Theoretical Short Notes Series- Module SE1
for SSC, RRB, KPSC, KSEB

SCORE ACADEMY

This note is for theoretical topics only. Please refer class sessions for numerical & application-level topics

Topic: Electrical Resistance

(Diploma/ ITI level questions)
Also relevant for AE level exams

- The property of a substance which opposes the flow of electric current (or electricity) through it is called Resistance

OR

- Resistance is the ability of a circuit which opposes current **(Detailed Explanation in Video Session 2.1_Comprehensive Electrical)**

- It is a passive two terminal electrical component.

The unit of resistance is OHM (Ω) where 1Ω = 1V/1A which is derived from the basic electrical Ohm's law, V = IR.

- The reciprocal of the Resistance is called Conductance
- Unit of conductance is mho "℧" or Ω^{-1}

Other definitions of Ohm "Ω" are as follows:

- If there is a potential difference of 1 volt between two ends of the conductor and the current flowing through it is 1 Ampere, then the resistance of that conductor would be 1 Ohm (Ω).

OR

- If 1 ampere of current is flowing through a resistance, and 1 joule per second (1Watt) energy (in the form of heat) is generated, then the measurement of that resistance is 1 Ω.

OR

- Ohm is the measurement quantity of resistance, which produces one joule of energy (in the form of heat) in one second, when one ampere of current is flowing through it.

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TYPES OF RESISTORS

Resistors are available in different size, shapes and materials. The figure below shows the different types of resistor chart/tree.

There are two basic types of resistors:

1. Linear Resistors
2. Non-Linear resistors

1. Linear Resistors

Those resistors, whose values change with the applied voltage and temperature, are called linear resistors. In other words, a resistor, whose current value is directly proportional to the applied voltage, is known as linear resistors. The linear resistors are of two types; ***Fixed Resistors and Variable Resistors***

1.1 Fixed Resistors:

Fixed resistors are the type of resistors which offers a fixed amount of resistance in the circuit. A fixed resistor cannot be changed as it is set at a specific value.

Advantages:

- They are very cheap and small in size, hence, occupy less space
- They are reliable and available in different ohmic and power ratings.
- Fixed resistor can be easily connected to the circuit and withstand for more voltage

Disadvantages:

- They are less stable.
- Their temperature coefficient is very high.
- They make a slight noise as compared to other types of resistors.

Types of Fixed Resistors

a) Carbon Composition Resistors
b) Wire Wound Resistors
c) Thin Film Resistors
d) Thick Film Resistors

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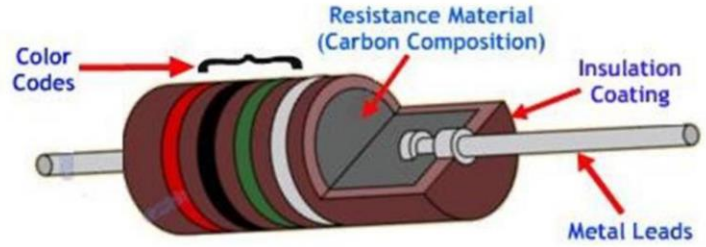
Carbon Composition Resistors

Carbon composition resistors often called carbon composite are an old type of resistor that is not used in new equipment these days. The carbon composition resistor was able to withstand the operating environment of the equipment for which it was used, but in comparison with the standards of today its performance was poor in several respects.



Construction: A typical fixed resistor is made from the mixture of granulated or powdered carbon or graphite, insulation filler, or a resin binder. The ratio of the insulation material determines the actual resistance of the resistor. The insulating powder (binder) is made in the shape of rods and there are two metal caps on the both ends of the rod.

There are two conductor wires on the both ends of the resistor for easy connectivity in the circuit via soldering. A plastic coat covers the rods with different colour codes (printed) which denote the resistance value. They are available in 1 Ω to 25 MΩ and in power rating from ¼ watt to up to 5 Watts.

Applications

i. The composition resistor is used in the high energy pulses.
ii. It has a relatively small size.
iii. High voltage power supplies
iv. Welding
v. High power.

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1.1.2 Wire wound resistor

Wire wound resistor is made from the insulating core or rod by wrapping around a resistive wire. The resistance wire is generally Tungsten, Manganin, Nichrome or Nickel or Nickel Chromium alloy and the insulating core is made of porcelain, Bakelite, press bond paper or ceramic clay material.

The Manganin wire wound resistors are very costly and used with the sensitive test equipments e.g. Wheatstone bridge. They are available in the range of 2 W up to 100 W power rating or more. The ohmic value of these types of resistors is 1 Ω up to 200KΩ or more and can be operated safely up to 350°C.

The power rating of a high power wire wound resistor is 500 W and the available resistance values of these resistors are 0.1 Ω – 100k Ω

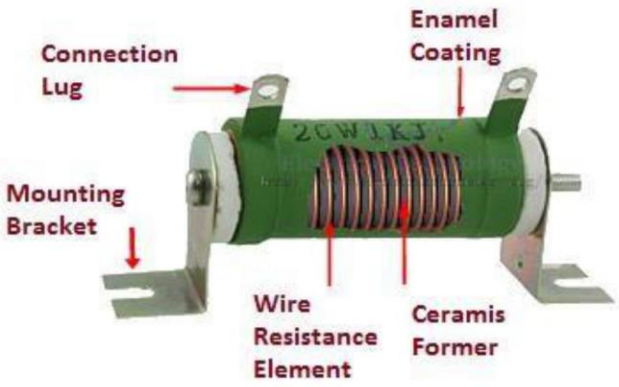

Fig: Wire wound resistor

Advantages:

i. Wire wound resistors make lower noise than carbon composition resistors.
ii. Their performance is well in overload conditions.
iii. They are reliable and flexible and can be used with DC and Audio frequency range.

Disadvantages:

i. They are costly
ii. They can't be used in high frequency equipment.

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Applications:

i. Wire wound resistors are used where high sensitivity, accurate measurement and balanced current control is required, e.g. as a shunt with ampere meter.
ii. Wire wound resistors are generally used in high power rating devices and equipment, Testing and measuring devices, industries, and control equipment.

1.1.3 Thick film resistor

Basically, all thick film resistors are made of high grid ceramic rod and a resistive material. A very thin conducting material layer overlaid on insulating rod, plate or tube which is made from high quality ceramic material or glass.
There are three further types of thick film resistors.

i. Metal Oxide Resistors

By oxidizing a thick film of Tin Chloride on a heated glass rod (substrate) is the simple method to make a Metal oxide Resistor. These resistors are available in a wide range of resistance with high temperature stability. In addition, the level of operating noise is very low and can be used at high voltages.

ii. Cermet Oxide Resistors (Network Resistors)

In the cermet oxide resistors, the internal area contains on ceramic insulation materials. And then a carbon or metal alloy film or layer is wrapped around the resistor and then fix it in a ceramic metal (which is known as Cermet). They are made in the square or rectangular shape and leads and pins are under the resistors for easy installation in printed circuit boards. They provide a stable operation in high temperature because their values do not change with change in temperature.

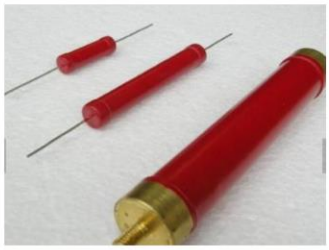

Fig: Cermet resistor

iii. Fusible Resistors

These kinds of resistors are same like a wire wound resistor. When a circuit power rating is increased than the specified value, then this resistor is fused, i.e. it breaks or opens the circuit. That's why it is called Fusible resistors.

They used widely in TV Sets, Amplifiers, and other expensive electronic circuits. Generally, the ohmic value of fusible resistors is less than 10 Ohms.

1.1.4 Thin film resistors

The production method of Thin film resistors is same like thick film resistors, but the difference is that there is a thin film instead of a thin film or layer of resistive material around. That's why it is called Thick film resistors.

There are two additional types of thin film resistors.

i. Carbon film resistors

Carbon Film resistors contains an insulating material rod or core made of high-grade ceramic material which is called the substrate. A very thin resistive carbon layer or film overlaid around the rod. These kinds of resistors are widely used in electronic circuits because of negligible noise and wide operating range and the stability as compared to solid carbon resistors.

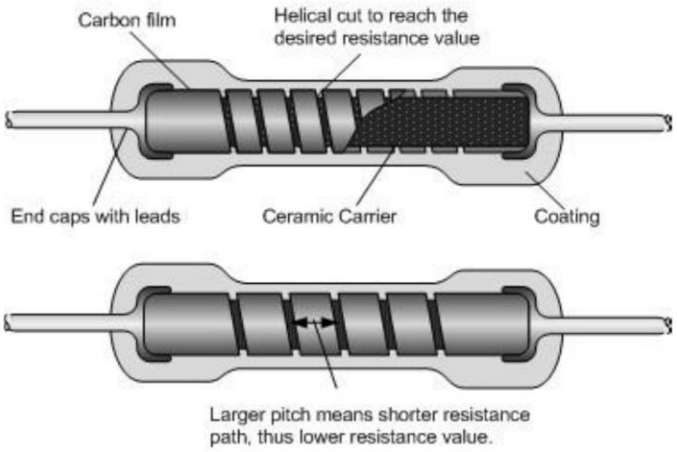

Fig: Carbon film resistor

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ii. Metal film resistors.

Metal film resistors are same in construction like Carbon film resistors, but the main difference is that there is metal (or a mixture of the metal oxides, Nickel Chromium or mixture of metals and glass which is called metal glaze which is used as resistive film) instead of carbon. Metal film resistors are very tiny, cheap and reliable in operation. Their temperature coefficient is very low (±2 ppm/°C) and are used where stability and low noise level is important.

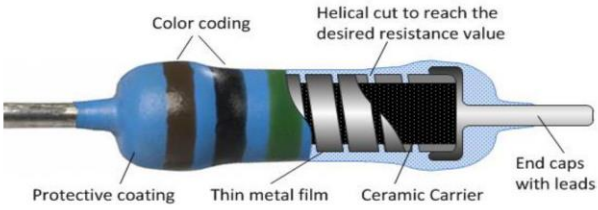

Fig: Metal Film Resistor

This theoretical short note is relevant for ***KPSC JE/ Sub – Engineer Level exams***

Few questions/topics are useful for AE level exams also

ELECTRICAL INSPECTORATE, KSEB/ KPSC Assistant Engineer, PWD Assistant Engineer, Sub Engineer, Tradesman, Junior Instructor, Overseer, SSC JE, Electrician

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1.2 Variable Resistor

As the name indicates, those resistors whose values can be changed through a dial, knob, and screw or manually by a proper method. In these types of resistors, there is a sliding arm, which is connected to the shaft and the value of resistance can be changed by rotating the arm. They are used in the radio receiver for volume control and tone control resistance.

There are mainly three types of variable resistors:

i. Potentiometers
ii. Rheostats
iii. Trimmers

1.2.1 Potentiometers

Potentiometer is a three terminal device which is used for controlling the level of voltage in the circuit. The resistance between two external terminals is constant while the third terminal is connected with moving contact (Wiper) which is variable. The value of resistance can be changed by rotating the wiper which is connected to the control shaft.

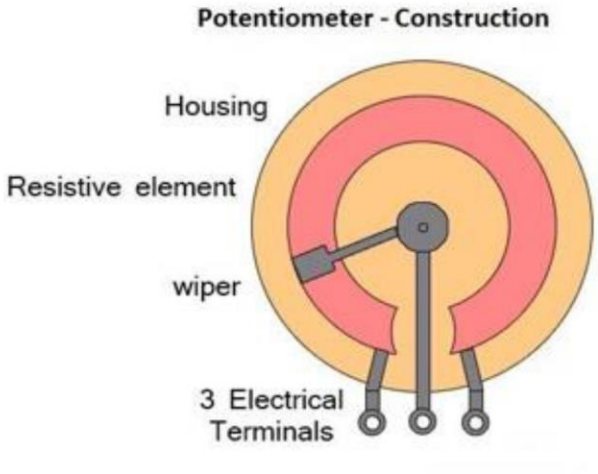

Fig: Potentiometer

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1.2.2 Rheostat

A rheostat is a variable resistor which is used to control current. They are able to vary the resistance in a circuit without interruption. The construction is very similar to the construction of potentiometers. It uses only two connections, even when 3 terminals (as in a potentiometer) are present. The first connection is made to one end of the resistive element and the other connection to the wiper (sliding contact).

In contrast to potentiometers, rheostats have to carry a significant current. Therefore, they are mostly constructed as wire wound resistors. Resistive wire is wound around an insulating ceramic core and the wiper slides over the windings.

Fig: Different types of Rheostats

Applications

a. Used as Power control devices, for example to control light intensity (dimmer), speed of motors, heaters and ovens.
b. Rheostat is generally used in the applications where high voltage or current is required

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What is the main Difference between Potentiometer and Rheostats?

Basically, there is no difference between Potentiometer and Rheostat. Both are variable resistors. The main difference is the use and circuit operation.

For example, if we connect a circuit between resistor element terminals (where one terminal is a general end of the resistor element while the other one is sliding contact or wiper) as a variable resistor for controlling the circuit current, then it is Rheostats.

On the other hand, if we do the same as mentioned above for controlling the level of voltage, then this variable resistor would be called a Potentiometer.

1.2.3 Trimmers

There is an additional screw with Potentiometer or variable resistors for better efficiency and operation and they are known as Trimmers. The value of resistance can be changed by changing the position of screw to rotate by a small screwdriver.

They are made from carbon composition, carbon film, cermet and wire materials and available in the range of 50 Ohms up to 5 mega ohms. The power rating of Trimmer potentiometers is from 1/3 to ¾ Watts.

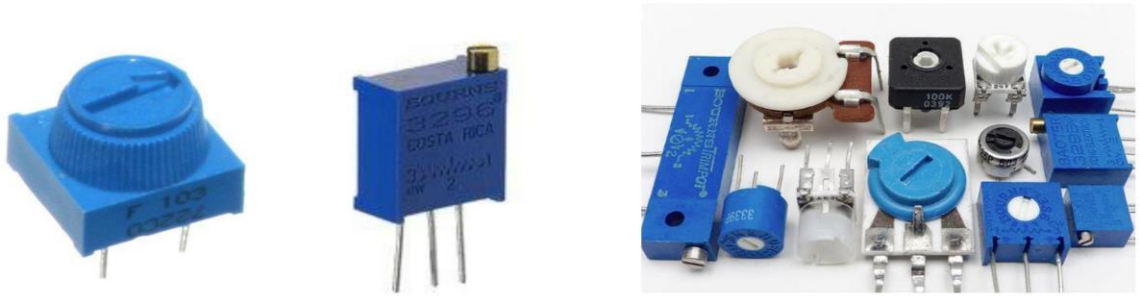

Fig: Different types of Trimmers

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2. Non-Linear Resistors

Nonlinear resistors are those resistors, where the current flowing through it does not change according to Ohm's Law but, changes with change in temperature or applied voltage.

In addition, if the flowing current through a resistor change with change in body temperature, then these kinds of resistors are called Thermistors. If the flowing current through a resistor change with the applied voltages, then it is called a Varistors or VDR (Voltage Dependent Resistors).

Following are the additional types of Non-Linear Resistors.

i. Thermistors
ii. Varistors (VDR)
iii. Photo Resistor or Photo Conductive Cell or LDR
iv. SMD (Surface Mount Technology) Resistors

2.1 Thermistors

Thermistors are a two terminal device which is very sensitive to temperature. In other words, Thermistors is a type of variable resistor which notices the change in temperature. Thermistors are made from the cobalt, Nickel, Strontium and the metal oxides of Manganese. The Resistance of a Thermistor is inversely proportional to the temperature, i.e., resistance increases when temperature decrease and vice versa.

It means, Thermistors has a negative temperature coefficient (NTC) but there is also a PTC (Positive Temperature Coefficient) which a made from Barium Titanate semiconductor materials and their resistance increases when increases in temperature.

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Fig: Different types of Thermistors and Construction

Applications:

i. *Very low temperature thermometers*: They are used as resistance thermometers in very low- temperature measurements
ii. *Digital thermostats*: These thermistors are also commonly used in modern digital thermostats
iii. *Battery pack monitors*: As modern batteries such as Li-ion batteries are very sensitive to overcharging, the temperature provides a very good indication of the charging state, and when to terminate the charge cycle
iv. *In-rush protection devices*: Thermistors can be used as in-rush-current limiting devices in power supply circuits. They present a higher resistance initially which prevents large currents from flowing at turn-on, and then heat up and become much lower resistance to allow higher
v. current flow during normal operation. These thermistors are usually much larger than measuring type thermistors, and are purpose designed for this application

2.2 Photo Resistor or Photo Conductive Cell or LDR (Light Dependent Resistors)

Photo Resistor or LDR (Light Dependent Resistors) is a resistor which terminal value of resistance changes with light intensity. In other words, those resistors, which resistance values changes with the falling light on their surface is called Photo Resistor or Photo Conductive Cell or LDR (Light Dependent Resistor). The material which is used to make these kinds of resistors is called Photo conductors, e.g., cadmium sulfide, lead sulfide etc.

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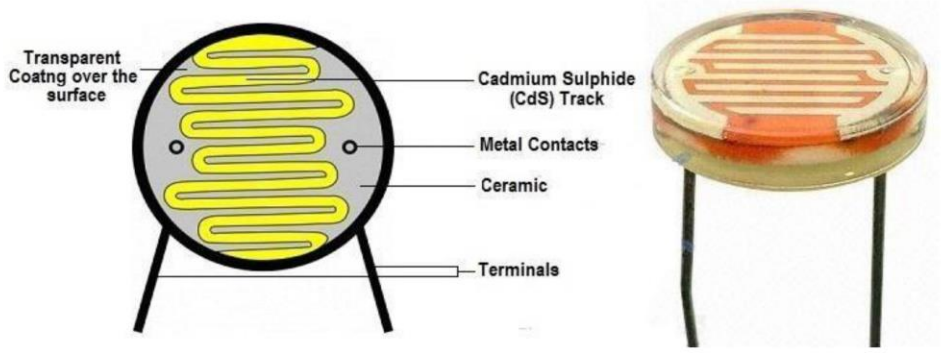

Fig: Typical diagram of LDR

When light falls on the photoconductive cells (LDR or Photo resistor), then there is an increase in the free carriers (electron hole pairs) due to light energy, which reduce the resistance of semiconductor material (i.e., the quantity of light energy is inversely proportional to the semiconductor material). It means photo resistors have a negative temperature coefficient.

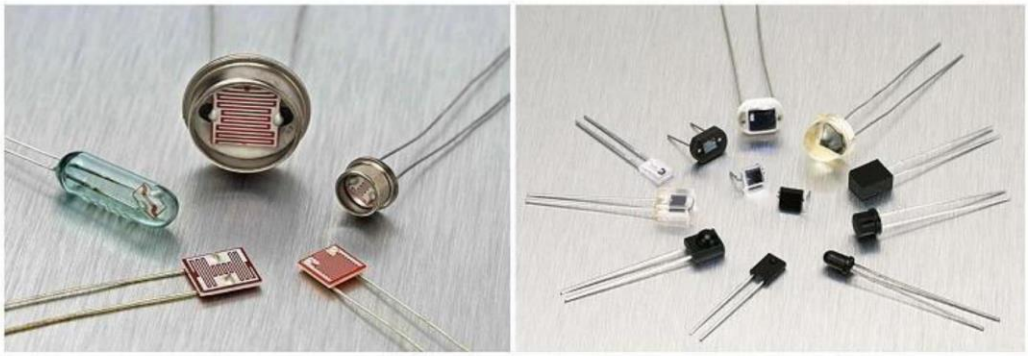

Fig: Types of Photo Conductive cells

2.3 Varistors

Varistors can be considered to be a form of resistor in which the resistance changes significantly with the applied voltage. The most common type of Varistors utilize a metal oxide and hence they are often known as Metal Oxide Varistors or MOV for short.

In view of the fact that their resistance is dependent upon the voltage applied, they can also be known as voltage dependent resistors.

Their more familiar name Varistor, is derived from the fact that these components are 'variable-resistors', the word, Varistor is a contraction of the two words.

Applications:

1. Surge protected power adaptors and strips.
2. Telephone and other communication lines.
3. Power supplies - typically those connected to mains power lines.
4. General electronics equipment protection.
5. Automotive electronics - car electrics are notorious for having many spikes on the power lines.
6. Industrial high energy AC line protection.

Varistors are also used in some circumstances as microwave mixers for modulation, detection and also frequency conversion, although this is not a standard application.

Varistors are able to provide vital protection for electronic circuits that can be subject to impulses and voltage spikes. They are able to divert the energy to ground and, in that way, protect equipment. These Varistors are used in many items like surge protected main sockets and the like. These are used for protecting computers and other items of equipment that may be susceptible to mains surges and spikes.

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Level -1 Questions

(KPSC, SSC, RRB JE/State PSC/ KSEB **previous Diploma /ITI level questions)**

1. Which one of the following is a passive element to an electric circuit? (SSC 2018 -S-1)
   A. Current source
   B. Voltage source
   C. Resistors
   D. Battery
2. Which one of the following is the mathematical expression of the Ohm's Law? (SSC 2018 -S-1)
   A. V = I
   B. V = R/I
   C. V = I.R
   D. V = R
3. If 1st band = Orange; 2nd band = Orange; 3rd band = Orange; and I = 10 mA, then by using the formula of Ohm's law find the value of voltage source which powers the source
   A. 3 V
   B. 33 V
   C. 330 V
   D. 500 V
4. The meter which measures resistance is known as
   A. Ammeter
   B. Multimeter
   C. Voltmeter

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D. Ohmmeter

5. Which of the following insulator is most effected by heat?
   A. PVC
   B. Mica
   C. Paper
   D. Leatheroid

6. The resistance of a perfect insulator is equal to
   A. Zero
   B. Kilohms
   C. Mega Ohms
   D. Infinite

7. The resistance of wire is measured by using
   A. Voltmeter
   B. Ammeter
   C. Fluxmeter
   D. Multimeter

8. Which among the following is a nonlinear resistance?
   A. Wire wound resistor
   B. Metal Oxide resistor
   C. Fusible resistor
   D. Thermistor

9. The reciprocal of resistance is
   KPSC 2005
   A. Reactance
   B. Admittance
   C. Permeability
   D. Conductance

10. For carbon resistance, what is the colour for 4?
    A. Green
    B. Yellow
    C. Black
    D. Grey

11. Which type of resistors is called as thermistors?
    A. PTC resistors
    B. Varistors
    C. LDR
    D. NTC resistors

12. For human body the ear-to-ear resistance is about
    A. 100 ohms
    B. 400 ohms
    C. 1000 ohm
    D. 800 ohms

13. Fourth color band of a resistance is brown in four color band system, the tolerance of the resistance is
    A. 2%
    B. 5%
    C. 1%
    D. 3%

14. A tolerance of 20% in the value of carbon resistor is represented by
    A. Gold band
    B. Black band
    C. Silver band
    D. Without any band

15. With the rise in temperature; the resistance of carbon
    A. Decreases
    B. Increases
    C. Becomes zero
    D. Remains unchanged

16. The OTC resistor is called
    A. Thermistors
    B. Sensistors
    C. Varistors
    D. LDR

17. An example of non-ohmic resistance is
    A. Copper wire
    B. Carbon resistance

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C. Aluminum wire
D. Tungsten wire

D. Tin Sulphate

18. Resistance of a material always decreases if.
A. Temperature of a material is decreased
B. Temperature of a material is increased
C. No: of free electrons available become more
D. None of the above

Resistance - Level-1 Questions/ KEY			
1.	C	11.	D
2.	C	12.	A
3.	C	13.	C
4.	D	14.	D
5.	C	15.	A
6.	D	16.	B
7.	D	17.	D
8.	D	18.	C
9.	D	19.	D
10.	B	20.	A

19. Resistance of earth should be
A. High
B. Low
C. Infinite
D. The minimum possible

20. The material used in Metal Oxide resistor is
A. Tin Chloride
B. Barium Sulphate
C. Lead Oxide

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