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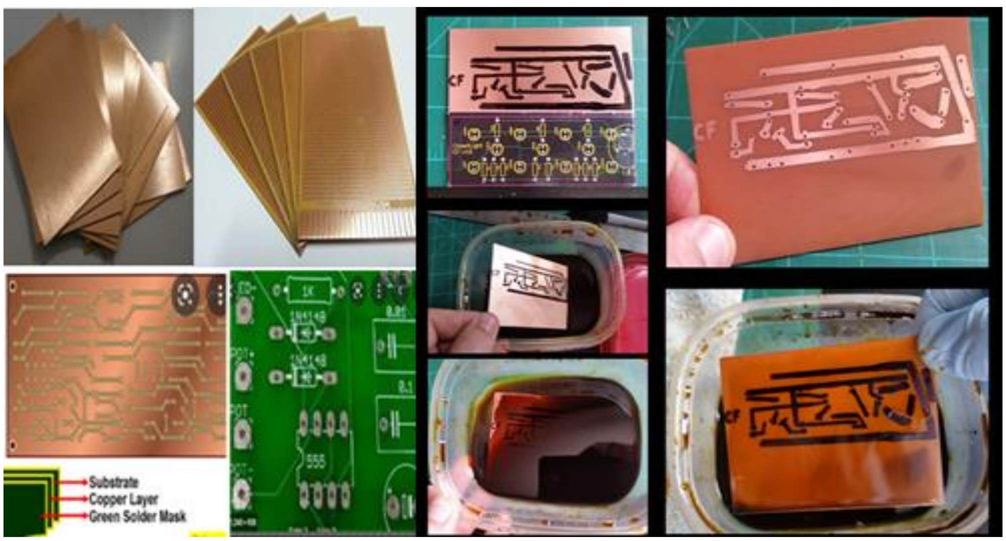
Ministry of Labor and Skills

ELECTRICAL/ELECTRONICS EQUIPMENT SERVICING

LEVEL – II

Based on April, 2022 curriculum Version- 1



Module Title: Design and Construct Simple Printed Circuit Board

Module Code: <u>EISE EES2 M05 0822</u>

Nominal duration: 120Hours

Prepared by: Ministry of Labour and Skill

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Addis Ababa, Ethiopia

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Acknowledgement

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Acronym

PCB -- Printed Circuit Board

SWG --- Standard Wire Gauge"

OSH --- Occupational Safety and Health

WHO-- World Health Organization

AC --- Alternative Current

DC ---– Direct Current

RMS –-- Root Main Square

MSDS--- Material Safety Data Sheets

JSA--Job Safety Analysis

LED -- Light Emitting Diode

CAD --- Computer Aided Design

PC -- Personal Computer

AF--- Audio Frequencies

RF--- Radio Frequencies

VHF --- Very High Frequency

UHF ---Ultra High Frequency

SHF -- Super High Frequency

PWM -- Pulse width modulation

PRM--- Pulse Rate Modulation

EMF -- Electromotive Force

LC --- Inductive Capacitive

Introduction to the Module

In electrical/electronics equipment servicing filed; the Design and construct simple printed circuit board project helps to know the printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate**.** Printed Circuit Board Terminology having a basic understanding of printed circuit board terminology can make working with a PCB manufacturing company much faster and easier. This glossary of circuit board terms will help you understand some of the most common words in the industry. While this isn't an all-inclusive list, it is an excellent resource for your reference. Glossary of Terms Active Components: This term refers to a type of component that is dependent on the flow direction of an electrical current. For example, a transistor, rectifier or valve would be considered active. Short for any layer inner via hole, this is a type of technology used to build multi- layer PCBs. This method uses a solder to create an electrical connection between PCB layers. often replaces traditional vias and is a useful production method for creating high-density PCBs. Analog Circuit: It refers to circuits processing analog signals (continuous and variable signal). The outputs are non-binary within this type of circuit that is suitable for **design and construct simple printed circuit board**

This module covers the units:

- Plan to construct electrical/electronic circuits
- Design and construct printed circuit board (PCB)
- Construct electrical /electronic circuits on PCB
- Test the construction of electrical/ electronic circuits

Learning Objective of the Module

- Preparing to construct electrical/electronic circuits
- Designing printed circuit board (PCB)
- Constructing electrical /electronic circuits on PCB
- Testing construction of electrical/ electronic circuits

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: plan to construct electrical/electronic circuits

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Plan to ensure occupational health and safety
- Check the material of OHS procedure
- Select appropriate tools and equipment's
- Connect and solder electrical/electronic circuits correctly.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Ensure occupational health and safety
- Inspect the material for PCB constructing
- Select appropriate tools and equipment's
- Connect and solder electrical/electronic circuits correctly.

1.1. Occupational health and safety

1.1.1. Introduction to occupational health and safety

Occupational safety and health (OSH), also commonly referred to as occupational health and safety (OHS), occupational health, or workplace health and safety (WHS), is a multidisciplinary field concerned with the safety, health, and welfare of people at work.

OSH may also protect co-workers, family members, employers, customers, and many others who might be affected by the workplace environment. In the United States, the term occupational health and safety is referred to as occupational health and occupational and non-occupational safety and includes safety for activities outside of work.

In common-law jurisdictions, employers have a common law duty to take reasonable care of the safety of their employees. Statute law may in addition impose other general duties, introduce specific duties, and create government bodies with powers to regulate workplace safety issues: details of this vary from jurisdiction to jurisdiction.

All organizations have the duty to ensure that employees and any other person who may be affected by the organization's activities remain safe at all times.

As defined by the World Health Organization (WHO) "occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards."

1.1.2. The main focus in occupational health

A. There is three main focus OH different objectives:

I. the maintenance and promotion of workers' health and working capacity;

II. the improvement of working environment and work to become conducive to safety and health and

III. Development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings.

The concept of working culture is intended in this context to mean a reflection of the essential value systems adopted by the undertaking concerned. Such a culture is reflected in practice in the managerial systems, personnel policy, principles for participation, training policies and quality management of the undertaking."

B. Occupational health should aim at:

I. The promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;

II. The prevention amongst workers of departures from health caused by their working conditions;

III. The protection of workers in their employment from risks resulting from factors adverse to health;

IV. The placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities; and, to summarize,

V. The adaptation of work to man and of each man to his job

1.1.3. Identifying safety and health hazards

A. Hazards, risks, outcomes

The terminology used in OSH varies between countries, but generally speaking:

- A hazard is something that can cause harm if not controlled.
- The outcome is the harm that results from an uncontrolled hazard.
- A risk is a combination of the probability that a particular outcome will occur and the severity of the harm involved.

“Hazard”, “risk”, and “outcome” are used in other fields to describe e.g. environmental damage, or damage to equipment. However, in the context of OSH, “harm” generally describes the direct or indirect degradation, temporary or permanent, of the physical, mental, or social well-being of workers. For example, repetitively carrying out manual handling of heavy objects is a hazard.

1.1.4. Hazard identification

Hazard identification or assessment is an important step in the overall risk assessment and risk management process. It is where individual work hazards are identified, assessed and controlled/eliminated as close to source (location of the hazard) as reasonably as possible. As technology, resources, social expectation or regulatory requirements change, hazard analysis focuses controls more closely toward the source of the hazard. Thus hazard control is a dynamic program of prevention. Hazard-based programs also have the advantage of not assigning or implying there are "acceptable risks" in the workplace. A hazard-based program may not be able to eliminate all risks, but neither does it accept "satisfactory" – but still risky – outcomes. And as those who calculate and manage the risk are usually managers while those exposed to the risks are a different group, workers, a hazard-based approach can by-pass conflict inherent in a risk-based approach.

1.1.5. Risk assessment

Modern occupational safety and health legislation usually demands that a risk assessment be carried out prior to making an intervention. It should be kept in mind that risk management requires risk to be managed to a level which is as low as is reasonably practical.

This assessment should:

- Identify the hazards
- Identify all affected by the hazard and how
- Evaluate the risk
- Identify and prioritize appropriate control measures

The calculation of risk is based on the likelihood or probability of the harm being realized and the severity of the consequences. This can be expressed mathematically as a quantitative assessment (by assigning low, medium and high likelihood and severity with integers and multiplying them to obtain a risk factor), or qualitatively as a description of the circumstances by which the harm could arise.

1.2. Check the material of OHS procedure

An internationally acknowledged requirement is to analyze and provide technical solutions for prevention and safety during the use and to construct electrical/electronic circuit's equipment's. These accidents particularly occur during the washing and maintenance phases, especially when such practices are carried out inside the hopper when the rotating parts of the electrical/electronic circuits in action. The current technical standards and the various safety requirements under consideration have not always been effective for protecting workers. To this end, the use of SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) allowed us to highlight critical and positive aspects of the different solutions studied for reducing the risk due to contact with the electrical/electronic circuit's parts.

Personal protective equipment for constructing electrical/electronic circuit's

- Safety hat
- Safety shoes
- Mask
- Safety goggles
- Hand gloves

A. Safety Hat

The most serious risks are physical injuries, which can be as a result of the impact of a falling object or collision with fixed objects at the workplace. Due to the nature of these work activities, it is not always possible to eliminate such risks with just appropriate organizational solutions or collective protective equipment. Therefore, the only way to ensure the safety of workers is by using safety helmets. The type of helmet will depend on the specific nature of the physical risks that have been identified in the risk assessment undertaken for the activity.

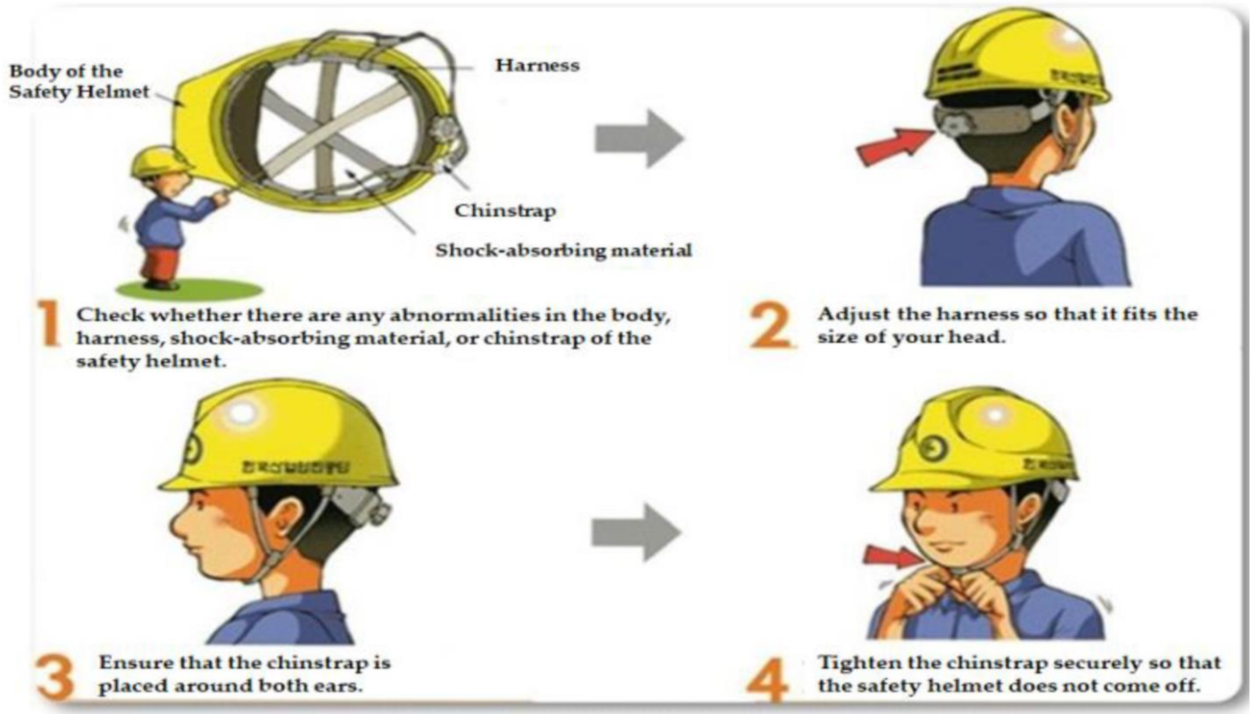

Figure 1.2. Safety hat

B. Safety shoes

When you think about shoes for the workplace, heavy-duty footwear such as steel toe boots may come to mind. These boots, which have reinforced toes to protect the feet from hazards such as heavy objects, are important personal protective equipment (PPE) at many worksites. Many kinds of shoes exist that can make jobs safer, though, not just steel toe boots. Other types of boots and shoes can provide traction, arch support and other safety benefits. To find the right foot protection for the jobs in your workplace, you'll need to do a hazard assessment and determine what kinds of risks such as slipping and falling or sharp objects pose a threat to your employees' feet. Then select shoes or boots that offer the right protection.].

- **Purpose of safety shoes**
  - ✓ protect from falling & flying objects
  - ✓ protect from punctures
  - ✓ protect from cutting hazards
  - ✓ protect from electrical hazards
  - ✓ prevent slips, trips & falls
  - ✓ prevent fatigue
  - ✓ protect from extreme weather

- ✓ prevent burn

Figure 1. 2.1. Safety Shoes

C. Mask

Many workers use Repaired Product in their work which contains chemicals that may be harmful to their health. These chemicals can enter the body in various ways: breathing in the chemicals or dust from the Repaired Products they use; Direct contact with the chemicals or Repaired Product dust via skin and/or eyes; or accidentally ingesting thechemicals or dust. However, there are many ways workers can protect themselves.

Air Purifying Respirators are the only masks that will protect against chemical gases and vapors. The type of cartridge the mask uses can vary, depending on what type of chemical is being used in the salon.

Figure 1.2.2. Air Purifying Respiratory Mask

D. Inspect the Safety goggles

If a worker is suffering from an eye injury, it’s most likely due to improper eye protection or lack of any eye protection at all. Many people do not realize the importance of eye protection in the workplace. Potential hazards can be avoided simply by covering your eyes. Here are the top five reasons why you need to wear safety glasses.

Safety glasses can prevent foreign objects that are floating around from damaging your vision. Dangerous particles or chemicals could be floating around in your workplace. Some jobs that are at a high risk include construction, maintenance, welding, plumbing, and mining. Dirt, dust, pollen, and wood can irritate your eyes and potentially cause long lasting damage.

Avoid major accidents. Shield your eyes from splashes of chemicals, grease or oil, fumes, burns, and flying wood chips. Wiping substances into your eyes, sometimes without noticing, can easily scratch them. You can have recurring, long-term problems, including blindness, from only a minor injury.

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Figure1.2.3. Safety Glasses

E. Hand gloves

If there is one thing more important than ensuring workers are wearing safety gloves, it is ensuring workers are wearing the correct safety gloves for the specific industry and tasks they perform on the job. Wearing the wrong safety gloves won't protect the wearer from all the potential hazards in their environment. There are some considerations that need to be made when choosing safety gloves.

Figure1.2.4. Hand Gloves

The following injuries can be avoided by selecting the correct safety gloves for the handling application, and ensuring that these safety gloves are worn at the right times:

- Puncture wounds
- Cuts and scrapes
- Heat and chemical burns

- Hazardous substances that can irritate or be absorbed by the skin
- Extreme heat or cold
- Biological agents like bacteria and viruses
- Loss of finger, nail and skin
- Needle stick injuries

1.3. Selecting suitable tools and equipment's

It is hard to do a good job of electronics construction unless proper electronic tools and knowledge of using them are adequate.

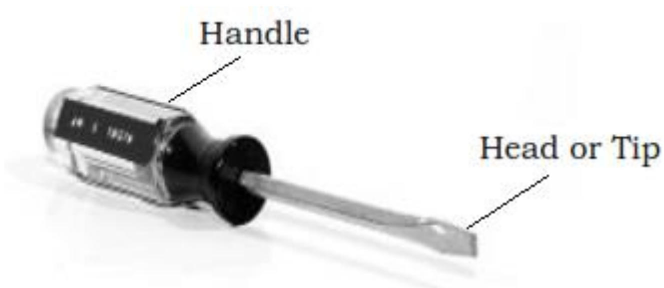
1.3.1. Electrical tools And Electrical equipment

A. **Electrical tools** normally refer to electrical hand tools - typically tools used in construction activities such as electrical drills, wire strippers, and can also include electrician tools such as electrical meters (voltmeters, multi-meters, etc.). Electrical tools are plentiful and you can find them for tool shops.

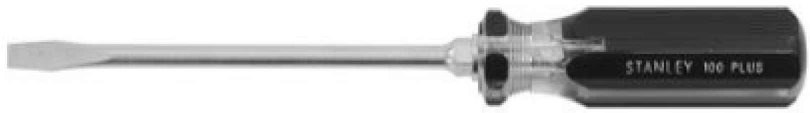
B. **Electrical equipment** refers to manufactured systems that distribute, transform, protect, or convert electrical energy. Electrical equipment includes motors, generators, transformers, switches and switchgear, and more, and ranges from low voltage (up to 600V), medium voltage (1kV to 38kV) or high voltage.

1.3.2. Driving of Tools

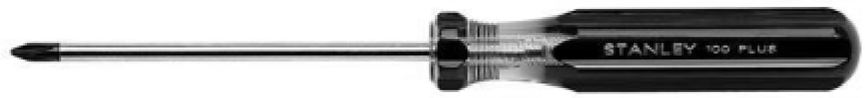
A. **Screwdriver**. It is a device specifically designed to insert and tighten or to loosen and remove screws. A screwdriver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip and some way to position and support the screwdriver. A typical hand screwdriver comprises an approximately cylindrical handle of a size and shape to be held by a human hand and an axial shaft fixed to the handle, the tip of which is shaped to fit a particular type of screw. The handle and shaft allow the screwdriver to be positioned and supported when rotated to apply torque.



B. **Flat Screwdriver**. It is used to drive or fasten negative slotted screws.



C. Phillips Screwdriver. It is used to drive or fasten positive slotted screws. It is a screwdriver that could take greater torque and can provide tighter fastenings.



1.3.3. Soldering Tools

Soldering Iron is a device used for applying heat to melt solder in attaching two metal parts. A soldering iron is composed of a heated metal tip and an insulated handle.

Heating is often achieved electrically, by passing a current, supplied through an electrical cord, through a heating element.

For electrical work, wires are usually soldered to printed circuit boards, other wires, or small terminals. A low-power iron (1530 Watts) is suitable for this work.

Fig 1.3. soldering iron

Some soldering irons have interchangeable tips for different types of work. Fine round or chisel tips are typically used for electronics work. A new tip needs to be coated, heated, and then covered with solder before its first use. This procedure is called "tinning". The tinning forms a liquid layer, which facilitates the transfer of heat to the work piece. A dirty tip does not transfer heat well. The tip needs to be kept coated with a shiny layer of solder by occasional wiping and applying solder directly to the tip.

1.3.4. Soldering station

Working with surface-mount parts requires soldering tools that are capable of working with small parts and closely spaced leads. Soldering stations for surface-mount work can be rather pricey, particularly for the stations that also include a hot-air attachment. The good news is that a soldering station like the one shown in Figure below will handle a lot of SMT tasks if used with a fine tip and the appropriate temperature.

Figure below shows a soldering station specifically designed for working with surface-mount parts. In addition to the soldering iron with a fine-point tip, it also has a hot-air blower with a selection of nozzles. The hot air is used to disorder or rework a surface-mount part. The kit comes with the magnifying light shown.

Fig 1.3.1. soldering station

A. Soldering Tool Stand is a place of the soldering iron to keep them away from flammable materials. The stand often also comes with a sponge and flux pot for cleaning the tip.

Fig1.3.2. Soldering iron stand

B. <u>Brass Sponge</u> - As you solder, your tip will tend to **oxidize**, which means it will turn black and not want to accept solder. Especially with lead-free solder, there are impurities in the solder that tend to build up on the tip of your iron, which causes this oxidization. This is where the sponge comes in. Every so often you should give your tip a good cleaning by wiping off this build-up. Traditionally, an actual wet sponge was used to accomplish this. However, using a wet sponge can drastically reduce the lifespan of your tip. By wiping your tip on a cool, wet sponge, the tip tends to expand and contract from the change in temperature. This expansion and contraction will wear out your tip and can sometime cause a hole to develop in the side of the tip. Once a tip has a hole, it is no good for soldering. Thus, brass sponges have become the standard for tip cleaning. Brass sponges pull the excess solder from your tip while allowing the tip to maintain its current heat level. If you do not have a brass sponge, a regular sponge is better than nothing.

Fig 1.3.3. Brass sponge

C. Disordering tool. It is used for the removal of solder and components from a circuit when troubleshooting, repair purposes and to save components. Electronic components are often mounted on a circuit board and it is usually desirable to avoid damaging the circuit board, surrounding components, and the component being removed.

Fig 1.3.4. Sucker

1.3.5. Boring Tools

A. 12 Volt Mini-Drill. It is used to bore or drill holes in the printed circuit board (PCB).

Fig 1.3.5. 12 volt mini drill

B. Portable Electric Drill. It is used for boring hole/s in the plastic chassis or metal chassis with the used of drill bits.

Fig 1.3.5. Portable electric drill

C. Round Files. They are also called rat-tail files gradually tapered and are used for many tasks that require a round tool, such as enlarging round holes or cutting a scalloped edge.

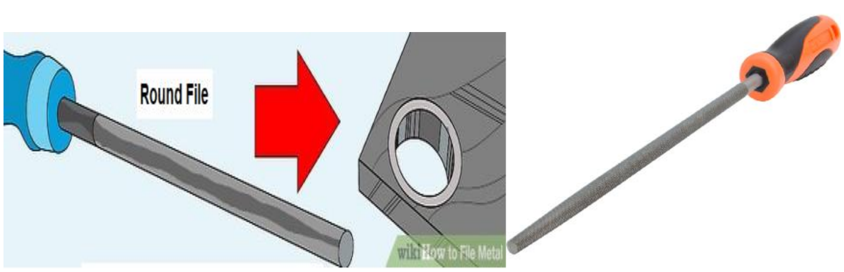


Fig 1.3.6. Files (flat, half round and round)

1.3.6. Cutting Tools

A. **Utility Knife**. It is a common tool used in cutting various trades and crafts for a variety of purposes.

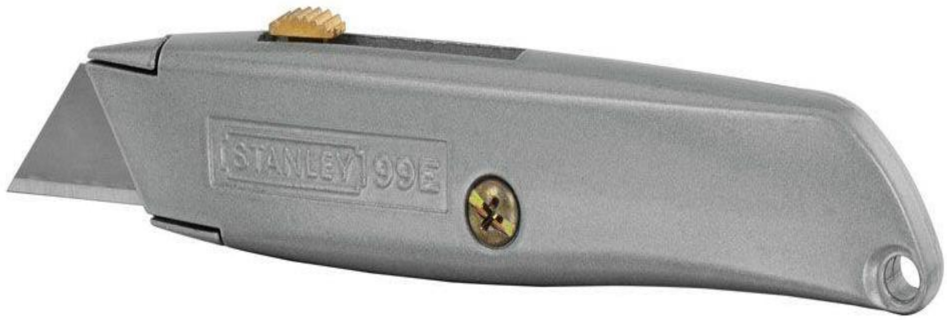


Fig 1.3.7. Utility knife

B. **Hacksaws**. They are saws for cutting metal. Some of them have pistol grips which keep the hacksaw firm and easy to grip. The small hand-held hacksaws are consisting of a metal arch with a handle that fits around a narrow, rigid blade. The blade has many small saw teeth along one side. It can either be attached such that the teeth face away from the handle, resulting in sawing action by pushing, or be attached such that the teeth face toward the handle, resulting in sawing action by pulling. On the push stroke, the arch will bend a little, releasing the tension on the blade. The blade is normally quite brittle; so extra care is needed to be taken to prevent brittle fracture of the blade.

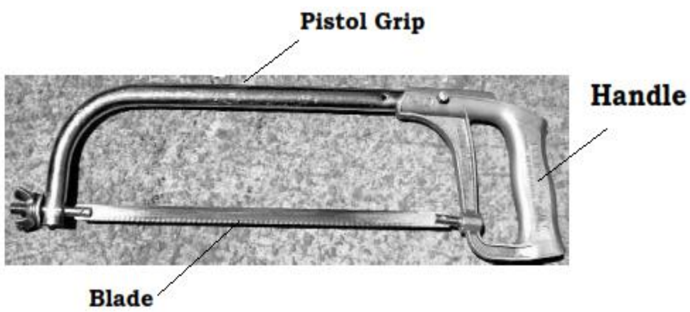


Fig 1.3.8. Hacksaw

1.3.7. Materials used in constructing electrical/electronic circuits

F. Soldering lead

Solder is a metallic compound that has a low melting point, usually around 200°C. The composition of solder varies depending on the type, but usually contains lead or tin or both. The most common types are given below. It is available in wire, stick or pellet form. Sticks and pellets are for solder-pots; for normal soldering, you will need solder wire.

Solder wire is available in widths given in "standard wire gauge" (SWG). The larger the SWG number, the thinner the wire. Common gauges are 18 and 22, although others are available. 18-gauge solder is suitable for soldering large components and thick wire, as a large quantity of solder can be delivered quickly. 22 gauge solder is thinner than 18 gauge, and should be used for most electronics work, as it allows much greater control over the quantity of solder delivered, and the chances of accidentally bridging a gap due to over-application or the wire's width are greatly reduced. Finer gauges such as 26 are available for very fine work with SMT (surface-mount) components.

Fig 1.3.9. Soldering leads (solder)

60/40 solder is made of 60% tin and 40% lead. It has a melting point of around 190°C, depending on the exact composition. Iron tip temperatures of at least 300°C are recommended. It is also very soft, meaning that cracks do not form so readily if the joint moves during cooling.

63/37 solder is made of 63% tin and 37% lead. It has a melting point of 183°C, slightly lower than the more common 60/40 blend. The primary advantage of this solder is not the lower melting point, but its eutectic property.

50/50 is made of a half and half mix of tin and lead. Never use 50/50 solder for electronics — it is meant for plumbing. Otherwise, you may end up with failed joints.

G. Flux

Flux is a compound that is used to improve the quality of the soldered joint. It does this in three ways:

- It chemically removes oxidation from the surfaces being soldered.

- It prevents air from oxidizing the surfaces once they have been cleaned.
- It increases the "wetting" of the surfaces when the solder is applied

Wetting is the degree to which the solder flows across the surfaces being joined. Without flux, a **dry joint** may be formed, making a poor connection.

Fig 1.3.10. Flux

H. Jumper wire

In order to make quick, temporary connections between some electronic components, you need jumper wires with small "alligator-jaw" clips at each end. These may be purchased complete, or assembled from clips and wires.

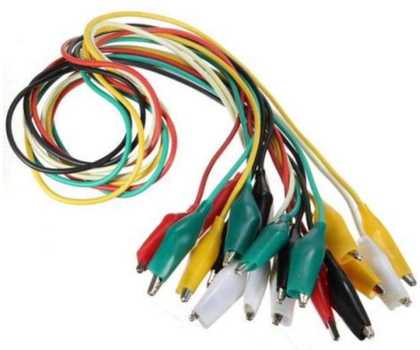
1. 

Fig 1.3.11. Jumper wire

I. Ferric chloride

Usually to etch the copper from the PCB, an aqueous solution of ferric chloride (also called iron (III) chloride, $FeCl_3$) is used. It works quite well but it's terribly slow: a fresh solution will probably etch a PCB in about 30 minutes. But as copper is consumed from the boards, the etchant becomes saturated and less effective: the time required can easily double after a few PCBs. Furthermore, the speed of this reaction is also dependent on temperature, the colder the slower.

Fig 1.3.12. Ferric chloride

J. Permanent marker (ink)

To transfer your design to the copper or for correction, use a permanent marker (solvent-based permanent-marker pen) and draw your traces directly on the copper which is capable of resist the etchant Ferric Chloride solution. One layer of ink is not enough, let it dry for 10 minutes and redraw it again on top to make the layer thicker.

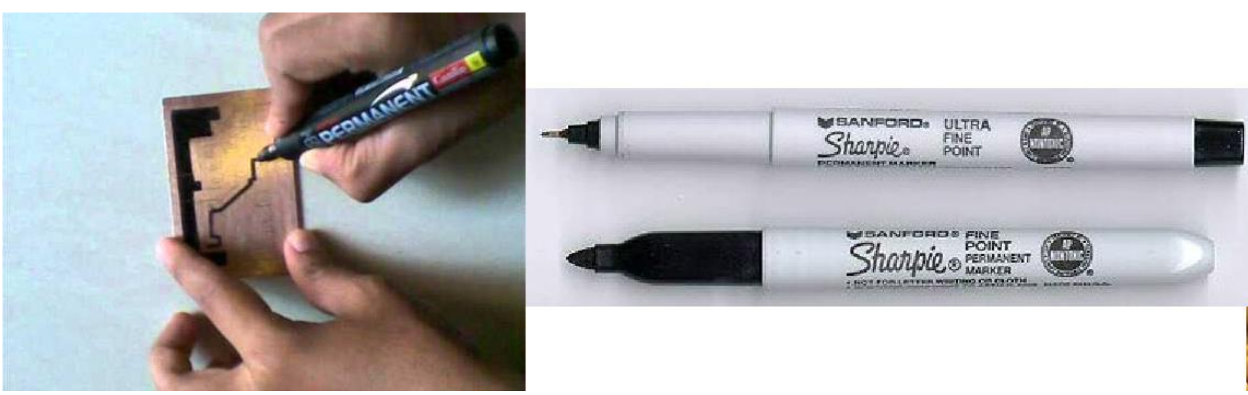


Fig 1.3.13. Permanent marker (ink)

K. Printed circuit board (PCB)

A printed circuit board (PCB) made from glass reinforced plastic with copper track in the place of wires. They mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate.

A printed circuit board has pre-designed copper tracks on a conducting sheet. The pre-defined tracks reduce the wiring thereby reducing the faults arising due to lose connections. One needs to simply place the components on the PCB and solder them.

Fig 1.3.14. PCB

Different method to make PCB

There are in all three basic methods to make PCB

1. Iron on Glossy paper method
2. Circuit by hand on PCB
3. Laser cutting edge etching.

Since laser method is industrial method to make PCB we will get in detail of first two methods to make PCB at home.

To Creating PCB layout of your circuit, we usually did by converting your circuit's schematic diagram into a PCB layout using PCB layout software. There are many open source software packages for PCB layout creation and design.

L. Bread board or Solder less breadboard

A few tools are required for basic electronics work. Most of these tools are inexpensive and easy to obtain.

Also essential is a solder less breadboard, sometimes called a prototyping board, or proto-board. This device allows you to quickly join electronic components to one another without having to solder component terminals and wires together. They have different size and physical characteristics

1. Insulated bread board
2. Un insulated breadboard

M. Strip board (uninsulated breadboard)

Strip board is one of the commonly-used types of prototyping board. These boards are intended for permanently assembling one-off circuits, especially prototypes. The board is made from insulating material, usually a resin-bonded plastic or fiberglass. One side has parallel copper strips on it, spaced 2.54 mm apart. There are holes bored in these strips, also 2.54 mm apart. Components are placed on the other side of the board with their wires bent to pass through the holes. The wires are soldered to the copper strips, the projecting ends being cut off to make the assembly neater.

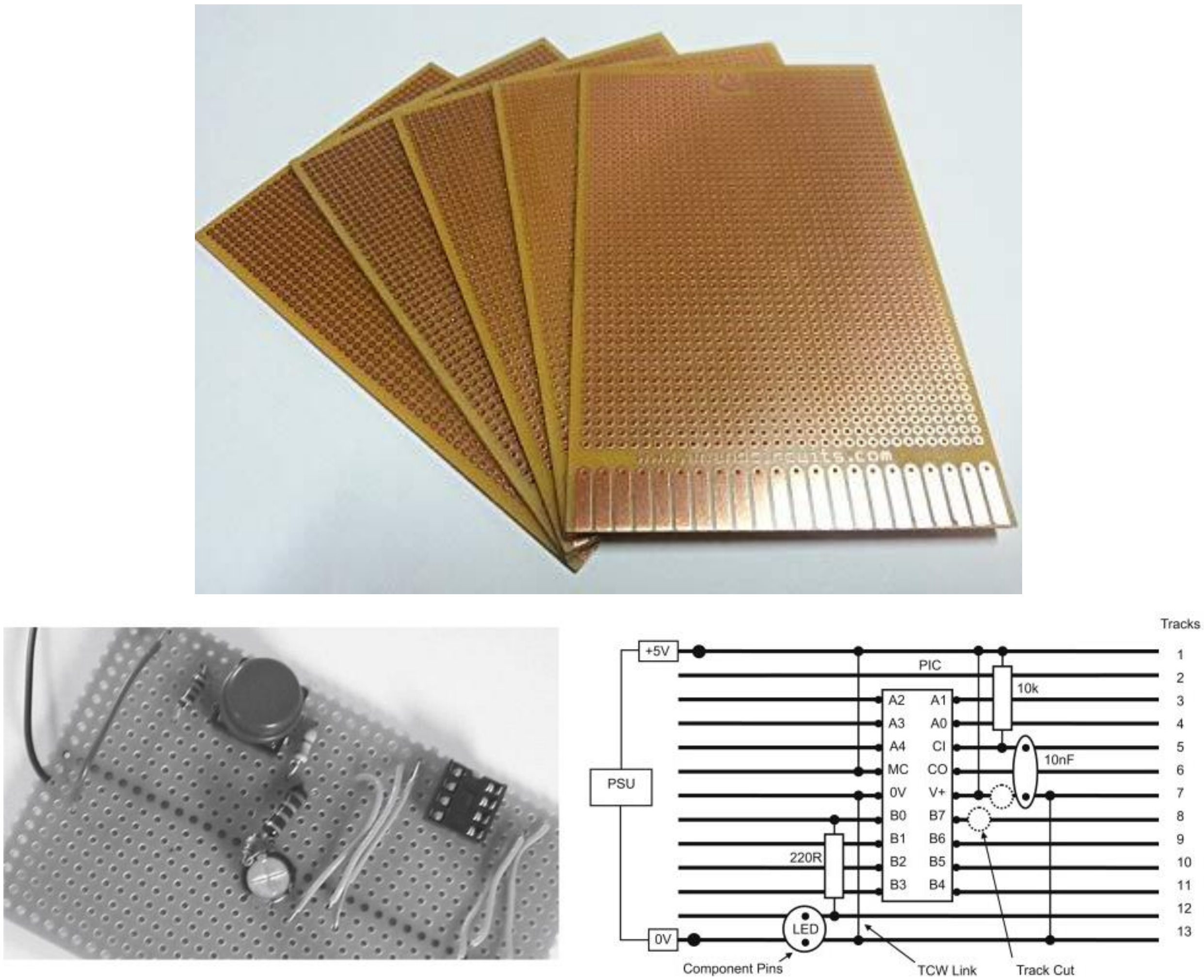


Fig 1.3.15. Strip board (uninsulated breadboard)

N. Breadboard (insulated breadboard)

The breadboard consists of a plastic housing usually made of ABS plastic that has a series of holes arranged in rows of 5. These holes are sized to allow wire of up to 20 AWG to be inserted. Each of the rows of 5 holes has internal spring contacts that connect the 5 holes electrically. These contacts are inserted into the plastic housing from the back side. When a component lead or wire is inserted into one of these holes, the spring contacts electrically connect it to anything else that is inserted into one of the other 4 remaining holes in the same row of contacts. This forms a circuit node.

These rows of contacts are then arranged into two columns. These two columns of contacts are separated by a 0.3" space to form a breadboard. This spacing is chosen because the typical DIP style IC has leads on a 0.3" spacing from one side of the IC to the other. By placing the IC across this space in the middle of the breadboard, each of the pins of the IC is connected to its own separate row of 5 contacts.

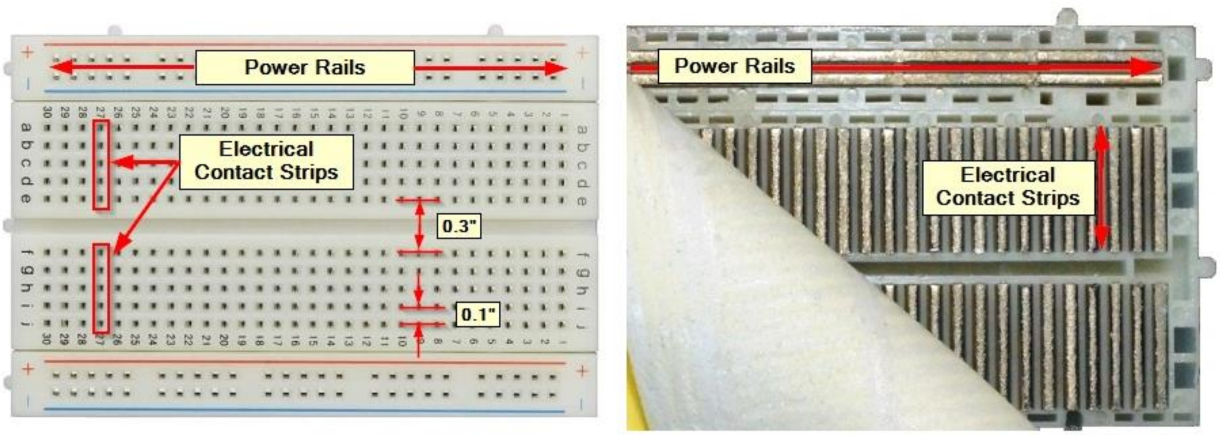


Fig 1.3.16. Breadboard (insulated breadboard)

1.3.8. Designing tools

A. Electronic circuit design and simulation software: uses mathematical models to replicate the behavior of an actual electronic device or circuit. Simulation software allows for modeling of circuit operation and is an invaluable analysis tool. Due to its highly accurate modeling capability, many colleges and universities use this type of software for the teaching of electronics technician and electronics engineering programs. Electronics simulation software engages its users by integrating them into the learning experience. These kinds of interactions actively engage learners to analyze, synthesize, organize, and evaluate content and result in learners constructing their own knowledge.

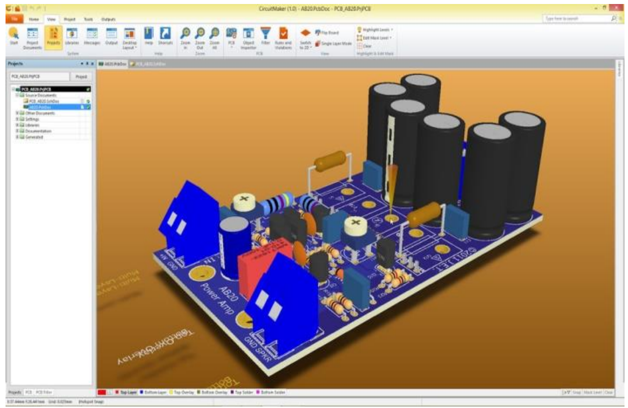


Fig 1.3.17. Circuit simulation on circuit-maker CAD software

Simulating a circuit's behavior before actually building it can greatly improve design efficiency by making faulty designs known as such, and providing insight into the behavior of electronics circuit designs.

Examples of Electronic circuit design and simulation software:

- Circuit Maker
- Open Circuit Design Software
- KiCad EDA
- ADS Circuit Design Software
- SuperSim Circuit Design Software
- Portus.

B. Computer: is a device that accepts information (in the form of digitalized data) and manipulates it for some result based on a program, software, or sequence of instructions on how the data is to be processed.

By installing Electronic circuit design and simulation software, we can use them to design and construct electrical/electronics circuit.

Fig 1.3.18. Computer (desktop and laptop)

I. Auxiliary Tools

- **Magnifying Glass** It is a convex lens which is used to produce a magnified image of an object. The lens is usually mounted in a frame with a handle (see image). Roger Bacon is the original inventor of the magnifying glass. A magnifying glass works by creating a magnified virtual image of an object behind the lens.

The distance between the lens and the object must be shorter than the focal length of the lens for this to occur. Otherwise, the image appears smaller and inverted, and can be used to project images onto surfaces. The framed lens may be mounted on a stand, keeping the lens at the right distance from the table, and therefore at the right distance from the object on the table. The latter applies if the object is small and also if the height is adjustable. Some magnifying glasses are foldable with built-in light

Fig 1.3.19. . Magnifying glass

- **Anti-Static Brush**. It is made of bristles set in handle used for cleaning dirty parts of a circuit or an object.

Fig 1.3.20. Anti-static brush

- **Tweezers**

Small tweezers is used to hold small components especially when doing soldering and de-soldering of surface mount components.

Fig 1.3.21. Tweezers

1.4. Connecting and soldering electrical/electronic circuits correctly

1.4.1. Definition of circuit

An electronic circuit is a complete course of conductors through which current can travel. Circuits provide a path for current to flow. To be a circuit, this path must start and end at the same point. In other words, a circuit must form a loop. An electronic circuit and an electrical circuit has the same definition, but electronic circuits tend to be low voltage circuits.

For example, a simple circuit may include two components: a battery and a lamp. The circuit allows current to flow from the battery to the lamp, through the lamp, then back to the battery. Thus, the circuit forms a complete loop.

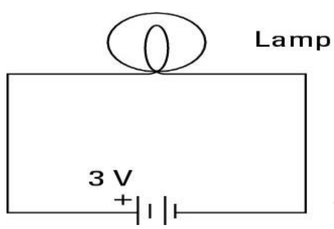


Fig. 1.4: DC **electronic circuit**

Of course, circuits can be more complex. However, all circuits can be distilled down to three basic elements:

A. **Voltage source:** A voltage source causes current to flow like a battery, for instance.
B. **Load:** The load consumes power; it represents the actual work done by the circuit. Without the load, there is not much point in having a circuit. The load can be as simple as a single light bulb. In complex circuits, the load is a combination of components, such as resistors, capacitors, transistors, and so on.
C. **Conductive path:** The conductive path provides a route through which current flows. This route begins at the voltage source, travels through the load, and then returns to the voltage source. This

path must form a loop from the negative side of the voltage source to the positive side of the voltage source.

D. The steps of preparing circuits for connection and soldering are:

I. Material and equipment selection

II. Placing the components in the project board according to the design of the circuit

III. Removing the insulation of wires.

1.4.2. Construction and Soldering Techniques

1. Component mounting. Components are pushed through from the top side of the board and the leads are bent slightly to hold the component while soldering.
2. Components are then soldered to the board as shown in Figures 4.
   a. The soldering iron tip should be placed in contact with both the trace (foil)and the lead. The two should be heated only enough to melt solder in order to avoid damaging sensitive components and to avoid delaminating of the PCB traces.
   b. Solder is then touched to the area and allowed to flow freely around the lead and to cover the solder pad. A minimal amount of solder should be applied. Only enough solder to cover the joint and to form a smooth fillet should be used.
   c. The iron should be removed after the solder has flowed properly and wetted all surfaces. The component and the board should not be moved until the solder has hardened (up to several seconds, depending on the lead and trace

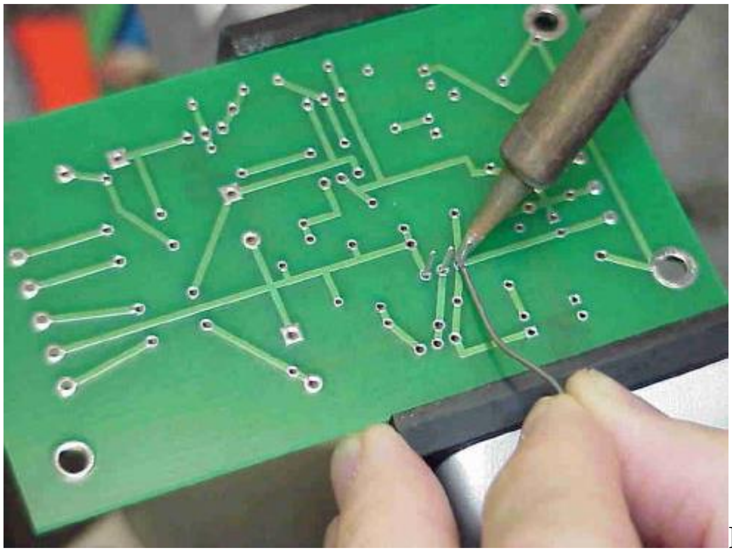


Figure 1.4.1. Soldering a component to a PCB

A. How to Solder

- We're going to solder an LED to a circuit board.

Step 1: Mount the Component – Begin by inserting the leads of the LED into the holes of the circuit board.

Step 2: Heat The Joint – Turn your soldering iron on and if it has an adjustable heat control, set it to 400'C.

Step 3: Apply Solder To Joint – Continue holding the soldering iron on the copper pad and the lead and touch your solder to the joint.

Step 4: Snip The Leads – Remove the soldering iron and let the solder cool down naturally.

Self-Check 1.1

Test I: short Answer writing

Instruction: write short answer for the given blank space provided question. You are provided 4 minute for each question and each point has 5 Points.

1. -------------is a device used for applying heat to melt solder in attaching two metal parts.
2. -------------is a place of the soldering iron to keep them away from flammable materials.
3. ------------- is used for the removal of solder and components from a circuit when troubleshooting, repair purposes and to save components.
4. --------------is a convex lens which is used to produce a magnified image of an object.

TEST. II : Choose The best answer (each 5 points)

1. Working long hours outside with ________ exposure can affect the fragile tissues in the eye.

A) UV light B) Hand Gloves

C) Eye Glass D) All

2. One of the following is not Personal protective equipment for Mechatronics

A) Safety hat B)Safety shoes

C) Mask D) None

3. One of the following injuries can be avoided by selecting the correct safety gloves for the handling application.

A) Extreme heat or cold B) Biological agents like bacteria and viruses

C) Loss of finger, nail and skin D) All

TEST .III: WRITE SHORT ANWER

1. List out same of the materials used to construct electrical electronics circuits.
2. Five of the soldering equipment and materials used when connecting and soldering Electrical/electronic circuits. (2 points each)
   a. ______________________________________
   b. ______________________________________

Operation Sheet 1. 1: Select appropriate tools and equipment's to construct electrical/electronic circuit.

Operation title: Procedures of select appropriate tools for to construct electrical/electronic circuit.

Purpose: To practice and demonstrate the knowledge and skill required to select tools to construct electrical/electronic circuit on PCB.

Instruction: Use the given steps below with the tools and equipment by selecting appropriate tools for to construct electrical/electronic circuit. For this operation you have given 3Hour and you are expected to provide the answer with in steps.

Procedures in doing the task

Step 1: prepare clean and safe work station

Step 2: analyze and understand the given task

Step 3: list out tools, materials and equipment's necessary for the specific task

Step 4: calibrate/adjust the equipment to be used for the task if necessary

Step 5: make the workstation ready for the task to be start

Tools and requirement:

Soldering lead - **Soldering station**

Flux - Sucker

- Portable Electric Drill - Brass Sponge -
- Jumper wire
- Ferric chloride
- chloride
- Permanent marker (ink)
- Printed circuit board (PCB)
- Bread board or Solder less breadboard
- Strip board (uninsulated breadboard)
- Driving of Tools
- Flat Screwdriver
- Phillips Screwdriver

LAP Test - 1

Instructions: Given necessary templates, tools, materials and equipment you are required to perform the following tasks within 5 hour.

Task 1: Check materials with specifications and tasks given

Task 2: Select appropriate tools and equipment's for task required

Task 3: Plan and follow procedures to ensure occupational health and safety (OHS) guidelines

Task 4: Prepare electrical/electronic circuits for connecting and soldering correctly with instructions and work site procedures

- **Precautions:** select necessary templates, tools, materials and equipment before constructing electrical /electronics circuit on PCB t on the given format
- **Quality Criteria:** they given constructing electrical /electronic circuit on PCB is with Correct specification.

Unit Two: Design and construct printed circuit board (PCB)

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Safety procedures for PCB Design.
- check the material
- work safely with in standard procedures
- Apply proper etching procedure.
- Holes for electronic components.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify safety procedures for constructing PCB.
- Inspect the materials
- work safely with in standard procedures
- Apply proper etching procedure for constructing PCB.
- Create holes for electronic components.

2.1. Safety procedures for PCB Design

2.1.1. Safety

Safety: Relative freedom from danger, risk, or threat of harm, injury, or loss to personnel and/or property, whether caused deliberately or by accident.

Hazards may occur due to improper handling of tools and equipment, unsafe work areas, operating machines without knowing how to operate and using materials out of their intended purpose.

2.1.2. Personal Protective Equipment (PPE)

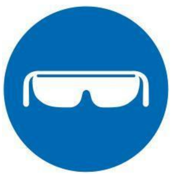
B. What is Personal Protective Equipment?

Personal Protective Equipment (PPE) is anything used or worn by a person to minimize risk to the person’s health or safety and includes a wide range of clothing and safety equipment. PPE includes boots (safety shoes, face masks, hard hats (helmet), ear plugs, respirators, gloves, safety harnesses and high visibility clothing.

- SAFETY FOR THE HEAD

Wearing a **helmet** offers protection and can prevent head injuries. Select a sturdy helmet that is adapted to the working conditions. These days you can find many elegant designs and you can choose extra options such as an adjustable interior harness and comfortable sweatbands.

2. PROTECT YOUR EYES



The eyes are the most complex and fragile parts of our body. Each day, more than 600 people worldwide sustain eye injuries during their work. Thanks to a good pair of **safety glasses**, these injuries could be prevented. Do you come into contact with bright light or infrared radiation? Then **welding goggles or a shield** offer the ideal protection!

3. HEARING PROTECTION

Do you work in an environment with high sound levels? In that case it is very important to consider hearing protection. **Earplugs** are very comfortable, but earmuffs are convenient on the work floor as you can quickly put these on or take them off.

4. MAINTAIN A GOOD RESPIRATION

Wearing a **mask** at work is no luxury, definitely not when coming into contact with hazardous materials. 15% of the employees within the EU inhale vapours, smoke, powder or dusk while performing their job. **Dust masks** offer protection against fine dust and other dangerous particles. If the materials are truly toxic, use a **full-face mask**. This adheres tightly to the face, to protect the nose and mouth against harmful pollution.

5. PROTECT YOUR HANDS WITH THE RIGHT GLOVES

Hands and fingers are often injured, so it is vital to protect them properly. Depending on the sector you work in, you can choose from gloves for **different applications**:

- protection against vibrations
- protection against cuts by sharp materials
- protection against cold or heat
- protection against bacteriological risks
- protection against splashes from diluted chemicals.

6. PROTECTION FOR THE FEET

Even your feet need solid protection. **Safety shoes** (type Sb, S1, S2 or S3) **and boots** (type S4 or S5) are the ideal solution to protect the feet against heavy weights. An **antiskid sole** is useful when working in a damp environment, definitely if you know that 16,2% of all industrial accidents are caused by tripping or sliding. On slippery surfaces, such as snow and ice, **shoe claws** are recommended. Special socks can provide extra comfort.

7. WEAR THE CORRECT WORK CLOTHING

Preventing accidents is crucial in a crowded workshop. That is why a good visibility at work is a must: a **high-visibility jacket and pants made of a strong fabric** can help prevent accidents. Just like the hand protection, there are versions for different applications.

2.2. Check the materials

2.2.1. Concept of Specification (spec)

Exact statement of the particular needs to be satisfied, or essential characteristics that a customer requires (in a good, material, method, process, service, system, or work) and which a vendor must deliver. Specifications are written usually in a manner that enables both parties (and/or an independent certifier) to measure the degree of conformance. They are, however, not the same as control limits (which allow fluctuations within a range), and conformance to them does not necessarily mean quality (which is a predictable degree of dependability and uniformity).

2.2.2. Types of material specification

Specifications are divided generally into two main categories:

(1) Performance specifications: conform to known customer requirements such as keeping a room's temperature within a specified range.

(2) Technical specifications: express the level of performance of the individual units, and are subdivided into (a) individual unit specifications which state boundaries (parameters) of the unit's performance consisting of a nominal (desired or mandated) value and tolerance (allowable departure from the nominal value, (b) acceptable quality level which states limits that are to be satisfied by most of the units, but a certain percentage of the units is allowed to exceed those limits, and (c) distribution specifications which define an acceptable statistical distribution (in terms of mean deviation and standard Deviation) for each unit, and are used by a producer to monitor its production processes.

2.2.3. Importance of material specification

When completing a job for someone else you should always try and follow every specification so you can get future work from them.

You may have to make sure that you follow every specification when you are trying to set up a new factory.

It is not only sufficient to plan the required materials, tools and equipments for the lesson, it needs to check and identify which of them are: defect free (normal), to be maintaining easily and not to be maintained. In addition to the above consumable components, it is intended that the following consumable materials, tools and testing instruments which are going to be used in this UC are listed in the table below. The details list of these materials, tools and instruments (with their specification, quantities, items to trainee's ratio) are present in Annex "Resource Requirement" in the corresponding curriculum. Hence, based on both these information, the trainer can prepare consumable materials, tools and equipment request detail plan before the practical training time.

2.3. Work safely with in standard procedures.

2.3.1. Introduction to Responsibility Safe Work Practices

A safe work environment is not enough to control all electric hazards. You must also work safely. Safe work practices help you control your risk of death from workplace hazards. If you are working on electrical circuits or with electrical tools and equipment, you need to use safe work practices.

Before you begin a task, ask yourself:

- What could go wrong?
- Do I have the knowledge, tools, and experience to do this work safely?

All workers should be very familiar with the safety procedures for their jobs. You must know how to use specific controls that help keep you safe. You must also use good judgment and common sense.

2.3.2. Safety procedures for hand tools and equipment

We are already familiar with the different hand tools and their proper use. Know we need to know how to be safe in using these. What are the safety precautions in using hand tools and equipment? What are it’s do’s and don’ts’s?

A. safety precautions in using hand tools and equipment

- All tools must be kept in good condition with regular maintenance.
- Right tool must be used for job.
- Each tool must be examined before use and damaged or defective tools not to be used.
- Tools must be operated according to manufacturer’s instruction.
- The right protective equipment for the tool and activity must be used.

A. Procedures in Cleaning, Tightening and Simple Repair for Hand tools and Equipment

1. Cleaning the tools after use is highly recommended.

2. All tools and equipment must be placed in a clean and dry place.

3. The work area must always be kept neat and tidy.

4. Lubricants must also be applied after tightening to reduce the friction.

5. Before cleaning any tool, be sure to wear the proper personal protective equipment (PPE). Gloves, masks and goggles are usually worn when cleaning tools since most cleaning agents and solutions are harmful to the human body.
6. Only use cleaning agents as prescribed by the tool or equipment's manufacturer. Follow the cleaning procedures as well to make sure that no damage will be inflicted on the tools.

The electrical and electronics industry includes a range of work activities such as using measuring instruments, soldering, using hand, power and specialist tools and constructing circuits.

A. Carrying out electrical work

An electrical risk is a risk to a person of death, shock or other injury caused directly or indirectly by electricity.

The main hazards associated with these risks are:

- contact with exposed live parts causing electric shock and burns (for example exposed leads or other electrical equipment coming into contact with metal surfaces such as metal flooring or roofs);
- the use of outdated, poorly maintained equipment or unsafe use of equipment;
- faults which could cause fires; and,
- Fire or explosion where electricity could be the source of ignition in a potentially flammable or explosive atmosphere.

Electrocution incidents can be fatal. Non-fatal shocks can result in serious and permanent burn injuries to skin, internal tissues and damage to the heart. Other injuries or illnesses may include muscle spasms, palpitations, nausea, vomiting, collapse and unconsciousness. Electric shocks may also contribute to related incidents including falls from ladders, scaffolding or other elevated work platforms.

Those working with electricity may not be the only ones at risk. Poor electrical installation and faulty electrical appliances can lead to electric shock to others at or near the workplace.

The risk of injury from electricity is strongly linked to where and how it is used. The risk of injury is greatest in harsh conditions such as:

- Outdoors or in wet surroundings - equipment may become wet and may be at greater risk of damage; and,
- In cramped spaces with earthed metalwork, such as inside a tank or bin - it may be difficult to avoid electrical shock if an electrical fault develops.

Some items of equipment also involve greater risk of electrical injury than others. Portable electrical equipment is particularly liable to damage. Plugs, sockets, connections and cables on portable electrical equipment and extension leads connected to frequently moved equipment are all particularly susceptible to damage and therefore may pose a greater electrical risk.

B. Duty to manage risks

A person conducting a business or undertaking must manage electrical risks at the workplace. If elimination is not reasonably practicable, the risks must be minimized so far as is reasonably practicable. Any person conducting a business or undertaking with management or control over electrical equipment (including an electrical installation) must ensure, so far as is reasonably practicable, that the equipment is safe to use. This duty applies regardless of whether the person conducting a business or undertaking owns or supplied the electrical equipment.

C. Reducing the risk

Inspecting and testing electrical equipment will help determine whether it is electrically safe. Regular visual inspection can identify obvious damage, wear or other conditions which might make electrical equipment unsafe. Many electrical defects such as damaged cords are detectable by visual inspection.

Regular testing can detect electrical faults and deterioration that cannot be detected by visual inspection. The nature and frequency of inspection and testing depends on factors such as the nature of the electrical equipment, how it is used and its operating environment.

The Work Health and Safety Regulation 2011 prescribes mandatory testing and tagging for electrical power equipment used in 'a hostile operating environment'. This term is used to describe an environment in which the normal use of electrical equipment exposes it to operating conditions that are likely to result in damage or a reduction in its expected life span. This includes conditions that involve exposing the electrical equipment to moisture, heat, vibration, mechanical damage, corrosive chemicals or dust such as in outdoor workplaces, commercial kitchens and workshops.

Electrical equipment that is connected by a plug and socket used in a hostile operating environment must be regularly inspected and tested by a competent person. If this equipment has not been regularly tested then it must not be used until it is tested.

Brand new equipment that is 'out of the box' does not need to be tested before being put into service unless there are reasonable grounds to believe it is electrically unsafe.

As a general rule, electrical equipment used in a hostile operating environment should be inspected and tested at least once every 12 months. More frequent testing will be required where plug in equipment is exposed to increased risk of mechanical damage or electrical deterioration such as when it is used in the manufacturing or hire environment. Also as a general rule, electrical equipment connected by a plug and socket that is used on construction and demolition sites should be inspected and tested at least once every three months. More frequent testing may be required as indicated by a site-specific risk assessment.

D. Unsafe electrical equipment

A person conducting a business or undertaking must ensure that any unsafe electrical equipment within their management or control is disconnected or isolated from its electricity supply and once disconnected is not reconnected until it is repaired or tested and found to be safe or is replaced or permanently removed from use.

Isolation, tagging and lock out procedures are all designed to protect people and property in a workplace from hazards related to electrical power, damaged equipment or machinery or when repairs, maintenance or inspections are carried out.

Yellow and black 'OUT OF SERVICE' tags are used to warn people that machinery, appliances or equipment is damaged, unsafe or out of service for repairs. While an 'OUT OF SERVICE' tag is attached the machinery, appliance or equipment must not be operated.

To attach an 'OUT OF SERVICE' tag a worker must:

- be authorized to fix and remove them;
- write their name and the fault on the tag;
- place the tag in a prominent position;
- place tags at common isolation points; and,
- Leave tags on until the machinery or equipment is repaired and is safe to use.

2.4. Applying proper etching procedure.

2.4.1. PCB Etching Process

All PCB’s are made by bonding a layer of copper over the entire substrate, sometimes on both sides. Etching process has to be done to remove unnecessary copper after applying a temporary mask, leaving only the desired copper traces.

Though there are many methods available for etching, the most common method used by electronics hobbyists is etching using ferric chloride ir hydrochloric acid. Both are abundant and cheap. Dip the

PCB inside the solution and keep it moving inside. Take it out at times and stop the process as soon as the copper layer has gone. After etching, rub the PCB with a little acetone to remove the black color, thus giving the PCB a shining attractive look. The PCB layout is now complete.

Once the second coat of marker is completely dry it is time to give the board a bath in ferric chloride. Ferric chloride is a corrosive, acidic chemical compound that will eat away all copper on the board that is not protected by the marker's ink. Pour a modest amount of ferric chloride into a plastic container with a lid; just enough to cover the board completely. Let the board soak for 10 minutes, make sure the lid is properly secured and agitate it every few minutes by rocking the container back and forth. After 10 minutes inspect the board and if no copper is visible, remove the board while wearing a latex glove. Pat the board dry with a disposable rag to remove all ferric chloride from the board. Rinse the board with acetone that will make quick work of the marker ink to reveal your unharmed traces. The etching process is complete!

Fig.2.3. PCB etching process

- **Populate the Board and Test Your Circuit**

After the board has been etched, use a multi-meter to do a continuity test. Make sure all traces were successful and also begin and terminate in the correct locations before applying power to the circuit. Once all traces have been verified, add the components to their correct position and solder them in. Apply voltage and watch in awe as your perfectly etched circuit functions exactly as

2.5. Fix holes for electronic components.

2.5.1. PCB Drilling

The components that have to be attached to the multi-layered PCB can be done only by VIAS drilling. That is, a pated-through hole is drilled in the shape of annular rings. Small drill bits that are made out of tungsten carbide is used for the drilling. A drill press is normally used to punch the holes. Usually, a 0.035 inch drill bit is used. For high volume production automated drilling machines are used.

Sometimes, very small holes may have to be drilled, and mechanical methods may permanently damage the PCB. In such cases, laser drilled VIAS may be used to produce an interior surface finish inside the holes.

Conductor Plating

The outer layer of the PCB contains copper connections (the part where the components are placed) which do not allow solder ability of the components. To make it solder able, the surface of the material has to be plated with gold, tin, or nickel.

Solder Resist

The other areas which are not to be solder able are covered with a solder resist material. It is basically a polymer coating that prevents the solder from bringing traces and possibly creating shortcuts to nearby component leads.

PCB Testing

In industrial applications, PCB's are tested by different methods such as Bed of Nails Test, Rigid Needle adaptor, CT scanning test, and so on. The basic of all tests include a computer program which will instruct the electrical test unit to apply a small voltage to each contact point, and verify that a certain voltage appears at the appropriate contact points.

PCB Assembling

PCB assembling includes the assembling of the electronic components on to the respective holes in the PCB. This can be done by through-hole construction or surface-mount construction. In the former method, the component leads are inserted into the holes drilled in the PCB. In the latter method, a pad having the legs similar to the PCB design is inserted and the IC's are placed or fixed on top of them. The common aspect in both the methods is that the component leads are electrically and mechanically fixed to the board with a molten metal solder.

Ways to make a Circuit Board

There are in all three basic methods to make PCB:

1. Iron on Glossy paper method (circuit designed using CAD software)
2. Circuit by hand on PCB (circuit drawn manually)
3. Laser cutting edge etching.

In the first and the second method of making PCB, most of the steps are similar but the only difference between them is at the way of transferring the circuit to the PCB. In the first method the circuit to be constructed is designed on circuit making CAD software and in the 2nd method the circuit is directly designed on the PCB by hand using permanent black marker. Since laser method is industrial method to make PCB we will get in detail of first two methods to make PCB at home.

2.5.2. PCB Design:

PCB design is usually done by converting your circuit's schematic diagram into a PCB layout using PCB layout software or manually by hand. There are many cool open source software packages for PCB layout creation and design.

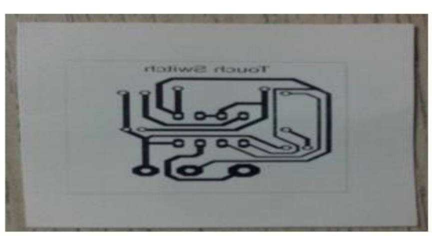
Materials required for making Circuit Board

- FeCl3 powder/solution (same as etching solution),
- photo/glossy paper, permanent black marker,
- blade cutter,
- sandpaper,
- kitchen paper and
- Cotton wool.

STEP 1: Take printout of circuit board layout

Take a print out of your PCB layout using the laser printer and the A4 photo paper/glossy paper. Keep in mind the following points:

- You should take the mirror print out.
- Select the output in black both from the PCB design software and printer driver settings.
- Make sure that the printout is made on the glossy side of the paper.



PCB print on glossy paper

STEP 2: Cutting the copper plate for the circuit board

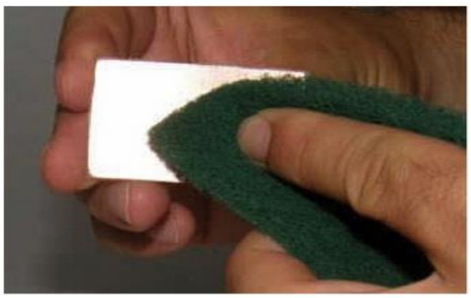
Cut the copper board according to the size of layout using a hacksaw or a cutter.

Copper clad plate

Cutting the plate

1.

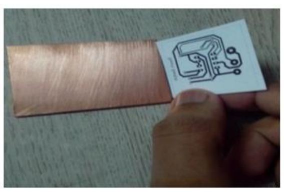
Next, rub the copper side of PCB using steel wool or abrasive spongy scrubs. This removes the top oxide layer of copper as well as the photo resists layer. Sanded surfaces also allow the image from the paper to stick better**.**



Rubbing away the top oxide layer

STEP 3: Transferring the PCB print onto the copper plate

Method 1 Iron on glossy paper method (for complex circuits): Transfer the printed image (taken from a laser printer) from the photo paper to the board. Make sure to flip top layer horizontally. Put the copper surface of the board on the printed layout. Ensure that the board is aligned correctly along the borders of the printed layout. And use tape to hold the board and the printed paper in the correct position.



Place the printed side of the paper on the plate

Method 4: Circuit by hand on PCB (for simple and small circuits): Taking the circuit as reference, draw a basic sketch on copper plate with pencil and then by using a permanent black marker.

Using the permanent marker
for sketching the PCB

STEP 5: Ironing the circuit from the paper onto the PCB plate

After printing on glossy paper, we iron it image side down to copper side. Heat up the electric iron to the maximum temperature. Put the board and photo paper arrangement on a clean wooden table (covered with a tablecloth) with the back of the photo paper facing you.

Using pliers or a spatula, hold one end and keep it steady. Then put the hot iron on the other end for about 10 seconds. Now, iron the photo paper all along using the tip and applying little pressure for about 5 to 15 mins.

Pay attention towards the edges of the board – you need to apply pressure, do the ironing slowly. Doing a long hard press seems to work better than moving the iron around. Here, the heat from the iron transfers the ink printed on the glossy paper to the copper plate.

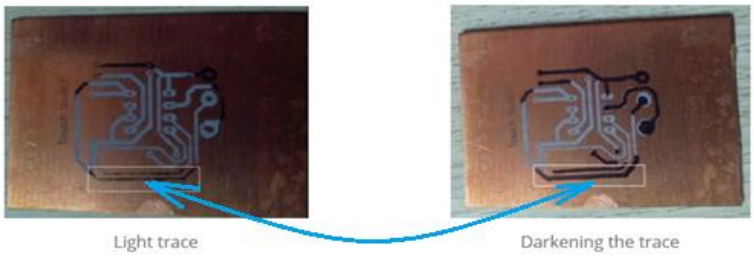
Iron the paper onto the plate

CAUTION: Do not directly touch copper plate because it is very hot due to ironing.

After ironing, place printed plate in Luke warm water for around 10 minutes. Paper will dissolve, then remove paper gently. Remove the paper off by peeling it from a low angle.

Peeling the paper

In some cases while removing the paper, some of the tracks get fainted. In the figure below, you can see that the track is light in color hence we can use a black marker to darken it as shown.

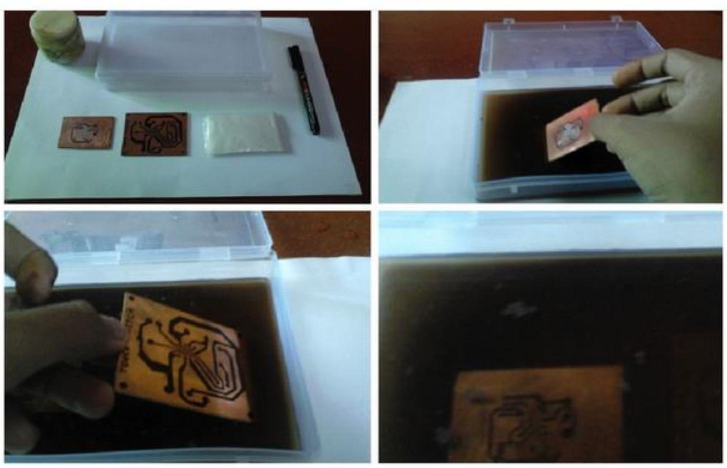


STEP 6: Etching the plate

You need to be really careful while performing this step.

- First put rubber or plastic gloves.
- Place some newspaper on the bottom so that the etching solution does not spoil your floor.
- Take a plastic box and fill it up with some water.
- Dissolve 2-3 tea spoon of ferric chloride power in the water.
- Dip the PCB into the etching solution (Ferric chloride solution, $FeCl_3$) for approximately 30 mins.
- The $FeCl_3$ reacts with the unmasked copper and removes the unwanted copper from the PCB.

This process is called as Etching. Use pliers to take out the PCB and check if the entire unmasked area has been etched or not. In case it is not etched leave it for some more time in the solution.



Etching the plate

Gently move the plastic box to and fro so that etching solution reacts with the exposed copper. The reaction is given as:

Cu + FeCl3 = CuCl3 + Fe

After every two minutes check if all the copper has been removed. If it hasn't then place it back in the solution and wait.

CAUTION: Always use gloves while touching the plate having the solution.

Etched copper plate

STEP 7: Cleaning, disposing and final touches for the circuit board

Be careful while disposing the etching solution, since its toxic to fish and other water organisms. And don't think about pouring it in the sink when you are done, it is **illegal** to do so and might damage your pipes. So dilute the etching solution and then throw it away somewhere safe.

A few drops of thinner (nail polish remover works well) on a pinch of cotton wool will remove completely the toner/ink on the plate, exposing the copper surface. Rinse carefully and dry with a clean cloth or kitchen paper. Trim to final size and smoothen edges with sandpaper

Removing the ink

Now, drill holes using a PCB driller like this: PCB driller and solder all your cool components. If you want that traditional green PCB look, apply solder resist paint on top: PCB lacquer. And finally! Your super cool circuit board would be ready!

Step 7: Drilling the etched PCB

Place the PCB on support for raising some height from the table surface, Use PCB hand drill or electrical pcb drill to make holes into the PCB.

After this, the PCB is ready for component placement and soldering.

2.5.3. Preparation of PCB design by using software

For more practice to preparation of PCB by using software, we should follow below steps. Materials and Equipment's

•Laser printer

•Copper clad board

•Scotch pads or fine steel wool

•Laminator

•Ferric chloride or ammonium per sulfate

•Plastic or glass tray

•Sharply marker

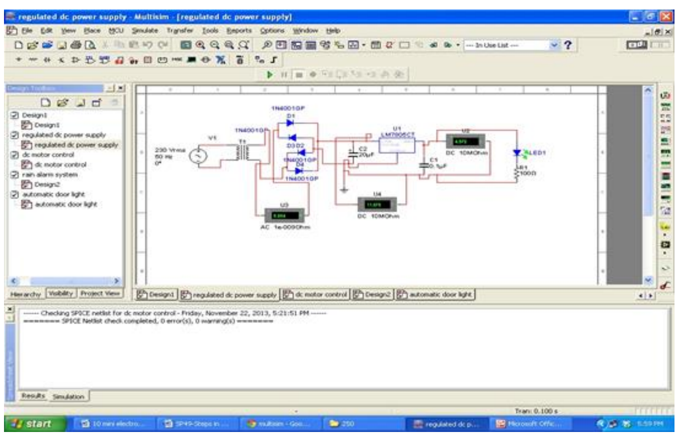
•Drill press

•Wire gauge drill bits

•Magazines

2.5.4. Steps of PCB design by using software

Step– 1 Make design using Multisim/Egale software on PCs



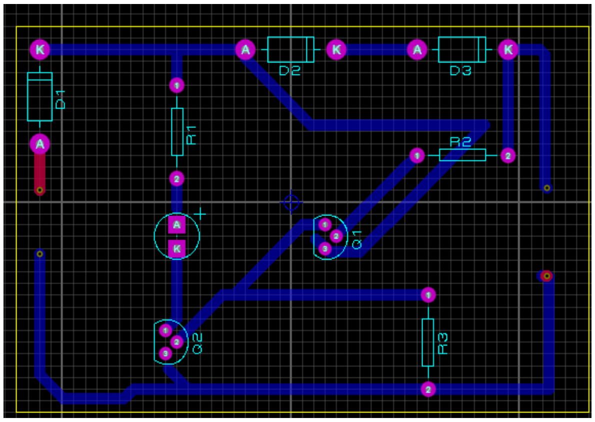
Below are the given steps to draw a circuit using Multisim and simulation step

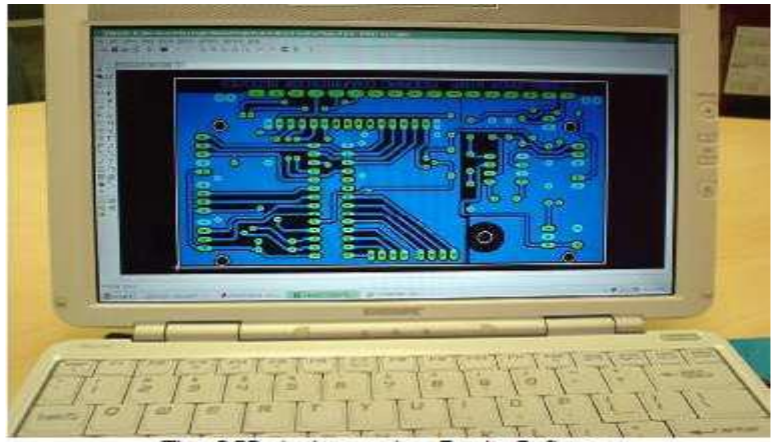
1. On your windows panel, click on the following link: Start >>> Programs –> National –> Instruments –> Circuit design suite 11.0 –> multisim 11.0.
2. A multisim software window appears with a menubar and blank space resembling a breadboard, to draw the circuit.
3. On the menu bar, select place –> components
4. A window appears with the title-'select the components'
5. Under the heading 'Database' – select 'Master Database' from the drop down menu.

6. Under the heading ‘group’- select the required group. If you want to go for voltage or current source or ground. If you want to go for any basic component like a resistor, a capacitor etc. Here first we have to place the input AC supply source, hence select Source –>Power Sources –> AC_power. After the component is placed (by clicking the ‘ok’ button), set the value of RMS voltage to 230 V and frequency to 50Hz.
7. Now again under the components window, select basic, then transformer, then select TS_ideal. Since for an ideal transformer, the inductance of both coils is same, to achieve our output we have the change the secondary coil inductance. Now we know ratio of inductance of the transformer coils is equal to square of the ratio of turns. Since turns ratio required in this case is 19, therefore we have to set the secondary coil inductance to 0.27mH. (Primary coil inductance is at 100mH).
8. Under the components window, select basic, then diodes, and then select the diode IN4003. Select 4 such diodes and place them in a bridge rectifier arrangement.
9. Under the components windows, select basic, then Cap _Electrolytic and select the value of capacitor to be 20microFarad.
10. Under the components window, select power, then Voltage_ Regulator and then select ‘LM7805’ from the drop down menu.
11. Under the components window, select diodes, then select LED and from the drop down menu, select LED_green.
12. Using the same procedure, select a resistor with the value of 100 Ohms.
13. Now that we have all the components and have an idea about the circuit diagram, let us get into drawing the circuit diagram on the multisim platform.
14. To draw the circuit, we have to make proper connections between the components using wires. To select wires, go to Place, then wire. Remember to connect the components only when a junction point appears. In multisim, the connecting wires are indicated by red color.
15. To get an indication of the voltage across the output, follow the given steps. Go to Place, then ‘Components’, then ‘indicator’, then ‘Voltmeter’, then select the first component.
16. Now your circuit is ready to be simulated.
17. Now click on ‘Simulate’ then select ‘Run’.
18. Now you can see the LED at the output blinks, which is indicated by the arrows going green in color.

19. You can verify whether you are getting correct value of voltage across each component by placing a Voltmeter in parallel.

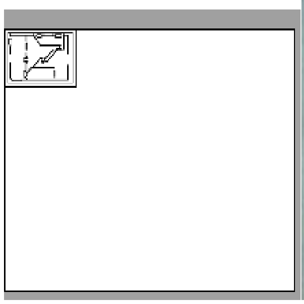
Step 2: convert the design into PCB layout using the software

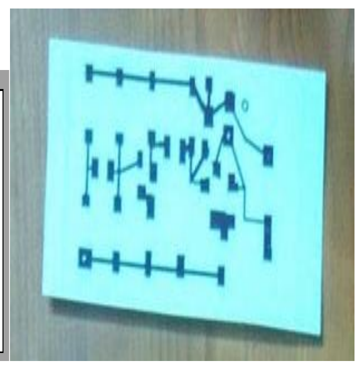




The PCB design, using Eagle Software (www.cadsoft.com)

Step 3. Print out the circuit from PC



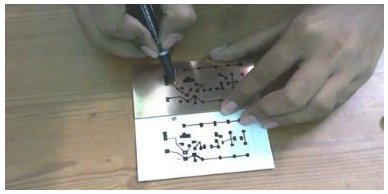


Step 4: Cleaning Copper Clad

Scrub the copper clad with scrubber until it becomes shines.

Step 5: transferring the printed circuit to the Copper Clad

Method 1 Circuit by hand on PCB (for simple and small circuits): Taking the circuit as reference, draw a basic sketch on copper plate with pencil and then by using a permanent black marker.



Method 2 Iron on glossy paper method (for complex circuits): Transfer the printed image (taken from a laser printer) from the photo paper to the board. Make sure to flip top layer horizontally. Put the copper surface of the board on the printed layout. Ensure that the board is aligned correctly along the borders of the printed layout. And use tape to hold the board and the printed paper in the correct position.

- warm up the laminator

- Transfer the Image

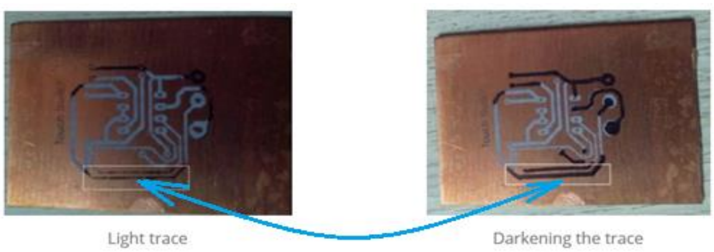
Place your printout face down on the copper clad board. While holding it as flat against the board as possible, begin feeding it into the laminator face up. Once the roller in the laminator grabs the board let it slip through your fingers while maintaining enough drag to keep the paper flat against the board. After about 2seconds the board will exit the other side of the laminator. Rotate the board 180 degrees and pass it back through the laminator again face up. After it finishes its second pass put the very hot board to the side to cool to room temperature. THE BOARD WILL BE VERY HOT FOR THE NEXT 10 MINS!

- Removing the Paper

Once your board has cooled to room temperature place the board in a bowl of warm soapy water and let is soak until the paper is soft and mushy (a few minutes). Depending on the magazine paper you may have to peel off the paper or even rub the board with your fingers to remove the part. With the Parts Express magazine it practically falls off. Remove the paper and as much paper residue as you can and lightly dry the PCB with a paper towel.

Step 6: Inspect and Correct

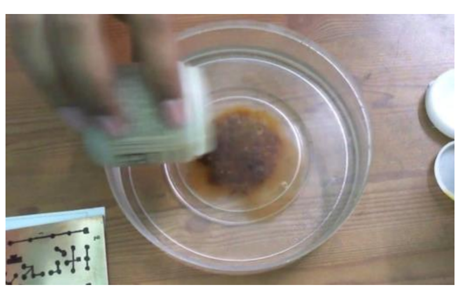
Inspect the PCB for any areas that the toner didn't adhere to or flaked off during the paper removal. Using a Sharpie marker fill in those areas, Chances are you'll have to fill in a few spots on your boards until you find a paper that works for you. If your PCB is beyond repair with a Sharpie then go back at step two and start over. The beauty is that you aren't wasting expensive specialty paper, chemicals, or copper clad board when these rare mistakes happen. After making your repairs let the ink from the Sharpie dry.



Step 7: transferring the printed circuit to the Copper Clad

Add sufficient amount of ferric chloride powder to the water and stir it well to make ferric chloride solution for PCB etching.

The most common etchants Ferric chloride Others include ammonium per sulfate and home brew mixtures of muriatic acid and hydrogen per oxide. Follow the instructions provided with the type of etchant that you select.



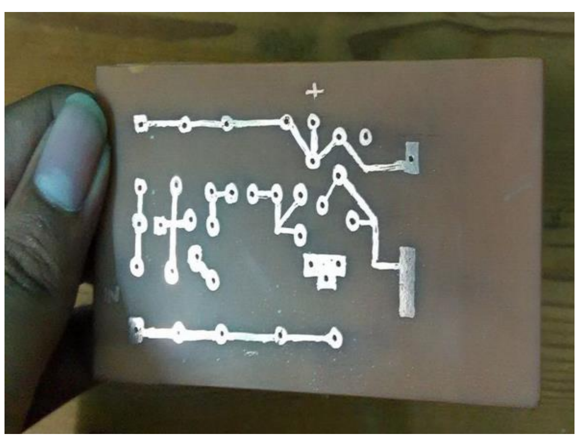
Place the copper clad in the solution such that layout facing upward and wait for few minutes until etching is completed.

Step 8: Cleaning Marker Traces

After the etching is completed, place the PCB in water and clean it. Clean the permanent marker traces by using nail polish remover or petrol.

Step 9: Drilling the etched PCB

Place the PCB on support for raising some height from the table surface, Use PCB hand drill or electrical pcb drill to make holes into the PCB.



After this, the PCB is ready for component placement and soldering.

Self-Check -2.1.

Test II: <u>short Answer writing</u>

Instruction: write short answer for the given question. You are provided 4 minute for each question and each point has 5 Points.

1. Before we begin our tasks in our workplace, what do we ask ourselves for safety?
2. What is Personal Protective Equipment?
3. When does PPE used?
4. Match the different PPEs with their uses. Write the letter on a separate provided. (5 points)
5. Write three that are included under common measures to control electrical risks at a workplace.
   - ______________________________________
   - ______________________________________
6. On completion of electrical work, workers should
   - ______________________________________
   - _____________
7. Maching from column "B" to Column "A"

"A"	"B"
1. Helmet	A. Protect the feet against heavy weights
2. Safety glasses	B. Protect Hands and fingers against cuts by sharp materials
3. Mask	C. Protect eyes from eye injuries
4. Gloves	D. Protect head from head injuries
5. Safety shoes	E. Protect workers from inhale vapors, smoke, powder or dusk

Operation Sheet 2. 1: Design and construct printed circuit board (PCB)

Operation title: Procedures of design and construct printed circuit board (PCB)

Purpose: To practice and demonstrate the knowledge and skill required design and construct printed circuit board (PCB) to construct electrical/electronic Components.

Instruction: Use the given select tools and equipment so that design is usually done by converting your circuit's schematic diagram into a PCB layout using PCB layout software. For this operation you have given 3Hour and you are expected to provide the answer on the given steps.

STEP 1: Take printout of circuit board layout

STEP 2: Cutting the copper plate for the circuit board

STEP 3: Transferring the PCB print onto the copper plate

STEP 4: Circuit by hand on PCB (for simple and small circuits)

STEP 5: Ironing the circuit from the paper onto the PCB plate

STEP 6: Etching the plate

STEP 7: Cleaning, disposing and final touches for the circuit board

- **Tools and requirement:**
  - FeCl3 powder/solution (same as etching solution),
  - photo/glossy paper, permanent black marker,
  - blade cutter, - Drill press
  - sandpaper, - Wire gauge drill bits
  - kitchen paper and
  - Cotton wool.
  - Laser printer
  - Copper clad board
  - Scotch pads or fine steel wool
  - Laminator
  - Ferric chloride or ammonium per sulfate
  - Plastic or glass tray
  - Sharply marker
  -

LAP Test – 2.1.

Instructions: Given necessary templates, tools, materials and equipment you are required to perform the PCB design for the following tasks within 5 hour.

Task -1: Prepare coated circuit board layout.

Task -2: select copper plate according to the give length and width.

Task – 3: prepare Iron on glossy paper to Transferring the image on PCB to print onto the copper plate.

Task – 4: Taking the circuit as reference, draw a basic sketch on copper plate by hand on PCB.

Task – 5: Perform the heat from the iron transfers the ink printed on the glossy paper to the copper plate (Ironing the given circuit).

Task – 6: perform to remove unnecessary copper after applying a temporary mask, leaving only the desired copper traces (Etching the plate processes).

Precautions: select necessary templates, tools, materials and equipment before constructing electrical /electronic circuit on PCB t on the given format

Quality Criteria: the given constructing electrical /electronic circuit on PCB is with correct specification

Unit Three: Construct electrical /electronic circuits on PCB

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- safety procedures of hand tools
- understand work safely
- Important electrical/electronic components
- Constructing electrical / electronic circuits
- Correct sequence of operation.
- Adjusting necessary accessories used
- Undertaking confirmation of construction successfully

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Observe safety procedures
  - Undertake work safely
- Identify important electrical/electronic components
- Construct electrical / electronic circuits
- Make correct sequence of operation.
- Adjust necessary accessories used
- confirm of construction of all electrical/electronic circuit successfully

3.1. Safety procedures of hand tools

3.1.1. OH& S policies and procedures

The purpose of the Health and Safety policies and procedures is to guide and direct all employees to work safely and prevent injury, to themselves and others. All employees are encouraged to participate in developing, implementing, and enforcing Health and Safety policies and procedures.

A. Electrical guarding and protection against mechanical hazards;

- ✓ Risk of loss of stability
- ✓ Machinery and its components and fittings should be stable enough to avoid overturning, falling or uncontrolled movements during use, transportation, assembly and dismantling.
- ✓ If the shape of the machinery itself or its intended installation does not offer sufficient stability, appropriate means of anchorage should be incorporated and indicated in the instructions.
- ✓ Risk of break-up during operation
- ✓ The various parts of machinery and their linkages should be able to withstand the stresses to which they are subject when used.
- ✓ The durability of the materials used should be adequate for the nature of the working environment foreseen by the manufacturer, in particular as regards the phenomena of fatigue, ageing, corrosion and abrasion, and the maintenance schedule of the owner.

3.1.2. Apply OHS requirements, policies and procedures

Procedure: 1- Identify and assess risks

- ✓ Hazards in the work area are identified, assessed and reported to designated personnel
- ✓ Safety risks in the work area are identified, assessed and reported to designated personnel
- ✓ Safe work practices, duty of care requirements and safe work instructions are followed for controlling risks.
- ✓ OHS, hazard, accident or incident reports are contributed to according to workplace procedures and Australian government and state or territory OHS legislation and relevant information.

Procedure: 2- Identify hazardous materials and other hazards on work sites

- ✓ Hazardous materials on a work site are correctly identified and, if appropriate, handled and used according to company and legislated procedures
- ✓ Measures for controlling risks and construction hazards are applied effectively and immediately.
- ✓ Hazardous materials that have safety implications for self and other workers are secured immediately they are identified, using appropriate signs and symbols.
- ✓ Asbestos-containing materials are identified on a work site and reported to designated personnel.

Procedure: 3-Plan and prepare for safe work practices easily with help

- ✓ Correct personal protective equipment and clothing for each area of construction work are identified, worn, correctly fitted, used and stored according to enterprise procedures.
- ✓ Selection of tools, equipment and materials, and organization of tasks are performed in conjunction with other personnel on site and in accordance with enterprise procedures.
- ✓ Required barricades and signage are determined and erected at the appropriate site location.
- ✓ Material safety data sheets (MSDS), and job safety analysis (JSA) and safe work method statements relevant to the work to be carried out are identified and applied.

3.2. Understand work safely

3.2.1. Apply safe work practices

- ✓ Tasks are performed in a manner that is safe for operators, other personnel and the general community in accordance with legislative requirements, and enterprise policies and procedures.
- ✓ Plant and equipment guards are used in accordance with manufacturer specifications, work site regulations and Australian standards where applicable.
- ✓ Procedures and relevant authorities for reporting hazards, incidents and injuries are used.
- ✓ Prohibited tools and equipment in areas with identified asbestos are recognized and not used.
- ✓ Work site safety signs and symbols are identified and followed

- ✓ Work site area is cleared and maintained to prevent and protect self and others from incidents and accidents and to meet environmental requirements.

- **Procedure 1-Follow emergency procedures**
  - ✓ Designated personnel are identified in the event of an emergency for communication purposes.
  - ✓ Safe workplace procedures for dealing with accidents, various types of fire and other emergencies are followed, including identification or use, if appropriate, of fire equipment within scope of responsibilities
  - ✓ Emergency response and evacuation procedures are known, practiced and carried out effectively when required.
  - ✓ Emergency first aid treatment of minor injuries is carried out correctly and details of any treatment administered are reported accurately to designated personnel as soon as possible.

3.2.2. Five elements of an effective safety culture.

- **Responsibility.** Companies with strong safety cultures share the value of responsibility.
- Accountability. Managers must be held accountable to lead by example each and every day. ...
- **Clear Expectations**. Safety expectations need to be set and communicated to everyone in the organization. ...
- **Ethics.** ... Ethically driven management systems are important in developing a strong safety culture. The goal is for employees to make decisions that not only satisfy the procedures in the safety manual but that are also ethical and moral. The individuals you hire for your company should have the ability to make ethical and rational decisions in everyday situations, and share your company's core values. Hiring the right people with the right attitudes goes a long way towards creating a strong safety culture.
- **Next Steps.** A safety perception survey can help you evaluate your company's safety culture to determine areas for improvement.

3.3. Important Electrical/Electronic components

3.3.1. Introduction to Electrical/Electronics components

There are various basic electrical and electronic components which are commonly found in different circuits of peripherals. In many circuits, these components are used to build the circuit, which are classified into two categories such as active components and passive components. . Active components are nothing but the components that supply and control energy. Passive components can be defined as the components that respond to the flow of electrical energy and can dissipates or store energy. These components can be found in numerous peripherals like hard disks, mother boards, etc. Many circuits are designed with various components like resistors, capacitors, inductors, transistors, transformers, switches, fuses, etc.

3.3.2. Active Component

A. Definition - What does Active Component mean?

An active component is a device that has an analog electronic filter with the ability to amplify a signal or produce a power gain. There are two types of active components: electron tubes and semiconductors or solid-state devices. A typical active component would be an oscillator, transistor or integrated circuit.

An active component works as an alternating-current circuit in a device, which works to increase the active power, voltage or current. An active component is able to do this because it is powered by a source of electricity that is separate from the electrical signal.

The majority of electronic devices are semiconductors, the most common of which is a transistor. A basic transistor is generally used in an amplifier, which increases the active current I/O signal using a direct current (DC) power supply to provide the necessary power.

An active device has the ability to control electron flow and either allows voltage to control the current or allows another current to take control. Voltage-controlled devices, such as vacuum tubes, control their own signal, while current-controlled devices, such as bipolar junction transistors, allow one current to control another.

All active components require a source of energy, which generally comes from a DC circuit. In addition, an active device can generally infuse power into a circuit such as a transistor, triode vacuum tube or tunnel diode.

A component that is not active is called a passive component. It consumes energy and does not have the ability to boost power. Basic passive components include capacitors, resistors and inductors.

3.3.3. Passive Component

B. Definition - What does Passive Component mean?

A passive component is a module that does not require energy to operate, except for the available alternating current (AC) circuit that it is connected to. A passive module is not capable of power gain and is not a source of energy. A typical passive component would be a chassis, inductor, resistor, transformer, or capacitor.

Generally, passive components are not able to increase the power of a signal nor are they able to amplify it. However, they can increase current or voltage by an LC circuit that stores electrical energy from resonant frequencies or by a transformer that acts like an electrical isolator.

In the context of electronic technology, there are stricter guidelines for the term passive component. Electronic engineers view this term usually in correlation with circuit analysis, which involves methods of finding the currents through and the voltages across every component in the network

An electronic circuit that is composed of just passive components is called a passive circuit. A module that is not passive is called an active component.

B. Passive components can be divided into two types:

- **Loss or dissipative:** Does not have the capacity to absorb power from an external circuit over a period of time. A classic example would be a resistor.
- **Lossless**: Does not have an input or output net power flow. This type includes components such as inductors, capacitors, transformers, and gyrators.

The majority of passive components that have two terminals are usually defined as a two-port parameter, which is an electric circuit or module that has two pairs of terminals linked together by an electric network. Two-port parameters comply with the standards of reciprocity. A two-port network would be a transistor, electronic filters, or impedance matching networks. A transducer or switch would not be a two-port parameter because it is a closed system. Although active components typically have more than two terminals, they are not classified as a two-port parameter because they lack the properties.

Passive components that use circuit architecture would include inductors, resistors, voltage and current sources, capacitors, and transformers. Likewise, passive filter are comprised of four elementary linear elements that include an inductor, capacitor, resistor, and transformer. Some high-tech passive filters can have non-linear elements like a transmission line.

3.3.4. Difference between Active and Passive Components

The active and passive components are differentiated on various factors like nature of the source, its functions, power gain, controlling the flow of current. Various examples of the component, nature of the energy, requirement of the external resistance. The **Difference between Active** and **Passive Components** is given below in the tabulated form.

Table 3.1. Comparison Chart b/n active and passive

BASIS	ACTIVE COMPONENTS	PASSIVE COMPONENT
Nature of source	Active components deliver power or energy to the circuit.	Passive elements utilizes power or energy in the circuit.
Examples	Diodes, Transistors, SCR, Integrated circuits etc.	Resistor, Capacitor, Inductor etc.
Function of the component	Devices, which produce energy in the form of voltage or current.	Devices, which stores energy in the form of voltage or current.
Power Gain	They are capable of providing power gain.	They are incapable of providing power gain.
Flow of current	Active components can control the flow of current.	Passive components cannot control the flow of the current.
Requirement of external source	They require an external source for the operations.	They do not require any external source for the operations.
Nature of energy	Active components are energy donor.	Passive components are energy acceptor.

In this article difference between Active and Passive components are explained considering various points. **Active components** are the elements or devices which are capable of providing or deliver energy to the circuit. **Passive components** are the devices which do not require any external source for the operation and are capable of storing energy in the form of voltage or current in the circuit.

- Active components are those who deliver or **produce energy** or power in the form of a voltage or current. Passive components are those who **utilizes or store energy** in the form of voltage or current.
- Examples of the active components are Diodes, transistors, SCR, integrated circuits, etc. similarly examples of the passive components are resistor, capacitor and inductor.
- Active components are capable of providing the **power gain**, whereas the passive components are not capable of providing the power gain.
- Active components can control the **flow of current**, but the passive components cannot control the flow of the current.
- Active components are energy donor, whereas the passive components are energy acceptor.
- The active component requires an external source for the operation, whereas the passive components do not require any external source for the operations.

A. Active components include:

Diodes (All) ▪ Rectifier Diode ▪ Schottky Diode ▪ Zener Diode ▪ Unipolar / Bipolar Diode ▪ Varicap ▪ Varactor ▪ Light-Emitting Diode (LED) ▪ Solar PV Cell, PV Panel	Transistors (All) ▪ Photo Transistor ▪ Darlington Transistor ▪ Compound Transistor ▪ Field-Effect Transistor (FET) ▪ JFET (Junction Field-Effect Transistor) ▪ MOSFET (Metal Oxide Semiconductor FET) ▪ Thyristors ▪ Composite Transistors
Integrated Circuits (All) ▪ Digital Circuit ▪ Analog Circuit ▪ Hall Effect Sensor	▪ CRT / LCD / VFD / TFT / LED ▪ Vacuum Tubes ▪ Rectifier Tubes ▪ Emitters

▪ Current Sensor ▪ BGA Packages ▪ Processor ▪ Power ICs ▪ Optoelectronic Components	▪ Gas discharge tube ▪ Ignitron ▪ Thyratron ▪ Battery / Power Supply ▪ Electric Generator

B. Passive components include:

▪ Resistors (All Types) ▪ Capacitors (All Types) ▪ Inductors / Coil ▪ Memristor / Network ▪ Sensors	▪ Detectors ▪ Transducers ▪ Antennas ▪ Assembly Modules

C. Electromechanical components

▪ Piezoelectric devices ▪ Crystals ▪ Resonators ▪ Terminals and Connectors ▪ Cables	▪ Switches ▪ Circuit Protection Devices ▪ PCB ▪ Mechanical Devices such as a Fan, Lamp

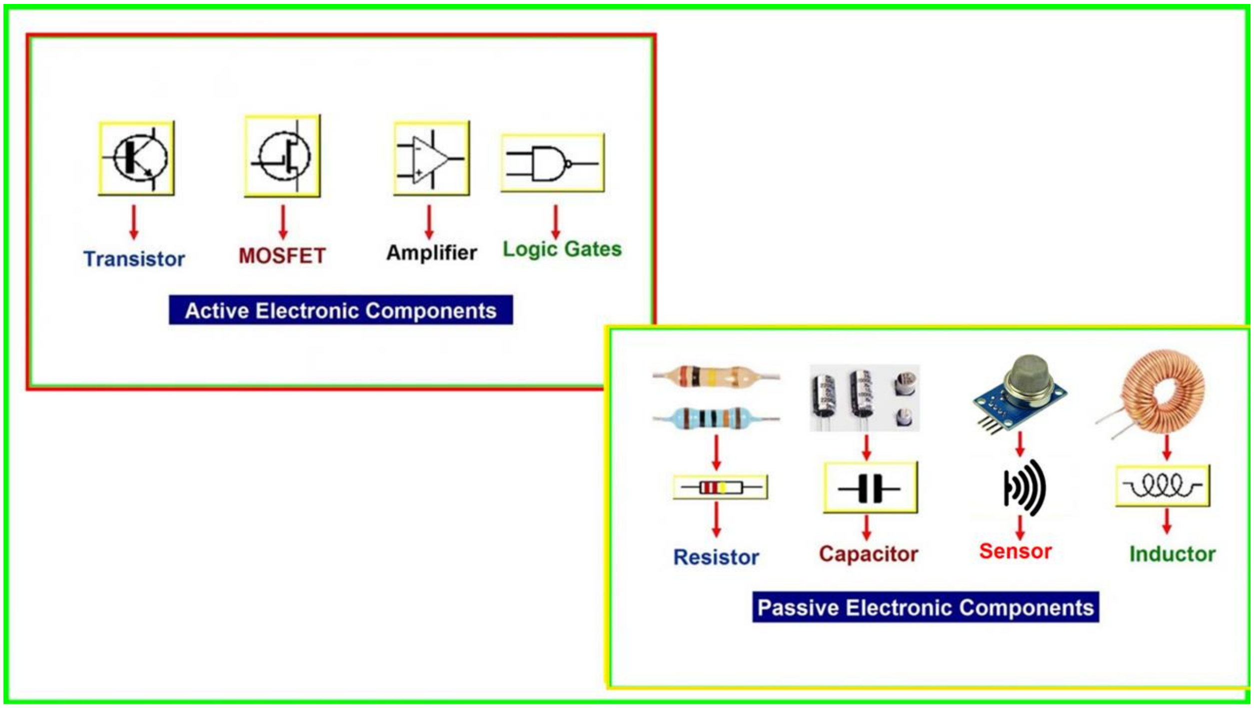


FIG 1.3.5. Passive and active Electronic component

3.3.5. The Basic elements of an Electric Circuit

Every electric circuit, regardless of where it is or how large or small it is, has four basic parts: an energy source (AC or DC), a conductor (wire), an electrical load (device), and at least one controller (switch).

A. The Energy Source

In an electrical circuit, the power source provides the voltage (the force that pushes electrons through a conductor -- measured in volts) and current (the rate of flow of electrons -- measured in amperes) to energize a device attached to the circuit.

B. The Conductor

In a typical electrically powered environment that uses common electrical devices, the conductor is the wiring in a home or device that provides the path of the circuit, on which the energy flows. The conductor (conduction) system interconnects all of the other parts of the circuit.

C. The controller (switch)

The controller (switch) provides the control that closes (continues) or opens (breaks) the electrical energy flow on the circuit. A variety of circuit switches exist, including wall switches, push buttons, key toggles, and many biometric devices.

D. The Load

Any device attached to an electrical circuit that is activated or energized by the flow of electricity to it, provides the electrical load on the circuit. The load is the amount of electrical energy the device uses to complete its task. This electrical consumption is measured in watts, which equals the current (amps) multiplied by the volts on the circuit. Lights, TVs, motors, heaters and appliances are load devices that consume power.

3.4. Electrical /electronic circuits

3.4.1. Amplifier

Amplifier is the generic term used to describe a circuit which produces and increased version of its input signal. However, not all amplifier circuits are the same as they are classified according to their circuit configurations and modes of operation.

In "Electronics", small signal amplifiers are commonly used devices as they have the ability to amplify a relatively small input signal, for example from a *Sensor* such as a photo-device, into a much larger output signal to drive a relay, lamp or loudspeaker for example.

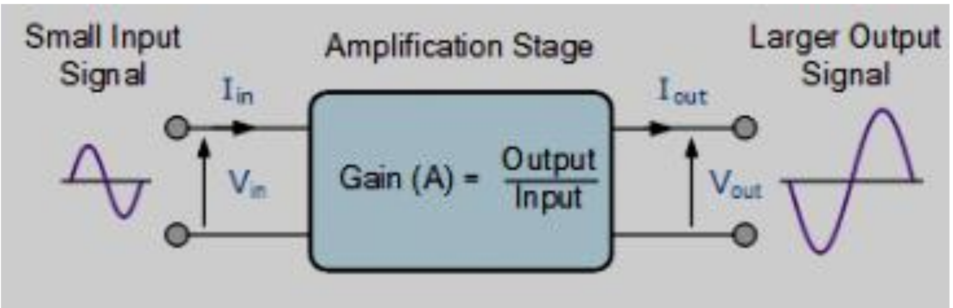


FIG 3.4.1. amplifier block diagram

There are many forms of electronic circuits classed as amplifiers, from Operational Amplifiers and Small Signal Amplifiers up to Large Signal and Power Amplifiers. The classification of an amplifier depends upon the size of the signal, large or small, its physical configuration and how it processes the input signal that is the relationship between input signal and current flowing in the load.

The type or classification of an Amplifier is given in the following table.

Table 3.4.1. Classification of Signal Amplifier

Type of Signal	Type of Configuration	Classification	Frequency of Operation
Small Signal	Common Emitter	Class A Amplifier	Direct Current (DC)
Large Signal	Common Base	Class B Amplifier	Audio Frequencies (AF)
	Common Collector	Class AB Amplifier	Radio Frequencies (RF)
		Class C Amplifier	VHF, UHF and SHF Frequencies

Amplifiers can be thought of as a simple box or block containing the amplifying device, such as a Bipolar Transistor, Field Effect Transistor or Operational Amplifier, which has two input terminals and two output terminals (ground being common) with the output signal being much greater than that of the input signal as it has been “Amplified”.

An ideal signal amplifier will have three main properties: Input Resistance or (R_{IN}), Output Resistance or (R_{OUT}) and of course amplification known commonly as Gain or (A). No matter how complicated an amplifier circuit is, a general amplifier model can still be used to show the relationship of these three properties.

3.4.2. Ideal Amplifier Model

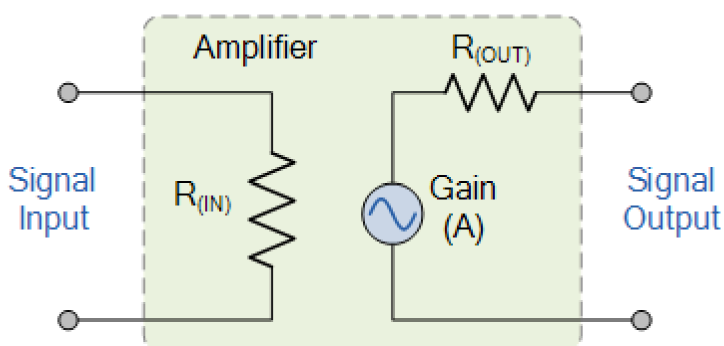


FIG. 3.4.2. Simple representation of ideal amplifier

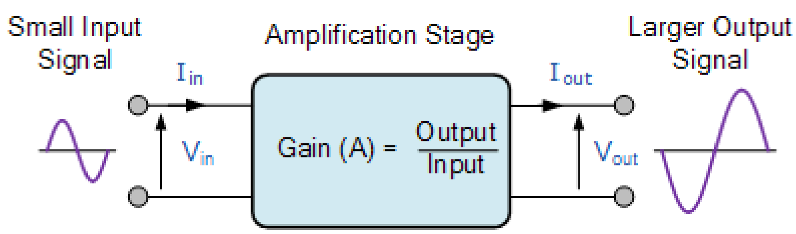
The amplified difference between the input and output signals is known as the Gain of the amplifier. Gain is basically a measure of how much an amplifier “amplifies” the input signal. For example, if we have an input signal of 1 volt and an output of 50 volts, then the gain of the amplifier would be "50". In other words, the input signal has been increased by a factor of 50. This increase is called **Gain**.

Amplifier gain is simply the ratio of the output divided-by the input. Gain has no units as it's a ratio, but in Electronics it is commonly given the symbol "A", for Amplification. Then the gain of an amplifier is simply calculated as the "output signal divided by the input signal".

Amplifier Gain

The introduction to the amplifier gain can be said to be the relationship that exists between the signals measured at the output with the signal measured at the input. There are three different kinds of amplifier gain which can be measured and these are: *Voltage Gain* (Av), *Current Gain* (Ai) and *Power Gain* (Ap) depending upon the quantity being measured with examples of these different types of gains are given below.

- Amplifier Gain of the Input Signal



Voltage Amplifier Gain

$$Voltage\,Gain\,(A_v) = \frac{Output\ Voltage}{Input\ Voltage} = \frac{Vout}{Vin}$$

Current Amplifier Gain

$$Current\,Gain\,(A_i) = \frac{Output\ Current}{Input\ Current} = \frac{Iout}{Iin}$$

Power Amplifier Gain

$$Power\,Gain\,(A_p) = A_v \; x \; A_i$$

Note that for the Power Gain you can also divide the power obtained at the output with the power obtained at the input. Also when calculating the gain of an amplifier, the subscripts v, i and p are used to denote the type of signal gain being used.

Ideal Amplifier

We can know specify the characteristics for an ideal amplifier from our discussion above with regards to its **Gain**, meaning voltage gain:

- The amplifiers gain, (A) should remain constant for varying values of input signal.
- Gain is not be affected by frequency. Signals of all frequencies must be amplified by exactly the same amount.
- The amplifiers gain must not add noise to the output signal. It should remove any noise that is already exists in the input signal.
- The amplifiers gain should not be affected by changes in temperature giving good temperature stability.
- The gain of the amplifier must remain stable over long periods of time.

3.4.3. Power Amplifier

A power amplifier is an electronic amplifier designed to increase the magnitude of power of a given input signal. The power of the input signal is increased to a level high enough to drive loads of output devices like speakers, headphones, RF transmitters etc. Unlike voltage/current amplifiers, a power amplifier is designed to drive loads directly and is used as a final block in an amplifier chain.

The input signal to a power amplifier needs to be above a certain threshold. So instead of directly passing the raw audio/RF signal to the power amplifier, it is first pre-amplified using current/voltage amplifiers and is sent as input to the power amp after making necessary modifications. You can observe the block diagram of an audio amplifier and the usage of power amplifier below.

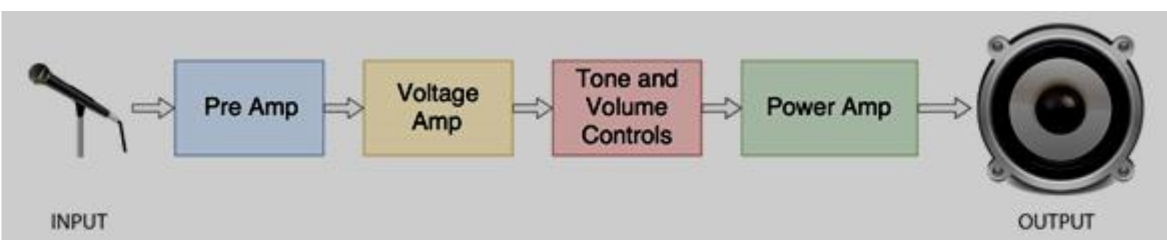


FIG 3.4.3. Block diagram of an audio amplifier

In this case a microphone is used as an input source. The magnitude of signal from the microphone is not enough for the power amplifier. So first it is pre-amplified where its voltage and current are increased slightly. Then the signal is passed through tone and volume controls circuit which makes aesthetic adjustments to the audio waveform. Finally the signal is passed through a power amplifier and the output from power amp is fed to a speaker.

3.4.4. Types of Power Amplifiers

Depending on the type of output device that is connected, power amplifiers are divided into the following three types.

A. Audio Power Amplifiers

This type of power amplifiers are used for increasing the magnitude of power of a weaker audio Signal. The amplifiers used in speaker driving circuitries of televisions, mobile phones etc. come under this category.

The output of an audio power amplifier ranges from a few mil-watts (like in headphone amplifiers) to thousands of watts (like power amplifiers in Hi-Fi/Home theatre systems).

B. Radio Frequency Power Amplifiers

Wireless transmissions require modulated waves to be sent over long distances via air. The signals are transmitted using antennas and the range of transmission depends on the magnitude of power of signals fed to the antenna.

For wireless transmissions like FM broadcasting, antennas require input signals at thousands of kilowatts of power. Here, Radio Frequency Power amplifiers are employed to increase the magnitude of power of modulated waves to a level high enough for reaching required transmission distance.

C. DC Power Amplifiers

DC power amplifiers are used to amplify the power of a PWM(Pulse Width Modulated) signals. They are used in electronic control systems which need high power signals to drive motors or actuators. They take input from microcontroller systems, increase its power and feed the amplified signal to DC motors or Actuators.

3.4.5. Power Supply

A power supply is an electronic circuit or a device that converts the primary electric power in to ac or dc needed by different types of electronic circuit. A power supply may be implemented as a discrete, stand-alone device or as integral device that is hard wired to its load and designed to provide various ac and dc voltages. Therefore, all electronic equipment's require a source of power for normal operation; but most electronic equipment needs source of dc power to operate properly.

A. AC Power supply: - An AC power supply typically takes the voltage from the mains supply and lowers it to the desired voltage. It is also known as **unregulated power supply;** this is because its output voltage varies depending on the load and on variation on the AC supply voltage.

B. DC power Supply: - The function of the DC power supply is to provide the necessary DC voltage and current, with low levels of AC ripple and with a good stability and regulation. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source.

That is, nearly all Electronic circuits require a source of well-regulated dc, at voltages of typically between 5 V and 30 V.

Thus a power supply system can be defined as an electronic circuit which converts the ac input of 50/60Hz power line to a dc output voltage.

Generally DC Power supplies for electronic devices can be divided in to **Conventional (linear)** and **switching mode** power supplies.

The conventional power supply is usually a relatively simple design, but it becomes increasingly bulky and heavy for high-current equipment due to the need for large transformers and heat sinker electronic regulation circuitry. Switched mode power supply of the same rating as a linear power supply will be smaller, is usually more efficient, but will be more complex.

3.4.6. Conventional or linear power supply

The block diagram of a linear dc power supply is shown in Fig.1 below. Since the mains input is at a relatively high voltage, a step-down transformer of appropriate turn's ratio is used to convert this to a low voltage. The ac output from the transformer secondary is then rectified using rectifier diodes to produce an unsmoothed (sometimes referred to as pulsating dc) output. This is then smoothed and filtered before being applied to a circuit which will regulate (or stabilize) the output voltage so that it remains relatively constant in spite of variations in both load current and incoming mains voltage. Figure 2 shows how some of the electronic

Components that we have already met can be used in the realization of the block diagram in Fig. 1The iron-cored step-down transformer feeds a rectifier arrangement.

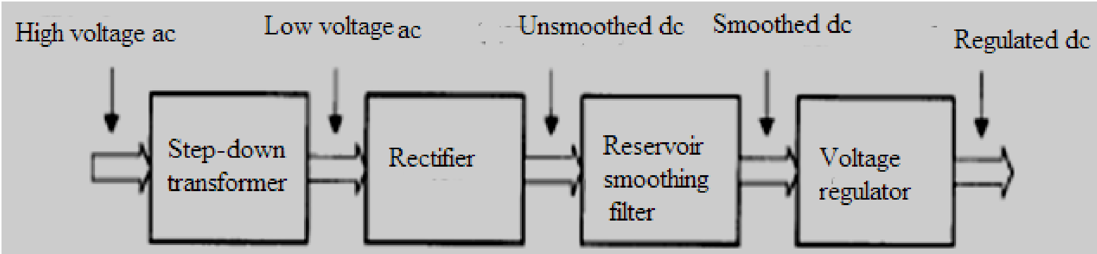


FIG. 3.4.6. block diagram of dc power supply

3.4.7. Main Parts of power supply

The power supply unit used to convert alternating current to direct current consists of four main parts.

a) Transformer b) Rectifier c) Filter d) Voltage regulator

As you know electronic systems are designed to manage the flow of information. In order to achieve this function all of the electronic circuit with its system requires certain constant dc supply voltage. If a small amount of power is needed batteries can be used to deliver a dc supply, as to supply this type of equipment such as Calculators, watches and multi meters etc

With large electronic system such as computers, TV sets, video systems. The dc supply voltage is obtained from a dc power supply, which is generally a sub system within the main system.

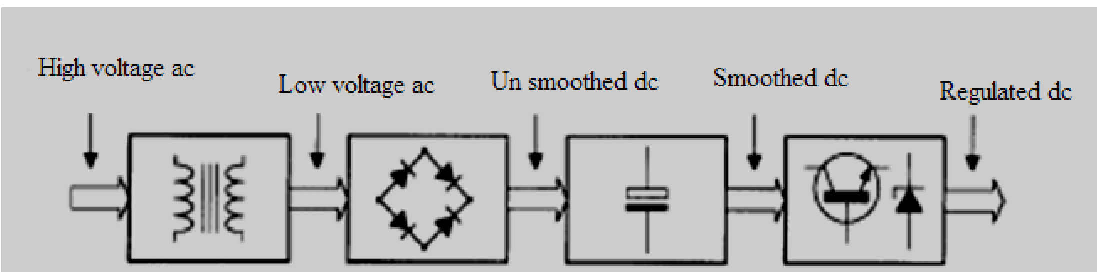


FIG 3.4.7. Block diagram of dc power supply showing main components

The function of each block diagram is as follows.

1. Transformer: Since the final voltage desired is generally not 220V so a transformer is usually include stepping the ac line voltage up or down depending on the exact needs of the electronic circuits. Generally electronic circuits require low voltage supply; therefore mostly the purpose of the transformer is to step down the line voltage.

2. Rectifiers: It is used to convert alternating current (ac) to direct current (pulsating dc), which is unidirectional current that supplied to the filter circuit as an input. Basically there are two types of rectifiers, such as half wave and full wave (center tap and bridge).

a) **Half wave Rectifier**-The simplest form of rectifier circuit makes use of a single diode to “chop off” half of the ac input cycle.

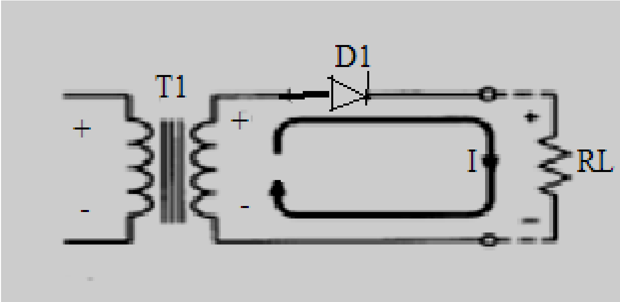


FIG 3.4.8. Schematic diagram of a Half wave rectifier

b) **Full wave Rectifier: -** the half wave rectifier output is difficult to filter to a smooth dc level because an output voltage and current are only half of each input cycle to the load. Unfortunately, the half-wave rectifier circuit is relatively inefficient as conduction takes place only on alternate half-cycles. A better rectifier arrangement would make use of both positive *and* negative half-cycles. These **full-wave rectifier** circuits offer a considerable improvement over their half wave counterparts. There are two types of full wave rectifiers, these are center tap and bridge rectifier.

1. **Full-wave, Center-Tap Rectifier**: It requires two diodes and a center tapped transformer.

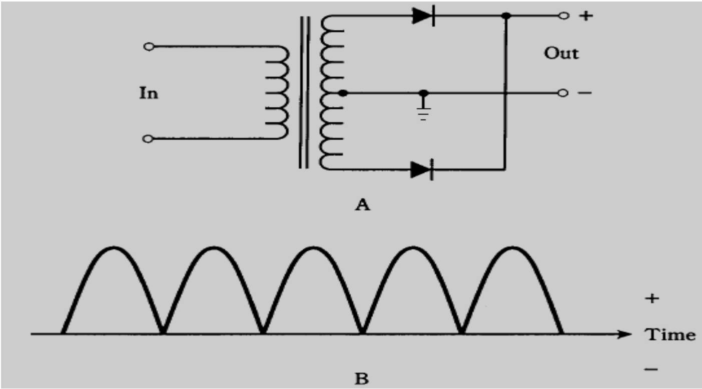


FIG 3.4.9. Schematic diagram of a full-wave, Center-tap rectifier and its out put

2. **Full-wave Bridge Rectifier:** Another way to get full-wave rectification is the **bridge rectifier**. The output waveform is just like that of the full-wave, center-tap circuit. The bridge circuit does not need a center-tapped transformer secondary and it needs four diodes rather than two. This is its main practical advantage.

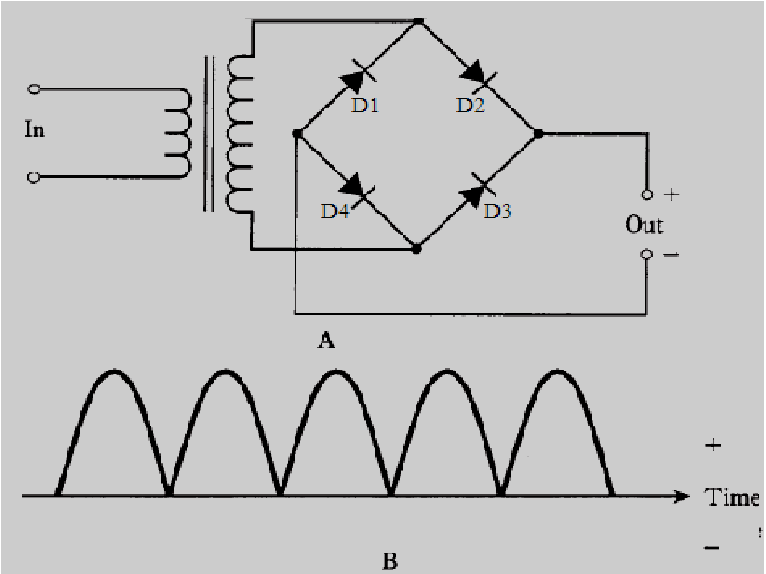


FIG 3.4.10. Schematic diagram of a full-wave bridge rectifier and its out put

3. Filter or smoothing circuits: used to convert the pulsating dc output coming from the rectifier in to a constant or smooth dc voltage. The simplest filter is one or more large-value capacitors, connected in parallel with the rectifier output.

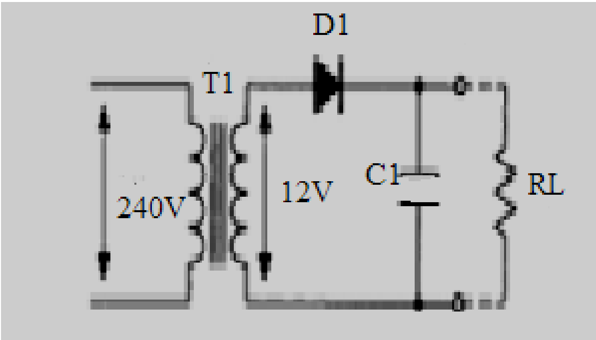


Fig 3.4.11. A half wave rectifier circuit with filter capacitor

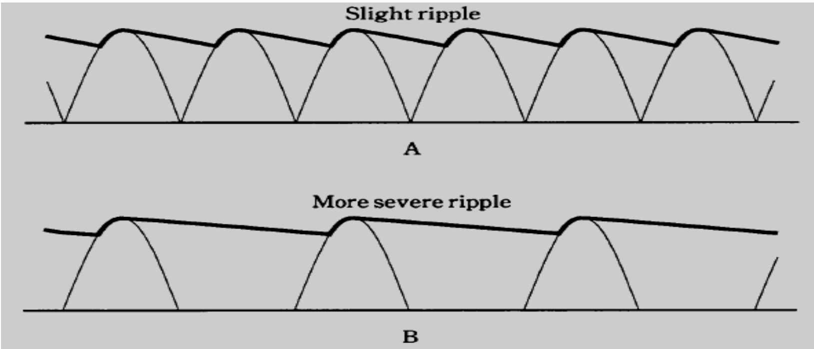


FIG. 3.4.12. Filtered output for full-wave rectification (A) and half-wave rectification (B)

4. Voltage Regulators: All source of power supply have internal resistance due to this resistance there will be an IR drop within the power source and the terminal voltage (output voltage across the load) will decrease as the load is applied. The higher the load the higher the IR drop therefore the term regulation is used as an indication of a power source to maintain a constant output voltage. This is done if reverse-biased Zener diode is connected across the output of a power supply; the diode will limit the output voltage of the supply as long as it has a high enough power rating.

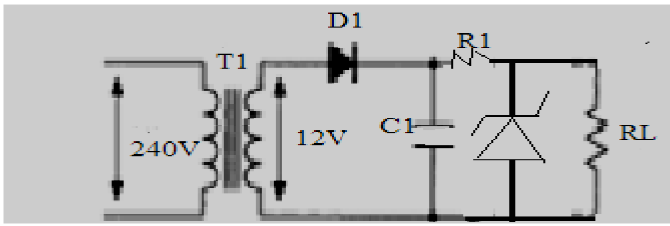


Fig 3.4.13. Voltage regulator

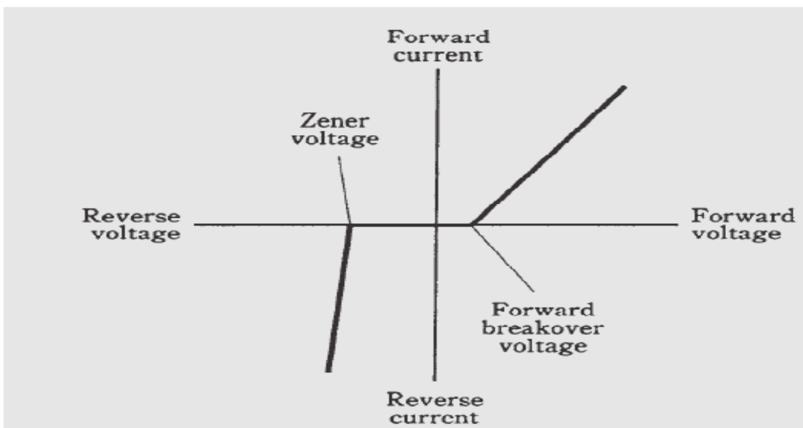


FIG 3.4.14. Current through a Zener diode, as a function of the bias voltage

3.4.8. Switch Mode Power Supply

It is a power supply that provides the power supply function through low loss components such as capacitors, inductors and transformers and the use of switches that are in one of two states, on or off. The advantage is that the switch dissipates very little power in either of these two states and power conversion can be accomplished with minimal power loss, which equates to high frequency.

SMPS have been used for many years in industrial applications where good efficiency, light weight and small size were of prime concern. Today SMPS often called (often called “chopper” “switchers”) are used extensively in AC powered electronic devices such as computers, monitors, television receivers and VCRs.

In SMPS, the AC mains input is directly rectified and then filtered to obtain a DC voltage. The resulting DC voltage is then switched on and off at a high frequency by electronic switching circuitry, thus producing an ac current that will pass through a high frequency transformer or inductor. Switching occurs at a very high frequency there by enabling the use of transformers and filter capacitors that are much smaller, lighter, and less expensive than those found in linear power supplies operating at mains frequency. After the inductor or transformer secondary, the high frequency AC is rectified and filtered to produce DC output voltage.

D. SMPS are always regulated to keep the output voltage constant; the power supply employs a feedback controller that monitors current drawn by the load. The switching duty cycle increases as power output requirements increase.

SMPS often include safety features such as current limiting circuit to protect the device and the user from harm. In the event that an abnormal high current power draw is detected, the SMPS can assume this is a direct short and will shut itself down before damage is done.

SMPS have an absolute limit on their minimum current output. They are only able to output above a certain power level and cannot function below that point. SMPS with protection circuits may briefly turn on but then shut down when no load has been detected.

Some SMPS use filters or additional switching stages in the incoming rectifier circuit to improve the wave form of the current taken from the AC line. This adds to the circuit complexity.

- **SMPS offers three main advantages over a conventional linear power supply.**
    1. High efficiency & less heat generation
    2. Better regulation
    3. **Smaller size and weight.**

Of these, greater efficiency is the biggest advantage. Conventional linear power supplies are inefficient because they regulate by damping the excess power in to heat. That is to maintain regulation for all load conditions; more power is applied to regulator than is needed by the load. This unused power is dissipated as heat. The AC power transformer, operating at 60 Hz, also contributes to the efficiency of some power supplies. When all the efficiencies are added, conventional, linear power supplies are typically 40-50 % efficient, while SMPS have efficiencies from 60-90%. This is very important when the designer wants to reduce generated heat, reduce power costs, or increase battery life. Switchers are very efficient regulators because they only produce as much power as is needed by the load. Another key benefit of SMPS is their ability to closely regulate the output voltage. Switchers adjust for changes in continuously, and follow load changes almost immediately. In addition, switchers have the unique ability to maintain the correct output under low input voltage conditions. In fact switchers can actually produce an output voltage that is higher than the DC voltage applied to the input. A final advantage of switchers is their relatively small size and weight. Because switchers at high frequencies, the parts are physically smaller than those needed for a conventional, 60 Hz power supply of the same power rating. The transformers, capacitors and coils are both physically smaller and lighter. This makes them ideal for use in portable equipment.

E. Basic Switcher operation

The heart of all SMPS is the switching transistor and switching transformer. Unregulated power is supplied to the switching transistor through the primary winding of the transformer. The switching transistor is a switch, and when the switch is closed (the transistor is turned on) it provides a path for current to flow through the transformer primary to ground. Changing how fast or how long the switch remains closed regulates the output voltages. As the transistor is switched on and off the magnetic field alternately expands and collapses in all of the transformer windings. The output of the transformer is applied to high speed switching diodes and filters which produce the DC output voltages of the SMPS. In SMPs voltage regulation is achieved by sampling the DC output voltage and comparing it to a reference. The resulting correction voltage is used to control the frequency or “ON” time of the switching transistor, which in turn delivers more or less power to the load.

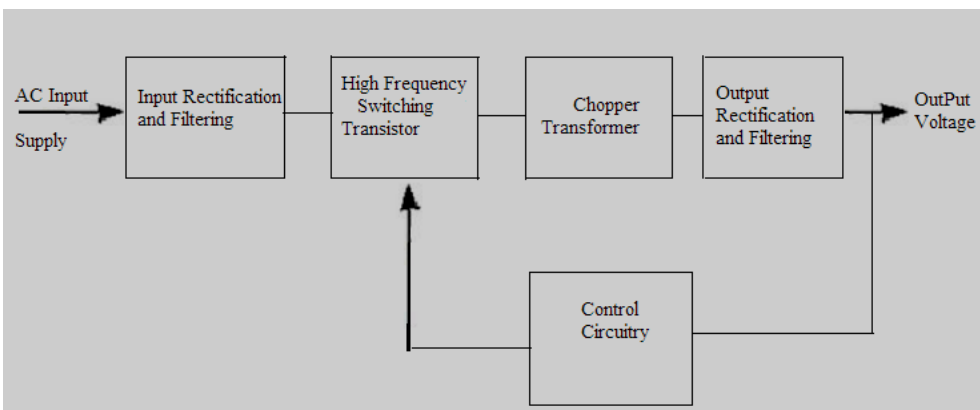


Fig 3.4.8. Basic Block diagram of SMPS

There are two types of regulators used in SMPS, such as pulse width modulated (PWM) and pulse rate modulated (PRM). TV receivers and computer monitors may use either type. PWM regulates by varying the “ON” or conduction time of the switching transistor.

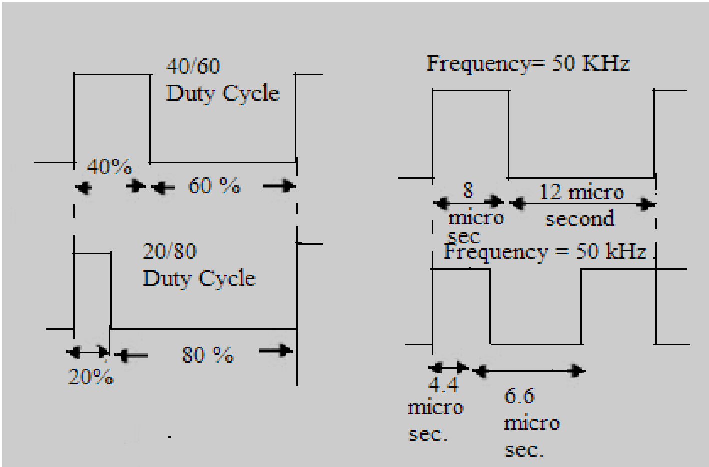


FIG. 3.4.8.1. Shows an example of PWM and PRM.

The control circuit uses the feedback voltage to regulate the switching transistor.

F. Pulse width Modulation

As the width of the pulse is increased, the switching transistor stays on longer, and more energy is applied to the switching transformer. This produces an increase in the DC output voltage. Likewise, as the pulse width is made narrower, the transistor is on for a shorter amount of time, and less energy is applied to the transformer.

G. Pulse Rate Modulation

The PRM regulator varies the rate (frequency) at which the switching transistor or is turned off and on. The pulse rate increases, the "on time" decreases. Thus, if the output voltage is too high, the switching transistor is turned on and off at a faster rate.

3.4.9. Digital Logic gates

Logic gates perform basic logical functions and are the fundamental building blocks of digital integrated circuits. Most logic gates take an input of two binary values, and output a single value of a 1 or 0. Some circuits may have only a few logic gates, while others, such as microprocessors, may have millions of them. There are seven different types of logic gates, which are outlined below.

In the following examples, each logic gate except the NOT gate has two inputs, A and B, which can either be 1 (True) or 0 (False). The resulting output is a single value of 1 if the result is true, or 0 if the result is false.

3.4.10. Basic logic gates

There are seven basic logic gates: AND, OR, XOR, NOT, NAND, NOR, and XNOR.

1. **AND** - True if A and B are both True
2. **OR** - True if either A or B are True
3. **NOT** - Inverts value: True if input is False; False if input is True
4. **XOR** - True if either A or B are True, but False if both are True
5. **NAND** - AND followed by NOT: False only if A and B are both True
6. **NOR** - OR followed by NOT: True only if A and B are both False
7. **XNOR** - XOR followed by NOT: True if A and B are both True or both False

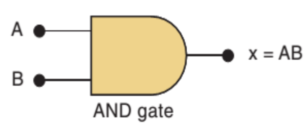
I. AND gate

The AND gate is so named because, if 0 is called "false" and 1 is called "true," the gate acts in the same way as the logical "and" operator. The following illustration and table show the circuit symbol and logic combinations for an AND gate. (In the symbol, the input terminals are at left and the output terminal is at right.) The output is "true" when both inputs are "true." Otherwise, the output is "false." In other words, the output is 1 only when both inputs one AND two are 1.

AND

A	B	x = A • B
0	0	0
0	1	0
1	0	0
1	1	1

(a)



(b)

FIG 3.4.10. AND gate (a) truth table (b) symbol

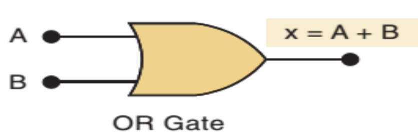
II. OR gate

The OR gate gets its name from the fact that it behaves after the fashion of the logical inclusive "or." The output is "true" if either or both of the inputs are "true." If both inputs are "false," then the output is "false." In other words, for the output to be 1, at least input one OR two must be 1.

OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

(a)



(b)

FIG 3.4.11. OR gate (a) truth table (b) symbol

III. XOR gate

The XOR (exclusive-OR) gate acts in the same way as the logical "either/or." The output is "true" if either, but not both, of the inputs are "true." The output is "false" if both inputs are "false" or if both inputs are "true." Another way of looking at this circuit is to observe that the output is 1 if the inputs are different, but 0 if the inputs are the same.

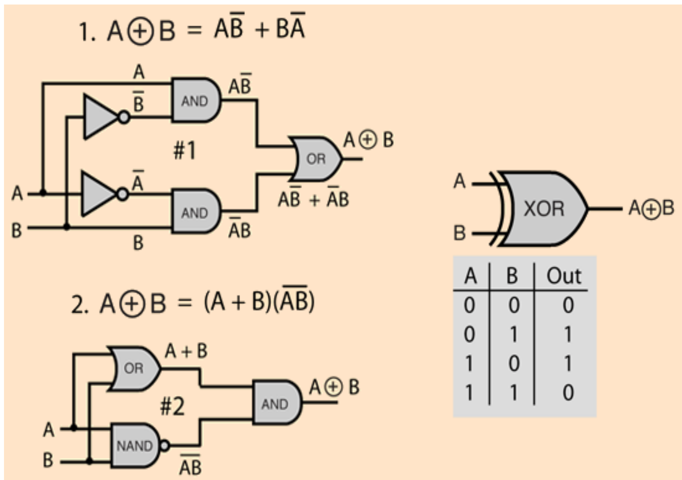


FIG 3.4.12 XOR gate (a) truth table (b) symbol

IV. Inverter or NOT gate

A logical inverter, sometimes called a NOT gate to differentiate it from other types of electronic inverter devices, has only one input. It reverses the logic state. If the input is 1, then the output is 0. If the input is 0, then the output is 1.

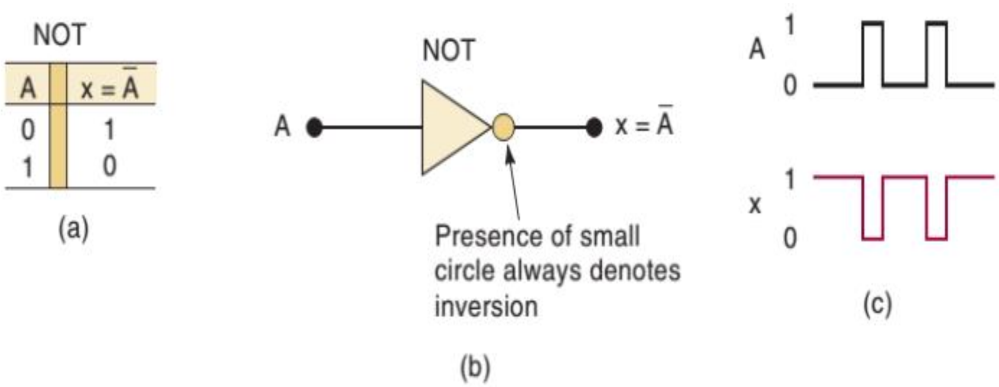
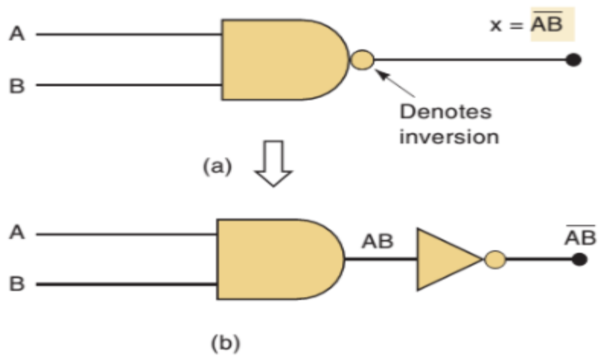


FIG 3.4. 13. NOT gate (a) truth table (b) symbol (c) output signal

V. NAND gate

The NAND gate operates as an AND gate followed by a NOT gate. It acts in the manner of the logical operation "and" followed by negation. The output is "false" if both inputs are "true." Otherwise, the output is "true."



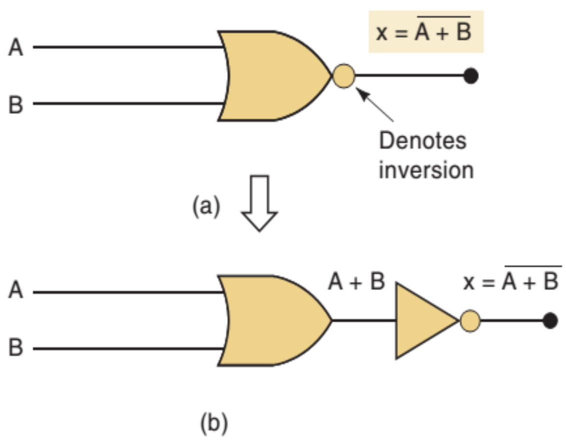
A	B	AND: AB	NAND: $\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

(c)

FIG 3.4.14. NAND gate (a&b) symbol (c) truth table

VI. NOR gate

The NOR gate is a combination OR gate followed by an inverter. Its output is "true" if both inputs are "false." Otherwise, the output is "false."



A	B	OR: A + B	NOR: $\overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

(c)

FIG 3.4.15. NOR gate (a) & (b) symbol (c) truth table

VII. XNOR gate

The XNOR (exclusive-NOR) gate is a combination XOR gate followed by an inverter. Its output is "true" if the inputs are the same, and"false" if the inputs are different.

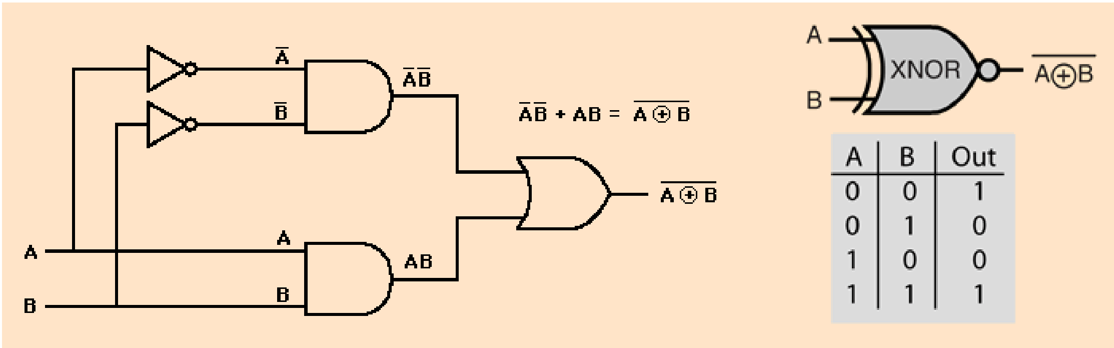


FIG 3.4.16. XNOR gate (a) truth table (b) symbol

3.4.11. Oscillator

An **oscillator** is a circuit which produces a continuous, repeated, alternating waveform without any input. Oscillators basically convert unidirectional current flow from a DC source into an alternating waveform which is of the desired frequency, as decided by its circuit components.

The basic principle behind the working of oscillators can be understood by analyzing the behavior of an LC tank circuit shown in Figure 1 below, which employs an inductor L and a completely pre-charged capacitor C as its components. Here, at first, the capacitor starts to discharge via the inductor, which results in the conversion of its electrical energy into the electromagnetic field, which can be stored in the inductor. Once the capacitor discharges completely, there will be no current flow in the circuit.

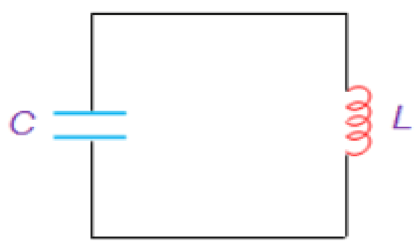


FIG 3.4.11. LC tank circuit

However, by then, the stored electromagnetic field would have generated a back-emf which results in the flow of current through the circuit in the same direction as that of before. This current flow through the circuit continues until the electromagnetic field collapses which result in the back-conversion of electromagnetic energy into electrical form, causing the cycle to repeat. However, now the capacitor would have charged with the opposite polarity, due to which one gets an oscillating waveform as the output.

However, the oscillations which arise due to the inter-conversion between the two energy-forms cannot continue forever as they would be subjected to the effect of energy loss due to the resistance of the circuit. As a result, the amplitude of these oscillations decreases steadily to become zero, which makes them damped in nature.

This indicates that in order to obtain the oscillations which are continuous and of constant amplitude, one needs to compensate for the energy loss. Nevertheless, it is to be noted that the energy supplied should be precisely controlled and must be equal to that of the energy lost in order to obtain the oscillations with constant amplitude.

This is because, if the energy supplied is more than the energy lost, then the amplitude of the oscillations will increase (Figure 2a) leading to a distorted output; while if the energy supplied is less than the energy lost, then the amplitude of the oscillations will decrease (Figure 2b) leading to unsustainable oscillations.

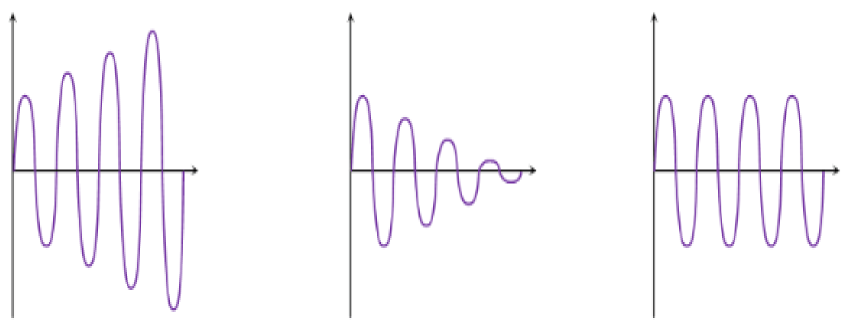


FIG 3.4.12. (a)Increasing oscillations (b)Decaying oscillations (c)Constant-Amplitude oscillation

Practically, the **oscillators** are nothing but the amplifier circuits which are provided with a positive or regenerative feedback wherein a part of the output signal is fed back to the input (Figure 3). Here the amplifier consists of an amplifying active element which can be a transistor or an Op-Amp and the back-fed in-phase signal is held responsible to keep-up (sustain) the oscillations by making-up for the losses in the circuit.

3.5. Correct sequence of operation.

3.5.1. Soldering/de-soldering method and techniques

If you were to take apart any electronic device that contains a circuit board, you'll see the components are attached using soldering techniques. Soldering is the process of joining two or more electronic parts together by melting solder around the connection. Solder is a metal alloy and when it cools it creates a strong electrical bond between the parts. Even though soldering can create a permanent connection, it can also be reversed using a desoldering tool as described below.

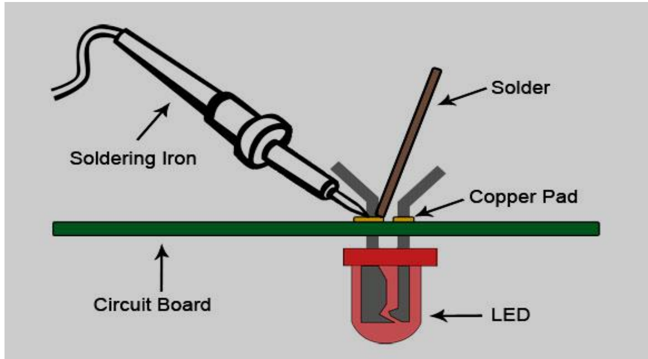


FIG. 3.5. De-soldering method and techniques

Soldering is a process in which two or more metal items are joined together by melting and then flowing a filler metal into the joint—the filler metal having a relatively low melting point. Soldering is used to form a permanent connection between electronic components.

The metal to be soldered is heated with a soldering iron and then solder is melted into the connection.

- Only the solder melts, not the parts that are being soldered.
- Solder is metallic "glue" that holds the parts together and forms a connection that allows electrical current to flow.
- You can use a solder less breadboard to make test circuits, but if you want your circuit to last for more than a few days, you will want to solder the components together.

A. Safety Precautions

- **Caution:** A soldering iron can heat to around 400°C, which can burn you or start a fire, so use it carefully.
- Unplug the iron when it is not in use.
- Keep the power cord away from spots where it can be tripped over.
- Take great care to avoid touching the tip of the soldering iron on a power line. If a power cord is touched by a hot iron, there is a serious risk of burns and electric shock.
- Always return the soldering iron to its stand when it is not in use.
- Never put the soldering iron down on your work bench, even for a moment!
- Work in a well-ventilated area.
- The smoke that will form as you melt solder is mostly from the flux and can be quite irritating. Avoid breathing it by keeping your head to the side of, not above, your work.
- Solder contains lead, which is a poisonous metal. Wash your hands after using solder.

3.5.2. **Preparation for Soldering**:

A. Warm-up

Allow the soldering iron to reach adequate temperature. The recommended temperature setting is between 600 and 750° F. Some tips may have recommended operating temperatures that should be observed.

B. Clean Tip

A clean tip promotes heat transfer and helps to prevent unwanted "solder bridges" from forming. A heavily oxidized tip will make it impossible to solder properly.

The steps to maintain clean tips are as follows:

- Moisten sponge.
- Wipe tip on sponge.
- "Wet" tip with solder – just enough for a very thin coating.
- Repeat if necessary to obtain a clean, shiny tip surface. Also, repeat between each solder operation to maintain a clean tip (See Figure 3).

FIG 3.5.1. A properly cleaned and "wetted" soldering iron tip.

C. Tinning the Tip

Before you can start soldering, you need to prep your soldering iron by tinning the tip with solder. This process will help improve the heat transfer from the iron to the item you're soldering. Tinning will also help to protect the tip and reduce wear.

Step 1: Begin by making sure the tip is attached to the iron and screwed tightly in place.

Step 2: Turn on your soldering iron and let it heat up. If you have a soldering station with an adjustable temp control, set it to 400′ C/ 752′ F.

Step 3: Wipe the tip of the soldering iron on a damp wet sponge to clean it. Wait a few seconds to let the tip heat up again before proceeding to step 4.

Step 4: Hold the soldering iron in one hand and solder in the other. Touch the solder to the tip of the iron and make sure the solder flows evenly around the tip.

You should tin the tip of your iron before and after each soldering session to extend its life. Eventually, every tip will wear out and will need replacing when it becomes rough or pitted.

The steps of preparing circuits for connection and soldering are:

- Material and equipment selection
- Placing the components in the project board according to the design of the circuit removing the insulation of wires

D. Construction and Soldering Techniques

3. Component mounting. Components are pushed through from the top side of the board and the leads are bent slightly to hold the component while soldering.
4. Components are then soldered to the board as shown in Figures 4.
   a. The soldering iron tip should be placed in contact with both the trace (foil)and the lead. The two should be heated only enough to melt solder in order to avoid damaging sensitive components and to avoid delaminating of the PCB traces.
   b. Solder is then touched to the area and allowed to flow freely around the lead and to cover the solder pad. A minimal amount of solder should be applied. Only enough solder to cover the joint and to form a smooth fillet should be used.
   c. The iron should be removed after the solder has flowed properly and wetted all surfaces. The component and the board should not be moved until the solder has hardened (up to several seconds, depending on the lead and trace

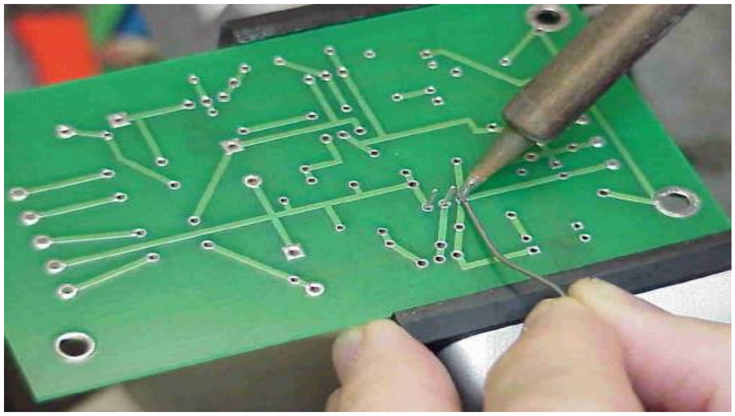
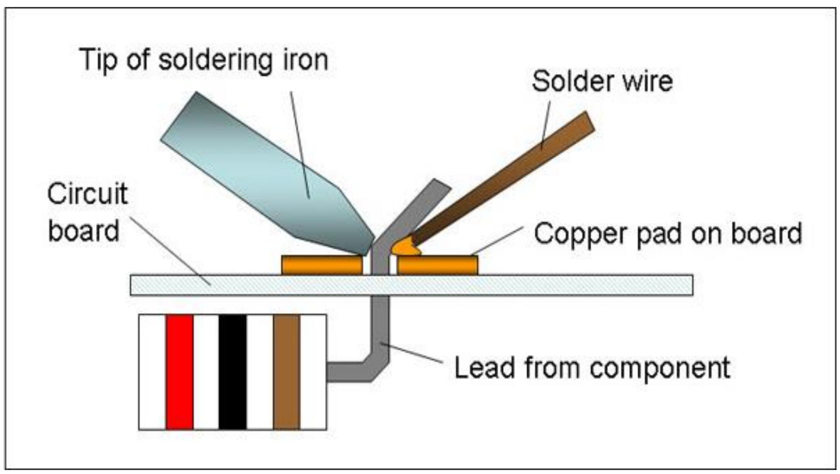


Figure 3.5.2. Soldering a component to a PCB

E. Good soldering and Bad soldering Joints

Here are some example of Good soldering and Bad soldering joint.



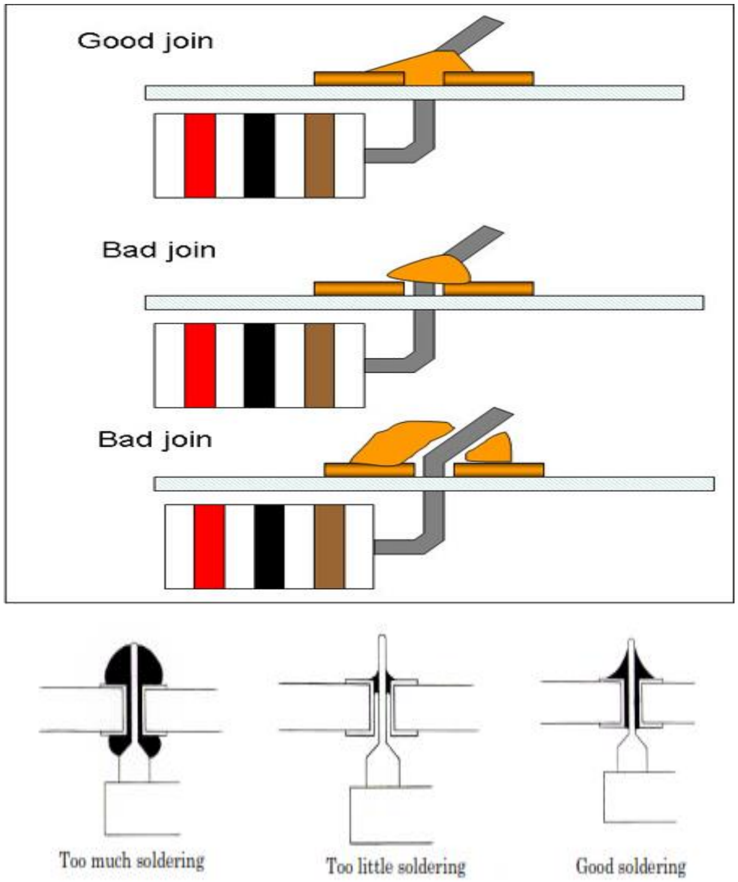
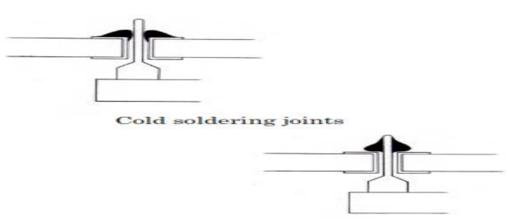


Fig. 3.5.3. Good soldering technique's

F. **Cold Solder joints:** A cold joint is a joint in which the solder does not make good contact with the component lead or printed circuit board pad. Cold joints occur when the component lead or solder pad moves before the solder is completely cooled. Cold joints make a really bad electrical connection and can prevent your circuit from working.

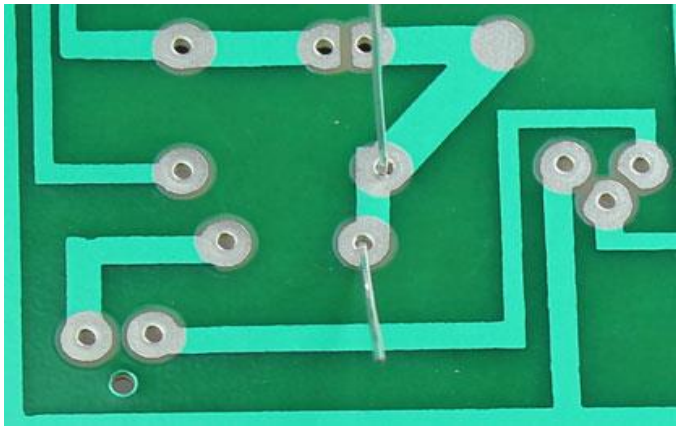
Cold joints can be recognized by a characteristic grainy, dull gray color, and can be easily fixed. This is done by first removing the old solder with a Disordering tool or simply by heating it up and flicking it off with the iron. Once the old solder is off, you can re-solder the joint, making sure to keep it still as it cools.



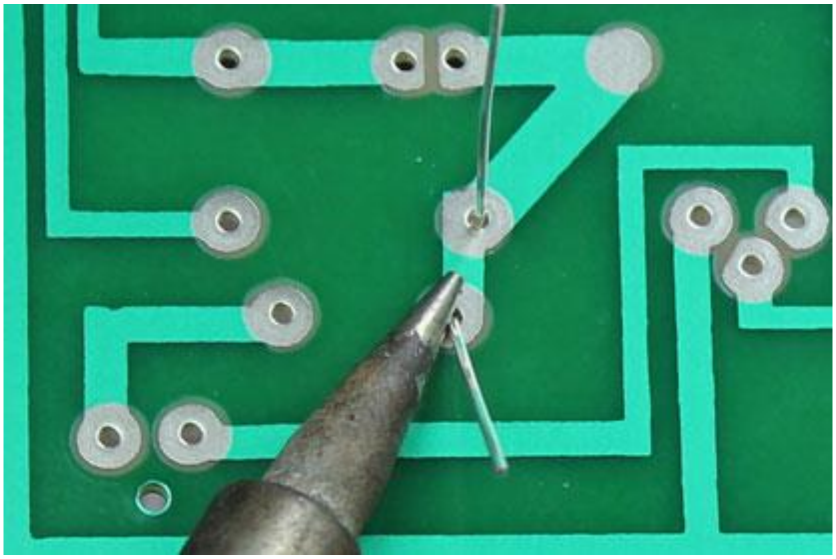
How to Solder

To better explain how to solder, we're going to demonstrate it with a real world application. In this example, we're going to solder an LED to a circuit board.

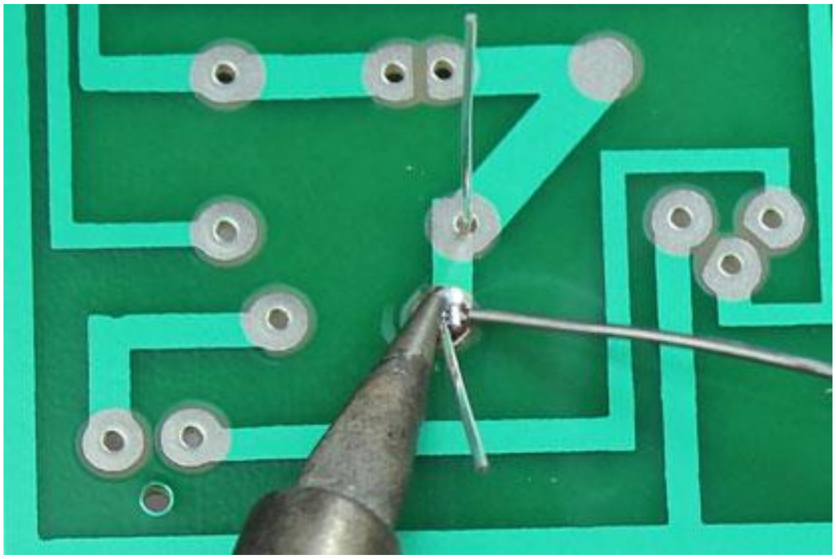
Step 1: Mount the Component – Begin by inserting the leads of the LED into the holes of the circuit board. Flip the board over and bend the leads outward at a 45′ angle. This will help the component make a better connection with the copper pad and prevent it from falling out while soldering.



Step 2: Heat The Joint – Turn your soldering iron on and if it has an adjustable heat control, set it to 400'C. At this point, touch the tip of the iron to the copper pad and the resistor lead at the same time. You need to hold the soldering iron in place for 3-4 seconds in order to heat the pad and the lead.

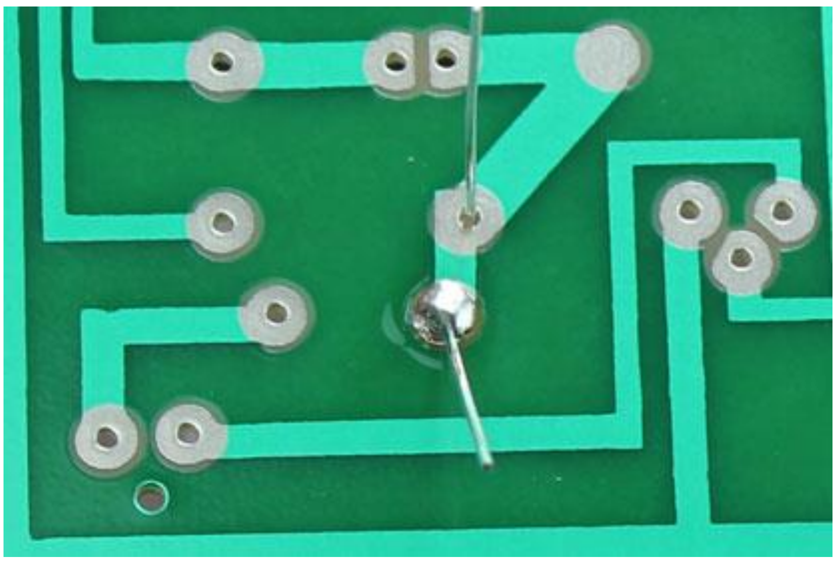


Step 3: Apply Solder To Joint – Continue holding the soldering iron on the copper pad and the lead and touch your solder to the joint. **IMPORTANT** – Don't touch the solder directly to the tip of the iron. You want the joint to be hot enough to melt the solder when it's touched. If the joint is too cold, it will form a bad connection.



Step 4: Snip The Leads – Remove the soldering iron and let the solder cool down naturally. Don't blow on the solder as this will cause a bad joint. Once cool, you can snip the extra wire from leads.

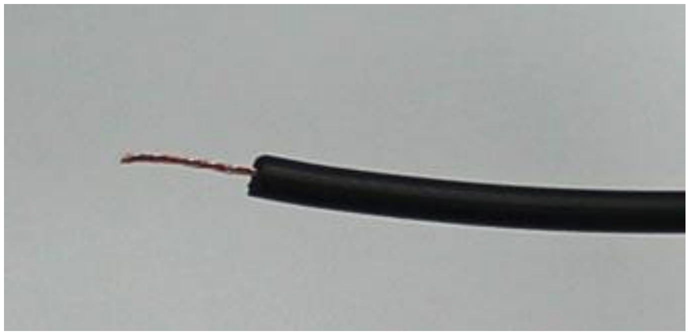
A proper solder joint is smooth, shiny and looks like a volcano or cone shape. You want just enough solder to cover the entire joint but not too much so it becomes a ball or spills to a nearby lead or joint.



- **How To Solder Wires**

Now it's time to show you how to solder wires together. For this process, it's recommended to use helping hands or other type of clamp device.

Begin by removing the insulation from the ends of both wires you are soldering together. If the wire is stranded, twist the strands together with your fingers.



Make sure your soldering iron is fully heated and touch the tip to the end of one of the wires. Hold it on the wire for 3-4 seconds.

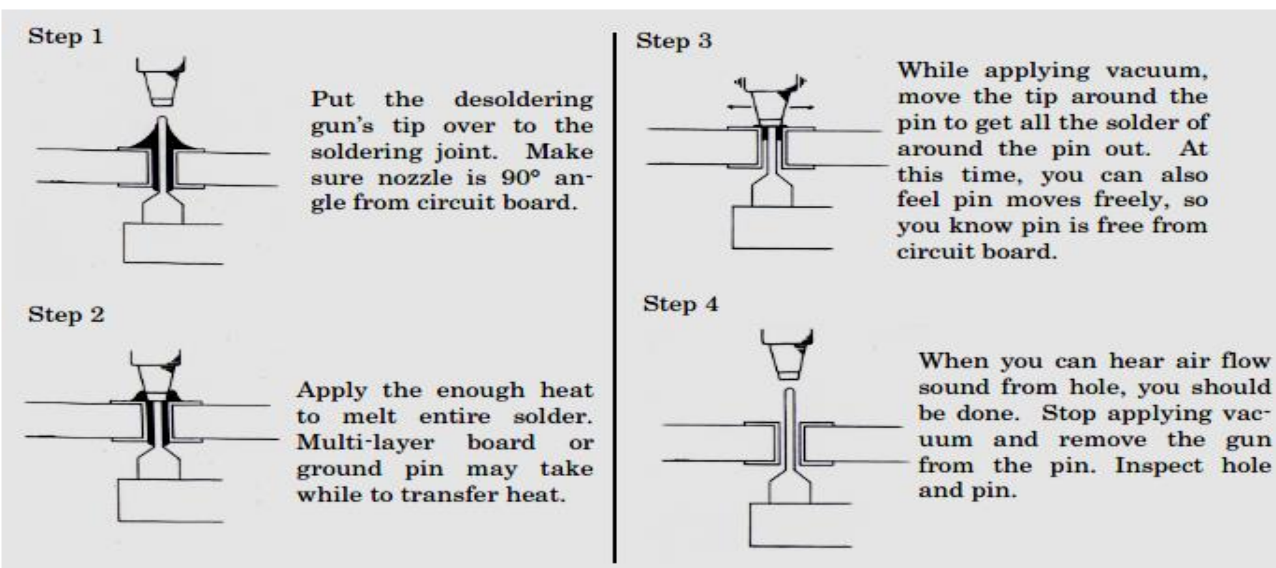
Keep the iron in place and touch the solder to the wire until it's fully coated. Repeat this process on the other wire.

Hold the two tinned wires on top of each other and touch the soldering iron to both wires. This process should melt the solder and coat both wires evenly.

Remove the soldering iron and wait a few seconds to let the soldered connection cool and harden. Use heat shrink to cover the connection.

3.5.3. De soldering

De soldering is removing the solder from a joint and components from a circuit board for troubleshooting, repair and replacement. De-soldering is required when electronic components need to be removed from circuit, usually because they are faulty. It may sometimes be necessary during testing or assembly, if a wrong part has been fitted or a modification has to be made. In the field, it's not uncommon for faulty electronic components to be swapped out, or poor joints(perhaps "dry" or gray joints) to need re-making properly, months or years after manufacture.



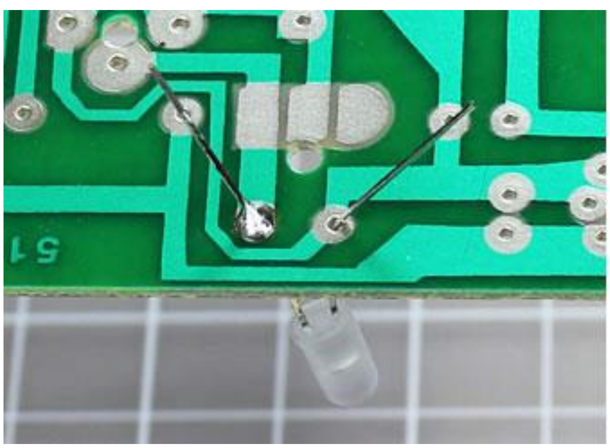
When you done with Desoldering, the parts that you are trying to remove should move freely. Ifit doesn't, find which pin is still has solder left, and re-apply fresh solder to it and try Desoldering process again. The multi-layer circuit board requires more heat to get solder to melt. Make sure pin start to move freely by moving the tip of soldering gun before you apply vacuum to it.

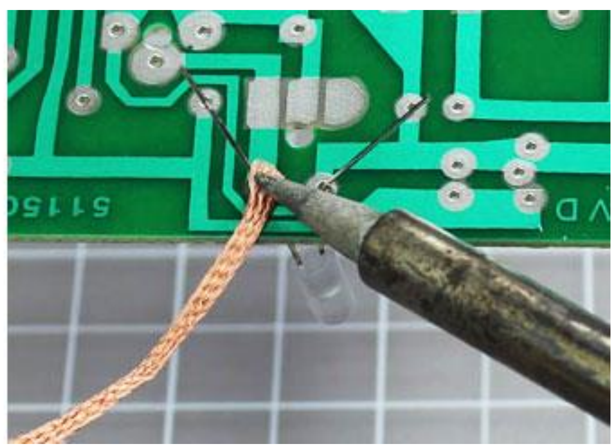
Desoldering using desoldering braid

To de-solder a joint, you will need solder wick which is also known as desoldering braid.

Step 1 – Place a piece of the de-soldering braid on top of the joint/solder you want removed.

Step 2 – Heat your soldering iron and touch the tip to the top of the braid. This will heat the solder below which will then be absorbed into the de-soldering braid. You can now remove the braid to see the solder has been extracted and removed. Be careful touching the braid when you are heating it because it will get hot.





3.6. Adjusting Accessories used, if necessary

Desoldering in theory should utilize the same temperatures as soldering. Flux present during soldering helps reduce the required temperature. The same is true for desoldering, apply some flux to remove contaminants.

The melting point (per Weller) for various solder compositions is as follows:

Tin/Lead	Melting Point °C (°F)
40/60	230 (460)
50/50	214 (418)
60/40	190 (374)
63/37	183 (364)
95/5	224 (434)

Please note, these temperatures are melting points, ***not*** recommended soldering or desoldering iron temperatures.

Most guides recommend starting with the lowest temperature that will work in a short amount of time. This is a matter of opinion, but generally no less than 260°C (500°F).

The following factors will greatly affect de-soldering performance:

- The type of solder used (lead-free requires higher temperatures)
- The age of the board and amount of contamination
- The number of layers in the board
- Size of ground/power/thermal planes connected to joint being desoldered
- Mass of component, leads, heat sink, etc.

For example, desoldering a small through-hole component with small traces on a 2-layer board is much easier than desoldering the same component on a multi-layer board with large copper pours connected to the component. A larger component with more mass will require more time or more heat.

Think of it this way, if you set your temperature to 370°C (700°F) (a starting temperature recommended by Weller), the mass of solder and copper closest to the iron tip will heat quickly, but it will take some time for that heat to spread. If you are desoldering something with a heat sink or a ground plane, the extra mass will conduct heat away from the area of interest, and you must either apply the iron for a longer duration, or increase the temperature. The danger is that you may damage components if you exceed their temperature tolerance.

The Hakko 808 desoldering gun (which I use) ranges from 380-480°C (715-895°F). It does a remarkable job for most things, but I've occasionally needed to preheat a board for stubborn components that have a lot of mass or are connected to a heat sink.

Your temperature selection of 400°C (750°F) seems good. You could start at a lower temperature since you have the option, depending on the above factors.

3.7. Undertaking confirmation of construction successfully

Once the joint is made you should inspect it. Check for cold joints (described a little above and at length below), shorts with adjacent pads or poor flow. If the joint checks out, move on to the next. To trim the lead, use a small set of side cutters and cut at the top of the solder joint. After you have made all the solder joints, it is good practice to clean all the excess flux residue from the board. Some fluxes are hydroscopic (they absorb water) and can slowly absorb enough water to become slightly conductive. This can be a significant issue in a hostile environment such as an automotive application. Most fluxes will clean up easily using methyl hydrate and a rag but some will require a stronger solvent. Use the appropriate solvent to remove the flux, then blow the board dry with compressed air.

3.7.1. Common Problems and Troubleshooting

A. Solder will not flow.
  - The parts to be joined may be dirty. Remove the solder and clean the parts.

B. The connection looks grainy or crystalline.
  - Parts were moved before the solder was allowed to cool.
  - Reheat to form a good joint. You may need a larger soldering iron to heat connections adequately.

C. The tip is oxidized.
  - Soldering is much easier with a shiny, clean tip.
  - Clean the tip with a damp synthetic sponge while the iron is hot.
  - To avoid oxidizing the tip, do not leave the iron plugged in when not in use.
  - Do not use the iron at a higher temperature than is necessary to melt solder.
  - Clean the tip of the iron on a damp synthetic sponge as soon as it starts to change from a silver color.

D. There is too much or too little solder.

- Using too much solder can cause a solder bridge, which means that two adjacent joints are accidentally connected.
- Using too little solder might result in poor electrical continuity between the board and component. The connection should be smooth, shiny, and rigid

Self-Check -3.1

Test I: <u>short Answer writing</u>

Instruction: write short answer for the given question. You are provided 4 minute for each question and each point has 5 Points.

1. ____________________________ Is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated Distinguish the difference between the half wave and full wave rectifier.
2. What is active and passive components mean?
3. Write the difference between active and passive components and give an example for both.
4. Write the steps to follow when preparing PCB for electrical electronic circuit construction (both using CAD software and manually)

Test II: <u>Chose the best Answer from the give alternative</u>

1. An AC power supply typically takes the voltage from the mains supply and lowers it to the desired voltage. It is also known as _____________-

A Filter circuits B. Rectifiers: C. DC power Supply D. unregulated power supply

2. __________is to provide the necessary DC voltage and current, with low levels of AC ripple and with a good stability and regulation

A DC power Supply B. Rectifiers C. Filter circuits D. unregulated power supply

3. ____________ is usually included stepping the ac line voltage up or down depending on the exact needs of the electronic circuits.

A Filter circuits B. unregulated power supply C. a transformer D. Rectifiers

4. ______________ used to convert alternating current (ac) to direct current (pulsating dc), which is unidirectional current that supplied to the filter circuit as an input.

A Filter circuits B. unregulated power supply C. a transformer D. Rectifiers

Test III: <u>Say True or False</u>

1. All source of power supply have internal resistance
2. **SMPS** are always regulated to keep the output voltage constant
3. Power supply employs a feedback controller that monitors current drawn by the load.
4. width of the pulse is increased, the switching transistor stays on longer

Operation Sheet 3. 1: Constructing electrical /electronic circuits on PCB by using Soldering Techniques

Operation title: Procedures of constructing electrical /electronic circuits on PCB

Purpose: To practice and demonstrate the knowledge and skill required design and construct printed circuit board (PCB) to construct electrical/electronic Components.

Instruction: Use the given select tools, equipment and electronic components so that construct is usually done by preparing your circuit's schematic diagram layout using PCB layout software. For this operation you have given 5 Hour and you are expected to provide the answer on the given steps.

Step 1 - Prepare Safety Materials

Step 2 - Mount the Component

Step 3 - Plug in the Soldering Iron

Step 4 - Use the Solder Wick

Step 5 - Heat the Joint

Step 6 - Apply Solder To Joint

Step 7 - Snip the Leads –

Step 8 - Cut the Wick

Step 9 - Clean Up

Tools and requirement:

- Soldering flux
- Soldering iron
- Soldering gun
- Lead
- PCB
- Electronic components (passive and active)
- IC, S
- blade cutter,
- sandpaper,
- sponge etc-----)

LAP Test – 3.1.

Instructions: Given necessary templates, tools, materials and equipment you are required to perform the PCB design for the following tasks within 5 hour.

Task -1: Prepare PPE material for starting construction electrical/electronics.

Task – 2: select appropriate components according to the give designed circuit to be constructed.

Task – 3: prepare Components are pushed through from the top side of the board

Task – 4: Plug the soldering iron into the outlet and wait for it to reach a working temperature

Task – 5: Turning your soldering iron on and if it has an adjustable heat control, set it to 400^0C.

Task – 6: holding the soldering iron on the copper pad and the lead and touch your solder to the joint.

Task – 7: Removing the soldering iron and let the solder cool down naturally.

Precautions: select necessary templates, tools, materials and equipment before constructing electrical /electronic circuit on PCB t on the given format

Quality Criteria: the given constructing electrical /electronics circuit on PCB is with Correct specification

Unit Four: Test electrical/ electronic circuits on PCB

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Conduct PCB test
- Accurate operation of the constructed circuit.
- Unintended events or conditions.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Conduct test Of final constructed
- Check the accurate operation of the construction of electrical/ electronic circuits on PCB.
- Respond unplanned events or conditions.

4.1. Conducting test

4.1.1. How conduct to test a circuit PCB

Key Points:

A list of basic tools for circuit board testing.

Learn various ways to test a circuit board.

Explore PCB optimization ideas to aid future testing.

Fig. 4.1. Digtal multi-meter

A multi-meter is a must-have tool for circuit board testing.

The same confidence is reflected during times when I need to test a circuit board. While there's no steering wheel involved, I have other tools that help in identifying faults in the circuit. It can be a struggle but when you have a systematic test procedure you're bound to locate the fault eventually.

4.1.2. Tools You'll Need to Test a Circuit

You'll need to be well prepared before testing a circuit. Here's a checklist of basic tools you should have:

- Analog/Digital multi-meter.
- Soldering gun.
- De-soldering station.
- Magnifying glass.

These are tools that will solve common problems like short circuits, broken traces, or faulty components.

4.1.3. how to test a circuit board that stops working

A. Start with a Visual Inspection

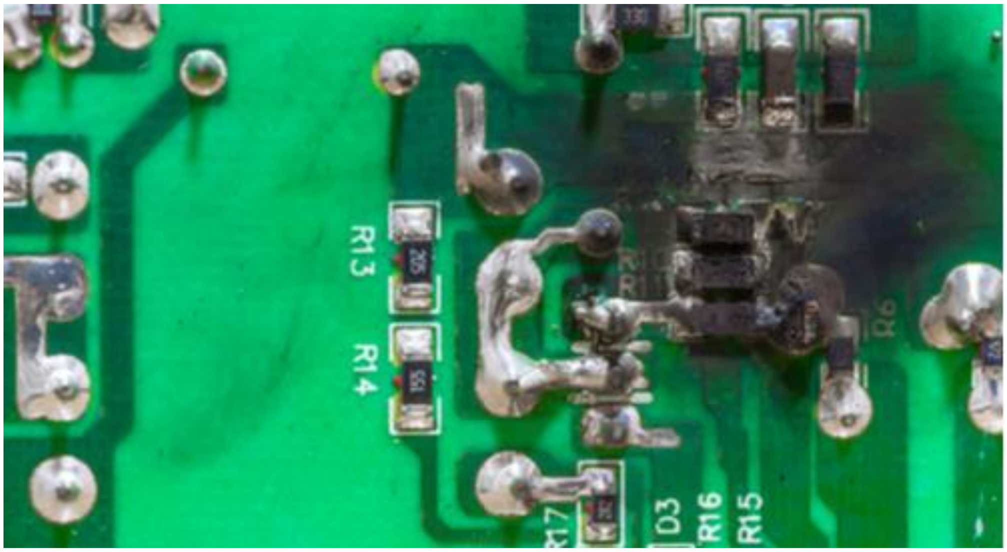


Fig. 4.1.3. Look for burnt components during your visual inspection.

When a circuit board suddenly stops working, there are sometimes obvious signs of what went wrong. You'll need to rely on your vision to spot faulty components or broken traces. Often, circuit boards deployed in the field are damaged by electrical surges and there are telltale signs on the PCB. Look for a burnt spot, particularly on the power supply module or I/O and connectivity ports. Pay attention to cracked ICs, broken traces, and blown capacitors. Sometimes, you could trace the damaged components by their acrid scent.

4.1.4. Check the Power Module

If the components look fine, you'll need to power up the circuit board. Measure the voltage of the power rails with the multi-meter. Both the input and output of the voltage regulator need to show the expected values. Check the fuse if the input voltage measured at the voltage regulator is 0V. If the fuse is replaced and immediately breaks after power-up, it means other components are shorted and draining a huge amount of current.

A voltage of 0V, or below Vcc, at the output often means that the regulator or a component along the voltage rail has a short circuit. If that's the case, the damaged component will heat up quickly. Bring your hand close to the components to feel if one is giving off excessive heat. Be careful to not directly touch the component when it's powered on, as it can be extremely hot. Remove the overheated components and confirm that the voltage has returned to the expected value. If voltage observed is still different than the expected voltage, there could be more components that are damaged down the voltage line. Refer to the schematic and remove the next component that is near the edge of the PCB. If there aren't signs of overheated components then look for broken traces. A broken trace could result in the voltage being detected at some points of the trace but not in others. Use your multi-meter to narrow down where the discontinuity is.

4.1.5. Check the Input/output Ports

The I/O are also common points of failure. Damage on I/O ports seldom shuts down the whole circuit, but it usually results in anomalies in the system. For example, an alarm controller that always senses an open door even if it's closed or a motor that is continuously activated. If the I/O is protected by fuses, Zener diodes, or varistors, ensure that they are functioning well. If so, the logic IC or the microcontroller is likely damaged. The only way to find out is to replace the parts with good ones.

- **Check Communication Ports**

Circuit boards with communication ports like Ethernet and RS485 have an increased risk of failure. When communication failure is detected, check for burns or cracked communication ICs or protective components like Zeners. Optimizing Circuit Boards for Troubleshooting

4.1.6. Functional test

In this test method electrical signals typical of the operation of the circuit are applied to the connectors on the PCB. The responses to these signals are recorded and compared to the correct response.

- Advantages of functional test:
  - The components are tested in their operating environment.
  - Design faults may be found.
  - Timing problems may be found.
- **Disadvantages of functional testing**:
  - Necessary software development is time consuming.
  - Requires highly skilled personnel.
  - Will normally not localize the fault.
  - Long testing time.
  - New faults may be generated in the test.

- Limited fault coverage.

A. In-circuit test

In this test method each component is tested individually with test probes. Neighboring components must be isolated by guarding techniques in analogue circuits or latching in digital circuits [6.3].

- **Advantages of in-circuit testing:**
  - Short testing time: The test localizes the fault.
  - Many faults may be found simultaneously.
  - Less time consuming software development.
  - The PCB does not need to be powered up, and the danger of generating faults by the test is reduced.
- **Disadvantages:**
  - Time consuming test.
  - The interactions between components are not tested.
  - Require expensive test fixture.
  - Access to all nodes in the circuit is necessary.

The circuit complexity and production volume are important factors in the decision of test method. Therefore the typical extra board area needed for the test points for in circuit testing is less than 5 %, and the cost of area is rarely an important argument against in-circuit test. A combination of the two methods is also common: Smaller functional blocks may be functionally tested, and critical components may be in circuit tested.

4.2. Check the accurate operation of the constructed circuit

There are various factors that determine the quality of the power supply like the load voltage, load current, voltage regulation, source regulation, output impedance, ripple rejection, and so on. Some of the characteristics are briefly explained below:

- **Load Regulation** – The load regulation or load effect is the change in regulated output voltage when the load current changes from minimum to maximum value.

Load regulation = $V_{no\text{-}load}$ - $V_{full\text{-}load}$

Vno-load refers to the Load Voltage at no load

Vfull-load refers to the Load voltage at full load.

From the above equation we can understand that when Vno-load occurs the load resistance is infinite, that is, the out terminals are open circuited. Vfull-load occurs when the load resistance is of the minimum value where voltage regulation is lost.

% Load Regulation = $[(V_{no\text{-}load} - V_{full\text{-}load})/V_{full\text{-}load}] * 100$

4.1.5. **Minimum Load Resistance** – The load resistance at which a power supply delivers its full-load rated current at rated voltage is referred to as minimum load resistance.

Minimum Load Resistance = $V_{full\text{-}load}/I_{full\text{-}load}$

The value of Ifull-load, full load current should never increase than that mentioned in the datasheet of the power supply.

- **Source/Line Regulation** – In the block diagram, the input line voltage has a nominal value of 230 Volts but in practice, here are considerable variations in ac supply mains voltage. Since this ac supply mains voltage is the input to the ordinary power supply, the filtered output of the bridge rectifier is almost directly proportional to the ac mains voltage.

The source regulation is defined as the change in regulated output voltage for a specified rage of lie voltage.

- **Output Impedance –** A regulated power supply is a very stiff dc voltage source. This means that the output resistance is very small. Even though the external load resistance is varied, almost no change is seen in the load voltage. An ideal voltage source has an output impedance of zero.
  - **Ripple Rejection –** Voltage regulators stabilize the output voltage against variations in input voltage. Ripple is equivalent to a periodic variation in the input voltage. Thus, a voltage regulator attenuates the ripple that comes in with the unregulated input voltage. Since a voltage regulator uses negative feedback, the distortion is reduced by the same factor as the gain.

4.3. Responding unplanned events or conditions

A. Electrical Hazard

The risk of an electrical hazard has the potential to interact with terrestrial environment and socioeconomic environment.

Live high voltage conductors pose the risk of injury or death to individuals or wildlife if contacted directly or indirectly. Mitigation measures to minimize the risk of electrical injuries to those in or proximate to a power transmission corridor are not generally a requirement for land-based transmission, given the height of conductors. Downed conductors can allow for the potential interaction of live electrical cables with personnel or wildlife in the area. Unauthorized access to secure locations can also put individuals at risk of electrocution. Avifauna can also interact with high voltage conductors by landing on and touching energized conductors and grounded hardware at the cable riser stations and can become electrocuted in certain circumstances.

4.3.1. Risk Management and Mitigation

The following mitigation measures will be applied to reduce the probability of an electrical hazard and associated environmental effects.

- During the operation phase of the Project, Project components will be inspected periodically and repaired as required.
- Safe operating procedures will be established for all work activities, both during the construction and operation phases of the Project.
- NB Power’s safety and environmental policies will be followed.
- Proper signage and public warning will be installed around project land-based components/facilities (e.g., “High Voltage”).
- Access to the work site during construction and energizing activities will be limited to NB Power and their consultants and required contractor crews.

- Physical safeguards such as security fences surrounding facilities will be implemented.
- Access to facilities will be restricted to authorized personnel only.
- The use of appropriate down lighting will be incorporated around Project components (e.g., cable riser stations) to discourage vandalism and loitering.

4.3.2. Potential residual environmental effects and their significance

If an electrical hazard incident were to occur, the terrestrial environment and socioeconomic environment could be affected.

As the submarine cables will be buried in the near shore environment (i.e., between the shore and the cable riser stations) and the cable riser stations will be fenced in, the probability of an electrical hazard incident is low because there is limited opportunity for individuals or wildlife to be exposed to them.

Therefore, potential environment effects arising from electrical hazards on the terrestrial or socioeconomic environments are not anticipated to be substantive.

In consideration of the buried nature of the cables in areas accessible to the public and wildlife, and in light of the mitigation to be implemented, the residual environmental effects of an electrical hazard during all Project phases are rated not significant for all potentially affected VCs. This determination is made with a high level of confidence. There is the potential that a protected species or person could be harmed or even killed were they to come in contact with the energized electrical components of the Project, and this would represent a significant residual environmental effect; however, given the safeguards in place, this is a highly unlikely scenario. Consequently, a significant environmental effect arising from this possibility is also considered to be unlikely to occur.

Self-Check – 4.1.

Test I: short Answer writing

Instruction: write short answer for the given question. You are provided 4 minute for each question and each point has 5 Points.

1. What are the factors that affect the quality of the power supply? List at list four of them and explain.
2. Discuss on unplanned events or conditions caused during construction of electrical/electronic circuit.
3. Write at list three advantage and disadvantage of functional testing.
4. Write at list three advantage and disadvantage of in-circuit testing.

Test II: Say True or False

1. Voltage regulators stabilize the output voltage against variations in input voltage.
2. Ripple is equivalent to a periodic variation in the input voltage
3. A regulated power supply is a very stiff dc voltage source
4. The load regulation is the change in regulated output voltage when the load current changes from minimum to maximum value

Test III: Choose the best answer from the given alternative below.

1. Which one is the following is the advantages of functional test:

   A. Timing problems may be found B. Long testing time

   C. New faults may be generated in the test D. Limited fault coverage

2. Which one is the following is NOT the disadvantages of functional test:

   A. Timing problems may be found B. Long testing time

   C. New faults may be generated in the test D. Limited fault coverage

Operation Sheet 4. 1: Test the construction of electrical/ electronic circuits

Operation title: Procedures of testing the construction of electrical/ electronic circuits

Purpose: To practice and demonstrate the knowledge and skill required test the constructed electrical/ electronic circuits.

Instruction: Use the given select tools, equipment and electronic components so that to be conducting testing the construction of electrical/ electronic circuits is usually done by preparing your test instruments . For this operation you have given 2 Hour and you are expected to provide the answer on the given steps.

STEP 1: Select the testing equipment.

STEP 2: Testing the continuity of construction of electrical/electronic circuit.

STEP 3: Testing short and open circuit.

STEP 4: Testing the Input and output voltage.

STEP 5: Test the conduct of electrical/electronic circuit.

Tools and requirement:

- FeCl3 powder/solution (same as etching solution),
- photo/glossy paper, permanent black marker,
- blade cutter,
- sandpaper,
- kitchen paper and
- Cotton wool.
- Laser printer
- Copper clad board
- Scotch pads or fine steel wool
- Laminator
- Ferric chloride or ammonium per sulfate
- Plastic or glass tray
- Sharply marker
- Drill press
- Wire gauge drill bits
- Magazines

LAP Test – 4.1.

Instructions: Given necessary templates, tools, materials and equipment you are required to conducting testing the construction of electrical/ electronic circuits for the following tasks within 2 hour.

Task 1: Conduct testing of the completed construction of electrical/electronic circuits.

Task 2: Check the accurate operation of the constructed circuit

Task 2: Respond to unplanned events or conditions.

Precautions: select necessary templates, tools, materials and equipment before conducting testing the construction of electrical/ electronic circuits on the given format.

Quality Criteria: the given conducting testing the construction of electrical/ electronic circuits is with Correct measured value of input and out puts

List Of Reference Materials

1. Reference Designations for Electrical and Electronics Parts and Equipment: ASME Y14.44-2008 : Section 2.1.5.3 (2). ASME, Fairfield, NJ. 2008.
2. 2) Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters): IEEE-315-1975 (Reaffirmed 1993): Section 22. IEEE and ANSI, New York, NY. 1993.
3. 3) Reference Designations for Electrical and Electronics Parts and Equipment: ASME Y14.44-2008 : Section 2.1.5.3 (1). ASME, Fairfield, NJ. 2008.
4. 4) The Art of Electronics, 2nd Edition, p56. Cambridge University Press. 1989.
5. 5) https://smallbusiness.chron.com/workplace-safety-43459.html
6. 6) http://examradar.com/logic-gates/
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9. http://s1.nonlinear.ir/epublish/book/Electronic_Troubleshooting_0071819908.pdf
10. https://www.clemson.edu/cecas/departments/ece/document_resource/undergrad/electronics/CInquiryLabManual.pdf
11. https://www.youtube.com/watch?v=GW_-ycgJXhg
12. https://www.youtube.com/watch?v=s9g-I3t_Ki8&t=20s
13. https://www.youtube.com/watch?v=i4jTHhXuKLA&t=25s
14. https://www.youtube.com/watch?v=gkeJzRrwe5k

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