

The Factors that Affect Resistance

There are four factors that affect resistance. They are

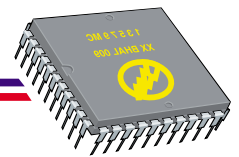
- **The type of material**
- **The length of the structure**
- **The cross sectional area of the structure**
- **The temperature of the structure**

The type of material

We know that silver and copper are excellent conductors of electricity. We also know that glass and rubber are very poor conductors of electricity. These are called insulators. All other materials will fall somewhere between these two extremes. Excellent conductors have a near zero value of resistance while insulators have an extremely high value of resistance. This value of resistance is called the material's resistivity. Each type of material will have a different resistivity. (See Figure 2).

The length of the structure

Lets say that I have two pieces of copper wire that are the same thickness. One is 10 metres long and the other is 20 metres long. If I measure the resistance of each length I should find that the 20 m piece has twice the resistance of the 10 m piece. (provided that the temperature is constant) Obviously the length of the structure will affect the resistance. The longer the length, the more collisions take place and therefore the resistance will be higher. This means that the resistance of the wire is directly proportional to the length of the wire.



The cross sectional area of the structure

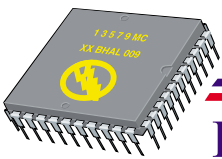
Lets say that I have two pieces of copper wire that are exactly the same length. This time one piece of wire has a much smaller thickness than the other. This means that the smaller thickness wire will have a smaller cross sectional area. If I measure the resistance of each piece of wire I will find that the wire with the smaller cross sectional area will have a higher resistance (provided that the temperature is constant). This means that the resistance of the structure increases as its cross sectional area decreases. In other words the resistance of the wire is inversely proportional to its cross sectional area.

Temperature

Lets say that I have one piece of copper wire 10 metres long. At 20 degrees C, it will have a certain value of resistance. If I were to put that piece of wire in an oven and increased its temperature to 100 degrees C., I would find that its resistance increased. This means that the copper wire has a ***positive temperature coefficient***. The relationship between resistance and temperature is roughly linear. This means that for every one degree C. rise in temperature you can expect the same rise in resistance.

Summary

As you can see each one of the four factors above directly affect resistance. Generally we use copper as a conductor for wire. This is because we know that this material is a good conductor and has a low resistivity.



Resistivity

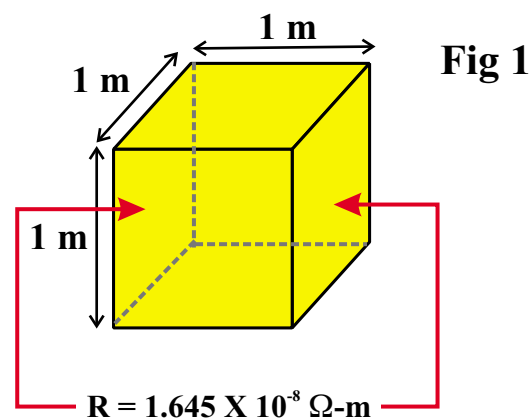
We can also see that the length of the wire is important. The longer the wire, the more resistance it has and this can be an important factor in some circuits.

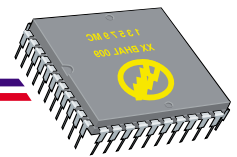
Diameter of wire is also important. From the discussion above you know that resistance increases as the cross sectional area decreases. This means that size of the wire we use is important. If we use a wire size that is small, we can expect the higher resistance. Higher resistance means more heat is given off by the wire. In some situations this can be a very important.

We know that resistance is directly affected by temperature. All pure metals have a positive temperature coefficient. This simply means that its resistivity increases as temperature increases.

Defining the Resistivity of Materials

The table (Fig 2) shows the resistivity of some of the common materials. In order to define these values, a piece of the material was cut into an exact one metre cube (see figure 1). As you can see, the material has a cross-sectional area of exactly 1 m^2 and a length of 1 m . If the temperature is constant at 20 degrees C , we can measure its resistance. The value is expressed in ohm-metres ($\Omega\text{-m}$). If Figure 1 was silver, the value of resistivity would be $1.645 \times 10^{-8} \Omega\text{-m}$. This defined value is designated by the Greek symbol ρ (rho)





Resistivity

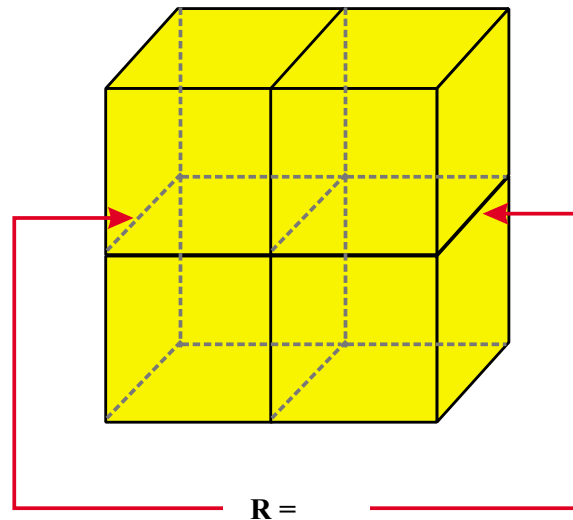
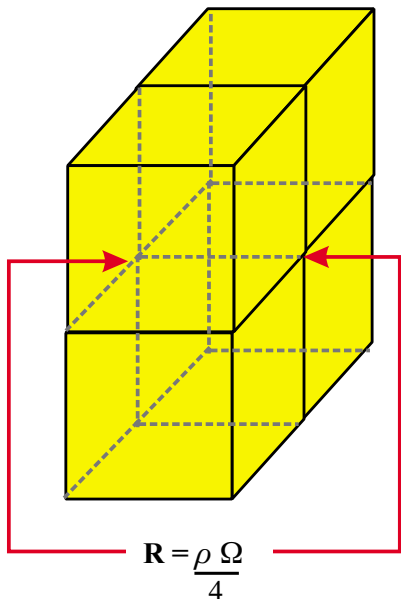
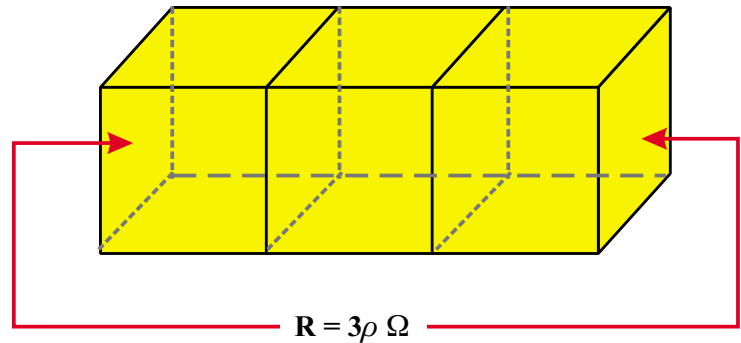
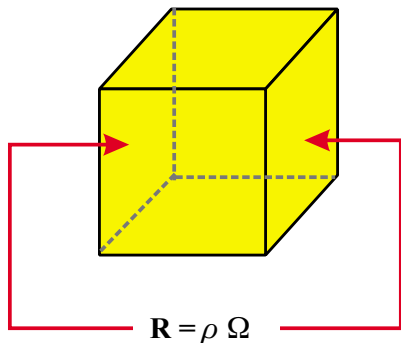
Resistivity of Materials

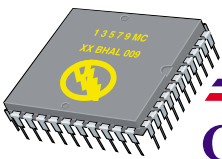
Material **Resistivity, ρ**

Silver	1.645×10^{-8}	(Ω-m @ 20°C)
Copper	1.723×10^{-8}	
Gold	2.443×10^{-8}	
Aluminum	2.825×10^{-8}	
Tungsten	5.485×10^{-8}	
Nickel	7.80×10^{-8}	
Glass	10^{10} to 10^{14}	

Figure 2

What is the value of the bottom right unit?





Colour Coding of Resistors

Resistors

Resistance can be useful to us. Often, in electronic circuits, we require specific values of resistance. This is achieved by using a resistor. Resistors are made in many different values. These values are generally colour coded on the body of a resistor.

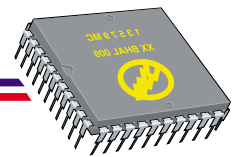
We know that current flow through a resistance causes heat. In a resistor, this heat must be dissipated, and this is achieved by transferring the heat to the ambient air that surrounds the resistor. The amount of heat that the resistor can dissipate is directly proportional to the physical size of the resistor. The resistor's ability to dissipate heat is measured in watts. As the wattage of the resistor increases so does its physical size. The diagram on page 73 of your **Circuit Analysis** textbook shows the relationship of size vs. the wattage of a few small resistors. Your first-year kit contains 1/8 watt and some 1/4 watt resistors.

If there are several types of small fixed resistors in common use. These include carbon composition, carbon film, metal film, and wire wound types.

Please read Chapter 3.5 to 3.7 in the Circuit Analysis text.

Colour Coding on Resistors

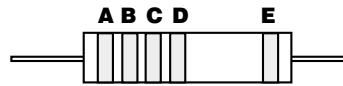
There are several different methods in use for colour coding resistors. Fortunately there are similarities between the methods. The bands are always read from left to right, left being defined as the side of the resistor with the band nearest to it. The diagrams following show the procedure.



Resistor Colour Codes

Five Band Precision Resistor

- Note:(1) Bands A to D are grouped together.
 (2) Band E is tolerance



	Band A	Band B	Band C	Band D	Band E	Band F
Colour	First Digit	Second Digit	Third Digit	Multiplier	Tolerance	Reliability
Black		0	0	1		
Brown	1	1	1	10	± 1 %	1 %
Red	2	2	2	100	± 2 %	0.1 %
Orange	3	3	3	1000	± 3 %	0.01 %
Yellow	4	4	4	10,000	± 4 %	0.001 %
Green	5	5	5	100,000	± 0.5 %	
Blue	6	6	6	1,000,000	± 0.25 %	
Violet	7	7	7	10,000,000	± 0.1 %	
Gray	8	8	8	100,000,000		
White	9	9	9	1,000,000,000		
Gold				0.1	± 5 %	
Silver				0.01	± 10 %	
No Colour					± 20 %	
	Band A	Band B	Band C	Band D	Band E	Band F

Standard Four Band Resistor

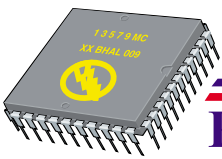
- Note:(1) Bands 1 to 3 are grouped together.
 (2) Band 4 is tolerance



Five Band Resistor with Reliability Band

- Note:(1) These are composition type resistors.
 (2) Bands are evenly spaced





Resistor Codes

Resistor Number Codes

Some resistor manufacturers will have the ohmic value of the resistor written in numbers on the body of the unit. The examples below shows the method used. Note that the decimal point is replaced with R, K, or M. The letter is placed where the decimal point should be in the number. Mentally insert the decimal point in place of the letter then:

Multiply the number by:

1	if the letter is R
1000	if the letter is K
1000000	if the letter is M

Examples

Resistance Values

0.47 Ω

1 Ω

4.7 Ω

100 Ω

1 k Ω

10 k Ω

10 M Ω

Marked As

R47

1R0

4R7

100R

1K0

10K

10M

Tolerance is indicated as follows:

F = $\pm 1\%$ G = $\pm 2\%$ J = $\pm 5\%$ K = $\pm 10\%$ M = $\pm 20\%$

R33M = 0.33 Ω $\pm 20\%$

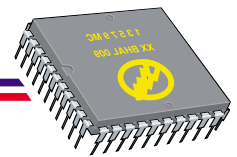
4R7K = 4.7 Ω $\pm 10\%$

390RJ = 390 Ω $\pm 5\%$

6K8F = 6.8k Ω $\pm 1\%$

68KK = 68 k Ω $\pm 10\%$

4M7M = 4.7 M Ω $\pm 20\%$



An Overview of Voltage Current and Resistance

Current

Current is the flow of electrons in a circuit. The more electrons that flow in a circuit, the higher the current will be. Current is measured in Amperes (A)

Voltage

Voltage use the electrical pressure that causes current to flow in a circuit. It is measured in VOLTS (V or E).

Resistance

Resistance is anything that causes opposition to the flow of electrons a circuit . Resistance is measured in Ohms (Ω). As electrons move through a length of copper wire, these electrons collide with other electrons and with the copper atoms themselves. These collisions create heat. If the current in this length of wire is increased, then the number of electrons moving down the wire has increased. More electrons moving in the wire means more collisions and more heat. These collisions oppose the movement of the electrons.