# RESISTANCE/RESISTOR

***Subject Name: Electrical Fundamentals***

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# INDEX

# Resistance of a Conductor

"Conductor" usually refers to materials that offer low resistance to current flow.

The best conductors are materials, chiefly metals,which possess a large number of free electrons.

The best conductors are silver, copper, gold,and aluminium; but some nonmetals, such as carbon and water, can be used as conductors.

The unit used to measure resistance is called the ohm.

The symbol for the ohm is the Greek letter omega (Ω).

In mathematical formulas, the capital letter "R" refers to resistance.

The resistance of a conductor and the voltage applied to it determine the number of amperes of current flowing through the conductor. Thus, 1 ohm of resistance will limit the current flow to 1 ampere in a conductor to which a voltage of 1 volt is applied.

**Factors Affecting Resistance**

The resistance of a material is determined by four properties:

1. Material
2. Length
3. Area
4. Temperature.

1. The resistance of a metallic conductor is dependent on the type of conductor material. It has been pointed out that certain metals are commonly used as conductors because of the large number of free electrons in their outer orbits. Copper is usually considered the best available conductor material, since a copper wire of a particular diameter offers a lower resistance to current flow than an aluminum wire of the same diameter.
2. The resistance of a metallic conductor is directly proportional to its length. The longer the length of a given size of wire, the greater the resistance. If the same size conductor is doubled in length, the same electrons set in motion by the 1 volt applied now find twice the resistance.

3. The resistance of a metallic conductor is inversely proportional to the cross-sectional area.

   If the cross-sectional area of a conductor is doubled, the resistance to current flow will be reduced in half because of the increased area in which an electron can move without collision or capture by an atom.

4. The fourth major factor influencing the resistance of a conductor is temperature.

   Although some substances, such as carbon, show a decrease in resistance as the ambient (surrounding) temperature increases, most materials used as conductors increase in resistance as temperature increases. The resistance of a few alloys, such as constantan and Manganin change very little as the temperature changes.

The first three properties are related by the following equation at T = 20 °C (room temperature):

$$R = \frac{(\rho \times l)}{A}$$

Where

R = resistance in ohms

ρ = Resistivity of the material ohms-meter

l = Length of the sample in meter

A = area in square meter

# Colour Code of Resistors

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## Colour  Coding with the end-to-center band marking system

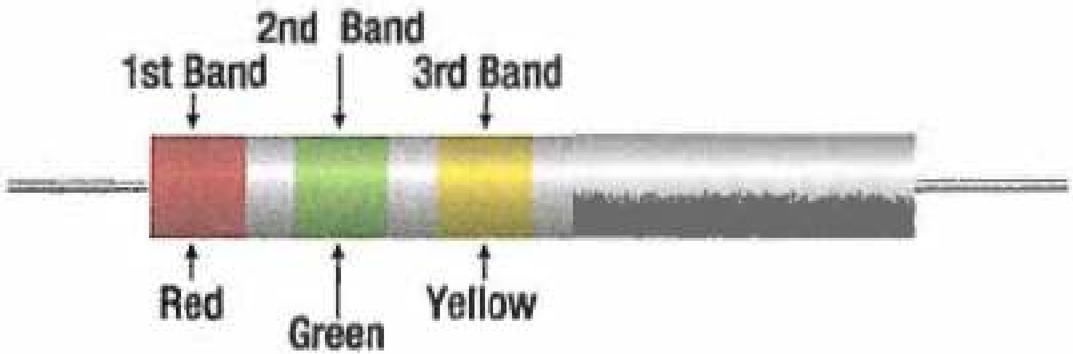
The resistor is normally marked with bands of color at one end of the resistor.

1. The first color band (nearest the end of the resistor) will indicate the first digit in the numerical resistance value.

2. The second color band will always indicate the second digit of ohmic value.
3. The third color band indicates the number of zeros to be added to the two digits derived from the first and second bands, ***except in the following two cases: (A) If the third band is gold in color, the first two digits must be multiplied by 10 percent. (B) If the third band is silver in color, the first two digits must be multiplied by 1 percent.***
4. If there is a fourth color band, it is used as a multiplier for percentage of tolerance, as indicated in the color code chart. ***If there is no fourth band, the tolerance is understood to be 20 percent.***

What is tolerance?

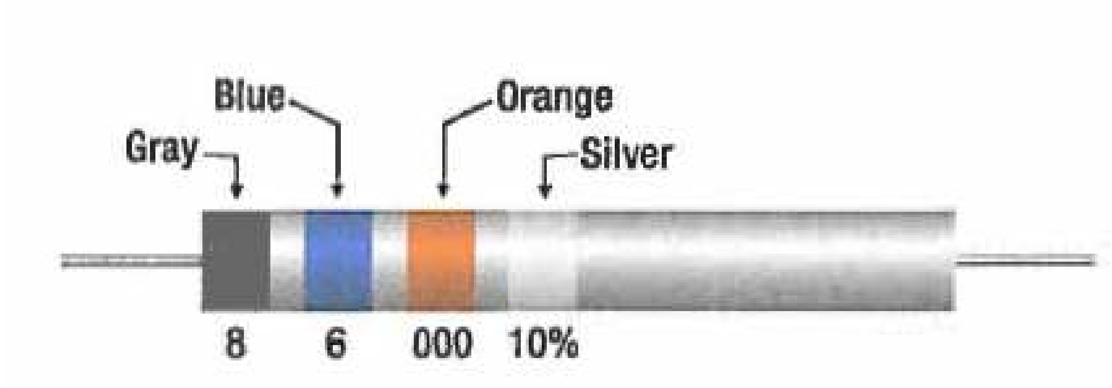
It is very difficult to manufacture a resistor to an exact standard of ohmic values. The percentage variation between the marked value and the actual value of a resistor is known as the "tolerance" of a resistor.




| Color | Numerical Value | Significance |
|---|---|---|
| 1st Band — Red | 2 | 1st Digit |
| 2nd Band — Green | 5 | 2nd Digit |
| 3rd Band — Yellow | 4 | No. of Zeroes to Add |

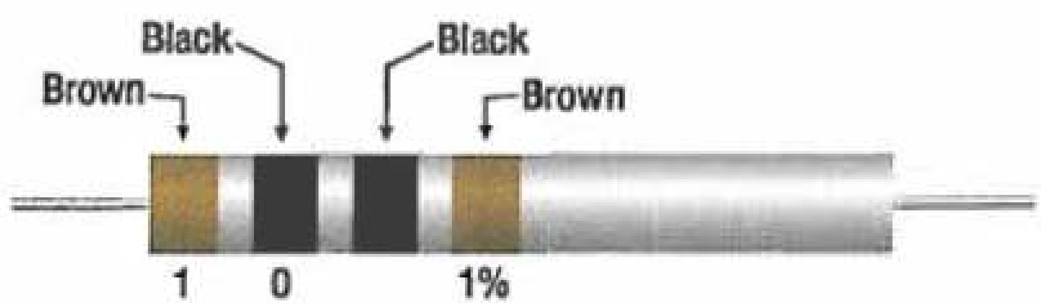
| Resistor Color Code | | |
|---|---|---|
| Color | Number | Tolerance |
| Black | 0 | — |
| Brown | 1 | 1% |
| Red | 2 | 2% |
| Orange | 3 | 3% |
| Yellow | 4 | 4% |
| Green | 5 | 5% |
| Blue | 6 | 6% |
| Violet | 7 | 7% |
| Gray | 8 | 8% |
| White | 9 | 9% |
| Gold | — | 5% |
| Silver | — | 10% |
| No color | — | 20% |

Example.
Calculate maximum and minimum value for a resistor having 20 percent tolerance. The resistor value is 250 000 Ω.
20 percent of 250 000 Ω equals 50 000 Ω.
Since the 20 percent tolerance is plus or minus:
Maximum resistance
= *250 000* Ω + *50 000* Ω
= *300 000 O*Ω
Minimum resistance
= *250 000* Ω - *50 000* Ω
= *200 000* Ω




This resistor code should be read as follows:
The resistance of this resistor is 86 000 ± 10 percent ohms. The maximum resistance is 94 600 ohms, and the minimum resistance is 77 400 ohms.

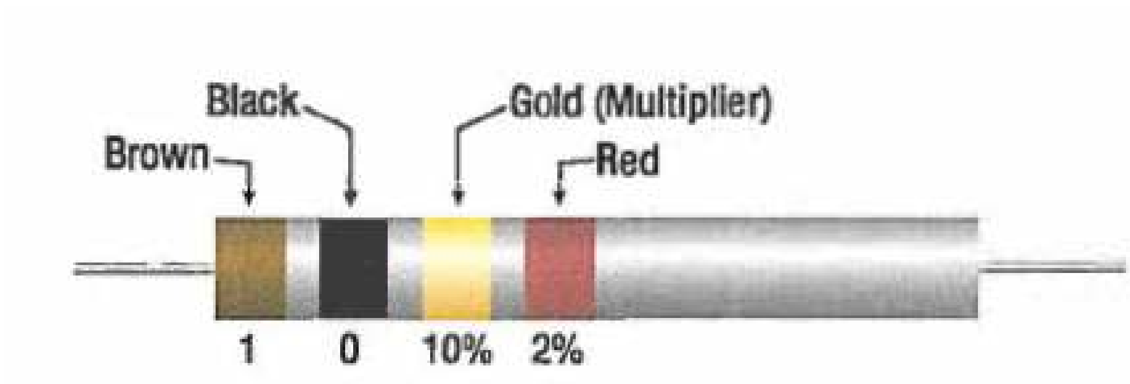
An example of a resistor with a black third color band. The color code value of black is zero, and the third band indicates the number of zeros to be added to the first two digits.
In this case, a zero number of zeros must be added to the first two digits; therefore, no zeros are added. Thus, the resistance value is 10 ± 1 percent ohms. The maximum resistance is 10.1 ohms, and the minimum resistance is 9.9 ohms.



Example

When the third band is gold in color, it indicates that the first two digits must be multiplied by 10 percent. The value of this resistor in this case is:

10 x 0.10 ± 2% = *1 = 0.02 ohms*



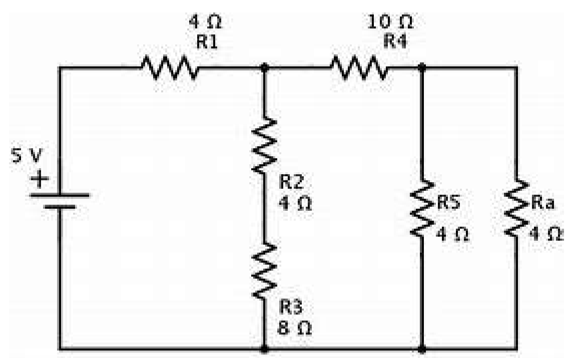

***When the third band is silver, the first two digits must be multiplied by 1 percent.***

When the third band is silver, ***the first two digits must be multiplied by 1 percent.***

# How do you calculate the resistance of a parallel circuit?

- Parallel Circuit Resistance. In a Series circuit (loads connected in a row end to end) it's easy to calculate total circuit resistance because you simply add up all the resistances and you have the total. In a Parallel circuit the **voltage is the same across all the loads, the amperage is simply added up but the resistance is a bit more tricky**.

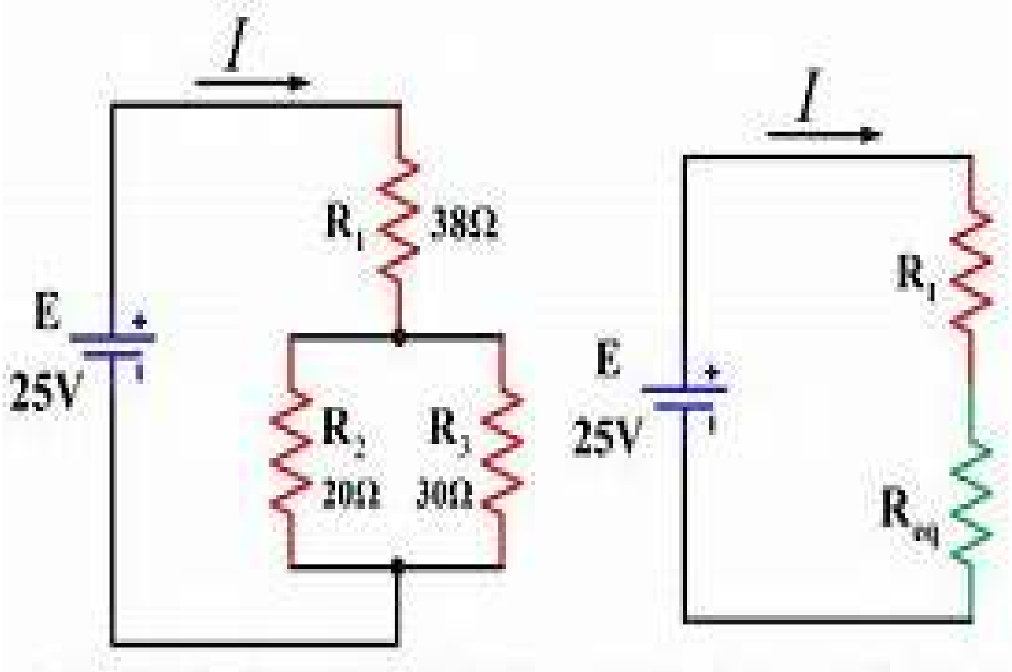
1. How do you calculate the resistance of a parallel circuit?



- **How to Solve a Series Circuit - Part 1 Resistance, Voltage, and Current**
- Review Ohm's Law.
- Add up to the total resistance.
- Find the total voltage.
- Calculate the current.
- Keep track with a chart.
- Voltage in a Series Circuit. The **voltage dropped across the resistor** in a circuit consisting of a single resistor and a **voltage source** is the total voltage across the circuit and is equal to the applied voltage.

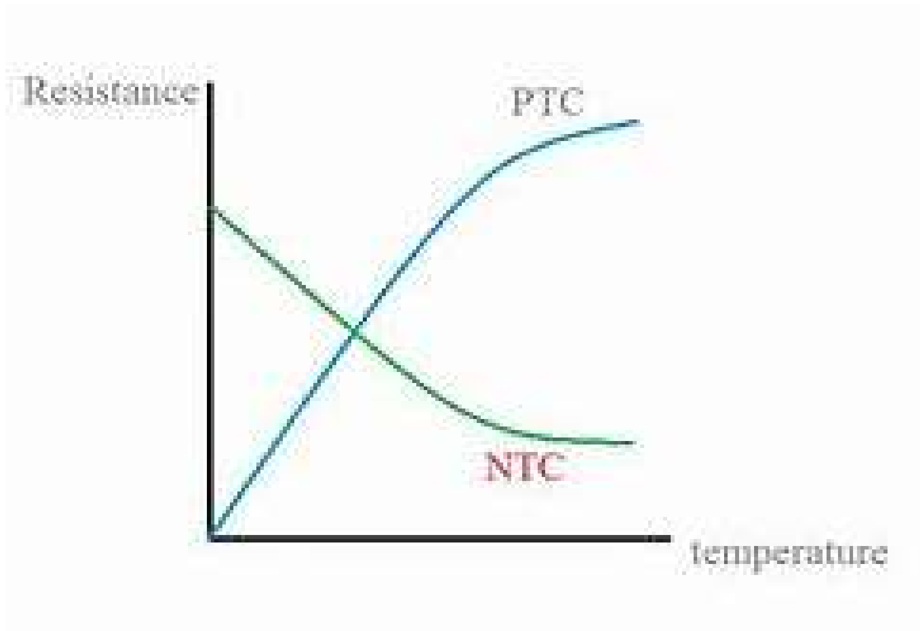
- **How to Make a Parallel Circuit - Building a Parallel Circuit with Wires and a Switch**
- Choose this method for a slightly advanced project.
- Gather the main components of a parallel circuit.
- Prepare your wires.
- Connect the first lightbulb to the battery.
- Begin to connect the switch to the battery.

# Resistance Connected In series & Parellel



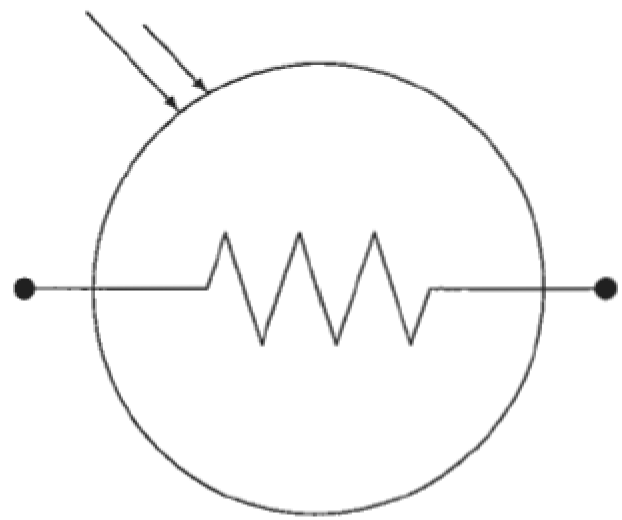

(a) Series-Parallel Resistor Circuit (b) Equivalent Series Circuit

# Characteristics of positive & Negative temp. coefficient

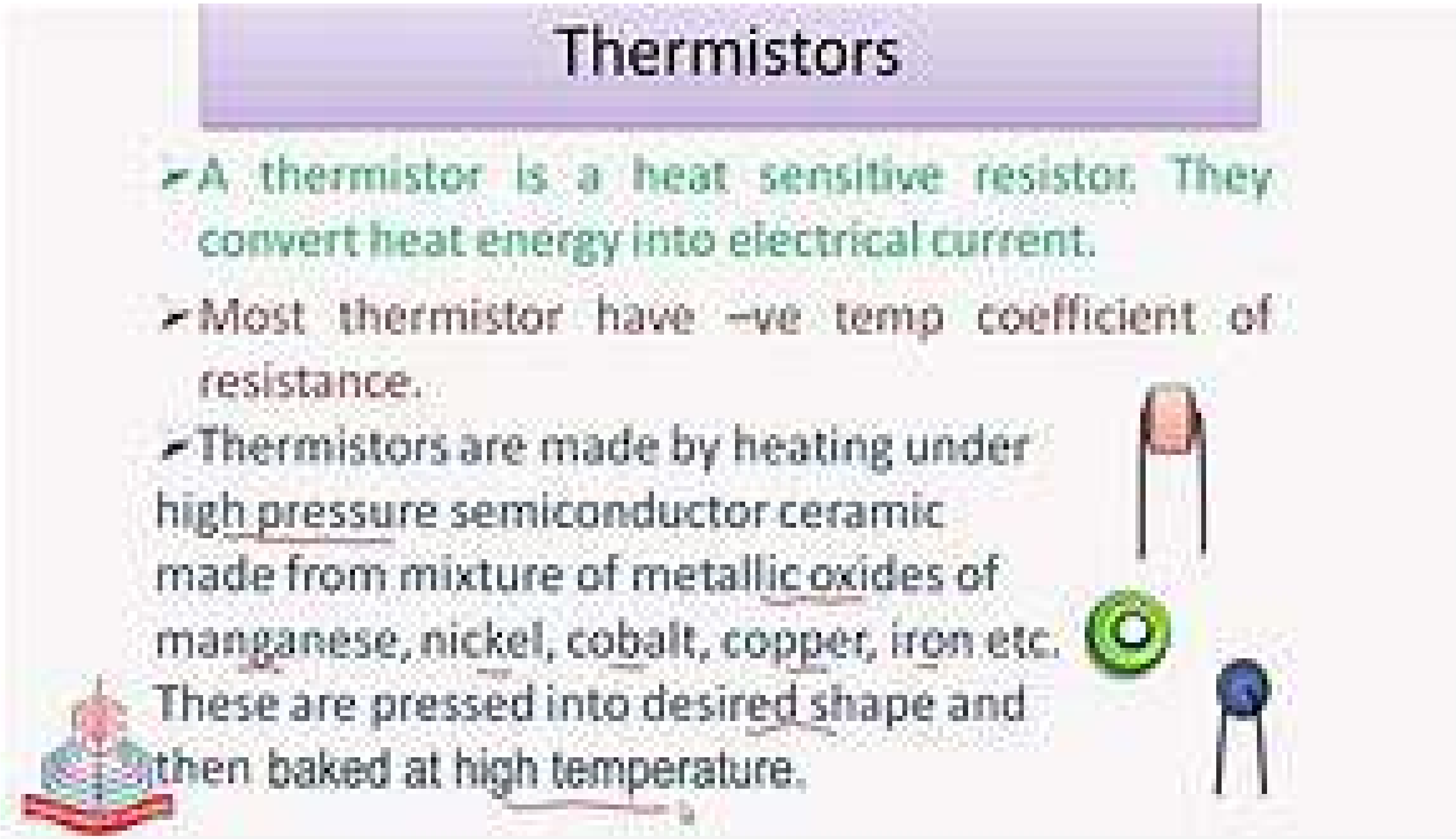


## 5. PHOTOCONDUCTIVE CELLS

The photoconductive cell schematic is as shown. It has a negative temperature coefficient. The resistance is controlled by light intensity.



# What is Thermistor?



# Mainly two types of Thermistor

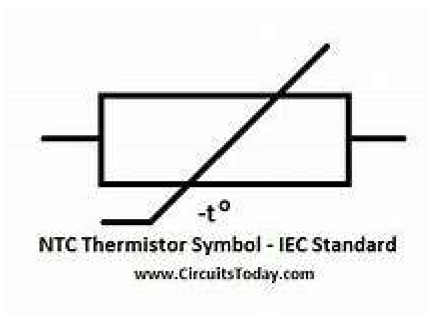
## THERMISTORS

- A thermistor is a type of resistor with resistance varying according to its temperature.
- The resistance is measured by passing a small, measured direct current through it and measuring the voltage drop produced.
- There are basically two broad types

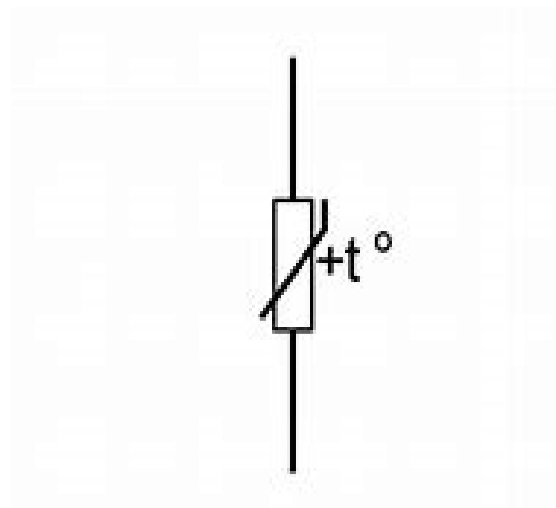
1. *NTC-Negative Temperature Coefficient:* used mostly in temperature sensing
2. *PTC-Positive Temperature Coefficient:* used mostly in electric current control.

# Symbol of Thermistor

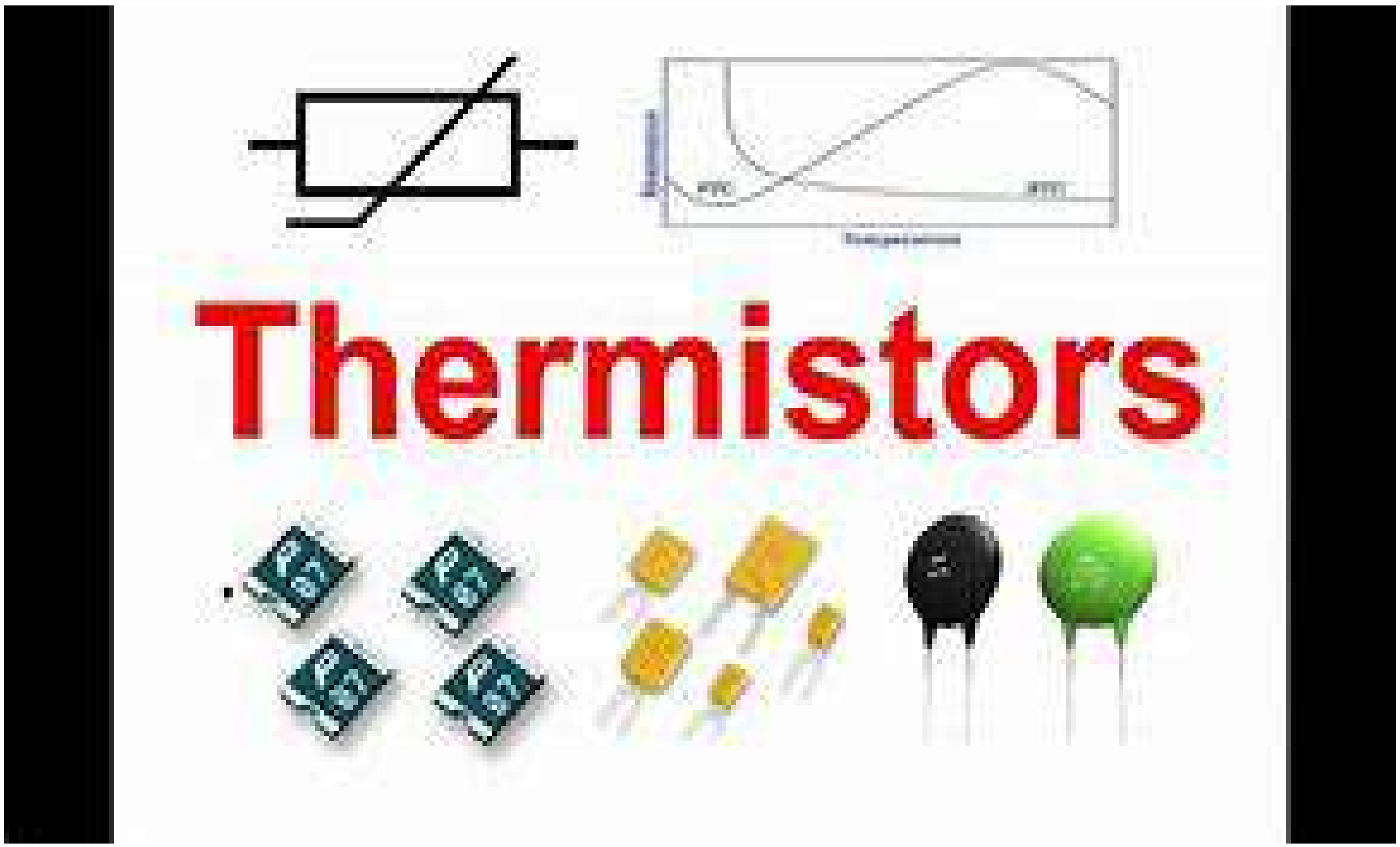
**Negative Temp Coefficient Thermistor**




**Positive Temp Coefficient Thermistor**

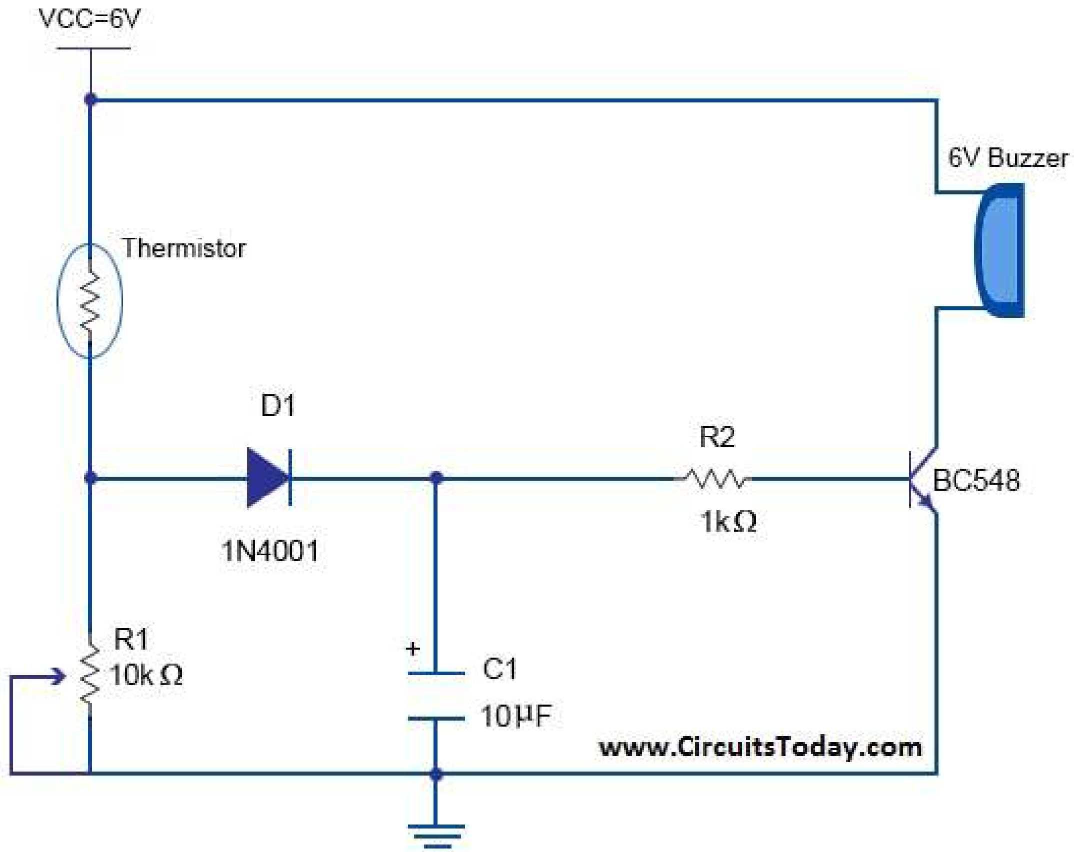


# Different Shapes of Thermistor



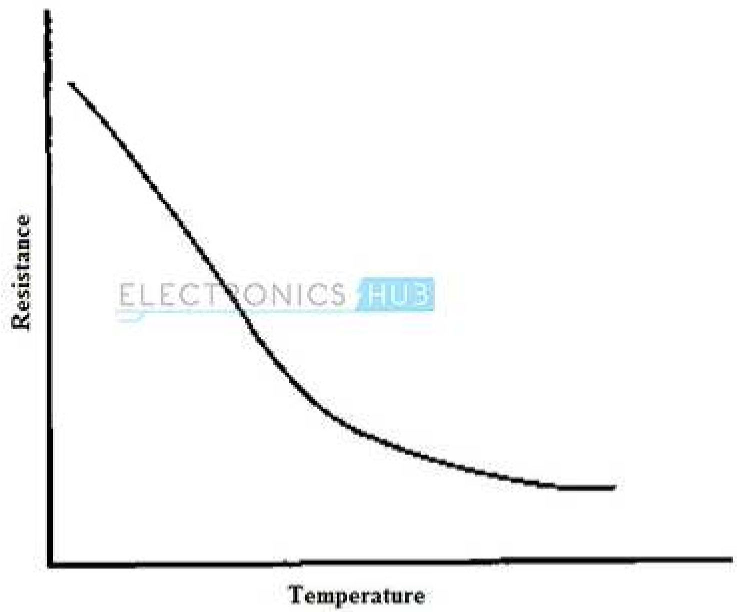
# Negative Temperature

# Application of NTC-Thermistor

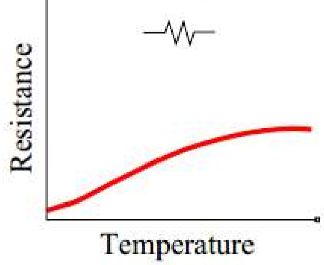
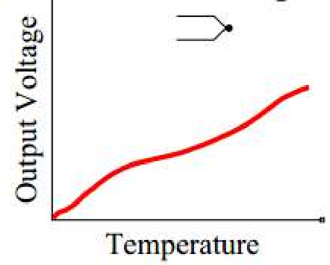
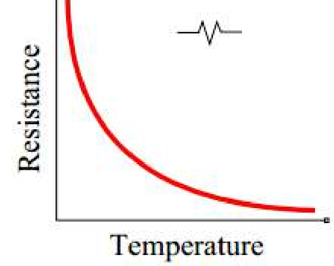



**Fire Alarm Circuit Using NTC Thermistors**

# Characteristic of Thermistor (Resistance v/s Temperature)

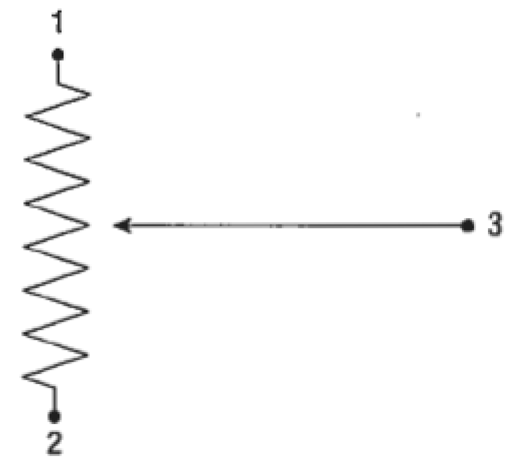


# Comparison between RTD,Thermocouple & Thermistor

| RTD | Thermocouple | Thermistor | |
|---|---|---|---|
|   |   |   | Output Characteristics |
| • Most accurate<br>• Best stability<br>• Higher linearity<br>• Best interchangeabilty<br>• Wide temperature range | • Largest variety of styles<br>• Self-powered<br>• Rugged<br>• Largest temperature range<br>• Small size / fast response | • High resistance values<br>• Large resistance change<br>• Two wire ohms measurement<br>• Low sensor cost<br>• Small size / fast response | Advantages |
| • Current source required<br>• Smaller resistance change<br>• Low absolute resistance<br>• Self heating<br>• Higher sensor cost | • Lowest stability<br>• Low voltage output<br>• Nonlinear<br>• Cold junction reference needed<br>• Lowest sensitivity | • Limited temperature range<br>• Current source required<br>• Nonlinear<br>• Self heating<br>• Fragile | Disadvantages |
| -260 to 850°C | -200 to 1800°C | -80 to 300°C | Temperature Range |

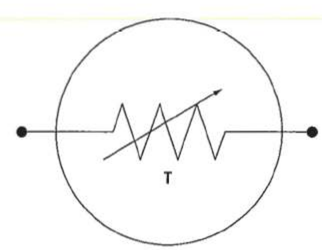
## 3. POTENTIOMETER

The schematic symbol for the potentiometer is as shown. ***The potentiometer is considered a three*** terminal device. The potentiometer is used to vary the voltage in a circuit.

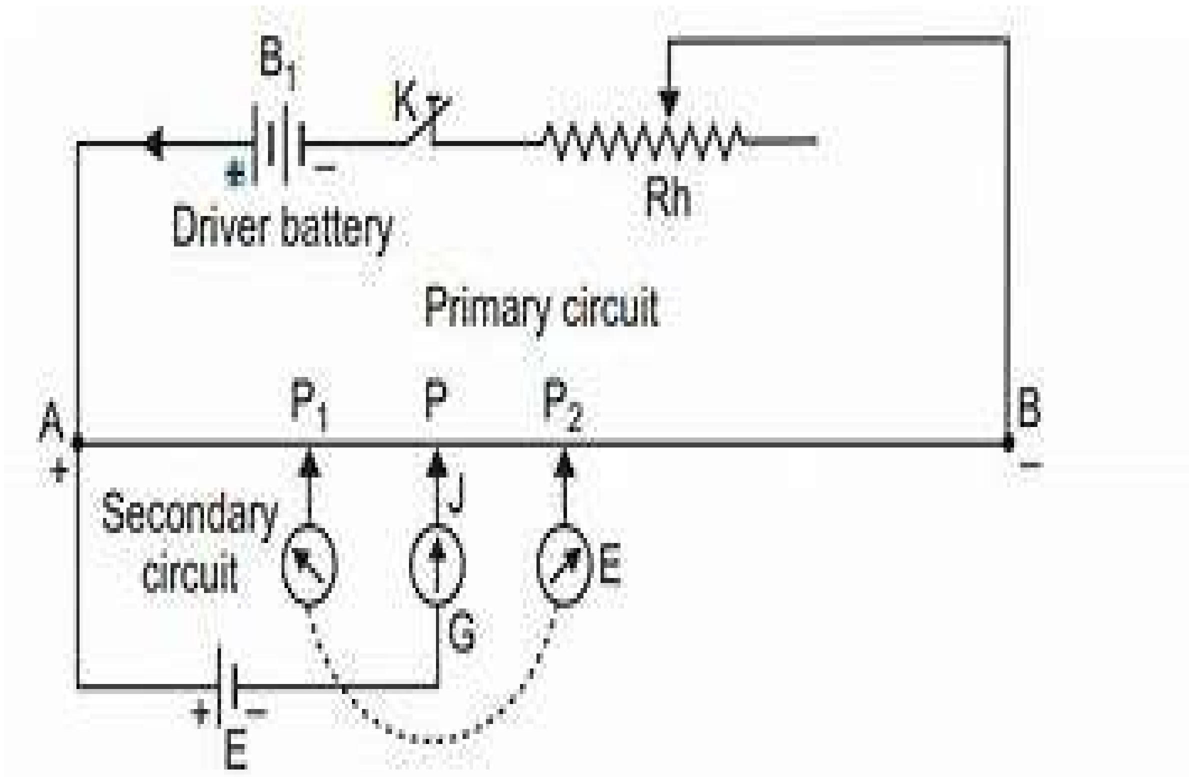



## 4. THERMISTORS

**The schematic symbol for the thermistor is as shown.** The thermistor is a type of a variable resistor, which is temperature sensitive. This component has what is known as a negative temperature coefficient, which means that as the sensed temperature increases, the resistance of the thermistor decreases.

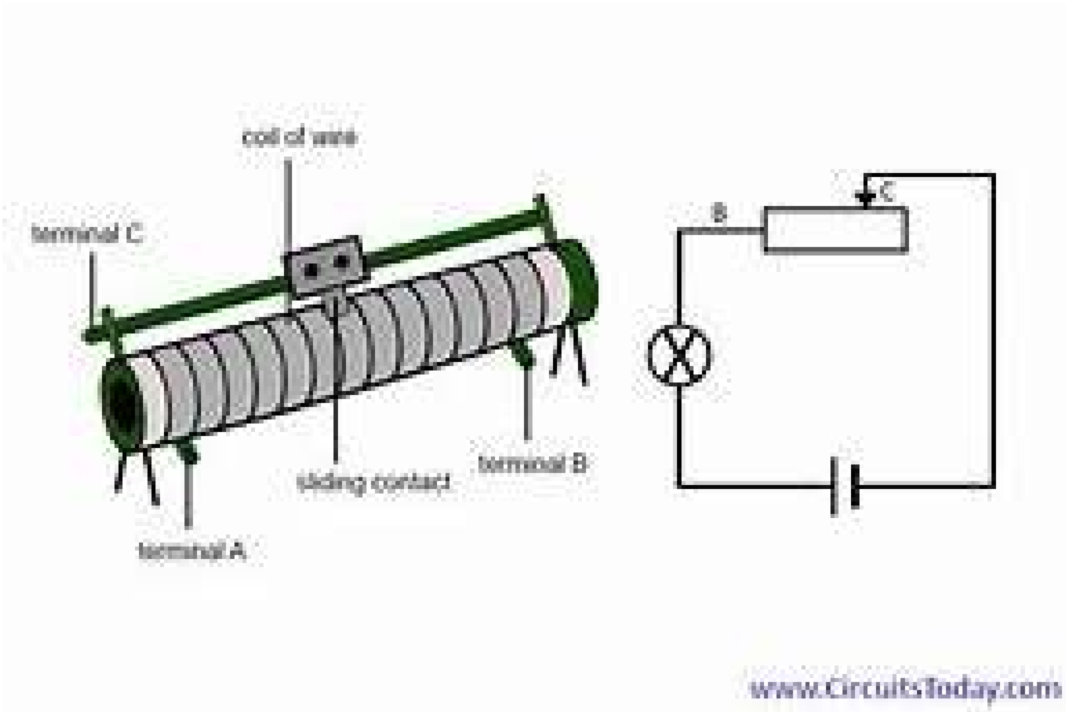


# Potentiometer



# Working, construction & Application of Potentiometer

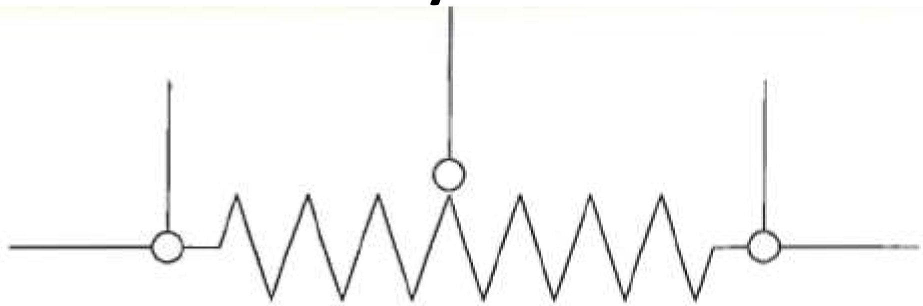
# Explain the working, construction of rheostat.



# Image of Rheostat

# Schematic Symbols

**1. WIRE WOUND Symbol**



**Note: Wire wound resistors typically control large amounts of current and have high power ratings.**

2. **Rheostat Symbol** :The schematic symbol for the rheostat is shown below**. *A rheostat is a variable resistor used to vary*** the amount of current flowing in a circuit.

- For conductors **resistance** increases with increase in **temperature** as atoms within conductor vibrate more which offers more **resistance** to the flow of charge except carbon. Carbon atoms loose electron with increase in **temperature** which decreases **resistance** of carbon with increasing **temperature**

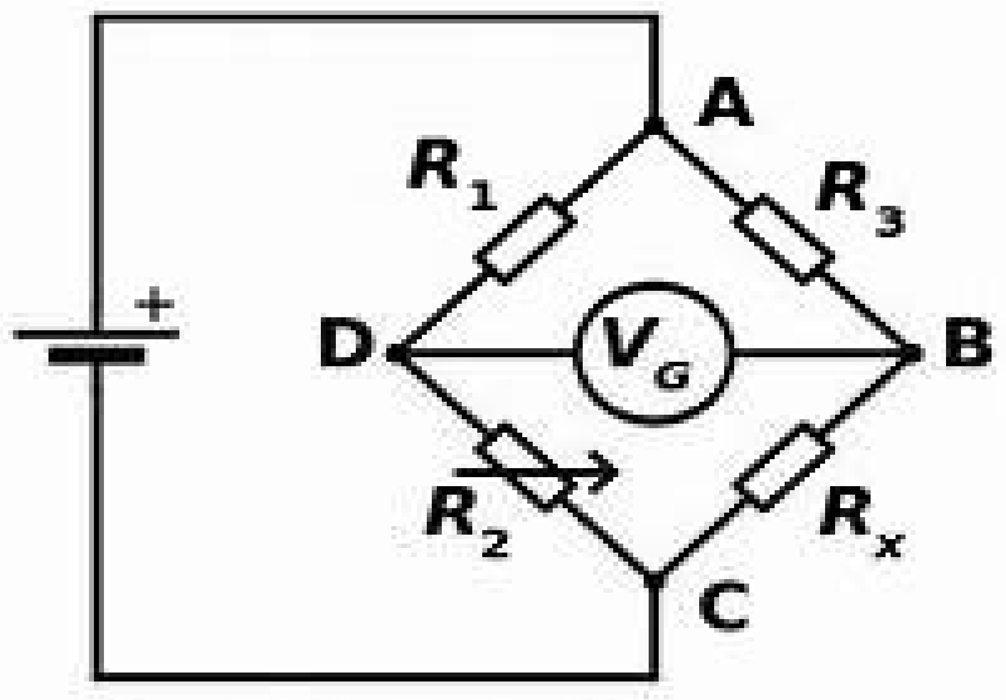
## WHEATSTONE BRIDGE

A Wheatstone ·Bridge is used to find out the value of an unknown resistance. It is a circuit constructed of three resistors with known values (Ri, R2, R3) and a voltmeter (VG), A fourth resistor (Rx) of unknown value is also included as shown in ***Figure.*** ***The voltage values at D*** **and B vary with the total resistance on each side of the "bridge"**. , when the resistance on both sides of the circuit bridge are equal, there is no difference in potential at points D and B and the voltmeter wired between these points indicates "O“ and the bridge is said to be balanced.

Stated another way, the ratio of R2 / R1 = Rx /R3.

Rx = R1 / R2 * R3.

# Explain in detail about Wheatstone bridge.



wheatstone Bridge

# Working of wheatstone bridge

## How a Wheatstone Bridge works?

- The dc source, E is connected across the resistance network to provide a source of current through the resistance network.
- The sensitive current indicating meter or null detector usually a galvanometer is connected between the parallel branches to detect a condition of balance.
- When there is no current through the meter, the galvanometer pointer rests at 0 (midscale).
- Current in one direction causes the pointer to deflect on one side and current in the opposite direction to otherwise.
- The bridge is balanced when there is no current through the galvanometer or the potential across the galvanometer is zero.