

OBJECTIVES

- Describe the common uses of Resistors in an electrical circuit
- Define the color code used to identify the ohmic value of a resistor
- List and discuss the common electrical components that have resistances

INTRODUCTION

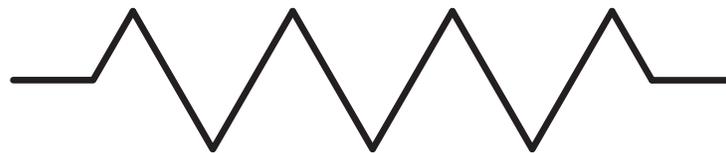
Resistors have been used in most of the electrical labs of this course so far, but they have not been described in detail, nor has their electrical purposes been given, other than to limit current. In this lesson, resistors will be discussed in some detail, and the variety of electrical components that fall under the classification of “Resistor” will be shown.

Resistors

The property of a circuit that opposes current is called RESISTANCE. Electrical components that are manufactured with this property in mind are called RESISTORS. These electronic devices are commonly used to reduce the power or current in an electronic device and to develop a working voltage by dividing up the Source Voltage (V_t). Perhaps the most common to mobile electronics installers is that of reducing the output of a speaker in an audio system.

How Do They Work?

Resistors operate on the principle that energy can be neither created or destroyed, only changed from one state to another. In the case of the resistor, voltage is reduced by converting electrical energy into heat or thermal energy. All resistors generate heat as a product of their function. A resistor is made of a material that has a specific amount of resistance to current flow. By selecting the correct amount of desired resistance in a circuit the installer can control the amount of output that passes through the resistor to the electronic component.



Electrical Symbol for a Resistor

Unit of Measure

Resistors are selected for the amount of resistance they possess. This value is measured in Ohm's (Ω). The amount of resistance can range from just a fraction of an Ohm (Ω) to millions of Ohm's.



The Omega symbol is used to illustrate the amount of resistance in Ohm's. Resistors are also rated for the amount of Wattage they can handle or in other words, how much heat they can dissipate.

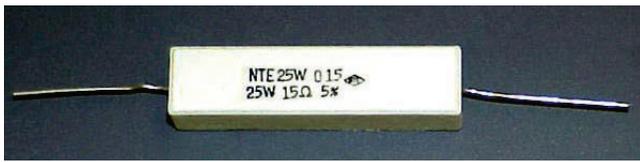
Resistor Types

There are two general categories of resistors that you may use as an installer; they are FIXED and VARIABLE resistors.

Fixed Resistors

These types of resistors are common to circuits where a constant amount of resistance is desired. A fixed amount of resistance and power handling are identified on the outer case of the resistor.

These types of resistors come in many forms but the most common to the mobile electronics industry are either carbon, or high wattage (Fireproof) wire wound resistors. The latter being used for applications where a great deal of energy must be dissipated as heat.



High Wattage Resistor



Low Wattage Resistor

Resistor Value Calculation

Most fixed value resistors are labeled by a series of color coded bands wrapped around the resistor. These color bands identify several features of the resistor to the user. In Figure 1, five color bands are shown around the resistor. This is the maximum number; but there may be as few as three. Note also that these color bands are oriented towards one end of the resistor. They are read from left to right starting with the far left band.

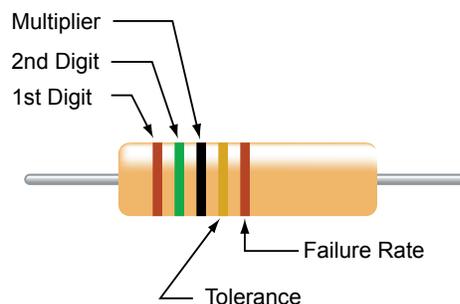


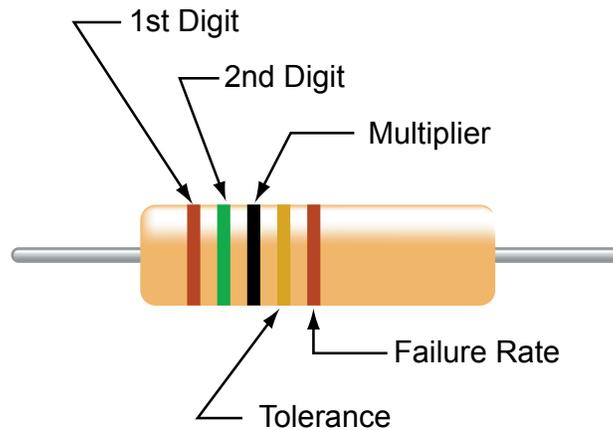
Figure 1

The first three (3) bands have to do with the value of the resistor in resistance (Ohms). The “First Digit”, “Second Digit”, and “Multiplier” identify the value of the resistor.

The fourth (4) band (if present) identifies the accuracy or Tolerance of the resistor. This specification is measured in percentage (%) of accuracy. In other words, if a 1 Ohm resistor has a tolerance of +/- 10% the actual value of the resistor may be somewhere between .9 and 1.1 Ohms.

The fifth (5) and final band (if present) indicates the failure rate of the resistor. This number is rated as a percentage of failure per 1000 hours of operation.

Figure 2 outlines the color codes for fixed (carbon) resistors. Note that the same colors are used to determine several different aspects of the resistor. That is to say that there are 12 colors used to identify all of the resistors specifications.



RESISTOR COLOR CODES					
COLOR	1st Digit	2nd Digit	Multiplier	Tolerance	Failure Rate
Black	0	0	1		
Brown	1	1	10		1%
Red	2	2	100		0.1%
Orange	3	3	1,000		0.01%
Yellow	4	4	10,000		0.001%
Green	5	5	100,000		
Blue	6	6	1,000,000		
Violet	7	7	10,000,000		
Gray	8	8	100,000,000		
White	9	9			
Gold			0.1	+/- 5%	
Silver			0.01	+/- 10%	
No Color				+/- 20%	

Figure 2

Sample Resistor Value Calculation

The following illustration and table take you through the process of calculating the value of a resistor. Note that each color band corresponds with a numerical value. The following values provide us with a specific picture of the resistors characteristics:

- a) 1st Digit - Brown, corresponds with a value of 1.
- b) 2nd Digit - Green, corresponds with a value of 5.
- c) Multiplier - Black, corresponds with a value of 1.

Calculation $15 \times 1 = 15$ or 15 Ohms of resistance.

- d) Tolerance - Gold, corresponds with a value of $\pm 5\%$.
- e) Failure Rate - Brown, corresponds with a value of 1%.

Resistor Value

15 Ohms of Resistance
 $\pm 5\%$ Tolerance
 1% Failure Rate

Multiplier

2nd Digit

1st Digit

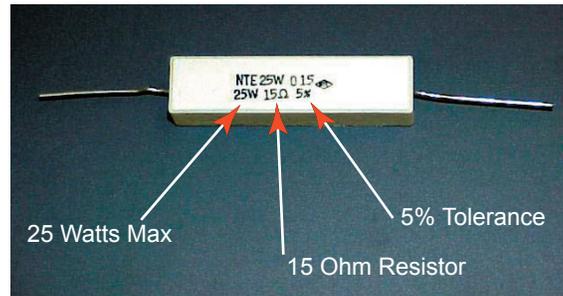
Failure Rate

Tolerance

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Red	2	2	100		0.1%
Orange	3	3	1,000		0.01%
Yellow	4	4	10,000		0.001%
Green	5	5	100,000		
Blue	6	6	1,000,000		
Violet	7	7	10,000,000		
Gray	8	8	100,000,000		
White	9	9			
Gold			0.1	$\pm 5\%$	
Silver			0.01	$\pm 10\%$	
No Color				$\pm 20\%$	

High Wattage Resistor Value Calculation

High wattage resistor values are usually stamped on the resistor itself. In the example below, note the label indicating the value of the resistor. In this particular example we see a 25 Watt, 15Ω (Ohm) resistor with a tolerance of +/- 5%.



Fixed Resistor Applications

Resistors by their nature are always used to reduce the signal being sent to a device. In mobile electronics we typically use resistors to reduce the output of a device.

Carbon (Low Wattage) Resistors

Carbon (low wattage) resistors typically come in 1/8 watts to 2 watts in power handling. Wattage ratings are not typically labeled on these resistors. Either the package or the physical size of the resistor is an indication of the wattage. The larger the resistor the greater the wattage. These resistors can be used to reduce the signal being sent to an amplifier from a head unit, EQ, or any other processor. This may be necessary to do when matching a high voltage head unit with a processor, EQ or amplifier that will not work properly with a high voltage input.

The resistor would be installed in series with the preamp low level signal coming from the head unit, EQ or processor.

High Wattage Resistors

High wattage resistors are typically used to reduce the output of an amplifier to a speaker. In many cases when installing component speakers for example, a speaker's volume needs to be reduced in relation to the rest of the speakers in the system. If a pair of tweeters, for example, were too loud in comparison to the midrange speakers, a resistor could be introduced in series with the positive speaker wire attached to each tweeter. This is especially useful when a components speaker system is connected to a passive crossover where if the amplifier output was turned down, both the tweeter and the mid would be reduced in volume.

Choosing the Right High Wattage Resistor

Resistor value is relatively easy to determine when dealing with speaker level outputs of an amplifier. The two determining factors are those of the amount of resistance and the wattage.

- a) Wattage - Resistor wattage should match that of the output of the amplifier. If for example, the amplifier output is 50 Watts, or 25 Watts per channel, a 25 Watt or greater resistor should be selected. It gets a little trickier when the amplifier output is sent to a passive crossover as more than one speaker is sharing the 25 watts. It stands to reason that each speaker would get less than the entire 25 Watts of power. However, as a precaution, a 25 Watt resistor would still be the best choice.

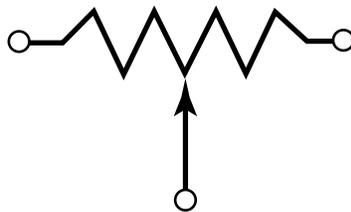
b) Resistance - You can dial the amount of attenuation (reduction in output) in by selecting the proper amount of resistance. For example, if the resistor is going to be in series with a 4Ω speaker, adding a 4Ω resistor would provide the amplifier with 8 Ohms of resistance or an 8Ω load. This doubling of the load would decrease the output of the speaker by 3dB (Decibels). Adding an 8Ω resistor would provide a 12Ω load to the amplifier resulting in a further reduction of power and so on.

Variable Resistors

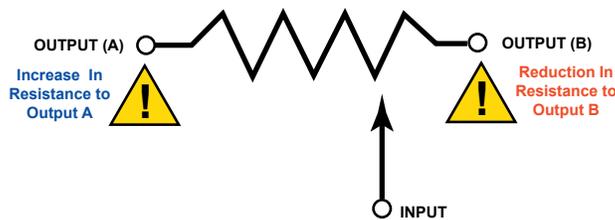
Variable resistors are used when a selectable control is needed (volume control) or the value for a fixed resistance is in doubt when designing a circuit. Variable resistors give the electrical circuit adjustability by providing the user with the ability to change the amount of resistance.

Potentiometer

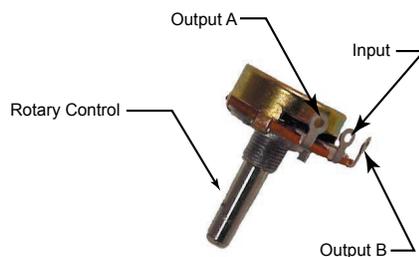
The most common type of manually controlled variable resistor is the POTENTIOMETER (POT for short). The schematic symbol looks like this:



A potentiometer has three connections. Two connections are at either end of the resistive element (output A & B), and one is in the center (input). The input can be moved to anyplace in between the outputs.



This controls the amount of resistance to either end (Output A, Output B). In the illustration above the input is shown in an offset position. This position will provide more resistance to “Output A”, while reducing the resistance to “Output B”. A center position provides equal resistance to both A, and B outputs.



In the photograph above we see a typical variable resistor as used in mobile electronics. These types of resistors are used in calibrating (adjusting) the level or volume of speakers in an audio system. This particular one is designed to be mounted through a hole and secured with shaft nuts. A knob is then attached to the “rotary control”.

Sample Circuit

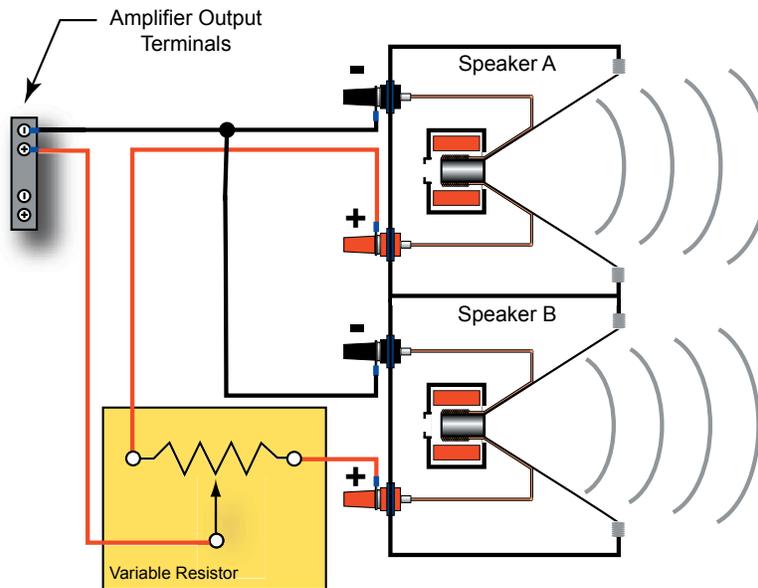


Illustration 1

Illustration #1 shows a variable resistor (Potentiometer) installed between two speakers (Speaker A, Speaker B). Note that in its current state (Center) both speakers receive the same amount of signal and play at the same volume.

Illustration #2 shows the variable resistor as OFF center. This introduces more resistance to Speaker A than that of Speaker B. Speaker B plays louder as a result of the increased resistance to speaker A.

This type of application is most common to the FADER control of an audio system where the Front to Rear output level is controlled by a variable resistor. In illustration #1 & #2 only one channel is portrayed. In reality a DUAL GANG POTENTIOMETER would be used. The Dual Gang potentiometer has two variable resistors controlled by a single rotary control. One variable resistor controls the RIGHT channel of the audio system and the other controls the LEFT channel.

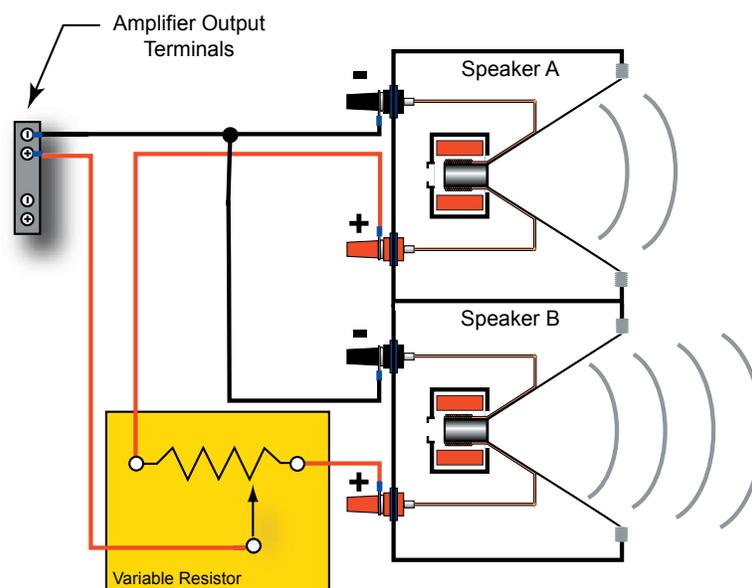
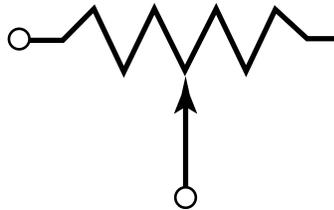


Illustration 2

Rheostat

Think of the Rheostat as a variable resistor with 2 terminals instead of the 3 terminals typical to the Potentiometer. The Rheostat and Potentiometer are so similar in fact, that you could use a potentiometer as a Rheostat by simply connecting only two (2) of the terminals instead of all three (3). Connection would be made to the input and one (1) of the two (2) outputs. Unlike the variable resistor which is used to divide a signal between two speakers the Rheostat is used as a volume or level control. The Rheostat has a single input and output terminal. The level of resistance controls the amount of voltage allowed to pass to the output terminal.

Rheostats are common to audio system volume controls and various level controls. A subwoofer level control for example uses a rheostat to control the amount of current that passes to the subwoofer amplifier.

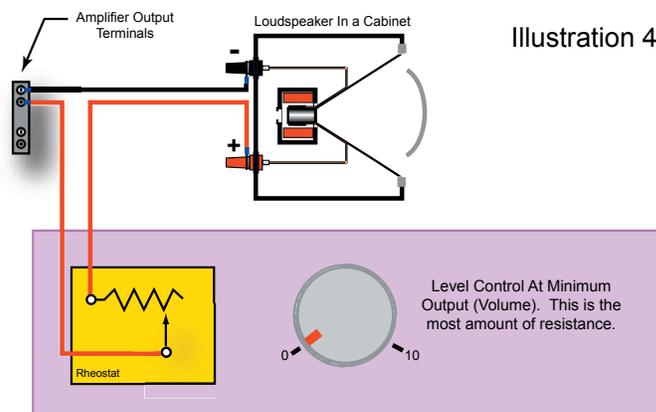
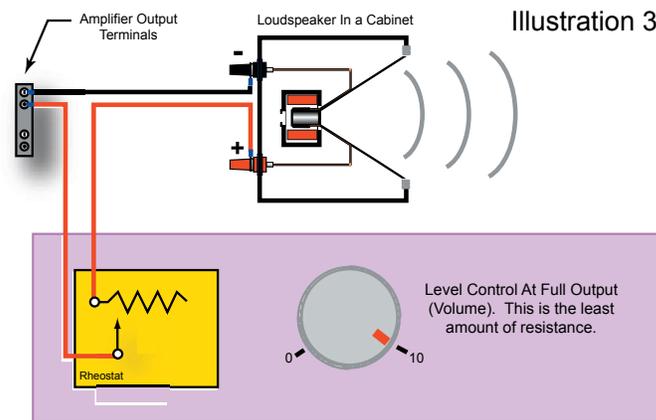


Electrical Symbol for a Rheostat

Illustrations 3 and 4 show the principle of the rheostat when applied to a loudspeaker. In these examples we see that as resistance increases the output or volume of the speaker decreases.

Note that in illustration 3 the amount of resistance is at its lowest. Note also that the volume control is turned all the way up. This results in a maximum output of the speaker as there is little or no resistance to current flow from the amplifier.

Illustration 4 shows what happens when the volume control is turned down to its lowest setting. This setting introduces the greatest amount of resistance from the rheostat. This results in a decrease in volume or output to the speaker.

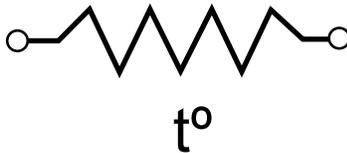


Rheostats and Variable Resistors are used throughout most of the electronic components you will be installing. A level control on an amplifier for example is a rheostat that controls the amount of signal passing to the amplifier from the head unit. The head units volume control is sometimes a rheostat. The controls on Crossovers and EQ's are also either rheostats or variable resistors. When installing a security system you control the sensitivity of the shock, motion, glass breakage,... etc, sensors by adjusting a variable resistor or rheostat.

Thermistors

Another useful variable resistive component is the THERMISTOR. Thermistors are variable resistors that change their resistance as temperature changes. This is not uncommon as all conductors change their resistance with temperature. The difference is that unlike most conductors that raise their resistance when temperature increases (positive temperature coefficient), a thermistors resistance decreases as temperature increases. (Negative temperature coefficient).

Thermistors are used for circuit temperature compensation or for circuit temperature reactance (cooling fans or over temperature monitoring).



Electrical Symbol for a Thermistor