UNIVERSITY OF MANITOBA Department of Electrical and Computer Engineering

Name: ____________________

Student Number: ____________________ **Date:**

Lab Section: ____________________

Instructor: ____________________

Lab Partner: ____________________

ENG 1450 Introduction to Electrical and Computer Engineering
Lab 1 - Ohm's Law

1 Instrument and Circuit Elements Used in This Lab

1.1 Breadboard box

A breadboard is used for mounting and interconnecting components of a circuit. Figure 1 shows the electrical connection scheme of the breadboard box. The most important parts of a breadboard box are the superstrips which are the white plastic strips with lots of holes for inserting ends of connecting wire. The narrow superstrips, which have two vertical sets of holes, are connected so that all holes lying on the same vertical line are connected to each other. These vertical lines are commonly used for connecting power supplies (ground and V_{cc}). The two wide superstrips, which have five horizontal sets of holes, are connected such that all holes lying on the same horizontal line are connected to each other. It should be noted that the horizontal lines in the left and the right halves of the board are isolated from each other.

The most important key of the breadboard is its power switch, which is located on the left-top corner of the breadboard. The top of the breadboard box has also three red knobs for variable 0 to +/-15V and a fixed 5V power supplies. The ground (GND) (black knob) post on the top of breadboard is the ground of all the power supplies and also internally connected to the breadboard box case when the power is on, so that the case itself can act as a ground. Directly below each power supply knob is a hole that wire ends can be inserted into it and brings the power supply to the terminal strips. It is recommended to wire end a vertical strip to the GND post in order to provide a safe and common ground for your circuit.

At the bottom of the breadboard box there are three coaxial connectors. Coaxial cables from signal generators and oscilloscopes are connected to these connectors. The coaxial cable has a central inner signal wire and an outer concentric shielding braided cylindrical wire. The outside shell of each coaxial connected is screwed to the case of the breadboard box and therefore is at ground potential.

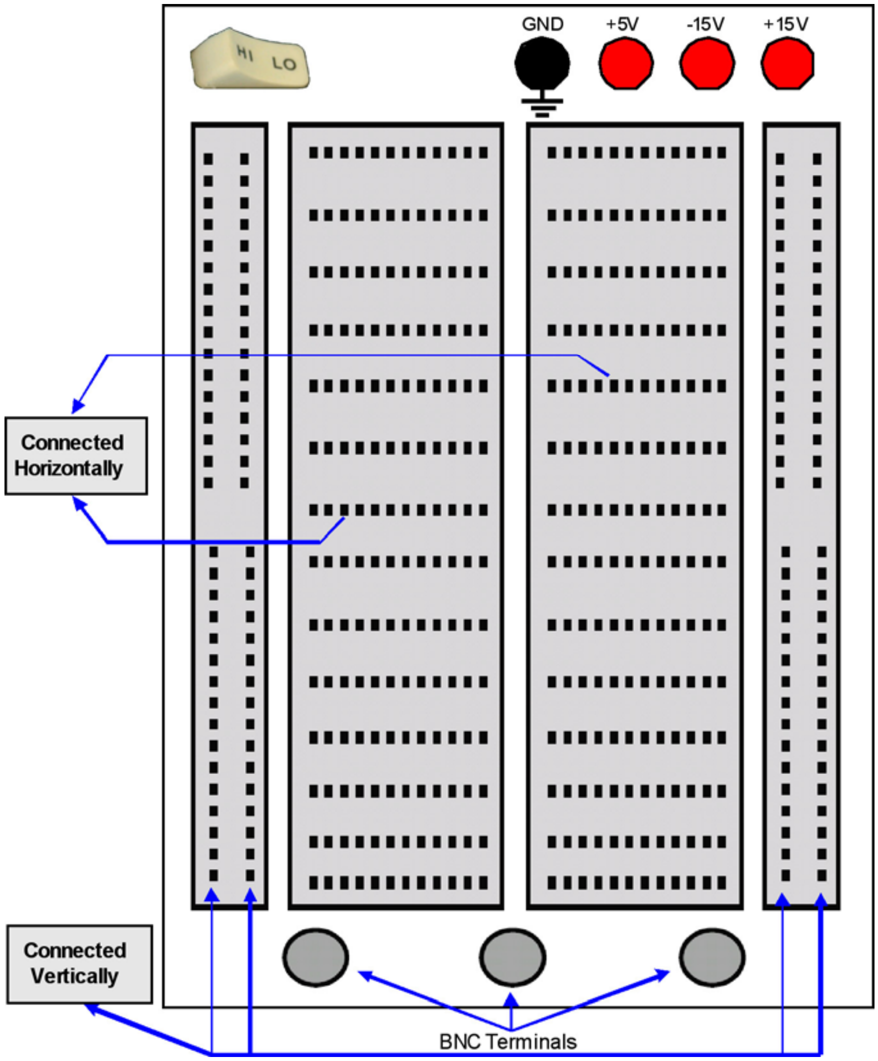


Figure 1. Breadboard box electrical connections

1.2 Digital Multimeter (DMM)

Using DMM157 (Figure 2), you can measure AC/DC voltage, AC/DC current, resistance and continuity (short circuits). Here, we briefly discuss the basic function of DMM157 multimeter.

Figure 2. DMM157

Measuring Voltage

- Set the multimeter dial to V≂.
- Connect the circuit nodes between VΩ→| (red post) and **COM** (black post) inputs. *Note that to measure voltage; the voltmeter must be connected in parallel with the circuit to produce large input impedance and the current flowing through the probes be negligible.*
- Push blue button to switch between AC and DC voltage and also change the voltmeter range from mill volt to volt. Note that in the case of AC voltage configuration, the measured voltage is the RMS (root mean square) value of the voltage in one period of the signal.

Measuring Current

- Set the multimeter dial to µA≂ or mA≂ depending on the range of your signal.
- Connect the circuit nodes between µA mA ⊣⊢ (blue post) and **COM** (black post) inputs. *Note that to measure current; the ammeter must be connected in serial with the circuit to produce small input impedance and the voltage drops over the probes be negligible.*
- Push blue button to switch between AC and DC currents. Note that in the case of AC current configuration, the measured current is the RMS (root mean square) value of the current in one period of the signal.

Measuring Resistance

- Set the multimeter dial to Ω.
- Connect the circuit nodes between VΩ→| (red post) and **COM** (black post) inputs. The multimeter measures the resistance of the circuit by injecting a reference current to the circuit and calculating its voltage. The ratio between the voltage and current is displayed as the resistance.
- Note the measuring should be performed while the examined resistor is separated from the rest of the circuit and no power goes through it.

Checking Continuity

- This configuration is used to check the continuity between two leads of the circuit.
- Set the multimeter dial to ·))) →|.
- Connect the circuit leads between VΩ→| (red post) and **COM** (black post) inputs.
- In the case of continuity the multimeter produces a beep sounds. In either cases of continuity or discontinuity between the examined leads the resistance between the leads is shown on the display.
- Note the measuring should be performed while the power is off.

1.3 Resistors

Resistors are devices that not only conduct electricity but also dissipate electric energy as heat. Therefore by adding resistance, supply voltage may be reduced, or current be limited. There are two general types of resistors: composition resistors and wire-wound resistors.

Types of Resistors

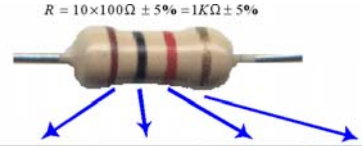
Carbon composition resistors are the most common of the composition resistors. They are relatively inexpensive and available in power ratings of 1/10 to 5W. The resistive element contains a mixture of graphite powder and silica as well as a binding compound, which is molded under a combination of heat and pressure. Since graphite is a semiconductor and silica is an insulator, higher resistance values are obtained by increasing the amount of silica in proportion to the graphite. However, carbon

composition resistors are not suitable for cases that the amount of resistor must be very precise because their resistance changes by time and temperature.
Wire-wound resistors are considerably different from composition resistor. They are made from alloys of high resistively drawn into wire with precisely controlled characteristics. This wire is then wrapped around a ceramic-core form. Different wire alloys are used to provide various resistor ranges. Their high stability and power rating up to 250W characterize wire-wound resistors.
There are two basic types of variable resistors: the rheostat and the potentiometer. The rheostat is a two-terminal variable resistor that consists of a resistance element, wound around a circular insulated form. Inside this form is a contact that is rotated to vary the resistance. Rheostats are used to control the circuit current by varying the amount of resistance in the resistance element. This is accomplished by "tapping the resistance element.
The potentiometer is a variable resistor having three electrical connections, the center one being the movable contact, wiper. Both ends of the resistance element of the potentiometer are connected in the circuit. Carbon potentiometers are used in circuits with low currents.

Resistor Color Code
The resistance value of a carbon composition resistor is specified by a set of four color code bands on the resistor housing. To determine the ratings of the resistor, it is held so that the bands are on the left and reliability designation is on the right. The first and second bands produce a two-digit number, the third band indicates the multiplier, and the fourth band designates the percent tolerance, or accuracy of the resistor's rating. Figure 3 shows the color code for carbon composition resistors along with a sample resistor and its resistance. When the resistor contains only three bands, the tolerance is taken as ± 20%.
Some resistors also have a fifth color band, which indicates the reliability factor. The fifth band gives the percentage of failure per 10000 hours of use. For example, a 1% failure would indicate that 1 out of every 100 resistor will not lie within the tolerance range after 1000 hours of operation at its rated power.
In summary, for selecting a resistor, the following parameters must be considered:

- The amount of resistance;
- The maximum amount of current that is going through the resistor;
- The tolerance of the resistor;
- The effect of temperature on the resistance;
- The inductance and capacitance effect of the resistor.

$R = 10 \times 100\Omega \pm 5\% = 1K\Omega \pm 5\%$



Color	1st Band	2nd Band	Multiplier	Tolerance
Black	0	0	1_	
Brown	1	1	10_	
Red	2	2	100_	± 2%
Orange	3	3	1K_	
Yellow	4	4	10K_	
Green	5	5	100K_	
Blue	6	6	1M_	
Violet	7	7	10M_	
Gray	8	8		
White	9	9		
Gold				± 5%
Silver				± 10%

Figure 3. Color codes for resistors

2 Ohm's Law

The equipment required for this lab exercise includes:

- a prototype board with adjustable 0 to 15 V supply,
- two Digital Multimeters (DMM),
- a 3.3kΩ, 1/4W resistor,
- and, a light bulb.

Part a

Build the simple circuit shown in Figure 4.

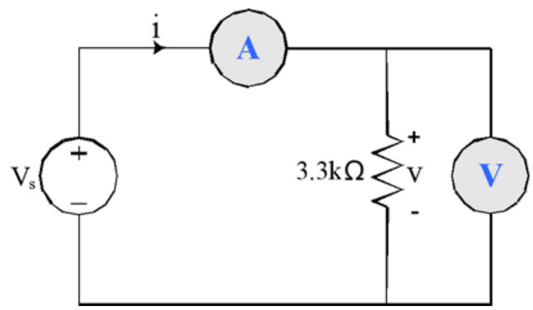


Figure 4: Experimental investigation of Ohm's Law.

Vary the source voltage in the range $0 \le V_s \le 15$ and record 10 measurements of the voltage (v) and current (i) in Table 1.

Table 1: Measurements associated with the experimental investigation of Ohm's Law.

v(V)	i(mA)

Plot the measured data on the graph provided in Figure 5. Mark the data points (for example, with an x or an o).

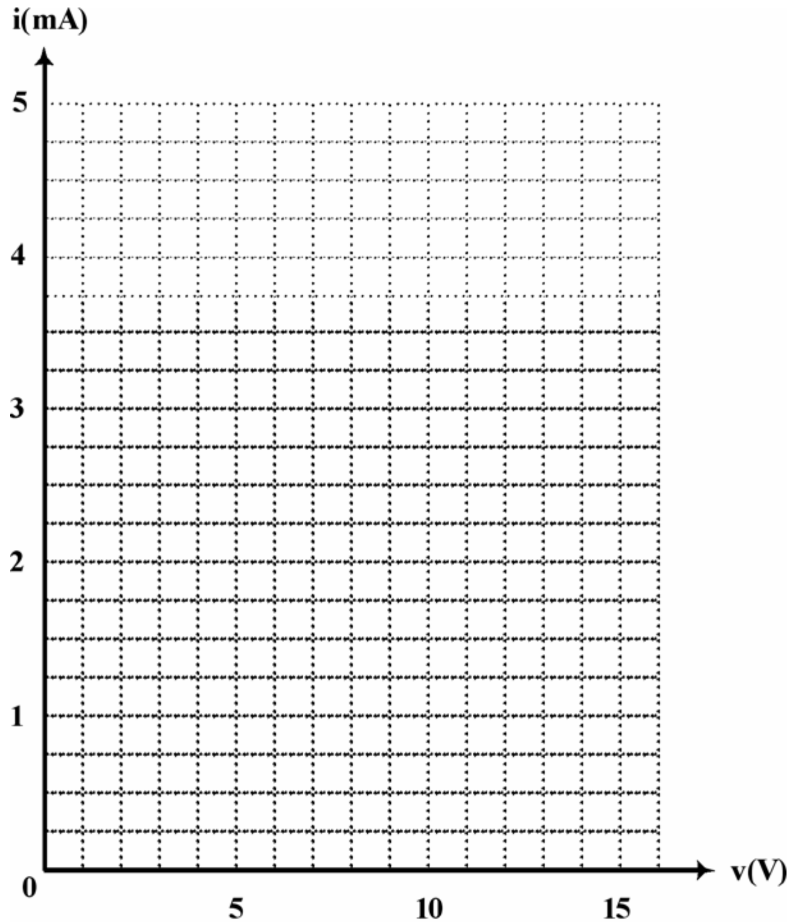


Figure 5. plot of v(V) versus i(mA) for the circuit shown in Figure 4.

Try to fit a line to your results in Figure 5. What is the physical interpretation of the slope?

Explain how can you find value of the resistor from the results of Table 1 and Figure 5?

What is the value of the resistor?

R= -------------Ω.

Compare the measured value with the value you expected. Is there a difference? If yes, is it acceptable?

Part b

Build the circuit shown in Figure 6.

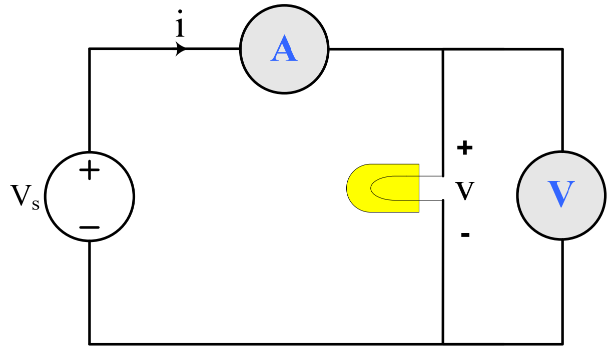


Figure 6: Experimental investigation of Ohm's Law with light bulb.

Vary the source voltage in the range $0 \leq V_s \leq 15$ and record 10 measurements of the voltage (v) and current (i) in Table 2. Start from small values of voltage such as 0.5V and record the voltage and current when the light bulb turns on.

Table 2: Measurements associated with the experimental investigations of a light bulb.

v(V)	i(mA)

Plot the measured data on the graph provided in Figure 7. Mark the data points (for example, with an x or an o).

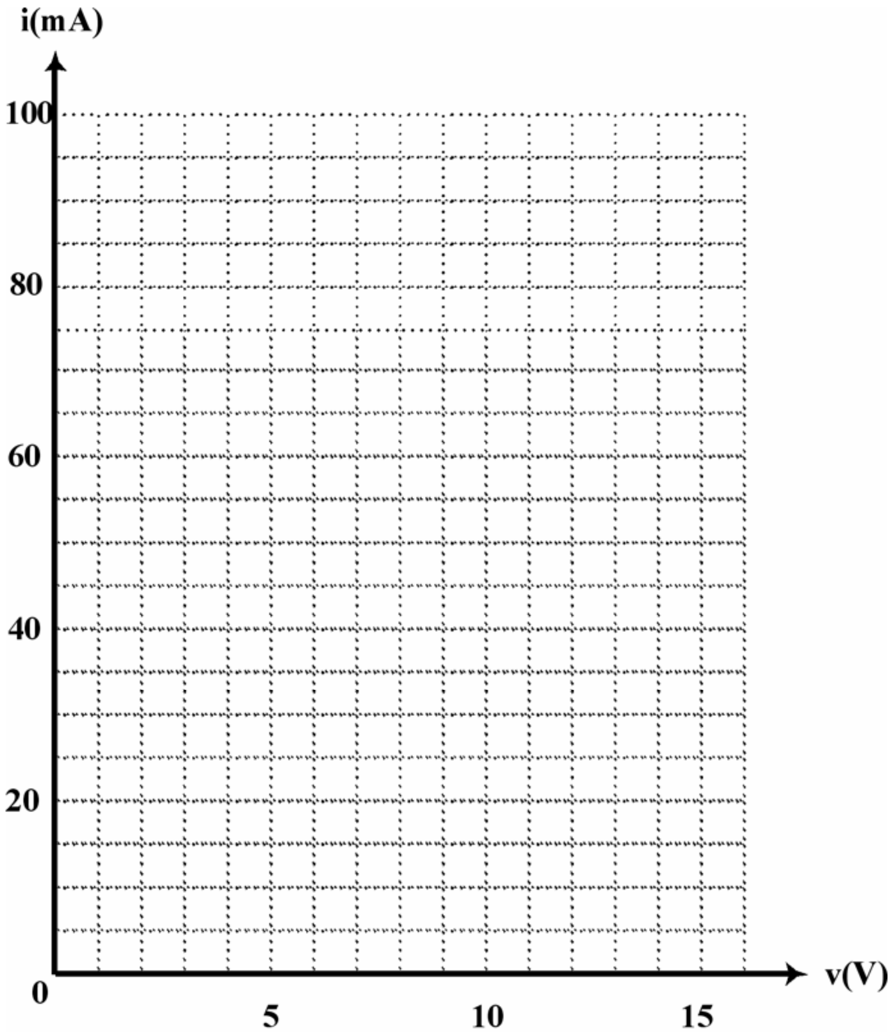


Figure 7. plot of v(V) versus i(mA) for the circuit depicted in Figure 6.

Compare the I-V characteristics of light bulb with that of resistor? What does produce the difference?

How can you approximate resistance of the light bulb before and after it turns on?

Before turning on: R= ------------Ω.

After turning on: R= ------------Ω.