ELECTRICITY
Measuring Instruments

ELECTRIC CIRCUITS AND MEASURING INSTRUMENTS

A closed path in which a current can flow is called an electric circuit. An electric circuit may have one or more electric elements such as bulbs (or lamps), cells, switches (or plug keys), metal wires, etc. Each element of a circuit has a specific function to play. For example, wires can be used to connect one element to the next. And a plug key or a switch can be used to either complete or break the closed path, thereby starting or stopping the current in the circuit .

Some common circuit elements and their symbols are shown in Figure.

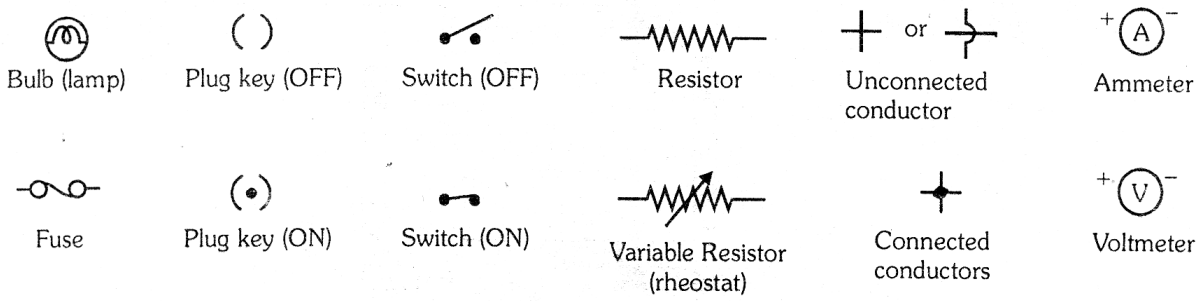


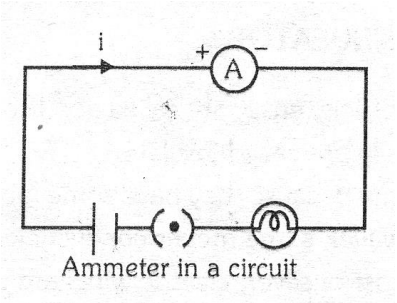
Fig. Some symbols used in circuit diagrams

COMMON MEASURING INSTRUMENTS

The electric current in a circuit is measured by an instrument called the ammeter, and the potential difference between two points in it is measured by a voltmeter (in voltage stabilizers). In these meters, a needle moving over a graduated scale gives the value of the measured quantity. Each meter has two terminals. The terminal marked '+' is connected by a wire to the higher-potential side of a circuit, while the terminal marked '-' is connected to the lower-potential side.

USING AN AMMETER TO MEASURE CURRENT

To measure the current through an element of a circuit, an ammeter is connected in such a way that the current flowing through it also flows through the element. Such a connection is called a series connection. In Figure, the current I flowing through the lamp also flows through the ammeter. The reading of the ammeter gives the current through the lamp. Note that if the ammeter is removed , there will be a gap, and the current through the circuit will stop .

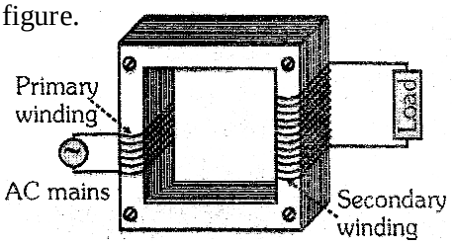


Ammeter in a circuit

Two or more electric elements are said to be connected in series if the current flowing through one also flows through the rest.
An ammeter is always connected in series in a circuit.

Measuring Instruments

Transformer: a device which changes small a.c. potential difference to a large a.c. potential difference. Transformer consists of two coils of wire wound around a core of soft iron. One coil is known as primary coil and the other is known as secondary coil as shown in figure.



Transformer is used to transmit a.c. to distance places through conductors (called transmission lines) without much loss of electric energy or power.

ELECTRIC FUSE: An electric fuse is a safety device used to save the electrical appliances like electric bulbs ,electric tubes, T.V. etc. from burning when large current flows in the circuit. Electric fuse is a wire made of copper or aluminum or tin-lead alloy. The melting point of the material of which the electric fuse wire is made should be low.
Suppose a fuse is not connected in the path of a live wire of the circuit. In such case, the circuit may be over heated if the curent in the circuit exceeds the safe limit. There is a change of short circuiting of the circuit which causes the fire. So to avoid short circuiting of the circuit, a fuse must be but in the path of the circuit .

FUNCTION OF EARTH WIRE: Due to the long use, some covered wires inside the appliance may become bare and may make contact with metallic body of the appliance. In such a case the appliance gives a shock if not earthed. The earth wire keeps the potential of the of appliance zero and shock is avoided

USE OF SWITCH: All electrical appliances are provided with separate switches. All switches are connected with live wire as well as with neutral wire. When we switch off an appliance, then it gets disconnected from the live wire. Now if one touches the metallic body of the appliance there is no danger of electric shock. But , if connections to the switch are in such a way that on switching off the appliance, neutral wire gets disconnected but not live wire, then is danger of electric shock.

SHORT CIRCUIT

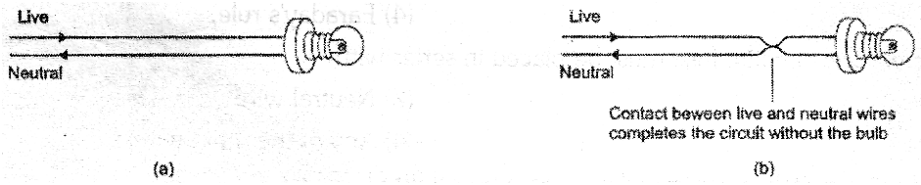


Fig. (a) normal eclectic circuit (b) Short circuit

When the live wire and the neutral wire come into direct contact. This occurs when the insulation of wires is damaged or there is a fault in the appliance. In such a situation, the current in the circuit abruptly increases. This is called short-circuiting. When short circuiting occurs, the resistance of the circuit becomes very small and hence huge amount of current flows through it. Large amount of current in the circuit produces large amount of heat which raises the temperature of circuit to very high value. As a result of this, the circuit catches fire.

ELECTRIC BULB

An electric bulb has a simple structure. It consists of a sealed glass bulb that has a tungsten filament connected to two electrical contacts. The bulb is filled with a an uncreative gas like argon or nitrogen. To produce white light, the filament has to be heated to about 3000^0 C by passing a currant though it. Obviously, the material of the filament should such that it does not melt at this temperature . Tungsten is used for the filament because its melting point is about 3400^0 C. The sealed glass bulb serves two purposes. First, it protects the filament from oxidation and the effects of humidity. Secondly, the small enclosed volume makes it easier to maintain the required temperature, as without it the loss of heat would be more.

Electric Fuse:

An electric fuse in an easily fusible wire of short length put into an electric circuit for protection purpose. It is arranged to melt ("blow") at a definite current. It is an alloy of lead and tin (**37% lead + 63% tin**). It has a low resistivity and low melting point. As soon as the safe limit of current exceeds, the fuse "blows" and the electric circuit is cut off.
Consider a wire of length **L**, radius r and resistivity **p.** Let I be the current flowing through the wire. Now rate at which heat is produced in the wirem.

$$P = I^2 R = \frac{I^2 \rho L}{\pi r^2} \qquad \left[\therefore \frac{\rho L}{A} = \frac{\rho :}{\pi r^2}\right]$$

This heat increases the temperature of the wire. Due to radiation some heat is lost. The temperature of the fuse becomes constant when the heat lost due to the radiation becomes equal to the heat produced due to the passage of current. This given the value of current which can safely pass through the fuse. In other words, we have,

$$I \propto r^{3/2}$$

Illustration:

2. Two lamps, one rated 100 W at 220 V and other 60 W at 220 V are connected in parallel to a 220 V supply. What is current drawn from the supply line?

Sol. Given that

V = 220 V

P_1 = 100W and P_2 = 60 W

$\therefore$ Current $I_1 = \frac{P_1}{V} = \frac{100}{220} = \frac{5}{11}$ A

Similarly,

Current $I_2 = \frac{P_2}{V} = \frac{60}{220} = \frac{3}{11}$ A

Hence, total current drawn from the supply line = $\frac{5}{11} + \frac{3}{11} = \frac{8}{11} A = 0.727 A.$