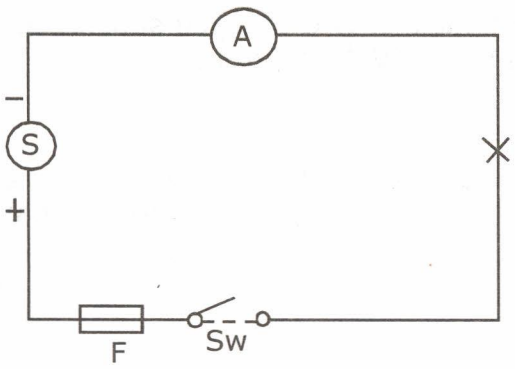
Positive Charge

The absence of electrons in the other material is called positive charge.

Current

The flow of electrons in one direction, negative to positive is called Current. Its symbol is 'I' & it's unit is 'ampere', symbol is 'A'. Ammeter is used for measuring current. It is connected in series with load & supply.



S = Source
F = Fuse
SW = Switch
L = Lamp
A = Ammeter

Fig: 3 Connection of ammeter.

Electron theory current flow & conventional current flow. According to the electron theory, current flow is always from a negative charge (–) to a positive charge (+).

Before the electron, theory of matter was discovered, this concept of current flow is called conventional current flow. For your study of electricity, current flow is concluded to be the same as convential current i.e. Current flows from positive terminal of the source to the negative terminal of source through the load.

UNIT AMPERE

One ampere of current is said to flow through a conductor when one coulomb of charge flows per second of charge flows per second across a cross-section of the conductor. (1 ampere = 1 coulomb / 1 second)

ELECTROMOTIVE FORCE

When the current flows, the electrical energy of the charges is utilized to move electrons/ charges from positive to negative terminals. This electrical energy is called electromotive force. Symbol is e.m.f. The unit of e.m.f. is volts & its symbol is 'V'. In other words when electrons/ charges move from one terminal to another terminal as current flows the moving force is Electromotive force. Voltmeter is used for measuring e.m.f.

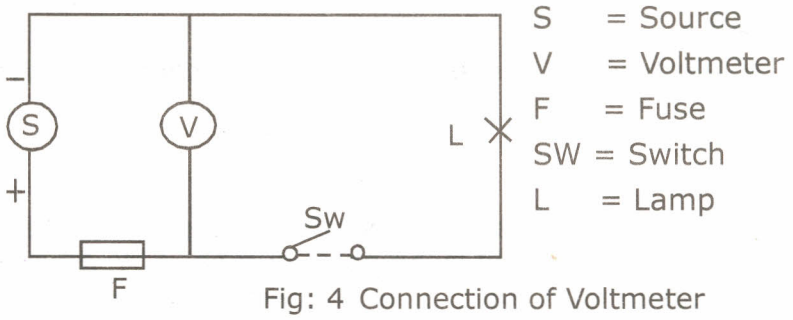


Fig: 4 Connection of Voltmeter

POTENTIAL DIFFERENCE

The difference in the electric potentials of two charged substances is called Potential Difference. Its unit is 'Volt' & symbol is 'V'.

UNIT VOLT

A potential of 1 Volt at a point means that 1 Joule of work is done in bringing a positive charge of 1 coulomb from infinity to that point.

1Volt = 1 Joule/ 1 second.

RESISTANCE

The opposition to current flow is not the same for all material. Current flow itself is the movement of 'free' electrons in a material determines its opposition to current flow. Atoms of some materials give up their outer electrons easily & such materials offer little opposition to current flow, while other materials hold on to their outer electrons & such materials offer considerable opposition to current flow. Every material has some opposition to current flow, whether large or small & this opposition is called resistance.

OR

The property of a substance which opposes the flow of current through it is called resistance. Its symbol is 'R'. The unit of resistance is 'ohm' & its symbol is Ω

UNIT OHM

One ohm is defined as resistance of that conductor which allows a passage or a current of one ampere through it when a potential difference of one volt is maintained across its ends.

INTEXT QUESTIONS 4.1

a) Fill in the blanks:

1. A body which has definite weight & which occupies some space is called _____.

2. Smallest particle of a matter is known as _____.
3. Electrons consist of _____ charge.
4. The flow of electrons in one direction is called _____.
5. Unit of current is _____.

b) State True or False:

1. Protons consist of negative charge. ( )
2. Ammeter is connected in parallel. ( )
3. The unit of EMF is Volt. ( )
4. Opposition to the current is known as resistance. ( )
5. Ohm is unit of resistance. ( )

4.4 ELECTRICAL POWER

Power means rate of doing work. Whenever, voltage causes electron movement, work is done in moving electrons/ charge from one point to another. The rate at which work is done is called electric power. Its symbol is 'P'. The basic unit of power is the Watt, which equals the voltage multiplied by the current. Its symbol is Watt. The wattmeter is used for measuring power.

To find the power, following formula is used -

$$P = E \times I$$

Where,

P = Power, in watt,

E = Voltage, in volt,

I = Current, in ampere.

Ex. 1 An electric resistance iron takes a current of 4 ampere at a e.m.f. of 230 Volts, calculate the power of lamp?

Ans: $P = E \times I$

$= 230 \times 4$

$= 920$ Watts

Horsepower–It is a unit of measurement of mechanical power.Its symbol is hp

$1hp = 75mkg / s$

$= 75 \times 9.81$

$= 735.5$ Nmls or watt. (1 kg weight = 9.81N).

Module-4

Notes

INTEXT QUESTIONS 4.2

1. Define the electrical power?

2. An electric heater takes a current 4.35 ampere at EMF of 230 volts calculate the power of electric heater?

4.5 ELECTRICAL ENERGY

Capacity for doing work is called energy. That means energy required for electrical work done in a particular time period is called electrical energy. Its symbol is 'E'. The unit of electrical energy is kilowatt hours and its symbol is Kwh. If 1 kwh power is used in 1hour the energy consumed is 1 kilowatt hour. Or Board of Trade Unit (B.O.T.V.)

$$Kwh = \frac{I \times E \times H}{1000}$$

Where,

Kwh = Kilowatt in units

E = E.m.f, in volt

I = Current in ampere

h = hour

Ex. 1 A motor running on 230-v mains is takes 35 amperes current, for period of 50 hours per week. If the cost of power is Rs. 4 per unit find the cost of running, this motor for 5 hours working.

$$= \frac{230 \times 80 \times 30 \times 4}{1000}$$

$$= \frac{230 \times 35 \times 50}{1000}$$

= 402.5 units.

Bill = Kwh × Rate per unit

= 402.5 × Rs. 4

= Rs. 1610

INTEXT QUESTIONS 4.3

1. What is energy?

2. A motor running on 230V. Mains take 80 amperes current from the mains. It is used 4 hours per day. If it is used 30 days & rate is Rs. 3 per unit, calculate the bill.

4.6 WHAT YOU HAVE LEARNT

- In this unit you have learnt about basic terms of electricity.
- Basic term of current its symbol, unit.
- Basic term of EMF & its symbol unit.
- Connection of Ammeter & voltmeter.
- Definition of resistance & its unit.
- Definition of power & its unit.
- Definition of energy & its unit.
- Simple examples of power & energy.

4.7 TERMINAL QUESTIONS

1. What is Matter? Explain in detail.

5. Write a short notes on the Following:

a) Atom

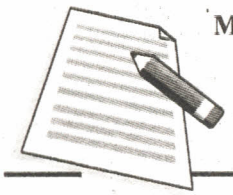
b) Molecule

c) Nucleus

d) Proton

e) Neuteron

f) Electron



4.8 ANSWER TO INTEXT QUESTIONS

4.1

a) Fill in the blanks:

1. Matter
2. Atom
3. Negative
4. Current
5. Ampere

b) True or False:

1. False
2. False
3. True
4. True
5. True

4.2

1. Power means rate of doing work.

2. $$P = \frac{E \times I}{1000}$$

$$= \frac{230 \times 4.35}{1000}$$

$$= 1Kw$$

4.3

1. Capacity for doing work is called energy.

2. $$Kwh = \frac{E \times I \times H \times D}{1000}$$

$$= \frac{230 \times 80 \times 30 \times 4}{1000}$$

$$= 2208 \text{ units.}$$

$$Bill = 2208 \times Rs.\ 3$$

$$= Rs.\ 6624$$

5

CIRCUITS & OHM'S LAW

5.1 INTRODUCTION

In earlier lesson we have studied the basic electricity. Now you are well aware of voltage, current, resistance etc. In this lesson we will discuss about circuits, their types, uses etc. & ohm's law.

5.2 OBJECTIVES

After reading this lesson you will be able to:

- Understand the Electric circuit.
- Know the types of circuit with its respective effects.
- Define the Ohm's law
- Understand Laws of resistance.
- Classify the circuits:

  Series circuit , Parallel circuit & Series- Parallel circuit

5.3 ELECTRIC CIRCUIT

Basically, an electric circuit consists of a power source, a safety device, controlling device and a device & wires to connect each other.

Simple Circuit

In this figure circuit consisting of only one lamp having resistance, safety device like fuse, controlling device like one way switch, & the voltage source and the connecting wires, it is called simple circuit.

In this circuit D.C. generator, battery, or mains are sources and fuse is a safety device which is used to protect generator from heavy current.

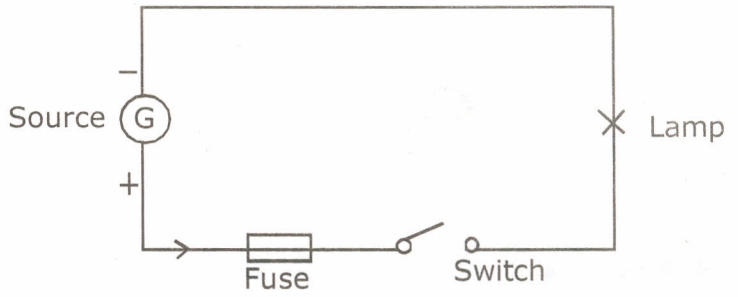


Fig: 5.1 Simple Circuit

Switch is used as controlling device to break the path of current i.e. to make on/ off lamp.

A Lamp is a device which converts electrical energy into light energy as a device. We can use fan, tubelight, motors etc.

In this circuit, when supply voltage is applied to the electrical device conventional current flows from positive terminal (+) of generator through the fuse element. Thereafter, it reaches one terminal of the switch, if switch is on it goes to second terminal of switch, next it goes to one terminal of lamp, current travels through the filament of lamp then it returns to negative terminal of generator through negative wire. This is complete path of electrical current.

Closed Circuit

In close circuit, when supply voltage is applied to the electrical device, conventional current start to flows from positive terminal (+) of generator through positive wire. It reaches one terminal of fuse & come out from another terminal of switch through the fuse element. Next it reaches one terminal of the switch, if switch is on it goes to second terminal of switch, next it goes to one terminal of lamp, current travels through one filament of lamp then it returns to negative terminal of generator through negative wire. This is complete path of electrical current. Resistance of close circuit is always medium & some power is wasted in this circuit.

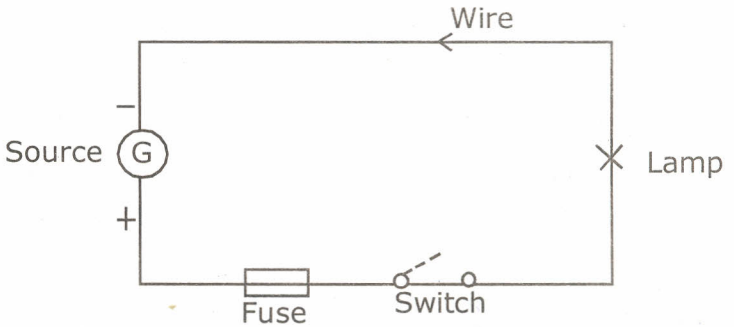
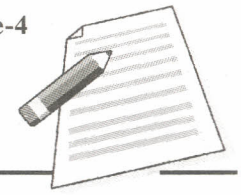


Fig: 5.2 Closed Circuit



Open Circuit

You already know that for current to flow through a circuit, a closed path must be provided between positive (+) & negative (–) terminals of the voltage source any, break in the closed path open the circuit & stops the flow of current.

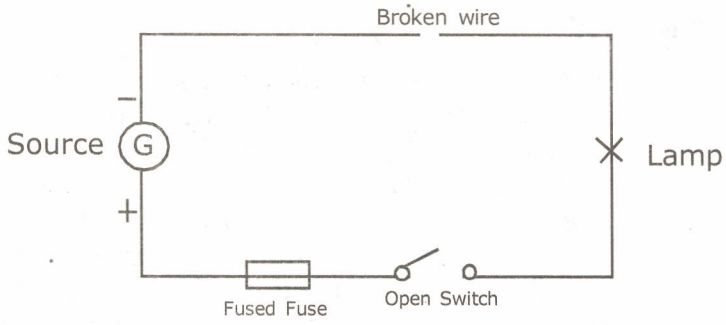


Fig:5.3 Open Circuit

Any break in the circuit is known as open circuit. Open switch, a wall socket, broken wire, fused lamps, switch off are examples of open circuit. In an open circuit, there is an infinitely high resistance in the circuit; there is no voltage drop across the load. There is also no power used by the load & so the total power consumed in a circuit is zero.

Short circuit

You have seen how an open circuit prevents current flow by breaking the closed path between terminals of the voltage source.

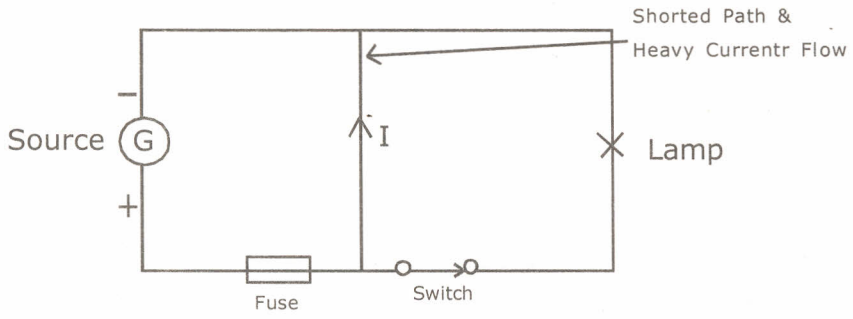


Fig: 5.4 Short Circuit

A short circuit produces just the opposite effects. A short circuit occurs whenever, the resistance of a circuit or part of circuit drops from its normal value to essentially zero resistance. This happens if two terminals of a lamp in circuits are directly connected, the voltage source leads contact each other or two current carrying uninsulated wires touches or the circuit is improperly wired these types of shorts are called short circuit.

The resistance of the circuit becomes so very low that a very high current flows through the circuit. It causes to damages wiring, equipment or source.

Circuits are usually protected against excessive current flow, by the use of fuses.

5.4 OHM'S LAW

You have seen that if a certain current flows in a circuit, it flows because a certain electromotive force & that the amount of current is limited by the resistance of the circuit. The amount of current depends upon the amount of electrical pressure & amount of resistance. This fact was discovered by a George S. Ohm & now it is famous as Ohm's law which is the fundamental equation of an electrical science. Since it was first started in 1827. Ohm's law is that the current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance. Following formula's used to find out current, resistance, voltage.

$$I = \frac{E}{R},\ R = \frac{E}{I},\ E = I \times R$$

Where,

I = Current, in ampere

E = Voltage, in volt

R = Resistance, in Ohm

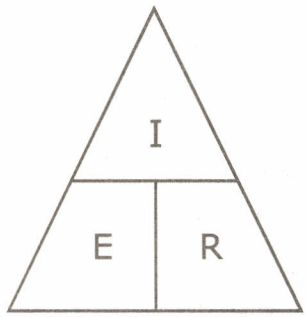


Fig: 5.5 Triangular of
Voltage, Current, Resistance

An aid to remembering the Ohm's law relationship is shown in the divided triangle.

If you know the voltage & resistance of the circuit, you can find out current, then by simply applying the following equation -

$$I = \frac{E}{R}$$

Ex - 1. A 100 Ohms resistance is connected across 230 volts DC.Supply. Calculate the current flowing through the circuit?

Ans- Given- E = 230 V. R = 100 Ohms

$$\frac{E}{R} = \frac{230}{100} = 2.3A$$ ...Ans.

If you know resistance & current of the circuit, you can find out voltage, by applying the following equation -

$$E = I \times R$$

Ex - 2. A current of 5 ampere of flowing through resistance, Calculate supply voltage?

Ans- Given

I = 5A R = 50 Ohms

$E = I \times R = 5 \times 50 = 250$ Volts

E = 250 Volts

...Ans.

If you know the voltage & current of the circuit, you can find out resistance by applying the following equation -

$$R = \frac{E}{I}$$

Ex - 3. A resistance is connected across 230 volts DC supply if current passing through the resistance is 12.5 ampere. Calculate the value of resistance?

Ans- Given

I = 12.5 ampere E = 230 Volts

$$R = \frac{E}{I} = \frac{230}{12.5}$$

R = 18.4 Ohms ...Ans.

INTEXT QUESTION 5.1

(A) Fill in the blanks:

1. Fuse is a _____ device.
2. Lamp is a device which converts _____ energy in _____ energy.

3. In simple circuit power source device & _____ device & _____ device are used.
4. A complete path of electrically current is _____ circuit.

(B) State True or False:

1. The lamp is the power source.
2. Piano type switch are used as controlling device.
3. In a close circuit current flows from positive terminal of source to the negative terminal of source through given resistance.
4. The relationship between voltage, current, resistance is given ohm's law.
5. To find out infinity value of current flowing through circuit then ohm's law used.

(C) Match the pairs

a) Voltage	1) Switch
b) Current	2) Volts
c) Resistance	3) Fuse
d) Controlling device	4) Ohm
e) Safety device	5) Ampere

LAW OF RESISTANCE

You have seen that the current flowing through the circuit depends upon voltage & current. Now we are going to see on which factors resistance depends, these factors are known as laws of resistance.

1. The resistance of the conductor to varies directly with its length. The longer length, greater the resistance, shorter the length, lower the resistance.

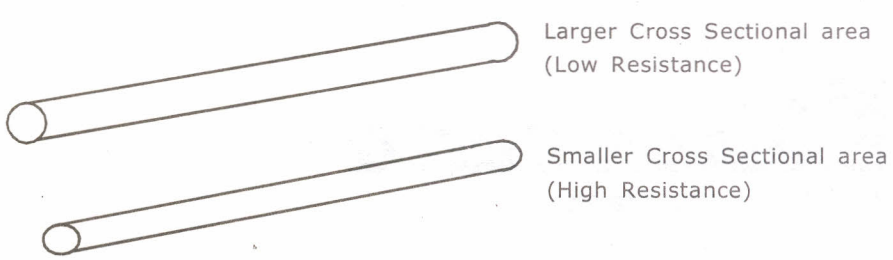


Fig: 6 Relation between resistance and cross sectional area

Ex 1. The resistors of 10 ohm's, 15 ohm's, and 30 ohm's are connected in series across a battery, what is the total resistance?

Ans- Given,

R_1 = 10 ohms R_2 = 15 ohm

R_3 = 30 ohm

$R_T = R_1 + R_2 + R_3$

$R_T = 10 + 15 + 30$

R_T = 55 Ohm ...Ans.

In a series circuit there is only one path for current flow, this means that all the current must flow through each resistance in the circuit.

Ans- $I_T = I_1 + I_2 + I_3$

where,

I_T = Total current, in ampere

$I_1 + I_2 + I_3$ = Individual current of each resistance in ampere.

Ex 2. A series circuit consists of 3 resistors having values of 20 ohms, 30 ohms and 50 ohms respectively calculte the current flowing through the circuit and current flowing through each resistance if it is connected 200 volts supply?

Ans- Given,

R_1 = 20 ohms R_2 = 30 ohms

R_3 = 50 ohms E = 200 Volt

First we calculate R_T

$R_T = R_1 + R_2 + R_3$

$= 20 + 30 + 50$

= 100 ohms.

Now we calculate current (total)

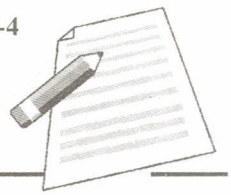
$$I_T = \frac{E}{R_T} = \frac{200}{100} = 2A$$ ...Ans.

The resistance are connected in series so current flowing through

R_1, R_2, R_3 is = 2A

therefore, I_1 = 2A, I_2 = 2A, I_3 = 2A

In series circuit the sum of the resistance voltage drop must equal to source voltage.



2. The resistance of the conductor is inversely proportional to its cross-sectional area. The larger cross sectional area of a conductor, smaller the resistance & the smaller cross-sectional area, higher the resistance.
3. The resistance of the conductor depends upon the material. Each material offers a different resistance to the movement of electrons. Silver, Copper, Gold, Aluminum material has low resistance, with respective its resistance.
4. The resistance of conductor depends on the temperature of the conductor. At higher or lower temperature, the resistances of all material changes. In most cases, the temperature of a material goes up, its resistance also goes up, but with some other material, increased heat causes the resistance to go down the amount that resistance is affected by each degree of temperature changed is called temperature co-efficient.

5.5 CLASSIFICATION OF CIRCUITS

We seen a simple circuit in which source, fuse, switch & lamps are connected in series with the help of wires. In this circuit only one lamp was connected. However, you will often find that a circuit has more than one load. It may have 2, 3, 4 or a number of lamps or resistance. They may be connected in series or parallel.

Series Circuit

Whenever you connect resistances end to end they are said to be series connected. If all the resistances around a circuit are connected in end to end so that there is only one path for current flow. They form a series circuit. In series circuit total resistance equals, the sum of the individual resistances. There total resistance of series circuit we can calculate by following equation-

$$R_T = R_1 + R_2 + R_3$$

where,

R_1, R_2, R_3 = Individual Resistance; in ohms

R_T= Sum of individual resistances; in ohms.

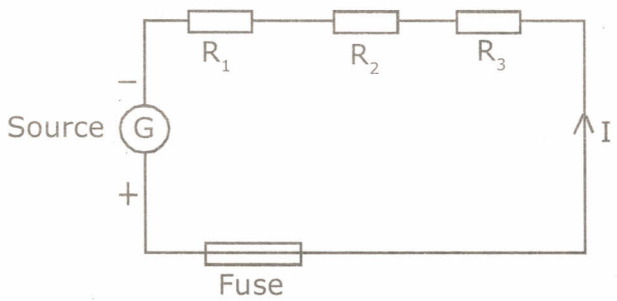


Fig: 5.7 Series circuit

Example - 2. A series circuit consist of 3 resistors having values of 20, 30 & 50 ohms respectively. Find the applied voltage, if the current through circuit is 2 ampere?

Ans- Given,

R_1 = 20 ohms, R_2 = 30 ohms, R_3 = 50 ohms, I = 2A

Let us calculate voltage drop across each resistance.

$V_{R_1} = I \times R_1 = 2 \times 20 = 40$ V

$V_{R_2} = I \times R_2 = 2 \times 30 = 60$ V

$V_{R_3} = I \times R_3 = 2 \times 50 = 100$ V

therefore, $V_{R_1} = 40$ V, $V_{R_2} = 60$ V, $V_{R_3} = 100$ V

Once individual voltage drops are known they can be added to find total or applied voltage.

therefore, $E_1 = V_{R_1} + V_{R_2} + V_{R_3}$

$= 40 + 60 + 100$

$= 200$ V

$E_1 = 200$ V ...Ans.

The total voltage drop across a resistor in a circuit is proportional to the ohmic value of the resistors.

OPEN CIRCUIT IN SERIES

You already know that a current to pass through a circuit, a closed path is required, so any break in the series circuit causes an open circuit, & stops current flow. There is no power wastage in circuit.

If more than 2 lamps are connected in series and if one of them is fused then there is no current flowing through the circuit and so one lamp will light.

SHORT CIRCUIT IN SERIES

If the short circuit created in series circuit the total resistance will be reduces & a large current will flow through the circuit.

Uses of series circuit:

1. Decorative
2. Fan regulator which is connected in series with fan can reduce the speed.
3. To measure circuit current with the help of ammeter.
4. The fuse used for protection of electrical installation.
5. To control the speed of DC Motors.
6. To increase the battery voltages.

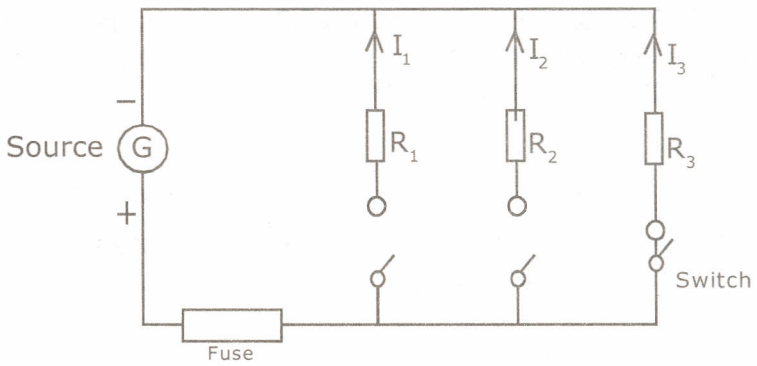


Fig: 8 Parallel Circuit

Parallel Circuit

When you connect resistances side by side with the ends connected, they are parallel connected. A parallel circuit is one in which there are one or more points where current divided & flows different paths.

When circuit connected in such a way that they provide different current paths it is to be said that connected in parallel. In parallel circuit, total resistance is not the sum of individual resistances. More resistances there are the lower is the total resistance & total resistance is smaller than any of the individual resistance. The total resistance can be find out by a $\frac{\text{Product}}{\text{Sum}}$ or product over the Sum method to use this method you first multiplied the values of two resistances to get their product then added the values of two resistances to get there sum. Finally you divide the $\frac{\text{Product}}{\text{Sum}}$, & the result is total resistance following equation may be used.

$$R_T = \frac{\text{Pr oduct}}{\text{Sum}} = \frac{R_1 \times R_2}{R_1 + R_2}$$

This method can be used only for two parallel resistances. This method is not suitable for more than two resistances which are connected in parallel.

Combinations of 3 or more unequal resistances in parallel are sometimes used. To find the resistance of such combinations, you first find the total resistance of any two of the resistances. Combine this total in the same way with another of the resistance values & you have total for 3 resistances. Continue to combine the total with additional resistances until all of the resistances has been combine to give the total resistance of all parallel resistances.

You can apply another method also, to find out the effective resistance of the parallel circuit.

therefore, $\frac{1}{\text{Reff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

The reciprocal of the resistance $\frac{1}{R}$ is known as the conductance of a circuit. Using this term,

you can state that the combined conductance of a number of conductors in parallel is equal to sum of their separate conductance.

e.g. 1. 4 ohms, 2 ohms & 6 ohms respectively 3 resistors are connected in parallel. Calculate the combined resistance (Reff.) of the circuit.

Ans- Given,

R_1 = 4 ohms

R_2 = 2 ohms

R_3 = 6 ohms

$$\frac{1}{Reff} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{4} + \frac{1}{2} + \frac{1}{6}$$

$$= \frac{3+6+2}{12} = \frac{11}{12}$$

Reff $= \frac{12}{11}$ = 1.1 ohms therefore, Reff = 1.1 ohms

Parallel circuit voltages

In this type of circuit the voltages across each branch resistance is equal to that across the other. In other words, in a parallel circuit, the same voltage is present across the resistors of a parallel group. This voltage is equal to the applied voltage.

therefore, $V_T = V_{R_1} = V_{R_2} = V_{R_3}$

e.g. 1. 3 resistors of 4ohms, 2 ohms , & 6ohms respectively are connected in parallel. If current flowing through 4 ohms resistance is 2.5 A, current flowing through 2 ohms resistance is 5 A & current flowing through 6 ohms resistance 1.68 A, calculate voltage across each resistance & supply voltage?

Ans: Given-

R_1 = 4 ohms

R_2 = 2 ohms

R_3 = 6 ohms

$V_{R_1} = I \times R_1 = 2.5 \times 4 = 10$ V

$V_{R_2} = I \times R_2 = 5 \times 2 = 10$ V

$V_{R_3} = I \times R_3 = 1.68 \times 6 = 10$ V

$V_T = V_{R_1} = V_{R_2} = V_{R_3}$

1 = 10 = 10 = 10 = 10V

therefore, V_T = 10 V

Current in Parallel Circuit:

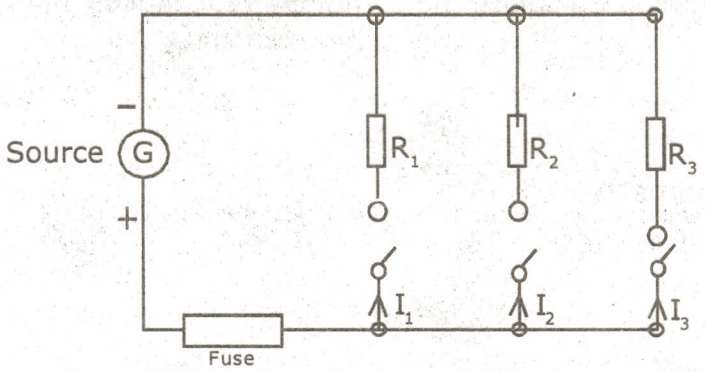


Fig: 9 Current in parallel Circuit

Current divides among the various branches of a parallel circuit in a manner depending on the resistance of each branch. However source current in a parallel circuit divides among the available paths in relation to the value of resistors in the circuit for a given voltage current varies inversely with resistance.

e.g.1. Three resistances of 10 ohms, 20 ohms & 30 ohms respectively are connected in parallel across 50 volts DC supply calculate the current flowing through each circuit & total current of the circuit?

Ans- Given

R_1 = 10 ohms

R_2 = 20 ohms

R_3 = 30 ohms

E = 50 V

$I_{R_1} = \frac{E}{R_1} = \frac{50}{10} = 5$ A

$I_{R_2} = \frac{E}{R_2} = \frac{50}{20} = 2.5$ A

$I_{R_3} = \frac{E}{R_3} = \frac{50}{30} = 1.67$ A

R_3 30

therefore, I_{R_1} = 5 A, I_{R_2} = 2.5 A, I_{R_3} = 1.67 A

Let us calculate circuit current:

$I_{R_T} = I_{R_1} + I_{R_2} + I_{R_3}$

$= 5 + 2.5 + 1.67$

$I_{R_T} = 9.17$ A

Short in Parallel Circuit

The equivalent resistance of the straight wire & the resistors, all connected in parallel, will be less than the resistance of the straight wire. This follows from the fact that the total resistance of a parallel circuit is always less than the smallest resistance in the branch. Since a complete path still exists to permit current flow, & the equivalent resistnce is effectively zero, the current will rise rapidly until the current capacity of the fuse is reached. The fuse will then open the circuit causing the current to stop flowing. A short usually causes components to fail in a circuit which is not properly used or otherwise protected. The failure may take the form of burned out resistor, damaged source or a fire in the circuit components & wiring.

Uses of parallel circuit

1. In general lighting (house, shops, offices)
2. Ammeter shunt.

Series - Parallel Circuit

Circuits consisting of three or more resistors may be connected in, partly series, & partly parallel one in which a resistance is connected in series with a parallel combinations & the other in which one or more branches of a parallel circuit consist of resistances in series. While solving circuit first solve parallel circuit first solve parallel circuit & then series circuit by applying parallel circuit & series circuit laws respectively.

5.6 WHAT YOU HAVE LEARNT

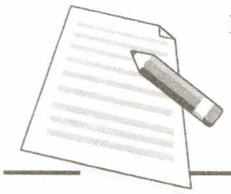
In this unit you have learnt about circuits & ohms law. We also learn the simple circuit i.e. electric circuit. Close circuit, open circuit, short circuit are the types of circuit. Ohms law founded by George S.Ohm.

This is the Formula of to find out the voltage, current resistance. We studied:

the Laws of resistance and Classification of circuit.

5.7 TERMINAL QUESTIONS

1. Which factors consist by an electrical circuit?
2. What do you mean by close circuit?
3. What are the examples of open circuit?



4. What is the meaning of short circuit?
5. State the ohm's law?
6. State ohms law with equations?
7. What is simple circuit? Explain with neat diagram
8. Write a short note on series circuit
9. Write a short note on parallel circuit
10. State the uses of series circuit parallel circuit & series parallel circuit?

5.8 ANSWER TO INTEXT QUESTIONS

(A) 5.1

1. Safety
2. Electrical, light energy
3. Safety, controlling
4. Closed

(B) True or False:

1) True
2) True
3) True
4) False
5) True

(C)

(a) - 1
(b) - 2
(c) - 4
(d) - 1
(e) - 3

6

WIRE & CABLES

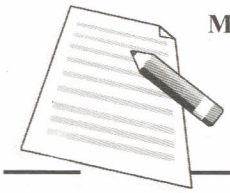
6.1 INTRODUCTION

In previous lesson we have studied about simple circuit, types of circuit, their characteristics, ohm's law & its applications, series and parallel circuit. Do you know that we always need some types of conductors and insulators to produce electricity, to transmit, to distribute and to use the electricity. We will discuss the conductors, insulators, wire and cables in this lesson.

6.2 OBJECTIVES

After the reading this lesson, you will be able to:

- Understand Conductor, Conductance, Resistance.
- Classify of conductors.
- Explain use of conductors.
- Know types of wires and its uses.
- Standard Wire Gauge.
- Identify the Cables, types of cable.
- Use of cables.
- Understand the Current carrying capacity of wire and cable.
- Learn the Conductors splices and terminals connections.
- Know Types of terminal.



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Notes

6.3 CONDUCTOR

A conductor is a wire or combination of wires not insulated, suitable for carrying electric current is called Conductor.

Conducting Material

The material / substance which permit the free motion of electric current through it is known as conducting material. From these conducting material we makes round and strip shape conductors which are suitable for carrying current in electrical work.

Conductance

The ability of substance which allows to flow of current through it is called' conductance".

Its symbol is 'G'.

The unit of conductance is 'Mho' and its symbol $\mho$. It is exactly opposite of resistance.

Resistance

It is a property of material which opposes the flow of current through it is called resistance.

Its symbol is 'R'.

The unit of resistance is ohm.

CLASSIFICATION OF CONDUCTORS

A conductors are classified in:

(1) With respective Physical Appearance

a) Solid conductor.

b) Stranded conductor.

c) Multistranded conductor.

d) Flexible conductor.

(2) With respective material used

a) Bright electrolyte grade copper.

b) Electrical grade aluminum conductor.

(3) With respective of their property

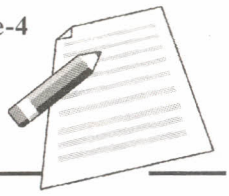
a) Good conductor.

b) Bad conductor.

c) Non conductor (Insulators).

(4) With respective their shapes

a) Round shape.



b) Strip shape.

c) Rod shape.

d) Rope shape.

(1) With respective Physical Appearance:

a) Solid conductor

A single wire is known as solid conductor. They are used in cable, over head wiring and house wiring. It is available in different diameters.

Usually the conductor is made up of copper, aluminum and steel.

b) Stranded conductors

The group of conductors having small diameter with respective solid conductors are known as stranded conductors. They are used generally because of their increased flexible and consequent case in handling. In stranded conductors 1, 7, 19, 37 strands having 1.13 to 3.73 mm diameter are used.

c) Multistranded conductors

Conductors having smaller diameter with respective stranded conductors are known as multistranded conductors. This type of conductors are used in multistranded wires and cables. In multistranded wires 14, 22, 24,84 strands having 0.2 or 0.3 mm diameter are used.

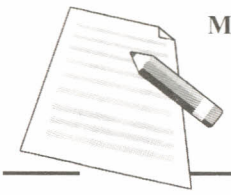
d) Flexible conductors

Conductor having smallest diameter with respective multistranded conductors are known as Flexible Conductor. This type of Conductor is used for domestic appliances. In Flexible Conductors 14, 23, 40 strands having diameter of less than 0.2 are used.

(2) With respective of material used

a) Electrical grade copper – Copper has a higher conductivity. It can be drawn out, has relatively high stencil strength and it can be easily soldered. It is more expensive and heavier than aluminum. It is used for wires, cables, bus bars. Now a days, copper wire must be used in house wiring, ranging from 1.5 sq.mm., 4 sq.mm., 6 sq.mm.

b) Electrical grade aluminum – Aluminum has lower conductivity about 60% of copper. It is cheap and lighter than copper. Generally, it is used in transmission and distribution line, bus bar and body of motor etc. They are available in 1 sq.mm. 5 sq.mm., 4 sq.mm.,6 sq.mm. sizes.



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Notes

c) G. I. Wire – G. I. Wire has a lowest conductivity. It can be drawn out in small gauge. It has very high stencil strength. It is heavier than aluminum and it is used in transmission line, in over-head line and to give strain to pole.

(3) With respective of their property

a) Good conductors – Those conductors which offer very low resistance are called good conductors. Such as silver, copper, aluminum etc. They are used for carrying current from one place to another place.

b) Bad conductors – Conductors which offer medium resistance are called bad conductors. Tungsten, Eureka, Nicrome and Carbon are the bad conductors. They are used for converting electrical energy in heat, light, chemical sound effects.

c) Non conductors – The substances which offers very high resistance to the flow of electric current are called non conductors or insulator.

Porcelain, bakelite, asbestos, glass, rubber and pvc are examples of non conductors. They are used for covering the conductors.

USES OF CONDUCTORS:

1. To carry the current from one place to another place.
2. Making bus bar.
3. For strengthening the pole.
4. Making fuse wire.
5. Making heating wire.
6. Making a connection of appliances to supply.

6.4 Wire: Wire is used to carry the current from one place to another

Types of wire

1. According to insulation -

Old type

a) V. I. R. wires.

b) C. T. S. wires.

c) T.R.S. wires.

d) Lead cover wire.

New type

a) PVC wires.

b) PVC FR wires.

c) PVC F.R.L.S. wire.

2. According to conducting material -

a) Copper conductor wires.

b) Aluminum conductor wires.

3. According to voltage grade -

a) Low Voltage grade wires.

b) Medium voltage grade wires.

c) High voltage grade wires.

4. According to uses-

a) Domestic wires.

b) Industrial wires.

c) Winding wires.

d) Heating wires.

1) According to insulation

(a) V.I.R. wires-(Vulcanized India Rubber)

In this type of wire a tinned copper conductors or aluminum conductors are used. The conductors are covered by Vulcanized India Rubber. It is then covered with cotton tape and cotton braiding. Finally, it is dipped in bitumen compound. The copper conductor is tinned to provide protection against corrosion due to presence of traces of sulphur, zinc oxide and other mineral ingredients in the V.I.R. It is available in single cotton covered, double cotton. It is available in 1/18, 3/20, 3/22, 7/20, 7/22, 7/16, 19/22, 19/16 sizes. It is suitable for indoor conduct wiring, casing capping wiring and cleat wiring. This type of wire is available in single core only. It is suitable for low and medium voltage supply only.

(b) C.T.S. wire-(Cabe Tyre Sheath wire)

In this type of wires, a tinned copper conductors are used. These conductors are covered by red and black color rubber. It is then coated with a layer of hard rubber. It is available in sizes 1/18, 3/20, 7/22 etc. It does not absorb moisture. It is used in batten wiring service lines and short distance overhead lines. It is available in 250/440 voltage grade only.

(c) T.R.S. wires-(Tough Rubber Sheath)

V.I.R., C.T.S., T.R.S. wires are old types wires which are not used in market.

(d) PVC wires

In this type of wire, copper or aluminum conductors are used. Conductors are covered by polyvinyl chloride insulation. It is available in sizes $1mm^2$, $1.5mm^2$, $2.5mm^2$, $4mm^2$ etc. It is available in single core, twin core and three core. Now a days PVC wires are widely used. Its life is long. It can be used in PVC conducts PVC casing capping, overhead wiring etc. These are not sensitive to mild dose of water, heat, oil, acid, alkalis, sunrays, ultraviolet rays etc. It is available in 600, 660, 1100 Voltage grade. F.R. wires and F.R.L.S. wires are widely used, because current carrying capacity and voltage rating is more than old PVC wires.

Uses of wires

1. Multistranded wires are used in domestic wiring.
2. Stranded wires are used in domestic and small industries wiring.
3. Solid wires are generally used in domestic wiring.

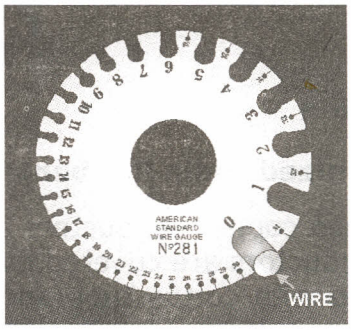


Fig: 6.1 Standard Wire Gauge

STANDARD WIRE GAUGE

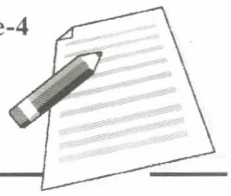
The standard wire gauge (SWG) is an instrument used for determining the size of a conductor of the wire and cable. It is a thin circular plate of steel with a number of slots on its circumference. Each slot is marked with specific number denoting gauge. Holes are provided at the end of each slot for removing the wire easily.

INTEXT QUESTIONS 6.1

1) Fill in the blanks:

1) The conductors which offer very low resistance are called _____.

2) The conductors which offer medium resistance are called _____.



2) Match the following:

1)	Good conductor	a)	Size of conductor
2)	PVC Wire	b)	Silver
3)	Non conductor	c)	Porcelain
4)	Standard Wire Gauge	d)	Polyvinyl Chloride

6.5 CABLES

A cable is either a stranded conductor (single-conductor cable) or a combination of conductors insulated from one another. The term cable is a general one and in practice it is usually applied only to the larger sizes of conductors. A small cable is more often called a stranded wire or cord. Cables may be bare or insulated. The insulated cables may be covered with lead, or protective armor.

Types of Cables

Cables can be classified according to various factors given below:

1) According to insulation:

a. Cotton covered Cable.

b. Silk coated Cable.

c. Asbestos covered Cable.

d. Rubber coated Cable.

e. PVC coated Cable.

2) According to conductors material:

a. Copper.

b. Aluminium.

3) According to their shapes:

a. Round shape.

b. Flat shape.

4) According to cores:

a. Two core.

b. Three core.

c. Three and half core.

5) According to mechanical protection:

a. Unarmored.

b. Armored.

6) According to voltage grade:

a. Low voltage grade.

b. High voltage grade.

Uses of cables:

1. Small industries.
2. Big industries and factories.
3. Distribution lines.
4. Transmission lines (High voltage cable).
5. Low voltage cables are used in domestic wiring for appliances.

CURRENT CARRYING CAPACITY OF WIRE OR CABLE

It is a maximum safe value of current in amperes which can pass through a cable without generating heat above room temperature. Any excess current flowing above safe value will result in heating of cable in a very short duration which will damage the insulation and if persists for a long period will result in short circuit. Any insulation will always have a short time over current capability but it's not recommended to use this capability under normal operating conditions.

CONDUCTOR SPLICES AND TERMINAL CONNECTIONS

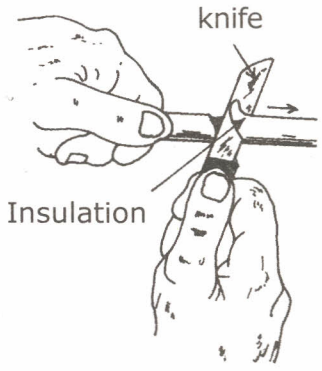


Fig: 6.2 Striping Insulation

Conductor splices and connections are an essential part of any electric circuit. When conductors join each other, or connect to a load, splices or terminals must be used. It is important that they be properly made splice or connection both mechanically and electrically as strong as the conductor or device with which it is used.

STRIPING THE INSULATION

The first step in making a splice is preparing the wires or conductor. Insulation must be removed from the end of the conductor and