Introduction to electricity

Objectives: At the end of this lesson you shall be able to
- **describe electricity and structure of matter**
- **describe atomic structure**
- **describe the energy shell and electron distribution**
- **describe conductors, insulators and semi conductors.**

Introduction

Electricity is one of today's most useful sources of energy. Electricity is of utmost necessity in the modern world of sophisticated equipment and machinery.

Electricity in motion is called electric current. Whereas the electricity that does not move is called static electricity.

Examples of Electric current

- Domestic electric supply, industrial electric supply.

Examples of static electricity

Shock received from door knobs of a carpeted room. Attraction of paper of the comb.

Structure of matter

To understand electricity, one must understand the structure of matter. Electricity is related to some of the most basic building blocks of matter that are atoms (electrons and protons). All matter is made of these electrical building blocks, and, therefore, all matter is said to be 'electrical'.

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms.

Atomic Structure

Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, protons and neutrons. The protons and neutrons are located in the centre, or nucleus, of the atom, and the electrons travel around the nucleus in orbits.

The Nucleus

The nucleus is the central part of the atom. It contains the protons and neutrons of an atom as shown in Fig 1

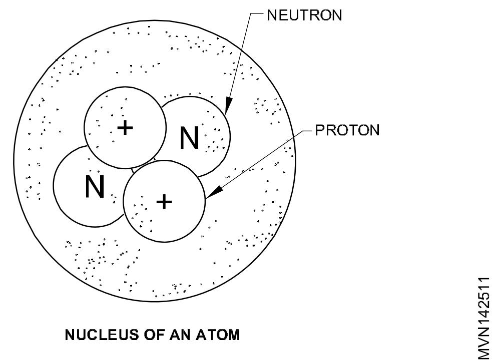
Protons

The proton has a positive electrical charge. (Fig 1) It is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

Electron

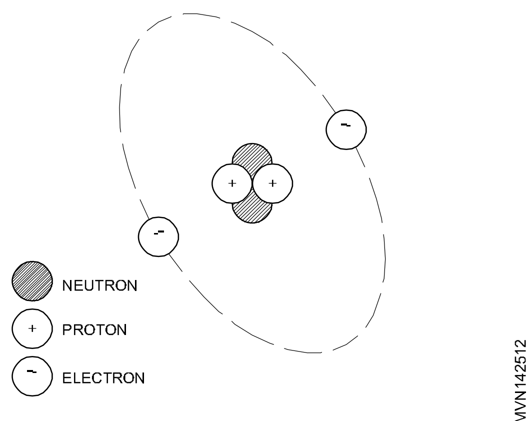
It is a small particle revolving round the nucleus of an atom as shown in Fig 2. It has a negative electric charge.

Fig 1



The electron is three times larger in diameter than the proton. In an atom the number of protons is equal to the number of electrons.

Fig 2



Neutron

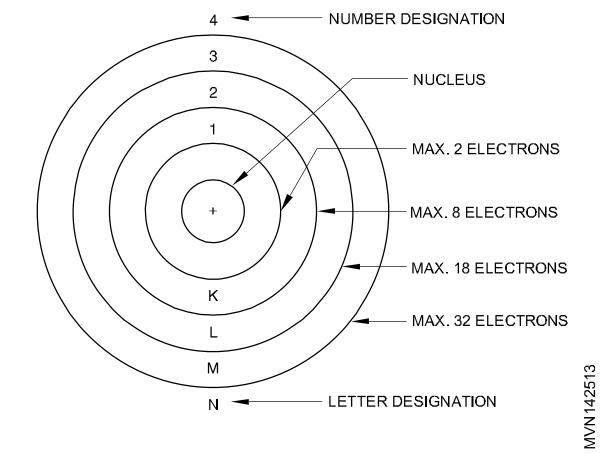
A neutron is actually a particle by itself, and is electrically neutral. Since neurtons are electrically neutral, they are not too important to the electrical nature of atoms.

Energy Shells

In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major steel layers are identified by numbers of by letters starting with 'K' nearest the nucleus and continuing alphabetically outwards. There is a maximum number of electrons that can be contained in each steel. Fig 3 illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

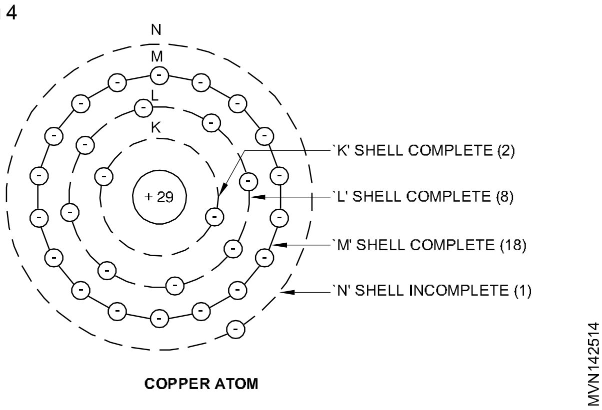
If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is

Fig 3



filled with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four sheels with a number of electrons in each shell as shown in Fig 4.

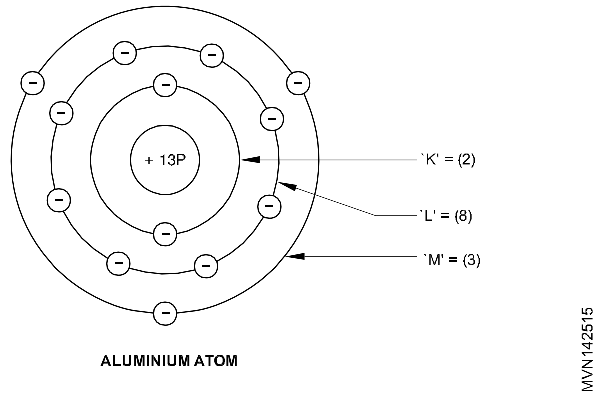
Fig 4



COPPER ATOM

Similarly an aluminium atom which has 13 electrons has 3 shell as shown in Fig 5.

Fig 5



ALUMINIUM ATOM

Electron distribution

The chemical and electrical behaviour of atoms depends on how completely the various shell and sub-shells are filled.

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Metals possess the following characteristics

- They are good electric conductors.
- Electrons in the outer shell and sub-shells can move more easily from one atom to another.
- They carry charge through the material.

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the attracting force exerted by nuclues on the valence electrons is less. Therefore, valence electrons can be set free most easily. Whenever a valence electron is removed from its orbit it becomes a free electron. Electricity is commonly defined as the flow of these free electrons through a conductor. Though electrons flow from negative terminal to positive terminal, the conventional current flow is assumed as from positive to negative.

Conductors Insulators and Semiconductors

Conductors

A conductor is a material that has many free electrons permitting electrons to move through it easily. Generally, conductors have incomplete valence shells of one, two or three electrons. Most metals are good conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, Silver and Gold.

Insulators

An insulator is a material that has few, if any, free electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air, glass, rubber, plastic, paper, porcelain, PVC, fibre, mica etc.

Semiconductors

A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductor have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Joining of wires by crimping and soldering

Objectives: At the end of this lesson you shall be able to
- **state the necessity of proper termination**
- **list the different types of terminations**
- **state the care needed for connections and terminals**
- **state the method of soldering the cable ends using an electric soldering iron.**

Necessity for proper termination

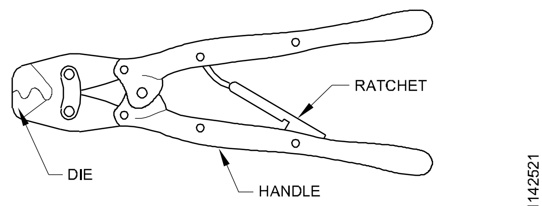
Cables are terminated at electrical appliances, accessories and equipment etc. for providing electrical connections. All terminations must be made to provide good electrical continuity, and made in such a manner as to prevent contact with other metallic parts and other cables.

Loose terminations will lead to overheating of cables, plugs and other connecting points due to higher resistance at those terminations. Fires may also be started due to the excess heat. Wrong termination like excess or extended conductor touching metallic part of the equipment may lead to giving shock to the person who comes in contact with the equipment. Touching of strands projecting from one terminal with other terminal leads to short circuit. To conclude, we can state that wrong termination will lead to overheating of terminating points and cables, short circuits and earth leakage.

Different types of termination

Crimp connection : In this type of connection the conductor is inserted into a crimp terminal and is then crimped with a crimping tool (Fig 1).

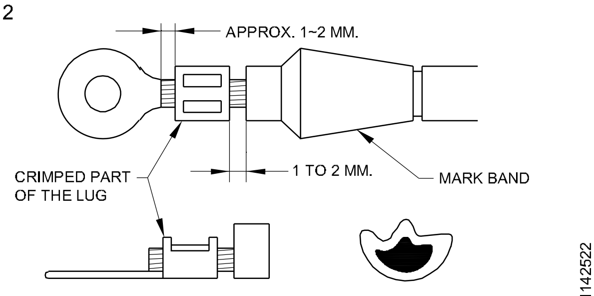
Fig 1



CRIMPING TOOL

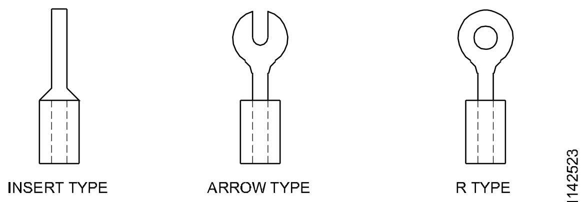
It is important to choose a crimp terminal that matches the conductor diameter and the dimensions of the connecting screw terminal . (Figs 2 and 3)

Fig 2



CRIMP TERMINAL CONNECTION

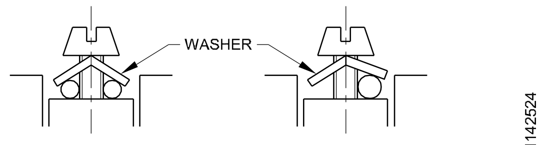
Fig 3



VARIOUS KINDS OF CRIMP TERMINALS

Insert screw setting: The conductor is inserted between the terminal block and the special form of washer (Fig 4), and then the screw is tightened.

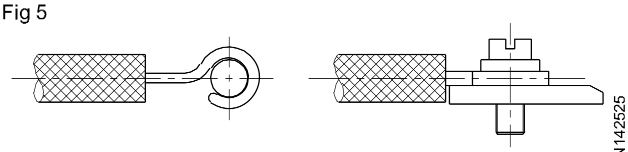
Fig 4



INSERT AND SCREW SETTING

Screw on terminals with loop/ring conductor: A loop is formed clockwise in the bare portion of the conductor to match the size of the screw diameter. Then the loop is inserted to the screw and tightened. (Fig 5) In the case of a stranded conductor, soldering of the loop is essential to prevent strands getting fray.

Fig 5



RING MAKE-UP SCREW SETTING

Soldering

One method of termination is to solder the cable ends to the terminals. Soft solder is an alloy of tin and lead. It is used to join metals together by being melted on to a joint to provide a film that unites the surfaces.

For soldering of wires to a terminal, a solder, which will solidify rapidly, is needed. This shortens the time taken to perform the operation and lessens the risk of the components becoming displaced before the solder cools.

Cored solder: The solder used for electrical /electronic work is usually in a cored form having a core or cores of resin flux. Cored solder 60:40 (60% tin 40% lead) is mostly used for electrical work.

Earthing and its importance

Objectives : At the end of this lesson you shall be able to
- **describe the necessity of earthing**
- **explain the reasons for system and equipment earthing**
- **describe the shielding.**

Necessity of earthing

While working in electrical circuits, the most important consideration for an Electrician is the safety factor - safety not only for himself but also for the consumer who uses the electricity.

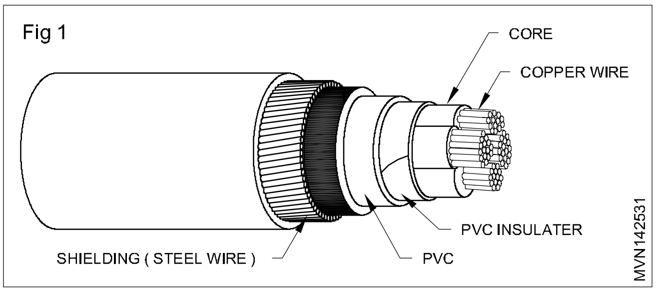
Reasons for earthing

An electric shock is dangerous only when the current through the body exceeds beyond certain milliampere value. In general any current flowing through the body beyond 5 milliamperes is considered dangerous.

Shielding

Shielding is the (Fig.1) protective device layer over the insulated cable. Shielded cable or screened cable is an electrical cable one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal - braided spiral winding of copper tape, or a layer of conducting polymer.

Fig 1



Uses

- It act as earth / ground for the electrical appliances.
- It protect the cables from moisture entering as well as flexible.
- It also act as mechanical strength as well as flexible to the cables.
- It protect the cable from all weather condition like water, oil, gases and heat.

Ohm's Law

Objectives: At the end of this lesson you shall be able to
- **define EMF, PD, Current and resistance and state their units**
- **state the units of each term**
- **name the instruments used for measurement**
- **define ohm's law**
- **explain close circuit, open circuit and short circuit**
- **distinguish of AC and DC meters**
- **explain pire wheel.**

Electrical terms and definitions EMF and Pd

The force tending to make electrons to move along a conductor is called the potential difference (pd) in the conductor and is expressed in volts. This is also called the electric pressure or the voltage.

The voltage developed by a source such as a battery of a generator is called its electromotive force. (emf)

When one ampere current flows through one ohm resistance the p.d. across the resistance is said to be one "Volt". Voltmeter is used to measure the voltage of a supply and is connected in parallel to the supply. EMF/Pd is denoted by letter "V".

Current

The flow of electrons is called current. Its unit is ampere. When one volt is applied across a resistance of one ohm the amount of current passess through the resistance is said to be one "Ampere". It is denoted by "A". Smaller units are milliampere and microampere. Ammeter should be connected in series with the load.

Resistance

It is the property of a substance which opposes the flow of electricity. Its unit is ohm. The resistance of a conductor, in which a current of one ampere flows when potential difference of one volt is applied across its terminals, is said to be one ohm.

An ohmmeter is used to measure the resistance of an electric circuit. It is denoted by "Ω" Bigger units are Kilo ohms and Mega ohms.

$1\ K\ \Omega = 10^3$ ohms

$1\ Mega\ \Omega = 10^6$ ohms

Ohmmeter should be connected in parallel with the load and should not be connected when there is a supply.

There is a definite relationship between the three electrical quantities of Voltage, Current and Resistance.

Ohm's Law states

`The current is directly proportional to the voltage and inversely proportional to the resistance' when the temperature remains constant.

An aid to remember the Ohm's law relationship is shown in the divided triangle. (Fig 1)

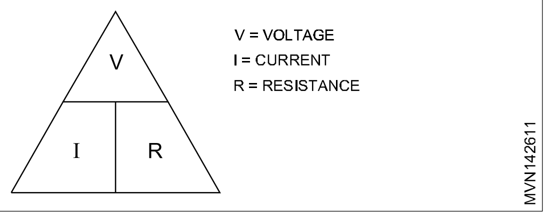


Fig 1

Written as a mathematical expression, Ohm's Law is -

$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Current (I)}}$$

$$\text{or } I = \frac{V}{R}$$

Of course, the above equation can be rearranged as:

$$\text{Resistance (R)} = \frac{\text{Voltage (V)}}{\text{Current (I)}}$$

$$\text{or } R = \frac{V}{I}$$ (Refer Fig 2)

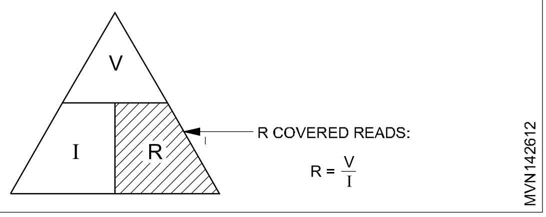


Fig 2

Example

How much current(I) flows in the circuit shown in Fig.3?

Given:

Voltage(V) = 1.5 volts

Resistance(R) = 1 k ohm

= 1000 ohms.

Find:

Current(I)

Formula

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

Solution:

$$I = \frac{1.5\text{ V}}{1000\text{ ohms}} = 0.0015\text{ amp}$$

Answer:

The current in the circuit is 0.0015 A

or

the current in the circuit is 1.5 milliampere (mA).

(1000 milliamps = 1 ampere)

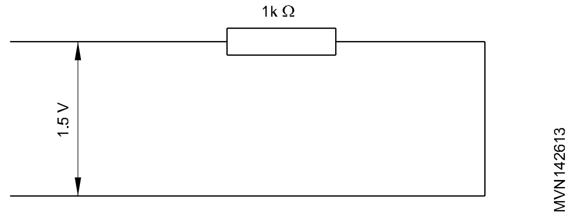


Fig 3

Electric Circuit (closed circuit, open circuit and short circuit)

An electric circuit is the path in which the electric current flows. Fig. 4 shows a simple circut.

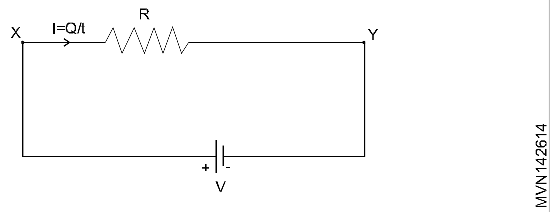


Fig 4

B is the source of electric energy (a cell) L is the lamp, the load or appliance to use the electric energy, S is the switch to control the circuit, i.e. to make the circuit on or off, F is the fuse to protect the circuit from faults, B, S and F have terminals marked 1, 2, 3, ... Connecting wires connect them systematically. Electric current starts from terminal 1, goes to terminal 2 through the connecting wire. When S 'ON' it passes to 3 and through F and L it returns to the terminal 8 of the source. Thus the current's path is completed. A circuit like this is called a closed circuit. If the switch is off or the connecting wires are cut or disconnected, it becomes an open circuit. Current cannot pass in an open circuit. If an extra wire connects terminals 5 and 7, the current will find an easier path. This forms a short circuit. In this case, the current does not pass through the load. The current may be very high. The fuse protects the circuit in such cases.

Identification of A C and D C Meters

AC and DC meters can be identified as follows

1) By the symbol available on the dial / scale.

a) Direct current

b) Alternating current

2) By seeing the graduation on the dial / scale

a) If the graduation of dial is uniform throughout, it is a D C meter.

b) If the graduation of dial is cramped at the beginning and at the end, it is an A.C. meter

3) By seeing the terminals

a) In the d C meter the terminals are marked with + and– The positive (+) terminal is Red in colour and the negative (–) terminal is Black in colour.

b) In the A.C. meter there is no marking on the terminals and no difference in colour.