

Basic Electricity - Introduction and uses of electricity, electric current AC,DC their comparison, voltage, resistance and their units

Electricity is a kind of energy. It is the most useful sources of energy which is not visible but its presence can be felt by its effects. Electricity is obtained by conversion of other forms of energy like heat energy, chemical energy, nuclear energy, mechanical energy and energy stored in water etc.,

To understand electricity, one must understand the structure of an atom.

Basically an atom contains electrons, protons and neutrons. The protons and neutrons are located in the centre of an atom and the electrons, a negative electric charge particle revolving around the nucleus in an atom. The proton has a positive charge. Neutrons are neutral and have no charge.

Sources of electricity

Battery

Battery stores electrical energy in the form of chemical energy and it gives power when required. Battery is used in automobiles and electronics, etc.,

Generator

It is a machine which converts the mechanical energy into electrical energy.

When a conductor rotates between a magnetic field using prime mover an emf will be induced. By using this method all types of AC and DC generator - generates power.

E.g. Thermal power station
Hydro power station
Nuclear power station
Wind power station
Solar power station

Thermo couple

If two dissimilar pieces of metals are twisted together and its joined end is heated in a flame, then a potential difference or voltage will be induced across the ends of the wires. Such a device is known as a Thermo couple. Thermo couple is used to measure very high temperature of furnaces.

Effects of electric current

When an electric current flows through a medium, its presence can be felt by its effects, which are given below.

1 Physical effect

Human body is a good conductor. when the body touches the bare current carrying conductor, current flows through the human body to earth and body gets severe shock or cause even death in many cases.

2 Magnetic effect

When an electric current passes through a coil, a magnetic field is produced around it.

E.g. : Electromagnet Motor, Generator, Electric bell

3 Chemical effect

When an electric current passes through an electrolyte, chemical action takes place. Because of that, an electrical energy is stored in a battery as a chemical energy.

E.g.: Electroplating, Cells and battery charging, refining of metals etc.,

4 Heating effect

When an electric current passes through any conductor, heat is produced in the conductor due to its resistance.

E.g. : Electric heater, Electric iron box, Electric lamp, Geyser, Soldering iron, Electric kettles, Electric welding etc.,

5 X-ray and Laser rays effect

When a high frequency voltage is passed through a vacuum tube, a special type of rays come out, which is not visible. These rays are called x-rays. Laser rays also can be produced by electric current.

6 Gas effect

When electrons pass through a certain type of sealed glass shell containing gas, then it emits light rays.

E.g: Mercury vapour lamp, Sodium vapour lamp, Fluorescent lamp, Neon lamp etc.,

Uses of Electricity

- | | |
|-----------------|---|
| 1 Lighting | - Lamps |
| 2 Heating | - Heaters, ovens |
| 3 Power | - Motor, fan |
| 4 Traction | - Electromotive, lift, crane |
| 5 Communication | - Telephone, telegraph, radio, wireless |
| 6 Entertainment | - Cinema, radio, T.V. |
| 7 Medical | - x-rays, shock treatment |
| 8 Chemical | - Battery charging, electroplating |
| 9 Magnetic | - Temporary magnets |
| 10 Engineering | - Magnetic chucks, welding, x-rays of welding |

Classification

- Static electricity
- Dynamic electricity

STATIC ELECTRICITY

If a dry glass rod is rubbed with silk cloth the glass rod gives out negative electrons, and therefore, becomes positively charged. The silk cloth receives negative electrons and therefore it becomes negatively charged. They acquire the property of attracting small pieces of paper etc. because like charges repel and unlike charges attract each other. The electric charge on the silk cloth is stationary and is called static electricity. This type of electricity cannot be transmitted from one place to another.

DYNAMIC ELECTRICITY

The electrons in motion are called current electricity or electric current. This type of electricity is carried through wires and cables. Therefore, this electricity can be transmitted from one place to another. This type of electricity can be produced by cells, batteries, generators alternators etc.

What is the difference between an atom and an element? How are molecules different from atoms? I am often asked these questions in my sessions over and over again and so I finally decided to write a comprehensive post on them. Find answers to all your questions in this section that is designed to help students explore and understand the relationship between atoms, elements, molecules, compounds and mixtures in a manner that is simple and easy to understand.

Types of electric current

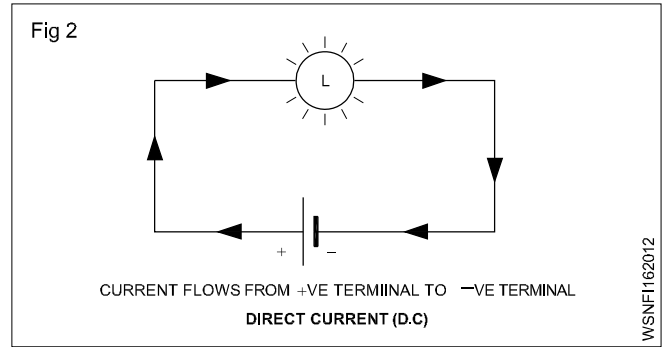
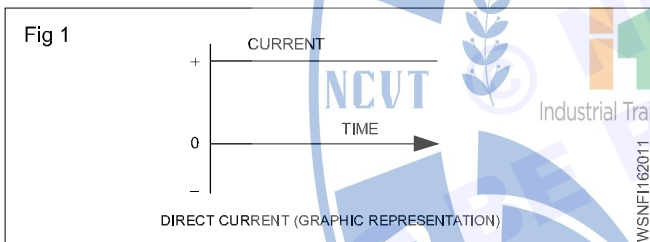
- Direct current
- Alternating current

Direct current

In direct current (DC) the direction and magnitude of the current does not change (Fig 1). The steady current flow will be from the positive terminal to the negative terminal. (Fig 2)

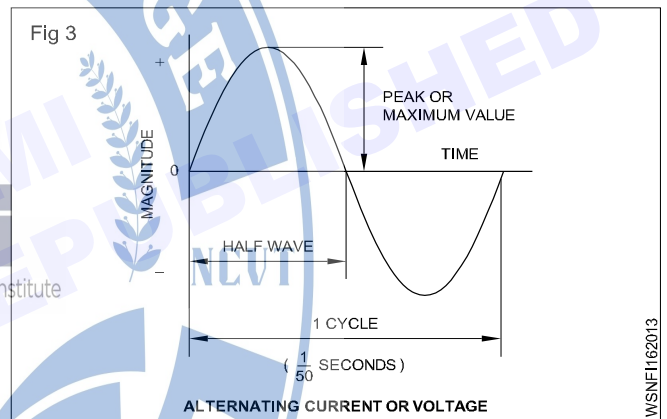
Examples

DC Sources : Cells, batteries and DC generators (Fig 2)



Alternating current (Fig 3)

The current flow will be from the phase terminal to the Neutral terminal. In the alternating current (AC) both the direction and magnitude of the current will be changing at definite intervals of time. The graph shows how an AC current or voltage changes with time. The current increases to the maximum value in one direction, falls to zero and increases to the maximum value in the other (opposite) direction before falling to zero again. Thus a cycle is one complete series of changes. The normal supply frequency is 50 cycles per second.



Difference between AC and DC

AC	DC
1 It is generated in the ranges of 6,600 V, 11000 V and 33,000 V.	It is generated up to 6,600 V only
2 Voltage can be stepped up or stepped down by using transformer	It is not possible
3 Transmission cost is less	Cost High
4 Less maintenance	High maintenance
5 Power up to 5,00,000 kw can be generated in a single alternator.	Power up to 10,000 kw can be generated in a single generator
6 AC generator can run at high speeds. So, speed control is not easy.	It can't run at high speeds. Speed control is easy.
7 Slip rings and brushes are used to collect the current.	Commutator and brushes are used to collect the current

Advantages of A.C.

- In transmission there is saving in copper wire.
- Since there is no spark in A.C. machine there is no interference in Radio sound.
- This can be produced to maximum voltage i.e. 33000volts.

- Voltage can be dropped or raised with the help of transformers.
- Its mechanism is simple and cheap.
- Output is more due to availability of more than one phase.

Disadvantages of A.C.:

- A single phase motor is not self-starter.
- Due to thin wire in A.C., the voltage drop is more.
- It cannot be used for electroplating and in charging secondary cells.
- The speed of motors run by it is difficult to change.
- There is danger to security due to high voltage.

Electrical terms and units

Quantity of electricity

The strength of the current in any conductor is equal to the quantity of electrical charge that flows across any section of it in one second. If 'Q' is the charge and 't' is the time taken,

$$\text{then } I = \frac{Q}{t} \quad Q = I \times t$$

The SI unit of current is coulomb. Coulomb is equivalent to the charge contained in nearly 6.24×10^{18} electrons.

Coulomb

In an electric circuit if one Ampere of current passes in one second, then it is called one coulomb. It is also called ampere second (As). Its larger unit is ampere hour (AH)

$$1 \text{ AH} = 3600 \text{ As (or) } 3600 \text{ coulomb}$$

Electro motive force (EMF)

It is the force which causes to flow the free electrons in any closed circuit due to difference in electrical pressure or potential. It is represented by 'E.' Its unit is Volt.

Potential difference (P.D)

This is the difference in electrical potential measured across two points of the circuit. Potential difference is always less than EMF. The supply voltage is called potential difference. It is represented by V.

Voltage

It is the electric potential between two lines or phase and neutral. Its unit is volt. Voltmeter is used to measure voltage and it is connected parallel between the supply terminals.

Volt

It is defined as when a current of 1 ampere flows through a resistance of 1 ohm, it is said to have potential difference of 1 volt.

Current

It is the flow of electrons in any conductor is called current. It is represented by 'I' and its unit is Ampere. Ammeter is used to measure the current by connecting series with the circuit.

Ampere

When 6.24×10^{18} electrons flow in one second across any cross section of any conductor, the current in it is one ampere. (or) If the potential difference across the two ends of a conductor is 1 volt and the resistance of conductor is 1 ohm then the current through is 1 ampere.

Resistance

It is the property of a substance to oppose to the flow of electric current through it, is called resistance. Symbol: R, Unit : Ohm (Ω), Ohm meter is used to measure the resistance.

Ohm

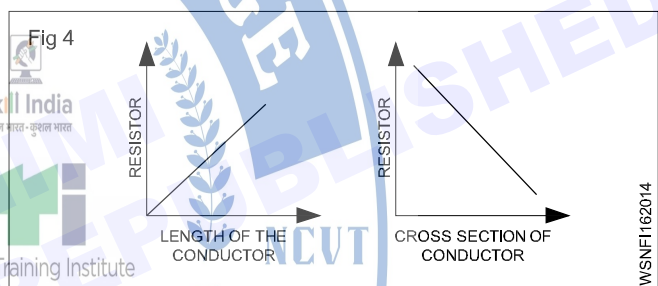
If the potential difference across the two ends of conductor is 1 volt and the current through it is 1 ampere, then the resistance of the conductor is 1 Ohm.

Laws of resistance

The resistance offered by conductor depends on the following factors.

The resistance of the conductor

- is directly proportional to the length of the conductor ($R \propto L$)
- Varies inversely proportional to its cross sectional area of the conductor ($R \propto \frac{1}{A}$)
- Depends on the material with which it is made.



- depends on the temperature of the conductor

$$R \propto L ; R \propto \frac{1}{A} ; R \propto \frac{L}{A} ; R = \rho \frac{L}{A}$$

Specific resistance

The specific resistance of a material is the resistance offered to a current it passed between the opposite faces of the unit cube of the material. Specific resistance is measured in Ohm - m or micro ohm - cm.

Each material has its own specific resistance or resistivity.

E.g. : Copper - $1.72 \mu\Omega \text{ cm}$, Silver - $1.64 \mu\Omega \text{ cm}$, Eureka - $38.5 \mu\Omega \text{ cm}$, Iron - $9.8 \mu\Omega \text{ cm}$, Aluminium - $2.8 \mu\Omega \text{ cm}$, Nickel - $7.8 \mu\Omega \text{ cm}$.

$$R = \frac{\rho l}{A} \text{ ohm cm}$$

R = Resistance in ohms

l = Length of the conductor in cm

ρ = Specific Resistance in ohm cm
(symbol pronounced as rho)

A = Area of cross - section in cm^2

Electric Power

In mechanical terms we defined power as the rate of doing work. The unit of power is Watt. In an electrical circuit also the unit of electrical power is 1 Watt. In mechanical terms 1 Watt is the work done by a force of 1 N to move the body through 1 metre in one second. In an electrical circuit, the electromotive force overcomes the resistance and does work. The rate of doing work depends upon the current flowing in the circuit in amperes. When an e.m.f of one volt causes a current of 1 ampere to flow the power is 1 Watt.

Hence Power = Voltage x Current

$$P = V \times I$$

Power in Watts = Voltage in Volts x Current in Amperes

Electric work, energy

Electrical work or energy is the product of electrical power and time

Work in Watt seconds = Power in Watts x time in sec

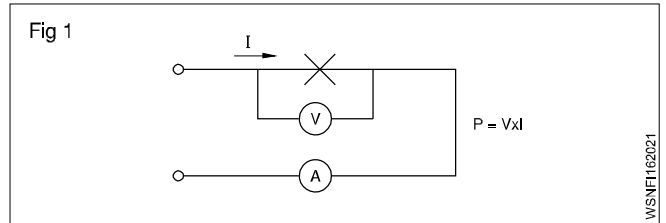
$$W = P \times t$$

Since 1 joule represents 1 Watt x 1 sec, which is very small, larger units such as 1 Watt hour and 1 kilowatt hour are used.

$$1 \text{ W.h} = 3600 \text{ Watt sec.}$$

$$1 \text{ Kwh} = 1000 \text{ Wh} = 3600000 \text{ Watt sec.}$$

Note: The charge for electric consumption is the energy cost per Kwh and it varies according to the country and states.



V - Voltage (Volts) V

i - Current Intensity (Amperes) A

P - Power (Watts, Kilowatts) W, kW

W - Work, Energy (Watt hour, Kilowatt hour) wh, Kwh

t - time (hours) h

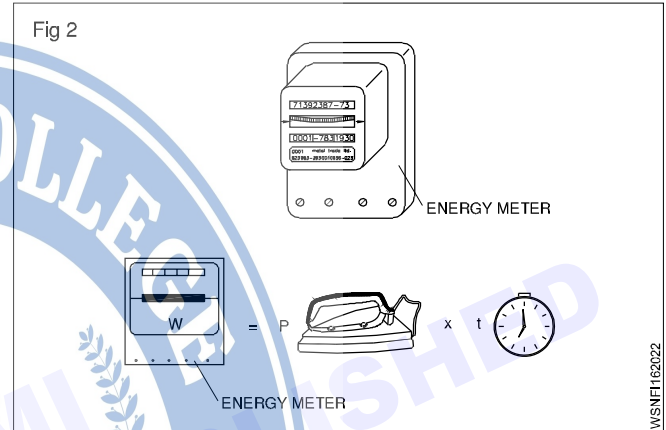


Table of analogies between mechanical and electrical quantities

Mechanical quantity	Unit	Electrical quantity	Unit
Force 'F'	N	Voltage 'V'	V
Velocity $v = \frac{\text{Displacement}}{\text{Time}}$	m/s	Current 'I'	A
Time 't'	seconds	Time 't'	seconds
Power $P = F \times v$	$N \frac{m}{\text{sec}}$	Power $P = V \times i$	$W = V \times A$
Energy = $F \times v \times t$	$j = Nm$	Energy $W = V \times i \times t$	$j = W \times s$

$$\begin{aligned}
 W &= VI \\
 &= I^2R \\
 &= \frac{V^2}{R} \\
 R &= \frac{V}{I} \\
 &= \frac{V^2}{W} \\
 &= \frac{W}{I^2}
 \end{aligned}$$

$$\begin{aligned}
 V &= IR \\
 &= \frac{W}{I} \\
 &= \sqrt{WR} \\
 I &= \frac{V}{R} \\
 &= \frac{W}{V} \\
 &= \sqrt{\frac{W}{R}}
 \end{aligned}$$