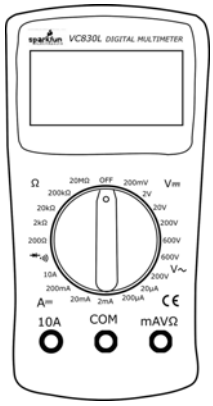
Name: _____ Date: _____

How to Use a Multimeter



Introduction

A multimeter is an indispensible tool that is used to diagnose and troubleshoot circuits. As its name states, it is a meter capable of measuring **multi-**ple things related to electricity, namely: **voltage**, **current**, and **resistance**. So… how *do* I use a multimeter? Let's take a look. We will be using the SparkFun VC830L throughout the tutorial but these methods should apply to most multimeters.

Parts of a Multimeter

A multimeter is has three parts:

- Display
- Selection Knob
- Ports

The **display** usually has four digits and the ability to display a negative sign. A few multimeters have illuminated displays for better viewing in low light situations.

The **selection knob** allows the user to set the multimeter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω).

Two probes are plugged into two of the **ports** on the front of the unit. **COM** stands for common and is almost always connected to Ground or '**-**' of a circuit. The **COM** probe is conventionally black but there is no difference between the red probe and black probe other than color. **10A** is the special port used when measuring large currents (greater than 200mA). The **mAVΩ** is the port that the red probe is usually plugged in to. This port allows the measurement of current (up to 200mA), voltage (V), and resistance (Ω).

The probes have a *banana* type connector on the end that plugs into the multimeter. Any probe with a banana plug will work with this meter. This allows for different types of probes to be used. To start, connect the red probe into the **mAVΩ** port and the black probe into the **COM** port.

Continuity

Continuity is quite possibly the single most important function for troubleshooting and debugging circuits. This feature allows us to test for conductivity of materials and to trace where electrical connections have been made or not made. Set the multimeter to ‘Continuity’ mode. It may vary among DMMs, but look for a diode symbol with propagation waves around it (like sound coming from a speaker).

Touch the two probe ends together. Do you hear the tone? Checking for continuity is sometimes also called "ringing out" a circuit. You can use this to test which holes on a breadboard are connected and which ones aren't. You can also use this to trace out a circuit. Because you often can't see where all of the wires go, this is a quick way to test to see if two points are connected electrically.

Measuring Resistance

Ω Similar to testing for continuity is measuring resistance. The continuity setting simply rings a tone when the resistance is low (on the order of a few ohms). But, if you want to know an actual value for the resistance, this is the setting you want. Turn the knob to one of the resistance settings. These are marked by the Omega symbol (Ω). This represents the unit ohms which is used to measure resistance.

There are several settings possible. These are ranges and represent the maximum range that you can measure. If you want to measure a small resistor to a high accuracy, you might set the multimeter to the 200Ω setting. If you try to measure a resistance greater than the range, it will simply display [1.]. Notice that there are no zeros displayed. This means that the meter senses the resistance to be greater than the range. Try moving the range up a notch and measuring it again.

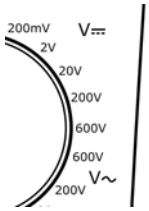
Because the display has no units on it, it is assumed that the number displayed matches the same units as the setting. If you have the range set to 200Ω, then the display will be in Ω. If you have the range set to 2kΩ, 20kΩ, or 200kΩ, then the value displayed will be in units of kΩ.

- Measure the resistance of the 330 Ohm resistor (Orange-Orange-Brown). What values do you record for each of the settings? All resistors have a tolerance band. These are typically 5%. What is the %error for your measurement? Is it within the tolerance?

- What happens when you connect these resistors together in parallel? What is the combined resistance. Now, connect two resistors in series. What is the combined resistance in this configuration?

- Test the resistance of the photoresistor. Hold you hand or something else opaque above the photo resistor. Measure the resistance of the photoresistor for various different heights.

Measuring Voltage



Voltage is a measurement of electrical potential between two points. It is sometimes also called the ***potential difference***. Similar to the settings when measuring resistance, the various settings for measuring voltage specify the maximum range.

You will notice that there are two different ranges when measuring voltage. The one on the top has two straight lines and the one below has a squiggly line. The two straight lines indicate direct current (DC) measurements. This is what is most common in electronics. The other one is alternating current (AC), and this is the type of electricity that is found in the walls of your house. Be sure that you have the knob turned to the right setting. The 20V setting is probably the most typical for our applications.

Now, let's measure the voltage on an Arduino board. Plug your Arduino board into your computer using the USB cable for power. To measure voltage, connect the black probe to GND or ground. Now, use the red probe to test the voltage at various points (with respect to GND).

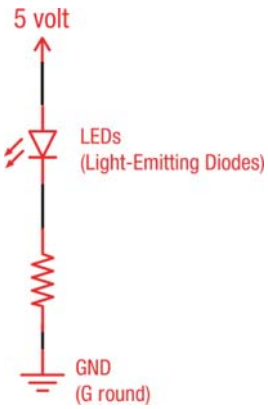
- What is the voltage of the 5V pin? What is the voltage of the 3.3V pin? Characterize your measurements as a % error.

- Now, connect your Arduino board to a 9V power supply. Re-measure these two pins. What do you notice?

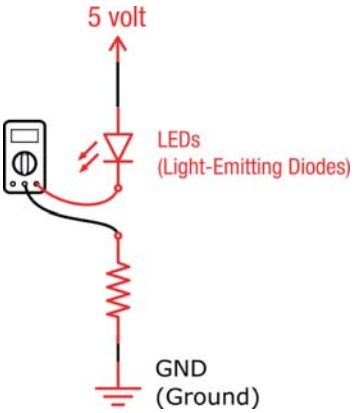
- What happens if you switch the positions of the black probe and the red probe? How does this affect your measurement?

- On the SparkFun RedBoard, there is a very bright power LED. Measure the voltage across the LED. To do this, you will use the red and black probes and pinch the ends of the LED. What is the voltage across the LED? Can you determine which side of the LED is positive (+) and which side is negative (-)?

Measuring Current



Current is the rate of moving charges in a circuit. We now know that this is the movement of electrons, but by convention, we still look at current as the movement of charges from positive (+) to negative (-). In order to capture the rate of moving charges, you need to break the circuit and put the meter in-line where you want to measure current. Move the knob to the appropriate current range that you expect to measure. If you are measuring anything above 200 mA, you need to also move the red probe to the **10A** port.



To measure the current going through a simple LED and resistor circuit, for example, you would have to first splice into the circuit somewhere. Here, we spliced into the circuit just after the LED. The current path must go through the meter. Because this is a series circuit, you can measure the current anywhere along this path (i.e. before the LED, after the LED, or after the resistor)

When you are measuring current, be very careful not to exceed the limits. When you go beyond the current limits, you run the risk of also blowing a fuse on the multimeter. The standard **mAVΩ** port can handle up to 200 mA. If you think you'll be measuring more than this, move the red probe to the **10A** port and change knob to the 10A setting.

Extension Questions

- For measuring things like resistance or voltage, what advantage do you have when using the smallest range possible? Why not always use the largest range (like 200V)?

- The resistor that is in-line with the Power LED is a 1 kΩ. Since I can't splice the meter into this circuit to measure the current, use Ohms Law ($V = I \bullet R$), determine the current that is flowing through the green power LED.

- What is the best setting for measuring the resistance of a 330 Ω resistor. When you measure this, what do you see on the display. What does this mean?

- What is the difference between the V~ settings and the other Voltage settings? When would I use one versus the other?