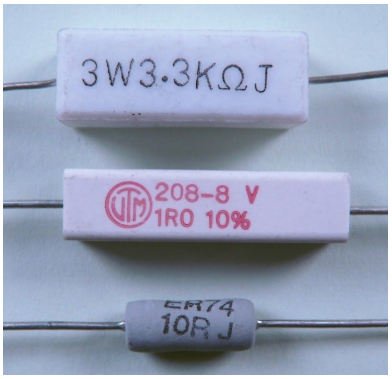
Resistors

Introduction



A resistor is a component that opposes the flow of current.

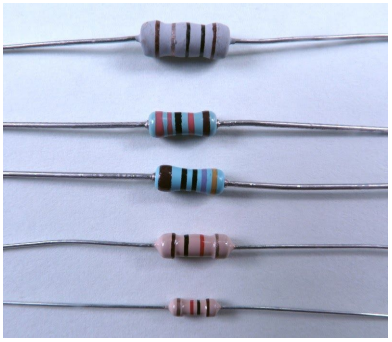
There are many different types of resistors. Some resistors have a fixed resistance and are called ohmic resistors. Some resistors have a resistance that changes depending on environmental conditions such as light level or a resistance that can be changed by the user.

Properties of Resistors

All resistors have:

- A value measured in ohms (Ω) that is a physical property of the resistor i.e. how it is constructed. The resistance of a resistor may or may not be a fixed value, it might vary.
- A maximum power rating which, if exceeded, results in damage. Resistors transfer electrical energy to thermal energy. Any resistor is designed to dissipate a certain amount of power, for example the resistors used in circuit construction can dissipate up to 1/4 watt without damage whereas a high power resistor might be able to handle 100 W without being damaged
- A tolerance that indicates how close the value actually is to the stated value of resistance. Most resistors that are used in basic electronics have a tolerance of ±5%. This means that, if the resistor nominally has a value of 1000 Ω, the actual value could be anywhere between 950 Ω and 1050 Ω. Looking at the power resistors shown above, the middle one is marked as ±10% and the other two are marked with "J" which indicates ±10%.

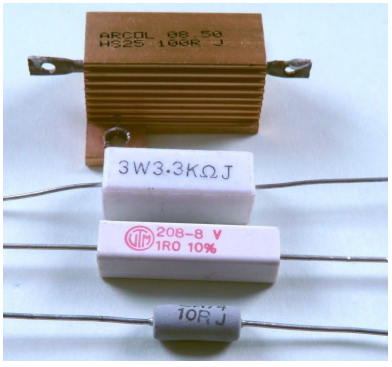
Ohmic resistors



A resistor that has a linear graph - and therefore a fixed resistance - is called an ohmic resistor. In this case the result will be a straight line through the origin and the gradient will be numerically equal to the resistance if voltage is plotted on the y-axis. Therefore an ohmic resistor is a component that obeys Ohm's Law such that the current and voltage are directly proportional and the resistance remains constant. A good example of ohmic components are fixed value resistors and lengths of wire at a fixed temperature.

NOTE: The resistance of a component is numerically equal to the gradient of the V-I graph ONLY for an ohmic resistor. In all other cases, the gradient of the (non-linear) curve does not give the resistance.

Fixed resistors

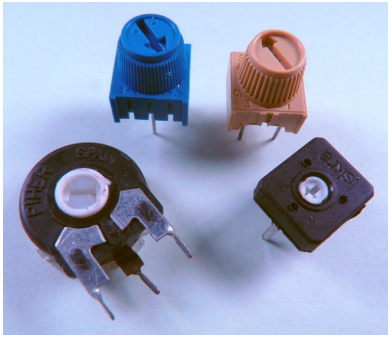


A fixed resistor is, as the name suggests, a fixed predetermined value. Lower power resistors are either made from carbon film or metal film and are the sort of resistor used in timing circuits, analogue circuits, as pull down resistors and to limit low current values in electronic circuits.

Power resistors can be either ceramic or wire wound and are designed to dissipate a lot of power - large power resistors may even need to be bolted to a heatsink to keep them working correctly. Power resistors are used to limit the current flowing in a circuit or, sometimes, to generate heat.

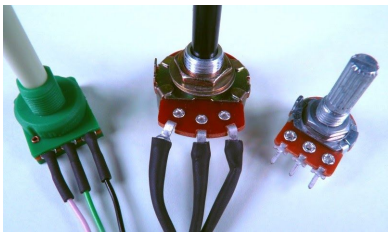
As already stated, fixed resistors obey Ohm's Law which states that the Potential Difference and Current are directly proportional at a constant temperature.

Variable resistors and potentiometers



A variable resistor is, as the name suggests, able to have a range of resistances between zero and some stated maximum resistance. Therefore a 10 kΩ variable resistor can have any value between 0 Ω and 10 kΩ as determined by the user. Variable resistors are used to control the current in a circuit, an example might be dimming a bulb or slowing a motor or to change time delays or other properties of a circuit.

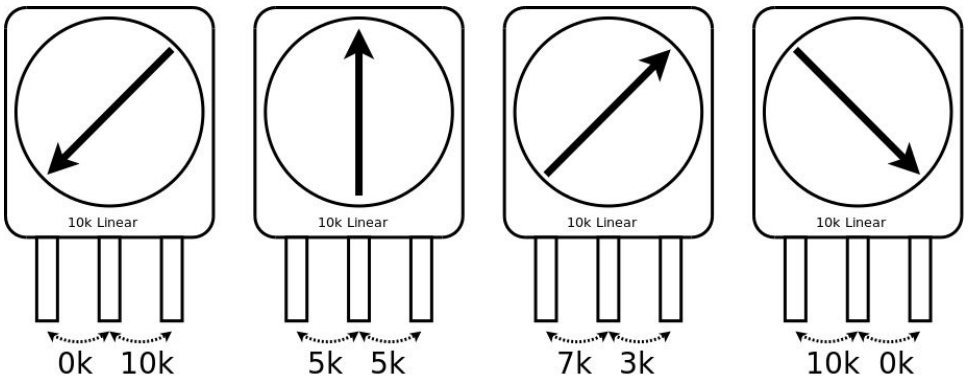
A variable resistor that is not designed to be varied on a regular basis - i.e. a resistor that can be set to a certain value and then left alone - is called a trimmer. Trimmers or presets are usually small, mounted directly to the circuit board and adjusted with a screwdriver.

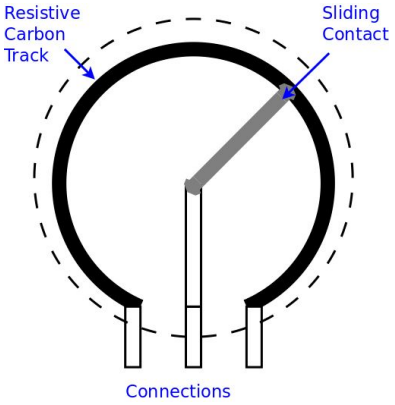


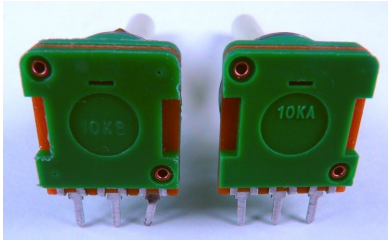
A potentiometer is a much more useful form of variable resistor. In fact a variable resistor is, in reality, a potentiometer with one of the connections remaining unused. A potentiometer has 3 connections.

The resistance between the two outer connections is a fixed value. The resistances between the centre connection and each of the two outer connections is variable but the two always add up to the same total resistance.

Inside a potentiometer a sliding contact moves along a carbon track (or a wire wound track). The resistance of the track remains fixed but the resistance between the end and the sliding contact changes





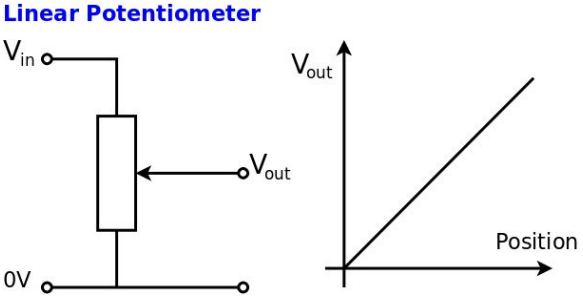


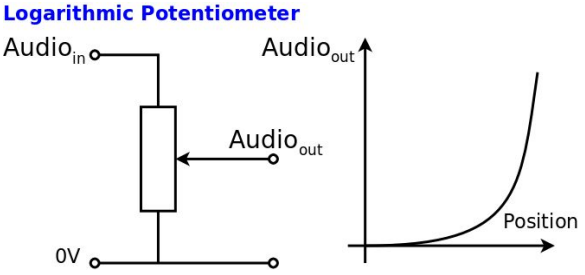
The resistance of a rotary or linear potentiometer can either change linearly with position or logarithmically with position.

In the case of the logarithmic potentiometer ("log pot" for short), a small change in position results in a small change in resistance at one end of the track but the same small change of position results in a large change in resistance at the other end of the track. A logarithmic potentiometer is identified by the letter A. Logarithmic potentiometers are used in audio applications such as volume controls.

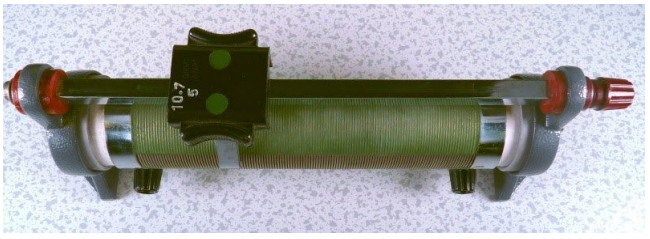
In the case of the linear potentiometer, the resistance between the center connection and the outside connection varies linearly with angle - as the angle increases, so does the resistance. A linear potentiometer is identified by the letter B. Linear potentiometers are used to provide a variable voltage source for comparator circuits etc.

Essentially the function of a potentiometer is to act as a potential divider. A potential difference is applied across the outermost connections. The inner connection is a fraction of the applied potential difference. This is useful in voltage supplies and volume controls.





Rheostat

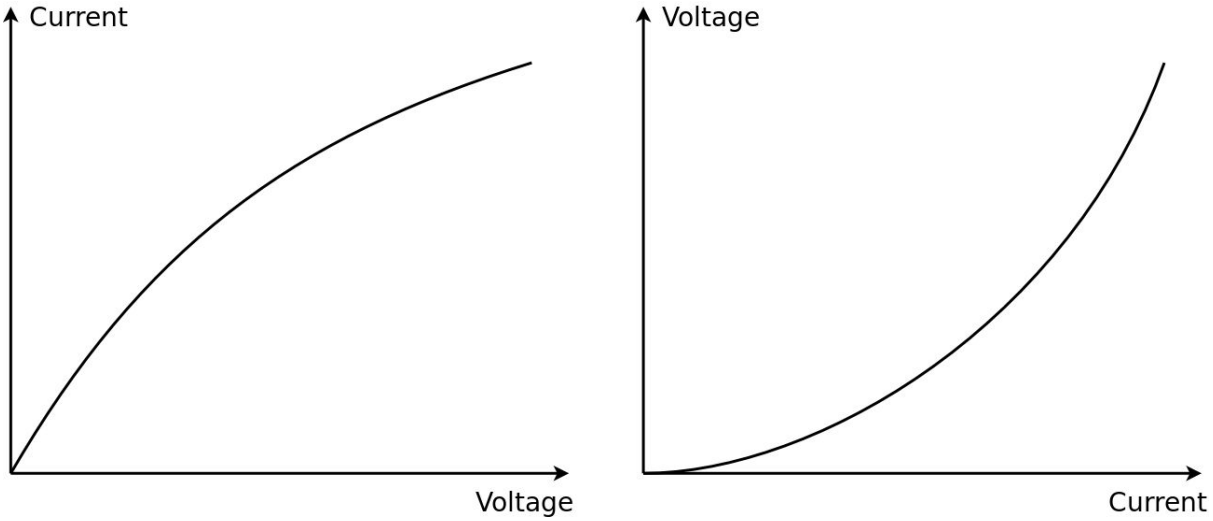


A rheostat is a potentiometer that can handle large currents. Therefore, a rheostat is a power version of a potentiometer. Rheostats are often used to limit current and are most often configured as a simple variable resistor.

Heating elements

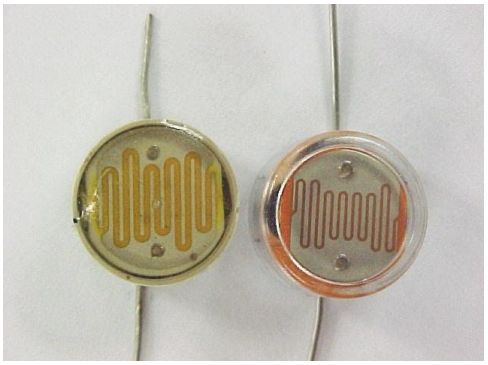
Resistance wire is made of a material such as constantan or nichrome, that has a high resistance compared to normal conductors such as copper and aluminium.

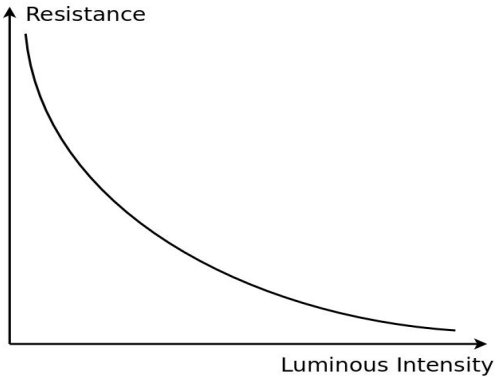
Because a length of resistance wire has significant resistance, it will dissipate energy i.e. it will get hot. This is useful for heating elements in devices such as toasters. Because the wire in a heater is allowed to get hot - no attempt is made to keep the temperature constant - the resistance changes. A heater is a non-ohmic device. The same applies for a filament bulb, the filament glows white hot and so the resistance changes meaning a bulb is also a non-ohmic device.



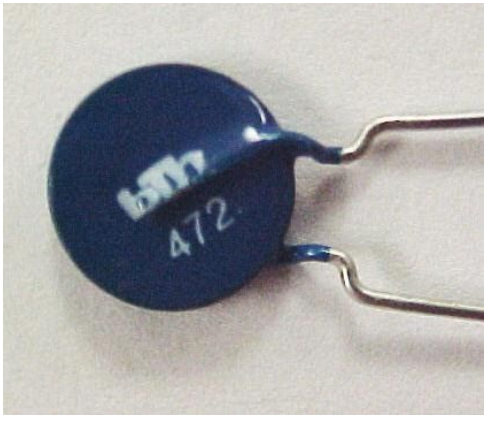
In a resistor such as a hot wire or a filament in a bulb the resistance increases as the temperature increases. The temperature increases because of the current flowing in the conductor. Therefore, in a heating element or filament, the resistance increases as the current and voltage increase. The V-I graph is a curve. NOTE: The gradient of the graph is not the resistance ... this is only true for the special case of an ohmic conductor.

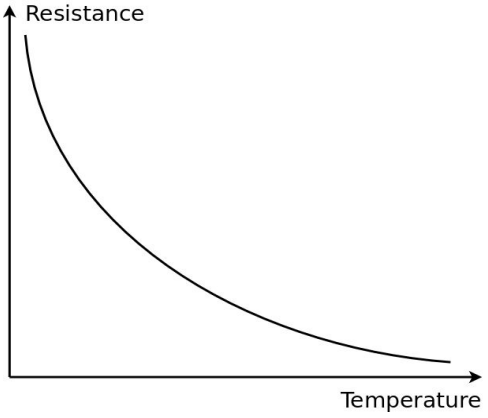
LDRs and Thermistors





A Light Dependent Resistor (LDR) is a semiconductor device. The resistance of the semiconductor reduces when energy is supplied. Therefore, the design of an LDR is such that the resistance of the LDR reduces as the light level increases. An LDR is often used as part of a potential divider to make a light sensitive circuit where the output voltage changes with light level. An LDR has a nominal value under standard conditions so different LDRs might have different resistance values under the same lighting conditions but they will all vary in the same way, reducing their resistance as light level increases.



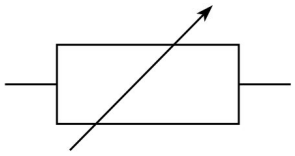
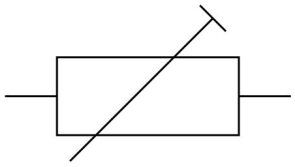
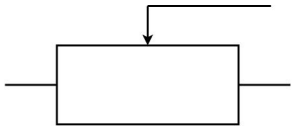
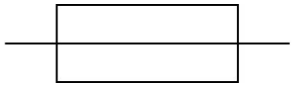
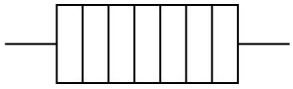
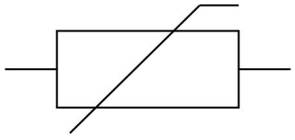
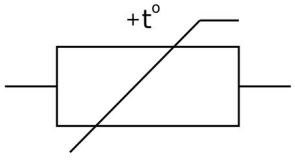
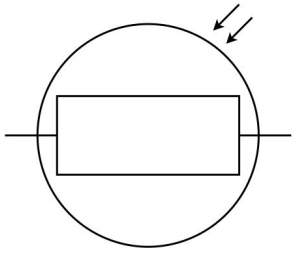


An NTC thermistor is another semiconductor device. The resistance of the semiconductor reduces when thermal energy is supplied. Therefore, the resistance of the thermistor reduces as the temperature increases. This is the usual type of thermistor used in electronics. NTC stands for "Negative Temperature Coefficient" because the resistance goes down as the temperature goes up and vice versa. Thermistors are often used in potential divider circuits to form temperature dependent circuits.

The graph shows how the resistance changes with temperature for an NTC thermistor.

A PTC thermistor behaves in the opposite manner to a regular NTC thermistor. In the case of a PTC thermistor, the resistance of the thermistor increases as the temperature increases. These are the more unusual type of thermistor in school electronics although they have many useful applications in the real world. PTC means "Positive Temperature Coefficient".

Circuit Symbols

	Fixed value resistor
	Variable resistor, rheostat
	Trimmer resistor
	Potentiometer - note that it has three connections
	Fuse
	Heating element
	NTC Thermistor
	PTC Thermistor
	Light Dependent Resistor

Website

http://www.pfnicholls.com/Electronics/Resistors.html

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