Linear and Nonlinear Resistors

Introduction

The current in an electrical circuit depends on the magnitude of the source voltage and the resistance of the various components. For a linear component, the voltage-current ratio is constant. This is usually referred to as Ohm’s Law, stated as

\[ V = IR \]  

but for a nonlinear component, the \( V/I \) ratio is not constant. So, while the resistance as a particular voltage and current can be obtained from Ohm’s law, it will not be constant over the range of currents used. In this experiment you will study the different behaviours of a regular resistor and a light bulb.

Procedure

1. Construct the series circuit shown, using \( V \sim 12 \) volts dc. \( R_x \) is an “unknown resistance” and \( R_1 \) is a variable decade resistance box. Starting with \( R_1 = 0 \Omega \), measure the voltage across \( R_x \) and the current in it. By increasing \( R_1 \) in suitable steps obtain a series of voltage and current values, and plot a graph of \( V_{R_x} \) vs \( I_{R_x} \).

2. Verify that the resistor obeys Ohm’s law and determine a value for \( R_x \). What is the uncertainty in \( R_x \)? Check your result by measuring its value using a DMM.

3. How does the resistance of the voltmeter affect the voltage reading across a particular resistor? Does it matter if the voltmeter’s resistance is low (~ few kΩ), or large (~ MΩ)? Explain your answer.

Non-Linear Resistors

1. Non-linear conductors such as semiconductors, thermistors and diodes do not have a constant resistance. Instead, we can write the voltage drop as a function of current in
the form

\[ V = A.I^n \]  

where \( A \) is a constant.

2. Replace the resistance \( R_x \) by a light bulb and obtain a data table which shows the voltage drop across the bulb and the current. Use the laboratory computer to plot this data and determine values for \( n \) and \( A \).

3. Explain why you think the graph displays this kind of behaviour. [Hint: think of Stefan’s Law]