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Introduction to Resistors

For most applications, resistors are among the smallest and simplest components in an electronic circuit. Resistors are often the last component to be specified because they are widely available in terms of sizes, resistance values and tolerances. If there are no unusual requirements, this will not pose a problem. However, if there are requirements which standard chip resistors or axial leaded resistors cannot fulfill, it is important to understand the resistor basic function and some details of how resistors are specified to make the correct design decision.

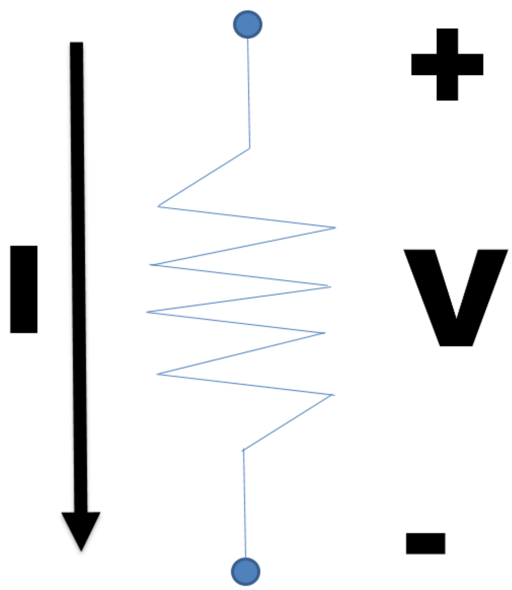

Figure 1, Resistor circuit symbol

Defining the Resistor

Current through any conductor is proportional to the voltage across that conductor. Resistors utilize this fundamental principle by changing the amount of current allowed through it at a specific voltage. The amount of allowable current is described by the constant known simply as **resistance** *(measured in ohms)*. Higher resistance means higher voltage required for a given amount of current. Lower resistance means lower voltage for the same amount of current. A resistor restricts the flow of current while causing voltage to drop across the resistor. The resistor accomplishes this by converting electrical energy into heat. The amount of energy that a given resistor can be expected to convert into heat is measured by the power rating of the resistor, which is given in the unit of **wattage**. The higher the wattage rating, the greater the amount of energy the resistor can handle and convert into thermal energy. A higher the power rating generally requires a larger size resistor for a given series or technology.

Stackpole Electronics, Inc.
Resistive Product Solutions

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Electrical Specifications							
Type/Code	Power Rating (Watts) @ 70ºC	Maximum Working Voltage	Maximum Overload Voltage	Resistance Temperature Coefficient	Ohmic Range (Ω) and Tolerance		
					0.5%	1%	5%, 10%, 20%
RPC0402	0.2W	50V	100V	±300 ppm/ºC	-	1 - 20	
				±100 ppm/ºC	1 - 1M	20.5 - 1M	22 - 1M
RPC0603	0.1W	50V	100V	±200 ppm/ºC	10 - 294	1 - 294	10 - 270
				±100 ppm/ºC	300 - 1M		
RPC0805	0.25W	150V	300V	±200 ppm/ºC	10 - 294	1 - 294	1 - 270
				±100 ppm/ºC	300 - 20M		
RPC1206	0.33W	200V	400V	±200 ppm/ºC	10 - 20	1 - 20	
				±100 ppm/ºC	20.5 - 20M		22 - 20M
RPC1210	0.5W	200V	400V	±200 ppm/ºC	10 - 20	1 - 20	
				±100 ppm/ºC	20.5 - 20M		22 - 20M
RPC2010	0.75W	400V	800V	±200 ppm/ºC	10 - 20	1 - 20	
				±100 ppm/ºC	20.5 - 20M		22 - 20M
RPC2512	1.5W	500V	1000V	±200 ppm/ºC	10 - 20	1 - 20	
				±100 ppm/ºC	20.5 - 20M		22 - 20M

Figure 2, Example of electrical specification information given for resistors

Other Resistor Parameters and Definitions

Along with the resistance value and power rating of a resistor, it is important to know several pieces of information to ensure the right resistor is being specified for an application. Not all applications will require knowledge of all the ratings or capabilities discussed here. One rating that will need to be specified for nearly any resistor is **tolerance**. The **tolerance** of a resistor is the maximum deviation (either up or down) from the specified resistance value (also called **nominal resistance**). Tolerance is usually specified as a percentage above and below the nominal resistance, such as +/- 1% or +/- 5%. A tighter tolerance means less deviation in resistance value, and more consistent performance within any lot of resistors.

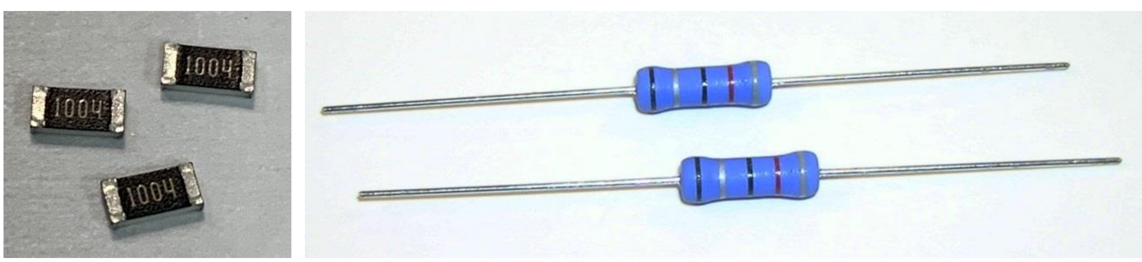

Figure 2, Examples of common surface mount and axial leaded resistors

Another common parameter is the **temperature coefficient of resistance** or **TCR**. This parameter measures how the resistance value changes at different temperatures. TCR is typically specified in the units of parts per million per degree Celsius. The lower the TCR, the more stable the resistance value is over normal operating temperature ranges.

For other applications, the **working voltage rating**, **overload voltage rating**, or **pulse capability** may be important. Most resistors will have either a voltage rating or a pulse rating or both. **Working voltage** for a resistor is defined as the maximum Vrms or Vdc that a resistor can safely withstand continuously. The resistor can only handle this voltage if the resulting power from this voltage does not exceed the power rating of the resistor. For example, a high voltage on a resistor with a low resistance value will result in a high amount of power through the part and can quickly exceed the power handling capability of the resistor.

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If pulse power or pulse voltage handling are critical, then it is important to select a resistor with the proper pulse voltage or pulse power ratings. Guaranteed pulse ratings will usually only be provided for resistor types that are specifically designed for pulse handling. Due to variations in manufacturing and materials, most general purpose resistors do not specify pulse ratings. Pulse withstanding resistors are normally constructed with high voltage or high temperature materials and have special processing and trimming techniques to maximize the pulse handling capability.

Resistor Types and Technologies

There are almost as many resistor types as there are applications for resistors. Resistors are used in nearly every electrical circuit. They are used in combination with capacitors and / or inductors to establish time constants and act as filters. They are used to set operating currents and signal levels. In power circuits resistors have a variety of functions. They can be used to drop or lower voltage, to measure output current, or for discharge loads for capacitors after power has been removed. In precision circuits they are used to provide voltage ratios and establish precise gain values. They are used for pull up and pull down resistors in logic circuits to increase speed. In high voltage electronics, resistors are used for voltage division and measurement or to equalize currents between parallel connected diodes or capacitors. They may even be used simply as heating elements.

Conclusion

Resistors are generally easy to use and understand, but they are sometimes taken for granted. It is important to understand the different characteristics of a resistor to ensure that the correct part is being specified. By understanding the capabilities and limitations of different types of resistors, the designer can select the optimal resistor for his or her design.