Soldering of wires

Objectives : At the end of this lesson you shall be able to
- **explain the purpose of solder and flux and their types**
- **describe the soldering technique**
- **describe the features of soldering iron**
- **explain desoldering and desoldering tools**
- **study the soldering and desoldering station and their specification**
- **explain the desoldering methods using pump and wick.**

Need for soldering

Requirements of an electrical joint

[1] The electrical joint must provide ideally zero resistance or at least a very low resistance path, for the flow of current.

[2] The electrical joint made should be strong enough to withstand vibrations, physical shock, bumps etc, without causing any deterioration to the quality and strength of the joint.

[3] The electrical joint should be able to withstand corrosion and oxidation due to adverse atmospheric conditions.

All the above requirements of an electrical joint can be achieved by making a solder joints.

Solder

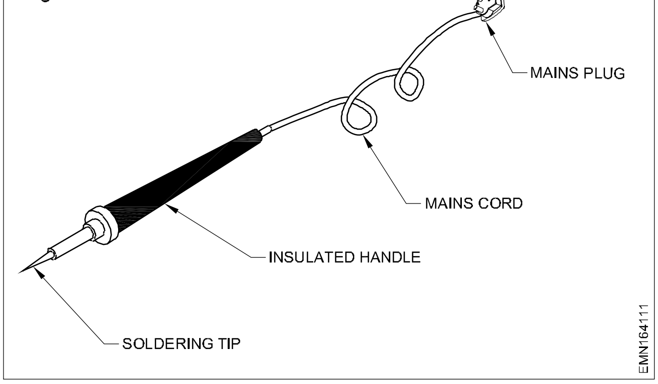
In a soldered joint, the solder is a mixture of metals, generally TIN and LEAD. It is made to melt at a certain temperature. It acts as a filler between the parts of the connection/joint to form a continuous, low resistance metallic path for conduction of electricity.

In soldering, as the metal surface is wetted (free flow of liquid solder over a surface) by the solder, a complex chemical reaction, bonds the solder to the metal surface.

The tin content of the solder diffuses with the metal surface to form a layer of a completely new alloy. The alloy so formed will have the same structure as the constituent metals and retain their metallic properties and strength.

Soldering and soldering irons

Fig 1



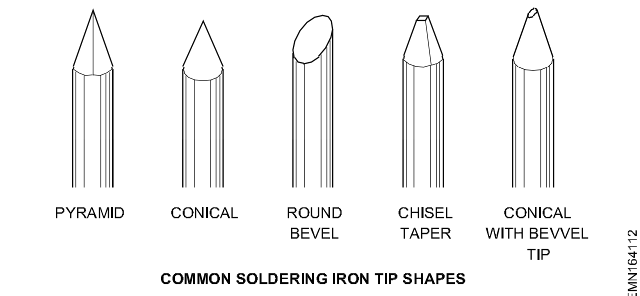
While soldering, the solder is made to melt between the metallic surfaces of the joint, using a soldering iron, as shown in Fig 1. A **soldering iron** is an instrument used to produce the required heat to carry out soldering.

Soldering irons of different wattage ratings starting from 10 watts to more than 150 watts are available commercially. Depending on the type, size and heat sensitivity of the components being soldered, the most suitable wattage soldering iron should be chosen. Most of these soldering iron work on 240V, 50Hz AC mains supply. There are special type irons which work on dc supply also. For soldering delicate components, soldering irons with temperature controlling facility are used. These are known as soldering stations.

Soldering iron tips

Soldering irons are designed to take, a variety of tip sizes and shapes as shown in Fig 2. The choice of the iron and the tip to use depends on, the nature of the joint to be soldered. A proper selection of the soldering iron and tip is important for obtaining good quality soldered joint. To solder effectively, the tip of the soldering iron must be kept clean all times.

Fig 2



COMMON SOLDERING IRON TIP SHAPES

Types of solders

Solders are available in many forms. The type to be chosen depends on, the type of soldering to be carried out. The wire type solder is the most commonly used solder for hand soldering work, using low wattage soldering iron.

Solders available in the market may have different tin-lead proportion in it. For general electronic circuit soldering work, solder with 60% tin and 40% lead is most suited. This solder is commonly called 60/40 solder. This solder has been specially developed to possess superior properties required for electronic circuit work.

Soldering FLUX

A protective oxide layer forms on the exposed surface of most metals. The rate at which the oxide layer is formed varies from metal to metal. The layer forms quickly on newly exposed metal, and over time, the layer slowly become quite thick.

This oxide layer on metals interferes with soldering. Hence, it must be removed before a soldered joint can be made.

The purpose of flux is to first dissolve the thin layer of oxide from the surface of the metals to be joined, and then form a protective blanket over them until the solder can flow over the joint surfaces to form the joint.

However, thick layers of oxide must be removed using an abrasive method as all types of flux are not capable of dissolving their oxide layers.

Types of flux

There are several types of fluxes used in different types of soldering. The type of flux used for soldering electronic components is called **rosin**. Rosin is made from a resin obtained from the sap of trees.

Rosin flux is ideal for soldering electronic components because, it become active at the soldering temperature, but revert to an inactive state when cooled again. An additional advantage is that it is non-conductive.

The rosin has activators or halides added to it. The activators used in rosins are mild acids that become very active at soldering temperatures. These acids dissolve the oxide layer on the metals to be soldered.

Organic and inorganic acid fluxes are available. These fluxes are not suitable for soldering electronic circuits.

Common forms of flux

Flux is available in a variety of forms to suit various types of application. Flux is available as a liquid, paste or a solid block. For most applications flux is often put in the solder itself during manufacture.

> **Not all flux types are available in all forms. For hand soldering work on electronic circuits, the best form for the flux is either as a liquid or a paste.**

Rosin cored solder

Several manufacturers produce solder wire with the flux already included in one or more cores running along its length. This is known as **cored solder**.

The most popular type of cored solder for electronic hand soldering contains rosin type flux. Such solder is known as **rosin cored solder**.

When the solder is heated, the rosin flux melts before the solder. The rosin then flows out over the surface to be soldered ahead of the solder.

The amount of flux contained in the core is carefully controlled by the manufacturer and for most applications it will be sufficient. However, it is a common practice to apply additional liquid flux or flux paste to the joint, just prior to making the joint. This additional flux ensures that, sufficient flux available while the joint is being made. When the soldering has been completed, excess flux if any has to be removed.

Rosin-cored solder is available in different gauges as. It is important to choose a size suitable for the job at hand as given below;

– use 22 gauge for small joints

– use 18 gauge for medium joints

– use 16 gauge for large joints.

Soldering Technique

Soldering a joint

Selection and preparation of the soldering materials is the most time consuming phase of making a solder joint. Heating the joint and applying solder is the least time consuming but, it is the most important part of the soldering process.

Critical factors during soldering

1) Controlling the temperature of the workpiece

2) Limiting of time that a workpiece is held at soldering temperature.These factors are specially critical while soldering electronic components like resistors, capacitors, transistors, ICs etc., Failure to correctly time and coordinate the heating of the joint and add solder, will result in a poor quality joint and may even damage the components.

Stages in soldering

The soldering process can be divided into several distinct stages or phases as given below:

1 Selection and preparation of materials.

2 Heating the joint and adding solder.

3 Cooling the joint.

4 Cleaning the joint.

5 Inspecting the joint.

SELECTION AND PREPARATION OF MATERIALS

Selection of soldering iron wattage

Soldering irons are available in different wattage ratings starting from 10 watts to several 100 watts. The wattage of a soldering iron specifies the amount of heat it can produce. As a thumb rule, higher the physical dimension of the workpiece, higher should be the wattage rating of the soldering iron. Some of the suggested wattage choices are given below:

i) For soldering less temperature sensitive components such as, resistors on lug boards, tag boards, use 25 to 60W iron. For soldering on printed circuit boards, use 10 to 25 W iron.

ii) For soldering highly temperature sensitive components such as, diodes, transistors and integrated circuits, use 10 to 25 watts iron.

Selection of soldering iron tip

To ensure that the joint is heated to the required temperature ideally,

- the area of the tip face should be approximately equal to the area of the joint to be soldered
- the tip should be long enough to allow easy access to the joint.
- the tip should not be too long, as this may result in too low temperature at the tips working face.

In most soldering irons, the tip can be easily removed and replaced.

Selection of tip temperature

Good quality soldering iron tips have numbers punched on them. These numbers indicate the temperature to which the tip can be heated.

Tip No.	Temperature °C	Temperature °F
5	260	500
6	316	600
7	371	700
8	427	800

Selection of tip shape

Suggested soldering tip shapes selection table is given below;

Type of soldering work	Soldering tip shape to choose
Wires, resistors and other passive components on to lug/tag boards	CHISEL TIP
All miniature electronic components except ICs on to lug boards and printed circuit boards (PCB)	BEVEL TIP
Integrated circuits (ICs) on to printed circuit boards (PCBs)	CONICAL TIP

Selection of solder and flux

There are several sizes of the cored solders whose choice depends on the size of the joints to be soldered. Also the tin and lead percentage of the solder should be checked before using the solder. Different tin and lead combinations of solder need different temperatures for it to melt and reach the liquid state.

For electronic soldering applications, solder of tin and lead of 60/40 proportion is used. This solder proportion has a melting point of 200°C which is the required temperature for general purpose soldering irons.

While soldering to make a strong solder joint the flux should melt first, and then the solder. Therefore, while using rosin cored solder, cut off the first 5 to 10mm of the solder using a side cutter,so that any earlier melted portion of the solder blocking the rosin core is removed.

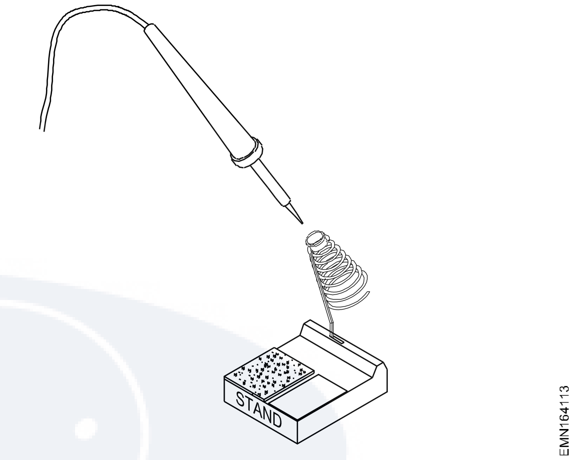
For ease of application, the flux used in addition to the cored flux in solder should be of paste form.

Flux is a chemical substance which has acidic properties. Therefore, it is advised not to touch flux by hand. Use a stick or a thin stiff brush to apply flux on workpieces. Hands should be washed after soldering work.

Soldering stand

Soldering stand plays an important role of retaining the soldering iron tip temperature around the required soldering temperature. The soldering stand should not allow the external temperature to cool the bit. At the same time the stand should not contain all the heat generated.

Fig 3



Soldering stands are specially designed as shown in Fig 3 to fulfill the above requirements. Such a design also prevents accidental burn injuries to the user of the soldering iron.

Another important requirement of a soldering stand is its mechanical stability. When the iron is taken out or placed in the stand frequently, the stand should not topple. An unstable stand is sure to cause burn injuries while carrying out serious soldering work.

Inspection of soldering iron

Most soldering irons are powered by AC mains voltage. This voltage level is high and can give shock if one is careless. Soldering irons will generally have lengthy mains cable. While using the iron, the mains cable gets twisted and will have to bear physical strain. Because of this strain, the insulation of cable may get cut. This may lead to live wires protruding out. The live wires give severe electrical shocks if it touches the user.

Hence, a thorough inspection of the soldering iron is a must before using through it.

Preparation of soldering iron for soldering

HEATING THE JOINT AND ADDING SOLDER

Tips for heating and applying solder to a joint to be soldered are given below:

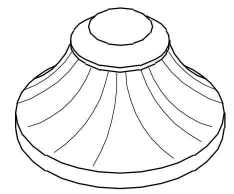
- Do not apply additional flux required for a joint in one place. Apply a small amount of flux around the joint. Do not allow the flux to flow outside the area to be soldered.

– Place the iron tip at the connection such that the tip gets maximum contact with parts to be joined.

– Slowly feed the solder into the joint starting close to the soldering tip and moving towards the edge of the joint.

– Continue applying the solder to the joint until complete wetting of the joint has been achieved and the joint has a concave fillet as shown in Fig 4.

Fig 4



– After enough solder has been applied and solder removed, keep the soldering iron tip on the joint for a moment to ensure that all the flux on the joint has reached the soldering temperature. This will allow majority of the acids within the joint to break down, which otherwise will corrode the joint after a period of time.

Generally the time taken to make a good soldered joint is between 3 to 7 seconds from applying the soldering iron.

COOLING THE JOINT

Tips for cooling a solder joint are given below:

– Allow the joint to cool without assistance. Do not blow air from your mouth or from any other source to cool the joint. Forced cooling, cools the joint much earlier than it has to, resulting in a dry or brittle solder joint which will lead to mechanical and electrical defects of the joint.

– Do not move any part of the joint while it is cooling. This disturbs the chemical bonding taking place. Movement of the joint while it is cooling results in a dry joint.

CLEANING THE JOINT

When a solder joint is made, the amount of flux applied should be just sufficient to make a good joint. But, quite often, there will be a brown waxy substance left on the joint. This is nothing but the flux residue. In its original state this residue is corrosive. Hence, the flux residue or excess flux must be removed from the joint before soldering can be considered as complete.

If the flux residue and excess flux are not properly removed, their corrosive nature of the flux will gradually destroy the component leads and the circuit board. The flux residue is also *tacky* and, if not removed, will collect dust and debris often leading to circuit failure.

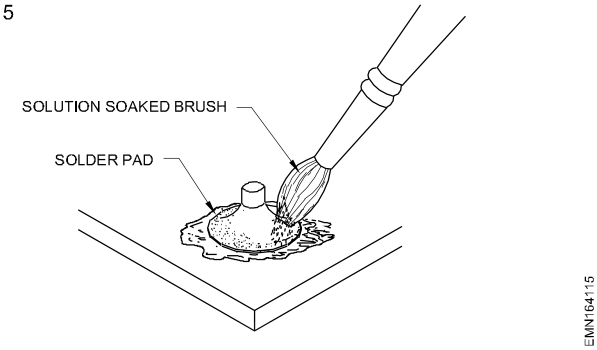
Removal of flux residue requires the use of solvents. The type of solvent depends on the flux used.

IsoPropyl Alcohol (IPA) is one of the solvents used for removing residual flux. It is available either undiluted or pre-mixed with water and can be obtained in pump sprays, aerosols, cans and drums depending on the quantity and style of use.

Cleaning using water/IPA solution

Determine the right method of application. (spray or liquid). Apply the solvent to the soldered joint. Use a clean acid brush, or some other type of stiff brush, to gently scrub the joint as shown in Fig 5, to help dissolve the residue, taking care to avoid splashing the mixture.

Fig 5



When the residue has been dissolved, dry the joint with a lint-free cloth to remove as much of the dissolved residue as possible.

Don't 's While Soldering

- **Do not use a poorly tinned soldering tip.**
- **Do not cool the tip of the iron by wiping it excessively on a damp sponge.**
- **Do not allow the solder to be carried to the joint on the tip of the soldering iron.**
- **Do not attempt to speed up the cooling of the joint by blowing on it.**
- **Do not move the soldered joint until the solder has cooled to solid state.**
- **Do not try and improve a bad solder joint by reheating. All the original solder must be removed and the joint preparation and soldering should be redone.**

Features of soldering iron

There are a number of features that the soldering irons posse need to be examined before a choice of a particular soldering iron is made. These include: size, wattage or power consumption, voltage method of temperature control, anti-static protection, type of stand available, and general maintenance and care issues.

Size: There is a wide variety of sizes of soldering iron available. Obviously those that are smaller will be more suited to fine work, and those that are larger will be more suited to the solder of items that are less delicate. The physical size will also run in parallel with the wattage or power consumption of the iron.

Wattage or power consumption: The power consumption or wattage of a soldering iron is often quoted. The wattage can vary. For basic non-temperature controlled irons, a wattage of 40 watts may be good for general work, and higher if heavy soldering is envisaged. For small PCB work, 15 or 25 watts is good value. For temperature controlled irons slightly higher wattages are common as the temperature control acts more quickly if more heat can be directed to the bit more quickly to compensate for removal of heat via the work item.

Voltage: While most soldering irons on sale in a particular will country have the correct mains voltage, 230V AC and there are also soldering irons that can run from 12 V. Some irons may be made for specialist applications where they need to run from low voltages.

Temperature control: Soldering irons use two main varieties of temperature control. The less expensive irons are regulated by the fact that when they come up to temperature, the loss of heat is the same as the heat generated. In other words they employ no form of electronic regulation. Other, more costly types have thermostatic contol. This naturally regulates the temperature far better.Usually the temperature can be adjusted to the required value.These irons come into their own because when heat is drawn away by a large object being soldered,they will maintain their temperature far better. Those with no regulation may not be able to maintain their temperature sufficiently when soldering a large object,with the result that it is more difficult to melt the solder under these conditions.

Anti-static protection: With the increasing susceptibility of many electronic components,particulary the very advanced integrated circuit chips,static protection is becoming more of an issue. While most components being used by home constructors are often not damaged by static,some are. It is therefore a wise precaution to at least consider whether the soldering iron that is bought is one that has static protection.

Maintenance: When using any soldering iron it is essential that spare parts can be obtained. The soldering iron "bits" used to undertake the actual soldering have a limited life and eventhough the rest of the iron may work for many years,it will be necessary to change the bits at regular intervals. Additionally it is worth ensuring for the more expensive soldering irons,such as those with temperature control,that spare parts are available should they need repair.

Desoldering and desoldering tools

Desoldering

Many a time it may be necessary to disconnect/remove components and wires from a soldered or wired circuit due to the following reasons;

- Component failure(open,short etc).
- Incorrect component installation(polarity,position etc).
- Faulty or defective solder connections(dry solder etc).
- Circuit modifications(replacing,removing components etc).

Disconnecting a component or wire from any soldered circuit involves two separate actions. These are:

1 **DESOLDERING THE CONNECTION** - this action involves removal of the solder from a joint

2 **REMOVAL OF THE COMPONENT** - this action involves removing the component lead from the joint.

De-soldering the connection

De-soldering is a process of heating a soldered joint, to melt the existing solder and removing the molten solder from the joint.

De-soldering makes it easy to separate or pull-out the components,wires from the joint without unnecessary damage to the components and wires.

The heat required to melt the solder is supplied by a soldering iron. But removal of the molten solder from the joint requires the use of one of the following;

– Plunger de-soldering tool or desoldering pump

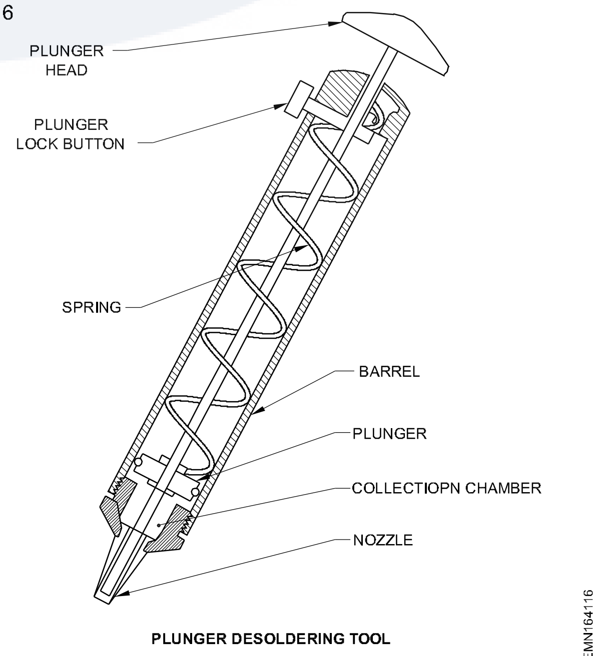
– Wicking braid

But, in many cases, desoldering is done using a nose plier and a soldering iron. First, the joint to be disconnected is heated using the soldering iron. Once the solder at the joint melts, the component lead is pulled away using a nose plier. This method of desoldering can be used for heavy components with strong leads. But this method should not be used for desoldering thin lead delicate components such as transistors, integrated circuits etc., This is because, in this method there is likelyhood of component getting overheated or the leads getting cut or leads getting detached from the body of the component.

PLUNGER DE-SOLDERING TOOL

A typical plunger de-soldering tool is shown in Fig 6.

Fig 6



PLUNGER DESOLDERING TOOL

Plunger type desoldering tool is the most commonly used desoldering tool. This tool works on the principle of air suction. When the plunger head is pushed fully inside gets locked with the help of the plunger button. This is known as cocking tool.

In this condition, the nozzle of the desoldering tool is kept almost touching the joint to be desoldered. If the joint is heated, the solder at the joint melts. If the plunger button of the desoldering pump is pressed, it releases the spring tension and moves the plunger up with a jerk. This causes the air to be sucked-in through the nozzle. Since the nozzle is now in contact with the molten solder, the molten solder is also sucked-in through the nozzle and gets collected in the collection chamber.

When the solder is removed using a plunger de-soldering tool, all the molten solder of a joint may not be sucked by the de-soldering tool at the first attempt, the joint must be reheated and the solder removed in two or three attempts.

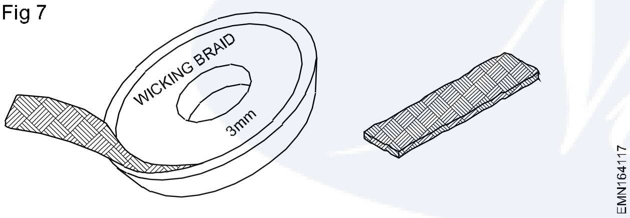
After doing one suction of molten solder, while cocking the tool for second suction, face the nozzle into a dirt collector. This is because, the solder collected at the tip of the nozzle gets pushed out every time the tool is cocked.

After several operations, the waste solder collected within the tool will begin to interfere with its operation. To prevent clogging of nozzle, this solder must be removed periodically and the tool must be cleaned and lubricated.

WICKING BRAID

Wicking braid as shown in Fig 7 is another simple de-soldering aid. This is made of copper and is soaked in flux. Wicking braid is nothing but a tape made of thin strands of copper knitted to form a mesh Fig 7.

Fig 7



A wicking braid relies on the tendency of the hot solder to flow towards the heat source. When a soldered joint is heated via a wicking tape as shown in Fig 23a, the molten solder gets drawn into the wicking braid as shown in Fig 23b. Thus the joint is now free from solder and the component can be removed easily.

The flux content of the wicking braid varies from brand to brand. Generally, the higher the level of flux in the braid, the more efficient it will be at drawing the solder from the joint.

Wicking braids are available in small, hand-held rolls and is supplied in a range of sizes from 0.8 to 6 mm wide so that the correct width of wicking braid can be selected for the joint to be de-soldered.

De-soldering using a wicking braid is commonly used for removing miniature components soldered on printed circuit boards(PCB’s).

Removal of component

When solder is removed from the joint, the component can then be removed from the circuit board. If a component was soldered using clinched lead method. it is essential to remove the bridge of solder holding the lead.

To remove the solder bridge, follow the steps.

There are other special tools used for de-soldering such as De-soldering iron and multi-contact de-soldering block.

Soldering and desoldering station

Printed circuit board have changed the face of Electronics industry. Comparing the today's PCBs with the old hardwired, steel chassis devices, they lack the strength making them vulnerable to cracks and related defects. It may sometimes be possible to repair a broken PCB but it is very difficult process. Locating the cracked copper trace on the PCB is the most difficult part of the repair PCBs get damaged very easily. A little rough handing during installation or troubleshoot will invite a crack in the trace. While placing or removing PCBs from their sockets, one needs to put little extra force. This itself might cause a crack in the trace. Similarly when a component on a PCB is removed or inserted a little more heat for a little long period will make copper trace to come off the board's substrate. There may result a microscopic crack in the trace.

Soldering and Desoldering Stations

A typical competitive soldering station with ESD safe by design will comprise of hot air station soldering, LED double digital display. This kind of stations will come with PID controlled closed loop of sensor. The desolder station can give rapid heating, precise and stable temperature, suitable for soldering and de-soldering surface mounted. Such as QFPM PLCC, SOP, BGA etc package of ICs. Hot air station and intelligent cooling system, adopts imported heating wire, for a long life. There are normally light portable handle and suitable for mounting and reworking SMD component by hand for a long time.

Typical specifications of a Solder and Desolder stations:

Hot Soldering Station :

Air Flow	:	0.16 - 1.2 Nm3/h
Pump Consumption	:	45W
Temp. Control	:	150-450°C
Heater	:	250W Metal
Rated Voltage	:	110V/220V 50/60Hz AC
Power Consumption	:	270W
Air Pump	:	Membranous
Solder Equipment	**:**	
Power Consumption	:	60W
Output Voltage	:	24V AC
Temp. Control	:	200-480
Ground Resistance	:	20 ohms

Heater : Ceramic Heating Element

A typical hot soldering station is shown in Fig 8.

Fig 8

Desoldering by using pump and wick

DESOLDERING is the process of removing soldered components from a circuit made on PCB. Desoldering pump along with the soldering iron is used for this purpose. A desoldering pump also known as solder sucker is a small mechanical device which sucks the liquid/molten solder from the joint where the components are mounted. In order to desolder a component from the PCB,we first heat up the solder joint with the soldering iron till the solder liquefies/melts. At the same moment we actuate the soldering pump by pressing the trigger lever and bring the tip over the molten metal and pull the trigger back by pressing a button. At this instant the lever is pulled back and the tip of the pump sucks the molten solder. This process is repeated until all the residue solder is sucked by the pump and the hole on the PCB is clear to solder a fresh component.

To actuate the pump the lever is pressed until there is a click sound which indicates that the lever will remain locked in the same position.

The desoldering pump's buttom head contians a hole through which the molten solder is sucked when the pump is triggered. The head is designed such that the extracted solder does not solidify and block it, consequently the sucked metal can be removed and discarded easily.

Desoldering Wick/ braid

Place the braid over a connection and heat the opposite side with an iron Sometimes adding a small amount of solder to the iron tip can actually speed up the process because that solder will help the iron transfer heat into the braid faster. Cut off and discard tyhe dused wick. The only concern with using desoldering wick/braid is that the components and pads can easily become overheated, especially surface mount pads. As always, try to minimize the time parts are heated. This wick is 1" wide and 5 feet long, which should be statisfactory for most through-hole and many surface mount connections. Width is important because it dictates how much solder a certain length of braid can hold. Too thin, and the solder will quickly fill up the braid and stop it from absorbing. Too thick, and it will be hard not to touch neighboring joints. This particular braid is coated in pure resin - based flux that will leave a non-corrosive, non-conductive, and environmentally friendly residue the residue can be cleaned with alcohol if desired for cosmetic reason, but unless you are making military spec devices, cleaning should not be necessary. The casing is ESD safe.

Switches

Electrical accessories: An electrical 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.

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, tumbler switch

2 Single pole, two-way switch

3 Intermediate switch

4 Bell-push or push-button switch

5 Pull or ceiling switch

6 Single pole single throw switch (SPST)

7 Single pole double throw switch (SPDT)

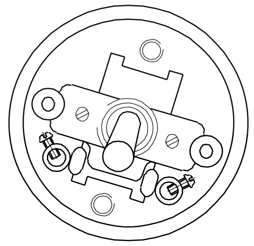
8 Double pole single throw switch (DPST)

9 Double pole double throw switch (DPDT)

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

Single pole, tumbler 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. It is used for controlling light or fan or 6 amps socket circuits. One - way switch is as shown in Fig 9.

Fig 9

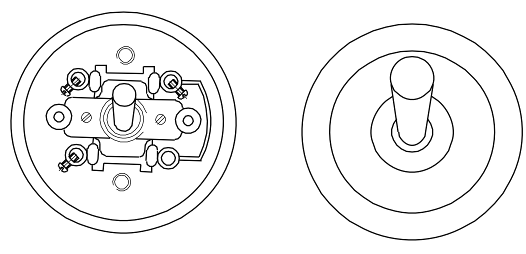


6 AMP SINGLE-WAY SURFACE MOUNTING SWITCH (COVER REMOVED)

EMN164119

Single pole, two-way switch: This is a three terminal device capable of making or breaking two connections from a single position as shown in Fig 10. These switches are used in staircase lighting where one lamp is controlled

Fig 10



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

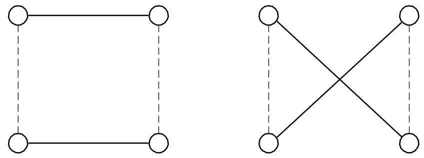
(b) A 2-WAY SWITCH WITH A METAL CAP

EMN16411A

from two 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 as shown in 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.

Intermediate switch: This is a four-terminal device capable of making or breaking two connections from two positions as shown in Fig 11. This switch is used along with 2 way switches to control a lamp from three or more positions.

Fig 11



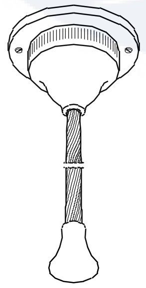
INTERMEDIATE SWITCH CONNECTIONS

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 shown in Fig 12 is normally a two-terminal device functioning as a one-way switch to make or break a circuit.

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.

Fig 12

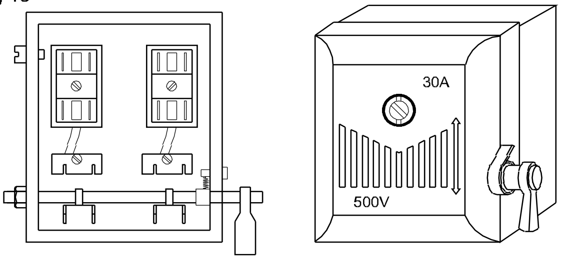


PULL SWITCH

Double pole switch (D.P.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.

Double pole iron-clad main switch : This switch shown in Fig 13 is also referred to as D.P.I.C. switch and is mainly used for single phase domestic installations, to control the main supply. It controls phase and neutral of the supply simultaneously. 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 13



DPIC MAIN SWITCH

Specification of these switches should have:

– current rating

– voltage rating

– type of enclosure

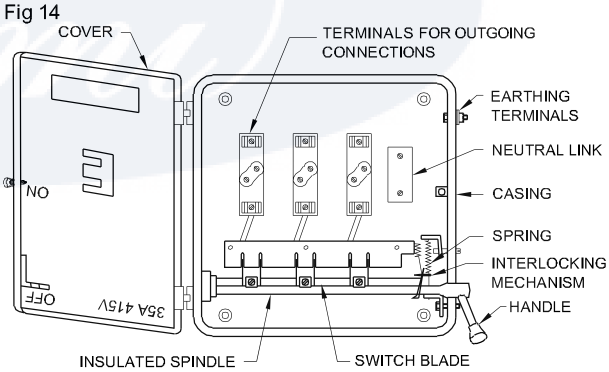
(sheet steel or cast iron).

Triple (three) pole iron-clad main switch: This is shown in Fig 14 and 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.

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

Fig 14



FUSED ICTP `N' SWITCH

– 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.

Switches used in electric industry

Switching is the most fundamental function in electronics and plays a vital role in every system

Most widely used switch configurations in the industry today are:

1 Single Pole Single Throw (SPST)

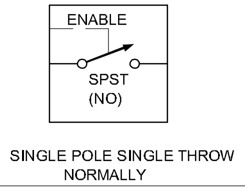
2 Single Pole Double Throw (SPDT)

3 Double Pole Double Throw (DPDT)

Single Pole Single Throw (SPST) is an analog switch used in many industrial instruments and consumer devices to implement test interfaces etc. It consumes very low power with maximum current in the range of 690 nA

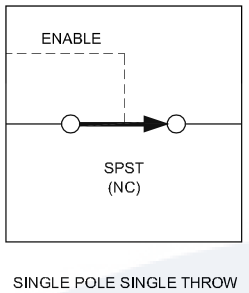
Normally open **SPST** switch can isolate multiple peripherals from source and select the required one. (Fig 15)

Fig 15



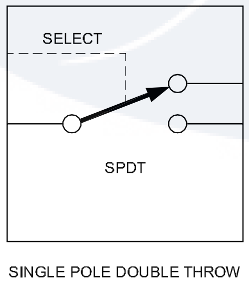
Normally closed **SPST** switch can connect at all times to a peripheral and when not desired the output can be totally stopped by a press of a switch. (Fig 16)

Fig 16



Some **SPDT** switches have a select pin and other will have a enable pin. The master in the design for digital control chooses the required trigger action. (Fig 17)

Fig 17



Schmitt trigger action at select and enable control pins results in higher reliability.

Digital bus switches are widely used multiple peripheral and host selection functions, power and clock management, sample and hold circuits, test and debug interfaces etc.

A **dual SPDT** switch in (Fig 18) can be used

1 to route the audio signal from either base band processor to speaker

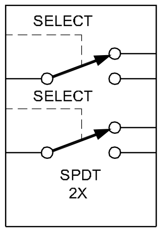
2 to wirelessly route the audio signals between cell phone and an external hands-free device.

The **dual SPDT** and dual SPST switches are available either for simultaneous selection or for simultaneous enable.

Simultaneous select is to connect one of the two signal points or peripherals

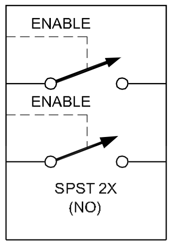
Simultaneous enable is normally open and upon control by master gets enabled remain enabled till disabled.

Fig 18



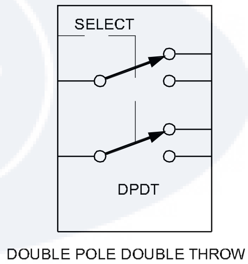
The symbol of dual SPST switch is shown in (Fig 19)

Fig 19



A DPDT switch is a dual SPDT switch into a single select pin as shown in (Fig 20)

Fig 20



Active electronic components

Objectives: At the end of this lesson you shall be able to
- **state the passive components**
- **explain the active components.**

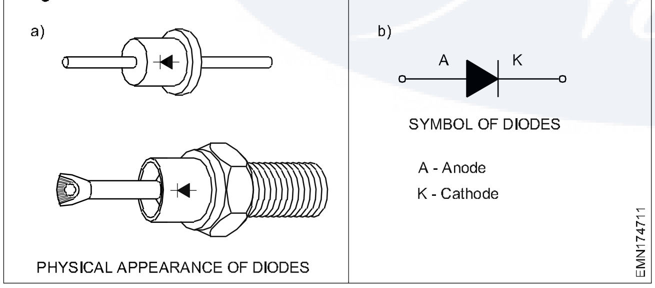
Passive components : Components like resistors, capacitors and inductors used in electronic circuit are called as passive components. These components by themselves are not capable of amplifying or processing an electrical signal. However these components are equally important in electronic circuit as at of active components, Without the aid of passive components, a transistor (active components) cannot be made to amplify electrical signal.

Circuits formed with passive components obey the electrical circuit laws such as Ohm's law, Kirchoff's Laws etc.,

Active components : In electronic circuits, components other than resistors, capacitors and inductors are also used. Namely transistors, diodes, vacuum tubes, SCRs, diacs, zener-diode etc. The application of electrical circuit laws (Ohm's law etc.) in the circuit containing the above components will not give correct results. i.e. these components do not obey Ohm's law, Kirchhoff's law etc. These components are called active components.

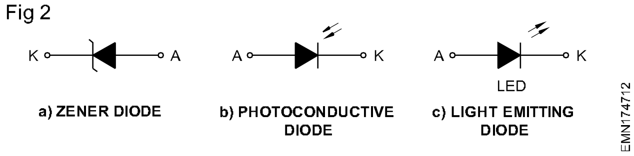
The different active components and the method of representing them by symbols are given in fig 1.

Fig 1



The different types of diodes (Fig 2) used for specific purposes are represented by the symbols given.

Fig 2



Transistor : Figure 3a shows the physical appearance of transistors. There are two symbols to represent a transistor. (Fig 3b). The selection of a symbol is based on either the NPN or the PNP type of transistor.

SCR (Silicon controlled rectifier) : Figure 4a shows the physical appearance of one type of SCR and the symbol is shown in Fig 4 b. SCRs are also called thyristors and used as switching devices.

Fig 3

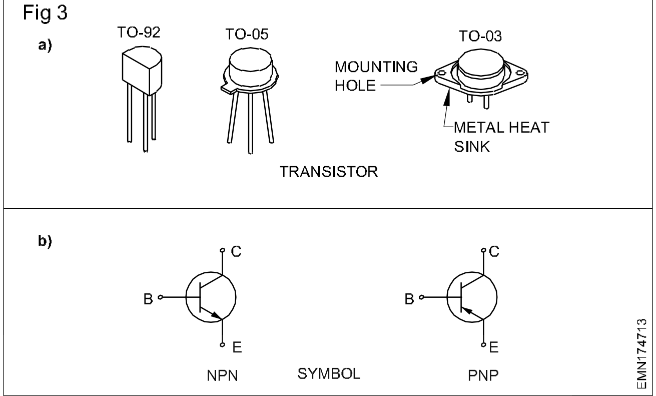
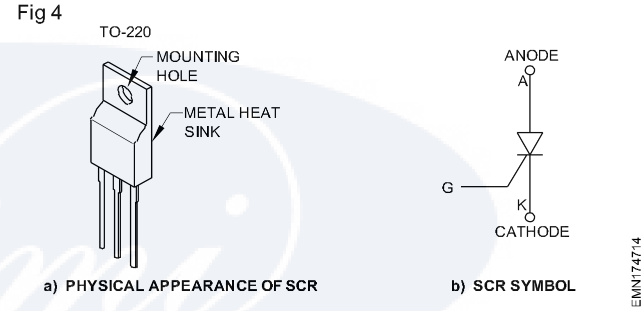
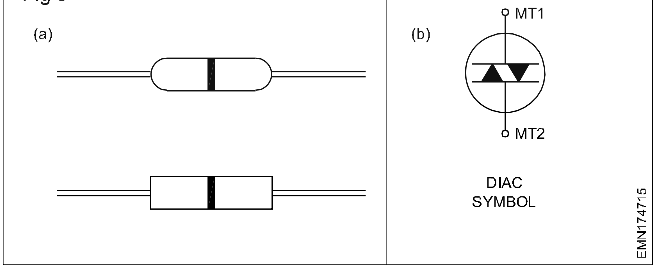


Fig 4



Diac : A diac (Fig 5a) is a two-lead device like a diode. It is a bidirectional switching device. Its symbol is shown in Fig 5b.

Fig 5



Triac : A triac is also a semiconductor device with three leads like two SCRs in parallel. The triac can control the circuit in either direction. (Fig 6)

Bridge rectifier or diode bridge : It is a single package of four semiconductor diodes connected in bridge circuit. The input AC and the output DC leads are marked and terminated as shown in the Figure 7.

UJT (Uni-junction transistor) : It has two doped regions with three leads and has one emitter and two bases.

FET (Field effect transistor) : Fig 9a give a pictorial view of the component, and the related symbol to represent the field effect transistor is shown in Fig 9b. The selection of the symbol is based on whether the FET is a 'N' channel or a 'P' channel one.

Fig 6

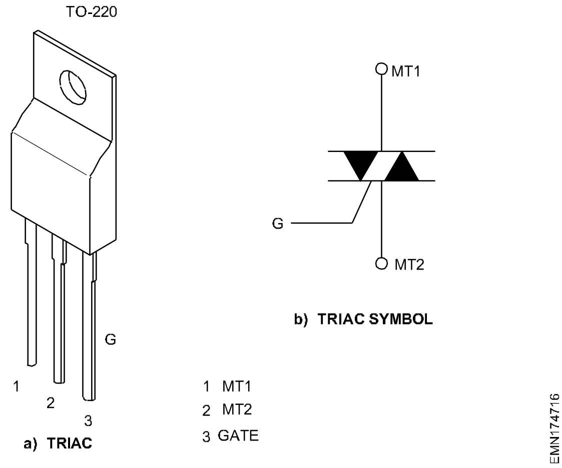


Fig 7

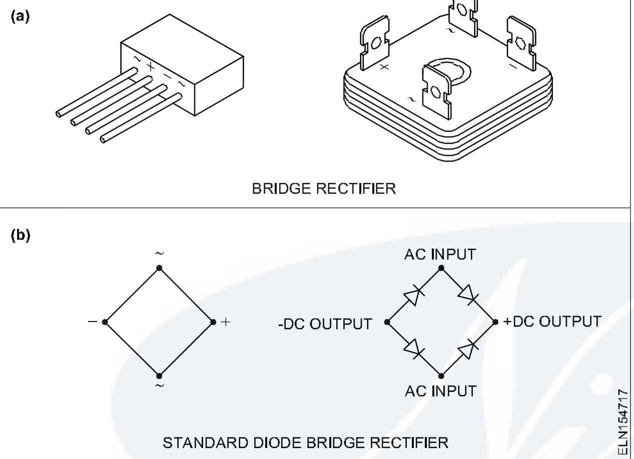


Fig 8

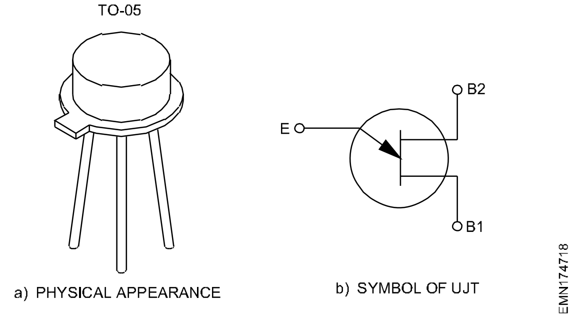
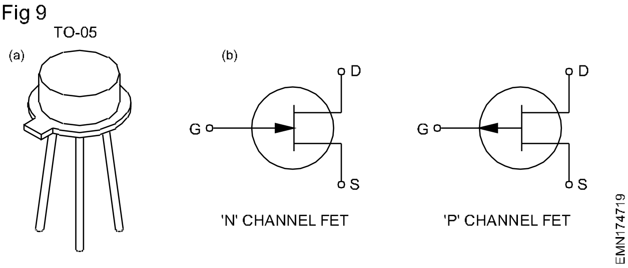


Fig 9



Note:- The devices like transistor, SCR, triac, UJT & FET may look alike due to similarity in encapsulation. They can be identified only by the code numbers and relevant data books.

Passive components - Resistors

Objectives : At the end of this lesson you shall be able to
- **state the function of a resistor in a circuit**
- **explain the classifications of resistors**
- **explain the classifications of fixed value resistors.**
- **state the power rating of resistors**
- **state the tolerance in a resistor**
- **find the value of a resistor using colour code**
- **state the constructional details of fixed and variable resistors.**

Resistors

Resistors are electronic components, used to reduce, or limit, or resist the flow of current in any electrical or electronic circuit. Chart 1 at the end of this lesson shows different types of resistors.

Fig 1 shows a circuit in which the bulb glows brightly. Fig 2 shows the same circuit with a resistor, and the bulb glows dim. This is because, the current in the circuit is reduced by the 1000 ohms resistor. If the value of this resistor is increased, current in the circuit will be further reduced and the light will glow even dimmer.

Fig 1

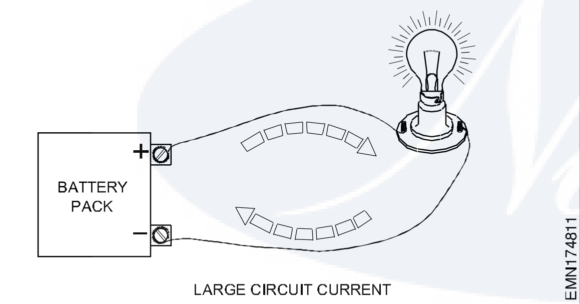
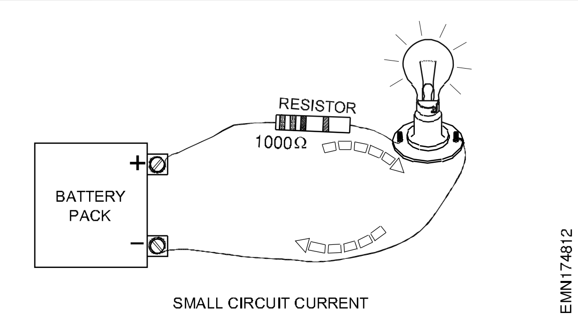


Fig 2



Resistors are made of materials whose conductivity fall in-between that of conductors and insulators. This means, the materials used for making resistors have free electrons, but not as many as in conductors. Carbon is one such material used most commonly for making resistors.

When a large number of electrons are made to flow through a resistor, there is opposition to the free flow of electrons. This opposition results in generation of heat.

Unit of resistance

The property of the resistor to limit the flow of current is known as *resistance*. The value, or quantity of *resistance* is measured in units called **ohms** denoted by the symbol Ω.

Resistors are called *passive devices* because, their resistance value does not change even when the level of applied voltage or current to it is changed. Also, the resistance value remains same when the applied voltage is AC or DC.

Resistors can be made to have very small or very large resistance. Very large values of resistances can be represented as given below;

1000 Ω	= 1 x 1000 Ω	= 1 x kiloΩ	= 1 K Ω
10,000 Ω	= 10 x 1000 Ω	= 10 x kiloΩ	= 10 K Ω
100,000 Ω	= 100 x 1000 Ω	= 100 x kilo Ω	= 100 K Ω
1000,000 Ω	= 1000 x 1000Ω	= 1000 x kiloΩ	= 1000 KΩ
		= 1Mega Ω	= 1MΩ

Classification of Resistors

Resistors are classified into two main categories.

1. Fixed 2. Variable

Fixed value resistors

Its ohmic value is fixed. This value cannot be changed by the user. Resistors of standard fixed values are manufactured for use in majority of applications.

Fixed resistors are manufactured using different materials and by different methods. Based on the material used and their manufacturing method/process, resistors carry different names.

Fixed value resistors can be classified based on the type of material used and the process of making as follows.

FIXED VALUE RESISTORS

- Carbon composition resistors
- Wire-wound resistors
- Film resistors
  - Carbon - film resistors
  - Metal film resistors
  - Metal oxide film resistors
  - Cermet film resistors
  - Integrated resistors
- Printed resistors

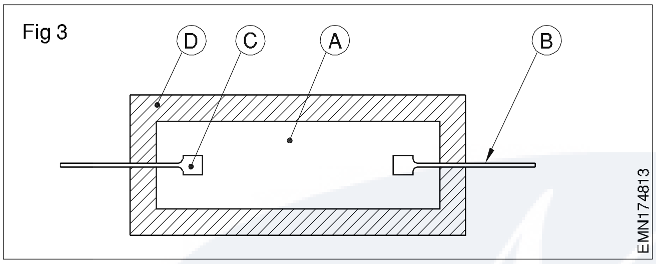
Physical appearance of some types of fixed value resistors is shown in Chart 1 at the end of this lesson.

Carbon Composition Resistors

Construction

These are the simplest and most economical of all other types. Brief constructional detail of the simplest type of carbon composition resistors commonly called *carbon resistor* is shown in Fig 3.

Fig 3



A mixture of finely powdered carbon or graphite(A), filler and binder is made into rods or extruded into desired shapes. Leads(B) made of tinned copper are then attached to the body either by soldering or embedding(C) in the body. A protective layer/tube(D) of phenolic or Bakelite is moulded around the assembly. Finally its resistance value is marked on the body.

Power rating

As already discussed, when current flows through a resistor, heat is generated. The heat generated in a resistor will be proportional to the product of applied voltage (V) across the resistor and the resultant current (I) through the resistor. This product VI is known as *power*. The unit of measurement of power is *watts*.

The physical size of a resistor should be sufficiently large to dissipate the heat generated. The higher the physical size, the higher is the heat that a resistor can dissipate. This is referred to as the power rating or wattage of resistors. Resistors are manufacturerd to withstand different power ratings. If the product of V and I exceeds the maximum wattage a resistor can dissipate, the resistor gets charred and loses all its property. For instance, if the applied voltage across a 1 watt resistor is 10 volts resulting in 0.5 Amps of current through the resistor, the power dissipated (VI) by the resistor will be 5 watts. But, the maximum power that can be dissipated by the 1 w resistor is much less. Therefore, the resistor will get overheated and gets charred due to overheat.

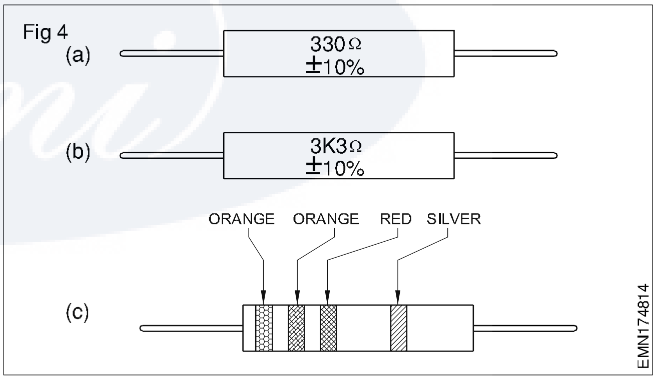
Hence, before using a resistor, in addition to its ohmic value, it is important to choose the correct wattage rating. If in doubt, choose a higher wattage resistor but never on the lower side. The power rating of resistors are generally printed on the body of the resistor.

Resistor values - coding schemes

For using resistors in circuits, depending upon the type of circuit in which it is to be used, a particular type, value and wattage of resistor is to be chosen. Hence before using a resistor in any circuit, it is absolutely necessary to identify the resistor's type, value and power rating.

Selection of a particular type of resistor is possible based on its physical appearance. Table 4 at the end of this lesson illustrates the physical appearance of most commonly used fixed value resistors. The resistance value of a resistor will generally be printed on the body of the resistor either directly in ohms as shown in Fig 4a or using a typographic code as shown in Fig 4b or using a colour code as shown in Fig 4c.

Fig 4



Colour band coding of resistors

Colour band coding as shown in Fig 6c is most commonly used for carbon composition resistors. This is because the physical size of carbon composition resistor is generally small, and hence, printing resistance values directly on the resistor body is difficult.

Tolerance

In bulk production/ manufacturing of resistors, it is difficult and expensive to manufacture resistors of particular exact values. Hence the manufacturer indicates a possible variation from the standard value for which it is manufactured. This variation will be specified in percentage tolerance. Tolerance is the range(max -to- min) within which the resistance value of the resistor will exist.

Table No.4 of pocket table book gives a list of commercially available standard preferred value of resistors.

Refer to the Pocket Table book, table nos 1, 2 and 3 for methods to read the value of resistors and their tolerance for resistors using 3 band, 4 band and 5 band colour coding schemes.

Typo graphical coding of resistors

In the typographical coding scheme of indicating resistance values, the ohmic value of the resistor is printed on the body of the resistor using a alpha-numeric coding scheme.

Some resistance manufacturers use a coding scheme of their own. In such cases it will be necessary to refer to the manufacturer's guide.

Applications

Carbon composition, fixed value resistors are the most widely used resistors in general purpose electronic circuits such as radio, tape recorder, television etc. More than 50% of the resistors used in electronic industry are carbon resistors.

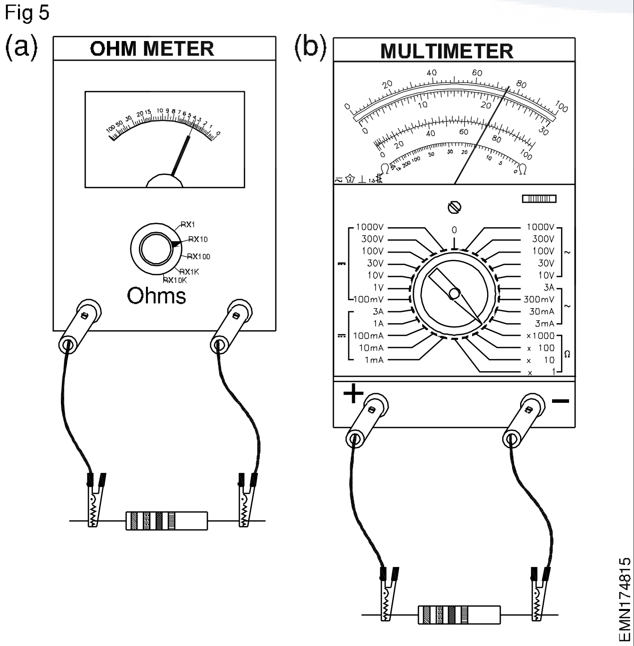
Measuring ohmic value of resistors

It is not possible to read the *exact ohmic value* of a resistor from colour/other coding schemes due to manufacturing tolerance built into the resistors. To find the exact ohmic value of resistors *ohmmeters* are used. When a resistor is placed between the test probes of an ohmmeter as shown in Fig 5a, the meter shows nearest to the exact resistance of the resistor directly on the graduated meter scale. Multimeters are also used to measure the value of resistors as shown in Fig 5b.

When a multimeter is used for resistance measurement, the resistance range switch on the meter should be put to the most suitable resistance range, depending upon the value of resistance being measured.

Table No.11 of Pocket table book suggest the meter ranges for measuring different resistor values accurately.

Fig 5



Wire-wound Resistors

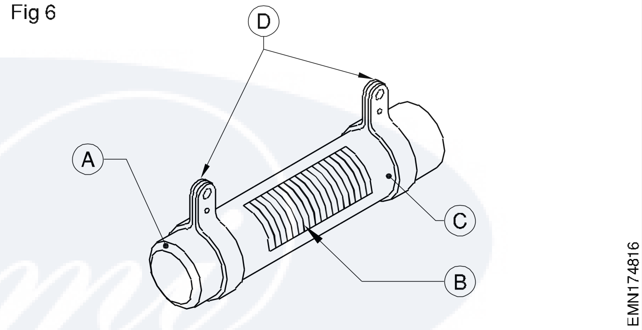
Resistors, in addition to having a required ohmic value, should also be capable of dissipating the heat produced. Carbon by its nature has a limitation in the maximum heat it can dissipate. Carbon resistors become too hot when high current flows through them. This increased heat in carbon resistors changes the ohmic value of the resistors. Sometimes the resistors may even burn open due to excessive heat. Hence carbon resistors are suited only in low power circuits safely up to 2 watts.

This limitation in carbon resistors can be overcome by using wires of resistive materials like Nichrome, Manganin etc., instead of carbon. Resistors made using wires of resistive materials are known as *wire-wound* resistors. These resistors can withstand high temperature, and still maintain the exact ohmic values. In addition, wire-wound resistors can also be made to have fractional ohmic values which is not possible in carbon composition resistors.

Construction

Typical construction of a fixed value wire-wound resistor is shown in Fig 6 . Over a porcelain former (A), resistive wire (B) such as Nichrome, Manganin or Eureka is wound. The number of turns wound depends on the resistance value required. The wire ends are attached to terminals(D).

Fig 6



The entire construction, except the terminals are coated using an insulating binder(C) such as shellac/ceramic paste to protect the wire-wound resistor from corrosion etc. In very high voltage/current application, the resistive wires are coated with vitreous enamel instead of shellac. The vitreous enamel coating protects the wire-wound resistor from extreme heat and inter-winding firing/discharge.

Resistor values

Wire-wound resistors are available from a fraction of an ohm to 100's of Kilo ohms, with a power ratings of 1 watt to several 100s of watts. The higher the power rating, the thicker the resistive wire used, and bigger will be the physical size of the wire-wound resistor.

Applications

Wire-wound resistors are commonly used in electronic circuits where small values, precision values, high wattage ratings are required. A few applications are : regulated power supplies, amplifiers, motor controls, servo control circuits, TV receivers etc.

Chart 1 for lesson 1.7.48 to 1.7.50

FIXED VALUE RESISTORS