

Introduction

1. Objective

In this lab, you learn how to use the basic equipment on your workbench – the breadboard, power supply and multimeter. You use the breadboard to build your circuit, the power supply to provide energy (voltage) to your circuit and the multimeter to measure voltage, current or resistance.

2. Constructing Circuits

A real circuit is very different to the world of circuits on a white board or blackboard. However, you will not be responsible for understanding these differences. As a matter of fact, these differences have negligible effect on your measurements. However, you will be responsible for clean wiring. As a result, let us talk the most important item on your lab bench – the breadboard.

Figure 1. shows a picture of the breadboard. Figure 2 shows how the holes in the breadboard are connected.



Figure 1. The breadboard

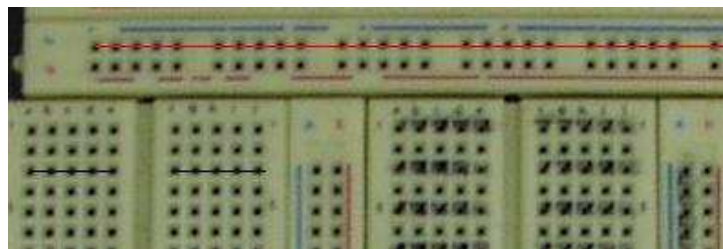


Figure 2. Zoomed in view of the breadboard illustrating how the holes are connected

Figure 2 is probably difficult to visualize - make sure you know how to use breadboard by the end of lab 1.

Using the breadboard is not difficult, but building neat circuits is! Figure 3 shows one good wiring practice. Notice how the wires are all “sitting” on the breadboard. This will minimize debugging time. **DO NOT MAKE A “HAIRY CIRCUIT” - EXTREMELY LONG WIRES THAT RISE ABOVE THE BREADBOARD.**

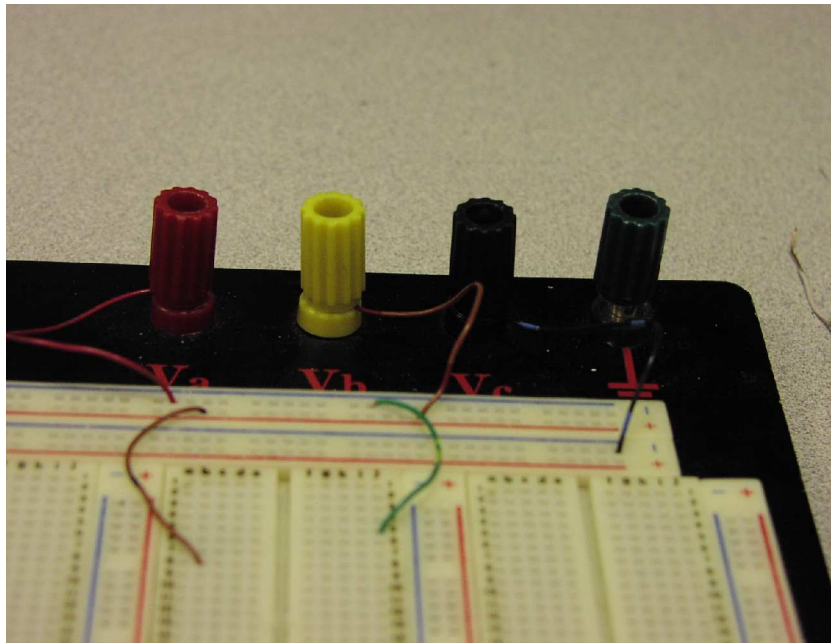


Figure 3. Neat wiring on a breadboard

Resistors and Voltage Sources

Figure 4 below shows different kinds of the most common type of resistor – the carbon-film resistor. The resistors are sized differently depending on how much power they can dissipate. Higher power dissipation translates to a bigger resistor.

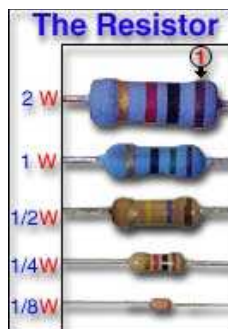


Figure 4. Picture of different kinds of carbon-film resistors
(source: <http://www.compworks.faithweb.com/electronics/components/resistor101.html>)

The color code on the resistor helps you read its value – the TA will illustrate with some examples. A real resistor circuit on the breadboard will be shown in section 6. Let us now talk about how you will supply power to your circuit – the DC (Direct Current) power supply. A front view of this power supply is shown in figure 5.



Figure 5. The digital DC power supply

You have three choices of voltage – 6 V, 25 V or -25 V. For using the 6 V power supply, you connect to the 6 V + - terminals shown above. The – terminal is hooked up to the ground of the power supply.

The concept of a ground is probably the hardest concept to understand in electrical engineering. You can find a very good article on this concept at <http://www.ee.upenn.edu/rca/instruments/misc/tutorials/Ground/grd.html>. This paragraph attempts to summarize some of the important concepts. According to Kirchoff's current law (KCL), current entering a circuit = current leaving as shown in figure 6 below.

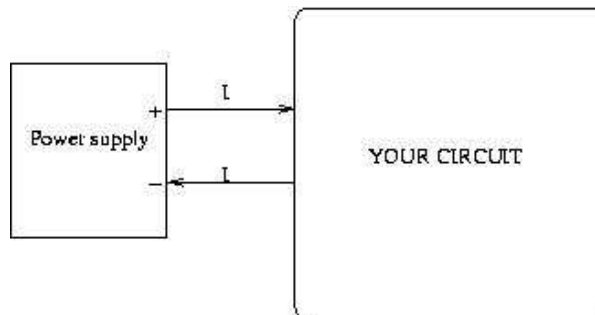


Figure 6. KCL used to illustrate the concept of a ground. If I amps enters your circuit, I amps has to leave your circuit.

Ground in a circuit usually denotes the wire that carries this return current as shown in figure 7 below.

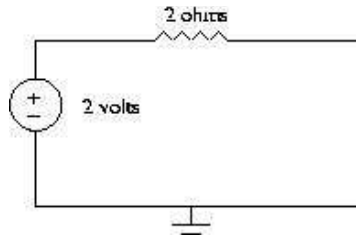


Figure 7. A simple circuit with a ground symbol

The reason for choosing the word “ground” is historical. Early electrical engineers theorized the earth was electrically neutral. This established a convenient reference frame for voltage measurements – a voltage is a potential difference and the earth served as the reference. They also used the earth as a current return path to the lowest potential point of the generating system, as shown in figure 8.

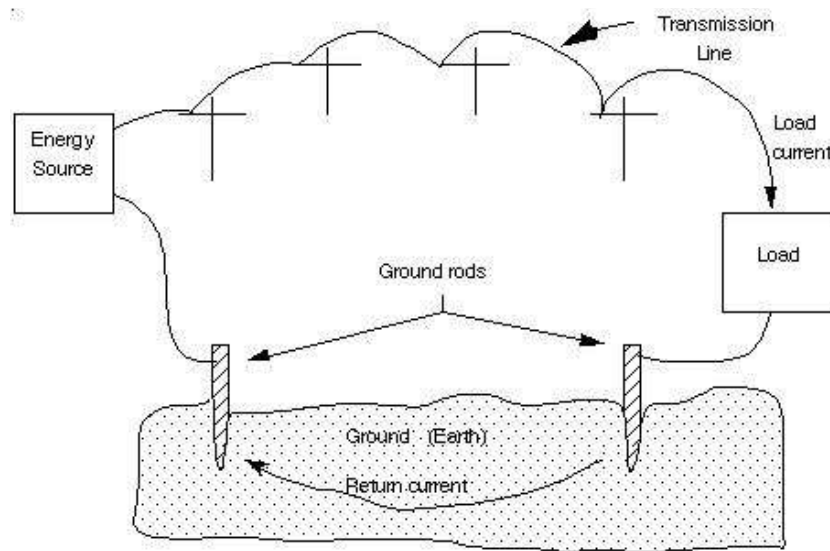


Figure 8. The concept of an earth ground

Since every circuit must have a return path for the current, a ground simply means the potential at that node in a circuit is zero. This statement will become clear when we talk more about circuits. Let us now talk about how to actually measure potential differences using the multimeter.

4. The Multimeter

A multimeter is a device that can measure many (multi) things – voltage, current and resistance are the quantities you will be concerned with in this lab. Figure 9 shows the multimeter used in the EECS 100 lab.



Figure 9. The multimeter configured to measure current.

A multimeter configured to measure voltage is called a voltmeter; configured to measure current is called an ammeter and configured to measure resistance is called an ohmmeter. The details of configuring the meter to measure current, voltage and resistance will be covered by the TA in lab. The concept behind the measurement of current and voltage will be discussed here.

It will be helpful to discuss this concept by drawing an analogy to mechanical engineering: you can think about current as water flowing through a pipe. Water can flow through a pipe because of difference in potential energy – water can flow from the tank on the 1st floor of an apartment complex to the basement. Figure 10 illustrates two possibilities to set up a potential meter that measures this potential difference.

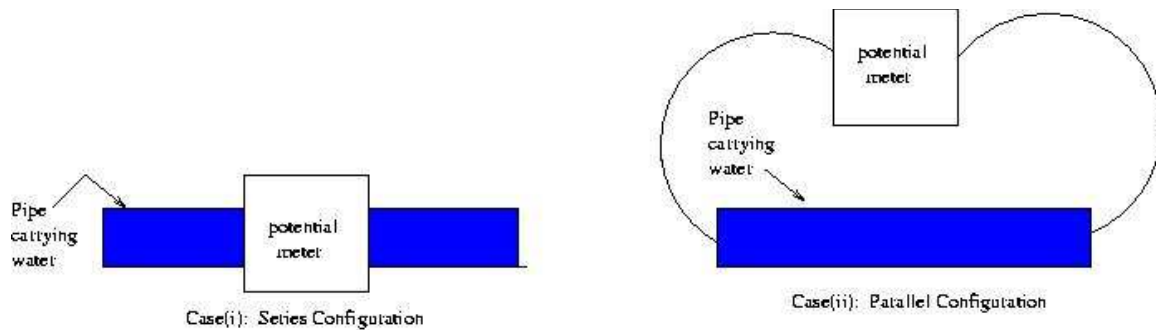


Figure 10. Series vs. parallel configuration of the potential meter

If you think about it, case (ii) in figure 10 makes sense for measuring voltage. You are measuring potential *difference* - hence you want to hook the meter across the two points to measure their potential difference. Thinking in a similar manner, we can see that an ammeter is hooked up in series with the circuit to measure current. Voltmeter and ammeter configurations to measure voltage and current in a circuit are shown in figure 11¹.

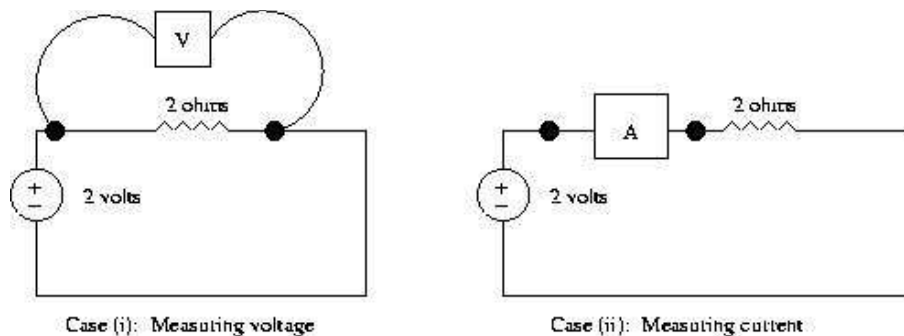


Figure 11. Parallel configuration for measuring voltage and series configuration for measuring current

To hook up an ohmmeter to measure resistance, you connect it across the resistor. You will have a chance to practice these techniques in the experiment, coming up next...

¹ You may have heard electrical engineers talk about “*voltage across*” and “*current through*” – now you see why. **NEVER SAY** “voltage through” and “current across”.

5. The Experiment

~~PLEASE NOTE: 1. YOU GET 4 POINTS (FOR THE PRELAB) IF YOU SHOW UP FOR LAB~~
~~2. FORM GROUPS~~
~~3. WIRE NEATLY~~
~~4. CLEAN UP YOUR STATION AFTER YOUR DONE~~
~~5. IF YOU HAVE ANY QUESTIONS ON THE BREADBOARD, POWER SUPPLY OR MULTIMETER - ASK THE TA ASAP!~~

TASK 1:

Your TA will give you a random resistor. Find out the resistance using the color code. Now measure the resistance using the ohmmeter. Record the values in the table below.

Resistance using color code (ohms)	Resistance using ohmmeter (ohms)	% error

Table 1. Resistance measurement

TASK 2:

Construct the simple series circuit shown in figure 12 (sample breadboard connection in figure 13). Use a 4 volt input source and two 1kohm resistors in series. Fill in table 2 using the voltmeter and ammeter.

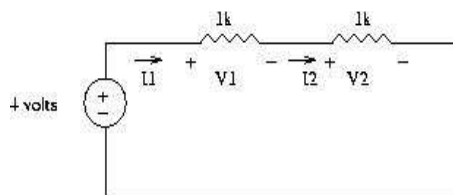


Figure 12. Series circuit

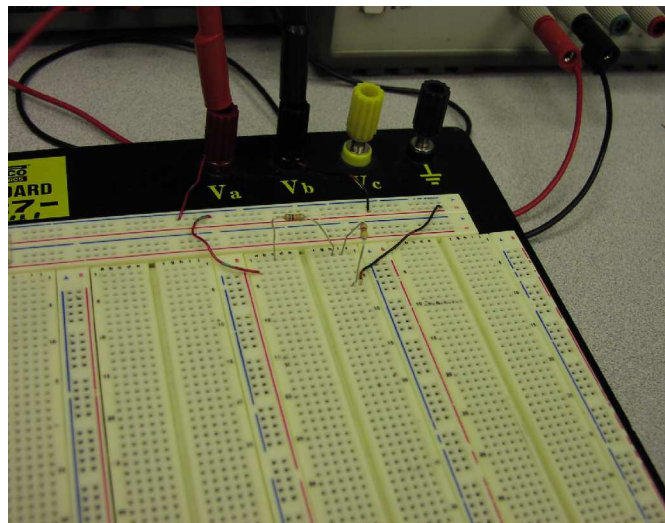


Figure 13. Sample breadboard circuit

Voltage across R1 (V1)	
Current through R1 (I1)	
Voltage across R2 (V2)	
Current through R2 (I2)	

Table 2. Series circuit measurements

CONCLUSION: 1. $V1 + V2 =$ _____ Input voltage = 4 volts. % error = _____
 2. $I1$ (circle one:) < = > $I2$

TASK 3:

Construct the simple parallel circuit shown in figure 14 (sample breadboard connection in figure 15). Use a 4 volt input source and two 1kohm resistors in series. Fill in table 3 using the voltmeter and ammeter. Use the ammeter to measure I .

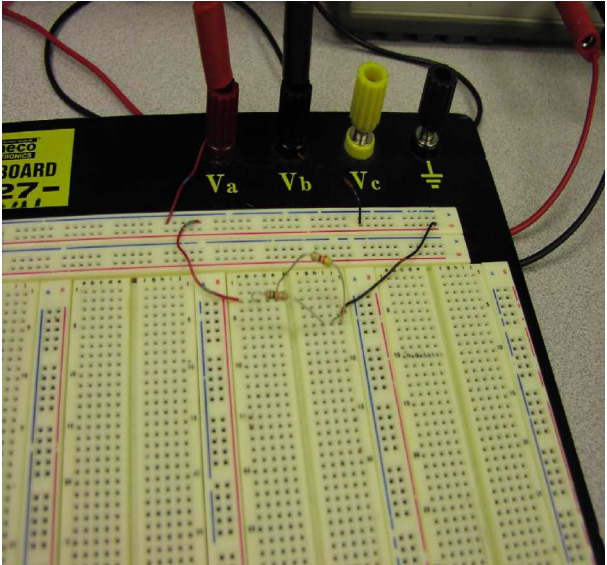
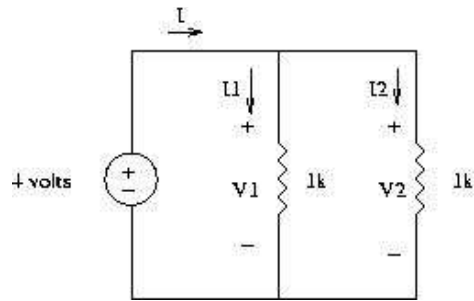


Figure 14. Parallel Circuit

Figure 15. Breadboard connection

Voltage across R1 (V1)	
Current through R1 (I1)	
Voltage across R2 (V2)	
Current through R2 (I2)	

Table 3. Parallel circuit measurements

CONCLUSION: 1. $I1 + I2 =$ _____ Input current (I) = _____. % error = _____
 2. $V1$ (circle one:) < = > $V2$