BME 3511 Laboratory 1

Introduction to common electrical & electronic components

Objective:

The objective of this exercise is to introduce the students to common electrical components such as Resistors, LEDs, Batteries, DC Voltage sources, and Measurement devices. By the end of this lab activity the student will:

- Identify a resistor's nominal value based on the 4-band resistor color code.
- Distinguish the anode (positive) and cathode (negative) leads of a LED.
- Describe the function/operation of DC Voltage sources (batteries).
- Describe the various DMM functions and explain how to use a DMM to measure voltage, current, and resistance.
- Collect and report data in a standard format

Background:

Resistors:

Resistors are devices that are used in electronic circuits to provide resistance to the flow of current. The resistance is measured in units of "Ohms"; the symbol for the unit of measurement is the capital Greek letter 'omega' (**Ω**). Typically, resistors are small and cylindrical as shown in the figure below therefore it is difficult to print the resistance in a readable form on the cylindrical body:

Figure 1: Shows a variety of resistors with different resistive values.

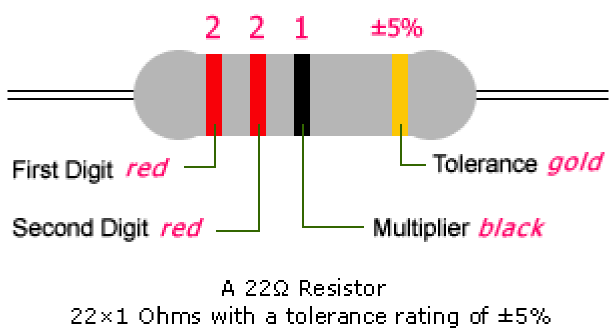
Instead, they are commonly marked with colored bands to indicate their resistive value. The bands are rings around the body of the device that when read will allow you to determine the approximate resistive value. The resistor color code typically uses four color bands; some countries or companies may use five or even six bands for special purpose applications. For the purpose of this class, we will focus on the four band resistor. The first two bands indicate the **two most-significant digits** of the resistor's value. The third band is a weight value, which **multiplies** the two significant digits by a power of ten. The final band indicates the **tolerance** of the resistor. The tolerance explains how much more or less the *actual* resistance of the resistor can be compared to what its nominal value is. No resistor is made to perfection, and different manufacturing processes will result in better or worse tolerances. For example, a 1kΩ resistor with 5% tolerance could actually be anywhere between 0.95 kΩ and 1.05 kΩ. How do you tell which band is first and last? The last, tolerance band is often clearly separated from the value bands, and usually it'll either be silver or gold. Here's a table of each of the colors and which value, multiplier or tolerance they represent:

Color	Digit value	Multiplier	Tolerance
Black	0	10^0	
Brown	1	10^1	
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	
Gray	8	10^8	
White	9	10^9	
Gold			±5%
Silver			±10%

Table 1: Sample Resistor Color Code Chart.

Example 1:

Here is a pictorial example of how to read a resistors:



Example 2:

Here we will do an example of how you would read a resistor using Table 1. Look at the resistor presented below:

Figure 2: A resistor with the gold band (tolerance band) situated at the right.

Notice that there are four (4) bands present on this resistor: brown, black, brown and gold. The first two band (brown and black, respectively) represent the two most-significant digits of the resistor's value. The third band is a brown band and it represents the weight value, which multiplies the two significant digits by a power of ten. The final band, gold, indicates the tolerance of the resistor. Now using Table 1 we see that the first digit is **1**, the second digit is **0**. We can group these to get **10**; we then use Table 1 again to determine that the multiplier term is 10^1 therefore we multiply the first two terms with the multiplier to get: **10***10^1 = 100 ohms as our answer. However, we are not done since we still have to account for the tolerance band; from Table 1 we see that our tolerance is ±5%, so we multiply 100 by ±5% to get: 100*±0.05= 5. Finally, we get that our resistance value can fall is the range of 100+5 ohms or a 100-5 or it falls anywhere between 95-105 ohms.

LED:

LEDs or **L**ight **E**mitting **D**iodes, are semiconductor devices that produce visible light when an electrical current passed through them. Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor. To distinguish the anode (positive) from the cathode (negative) of the LED just look at the plastic housing, If the LED has a flat area (on the plastic housing), the lead adjacent to the flat area is the negative (cathode) lead.

Figure 3: This diagram shows a picture of an LED. Notice the flat edge on the right side, indicating that this is the negative terminal and the left side is the positive terminal.

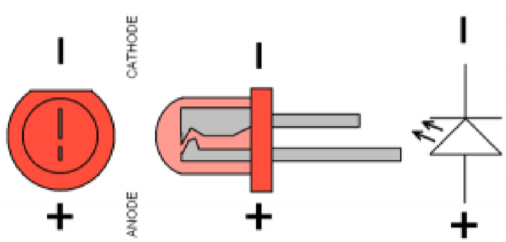
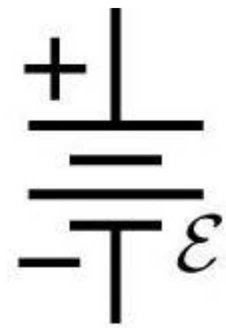


Figure 4: This diagram shows a diagram of a top down view on determining the anode and cathode of an LED.

Voltage Sources:

The majority of electrical devices and applications involve electric charges in motion. The electric potential difference or **voltage** causes the flow of charge. When there is zero voltage (i.e. when there is no difference in electric potential) there is no flow of charge. The rate of flow of charges per unit time through a material is defined as **electric current**. The electric current is a measure of how many charges flow past a section of the conductor during a period of time (e.g. per second interval). Current flows through connecting wires (conductors) and other electrical devices in a closed path or loop known as an "**electric circuit**". A potential difference (**voltage**) is created by a separation of charge across the ends of the conductor. So, for a sustained electric current, a **voltage source** must maintain the separation of charges, thereby creating the potential difference that pushes charges through a conductor. To maintain a steady current, a voltage source does work to "pump" (positive) charges to a higher electric potential. These charges in turn expend the potential energy through the circuit as they flow back to the lower electric potential. The most common voltage sources are **batteries** and electric power **generators.**

A **battery**, as a voltage source, uses chemical energy (during a chemical reaction inside the battery) to separate and store positive charges at the positively charged terminal and also store negative charges at the negatively charged terminal of the battery, hence creating a potential difference. The negative terminal of a battery is usually **grounded** or assigned an electric potential of 0.0 V (i.e., zero volt). Therefore, the voltage of other parts of the circuit is measured relative to the 0 V at the negative terminal. The schematic symbol of a battery is shown below. Note the labels: (+) at the positive terminal, and (-) at the negative terminal.



It must be emphasized that a battery maintains a fixed voltage, but does not provide a constant current. The amount of current depends on the maximum possible voltage of the battery and the electric resistance of the devices connected in the circuit.

Voltage sources such as chemical batteries, solar cells, and fuel cells produce **direct current (dc)** in which the charges flow in one direction. Electric utilities, household electrical circuits, and the electrical industry use the **alternating current (ac)**, usually produced by an electric generator. The electrons in an alternating current move back and forth due to the reversing directions of the electric field inside the wire. For now, we will focus on DC as AC will be discussed at a later time.

Digital Multimeter (DMM)

A digital multimeter (DMM), an indispensable tool that you can use to diagnose circuits, learn about other people's electronic designs, and even test a battery, hence the 'multi'-'meter' (multiple measurement) name. We will be using the DVM850BL model multimeter throughout this course but these methods should apply to most multimeters.

A multimeter is has three parts:

- Display
- Selection Knob
- Ports

The **display** shows the reading of the measured quantity and typically has four digits and the ability to display a negative sign. 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 port used when measuring large currents (greater than 200mA), **mAVΩ** is the port that the red probe is conventionally plugged in to. This port allows the measurement of current (up to 200mA), voltage (V), and resistance (Ω). Here is an image to introduce you to the DMM:

Lab Procedure

Lab Experiment Procedure

1. Given the nominal values and tolerances in Table 2, determine the corresponding color code bands. **Record them in the proper cells in the table.**
2. Given the color codes in Table 3, determine the nominal value, tolerance and the minimum and maximum acceptable values. **Record them in the proper cells in the table**.

Value	**Band 1**	**Band 2**	**Band 3**	**Band 4**
27 @ 10%				
56 @ 10%				
180 @ 5%				
390 @ 10%				
680 @ 5%				
3.6 k @ 10%				
7.5 k @ 5%				
10 k @ 5%				
47 k @ 10%				
820 k @ 10%				

Table 2: Table for resistor color codes

Colors	Nominal	Tolerance	Minimum	Maximum	Measured
red-red-red–gold					
green-blue-brown**–gold** 09-18-16					
orange-orange-black–gold					
brown-green-green–gold					
blue-grey-red–gold					
brown-red-red–gold					
yellow-purple-brown–gold					
red-red-brown–gold					
red-purple-brown–gold					
brown-**green-orange–gold** 09-18-16					
orange-blue-brown–gold					

Table 3. Table for estimating values

Questions

1. Is it possible to get multiple answers for the measured value in Table 3? Why or why not?

2. How would you check your actual value? (Hint: What equipment would you use?)

3. Choose a resistor of your choice and draw it, calculate its resistive value and determine the current across that resistor if the voltage V is equal to 2 Volts.

References:

- "Resistors." *Resistors*. N.p., n.d. Web. 18 May 2015. <https://learn.sparkfun.com/tutorials/resistors>.
- "How to Read Resistors." *WikiHow*. N.p., n.d. Web. 18 May 2015. <http://www.wikihow.com/Read-Resistors>.
- "Learn About LED Bulbs." *: ENERGY STAR*. N.p., n.d. Web. 18 May 2015. <https://www.energystar.gov/index.cfm?c=lighting.pr_what_are>.
- "How Light Emitting Diodes Work - HowStuffWorks." *HowStuffWorks*. N.p., n.d. Web. 18 May 2015. <http://electronics.howstuffworks.com/led.htm>.
- "LED Basics: How to Tell Which Lead Is Positive or Negative - West Florida Components." *West Florida Components*. N.p., 05 Jan. 2010. Web. 18 May 2015. <https://www.westfloridacomponents.com/blog/led-basics-how-to-tell-which-lead-is-positive-or-negative/>.
- " Voltage Sources and Electric Current." *Voltage Sources and Electric Current*. N.p., n.d. Web. 18 May 2015. <http://facstaff.gpc.edu/~pgore/PhysicalScience/electric-current3.html>.
- "How to Use a Multimeter." *How to Use a Multimeter*. N.p., n.d. Web. 18 May 2015. <https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter>.
- http://commons.wikimedia.org/wiki/File:Tw-resistor-color-code-ex22-ohms.gif
- Dr. Hance's Lab