resistance value was unknown and you had to change the resistance range setting during the measuring process, the  $0\Omega$  must be rechecked.

	<p>Setting:        R x 10K</p> <p>Reading on Scale: 15</p> <p>Measured Value: 15 x 10K = 150K</p>
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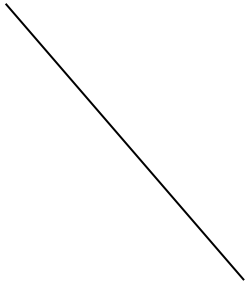
DC Scale

The Zero amp or volt is at the left most end. The scale is dependent on the range setting at the knob.

	<p>Setting:        100V d.c.</p> <p>Reading on Scale: 1 (out of 10)</p> <p>Measured Value: <math>\frac{1}{10} \times 100 = 10Vd.c.</math></p>
 <p style="font-size: 2em; font-weight: bold; margin: 0;"><math>\frac{1}{10} \times 100 = 10</math></p>	<p>Setting:        2.5mA d.c.</p> <p>Reading on Scale: 8.7 (out of 10)</p> <p>Measured Value: <math>\frac{8.7}{10} \times 2.5 = 2.175mA d.c.</math></p>

AC Scale

The Zero amp or volt is at the left most end. The scale is dependent on the range setting at the knob.

	Setting: 10V a.c.  Reading on Scale: 30 (out of 250)  Measured Value: $\frac{30}{250} \times 10 = 1.2Va.c.$
$\frac{30}{250} \times 10 = 1.2$	Setting: 250V a.c.  Reading on Scale: 182.5 (out of 250)  Measured Value: $\frac{182.5}{250} \times 250 = 182.5Va.c.$

**Resistance measurement using ammeter and voltmeter**

Resistance can also be measured by using an Ammeter, a Voltmeter and a Power supply.

The Ammeter measures the flow of electric current, while the Voltmeter measures the voltage across the load.

The value of Resistance can be calculating by using the Ohm's Law equation:

$\text{Resistance} = \frac{\text{Voltmeter Reading (in volts)}}{\text{Ammeter Reading (in ampere)}}$	In $\Omega$ Ohms.
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**Circuit diagram:**

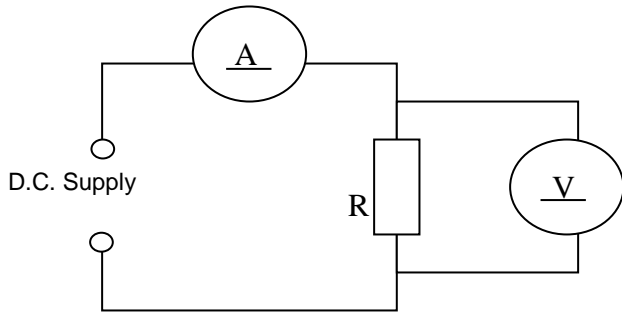


Figure 9- Shows the connection of Ammeter and Voltmeter to measure the resistance of resistor R.

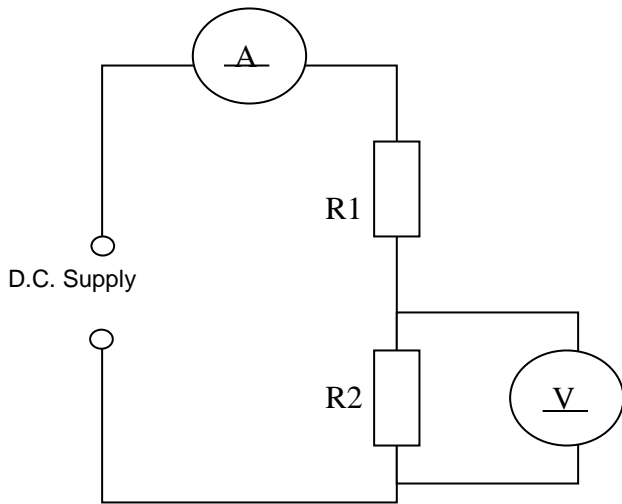


Figure 10- Shows the connection of Ammeter and Voltmeter to measure the resistance of resistor R2.

**Example:**

With reference in figure 12, if the ammeter reads 2 A and the voltmeter reads 12V, determine the value of resistor R.

**Solution:**

$$R = \frac{V}{I} = \frac{12}{2} = 6\Omega$$

Therefore, the value of resistor R is 6Ω.



## AMMETER

An Ammeter is an instrument used to measure the electric current in the circuit. The unit of electric current is ampere, hence the meter scale is usually calibrated in amperes.

In some cases where very small quantity of current is being measured, the meter scale is calibrated in milliamperes, the instrument then is called Milliammeter.

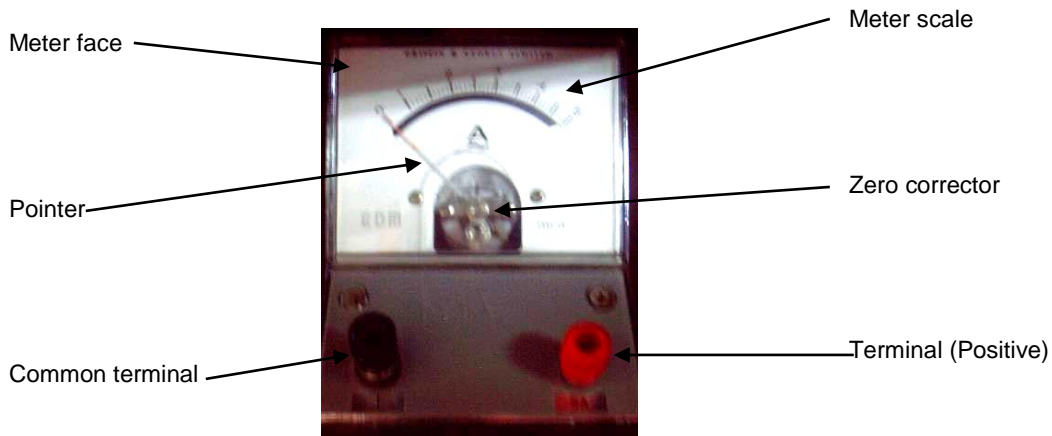


Fig. 11 - shows the basic A.C. Ammeter.

### Three (3) Basic Rules for Measuring Electric Current in the Circuit.

1. Connect the Ammeter in 'series' with the load or circuit where current is to be measured.
2. Use an Ammeter with a full scale range which is greater than the maximum expected current to protect the meter from being damaged.
3. Use an Ammeter with low internal resistance to obtain an accurate reading.

There are two general types of Ammeter, namely;

1. D.C. Ammeter.
2. A.C. Ammeter.

Nowadays, AC-DC Ammeters are also available.

### Connection of Ammeters:

Ammeters are always in series with the load. Failure to do this may result in permanent damage to instruments.

You also must pay attention to polarity (positive and negative terminals) when using a DC Ammeter in a d.c. circuit. The positive terminal of a d.c. ammeter must be connected with reference to the positive polarity of the supply (battery) See figure 2 and 4.

In the case of A.C. Ammeter the polarity or terminal connections can be interchanged.

### Circuit diagram.

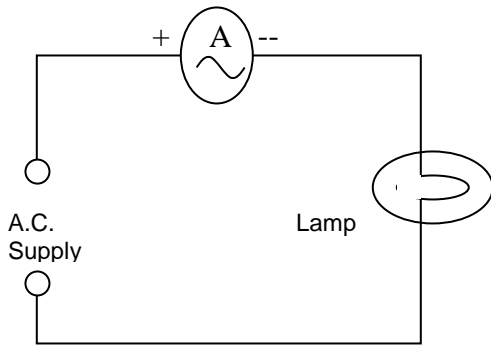


Fig.12 - Shows the connection of an A.C. Ammeter.

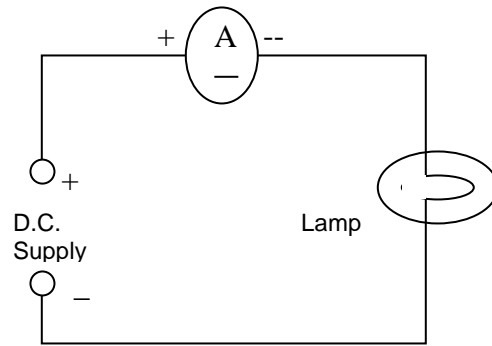


Fig.13 - Shows the connection of an D.C. Ammeter.

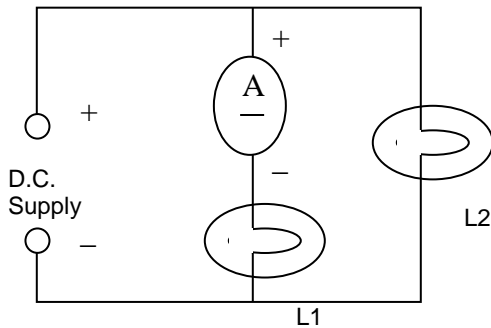


Fig.14 - Shows the connection of a D.C. Ammeter to measure the current through lamp 1.

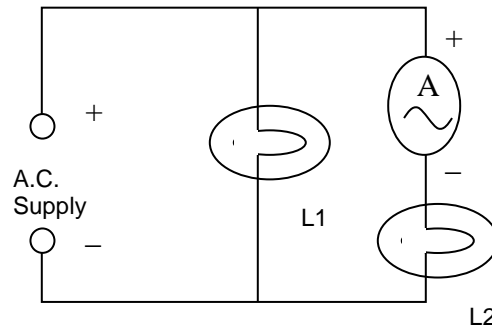


Fig.15 - Shows the connection of a A.C. Ammeter to measure the current through lamp 2.

### **VOLTMETER**

A voltmeter is an instrument used to measure the voltage/potential difference of electromotive force) in the circuit. The unit of voltage is volt, hence the meter scale is usually calibrated in volts. In some cases where small quantity of voltage is being measured, the meter scale is calibrated in millivolts, the instrument then is called millivoltmeter.

#### **Three (3) Basic Rules for Measuring the Voltage in the Circuit.**

1. Connect the voltmeter in 'parallel' with the load or circuit where voltage is to be measured.
2. Use a Voltmeter with a full-scale range which is greater than the maximum expected voltage to protect the meter from being damaged.
3. Use a voltmeter with high input impedance as compared to the circuit resistance.

The voltmeter is a high impedance device, so any attempt to connect it in series will greatly increases circuit resistance, causing improper operation.

There are two general types of voltmeter, namely;

- a. D.C Voltmeter and
- b. A.C. Voltmeter.

Similar to D.C Ammeter, D.C. Voltmeter terminals must be connected in correct polarities.  
In the case of A.C. Voltmeter the polarity or terminal connections can be interchanged.

**Voltmeter Connection.**

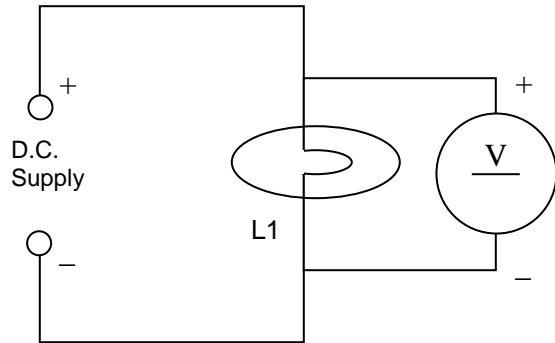


Fig.16 - Shows the connection of a DC Voltmeter to measure the voltage across the lamp 1.

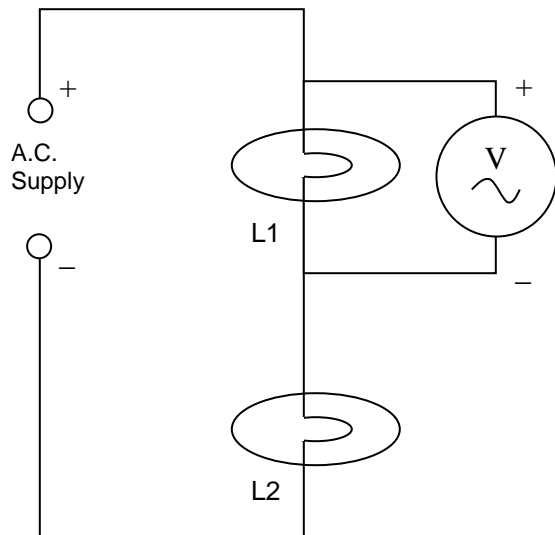


Fig.17- Shows the connection of an A.C. Voltmeter to measure the voltage across the lamp 1.

## **OHMMETER**

An Ohmmeter is an instrument used for measuring electrical resistance. The unit of resistance is ohm, hence, the meter scale is usually calibrated in ohms. In some cases where very large quantity of resistance is being measured, the meter scale is calibrated in Kilo-Ohms ( $K\Omega$ ).

Another version of instrument similar to ohmmeter which is calibrated in much higher scale, mega-ohms ( $M\Omega$ ) is known as a 'Megger'. A Megger is an electrical instrument used to measure the insulation resistance of a cable.

### **Three (3) Functions of the Ohmmeter.**

2. For measuring resistance.
3. For continuity testing.
4. For polarity testing.

### **The resistance of a resistor can be measured by:**

1. Ohmmeter or multimeter (VOM).
2. Ammeter and Voltmeter method (Ohm's law).