VL-E3: TO PLOT THE I-V CHARACTERISTIC CURVES FOR AN OHMIC CONDUCTOR, A THERMISTOR AND A DIODE

Objectives:

- To plot the graphs of I-V characteristics for an ohmic conductor, a thermistor and a diode.
- Find out the resistances for ohmic conductor, thermistor and diode (at forward bias condition).

System requirements:

Computer (Desktop/Laptop), Operating system: Windows, **I-V characteristics_**vle (zipped) File.

Advise:

Students are advised to **strictly** follow the **procedures written in this manual** while performing the experiment. D**o not try to explore anything else in the experiment.**

Theory:

The current-voltage (I-V) characteristic curves of an electrical component are a set of graphical curves, which are used to define its operation within an electrical circuit. The I-V curves show the relationship between the current flowing through an electronic device and the applied voltage across its terminals. They are generally used as a tool to determine and understand the basic parameters of a material and can also be used to mathematically model its behavior within an electronic circuit. If an electrical supply voltage, V, is applied to the terminals of a resistive element R, the resulting current, I, can be measured using the formula: $I = V/R$, which is called Ohm's Law. If the voltage across the resistor increases, the current flowing through it also increases and it would be possible to construct a graph to show the relationship between the voltage and current. In case of an Ohmic conductor, the relationship between voltage and current is linear at a constant temperature.

A thermistor is a type of resistor whose resistance is strongly dependent on temperature, and it is normally made of semiconductor material. The change of resistance with temperature of a thermistor is high compared to the metallic conductor, and is usually negative implying that the resistance decreases with temperature increase. The I-V characteristics curves are highly nonlinear for a thermistor. Increased potential difference across the thermistor results in increased current which in turn causes the temperature to rise. As the temperature rises, the lattice ion's vibration increases and reduces the drift velocity of the charged particles. However, the number of free electrons and holes due to the temperature increase is more significant than the reduction in drift velocity. Hence, resistance of negative temperature coefficient (NTC) thermistor decreases with increase in temperature. Another type of thermistor, called positive temperature coefficient (PTC) resistor, exists as well. The resistance of PTC type thermistors increases as the temperature increases.

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the opposite direction. It is a semiconductor device, constructed using p and n-type semiconductors joined together to form a PN junction. The I-V characteristics curves of diodes reflect the operation of these PN junctions. These devices have non-linear I-V characteristics, as different from that of Ohmic conductor. The primary function of a semiconductor diode is rectification of alternating current to direct current. When the forward voltage exceeds the internal barrier voltage of diode's PN junction, which for silicon is about 0.7 volts, avalanche occurs and the forward current increases rapidly for a very small increase in voltage. When the diode is reversed biased, the diode blocks current except for an extremely small leakage current, and operates in the lower left quadrant of its I-V characteristic curves.

Procedures:

1. At first unzip "**I-V characteristics (zipped)**" File. Click on the executable file "**I-V characteristics_vle**", then a window will be opened as shown in Fig. 1.

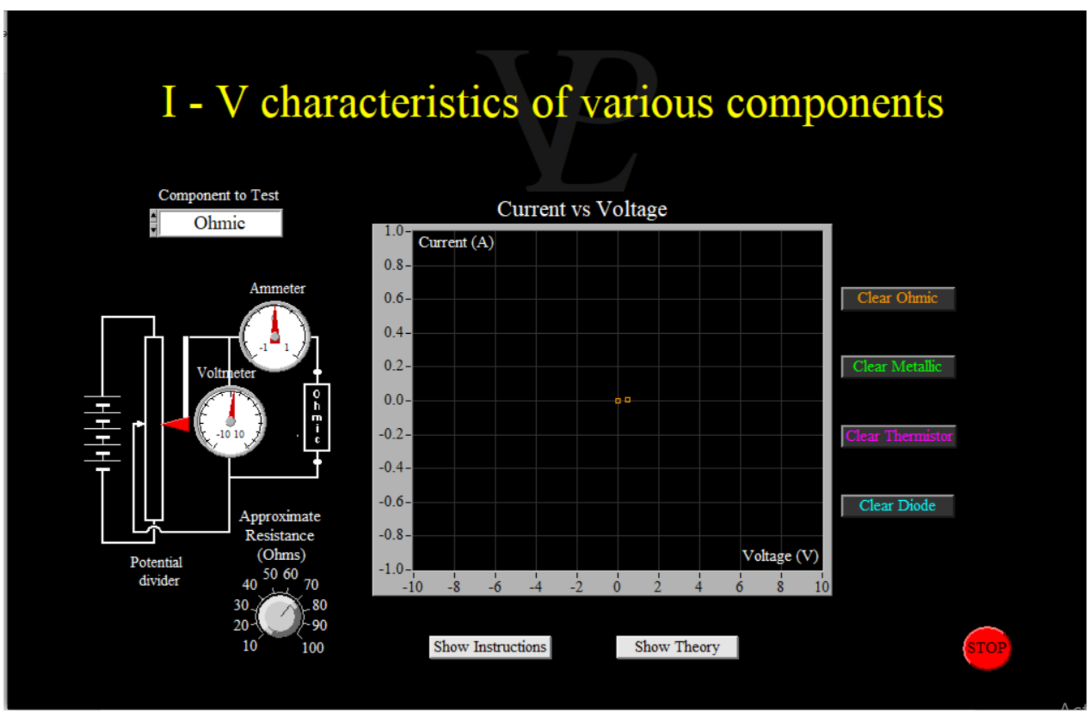

Fig: 1. VP Lab Experimental setup.

2. Set the "Component to Test" in '**Ohmic**' and do not change the "Approximate Resistance (Ohms)" knob, as shown in Fig. 1, during the whole experiment.
3. Keep the red pointer (red arrow) at the bottom position of the potential divider and move it to the upper position gradually. You will have a graph from which you will obtain data of the experiment.
4. For getting the experimental data from the graph, right click on the graph and it will display different options. Go to 'show' and select the 'cursor display' option (as shown in Fig. 2). It will display two cursors but they are locked. Unlock any one cursor by clicking on the locked button. You will see two cursor pointers (two yellow lines) along X- and Y-axes. Drag the cursor pointers to select one data point (Fig. 2). Then, you will observe data value in the cursor display. Move the cursor to the next data point and take the value. In this way, take at least 10 data points and make the data table of V and I.

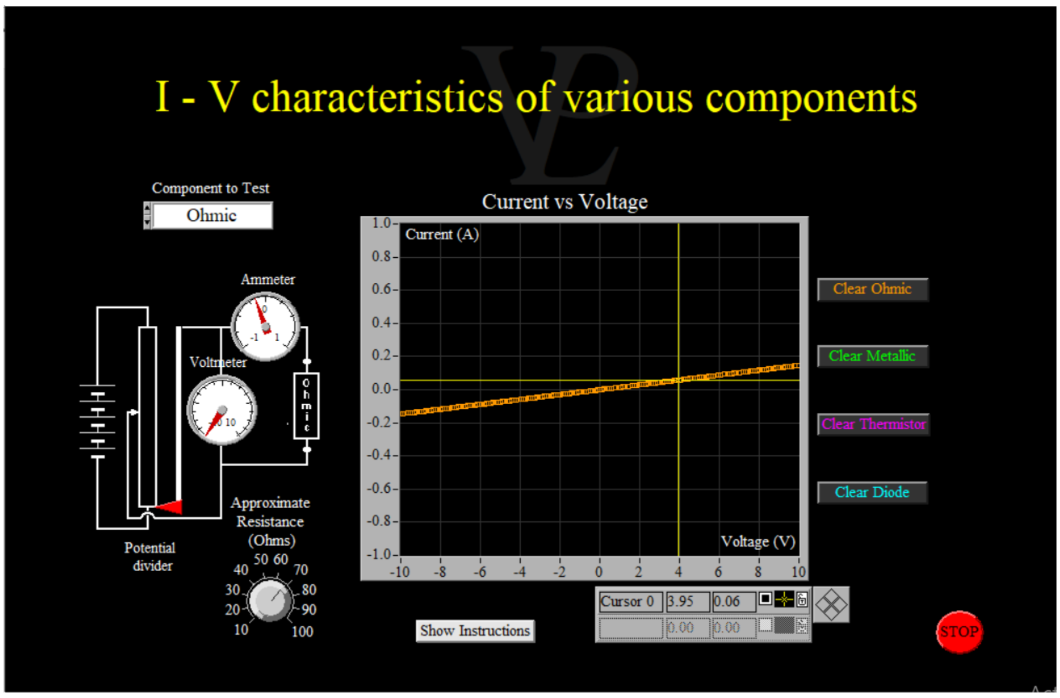

Fig: 2. An I-V characteristic graph for ohmic resistor.

5. Clear the I-V characteristic graph for ohmic conductor by clicking the knob '**Clear Ohmic**'. Set the "Component to Test" in '**Thermistor**' and perform the experiment similar to step 3. Take the data similarly to step 4.
6. Clear the I-V characteristic graph for Thermistor by clicking the knob '**Clear Thermistor**'. Set the "Component to Test" in '**Diode**' and perform the experiment similar to step 3. Take the data similarly to step 4.
7. Draw all the I-V characteristic graphs for ohmic resistor, thermistor and diode in a single graph paper.

Data collection:

Table 1: Voltage-dependent current for ohmic conductor, thermistor and diode.

	Ohmic resistor		Thermistor		Diode	
No.	Voltage, *V* (Volt)	Current, *I* (Amp)	Voltage, *V* (Volt)	Current, *I* (Amp)	Voltage, *V* (Volt)	Current, *I* (Amp)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Graph for analysis:

I-V characteristic graphs for different electrical components are shown below:

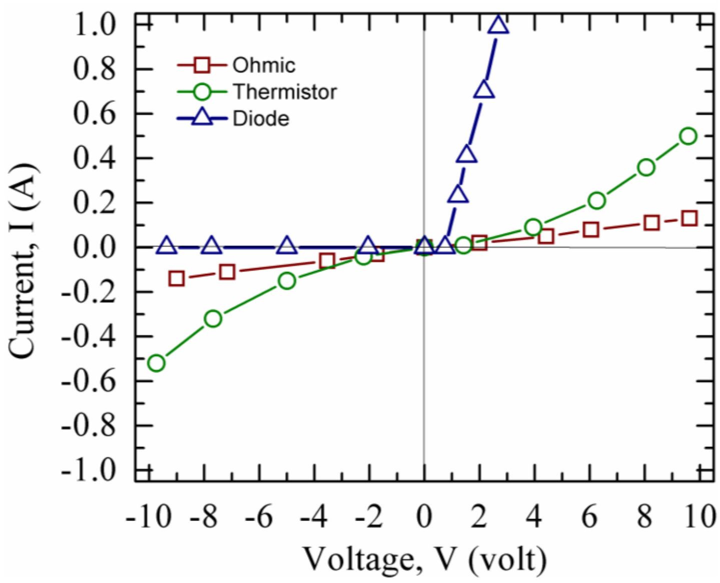

Fig. 3: The I-V characteristic graphs for an Ohmic conductor, a thermistor and a diode.

Calculation:

- Calculate the resistances for the Ohmic conductor and Thermistor at a particular value of voltage say at 8 V.
- Calculate the resistance of diode at forward bias condition by measuring the slope of the respective graph. Find out the value of internal barrier voltage (diode cut-in voltage) of PN junction of diode.

Results:

The results of I-V characteristic for an Ohmic conductor, a thermistor and a diode are shown in graph. The values of the resistances for the Ohmic conductor and Thermistor at 8 V (say) are ------ and -------- Ohm, respectively. The resistance of diode at forward bias condition is ------- Ohm. The value of internal barrier voltage of PN junction of diode is ---------V.

Discussion:

Based on your understanding from this experiment, answer the following questions:

1) Why are the I-V characteristic graphs for an Ohmic conductor, a thermistor and a diode different?
2) What do you understand by the negative temperature coefficient and positive temperature coefficient type thermistor?
3) What is a Diode? What is the main function of a diode?
4) Which materials are generally used for the fabrication of thermistor and diode?
5) Explain the internal barrier voltage (diode cut-in voltage) of a diode'. What is leakage current of a diode?
6) What is diode break-down voltage? What are Zener diode and Avalanche diode?