Experiment 1

Linear and Nonlinear Elements

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Carbon Resistor		Si Diode		Light bulb (low currents)		Light Bulb (high currents)	
V (Volts)	I (mA)	V (Volts)	I (mA)	V (Volts)	I (mA)	V (Volts)	I (mA)
0.4	0.78	0.4	0.00	0.010	5.68	0.5	87.6
0.8	1.56	0.45	0.02	0.02	10.90	1.0	114.4
1.2	2.33	0.50	0.10	0.03	16.23	1.5	139.2
1.6	3.12	0.53	0.22	0.04	21.10	2.0	161.1
2.0	3.89	0.55	0.34	0.05	26.00	2.5	181.8
2.4	4.68	0.57	0.47	0.06	30.60	3.0	198.8
2.8	5.45	0.60	0.90				
3.2	6.24	0.62	1.45				
3.6	7.04	0.64	2.30				
4.0	7.80	0.66	3.75				
4.4	8.57	0.68	5.53				
4.8	9.37	0.70	10.56				

Note: The original datasheet signed by Dr.Khalid
is attached to the end of report

Abstract:

In this experiment, we must achieve the following goals

Determine if these (Carbon Resistor , Diode, lamp) conductors are linear or nonlinear components .

To determine the aforementioned, we put the element under a known voltage difference and we measure the current and repeat this experiment to determine if the element is linear or non-linear.

Introduction:

Apparatus:

DC voltage source, one carbon resistor, two digital multimeters, connecting wire, adecade resistor box, a silicon diode, a light bulb.

In this experiment we build three electrical circuits attached (Figure1.1, Figure1.2, Figure1.3).

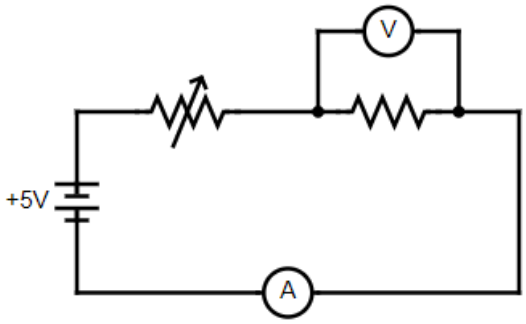


Figure1.1

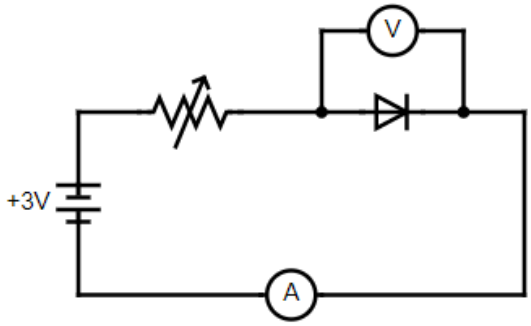


Figure1.2

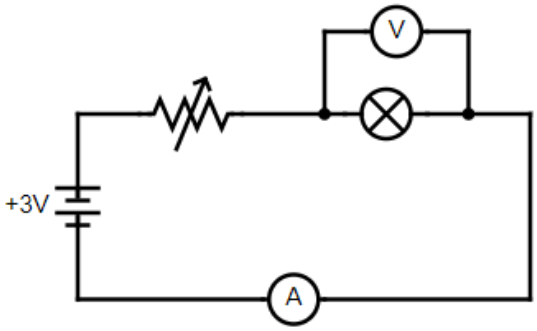


Figure1.3

These three circuits have almost the same structure, The difference between these circuits is in the component whose voltage we want to measure only.

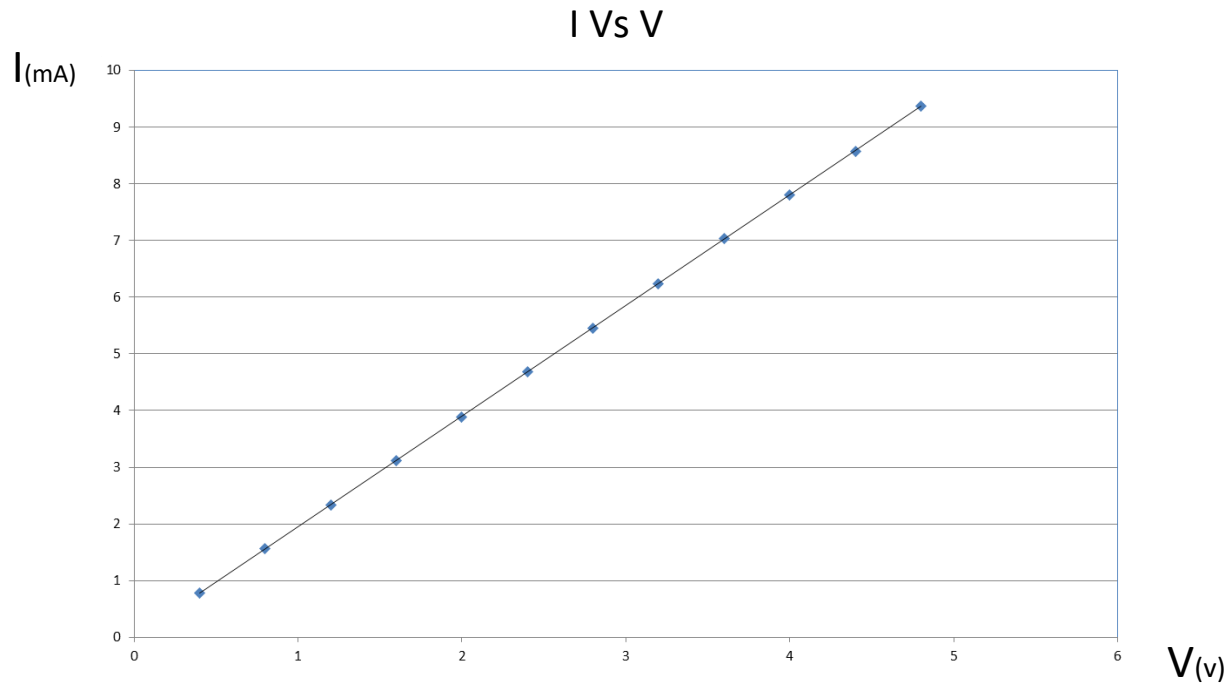
in Figure 1.1: In carbon resistor we apply the graph of current VS voltage according to the data, If the graph of the I-V characteristic for carbon resistor was a straight line that means the carbon resistor is a linear element, and it is obeys to Ohm's law (V=I*R), If not, this means that the carbon resistor is not obeys to Ohm's law and is non-linear.

in Figure 1.2: In diode we apply the graph of current VS voltage according to the data, If the graph of the I-V characteristic for diode was a straight line that means the diode is a linear element, and it is obeys to Ohm's law, If not, this means that the diode is not obeys to Ohm's law and is non-linear.

in Figure 1.3: In lamp, Which contains a tungsten wire, which converts electrical energy into thermal energy, and therefore the resistance depends on the temperature of the material according: $R = R0\ [1 + \alpha(T-T0)]$, Thus, the resistance increases with increasing temperature.

Data & Analysis:

For carbon resistor:

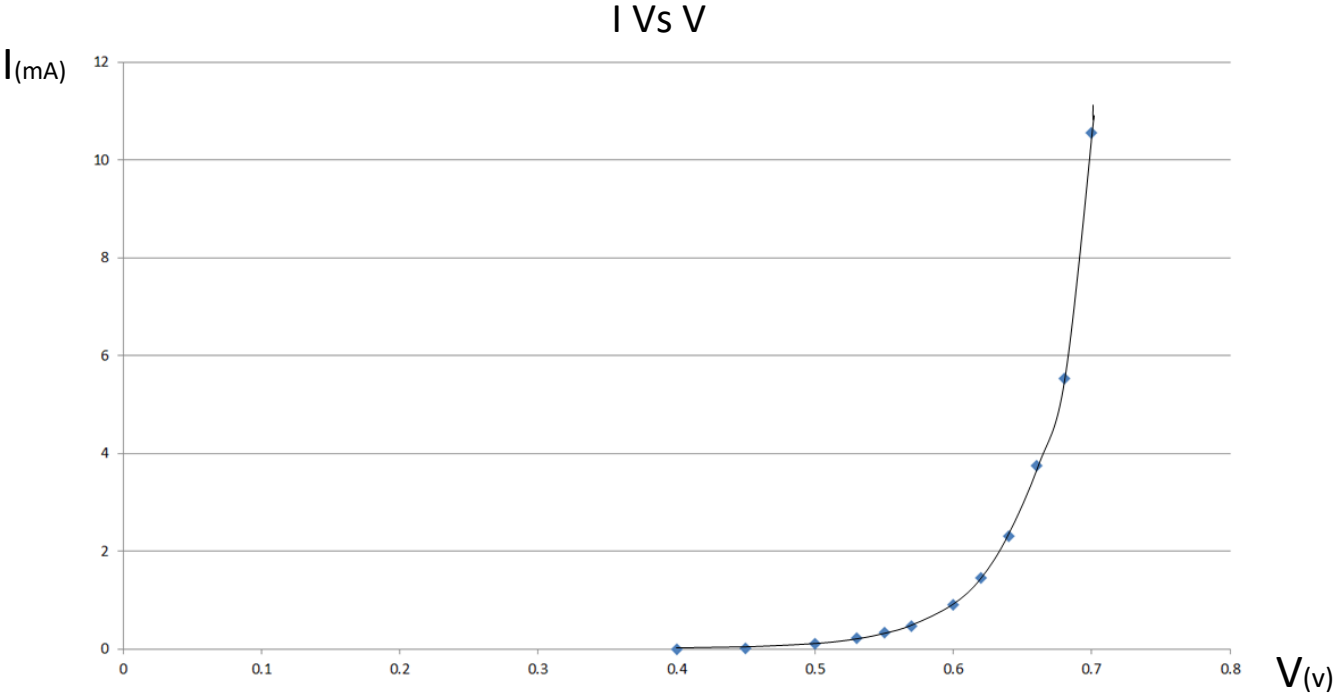


$$\text{Slope} = R^{-1} = \frac{\Delta I}{\Delta V}$$

$$\text{Then} \quad R = \frac{\Delta V}{\Delta I} = \frac{2.0-2.4}{(3.89-4.68)*10^{-3}} = 506.33\ \Omega$$

So the carbon resistance is a linear element and its value is 506.33 according to Ohm's law

For Diode:



After apply the graph of current VS voltage according to the data, we see the diode is not obeys to Ohm's law and is non-linear element.

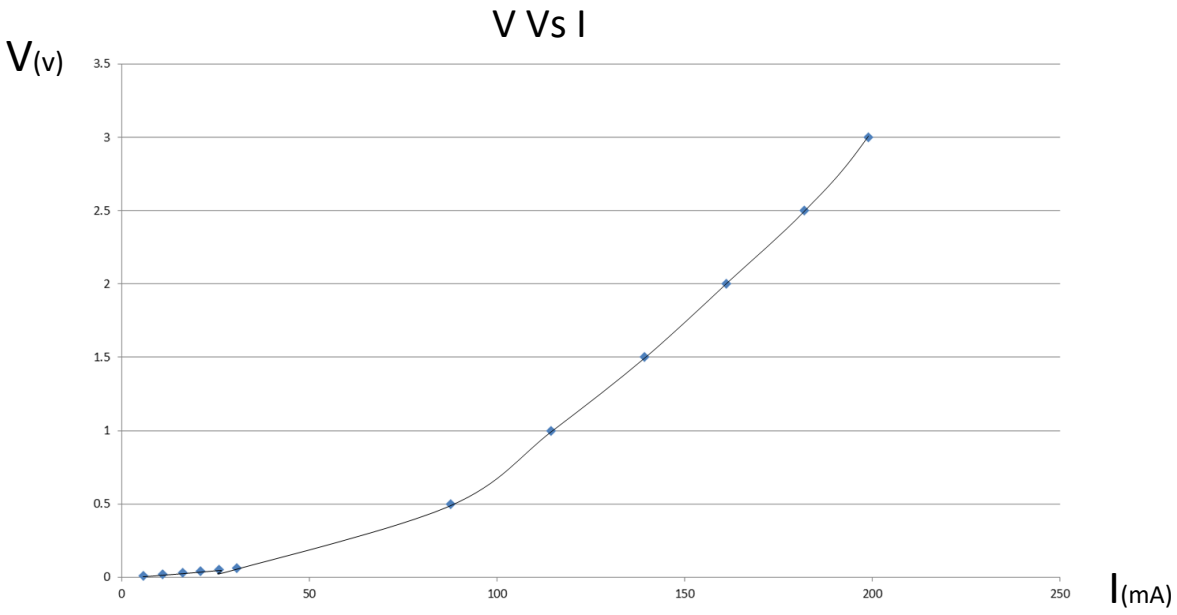
the resistance at two different points(tangent):

$$\text{Slope of the tangent} = R^{-1} = \frac{\Delta I}{\Delta V}$$

$$\text{Then} \quad R = \frac{\Delta V}{\Delta I} = \frac{0.4-0.66}{(0.0-3.75)*10^{-3}} = 69.33\ \Omega$$

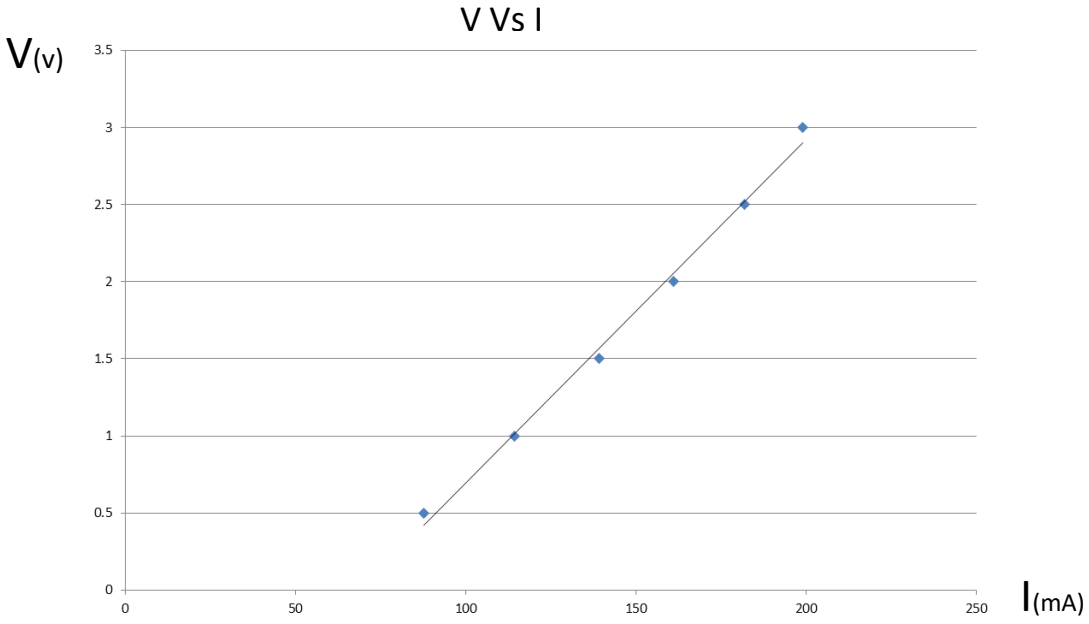
For lamp:

First, attach the graph for the case of low currents with high currents:



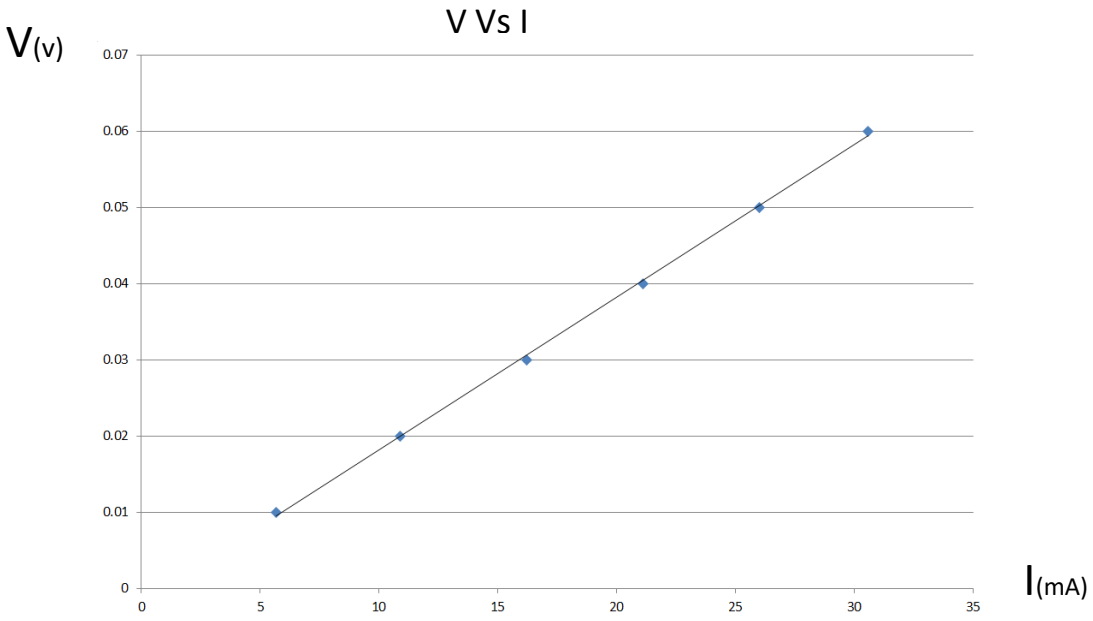
From the above graph, it is clear that lamp is a non-linear element, as the resistance increases with increasing temperature of the tungsten wire, as shown in the following equation : R = R0 [1 + α(T-T0)] , where the value of R is the slope value obtained from the graph in the case of high current and the value of R0 is the slope value obtained from the graph in the case of low current and T0 is room temperature and the value of α equal 4.5 * 10^{-3}.

To find R (high currents):



$$R = \frac{\Delta V}{\Delta I} = \frac{1.0-2.5}{(114.4-181.8)*10^{-3}} = 22.26\ \Omega$$

To find R0 (low currents):



$$R0 = \frac{\Delta V}{\Delta I} = \frac{0.01-0.04}{(5.68-21.1)*10^{-3}} = 1.95\ \Omega$$

Now we can apply:

$$R = R0\ [1 + \alpha(T-T0)]$$

$$22.26 = 1.95\ [\ 1 + (4.5 * 10^{-3})(T-20)]$$

$$11.4538 = \ 1 + (4.5 * 10^{-3})(T-20)$$

$$10.4538 = \ 4.5 * 10^{-3}\ (T-20)$$

$$2914.5 = T-20$$

Then $T = 2334.5^{\circ}\ c$

Conclusion:

The I-V characteristic of a circuit component refers to the relationship between the current flowing through it and the voltage differential between its terminals. Linear components are those that exhibit I-V characteristics in a straight line. Non-linear components are those that do not have straight-line I-V characteristics.

Based on the results of the experiment:

Carbon Resistor is a linear element because the relationship between current and voltage in the I-V characteristic is linear.

But the Diode was non-linear because the relationship between current and voltage in the I-V characteristic is non-linear.

For the Lamp, it is a non-linear element as well, so that its resistance increases with increasing temperature, so the I-V characteristic is non-linear.