Experiment 16
Current Measurement and Ohm's Law

Parts Bin

Assembled PCB with breadboard

1,000 Ω resistor (brown, black, red bands)

10,000 Ω resistor (brown, black, orange bands)

Tool Box

Wiring kit

DMM

You should now be familiar with electrical pressure (voltage) and how it corresponds to pressure applied to water. As part of this, you should be familiar with the different voltage drops experienced by the different devices in the circuit. When the water examples were discussed, the force was applied to the molecules of water; now it is time to look at what is moved by electric force (voltage) to produce electricity.

As you are probably aware, electrons, which are negatively charged subatomic particles, make up electric current. When we talk about the size of atoms, it is hard to understand just how small they are and how many are in an object. The basic unit of charge is the *coulomb*, and it consists of 1.60219×10^{19} electrons. This exponent may not seem very large (your scientific calculator can probably do exponents to the base 10 of 99 or more). To give you an idea of how big it actually is, consider that there are about 2 trillion (2×10^{15}) planets in the Milky Way galaxy. One coulomb has about 8,000 times more electrons than there are planets in our galaxy.

To move the free electrons in a metal, negative electrical pressure (called voltage) is exerted on them and they will move away from the force toward a more positive location. This movement of electrons is known as *negative electrical current*.

When electricity was first being understood and defined, the nature of the atom was not understood at all. In fact, the prevailing theory of electricity was that electricity was a fluid that existed in certain materials and it could be moved by the application of some kind of electrical pressure (which we call voltage). To help define how electricity behaved, Benjamin Franklin postulated that this fluid moved from the positive terminal of a power source to the negative (the terms "positive" and "negative" being completely arbitrary). Unfortunately, this was wrong. Actual electrical current moves from the negative terminals to the positive terminals, but due to the acceptance of Franklin's theory of electricity travelling from positive to negative, we are stuck with this as the definition of electrical current. Working with this convention isn't too onerous because electrons are simply too small for us to see and move too fast for us to follow.

The most positive location in an electrical circuit is the positive terminal of the power source. If the positive terminal of the power source is not present (an open circuit exists), then the electrons will bunch up in the conductor until their collective voltage is equal to the voltage applied to the circuit.

The movement of electrical current can be observed and measured using your DMM, wired in a circuit as shown in Figure 3-19. First measure the voltage across the 1,000 Ω resistor and record it (I measured 8.89 volts). Then, setting your DMM to measure 0 to 20 milliamperes (mA) of current (explained in your DMM's manual), break the circuit and measure the current passing through it. I measured 8.93 mA.

Next, repeat the experiment using a 10,000 Ω resistor in place of the 1,000 Ω resistor. My voltage measurement was 8.84 volts and the current through the resistor was 0.90 mA.

Looking at these results, you should notice that the current through the 10,000 Ω resistor circuit was one-tenth the current through the 1,000 Ω resistor circuit. This implies that a voltage/current/resistance relationship exists that is similar to the following formula:

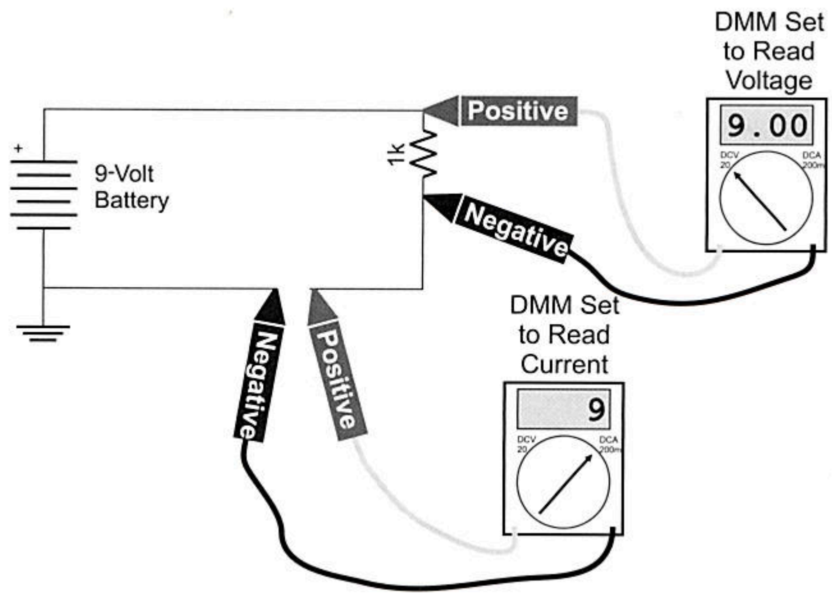

Figure 3-19 *Measuring voltage across a current as well as through it*

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Current = Constant x Voltage/
          Resistance
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You can test this by placing a different battery (with a different voltage output) into the circuit and repeating the measurement. No matter how many different ways you test this (with different resistors and batteries), you will find that the previous formula is true.

This is a basic rule of the universe known as *Ohm's law* and can be stated as "the current through an electrical circuit is proportional to the voltage applied to it and inversely proportional to the resistance within it." George Ohm first discovered this relationship between voltage current and resistance in 1826, and to recognize this accomplishment, the unit of resistance was named the ohm in his honor.

To simplify the application of the law, the *Systeme International* (SI) units for voltage, resistance, and current were chosen so the formula does not need a constant. Replacing voltage with the symbol "V," resistance with the symbol "R," and current with the symbol "i," Ohm's law can be written out simply as

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V = i x R
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Understanding and remembering this formula is critical if you are going to work with electronic circuits. You might want to remember it using a mnemonic like

Twinkle, twinkle, little star,
Voltage equals eye times are.

Another way of remember Ohm's law is to use the "Ohm's law triangle." This tool will return the formula for any of the three parts when you place your finger over one of the three symbols. In Figure 3-20, I show that by placing my finger over the "I" in the triangle, I can see that current is equal to voltage divided by resistance.

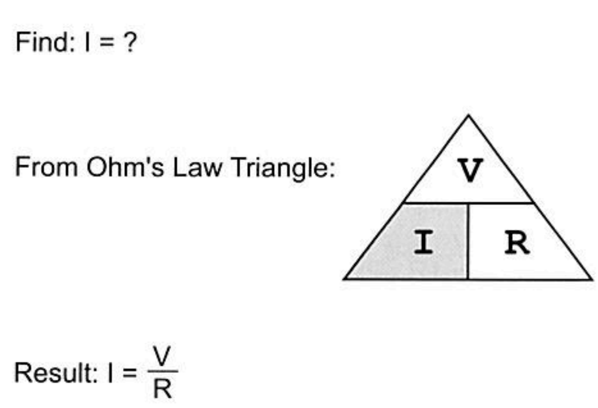

Figure 3-20 *Ohm's law triangle example*

... question COMPLETELY in COMPLETE sentences.

Raking Muck with the Muckrakers

1. Identify 2 reasons why you think muckraking emerged in the early 20^{th} century.

2. What type of corruption was uncovered by:

Lincoln Steffens-

Ida M. Tarbell-

Thomas W. Lawson-

David G. Phillips-

3. What other corruptions did muckrakers expose?

Political Progressivism

4. What are three ways Progressives gave political power back to the people? (Hint- bolded words)

So far, I have been referring to resistors in units of ohms. You will find that most resistors that you work with are either in the thousands or millions of ohms, and it gets tedious writing them out as 1,000 Ω or 1,000,000 Ω. To simplify the writing down of large resistances, the symbol "k" is used for thousands of ohms, and "M" is used for millions of ohms. This means that 4,700 Ω is written out as 4.7k or 2,200,000 Ω is written as 2.2M. In some books and schematic diagrams, you will see these values written out as "4k7" and "2M2." They mean the same thing, but the space needed for the decimal point is replaced by the symbol for thousands or millions of ohms.