Name: ___________________________

Ohm's Law and Resistor Lab

Ohm's Law

Ohm's law is the most basic law of electricity. It was formulated in 1827 by the German physicist and mathematician Georg Simon Ohm. Through his experiments, Ohm discovered the relationship between voltage difference, current and resistance. In the following simple section, we run a similar experiment to study the effect of voltage on current.

Voltage and Current Relationship

In this part of the lab, you will use the following simple LED circuit. The LED and resistor have already been constructed for you on a "breadboard".

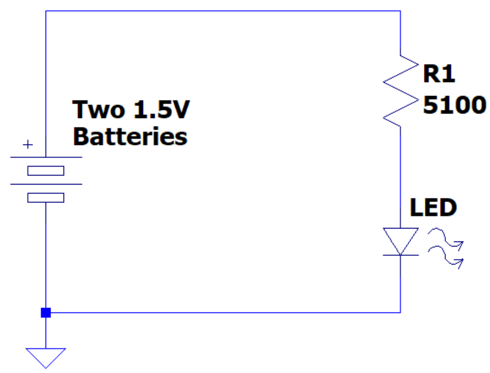


Figure 1 - Simple LED Circuit with 3V input

A. When instructed to do so, connect the battery holder with two 1.5V batteries (3V total) to your circuit. (Make sure the positive/red lead is connected to the resistor and the negative/black lead to the LED.
B. Observe the brightness of the LED.
C. Now connect one 9V battery to your circuit as shown below.

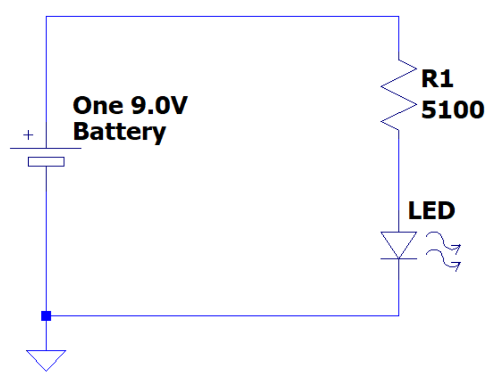


Figure 2 - Simple LED Circuit with 9V input

Revision Date: June 25, 2019

Name: ___________________________

D. How did the brightness of your LED change? Did it become brighter or dimmer?

E. Assuming that the brightness of the LED is directly proportional to the amount of current flowing through it, what can you tell about the relationship between voltage and current?

Based on a very similar experiment, Georg Ohm noticed that as he increased the voltage difference across a fixed resistance, the current increased proportionally. In language of math, we show this direct proportionality as follows.

Resistance and Resistors

The inherent property of material to constrict the flow of current (electrons) is called resistance. In water pipes, it is the friction between water molecules and pipe wall or sand particles that causes resistance. In electricity, electrons experience resistance when they jump from atom to atom. In some material (metals in general) electrons can jump more freely than others (e.g. plastic, paper or wood).

Just as friction in water flow converts kinetic energy to heat, electric resistance converts electrical energy to heat that is wasted. Electrons are doing work to overcome resistance, and that work is converted to heat.

Unit of resistance is Ohms (Ω), and it is named after the German physicist and mathematician Georg Simon Ohm. Typical resistance values range from milliohms (1/1000 of an Ohm) to mega Ohms (Millions of Ohms).

Resistors are man-made components that control current (rate of electron flow) in a predictable manner. The water analogy for a resistor is a sand pipe where the length of the sand column or the compactness of it can change the resistance to water flow.

In the next section, we run an experiment to determine the relationship between current and resistance.

Name: ___________________________

Resistance and Current Relationship

Let's use our circuit from Figure 2 to re-observe the brightness of the LED in the circuit with one 9V battery. The circuit is shown below for your reference.

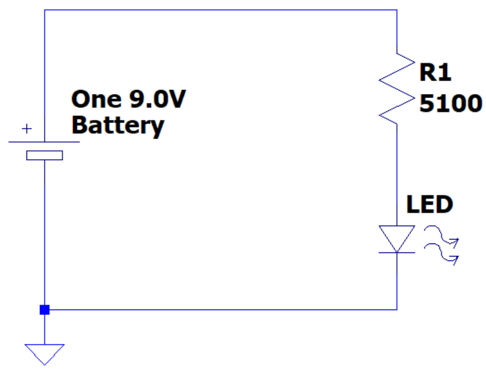


Figure 3 - Simple LED Circuit with 9V input

A. Change the resistor R1 to 10,000Ω instead of 5100Ω.

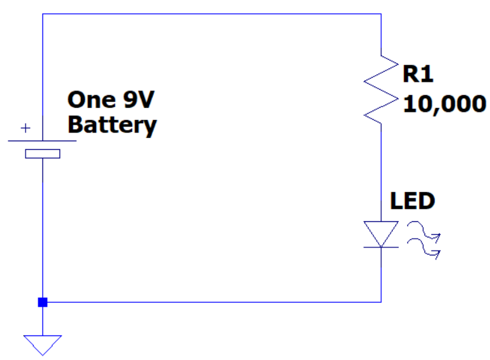


Figure 4 - LED Circuit with a 2000Ω Resistor

B. How did the brightness of the LED change in comparison to the circuit with the 5100 Ω resistor?

C. Again, assuming that the brightness of the LED is directly proportional to the amount of current flowing through it, what can you tell about the relationship between resistance and current?

Name: ___________________________

This behavior was also the observation that Georg Ohm had made; he noticed that if he kept the voltage difference the same but increased the resistance, the current decreased. Therefore,

It turns out that no other parameter in the circuit affects the amount of current. Therefore, voltage difference and resistance are the only factors affecting the current flowing in the circuit.

D. Based on these observations, what do you believe is the equation relating current to voltage and resistance?

The unit of potential (voltage) difference is Volts; that of resistance is Ohms (Ω); and the unit of current is Amperes. If V is given in mV and R in Ohms, current will be in mA.

Other useful forms of Ohm's law are

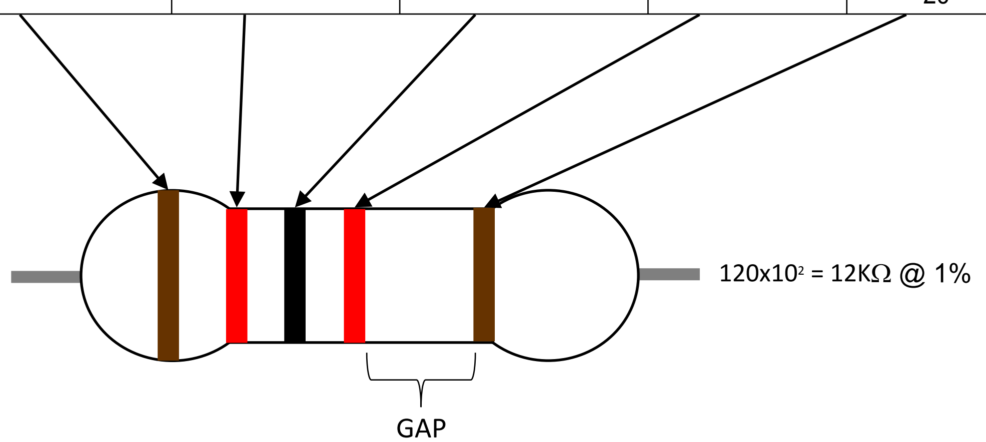
Revision Date: June 25, 2019

Resistors Color Coding Scheme

Through-hole resistors use a color coded scheme to represent the value of the resistor. This scheme uses different colors, shown in Table 1 below, to designate a different digit.

Table 1 - Resistor Color Coding Scheme

Color	Significant Digits			Multiplier	Tolerance (%)
Black	0	0	0	$\times 10^0 = \times 1$	
Brown	1	1	1	$\times 10^1 = \times 10$	1
Red	2	2	2	$\times 10^2 = \times 100$	2
Orange	3	3	3	$\times 10^3 = \times 1K$	
Yellow	4	4	4	$\times 10^4 = \times 10K$	
Green	5	5	5	$\times 10^5 = \times 100K$	0.5
Blue	6	6	6	$\times 10^6 = \times 1M$	0.25
Violet	7	7	7	$\times 10^7 = \times 10M$	0.1
Grey	8	8	8	$\times 10^8 = \times 100M$	0.05
White	9	9	9	$\times 10^9 = \times 1G$	
Gold			3rd digit significant only in a 5 band configuration	$\times 10^{-1} = \times 0.1$	5
Silver				$\times 10^{-2} = \times 0.01$	10
None					20



Depending on the tolerance value, a resistor might contain 4 or 5 bands. Resistors with tolerances larger than or equal to 5% contain only 4 color bands while resistors with tolerances smaller than 5% contain 5 color bands. Regardless of the number of bands, the last (right most) color band signifies the tolerance value; the color band second to last signifies the magnitude (exponent) or the multiplier; and the remaining bands signify the digits in the precision part of the value. Therefore, a 4 color band resistor has 2 significant digits in its precision part while a 5 color band resistor has 3 significant digits.

The color bands are read from left to right where the tolerance band is the right most band with a gap between the tolerance band and the rest of the bands as shown in the diagram above.

Revision Date: June 25, 2019

Name: ___________________________

In the example above, there are 5 color bands; therefore, the first 3 bands are significant digits, the fourth band is the exponent, and the right most band is the tolerance. The first (left most) band is brown = 1, the second band is red = 2 and the third band is [redacted] = 0. Therefore, the significant digits are 120. The fourth band is red = 2, and therefore, the exponent is 2. Combining the precision part and the exponent part gives us the value $120x10^{2}$ or 12KΩ for the value of the resistor. The left most band is brown = 1 which indicates that the tolerance of this resistor is 1%.

Resistance Color Coding Lab

1. Given the nominal values and tolerances in the table below, determine and record the corresponding color code bands:

Value	Band 1	Band 2	Band 3	Band 4	Band 5
27 @ 10%					
125 @ 1%					
2.7K @ 5%					

2. Given the color codes in the table below, determine and record the nominal values and tolerances in each row:

Colors	Nominal	Tolerance	Minimum	Maximum
Red-red-black-silver				
Blue-gray-black-gold				
Brown-green-gray-red-red				
Gray-red-yellow-none				

Name: ___________________________

Resistors as Sensors

Special materials can change resistance due to changes in environment. These materials are used in various sensors to detect these changes. Photoresistors are one example of resistors that respond to the amount of light that is shining on them. Photoresistors decrease their resistance as the amount of incident light increases, and they increase their resistance as the amount of light decreases.

Thermistors or thermal resistors are another example of materials that change their resistance due to temperature. A Thermistor's resistance decreases as the temperature is increased, and it is increase as the temperature is decreased.

A Simple Photo-sensor Circuit

In this part of the lab, you will be building a simple circuit that indicates the amount of ambient light.

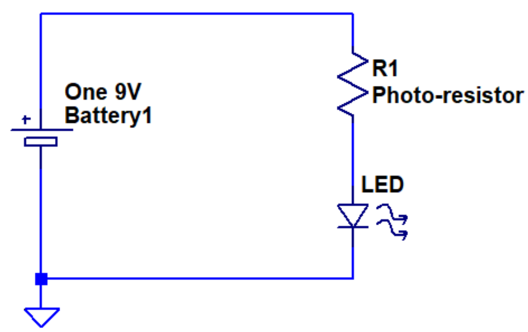


Figure 5 – A Simple Photo-sensor Circuit

A. Build the circuit shown in Figure 5 and use a photo-resistor in place of R1. Use test clips to connect the photo-resistor to the circuit.
B. Take the photo-resistor under the desk to reduce the light shining on it. What happens with the LED? Why?

C. Use your phone's flash light to shine light on the photo-resistor. What happens with the LED? Why?

Revision Date: June 25, 2019