

B.Sc.I Electronics
Semister I
Paper I Basic Electronics

Chapter 1
 STUDIES OF COMPONENTS

Unit:1. Resistors& capacitors 9

Definition of active and passive elements Resistors: - Definition, symbol and colour code method. Types of resistors: - Linear Resistors (Fixed): -Carbon composition, carbon ceramic, carbon film, wire wound. Linear resistors (Variable): -Wire wound, Potentiometer, Preset. Non-Linear resistors: - Thermistors, photo resistors and varistors. [Construction, specification application only.]

Capacitors: - Definition, . Capacitance, capacitive reactance (XC), Energy stored in a capacitor, charging and discharging of a capacitor, leakage current in capacitor, stray capacitance. Types of capacitors: - Fixed electrostatic capacitors: -ceramic, mica, plastic and paper [Construction of ceramic capacitor only]

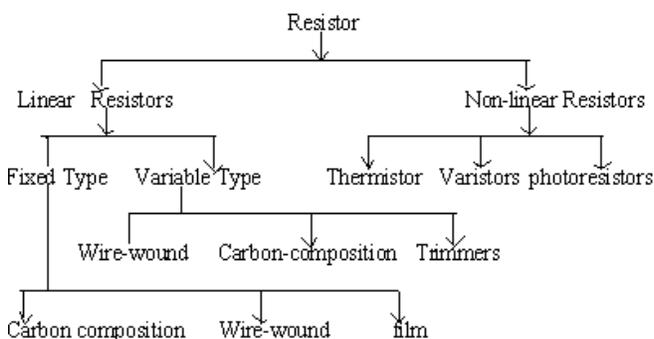
Fixed electrolytic capacitors: - Aluminum and Tantalum polycarbonate polyethylene. [Construction of Aluminum only]
 Variable capacitors: -Air dielectric capacitor and Trimmers.

Reference: Applied Electronics by:R.S.Sedha

Circuit Elements: - The individual components which make up an electronic circuit are called circuit elements or circuit components. These elements are of two types;-

1) Passive Elements and 2) Active Elements

1) Passive Elements: - Any device or a component which does not introduce gain or does not have directional function is known as passive circuit element. Such components conduct current in either direction and therefore are known as bilateral devices. [These elements are not an energy sources.]



Examples: - Resistors, Capacitors, and Inductors.

2) Active Elements: - The components which take part in the transformation of energy are called active elements. Such components introduce gain and they show unidirectional function i.e. these components conduct current only one direction. Hence they are also known as Unilateral Device.

Examples: - BJT, FET, UJT Diode etc. [These are energy sources]

Resistor: - A resistor resists or opposes the flow of current through it. It can be connected in the circuit in either direction. The current flowing through it is proportional to the applied voltage.

Use of Resistor:-

- 1) To control the flow of electric current
- 2) To provide desired amount of voltage in electric or electronic Circuit.

Resistance: -The opposing force for the flow of electric current through the Material is called resistance of that material. Resistance of material is measured in Ohm. Its symbol is Ω .

Classification of Resistors: -

I) Linear Resistors: - The resistors, through which the current is directly proportional to the applied voltage, are called linear resistors. Such resistors have a property that their resistance values do not change with variation in applied voltage, temperature or light intensity. These resistors are of two types:

- i) Fixed Type and ii) Variable type

Fixed Resistors:- The resistors whose value do not change with the variation in applied voltage, temperature & light intensity are called fixed resistors.

II) Non-linear Resistors: - The resistors, through which the current is not directly proportional to the applied voltage, are called non-linear Resistors. These resistors are of three types –

- i) Thermistors, ii) LDR (photoresistors) and iii) VDR (varistors)

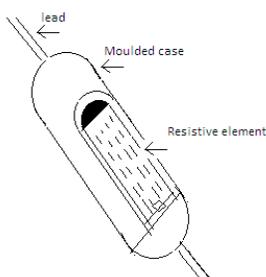
Important Specifications of Resistors

The resistors are specified in terms of i) Their resistance value, ii) Tolerance, iii) Power rating and iv) Thermal Stability v) Voltage coefficient of resistance.

- i. Resistance Value: - Either printed or colour coded
- ii. Tolerance: - The amount of variation permitted in the normal or marked value of resistor is called tolerance. It is usually specified in percentage as: - If no colour $\pm 20\%$, If Silver band $\pm 10\%$, If Gold band $\pm 5\%$.
- iii. Power Rating: -The maximum amount of heat dissipated by a resistor without damage to the resistor is called the power rating of the resistor. Since power rating is $\propto I^2$ therefore current must not be higher than its safe value. If current exceeds the safe value, the resistor will burn out.
- iv. Thermal Stability OR Temperature coefficient of resistance: - The change in resistance to the purchase resistance for change in temperature is called the temperature coefficient of resistance. Usually expressed in ppm/ $^{\circ}\text{C}$ [parts per million per degree Celsius] Smaller value of temp. Coefficient means a higher thermal stability.
- v. Voltage coefficient of resistance: The percentage change in resistance per volt DC from the purchase resistance of resistor usually given as percent per volt. Ex. $-0.5\%/V$.

LINEAR RESISTORS: Fixed type resistors

1) Carbon composition Resistors:-a) Construction:- This type of resistors is made up of a mixture of finely divided carbon & some non conducting insulating material usually silica & a synthetic resin binder. The mixture of carbon and silica is adjusted to produce different values of resistances. More the carbon, the lower is the resistance. This mixture plus leads & insulating material is compressed & enclosed in a plastic case for insulation & mechanical strength. The two ends of the carbon resistance element are joined to metal caps with leads of tinned wire for soldering the connections into a circuit.



b) Important Specifications:-

- i) Resistance range: - 1Ω to $22M\Omega$
- ii) Power rating: - $1/8$, $1/4$, $1/2$, 1 , and 2 Watts
- iii) Tolerance: - $\pm 5\%$, $\pm 10\%$, $\pm 20\%$.
- iv) Operating temp. Range: - -55°C to $+150^{\circ}\text{C}$
- v) Temperature Coefficient: - ± 1200 ppm/ $^{\circ}\text{C}$

c) Uses: - These are used in general purpose electronic equipment.

Ex: - Television (TV), Radio, Video, Cassette Recorder (VCR), Video Cassette Player (VCP), Uninterrupted Power Supply (UPS) etc. These are not used in precision work because of their poor stability.

d) Advantages:-

- i) Small size
- ii) Low cost
- iii) Good Stability
- iv) These are pure resistors up to frequency of several M Hz.

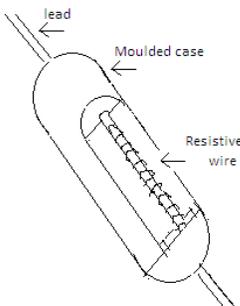
e) Disadvantages:-

- i) Power rating of up to 2 W only.
- ii) Resistance changes 5% per year.

2) Wire-Wound Resistors:- **a) Construction:** These resistors are made by winding resistive wire made of tungsten or manganese or Nichrome (alloy of Ni 50% + Cr 16% + Fe 34%) on a ceramic rod as shown in figure above. The resistance value required is derived from i) Length of the wire ii) Diameter of the wire and iii) resistivity of the wire. The ends of the wire are welded on a metal cap. Then the assembly is coated with insulating material such as cement or ceramic.

b) Specifications:-

- i) Resistance Range: - 1Ω to 150Ω
- ii) Tolerance: - $\pm 1\%$ to $\pm 10\%$
- iii) Power Rating: - 1W to 50W
- iv) Temp. Coefficient: - $+50$ to $+200$ ppm/ $^{\circ}\text{C}$
- v) Operating Temp. Range:- up to 300°C



c) Uses:-

- i) Used in power supply & control circuit, circuits where low noise is required.

d) Advantages:-

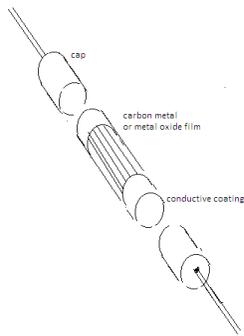
- i) High power handling capacity.
- ii) Low noise.
- iii) Good Thermal Stability.

iv) good overload characteristics.

e) Disadvantages:-

- i) Large size
- ii) High Cost.
- iii) Cannot be used beyond 50KHz [Since more associated L and C at high frequencies].

3) Carbon film Resistors:- **a) Construction:-** Pure carbon can be deposited onto a ceramic rod by the high temperature thermal decomposition of gaseous hydrocarbons. Resistance value is adjusted by controlling the thickness of the coating. The big advantage of carbon film resistor over carbon composition resistor is its better Stability.

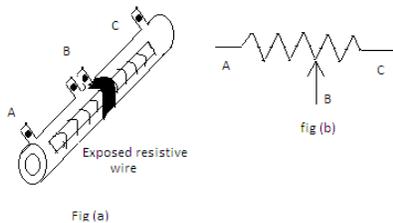


b) Specifications:-

- i) Resistance Range: - 1Ω to $10 \text{ M}\Omega$
- ii) Tolerance: - more than 2%
- iii) Working voltage: - up to 500 V
- iv) Power Rating: - $1/8$ W to 1.2 W
- v) working temp. upto 120°C .

Linear Variable Resistors:- These are three terminal resistors out of which two are fixed & one is movable, thereby resistance can be changed between 0 & a certain maximum value.

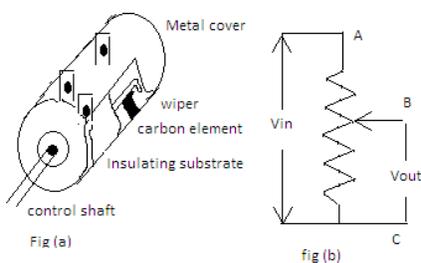
I) Variable wire wound Resistor: These resistors are made of nichrome wire wound on a ceramic core & covered with an insulating coating. A window is left in the insulating cover, which exposes the resistor wire as shown in fig. An adjustable tap B rides along the exposed wire, which makes electrical contact with the wire. Fig (b) shows the schematic symbol of a variable resistor. The points A & C represent the end points & b indicates the adjustable point. (These are not used for continuously variable control but they are preset at a given value & held at that value for extended period of operation).



Resistance Range: - 1Ω to $150 \text{ K}\Omega$

- ii) Tolerance: - more than 5%, 10 %
- iii) Power Rating: - 3 W to 200 W

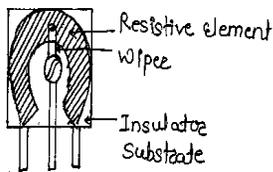
II) Potentiometers : - It is three terminal variable resistor whose outer terminals are fixed & middle terminal is variable as shown in fig(a). The variation is provided by a wiper connected to a control shaft. When a control shaft is moved, the wiper moves over a resistive element. This movement provides a continuous variation in resistance between the middle terminal & either outside terminal. Fig(b) shows an arrangement of a potentiometer used as a voltage divider. By moving the control shaft on either side of the middle terminal, any part of the input voltage can be taken at the output. The resistive element is made from material such as carbon composition, carbon film, cermet & wire. Carbon composition potentiometers have low cost, long life, low noise & good reliability and used as volume controls, tone control, linearity & brightness controls in radios & TV receivers. Molded type potentiometers are mainly used in test instruments, computer servo systems.



Specifications:

- i. Range of values : 100Ω to $10 \text{ M}\Omega$
- ii. Power ratings : $1/2$ W to $2 1/4$ W
- iii. Tolerance : $\pm 20\%$ for 100 to $1 \text{ M}\Omega$
 - a. $\pm 30 \%$ for above $1 \text{ M}\Omega$

III) Preset (Trimmers): These are used in electronic circuits to trim (to set) the circuit to the required operating conditions by inserting a small screw driver into a slot & turning one or more times. The trimmers are available both in single turn & multi turns. The materials used in the construction of a trimmer are carbon composition, carbon film cermet & wire.



Resistance values: 50 Ω to 5 MΩ
 Power ratings : 1/4 W to 3/4W

Hg: Thermistor (preset)

Non-linear Resistors

These resistors are made from semiconducting material. The non-linear property of the resistors arises due to the breaking of covalent bonds in the semiconducting materials. The source of energy for the creation of charge carriers in semiconductors may be voltages, temperature or incident light. The non-linear resistors are of the following three types.

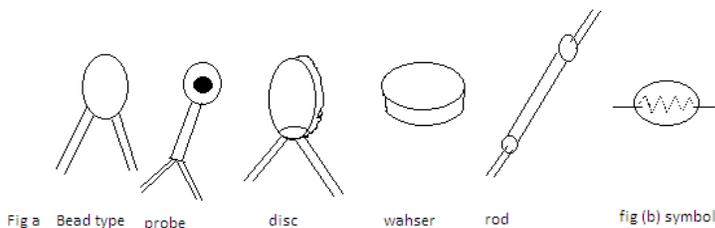
- 1) Thermistors
- 2) Photoresistors
- 3) Varistors

1) Thermistors :-

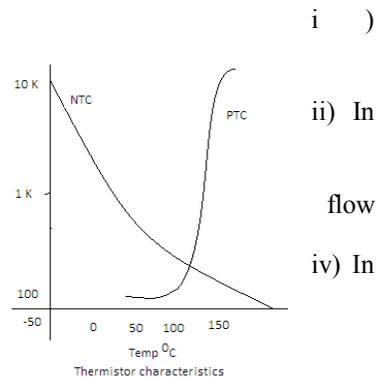
THERMally sensitive resISTORS mean Thermistors. These are used to detect very small change in temp. The variation in temp is reflected through the variation of the resistance of the device. There are two types.

- a) Negative temp. Coefficient (NTC) type: The resistance decreases with the increase in temp. These are manufactured by sintering (process in which powdered materials are fused together by the application of heat) semiconductor ceramic materials prepared from mixtures of metallic oxides of cobalt, nickel, manganese etc. have high negative temp coefficient.
- b) Positive temp coefficient (PTC) type: In these types of thermistors the resistance increases with the increase in temp. These thermistors are made from doped barium titanate semiconducting material. This material has a very large change in resistance for a small change in temp.

Thermistor characteristics: fig shows temp resistor characteristics for NTC & PTC thermistors. It may be noted that NTC thermistor has a resistance of about 10KΩ to 100 Ω at -50°C & 150°C respectively. It means that a temp change of 200°C has resulted in 100: 1 change in resistance. In case of PTC curves rises rapidly.



Applications:
 Used in
 temperature measurement
 liquid level measurement
 iii) In rate measurement

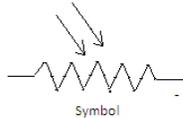
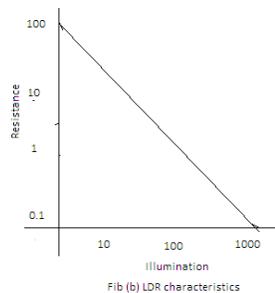
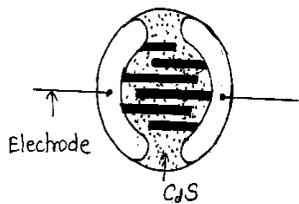


time- delay circuit

Photo resistors: These are also called photo conductive cells. These are made from semiconductor material whose resistance decreases when illuminated with light energy. When exposed to light, the covalent bond breaks. This produces charge carriers. The resistance of the semiconductor varies inversely with the amount of light.

The light sensitive semiconductor wafer is produced by pressing a semiconductor powder or by depositing this material on a dielectric base in vacuum. The metal film kept on this is connected to metal leads (tin or indium). The area of the sensitive material varies from 0.5 to 30 mm². The semiconducting material used are cadmium selenide CdSe, cadmium sulphide CdS, lead sulphide PbS, thallium sulphide TlS.

The illumination characteristic is as shown in fig. where logarithmic scales have been used. It is seen that when not illuminated, the LDR has a resistance of more than 100KΩ (known as dark resistance). When illuminated, the resistance falls to only a few hundred ohms.

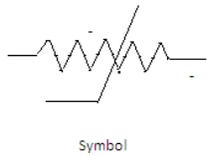


These resistors are used in photoelectric counter, light meter, as on-off switch & in photoelectric relay circuit. It is also used in voltage regulator circuit, automatic brightness & control in TV & light failure alarms.

Specifications:
 than 10 PF, permissible

Resistance in dark is greater than 10M Ω, capacitance is less voltage is 100 volts peak.

Varistors: Varistor is also known as voltage dependent resistor. These are non linear resistors with large negative voltage coefficient. There are two types of varistor. 1) Silicon carbide in which the slope of I-V curve changes relatively gradually. 2) Metal oxide (zinc oxide) in which the slope of curve changes more abruptly.



Symbol

When either type varistor is exposed to high energy voltage transients, the varistor impedance changes from a high stand by value to a low conductive value, thus clamping the transient voltage to a safe level. The destructive energy of the incoming high voltage pulse is absorbed by the varistor, thus protecting voltage sensitive circuit components.

At low applied voltage, the metal oxide varistor is essentially an open circuit. When applied voltage exceeds rated clamping voltage, the device effectively becomes a short circuit protecting the component that it shunts.

The metal oxide type varistor has an encapsulated polycrystalline ceramic body, with metal contacts & wire leads. Zinc oxide & bismuth are mixed with other powdered metal additives & then pressed to discs & sintered at a temp above 1200°C.

Applications: The VDR are used to protect circuits & circuit components from inductive surge. Varistor is also used to boost EMV stabilizing circuits of TV. They are also used in bias compensating circuits.

Ex 1 :-What is the maximum value of 100 Ω resistor with tolerance band missing?

Ans:- Maximum Resistor value is = $100+20\%$
 $= 100+20 = 120\ \Omega$

Ex2:- What is the colour code for 2.7 k Ω ± 10% resistor

Ans:- We know that $2.7\ \text{k}\ \Omega \pm 10\% = 2700 \pm 10\%$
 colours are red violet red silver.

Resistance colour code:--

All carbon composition and film resistors are colour-coded to indicate their resistance in ohms. In this system, the bands of different colours are used to identify the resistance and tolerance value. Generally there are four bands which indicate the value of that resistor. Reading from left to right the first colour band close to the end indicates the first digit in numerical value. The second band gives second digit. The third band is the decimal multiplier, giving the number of zeros after the two digits. Fourth band indicates the tolerance. The power rating is determined from the physical size of a resistor. Following table represent the colour code of resistors.

Colour	Significant Digit	Multiplier	Tolerance
<u>B</u> lack	0	1	
<u>B</u> rown	1	10	
<u>R</u> ed	2	100	
<u>O</u> range	3	1000	
<u>Y</u> ellow	4	10000	
<u>G</u> reen	5	100000	
<u>B</u> lue	6	1000000	
<u>V</u> iolet	7	10000000	
<u>G</u> rey	8	100000000	
<u>W</u> hite	9	1000000000	
Gold		0.1	± 5%
Silver		0.01	± 10%
No Colour			±20%

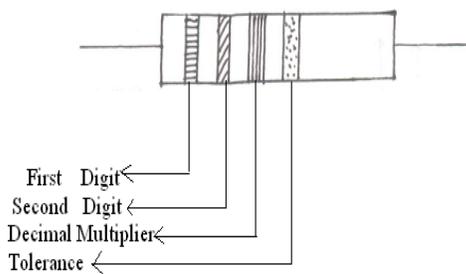


Fig.: colour code for resistors

For Ex: If colours from left to right are Red, Violet, and Red Gold.

Then resistance value is $2700 \pm 5\% \ \Omega$.

Resistance Colour Code for Values Less Than 10 Ω:--

In this case, the third band is either Gold or Silver. If the third band is Gold, multiply the first two digits by 0.1. If it is Silver, then multiply by 0.01. However the forth band represents the tolerance value as earlier.