Types of wiring : Domestic and Industrial - selection of cable size

Objectives: At the end of this lesson you shall be able to
- **state the types wiring used in domestic installations**
- **state the use of cord grip and underwriter's knot.**

Introduction

The type of wiring to be adopted is dependent on various factors viz. location durability, safety, appearance, cost and consumer's budget etc.

Types of wiring

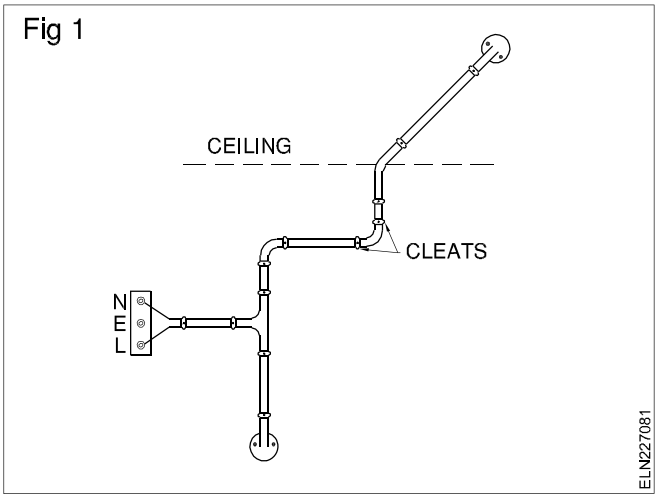
The following are the types of internal wiring used in domestic installations.

- Cleat wiring (for temporary wiring only)
- CTS/TRS (batten) wiring
- Metal/PVC conduit wiring, either on surface or concealed in the wall.
- PVC casing & capping wiring

Cleat wiring

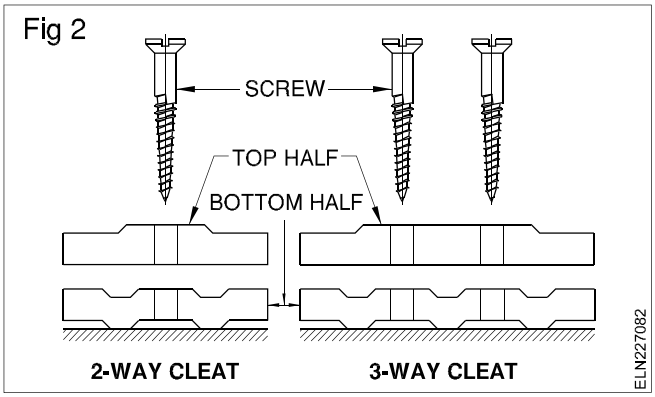
This system uses insulated cables supported in porcelain cleats (Fig 1).

Fig 1



Cleat wiring is recommended only for temporary installations. These cleats are made in pairs having bottom and top halves (Fig 2). Bottom half is grooved to receive the wire and the top half is for cable grip.

Fig 2



Initially the bottom and top cleats are fixed on the wall loosely according to the layout. Then the cable is drawn through the cleat grooves, and it is tensioned by pulling and the cleats are tightened by the screw.

The cleats are of three types, having one, two or three grooves, so as to receive one, two or three wires.

Cleat wiring is one of the cheapest wirings considering the initial cost and labour, and is most suitable for temporary wiring. This wiring can be quickly installed, easily inspected and altered. When not required this wiring could be dismantled without damage to the cables, cleats and accessories. This type of wiring may be done by semi-skilled persons.

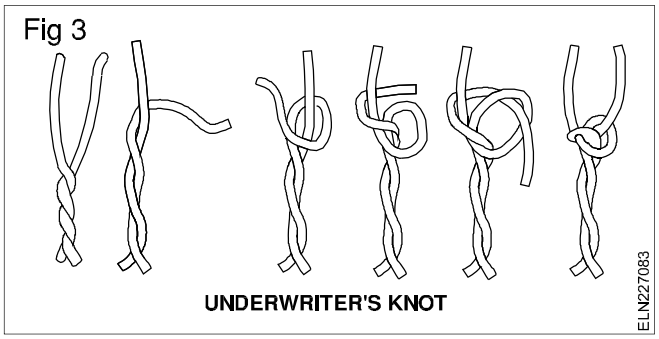
Cord grip and underwriter's knot

When a lamp or lamp with its shade is hung from the ceiling, the flexible cable connected to the lamp-holder is subjected to mechanical stress due to the weight of the lamp-shade and the lamp.

If the stress is not removed, the cable connection may come out of the terminals and result in shock hazards. To relieve the strain from the terminals of pendants, lamp-holders and ceiling roses, a cord grip or an underwriter's knot is used. A cord grip or underwriter's knot is also used in pull switches and other portable appliance connectors.

Underwriter's knot (Fig 3)

Fig 3

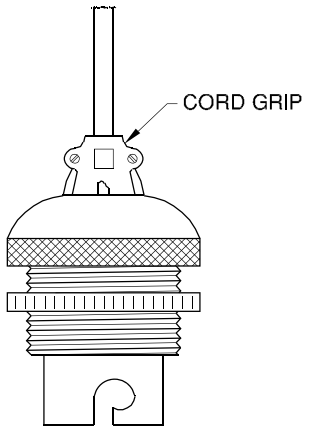


A knot is made on twin-twisted or twin-core flexible cable inside the accessories' cap cover.

Cord grip (Fig 4)

In some of the electrical accessories like lamp-holders, appliance connectors, plug pin tops etc. a cord grip arrangement is provided. These are an effective means of relieving the terminals from strain due to pulling or twisting of the cord.

Fig 4



ELN227084

LAMP-HOLDER WITH CORD GRIP

Types of electrical wiring

Objectives: At the end of this lesson you shall be able to
- **explain the types of electrical wiring and their application**
- **state the advantages and disadvantages of each types.**

Many wiring systems are developed to meet the safety requirements, economy of cost, easy maintenance and trouble shooting. A particular system can be chosen according to technical requirements but the system needs to be approved by the local electricity authorities. The following are the fundamental requirements for any wiring system. They are:

i For safety, switches should control the live phase wire. The second terminal of the switch called as half wire should be connected to the appliance or socket through the wire. The neutral can be connected directly to the appliance, socket or lamp. This enables the workman to rectify the defects of the particular lamp or appliance by switching off the particular circuit only and the main supply need not be switched 'off'.

ii For safety, fuses should be placed in the live/phase wire only. The lamp should not get supply when the fuse is blown.

iii To supply the rated voltage, parallel connections should be given to all lamps and appliances.

Types of wiring system: There are three types of wiring systems used for tapping supply from mains to the different branches. They are as follows.

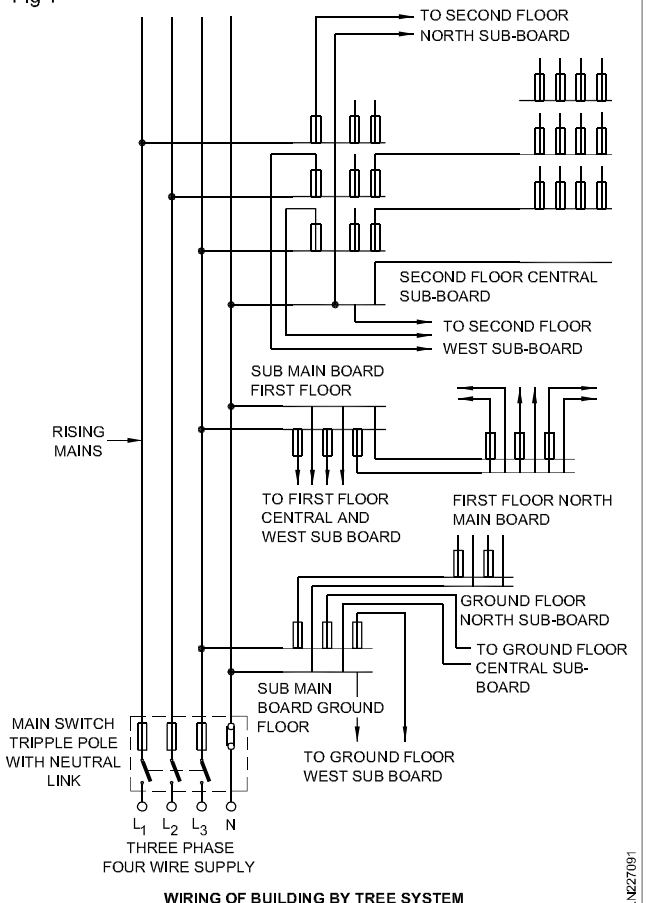
1 Tree system

2 Ring main system

3 Distribution board system

Tree system: In this system, copper or aluminium strips in the form of bus bars are used to connect the main supply to the raising mains (Fig1). This system is suitable for multi-story buildings and the bus bar trunking space is provided in the building at a convenient location and at load centres for the purpose of economy.

Fig 1



ELN227091

WIRING OF BUILDING BY TREE SYSTEM

At each floor the running main is connected to the sub-main board through proper cable terminations. If there are more than one flat in each floor the individual main switches for the flat get their supply from the sub-main board through a distribution network which may include an energy meter for each flat.

However the system adopted within the flat will be the distribution board system.

Advantages

1 The length of the cables required for installation will become less. Hence, the cost is less.

2 This system is suitable for high rise buildings.

Disadvantages

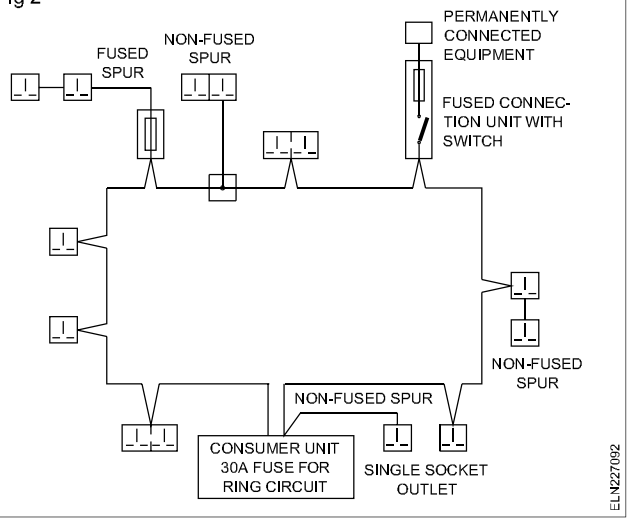
1 The voltage across the appliances which are at the farthest end of the tree system may be less when compared to the one connected to the nearest end if the bus bars size is not of sufficient size.

2 As fuses are located at different places, fault location becomes troublesome.

3 When aluminium bus bars are used for economic considerations, the tappings can become loose and interrupt power supply.

Ring main system: This system consists of two pairs of cables of size 4 or 6sq.mm which run through the rooms and are brought back to the main or sub-board (Fig 2 and 3). Tappings are taken for sockets or ceiling roses from the pair of cables through fuses and controlling switches. There may be saving of copper used because the current can be fed from both sides. As this system requires special sockets or plugs with fuses it becomes costly; and hence rarely used in India.

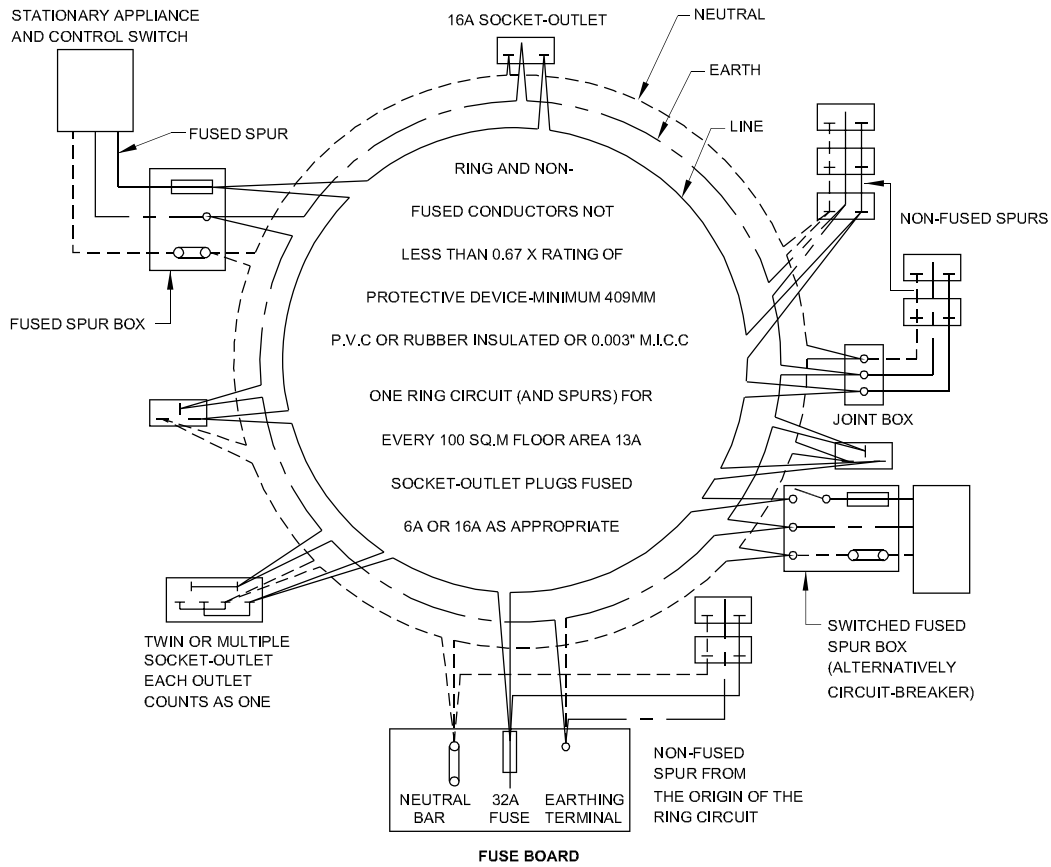
Fig 2



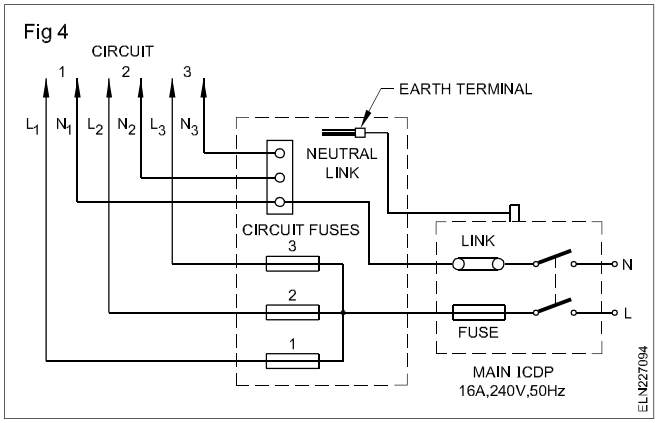
As per IEE regulations one ring circuit has to be there for every 100 sq metres of the floor area or part thereof. The number of power plugs fed from branch lines (spurs) should not exceed two and the total current should not exceed 30 amps. Protection for individual power plug can be provided by having built-in-fuses with the individual power plugs or by having MCB type switch and socket arrangement.

Distribution board system: This is the most commonly used system. This system enables the appliances connected to the system to have the same voltage. The main switch is connected to the distribution board through

Fig 3



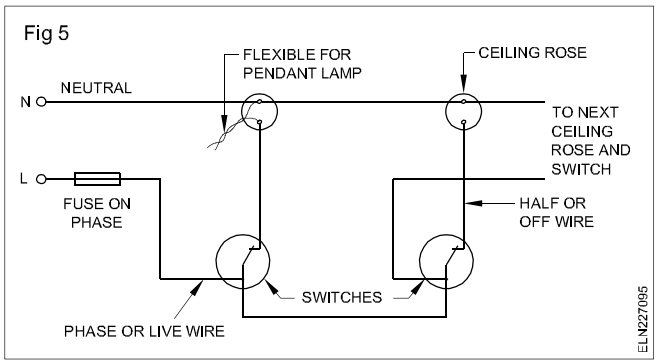
suitable cables. The distribution board has a number of fuses depending upon the number of circuits required in the installation, and the phase and neutral cable of each phase are taken from the distribution board (Fig 4).



As each circuit can have power up to 800 watt, the phase wire which is taken from the circuit fuse of the distribution board is looped to the other light switches or fan switches of the same circuit by any one of the following ways.

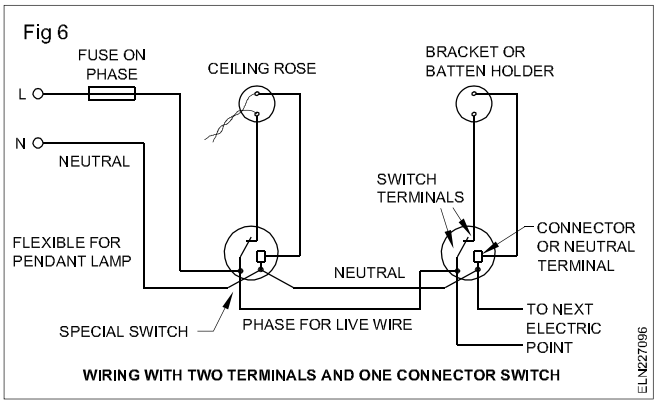
No joint is allowed in the cable route except in switches, ceiling roses and joint boxes.

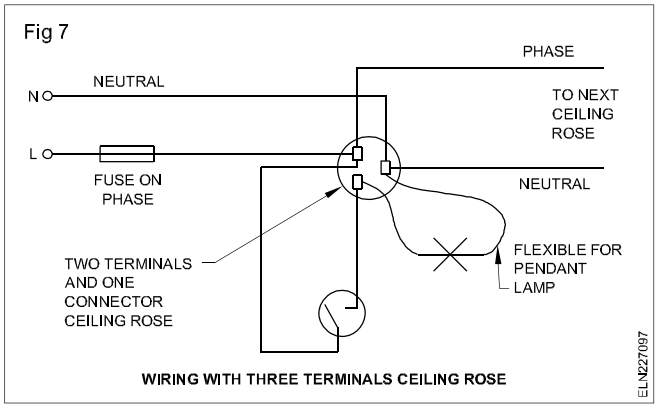
a Looping out from switch and ceiling rose: Fig 5 shows the simple looping in method which is commonly employed. The phase wire which is connected to the terminals of the switch is looped out to the next switch and so on, whereas the neutral wires are looped together from ceiling roses (Fig 5). Cable consumed in this system is very high.



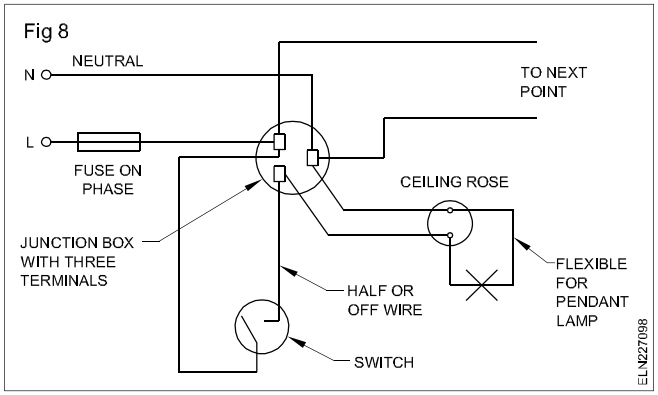
b Looping out from switch: This system employs special switches having two terminals and one connector (Fig 6). Both the phase and neutral cables are taken to the switch for looping the cables. As these accessories are not commonly manufactured in India such a system is not used.

c Looping out from 3-plate Ceiling roses: In this type of system, three terminal ceiling roses need to be used (Fig 7). As this system uses less cables when compared to (a), this system is in use in some parts of India.





d Looping out with junction box: In this system a pair of conductors from the distribution board is brought to the junction box and tappings are taken to switches, two plate ceiling roses as well as other points from the junction box are shown in Fig 8. This method may be economical for lodges where a row of rooms are constructed on either side of a common corridor.



Distribution board system

Advantages:

1 All loads are connected across the same voltage

2 Fault location is easy.

Disadvantages:

1 Requires skilled labour

2 Costlier than other systems.

Comparison of different types of wiring at a glance is given in the following table.

Different types of wiring at a glance

Sl. No.	Particulars	Casing & Capping	Batten wiring		Conduit wiring	
		PVC (Poly Vinyl Chloride)	TRS (Tough Rubber Sheathed)	LCC (Lead Covered Cable)	Metal	PVC
1	Material	PVC casing and capping PVC wires wooden gutties screws, blocks and boards.	T.W.Batten TRS/CTS wires gutties, screws, nails, clips, board & blocks.	Batten lead covered wire gutties, screw clips, board and blocks.	Metal conduit pipe, saddles hooks, wooden gutties, bend and socket and other accessories screws, block and board.	PVC conduit pipe, saddles, hooks, wooden gutties, bend and socket and other accessories screws block and board.
2	Cost	Fairly cheap	Cheap	Expensive	Expensive	Cheap
3	Life	Fairly long	Long	Long	Very long	Long
4	Mechanical Protection	Fair	Fair	Good	Very good	Good
5	Protection	Bad	Fair	Fair	Very good	Bad
6	Safety	Fair	Good	Good	Very good	Fair
7	Labour	Skilled	Skilled	Skilled	Highly skilled	Skilled
8	Extension and removal	Easy	Easy	Difficult	Not so easy and costly.	Easy
9	Time	Fairly short	Short	Fairly long	Very much longer	Fairly long
10	General reliability	Good	Fairly good	Fairly good	Very good	Good
11	Appearance	Good	Good	Good	Very good	Very good
12	Nature of application	Office only for Computer wiring.	Domestic & Office building	Domestic & Office building	Workshop	Domestic

Types of domestic wiring

Objectives: At the end of this lesson you shall be able to
- **explain the layout, installation plan, circuit -diagram, wiring diagram and state their uses**
- **state the B.I.S. regulation pertaining to wiring installation.**

In electrical wiring work, the electrician is supplied with a layout of wiring installation and an installation plan initially.

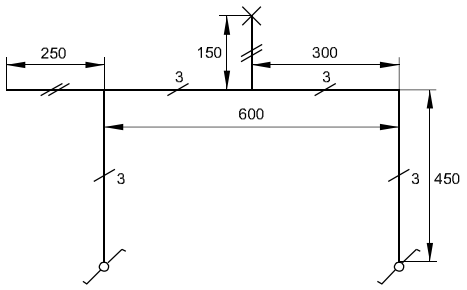
On the basis of the layout and installation plan, the electrician should draw the circuit and wiring diagrams before the commencement of work for systematic execution of the work.

The terms used in wiring installation drawings are explained here.

Layout diagram: Some customers give their requirements in writing. But a few can give them in the form of a layout diagram to the electrician. In the case of a written requirement, the electrician will prepare a layout diagram and then get the approval of the consumer.

The layout diagram (Fig 1) is a simplified version of the wiring diagram. Its purpose is to inform the reader quickly and exactly, what the circuit is designed for without giving any information on the circuit itself.

Fig 1



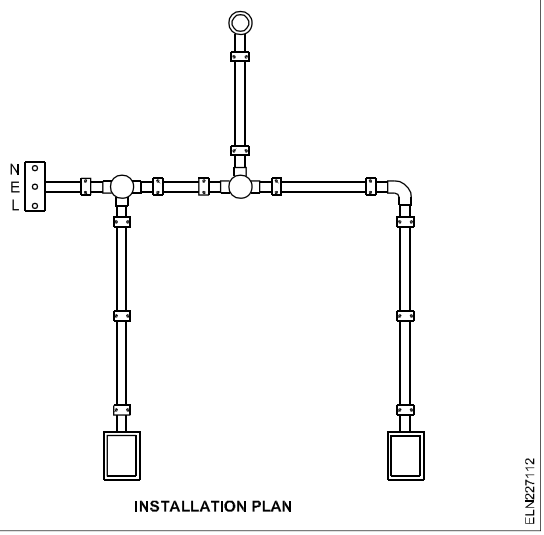
This type of layout diagram is used for preparing architectural diagrams, plans, etc. of a building.

In a layout diagram, it is necessary to indicate with symbols details like whether the wiring is on the surface or concealed, and the run `up' or `down', the number of wires in run, dimensions, and accessories with appropriate I.S. symbols.

Normally the layout plan is drawn and then the wiring diagram. After completion of the wiring diagram, the number of cables to be run in each cable run and the size of conduit or batten are estimated. With the help of the distance marking in the layout plan, the estimation of cables, could be made.

Installation plan (Fig 2): This plan shows the physical position of accessories in an installation, and also gives the final appearance of the installation. It may not be possible to draw the installation plan for the entire layout diagram. But it can be restricted to a small part of the installation to highlight the type of conduit, accessories, spacing of gutties, clamps etc.

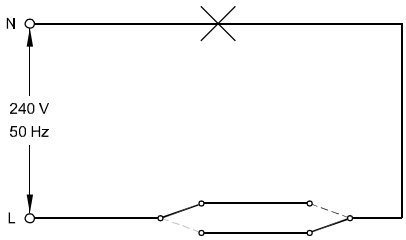
Fig 2



Circuit diagram (Fig 3): This shows the schematic connections of the circuit for a specific task in the simplest form, incorporating the graphical symbols.

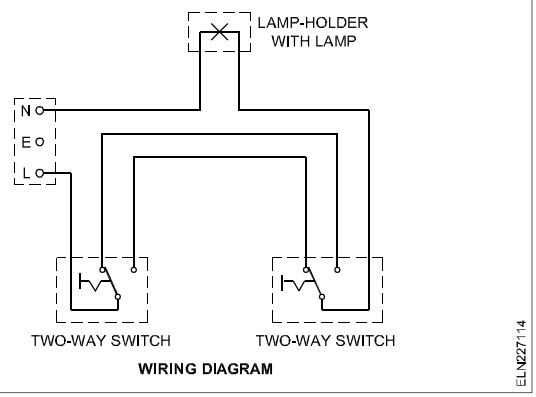
The purpose of a circuit diagram is to explain the function of the various accessories in the circuit. Fig 3 is an example of a circuit diagram for controlling a lamp from two different places.

Fig 3



Wiring diagram (Fig 4): This is the diagram in which the position of the components in the diagram bears a resemblance to their actual physical position.

Fig 4



WIRING DIAGRAM

The wiring diagram may not have distance marking. Use of the wiring diagram along with the layout diagram enables the technician in the initial stages of the planning to specify/estimate the required type, size and length of the cables, and also to decide on the vertical, horizontal and ceiling runs of the cable. The wiring diagram is of great use to test and rectify faults in the installation during maintenance work. Fig 4 also shows the wiring plan for controlling a lamp from two different places with their actual locations.

For his own good and to facilitate quick location of faults at a later stage, the customer should insist on the electrician giving him a copy of the wiring diagram soon after the completion of wiring. The electrician should make it a point to do so.

B.I.S. Regulations and the N .E. code pertaining to wiring installations

The wiring installation shall generally be carried out in conformity with the requirements of the Indian Electricity Act 1910, as updated from time to time and the Indian Electricity Rules 1956, framed thereunder, and also the relevant regulations of the electric supply authority of the concerned area (State Government).

To govern the installation of electrical wirings in buildings, with particular reference to safety and good engineering practice, the Indian Standard is published.

The following are some of the extracts of B.I.S. (Bureau of Indian Standards) regulations pertaining to wiring installations. All the B.I.S. regulations are recommended by the National Electrical Code (NEC).

B.I.S. regulations pertaining to wiring installations

Wiring: Any one of the following types of wiring may be used in a residential building.

- Tough rubber-sheathed or PVC-sheathed or batten wiring.
- Metal-sheathed wiring system
- Conduit wiring system:
  - a rigid steel conduit wiring
  - b rigid non-metallic conduit wiring
- Wood casing wiring

Fittings and accessories: All fittings, accessories and appliances used in wiring installations shall conform to Indian Standards. (I.S. mark)

The system should provide easy access to fittings for maintenance and repair, and for any possible modification to the system. Modifications to the system shall be done only by licensed electrical contractors, licensed under the Indian Electricity Rules.

Sub-circuits - different types: The sub-circuits may be divided into the following two groups:

- Light and fan sub-circuit
- Power sub-circuit.

After the main switch, the supply shall be brought to a distribution board. Separate distribution boards shall be used for light and power circuits.

Light and fan sub-circuits: Lights and fans may be wired on a common circuit. Each sub-circuit shall have not more than a total of ten points of lights, fans and 6A socket-outlets. The load on each sub-circuit shall be restricted to 800 watts. If a separate circuit is installed for fans, the number of fans in that circuit shall not exceed ten.

Power sub-circuits: The load on each power sub-circuit should normally be restricted to 3000 watts. In no case shall there be more than two outlets on each sub-circuit.

If the load on any power sub-circuit exceeds 3000 watts, the wiring for that sub-circuit shall be done in consultation with the supply authority.

A switch shall be provided adjacent to the normal entrance to any area for controlling the general lighting in that area. The switches should be fixed on a usable wall space and should not be obstructed by a door or window in its fully open position. They may be installed at any height up to 1.3m above the floor level.

Two-way switching is recommended for halls and staircases.

Switches and bell pushes should preferably be self-illuminating where they are often operated in dark.

Deep, dark cupboards and larders may be fitted with a lighting outlet, preferably with a door switch.

The light fittings in kitchens should be so placed that all working surfaces are well illuminated and no shadow falls on them when in normal use.

In living and dining rooms, if a cover or valance is provided, a lighting outlet should be provided, and it should have a separate switch.

In bedrooms it is recommended that some lighting be controlled from the bed location.

For bathrooms, it is recommended to use ceiling lighting with the switch located outside the bathroom. Alternatively an insulated cord-operated switch may be used. However, if the light switch is installed inside the bathroom, it should be out of reach of a person in a bath-tub or under the shower. Touching a switch with wet hand is highly dangerous.

It is recommended that lighting facilities be provided for lighting of all steps, walkways, driveways, porch, carport, terrace, etc, with switches for each provided inside the house at a convenient place. If the switches are installed outdoors, they should be weatherproof.

Waterproof lighting fittings should be used for outdoor lighting.

Socket-outlets: All plugs and socket-outlets shall be of 3-pin type, the appropriate pin of the socket being connected permanently to the earthing system.

An adequate number of socket-outlets shall be placed suitably in all rooms so as to avoid the use of long lengths of flexible cords.

Only 3-pin, 6A socket-outlets shall be used in all light and fan sub-circuits. 3 pin, 16A socket-outlets shall be controlled by individual switches which shall be located immediately adjacent to it. For 6A socket-outlets, if installed at a height of 130 cm above the floor level, in situations where a socket-outlet is accessible to children, it is recommended to use shuttered or interlocked socket-outlets.

In case an appliance requiring the use of a socket-outlet of a rating higher than 16A is to be used, it should be connected through a double-pole switch of appropriate rating.

Socket outlets shall not be located centrally behind the appliances with which they are used. Socket-outlets shall be installed either 25 or 130 cm above the floor as desired.

It is recommended that 3-pin, 6A socket-outlets may be provided near the shelves, bookcases, clock positions, probable bed positions etc.

Depending on the size of the kitchen, one or two 3-pin, 16A socket-outlets shall be provided to plug in hot plates and other appliances. Dining rooms, bedrooms, living rooms, and study rooms, if required, shall each be provided with atleast one 3-pin, 16A socket outlet.

No socket-outlet shall be provided in the bathroom at a height less than 130 cm.

A recommended schedule of socket-outlets is given below.

Location	6A Outlets	16A Outlets
Bedroom	2 to 3 Nos.	1 No.
Living room	2 to 3 Nos.	2 Nos.
Kitchen	1 No	2 Nos.
Dining room	2 Nos	1 No.
Garage	1 No	1 No.
Refrigerator	-	1 No.
Air-conditioners	-	1 No.
Verandah	1 No.	1 No.
Bathroom	1 No.	1 No.

Multi-plug adaptors for connecting more than one appliance to one socket outlet should not be used.

Fans: Ceiling fans shall be wired to ceiling roses or to special connector boxes. All ceiling fans shall be provided with a switch besides its regulator.

Fans shall be suspended from hooks or shackles with insulators between the hooks or shackles and also with insulators between the hooks and suspension rods.

Unless otherwise specified, all ceiling fans shall be hung not less than 2.75 m above the floor.

Flexible cords: Flexible cords shall be used only for the following purposes.

- For pendents
- For wiring of fixtures
- For connection of transportable and hand-held appliances

Flexible cords shall not be used in the following cases.

- As a substitute for the fixed wiring.
- Where cables may have to run into holes through the ceiling, walls, floors, windows, etc.
- For concealed wiring.
- If attached permanently to the walls, ceilings, etc.

Mounting levels of the accessories and cables as recommended in B.I.S. and N.E.C.

Height of main and branch distribution boards should be not more than 2m from the floor level. A front clearance of 1 m should also be provided.

All the lighting fittings shall be at a height of not less than 2.25 m from the floor.

A switch shall be installed at any height 1.3 m above the floor level.

Socket-outlets shall be installed either 0.25 or 1.3 m above the floor as desired.

The clearance between the bottom point of the ceiling fan and the floor shall be not less than 2.4 m. The minimum clearance between the ceiling and the plane of the blades of the fan shall not be less than 300 mm.

The cables shall be run at any desired height from the ground level, and while passing through the floors in the case of wood casing and capping and T.R.S. wiring, it shall be carried in heavy gauge conduit 1.5 m above floor level.

References

I.S. 732-1963
I.S. 4648-1968
N.E. Code

Method of marking the layout for wiring

Objective: At the end of this lesson you shall be able to
- **list the tools required for layout marking and state the method of marking the layout for wiring.**

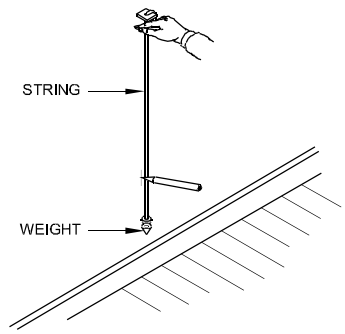
When installing electrical wiring in a building, it is necessary to mark the layout on the ceiling and walls to indicate the position of the various fittings and appliances to be installed and the routing of the cable runs.

To assist in the marking of the layout on the walls and ceilings, the following tools are used.

- Plumb bob or plummet
- Spirit-level
- Water-level

Plumb bob: A plumb bob consists of a block and a weight attached to each other by a string through their centres. When the plumb bob is placed on the wall, the weight is made to hang vertically through the string and the plumb line (string) indicates the true vertical (Fig 1).

Fig 1

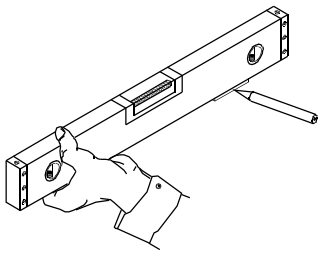


PLUMB BOB

Spirit-level: This consists of a level tube set in a straight edge. When the air bubble in the level tube locates centrally between the markings on the tube, the surface on which the straight edge is kept, it is deemed to be in a horizontal position. Spirit-levels are usually available in sizes from 150 mm to 1 m long (Fig 2).

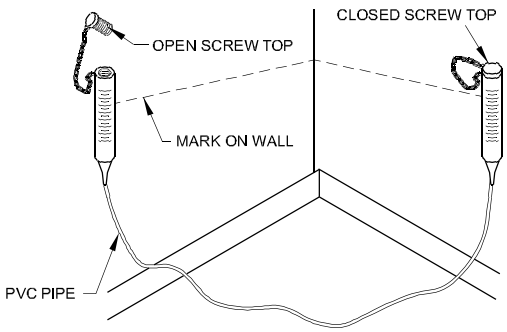
Water-level: A water-level consists of two calibrated glass tubes which are connected together by a flexible rubber tube. The tube is filled with water until the level is halfway up in both the glass tubes. The glass tubes shall be sealed when not in use. Instead of glass tubes on either side of a non-transparent tube, we can use an ordinary transparent PVC tube as water level(Fig 3) .

Fig 2



USE OF SPIRIT LEVEL

Fig 3



WATER LEVEL

Marking of layout: For marking of layout on walls and ceilings of an installation, chalking lines are used. Fine chalk powder is dusted on to a twine thread. When the twine thread dusted with chalk powder is held taut against a wall and `plucked', it marks the wall with a fine line of chalk dust.

Marking of true vertical runs: For marking the vertical lines, a `plumb bob' also known as plumb line, is generally used. A `plumb line' is used in the following manner.

Determine the position of the vertical line to be marked.

Hold the string(line) between the finger and the thumb at an appropriate distance from the weight to correspond with the height of the vertical line position marked.

Suspend the weight just clear of the floor or other obstructions, such as skirting boards, and rest the thumb against the wall and hold it steady until the string and the plumb bob are at rest, just clear of the wall's surface, at the location required as in Fig 1.

Make two pencil or chalk marks on the wall atleast 1 metre apart to correspond with the line of the string.

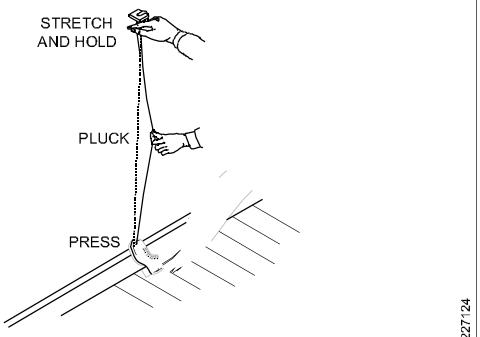
Draw a line joining the two marks using a straight edge and extend the lines as necessary.

For marking chalking twine (string) lines, stretch out the chalking twine, pull out a sufficient length for the height of the line required.

Hold the lower end with one foot and pull the string taut, adjusting the foot and hand as necessary until the line is directly over the two pencil marks on the wall. (Instead of holding the string with your foot, another person may be asked to assist.)

Use the free hand to lift the tautly held string about 20-30 mm away from the wall and release it. The string springs back to deposit a line of chalk dust on the surface of the wall (Fig 4).

Fig 4



MARKING VERTICAL LINES

A chalking line is usually used to mark long lines.

Marking `true' horizontal runs: The horizontal run is marked either by using a spirit-level or a water-level. Generally for electrical works, a spirit-level is used.

Mark the horizontal lines as outlined below.

Determine where you want the horizontal line to be drawn, using dimensions from the drawings and measuring off the fixed features such as the floor or ceiling. Make a single mark on the wall at the required height.

Hold the spirit-level with both hands and line it up with the mark on the wall.

Check the position of the air bubble in relation to the markings on the tube. Adjust the spirit-level until the bubble comes to rest exactly in the centre of the two markings.

Finally hold the level in position with one hand, and with the free hand draw a pencil line along the straight end of the level (Fig 2).

Use the straight edge of the level and line it up with the line already made and extend the pencil mark to the left and right of the original line.

Where long lines are required, repeat the above steps in the desired direction of the wall.

Measuring of horizontal and vertical runs: Horizontal lines can also be drawn by measuring off from a common base. For drawing horizontal lines on the walls, the common base could either be the floor, top of the skirting board or ceiling surface, provided the floor or the ceiling is reasonably level and even.

This method of measuring is used in many situations where installations are made parallel to existing features such as door frames, and skirting boards.

Marking cable runs on the ceiling: For marking on the ceiling, choose two adjoining walls which are at right angles to each other. Taking these walls as the base, take the measurement of the cable run route centres.

Keep the chalk-powdered string on the marking jointly by holding the edges of the string with the help of assistants and pull the strings hard to make the chalk marking on the ceiling.

Methods of connections in domestic wiring installations

Objectives: At the end of this lesson you shall be able to
- **explain the looping-back (loop-in) method**
- **explain the joint-box method**.

Introduction

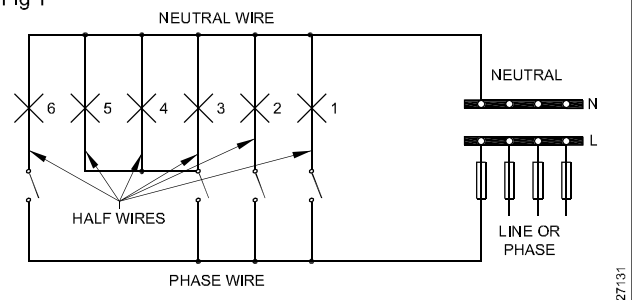
The circuit diagram of a sub-circuit of six lamps, three controlled separately by one-way switches, and three controlled as a group by a one-way switch (Fig 1). If the circuit were wired exactly as in the circuit diagram, a large number of joints would be necessary which are to be done in joint boxes only resulting in an increase in cost and labour. Two methods are adopted to execute the wiring economically. They are 1) the looping-back method and 2) the joint-box method.

Looping-back (loop-in) method

In this method, no separate joints are used. Instead twisted joints are used at the terminals of the accessories themselves. (In switches and ceiling roses)

Where the looping-back system of wiring is specified, the wiring shall be done without any junction or connector boxes on their line.

Fig 1



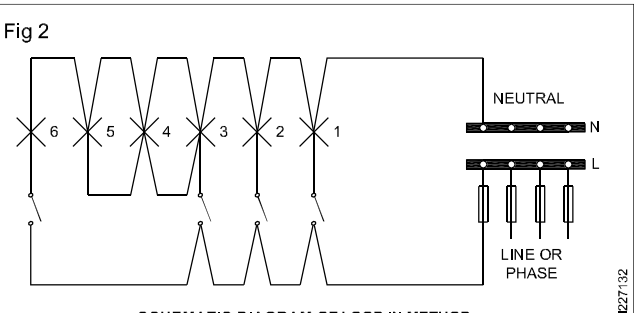
SCHEMATIC DIAGRAM

In domestic wiring installation, the looping-back system should be preferred.

The loop-back system can be adopted with two variations.

Loop-in method using 2-plate ceiling roses and switches: Fig 2 shows the schematic diagram of the circuit (Fig 1) as wired by the looping-in system. No separate joints are required in joint boxes. Twisted joints in the terminals of the two-plate ceiling roses and of the switches are, however, required. The schematic diagram (Fig 2) is not practicable and cannot be acceptable in any of the wiring systems like conduit, wooden batten or casing and capping system as it is generally necessary to run the cables close together in the same conduit, batten or casing.

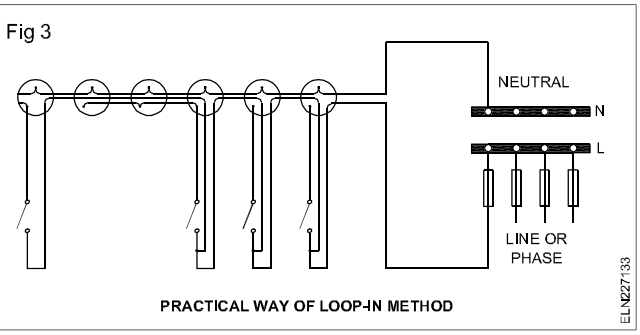
Fig 2



SCHEMATIC DIAGRAM OF LOOP-IN METHOD

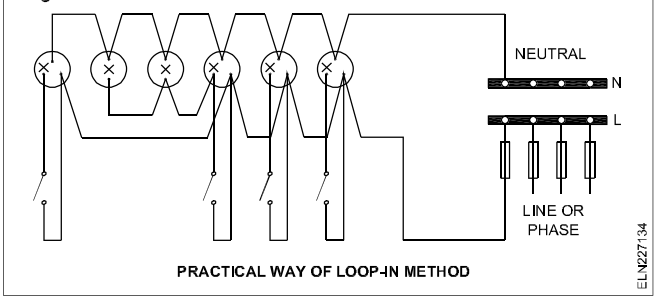
Fig 3 shows the same circuit suitable for practical work.

Fig 3



PRACTICAL WAY OF LOOP-IN METHOD

Fig 4



PRACTICAL WAY OF LOOP-IN METHOD

Loop-in method by 3-plate ceiling rose: We can also use 3-plate ceiling roses (Fig 4). Considerable cable length could be saved by using the third terminal of the ceiling rose as a looping-in terminal for the switch drop, so that two cables only are required from the ceiling rose to the switch.

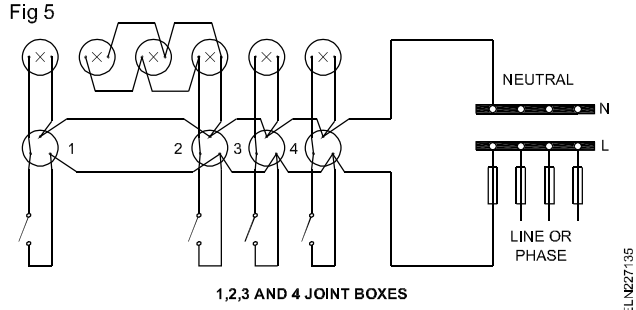
Joint-box method

In the joint-box method, wherever tapping has to be taken from the cable, joints are made. All joints in cable conductors shall be made by means of porcelain connectors or connector-boxes, and housed in suitable joint-boxes.

In any wiring system no bare or twist joints shall be made at intermittent points in the cable run of the main circuit or sub-circuit. If joining is unavoidable, such joints shall be made through proper cut outs or drawn through proper junction-boxes open for easy inspection.

The joint-box method of wiring system a pair of cables from the switches and ceiling roses will terminate in the junction box. The junction-box is kept in between the light points and switches for economy in the cable length (Fig 5).

Fig 5



1,2,3 AND 4 JOINT BOXES

Selection of the type and size of cable for a given wiring installation

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

- **state the factors to be considered for selecting the cable for a circuit**
- **apply the factors and select the cable.**

In order to determine the type and size of the cable for a given circuit, the following points should be taken into account.

- Suitability of the type of cable for the location of the circuit and the type of wiring.

- Size of the cable depending upon the current carrying capacity of the cable.
- Size of the cable depending upon the length of the wiring and permissible voltage drop in the cable.
- Minimum size of the cable based on the economy.

Location of the circuit and the type of wiring decide the type of cable.

It is necessary to consider whether the installation is for industry or domestic use and whether the atmosphere is damp or corrosive. Accordingly the type of cable has to be chosen.

Further the type of wiring determines the type of cable suitable for the installations.

The current carrying capacity of the cable decides the size of the cable.

In this, the first step is to find out the current expected to flow in the circuit when the total connected load is fully switched on. This current is the maximum current that would flow through the circuit in case all the loads are working at the same time. But this is not the case in actual situations.

Diversity factor

In the case of lighting installation all the lamps in a domestic installation may not be switched 'on' at the same time. Hence, it is assumed only two thirds of the lights (say 66%) only will be 'on' at a given time. This introduces a factor called 'diversity factor'.

When the connected load is multiplied by the diversity factor you get a load value which can be said as normal working load. Use of this diversity factor enables the technician to use a lesser size cable than the one calculated, based on the connected load. The suggested diversity factor according to IEE rules is given in Table 2.

Based on the working load the current in each circuit is to be calculated and the size of the cable suitable to carry the current has to be chosen from Tables 3, 4 and 5.

Voltage drop in the cable

In any current carrying conductor, voltage drop takes place due to its internal resistance. This voltage drop in a premises as per BIS 732 should not be more than 3 percent of the standard supply voltage when measured between the consumer supply point and any point of the installation when the conductors are carrying the maximum current under the normal conditions of service.

Tables 3 and 4 for aluminium cable and 5 for copper cable give the relation between voltage drop and length of the cable run for various cables. In case the voltage drop found in the cable exceeds the stipulated limit of 3% voltage drop, the technician has to choose the next bigger sized cable to maintain the voltage drop within limits.

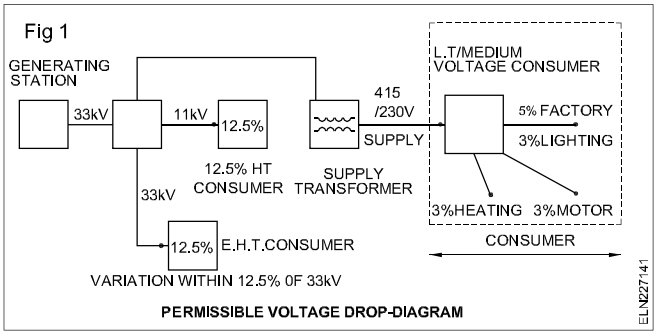
If the cable size is increased to avoid voltage drop in the circuit, the rating of the cable shall be the current which the circuit is designed to carry. In each circuit or sub-circuit the fuse shall be selected to match the load or the cable rating whichever is minimum, to ensure the desired protection (BIS 732).

Declared voltage of supply to consumer

On the other hand according to IE Rule No.54, the voltage at the point of commencement of supply at the consumer should not vary from the declared voltage by more than 5 percent in the case of low or medium voltage or by more than 12 percent in the case of high or extra high voltage (Fig 1).

At this stage it is better to remember that when current

Fig 1



flows through a conductor, the resistance offered by the conductor produces heat. The increase in heat is proportional to the cable resistance which in turn depends upon the cross-sectional area of the cable. Since overheating damages the insulation, the conductor size must be adequate to prevent this from occurring.

While choosing the cable size, voltage drop is a more severe limitation than any other criterion. Hence, it is advisable to select the cable size only after ascertaining the permissible voltage drop. Excessive voltage drop impairs the performance of heating appliances, lights and the electric motors.

Calculation of voltage drop

In DC and single phase AC two-wire circuits

Voltage drop = Current x Total resistance of cables

= 2 IR

where I is the current and

R is the resistance of one conductor only

Wherever voltage drop is given as 1 volt drop per metre run of cable, we have to assume that both (lead and return) cables are taken into account and the cable carries its rated current. In such cases the voltage drop for X metre length of cable for a current of Y amps is calculated as given.

$$\left\{\begin{matrix}\text{Voltage}\\ \text{drop}\end{matrix}\right\} = \frac{\left\{\begin{matrix}\text{Length of}\\ \text{the cable}\end{matrix}\right\} \text{x} \left\{\begin{matrix}\text{Actual current}\\ \text{of the load}\end{matrix}\right\}}{\left\{\begin{matrix}\text{Metre length of}\\ \text{the cable per one}\\ \text{volt drop}\end{matrix}\right\} \text{x} \left\{\begin{matrix}\text{Rated current}\\ \text{of the cable}\end{matrix}\right\}}$$

$$= \frac{XY}{\left\{\begin{matrix}\text{Metre length of}\\ \text{the cable per one}\\ \text{volt drop}\end{matrix}\right\} \text{x} \left\{\begin{matrix}\text{Rated current}\\ \text{of the cable}\end{matrix}\right\}}$$

3-phase circuits

$$\text{Voltage drop} = 1.73 \text{ x I R} = \sqrt{3}\,\text{IR}$$

where I is the line current

R is the resistance of one core only.

The above points could be explained through the following set of examples.

Example 1

A guest house installation has the following loads connected to the three phase 415 V supply with neutral. Select a proper size of cable for this installation.

Lighting - 3 circuits of tungsten lighting total 2860 watts

Power from 3 x 30A ring circuits to 16A socket outlets for

1 x 7 KW Water heater (Instant)
2 x 3 KW Immersion heater (Thermostatically controlled)
Cooking appliances: 1 x 3 KW cooker
1 x 10.7 KW cooker

Current demand in amperes in each of the circuit is calculated by referring the Table 1. Calculation of current taking account into the diversity factor from Table 2.

Assuming the declared voltage as 240 volts and the length of the longest run in a circuit as 50 metres

Permissible voltage drop at the rate of 3%

$$= \frac{3 \text{ x } 240}{100} = 7.2 \text{ Volts}$$

Referring to Table 3, if the size of the conductor selected is 35.0 sq.mm which can carry 69 amps, the voltage drop at 69 amperes rating will be 1 volt for every 7.2 metres cable run.

For 50 metres cable run the voltage drop at 69 amps current rating = 50 / 7.2 volts.

Voltage drop for 65 amps

$$= \frac{50 \text{ x } 65}{7.2 \text{ x } 69} = 6.54 \text{ Volts}$$

As the actual voltage drop in the circuit, that is 6.54 volts, is well within the permissible value, of 7.2 volts, the cable selected is suitable for the installation.

Table 1

Sl. No	Demand description	Current Demand (Ampere)	Diversity Factor (Table 2)	Current allowing for Diversity (Ampere)
1	Lighting	11.9	75%	9.00
2	Power i	30	100%	30
	ii	30	80%	24 } 72.00
	iii	30	60%	18
3	Water heaters (inst)	29.2	100%	29.2
4	Water heaters (thermo)	25.00	100%	25.00
5	Cooker i	12.5	80%	10.00
	ii	44.5	100%	44.5
Total current		= 213.1		189.7

Total current demand (allowing diversity) = 189.7 amps
Load spread over 3 phases = 189.7/3 = 63.23 amps, say 65 amps per phase.

Example 2

A three-phase 3-wire connection is to be given to a premises in which an electric motor of 50 H.P. is to be installed. 40 metres of cable run from the main switch is required for this purpose. Determine the size of the 3-core cable to be used, if the available voltage is 400 V 50 Hz (Assuming PF is 0.8).

$$\left\{\text{Current drawn by the motor}\right\} = \frac{50 \times 746}{\sqrt{3} \times 400 \times 0.8} = 67.3$$

As a 3-core cable is used, referring to Table 4 it will be seen that 35 sq.mm. (7/2.5) PVC cable will be in a position to carry the motor current safely.

$$\left\{\begin{matrix}\text{The Permissible}\\ \text{Voltage drop}\end{matrix}\right\} = \frac{400 \text{ x } 3}{100} = 12 \text{ Volts}$$

But as per Table 4, the selected cable will have 1 volt drop for every 7.1 m cable run.

Hence, for 40 metres the voltage drop is = 40 / 7.1 volts = 5.63 volts.

Referring to Table 4 we have voltage drop at 69 amps = 5.63 volts.

Hence the voltage drop at 67.3 amp is

$$= \frac{40 \text{ x } 67.3}{7.1 \text{ x } 69} = 5.49 \text{ Volts}$$

As the drop is within permissible limits, of 12V ,the 3-core PVC cable size 35 sq.mm (7/2.5) is suitable.

TABLE 2

Allowances for diversity

	Purpose of final circuit fed from conductors or switchgear to which diversity applies	Individual household installations, including individual dwellings of a block	Small shops, stores, offices and business premises.	Small hotels, boarding houses
1	Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2	Heating and power (but see 3 to 8 below)	100% of total current demand up to 10 amperes + 50% of any current demand in excess of 10 amperes.	100% FLC of largest appliance + 75% FLC of remaining appliances.	100% of FLC of largest appliance + 80% FLC of 2nd largest appliance + 60% FLC of remaining appliances
3	Cooking appliances	10 amperes = 30% FLC of connected cooking appliances in excess of 10 amperes + 5 amperes if socket outlet incorporated in unit.	100% FLC of largest appliance + 80% FLC of 2nd largest appliance + 60% FLC of remaining appliances	100% FLC of largest appliance + 80% FLC of 2nd largest appliance + 60% FLC of remaining appliances
4	Motors (other than lift motors which are subject to special consideration)	100% FLC of largest motor + 80% FLC of 2nd largest motor + 60% FLC of remaining motors.		100% FLC of largest motor + 50% FLC of remaining motors.
5	Water heaters (instantaneous type)*	100% FLC of largest appliance + 100% FLC of 2nd largest appliance + 25% FLC of remaining appliances.	100% FLC of largest appliance +100% FLC of 2nd largest appliance + 25% FLC of remaining appliances	100% FLC of largest appliance + 100% FLC of 2nd largest + 25% FLC of remaining appliances.
6	Water heaters (thermostatically controlled)	No diversity allowable.		
7	Floor warming installations	No diversity allowable.		
8	Thermal storage space heating installations	No diversity allowable.		
9	Standard arrangements of final circuits in accordance with Appendix 5	100% of current demand of largest circuit + 40% of current demand of every other circuit.	100% of current demand of largest circuit + 50% of current demand of every other circuit.	
10	Socket outlets other than those included in 9 above	100% of current demand of largest point of utilisation + 40% of current demand of every other point of utilisation.	100% of current demand of largest point of utilisation + 75% of current demand of every other point of utilisation.	100% of current demand of largest point of utilisation + 75% of current demand of every point in main rooms (dining rooms etc.) + 40% of current demand of every other point of utilisation.

*** For the purpose of this table an instantaneous water heater is deemed to be a water heater of any loading which heats water only while the tap is turned on and, therefore, uses electricity intermittently.**

It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.

Table 3

Current ratings and voltage drop for vulcanised rubber PVC or polythene insulated or tough rubber PVC lead sheathed, single core, aluminium wires or cables

Size of conductor		2 cable DC or single phase AC		3 or 4 cables balance 3 phase		4 cables DC	
Nominal area sq.mm	No. and diameter of wire in metres	Current rating in amperes	Approx. length of run for 1 volt drop in metres	Current rating in amperes	Approx. length of run for 1 volt drop/ metre	Current rating in amperes	Approx. length of run for 1 volt drop in metres
1.5	1/1.40	10	2.3	9	2.9	9	2.5
2.5	1/1.80	15	2.5	12	3.6	11	3.4
4.0	1/2.24	20	2.9	17	3.9	15	4.1
6.0	1/2.80	27	3.4	24	4.3	21	4.3
10.0	1/3.55	34	4.3	31	5.4	27	5.4
16.0	7/1.70	43	5.4	38	7.0	35	6.8
25.0	7/2.24	59	6.8	54	8.5	48	8.5
35.0	7/2.50	69	7.2	62	9.3	55	9.0
50.0	7/3.0 19/1.80	91	7.9	82	10.1	69	10.0

TABLE 4

Current ratings and voltage drop for vulcanised rubber, PVC or polythene insulated or tough rubber, PVC lead sheathed, twin, three or four cores aluminium wires or cables

Nominal area sq. mm.	No. and dia-meter of wire in metres	Current rating in amperes	Approx.length of run for 1 voltage drop/ metre	Current rating in amperes	Approx. length of run for 1 volt drop in metres
1.5	1/1.40	10	2.3	7	3.7
2.5	1/1.80	15	2.5	11	1.9
4.0	1/2.24	20	2.9	14	4.8
6.0	1/2.80	27	3.4	19	5.5
10.0	1/3.55	34	4.2	24	6.8
16.0	7/1.70	43	5.3	30	8.7
25.0	7/2.24	59	6.6	42	10.8
35.0	7/2.50	69	7.1	48	11.7
50.0	7/3.00 19/1.80	91	7.7	62	13.1
70.0	19/2.24	118	8.8	82	14.7
95.0	19/2.50	135	9.5	94	15.7
120.0	37/2.06	162	10.3	114	16.8

TABLE 5

Wattage loading of small VR Insulated copper conductor cables

Maximum permissible loading in watts at unity power factor for two single core cables in one conduit based on IEE current ratings subject to voltage drop

Cable Size			Current rating	Circuit Voltage		Approximate voltage drop per 10 metres run with current in Col 4. volts
mm	inch	approx. area in mm	amp	230V watts	250 V watts	
1	2	3	4	5	6	7
1/1.11	1/.044	1	5	1150	1250	1.97
3/0.74	3/.029	1.2	10	2300	2500	3.09
3/0.91	3/.036	2	15	3450	3750	2.98
7/0.74	7/.029	3	20	4600	5000	2.64
7/0.91	7/.036	4.5	28	6440	7000	2.37
7/1.11	7/.044	6.75	36	8280	9000	2.04
7/1.32	7/.052	9.5	43	9890	10750	1.75
7/1.62	7/.064	15	53	12190	13250	1.42
19/1.11	19/.044	18	62	14260	15500	1.30
19/1.32	19/.052	25	74	17020	18500	1.11
19/1.62	19/.064	38.75	97	22310	24250	0.96

Metal conduit pipe - methods of cutting, threading and bending

Objectives: At the end of this lesson you shall be able to
- **state the methods of cutting a metal conduit pipe**
- **state the purpose and process of threading and list out the precautions of conduit pipes**
- **list the different accessories used in conduit installation**
- **state the purpose and methods of bending the conduit pipes and list out the precautions.**

Cutting: Rigid and intermediate conduits may be cut with a hacksaw (Fig 1) or a pipe cutter (Fig 2) . With either method, the conduit must be locked in a pipe vice before making the cut. Fix the conduit in the vice so that the vice grips the conduit 50 or 75 mm from the point where the cut has to be made. This prevents the grip of the pipe vice from damaging the surface of the conduit that must be threaded.

If a hacksaw is used, use 24 teeth per 25 mm blade. Be sure to install the blade so that the cut is made on the forward stroke.

After cutting (Figs 1 and 2) the inside edge of the conduit must be smoothed with a half round file (Fig 3) or a pipe reamer mounted in a brace.

Be particularly careful while cutting the conduit with a pipe cutting tool. This tool tends to leave a sharp ridge on the inner edge of the cut. Be sure this ridge is removed and the conduit is smooth before installing a coupling or any fitting, to avoid damage to the insulation of conductors.

Fig 1

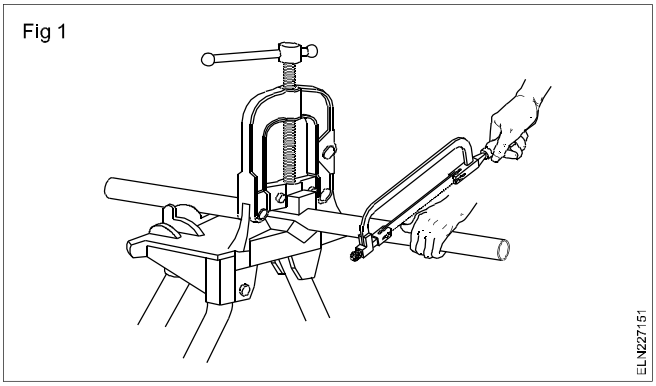
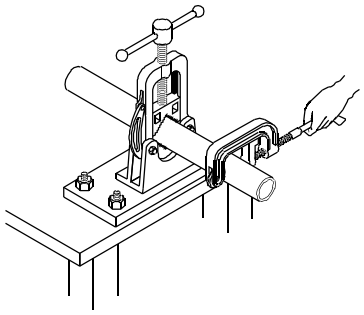


Fig 2



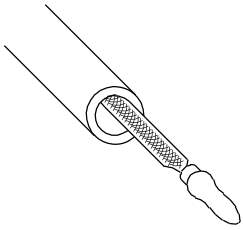
CUTTING A PIPE USING A PIPE CUTTER

ELN227152

Purpose of threading: When short lengths of conduits are to be used for switch or lamp drops, the cut end of the pipe needs to be threaded to enable fixing of the conduit to accessories. Threads on conduit pipes in all cases shall be between 11 mm to 27 mm long, sufficient to accommodate pipes to the full-threaded portion of couplers or accessories.

Threading: Conduit is threaded by using dies and a die stock. Apply cutting oil to the end of the conduit before starting to cut threads. Cutting the threads longer than necessary will leave the exposed threads subject to corrosion.

Fig 3



DEBURRING PROCESS

ELN227153

Do not use any lubricant which is an electrical insulator, as this may increase the resistance of the conduit assembly and affect its use as the circuit protective earthing conductor.

Precautions to be observed while threading conduit pipes

1 Chamfer the end of the conduit to be threaded. Make the depth of the chamfer equal to the pitch of the thread (1.5 mm for conduit).

2 Apply a lubricant frequently while threading the conduit pipe. It helps the die to cut more easily and the die to stay sharp.

3 Check whether stock is at right angles to the pipe axis.

4 Reverse turnings of the die stock are necessary to break off cut chips and to clear the cutting edges of the die.

5 Use only a brush to remove the metal burrs from the die. Do not use your hand.

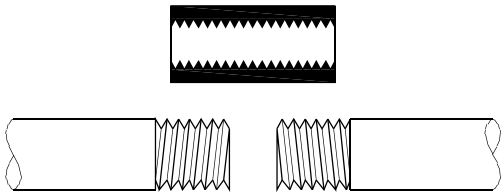
Conduit accessories

Conduit coupling: As conduits are commercially available in specific lengths only, it has become necessary to join two or more lengths to obtain the required runs. Joining of conduits is done by means of couplers.

There are two types of couplers used for rigid metal conduits as explained below.

Screwed couplers: They are also called running couplers and are made of cast iron, having female threads inside (Fig 4). The conduits to be joined should be threaded to a length sufficiently long to fit half way into the coupling such that no threaded portion is visible outside (Fig 5) to avoid corrosion.

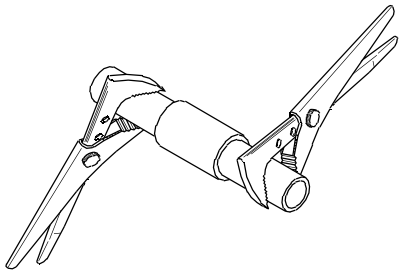
Fig 4



CONDUIT COUPLER ASSEMBLY

ELN227154

Fig 5



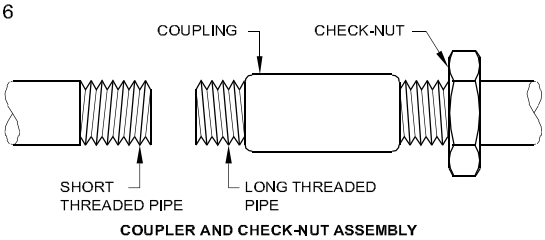
FIXING A CONDUIT COUPLER

ELN227155

This type of running couplers makes the joint mechanically weaker and electrically non-continuous. Hence the second type of coupler uses a check (jam) nut along with the running coupler which is a much better choice than the running coupler.

Check-nut and running coupler: For using this coupler, one of the conduits should have longer threads to accommodate fully the coupler, and the other conduit should have threads to a length equal to half the length of the coupler (Fig 6).

Fig 6



COUPLER AND CHECK-NUT ASSEMBLY

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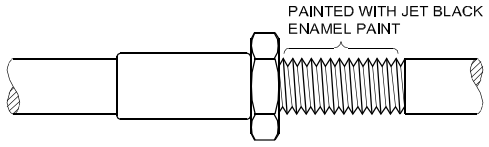
First the check-nut and then the coupler should be screwed inside the long threaded conduit. Then the short threaded conduit is butted with the long threaded conduit and the coupler is screwed on the short threaded conduit tightly.

Then the check-nut is screwed and tightened along the coupler (Fig 7).

Fig 7

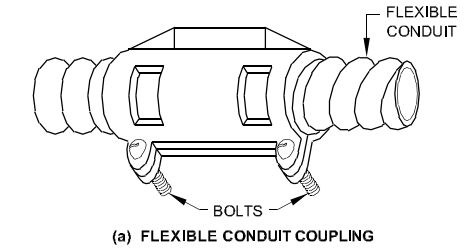


COUPLE AND CHECK-NUT ASSEMBLY.

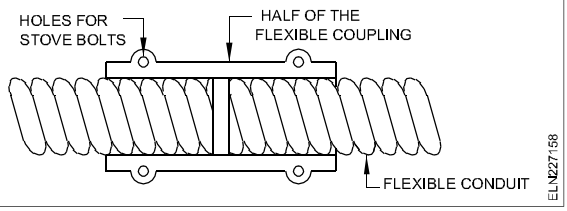
The exposed threaded portion of the long threaded conduit is painted with jet black enamel paint to prevent rust.

Coupling for flexible conduits: For flexible conduits, split couplings are used (Fig 8).

Fig 8

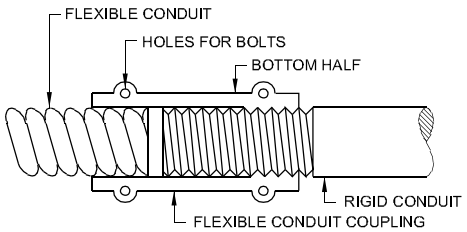


(a) FLEXIBLE CONDUIT COUPLING



Special type of split couplings (Fig 9) is to be used when the flexible conduit is to be connected to a rigid conduit at places where high flexibility is required. This coupling has threading on one side with the other side made suitable to grip the flexible conduit.

Fig 9



DUEL CONDUIT COUPLING

Metal conduit boxes: Termination of rigid conduits is done at metal conduit boxes of either cast iron or sheet metal. Various shapes and sizes of boxes are commercially available in the market. Junction boxes of round, square, rectangular and hexagonal shapes are manufactured for one-way, 2-way, 3-way and 4-way outlets.

These outlets may be straight, angular or tangential as required for the situation. When ordering, the specification should contain the material with which the box is to be made, the size of the conduit to be fitted, the number of ways, shape and the position of outlets.

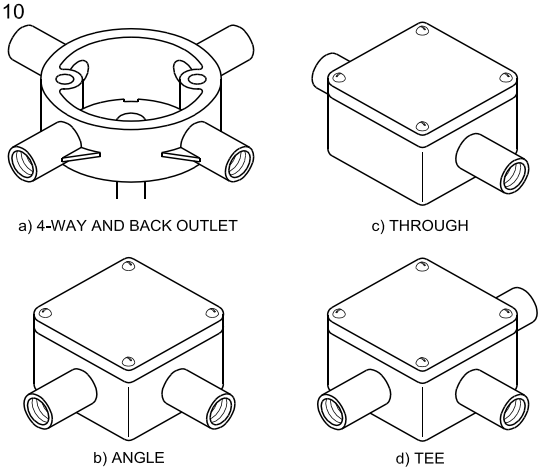
Example: Cast iron 20 mm, 3-way, round tee.

Fig 10 shows some of the popular types of outlet boxes. Cast iron 20 mm, 3-way, round tee.

Fig 11 shows various types of circular (round) boxes in a single line diagram.

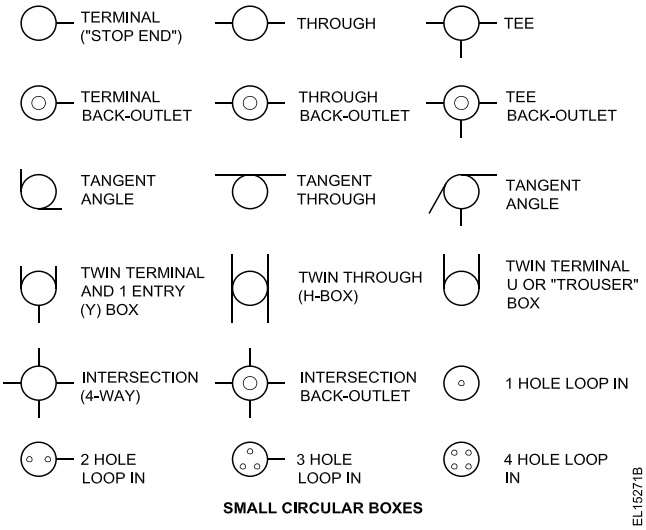
Fig 12 shows typical ceiling boxes, and Fig 13 shows wall boxes whereas Fig 14 shows switch boxes.

Fig 10



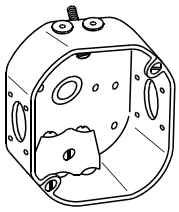
CONDUIT OUTLET BOXES

Fig 11



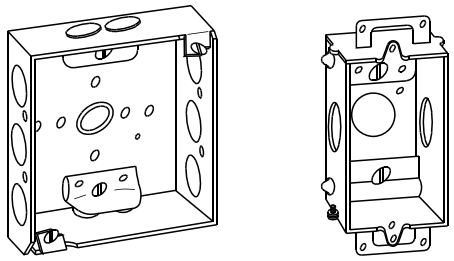
SMALL CIRCULAR BOXES

Fig 12



CEILING BOX FOR CONDUIT WIRING

Fig 13



WALL BOXES FOR CONDUIT WIRING

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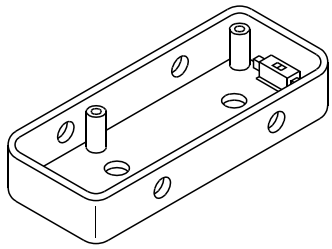
Fig 14



SWITCH BOXES FOR CONDUIT WIRING

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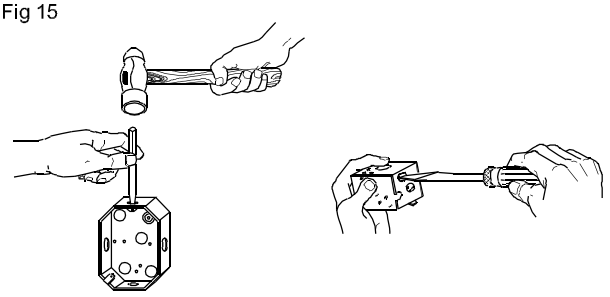
The ceiling, wall and switch boxes are normally provided with knock-out openings which can be removed when required by using punches or chisels with a stroke from a hammer. In some cases the knock-out openings could be made by the pry out-method with a screwdriver (Fig 15).

Fig 15



METHOD OF REMOVING THE KNOCK OUTS

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After removing the knock-outs, the conduit is to be fitted in the opening by any one of the methods shown in Fig 16.

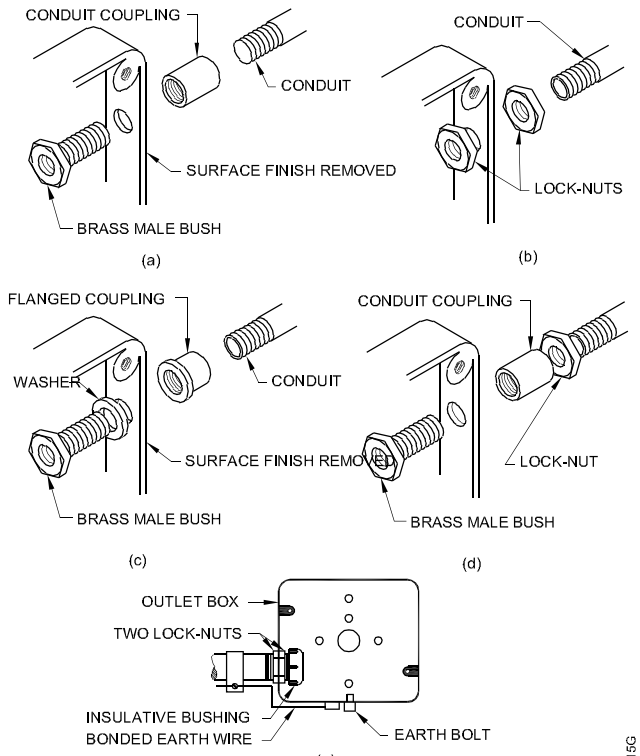
However, when brass bushes are not used in the terminating end of the conduits, it is necessary to use PVC bushes at the conduit ends to facilitate easy drawing of the cables and to avoid damage to the cable insulation.

Lock nuts: Hexagonal lock nuts are used at the conduit terminations (Fig 17) to make the terminations mechanically strong and electrically continuous. Remember that the paint at the box entries should be scraped out, before fitting the lock nut in position to facilitate electrical continuity.

Conduit bushings: These are made from brass or malleable iron or PVC and have a smooth large radius edge (Fig 18). This should be used at conduit terminations for dual purposes.

The first purpose is to protect the cable insulation from getting damaged during drawing of the cables, and the second purpose is to give a proper grip mechanically and make the conduit electrically continuous in the installation.

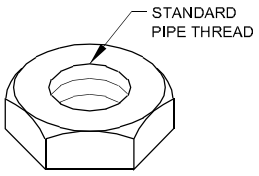
Fig 16



CONDUIT BOX ASSEMBLY

ELN227715G

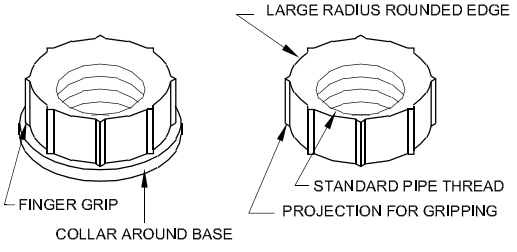
Fig 17



LOCK-NUT

ELN227715H

Fig 18



CONDUIT BUSHINGS

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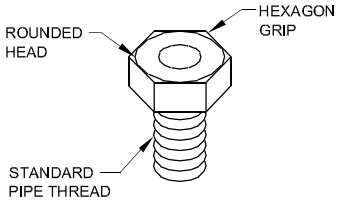
Conduit nipples (Fig 19) are provided in conduit termination along with couplers and they serve the same purpose as conduit bushes.

Conduit fittings like elbows, bends and Tees: All these fittings are available in two categories.

- Normal
- Inspection type

Fig 19

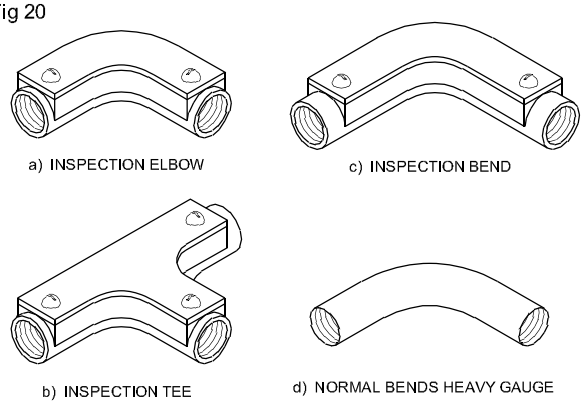


They are made from cast iron.

Elbows are suitable for short bends whereas bends are suitable for long bends. In general where a conduit runs between the wall and the ceiling, elbows are used.

Tees are used in switch-drops and diversions. Various types of these accessories (Fig 20).

Fig 20



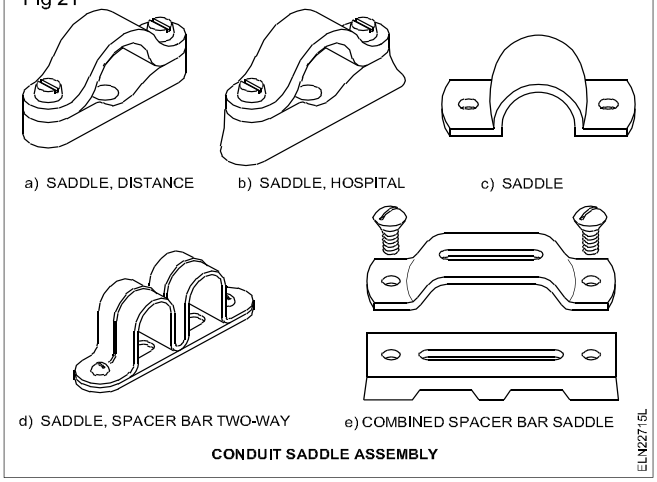
CONDUIT ACCESSORIES

Conduit saddles are used to fasten the conduit on the surface of the walls. These saddles could be used along with any one of the following bases. They are:

- spacers made from sheet metal
- distance piece made from wood or PVC
- hospital piece made from wood or PVC.

Various types of these base fittings along with the saddles are shown in Fig 21.

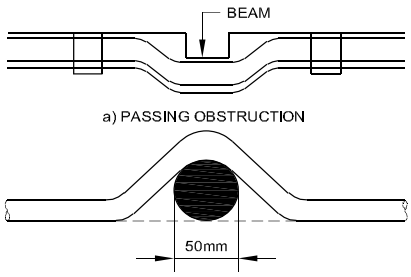
Fig 21



CONDUIT SADDLE ASSEMBLY

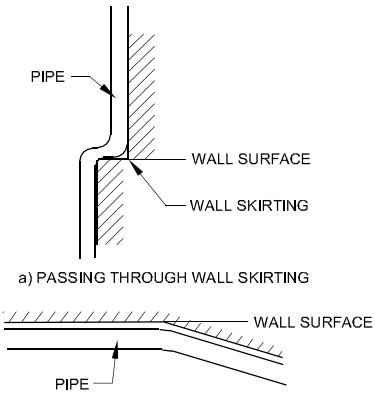
Conduit pipe bending: It is often necessary to set or bend the conduit to enable it to pass over an obstruction (Fig 22) or to turn a corner which is less or more than 90^0 (Fig 23). The bending may be a little offset to the line of conduit installation. This can be manipulated by proper bending as required.

Fig 22



OFFSETTING THE CONDUIT RUN

Fig 23

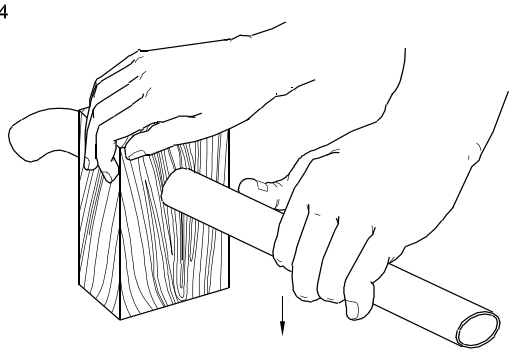


CONDUIT RUN THROUGH OFFSET WALL SURFACE

The bending may be done by using a simple bending block or by a hickey or with the help of a bending machine. Further, in concealed conduit wiring, the B.I.S. recommends bending of conduit pipes in preference to the use of bends and elbows.

Using bending block for bending conduit: The bending block (Fig 24) is made preferably with teak wood or strong country wood, and should have holes suitable for the conduit to be bent. Edges are chamferred to avoid kinks in the bent portion of the conduit. Light gauge conduits need to be filled with sand and heated before bending to have smooth bends.

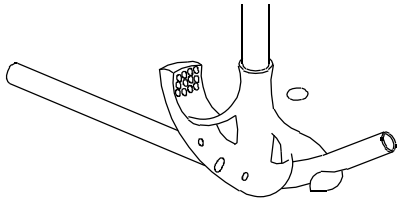
Fig 24



BENDING CONDUIT WITH THE BENDING BLOCK

Using hickey for bending conduits: A hickey is a special bending tool (Fig 25) and is made of forged steel or alloy steel. A particular size of pipe requires that size of hickey. Bending of pipes could be performed cold or hot by using a hickey.

Fig 25



BENDING CONDUIT WITH THE HICKEY

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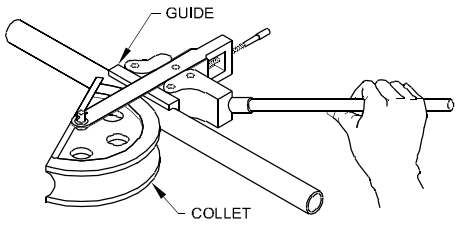
Using bending machine for bending conduit: Various types of bending machines are available in the market. They can either be operated by hand (Fig 26) or by hydraulic pressure. For each size of conduit, the guide and collet need to be changed.

Fig 26



BENDING CONDUIT WITH THE BENDING MACHINE

ELN22715Q

Precautions to be observed while bending

- The pipe used should be mechanically strong to withstand the pressure while bending.
- Poorly seam-welded pipes are not suitable for bending as they may split while bending.
- One of the easy methods of bending is to draw the bending curve on the floor and bend the pipe accordingly.
- When a wooden block is used for bending, chamfer both sides of the hole opening in the block.
- Ensure that the conduit does not twist while bending.
- Use a proper size of hickey according to the dia. of the pipe to be bent.
- While doing manual hot bending do not use wet sand as the steam generated during heating may cause an explosion.

Test board, Extension board and colour code of cables

Objectives: At the end of this lesson you shall be able to
- **explain the method of using a test board**
- **state the general colour codes used in cables.**

Test board: A test board is an electric switch board, used for conducting the following tests.

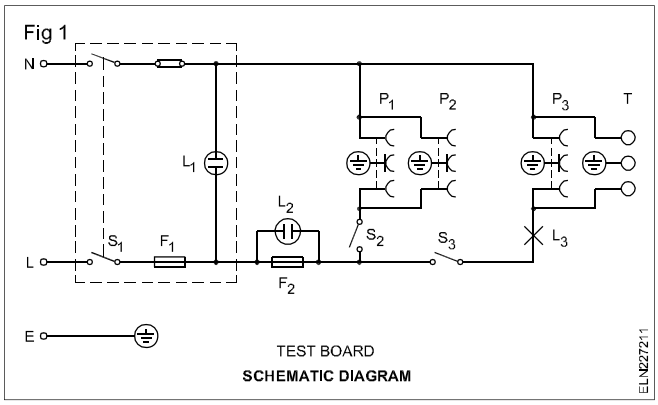
- **Continuity test** (Load connected in series with a lamp)

  Example: Testing of fan winding, condition of choke and tube light starter etc.

- **Direct test**

  Example : Testing electrical appliances of 1000 watts or lower rating for proper functioning.

Fig 1 source the schematic diagram of a test board with all the outlets and controls. Sockets P_1 and P_2 provide direct, single-phase supply whereas socket P_3 and terminal block T provide a single-phase supply in series with the lamp L_3.



Continuity test: While performing a continuity test, the appliance to be tested is connected to the socket P_3 or to the terminal T which are in series with the lamp L_3 and are controlled by switch S_3. Normally this test is conducted by the electrician to ascertain whether the appliance is open-circuited or short-circuited. A low wattage, appliance when connected, will make the lamp L_3 to burn dim, and a high wattage appliance will make the lamp to burn bright.

According to the brightness of the lamp, the behaviour of the appliance, as well as the wattage of the appliance and the lamp and the condition of the appliance could be judged. `No light' indicates either open circuit or high resistance in the appliance. In the same way, a choke coil and a starter of a tube light can be checked. (The flickering of the lamp L_3 with the starter indicates that the starter is good.)

Thus the testing board also works as a continuity tester.

Direct testing: By connecting the appliance direct to the socket P_1 or P_2, the performance of the appliance can be verified after repair.

Fuses: If the indicator lamp L_1 does not burn, it indicates no supply. On the other hand, in normal conditions, the indicator lamp L_2 will not burn, and it burns only when the fuse F_2 is open.

Thus the test board is a cheap and handy test set which is easy to use by an electrician to carry out his routine checks in the course of his work.

Colour identification of cables: The colour of the cables indicates their function. Table 1 gives the colour code and the alpha-numeric notation as recommended by N.E.Code.

The rules apply for marking conductors in equipment/ apparatus/installation.

TABLE 1

Alpha-numeric notation and colours

Designation of		Identification by	
		alpha	colour
Supply AC system	Phase 1	L1	Red
	Phase 2	L2	Yellow
	Phase 3	L3	Blue
	Neutral	N	Black
Apparatus AC system	Phase 1	U	Red
	Phase 2	V	Yellow
	Phase 3	W	Blue
	Neutral	N	Black
Supply DC system	Positive	L+	Red
	Negative	L-	Blue
	Mid-wire	M	Black
Supply AC system (Single phase)	Phase	L	Red
	Neutral	N	Black
Protective Earth conductor		PE	Green and yellow
Earth		E	Colour of the bare conductor.

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.