Resistance

OBJECTIVES

- Describe Resistance as the “Opposition to the flow of Current”
- Define the Unit of Measure for Resistance
- Describe the four properties that determines the resistance of a material

INTRODUCTION

It was discovered by Georg Simon Ohm in around 1825 that for a fixed voltage, the amount of current flowing through a material depends on several physical dimensions and properties of the material. In this section we will discuss the physical dimensions and properties that determine what we now call “Resistance”. We will also discuss what the purpose of resistance is in an electrical circuit.

Resistance

In the Current section, we listed the four elements of an electrical circuit: a Voltage source, a closed electrical path, a control, and a load. We usually think of the “load” as where the work will be accomplished in the electrical circuit, but to accomplish the work the load will also have what is called resistance. The resistance may be the resistance of the wires in the armature of a motor, the resistance of the transistors in an amplifier, or the resistance of the heating element of a heater, to name but a few examples.

Why is it important to have resistance in an electrical circuit? If you took a battery or other Voltage source and created a closed path from the positive post to the negative post, Current would flow. (See Figure 1) But how much current would flow? We will show later in the course that mathematically with zero resistance the current would be infinite. But in reality there is always a little resistance found in most materials that make up a circuit so the answer will be high but not infinite. Usually the amount of current for the circuit shown in Figure 1 will be high enough for some type of damage to occur. The damage might be that the wire gets hot enough to melt, or the battery will heat up and cause a fire or even explode. This wire or path across the battery is called a “Short”, and should be avoided.

If we place a “Load” in the circuit, with its associated resistance, the circuit will now limit the amount of current that will flow and the problems of a shorted circuit will go away.

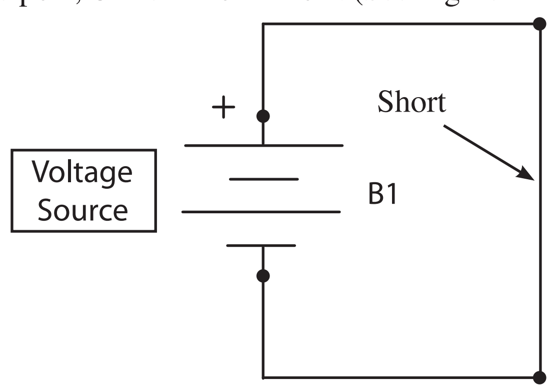


Figure 1 (Closed Path)

Symbol for Resistance: Ω (Upper case Greek letter Omega)

The symbol used to describe Resistance or “the oppposition to the flow of Current” is the upper case Greek letter Omega “Ω”.

Unit of Measure for Resistance: Ohms

The unit of measure for Resistance is named after its discoverer German physicist Georg Simon Ohm. A material is said to have a resistance of one Ohm if a potential of one Volt results in a current of one Ampere.

Determining the Resistance of a Material

There are physical properties that determine the resistance of a material, they are:

1) Conductivity

This is the willingness of current to flow through a material. Conductivity is directly related to the valance shell of the atoms that make up the material. The fewer electrons in the valance shell an atom has naturally the easier for that atom to give up those electrons and have current flow through the material. Likewise the more electrons in the valance shell an atom has naturally the harder for that atom to give up those electrons and have current flow through the material.

There are three common categories for Conductivity that we use for electronic circuits:

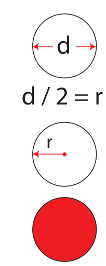
Conductor, which is a material made up of atoms with 1, 2, or 3 valance electrons. Conductors are usually metals, and are known for their low resistance to the flow of current. Silver is the best conductor, followed by Copper.

Semi-conductor, which is a material made up of atoms with 4 valance electrons. Common Semi-conductors are Silicon and Germanium, and are used primarily in computer chips and integrated circuits (IC's).

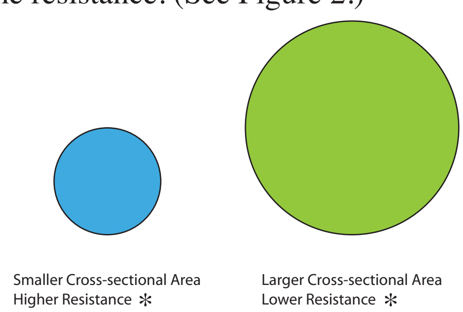
Insulator, which is a material made up of atoms with 5, 6, 7, or 8 valance electrons. Examples of Insulators are rubber, glass, mica, and most plastics, and are known for their high resistance to the flow of current.

2) Cross-sectional area

This is how much of the material is in the current path. One way of looking at this is again using a water model - is it easier for water to flow through a small pipe or a large pipe? If the pressure is the same in both pipes, more water would flow through the larger pipe than the smaller one. Why? Because the larger pipe has less resistance to the flow of water. This is the same with electrical resistance, the more material (bigger cross-sectional area) the lower the resistance. (See Figure 2.)



$\pi \bullet r^2$ = Cross-Sectional Area



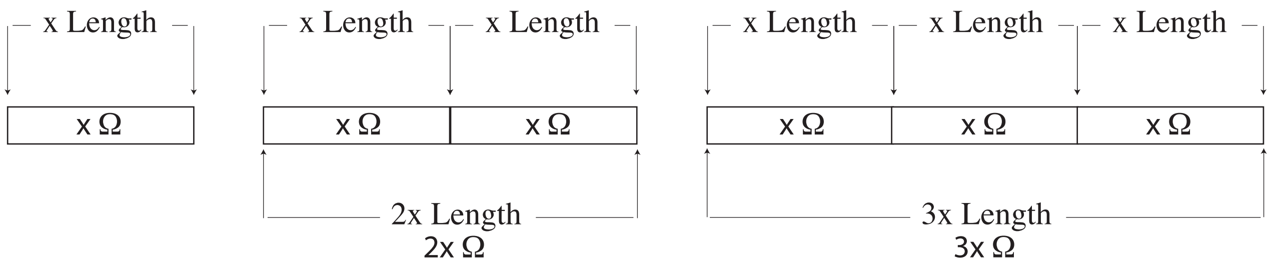
*If these two materials were exactly the same except for cross-sectional area.

Figure 2

3) Length

A good analogy for resistance through a material and how it changes with the length of material is, imagine a narrow hallway filled with people and you are trying to get through that hallway, you are going to bump into a certain number of people and have some opposition getting to the other end. Now imagine that narrow hallway is twice the length of the first and there are twice as many people filling that hallway, if you try to get through to the other end now you will bump into twice as many people and feel twice as much opposition.

If all else is the same and you double the length of a material the resistance will double (see Figure 3).



Ω is the Unit of Measure for Resistance

Figure 3

4) Temperature

All materials have what is call Temperature Coefficient of Resistance α (greek letter Alpha), which indicates how much resistance changes for a change in temperature. A positive value for α indicates an increase in resistance as temperature increases. A negative value for α indicates an increase in resistance as the temperature decreases, or an decrease in resistance as the temperature increases.