B.I.S. Symbols used for electrical accessories

Objectives: At the end of this lesson you shall be able to
- **interpret the various BIS symbols used in electrical wiring diagrams**

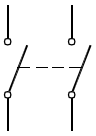
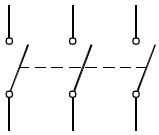
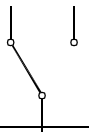
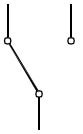
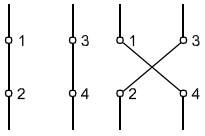
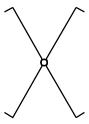
In electrotechnical engineering the symbols are used in layouts and wiring circuits to represent the electrical parts or the function of the circuit.

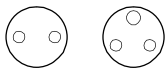
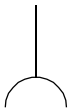
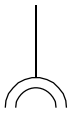
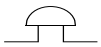
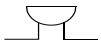
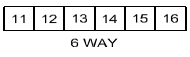
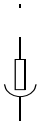
Since the drawing of the actual device is very laborious and would be drawn by each person differently, standardised symbols are used. With the help of the symbols, an electric circuit can be represented easily and can be described precisely as well.

The symbol represents only the function of a part irrespective of the structure and form.

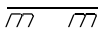
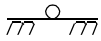
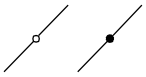
Depending on the purpose of an application, different wiring schemes are used. For example, current flow diagram representation, plans of installation etc. the symbols of various plans of installation (layout) and the current flow diagrams (circuit diagram) differ from one another. A few examples of standard symbols recommended by B.I.S. 2032 (different parts) used for wiring are given here.

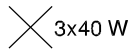
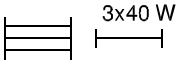
B.I.S. SYMBOLS FOR WIRING SCHEMES

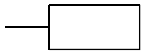
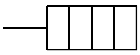
Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
1	One-way switch, single pole		
2	One-way switch, two poles		
3	One-way switch, three poles		
4	Multi-position switch single pole		
5	Two-way switch		
6	Intermediate switch		
7	Push-button or bell-push		

Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
8	Socket outlets, 6A		
9	Socket outlets, 16A		
10	Lamp or outlet for lamp		
11	Fuse		
12	Bell		
13	Buzzer		
14	Earth point		
15	Circuit breaker		
16	Terminal strip		N.A
17	Link (closed)		N.A
18	Plug and socket (male and female)		N.A
19	Ceiling rose		N.A
	N.A: Not applicable		

The B.I.S. Symbols used in the wiring is given here.

ITEMS	SYMBOLS
I Wiring	
1 General wiring	
2 Wiring on the surface	
3 Wiring under the surface	
4 Wiring in conduit	
a Conduit on the surface	
b Conduit concealed	
The type of conduit may be indicated, if necessary.	
5 Wiring going upwards	
6 Wiring going downwards	
7 Wiring passing vertically through a room	
II Fuse-boards	
1 Lighting circuit fuse-boards	
a Main fuse-board without switches	
b Main fuse-board with switches	
c Distribution fuse-board without switches	
d Distribution fuse-board with switches	
2 Power circuit fuse-boards	
a Main fuse-board without switches	
b Main fuse-board with switches	
c Distribution fuse-board without switches	
d Distribution fuse-board with switches	
III Switches and switch outlets	
1 Single pole pull-switch	
2 Pendent switch	
IV Socket outlets	
1 Combined switch and socket outlet, 6A	

ITEMS	SYMBOLS
2 Combined switch and socket outlet, 16A	
3 Interlocking switch and socket outlet, 6A	
4 Interlocking switch and socket outlet 16A	
V Lamps	
1 Group of three 40 W lamps	
2 Lamp,mounted on a wall or light bracket	
3 Lamp, mounted on ceiling	
4 Counterweight lamp fixture	
5 Chain lamp fixture	
6 Pendent lamp fixture	
7 Lamp fixture with built-in switch	
8 Lamp fed from variable voltage supply	
9 Emergency lamp	
10 Panic lamp	
11 Bulk-head lamp	
12 Watertight light fitting	
13 Batten lamp-holder (Mounted on the wall)	
14 Projector	
15 Spotlight	
16 Floodlight	
17 Fluorescent lamp	
18 Group of three 40W fluorescent lamps	

ITEMS	SYMBOLS
VI Electrical appliances	
1 General If necessary, use designation to specify.	
2 Heater	
VII Bells, buzzers and sirens	
1 Siren	
2 Horn or hooter	
3 Indicator (at `N' insert number of ways)	
VIII Fans	
1 Ceiling fan	
2 Bracket fan	

ITEMS	SYMBOLS
3 Exhaust fan	
4 Fan regulator	
IX Telecommunication apparatus	
1 Aerial	
2 Loudspeaker	
3 Radio receiving set	
4 Television receiving set	

Electrical wiring accessories

Objectives: At the end of this lesson you shall be able to
- **classify, specify, identify and state the uses of the accessories employed in domestic wiring**
- **state the IE rules related to safety and electric supply.**

Electrical accessories: An electrical domestic accessory is a basic part used in wiring either for protection and adjustment or for the control of the electrical circuits or for a combination of these functions.

Rating of accessories: The standard current ratings of the accessories are 6, 16 and 32 amps. The voltage rating is 240V AC as per B.I.S. 1293-1988.

Mounting of accessories: The accessories are designed to mount either on the surface or concealed (flush type).

Surface mounting type: Accessories are provided with a seating so that when mounted they project wholly above the surface on which they are mounted.

Flush-mounting type: These accessories are designed to mount behind or incorporated with a switch plate, the back of the plate being flush with the surface of the wall or switch box.

The electrical accessories used in wiring installation, are classified according to their uses.

– Controlling accessories
– Holding accessories
– Safety accessories
– Outlet accessories
– General accessories

Controlling accessories: The accessories which are used to control the circuits or an electrical point like switches are called `controlling accessories'. All the switches are specified in accordance with their function, place of use, type of mounting, current capacity and working voltage. For example - S.P.T. (Single pole tumbler) flush-mounted switch 6 amps 240 volts.

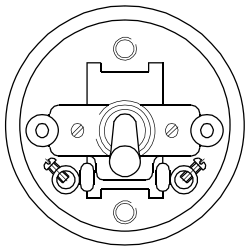
Types of switches according to their function and place of use

1 Single pole, one-way switch
2 Single pole, two-way switch
3 Intermediate switch
4 Bell-push or push-button switch
5 Pull or ceiling switch
6 Double pole switch (DP switches)
7 Iron clad double pole, (ICDP) switch.
8 Iron clad triple - pole (ICTP) switch.

Of the above 1,2,3,4 and 6 may be either surface mounting type or flush-mounting type.

Single pole, one-way switch: This is a two terminal device, capable of making and breaking a single circuit only. A knob is provided to make or break the circuit (Fig 1). It is used for controlling light or fan or 6 amps socket.

Fig 1



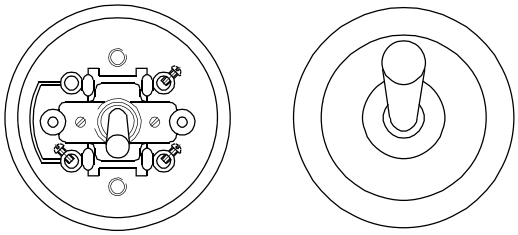
6 AMP SINGLE-WAY SURFACE MOUNTING SWITCH (COVER REMOVED)

ELN227021

Single pole, two-way switch: This is a three terminal device capable of making or breaking two connections from a single position (Fig 2). These switches are used in staircase lighting where one lamp is controlled from two different places. Though four terminals could be seen, two are short circuited and only three terminals are available for connection.

However, both single way and two-way switches with their cover look alike (Fig 2b) but can be differentiated by looking at the bottom. Single way switches will have two terminal posts whereas two-way switches will have four terminal posts.

Fig 2



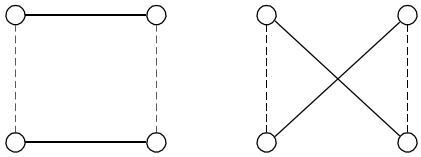
(a) 6 AMP 2-WAY SURFACE MOUNTING SWITCH (COVER REMOVED)

(b) A 2-WAY SWITCH WITH A METAL CAP

ELN227022

Intermediate switch: This is a four-terminal device capable of making or breaking two connections from two positions (Fig 3). This switch is used along with 2 way switches to control a lamp from three or more positions.

Fig 3



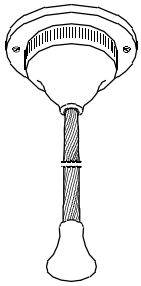
INTERMEDIATE SWITCH CONNECTIONS

ELN227023

Bell-push or push-button switch: This is a two-terminal device having a spring-loaded button. When pushed it `makes' the circuit temporarily and attains `break' position when released.

Pull or ceiling switch (Pendent switch): This switch is normally a two-terminal device functioning as a one-way switch to make or break a circuit (Fig 4).

Fig 4



PULL SWITCH

ELN227024

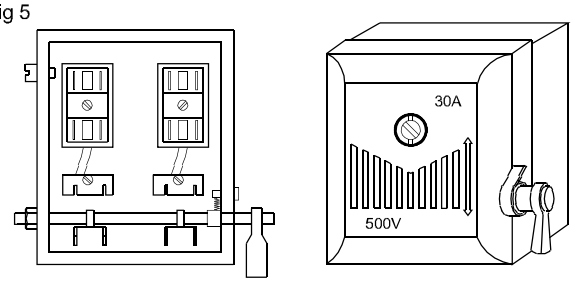
This switch is mounted on ceilings. As the user could operate the switch from a distance through the insulated cord, this could be used safely for operating water heaters in bathrooms or fan or lights in bedrooms.

Double pole switch (DP switch): This is a switch with two poles, the two poles being mechanically coupled together. It is operated with a knob. It is also provided with a fuse and a neutral link. These switches are used as main switches to control main or branch circuits in domestic installation.

Iron - Clad Double pole (ICDP) main switch : This switch is also referred to as DPIC switch and is mainly used for single phase domestic installations, to control the main supply. It controls phase and neutral of the supply simultaneously (Fig 5).

This switch consists of two fuse-carriers. The one in the phase circuit is wired with the fuse and the other in neutral is linked with a brass plate or thick copper wire. These switches should be earthed properly to safeguard the user. The current rating of the switch varies from 16 amps to 200 amperes.

Fig 5



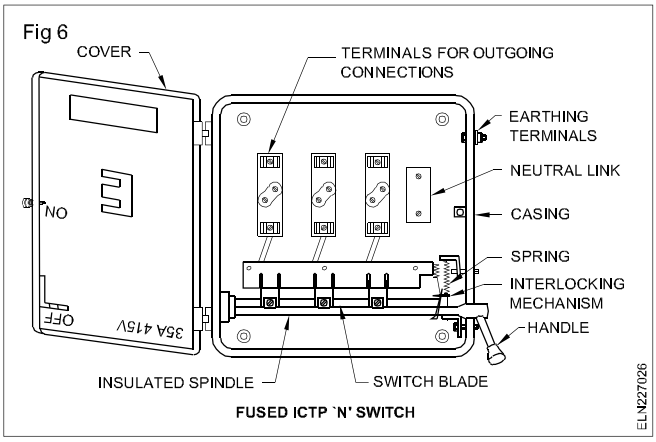
DPIC MAIN SWITCH

ELN227025

Specification of these switches should have:

– current rating
– voltage rating
– type of enclosure (sheet steel or cast iron).

Iron - Clad Triple pole (ICTP) main switch: This is also referred to as TPIC switch and is used in large domestic installation and also in 3-phase power circuits, the switch consists of 3 fuse carriers, one for each phase. Neutral connection is also possible as some switches are provided with a neutral link inside the casing (Fig 6).



These switches need to be earthed through an earth terminal or screw provided in the outer casing.

The current rating of the switch varies from 16 to 400 amps. Specification of these switches should have

– current rating
– voltage rating
– type of enclosure (sheet steel or cast iron)
– whether with neutral link or otherwise
– rewirable type fuse carriers or HRC type fuse carriers.

Holding accessories

Lamp-holders : A lamp-holder is used to hold a lamp. Earlier, brass holders were most commonly used but nowadays these have been replaced by bakelite holders. These may contain solid or hollow spring contact terminals. Four types of lamp-holders are mainly available.

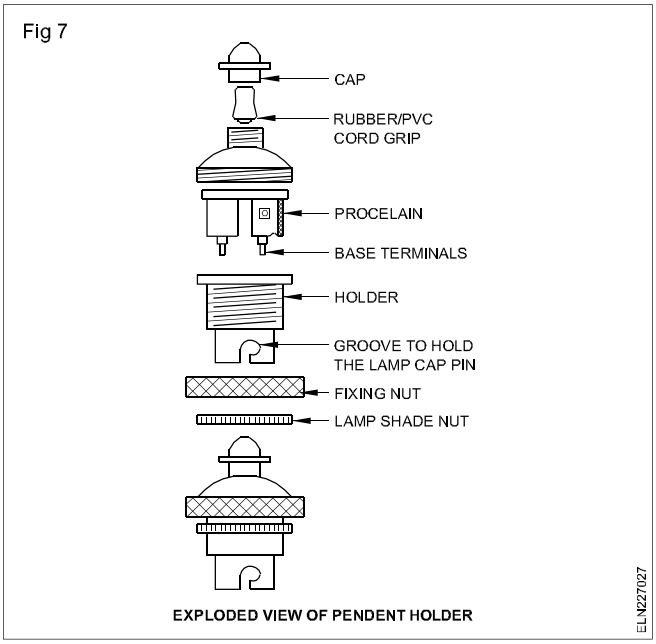
– Bayonet cap lamp-holders
– Screw type holders
– Edison screw type lamp-holders
– Goliath Edison screw type lamp-holders

According to the Bureau of Indian Standard, 732, clause 5.8, all incandescent lamps, unless hung at a height of 2.5m (8ft), shall be provided with standard bayonet holders for lamps up to and including 200 watts. For lamp powers above 200 W and up to 300 watts Edison screw holders are to be used and for above 300 watts Goliath screw holders are to be used.

Bayonet cap (BC) lamp-holders: In this type,the bulb is fitted into the slot, and is held in position by means of two pins in the lamp cap. It has solid or hollow spring contact terminals, and the supply mains through the switch are connected to these contacts. In BC types there are two grooves on the circular construction of all types of holders.

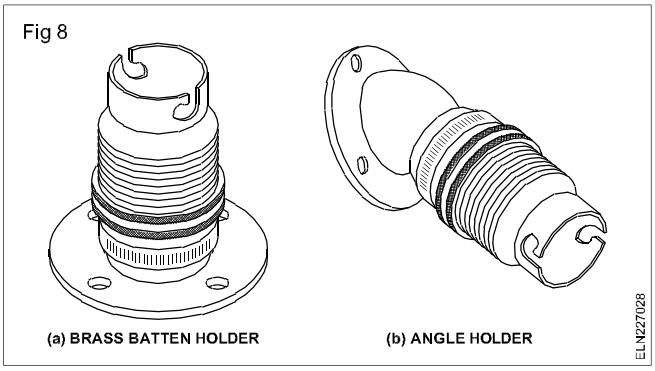
The groove and the contact terminals are at right angle to each other. In this type of holders, the lamp is inserted, forced in, turned slightly and then left in position. These holders can be classified further as explained below.

Pendent lamp-holders: This holder (Fig 7) is used in places where the lamps are required in a hanging position. These holders are made of either brass or bakelite. An exploded view of this holder shows the parts of the holder. These holders are used along with ceiling roses for suspending the lamps from the ceiling.



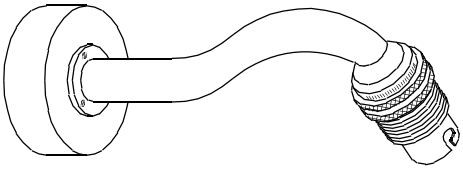
Batten lamp-holders: The straight batten holder (Fig 8a) is used on a flat surface on the round block, wooden board etc. These holders are made of either brass or bakelite.

Angle holders: The angle bottom holder, (Fig 8b) is to hold the lamp in a particular angle. These are made of either brass or bakelite. These are used for advertising boards, window display, kitchens etc.



Bracket holders: This holder (Fig 9) is used with a bracket. These are made of brass and are used to give direct light to a particular place. Brass bracket holders need to be earthed as per BIS recommendations.

Fig 9



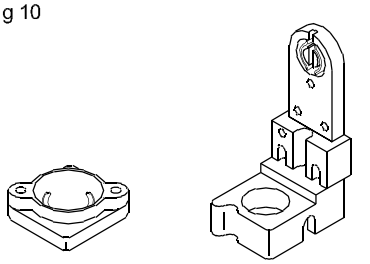
BRACKET HOLDERS

ELN227029

These are fixed on the bracket by the internal threading of the cap.

Tube light or fluorescent lamp-holders and starter-holders: Generally the fluorescent lamp-holders are of a bi-pin type (Fig 10).

Fig 10



HOLDER FOR THE STARTER

COMBINED TUBE AND STARTER HOLDER

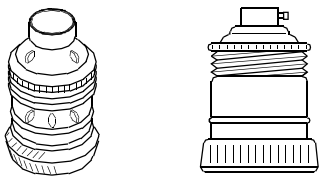
FLUORESCENT PIN TUBE HOLDER

ELN22702A

Edison screw-type lamp-holders: In this type, the holder is provided with inner screw threads and the lamp is fitted in it by screwing. It has a centre contact which is connected to the live wire and the screwed cap is connected to the neutral wire.

For lamps with wattage above 200W and not exceeding 300W, Edison screw-type holders are used. Edison screw (ES) lamp holders have spring-loaded central contact to ensure good contact (Fig 11).

Fig 11

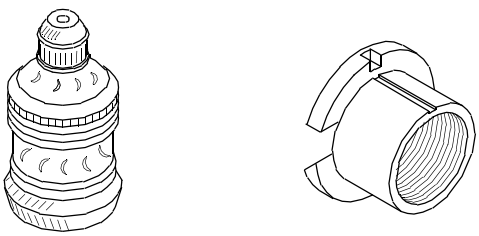


EDISON SCREW TYPE HOLDER

ELN22702B

Goliath Edison screw (GES) type holders (Fig 12)**:** The cover of this type of holder is made of porcelain. Such holders are used in studios, headlights, floodlights, focussing lights etc.

Fig 12



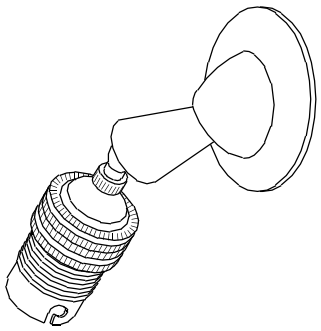
GOLIATH EDISON SCREW LAMP HOLDER

ELN22702C

These holders are used for more than 300W lamps.

Swivel lamp-holders: The swivel lamp-holder is designed for wide angle directional lighting which is used for the lighting of shop windows, showcases, etc. It consists of a ball and socket joint fitted between a back plate and the lamp-holders. It is available in bayonet cap type, small bayonet cap type and Edison screw type. All these type of holders are also available for wall fixing patterns or ceiling pattern (Fig 13).

Fig 13



ANGLE SWIVEL LAMP-HOLDER

ELN22702D

Specification of a lamp-holder: While specifying the lamp-holders, the type of material used for construction, type of gripping, type of mounting, working current and voltages should also be specified.

Safety accessories: A fuse is a safety accessory. It is connected in series with the circuit and protects the electrical apparatus and equipment from damage, when excess current flows.

The kit-kat type fuse is commonly used in domestic installation.

Types of fuses

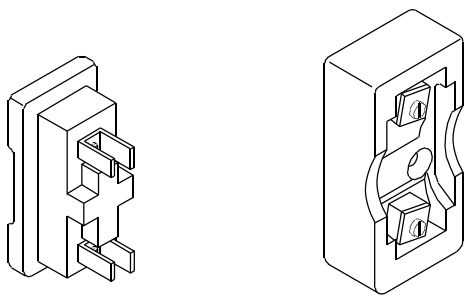
– Kit-kat type (Rewirable fuse)

– Iron-clad fuse cut out

Kit -kat type fuse: This fuse consists of a porcelain base having two fixed contacts, for connecting the incoming and outgoing cables.

The line and load wires are connected in the base terminals and the carrier is provided with a fuse (Fig 14). The base is fixed but the carrier is removable.

Fig 14



FUSE CARRIER

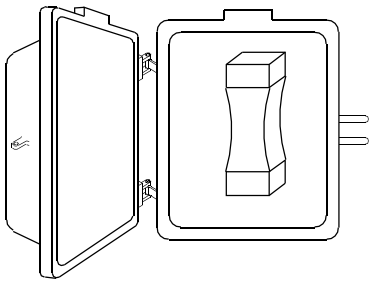
FUSE BASE

KIT-KAT FUSE

ELN227028

Iron-clad fuse cut outs (Fig 15): These are kit-kat fuses in an iron cover. The iron cover has facility to be closed and sealed with a lead seal. This is used at the incoming side of the power supply and sealed by the supply authorities to ensure the line is not loaded beyond a certain prescribed current capacity.

Fig 15



IRON CLAD CUT - OUT

ELN22702F

Outlet accessories: These accessories are used to take the supply for the portable appliances like table fans, TV, electric irons etc.

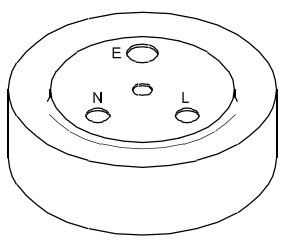
Socket outlet current rating: The standard ratings shall be 6,16 and 32 amperes and 240 volts. The following types are normally used for domestic purposes. They have to be specified according to the mounting type, number of pins, current capacity and voltage.

Two-pin socket: This socket is rated as 6A, 250V, having only two pins without earth connection. These are suitable only for double insulated appliances (having PVC or insulated body).

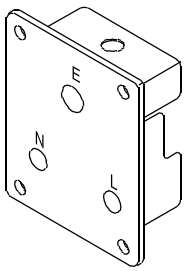
Two-pin plug top: It is used for taking the supply from the socket. It has got two pins of the same size.

Three-pin socket: This type of socket is suitable for light and power circuits. These sockets are rated as 6A, 250V or 16A, 250V, and are available as surface-mounting type and flush type (Fig 16). There are three terminals marked as Line (L) Neutral (N) and Earth (E). The line terminal is always on the right hand side, the neutral terminal on the left hand side, and the top is the earth terminal which is larger in diameter. In all the cases, the earth wire must be connected to the earth terminal of the socket.

Fig 16



3-PIN 16 AMP SOCKET WITH TOP COVER



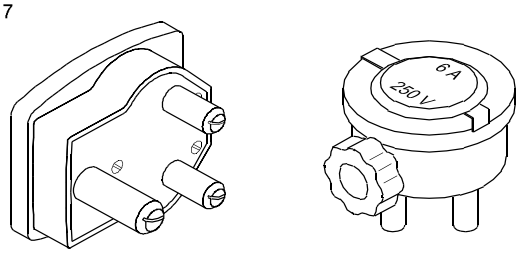
FLUSH TYPE SOCKET

ELN22702G

Three-pin plug top : It is used for taking the supply from the socket. It has three pins. Two are similar in size and the third one is bigger and longer which is for earth (Fig 17). These are also rated as 6A,250V or 16A, 250V. These are made of bakelite, PVC materials.

A socket which is controlled by a switch, is also available. Multi-pin sockets are also available which are suitable for 2 pins and 3 pins having 5 holes in one unit. Further multi-pin sockets for 3 pin of 6 amps and 16 amps are also available having 6 holes in one unit.

Fig 17



THREE-PIN PLUG TOP

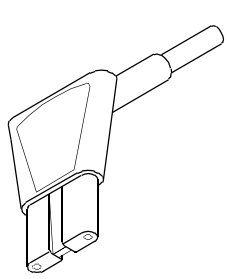
ELN22702H

General accessories : Some accessories are used for general and special purposes such as:

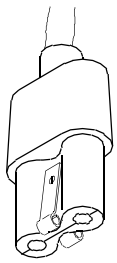
- appliance connectors (or) iron connectors
- adapters
- ceiling roses
  - a) two-plate
  - b) three-plate
- connectors
- distribution board
- neutral links.

Appliance connectors or iron connectors : These are used as female connectors to supply current to electric kettles, electric iron, hotplate, heaters etc. It is made of bakelite or porcelain. The wires are connected with two brass terminals and the earth connection is provided with a twin nickel spring. The cable entry has a rubber protection tybe. These are rated as 16A, 250V (Fig 18).

Fig 18



FLAT CONNECTOR WITH SIDE ENTRY



IRON CONNECTOR DIRECT ENTRY

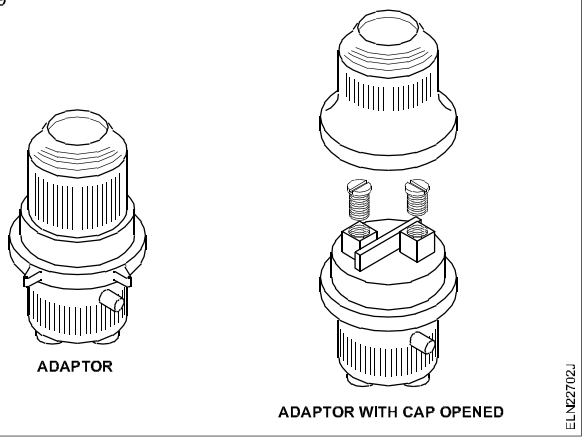
ELN227021

Adaptor (Fig 19)**:** They are used for taking supply from a lamp holder for small appliances. They are made out of bakelite. They are available in ratings up to 6 A 250 V.

Adaptors with multiple plugs are also available for taking supply to a number of appliances from a single point.

These adaptors should not be used in bathrooms or other damp places.

Fig 19



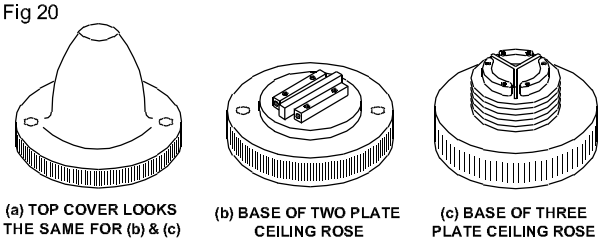
Ceiling roses: Ceiling roses are used to provide tapping points from the wiring for supplying power to fans, pendent-holders, tube lights etc. Normally flexible wires are used for tapping from the ceiling roses.

Ceiling roses have two parts, base and cover, both made of bakelite. The cover has a hole in the centre for the connecting wires to be taken out. There are threadings on the internal sides so that the cover may be fixed or tightened with the base. The base has terminals and holes for fixing on the block etc. and for wires to connect with the supply. Two types of ceiling roses are in use.

Two-plate ceiling rose (Fig 20 a & b)**:** This is made of bakelite and it has 2 terminals (phase & neutral) which are separated from each other by a bakelite bridge. Each of the terminal plates is provided with a metallic sleeve and a binding screw on one side through which the circuit wire from the back via the mounting block enters them. The other side of the terminal plate is provided with a washer and screw to tap wire connection. The two-plate ceiling rose is used for 6A, 250V current capacity. It is not used in circuits whose voltage exceeds 250V.

Three-plate ceiling rose: This type of ceiling rose has 3 terminals which are separated from each other by a bakelite bridge. It can be used for two purposes. (Fig 20 a & c)

Fig 20

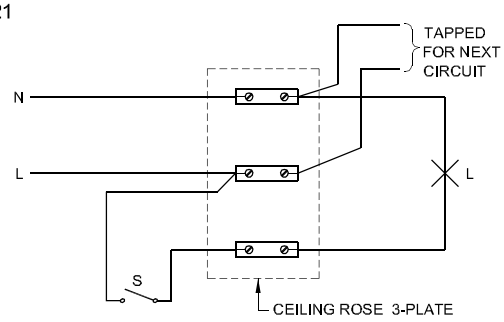


– Bunch light control

– To provide tapping for phase wire (Fig 21).

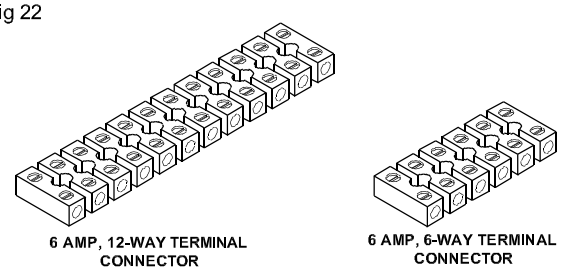
These ceiling roses are available in the rating of 6A, 250V. The covered 2 plate and 3 plate ceiling roses will look alike but could be identified by seeing the rear side.

Fig 21



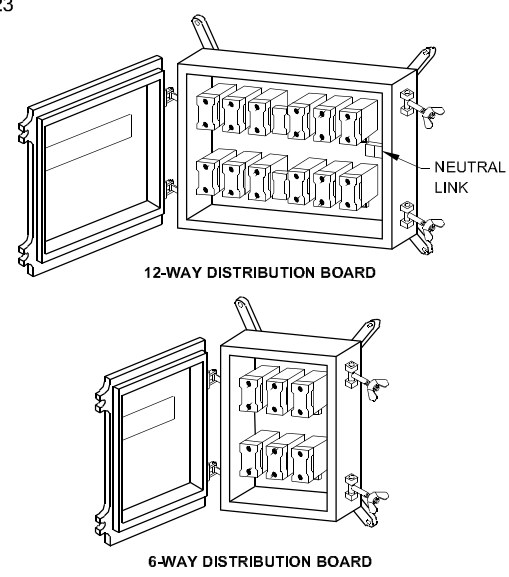
Connectors (Fig 22): Connectors are used to extend the length of the wire without joining. They are made of porcelain, bakelite or PVC based material. There is a brass sleeve with threading for small screws to tighten the wire in the sleeves. These are available in single way, two-way, three-way, six-way, 12-way types. These are rated according to the current and voltage capacity - 6A 250V, 16A 250V, 32A 250V, 16A 500V, 32A 500V etc.

Fig 22



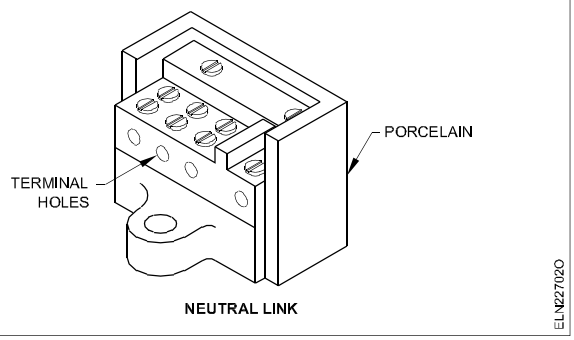
Distribution board (Fig 23): These are used where the total load is high and is to be divided into a number of circuits. These are used where the load is more than 800W. The number of fuses in the board is according to the number of circuits, and a neutral link is also provided so that the neutral wire can be taken for different circuits. All these branch fuses are enclosed in a metal box. These boards are available as two-way, three-way, 4,6,12-way types.

Fig 23



Neutral link: In a three-phase system of wiring installations, the phases are controlled through switches, and the neutral is tapped through a link called neutral link. The neutral link consists of a terminal for incoming current and a multi-way outgoing circuit. The metal terminals are mounted on high grade vitreous porcelain base (Fig 24). The ratings are 16A, 32A, 63A, 100A neutral link.

Fig 24

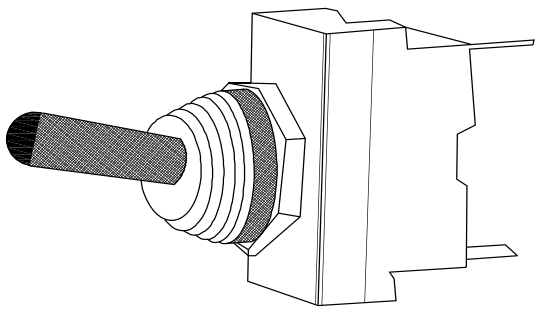


The accessories' rating shall be 240V and 6 or 16 amps from the year 1991, instead of 250V and 5 or 15 amps as per BIS 1293-1988.

Toggle switches (Fig 25)

It is an electric switch operated by means of a projecting lever that can be moved upward and downward and is also called as snap switches .

Fig 25



The toggle switches are generally specified based on

- Number of poles (single / double/ triple etc.)
- Number of throws (single / double/ double with center OFF etc.)
- Current rating (3,6,10,16,20 & 25A)
- Voltage rating (125V & 250V , AC)
- Size (8,10,12,15mm etc.)
- Knob type (Brass/ plastic and oval/ round/flat etc.)

Modular switches

The latest version of modular switch of different sizes and colours along with sockets combined and switches with indicators are available in market (Fig 26).

Fig 26

Indian Electricity Rules - Safety Requirements

The IE rules 1956 was made under sections 37 of Indian Electricity Act 1910. Now it is redefined after the enactment of the Electricity Act 2003. The Central Electricity Authority (measures relating to safety and electric supply) Regulation (CEAR) 2010 which came into effect from 20th September 2010, in place of Indian Electricity Rules 1956.

SAFETY RULES: Among safety rules, the following are important and indeed requires attention. Every rule in the Indian Electricity Rules 1956 is related either directly or indirectly to safety.

Rule 32: Switches shall be on the live conductor. No cutout, link or switch other than gang switch shall be inserted in the neutral conductor. Code of Practice of wiring shall be followed while marking the conductors.

Rule 50: Energy shall not be supplied, transformed,converted or used unless the following provisions are observed. A suitable linked switch or circuit breaker is erected at the secondary side of the transformer. Every circuit is protected by a suitable cut-out. Supply to each motor or group of motors is controlled by a linked switch or circuit breaker. Adequate precautions are taken to ensure that no live parts are exposed.

Special provisions in respect of high and extra high voltage installations

Rule 63: Approval of Inspector is necessary before energising any high voltage installations.

Rule 65: The installation must be subjected to the prescribed testing before energizing.

Rule 66: Conductors shall be enclosed in a metallic covering and suitable circuit breakers shall be provided to protect the equipment from overloading.

Rule 68: Incase of outdoor type of sub-station a metallic fencing of not less than 1.8 m height shall be erected around the transformer.

Provisions in terms of OH line

Rule 77: Clearance of lowest conductor above ground across street.

- Low and Medium Voltage lines - 5.8 m.
- High voltage Lines - 6.1 m.
- Clearance of lowest conductor above ground along a street. Low and Medium Voltage lines - 5.5 m.
- High voltage lines - 5.8 m.
- Clearance of lowest conductor above ground other than along or across the street. Low, Medium and High Voltage lines upto 11 KV if bare - 4.6m .
- Low, Medium and High upto and including 11KV, if insulated - 4.0m.
- High Voltage above 11 KV - 5.2 m.

Rule 79: Clearance of low and medium voltage lines from building,

- Vertical Clearance - 2.5 m.
- Horizontal clearance - 1.2 m.

Rule 80: Clearance from building of high and extra high voltage. Vertical Clearance High Voltage upto 33KV - 3.7m.

- Extra High Voltage above 33KV - 3.7 m, plus 0.3 m for every 33KV part there of.
- Clearance from building of high and extra high voltage - Pitched Roof . Vertical Clearance upto 11KV - 1.2m.
- Above 11KV upto 33KV - 2.2 m.
- Above 33KV - 2m. plus 0.3m for every 33KV part there of.

Rule 85: Maximum interval between supports. It shall not exceed 65 m except by prior approval of inspector.

Indian electricity rules regarding to internal wiring:

1 The minimum size of conductor used in domestic wiring must not be of size less than 1/1.12mm in copper or 1/1.40mm (1.5mm) in aluminium wire.

2 For flexible wires the minimum size is 14/0.193mm.

3 The height at which meter board, Main switch board are to be fitted 1.5 meters from ground level.

4 The casing will be run at a height of 3.0 meters from the ground level.

5 The light brackets should be fixed at a height of 2 to 2.5 meters from ground level.

6 The maximum number of points in a sub circuit is 10.

7 The maximum load in a sub circuit is 800W.

I.E. Rules regarding - Voltage drop concept:

1 **I.E. Rule 48:** The insulation resistance between the wiring of an installation and earth should be of such a value that the leakage current may not exceed 1/50000 the part or 0.02 percent of the F.L. current.

2 The permissible voltage drop in a lighting circuit is 2% of the supply voltage plus one volt.

3 The maximum permissible voltage drop in a power industrial circuit should not be more than 5% of the declared supply voltage.

4 The insulation resistance of any wiring installation should not be less than 1M Ω .

5 The earth resistance should not exceed the value of one ohm.

I.E. Rules regarding to power wiring:

1 In a power sub circuit the load is normally restricted to 3000 watts and number of outlets to two in each sub circuit.

2 All equipment used in power wiring shall be iron clad construction and wiring shall be of the armoured cable or conduit type.

3 The length of flexible conduit used for connections between the terminal boxes of motors and starters, switches and motors shall not exceed 1.25 meters

4 Every motor, regardless of its size shall be provided with a switch fuse placed near it.

5 The minimum cross-sectional area of conductor, that can be used for power mining of 1.25 mm for copper conductor cables and 1.50 mm for Aluminium conductor cables (refer ISI recommendations). Hence VIR or PVC cables of size lower than 3/0.915 mm copper or 1/1.80 mm Aluminium can not be used for motor wiring.

Circuit Breaker (CB) - Miniature Circuit Breaker (MCB)- Moulded Case Circuit Breaker (MCCB)

Objectives: At the end of this lesson you shall be able to

- **explain the types, working principle and parts of a miniature circuit breaker.**
- **state the advantages and disadvantages of MCB**
- **explain the working of combination circuit breaker (ELCB + MCB)**
- **state the categories and applications of MCBs**
- **state the application, advantage and disadvantage of MCCBs.**

Circuit Breaker

A circuit breaker is a mechanical switching device capable of making, carrying and breaking the currents under normal condition and breaking the currents under abnormal conditions like a short circuit.

Miniature circuit breaker (MCB)

A miniature circuit breaker is a compact mechanical device for making and breaking a circuit both in normal condition and in abnormal conditions such as those of over current and short circuit.

Types of MCB's

MCBs are manufactured with three different principles of operation namely

a Thermal Magnetic

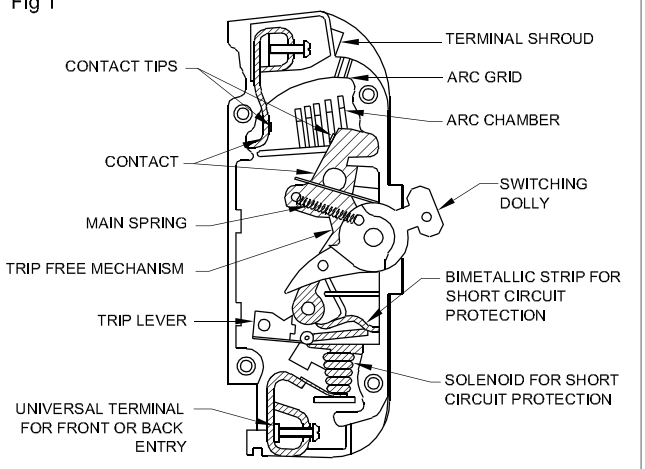
b Magnetic hydraulic and

c Assisted bimetallic

Thermal magnetic MCB

The switching mechanism is housed in a moulded housing with phenolic moulded high mechanically strong switching dolly. This type of MCB is also provided with bimetallic overload release (Fig 1).

Fig 1



The electric current gets through two contact tips one each on moving and fixed contact of silver graphite.

An arcing chamber incorporating de-ionising arc chutes for control and quick suppression of the arc is provided in the gap between two contacts. It has a ribbed opening closed by metal grid which allows ventilation and escape of gases.

For protection against over-load and short circuit, MCB's have thermal magnetic release unit. The overload is taken care of by bimetallic strip, short circuit currents and over loads of more than 100% are taken care by solenoid.

Working

The bimetallic strip when flexing due to temperature rise caused by increasing normal rated current beyond 130% rotates a trip lever carrying an armature to which it is to brought into field of a solenoid. The solenoid is designed to attract the armature to full position at about 700% overload or instantaneous short circuit current.

For initial portion of current wise (130% to 400%) tripping of circuit breaker is due to thermal action, between 400 to 700% tripping is due to combined thermal and magnetic action and beyond 700% due to fully magnetic action.

Magnetic hydraulic MCB

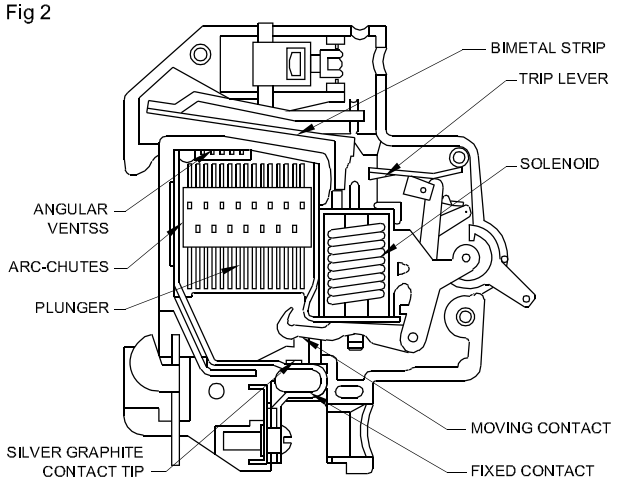
Magnetic hydraulic circuit breaker operates on the principle of a solenoid and hydraulically damped plunger.

Construction and working

A movable ferrous plunger is held against a non-ferrous tube containing polysiloxane liquid which have flat temperature viscosity characteristic in temperature range of 20 to 60°C. The solenoid is a series coil in the circuit of MCB. As the plunger moves towards a pole piece, the reluctance of magnetic path.

Containing the armature is cumulatively reduced leading to some magneto motive force producing a progressively increasing flux. The armature is then attracted causing the mechanism to trip and open the controls on overload or short circuit (Fig 2). Instantaneous tripping occurs on very large currents 7 to 8 times the full load current. The construction of magnetic hydraulic tripping mechanism is in Fig 2.

Fig 2

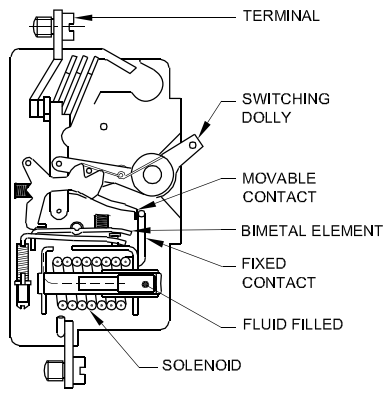


MAGNETIC HYDRAULIC MCB

Assisted Bimetal Tripping MCB (Fig 3)

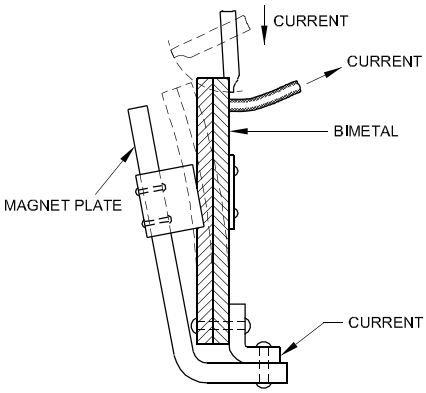
In the assisted bimetal form of construction, the time delay characteristic is provided by a thermally operated bimetal element which may be either directly or indirectly heated. Instantaneous tripping in short circuit condition is achieved by arranging a powerful magnetic pull to deflect the bimetal (Fig 4).

Fig 3



ASSISTED BIMETAL TRIPPING MCB

Fig 4



ASSISTED BIMETAL TRIPPING

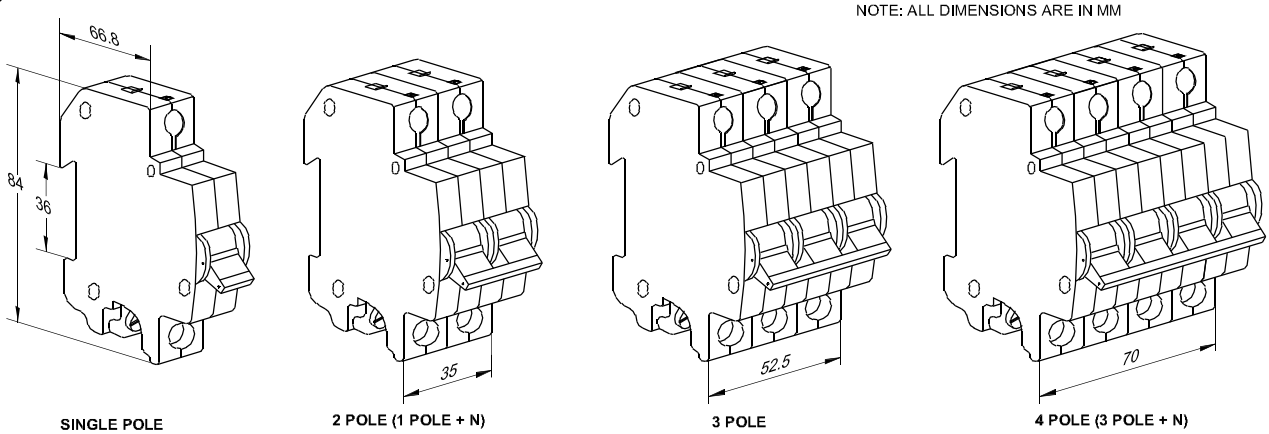
This method utilises the magnetic field which is produced when a current flows through the conductor. By locating the bimetal near to a substantial section of ferrous material, the magnetic field associated with current flowing in the bimetal will cause a sideways pull to be applied to the bimetal element, attracting the bimetal towards the ferrous material.

This sideways pull is arranged to coincide in direction with the normal direction of movement of the bimetal, which is powerful enough to deflect the bimetal (in heavy over load or short circuit condition) sufficiently to trip the breaker.

Design and rating of MCBs

MCBs are normally rated for 25°C ambient temperature and are available in the following various combination of poles and current ratings (Fig 5).

Fig 5



DIFFERENT TYPES OF MCB'S

Sl.No.	No. of poles	Current
1	Single pole MCB	0.5 to 60A
2	Double pole MCB (ie. 2 MCBs with common trip bar)	5 to 60A
3	Triple pole MCB	5 to 60A
4	Four pole MCB	5 to 60A

Isolators

An isolator is a switch. These cannot be used for automatic tripping. Isolators are not meant for either closing or breaking the circuit on load or short circuit. Isolators have the same physical dimensions of MCBs and are available in the following configurations and ratings.

No. of poles	Current rating
Single pole	30, 60, and 100A
Single pole with Neutral	30, 60, and 100A
Triple pole	60, and 100A
Four pole	60 and 100A

ELCB + MCB combination circuit breaker

Now a days some manufacturers have introduced an ELCB + MCB combination circuit breaker which can be used instead of using separate MCB and ELCB (earth leakage circuit breaker). This combination not only allows reduction in costs, but also ensures

- over current
- short circuit
- earth leakage
- earth fault.

Earth leakage circuit breakers are now generally called Residual Current circuit breakers (RCCB).

The rated load currents of the RCCB + MCB combination are 6A, 10A, 16A, 20A, 25A, 32A and 35A. The bimetal trip is so adjusted that no tripping will occur upto 1.3 times the rated current.

Categories of MCBs

Certain manufacturers like Indo Kopp manufacture the MCBs in three different categories namely 'L' series, 'G' series, and 'DC' series.

'L' series MCBs

'L' series MCBs are designed to protect circuits with resistive loads. They are ideal for protection of equipment like Geysers, ovens and general lighting systems.

'G' series MCBs

'G' series MCBs are designed to protect circuits with inductive loads. G series MCBs are suitable for protection of motors, air conditioners, hand tools, halogen lamps etc.,

'DC' series MCBs

'DC' series MCBs are suitable for voltage upto 220V DC and have a breaking capacity up to 6kA.

The tripping characteristics are similar to 'L' an 'G' series. They find extensive application in DC controls, locomotives, diesel generator sets etc.,

Advantages of MCB

1 Tripping characteristic setting can be done during manufacture and it cannot be altered.

2 They will trip for a sustained overload but not for transient overload.

3 Faulty circuit is easily identified.

4 Supply can be quickly restored.

5 Tamper proof.

6 Multiple units are available.

Disadvantages

1 Expensive.

2 More mechanically moving parts.

3 They require regular testing to ensure satisfactory operation.

4 Their characteristics are affected by the ambient temperature.

Application of (RCCB + MCB) combination circuit breakers

1 All residential premises can have incoming protection after energy meter instead of fixing fuse and main switch.

2 All domestic equipments like water heaters, washing machines, electric iron, pump sets etc.,

3 All construction and outdoor electrical equipments such as lifts, hosts, vibrators, polishing machines etc.,

4 All industrial distribution and equipments

5 All agriculture pump sets.

6 Operation theatres and electrically operated medical equipment such as X-ray machines.

7 All neon sign installations

8 All low and medium voltage electrical distributions.

Technical specification of MCBs

Related voltage	240/ 415V AC 50Hz
	Up to 220V DC
Current rating	0.5, 1, 1.6, 2, 2.5, 3, 4, 5, 6, 7.5,
	10, 16, 20, 25, 32, 35, 40 and 63A.
No. of poles	1,2,3
Types	'L' 'G' and 'DC' series
Breaking capacity	UP to 9kA
Mechanical life	1,00, 000 operations
Electrical life	50,000 operations
Overload capacity	15% over load
Housing	Glass fiber reinforced polyester
Fixing	Snap fixing on 35 mm DIN channel
Types of terminals	25mm² box type terminal at the
	incoming and outgoing.

Definition of Breaking capacity of MCB

The short circuit breaking capacity of the circuit breaker is the current more than the prospective fault current at the point of installation of circuit breaker. Prospective fault current is the maximum fault current which may have to be interrupted by the circuit breaker.

Moulded Case Circuit Breakers (MCCB)

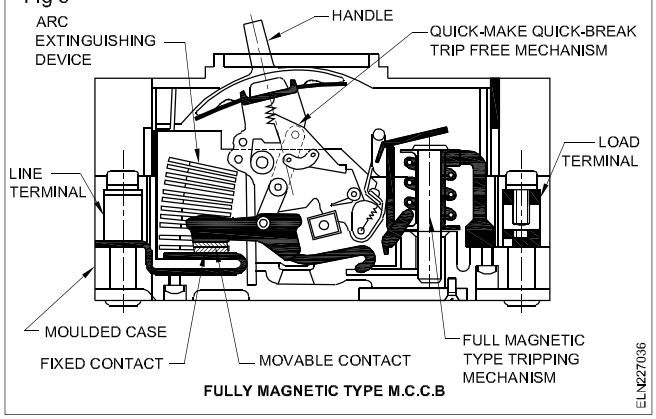
Moulded case circuit breakers are similar to thermo magnetic type MCBs except that these are available in higher ratings of 100 to 800amp at 500V 3-phase.

In MCCB, thermal and magnetic releases are adjustable. A shunt release is also incorporated for remote tripping and interlocking at MCCB. MCCBs are provided with under voltages release. There are two types of MCCB.

1 Thermal magnetic type.

2 Fully magnetic type (Fig 6).

Fig 6



Advantages of MCCB

1 MCCBs occupy much less space in comparison to fuse switch units.

2 MCCBs provide equal amount of protection against high faults as switch gears having HRC fuses.

Disadvantages

1 MCCBs are much costlier.

2 Leak proof situation required.

3 Sensitivity to insulation resistance low.

ELCB - types - working principle - specification

Objectives : At the end of this exercise you shall be able to

- **explain the working principle, different types and construction of an earth leakage circuit breaker (ELCB)**
- **explain the technical specifications of ELCB's.**

Introduction

The sensation of electric shock is caused by the flow of electric current through the human body to earth. When a person comes in contact with electrically live objects like water heaters, washing machines electric iron etc., the extent of damages caused by this current depends on its magnitude and duration.

This kind of current is called the leakage current which comes in milli-amps. These leakage current being very small in magnitude, hence undetected by the fuses/MCBs are the major cause for the fires due to electricity.

The leakage current to earth also results in the wastage of energy and excessive billing for electricity not actually used.

Residual current operated circuit breakers are inter-nationally accepted means of providing maximum protection from electric shocks and fires caused due to earth leakage current and also prevents the waste of electrical energy. These residual current circuit breakers (RCCB) are popularly called as Earth leakage circuit breakers (ELCB). The effect of electric current on human body in various levels represented in graph (Fig 1).

Basically ELCBs are of two types namely voltage operated ELCBs and the current operated ELCBs.

Voltage operated ELCB

This device is used for making and breaking a circuit. It automatically trips or breaks the circuit when the potential difference between the protected metal work of the installation and the general mass of earth exceeds 24V. This voltage signal will cause the relay to operate (Fig 2).

Fig 1

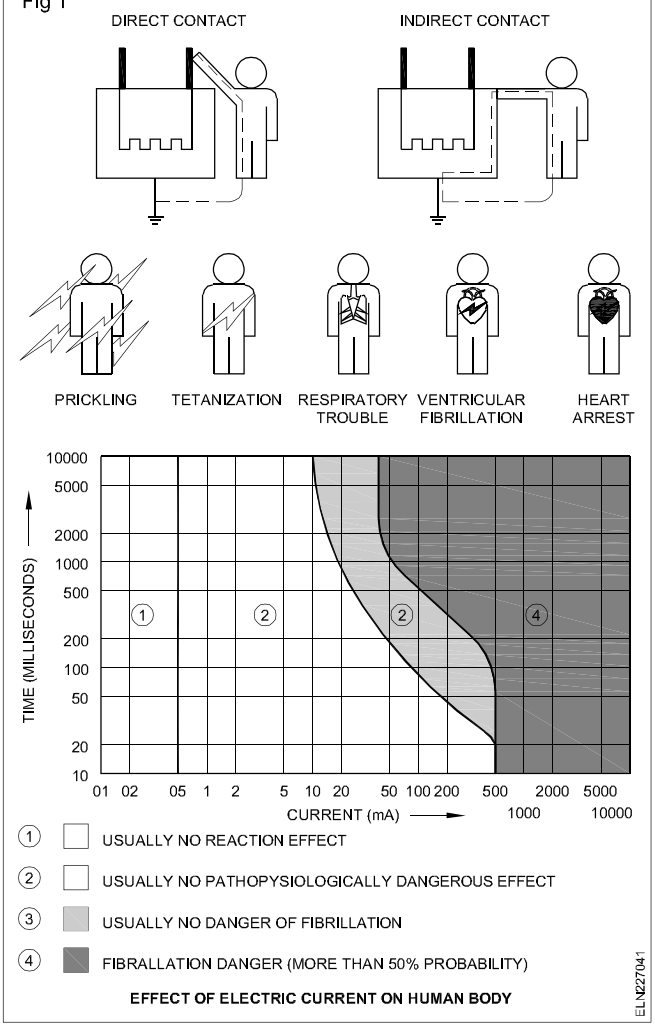
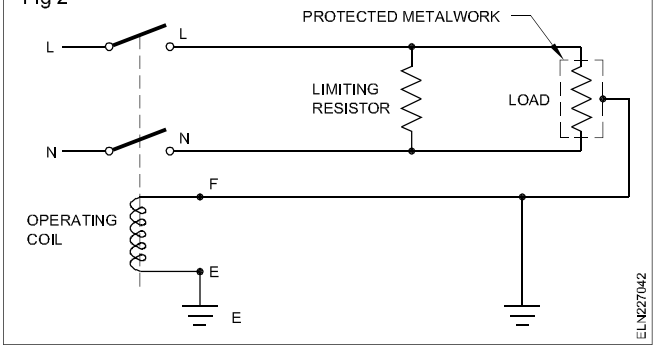


Fig 2



Voltage operated ELCBs are meant to be used where it is not practicable to meet the requirements of IEE wiring regulation by direct earthing or where additional protection is desirable.

Current operated ELCB

This device is used for making and breaking a circuit and for breaking a circuit automatically when the vector sum of current in all conductors differs from zero by a predetermined amount. Current operated ELCBs are much more reliable in operation, easier to install and maintain.

Construction of current operated ELCB

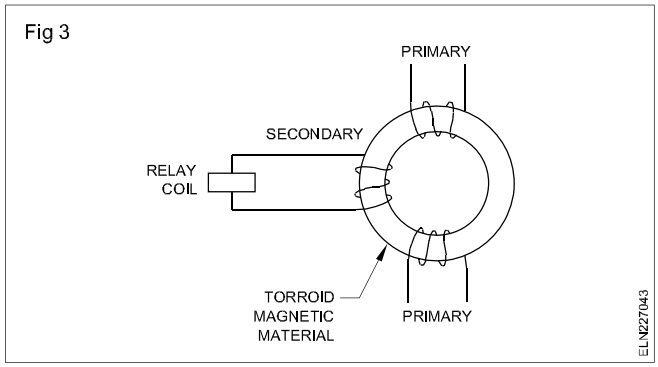
It consists of a Torroid ring made of high permeability magnetic material. It has two primary windings each carrying the current flowing through phase and neutral of the installation. The secondary winding is connected to a highly sensitive electro - magnetic trip relay which operates the trip mechanism.

Working principle

The residual current device (RCD) is a circuit breaker which continuously compares the current in the phase with that in the neutral. The difference between the two is called as the residual current which is flowing to earth.

The purpose of the residual current device is to monitor the residual current and to switch off the circuit if it rises from a preset level (Fig 3).

Fig 3



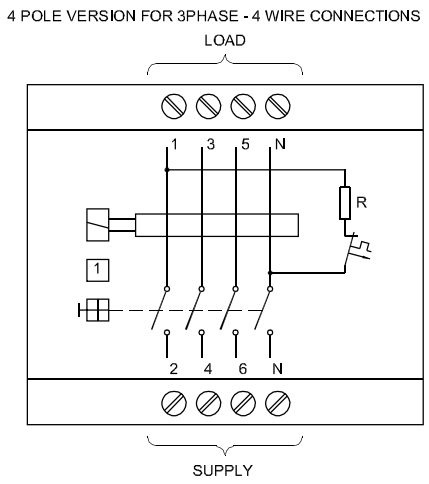
The main contacts are closed against the pressure of a spring which, provides the energy to open them when the device trips. Phase and neutral current pass through identical coils wound in opposing direction on a magnetic circuit, so that each coil will provide equal but opposing numbers of ampere turns when there is no residual current. The opposing ampere turns will cancel and no magnetic flux will be set up in the magnetic circuit.

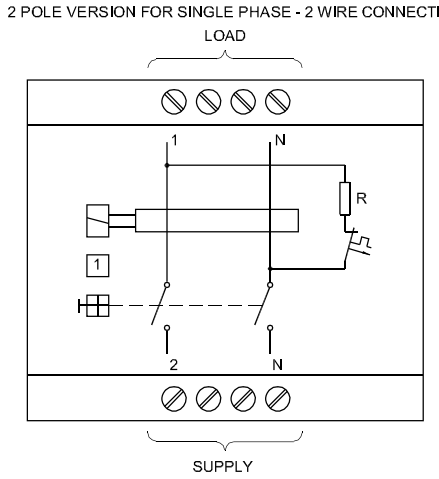
In a healthy circuit the sum of the current in phases is equal to the current in the neutral and vector sum of all the current is equal to zero. If there is any insulation fault in the circuit then leakage current flows to earth. This residual current passes to the circuit through the phase coil but returns through the earth path and avoids the neutral coil, which will therefore carry less current.

So the phase ampere turns exceeds neutral ampere turns and an alternating magnetic flux results in the core. The flux links with the secondary coil wound on the same magnetic circuit inducing an emf into it. The value of this emf depends on the residual current, so it drives a current to the tripping system which depends on the difference between them and neutral current.

When tripping current reaches a predetermined level the circuit breaker trips and open the main contacts and thus interrupts the circuit. A 3 - phase 4 wire electric system can also be protected by providing a 4 pole RCCB (Fig 4).

Fig 4

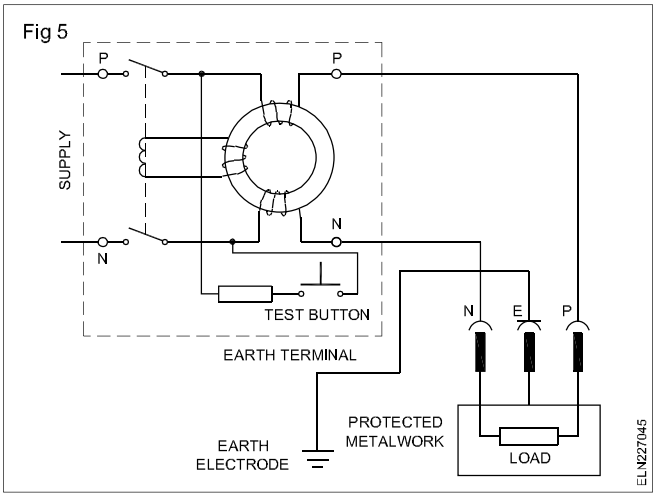




Test Switch

A test switch is a requirement as per BS842 (Fig 5). It is used to test the functioning of ELCB. When the test button is pressed it circulates additional current through neutral coil which is determined by the value of current limiting resistor R. As a result there exists a difference in current flowing through phase and neutral coils and hence the ELCB trips OFF.

Fig 5



Technical specification

The current ratings of ELCB are 25A, 40A and 63A.

No. of poles - 2 and 4

Nominal voltage - 240/415V 50Hz.

Sensitivities: ELCBs are designed to trip at leakage currents of 30mA, 100mA, and 300mA.

Electrical life: More then 10,000 operations.

Mechanical life:

20000 to 100000 operations.

Tripping time - < 30ms.

Time delayed RCCB

There are cases, where more than one RCCB is used in an installation, for example a complete installation may be protected by an RCCB rated at 100mA, while a socket intended for equipment may be protected by 30mA device.

Discrimination of the two devices then becomes important. For example an earth fault occurs in the equipment giving an earth fault current of 250mA. Since the fault current is higher, than the operating current of both devices, both will trip.

It does not follow, that the device with smaller operating current will trip first. This is a lack of discrimination between the two devices. To ensure proper discrimination, the device with a larger operating current, has a deliberate time delay built into its operation. It is called time-delayed RCCB. Images of 2 pole and 4 pole ELCB are given below (Fig 6).

Earth fault loop impedance

Earth wire from an equipment to the earth electrode is called earth loop. Earth fault loop impedance (Z_E) is the impedance of the fault current path. It must be low enough to ensure that the productive devices like ELCB will operate within the specified time.

In any case, the multiplication value of earth fault loop impedance in Ohms and the rated tripping current (I_t)in ampere of ELCB should not exceed 50V .

$Z_E \times I_t < 50V$.

Fig 6

a) 2-POLE ELCB

b) 4-POLE ELCB

ELN227046

Fuses

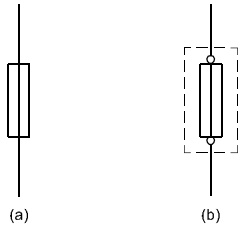
Objectives: At the end of this lesson you shall be able to
- **explain the purpose of the fuse in a circuit**
- **classify the different types of fuses and their uses.**

Purpose of fuses: A fuse is a safety device used for the purpose of protecting a circuit against excess current. In the event of excessive current, the fuse element melts and opens up the circuit thereby protecting it from damage.

Symbols: These are the graphical symbols used to illustrate an electrical fuse in electro-technical diagrams.

- General symbols of a fuse (Fig 1a)
- Fuse with terminals and protective housing (Fig 1b)

Fig 1



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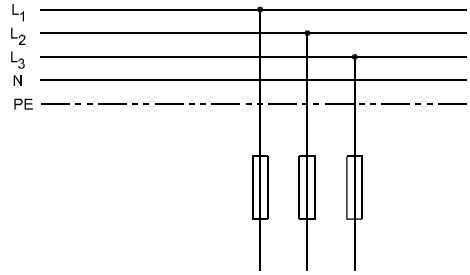
Placement of fuses: In electrical installations, the fuses are always connected into the live wires (Fig 2) and never into the neutral N or the protective earth line PE.

Terminology

Fuse element: The part of the fuse which is designed to melt and open up a circuit.

Fig 2



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Fuse-carrier: The removable portion for carrying the fuse element.

Fuse base: The fixed part of the fuse provided with terminals for connection to the circuit which is suitable for the reception of the fuse- carrier.

Current rating: Safe maximum current that can pass continuously without overheating.

Fusing current: The current at which the fuse element melts.

Cut-off factor: Time (period) taken by a fuse to interrupt the circuit in the event of a fault.

Fusing factor: Ratio between minimum fusing current and current rating.

Fusing factor = $\frac{\text{Minimum fusing current}}{\text{Rated current}}$

The fusing factor for a re-wirable fuse varies between 1.4 to 1.7 and may go up to 2.0, but for a HRC fuse it is 1.1

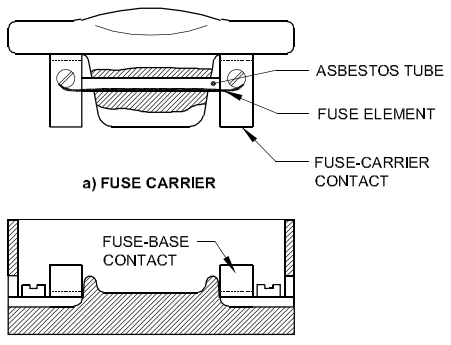
However, a fuse selected for over-current protection should not have a fusing factor of more than 1.4.

Types of fuses used in domestic wiring:

- Re-wirable type (up to 200A)
- Cartridge type (up to 1250A)

Rewirable type fuse (Fig 3): The fuse element in this type of fuse consists of a wire which may be replaced when necessary. These fuses are simple in construction and the initial cost as well as the renewal cost is very low.

Fig 3



The fuse elements used in this type are tinned copper wire, lead and tin alloy or aluminium wire (Table 1).

The fuse element will melt after approximately 2 minutes when carrying a current equal to twice the current rating. However, the cut-off time factor varies in rewirable fuses due to:

- the construction of the carrier (design of fuse-carrier/ base)
- the manner in which the fuse wire has been fitted
- the length of time the fuse was in service
- ambient temperature
- the amount of current etc.

Small fuse wires in parallel in a carrier to carry a large current should be avoided, as far as possible. The actual rating becomes less than the sum of the ratings of the individual strands. A paralleling factor of 0.7 to 0.8 is used to multiply the sum of the rating of individual strands to get the actual current rating.

Example: 35 SWG - copper wire has a fuse rating of 5 amps, and 3 strands in parallel together will a have current rating equal to 5x3x0.8=12 amps when 0.8 is taken as the paralleling factor.

Table 1

Current rating for	Approxi-mate fusing current Amp	Tinned copper wire		Alumi-nium wire dia. in mm
		S.W.G.	Diameter in mm	
1.5	3	40	.12192	--
2.5	4	39	.13208	–
3.0	5	38	.1524	.195
4.0	6	37	.17272	–
5.0	8	35	.21336	–
5.5	9	34	.23368	–
6.0	10	33	.254	.307
7.0	11	32	.27432	–
8.0	12	31	.29464	–
8.5	13	30	.31496	–
9.5	15	–	----	.400
10.0	16	29	.34544	–
12.0	18	28	.37592	–
13.0	20	–	----	.475
13.5	25	–	----	.560
14.0	28	26	.4572	–
15.0	30	25	.508	.630
17.0	33	24	.5588	–
18.0	35	–	----	.710
20.0	38	23	.6096	--
21.0	40	–	----	–
22.0	45	–	----	.750
24.0	48	22	.7112	.850
25.0	50	–	----	.90
29.0	58	21	.8128	–
30.0	60	–	----	1.00
34.0	70	20	.9144	1.22
37.5	80	–	----	1.25
38.0	81	19	1.016	--
40.0	90	–	----	1.32
43.0	98	–	1.1176	–
43.5	100	–	----	1.40
45.0	106	18	1.2192	–
55.0	120	–	----	1.60
62.0	130	–	----	1.70
65.0	135	17	1.4224	–
66.0	140	–	----	1.80
69.0	150	–	----	1.85
73.0	166	16	1.6256	–
75.0	175	–	---	2.06
78.0	197	15	1.8288	–
80.0	200	–	----	2.24
102.0	230	14	2.032	–

Disadvantages of rewirable type fuse:

- Deterioration of the fuse element by oxidation due to heating.
- Lack of discrimination.
- Effected by the fluctuation of the ambient temperature.
- Premature failure due to deterioration under normal load.
- Low speed operation (poor cut - OFF factor).
- External flash or arc on blowing.
- Poor rupturing capacity (under short-circuit condition).
- Wrong rating possible by human error.

Rewirable-type fuses up to 16A rated current should not be used in locations where short circuit level exceeds 2 KA, (I.S. 2086-963).

Cartridge fuses: Cartridge fuses are developed to over-come the disadvantages of the rewirable fuses. As cartridge fuse elements are enclosed in an air tight chamber, deterioration does not take place. Further the rating of a cartridge fuse could be accurately determined from its marking. However, the cost of replacement of cartridge fuses is more than that of rewirable fuses.

Cartridge fuses can be grouped as those with a:

- low rupturing capacity (Say rupturing capacity up to 50 KA.)
- high rupturing capacity. (Say rupturing capacity above 80 KA.)

Rupturing capacity is the ability of a fuse to open the faulty circuit without much arcing or damage to itself. For domestic installations, low rupturing capacity fuses are used whereas for power installations, high rupturing capacity (HRC) fuses are used.

Low rupturing capacity cartridge fuses can be further divided into:

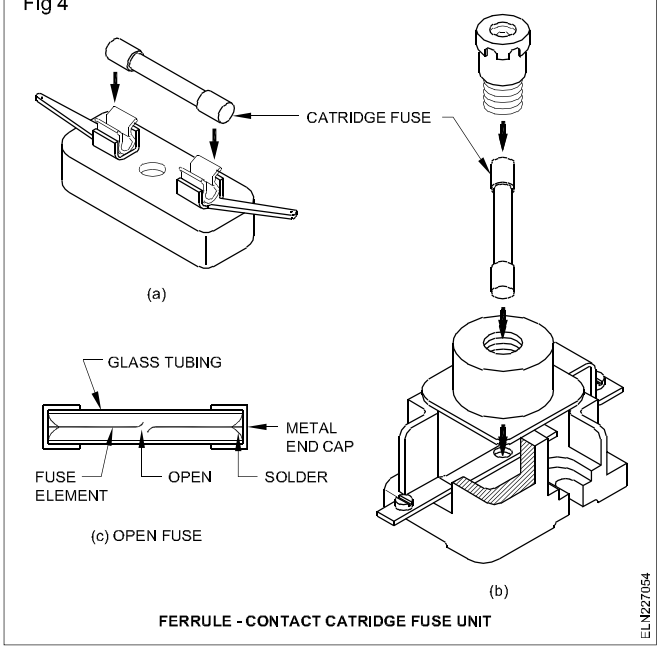
- Ferrule-contact cartridge fuses (Fig 4).
- diazed screw-type cartridge fuses (Fig 5).

Ferrule-contact cartridge fuses: This type, is used for protecting electrical and electronic circuits. These are available in 25, 50, 100, 200, 250, 500 milliamperes, and also in 1,2,5,6,10,16 & 32 amperes capacity.

Normally the current rating is written on one side of the cap, and while replacing, the same capacity fuse should be used. Its body is made of glass and the fuse wire is connected between two metallic caps.

This fuse can be plugged into the fuse socket (Fig 4a) or it can be fitted into a fuse base with a screw, type fuse- holder (Fig 4b).

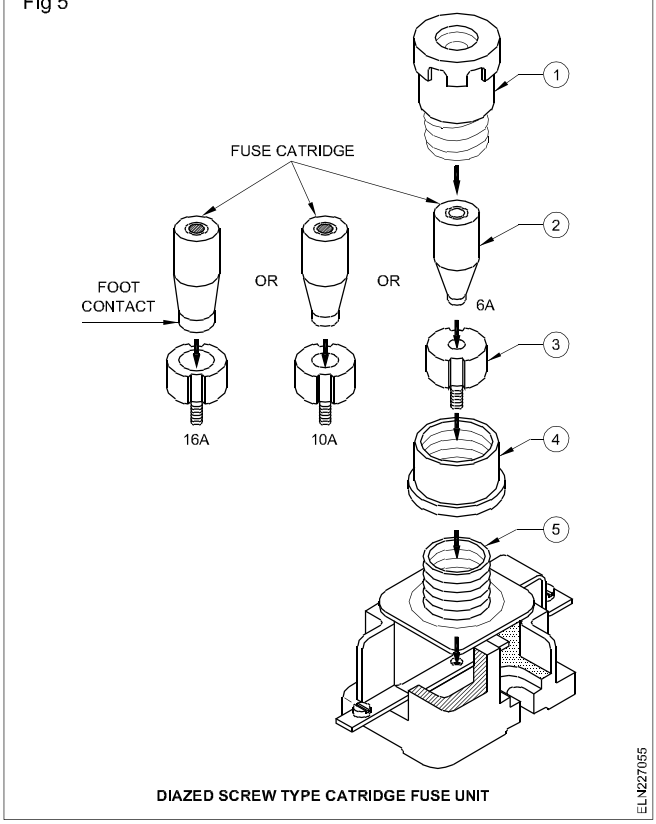
Fig 4



FERRULE - CONTACT CATRIDGE FUSE UNIT

Diazed screw-type cartridge fuses: This type of fuse is commonly used in domestic and industrical electrical installations . It consists of the following parts Fig 5.

Fig 5



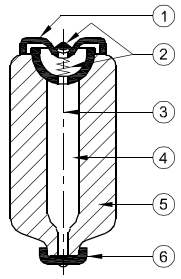
DIAZED SCREW TYPE CATRIDGE FUSE UNIT

- Screw cap or fuse cartridge-holder(1)
- Fuse cartridge(2)
- Fitting screw or contact screw(3)
- Protective plastic or ceramic ring(4)
- Fuse base or fuse socket(5)

Fuse cartridges are available for rated electric currents of: 2-4-6-10-16-20-25-32-50 and 63 amperes. To prevent the insertion of a fuse cartridge having a larger current rating than intended, the foot contacts of the fuse cartridges have different diameters for each rated current(the smaller the current the smaller the diameter of the foot contact). As there is also a separate fitting screw for each type of cartridge, it is not possible to insert, let's say, a 32 amp. fuse cartridge into the fitting screw of a 25 amp fuse cartridge.

The fuse cartridges has ceramic body of the cartridge with its foot and head contacts. The two contacts are linked by a fuse wire which is embedded in sand. Each cartridge has a break indicator which will be ejected from the cartridge if the fuse wire is burnt out (Fig 6).

Fig 6

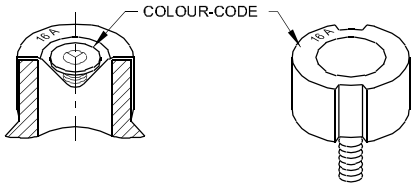


The parts of this fuse cartridge are

- head contact (1)
- break indicator (2)
- fuse wire (3)
- sand filling(4)
- ceramic fuse body (5)
- foot contact (6).

For easy identification of the fuse cartridges and the corresponding fitting screws, they are marked with various colours at the places (Fig 7). For each current rating, a different colour is used.

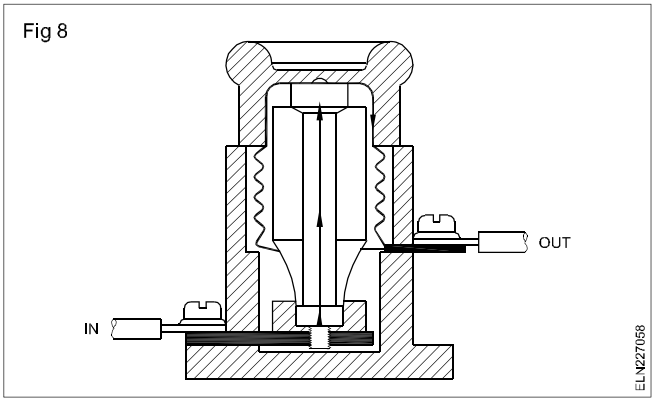
Fig 7



Pink	- 2 amperes	Blue	- 20 amperes
Brown	- 4 amperes	Yellow	- 25 amperes
Green	- 6 amperes	Black	- 32 amperes
Red	- 10 amperes	White	- 50 amperes
Grey	- 16 amperes	Copper	- 63 amperes

The flow of the electric current through the fuse base and the fuse is as shown in Fig 8. In order to prevent the accidental touching of a live line, the electrical supply must be connected to the terminal which is connected to the fixing screw at the bottom of the base.

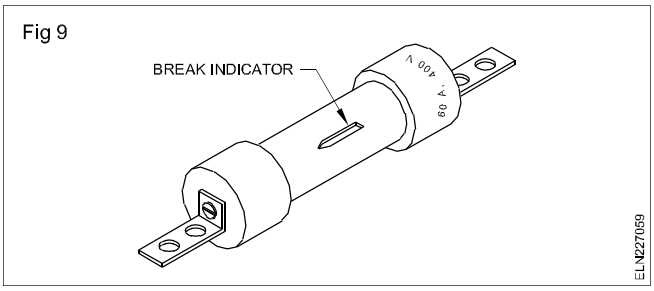
Fig 8



Diazed type fuses are available in two categories, a)quick-response type and b) delayed-action type. The quick-response type is used for heating circuits and normal loads whereas the delayed- action type is used for motor circuits and highly inductive circuits.

High rupturing capacity (HRC) fuses (Fig 9): They are cylindrical in shape and are made of a ceramic body filled in with a chemically treated filling powder or silica to quench the arcing quickly without any fire hazard.

Fig 9



Normally a silver alloy is used as the fusing element and when it melts due to the excessive current, it combines with the surrounded sand/powder, and forms small globules without making an arc, spark or gas. HRC fuses can open a short-circuited circuit within 0.013 second. It has an indicator to show the fuse has blown. The rupturing capacity of the fuse could be calculated from the following formula.

$$\text{Rupturing capacity in MVA} = \frac{\text{Fault current in amperes} \times \text{Circuit voltage}}{10^6}$$

As HRC fuses are capable of opening circuits having very high faulty currents, these are preferred in high power circuits even though the replacement cost is high.

Comparison between HRC & Rewirable fuses

Factor	Rewirable	HRC fuse
Rupturing capacity	Not recommended for currents exceeding 200 A or for more than 600V or where there is a possibility of S.C. fault of more than 5 MVA.	Normal types cater to fault loads up to 2500 KVA. For certain applitions, fuses up to 50 MVA are obtainable.
Rupturing speed(Cut-off factor)	Rating and cut-off are not absolutely reliable.	Very rapid. Usually AC supply current is cut off within the first half cycle.
Discrimination	Poor.	Accurate.
Safety in operation	Risk of flash-over under heavy fault condition.	No external flame.
Deterioration	Oxidation and consequent scaling causes reduction in the cross-sectional area, thus increasing resistance, and leading to over-heating and premature rupturing.	No oxidation. The element is completely sealed.
Fusing factor	Copper wire upto 20A -1.7. Over 20A- 2.0.	As low as 1.1.

Relays - types - symbols

Objectives: At the end of this lesson you shall be able to
- **define a relay and classify the relays**
- **classify relays according to the operating force and function**
- **state the common codes used for specifying contacts and poles**
- **specify a relay**
- **explain the function of the shading coil in an AC relay**
- **state the causes of the failure of the relay**
- **identify the symbols used in relay as per I.S.2032 (Part XXVII).**

Relay: A relay is a device which opens or closes an auxiliary circuit under predetermined conditions in the main circuit.

Relays are extensively used in electronics, electrical engineering and many other fields.

There are relays that are sensitive to conditions of voltage, current, temperature, frequency or some combination of these conditions.

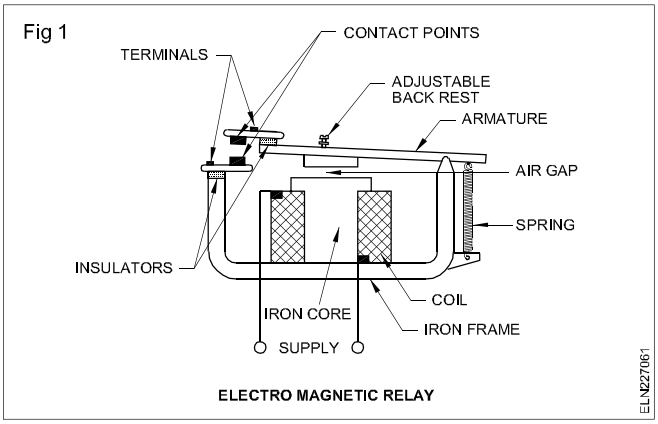
Relays are also classified according to their main operating force as stated under.

- Electromagnetic relays
- Thermal relays

Electromagnetic relay: A relay switch assembly is a combination of movable and fixed low-resistance contacts that open or close a circuit. The fixed contacts are mounted on springs or brackets, which have some flexibility. The movable contacts are mounted on a spring or a hinged arm that is moved by the electromagnet in the relay (Fig 1).

The other types of relays coming under this group are as follows.

Fig 1



ELECTRO MAGNETIC RELAY

Current sensing relay: A current sensing relay functions whenever the current in the coil reaches an upper limit. The difference between the current specified for pick up (must operate) and non-pick up (must not operate) is usually closely controlled. The difference in current may also be closely controlled for drop out (must release) and non-drop out (must not release).

Under-current relay: Under-current relay is an alarm or protective relay. It is specifically designed to operate when the current falls below a predetermined value.

Voltage sensing relay: A voltage sensing relay is used where a condition of under-voltage or over-voltage may cause a damage to the equipment. For example, these types of relays are used in voltage stabilizers. Either a proportional AC voltage derived from a transformer or a proportional DC derived from a transformer and rectifier used for this purpose.

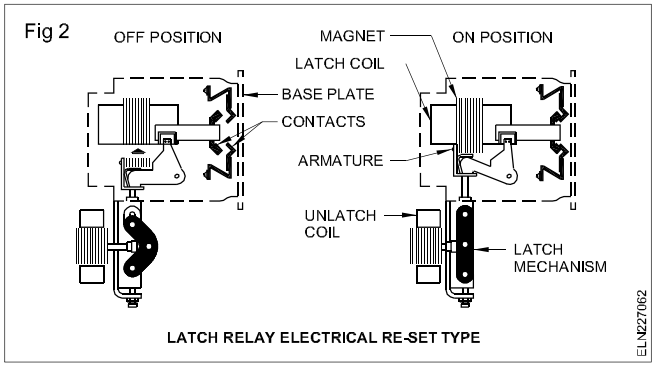
Latching relays

Latching relays are capable of maintaining their contacts in the last assumed position without the maintained current in the coil. These relays hold their contacts in position after power is cut off.

There are two basic kinds of latching relays called mechanical reset and electrical reset.

Mechanical re-set relays: Mechanical re-set relays have a coil, an armature mechanism, and a mechanical latching device that locks the armature in the operated position after the coil has been de-energised. Manual tripping of the locking mechanism, re-sets the relay.

Electrical reset relays: An electrical re-set relay (Fig 2) has the same operating mechanism, but it includes a second coil and armature to trip the latching mechanism. This system allows remote re-setting of the relays to their original position.



Reed relays

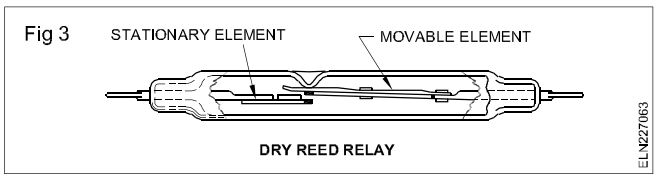
Reed relays physically look different than other kinds of relays. They consist of essentially magnetically actuated reed switches, with actuating solenoids or coils.

In the reed relay, freedom from contamination and the limited number of moving parts, avoid many disadvantages of the conventional electromechanical relays. In addition to the above, the contact resistance is kept to minimum due to the fact the contact points are made either with gold or rhodium. Further, these relays need very low power to operate and can handle a 250 watt solenoid load on their contacts.

There are three types of reed relays namely

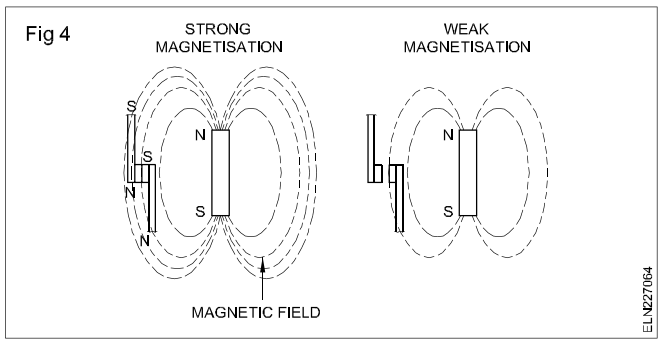
- dry-reed relay
- ferreed relay
- mercury wetted contact relay

Dry reed relay: Two opposing reeds are sealed in to a narrow glass tube (Fig 3). The reeds overlap at their free ends. At the contact area, they are usually plated with gold or rhodium to produce a low contact resistance. They may have multipole multicontact designs.

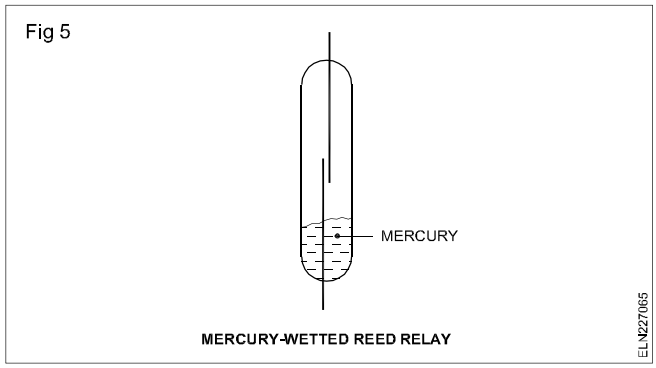


Ferreed relay: The word ferreed denotes a reed relay in which the dry-reed switch is contained with one or more magnetic members. The magnetisation can be changed by current pulses in associated coils.

In the magnetised state the magnetic members supply a field strong enough to close the contacts. In the other magnetised state, the field is too weak to hold the contacts closed (Fig 4). An operating pulse through the coil produces the first state. A release pulse produces the second state. The contacts can break or make within 5 micro-seconds duration.

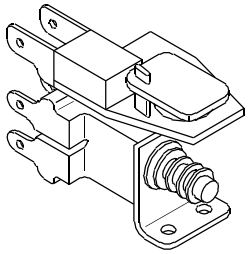


Mercury wetted contact relay: This relay consists of a glass enclosed reed with its base immersed in a pool of mercury (Fig 5) . When the coil surrounding the capsule is activated, mercury makes the contact between fixed and movable contacts.



Impulse relay: The impulse relay (Fig 6) is a special single-coil relay. It has an armature-driven mechanism that alternatively assumes one of two positions as the coil is pulsed. This mechanism moves the contact from one position to the other and back again as electrical pulses are received. The relay can operate on AC or DC power.

Fig 6

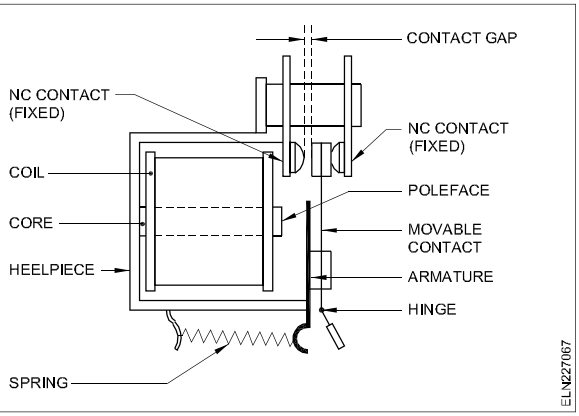


IMPULSE RELAY

ELN227066

Clapper-type armature relay: The simplest contact arrangement used in armature relays is the break-make or transfer-contact combination. A clapper-type armature, (Fig 7) opens or closes the contacts. A movable contact is attached directly to the armature by means of a flexible strip of metal. When the electromagnet operates, the armature moves this contact, opening and closing the two sets of contacts.

Fig 7

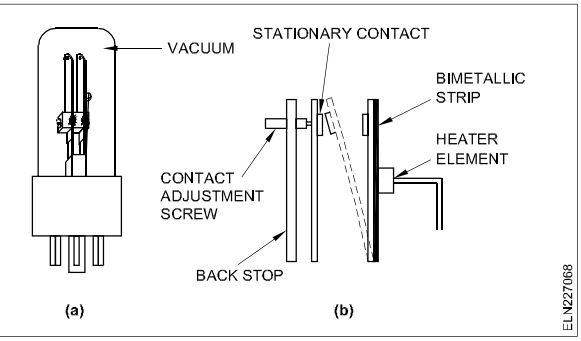


ELN227067

Thermal relay: A thermal relay (Fig 8) is one that operates by changes in temperature. Most of the bimetallic relays where the bimetallic element changes its shape, in response to changes in temperature comes under this group.

It takes time for the heating element to reach the necessary temperature and more time to raise the temperature of the bimetallic element. Therefore, thermal relays are often used as time-delay relays.

Fig 8



ELN227068

Poles and contacts: Relays may operate single or as multi-poles and may open or close specified contacts. In writing specifications certain abbreviations as stated below are commonly used.

SP - Single pole

SB - Single break

ST - Single throw

DB - Double break

DP - Double pole

DM - Double make

DT - Double throw

NO - Normally open

3P - Three pole

NC - Normally closed

4P - Four pole

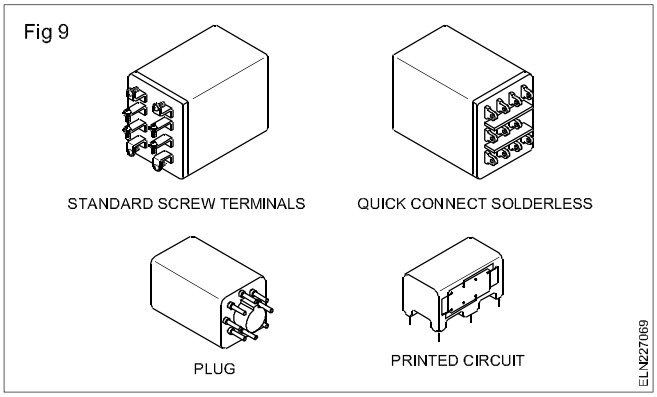
For example a 4PDT has a four-pole, double throw contact arrangement.

NO indicates the contacts are open in the unoperated position of the relay and they are called as normally open (NO) contacts.

NC indicates the contacts are closed in the unoperated position of the relay and they are called normally closed (NC) contacts.

Enclosures and mounts: Relays are normally enclosed in plastic or metal caps to protect the operating parts against dust and environment. Relays can be mounted to the circuit direct by plug-in system, PCB mounting or may be wired separately using screws terminals (Fig 9).

Fig 9



ELN227069

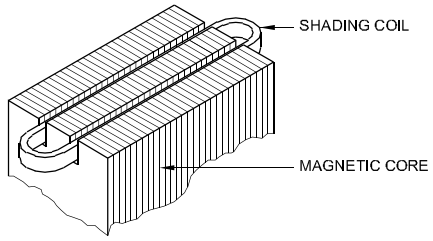
AC relay: In an AC relay magnet, the magnetic field continually changes direction. With a 50 Hz supply the magnetic field passes through zero 100 times per second. At the time of zero field, the armature starts to release. Although the field quickly builds up in the reverse direction, a noisy chatter can result.

To eliminate chatter, a shading coil (Fig 10) is placed near the tip of the magnet pole face. This shading coil establishes a magnetic field that lags the main magnetic field slightly and aids in keeping the magnet sealed when the main field passes through zero.

An AC relay should not be used in DC supply.

The AC relay when connected to DC supply, will draw more current in the absence of inductive reactance and result in burning out the coil.

Fig 10



Causes of relay failures: Relay failures are usually caused by the gradual deterioration of the parts. This deterioration can be electrical, mechanical or chemical in nature.

The environmental shirks that contribute to physical break-down include large temperature changes, shock, vibration and voltage or current changes. Therefore, it is important that these factors are taken into consideration to ensure reliable performance of relays.

In general, when a relay fails, look for the following.

1 Improper control voltage.

2 Dirt, grease or gum on contacts or moving parts.

3 Excessive heating of parts: discolouration or charred insulation on coil or base.

4 Bending of moving parts.

5 Corrosion or deposits on metal parts.

6 Excessive wear on moving parts.

7 Loose connections.

8 Improper spring tension.

9 Improper control pressure.

10 Improper functioning of the time delay device.

While specifying relays the following particulars are necessary.

Type of operating voltage

AC or DC

Sequence of operation _____

Operating voltage _____ volts

Current rating _____ amps

Coil resistance _____ ohms

Number of contacts _____ NO _____ NC

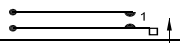
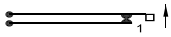
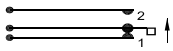
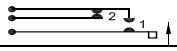
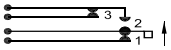
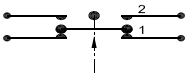
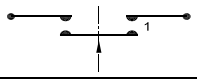
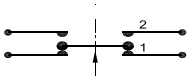
Number of poles _____

Type of mount _____

Type of enclosure _____

Table 1 given below lists some of the relay contact combinations.

Table 1

Design	Sequence	Symbol
1 SPST-NO	Make 1	
2 SPST-NC	Break 1	
3 SPDT	Break1 before make 2	
4 SPDT	Make 1 before break 2	
5 SPDT (B-M-B)	Break 1 before make 2 before break 3	
6 SPDT-NO	Center OFF	
7 SPDT-NC-NO (DB-DM)	Double break 1 double make 2	
8 SPST-NO (DM)	Double make 1	
9 SPST-NC (DB)	Double break 1	
10 SPDT-NC (DB-DM)	Double break 1 double make 2	

NE code Mounting accessories - specification of wooden boards and blocks

Objectives: At the end of this lesson you shall be able to
- **state the National Electrical Code of Practice with respect to mounting accessories and boards**
- **specify the wooden round blocks and boards for mounting electrical accessories.**

Recommendations of the National Electrical Code for mounting the accessories on the boards

When electrical accessories are to be mounted on the boards, the following National Electrical Code recommendations should be adopted.

– All ceiling roses, brackets, pendents and accessories shall be mounted on substantial wooden blocks, having a depth of not less than 4 cm.

– Where teak or hardwood boards are used for mounting switches, regulators etc., these boards shall be well varnished with pure shellac on all sides (both inside and outside), irrespective of being painted, to match the surroundings. The size of such boards shall depend on the number of accessories that could be conveniently and neatly arranged.

– No mounting of accessories shall be done within 2.5 cm of any edge of the panel of the board, and no hole other than the holes by means of which the panel is fixed shall be drilled closer than 1.3 cm from any edge of the panel.

– A switchboard shall not be installed with its bottom within 1.25 m above the floor unless the switchboard is enclosed in a box with locking arrangement.

– If the switchboards are recessed in the wall, the front shall be fitted with a hinged panel of teakwood or other suitable material, such as bakelite, or fitted with an unbreakable glass door in teakwood frame.

– Open type switchboards shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.

– Switchboards shall not be erected above gas stoves or sinks, or within 2.5 m of any washing unit in the washing room.

– Unnecessary crossing of connections should be avoided between apparatus and terminals, within the board.

– In a hinged type board, the incoming and outgoing cables shall be fixed at one or more points according to the number of cables on the back of the board, leaving suitable space in between the cables, which shall also, if possible, be fixed at the corresponding points on the switchboard panel. The cables between these points shall be of such length as to allow the switchboard panel to swing through an angle of not less than 90°.

Specification of commercially available boards, round blocks for mounting electrical accessories

The boards which are used for wiring installation are available in different sizes, made up of teak wood, P.V.C. or metal. When selecting the boards, the following points are to be considered.

Size of the board: The number and type of accessories to be mounted on the board decide the size of the board. After selecting the accessories to be mounted on the board, the layout may be formed on a cardboard template, and then the size of the board may be determined.

System of wiring: This decides whether boards should be placed on the surface of the wall or flush-mounted. Accordingly, a single or hinged board could be selected. However, depending upon the system like batten or metal conduit or PVC conduit, the board may be made of wood, metal or PVC respectively.

Place of wiring : This is another deciding factor to choose the material of the board. For indoors we may use board of any material depending upon the system of wiring.

Specification for blocks and boards

While specifying the boards for wiring installation, the following particulars shall be given.

– Material of the board - wood, PVC or metal.

– Size - length, breadth and height in mm.

– Thickness of the material in mm.

– Single or double (double-hinged or non-hinged type).

– Additional information like type of finish on wooden boards, colour of PVC or metal boards, surface or flush mounting etc.

T.W. round blocks: For specifying the round blocks, its overall diameter and thickness have to be given. Single and double (with base block) round blocks are available. Nowadays, P.V.C. blocks are also in use. The following sizes are available commercially. The first dimension denotes the overall diameter, and the second dimension denotes the thickness of the block.

Round blocks - single	Round blocks - double
75 mm x 25 mm	75 mm x 35 mm
75 mm x 40 mm	75 mm x 40 mm
90 mm x 25 mm	90 mm x 35 mm
90 mm x 40 mm	100 mm x 35 mm
100 mm x 25 mm	100 mm x 40 mm
100 mm x 40 mm	

Instead of round blocks, square blocks are also available. For certain special purposes hexagonal shape blocks are also used. According to the code of practice, the minimum thickness of round blocks should be 40 mm.

T.W. boards

For fixing two or more accessories on one board or for fixing accessories like fan regulators, D.P. switches etc. T.W. boards are used. Generally, the following sizes of boards are available commercially, in teak wood, PVC or metal.

The minimum thickness of non-hinged boards should be 40 mm whereas for hinged boards the thickness varies from 65 to 80 mm.

Specification: Metric System

Length	Breadth	Length	Breadth
100 mm	x 100 mm	300 mm	x 250 mm
150 mm	x 100 mm	380 mm	x 450 mm
150 mm	x 150 mm	450 mm	x 250 mm
200 mm	x 150 mm	450 mm	x 300 mm
200 mm	x 200 mm	600 mm	x 300 mm
250 mm	x 200 mm	600 mm	x 300 mm
300 mm	x 200 mm	750 mm	x 600 mm

Through and pilot holes - wood-machine screw specifications

Objectives: At the end of this lesson you shall be able to
- **determine the size of through holes, with respect to the cable size and the number of cables**
- **state the method of making pilot holes using a bradawl or gimlet or by undersized drills**
- **specify wood screws and machine screws.**

Determining the through hole size according to the cable size and number of cables

While drilling holes in the boards for cable entry, the overall diameter of the cable has to be known. The overall dia. of the cable may vary according to the type of insulation used, and also from one manufacturer to another. Further the size depends upon the voltage grading. Hence the best practice is to take a piece of the cable, measure the overall size and select a suitable drill so that the cable enters the hole freely. When the number of cables to be inserted is more than one, the drill size may be selected accordingly.

The overall dia. and the overall sizes of the cables are indicated in Table 1.

TABLE 1
Sizes of conductors

Conductor of cables		Approximate overall dia . of cables	
Normal area in mm^2	Number and dia of wire in mm	250V grade in mm	660 V grade in mm
1.5	1/1.40	4.20	5.40
2.5	1/1.80	4.60	6.00
4.0	1/2.24	5.25	6.80
6.0	1/2.24	6.00	7.35
10.0	1/3.55	7.10	8.10
16.0	7/1.70	8.85	9.65
25.0	7/2.24	10.80	11.50
35.0	7/2.50	11.75	12.25
50.0	7/3.00	13.40	13.90
70.0	19/2.24	---	16.70
95.0	19/2.50	---	19.10

Example: Referring to Table 1 it is found that for a 2.5 sq.mm. size conductor of the cable, the diameter of the cable (including insulation) is 4.6 mm. Hence, the hole size can be determined as 5 mm dia. and the drill required is of 5 mm dia.

The method of making pilot holes in wood using bradawl and gimlet

Pilot holes should always be made in the wood, when using wood screw for fixings so that the screw can be driven securely into the wood without damaging the wood, and is fixed with less effort.

First, position the accessories to be fitted on the board according to the layout and also to meet the aesthetic requirements. Open the cover and identify the placeswhere the pilot holes are to be made. The usual practice is to identify the cable entry 'through holes' and the screw fixing 'pilot holes' with different distinct markings.

Use a bradawl for making the pilot holes in softwood. If a gimlet is chosen, it should not be bigger than the wood screw proposed to be fitted. Pilot holes can be made in softwoods for screws up to size 6. For larger sized screws and for harder woods, pilot holes can be made best by a gimlet, or a second choice is by drilling undersized holes.

Select the correct size of drill for pilot holes: Drill sizes should be about 2 mm smaller in diameter than the diameter of the screw shank.

Drill hole to correct depth: In softwoods - hole depth equals 1/2 screw length.

In hardwoods - hole depth equals screw length.

For secure fixings it is important not to drill holes too deep.

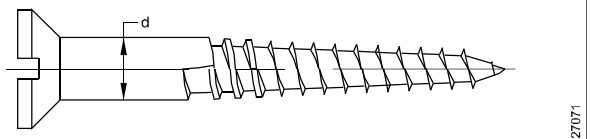
Wood screws: These screws have a single spiral of thread running from the point, clockwise for about two thirds of the length. The unthreaded part is called the shank, and gives the 'screw number' (Designation number).

Types of wood screws

Wood screws are classified with respect to the shape of the heads. Accordingly 3 types of wood screws are used for wiring installation.

Slotted countersunk head wood screws (Fig 1): This type of screws is used for general wood work for fitting miscellaneous hardware.

Fig 1

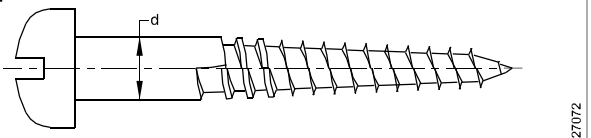


SLOTTED COUNTERSUNK HEAD WOOD SCREW

In electrical wiring for fixing wooden blocks, boards, battens and electrical accessories, countersunk holes should be used. The screw shall be driven until the head is flush with the work or slightly below surface.

Slotted round head wood screws (Fig 2): This type of wood screws is used for surface work, for installing electrical fittings and accessories where fitting holes are not countersunk.

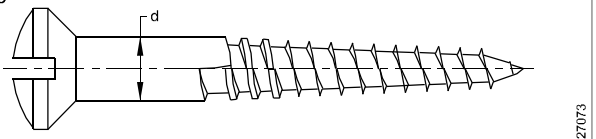
Fig 2



SLOTTED ROUND HEAD WOOD SCREW

Slotted raised countersunk head wood screws (Fig 3): Raised countersunk wood screws are used for fixing decorative electrical fittings. Even for fixing flush type electrical accessories on T.W. board or box, raised countersunk wood screws are used.

Fig 3



SLOTTED RAISED COUNTERSUNK HEAD WOOD SCREW

Of the three types of screws listed above, countersunk (flat head) screws are commonly used for electrical wiring installations.

Designation of wood screws: Wood screws shall be designated by the screw number, length, type of head and material. Table 2 gives the designation number, shank diameter available and length for slotted countersunk wood screws.

Example 1: A slotted countersunk head wood screw of shank 4.17 mm dia. length 20 mm, made of steel shall be designated as

Wood screw No. 8 x 20 countersunk steel (or)

Wood screw No. 8 x 20 I.S. 6760 steel.

The preferred length and screw number of countersunk wood screws are given in Table 2.

Example 2: A slotted round head wood screw of shank, 3.45 mm dia. length 30 mm, made of steel shall be designated as

Wood screw No.6 x 30 round head steel or
Wood screw No.6 x 30 I.S. 6739 steel.

Example 3: A slotted raised countersunk head wood screw of 2.08 mm dia. length 12 mm, made of steel shall be designated as

Wood screw No.2 x 12 raised countersunk steel, or
Wood screw No.2 x 12 I.S. 6736 steel.

Selection of the correct type, size and length of screws: Note the surface finish on the fixture at the fixing point, where a recess is provided. Select a countersunk screw; if not, select a round head screw.

Check the size of the hole in the fixture, then select a screw with a screw shank diameter equal to the hole size.

Decide on the length of the screw from the thickness of the fixture, and the thickness of the wood that the fixture is to be fixed in.

Screwing methods

In softwood: Locate the fixture and screw over the hole and tighten the screw.

In hardwood: Locate the screw in the hole and drive the screw for atleast 5 turns. Withdraw the screw, then locate the fixture and screw over the hole and tighten the screw. When the fixture has more than one fixing hole prepare the uppermost hole, and allow the fixture to hang from its fixing screw while the other fixing screws are located and then tightened.

Precautions to be adopted while fixing wood screws

– Before fixing the wood screws, the tip of the screws must be coated with rust-preventing material such as soap, wax etc.

Screws should never be hammered.

– Use a proper screwdriver which fits as closely as possible in the slots of the screws.

– Do not use a high-leverage screwdriver for fixing small screws.

– Pilot holes should be made, before fixing the wood screws.

Advantages of screws over nails

Screws provide for a more secure fixing than is possible with nails, and have the further advantage that they may be loosened or tightened as required. Screws can be made from rust-proof and corrosion-resistant materials, like brass, stainless steel, aluminium alloy, bronze etc.

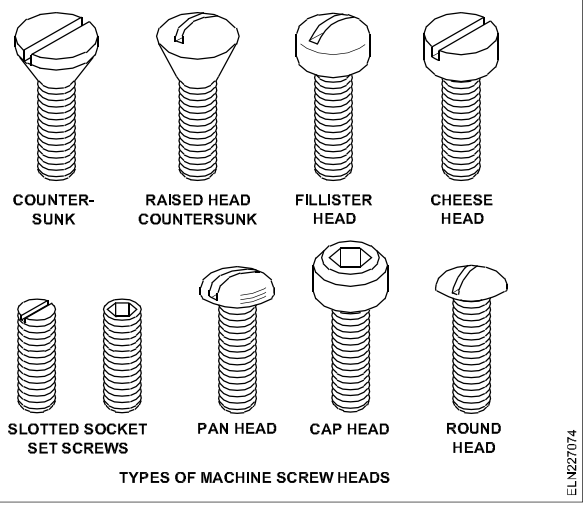
Machine screws: Machine screws are used for securing component and assembly work.

These screws should normally be screwed into tapped holes or used with nuts.

Types of machine screw head

Machine screws are mainly classified with respect to the shape of heads.The different types of screw heads in general use is given below (Fig 4).

Fig 4



TYPES OF MACHINE SCREW HEADS

Application: The cheese head type of screws is used for general assembly work.

Flush fitting screws are used when there is little clearance between assemblies or where protruding heads are not desirable.

The semi-flush type is used mainly for panel assembly or where a pleasing appearance is required.

Types of threads

Various types of thread screws are available.

Metric threaded screws: These screws are normally specified with alphabet `M'. M4, where `4' denotes the diameter of the screw in mm, and M denotes the type of thread in metric. Hence `M4 x 20' is a machine screw of metric thread having 4 mm dia. and 20 mm length.

BA (British Association) threaded screws: These screws are specified with the letters `BA'.

Unified national threaded screws (UNF): These screws are specified as `UNF' i.e. `Unified National Fine' or `UNC' i.e. `Unified National Coarse'.

Self-tapping screws: These are also called `Thread forming tapping screws'. They are specified in screw size and number, similar to the wood screws.

Specification: While specifying a machine screw, it is essential to mention the head type, screw length and the thread type.

Table 2

Screw No.	Nominal diameter of un- threaded shank in mm.	Preferred length in mm															
		8	10	12	15	20	25	30	35	40	45	50	55	60	65	70	75
0	1.52	✓	✓	✓													
1	1.78	✓	✓	✓													
2	2.08	✓	✓	✓													
3	2.39	✓	✓	✓													
4	2.74			✓	✓	✓	✓										
5	3.10			✓	✓	✓	✓	✓									
6	3.45			✓	✓	✓	✓	✓	✓	✓							
7	3.81			✓	✓	✓	✓	✓	✓	✓							
8	4.17			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9	4.52				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10	4.88				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓