Physics 375, Laboratory 1
DC Circuits

Overview

The purpose of this experiment is to use basic DC circuit elements on a breadboard, and to use a digital multimeter to test Ohm's law, Kirchhoff's laws and Thevenin's theorem.

Background

Kirchhoff's laws are an application of the conservation of charge and conservation of energy to electric circuits. The Kirchhoff current law states that conservation of charge requires the sum of all current into and out of a point in a circuit must equal zero. The Kirchhoff voltage law states that conservation of energy requires the sum of all voltage drops around a closed loop of a circuit must equal zero. Ohm's law describes the relation between energy lost by electrical charges as they pass through resistive circuit elements, and that relation is a constant $V=IR$. Thevenin's theorem takes the fact that Kirchhoff's and Ohm's laws are linear relations between voltage and current to prove that any network of batteries and resistors can be replaced by a single battery and resistor in series.

1. Ohm's Law

Connect the variable power supply, digital multimeter (DMM), and a resistor in a circuit:

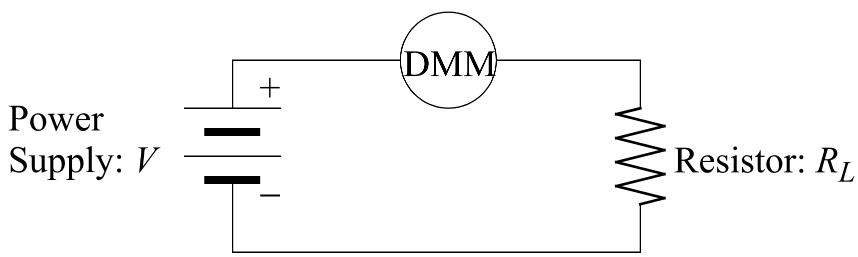


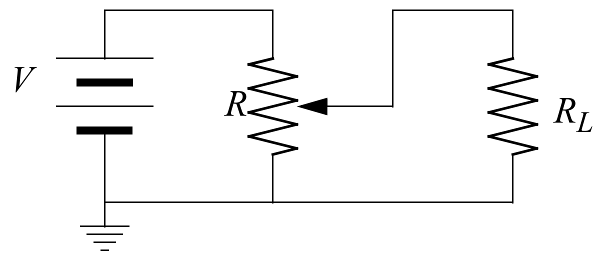
Figure 1: Circuit for V-I measurements

Set the DMM to measure DC current in mA. The power supply has a built-in voltmeter to measure DC volts. Use a 1 KΩ resistor for R_L. Measure the current for each of the following voltages: 0.2, 0.5, 1.0, 2.0, 5.0 V, and place them in a table. Use the values in the table to make a V-I graph for the resistor.

Repeat the above procedure replacing the resistor with a lamp. At what voltage does the filament start to glow? When does Ohm's Law fail for a lamp?

2. Resistor Divider

Build the following circuit using the variable DC supply, a 10KΩ potentiometer and a resistor.



$V = 4.0$ V
$R = 10$ KΩ
$R_L = 4.7$ KΩ

Figure 2: Resistor divider circuit

Before building the circuit, set the potentiometer knob somewhere between the two extremes. Use the DMM to measure the resistance between the two end terminals of the potentiometer, then measure the resistance from the center terminal to each end separately. Compare the sum of the two center-based measurements to the total between the two ends. Do they agree, and how well do they agree with the nominal value of 10 KΩ?

Now build the circuit in Figure 2 without connecting R_L. Measure the voltage between the center terminal of the potentiometer and ground. Use the resistances measured for the potentiometer to confirm the voltage divider relationship. Add the load resistor R_L and measure the voltage between the center terminal and ground. How has it changed and can you justify any change in the value?

3. Internal Power Supply Resistance

Place a 1.5 V household battery in series with a 10 Ω resistor leaving the remaining ends open. Measure the Thevenin equivalent circuit for the battery and resistor by measuring the open circuit voltage and closed circuit current. Find the equivalent resistance in the battery by subtracting the resistance measured for the resistor with the DMM.