Electricity

Air Washington Electronics ~ Direct Current Lab

Electricity

Overview

In this experiment, the student will connect a simple series DC circuit then take measurements for resistance, voltage, and current with a digital multimeter (DMM) and an analog volt-ohm-milliammeter (VOM).

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions.

Course Objectives

- Demonstrate acceptable techniques to construct circuits from schematic drawings on solderless and/or solder type breadboards.
- Demonstrate ability to document a breadboard circuit: test circuit operation
- Demonstrate knowledge of basic electronic components.
- Define/draw the schematic symbol and write the designating letter for electronic components, circuits and devices.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment: DC Power Supply and Digital Multimeter
- Demonstrate proper measurement techniques for voltage, current and resistance

Module Objectives

- Demonstrate ability to read a schematic to build a simple series circuit.
- Demonstrate ability to set up and take measurements with a digital multimeter.
- Demonstrate ability to set up and take voltage measurement with an analog multimeter.
- Demonstrate ability to set resistance multiplication factors and take measurements with an analog multimeter.
- Complete observations and conclusions for all activities.

Activities

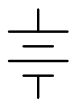
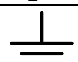
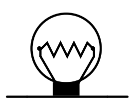
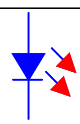
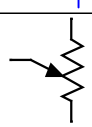
1. Using a Digital Multimeter
2. Using an Analog Multimeter

Reading a Schematic

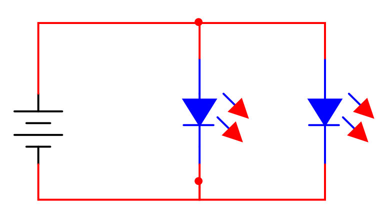
Building a circuit requires a schematic. A schematic is a kind of road map for how the circuit will work. It traces the path that the electrons will flow through the circuit. In the early labs, schematics will be simple. As you progress, the circuits will become more complicated and the configuration of the schematics will change as well.

For this course, the following symbols will be used in varying configurations.

Schematic Symbols and Terms

+ (positive)  - (negative)	Voltage	This symbol is used in this course to indicate a DC voltage source such as a DC Power Supply or a battery. The voltage level will indicated in units of volts, V. The longer lines are positive and the shorter lines are negative.
	Ground	This symbol indicates ground.
	Resistor	This is the symbol for resistors. The resistance will be indicated in units of ohms, Ω.
	Lamp	Many of the labs use an indicator lamp.
	LED (Light Emitting Diode)	LEDs are used in the labs to provide a visual indication of electron flow. They will be covered more in depth in later courses.
 50 %	Potentiometer	A potentiometer is a variable resistor. The "pot's" total resistive value will be indicated in ohms. In this image, the percentage of that value is indicated. 50% indicates that only half of the resistance is being used.
	Wire	Straight lines connect each component.

Simple Circuit Set Up

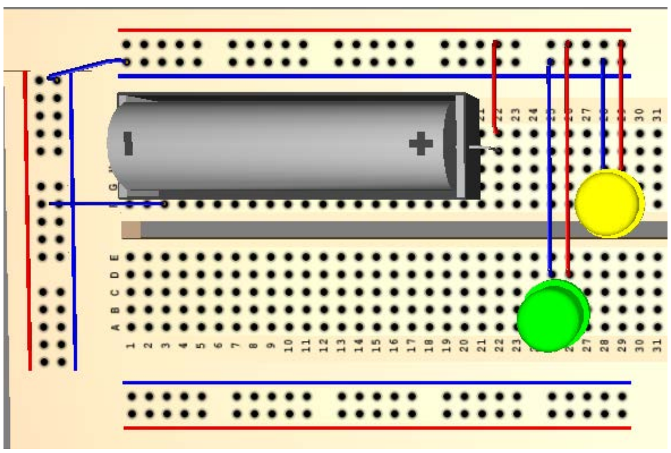


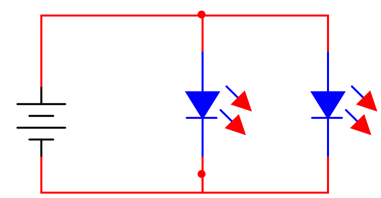
A simple circuit that allows for two lamps to be powered from the same power source would look like the schematic shown. There is a power source, wire for the path, and two LEDs connected in parallel.

In this class, lab circuits are built on a bread board and the rest of this module will discuss how to use a breadboard in your labs.

Electricity needs a path to follow. Using the design of the breadboard, you can build that path. There must be an applied voltage and a ground point. Between those two points there must exist a conductive path. In this case, the path is a wire. Watch the video in this module for detailed information how to set up a simple circuit on a breadboard.

Below is shown a simple circuit with a battery and two LEDs. This is the same circuit as is shown in the schematic. Note that the battery is attached to each of the bus lines. The negative side is attached to the blue bus line and the positive side to the red. Because each bus line has an electrically common connection, wires can connect to components from anywhere along their length. However, as the bus connection does not go around the corner, a jumper wire was used to connect the two bus lines together.



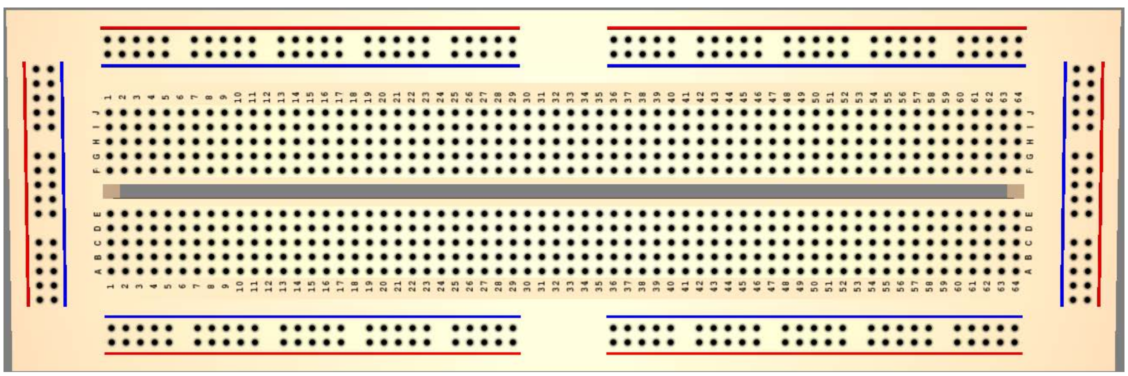


Basic Bread Boarding

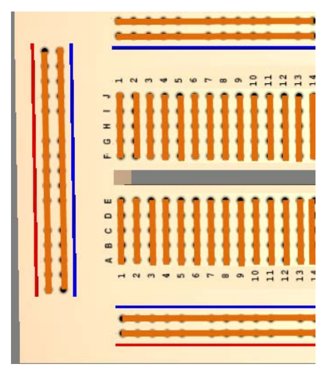
Throughout this course, you will be building and demonstrating circuits. To do this, you will use a bread board. This simple tool allows you to set up circuits for your experiments, take measurements, then do it all again for the next experiment. They are simple to use, but do take some practice. If you are new to bread boarding, the easiest way to ensure that mistakes are not made is to construct your circuit on the bread board look as much like the drawn circuit as possible.

The Bread Board

As shown in the image below, the bread board is basically just a convenient place to insert wires and components. Without it, you would need to figure out a way to hold all the components and wires together while designing a circuit. When you needed to make a change, you would have to disconnect all the connections, change the part, and then connect it all together again. With a bread board, you merely lift out the component you wish to change and insert a new one. If wires must be moved, you simply unplug the wire and move it to the new location.



If you could see inside the breadboard, it would look like the image in the second figure. This image shows how the holes on the breadboard are connected on the inside. Any hole that lies on the same line (or wire) are said to be electrically common. Any connection along that same set of holes is the same connection. The areas that are outlined with red and blue stripes are bus lines. The area in the center is where circuits are built.



Bus Lines

Bus lines are areas from which connections can be made anywhere along the line. They are not required for use, but do allow for flexibility and convenience. On the bread board, locate the sections with blue and red lines. These indicate the buses. The red is normally used for positive (voltage) and the black for negative (or ground). Once again, this is not a requirement, but it is generally expected and accepted that red represents positive or “hot” and black or dark blue represents negative.

In the center area of the bread board, there are numbered rows and lettered columns with a channel that goes down the middle of each side. The center channel isolates one set of rows and columns from the next and is used with integrated circuit (IC) chips. When circuits are built, it is this area that is used.

Wires & Jumpers

Copper wire creates the path that connects components together in an electric circuit. In later modules, you will learn more details about wire, but for now, it is important to have only a basic understanding. Standard wire sizes are measured in AWG (American Wire Gage). Unlike most measurements, the larger the gage, the smaller the wire.

The wire used for bread boarding is single strand 22 AWG, or 22 gage. Most of the components have pins or legs of the same or smaller size. For larger wattage resistors, the legs will be a bit larger. If you are having difficult inserting a wire or component into the holes on a breadboard, please stop and ask for assistance. Forcing the wire or component into the breadboard will damage it.

Because the bread boarding wire is single strand, it is not as resistant to damage by bending and twisting as stranded wire. The test leads and cables used for the power supplies are made of stranded wire and as such are much better suited to being manipulated. If you start to experience trouble with a bread board wire, it could be that it has been bent and reused one time too many. As you progress through the program, you will find that you will collect a collection of color coded jumpers. Inspect them occasionally for damage such as crimps, bends, and missing insulation. Missing insulation can become a shock hazard. Dispose of and replace any wire that has insulation missing and have exposed copper.

Wire in the lab will be called by several different names: jumper, wire, cable. It also comes in a variety of color. Color coding wire makes complex circuitry easier to follow. Some basic color coding is red for positive and black for negative or ground.

Preparing wire for use in the breadboard is simple and involves the use of wire strippers:

1. Cut off the amount of wire needed
2. Using the wire strippers, insert one of the wires into the slot labeled “22.” You only need about 1/8” of bare wire. While squeezing the handles, pull the long end of the wire away from the strippers
3. Repeat on the other end.
4. Dispose of the insulating material in the trash.

Additional Resources

Websites

Vanderbilt University: “The Breadboard” (http://eecs.vanderbilt.edu/courses/ee213/Breadboard.htm)

TechDose: “How to use Solderless Breadboards,” by Wayne Eggert (http://www.techdose.com/electronics/How-to-Use-Solderless-Breadboards/252/page1.html)

Multimedia

Collin’s Lab: The REAL Breadboard (http://www.youtube.com/watch?v=HrG98HJ3Z6w)

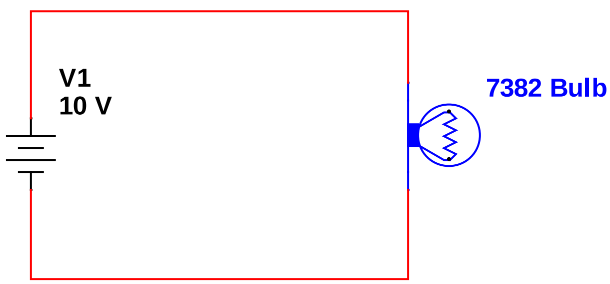
SNMU: How Breadboards Work (http://www.youtube.com/watch?v=lqw6ask5HK0)

1: Using a Digital Multimeter (DMM)

Components & Equipment Needed

- Bread Board
- Wire (22 AWG)
- DC Power Supply
- DMM
- 7382 Bulb

Schematic



Additional Instructions

These instructions are the standard requirements for the Electronics Program:

- When making measurements, always include the appropriate symbol for the unit of measurement (V, I, or Ω).
- Measurements should be taken to the 3rd place after the decimal.
- Leading zeroes are required for measurements less than one.
- Use engineering notation. For review see Grob's Basic Electronics, Introductory Chapter. For example, if you get the result "40421.01289 Ω," record your answer as "40.013 kΩ." Or "0.00124963 A," write this as "0.001 A" or "1 mA."

Procedure

Step 1: <u>**Preparing the Breadboard**</u>

☐ Connect the voltage and ground terminals to the breadboard by unscrewing the binding post nuts until you can see a small hole in the shaft.

☐ Using about 3" of 22 AWG wire that has been stripped of about ¼" of insulator at each end, insert one end into the hole and tighten down the nut. Insert the other end into the appropriate bus line. Keeping wires color-coded can simplify things.

☐ Use a small piece of wire (about 1”) to make a jumper. Strip off both ends about ¼”. You will need two of these: one for voltage and one for ground.

☐ Insert one of the jumpers into the voltage (red) bus and the other end into the working area of the bread board.

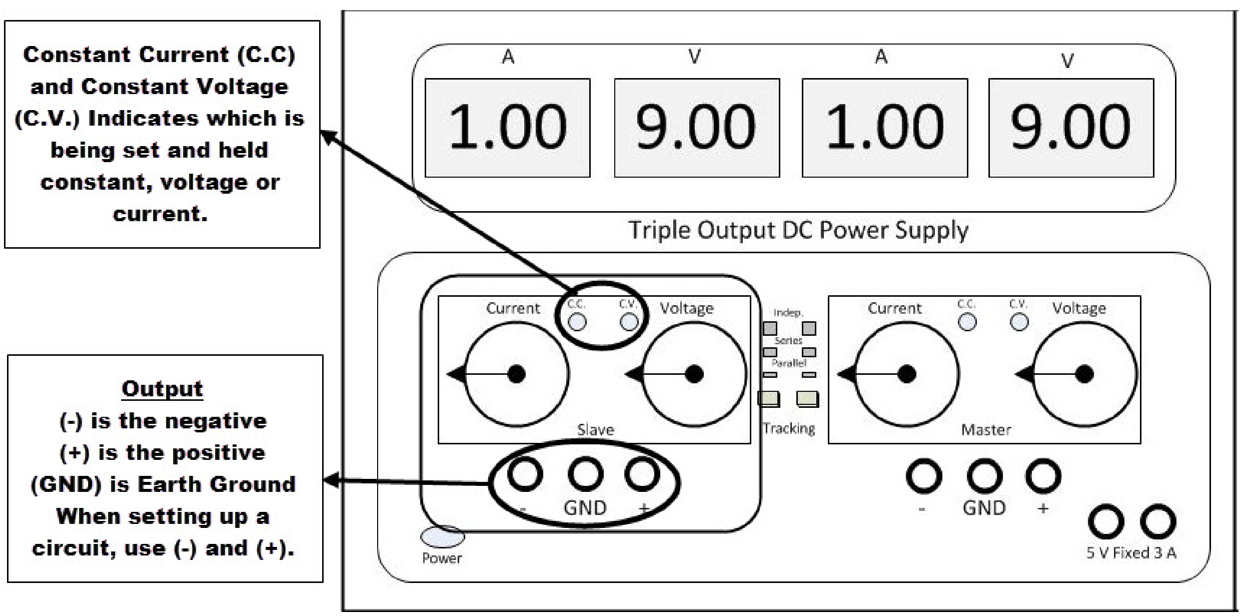
Step 2: Building the Circuit

☐ Insert the 7382 bulb so that one pin is in the same row as the jumper from the voltage bus and the other is in the next column.

☐ Insert the other jumper into the same row as the second pin of the 7382 bulb and the other end into the ground (blue) bus.

Step 3: Setting Up the Power Supply

➢ If you are using a variable DC Power Supply, follow the manufacturer directions for your particular model to set it for an output of 10 V. A typical Triple Output DC Power Supply as shown below is referenced in the following instructions.

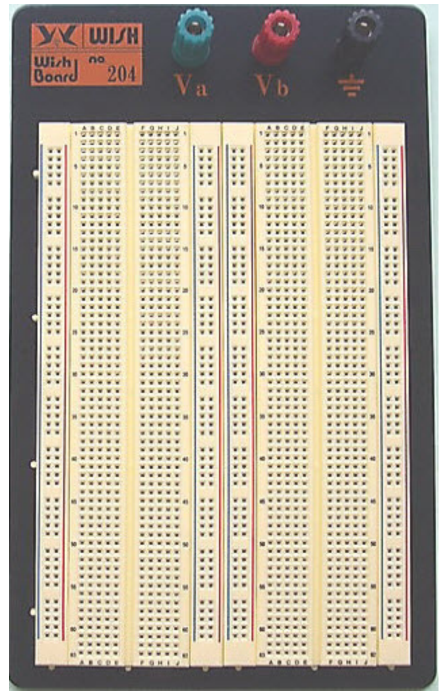


☐ Make sure the knobs on the power supply are turned all the way to the left (zero) and that it is set to “Independent.” With this setting, you can use either side of the power supply.

☐ Turn on the power supply and adjust the voltage knob until the CV (green) light clicks off and the CC (red) light clicks on. Watching the voltage reading on the LED screen, continue adjusting knobs until it reads 10.0 V. (C.V. means "Constant Voltage," C.C. means "Constant Current.")

☐ Turn off the power supply

Step 4: **Connect the Power Supply to the Breadboard**



- A common breadboard, the Wish Board 204, is shown to the right. Follow the manufacturer's directions for your particular breadboard, or for similar breadboards, follow the directions below:

☐ Insert a red cable with banana plug into the POS (+) terminal of the Power Supply and the other end into the red terminal of the breadboard.

☐ Insert a black cable with banana plug into the NEG (-) terminal of the Power Supply and the other end into the GND terminal of the breadboard.

☐ Do **NOT** turn on the power supply at this time.

Step 5: **Set up the DMM**

- When using a handheld DMM, remember to turn the dial to the appropriate setting (V, A, or Ω) and **make sure it is set for DC circuits**. For bench models, as soon as the power is turned on, press the correct button depending on what you are measuring.

☐ Insert the test leads into the proper jacks on the meter. For voltage and resistance, the **black** lead goes to the "COM" and the **red** lead goes to "V/Ω." For current, the **black** lead goes to "COM" and the **red** lead goes to the "A." Be aware that different meters will have different red jacks for current. If there are two red jacks, one is normally labeled 200 mA or 2 A MAX and the other 20 A MAX.   For purposes of this course, there is no need to use the 20 A MAX jack as we will not be working with current amounts greater than 1 A.

Step 6: **Measuring Resistance**

☐ Before turning on the power supply, remove the bulb and measure the resistance between the leads. Record the measurement in the table below.

☐ Return the bulb to the circuit and turn the power supply on. If the bulb does not light, review your circuit to ensure that there is continuity – make sure that the jumper wires are in the correct places to provide a closed path from the positive side of the power supply through the light bulb and back to the negative side of the power supply.

Step 7: **Measuring Voltage**

☐ Using the DMM (bench or handheld), measure voltage and record below. Measure the voltage across the bulb by using small jumpers that are inserted in the same rows as the bulb. Because the rows are connected, the same amount of voltage will be measured across them.

Step 8: **Measuring Current**

➢ **Turn off the power supply, or disconnect the battery, and set up the circuit to measure Current following the steps below:**

☐ Insert the DMM into the circuit by disconnecting the jumper between the positive bus and the light bulb. Leave it plugged into the bus line, but unplugged from the bulb.

☐ Insert a jumper wire on the positive side of the light bulb

☐ The positive lead of the DMM will go to the jumper on the positive bus and the negative lead will go to the jumper on the positive side of the bulb. Essentially, you have opened the circuit and have inserted the DMM into it. The current will now flow from the power supply, through the DMM, through the light bulb, and back to the power supply.

☐ Before turning on the power supply, double check your set up to make sure that it is correct. If in doubt, ask your instructor to check your wiring.

☐ Record current in the table below.

Resistance, Ω	Voltage, V	Current, mA

2: Using an Analog Volt-Ohm Meter

The directions below refer to a Simpson 260 VOM. For other makes and models, please refer to the manufacturer's instructions on how to properly set up the meter for measurement. Due to the real possibility of damage to the meter, only measurement for voltage will be taken. Because the bulb has low resistance and is also affected by the meter during resistance measurements, the three resistors will be used for resistance measurements.

Components & Equipment Needed

- Bread Board
- Wire (22 AWG)
- DC Power Supply
- Analog Multimeter or VOM
- 7382 Bulb
- Resistors: 100 Ω, 1000 Ω, 100,000 Ω
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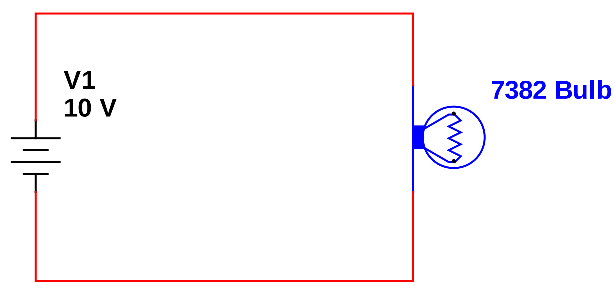
Schematic



Procedure

Step 1: **Measuring Voltage with the VOM**

☐ Set function switch at +DC

☐ Plug black lead into –COMMON jack and red lead into the + jack

☐ Set the correct range using the dial.

☐ If in doubt, always use the highest range setting to protect the meter

☐ Connect the black lead to the negative side of the circuit and the red lead to the positive side.

☐ Switch on the power supply.

☐ Measure voltage and record below. As with the digital multimeter, measure the voltage across the bulb by using small jumpers that are inserted in the same rows as the bulb.

V = ____________________

Step 2: **Measuring Resistors**

➢ **For this section, the circuit and power supply will not be used. Instead, measure three resistors: 100 Ω, 10,000 Ω, and 100,000 Ω.**

☐ Turn range switch to appropriate resistance range:

R x 1	0 - 200 Ω
R x 100	200 – 20,000 Ω
R x 1000	Resistance above 20,000 Ω.

☐ Plug black lead into –COMMON jack and the red lead into the + jack

☐ Connect the ends of the leads together – if the reading is NOT zero; adjust using the "ZERO OHMS" knob until it does.

☐ Set function switch at + DC or –DC

☐ Record the measurement in the table below.

☐ Repeat for each remaining resistor. Remember, the meter must be zeroed for each new resistor range.

Resistance, Ω
100 Ω =
10,000 Ω =
1,000,000 Ω =