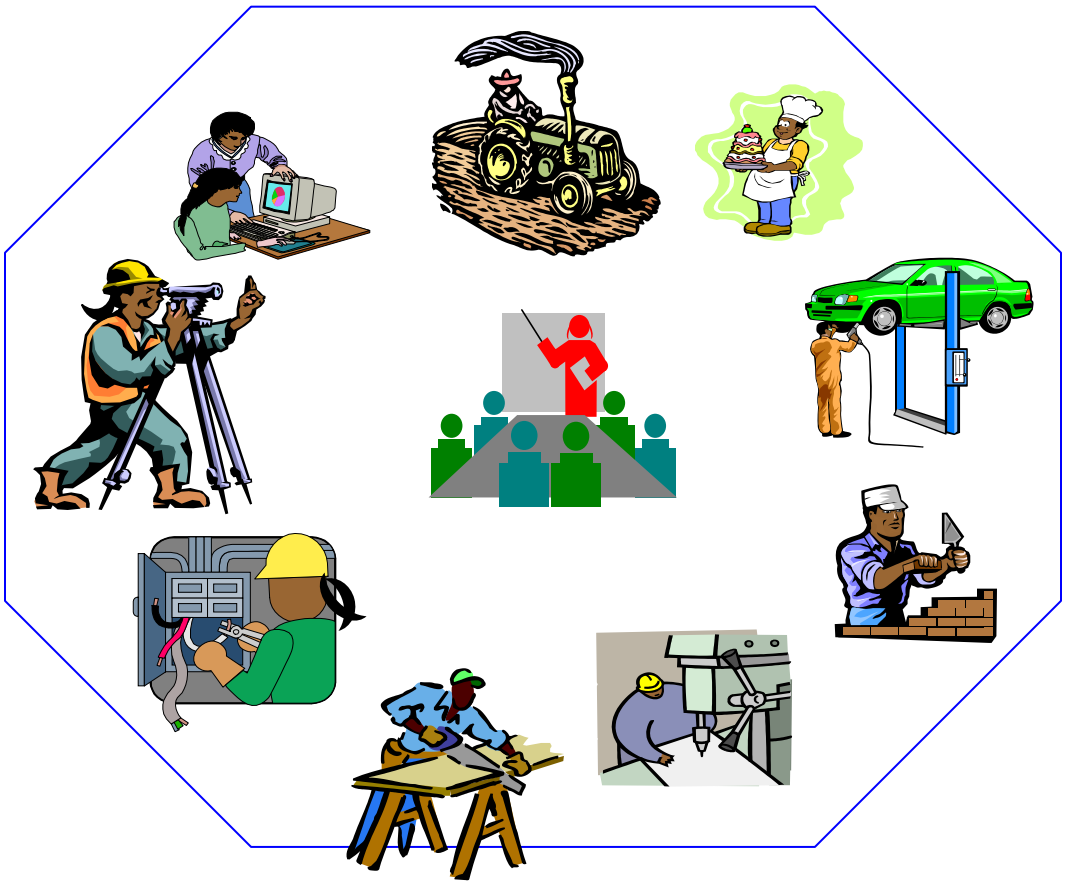
Intermediate Communication and Multimedia Equipment Servicing Level III

Based on May, 2011 V2 OS and Dec, 2020 V1 Curriculum



Module Title: Developing Basic Electronic System Design

LG Code: EEL CMS3 M06 LO (1-4) LG (18-21)

TTLM Code: EEL CMS3 TTLM 1120V1

December, 2020

Bishoftu, Ethiopia

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LG #18	LO #1- Prepare to Develop Basic Electronics System Design

Instruction sheet

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

- Identifying , obtaining OHS policy and procedures
- Reviewing established procedures for project planning
- Adapting established procedures
- Determining the extent of proposed project development
- Planning project work to meet schedule time lines
- Selecting resources based on compatibility with project requirements and budget constraints

This guide will also assist you to attain the learning outcome stated. Specifically, upon completion of this Learning Guide, you will be able to:

- Identify, obtain OHS policy and procedures
- Review established procedures for project planning
- Adapt established procedures
- Determine the extent of proposed project development
- Plans project work to meet schedule time lines
- Select resources based on compatibility with project requirements and budget constraints

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information's
4. Accomplish the "Self-checks

Information Sheet 1: Identifying, Obtaining OHS policy and Procedures

1.1. Identifying, obtaining OHS policy and procedures

Introduction

The occupational health and safety is about providing safety and health measures in different work environments and sectors. It is an area that is concerned with the health, safety, as well as welfare of people engaged in any organization. Every kind of work exposes individuals to a number of hazards, for instance, dangerous machinery, loads that have to be manually handled, electricity, toxic substances, working with display screen tools, risk of fire, or even psychological hazards like stress. It might seem obvious, but management of health and safety in the workplace is very important because along with protecting employees, it also increases productivity when employees are healthy and happy. OHS (Occupational safety and health) is important for legal, economic, and moral reasons.

Three steps think safe steps:

1. Spot the hazards

A hazard is anything that could hurt you or someone else.

Figure 1.1: Avoid Hazards

2. Assess the risk

It means working out how likely it is that a hazard will harm someone and how serious the harm could be.

Figure 1.2: Risk assess first

3. Make the changes

Consultation based on the concept that those who are exposed to the risk are often not those who make the decisions about OHS. For example, you can pick up things from the floor and put them away to eliminate a trip hazard.

Figure 1.3: warning hazards

- **Occupational safety**
  - ✓ **Legal**

Legal reason for OHS is related to the compensatory, punitive, and preventative effects of laws that protect the safety and health of workers. OHS legislation requires all organizations to ensure the safety, welfare, and health of employees and to conduct all work related activities in such a manner that they should not pose any harm to them.

- ✓ **Economic**

There are powerful economic reasons for decreasing work concerning accidents as well as ill health. In addition to decreasing costs, efficient safety and health management promotes the productivity of a business. Ill health and diseases related to work can result in many days absence from work. Accidents can hinder normal operations and is a possible addition to the operating costs of a company. Additionally, the strain and stress on other employees can demotivate them, or might lead to more mishaps. The medical expenses incurred by injured and ill workers in hospitals will be borne by the company.

- ✓ **Moral**

It is morally right to safeguard a worker from any kind of harm. It is the duty of all the companies to provide the best care to their employees. Friends and families would expect their loved ones who go out to make their livelihood to come back home safe. The grief, pain, and suffering of people who have their health affected or are hurt while working for their companies are felt by workers as well as their family members.

1.1.1. Hazardous and Risk Assessment Mechanisms

Workplace safety can only be achieved if ongoing attention is paid to it. A vital element of an effective approach to workplace safety is the need to identify and report workplace hazards and risks on a day to day basis. You cannot „do" workplace safety at the start of the year and believe it is „done" for the entire 12 months. A hazard is a situation in the workplace that has the potential to harm the health and safety of people or to damage plant and equipment.

Figure 1.4: Hazardious

- **Coordinating scheduled hazard identification activities**

The goal of any workplace health and safety strategy is to eliminate or reduce, as far as practicable, all workplace risks. This can be achieved by setting standards in accordance with applicable and current OHS legislation, implementing measures to meet those standards, monitoring the measures, and having an OHS management program of regular health and safety review and improvement.

This program should address risk/hazard management. This known as the three-stage process of:

- ✓ Identifying hazards in the workplace
- ✓ Assessing the risks to health and safety which those hazards create
- ✓ Implementing suitable measures to control the risks.

The stages of hazard management range from identifying potential hazards at the planning and purchasing stages, to implementing programs which address specific hazards, and consulting with workers.

All these phases should be covered by venue-specific workplace policies and procedures tailor-made to reflect the requirements of individual businesses and individual work practices.

- **Hazard Identification**

Hazard identification is the process used to identify all possible situations where people may be exposed to injury, illness or disease. It is the process used to identify all the possible situations in the workplace where people may be exposed to injury, illness or disease.

- **Ways to identify hazards**

Hazards can be identified in a number of ways:

- ✓ Consulting with HSRs
- ✓ Consulting with employees
- ✓ Undertaking workplace inspections
- ✓ Examining workplace records of incidents and dangerous occurrences or near misses
- ✓ Keeping up to date with safety-related matters and issues.

The most effective methods of identifying hazards use a combination of these ways.

- **Timely identification of hazards**

Management must ensure their actions enable appropriate and timely identification of hazards.

A *systematic* approach using the above techniques is recommended and attention should be paid to specific occasions when hazards may be introduced into the workplace. The most common times when hazards may be introduced are when changes to the workplace are implemented.

Examples of these instances include:

- Before premises or work stations are used for the first time and after they have been used for a while
- Before, during and after installation of plant and equipment

- Before, during and after alterations to plant, machinery or equipment
- Before, during and after alterations to layout of the workplace
- Before and after changes to existing work practices are introduced
- When any new information becomes available relating to relevant workplace health and safety risks
- After any near miss situation has occurred
- When any workplace accident, actual injury or event takes place
- In keeping with workplace schedules for regular workplace checks and hazard inspections – for example, every month, every quarter.
- Factors to consider when developing inspection protocols

When developing inspection systems it is important to establish:

- The emphasis and scope of the inspections – what will be inspected and which areas will be inspected
- How they are to be conducted. A walk around" the workplace is an essential element of any inspection system
- How often they are to be carried out. Regular inspections are critical: once every month is best but inspections should occur at least every three months
- Who will be involved in the inspections? Workers should be involved together with the HSR and a management-level representative
- Who is responsible for ensuring suggested improvements are taken into account?
- This will normally be management or the owner
- What checks should be carried out to ensure corrective action has been taken once a problem has been identified, analyzed and has had suitable control procedures developed for it? It is also important to check the implementation of risk controls has not, itself, introduced a new risk into the workplace
- How they are to be documented. Inspections should use a dedicated inspection checklist to record findings of the inspection.

The main reasons for doing workplace OHS inspections are to identify the health and safety hazards in the workplace that exist or have emerged over time.

During inspections, health and safety issues can often be identified and resolved before any harmful event takes place.

Inspections can also help to identify whether measures are in place to ensure the workplace complies with all relevant health and safety requirements (legislation and business policies). When deciding which aspects of the workplace are priority areas for routine inspection, it is important to consider:

- The existing and potential health and safety hazards within each workplace. Common sense is a good indicator, as is input from workers and analysis of workplace accident registers.
- The types of processes, operations and occupations present in the workplace. Historically certain tasks carry with them greater risks. For example, the risks in a kitchen are more numerous and potentially dangerous than those involved in an office environment.
- Any OHS legislated requirements relating to particular hazards, occupations, industrial processes and operations which apply to individual workplaces. Most OHS authorities have lists to assist in this regard detailing historical risks and what can be done to prevent or control them.
- Any new processes or arrangements which have been introduced. The introduction of anything new (process, product, equipment) has the potential to create a new or different risk or hazard. Remember the introduction of risk control measures may sometimes introduce a new/different hazard or risk.
- Equipment, substances or situations causing injury or disease in the past using anecdotal staff evidence and accident/near miss registers as the basis for identifying these.
- The need to follow up and monitor any changes suggested or implemented during previous inspections – to ensure they are effective and are being implemented.

Check list

Where areas for routine inspections have been established (such as the areas/departments which are the basis of DWGs) simple checklists which can be systematically completed during inspections should be prepared to facilitate and record findings. These will help save time and ensure a thorough inspection is carried out which is consistent every time it is undertaken.

In practice, these checklists form the basis of a comprehensive review of workplace practices on a regular basis (every month or three months).

Checklists will vary according to the workplace environment.

The types of hazards present will determine the areas covered in the checklist. Some areas to consider and develop checklists for are:

- ✓ Manual handling hazards addressing any activities where there is a need to push, pull, carry, manipulate, carry, lift, or use anything.
- ✓ Housekeeping practices relating to issues such as (but not restricted to) use of chemicals, bed making, cleaning of items (such as baths and toilets) and the vast variety of manual handling activities
- ✓ General tidiness of the workplace with attention to items being stowed in walkways, rubbish in the workplace, arrangement of items, storing of cartons and equipment
- ✓ Machinery with attention focused on correct operation, presence of all required safety guards and cut-off switches, noise levels and stability of items
- ✓ Chemical hazards addressing issues such as fumes, gases, storage, labeling, handling, Material Safety Data Sheets, personal protective clothing and equipment
- ✓ Electrical safety ensuring electrical items have been tested, tagged and are safe to use

- ✓ Office safety relating to the layout of offices, furniture used, use of equipment (especially computers and related equipment), and lighting as well as personal practices of office staff when engaged in office work
- ✓ Fire safety addressing firefighting equipment, access and exits, alarm systems, instructions for employees and presence of suitable EMPs
- ✓ First aid provisions. Verify all the necessary items are present in workplace first aid kits, that the kits are located where they should be and all the facilities in any First Aid rooms are present and in working condition. This check should also verify any workplace first aid providers have current first aid qualifications, updated as required so they maintain currency and required skill and knowledge levels
- ✓ Registers. Ensure they are located where required and are being completed as necessary.

Because each workplace is different, it is important to develop checklists which match the actual design and processes of the workplace, and the products and services each area/DWG is involved in providing.

Tailoring inspection checklists to suit the workplace will ensure all existing and potential health and safety problems can be identified.

Codes of Practice/Compliance Codes may contain checklists which can be used (or modified) to help identify particular hazards and hazard areas.

Working closely with staff on a day to day basis

Previous notes have stressed the need for a collaborative and consultative approach towards workplace safety.

A key to this approach is the ongoing identification of workplace hazards before they result in accident or injury.

Effective hazard identification requires application of all the techniques identified above (regular workplace inspections using checklists to record and document what is found) as well as close contact with staff and the operation of the business on a day by day basis.

This close contact is necessary so:

- Employees understand safety is an ongoing concern for management and demonstrating management are actually involved and „walking the talk
- Management can identify and address hazards at the earliest opportunity to prevent a potential risk becoming a workplace accident causing actual injury
- Staffs are reminded that they have an ongoing role in workplace safety and are able to contribute to workplace safety on an ongoing basis, and have an obligation to do so.

Examples of hazards which may need to be addressed

Traditionally, hazards have been able to be classified as one of the following:

- Hazards in the physical environment
- Hazards associated with plant and equipment
- Hazards associated with work practices and procedures
- Hazards associated with security issues
- It is possible your workplace has additional hazards. Check with your supervisor to determine what applies where you work.

Hazards in the physical environment

Responsible management should target attention to areas and issues associated with:

- The physical working space staffs are required to operate within. This is to identify physical placement of items posing a risk, ensure freedom from physical hazards, and ensure conditions are not cramped or overcrowded and function to facilitate the work to be done.
- Lighting. To ensure appropriate lighting, check that lights are operating correctly (no flickering fluorescents, no blown globes) and there is freedom from shadows and an absence of glare (especially for office workers)
- Hot and cold environments such as severe temperatures (and excess times at these temperatures) for those involved in hot kitchen work and/or loading deliveries into (or cleaning of) walk-in cool rooms and freezers.

- Exposure to the elements. This is a concern where there are staff workings outdoors around pools or as grounds staff. Issues may include protection against sun, wind and rain and the use of required personal protective clothing and equipment.
- Prevailing noise levels. This can be a special concern for those working in entertainment areas where there is amplified music, or who need to operate noisy equipment for extended periods.
- Electrical items. Ensure they are safe by having them checked and approved as safe. They should be used with a Residual Current Device (RCD) and staff operating them as required in accordance with establishment-based safe working procedures and manufacturer's instructions
- Flooring. Hazards in this regard can include frayed carpet causing a tripping hazard, wet floors due to work processes or spills, as well as uneven surfaces. The presence of steps and stairs should also be addressed
- Equipment designed to assist with manual handling. All workplaces should use manual handling and lifting aids to reduce the possibility of injury to workers.
- Options include:
    - ✓ Trolleys
    - ✓ Forklifts
    - ✓ Pallet movers
- Pests. These are a special concern for food safety. Pests can turn customers away, can cause food waste, and mice and rats have been known to cause fires when they chew through electrical wiring
- Crowds. During busy times management has an obligation to the public to protect them against injury when they are on the premises
- Large crowds provide the potential for injury and management have to prepare plans and provide staff to control these situations (restricting access to certain

areas, restricting access to the premises, eliminating bottlenecks, providing security staff to monitor and control areas).

Hazards with plant and equipment

Efforts to identify hazards in relation to machinery, tools, appliances and equipment should focus on:

- Ensuring regular service and maintenance is provided for all plant and equipment, items and utensils in accordance with manufacturer's instructions and to address malfunctions

Figure 1.5: Inspection and maintenance

- Ensuring staff receive adequate training in the use of all plant and equipment, items and utensils they are required to use.
- Ensuring electrical tests and checks are performed at least every 12 months to ensure the electrical safety of equipment and appliances, power points and switches.
- Ensuring staff are adhering to standard safe work practice when using electrical equipment/appliances such as:
  - ✓ Not operating electrical equipment while standing in water
  - ✓ Not using electrical equipment with wet hands
  - ✓ Not using appliances that are untagged as being tested and safe for use
  - ✓ Not using faulty appliances or items tagged as being "Out Of Operation/Service Unsafe For Use"
  - ✓ Not using electrical appliances for work they were not intended for

- Ensuring all malfunctioning tools and equipment are reported using verbal reporting mechanism or completing a workplace-based „Maintenance Request" form, and taking the faulty item out of service and tagging it as Out of Service.
- Ensuring only enterprise tools and equipment are to be used for undertaking work at the workplace. This means staff cannot bring in and use their own electrical tools and equipment.
- Ensuring all operational manuals, manufacturer's instructions and trouble-shooting guides are available to all users.

Hazards with working practices

Attention should be paid to the following as they commonly raise workplace hazards in one form or another:

- Opening and closing procedures (procedures used by a business or department at the beginning and end of a day or shift. Special attention must be paid at closing times to ensure all doors and windows are locked and no unauthorized persons are left on the premises.
- Safety and security procedures. There is a need for management to ensure they have established and implemented plans (EMPs) to address security issues identified as being likely for their business such as:
  - ✓ Theft and Robbery
  - ✓ Irrational or angry customers
  - ✓ Bomb threats
- Standard Operating Procedures for all work-related tasks to ensure they remain applicable given any changes in levels of trade, materials, equipment used, and/or techniques required.
- Roistering of staff. You need to ensure there are enough suitably trained, qualified and experienced staff is roistered on duty and that the changing nature of the workplace is reflected in the rosters being prepared.

- Length of time spent on certain tasks. Where there is a possibility of repetitive strain injury (RSI), other injury or boredom management need to rotate staff through different jobs (and/or provide appropriate extra breaks) to avoid inherent problems and injuries.

Note

Many of the issues raised above should be covered in the EMPs for the venue.

In addition, specifics to follow in responding to several of the emergency situations identified above are presented in the unit „Plan and conduct an evacuation of premises".

Coordinating risk assessments

While staff are encouraged to participate in workplace safety processes (consultation, collaboration and participative arrangements), they generally have no legal obligation to do anything unless specified by legislation. The legal obligation for workplace safety always rests with management and owners.

It is the managers and owners who must drive the entire workplace OHS process, preferably supported by staff.

Once the hazards have been identified, they should be listed for a risk assessment to be carried out in consultation with the relevant HSR and employees.

The purpose of risk assessment is to determine whether there is any likelihood of injury, illness or disease associated with each of the potentially hazardous situations identified in the hazard identification process by considering:

- Whether any person (workers and/or members of the public/visitors) would be exposed to the identified situations under all possible scenarios (such as, for example, during installation, commissioning, erection, operation, inspection, maintenance, repair, service and cleaning of plant, equipment or areas)
- The existing measures in place to protect the health and safety of people who may be exposed to the identified risk or hazard
- How adequate the existing measures are for protecting the health and safety of people who may be exposed.

If the likelihood anyone will be exposed to a situation under all possible scenarios is „nil", then there is no risk and no additional risk control measures are required.

The adequacy of existing control measures should be considered if there is the potential someone may be exposed to a particular situation.

Note: Existing control measures should not be regarded as adequate simply because an incident has not occurred.

This particularly applies where the existing control measures are only *administrative* controls (such as training, safety procedures, safety signs, supervision) or personal protective equipment and clothing (such as safety gloves, safety glasses, protective clothing, and respirators).

These types of control rely heavily on human behavior doing the right thing. The downfall of this approach is that any deviation in behavior (employees not following the safety procedures because some person or situation is distracting them or staff failing to wear protective clothing) could cause injury, illness or disease.

Remember, the thrust of workplace safety is for „safe place as opposed to safe person".

After the list of hazards has been finalized, documented and agreed on (by workers and management), a judgment needs to be made about the seriousness of each hazard and which one/s require the most urgent attention:

- Take a close look at each item on your „hazard identification" list and consider "What is the possible outcome if things go wrong?" Are you talking about cuts, scratches and bruises or is there the potential for someone to be seriously injured or even killed?
- Is the hazard an everyday task or something coming up only now and again giving you more time to find a solution?
- Are there things you can do right now as a short-term fix while you work out a better, more permanent solution?
- Never wait for all risks to be assessed before you start fixing things – make a start and begin by addressing at least one identified risk or threat

Once you have worked out which hazards have the greatest potential to cause injury or disease, or are a risk to public safety, they should be marked as your high-priority hazards. The other hazards should be ranked in priority order

The hazard list must be reviewed regularly to ensure every aspect of the workplace is monitored and any new hazards are immediately identified. Remember, workplace safety is a dynamic concept. You assess risks so you can make sure you control them effectively. The risk from a hazard is a combination of the chance of an incident occurring (that is, “Very likely", „likely", unlikely" or „very unlikely"), what could go wrong and how badly someone could be hurt.

Occupational health and safety management systems risk assessment as critical to prioritizing risk control measures and use the following formula to determine risk level:

Risk level = Consequence x Exposure x Probability where**:**

- Consequence is „the outcome severity (injury/illness) of the scenario"
- Exposure is „frequency and duration of exposure of persons to the chosen hazard"
- Probability is the „likelihood or chance that the chosen sequence and consequence will occur".

Issues to examine

To assess a risk then, you must examine all of the factors affecting the risk.

Assessment should occur in a „public" forum such as an OHS meeting where staff (impacted by the risk being discussed), HSRs and management all attend to consider the issue with a view to properly analyzing it so an effective and practicable control solution can be identified.

You need to look at:

- The number of people exposed to the risk
- Who these people are: the different types of people who are exposed and their special needs. They could be, for example, new workers, casual employees (who usually have different OHS needs to permanent staff because they often do not receive „standard" OHS training and are often not present to attend

standard staff meetings and briefings), visitors, contractors, members of the public, disabled workers and customers

- How near these people is to the risk
- How often they are exposed
- How long they are exposed for
- The combination of hazards they are exposed to
- How serious the resulting harm could be
- How easily someone could be hurt
- What the law says about risk control
- How common it is for the hazard to cause problems in other workplaces • Any factors that could increase the likelihood of illness and injury
- The work processes involved. This requires you to know the practices, procedures and protocols for performing the particular task under consideration
- How well your current precautions work. Has the hazard already caused any problems?

Reviewing risk assessments

The workplace is a dynamic environment and there is a need to review all the risk assessments you conduct „on a regular basis" (monthly or at least every three months). You will notice the Risk Assessment Worksheet presented below contains a space for the „Date" in order to facilitate this review activity. Additionally, risks must be reviewed when any significant change in the workplace takes place impacting on the risk (once again the HSR and other workers should be involved).

These changes may be required:

- Alerts or notifications from OHS authorities in relation to a practice, product, procedure, technique, and/or items of equipment
- Changes to internal operating procedures
- Introduction of new or more equipment
- Change in staffing – new staff, reduced staffing levels

- Modification to the work environment such as changes to job allocation, work station layout, relocation of items of equipment, different environmental conditions, a change in patron profile
- Based on concerns, feedback and/or complaints from workers, customers or management.

Reporting hazards

Where workplace hazards are identified they must be immediately reported to the appropriate person such as a supervisor or HSR.

A verbal report is usually the best option as it is quick and allows the other person to ask questions to clarify and better understand the issue.

A written form such as a „ Hazard notification" or „Hazard report" may also be required.

1.1.2. Implementation of safety regulations

When workplace risks and hazards have been identified and analyzed, suitable risk controls must be implemented. This Section discusses the use of risk control in the workplace to protect the safety of workers and others.

Controlling risk is the third step in risk management. The first step was hazard identification and the second step was risk assessment and analysis.

Implementing risk control methods means putting in place the risk control options deemed most appropriate and effective for the identified hazard. Where a manager or supervisor is unable to implement identified risk control methods these situations must immediately be reported to the „appropriate person" (owner, more senior manager) for their attention and action.

When hazards have been identified, and the risks to health and safety assessed, the risks need to be controlled. Risk control is a requirement as part of the employer's duty to provide and maintain so far as is practicable a working environment which is safe and without risks to health for employees and the public.

Risk control means taking action to eliminate or reduce the likelihood of exposure to a hazard that may result in injury or disease.

The Hierarchy of Control is a list of control measures in descending order of effectiveness that may be applied to specific risks only after an assessment and analysis has been made of all possible risk controls.

This highlights the need for time, planning and consultation throughout the entire process.

Note: while it is preferable that hazards and risks are subject to planned and comprehensive procedure if there is an immediate risk to health and safety, you must make sure the activity in question is ceased until measures are taken to remove the immediate risk. In most cases, effective control of a risk requires **a combination** of the following controls to be applied. In addition, remember it is vital to make sure the introduction of a control measure does not create another, new or different risk. Some control options are better than others. Again, „safe place" options are better than „safe person" options.

It is better to create a „safe place" than rely on people wearing protective clothing or „Behave safely". The „hierarchy" of control reflects this idea.

As an overview the Hierarchy of Control comprises the following controls:

- Elimination
- Substitution
- Isolation
- Engineering controls
- Administrative controls
- Personal protective clothing and equipment.

The effectiveness of these controls is in descending order of effectiveness. These controls may be classified under three levels as set out below.

Level 1: Elimination (the ultimate 'safe place' option)

At the top of the hierarchy of control is elimination.

It is the best option for controlling hazards but is not always available or practicable. Elimination means changing the procedure so it does not have to take place at all.

For example:

- A cleaning process which uses ultrasound instead of a chemical avoids the need for the chemical in the workplace
- Buying precut steaks eliminates the need for slicing steaks and using knives
- Getting rid of noisy equipment or facilities removes the need for hearing protection.

Elimination of hazardous substances should always be the priority simply because this is the most effective way of making the workplace safe.

Where elimination is not reasonably practicable, steps must be taken to identify effective measures to reduce the risk (Levels 2 and 3).

Level 2: 'Safe place' options which reduce the risk: Isolation, Substitution and Engineering controls

If elimination is not practicable, there is other „safe place" options which reduce the risk: substitution, isolation and engineering controls.

Substitution means replacing a hazardous process or substance with a less hazardous one:

- A detergent may be substituted for a chlorinated degreaser
- Using a neutral detergent instead of caustic soda for cleaning
- A chemical could be used in pellet form instead of a powder to reduce the risk of inhalation
- Applying a substance with a brush might be safer than spraying the substance onto a surface
- Lifting smaller and/or lighter packages. This may mean purchasing 5kg packs rather than 25kg bags of product
- Using an electric forklift instead of a petrol one
- Vacuuming instead of sweeping.

Isolation involves separating the risky process from people either by distance or by using barriers to prevent exposure:

- Placing a noisy piece of equipment in a soundproof box or behind a baffling wall
- Physically stopping people (customers) from coming into contact with the hazard

- Moving the hazard to some distant location.

Engineering controls include plant or processes which:

- Minimize the generation of risk
- Suppress or contain the risk
- Limit the risk should an event occur.

Examples include:

- Ventilation booths for spray painting
- Machine guards to prevent clothing, jewellery and body parts being caught in machinery and equipment
- Machine operation controls such as „Emergency Stop" buttons, automatic cut-offs, the ability to remotely operate an item
- Ventilation – exhaust fans to remove dust, smoke
- Wetting down techniques to reduce dust
- Changing the levels or height of work levels to minimize bending, twisting and similar actions during manual handling.

Level 3: Safe person' options: Administrative controls; Personal protective equipment and clothing

If it is not practicable to make the workplace itself safe it is necessary to look for „safe person" options, which are a lower priority because they depend on people "doing the right thing".

Administrative controls are safe work practices which help to reduce employee exposure to risk.

For example:

- Restricting access to certain areas at nominated times when the risk is lowest or non- existent
- Good housekeeping practices (in terms of keeping workplaces clean and tidy), including regular cleaning of work areas and regular and appropriate maintenance of workplace items and equipment

- Changing purchasing procedures so substances (such as cleaning chemicals) are supplied in ready to use containers and decanting is not required
- Providing trolleys to move items to reduce need for potentially harmful manual handling
- Providing accurate work instructions and methods of work (work practices, standard operating procedures) to guide workers in the safe way to perform their work
- Changing work practices to include job rotation (but note this, on its own, is generally regarded as an insufficient control method. Job rotation is the practice of moving staff between different jobs to help eliminate boredom and repetition and the associated dangers these introduce to work
- Shorter working periods for jobs performed under difficult conditions such as limiting work needing to be undertaken in extreme cold, heat, noise or where there is excessive vibration
- Training – providing necessary training in practices such as such as lifting and manual handling techniques.

The effective use of administrative controls relies on full cooperation of employees, so it is essential extensive consultation occurs during their development and implementation.

Adequate supervision and training are also important and a legal requirement.

Personal protective equipment (PPE) and clothing includes such things as:

- Eye protection – goggles, face masks, visors
- Respiratory protection
- Gloves and gauntlets
- Safety shoes and boots – including „clogs" for kitchen workers
- Protective clothing – aprons, thermal wear/suits, „pull off" ties for security staff
- Head protection – hard hats, and caps for food handlers.

Personal protective equipment is generally the least effective way to control risk and should only be used if you can't reduce the risk enough using other means.

It should then be used in conjunction with other measures.

Personal protective equipment might also be used as a temporary measure until other controls can be implemented.

All personal protective equipment should:

- Meet the relevant in-country Standards
- Be appropriate to its application
- Be issued to an individual and not shared
- Be properly maintained and cleaned.

Employees who have to use personal protective equipment must be trained so they know why and how to use the equipment effectively.

Remember: the most effective method of controlling risks is usually a ***combination*** of the above options.

Consider this

If you consider the hazard of slips in the kitchen, you cannot eliminate the kitchen floor, neither is it possible to always ensure the kitchen floor is not slippery or wet.

However you can substitute work practices. For example, only clean when there is minimal foot traffic through the kitchen.

You can control the risk by proper engineering by using non-slip matting.

You can make an administrative arrangement (by directing staff not to enter the kitchen during service and cleaning) and training them to raise awareness of the problem.

You can also use personal protective equipment (provision of rubber sole shoes), so although the only acceptable control for a broken hand brake on the venue courtesy bus is elimination of the problem, for slips in the kitchen a combination of controls is acceptable.

1.1.3. Safety training

Previous notes have highlighted the need for employers to provide training to staff in relation to OHS issues.

Identifying the OHS training gap

The OHS training gap is the difference between the OHS competencies staff need in order to perform their job safely, and the OHS competencies they actually possess.

Competencies comprise three vital elements:

- The necessary knowledge
- The necessary skills
- The „right" attitude.

This gap can be identified by:

- Undertaking an OHS Training Needs Analysis (TNA). This is a formal and structured approach to identifying the gaps *for every staff member* in all areas of their work. TNAs are an excellent way of determining the training needs for each staff member but they are relatively expensive and time consuming
- Observing staff performance to identify areas of their performance requiring attention
- Speaking to staff and asking them to identify the areas they believe they need OHS training in
- Looking at their personnel file/records (such as their application for employment and their résumé) to determine their existing skill/competency levels with a view to identifying the areas where training is required
- Employing the services of an outside consultant with specialist OHS knowledge and expertise to assess competency levels of staff within the business analyze the competencies needed and determine individual staff training requirements.
- The critical point to remember is that, once you have identified an OHS staff training need, it is you who must take action to provide the required training.

All employees benefit from OHS training. This includes casual, part-time and full-time staff and all staff is required to be supplied with such training.

Many long-serving staff is ignored when it comes to identifying OHS training needs. It is often thought they know what to do simply by virtue of their years of service, but this is

often not the case and they should be included in any approach to identifying OHS training needs.

While individual staff requirements will vary because of their particular roles, all staff will benefit from understanding OHS requirements (legislated and internally imposed).

Possible training requirements for new staff

Staff who are new to the business or staff who have transferred internally from one department/area to another may need training which enables them to:

- Understand the hazards of their work and workplace because these always differ between workplaces, work stations and businesses on the basis of many factors such as equipment used, processes, and layout
- Know how to advise management or their HSR about identified workplace hazards so they can be investigated and resolved
- Understand workplace consultative arrangements, including the role and functions of DWG, HSR and Health and Safety Committee
- Understand and follow health and safety procedures applying in their workplace with special attention paid to OHS issues in their particular section of the workplace
- Understand their responsibilities under applicable legislation which may relate to:
    - ✓ Compliance with mandatory work practices
    - ✓ Need for certification or licenses in order to undertake specified work activities
    - ✓ Reporting when unsafe situations occur and/or when prescribed workplace accidents or injury occur
- Understand their responsibilities in relation to safe work practices and allied workplace safety issues under the policies and procedures the business has established.

OHS considerations for Induction and Orientation

Many of the OHS issues about which staff must be aware are communicated to them as part of their formal Induction and orientation session.

Induction training for new employees could include:

- A tour of the work area so they gain an overview of the business and appreciation of where various department, facilities and equipment are physically located
- An explanation of venue amenities and facilities relating to OHS. This can include discussion about:
  - ✓ First aid kits
  - ✓ First aid rooms
  - ✓ First aid providers
  - ✓ Emergency equipment and systems

Enabling OHS training for staff

Difficulties occurring when attempting to plan staff training for all team members must not stand in the way of doing the training. Do not fall for the trap of thinking „it's all too difficult", and therefore do nothing.

- To facilitate the delivery of OHS training to staff, there may be a need to:
- Organize time release for staff so they can attend training
- Roster staff differently. There can be a need to run multiple training sessions to
- ensure all staff who have a training need can be trained
- Conduct off-site training using external training providers
- Close a department for a period while staff undertake training
- Undertake training out of hours which may mean having to pay staff extra money to stay back after normal working hours in order to do their training.

The choice of strategy will depend on:

- The trading hours of the venue
- Numbers of staff who require training
- Urgency of the training need
- Type of OHS training to be done
- The general level of cooperation from all concerned.

Senior management should be involved at this stage in the planning so they can lend their support to the training initiatives, and approve the necessary resources and allocation of time required.

Integrating OHS training into overall training

The OHS training program for a business should be integrated into the general training program for the workplace.

You may achieve this by adding specific OHS courses (or units or modules) to the overall business training plan, or by including OHS components into existing training courses. For example, every training module *without exception* may include an OHS element addressing the specific OHS issues for the particular training module.

Establishing an effective OHS training program requires the business to set broad objectives for the training. Possible objectives may be:

- Ensuring all employees can perform their work safely and without risks
- Ensuring line managers have an understanding of, and ability to, develop and implement OHS management systems and procedures to support the „safe place" concept
- Ensuring any external contractors who work in the business understand and follow the health and safety procedures which apply to the property so their work aligns with other „safe place" initiatives in the organization
- Ensuring all new and transferred employees understand health and safety policies and procedures so they know what is expected in relation to actual workplace performance.

Examples of training interventions

Training interventions are activities used to provide on-site training to staff. OHS-related training interventions include:

- Workshops where staff are led by a supervisor or trainer and address one or more specific OHS issues using activities such as lecture, discussion, practical exercises, case studies which may be supplemented by the use of guest speakers

- Information sessions where management or a trainer gathers staff together and provides them with required information. Verbal delivery of the information is the most common practice but this may be supported by:
    - ✓ Handouts of notes, fact sheets and other literature such as materials prepared in house by the training department, or safety materials provided by manufacturers of equipment, suppliers of chemicals or the OHS authorities or agencies
    - ✓ PowerPoint presentations
- Workplace mentoring and coaching where individuals in the business (usually senior personnel with extensive experience) develop a personal relationship with one or more staff and use this relationship as the basis for sharing information, providing on the job advice and instruction and discussing and solving workplace issues
- Lectures. These are formal training sessions where trainers deliver talks a nominated topic. Lectures may be supported by notes written on a board, handouts, and/or PowerPoint presentations
- Practical demonstrations. Where the training requires staff to learn how to „do" something, practical demonstrations are required. Demonstrations may occur one on one (as part of the mentoring or coaching approach) or can occur in a group setting. It is important that the practical nature of demonstrations is underpinned by the provision of relevant knowledge so staffs understand what they are doing and why they need to do it. Opportunity for practice must be included.
- Health and safety meetings. These are regular workplace meetings where the sole focus of the meeting relates to OHS issues. These issues may be new legislated or organizational requirements, findings related to analysis of workplace accident and injury data, explanation of new products, equipment or operating procedures, discussion of risk identification activities (such as workplace inspections), risk

assessment and analysis or consideration and research into potential risk control procedures.

- Introduction to fellow employees, especially those who constitute the DWG for the area in which they are going to work
- Introduction to HSR together with an explanation of their role, and details of how to engage with the established participative arrangements relating to workplace OHS
- Description of general workplace hazards and risk control measures including visual observation of problem areas, practice with control protocols and watching experienced staff perform work in a safe and proper manner
- Identification of the location of and demonstration of the use of fire fighting equipment. It is a standard requirement all staff have some form of training or experience in using fire-fighting equipment, especially fire blankets and fire extinguishers
- Details of emergency exits showing where they are, stressing the need to keep them free of obstruction and indicating any fire doors which may need to be closed in the event of fire.
- Identification and explanation of Emergency Management Plans for the business and details of evacuation plans for the business or area: this should include identification of:
    - ✓ Individual responsibilities under the plans
    - ✓ Evacuation routes – primary and secondary
    - ✓ Evacuation assembly points – primary and secondary
- Issue of personal protective clothing and equipment if required and explanation of when it must be used, and how it is to be used.

Training for various workplace roles

Supervisors need to be able to carry out any health and safety roles and functions assigned to them. This means a supervisor will not automatically know what is expected in terms of OHS simply because they are a supervisor.

They may need special training to:

- Recognize hazards in the workplace and conduct health and safety inspections
- Access and analyze identified hazards so they are fully understood in their context
- Select and apply appropriate risk control measures for identified hazards
- Investigate OHS situations such as incidents or dangerous occurrences
- Produce clear and accurate reports to support workplace research and investigation
- Communicate effectively with workers, managers and OHS authorities
- Consult effectively with management and others including external business, authorities or agencies
- Conduct effective on the job training on OHS issues
- Ensure employees understand and follow workplace procedures as required by legislation and the business.

Managers too may need training in order to discharge their legal obligations and/or to assist them participate in effective OHS collaborative and consultative processes.

They may require training in:

- OHS legislation as it applies to their business and their geographic location
- Health and safety principles and practice which serve to underpin OHS thinking, risk identification, risk assessment and analysis and development of effective risk control protocols
- Management systems to enable integration of OHS into other management activities and workplace priorities
- Assigning health and safety roles and functions to staff within the workplace
- Workplace hazard identification and assessment as part of the ongoing risk management procedures in place within the business
- Risk control strategies and options to address identified workplace risks.

A shared approach to training, where managers, supervisors and HSRs attend training *together* can produce good results.

Most OHS issues need managers and employees to work together to successfully resolve those issues, so it makes sense to have a joint approach to training.

Joint training can supplement specific training which relates to individual staff or DWG needs.

More on workplace health and safety training

Training is vital to assist employees perform their work safely. This means employers should arrange training which covers health and safety issues related to the tasks being performed, as well as training in the overall approach to health and safety taken by the business.

The importance of workplace OHS training in preventing workplace injury and illness is generally acknowledged and legislation may set out general and specific training requirements in certain areas for staff, management and/or HSRs.

Note training is never treated by legislation as a substitute for removing a hazard at its source.

For example, in manual handling if it is not practicable to carry out job modification or to provide and use mechanical aids to reduce the risk, it is necessary to implement a training program to show staff the safest way to address the task.

Higher levels controls (under the Hierarchy of Controls) must be considered first. The business cannot just default to „training" as the only method of risk control.

Self-Check1	Written Test

I. True or false questions

Highlight or circle the correct answer, or enter your answer in the space provided.

1. Emergency procedures have been devised to keep everyone safe.
2. A hazard is any situation that has the potential to cause injury, illness, or death
3. If no notification is made of an injury sustained compensation can be obtained for that injury
4. To reduce injury, a risk control process accompanied by hazard-management procedures needs to be established.
5. Safety signs can prevent accidents.
6. A duty of care in the workplace is the responsibility of the employer only.
7. The direct costs of workplace-related injuries are workers' compensation premiums paid and workers' compensation payments.
8. When providing a safe working environment for staff, employers must eliminate all risks to health and safety.
9. The safety and wellbeing of people in the workplace also includes guests and customers of the workplace.
10. If you have to evacuate the workplace during an emergency, ensure that you take all of your personal belongings before evacuating the building.

Note: - Satisfactory rating: 8 and above - Unsatisfactory Rating: below 8

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information Sheet 2:	Reviewing Established procedures for project Planning

2.1. Reviewing Established Procedures for Project Planning

A person conducting a business or undertaking must review and as necessary revise a control measure in the following circumstances: For more information refer information sheet 1.

- when the control measure does not control the risk it was implemented to control so far as is reasonably practicable
- before a change at the workplace that is likely to give rise to a new or different risk to health or safety that the measure may not effectively control
- if a new relevant hazard or risk is identified
- if the results of consultation indicate that a review is necessary
- if a health and safety representative requests a review

The following questions will help you evaluate how well you are currently managing electrical risks in your workplace: „

- Do you talk to your workers about electrical safety?
- Do any relevant new work methods or equipment have the potential to make work safer in your workplace? „
- Are procedures for identifying electrical hazards in the workplace effective? „
- Are electrical safety procedures followed?
- Do you encourage your workers to report electrical hazards? „
- Do you regularly inspect and maintain your electrical equipment to identify safety problems? „
- Do you fix or rectify identified electrical hazards in a timely manner

Self-Check 2	Written Test

Questions

The answers to each of these questions are shown on the last page

1. It is important that all staff that carry out physical activities in their day-to-day job role have:
   A. Appropriate life cover
   B. Appropriate training
   C. At least three other people supervising their work
   D. At least two days off after carrying out physical activities
2. Which of these **best** describes "the likelihood of an incident is occurring"?
   A Risk
   B Hazard
   C An event
   D An episode
3. Which of these is the **first** step to take when conducting a risk assessment?
   A Evaluate the risk
   B Identify the hazards
   C C Review your findings
   D Update risk assessments
4. Which of these is **most** likely to cause an accident in a workplace?
   A Administration
   B Manual handling
   C Adequate lighting
   D Excessive noise
5. Trailing electrical cables which trail through the middle of a busy walkway:
   A. Are very unlikely to cause any injury

B Are likely to injure someone if they trip over it

C Can be defined as high level health and safety hazards

D D Can be defined as high level fire hazards

6. Why should near misses be reported?

A. To educate employees

B. To test the first aider

C. To ensure complete recovery

D. To stop a more serious event occurring

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information Sheet 3:	Adapting established procedures

3.1. Adapting established Procedures

Ongoing Inspections

One of the most important ways to ensure that the workplaces stay healthy and safe is to regularly inspect the work site. Once hazards have been initially assessed, regular inspections are necessary to monitor and follow-up, to ensure things do not get out of control. Inspection is an ongoing task because the workplace is always changing. It is important to understand that an inspection does not replace a hazard assessment. A formal hazard assessment allows for systematic identification of hazards Inspections are intended to monitor how well the controls are working and if they are being used effectively. They are intended to monitor worksite conditions at a point in time. A system of regularly planned inspections will make identifying and controlling hazards a normal part of everyday work. Formal inspections should be conducted by a supervisor and a worker whenever possible.

Inspections provide two important pieces of information about the work site:

- information about hazards or potential hazards that have not been noted previously
- Confirmation of the effectiveness of controls for eliminating or reducing the risk of known hazards.

During the inspection the team:

- Looks at how work is performed.
- Identifies unsafe or unhealthy conditions and acts that can cause injury or illness so they can take corrective measures.
- Talk to workers about the tasks they are doing and about any concerns they might have.

The team might ask about a procedure a worker is doing and how well it works.

After the inspection, the team:

- Recommends ways to eliminate or control all identified hazards, gives target dates and identifies the individual responsible.

- Any critical issue must be dealt with immediately.

Sample: Work Site Inspection Checklist

Use a checklist when conducting regular health and safety inspections. Go over every aspect of the workplace to identify possible hazards. Use blank lines to add items that are specific to your workplace. For any No items, note the location and provide details.

Floors and Walkways	Yes	No
Are aisles clear of materials or equipment?		
Are doorways clear of materials or equipment?		
Are carpets or tiles in good condition and free of loose or lifting carpeting or tile?		
Are floors clean and free of oil or grease?		
Are floors kept dry?		
If supplies or materials are stored on the floor, are they away from doors and aisles and stacked no more than three boxes high?		
Stairs, Ladders and Platforms	**Yes**	**No**
Are ladders safe and in good condition?		
Are stair handrails fastened to the wall securely?		
Are stairwells clear of materials and equipment?		
Are stairs and handrails in good condition?		
Are ladders and stairs provided with antis lip treads?		
Walls	**Yes**	**No**
Are signs and fixtures securely fastened to the wall?		

Lighting	Yes	No
Are lighting levels in work areas adequate?		
Are work areas free of glare or excessive lighting contrast?		

Is task lighting provided in areas of low light or high glare?		
Are windows covered with blinds, drapes or other means of controlling lights?		
Does emergency lighting work?		
Equipment and Machinery	Yes	No
Are equipment and machinery kept clean?		
Is the equipment regularly maintained?		
Are operators properly trained?		
Are start/stop switches clearly marked and in easy reach?		
Is machinery adequately guarded?		
Is there enough work space?		
Are noise levels controlled?		
Are fumes and exhaust controlled?		
Do you have a lock-out procedure in place?		

Chairs	Yes	No
Are chairs in good condition?		
Are chairs properly adjusted?		
Computers	Yes	No
Are display screens free of dust?		
Are display screens bright enough, with sufficient contrast?		
Are display screens positioned at a comfortable viewing level?		

Garbage	Yes	No
Are bins located at suitable points?		
Are bins emptied regularly?		
Hazardous Materials	**Yes**	**No**
Are Material Safety Data Sheets (MSDSs) provided for all hazardous materials?		
Are containers clearly labeled?		
Are hazardous materials properly stored?		
Are hazardous materials disposed of properly?		
Environment	**Yes**	**No**
Is air quality good?		
Are workers protected from cool drafts or excessive heat?		
Are workers protected from excessive or irritating noise?		
Electrical	**Yes**	**No**
Are electrical cords in good repair?		
Is there clear access to electrical panels and switch gear?		
Are electrical cords secured?		
Are proper plugs used?		
Are plugs, sockets and switches in good condition?		
Are ground fault circuit interrupters available, if required?		
Are portable power tools in good condition?		

Fire Safety and Security	Yes	No
Are fire extinguishers clearly marked?		
Are fire extinguishers properly installed on walls?		
Have fire extinguishers been inspected within the last year?		
Are workers trained to use fire extinguishers?		
Are flammable liquids properly stored?		
Will space heaters shut off automatically when tipped over?		
Are emergency phone numbers close to phones?		
Are smoke, fire and burglar alarms in place?		
Are emergency exits clearly marked?		
Are emergency lights in working condition?		
Have sprinkler systems been inspected?		
Entrances and Exits	Yes	No
Is there safe access for workers and customers?		
Are emergency exits clear of materials or equipment?		
Are emergency exit signs working?		
Are emergency lighting units provided? Are they working?		
First Aid	Yes	No
Is the first aid kit accessible and clearly labeled?		
Is the first aid kit adequate and complete?		
Is the first aid kit clean and dry?		

Are emergency numbers displayed?		
Are injury report forms available?		
General Worker Questions	Yes	No
Do workers know where to go and who to call for first aid assistance?		
Do workers know where to find MSDSs for chemical products?		
Personal Protective Equipment	Yes	No
Do workers know where to find personal protective equipment?		
Do workers know how to use personal protective equipment?		
Do workers use personal protective equipment properly?		
Safe Work Practices	Yes	No
Do workers use proper manual lifting techniques?		
Are wastes disposed of properly?		
Do workers know how to deal with violent customers?		
Do workers know the procedures for working alone?		

Self-Check 3:	Written Test

Review Questions

1. What is a health and safety management system?

   _____

   _____

   _____

   _____

2. What are the employer's requirements for hazard assessment, as defined by the OHS Code?

   _____

   _____

   _____

3. Identify the major categories of workplace hazards.

   _____

   _____

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information Sheet 4:	Determine the Extent of Proposed Project Development

4.1. Determining the extent of proposed project development

Introduction

It is to use the Logical Framework Approach to deconstruct and reconstruct the project's design in order to identify information gaps concerning the relevance, feasibility and sustainability of the project. This provides step-by-step instructions to the preparation of problem and objective trees and a log frame.

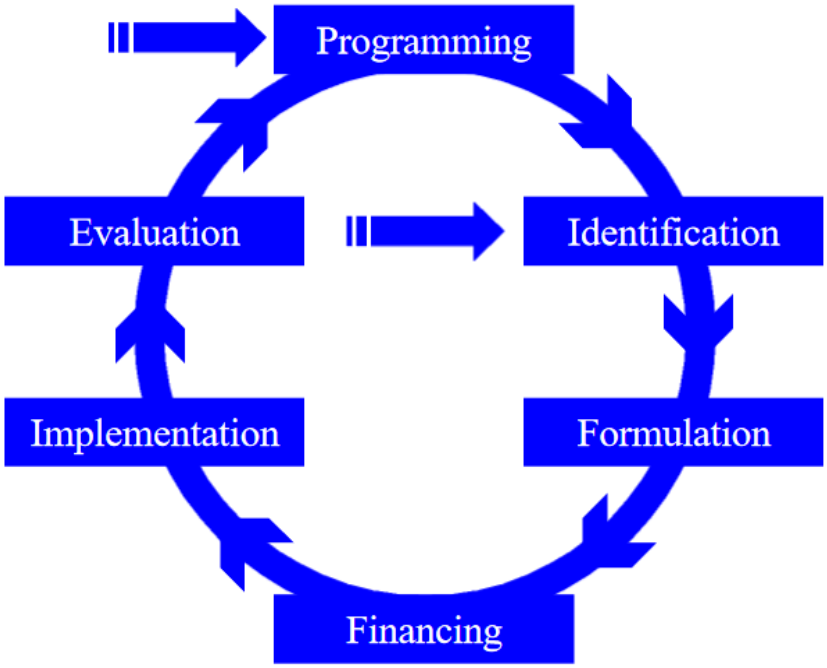


Figure 4.1: Logical Framework Approach projects design

As they are developed, it explains how these outputs should be analyzed to determine:

- The adequacy of the target group description and problem analysis
- The relationship between stakeholders, identified problems, and the proposed intervention
- The completeness and coherence of project objectives, and the adequacy of assumptions

- The extent to which mechanisms to build sustainability have been incorporated into the project's design
- The adequacy of the proposed performance measurement system

It is intended as a means of determine what information should be collected prior to and during the Feasibility Study, in order that the project is comprehensively researched and well-prepared. The output of this assessment process is therefore a set of questions concerning the project's Relevance, Feasibility and Sustainability.

The key concepts of Relevance, Feasibility and Sustainability can be explained as follows:

- ✓ **Relevance** relates to the importance of the problems to be addressed by the project, and starts with determining for whom the project is relevant. At the project purpose level, the project should address the specific problems of the target group (for example, declining revenues of small scale agricultural producers). At the overall objectives level the project should address the related but wider problems of society as a whole (for example, declining standards of living in rural areas).
- ✓ **Feasibility** relates to whether the project objectives can be effectively achieved. This requires an assessment of the coherence of the project's intervention logic and assumptions (e.g. if results are delivered, and assumptions hold true, will the project purpose be achieved?) and of the capability of the implementing agency to mobilize the necessary resources and expertise to undertake project activities within the time required.
- ✓ **Sustainability** relates to whether project benefits will continue to flow after the period of external assistance has ended. Although actual sustainability cannot be assessed ex ante, prospects for sustainability can be assessed by determining the extent to which mechanisms have been incorporated into project design to address the key factors which have influenced sustainability in the past.

Instruction 1: Analysis of the Project's Relevance part 1

It is the first test of the relevance of the project to the needs of the stated target group. The focus is therefore on identifying the target group, and assessing whether they and their problems are sufficiently described and analyzed.

Step 1: Read the project proposal

Step 2: Identify the beneficiaries and parties involved

Mark the entire stakeholder groups mentioned in the proposal, and summarize each group on blue cards. Identify the following groups:

- the target group (those who will benefit directly from the project)
- the final beneficiaries (if different from the above)
- the implementing agency

Step 3: Identify the problems to be addressed

Mark all of the problems mentioned in the proposal with a yellow text marker and write these on yellow cards. There should be one problem per card.

Step 4: Build a problem tree

Using the problem cards prepared in the previous step, develop a problem tree.

Step 5: Identify the objectives of the project

Mark all of the objectives mentioned in the proposal with a green text marker and write these on green cards. There should be one objective per card.

Step 6: Build an objective tree

Using the objective cards prepared in the previous step, develop an objective tree.

Step 7: Analyze the relationships between stakeholders, problem tree and objective tree

Use the following as guide questions, but draw on your own knowledge and experience as well:

- Has the target group been clearly identified and described, with a gender breakdown if necessary?
- Have the problems of other stakeholders important to the project's success been identified?

- Does the problem analysis describe problems of the target group, or is it only of a general nature?
- Does the problem analysis have major gaps?
- Are the causal relationships between problems sufficiently explained?
- Are all of the problems addressed by objectives?
- Which problems are not addressed?
- Do all of the objectives have an underlying problem?
- Which objectives are not justified?

Step 8: Formulate questions on the stakeholders, problem tree and objective tree

These questions should be clarified by the Delegation or proposing organization, or appear in the Terms of Reference for the Feasibility Study

Instruction 2: Analysis of the Project's Relevance part 2

It is to determine the extent to which stated project objectives address the real needs of the target group, and are consistent with the programming framework (the country strategy or National Indicative Programme).

Step 1: Prepare the Intervention Logic for the project

- Identify the Project Purpose from objective tree and write on a yellow card. Check in the proposal that the project intends to address this objective.
- Identify the Overall Objectives from objective tree and write on green cards. Place above the Project Purpose in the logical framework. Check in the proposal that the project intends to address these objectives.
- Identify the Results from the objective tree and write on red cards. Place beneath the Project Purpose in the logical framework. Check in that the project intends to deliver these services.
- Identify the main Activities from the objective tree and write on white cards. Place the activities under each corresponding result in the order of priority. Check in that the project intends to undertake these activities.

Step 2: Analyze the extent to which the project responds to identified problems and needs

Analyze whether the project addresses the identified needs of the target group. Some key problems may not be addressed by the project's stated objectives, while some stated objectives may not be supported by an identified problem or need.

Step 3: Formulate questions on the extent to which the proposed intervention responds to identified problems and needs

Instruction 3: Analysis of the Project's Feasibility (Part 1)

It is the first test of feasibility, and involves the identification and assessment of external factors, and then an assessment of the likelihood that project objectives can be achieved given the stated assumptions. In addition to assessing the logical coherence of the project, it is necessary to draw on evaluation experience to see whether similar projects have succeeded in the past.

Step 1: Identify the external factors

External factors are conditions in the project environment that may influence the project's success, but over which the project has no influence. From these reformulated problems, and the remaining objectives in the objective tree identify:

- Factors that are required to be fulfilled in order to start the Activities. These should be written on white cards and placed as preconditions in the bottom row 4th column.
- Factors additional to the Activities that are required to reach the Results. These should be written on white cards and placed in the 4th column at the level of Activities.
- Factors additional to the Results that are required to reach the Project Purpose. These should be written on red cards and placed in the 4th column at the level of the Results. (Some might already be placed from step 3).
- Factors additional to the Project Purpose that are contributing to the Overall Objectives. These should be written on yellow cards and placed in the 4th column at the level of the Project Purpose.

Identify from the document any other factors. These may already be stated as risks or assumptions, but remain to be assessed for their importance and probability of being realized.

Step 2: Assess external factors to be included in the log frame as assumptions

Assess the external factors identified during the previous instruction by running these through the following algorithm.

Step 3: Finalize the key assumptions to be included in the log frame

Following the assessment the external factors might be:

- dropped as they are not important,
- included as an Assumption and remain in the 4th column at their appropriate level, or,
- Formulated into Activities, Results or even the Project Purpose.

Step 4: Analyze the log frame on completeness and feasibility

Analyze whether the project's objectives are logical and coherent, whether the assumptions are adequately specified and explained, and whether the project is based on the lessons of experience. Use the following as guide questions, but draw on your own knowledge and experience as well:

- Will the Project Purpose contribute to the Overall Objectives if the assumptions hold?
- Will delivery of the Results lead to achievement of the Project Purpose if assumptions hold?
- Are the Activities sufficient to achieve the Results?
- Does the proposal indicate that the implementing agency will be able to undertake the Activities and deliver the Results?
- Are the assumptions adequately explained?
- Is the project design based on supporting evidence from past projects or other sources?

Step 5: Formulate questions on the project's feasibility

These questions should be clarified by the concerned parties (Delegation, Brussels, proposing organization), or appear in the Terms of Reference for the Feasibility Study.

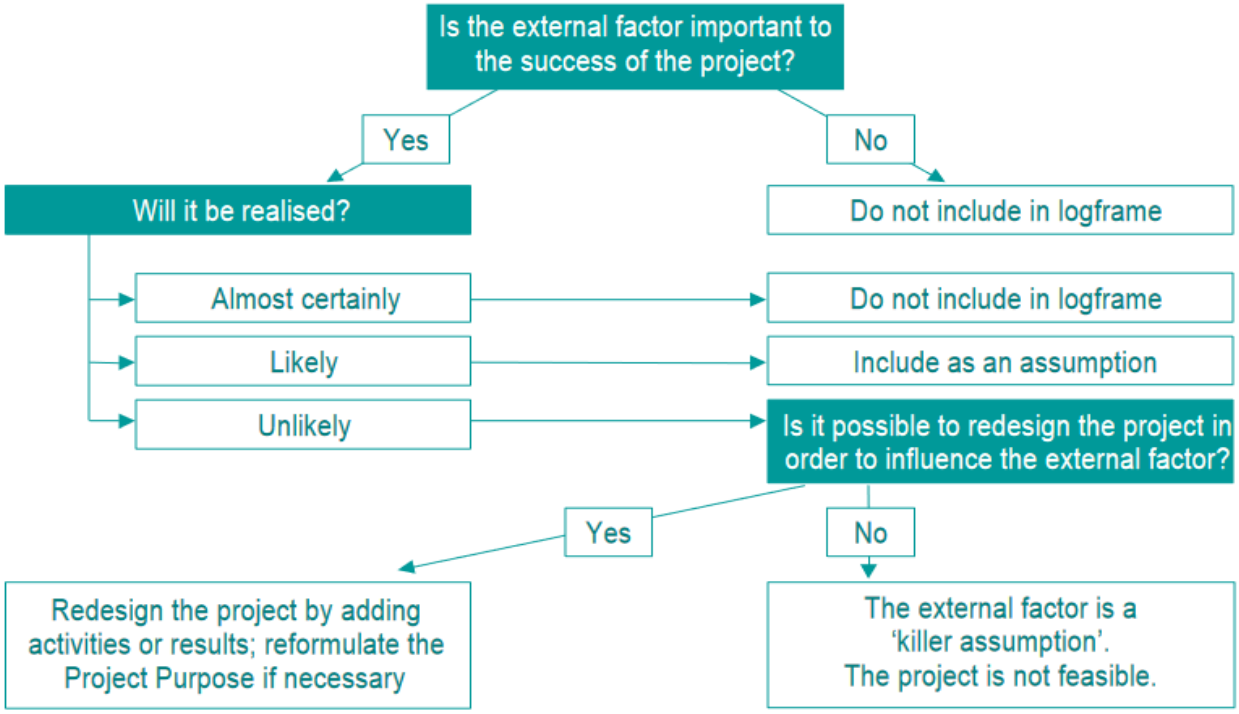


Figure 4.2: Analysis of the Project's Feasibility

Instruction 4: Analysis of the Project's Sustainability

It looks at the likelihood that services delivered by the project will continue to be delivered beyond the period of funding, enabling the target group to derive benefits in the longer term. This involves identifying which activities and results must continue, and then checking them against the six sustainability factors. This 'sustainability check' may lead to questions about the project, and to subsequent modifications in its design.

Step 1: Identify which activities and results will have to continue beyond the life of the project

A project can be said to be sustainable when the target group continue to derive benefits for an extended period after the main period of donor assistance has ended. In practice this means that some of the project services (the Results) should continue to be delivered beyond the lifetime of the project, and that certain activities will have to continue in order

that these services are maintained. Determine in the log frame those results and activities that need to continue after termination of the project (donor) intervention.

Step 2: Check the Results and Activities to be continued against the sustainability factors Use the following as guide questions, but draw on your own knowledge and experience as well:

Policy support:

- Is there evidence of sufficient support by the responsible authorities to put in place the necessary supporting policies and resource allocations (human, financial, material) during and following project implementation?

Appropriate technology:

- Is there sufficient evidence that the chosen technologies can be used at affordable cost and within the local conditions and capabilities, during and after project implementation?

Environmental protection:

- Have harmful environmental effects resulting from use of project infrastructure or services been adequately identified? Have measures been taken to ensure that any harmful effects are mitigated during and after project implementation?

Socio-cultural and gender issues:

- What evidence is there that all target groups support the project?
- Does the project take into account local socio-cultural norms and attitudes?
- Have sufficient measures been taken to ensure that all interest groups will have equal access to project services and benefits during and after implementation?

Institutional and management capacity:

- Is there sufficient evidence that the implementing authorities will have the capacity and resources (human and financial) to manage the project effectively, and to continue service delivery in the longer term?
- If capacity is lacking, what measures have been incorporated to build capacity during project implementation?

Economic and financial viability:

- Is there sufficient evidence that the benefits of the project will justify the costs involved, and that the project represents the most viable alternative to addressing the target group's needs?

Step 3: Formulate questions regarding each factor for sustainability

These questions should be clarified by the concerned parties (Delegation, Brussels, proposing organization), or appear in the Terms of Reference for the Feasibility Study.

Instruction 5: Analysis of the Project's Feasibility (Part 2)

Final test of feasibility, and involves the identification of indicators and sources of verification for project objectives. The indicators provide a basis for determining the ambition of the project (the target quantity and quality of services and benefits to be achieved), and together with sources of verification, the basis for the project's performance measurement system.

Step 1: Identify indicators and sources of verification for performance measurement

From the proposal, identify Objectively Verifiable Indicators (OVI's) for the Project Purpose and Results. Look for indicators describing Target Group, Quantity, Quality, Location and Time.

Step 2: Identify sources of verification for the indicators

From the proposal, identify the Sources of Verification (SOV) which will provide information on indicators. Place these in the 3rd column of the log frame.

Step 3: Analyze the proposed performance measurement system for the project

Analyze whether the Results and the Project Purpose are supported by quantified indicators, and that the necessary information will be available from existing sources or, if it is to be collected by project staff, at acceptable extra cost and effort. Use the following as guide questions, but draw on your own knowledge and experience as well:

- Are indicators specified for the Overall Objectives, Project Purpose and Results?
- Are the indicators presented in the document 'specific' to the objectives?
- Are indicators for the Project Purpose and Results quantified and time-bound?

- Are Sources of Verification specified for all indicators?
- Is there evidence that the indicators are measurable at reasonable cost by existing means or by procedures to be developed by the project?
- Has responsibility for information collection been clearly assigned?

Step 4: Formulate questions regarding the performance measurement system

Instruction 6: Preparation of Terms of Reference for the Feasibility Study

Step 1: Sort questions of Relevance, Feasibility and Sustainability

Gather the questions you have formulated during each of the instructions 1 - 5 and sort them into the three categories of Relevance, Feasibility and Sustainability. Check which ones will be addressed first the concerned parties (Delegation, Brussels, proposing organization), and which ones will have to be included in the Terms of Reference. These will appear in the chapter: 'Issues to be studied'.

Step 2: Draft the Terms of Reference

Write the Terms of Reference and avoid repetitions. Additionally to the 'issues to be studied' the Terms of Reference should also comprise procedural matters. As a general rule the Terms of Reference should contain the following chapters:

- Introduction
- Objectives of the study
- Background of the project
- Issues to be studied
- ✓ Relevance
- ✓ Feasibility
- ✓ Pre-conditions
- ✓ Sustainability
- Plan of work
- Expertise required
- Reporting requirements
- Time schedule

Self-Check 4:	Written Test

1. Which of the following is not considered to be a characteristic of a project?

A. An established objective

B. A clear beginning and end

C. Complex tasks

D. Only for internal use

1.1 Never been done before

2. From among the following activities, which is the best example of a project?

   A. Processing insurance claims

   B. Producing automobiles

   C. Writing a term paper

   D. Completing a college degree

   E. All of these are good examples of projects

3. Which of the following constraints is not typically found in managing projects?

   A. Time

   B. People

   C. Cost

   D. .Performance

   E. Both B and D are not typical constraints

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 5:	Planning project work to meet schedule time lines

5.1. Planning project work to meet schedule time lines

Introduction

Project in general refers to a new endeavor with specific objective and varies so widely that it is very difficult to precisely define it. Some of the commonly quoted definitions are as follows. Project is a temporary endeavor undertaken to create a unique product or service or result. It is a unique process, consist of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective confirming to specific requirements, including the constraints of time cost and resource.

Infrastructure Projects: include construction, improvement, rehabilitation or restoration of roads and bridges, railways, airports, seaports, communication facilities, irrigation, flood control and drainage, water supply, sanitation and sewerage systems, shore protection, energy/power and electrification facilities, national buildings, school buildings, hospital buildings, and other related construction projects that form part of the government capital investment.

Non-Infrastructure Projects: include agricultural, industrial, social, environmental, tourism, reclamation and all other types of government projects not otherwise classified as infrastructure.

Project Characteristics

Despite above diversities, projects share the following common characteristics. Unique in nature:

- Have definite objectives (goals) to achieve.
- Requires set of resources.
- Have a specific time frame for completion with a definite start and finish.
- Involves risk and uncertainty.
- Requires cross-functional teams and interdisciplinary approach.

Project Performance Dimensions

Three major dimensions that define the project performance are scope, time, and resource. These parameters are interrelated and interactive. The relationship generally represented as an equilateral triangle. The relationship is shown in figure 1.

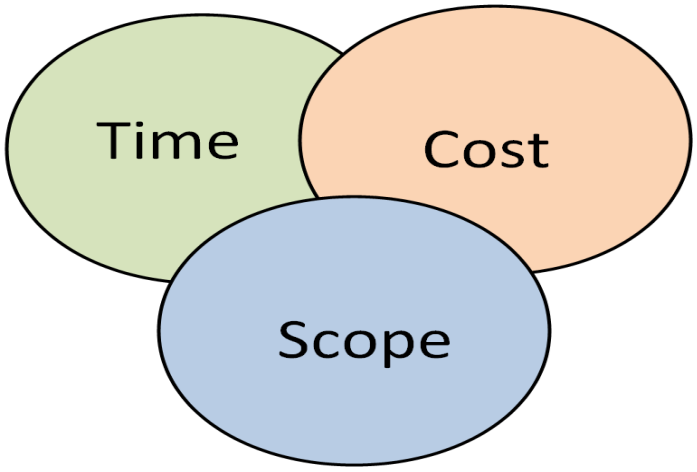


Figure 5.1: Project Performance Dimensions

It is evident that any change in any one of dimensions would affect the other. For example, if the scope is enlarged, project would require more time for completion and the cost would also go up. If time is reduced the scope and cost would also be required to be reduced. Similarly any change in cost would be reflected in scope and time. Successful completion of the project would require accomplishment of specified goals within scheduled time and budget. In recent years a fourth dimension, stakeholder satisfaction, is added to the project. However, the other school of management argues that this dimension is an inherent part of the scope of the project that defines the specifications to which the project is required to be implemented. Thus the performance of a project is measured by the degree to which these three parameters (scope, time and cost) are achieved.

Project Life Cycle

Every project, from conception to completion, passes through various phases of a life cycle synonym to life cycle of living beings. There is no universal consensus on the number of phases in a project cycle. An understanding of the life cycle is important to successful completion of the project as it facilitates to understand the logical sequence of

events in the continuum of progress from start to finish. Typical project consists of four phases- Conceptualization, Planning, and Scope Time Cost Figure 1. Project performance dimensions three Execution and Termination. Each phase is marked by one or more deliverables such as Concept note, Feasibility report, Implementation Plan, human resource development plan, Resource allocation plan, and Evaluation report.

Conceptualization Phase

Conception phase, starting with the seed of an idea, it covers identification of the product / service, Pre- feasibility, Feasibility studies and Appraisal and Approval. The project idea is conceptualized with initial considerations of all possible alternatives for achieving the project objectives. As the idea becomes established a proposal is developed setting out rationale, method, estimated costs, benefits and other details for appraisal of the stakeholders. After reaching a broad consensus on the proposal the feasibility dimensions are analyzed in detail.

Planning Phase

In this phase the project structure is planned based on project appraisal and approvals. Detailed plans for activity, finance, and resources are developed and integrated to the quality parameters. In the process major tasks need to be performed in this phase are

- ✓ Identification of activities and their sequencing
- ✓ Time frame for execution
- ✓ Estimation and budgeting
- ✓ Staffing a Detailed Project Report (DPR) specifying various aspects of the project is finalized to facilitate execution in this phase.

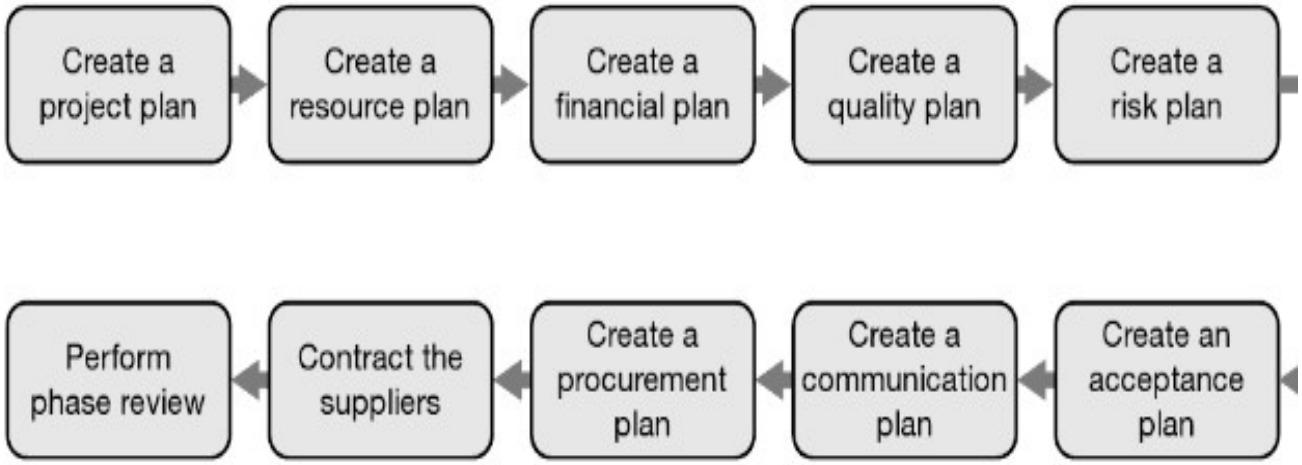


Figure 5.2: Project Planning Activities

Execution Phase

This phase of the project witnesses the concentrated activity where the plans are put into operation. Each activity is monitored, controlled and coordinated to achieve project objectives. Important activities in this phase are

- ✓ Communicating with stakeholders
- ✓ Reviewing progress
- ✓ Monitoring cost and time
- ✓ Controlling quality
- ✓ Managing changes

Termination Phase

This phase marks the completion of the project wherein the agreed deliverables are installed and project is put in to operation with arrangements for follow-up and evaluation.

Life Cycle Path

The life cycle of a project from start to completion follows either a “S” shaped path or a “J “shaped path (Figure 5.3 and 5.4). In “S” shape path the progress is slow at the starting and terminal phase and is fast in the implementation phase.

At the beginning detailed sector planning and coordination among various implementing agencies. Makes progress slowly and similarly towards termination, creating institutional

arrangement for transfer and maintenance of assets to the stakeholders progresses slowly.

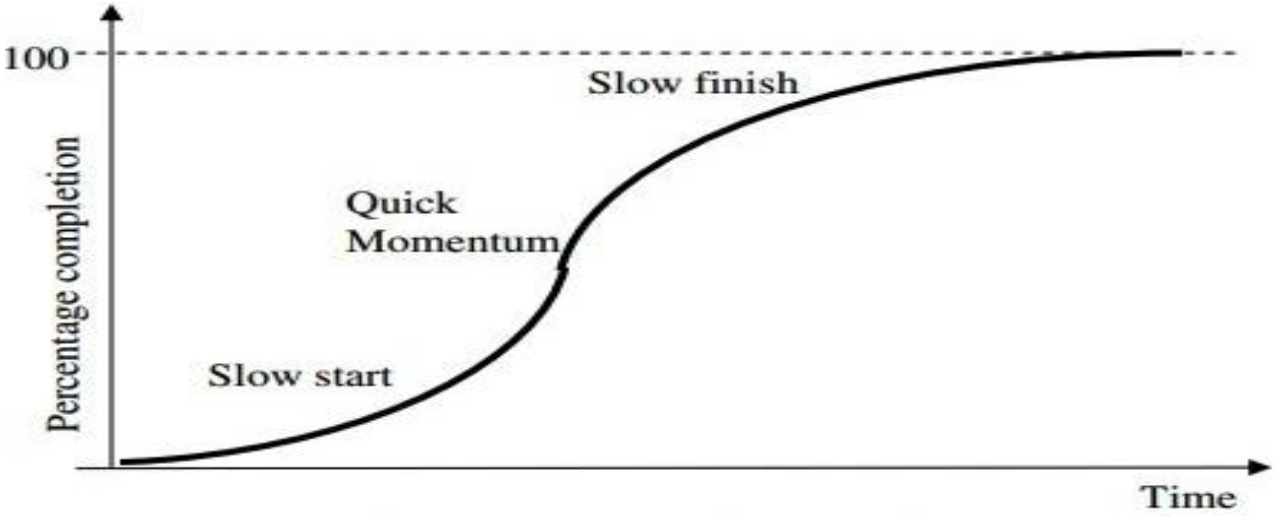


Figure 5.3: Project Life Path “S” Shape

In “J” type cycle path the progress in beginning is slow and as the time moves on the progress of the project improves at fast rate. In this the land preparation progresses slowly and as soon as the land and seedling are transplantation is under taken. This is shown in figure 3.

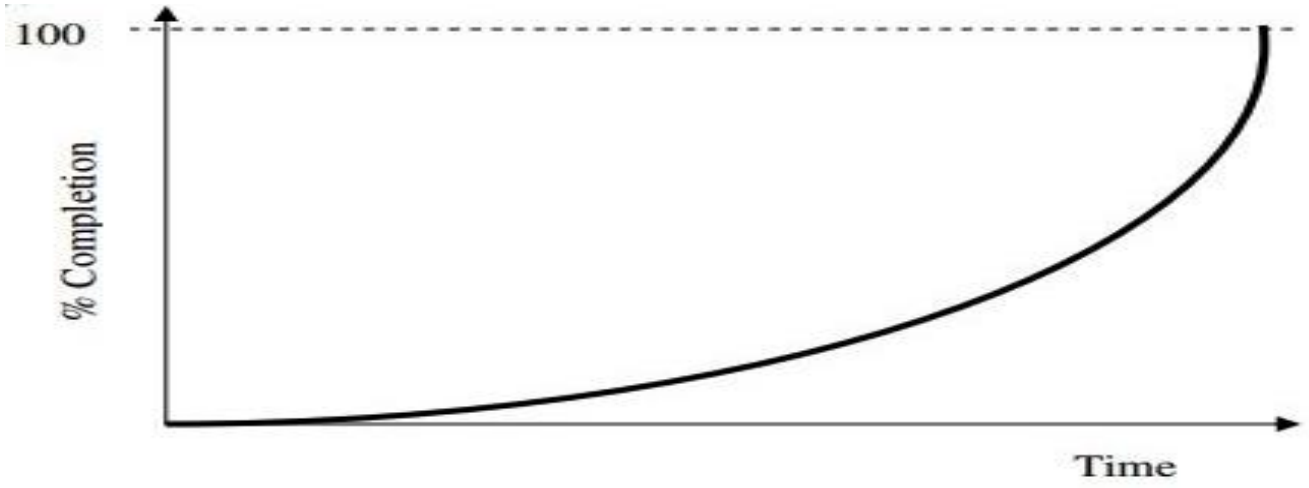


Figure 5.4 : Project Life Path “J” Shape

Dimensions of project plan development

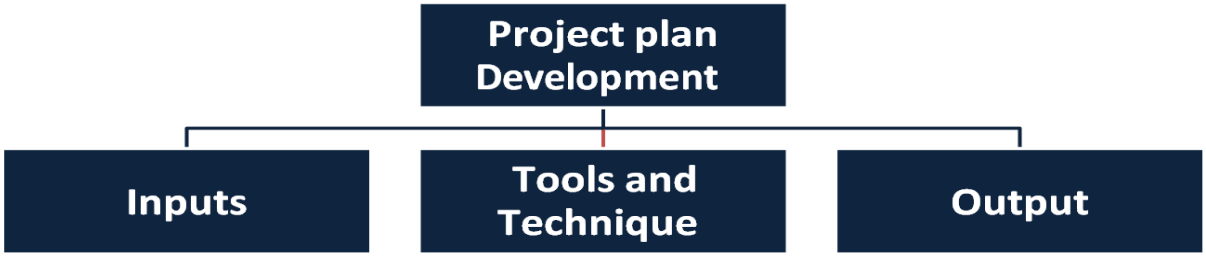


Figure 5.5 : **Dimensions of project plan development**

Inputs to project plan development

- Other planning outputs: includes all of the outputs derived from the core and facilitating processes as well as the work breakdown structure and supporting details
- Historical information; includes all available historical information to assist in verifying assumptions and assessing alternatives that are identified as part of this process
- Organizational policies: a formal and informal policy that includes but are not limited to:

✓ Quality management

✓ Personnel administration

✓ Financial controls

- Constraints: factors that will limit the project management team's options
- Assumptions: factors that are considered as true, real or certain but involves risk

Project plan and project planning

A formal, approved document used to guide both project execution and project control the processes involved in the development of a project plan.

Uses of project plan

- Guide project execution
- Document project planning assumptions
- Document project planning decisions

- Facilitate communication
- Define key management reviews
- Provide a baseline for progress measurement and control

Purpose of project planning

- Directing Objectives, Goals, Special influences and Constraints on the project scope
- Identifying actions, risks and responsibilities.
- Guiding Identification of required activities and establishing workable procedures.
- Preparing flexibility to adapt to changes and retain the qualities of integrity and durability.

Elements of a project plan

That can be easily absorbed by high-level executives within a few minutes that typically identify:

- Objectives
- Goals
- Constraints

- Specifications- Define the characteristics and the performance goals for the final end product.
- Work Statement - Tells the contractor what is desired, or what exactly the contractor proposes to do.
- Interrelate all tasks on a common time scale including:
  - ✓ Names of the tasks and work packages listed in the WBS
  - ✓ Names of the persons responsible for each task
  - ✓ Expected duration of each task
  - ✓ Due date of each task
- Procedures Guide: Covers the rules and practices to be observed during the project
- Budgets and Cost Control System: Provides the project manager with cost, schedule and performance status.

- Activity / Event / Network Plan: Representation of how the project activities and events progress.
- Materials and Equipment Forecast: Includes procurement and management of materials and equipment that starts with the documentation of what materials and equipments are needed.
- Cross-Impact Matrix: Indicates which organizational units and which key personnel are involved in the process of completing each task of the project.
- Project Organizational Plan:
  - ✓ Indicates breakdown of major project responsibilities
  - ✓ Who is specifically responsible for each project subsystem and task
  - ✓ Establish key responsibilities
- Management Plan: It should describe how management will conduct and monitor the project that includes:
  - ✓ Corporate organizational charts
  - ✓ Statements of authority and responsibility
  - ✓ Information and control systems
  - ✓ Top management plan of attack
- Project Plan Personnel: This includes the labor resource requirements and organization that will establish key responsibilities, numbers and qualifications.
- Reporting and Review Procedure: It includes an early assessment of required reports, meetings, presentations and project documents to determine those contributing to the overall or individual activity performance.

Table 5.1: Time Schedule or project work plan example

	Project Schedule							
Months/ Activities	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Document Review								
Field Visiting And Site Selection for availability of relevant data								
Data Collection Tool Preparation								
Work Flow Draft Design								
Developing algorithms and Programming								
System Design or Simulation Development								
Identifying and Selecting Components Devices, Instruments, Equipment								
Assembling the Components								
Actual Processing And Running the System								
Validating And Lab Testing								
Presentation The Report								
Demonstrating And Implementation								

Self-Check 5	Written Test

Write short notes on the following:

1. Define a project with help of example.
2. Explain briefly the Project Life Cycle and the phases involved with the help of an example
3. Explain with the help of a diagram the concept of the Triple constraint and its effect on a project.

Note: - Satisfactory rating: 7 and above - Unsatisfactory Rating: below 7

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information 6:	Selecting resources based on compatibility with project requirements and budget constraints

6.1. Selecting resources based on compatibility with project requirements and budget constraints

Something you should not do when you are developing a budget is making it up as you go along". As with most good practice in managing an organization, good practice in budgeting involves clarity of purpose, detailed planning and considerable thought. Among the questions you should be asking yourselves throughout the preparatory budgeting stages, and while you are actually developing your budget, are:

- Could we have spent less last year and still achieved the same results, or better?
- Have we wasted money in the past? If so, can we avoid doing so in the future?

In this section of the toolkit, we look at:

- What is a budget, who should be involved in budgeting, and why do we budget?
- The operational plans
- Estimating costs
- Sources of finance.

These are all issues that you need to address before you begin developing your budget. They are an extension of the planning process on which all budgeting is based.

Budget

A budget is a document that translates plans into money - money that will need to be spent to get your planned activities done (expenditure) and money that will need to be generated to cover the costs of getting the work done (income). It is an estimate, or informed guess, about what you will need in monetary terms to do your work.

A budget is **not**:

- Written in stone – where necessary, a budget can be changed, so long as you take steps to deal with the implications of the changes. So, for example, if you have budgeted for ten new computers but discover that you really need a generator, you could buy fewer computers and purchase the generator.
- Simply a record of last year's expenditure, with an extra 15% added on to cover inflation. Every year is different. (See also the section on different budgeting techniques.) Organizations need to use the budgeting process to explore what is really needed to implement their plans.
- Just an administrative and financial requirement of donors. The budget should not be prepared as part of a funding proposal and then taken out and dusted when it is time to do a financial report for the donor. It is a living tool that must be consulted in day to day work, checked monthly, monitored constantly and used creatively.
- An optimistic and unrealistic picture of what things actually cost – don't underestimate what things really cost in the hopes that this will help you raise the money you need. It is better to return unspent money to donors than to beg for a "bit more" so you can complete the work.

Two key questions you should be able to answer about budgeting are:

- Why budget? and
- Who should be involved in budgeting?
- Why budget?
- Why is it important for an organization, project or department to have a budget?

The budget is an essential management tool. Without a budget, you are like a pilot navigating in the dark without instruments.

- The budget tells you how much money you need to carry out your activities.

- The budget forces you to be rigorous in thinking through the implications of your activity planning. There are times when the realities of the budgeting process force you to rethink your action plans.
- Used properly, the budget tells you **when** you will need certain amounts of money to carry out your activities.
- The budget enables you to monitor your income and expenditure and identify any problems.
- The budget is a basis for financial accountability and transparency. When everyone can see how much should have been spent and received, they can ask informed questions about discrepancies.
- You cannot raise money from donors unless you have a budget. Donors use the budget as a basis for deciding whether what you are asking for is reasonable and well-planned.

Budgeting is a difficult and responsible job. Your organization's ability to do what it has planned to do and to survive financially depends on the budgeting process. Whoever does the budgeting must?

- Understand the values, strategy and plans of the organization or project;
- Understand what it means to be cost effective and cost efficient (see Glossary of Terms);
- Understand what is involved in generating and raising funds.

To ensure you have all these understandings, it is usually a good idea to have a small budgeting team. This may only mean that one person does a draft budget which is then discussed and commented on by the team.

Where staff is competent to take full responsibility for the financial side of the organization or project, the following would normally be involved in the budgeting process:

- The Finance Manager and/or Bookkeeper;
- The Project Manager and/or Director of the organization or department.

Where staff lacks confidence to do the budgeting, then Board members can be brought in. Some Boards have a Finance Committee or a Budget Sub-Committee. It is a good idea to have someone on your Board with financial skills. S/he can then help the staff with budgeting.

The budget is the business of everyone in the organization. At the very least, senior staff should understand the budget, how it has been drawn up, why it is important, and how to monitor it.

Where an organization has branches and/or regions, or several departments, then each branch, region or department should draw up the budget for its own work. These budgets then need to be consolidated (put together) in an overall budget for the organization. Each branch, region or department should be able to see how its budget fits into the overall budget, and should be able to monitor its budget on a monthly basis. Financial monitoring works best when those closest to the spending take responsibility for the budget.

The Operational Plans

Your operational plans are the plans for the actual work. They are also called action plans or business plans. In a normal planning cycle, the organization or project will begin with a strategic planning process. Here you look at the problem that needs to be addressed and the specific role of your organization or project in addressing it. This then is related to what actual activities need to be undertaken to achieve the planned impact. This is the operational plan and it is the operational plan that needs to be "costed." You cannot prepare a budget until you know what it is you are planning to do. Operational costs will only be incurred when you do the actual work. They are also known as direct costs.

You may ask whether you can't at least prepare a budget for the costs you know you will have anyway – like rent, telephone, stationery – before you get into strategic planning.

The answer is "no". Your overhead costs should be dependent on what you intend to do. So for example, if you decide to focus your activities in the rural areas, you may

decide you need much smaller offices in the urban area that has been your traditional work base. Your **overhead or core costs** are affected by your operational plans.

The planning cycle should look something like this:

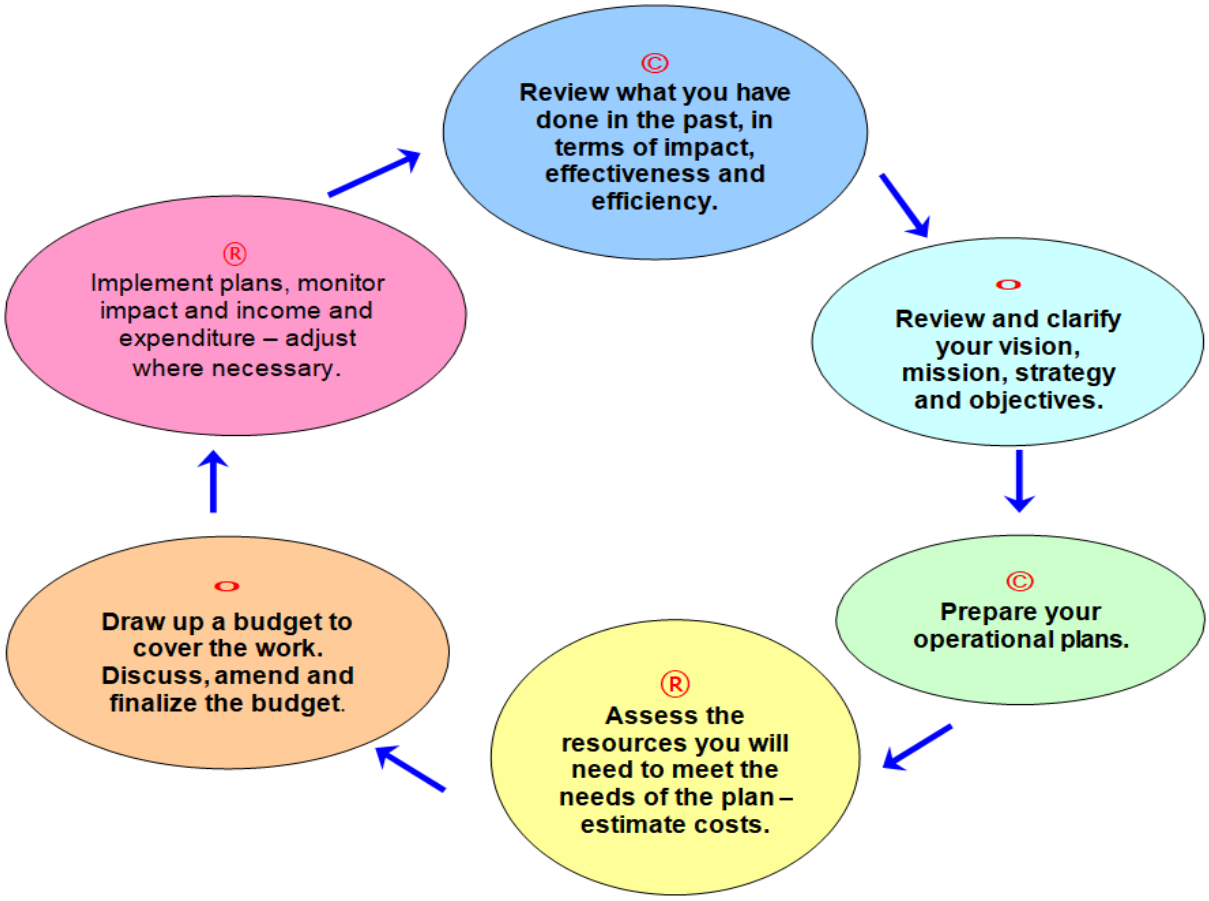


Figure 6.1: The planning cycle

Estimating Costs - Categories

The cost estimate is what helps you determine realistically what it will cost to implement your operational plan. When you carry out your plans you will probably need to make use of a wide range of inputs. Inputs include people, information, equipment, skills. Most of these inputs will have a cost attached to them. These are the costs you need to estimate in order to develop a budget.

Careful cost estimation helps in the following ways:

- It helps you develop an accurate budget; and

- It helps you to monitor and control the actual costs of carrying out activities.

The costs you need to estimate fall into the following categories:

- **Operational costs** – the direct costs of doing the work e.g. the cost of hiring a venue, or of printing a publication, or of travelling to the sites where fieldwork needs to take place. Here you would include materials, equipment, transport and services.
- **Organizational costs** (also called core costs) – the costs of your organizational base, including management, administration, governance. Once you have decided on the best organizational set-up to support your operational plans, you will incur the organizational expenses on a regular basis – even if you do not carry out your plans or have activity levels as high as you had hoped. So, for example, if you hire premises for four projects but only manage to carry out two, you will still have to pay rent for the extra space. If you have hired a full-time receptionist on the same belief, you will still have to pay her salary, even if she is under-utilized.
- **Staffing costs** – these are the costs for your core staff – the people involved in management, the people doing work that cuts across projects. (These costs can be included as a category under "organizational costs".) These costs include their salaries and any benefits such as medical aid or pension fund payments for which the organization is responsible. You can "charge staff costs out" to the various projects on which the staff members work. So, for example, if your Publications Officer is going to spend half her time working on publications for a particular project, then you can include half her salary and benefits in your costing for the project. If your Director is going to spend 15% of her time providing management support to the head of the same project, then 15% of her time and benefits can also be charged to the project.
- **Capital costs** – these are costs for large "investments" which, while they may be necessary because of a project or projects, will remain organizational assets even after the projects are over. Vehicles and equipment such as computers and photocopiers fit here. They may be used by all projects, or they might only be

required for a specific project. Depending on how you intend to use the equipment, you might budget for it under operational costs or under organizational costs.

Look at the section on frameworks for estimating costs for more help.

Frameworks for estimating costs

Note: Depending on the needs of your organization or project, your headings may be a bit different. This should give you some guidelines.

Table 6.1: Estimating operational costs:

Activity:			
	Unit cost	Quantity	Total cost of item
Materials Equipment Services Transport	The unit cost is the cost of a single item, or one unit. E.g. Cost per day, per kilometer, per person.	This is the number of units (how many) you will need for the activity. e.g. 200 Training packs, 130 days of trainers' time.	Multiply the total number of units by the unit cost.
Total cost for Activity			The sum of all the individual costs

Once you have done your estimates here, you may decide to assign a percentage of the various items to specific departments or projects. This is acceptable practice.

Table 6.2: Estimating organizational cost:

	2020	**2021**	**2022**
Management: Salaries/benefits: Donor liaison: Governance liaison: Public relations: Fundraising: Human resourcing:			

Administration: Salaries/benefits: Equipment: Software: Stationery:			
Governance and organizational development: Board meetings: Organizational processes: Resource centre:			
Overheads: Office rental: Electricity and water: Insurance: Maintenance: Legal fees and audit fees:			
Annual totals:			
Total:			

Here we want to look at how you go about including income in your budget.

What sorts of categories should be included in your income budget?

This will depend on your usual, or planned, sources of income generation. Some possible broad categories are:

- Promised donations
- Probable donations
- Possible donations
- Income generated from sales
- Income generated from services
- Subscriptions
- Membership fees
- Special events
- Investments
- Campaigns.

In your budget you make reasonable estimates of the income you can expect to generate from each category specified. These will serve as targets for your income generation.

Budgeting Guidelines

While budgeting depends to a certain extent on the particulars of your organization or project, there are certain guidelines which apply across projects and organizations.

Budgeting Rules

These are not rules that are fixed for all time. They offer some guidelines that will help you deal with common situations.

- It is usual for long-term projects and organizations to prepare a budget which makes projections for several years at a time. While it is usually only the budget for the forthcoming year that is really quite accurate, the projections for the following years gives some indication of the levels of funding that are likely to be needed. Some allowance is usually made for inflation for subsequent years, as well as for the anticipated activities which may differ from the first year. A three-year budget should be based on a three-year plan.
- Contributions in kind (not money, but goods) should be included as a note to the budget (for more on notes see the consolidated budget in the examples). Although they are not part of the budget, they reduce budget costs and so should be indicated.
- Some costs that need to be estimated but that often get forgotten:
    - ✓ Start-up costs – for a new organization or project, such as large-scale recruitment, moving in, building alterations, launching the project or organization.
    - ✓ Research and development – consultation, needs assessment, planning processes.
    - ✓ Democracy and governance – establishing the structures, recruiting for them, getting a constitution developed and accepted, training members of voluntary structures.
    - ✓ Marketing or public relations – building a professional image.
    - ✓ Replacement of capital goods.
    - ✓ Monitoring and evaluation costs for projects.

- Estimates are **informed** guesses, not just guesses. Do your homework, get quotes, phone around to arrive at a likely cost. Check any figures you have from previous years that may provide helpful information. Note down any price increases you already know about (e.g. a salary increase of 10% may have already been agreed.) Make notes of any unusual expenses that are likely to occur (e.g. moving your offices). A few dollars may not seem a big amount, but multiplied many times over this kind of discrepancy can make a big difference in your budget.
- Keep your notes! As you plan your budget and make decisions about how you will estimate costs, keep your notes handy so that you can go back and check where the amounts came from. You may, for example, work out your workshop costs on the basis of a certain amount for photocopying, based on an estimated per page cost. When, a year later, the costs are higher than anticipated, you should go back to your notes and see where the discrepancy comes in. Or, in another scenario, a donor makes ask you to explain how you arrived at the cost per participant for workshops.
- For your own management purposes, break the budget for the forthcoming year into a monthly budget.

Defining Your Line Items

Line items are the actual items listed in your budget. So, for example, under the category “training costs”, “stationery” might be a specific line item. Under the category “governance”, “training for Board members” may be a specific line item.

It is up to you to decide what your categories will be and to decide what the line items under each category will be. So, for example, one organization may include “governance” under “management”, and “donor liaison” under “fundraising”, while another may have them as separate categories or line items.

How do you decide which categories and line items you should use in your expenditure budget?

- If this is the first time you have done a budget, begin by listing all the items that are going to cost the project money. Later on, you will have some idea of the categories and items that make sense for your organization or project so you will be able to take short cuts when you lost your line items.
- Once you have the list, group things into categories according to the emphasis you put on categories in your management practices. So, for example, if you, as management, think it is important to keep track of training costs, then "training costs" would be a category. Items such as stationery, venues, printing costs, food, accommodation, transport, and trainers' fees and so on would be line items under that category. However, perhaps your organization does not do much training and only intends to run one training course as part of a bigger project. Then your category might be "Project X", and "training course" might be one line item.
- Think in terms of cost centers. A cost centre is a grouping of activities that make a coherent financial unit. So, for example, each project within your programme might be a cost centre. You then budget both income and expenditure for that cost centre and keep your financial records in terms of cost centers. This enables you to assess each project, department or unit financially. If you opt for a cost centre approach, your cost centers will determine the main categories under which you list line items. If you go this route, then the "directorate" would be a cost centre and so, for example, would "training" or "publications" or "resource centre."
- Sometimes it is possible to work out how much a category of expenses is costing even if that category has not been listed as such, and the item is reflected as a line item under a number of categories. So, for example, you may not have a category "transport", but if you want to know how much transport is costing the project or organization, you can add up the transport line item listed under several categories.

- If you plan to raise funds to cover a particular category, then, obviously, that category needs to be distinct in your budget. So, for example, if you want to raise money for capacity building in communities, then you need a category in the budget that is head “Capacity building in communities”.

Different Kinds of Budgets

In addition to your main working budget – what you realistically expect to generate or raise, and how this will be spent – you can also have some “what if” options budget. “What if” budgets allow you to prepare for the unexpected – whether it is good or bad? You’re “what if” budgets could include:

- A **survival budget**. This is the minimum required in order for the organization or project to survive and do useful work.
- A **guaranteed budget**. This is based on the income guaranteed at the time the budget is planned. Usually the “guarantees” are in the form of promises from donors. However, unexpected situations, such as a donor grant coming through very late, may make it necessary to switch to your survival budget.
- An **optimal budget**. This covers what you would like to do if you can raise additional money. Once extra money comes in or is promised, it becomes part of your working budget.

Different Budgeting Techniques

The two main techniques for budgeting are **incremental budgeting** and **zero based budgeting.**

- Incremental budgets are budgets in which the figures are based on those of the actual expenditure for the previous year, with a percentage added for an inflationary increase for the New Year. This is an easy method that saves time but it is the “lazy” way and is often inaccurate. This budgeting technique is only suitable for organizations where each year is very similar to the previous one in terms of activities. Very few dynamic organizations or projects are so stable that this budgeting technique really works for them.

- In zero based budgets, past figures are not used as the starting point. The budgeting process starts from “scratch” with the proposed activities for the year. The result is a more detailed and accurate budget, but it takes more time and energy to prepare a budget in this way. This technique is essential for new organizations and projects, but it is also probably the best route to go in a dynamic organization that is proactive in taking on new challenges.

Some Budgeting Issues

In this section we address some of the questions that are often asked about budgeting under the following headings:

Budgeting price increases

Budgets are prepared in advance. There are likely to be price increases between the time of preparation and the time when the amount is spent or received. Take this into account when you do your budgeting by estimating what the costs or value will be when the expenditure is made or the income received.

If there is likely to be an increase in costs then make sure that you also estimate for an increase in what you charge in fees for services or in sales of products.

You need to keep your calculations for your budget because some donors may be willing to provide a supplementary grant if you can show clearly that you calculations were based on a smaller rate of inflation than actually proved to be the case.

The level of detail needed

This is not a simple question to answer. On the one hand, the less detail you give, the more flexible you are. On the other hand, leaving the budget too open makes it less useful as a management tool. This does not mean that every single thought and detail should be included in the budget line items. So, for example, you could have a global amount for “training” under a project, provided that you have your own notes on how you arrived at the amount. In general, however, the detail, while it may restrict you in negotiations with donors, provides you with useful management information.

One way to deal with this is to have different versions of the budget for yourselves and for donors and potential donors. The donor version would be more flexible and less detailed, and the management version so less.

In general, your donor version should follow the guidelines provided by the donor agency for how it wants you to present your budget. If the agency does not have written guidelines, speak to the project or desk officer who deals with your area of work and aks for advice on how to prepare the budget.

Your management budget is translated into your bookkeeping system and, to the degree that the budget is detailed, your bookkeeping system will be detailed and will be able to provide you with valuable information about where and how you are spending your money or generating income.

Contingency amounts

A contingency amount is an amount that you put aside to deal with unforeseen events. While budgets should be informed guesses, there is still an element of "guessing" in them. The future is uncertain and organizations and projects have to survive in uncertain times. Because of this, some organizations allow for a "contingency" line item in their budgets – usually about 10% of the overall annual budget.

However, many donor agencies do not like this and refuse to fund a "contingency" line item, possibly because they believe that organisations and projects should be more accurate in their budgeting. One way to deal with this, is to build contingency amounts into the major line items in your budget, allowing for an additional 10% over and above your calculations.

Budgeting income generating projects

An example might be a training course for which you charge and from which you expect to make a profit over time.

In your overall budget for the project or organization, you could include the costs in the line items reflecting expenditure, and the income in your line items reflecting income. However, for management purposes you will want to be able to monitor in

greater detail than this, in order to establish at what stage a break-even point is reached.

Timeframes

Organizational budgets (for the whole organization) are usually calculated for a year at a time (based on the financial year of the organization). This also applies to ongoing departmental budgets. Once you have an annual budget, it is best to break it down into months, for management purposes. When you present a budget that covers several years, make sure that this budget is based on a medium-to long-term plan, and is not simply an uninformed guess. Budgets for specific, time bound projects may be calculated for the whole life of the project. For monitoring purposes it is probably best to break this overall project budget into years (where the project runs over several years). You may then also decide to break it up into months.

By now you should have done all your preparatory planning and be ready to draw up your budget. As you work through this section, you may want to refer to the budget given in the example – consolidated budget.

It is useful to think about the process of drawing up a budget in steps. By now you should have already gone through the first three steps as part of your preliminary work for developing the budget:

- List the items on which you spend money. You will know what these are from your action planning process. Group the items under headings or cost centers.
- Estimate the unit cost of the line items and then the annual costs.
- List your likely sources of income or revenue. Categorize them. This is the basis of your income budget.

Now you are ready to begin putting your budget into a budget format. The remaining steps are:

- Prepare your budget format.
- Do your addition.
- Add in notes to explain items that may not be clear.
- Get feedback on your budget.

- Finalize your budget.

Monitoring the budget

The budget is the most important tool you have for monitoring the finances of your organization, project or department. You use the budget to:

- monitor your income and expenditure to see whether or not you are on target;
- report how you are doing financially to your staff, board and donors;
- do cash flow projections;
- Make financial decisions.

Budget monitoring is used to measure how closely an organization is meeting its objectives in terms of its finances. Comparisons of actual income and expenditure against the budgeted income and expenditure need to be done regularly. This shows you, month by month, where you are over-spending, under-spending or on target. In order to be able to do a variance report and in order to be able to do cash flow projections, you need to break your overall budget up into a monthly budget.

The monthly breakdown is what gives you your management tool. For an example of a monthly breakdown of a budget, go to the example of a monthly breakdown.

Reporting Against Budget

The purpose of reporting against your budget is to show those to whom you are accountable, or those who are involved in your work, whether or not you are doing the work stipulated and whether or not you are going to have the resources you need to complete the work. When you report against your budget you are reporting on how close your financial planning has been to your actual financial performance.

The variance statement compares the expected income and expected expenditure with the actual income and expenditure. The variance statement gives you an overview of what has happened in the reporting period (one month, three months etc). It also gives you an overview of financial performance for the year thus far ("year-to-date"). A variance statement shows you whether there are any trends that are developing in financial performance about which you should be aware. It gives you

the opportunity to take action to correct problems. So, for example, if the variance statement shows you that you are repeatedly spending too much on stationery each month, you could:

- keep a tighter control over the stationery;
- Recognize that you have under-budgeted on stationery and either shift some money from somewhere else in the budget to stationery, or try to raise or generate more money to cover the anticipated shortfall.

The important thing is that you will be aware that all is not right and be able to take remedial action before the problem gets out of hand.

Spending too much is not the only problem. Sometimes when you spend too little you also have a problem. So, for example, an organization that finds it is way under budget on training expenses may identify the problem as being too little activity in the Training Department. This may require re-planning for the rest of the year to ensure that targets are met.

When you report to your department, your superiors in the organization and your board, you need to do so on the basis of a variance statement.

On the next page you will find a useful format for a variance statement. (See also the example of the variance statement.) Whenever you have a variance of 10% or more (either too much or too little), you need to look for an explanation and, if necessary, to take remedial action.

Table 6.3: Variance statement format:

		This reporting period		**Year-to-date**	
		Budget	**Actual**	**Budget**	**Actual**
Income	Sales				
	Consulting				
	Cost recovery				

	Interest from investment				
	Donations				
	Total income				
Expenditure	Project 1 Project 2				
	Directorate				
	Operational costs				
	Organizational costs				
	Staffing costs				
	Total expenditure				

Making Decisions

Monitoring the budget is not just something that you do so that you will know more about your financial performance as an organization or a project. You need the information to be able to take decisions.

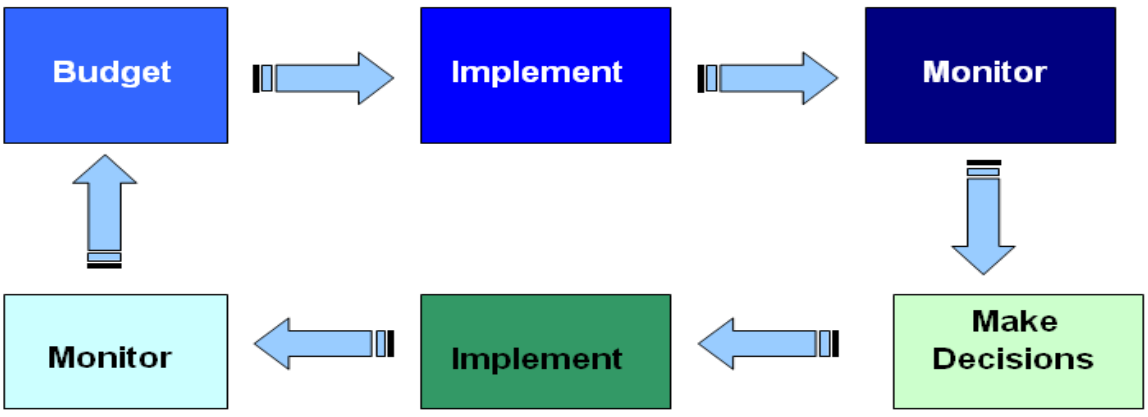


Figure 6.2: Budget making cycle

The success of the process is dependent on the ability of those with management responsibilities to make decisions and take action. The steps involved are:

- Prepare your baseline information. (Budget, monthly break down)
- Get information on financial performance.
- Analyze the information and work out what it is telling you.
- Look at the potential consequences to your financial strategy and plans.
- Draw up a list of options for action.
- Get consensus and a mandate to take action.
- Share adjustments and plans with the rest of the organization and, if necessary, your donors.
- Implement.
- Monitor.
- Build your learning's into future budgeting processes.

Self-Check 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. A budget is a plan of action expressed in…
   a. Financial terms
   b. Nonfinancial terms
   c. Both
   d. Subjective matter
2. Budget is prepared for a…
   a. Indefinite period
   b. Definite period
   c. Period of one year
   d. Six months
3. A budget is tool which helps the management in planning and control of…
   a. All business activities
   b. Production activities
   c. Purchase activities
   d. Sales activities
4. Budgetary control system acts as a friend, philosopher and guide to the…
   a. Management
   b. Share holders
   c. Creditors
   d. Employees

5. Budgetary control system facilitates centralized control with…
    a. Decentralized activity
    b. Centralized activity
    c. Both
    d. None
6. Budgetary control facilitates easy introduction of the…
    a. Marginal costing
    b. Ratio analysis
    c. Standard costing
    d. Subjective matter
7. Budgetary control helps the management in…
    a. Obtaining bank credit
    b. Issue of shares
    c. Getting grants from government
    d. All of these
8. Budgetary control system helps the management to eliminate…
    a. Undercapitalization
    b. Overcapitalization
    c. Both
    d. Subjective matter

Note: - Satisfactory rating: 8 and above - Unsatisfactory Rating: below 8

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

LG #19	LO #2. Develop design briefs

Instruction sheet

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

- Developing design briefly including requirements established in consultation with appropriate person(s)
- Developing design briefly in collaboration with all design professionals and contractors
- Identifying Competent persons required for the project and their roles specified in the design
- Reviewing Project design briefly against all inputs and adjusted to rectify any anomalies.

Documenting Project design brief proposal 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:

- Develop design briefly including requirements established in consultation with appropriate person(s)
- Develop design briefly in collaboration with all design professionals and contractors
- Identify Competent persons required for the project and their roles specified in the design
- Review Project design briefly against all inputs and adjusted to rectify any anomalies.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information sheet 1	Developing design brief including requirements established in consultation with appropriate person(s)

1.1. **Developing design brief in consultation with appropriate person(s)**

A design brief is a short statement that describes some or all of the following:

- the sort of product to be made and its purpose;
- who will use it;
- where it will be used;
- Where it might be sold.

An **open** brief provides general guidelines and offers the opportunity for a wide range of possible outcomes. A **closed** brief is more specific and detailed in its requirements. Here are examples of open and closed briefs for two lines of interest.

Open design brief: "Design and make a range of items that utilize simple sensing devices."

Closed design brief: "Design and make a sensing device that can be used to sense the temperature in a hen coop and sound an alarm should the temperature fall below 4°C."

The open brief provides the designer with the freedom to explore a wide range of sensing possibilities and situations. The closed brief provides opportunity to produce different solutions, but the nature of the sensing device required is more clearly defined so the range of possible outcomes is limited.

Open design brief: Design and make a product that uses timing

Closed design brief: "Design and make an electronic wristwatch with alarm facilities suitable for young people in the 15-19 age range."

A wide range of product types is possible from the open brief, including simple wristwatches, simple clocks, simple stop watches, and timer units for microwave ovens. In the closed brief the nature of the product and the end user are more clearly identified. This provides a more detailed picture of what is required.

The closed brief provides the opportunity to produce different solutions, but the limited ability of the users; the size, water-resistance requirement and probable limits to the purchasing price constrain the range of possible outcomes.

Specifying the product

You will need to develop the design brief into a performance specification. This will provide a list of criteria against which you can assess your design as it develops.

The performance specification will always;

- describe what the product has to do;
- describe what the product should look like;
- State any other requirements that need to be met.

For example:

- how it should be used;
- how much it should cost to manufacture;
- possible production levels – one-off or batch production;
- what materials it should be made from;
- what energy source should be used if it needs to be powered;
- ergonomic requirements related to end user;
- Legal requirements to be met in its development and use;
- Environmental considerations and requirements.

Here examples of performance specifications and products that meet their requirements.

Intruder alarm specification

What it has to do:

- detect break-ins through doors or windows;
- sound a loud alarm;
- Show on a display panel where the break in has occurred.

What it should look like:

- its presence should be obvious and not hidden;
- its visible parts should look hidden;
- The display panel should be easy to read.

Other requirements:

- It should be impossible to deactivate from outside the building;
- It should be suitable for batch production.

Electronic Circuit Design

Project Title: Rain detection and water level controlling using 8051 Microcontroller

Scenario:

The main theme of our project is to save water, in addition to water level controlling in the tank, we will open the cap of the tank if we detect the rain water and not only these, we have added another feature to our device by adding buzzer (alarm), so that it gives alarm when rain falls which help to bring back the items (clothes, eatables) that we have kept in sunlight for drying.

This project can be understood well by dividing it into three parts:

- Water level controller
- Rainfall detection
- Adding alarm

In first part will help us in controlling the water motor by sensing the water level in a tank. This system monitors the water level of the tank and automatically switches ON the motor whenever the tank is empty and switched OFF when the tank is full. In second part we detect rain water and in the third part we let the alarm to make sound if we detect rainfall.

Problem:

In this activity, you will design an electronic circuit that will control water level sensing in water tanks, controlling water level automatically and detection of rain and giving alarm if rain is detected. This approach would help in reducing water wastage as we can even use the rain water by allowing it into the water tank and the alarm will help the household men/women in bringing the items that were kept in sun for drying. Furthermore, we fix a LCD for indicating the level of water in the tank and this LCD also indicates the rainfall. Water is most commonly used resource for daily consumption, agriculture, industry. So, efficient use of water by monitoring the tank level of water is a potential constraint for home/office. Automatically controlling the motor by detecting the level of water would save lot of water. Water, one of the great natural resources should be utilized in proper form. But a huge amount of water is being wasted during daily life due to lack of control. Our proposed system guarantees to accumulate a good amount of usable water every day.

Self check 1	Written test

Directions: Answer the questions listed below. Use the Answer sheet provided in the next page.

1. _____ consists of analysis and synthesis of electronic circuits (2 points)
   A. Sequence
   B. Electronic circuit design
   C. Structure
   D. design brief
2. _____ a list of interactive steps taken by human or machine agents playing system roles (3 points)
   A. Sequence
   B. design brief
   C. Structure
   D. managers
3. _____is a document for a design project developed by a person. (5 points)
   A. Structure
   B. Situation
   C. design brief
   D. design brief

Note: - Satisfactory rating: 6.5 and above - Unsatisfactory Rating: below 6.5

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 2	Developing design briefly in collaboration with all design professionals and contractors

2.1. Developing design briefly in collaboration with all design professionals and contractors

Introduction

Organizations today seek to establish groups, committees, or coalitions as a strategic element for collaboration, many times committing themselves to achieving greater integration of efforts and having greater impact. This is a process that requires time, resources, commitment and leadership but, above all, should grow from the felt need of the participating organizations. Collaboration goes beyond merely participating with other groups or organizations in a task or activity. It requires planning, coordination of efforts and a specific objective that is common to all participants.

When should collaboration be initiated?

Even with the many benefits offered by a collaboration exercise, we know that it does not happen automatically. Sometimes it will be complicated and on other occasions it will be inefficient if not structured with detailed planning regarding expected results.

For this reason, before initiating any collaboration process it is important to answer the following questions:

- Is my organization ready to collaborate?
- What is the goal for this collaboration?
- What level of interaction does my organization require?

The diagram below graphically presents three possible levels of interaction which can serve as a reference to identify the degree of commitment that the participating organizations are willing to assume in order to work together to achieve their objectives.

Factors to consider when determining the intensity of a new collaboration type of participation:

- Number and nature of the tasks to be carried out.
- Degree of participation by the funding agencies
- Level of authority in decision making that the organizations can allow
- Amount of time and coordination required in order to be successful
- The degree of responsibility that each organization is willing to commit to

The Potential Benefits:

- Share abilities with some degree of specialization
- Create uniform messages and materials
- Share ideas and different perspectives about how to address complex issues
- Coordination of services and initiatives and complementarily of actions towards a common goal in order to avoid duplication of efforts
- Make services available more efficiently
- Donate or share space and equipment
- Finance or collect funds jointly
- Share community support/greater participation

Who to collaborate with

Based on the above premises, it can be assumed that one of the first and most important steps for establishing collaboration would be identification of potential partners. The selection of possible partners should be strategic. To this end we offer some questions that can help in the selection process. Before approaching a possible collaborator, answer the following questions:

- Who needs to be included in this collaboration in order for it to be successful?
- What organizations have the necessary resources, abilities and reputation?
- What are the resources that possible partners will be willing to contribute?

To initiate this process, prepare a list of the organizations, agencies and/or groups, with characteristics or similarities that could contribute to accomplishment of the collaboration objectives. This list should be very complete and include organizations with multi-disciplinary approaches who can contribute some benefit for accomplishment of the common goal. Once the list is prepared, you can analyze it using the four quadrant format for Classification of Alliances which is described below. This process will help determine the organizations with which it would be the most appropriate to work, and in which you should invest effort.

For most effective use of this tool, it is recommended that you define an indicator or objective of high strategic interest and the standards which would be used to measure high efficiency.

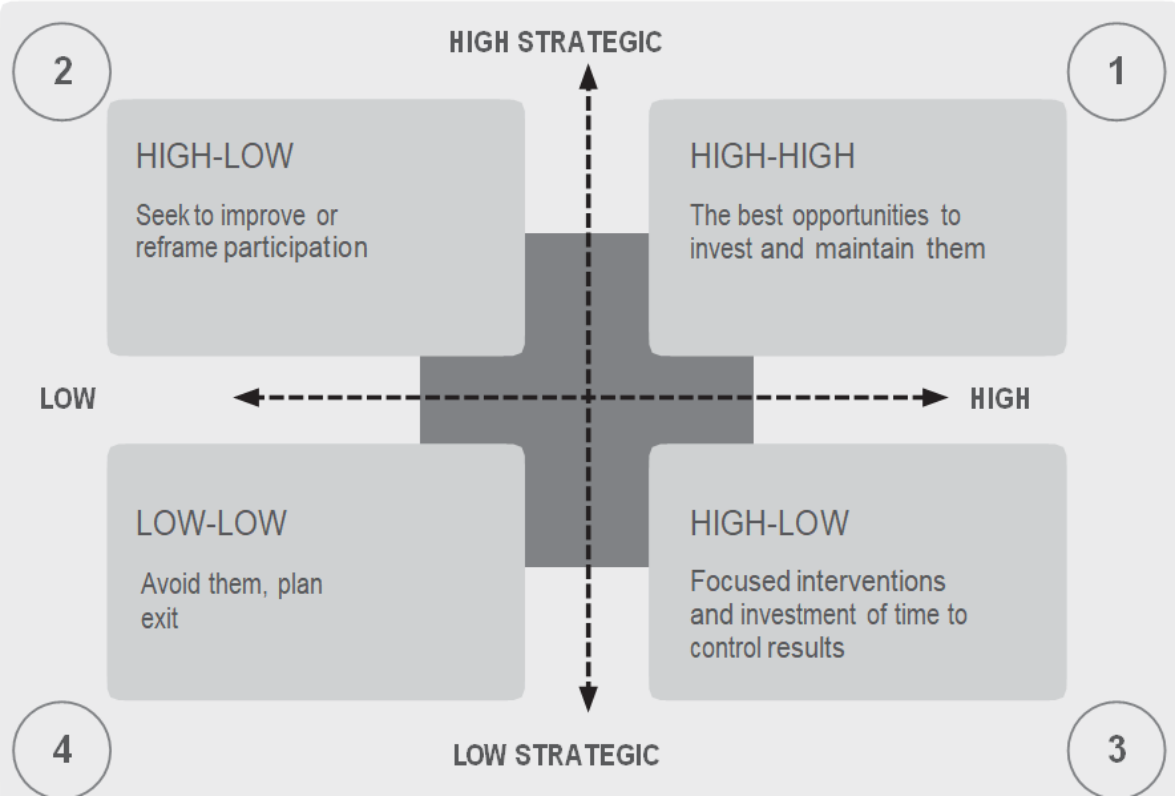


Figure 2.1: Classify Your Alliances

The first quadrant represents the best opportunity to establish an alliance, collaboration and/or joint work; due to the fact that the organization classified within this quadrant shares a level of strategic interest that meshes with the parameters of my organization and its levels of efficiency are high according to prior ranking. This would be a good place to invest time and resources and create procedures to be able to maintain the relationship. The organizations identified in the number two quadrant have high strategic interest but their efficiency ranking is low.

This type of alliance will require a greater investment of time for establishment of processes and systems that would ensure greater efficiency. In this situation it would be wise to reframe participation. The number three quadrant includes those organizations that have a low degree of strategic interest but high efficiency. With these organizations you should only focus on very clearly defined interventions and develop concrete objectives with timelines and measurement of results.

Organizations that fall into the number four quadrant definitely do not have much potential for contributing to accomplishment of objectives and goals proposed within a collaboration exercise. Where strategic interest and efficacy are both low, it is not advisable to invest time and resources.

Effective collaboration mechanisms

- **Lay the foundation and establish collaboration agreements or contracts**

One of the most effective mechanisms for collaboration is the establishment of agreements and/or contracts. These may take many forms; they can be formal or informal. Either way, we recommend that they be put in writing and the document should reflect all the key aspects of the relationship. The agreements should be inclusive, prepared by the people who will implement them and they should be validated by the decision makers in the organizations involved. Written agreements solidly establish the commitments agreed upon by the partners to carry out their collaboration efforts. It is important to remember that agreements are living documents that can be modified and that can also be used to:

- Establish a baseline to facilitate follow-up to the collaboration;
- Negotiate roles and responsibilities;
- Prepare a collaboration plan; and
- Develop a results framework.

Elements to include in a collaboration agreement and/or contract

The more details included in the agreement, the more tools that will be available to the participants for reviewing each of the items agreed upon and keeping the objective in focus.

- Context for collaboration
- Membership/Criteria for selection of members (formally assign a member of the organization)
- Purpose for the collaboration (collectively elaborate the purpose of the collaboration)
- Collaboration activities (what will be done in this collaboration)
- What are the projects and products of the collaboration (expected results of the collaboration)
- Collaboration process (example: communication, decision making, conflict management)
- Roles and responsibilities for each of the partners (mutual agreement on the established commitments)
- Time period for evaluation and renegotiation of the process
- Credits, recognitions and terms of payment (if relevant)
- Commitments and legal requirements
- Exclusion clause or finalization of collaboration

Organization

When organizations embark on a collaboration exercise, they should consider that especially during the first stages of the process, the participating agencies must dedicate a considerable amount of time to planning. Any action that is not planned could create obstacles for the implementation of joint interventions. It is important to organize the activities and document the processes, in order to create a systematized collaboration culture which will reduce potential obstacles during the life of the project.

We should remember:

- Clarify the process and plan. The process and plan will be the foundation for all the joint actions to be carried out by those involved in the collaboration.
- Maintain an open and proactive mindset, especially at the beginning. Remember, ideas are not good or bad. During the initial exploration stage, all contributions from the members should be welcomed. This can create a sense of ownership of the process. It is recommended that decisions not be made during this stage.
- Recognize that collaboration will not bring about immediate savings in time or resources. On the contrary, collaboration may take more time to get things done. It is recommended that the participating organizations consider and evaluate how this investment of time can affect their own processes to achieve more in less time when compared to working individually.

Organizational commitments

Frequently the collaboration processes are initiated by organizational leaders or decision makers. In some cases, the initiative to promote a collaboration exercise can be a requirement from the donors who are seeking to ensure greater impact within a specific geographic location.

The basic rules for participation should be spelled out within the agreement or collaboration contract. Based on these previously established agreements, decision makers should assign a person from the organization to participate and provide follow up to the collaboration process.

Before this happens, it is important to prepare a letter of organizational commitment which establishes and specifies the support that the organization will offer to the designated representative. The organization's representative should have the power to make decisions relevant to the collaboration whenever necessary. Some of the points that should be included in the letter of commitment include:

- The level of commitment that the participating organizations take on so that their participation will help achieve the mission, objectives and strategies of the collaboration in order to achieve their goals.

- Clear stipulation of what the organization expects as a result of this collaboration.
- The amount of time that the organization's representative can invest in this collaboration.
- The organization should recognize the time spent by the representative in the collaboration process as work time.
- The resources that will be made available so that the representative's participation can be effective.
- The degree of participation and commitment of the representative and his or her decision making power for collaboration activities.

Adequate Structure

Collaboration process will help reduce the time needed for resolving conflicts that might arise due to lack of clarity at different levels and stages of the collaboration.

Often when forming a new coalition, alliance or committee, there is a temptation to create a new organization for the collaboration, with an administrative apparatus that would add potentially unnecessary expenses. It is recommended that organization be made so that the participants share information and decision making and that they distribute the tasks and resources.

Successful collaborations are organized efficiently to ensure that the process and the results help to achieve the goals of those who participate. The majority of the time, collaborations function best when the participating organizations create a system within their own organizations for managing the time that will be needed and which is dedicated to complying with the requirements of the collaboration.

Usually collaborations adopt one of two structures either as boards or round tables. In the board mode, the members of the alliance make decisions jointly based on the needs (this generally happens in small groups). In the round table structure, small working subgroups are formed which carry out independent actions (in this case alliances tend to be larger).

Regardless of which structure is chosen, the collaborations could become:

Hierarchical: This is a pyramid like structure in which one person is in charge of the collaboration and ensures compliance with the agreements.

Individual: Each person is responsible for certain actions, the leadership is more distributed, the members feel involved, valued and useful. To achieve this kind of structure requires a greater time investment and coordination can be more difficult.

Group: The majority of the work is the responsibility of the group and only a few activities will be pertinent to individual members. Leadership is not well defined and responsibilities are not clear. Generally there is no formal follow-up on the agreements.

The importance of having a defined structure in the collaboration process is that it will help to strategically propose and distribute the actions and functions as well as making decision making processes more efficient. We should remember that the structures within the collaborations are temporary (generally they complete a cycle) and thus should remain flexible. Some structures also may disappear or change based on the dynamic of the participating organizations.

In the majority of cases, roles will be determined by the structure that is chosen and functions may change. It is important to ensure that the following functions are distributed equitably and according to the interests and abilities of the participants. It is recommended that the roles be rotated to promote learning and increase the sense of ownership and involvement.

Recommended Functions

- Call meetings: prepare the agenda and send invitations to the participants.
- Plan the meetings: ensure availability of the meeting place and any other inputs needed.
- Direct the meeting: responsible for following the agenda and facilitating the meeting.
- Mediation: work to resolve conflicts among participants or seek means of resolving them (this could be an external function).
- Take notes: prepare minutes of the meetings and distribute them among the representatives of the participating organizations.
- Logistics management: prepare a directory of the members and seek adequate mechanisms to facilitate communication and follow up the processes.
- Activity monitoring: measure progress in achievement of the commitments to achieve the mission and the results.

Protocol for Decision Making

Decisions made in collaboration will in some way affect the participating organizations. It is recommended that decisions be documented and this documentation should be accessible for review by all members. Work will flow more efficiently and productively when the collaboration structure contributes to the empowerment of the participants of small groups. That is, by formation of sub-groups that can act independently and make decisions related to their assigned area.

When well defined protocols for decision making are in place it won't be necessary to call full meetings given that the systematization of the processes will guide the members in the way forward. Protocols can be developed for various purposes and the agreements should be documented and shared with regard to how to make decisions as well as to what types of decisions can be made.

The structure of the collaboration to a certain degree will define the process for decision making, and the structure will be defined based on the size, purpose and focus of its members. In order to carry out this task, the types of decisions to be made and the mechanisms to use must be defined.

When preparing the protocols and procedures for decision making, the following information should be included:

- Will each organization have one vote?
- Who will have the right to vote? Will it be the representative or someone else in their organization?
- Do the people who will vote need to be present or can they do it electronically?
- In a large collaboration:
  - ✓ Will the votes be proportional?
  - ✓ Can anyone who is present vote, even if it is their first time participating or even if they don't represent a specific group?

We also recommend that a rule be created for establishing who does and does not have the right to vote. Additionally it may be stated that before making a decision, the participants who do not have the right to vote can have the right to express their opinions about the issue to be voted on.

Generally groups are more harmonious when there is clarity about the types of decisions that can be made, the specific mechanisms for doing so and who are entitled to make them.

Some group and individual decision making styles include:

- **Autonomous:** only those who need to know are informed. The group makes the decision and does not consult others either because the decision is not important because it doesn't impact the others or because only this small group is needed to implement it.
- **Consultative:** others are informed that a decision will be made since their input is needed or because the decision requires the intervention of the entities that are consulted.
- **Consensus:** a common platform is sought where everyone has the opportunity to present their opinion and everyone is in agreement. Consensus should be used when the decision will affect the majority and a group commitment is needed to implement the activities.

- **Democratic:** opinions are discussed exhaustively so that everyone understands the impact and consequences of a majority vote. In democratic processes everyone's opinion is heard but consensus is not needed. Thus, those who are not in agreement may feel that there are winners and losers.
- **Delegation:** the situation is presented and responsibilities and expectations are clarified in order to make and implement the decision. This style is used when the decision has an impact on others' work or when the rest of the group has the knowledge, abilities, experience and resources to implement the idea.

When all members are informed and the majority participate in decision making, participants feel ownership of the collaboration process. The choice of a decision making style will help those who are participating to feel that they are part of the process and they can participate more actively.

Create a Communication Plan

In order to build effective communication, mechanisms should be established to enable communication to flow formally and informally as well as openly and frequently.

Informal Communication: This type of communication is useful during meetings. Informal communication takes place when sharing information about what is happening in the community. During these moments of informal communication, more personal connections are made which contribute to improving communication and developing an environment of trust. It is important to remember to listen to everyone and also to speak with everyone. When appropriate, humor helps to build camaraderie.

Formal or Inter-organizational Communication: This requires time and effort. Minutes, proceedings, agendas or any other documentation should be produced, developed and distributed systematically.

It is also necessary to have a representative who facilitates the conversation at all levels to promote:

- Greater participation in decision making. In this way, the decision makers from the organizations are informed and can participate in decision making.
- Greater understanding of the collaboration structure. The rules, agreements and roles should be shared with the representatives from the agencies and they in turn should share them with the leaders of their agencies.
- Formalization of the collaboration processes and support in the preparation and definition, in writing, of the organizational agreements for participation.

Define Formal Communication Routes

- Create a directory of key people in each participating organization who should receive communication and who will participate in decision making.
- Clearly describe who should receive specific or sensitive communications, as well as the timing and format for distribution, and the person responsible for follow up and receiving feedback.
- Decide which of the participants will be responsible for guaranteeing that two way communications is maintained with the key people in the other participating organizations.
- Design an information system within the collaboration that permits collection of updated, relevant data and makes it available to all members in a timely manner.

It is also advisable to define a communication strategy using technology to facilitate coordination and collaboration processes. In some case, the geographic location may require a long distance communication system. Currently, some collaboration participants communicate by means of: email, memos, minutes or using the internet.

Social networks and other online services are an important means for sharing information. Some organizations have created or have joined online groups to discuss topics of shared interest and to support other groups. It is possible to create internet pages for a relatively low cost and these can be a very useful instrument for sharing information relevant to the collaboration processes. It is recommended that these communication systems based on technology only be used as a support for communication processes as they cannot take the place of periodic face to face meetings.

Self Check 2	Written Test

Directions: Answer the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1. ---------- is a written plan that identifies a problem to be solved (6 points)

   a. Oscillator
   b. Industrial
   c. Design Brief
   d. Class B Amplifier

2._____ is something that is vital to any design project (6 points)

   a. design brief
   b. power amplifier
   c. Class C Amplifier

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 3	Identifying competent persons required for the project and their roles specified in the design

3.1. Identifying competent persons required for the project and their roles specified in the design

Introduction

A Competent Person is a responsible profession which provides valuable services to the society. The privilege of the profession imposes high degree of obligations of morality, responsibility, professional knowledge and conduct as well as personal honor and integrity.

Should have knowledge (minds on) in:

- Basic tools, equipment, methods, safe work practices in the operation and routine maintenance of the mechanical and basic electrical components of the pollution control system.
- Typical unit operations and unit processes utilized for the treatment system.
- typical causes of the pollution control system non compliance problems

Should have skills (hands on) in:

- Reading and interpreting meters, gauges and other recording devices and in adjusting controls in the operation of the pollution control system.
- Conducting performance monitoring activities which involve sampling, in situ measurements and basic process control laboratory tests.
- Performing corrective actions to address common pollution control upset situations.

The Ethics of a Competent Person

- Shall strive his/her utmost to ensure that the pollution control system is optimally operated so that the discharge/ emission comply with the regulatory discharge/ emission standards all the time.
- Shall never engage or corroborate in any act that would result in a discharge/emission through by pass.

- Shall promptly act on any sign of impending upset of any unit operation or unit process of the pollution control system and inform/ consult the appropriate personnel in his/her organization for advice, further instruction or action.
- Shall not be involved in making false information or statement regarding the operation of the pollution control system even though directed to do so by the employer.
- Shall not falsely or maliciously attempt to damage the reputation of another Competent Person.
- Shall strive to cooperate with others in the profession and encourage the ethical dissemination of technical knowledge in best practices in the operation of the pollution control system.
- Having knowledge of unethical practices of another Competent Person shall distance away from that Competent Person in professional work.
- Shall uphold this Code of Ethics by behavior and example and encourage, by guidance and advice, other Competent Person to do the same.

Responsibilities

- Managing and leading the project team.
- Recruiting project staff and consultants.
- Managing co-ordination of the partners and working groups engaged in project work. Detailed project planning and control including:
- Developing and maintaining a detailed project plan.
- Managing project deliverables in line with the project plan.
- Recording and managing project issues and escalating where necessary.
- Resolving cross-functional issues at project level.
- Managing project scope and change control and escalating issues where necessary.
- Monitoring project progress and performance.
- Providing status reports to the project sponsor.
- Managing project training within the defined budget.
- Liaison with, and updates progress to, project steering board/senior management.

- Managing project evaluation and dissemination activities.
- Managing consultancy input within the defined budget.
- Final approval of the design specification.
- Working closely with users to ensure the project meets business needs.
- Definition and management of the User Acceptance Testing programme.

Self Check 3	Written Test

Directions: Answer the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1. _____ is a short paragraph describing the problem to be solved, establishing the need for the product (4 points)
   a. Design Brief.
   b. Current amplifiers.
   c. Loudspeaker
2. _____ is measured by several constituents (3 points)
   a. Loudspeaker.
   b. Current amplifiers.
   c. Dimension
   d. Driver amplifier
3. Functional competence constituents _____ dimension (3 points)

A. Three.

B. Seven.

C. Two

D. Four

Note: - Satisfactory rating: 5 and above - Unsatisfactory Rating: below 5

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 4	Reviewing Project design briefly against all inputs and adjusted to rectify any anomalies

4.1. Reviewing Project design briefly against all inputs and adjusted to rectify any anomalies

Introduction

Design Review is an independent and impartial evaluation process in which panels of experts on the built environment assess the design of a proposal. The projects that Design Review deals with are usually of public significance, and the process is designed to improve the quality of buildings and places for the benefit of the public.

Design Review

- Is conducted by expert practitioners with current experience in design and development, a record of good design in their own projects and the skills to appraise schemes objectively.
- Offers feedback and observations that will lead to the improvement of schemes, but does not redesign them.
- Gives decision makers the confidence and information to support innovative, high quality designs that meet the needs of their communities and customers, and to resist poorly designed schemes.

"Design Review is an independent and impartial evaluation process"

Ten principles of Design Review

All Design Review is focused on outcomes for people. It explores how a building or place can better meet the needs of the people who will use it and of everyone who will be affected by it. It does this by constructively endeavoring to improve the quality of architecture, urban design, and landscape and highway design.

For Design Review to succeed, it must be carried out using a robust and defensible process. It must also offer consistently high standards in the quality of its advice. These standards can be summarized in the following ten principles.

- Independent:
  - ✓ It is conducted by people who are unconnected with the scheme's promoters and decision makers, and it ensures that conflicts of interest do not arise.
- Expert:

- ✓ It is carried out by suitably trained people who are experienced in design and know how to criticize constructively. Review is usually most respected where it is carried out by professional peers of the project designers, because their standing and expertise will be acknowledged.

- Multidisciplinary
  - ✓ It combines the different perspectives of architects, urban designers, urban and rural planners, landscape architects, engineers and other specialist experts to provide a complete, rounded assessment.
- Accountable
  - ✓ The Review Panel and its advice must be clearly seen to work for the benefit of the public. This should be ingrained within the panel's terms of reference.
- Transparent
  - ✓ The panel's remit, membership, governance processes and funding should always be in the public domain.
- Proportionate
  - ✓ It is used on projects whose significance, either at local or national level, warrants the investment needed to provides the service.
- Timely
  - ✓ It takes place as early as possible in the design process, because this can avoid a great deal of wasted time. It also costs less to make changes at an early stage.
- Advisory
  - ✓ A design review panel does not make decisions, but it offers impartial advice for the people who do.
- Objective
  - ✓ It appraises schemes according to reasoned, objective criteria rather than the stylistic tastes of individual panel members.
- Accessible
  - ✓ Its findings and advice are clearly expressed in terms that design teams, decision makers and clients can all understand and make use of.

How Design Review adds value

When it is done well, Design Review is highly efficient, and it often saves time and money. The cost of the service is never more than a small proportion of the total development budget, and is massively outweighed by the value it adds. The process adds a layer of expertise that builds on the skills of the design team and the pre-application advice provided by the local authority.

- Can bring a greater breadth and depth of experience than is available within the project team or planning authority.
- Offers expert views that take account of a wide range of complex issues, and so helps to achieve sustainable development.
- Looks at schemes in context, and can challenge the design brief or the assumptions that lie behind the project.
- Gives planners, developers and their design team's confidence that they have had the best possible independent advice on design quality.
- Supports and encourages good design and innovative proposals.
- Identifies weak and inappropriate schemes at an early stage, when radical changes can be made with a minimum of wasted time and effort.
- Offers opportunities for continued learning, particularly about how to assess design quality, to the people observing the review process.

"The strength of a design review panel's advice lies in its independence, objectivity and ability to analyze a scheme"

Self Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1. What is the goal of documentation and review is? (5 points)

    a. to *decrease* development time

    b. amplifier circuit

    c. Signals are sent to an input

2, _____is used to focus the efforts of the design team (7points)

    a. design brief

    b. Design check

    c. design team

    d. amplifier circuit

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet 5	Documenting brief project design proposal

5.1. Documenting brief project design proposal

Introduction

Design problems are always complex having a number of (often conflicting) objectives, many constraints and just as many possible solutions. The designer will attempt to satisfy a client, the specialized requirements of a user group, the constraints of manufacture, the limitations of equipment and material suppliers, and the demands of the marketplace.

The process of design is at times noisy, active, exciting and creative. In other phases it can also be a slow process of developing and refining a set of ideas. Drawing becomes a thinking device, drawing as you 'feel' as well as to communicate with others both intuitive and rational at the same time. Designers need to look, question, interpret, communicate ideas and respond imaginatively to problems.

Designing is more than just solving problems: it involves leading and directing a creative and innovative activity, sometimes managing teams of specialists and experts, to bring together all the contributions to a design optimization.

The designer's role is one that is always responding to change and in many cases it means bringing about change.

This is set against the constantly changing attitudes and desires of society and advances in materials and technology.

The diagram below shows a model of the total design and development activity. There is a design 'core' consisting of the key phases of investigation, generating ideas, synthesis, manufacture and evaluation.

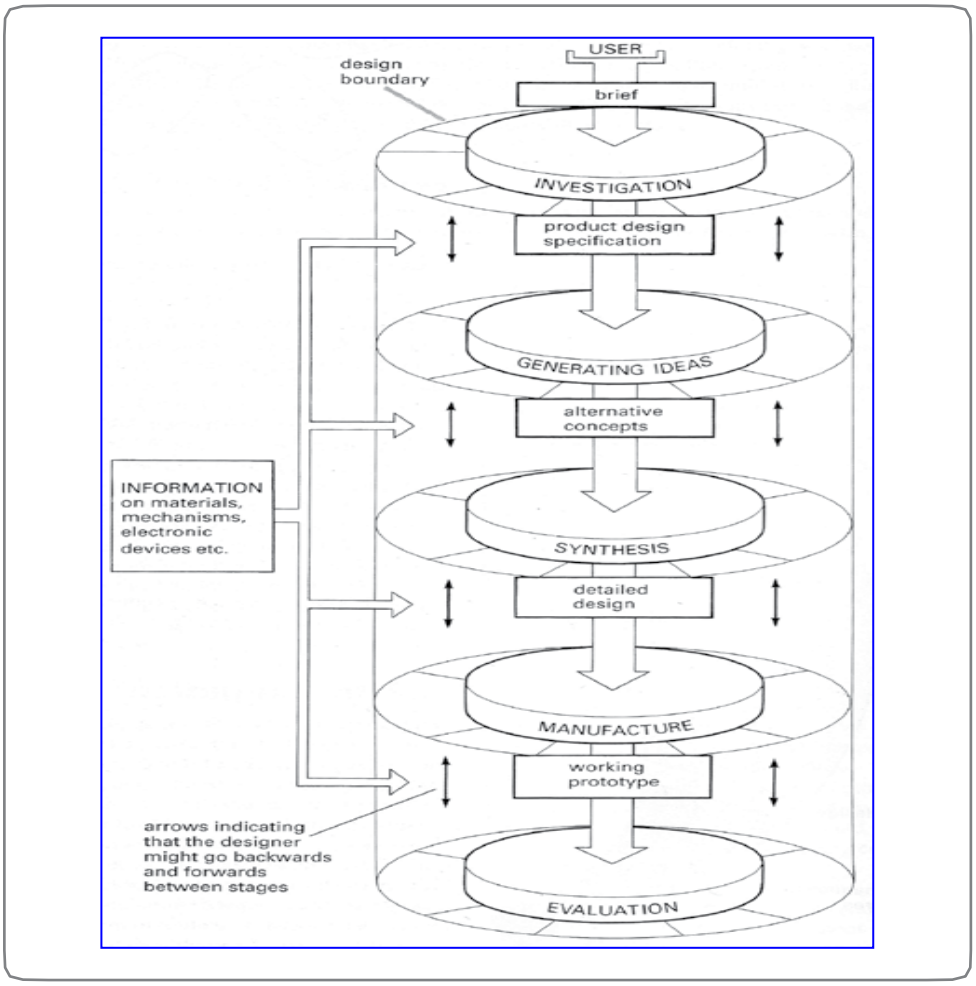


Figure 5.1: Model of the total design and development activity

5.1.1. Design Briefs

Design briefs must give sufficient information to put the problem in context and to indicate the requirements but they must not impose unnecessary constraints on any solutions which might be proposed. The designer's role is to interpret the client's brief. In cases where clients are very sure of their requirements this can be straighter forward. However, when clients are less sure designers need, through negotiating with their client, to conduct research and to develop a more precise statement of need.

Design briefs should not be regarded as unchangeable they can change as designers begin their research and communicate their findings.

5.1.2. Methodology

Research and investigation supports and is vital to the success of the project. Information gathering requires careful planning and thoughtful application. It is important that valuable time is not wasted collecting information that is unnecessary.

An interview or discussion with the client/user group to establish their thoughts and preferences regarding the proposed product can be a good starting point. This information should be used to guide analysis and research activities. In the analysis, the focus should be on the identified need and avoiding general statements.

Research could include the analysis of existing products to find out about materials, processes and construction methods used in commercial manufacture. Market research will allow the testing of the viability of the intended product beyond the needs of the client/user group. Surveys or questionnaires should be designed carefully and avoid questions that are too general and are not useful in helping the design process.

5.1.3. Primary Sources

Primary research involves collecting information yourself, from various sources, including:

- direct contact with experts
- communication with a client or user
- fieldwork physically collecting data
- questionnaires which are carefully constructed and offered to representative sample groups
- exhibitions and displays
- testing and experimentation
- modeling and computer simulations

Primary sources are original contributions, and have not been gathered in quite this form before. Many primary sources are people; others are direct observation, recording and measurement.

5.1.4. Secondary Sources

Secondary sources are generally easier to obtain and can provide good background information. They include:

- articles from books and magazines

- items from catalogues
- printed materials from companies
- handouts
- data sheets
- the Internet

5.1.5. Planning the project

It is important to establish a clear course of action when planning your research, otherwise too much information will be collected and this will waste time. Planning can be made easy by doing the following.

- identify the information needed and produce a research brief
- clarify how you expect to use the findings to improve your designing
- plan your information gathering
- use primary and secondary sources
- consult experts or your client/user
- keep accurate records
- evaluate your research activity against the research brief

When the entire information gathering has been completed, you should analyze your research in order to help you write a Product Design Specification (PDS) that is relevant, meaningful and measurable.

5.1.6. Design Specifications

The specification is a statement of the qualities that a design must possess in order for it to be a good solution to the problem. It is more precisely known as the Product Design Specification (PDS). A detailed specification will be used throughout the design process to review ideas and their development, and to check that the design requirements and client/user group needs are being satisfied.

The specification should be used as a basis for testing and evaluating the completed product. Any future modifications suggested should be referenced to specification criteria in order to check the success of the final product.

Consultation with the client/user group is needed to agree the specification points and to ensure that the criteria meet their needs.

The following sub-headings can be used to organize a logical and effective specification:

- Purpose – what is the aim or end-use of the product?
- Form – what shape/style must the product take?
- Function – what must the product specifically do?
- User requirements – what qualities must the product have to make it attractive to the client/user group?
- Performance requirements – what technical considerations need to be achieved within the product?
- Materials and components – what materials and components should be used to aid performance?
- Size – what physical dimensions are required?
- Safety – what factors need to be considered to make the product safe to use?
- Quality – how can a high-quality product be assured?
- Scale of production – how many are to be made and by what manufacturing process?
- Cost – what are the considerations in determining cost?

Each specification point must contain more than one piece of information. Each statement should be fully justified by giving a reason for the initial point. Specification points should be technical and measurable where possible, so that testing and evaluation can be realistic.

5.1.7. Manufacturing Specifications

Throughout the design development process the specification is detailed further until it reaches a more or less final form ready for manufacture. At this stage, the materials and processes that have been decided upon go into the development of the original specification to make up a manufacturing specification.

The manufacturing specification is an important reflection of the two-way dialogue between design and manufacture. It will include detailed working and/or engineering drawings. Manufacturing companies use manufacturing specifications to ensure that every possible decision has been considered adequately and then recorded prior to the major investment required to prepare for manufacturing.

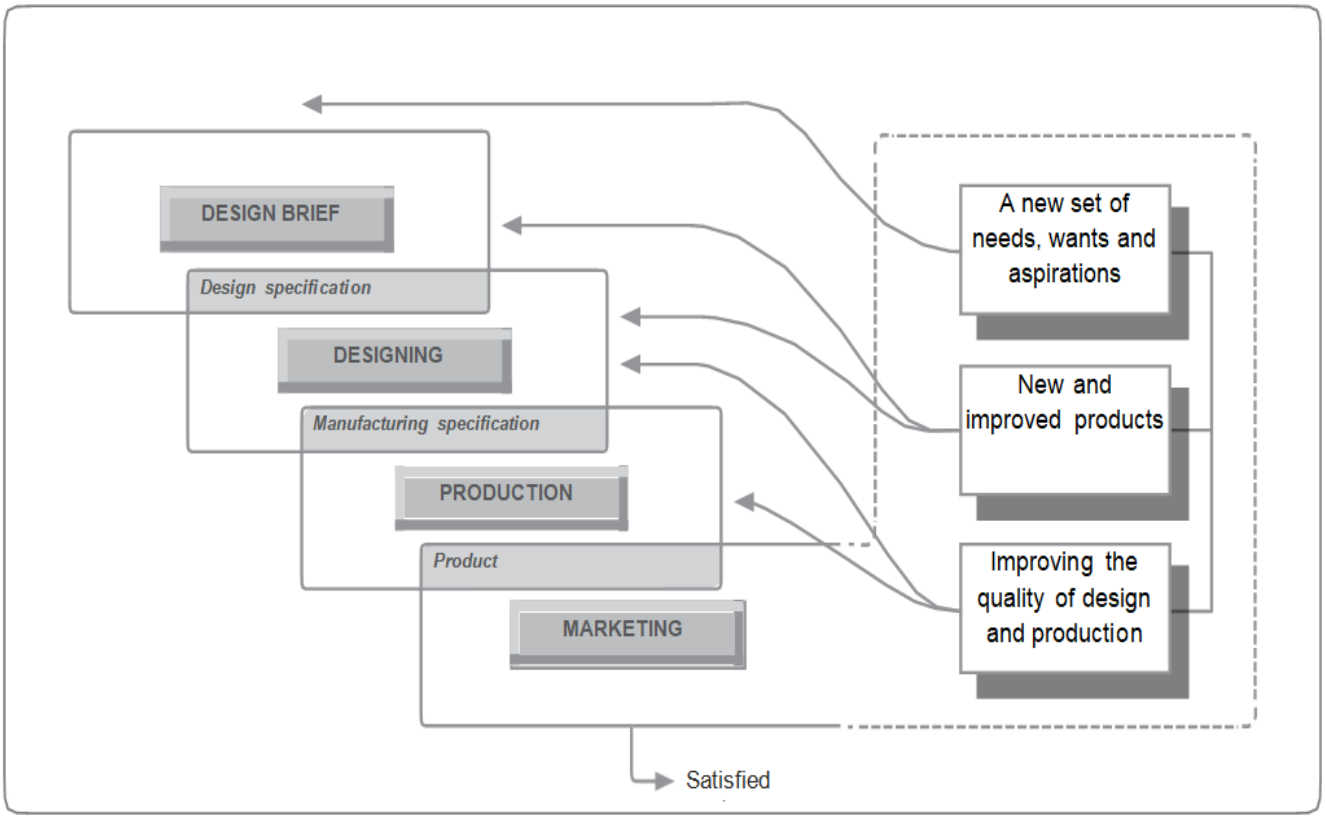


Figure 5.2: Design development process

5.1.8. Develop Project Proposals

Should contain the following:

1. Cover Sheet (Please use the attached Cover page format)

In all cases the Cover Sheet should be signed by an authorized official of the organization which will administer and be held accountable for the grant funds. The project title should be short and descriptive.

2. Table of Contents

It includes a table of contents listing the contents of your submission as well as the attachments that you wish to be considered.

3. Executive Summary

The Executive Summary is a short, precise summary of your project proposal. Please ensure to include a brief outline of your project description and how your project contributes to the achievement of national development.

4. Organization (This information will be provided by the International Office and Grant Funding Unit)

Describe your organization and address each of the points below:

- Mission, goals and mandate for your organization
- Structure of organization
- Ownership of the Organization
- Partners for this project and their role in the project (if applicable)
- Institutions impacted
- Impact on the non-university Tertiary Education sector
- Impact on National Development

5. Project Description

- Background:

Describe the need for the project and how the proposal was developed. Explain why the project is being proposed, how it relates to indicator achievement and how it is innovative. If the project is proposed by more than one organization, or will involve more than one organization in the implementation process, please explain the nature of the partnership required.

- Overall Purpose/objective of the Project:

The description of the purpose of the proposed project should be directly related to the priorities outlined in the TVET Sector Policy Support Programme Indicators, and should be as clear, concise and focused as possible. It should include the project's purpose, goals, specific objectives, method, and anticipated impact.

Objectives need to be stated in measurable terms and be specific and consistent with the statement of need and the purpose of the proposed project. Objectives should be formulated as a clear statement of what is expected to be achieved through project implementation. These expected "outcomes" should be measurable and conceptually related to the objectives and goals of the Sector Policy Support Programme and the Goals outlined in Medium- Term Policy Framework.

Describe the activities that will comprise project implementation.

6. Project Work Plan

This section of the proposal should present the detailed work plan for the project. This should cover how the project objectives will be accomplished, what outcomes will be produced, what needs to be done and by whom, how the work will be organized, within

what time frame, and how the outcomes of the project will be monitored and reports supplied to the EDF Steering Committee. Provide a schedule of work outlining the project's objectives, strategies, outcomes, main tasks and timelines. The use of a project log frame may prove to be useful.

7. Human Resources

Describe how and by whom the proposed project will be managed and executed and identify how the knowledge, skills and abilities required for implementation will be met.

8. Project Site (Geographic, Physical, Virtual, other)

Please describe the proposed project site to be used and the criteria for its election (if applicable).

9. Project Monitoring (Progress Reporting)

This section should contain a description of how the organization will monitor the progress and the outcomes of the project and its contribution to indicator achievement.

10. Proposed Budget

Your proposal should include a detailed Budget Justification explaining an estimate for each line item. If applicable, support from collaborating agencies and other funding sources that contribute directly to the project should be itemized in the budget by source, amount and duration.

11. Attachments

There is no limit to the number of pages allowed for the attachments, documentation from other funding agencies, letters of agreements with partners for the project, letters of support from other community groups or organizations. You may also forward copies of other materials that may assist the Project Selection Committee in considering your application.

Self Check 5	Written Test

Revision questions

1. The role of the designer when designing products is to work closely with the client, user and manufacturer.

   i. Give **two** main reasons why it is so important for the designer to establish a clear design specification with the client.

   ii. Outline **two** examples of the type of information that the designer would need to establish from the user in order to produce designs.

   iii. Outline **one** example of the type of information that the designer would need to establish from the manufacturer in order to produce designs.

2. When designing a household product such as an electric kettle the role of the designer is to compromise on the views of many individuals.

   i. With reference to an electric kettle suggests whose views the designer might need to consider and why there might be a need to compromise.

   ii. With reference to the electric kettle suggest **two** ways in which Ethiopian Standards may have influenced the design of this product.

3. The role of the designer when designing a mobile phone is to work closely with the user and manufacturer.

   i. Give **two** main reasons why it is so important for the designer to establish a clear design specification with the manufacturer.

   ii. Outline **two** examples of the type of information that the designer would need to establish from the user or form the manufacturer in order to produce designs.

Score = _____
Rating: _____

LG #20	LO #3. Design and develop basic electronic system

Instruction sheet

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

- OH&S policies and procedures.
- Applying knowledge of electrical Devices & Systems Design.
- Designing arrangements and Alternative.
- Budgeting considerations.
- Constructing Prototype and hardware systems.
- Rectifying Prototype malfunctions.
- UN planning events and conditions Solutions.
- Project designing and document approval.

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:

- OH&S policies and procedures are followed
- Knowledge of devices and systems and compliance standards are applied to the design
- Alternative arrangements for the design are considered based on the requirements outlined in the design brief.
- Safety, functional and budget considerations are incorporated in the design.
- Prototype hardware systems are constructed and tested for compliance with the design brief and regulatory requirements.
- Prototype malfunctions are rectified and retested to ensure effective operation of design.
- Solutions to unplanned events and conditions are provided consistent with organization policy
- Project design is documented for submission to appropriate person(s) for approval.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets”,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information sheet 1	Following OH&S policies and procedures

1.1. Following OHS policies and procedures

Your Company Name is committed to the goal of providing and maintaining a healthy and safe working environment, with a view to continuous improvement. This goal is only achievable by adherence to established objectives striving to exceed all obligations under applicable legislation, and by fostering an enthusiastic commitment to health, safety and the environment within Your Company Name personnel, contractors and visitors.

In particular:

- Management, working in cooperation with the Joint Health and Safety Committee, will strive to take all reasonable steps to reduce workplace hazards to as low as reasonably achievable.
- Supervisors and managers are held accountable for the health and safety of all employees under their supervision. This includes responsibility for applicable training and instruction, appropriate follow up on reported health and safety concerns, and implementation of recommended corrective action. This accountability is integrated into the performance appraisal system.
- Supervisors, workers and visitors are expected to perform their duties and responsibilities in a safe and healthful manner, and are accountable for the Health and Safety of themselves and others.
- Your Company Name is committed to providing all necessary training and instruction to ensure that appropriate work practices are followed on the job, and to promote their use off the job.
- If necessary, Your Company Name will take disciplinary action where individuals fail to work in a healthy and safe manner, or do not comply with applicable legislation or corporate policies and procedures.

Health, safety, the environment and loss control in the workplace are everyone's responsibility. Your Company Name expects that everyone will join in our efforts to provide a healthy and safe working environment on a continuous day to day basis. Only

through the dedication and efforts of all individuals can Your Company Name succeed in providing a healthy safe working environment.

Occupational Health and Safety in Workplaces

Occupational Health and Safety and You

One of your most important responsibilities is to protect your Health and Safety as well as that of your co-workers. This booklet will discuss some of your duties under the occupational Health and Safety legislation and help you to make your workplace safer and healthier.

- ✓ **What the law requires**

Workplaces under the jurisdiction are governed by your provincial legislation.

The legislation places duties on owners, employers, workers, suppliers, the self employed and contractors, to establish and maintain safe and healthy working conditions. The legislation is administered by your provincial legislation. Your officials are responsible for monitoring compliance.

- ✓ **Duties of Your Employer**

Your employer is responsible for providing you with safe and healthy working conditions. This includes a duty to protect you from violence, discrimination and harassment. You must cooperate with your employer in making your workplace safe and healthy.

Your Responsibilities

You must also comply with the legislation. You have responsibilities to:

- Protect your own Health and Safety and that of your co-workers;
- Not initiate or participate in the harassment of another worker; and
- Co-operate with your supervisor and anyone else with duties under the legislation.

Your Rights

The legislation gives your three rights:

- The right to know the hazards at work and how to control them;
- The right to participate in Occupational Health and Safety; and
- The right to refuse work which you believe to be unusually dangerous.

You may not be punished for using these rights. An employer can be required to legally justify any action taken against a worker who is active in Health and safety.

Your Right To Know

The Act requires your employer to provide you with all the information you need to control the hazards you face at work. For example, chemicals at the workplace must be listed. You are entitled to review this list. Your employer must train you to safely handle the chemicals you will work with. If you are inexperienced, you must receive an orientation which includes;

- What to do in a fire or other emergency;
- First aid facilities;
- Prohibited or restricted areas;
- Workplace hazards; and
- Any other information you should know.

You must also be supervised closely by a competent supervisor.

Your Right To Participate

You have the right to become involved in occupational Health and Safety. The legislation encourages employers and workers to work together to maintain a healthy and safe workplace. Employers at workplaces with (ten or more – consult your provincial act) workers must set up an occupational health committee of employer and worker representatives.

Committees Have Duties To:

- Regularly inspect the workplace;
- Conduct accident investigations;
- Deal with the Health and Safety concerns of employees;
- Investigate refusals to work;
- Meet at least (four times a year – consult your provincial act); and return minutes of each meeting to the Division.

Committee members are entitled to five days (consult your provincial legislation) of unpaid educational leave each year to take occupational Health and Safety courses.

They may attend courses provided by the Division without loss of pay or benefits.

Certain types of workplaces with less than (ten – consult your provincial act) employees must have a worker Health and Safety representative. The representative must be

selected by the workers at the workplace. He or she has many of the responsibilities of an occupational health committee.

Your Right To Refuse

You have the right to refuse to do work which you believe is unusually dangerous.

The unusual danger may be to you or to anyone else. An unusual danger could include such things as:

- a danger which is not normal for your occupation or the job;
- a danger under which you would not normally carry out your job; and/or
- a situation for which you are not properly trained, equipped or experienced.

To exercise this right, use the following guidelines.

Once you believe that the work you have been asked to do is unusually dangerous, you should inform your supervisor. Make sure that the supervisor understands that you are refusing to do the disputed job for health and safety reasons. Work with the supervisor to attempt to resolve the problem.

If the problem cannot be resolved by the supervisor to your satisfaction, and no worker health and safety representative or occupational health committee exists at the workplace, your supervisor should phone the Division and ask for advice. You also have the right to contact the Division at any time.

The supervisor has the right to assign you to other work (at no loss in pay or benefits) until the matter is resolved.

Do not leave the site without the permission of your employer.

If a committee exists at the workplace, contact your local representative and ask for help. Your supervisor should contact the co-chairpersons and ask them to investigate. They will try to resolve the matter. If they cannot resolve the matter to your satisfaction, they will convene for an emergency committee meeting. The committee will investigate and prepare a report on the refusal.

You have the right to continue to refuse until:

- measures have been taken to satisfy you that the job is now safe to perform; or
- Your occupational health committee has investigated and ruled against your refusal.

If the committee rules against your refusal, you have the right to appeal the ruling to an occupational health officer. The officer will investigate and prepare a report on the disputed work. If you disagree with the decision of the officer, you may appeal to the director of the Division.

An employer cannot assign another worker to do the disputed job unless the replacement worker is advised in writing:

- of the refusal and the reasons for it;
- of the reasons why the employer believes that there placement worker can do the disputed job safely;
- that the replacement worker also has the right to refuse; and
- Of the steps to follow when exercising this right.

Duties

Branch Manager

- Ensure that all reasonable steps are taken to prevent accidents.
- Ensure that standards and procedures are developed and maintained.
- Be familiar with the Occupational Health & Safety act and any revised regulations and ensure they are followed.
- Ensure that all employees are instructed in the procedures and requirements of Occupational Health & Safety.
- Review accident reports, safety audits and other related material relative to health or safety.

Safety Officer

- Ensure that all reasonable steps are taken to prevent accidents.
- Be familiar with Occupational Health & Safety act, the company policy and any other legislation pertaining to health or safety.
- Ensure all policies and legislation is followed by all levels of employees.
- Ensure safety meetings are held and minutes are recorded, posted and filed accordingly to Occupational Health & Safety regulations.
- Ensure all accidents are reported and investigated.

- Ensure MSDS (Material Safety Data Sheet) sheets are provided for all hazardous materials delivered to the workplace and are readily available for employees to review.
- Review all MSDS and advise/train employees in the safe use, storage and transportation of controlled or dangerous products including what to do in case of an accidental spill or emergency.
- Ensure employees are instructed in the procedures and requirements of Occupational Health & Safety.
- Review all accidents and near misses to determine root and basic causes, with suggestion/implementation of changes to prevent re-occurrence.
- Ensure all employees are trained in WHMIS (Workplace Hazardous Material Information System)

All Other Staff

- Comply with all Company Procedures, Safety Policy and requirements of Occupational Health & Safety.
- Be responsible for working safely and carrying out their duties with skill and care as to not cause accidental injury to themselves, fellow employees or the general public.
- Immediately report all injuries, near misses or potential hazards to their supervisor.
- Know the location of all fire extinguishers, fire alarms or other warning devices.
- Ensure all personal safety equipment is being used properly.
- Never engage in horse play or tomfoolery.
- Maintain clean and orderly work area.
- When in doubt … ASK

Suppliers

Provide MSDS for all hazardous material shipped to our warehouse.

Ensure all reasonable steps are taken to prevent an accident.

Be familiar with Occupational Health & Safety act.

General Safety Rules

- **All** accidents, injuries or near misses, regardless of their nature, shall be promptly reported to the safety officer.
- Clothing shall be appropriate to the duties being performed. Long pants, a clean neat shirt and steel toed shoes are the minimum requirements.
- Hard hats and safety vests are provided for all warehouse staff and **must** be worn at all times in the warehouse, loading or unloading of vehicles in the yard.
- Running is **not** permitted except in extreme emergencies.
- Smoking is not permitted in any part of the warehouse or office. You may only smoke in designated areas.
- Visitors and customers are to be escorted by staff while on company property.
- Hand tools are to be used for their intended purpose only.
- Only licensed personnel may operate forklifts or other warehouse equipment and must wear a seatbelt while doing so.
- Riding on equipment is prohibited except where designated for operator.
- Horseplay, fighting or tomfoolery is strictly prohibited on Your Company Name premises.
- All spacers are to be of equal proportion and undamaged. Damaged spacers are dangerous.
- Open lifts are to be stored on the floor or in assigned bunks. Do not stack an open lift; this act **will** result in disciplinary action up to and including dismissal. All lumber lifts must be banded.
- Only solid spacers are to be used on lumber products, no particle board spacers.
- All bunked products will be placed securely in the bunks.
- All spills will be immediately cleaned up and reported.
- Drawers and filing cabinets will be kept closed when not in use.
- Filing cabinet drawers are to be filled from the bottom up or the cabinet is to be securely fastened /anchored.
- Lifts and clutter will be cleaned up before the end of your workday.
- Aisles are to be kept clear at **ALL** times.

- Do not unload a truck alone under any circumstances, if someone can not help you then wait or call someone else for help. (Applies on and off Your Company Name property).

Safety Tips

- If you are not sure…..ask.
- Follow instructions and don't take chances.
- Wear your personal safety equipment.
- Never operate equipment you have not been trained for.
- Keep your work area clean.
- Stay clear of forklifts while they are being operated.
- Avoid injury by lifting correctly. If it's heavy ask for help. Max weight to be lifted is 75lbs.
- Make sure the job can be done safely.
- **DO NOT** unloads a truck alone.
- Portable Ladders
- Portable ladders must be secured against movement and placed on a base that is stable; the base of an inclined portable ladder is to be no further from the base of the wall or structure than ¼ of the height to where the ladder contacts the wall or structure.
- Pallets & Storage Racks
- All employees must ensure that pallets used to transport or store materials/containers are loaded, moved, stacked, arranged and stored in a manner that does not create danger to workers.
- Your Company Name must ensure that racks used to store materials or equipment are designed, constructed and maintained to support the load placed on them and are placed on firm foundations that can support the load.
- Employees must report any damage to a storage rack to the manager as quickly as is practical. All managers and employees must take all reasonable steps to prevent storage racks from being damaged to the extent that their integrity as a structure is compromised.

- First Aid
- An employer must ensure that the first aiders at a work site have successfully completed a first aid training course approved by a Director of Medical Services and hold a valid certificate in first aid. (Consult with your local medical services)
- An employer must keep record at the site of workers who are first aiders and post these names where they are accessible by all employees.
- Every branch must have a first aid kit on site; each kit must contain the following: (see your Provincial legislation)
- 10 antiseptic cleansing towelettes, individually packaged
- 25 sterile adhesive dressings, individually packaged
- 10 - 10cm X 10cm sterile gauze pads, individually packaged
- - 10cm X 10cm sterile compress dressings, with ties individually packaged
- - 15cm X 15cm sterile compress dressings, with ties, individually packaged
- 2 conform gauze bandages – 75mm wide
- cotton triangular bandages
- safety pins - assorted sizes
- 1 pair of scissors
- 1 pair of tweezers
- 125mm x 4.5 m of adhesive tape
- 1 crepe tension bandage – 75mm wide
- 1 resuscitation barrier device with a one-way valve
- 4 pairs of disposable surgical gloves
- 1 first aid instruction manual (condensed)
- inventory of kit contents
- 1 waterproof waste bag

Accident and Near Miss Reporting

The following protocol must be followed.

- All employees must immediately report any occupational injury, accident or near miss to the safety officer or their supervisor.

- Supervisors must immediately tend to injuries and then report them to the safety officer.
- Branch managers must immediately discuss the incident with the safety officer and injured persons.

The purpose of this procedure is to comply with Occupational Health & Safety act, workers compensation board and to determine the cause of the accident and make recommendations to prevent further re-occurrence. All reports of injury must be filed.

If an injury occurs a record must be kept and include the following:

- ✓ name of worker
- ✓ name and qualifications of person giving first aid
- ✓ a description of illness or injury
- ✓ the first aid given to the worker
- ✓ the date and time the illness or injury
- ✓ the date and time the illness or injury was reported
- ✓ where at the work side the incident occurred
- ✓ the work-related cause of the incident, if any

The employer must retain the records kept for 3 years from the date the incident is recorded. A person who has custody of records must ensure that no person other than the worker has access to workers records unless:

- ✓ The record is in a form that does not identify worker
- ✓ The worker has given written permission to the person
- ✓ The Director of Medical Services or a person authorized by the director requires to be produced under the act.

An employer must give a worker a copy of the records pertaining to the worker if the worker asks for a copy.

Critical Injury Protocol

First and foremost, always take whatever measures are required to provide proper care of an injured worker.

If a critical injury has occurred and the worker has been cared for, the branch manager, safety officer and W.C.B must be notified. The appropriate report must be completed as soon as possible; this is to ensure that important details are not forgotten.

A critical injury is an injury that….

- Places life in jeopardy
- Produces unconsciousness
- Results in substantial loss of blood
- Involves the fracture of a leg or arm, but not a finger or toe
- Involves the amputation of a leg, arm, hand or foot, but not a finger or toe.
- Consists of burns to major portion of the body.
- Causes loss of sight in an eye.

Accident Investigation Policy

All accidents that result in injury or property damage or that could have resulted in serious injury or property damage (near miss) must be thoroughly investigated.

The investigation must determine the cause of the incident so that appropriate action can be taken to prevent recurrence.

The safety officer shall be responsible for conducting the investigation. The investigation report shall be completed as soon as possible after the incident and reported to the branch manager. The safety officer and appropriate supervisor shall determine what steps are to be taken to prevent recurrence.

Any disputes arising from the investigation will be investigated and arbitrated by the branch manager.

Alcohol and Drug Policy

It is the responsibility of all employees to ensure an alcohol and drug free environment. If there is any awareness or suspicion that any employee, supplier or visitor is under the influence of illegal narcotics or alcohol, will be removed from the premises immediately. Should an employee report to work while under the influence of such substances, the employee will be taken home either in a cab or by the Branch manager. This is a zero tolerance policy

Action

Careless work and irresponsible behavior directly affect the quality of health and safety in the workplace. Even absenteeism influences safety by placing more duties on fellow employees.

The following instances shall be cause for verbal or written warning and possible dismissal.

- Absenteeism without cause
- Health and safety violations
- Poor conduct or misconduct
- Theft
- Sexual harassment
- Racial discrimination
- Carelessness
- Willful damage to company property
- Drug or alcohol use

Compliance with company and legislative safety standards is necessary to maintain a safe and healthy work environment. As with any program non compliance issues must be dealt with.

The following is a guideline for disciplinary actions for safety infractions based on seriousness of the offence.

- *First offence, employee will be given a documented verbal warning
- *Second offence, employee will be given a written warning and a one day suspension
- *Third offence, employee may be suspended or terminated (suspension or termination to fit seriousness of the offence).

Hazard Warning Signs

Whenever possible, warning signs will be displayed where a potential hazard may cause injury. Warning signs must be strictly adhered to.

Warning signs must be posted where hazards exist and must not be removed unless hazard has been controlled.

Environmental Policy

Your Company Name is committed to the Protection of the Environment for Present and Future Generations. All Employees Are Responsible for incorporating into Their Planning and Work the Actions Necessary to fulfill this Commitment.

Your Company Name Will Meet These Responsibilities by Endeavoring to Provide the **Resources for Continuing To:**

- Design and manage our operations to meet or surpass applicable environmental laws.
- Work in partnership with customers, suppliers, trade associations and government agencies to promote the environmentally safe handling and disposition of materials and products.
- Acquire knowledge and technologies to improve the environmentally save efficient use of our processes and products.
- Formulate and implement effective environmental emergency response systems.
- Involve our employees in our environmental programs and keep them informed of our performance.
- Promote employee awareness of this policy and enhance their capabilities to implement this policy.

Acknowledgement & Agreement Receipt

Date _____

I, _____, hereby acknowledge receipt of the Your Company Name “Occupational Health & Safety Manual”.

I have read, understand and agree to the terms of employment and will carry out and abide by the operational procedures and rules as outlined therein.

I agree:

To adhere to all company policies and procedures. To the use of safety equipment, at all times, which is required by my safe work procedures and by my clients. Government and client regulations shall be complied with at all times. I am responsible and accountable for my health and safety performance.

Employee’s Signature:_____

Manager, Your Company Name: _____

This page is to be forwarded to head office at time of signing.

Occupational Health and Safety Tips

Workplace safety is an important part of any job and requires that everyone in the company adhere to the safety guidelines and policies in place. Carefully following appropriate safety guidelines can go a long way toward preventing workplace injuries. Here are some ways you can work to stay safe on the job.

Be Aware

Always be alert to what's happening in your surroundings; remember that your safety is your responsibility. Understand the particular hazards related to your job or workplace, and keep clear of potentially hazardous areas or situations. Be awake and attentive on the job, and be particularly aware of machinery. Avoid going to work under the influence of alcohol or drugs, which can compromise your concentration, coordination, judgment, motor control and alertness.

Maintain Correct Posture

Use correct posture to protect your back while at work. If you sit at a desk, keep your shoulders and hips in line and avoid hunching over. Use correct form when lifting objects and avoid twisting and stooping. The following tips provide information about lifting correctly:

- Use both hands to lift or carry a heavy object.
- Adopt a proper lifting stance by putting the strain on your legs, keeping your back straight and not bending at the waist.
- Wear a back brace for heavy work.
- Test the weight before picking up the item.
- Lift items smoothly and slowly.
- Move your feet instead of your back when traveling or turning with a heavy object.
- Hold the load close to your body.
- Ask for help to move loads that are too heavy for you.

Take Breaks Regularly

Feeling tired and burned out makes you less likely to be aware of your surroundings and is a common cause of workplace injuries. Regular breaks help you stay fresh and alert on the job. It is particularly important to take short breaks when you have a task that requires repetitive movements over a long period of time.

Use Equipment Properly

Always take the proper precautions when operating machinery or using tools. Taking shortcuts is a leading cause of workplace injuries. Use the appropriate tool for the job, and use it in the right way. When using tools and machinery, put safety first with the following tips:

- Only use machinery you are trained and authorized to use.
- Keep tools clean and in good working order.
- Organize tools and always return them to their proper place.
- Make sure the machine operator sees you, don't approach from a blind spot or from behind.
- Only perform tasks you have been properly trained to perform.
- Never leave machinery unattended while it is running.
- Always obey operating instructions.
- Never remove or tamper with safety guards.
- If something seems wrong, immediately stop the machine and get assistance.
- Communicate with those around you.
- Never walk in front of heavy equipment.
- Read and follow all labels and instructions.
- Don't tamper with hazardous items, including cords, switches and electric controls.
- Wear appropriate and compact clothing; loose, billowing clothing and accessories can easily get caught in moving parts.
- Never place fingers or other objects into moving machinery.
- Turn off equipment before moving, cleaning, adjusting, oiling or un-jamming.

Locate Emergency Exits

Always know where emergency exits are located and keep the path to them clear. You should also have clear access to emergency shutoffs on machinery.

Report safety concerns

If you notice a potential safety hazard or risk, report it to your supervisor immediately so they can address the situation. Keep communication lines open and work as a team to create a safe working environment.

Practice effective housekeeping

Maintain a clean and organized workplace environment. Make housekeeping an ongoing project that everyone is involved in and keep these tips in mind:

- Prevent trips, slips and falls by keeping all floors clean and dry.
- Eliminate fire hazards by removing combustible materials and storing flammable materials away from sources of ignition.
- Control dust accumulation.
- Avoid tracking materials and cross contamination by keeping mats clean and having separate cleaning protocols for different areas.
- Use appropriate procedures to prevent falling objects.
- Keep the workplace clutter free.
- Store all materials and equipment properly.
- Regularly inspect tools and personal protective equipment to make sure they are in good working order.

Make use of mechanical aids

Take the extra time to obtain a wheelbarrow, crank, conveyor belt, forklift or other mechanical aid to assist you in lifting heavy objects. Attempting to lift something that is too heavy can cause injuries that could have been avoided.

Reduce workplace stress

Stress can contribute to difficulty concentrating and depression, which make it hard to be alert at work. There are many causes of stress at work including conflicts with others, heavy workloads, long hours and job insecurity. If you are experiencing workplace stress, talk to your supervisor about ways to address your concerns.

Use Appropriate Safety Equipment

It is important to use the proper safety equipment for a task to help protect yourself from injury:

- Wear appropriate clothing and shoes for your job.
- Know the location of fire extinguishers and first aid kits.

- Use a hard hat if there is a risk of falling objects.
- Wear gloves when handling toxic substances or sharp objects.
- Wear goggles when there is a hazard to your eyes.
- Use safety harnesses if there is a danger of falling.
- Wear non-skid shoes when working on slippery surfaces or lifting heavy objects.
- Wear a breathing mask.
- Use all protective equipment intended for your task including seat belts, protective headgear or clothing and safety glasses.

Creating an environment that is safe is the responsibility of everyone; do your part by following safety guidelines and policies. If you are injured on the job, notify your supervisor immediately and get assistance. Avoid taking risks when it comes to safety, be aware and do your part to maintain a safe workplace environment. If you've been injured on the job, call to schedule an appointment to see how our team of specialists can help to get you feeling better and back to work!

Self check 1	Written test

Question 1

1. A new worker is chatting with his coworkers. The new worker says: “Hi, I just started today and was given an orientation package. Please help me understand: What are the goals of the Occupational Health and Safety Act?

Study the replies of his co-workers. Which of the statement(s) given by his co-workers is/are accurate? Select all that apply.

a. To protect Workers from hazards on the job.
b. To set standards for health and safety in the workplace.
c. To set out the duties of Employers, Supervisors and Workers in the workplace.
d. To provide a checklist for safe and unsafe work conditions

2. A worker has large hands; he just used the last pair of large gloves in the box. He looked everywhere and there are no large gloves available.

Which action(s) should he take under the Internal Responsibility System? Select the appropriate answer(s) and Select all that apply.

a. He should carry out the activity without gloves.
b. He should report the lack of large gloves to his supervisor right away.
c. He should file a complaint to the Joint Health and Safety Committee.
d. He should wait until next month’s Health and Safety meeting to report the lack of gloves.

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information sheet 2	Applying Knowledge on devices and systems

2.1. Applying Knowledge on electronics devices and systems

Electronics and its application

People are surrounded by electronics televisions, radios, computers, mobiles, Laptop and DVD players, along with products with major electric components, such as microwave ovens, refrigerators, and other kitchen appliances, automatic vehicles, Robotics, as well as hearing aids and medical instruments and numerous applications in industry. An electronic device is that in which current flows through a vacuum or gas or semiconductor. This control of electrons is accomplished by devices that resist, carry, select, steer, switch, store, manipulate, and exploit the electron.

Electronics deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits**,** and associated passive interconnection technologies. Commonly, electronic devices contain circuitry consisting primarily or exclusively of active semiconductors supplemented with passive elements; such a circuit is described as an electronic circuit**.**

Pre Knowledge (Some of the basic definitions):

Passive Components: Capable of operating without an external power source. Typical passive components are resistors, capacitors, inductors.

Active components: Requiring a source of power to operate. Includes transistors (all types), integrated circuits (all types), TRIACs, SCRs, LEDs)

Applications of electronics:

Electronic components: capacitor (C), cathode ray tube (CTR), diode (D), digital signal processor (DSP, field effect transistor (FET), integrated circuit (IC), junction gate field effect transistor (JFET), inductor (L), Liquid crystal display (LCD), light dependent resistor (LDR, light emitting diode (LED), Metal oxide semiconductor field effect transistor (MOSFET), transistor (Q), resistor (R), relay (RLA, RY), switch (SW), transformer (T), thermistor (TH), transistor (Tr), integrated circuit (U, IC), variable capacitor (VC), variable resistor (VR) and more.

Consumer Electronics include products like Audio Systems, Video Systems, TV (Television), Computer, Laptop, Digital Camera, DVD Players, Home and Kitchen Appliances, GPS, Mobiles Phones.

Rectifier and state its use

The conversion of bidirectional alternating current (a.c.) into unidirectional direct current (d.c.) is called rectification. Electronic devices can convert a.c. power into d.c. power with very high efficiency.

Diodes are useful electrical components for rectification purposes. Diodes are used in many applications like the following.

- ✓ Converting AC power from the 60Hz line into DC power for radios, televisions, telephone answering machines, computers, and many other electronic devices.
- ✓ Converting radio frequency signals into audible signals in radios.
- ✓ Used as rectifier in DC Power Supplies**.**
- ✓ In Demodulation or Detector Circuits**.**
- ✓ In clamping networks used as DC Restorers
- ✓ In clipping circuits used for waveform generation.
- ✓ As switches in digital logic circuit

Rectifying diode

Review of P-type and N-type semiconductor junction of P-type & N-type i.e. PN junction Barrier voltage, depletion region, Junction Capacitance.

A p–n junction is a boundary or interface between two types of semiconductor material, p-type and n-type, inside a single crystal of semiconductor. p–n junctions are elementary "building blocks" of most semiconductor electronic devices such as diodes, transistors, solar cells, LEDs, and integrated circuits. After joining p-type and n-type semiconductors, electrons from the n region near the p–n interface tend to diffuse into the p region. The regions nearby the p–n interfaces lose their neutrality and become charged, forming the space charge region or depletion layer.

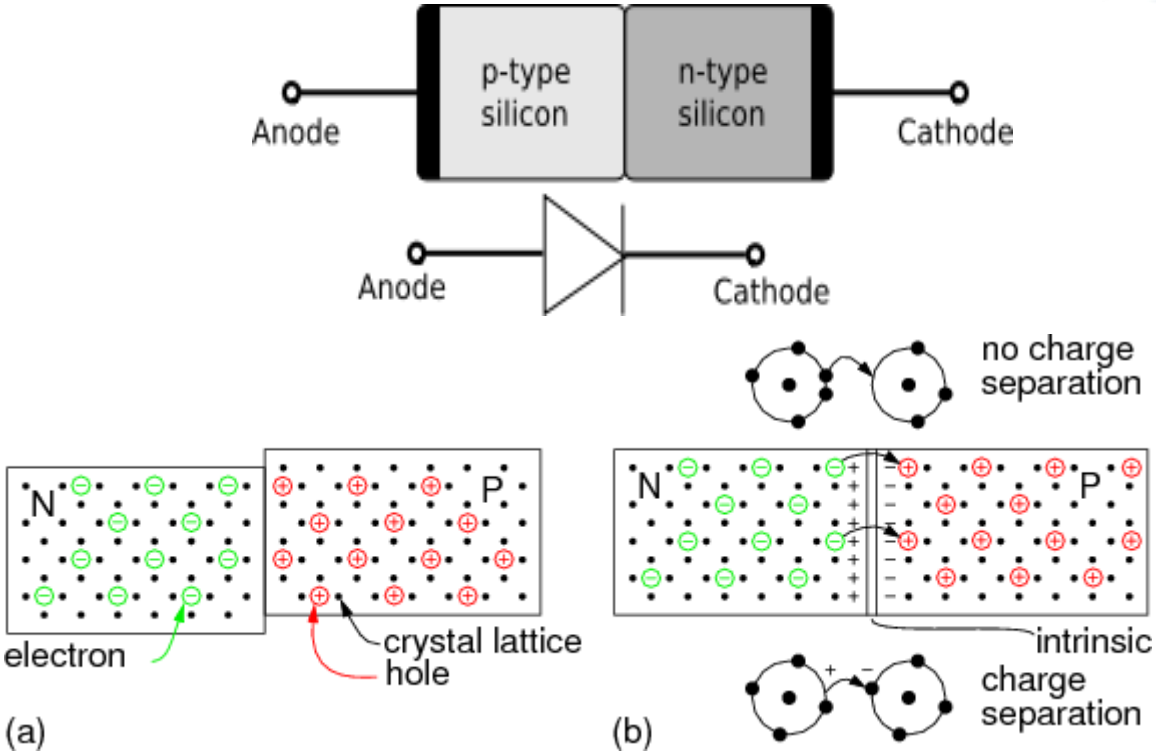


Figure 2.1 (a) Blocks of P and N semiconductor in contact have no exploitable properties. (b) Single crystal doped with P and N type impurities develops a potential barrier.

This separation of charges at the PN junction constitutes a potential barrier. This potential barrier must be overcome by an external voltage source to make the junction conduct.

- PN Junction Diodes

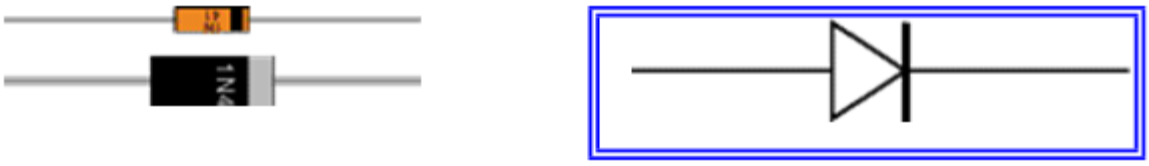


Figure 2.2: Circuit symbol

Function

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow.

Forward Voltage Drop

When a forward voltage is applied to diode, a small voltage experiences across a conducting diode, it is called the forward voltage drop and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant whatever the current passing through the diode so they have a very steep characteristic (current-voltage graph).

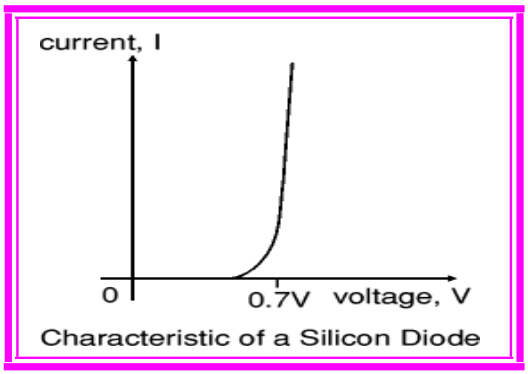


Figure 2.3: characteristics of a silicon diode

Reverse Voltage

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few µA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a maximum reverse voltage (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called breakdown.

Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents. In addition there are other types of diodes as such: LEDs, Zener diodes ,Tunnel diode,PIN diode,Photo diode and Varicap diode.

Connecting and soldering

Diodes must be connected the correct way round, the diagram may be labeled a or + for anode and k or - for cathode (yes, it really is k, not c, for cathode!). The cathode is marked by a line painted on the body. Diodes are labeled with their code in small print; you may need a magnifying glass to read this on small signal diodes!

Small signal diodes can be damaged by heat when soldering, but the risk is small unless you are using a germanium diode (codes beginning OA) in which case you should use a

heat sink clipped to the lead between the joint and the diode body. A standard crocodile clip can be used as a heat sink.

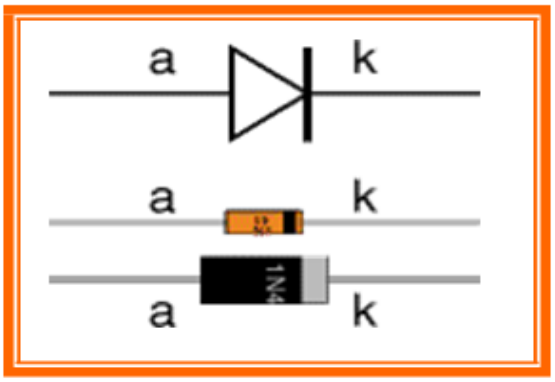


Figure 2.4: Diode Connecting and Soldering Polarity

Signal diodes (small current)

Signal diodes are used to process information (electrical signals) in circuits, so they are only required to pass small currents of up to 100mA.

General purpose signal diodes such as the 1N4148 are made from silicon and have a forward voltage drop of 0.7V.

Germanium diodes: have a lower forward voltage drop of 0.2V and this makes them suitable to use in radio circuits as detectors which extract the audio signal from the weak radio signal. For general use, where the size of the forward voltage drop is less important, silicon diodes are better because they are less easily damaged by heat when soldering, they have a lower resistance when conducting, and they have very low leakage currents when a reverse voltage is applied.

Biasing of Diode: The process of applying an external voltage is called as “biasing”**.**

Zero Bias: When no external voltage potential is applied to the PN junction diode called Zero Biased Junction Diode. However if the diodes terminals are shorted together, a few holes (majority carriers) in the P-type material with enough energy to overcome the potential barrier will move across the junction against this barrier potential. This is known as the “Forward Current” and is referenced as $I_{F.}$ Likewise, holes generated in the N-type material (minority carriers) and move across the junction in the opposite direction. This is known as the “Reverse Current” and is referenced as I_R. This transfer of

electrons and holes back and forth across the PN junction is known as diffusion, as shown Fig 9.

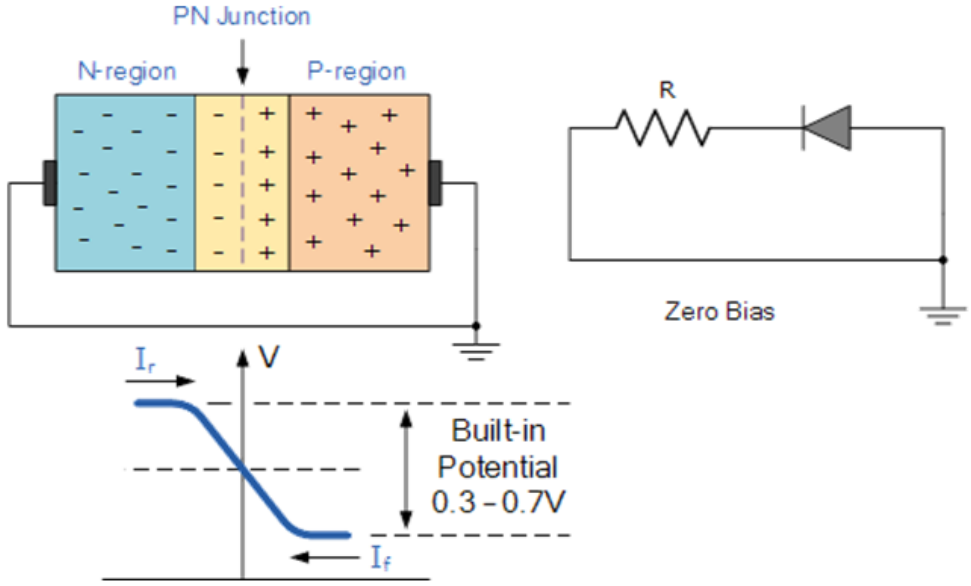


Figure 2.5: Zero bias

But how ever there are two ways in which we can bias a pn junction diode.

- Forward bias
- Reverse bias

Forward Bias – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of **Decreasing** the PN junction diodes' width.

Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of **Increasing** the PN junction diode's width.

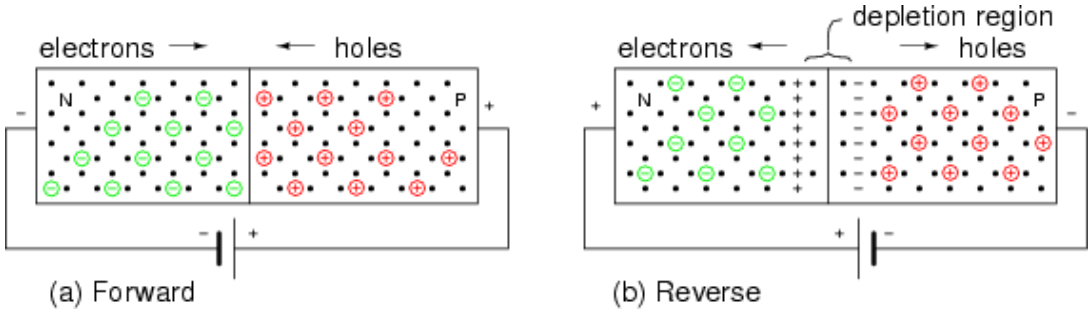


Figure 2.6: forward and reverse biased of diode

Forward & Reverse bias & V-I characteristics of PN junction Diode

✓ Forward Biased PN Junction Diode

When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the n- type material and a positive voltage is applied to the p-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.

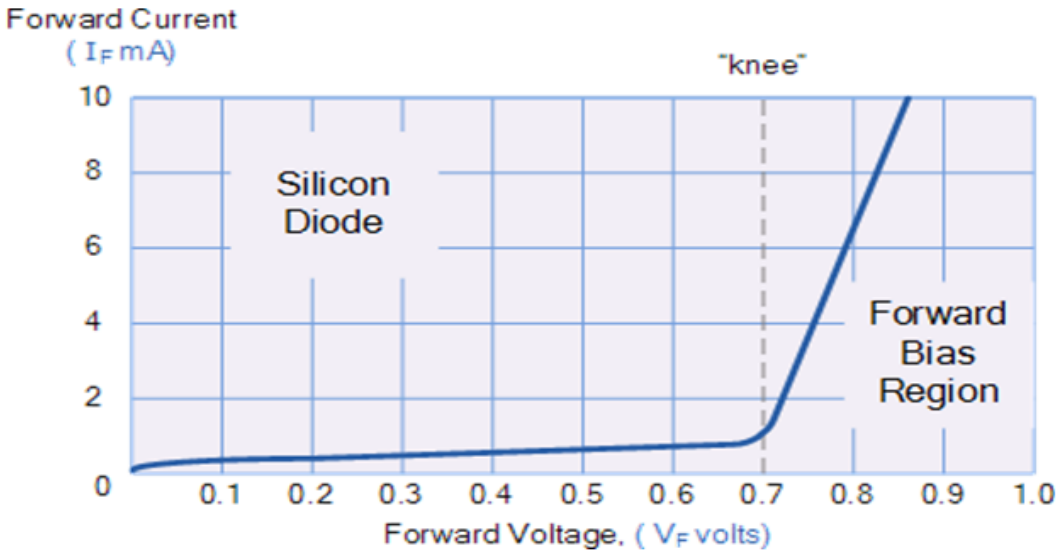


Figure 2.7: forward characteristics curve for a junction diode

The application of a forward biasing voltage on the junction diode results

- The depletion layer becoming very thin and narrow which represents a low impedance path through the junction thereby allowing high currents to flow.
- The point at which this sudden increase in current takes place is represented on the static I-V characteristics curve above as the “knee” point.

Reduction in the Depletion Layer due to Forward Bias

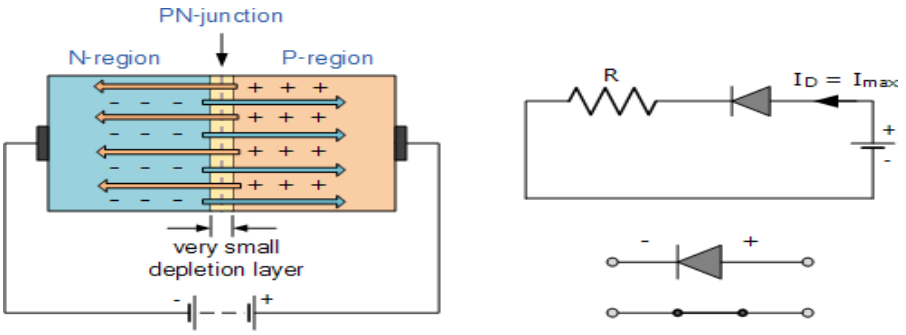


Figure 2.8: Forward bias

Reverse Biased PN Junction Diode

When a diode is connected in a Reverse Bias condition, a positive voltage is applied to the N- type material and a negative voltage is applied to the P-type material. The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.

Thus

- ✓ The depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator.
- ✓ The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.
- ✓ High resistances value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small leakage current does flow through the junction which can be measured in microamperes, (μA).

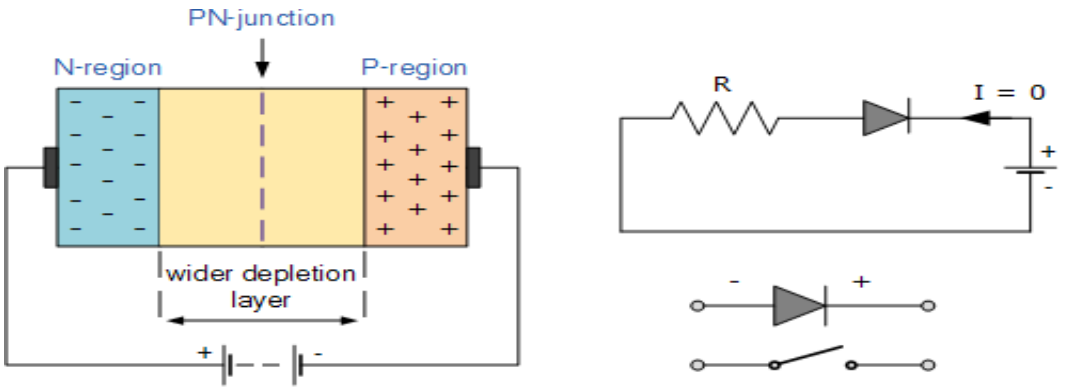


Figure 2.9: Reverse Biasing voltage

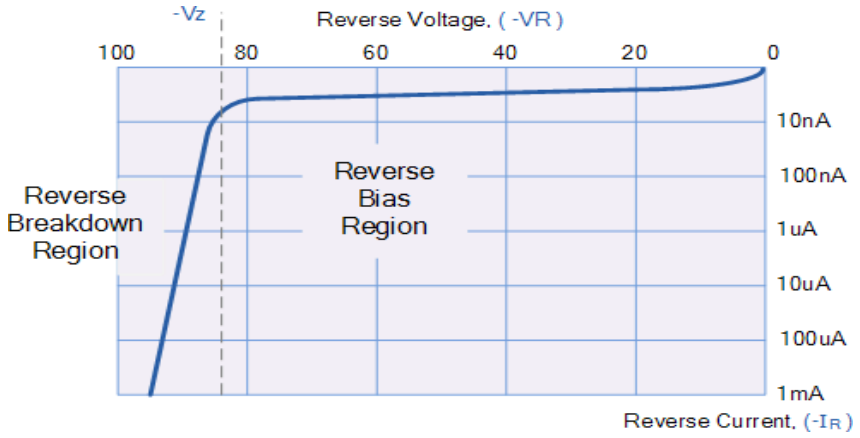


Figure 2.10: Reverse Characteristics Curve for a Junction Diode

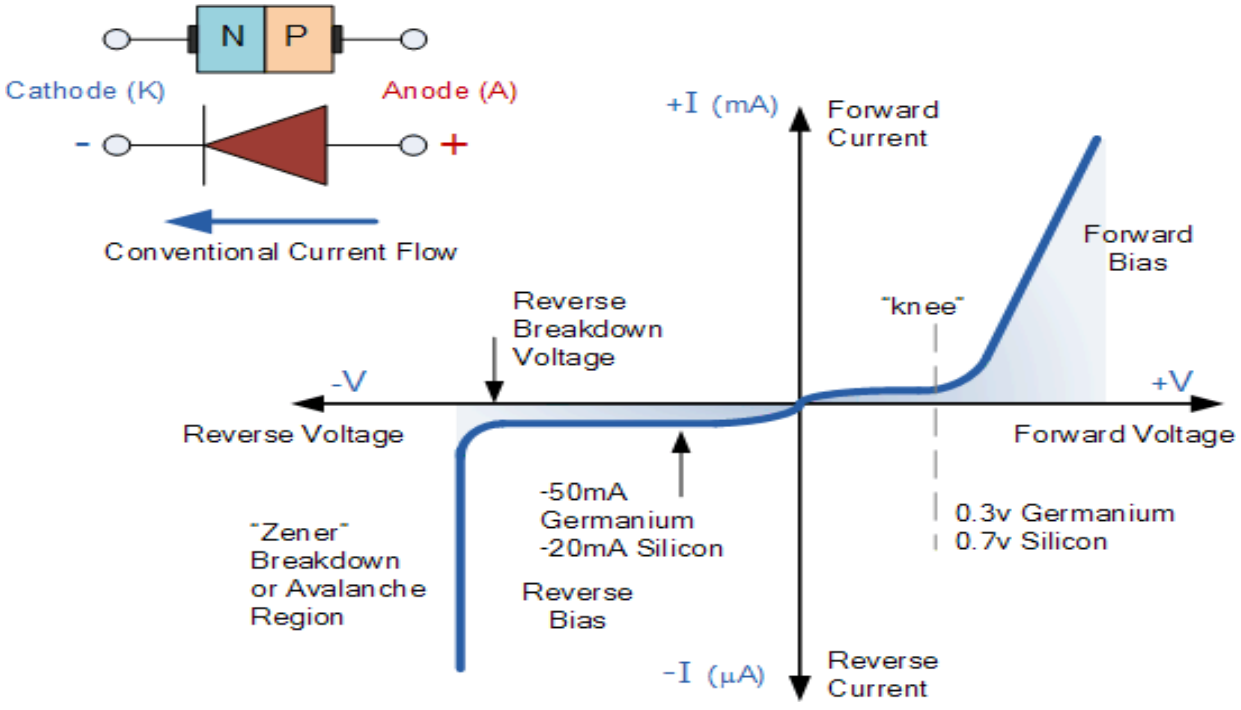


Figure 2.11: Junction Diode Symbol and Static I-V Characteristics

Junction capacitance

All PN junction diodes exhibit a junction capacitance. The depletion region is the dielectric spacing between the two plates which are effectively formed at the edge of the depletion region and the area with majority carriers.

Any variation of the charge within a p-n diode with an applied voltage variation yields a capacitance which must be added to the circuit model of a p-n diode. The capacitance associated with the charge variation in the depletion layer is called the junction

capacitance, while the capacitance associated with the excess carriers in the quasi-neutral region is called the diffusion capacitance. The actual value of capacitance being dependent upon the reverse voltage which causes the depletion region to change (increasing reverse voltage increases the size of the depletion region and hence decreases the capacitance).

This fact is used in varactor or varicap diodes to good effect, but for many other applications, especially RF applications this needs to be minimized. As the capacitance is of importance it is specified. The parameter is normally detailed as a given capacitance (in pF) at a given voltage or voltages. Also special low capacitance diodes are available for many RF applications.

Zener diodes

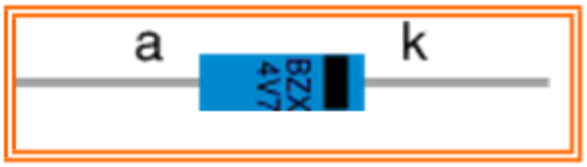


Figure 2.12: Zener Diode Symbol

Zener diodes or as they may sometimes be called, reference diodes operate like an ordinary diode in the forward bias direction. They have the normal turn on voltage of 0.6 volts for a silicon diode. However in the reverse direction their operation is rather different. Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non- destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.

Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point, so 4V7 means 4.7V for example. Some of Zener diodes are rated by their breakdown voltage and maximum power:

- The minimum voltage available is 2.7V.
- Power ratings of 400mW and 1.3W are common.

The vi characteristic of the Zener to voltage reference diode is the key to its operation. In the forward direction, the diode performs like any other, but it is in the reverse direction where its specific performance parameters can be utilized.

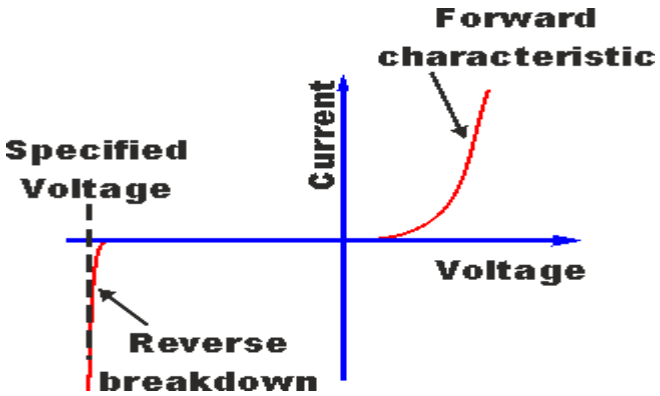


Figure 2.13: Zener diode characteristic

Although the voltage reference diode is normally referred to as a Zener diode, there are two different breakdown mechanisms that can occur:

- **Zener effect:**This effect predominates below 5.5 volts.
- **Impact ionization:** This effect predominates above 5.5 volts.

Simple Zener diode circuit for voltage regulator

When used in a regulator circuit, the Zener diode must have the current entering it limited. If a perfect voltage source was placed across it, then it would draw excessive current once the breakdown voltage had been reached. To overcome this Zener diode must be driven by a current source. This will limit the current to the chosen value. The value of the series resistor is simple to calculate. It is simply the voltage across the resistor, divided by the current required. The level of Zener current can be chosen to suit the circuit and the Zener diode used.

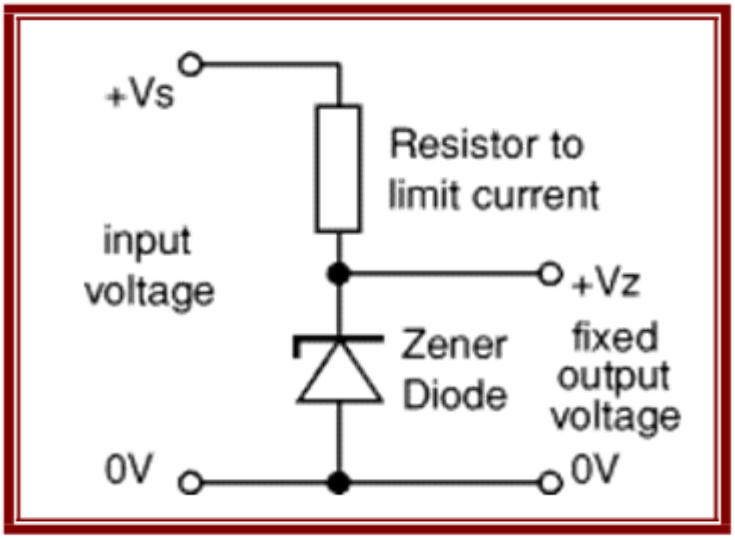


Figure 2.14: Simple circuit of a Zener diode shunt regulator

Application of Zener

Used in Voltage Stabilizer, Clipper Circuit, Reference voltage limiter circuits

Zener breakdown:

In Zener breakdown the electrostatic attraction between the negative electrons and a large positive voltage is so great that it pulls electrons out of their covalent bonds and away from their parent atoms. ie Electrons are transferred from the valence to the conduction band. In this situation the current can still be limited by the limited number of free electrons produced by the applied voltage so it is possible to cause Zener breakdown without damaging the semiconductor. The important points are:

- ✓ Both sides of PN junction are heavily doped
- ✓ Depletion layer is narrow
- ✓ A strong electric field is produced
- ✓ Large number of holes and electrons are produced
- ✓ Zener current is independent of applied voltage

Avalanche breakdown

Avalanche breakdown occurs when the applied voltage is so large that electrons that are pulled from their covalent bonds are accelerated to great velocities. These electrons collide with the silicon atoms and knock off more electrons. These electrons are then also accelerated and subsequently collide with other atoms. Each collision produces

more electrons which lead to more collisions. The current in the semiconductor rapidly increases and the material can quickly be destroyed. The important points are:

- ✓ Both sides of PN junction are lightly doped
- ✓ Depletion layer is large
- ✓ Electric field is not so strong
- ✓ Electron hole pairs are generated
- ✓ Charge carriers acquire energy from the applied potential

Special Diodes:

Tunnel Diode

The tunnel diode is a form of very fast semiconductor diode that can operate well into the microwave radio frequency region. Despite the operation of the tunnel diode its circuit symbol as shown in figure 2.15 is based on that for the standard diode, but has 'tails' added to the bar element of the symbol to differentiate it from other forms of PN junction diode.

Figure 2.15: Tunnel diode circuit symbol

Tunneling is an effect that is caused by quantum mechanical effects when electrons pass through a potential barrier. It can be visualized in very basic terms by them "tunneling" through the energy barrier. The tunneling only occurs under certain conditions. It occurs within tunnel diodes because of the very high doping levels employed. At reverse bias, the electrons tunnel from the valence band in the p-type material to the conduction band in the n-type material, and the level of the current increase monotonically The characteristic curve for a tunnel diode shows an area of negative resistance. When forward biased the current in the diode rises at first, but later it can be seen to fall with increasing voltage, before finally rising again.

It is also interesting to note that current also flows in the reverse direction - the reverse breakdown voltage is actually zero and the diode conducts in the reverse direction. The characteristics near the original are virtually symmetrical.

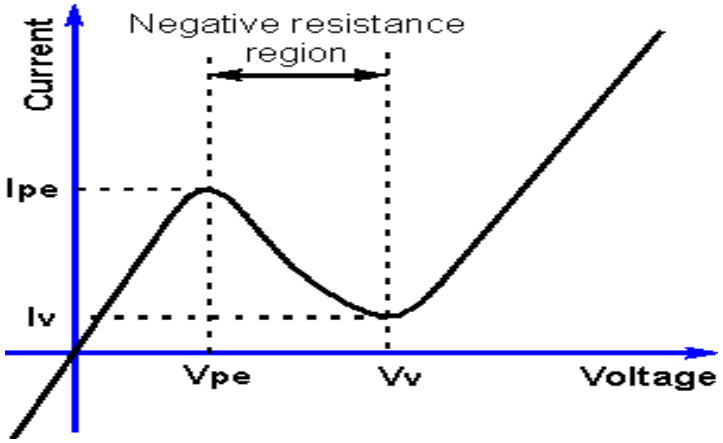


Figure 2.16: Tunnel diode VI characteristic

The reason for this is that there are a number of different components to forming the overall curve.

- ✓ **Normal diode current:** This is the 'normal' current that would flow through a PN junction diode.
- ✓ **Tunneling current:** This is the current that arises as a result of the tunneling effect.
- ✓ **Excess current:** This is a third element of current that contributes to the overall current within the diode. It results from what may be termed excess current that results from tunneling though bulk states in the energy gap, and means that the valley current does not fall to zero.

Advantages

- ✓ ***Very high speed:*** The high speed of operation means that the tunnel diode can be used for microwave RF applications.
- ✓ ***Longevity:*** Studies have been undertaken of the tunnel diode and its performance has been shown to remain stable over long periods of time, where other semiconductor devices may have degraded.

Disadvantages

- ✓ **Reproducibility:** It has not been possible to make the tunnel diode with as reproducible performance to the levels often needed.
- ✓ **Low peak to valley current ratio:** The negative resistance region and the peak to valley current is not as high as is often be required to produce the levels of performance that can be attained with other devices.

- **Applications**

✓ **Oscillator circuits:** Tunnel diodes can be used as high frequency oscillators as the transition between the high electrical conductivity is very rapid. They can be used to create oscillation as high as 5Gz. Even they are capable of creativity oscillation up to 100 GHz in a appropriate digital circuits.

✓ **Used in microwave circuits:** Normal diode transistors do not perform well in microwave operation. So, for microwave generators and amplifiers tunnel diode are. In microwave waves and satellite communication equipments they were used widely, but now a day's their uses are decreasing rapidly as transistor for working in wave frequency area available in market.

✓ **Resistant to nuclear radiation:** Tunnel diodes are resistant to the effects of magnetic fields, high temperature and radioactivity. That's why these can be used in modern military equipment. These are used in nuclear magnetic resource machine also. But the most important field of its use satellite communication equipments.

Optical Diodes: - LED, IRLED & photodiode

Light emitting diode (LED)

A light emitting diode (LED) is known to be one of the best optoelectronic devices. The device is capable of emitting a fairly narrow bandwidth of visible or invisible light when its internal diode junction attains a forward electric current or voltage. The visible lights that an LED emits are usually orange, red, yellow, or green. The invisible light includes the infrared light. We know that a P-N junction can connect the absorbed light energy into its proportional electric current. The same process is reversed here. That is, the P-N junction emits light when energy is applied on it.

This phenomenon is generally called electro luminance, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some part of the energy must be dissipated in order to recombine the electrons and the holes. This

energy is emitted in the form of heat and light. The electrons dissipate energy in the form of heat for silicon and germanium diodes. But in Galium-Arsenide-phosphorous (GaAsP) and Galium-phosphorous (GaP) semiconductors, the electrons dissipate energy by emitting photons. The circuit symbol of LED consists of two arrow marks which indicate the radiation emitted by the diode.

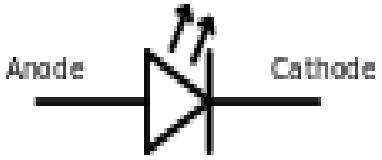


Figure 2.17: LED symbol

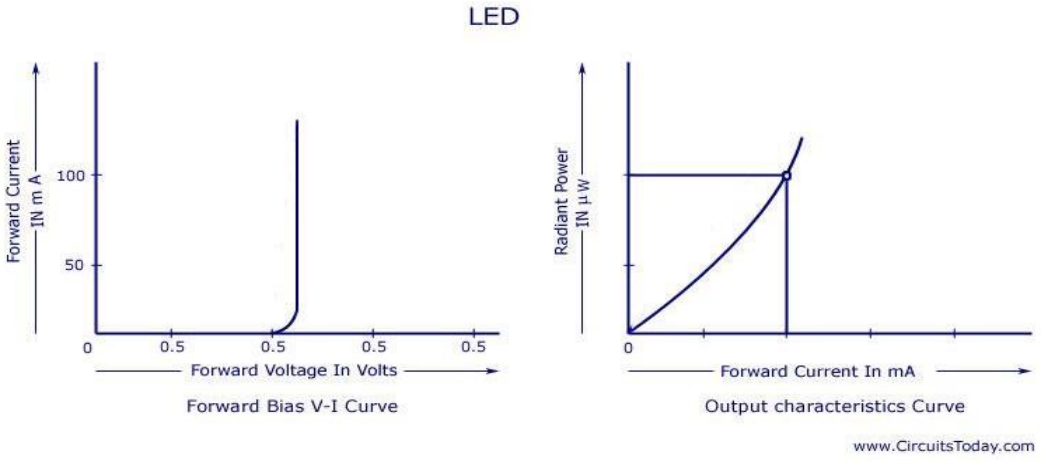


Figure 2.18: LED Characteristics

The forward bias Voltage-Current (V-I) curve and the output characteristics curve is shown in the figure above.

The circuit shown below is one of the main applications of LED. The circuit is designed by wiring it in inverse parallel with a normal diode, to prevent the device from being reverse biased. The value of the series resistance should be half, relative to that o f a DC circuit.

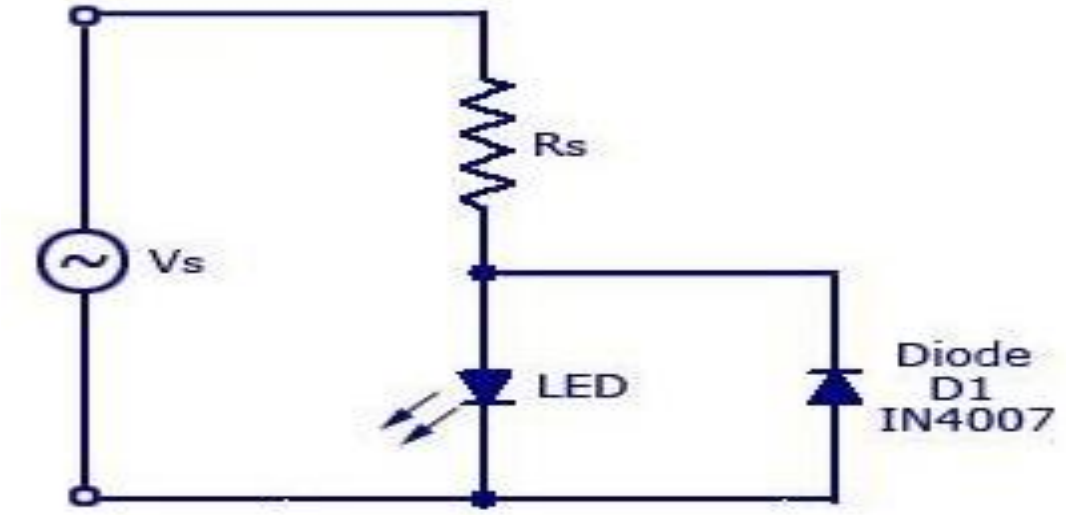


Figure 2.19: LED circuit as Indicator

Advantages of LED

- ✓ Very low voltage and current are enough to drive the LED.
- ✓ Voltage range – 1 to 2 volts.
- ✓ Current – 5 to 20 milli amperes.
- ✓ Total power output will be less than 150 milli watts.
- ✓ The response time is very less – only about 10 nanoseconds.
- ✓ The device does not need any heating and warm up time.
- ✓ Miniature in size and hence light weight.
- ✓ Have a rugged construction and hence can withstand shock and vibrations.
- ✓ An LED has a life span of more than 20 years.

Disadvantages

- ✓ A slight excess in voltage or current can damage the device.
- ✓ The device is known to have a much wider bandwidth compared to the laser.
- ✓ The temperature depends on the radiant output power and wavelength.

Photodiodes

A photodiode is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present.

It is optimized to produce an electron current flow in response to irradiation by ultraviolet, visible, or infrared light. Silicon is most often used to fabricate photodiodes; though, germanium and gallium arsenide can be used. The junction through who light enters the semiconductor must be thin enough to pass most of the light on to the active region (depletion region) where light is converted to electron hole pairs.

In Figure 2.20 shallow P-type diffusion into an N-type wafer produces a PN junction near the surface of the wafer. The P-type layer needs to be thin to pass as much light as possible. A heavy N+ diffusion on the back of the wafer makes contact with metallization. The top metallization may be a fine grid of metallic fingers on the top of the wafer for large cells. In small photodiodes, the top contact might be a sole bond wire contacting the bare P-type silicon top.

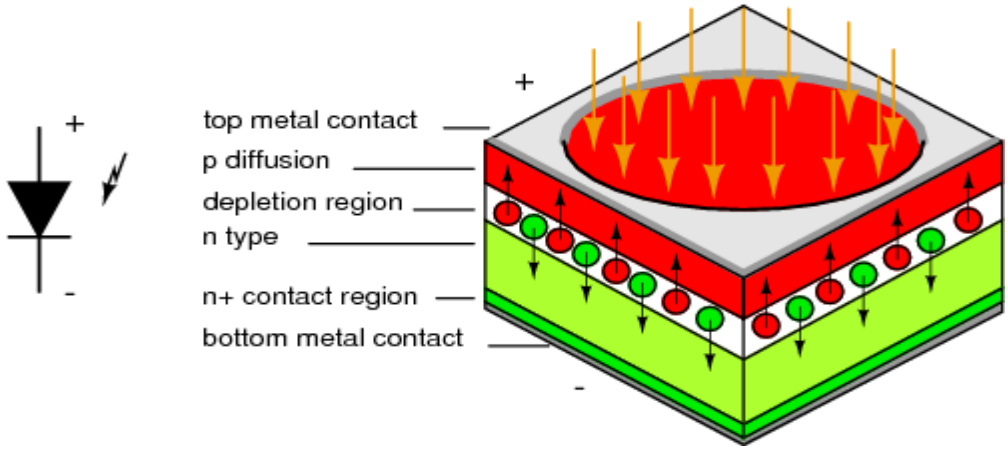


Figure 2.20: Photodiode: Schematic symbol and cross section

Applications

Photodiodes are used in consumer electronics devices such as compact disc players, smoke detectors, and the receivers for infrared remote control devices used to control equipment from televisions to air conditioners. For many applications either photodiodes or photoconductors may be used. Either type of photosensor may be used for light measurement, as in camera light meters, or to respond to light levels, as in switching on street lighting after dark. Photodiodes may contain optical filters, built-in lenses, and may have large or small surface

areas. Photodiodes usually have a slower response time as its surface area increases. The common, traditional solar cell used to generate electric solar power is a large area photodiode.

Infrared LED

IR LED is used in this circuit to transmit infrared light. An Infrared light-emitting diode (IR LED) is a type of electronic device that emits infrared light not visible to the naked eye. The wavelength and color of the light produced depend on the material used in the diode. Infrared LEDs use material that produces light in the infrared part of the spectrum, that is, just below what the human eye can see. Different infrared LEDs may produce infrared light of differing wavelengths, just like different LEDs produce light of different colors.

Since the human eye cannot see the infrared radiations, it is not possible for a person to identify whether the IR LED is working or not, unlike a common LED. To overcome this problem, the camera on a cell phone can be used. The camera can show us the IR rays being emanated from the IR LED in a circuit.

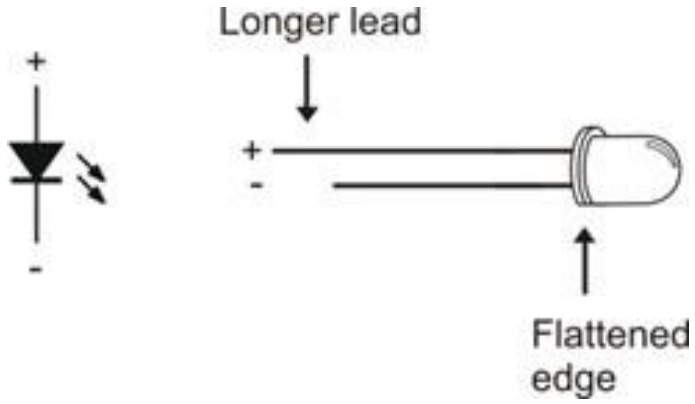


Figure 2.21: Symbol of IR LED

Infrared LEDs can be divided into the following three types: small power one (1mW-10mW), medium power LED (10mW-50mW) and large power LED (50mW-100mW and above). The modulated light can be generated by adding pulse voltage with specific frequency on the driving diode.

Infrared emitting diode infrared light, the principle and characteristics are as follows:

The matrix of infrared light is emitting diode light.

Infrared emission diode by the infrared radiation efficiency of the material (commonly gallium arsenide GaAs) made of a PN junction, applied to the PN junction forward bias injection current excitation infrared light. Infrared diode current is too small.

Applications:

Infrared LED chips with different wavelengths can be applied in extensive devices, for example:

- ✓ Free air transmission system
- ✓ Optoelectronic switch
- ✓ Floppy disk drive
- ✓ Infrared applied system
- ✓ Smoke detector
- ✓ video surveillance camera
- ✓ Infrared LED chip with wavelength of 940nm: suitable to be used in remote controller, such as remote controllers for household appliances.
- ✓ 808nm: suitable to be used in medical treatment appliances, space optical communication, infrared illumination and the pumping sources of the solid-state lasers.
- ✓ 830nm: suitable to be used in the automated card reader system in freeway.
- ✓ 840nm: suitable to be used in colored zoom infrared waterproof video camera.
- ✓ 850nm: suitable to be used in video cameras that are applied in digital photography, monitoring system, door phone, theft proof alarm and so on.
- ✓ 870nm: suitable to be used in video cameras in marketplace and crossroad.

Rectifiers and Filters

Rectifier: A semiconductor device which converts of an alternating current (AC) into direct current (DC)**.** For example: Semiconductor Diode**.**

Need of Rectifier: To provide continuous voltage (DC Voltage) required running almost all electronic devices & circuits.

- ✓ **Types of Rectifier:**
- ✓ **Half Wave Rectifier**:

In this type the rectifier conducts current only during the + ve half cycles of the a.c. supply.

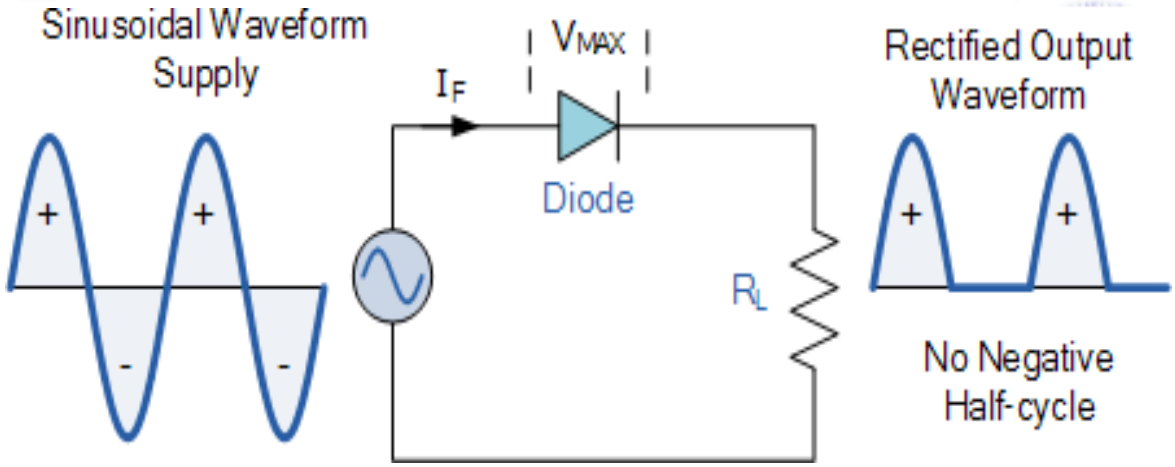


Figure 2.22: Have wave rectifier

Here – ve half cycles are suppressed i.e. during –ve half cycle no current passes through the diode hence no voltage appears across the load.

Max. Rectifier Efficiency= Max. d.c.output power/ a.c. input power =40.6%

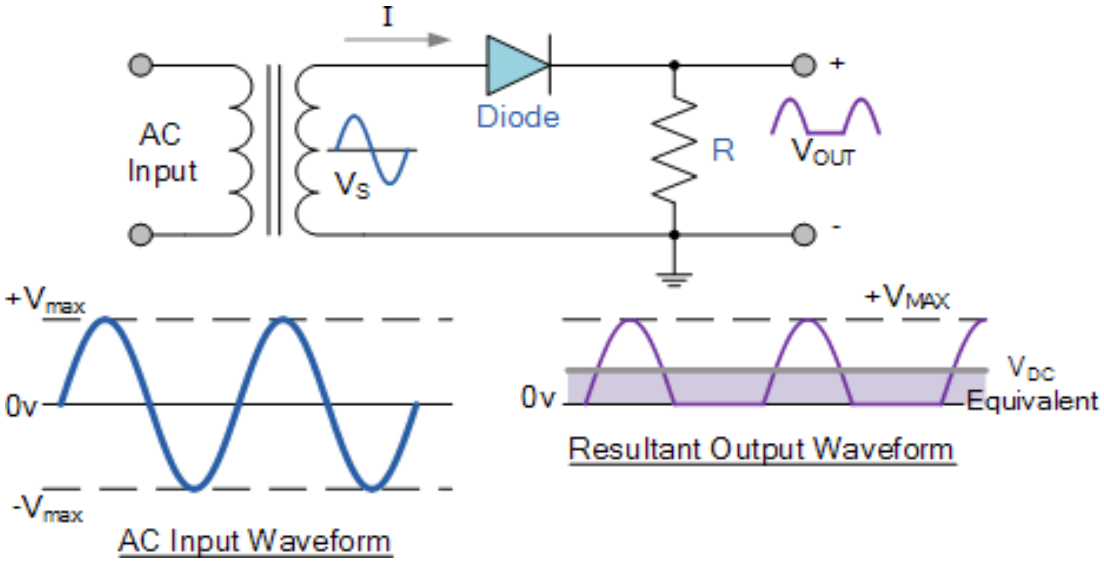


Figure 2.23: Have wave rectifier schematic diagram

Full wave rectifier

In this type, the rectifier utilizes both half cycles of a.c. input voltage to produce the d.c output.

Full Wave Rectifier (Centre Tapped Type)

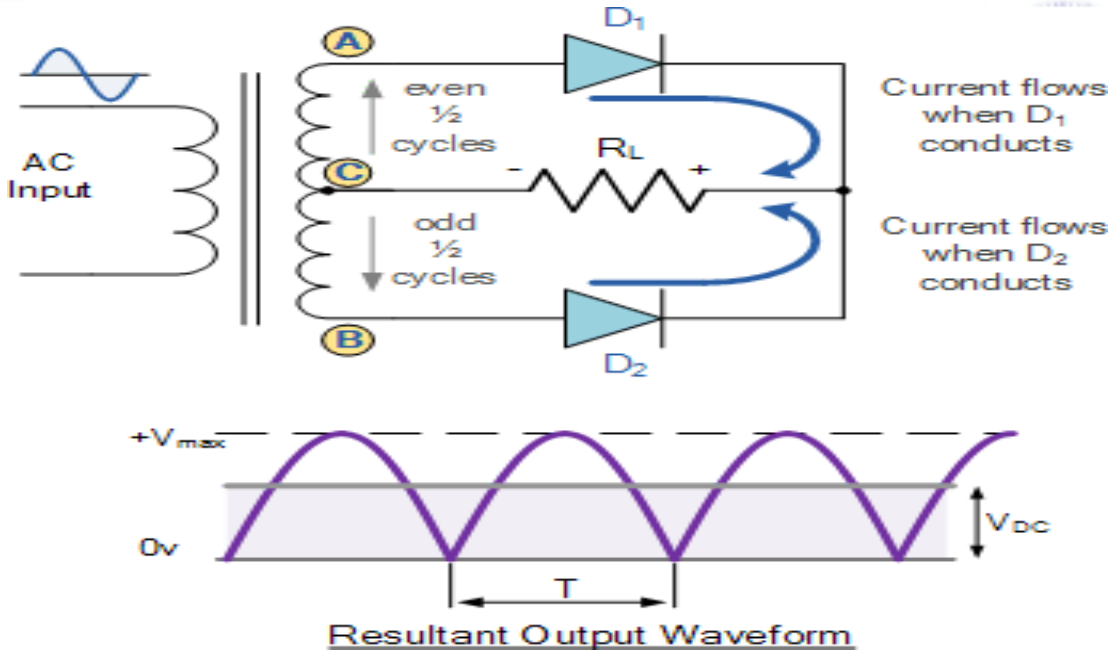


Figure 2.24: Full wave rectifier center tap type

During the positive half cycle of the supply, diode D1 conducts, while diodeD2 is reverse biased and the current flows through the load as shown. Similarly, during the negative half cycle of the supply, diodeD2 conducts, while diodeD1 is reverse biased and the current flows through the load as shown.

Full Wave Rectifier (Bridge Type): The Diode Bridge Rectifier

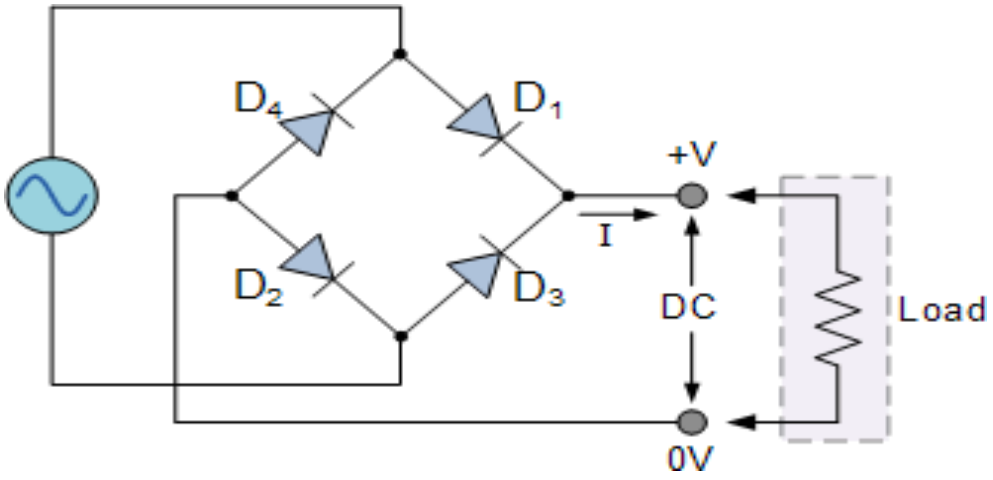


Figure 2.25: Full wave rectifier bridge type

During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

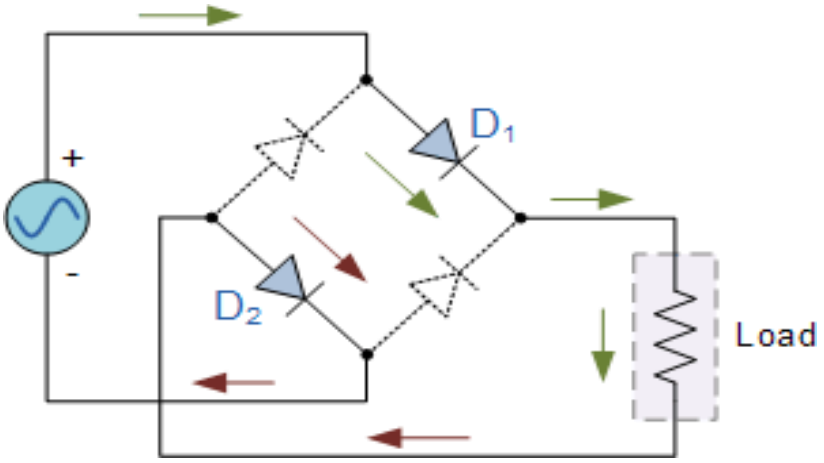


Figure 2.26: The Positive Half-cycle

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch “OFF” as they are now reversing biased. The current flowing through the load is the same direction as before.

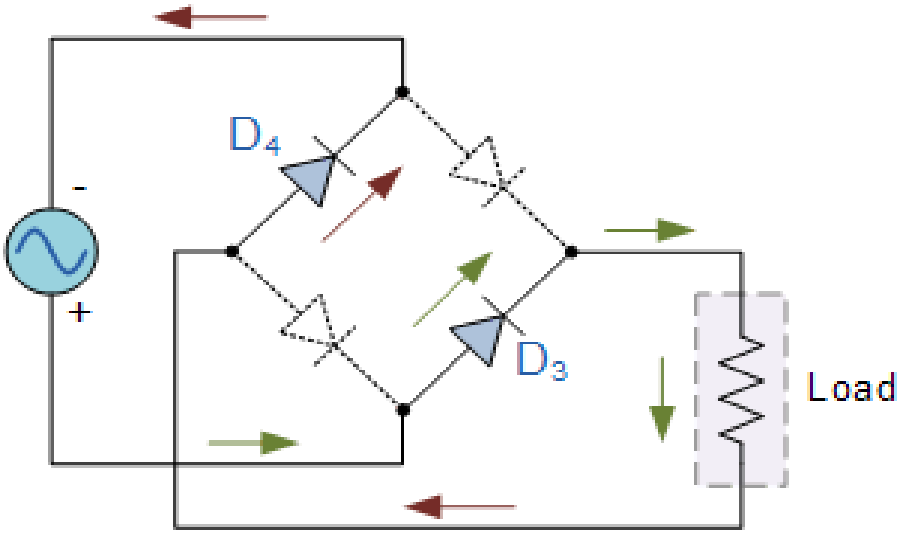


Figure 2.27: The Negative Half-cycle

Maximum rectifier Efficiency = Max. d.c. output power/a.c. input power = ή =81.2 %

- **Ripple**: Ripple is the output of a rectifier that contains both dc & ac component.

✓ **Ripple Factor:** The ratio of r.m.s value of ac component to the dc component in the rectifier output is known as ripple factor. Ripple Factor= r.m.s value of ac component/value of dc component.

- ✓ For Half wave rectification ripple factor =1.21
- ✓ For Full wave rectification ripple factor = 0.48
- **PIV (Peak Inverse Voltage):** It is the maximum reverse voltage that a diode can withstand without destroying the junction.

TUF (Transformer Utility Factor): Defined as the ratio of power delivered to the load to the ac rating of the transformer secondary.

TUF = dc power delivered to the load/ac rating of transformer secondary

$$= P_{dc} / P_{ac\ .rated}$$

$$= P_{dc}/P_{in.\ Rated}$$

Rectifier Efficiency: The ration of dc power output to the applied input ac power is known as rectifier efficiency.

Rectifier Efficiency = dc power output / input ac power

Table 2.1: Comparison of Three types of Rectifier

Sl. No.	Particulars	Half wave	Centre-Tap FWR	Bridge FWR
1.	No. of Diodes	1	2	4
2.	Max. Efficiency	40.6%	81.2%	81.2%
3.	Ripple Factor	1.21	0.48	0.48
4.	Output Frequency	50Hz	100Hz	100Hz
5.	PIV(Peak Inverse Voltage)	Vm	2Vm	Vm

Filters:

A filter circuit is a device which removes the ac component (ripple) of rectifier output but allows the dc component to reach the load.

- ✓ **Need of Filter:** To provide smooth DC output to the load.
- ✓ **Types of Filter:**

Shunt Capacitor: It is also called Capacitor Filter. It offers low reactance to ac &a very high reactance to the dc component.

The capacitive reactance is $X_C=1/2\pi fc$, for d.c , f=0 Then, $X_C=\infty$.

Hence a capacitor does not allow the d.c to pass through it.

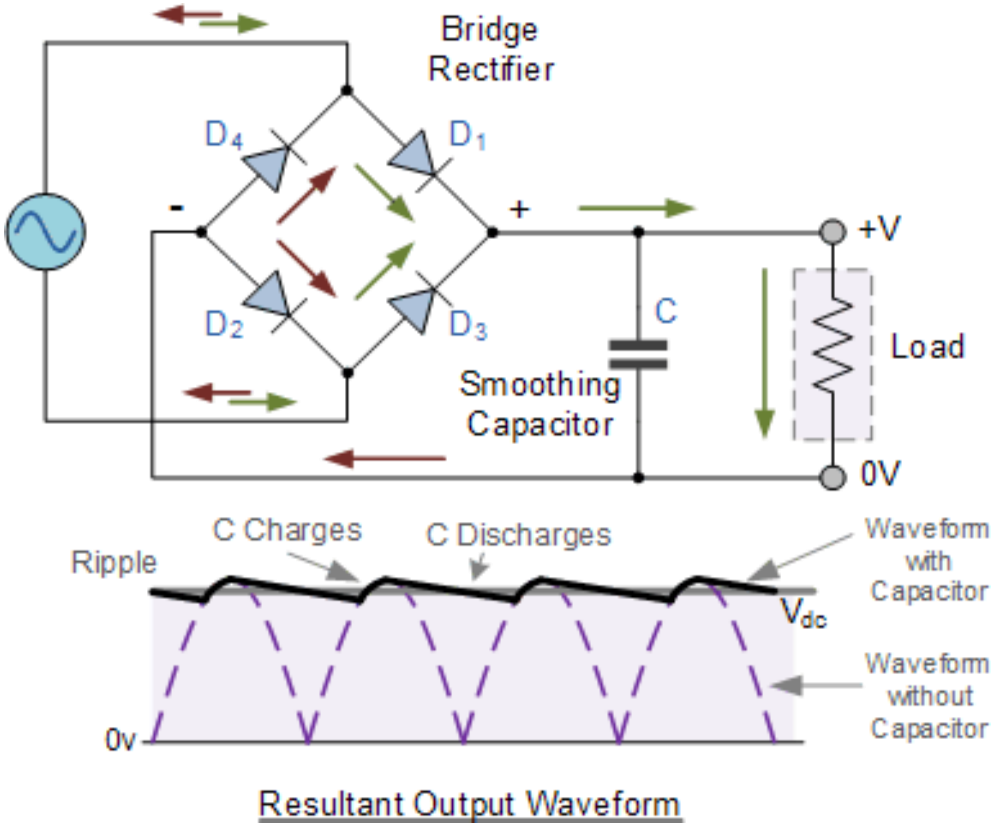


Figure 2.28: The capacitor shunt type Filter

- ✓ **Choke input filter**: In this filter one inductor & one capacitor is used.

The inductive reactance is $X_L=2\pi fL$, for d.c , f(frequency)=0 Then, $X_L=0$.

Inductor allows the d.c to pass through it. It offers high reactance to the ac component but offers almost zero reactance to the dc component.

That means it allows only dc component to flow through it.

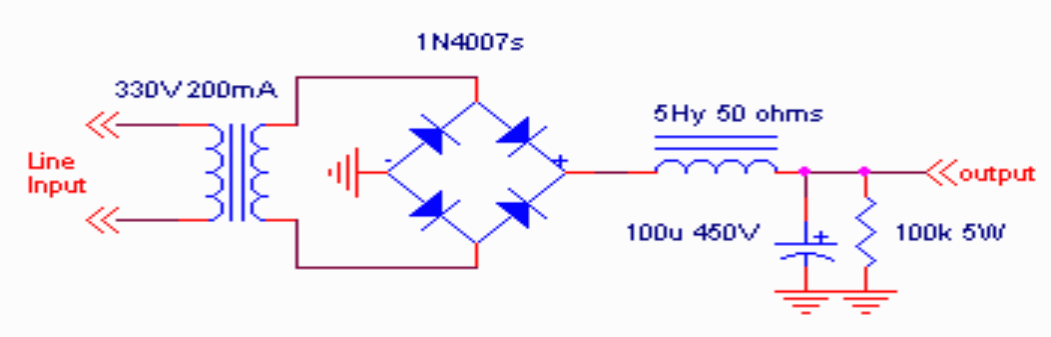


Figure 2.29: Choke input filter

- ✓ **Capacitor input filter:** It is also called π -Filter.

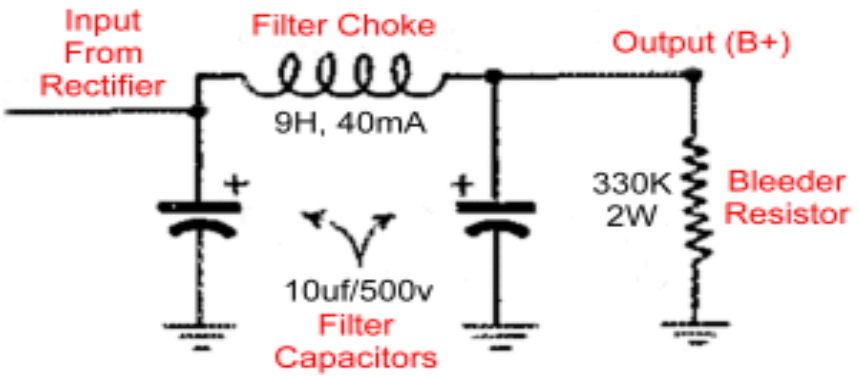


Figure 2.30: π -Filter

In this filter one inductor and two capacitors are used.

Here pulsating output from rectifier is applied across 1st capacitor which offers zero reactance to a.c and infinite reactance to d.c. Hence d.c component continues to reach across L (Choke Filter). The filter choke then allows the d.c component easily by blocking a.c component if any. Finally the 2nd capacitor across load bypasses the a.c component if any which the choke (L) failed to block by making d.c component to reach across load.

Transistor:

A transistor consists of two pn junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

Accordingly there are two types of transistors namely:

- ✓ P-N-P transistor
- ✓ N-P-N transistor

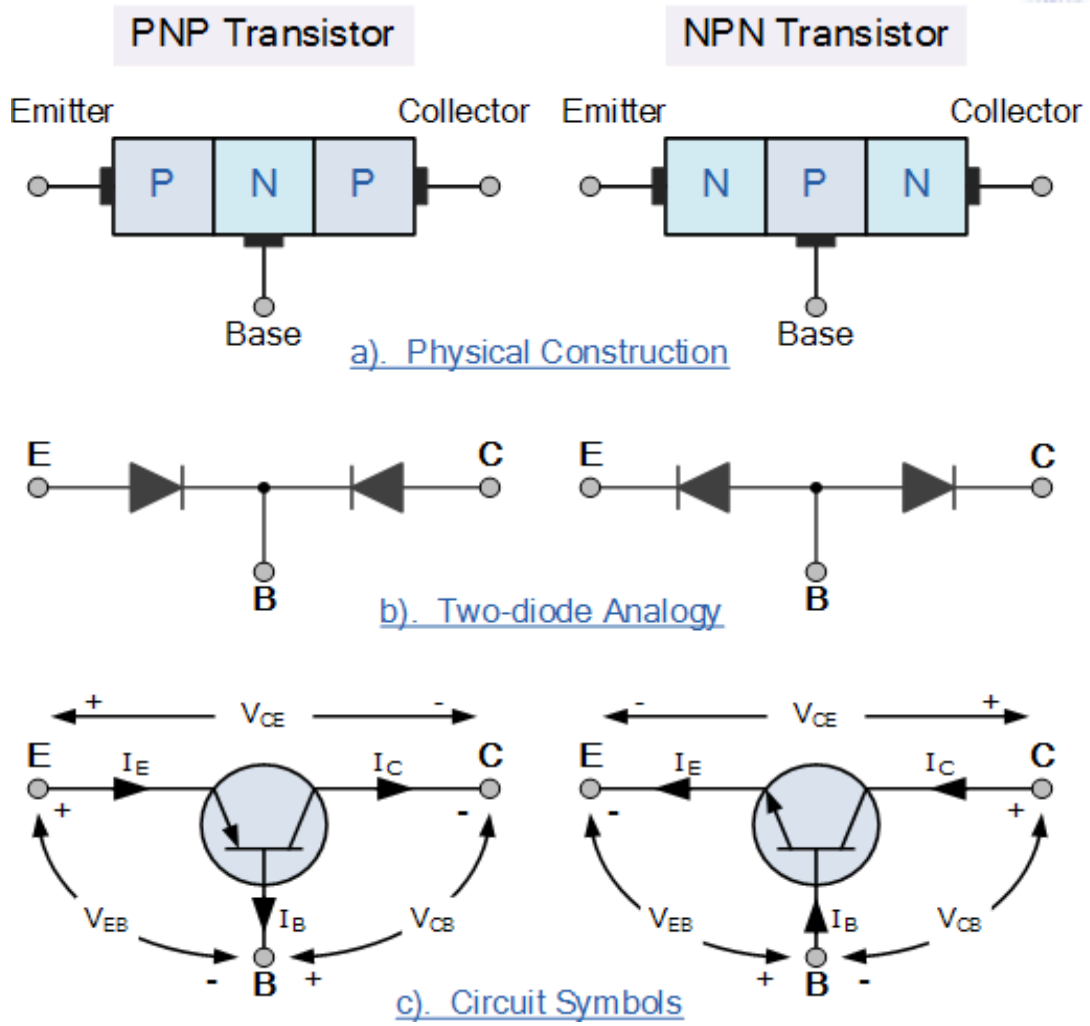


Figure 2.30: Configuration of transistor

Advantages: Small size, Light weight, Low supply voltage, No heating, high voltage gain, mechanically strong. Bipolar Junction Transistor (BJT): A BJT consists of two p-n junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

Types of Transistor (BJT) Basic concept: NPN transistor.

It has three sections of doped semiconductors.

- ✓ **Emitter:** The section on one side that supplies carriers (Electrons/Holes) is called Emitter. The emitter is always forward biased w.r.t. base so that it can supply large no of majority carriers (Electrons)

- ✓ **Base:** The middle section which forms two pn junctions between emitter & collector is called the Base
- ✓ **Collector:** The section on one side that collects carriers (Electrons/Holes) is called Collector. The collector is always forward reverse biased with respect to base. Its function is to removes charges from its junction with the base.

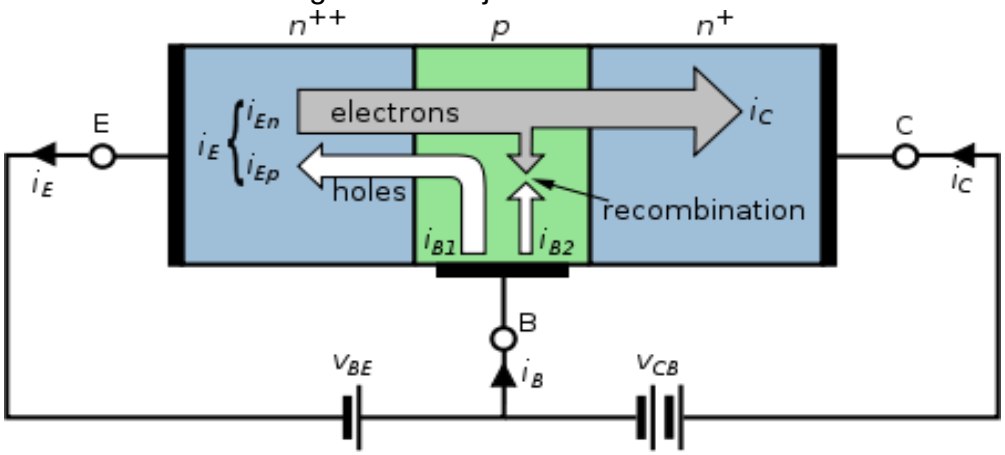


Figure 2.31: Connection of transistor

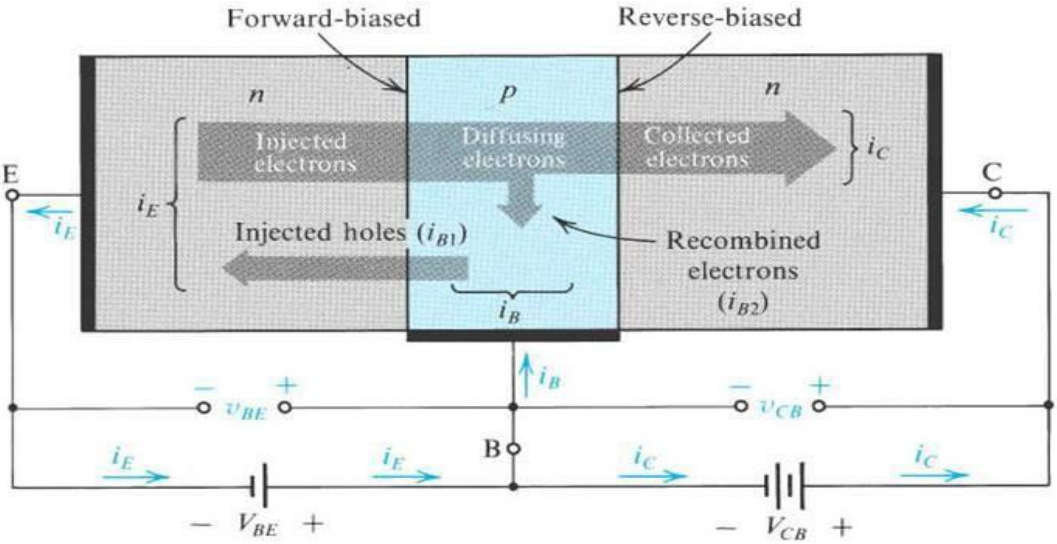


Figure 2.32: Testing of transistor

- **Conventional Current Flow in npn:** The base emitter junction is forward biased. Allowing low resistance in emitter (input) side & base-collector junction is reverse biased & provides high resistance in collector (Output) side. Accordingly the current flows from emitter towards base & collector.

$$I_E = I_B + I_C$$

Emitter Current = Base Current + Collector Current

- **PNP transistor:** Similarly the in pnp, the current conduction is due to majority carriers i.e. Holes as shown below.

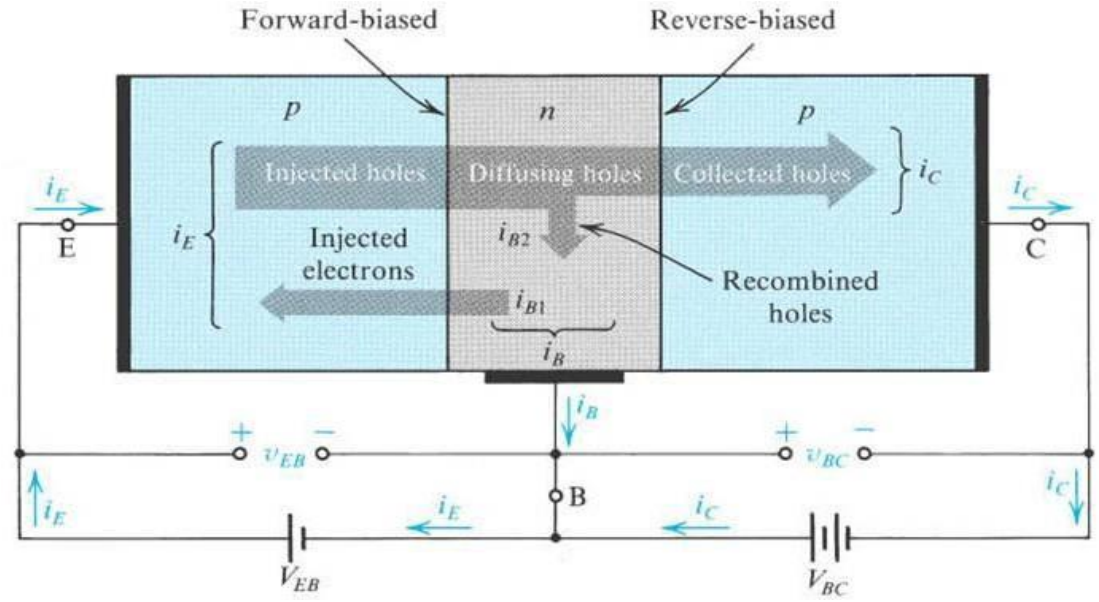


Figure 2.33: Relation between different currents in transistor (IE, I_B, and IC)

Emitter Current = Base Current + Collector Current

Transistor Configurations: CB, CE& CC

As the Bipolar Transistor is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

- ✓ Common Base Configuration - has Voltage Gain but no Current Gain.
- ✓ Common Emitter Configuration - has both Current and Voltage Gain.
- ✓ Common Collector Configuration - has Current Gain but no Voltage Gain.

The Common Base (CB) Configuration:

As its name suggests, in the Common Base or grounded base configuration, the BASE connection is common to both the input signal AND the output signal with the input signal being applied between the base and the emitter terminals. The corresponding output signal is

taken from between the base and the collector terminals as shown with the base terminal grounded or connected to a fixed reference voltage point.

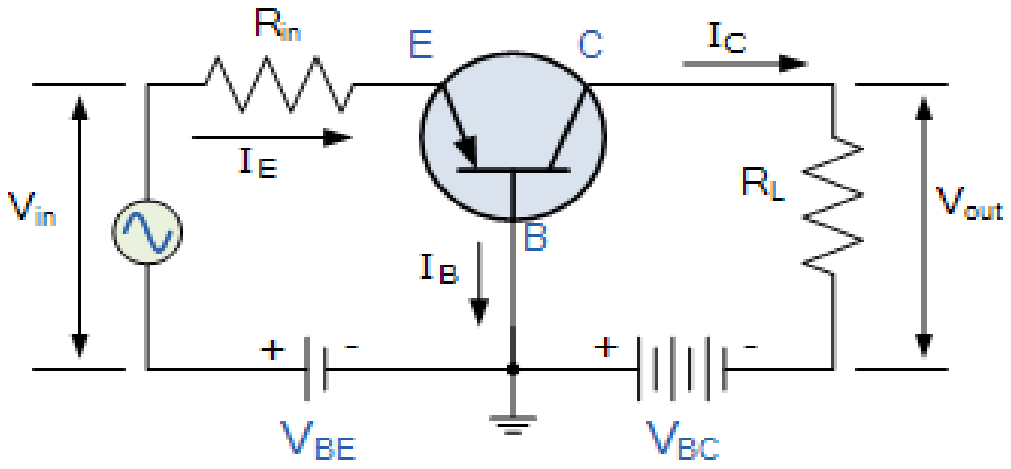


Figure 2.34: The Common Base (CB) Configuration

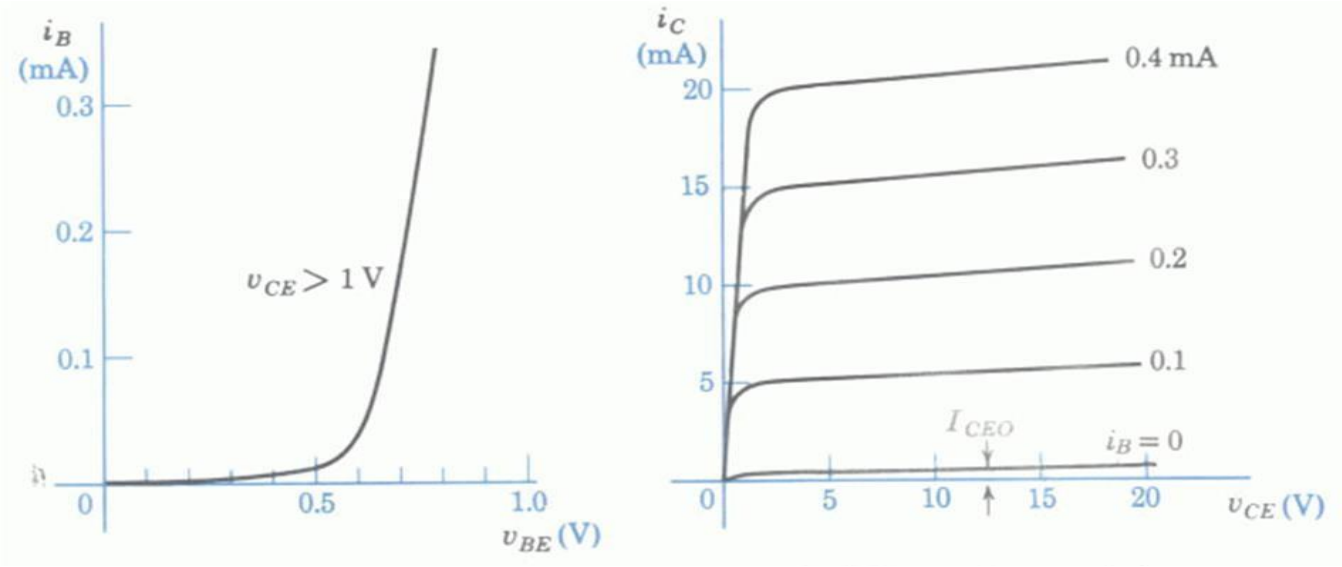


Figure 2.35: Base and Collector Input Output Characteristics

The Common Emitter (CE) Configuration:

In the Common Emitter or grounded emitter configuration, the input signal is applied between the base, while the output is taken from between the collector and the emitter as shown. This type of configuration is the most commonly used circuit for transistor based amplifiers and which represents the “normal” method of bipolar transistor connection.

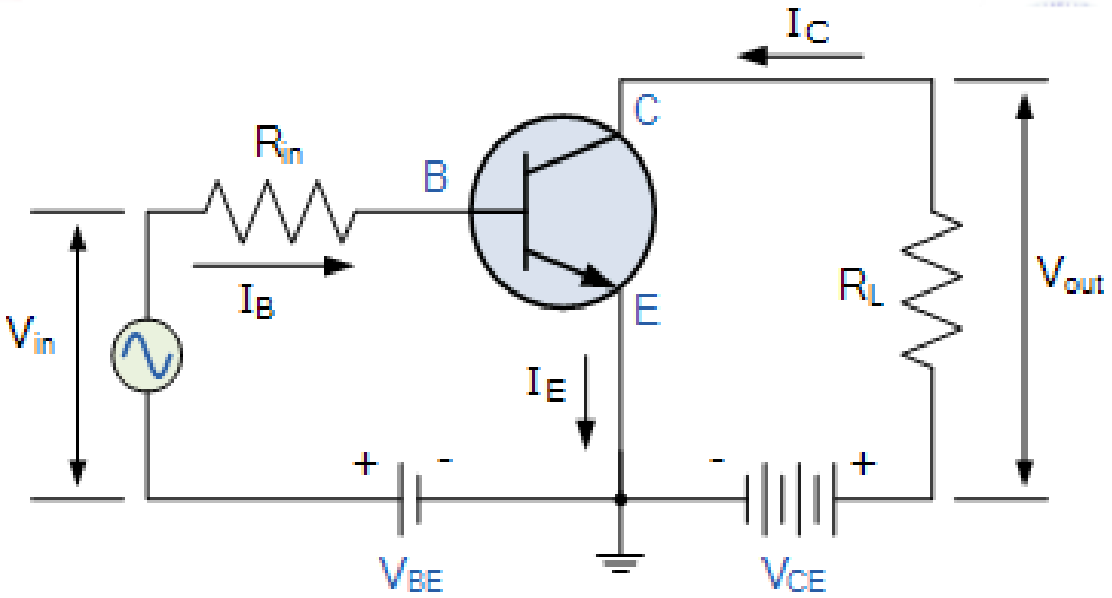


Figure 2.36: Circuit diagram to find the characteristics

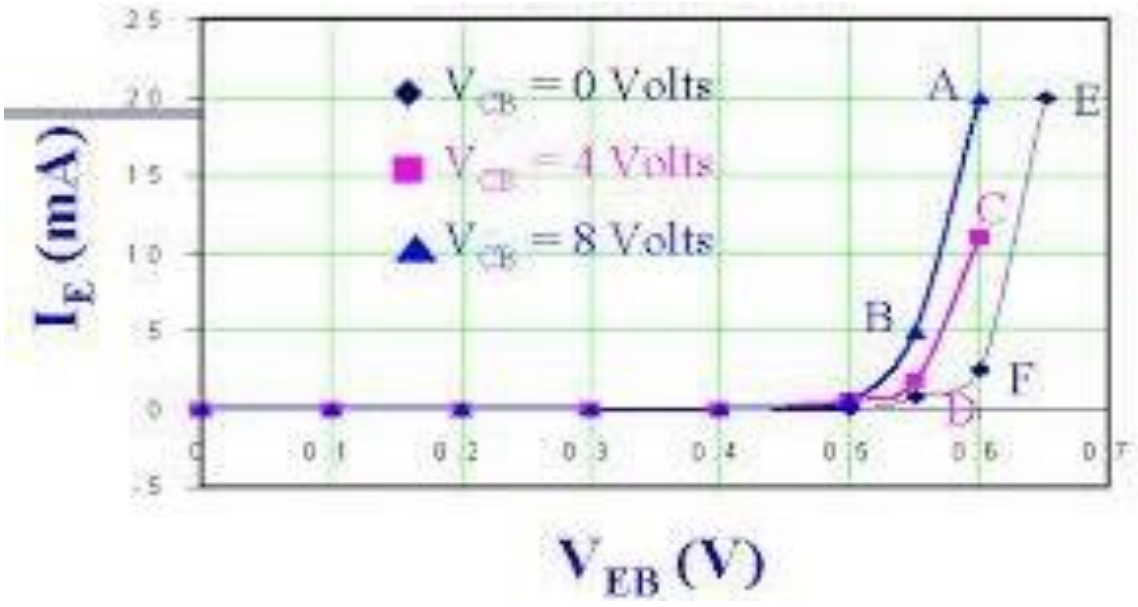


Figure 2.37: Input Characteristics

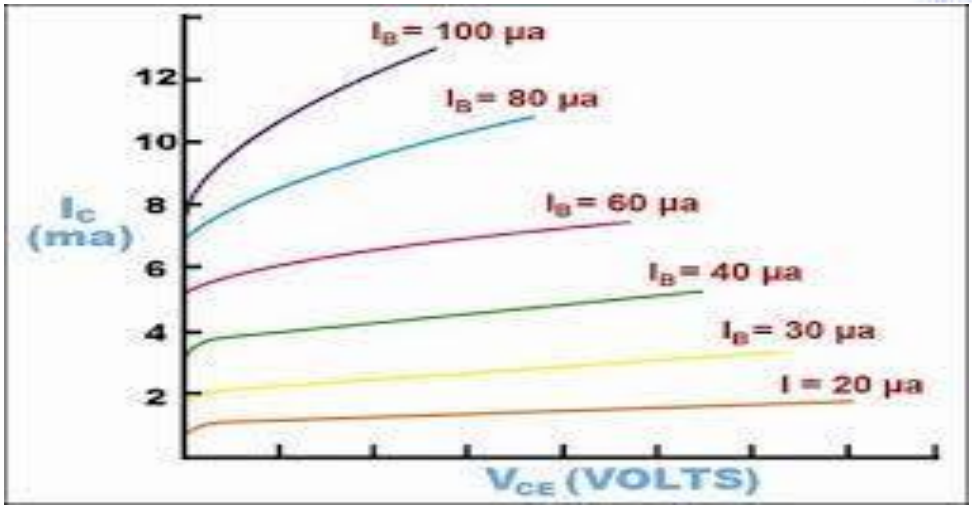


Figure 2.38: Output Characteristics

The Common Collector (CC) Configuration:

In the Common Collector or grounded collector configuration, the collector is now common through the supply. The input signal is connected directly to the base, while the output is taken from the emitter load as shown. This type of configuration is commonly known as a Voltage Follower or Emitter Follower circuit: The emitter follower is a current amplifier that has no voltage gain.

Its important characteristics are:

- ✓ No voltage gain.
- ✓ It has high input impedance & low output impedance.
- ✓ Relatively high current & power gain.
- ✓ Input & output ac voltages are in phase.

Thus it is an ideal circuit for impedance matching and DC load line analysis.

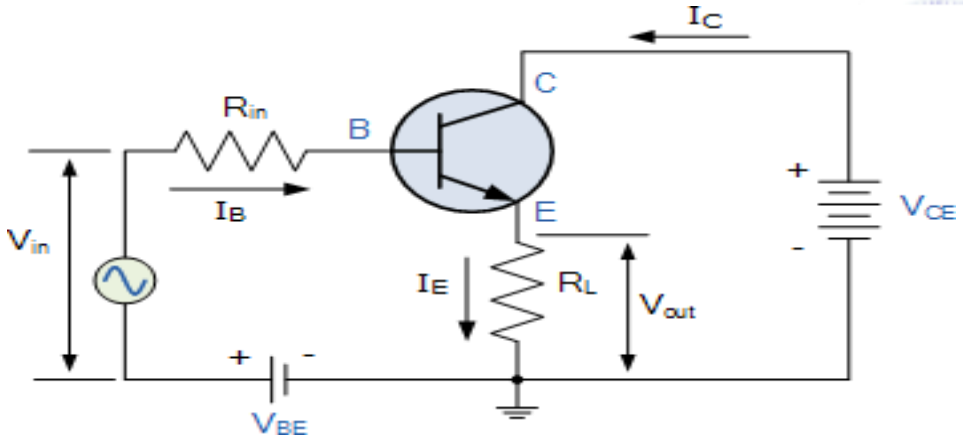


Figure 2.39: Common Collector (CC) Configuration

Working Principle: As the collector is at ac ground, the circuit is known as CC amplifier.

- ✓ There is no collector load(R_C) and emitter bypass capacitor (C_E)
- ✓ The emitter resistor (R_E=R_L) itself acts as the load.
- ✓ The biasing is provided by input resistor (R_{in})

Transistor Parameters

- ✓ Input Resistance: It is the ratio of change input voltage to the change in input current.
- ✓ Output Resistance: It is the ratio of change output voltage to the change in output current.

Table 3.2: Transistor Parameter

Transistor Parameters	CB	CE	CC
I/P Resistance	Low	Low	Very High
O/P Resistance	Very High	High	Low
Application	High frequency	Audio frequency	Impedance Matching

Construction, Working Principle, Characteristics of Photo Transistor

Photo Transistor

A phototransistor is a light-sensitive transistor. A bipolar transistor encased in a transparent case so that light can reach the base-collector junction.

The phototransistor symbol for use in electronic circuit diagrams is very straightforward. It is formed from the basic transistor symbol with arrows point in to it to indicate that it is light sensitive.

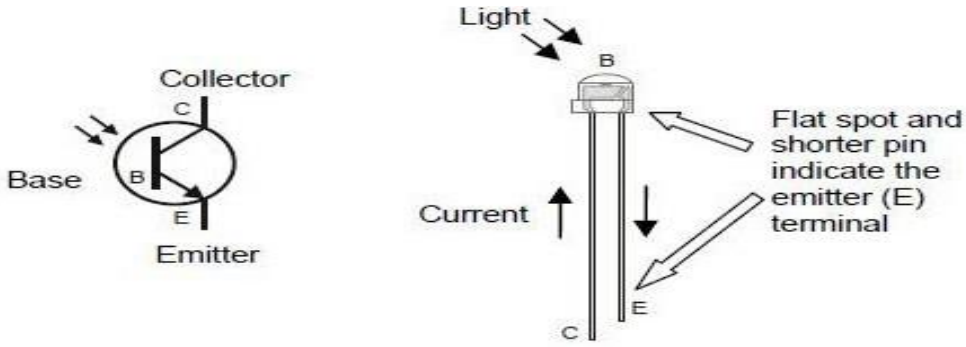


Figure 2.40: Phototransistor symbol

- Working Principle: The electrons that are generated by photons in the base-collector junction are injected into the base, and this photodiode current is amplified by the transistor's current gain β. If the emitter is left unconnected, the phototransistor becomes a photodiode.

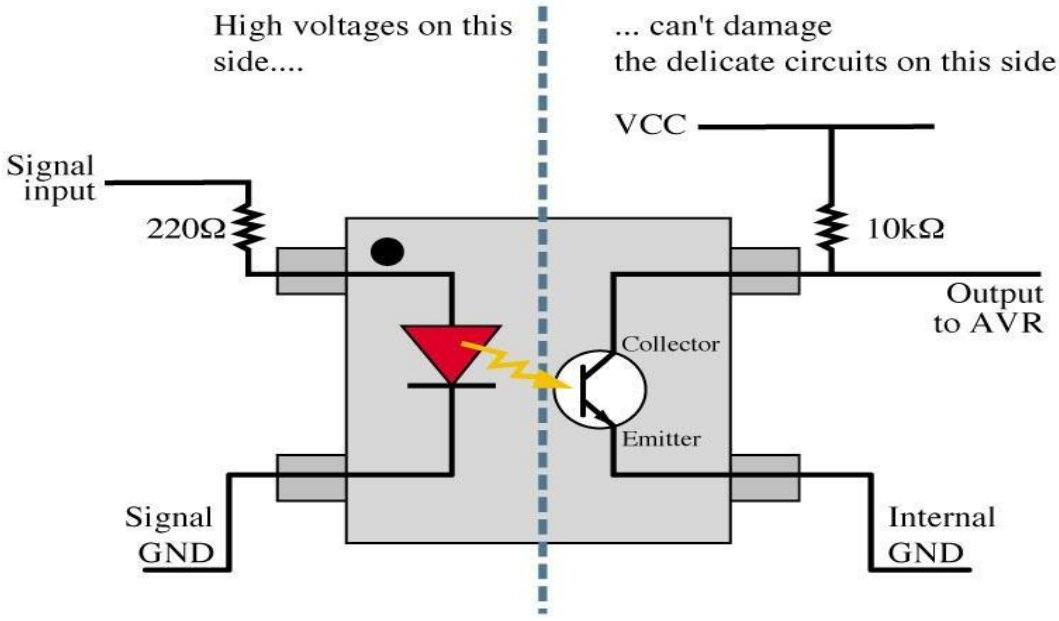


Figure 2.41: Phototransistor configuration

The phototransistor circuit configuration has effectively the same topology as the normal common emitter transistor circuit - the emitter is taken to ground via a load resistor, and the output for the circuit being taken from the emitter connection of the device.

The circuit generates an output that moves from the low state to a high state when light is detected.

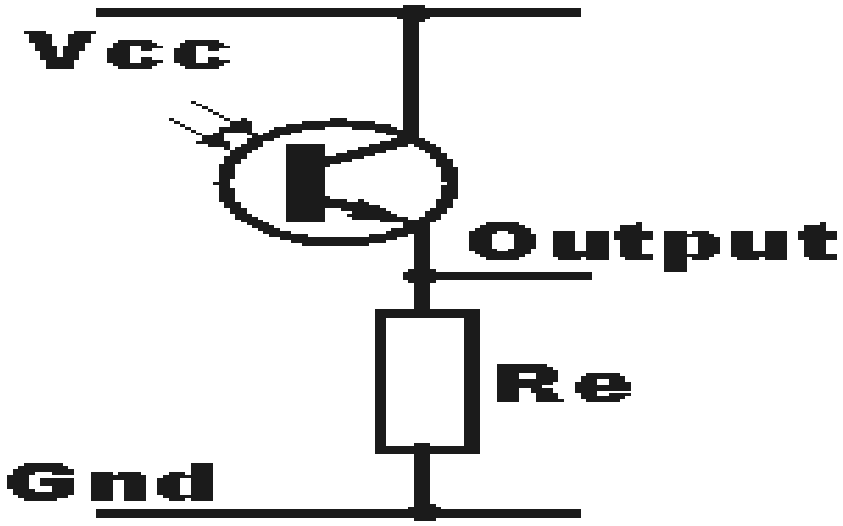


Figure 2.42: Common collector / emitter follower phototransistor circuit

Phototransistor circuit operation:

The phototransistor circuits can be used on one of two basic modes of operation. They are called active or linear mode and a switch mode.

- ✓ **Active Mode of Operation:** In this mode the phototransistor gives linear output which is proportional to the light intensity (Stimulus) that falls on its base. Here transistor is ON state.
- ✓ **Switch mode of Operation:** In this mode no light falls on the base of transistor therefore, no current flows, and it can be said to be in the "OFF" state.
- ✓ Use: This type of phototransistor mode is useful for detecting objects, sending data or reading encoders, etc. The phototransistor can be used in a variety of circuits and in a number of ways dependent upon the application. Being a low cost device the phototransistor is widely used in electronic circuits.

Opto-Coupler

An optocoupler is a device that uses light (LED) to couple a signal from its input to its output (Photodiode).The opto-coupler or opt isolator is essentially a device that uses a short optical path to couple an electrical signal from one area to another. Typically the opto coupler is housed within a single small package, often around the size of a small integrated circuit, although sizes vary according to the application and the specification.

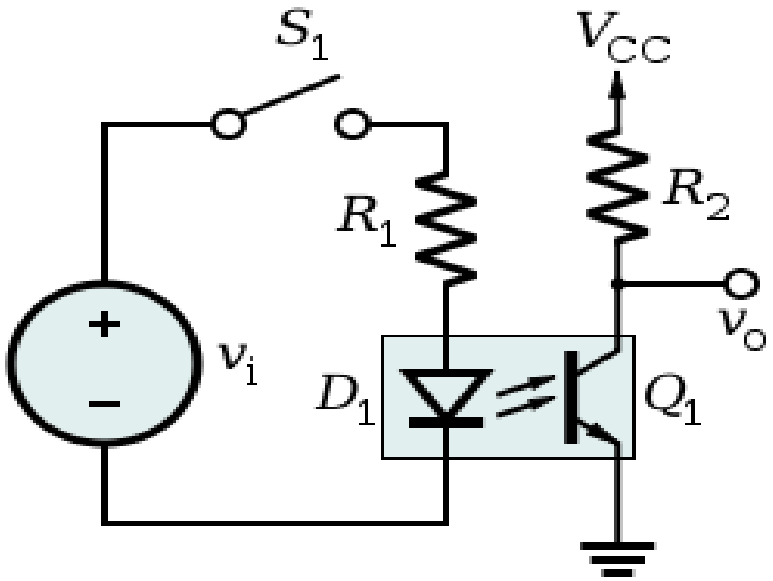


Figure 2.43: Circuit of Photo transistor opto coupler

Application: Are used for a variety of applications from providing voltage isolation between two circuits to coupling data circuits one application for opt coupler technology is for use within optical encoders, where the opto-coupler provides a means of detecting visible edge transitions on an encoder wheel to detect position, etc.

Unipolar Transistor (JFET)

Junction Field Effect Transistor: A JFET is a three terminal semiconductor device in which current conduction is by one type of carrier i.e., electrons or holes.

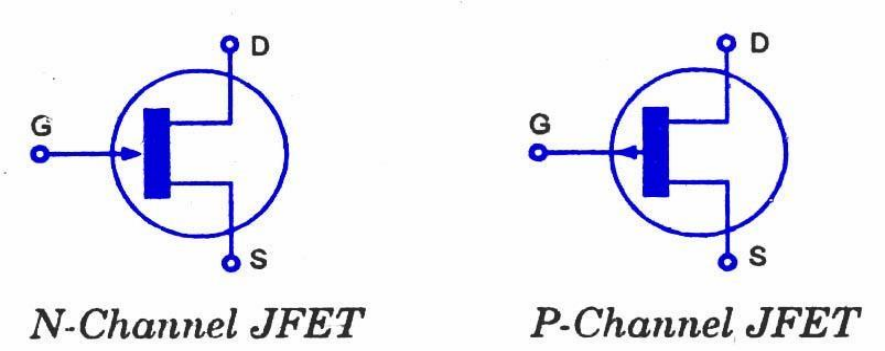


Figure 2.44: Unipolar Transistor symbol

A JFET consists of a p-type or n-type silicon bar containing two pn junctions at the sides as in figure below.

JFET has three terminals viz., Gate (G), Source(S) and Drain (D) The bar forms the conducting channel for the charge carriers.

- **N-channel JFET:** If the bar is of n-type, it is called n-channel JFET as shown below.
- P-channel JFET: If the bar is of p-type, it is called p-channel JFET as shown below.

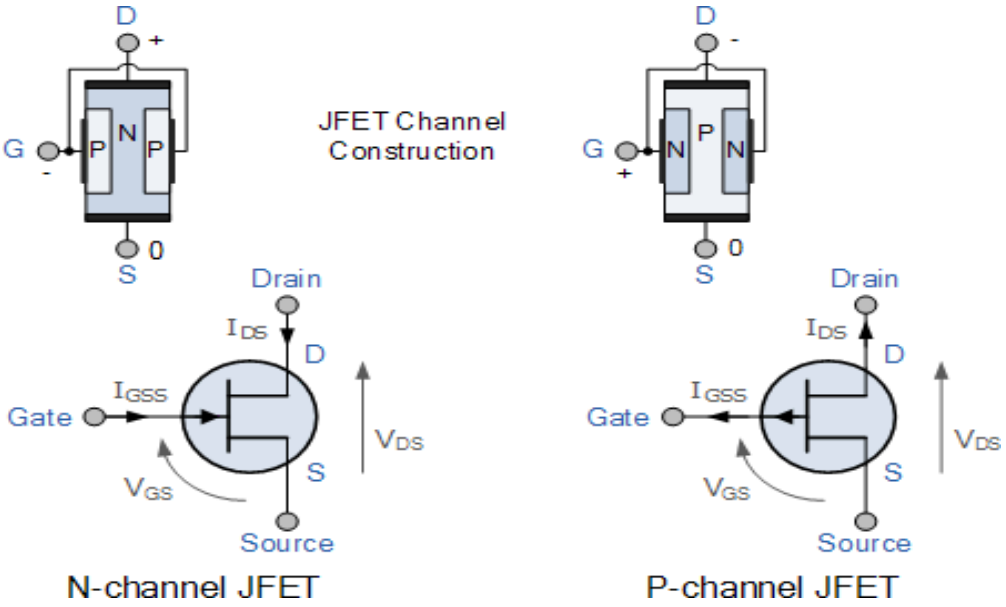


Figure 2.45: Construction features of Unipolar transistor

Working Principle

The JFET operates on the principle that channel width and hence resistance of the conducting channel can be varied by changing the reverse voltage between gates to source (VGS). The

input circuit (i.e. gate to source) of a JFET is always reversing biased. This means that the device has high input impedance. The drain is so biased with respect to source that drain current I_D flows from the source to drain. In all JFET s source current I_S equal to drain current I_D that is $I_S=I_D$

- Applications:
- ✓ Impedance Matching (High I/P & Low O/P for low noise application)
- ✓ Phase shift Oscillator (To minimize Loading Effect)
- ✓ As RF Amplifier (Reducing noise level and will respond to low signal at the antenna)

Single Stage CE Amplifier with Voltage Divider Bias

One of the primary uses of a transistor is to amplify ac signals. This could be an audio signal or perhaps some high frequency radio signal. It has to be able to do this without distorting the original input. The boundary between cutoff and saturation is called the linear region. A transistor which operates in the linear region is called a linear amplifier.

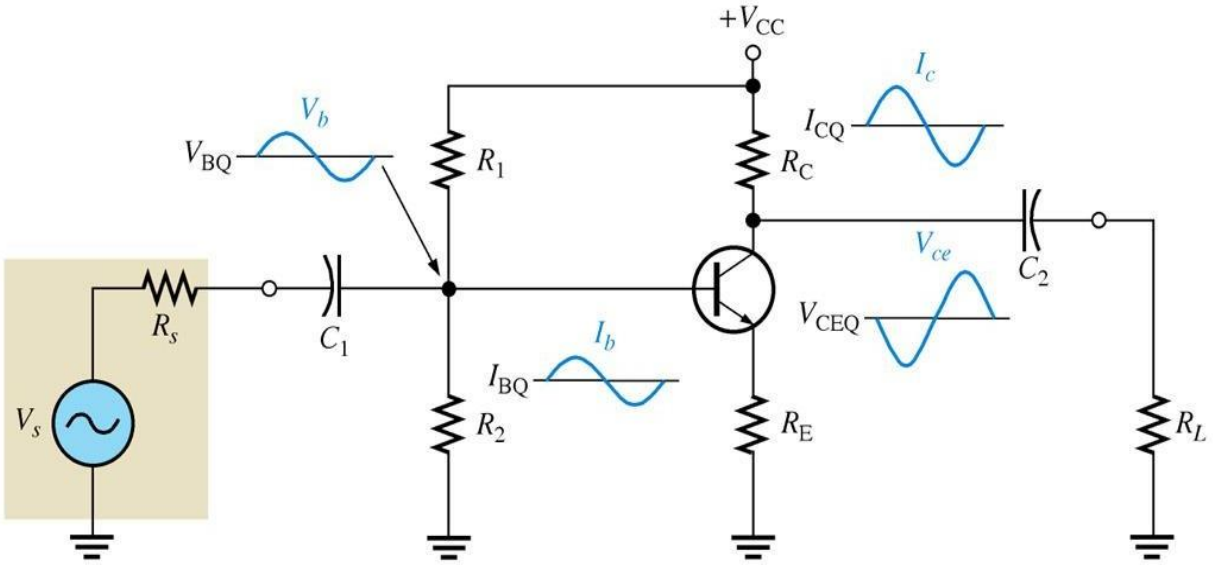


Figure 2.46: CE Amplifier with Voltage Divider Bias

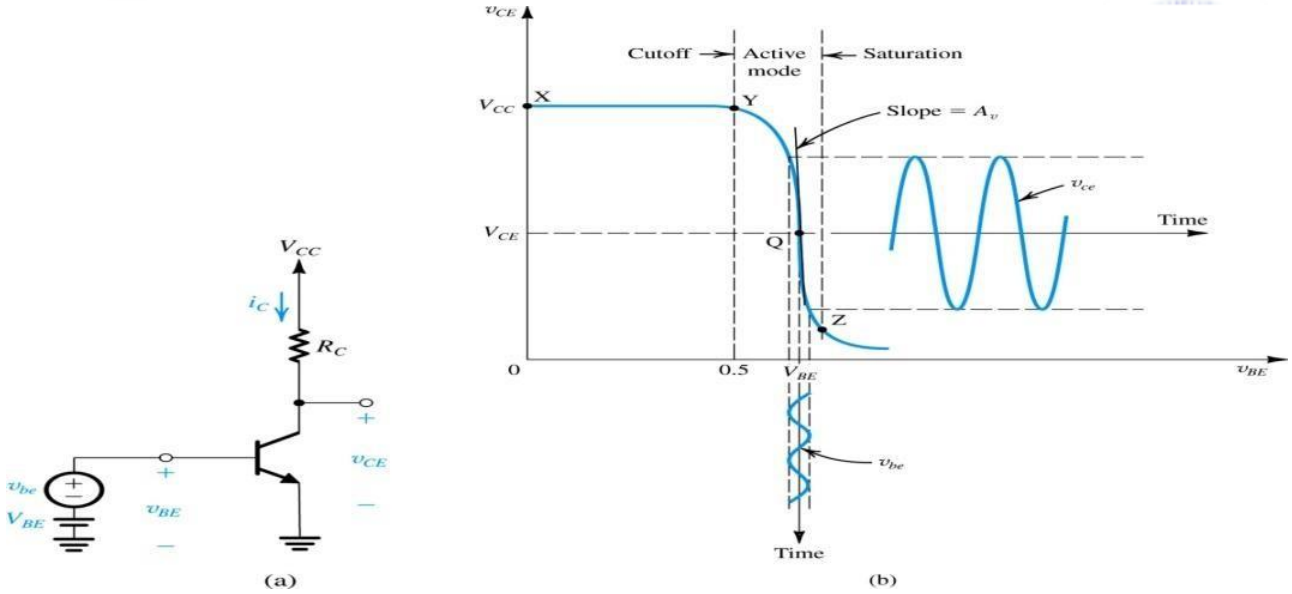


Figure 2.47: A CE Amplifier characteristics

The above circuit shows the practical circuit of transistor amplifier with common emitter configuration. Resistance R_1, R_2 and R_E forms the biasing and stabilization circuit. The biasing circuit must establish a proper operating point otherwise a part of the negative half cycle of the signal may be cut off in the output. This circuit consists of three capacitors C_{in} or C_1, C_E, C_C or C_2.

Input Capacitor (C_{in} or C_1):- Capacitor C_{in} is used to couple the signal to the base of the transistor. If it is not used the source resistance will come across R_2 and thus change the bias.

Emitter bypass Capacitor (C_E):- this capacitor is used in parallel with R_E to provide a low reactance path to the amplified a.c signal.

Coupling Capacitor (C_C or C_2):- Coupling capacitor couples one state of amplification to the next stage. To reduce the drastic change due to the shunting effect of R_C.

Load Line Analysis

A.C. load line is the line on the O/P characteristics of a transistor circuit which gives the value of i_C and v_{CE} when the signal is applied.

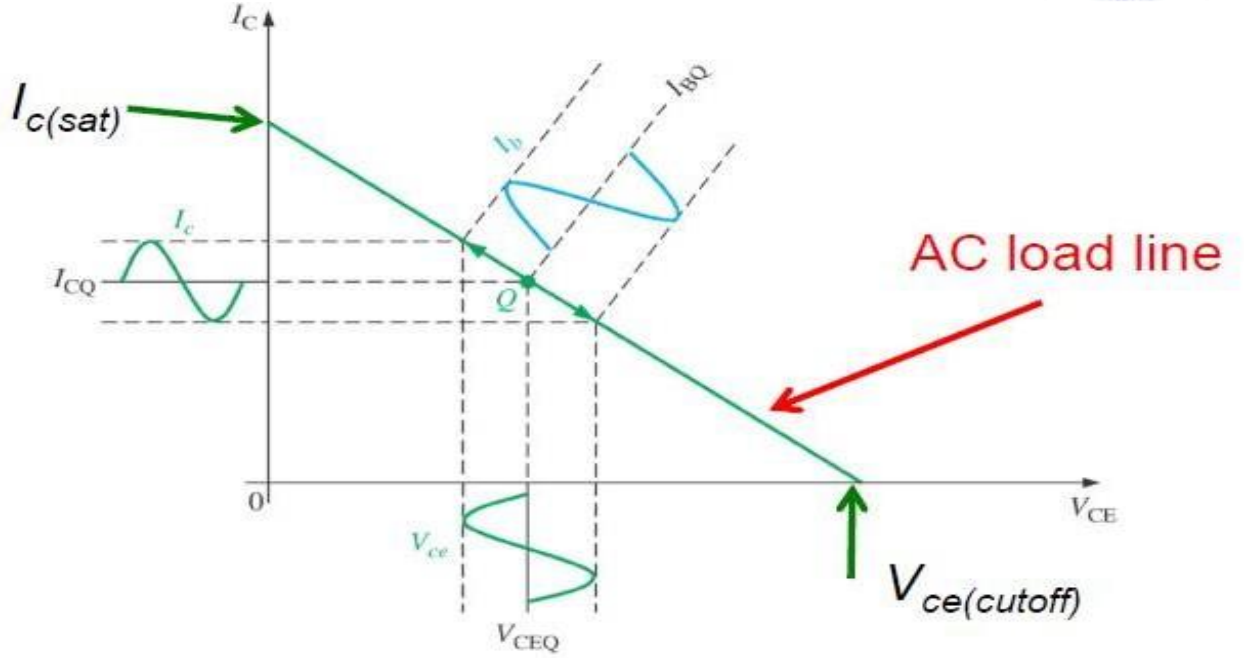


Figure 2.48: AC load Line Output characteristics of a transistor circuit

$V_{CE\,max}=V_{CE}+IC_{RAC}$

$C_{MAX}=I_C+V_{CE}/R_{AC}$

Where $R_{AC}= R_C||R_L$

Voltage Gain

The voltage gain of the amplifier is the ratio of a.c. output voltage to the a.c. input signal voltage. Therefore, to find the voltage gain, we should consider only the a.c. currents and voltages in the circuit.

A.C. load $R_{AC} = R_C||R_L$

O/P Volt. $V_{out} = i_cR_{AC}$

I/P Volt. $V_{in} = i_bR_{in}$

Volt. Gain $A_v=V_{out}/V_{in}$

Av= icRAC/ ibRin

$A_v=\beta(R_{AC}/R_{in})$

Power gain $A_P=\beta^2 (R_{AC}/R_{in})$

Bel and Decibel

The bel represented the power ratio of 10 to 1 between the strength or intensity i.e., power, of two sounds, and was named after Alexander Graham Bell. Thus a power ratio of 10:1 = 1 bel, 100:1 = 2 bels, and 1000:1 = 3 bels. It is readily seen that the concept of bels represents a logarithmic relationship since the logarithm of 100 to the base 10 is 2 (corresponding to 2 bels), the logarithm of 1000 to the base 10 is 3 (corresponding to 3 bels), etc. The exact relationship is given by the formula

Bel = log (P2/P1)

Where P2/P1 represents the power ratio

Since the bel is a rather large unit, its use may prove inconvenient. Usually a smaller unit, the Decibel or dB, is used. 10 decibels make one bel. A 10:1 power ratio, 1 bel, is 10 dB; a 100:1 ratio, 2 bels, is 20 dB. Thus the formula becomes

Decibels (dB) = 10 log (P2/P1)

Bandwidth

Bandwidth is defined as a band containing all frequencies between upper cut-off and lower cut-off frequencies. Upper and lower cutoff (or 3dB) frequencies corresponds to the frequencies where the magnitude of signal's Fourier Transform is reduced to half (3dB less than) its maximum value. Bandwidth enables computation of the power required to transmit a signal.

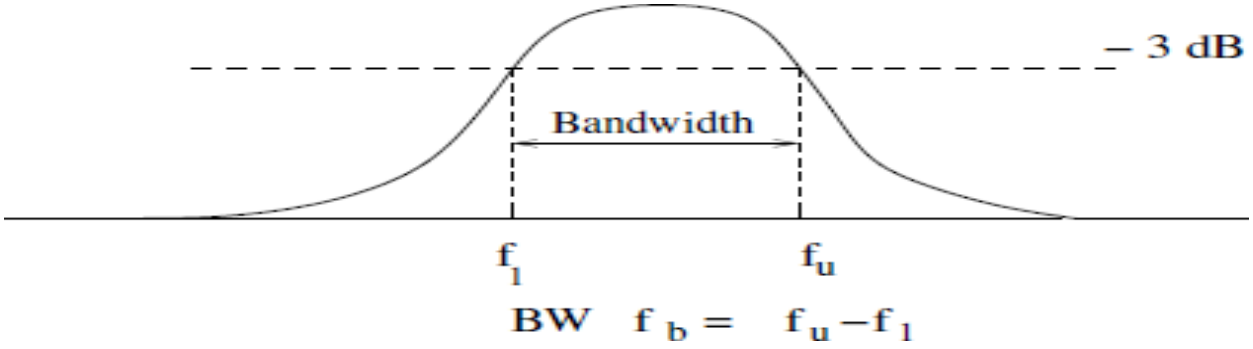


Figure 2.49: Band Width

Where f_u is the upper cut-off frequency and f_l is the lower cut-off frequency.

Multistage or Cascade Amplifiers

A transistor circuit containing more than one stage of amplification is known as multi stage amplifiers.

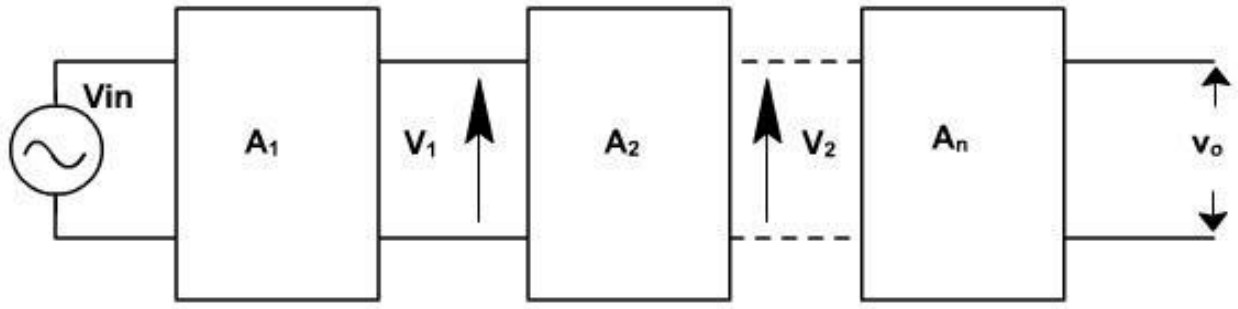


Figure 2.50: Block diagram of Cascade Amplifiers

In a multistage of amplifier, a number of signal amplifier are connected in cascade arrangement i.e. output of first stage is connected to the input of the second stage through a suitable coupling device and so on. The purpose of coupling device is

- To transfer a.c. output of one stage to the input of the next stage.
- To isolate the d.c. conditions of one stage from the next stage.

It is possible to create multistage cascade where each stage is separately biased and coupled to adjacent stages via DC blocking capacitors.

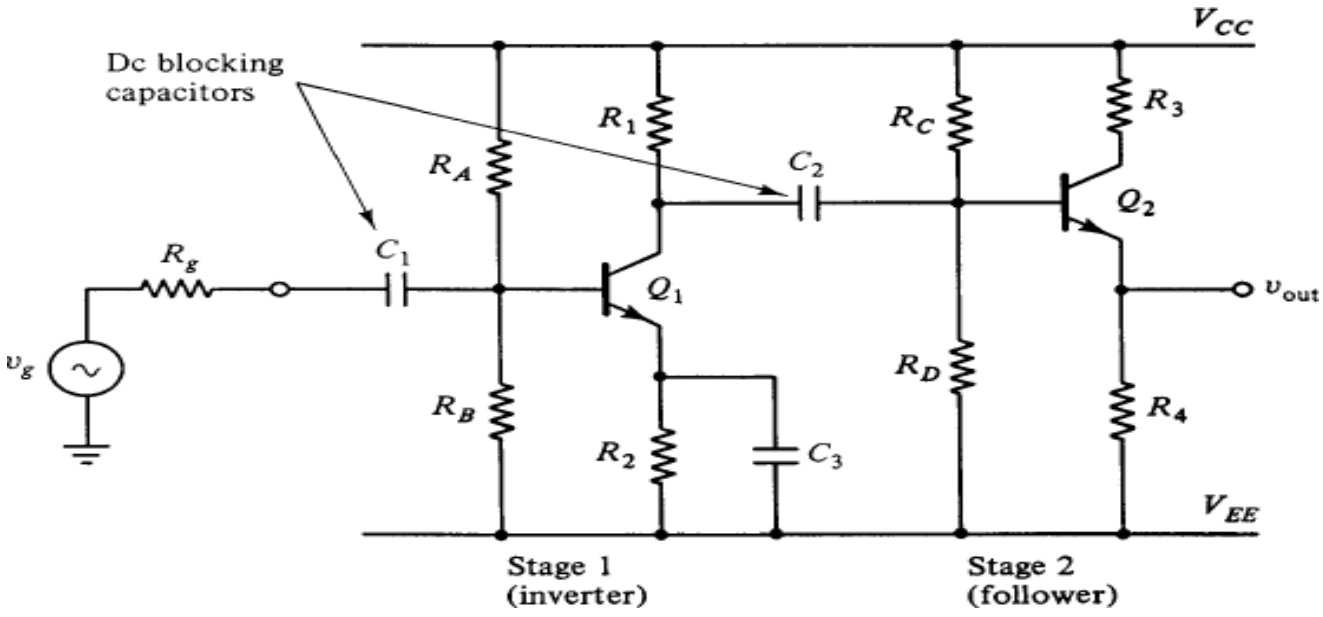


Figure 2.51: Circuit diagram of Cascade Amplifiers

Computer Aided Design of ElectronicDevices

Designing printed circuit boards

Designing printed circuit boards PCB is the key task of each development process. Well designed circuit and printed matter itself influence the quality, as well as device reliability. With design process, we determine all elements and the size of the circuit. When choosing components and printed matter size, we can meet many ecological guidelines. Usually, we use components that are smaller, less energy consuming and the design circuits that require less space. Today we know many advanced technologies that enable multi-layer printed matter. These enable smaller circuit surface and consequently lower material consumption. On the other hand, we need to know that production technology is much more expensive and uses more energy, which is less eco-friendly. When designing printed matter, we need to find a compromise between chosen elements and printed matter size that it will have a lower ecological impact in the production phase. Apart from these aspects, we need to consider certain guidelines and regulation on printed matter design with the intention of achieving high reliability and quality of printed matter and the final device.

The standards for printed matter design are monitored by IPC association. They manage printed matter production standardization and material use. The main document that covers design of printed circuit boards is document ICP-2221 - Generic Standard on Printed circuit board Design.

The standard steps in printed matter design are:

- Project specification.
- Electrical scheme design.
- Circuit design.
- Prototyping.
- Testing.
- Production.

Currently, there are many tools on the market that enable designing of printed circuits. Here are some of the most commonly used:

- **AutoTRAX** (Scheme, PCB design with built-in Spice simulator)
- **Advanced Design System** (Intended for RF electronics - mobile phones, WiFi network, satellite communication, radars, VF circuit - VF simulators)

- **Eagle** (Scheme, PCB design, available free version for smaller projects, academic environment, 3D view, etc.).
- **Altium designer** (Used to be Protel, schemes, PCB, support for FPGA – Field Programmable gate array, with the programming option, translation of program code, 3D view)
- **OrCAD tools** (Scheme, PCB)
- **CADSTAR** (Scheme, diagrams, PCB, available free version with basic functions CADSTAR Express)
- **KICAD** (open-code environment, scheme, PCB and 3D view)

Designing electronic schemes

When designing electronic schemes, it is important that the scheme is organized, relations are logical, and there is as little crossing as possible. A good scheme is also designed in a way that it is very similar to the final printed matter. For example, if we want to place a capacitor near a certain electronic component, then we also draw it near the symbol or component in the scheme. We stick to the unwritten rule that all inputs are on the left and all outputs on the right side of the scheme. If necessary, we also use comments and notes. In complex circuits, we define scheme areas for better visibility. All areas together make the complete device scheme. The areas are only virtual scheme sections that round up the parts of the circuits. For example, we draw the power supply part separately or on a certain area of the scheme. The controlling part is also designed on its own area, etc. figure 2.53 presents the classical scheme for printed circuit board design.

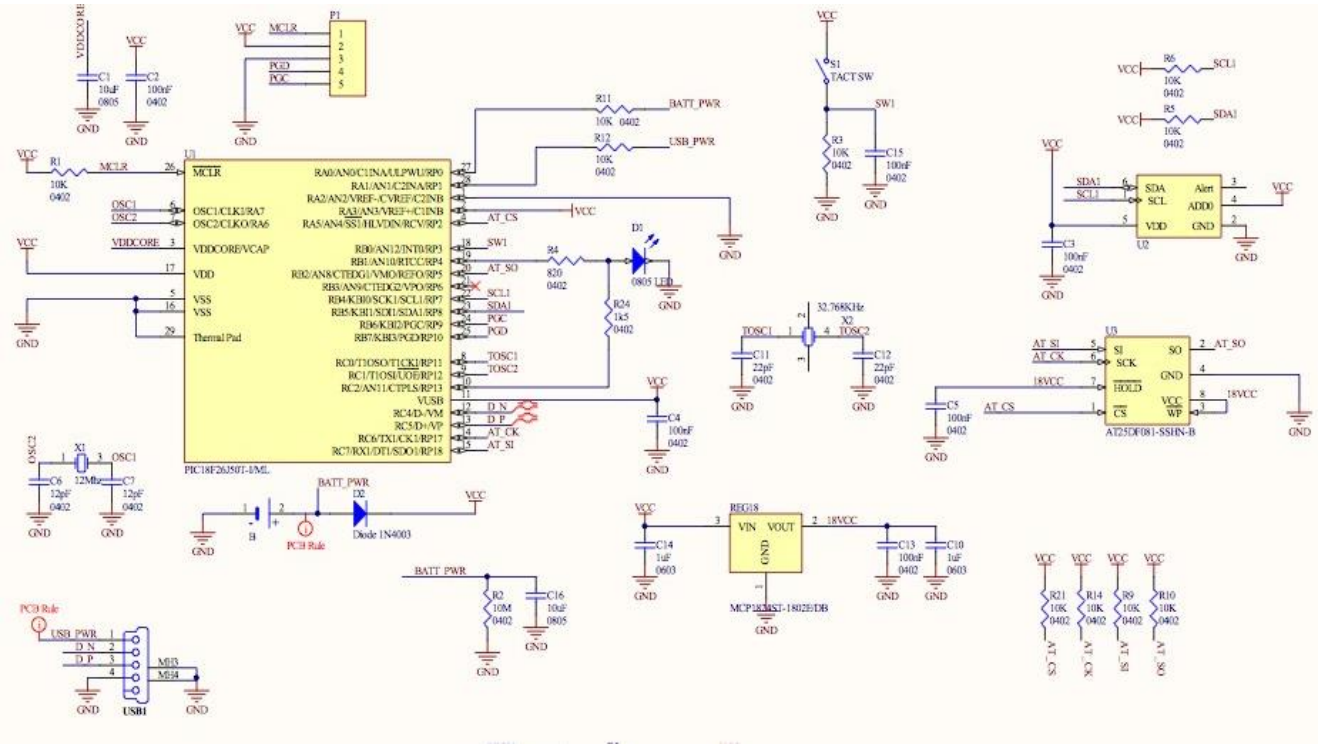


Figure 2.53: Scheme for designing a printed circuit board

Designing printed matter

Equally important is making the scheme for the next step in printed matter production. Designing printed matter consists of element arrangement and connections between them. With production of printed matter, we determine the final appearance of printed matter. In the production, it is very important that we use element libraries. In these, we can find characteristics and dimension of the element, as well as names of connected clamps. In printed matter production we need to consider the following rules:

- Printed matter choice (material, width).
- A number of printed matter layers.
- Layer arrangement.
- Circuit arrangement on printed matter.
- Consideration of parasitic impacts.
- The component layout on printed matter

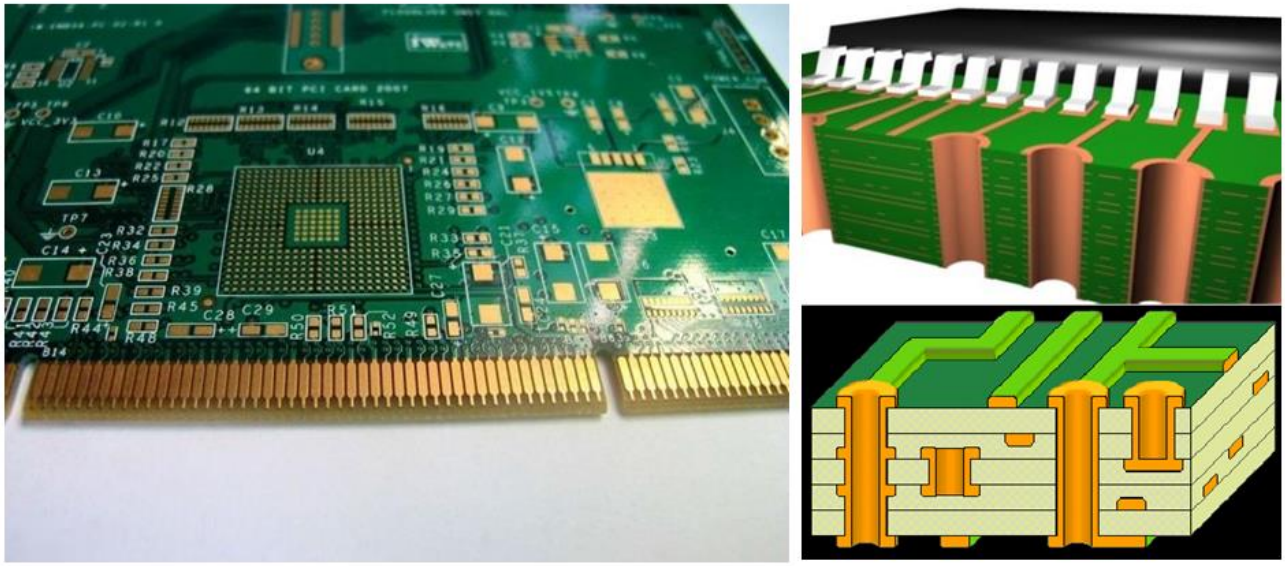


Figure 2.54: Printed Matter – PCB

In printed matter production, we often encounter different metric systems. Electronic components usually have dimensions and arrangement of connection legs presented in inch units. In Europe, metric units are used more often. Inch unit is more often used for dimensions of connections, copper connectors, and pads. Metric units are used for determining hole dimension, printed matter size and circuit housing dimensions.

Copper lines

Copper line thickness is chosen depending on electrical requirements and space on printed matter. Thicker lines give faster responses and better results. Wider and thicker lines have lower resistance and shorter length, their production is easier and cheaper, they are easier to be repaired and examined. When choosing printed matter manufacturer, we need to know what are some of the closest lines and the smallest spacing's that the manufacturer can still provide.

For example, offer 10/8 means that the lines can be at least 10 mil wide and the distance between them can be at least 8 mil. The typical offers are 10/10 or 8/8. Generally, printed matter with 12/12 can be produced by almost every manufacturer. IPC standard recommends the lowest limit up to 4/4. Smaller distances can mean the costs of producing printed matter are significantly higher. An example of good practice of using a wider line and its narrowing at places where it is necessary is presented in figure 2.55. This way, we can retain lower total impedance.

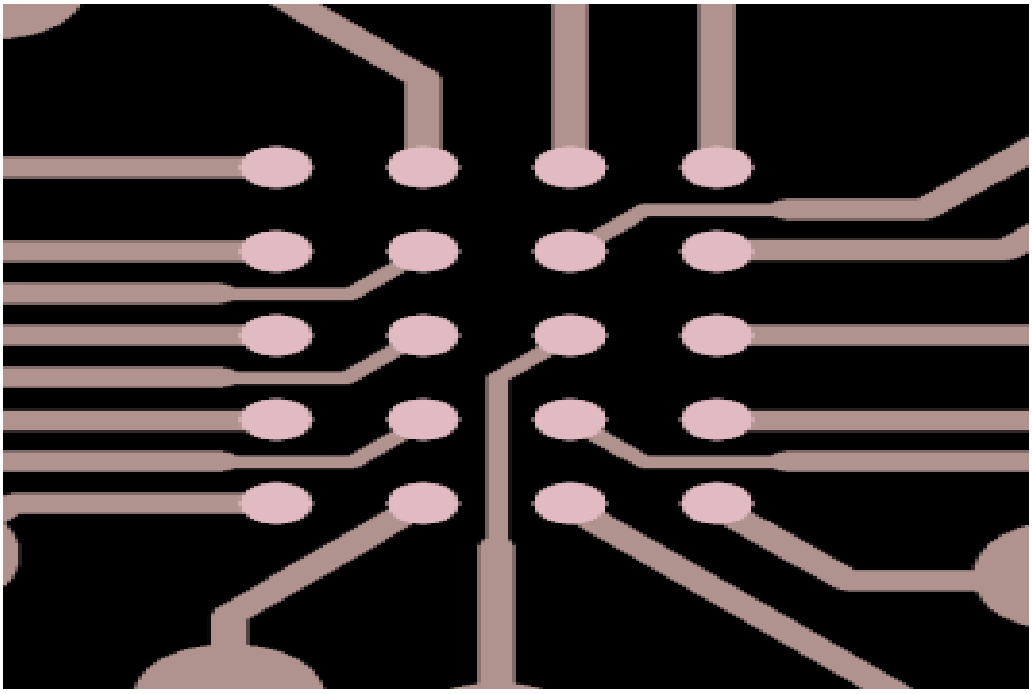


Figure 2.55: Example of Narrowing Line

Wire width and length is determined by electrical current and electrical signal frequency. For higher currents, it is recommended that we use as thick lines as possible. More narrow lines have higher resistance, which causes losses and unwanted conductor heating. Table 2.3 below presents recommended line width depending on the current at a temperature increase of 10˚C.

Table 2.3: Copper line width in printed matter by current.

Proffered Line Width (mil) 1mil=0.0254mm		
Current [A]	1oz Width (µm)	2oz Width (µm)
1	350	175
2	1050	525
3	1750	875
4	2800	1400
5	3850	1925
6	5250	2625
7	6300	3150
8	7700	3850
9	9100	4550
10	10500	5250

Copper wire resistance is calculated with the formula:

$$R = \frac{\rho_{Cu} l}{S}, \quad \rho_{Cu} = 1.724 \times 10^{-6} \Omega cm,$$

Where R are resistance, l length, S cross-section and ρCu specific copper resistivity; Line length is conditioned by anticipated signal frequency. Example of good practice gives estimation on line length depending on signal frequency:

$$L = \frac{1}{20}\lambda = \frac{1c}{20\upsilon},$$

Where L is permissible line length, λ is wavelength, υ is wave frequency, c is speed of the light. At high frequency signals the, condition cannot be fulfilled, so it is necessary to consider signal propagation time on the given line, which causes time delay. In parallel conductors, it is important that they are shorter and equal in length. Most program packages correct lengths of critical conductors. At high frequency lines, we also avoid RF connectors, which cause disturbances and signal loss.

Vertical interconnect access (VIA)

VIAs are metalized copper lines with different layers. They are very similar to connecting pads that we must not confuse them with. The connection pad is part of the component socket, and VIA only bridges connections between different printed matter layers.

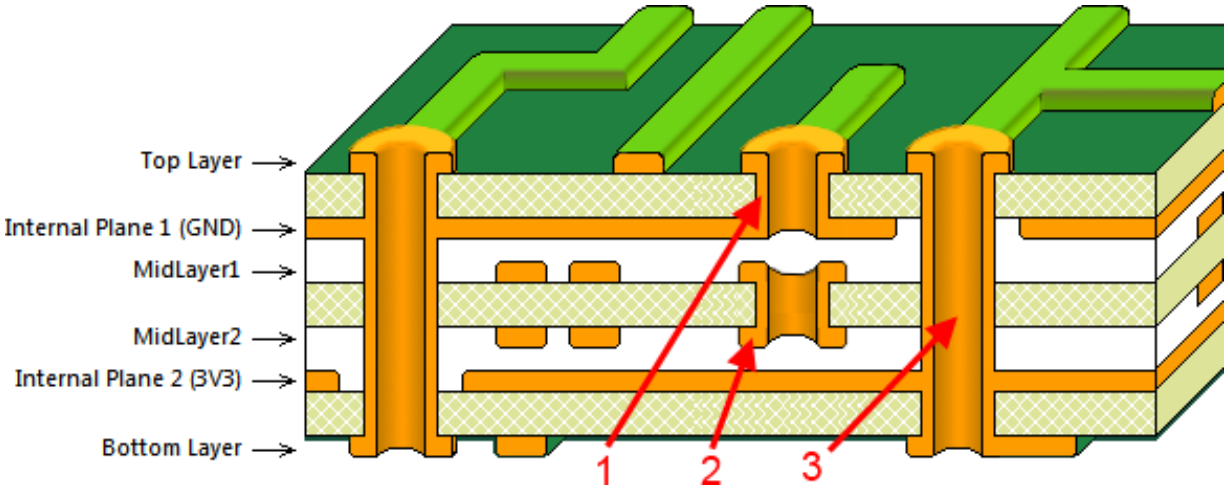
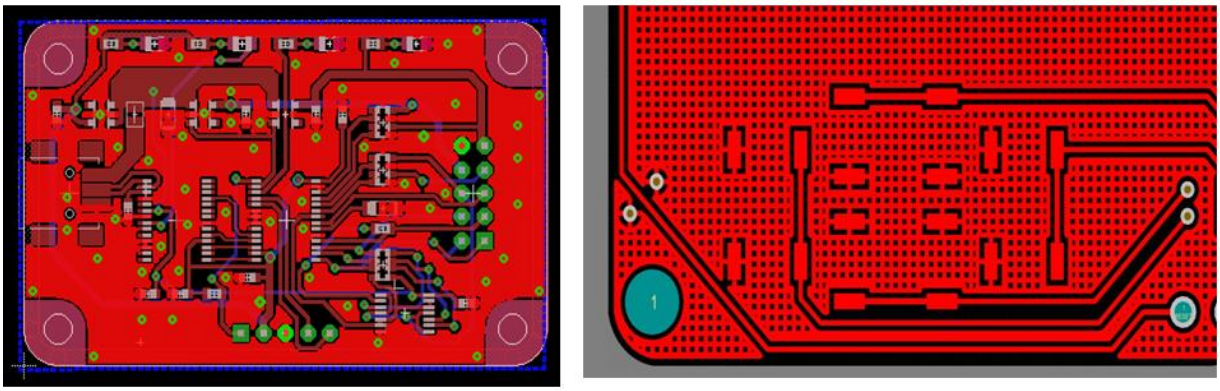


Figure 2.56: VIA in multilayer printed matter

Polygons

Polygons are used for filling larger areas with pure copper or copper texture, seen in figure 2.27. Polygons are interconnected by connection pads and VIAs. Usually, they are used for substituting grounding and power supply surfaces. We install them at the end after all other copper lines are already plotted.



A) B)

Figure 2.57: Printed Matter Polygon; A) Top Layer, B) Copper Texture.

When plotting polygon and lines, we need to consider the empty space between lines or polygon. Too small distances are not preferable because they can cause hairline short circuits that can occur in the production phase. We also need to consider the lower limit for producing printed matter. It depends on the manufacturer and production technology. The common rule is 15 mil for wire components and 8 to 10 mil as the lower limit for elements that are montage on the surface. For circuits that work at network voltage 230 V/110 V, we need to consider safety standards that are valid for a certain geographic area. The basic rule is that between phase and zero current has to be at least 3.2.mm of distance. The smallest distance between high-voltage parts and parts with which user can come in contact with is 8mm. A simple guideline is that the distances should be bigger rather than smaller when it is inside the granted dimensions!

By dimensions, we also need to consider galvanic isolation. These distances are defined by IPC standard. Distances differ by whether they are inside or outside of printed matter and the area where the electronic component will be used (humid environment, altitude, etc.). We often protect printed matter with lacquer coating that increases galvanic corrosion resistance and protects the circuit from external effects. Table 2.4 presents standard distances and layers for different components of a printed circuit by voltage. Galvanic isolation is determined by breakdown voltage. Breakdown strength is a material characteristic that is given by the following formula:

$$E_p = \frac{U_p}{d} \quad \left[\frac{V}{m}\right],$$

Where Epelectrical breakthrough strength is Up is electric voltage and d is an isolant dimension. Different isolants have different electric breakthrough strengths, presented in table 2.4.

Table 2.4: Prescribed distances for galvanic isolation of printed matter lines

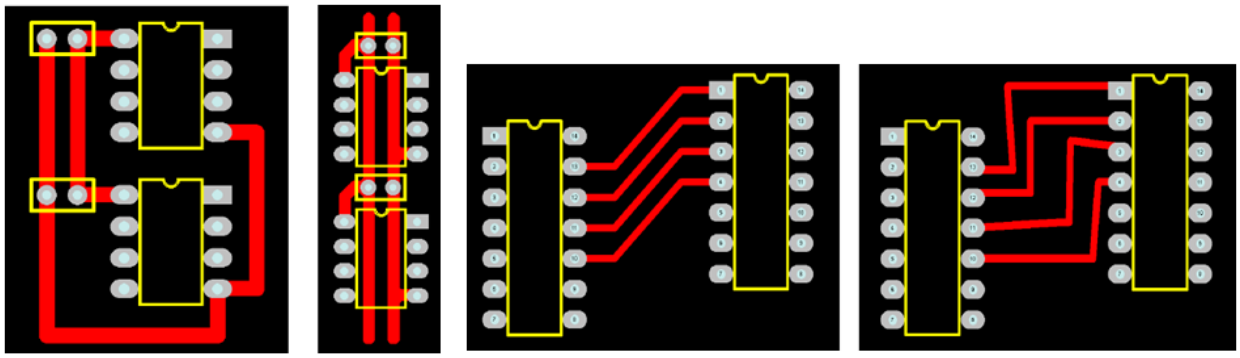
Voltage	Internal layers	External conductors uncoated	External conductors coated
[V]	[mm]	[mm]	[mm]
15	0.05	0.1	0.05
20	0.05	0.1	0.05
50	0.1	0.6	0.13
100	0.1	0.6	0.13
150	0.2	0.6	0.4
170	0.2	1.25	0.4
250	0.2	1.25	0.4
300	0.2	1.25	0.4
500	0.25	2.5	0.8
1000	1.5	5	2.33
4000	9	20	11.48
5000	11.5	25	11.53

Table 5.3: Electric breakthrough strength of some materials

Isolant (20C)	$E_p \left[\frac{V}{m}\right] x10^6$
Air	3
Paper	10
Pubber	10
Transformer oil	15
Porcelain	20
Polyvinyl Chloride-PVC	50
Polystyrol	80

Basic rules for connecting printed matter components

The connection of components means installation of copper lines on printed matter between component connectors. Electric connections between two or more connection pads are called electric signal network. We strive for shorter electric signal network because longer lines cause more serious parasitic effects. The lines should break at 45° angle, or we can use rounded lines. Copper lines are connected at the middle of connection pads, for which we use working network or function “snap to object”, which depends on program package. The connection between two points can consist of only one line. For higher currents is necessary to use larger VIAs, which decrease impedance and increase reliability. Between connection pads on distance 100mil, we decrease line width. Power supply and grounding lines should be wider for higher current loads. Power supply and grounding lines have to be set as closely together as possible, which can be efficiently blocked by capacitance elements. There should be no copper “islands” without connections. These islands have to be grounded or deleted. Image 8 presents different ways of connecting elements.



A) B) C)

Figure 2.58: printed matter connections: a) appropriate, b) appropriate, c) not appropriate.

Choosing printed matter

When choosing materials for the printed matter, we have different possibilities that differ in several characteristics, such as: fire safety, temperature stability, moisture absorption. These characteristics are defined by international association NEMA - National Electrical Manufacturers Association. Table 2.4 presents an overview of materials for production of printed matter.

Table 2.4: Types of materials for printed circuits

Material	Comment
FR-1	Bakelite: at room temperature poor moisture resistance.
FR-2	Bakelite: suitable for single-layered PCBs, good moisture resistance.
FR-3	Epoxy resins: a balanced material with good mechanical and Electrical properties.
FR-4	Glass fibers: excellent mechanical and electrical properties.
FR-5	Glass fibers: high strength at high temperatures, self-extinguishing.
G10	Woven glass and epoxy: high insulation resistance, maximum Mechanical strength, high moisture resistance.
G11	Woven glass and epoxy: resistant to bending at high temperatures, extreme solvent resistance.

CEM-1	Cotton paper and epoxy.
CEM-2	Cotton paper and epoxy.
CEM-3	Non-woven and epoxy.
CEM-4	Woven glass and epoxy.
CEM-5	Woven glass and polyester.
PTFE	Pure - expensive, low dielectric loss, for high-frequency applications**;** very low moisture absorption (0.01%), mechanically soft. Difficult to laminate, rarely used in multilayer applications.
RF-35	Fiberglass-reinforced ceramics-filled PTFE. Relatively less expensive, good mechanical properties, good high-frequency properties.
Alumina	Ceramic: Hard, brittle, very expensive, very high performance, good thermal conductivity.
Polyimide	A high-temperature polymer: Expensive, high-performance, higher water absorption (0.4%). Can be used for cryogenic temperatures to over 260 °C.

Label FR stands for flame retardant material. The thickness of the copper coating on printed matter is by standards 0.5oz (18 µm), 1oz (35 µm) or 2oz (70 µm). There are also other standards that are less often used (12 µm) and (105 µm). The printed matters with aluminum or metal core have a copper coating of even 70µm to 400µm. The most often used material in industrial environments is FR-4. This material is the optimal choice regarding price and causality. When designing printed matter, we also choose a number of layers. The high number of layers generally increases production costs but also enables production of smaller and more resistant printed matters.

One-sided printed board: It is suitable for simple low-frequency circuits, as seen in image 9. The circuit can be produced with many bridges. Such circuits have worse resistance to electromagnetic disturbances. Designing of complex circuits on one layer PCB requires much more effort and innovativeness. Usually, they are used for pilot devices and early component testing.

Two-sided printed board: Often are made of material FR-4, as seen in image 10. The circuit is easier to be connected with. If possible, the bottom surface is intended for

grounding, and other connections are left on the top surface. Advantages of grounding surface are increased mechanical stability of printed matter and lowered impedance of all grounding connections (reduces noise). It adds distributed capacitance to each connection on the top layer, which helps prevent electromagnetic disturbances. It acts as a shield from electromagnetic noise, the source of which can be printed matter environment.

Multi-sided printed matter: There can be 4, 6, 8, 10 or up to 38 layers used. These are more suitable for sensitive high-frequency devices. The usual thickness of 2-sided printed matter is 1.5mm, which is too much. At a smaller distance between the upper and bottom layer, we achieve better distributed capacitance. It is also easier to connect the power supply and grounding connections (power supply and grounding layers). Connecting is easily done through VIAs. Other signal lines have a lot of space on all other layers, which significantly simplifies connecting. Higher capacitance distribution between the power supply and grounding layers which decreases high-frequency noise. It also better blocks EMI/RFI disturbances. Production of multi-layer printed matters is significantly more expensive in comparison to those circuits with fewer layers.

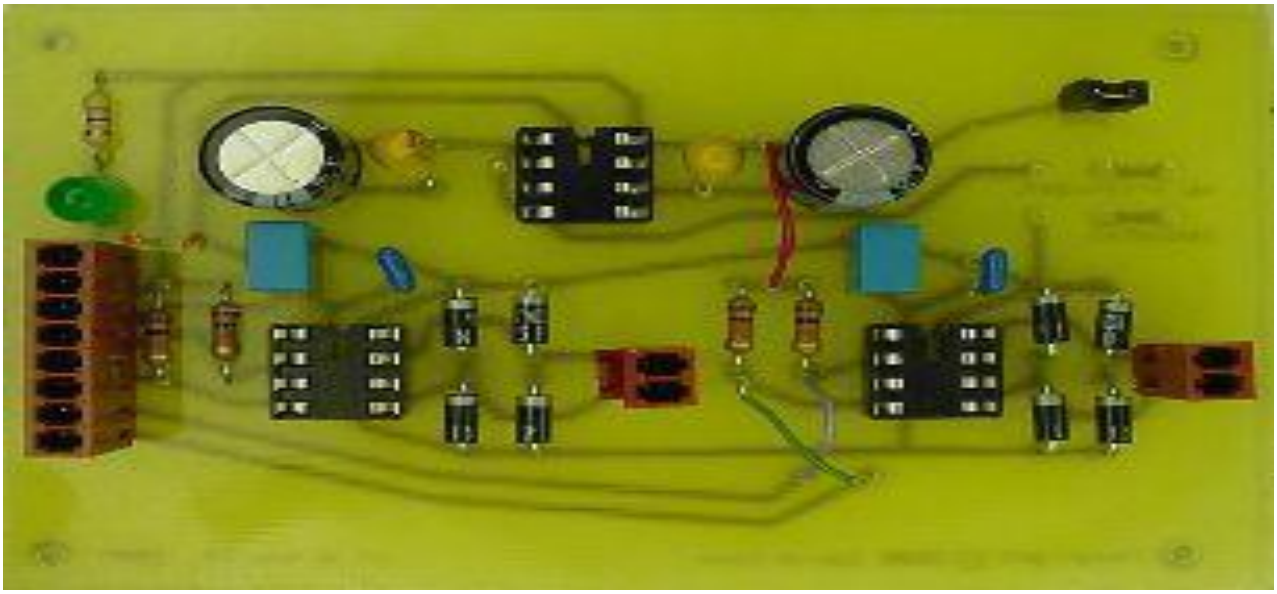


Figure 2.59: One-sided printed matter

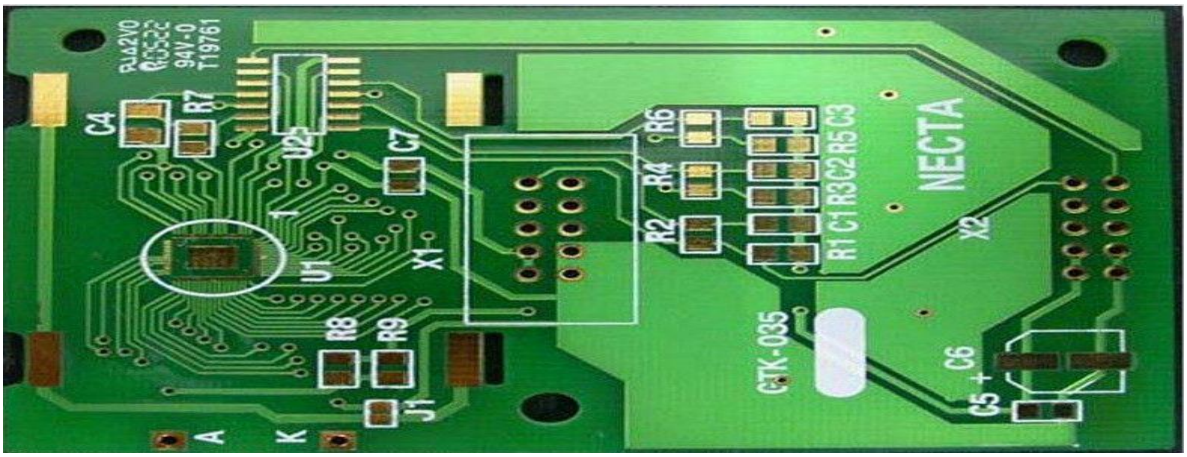


Figure 2.60: Two-sided printed matter

Altium Designer

Program Altium-Designer is a professional environment for designing printed circuits in all phases, which are:

- Designing of flowcharts and block diagrams.
- Designing of printed circuit boards-PCB.
- Designing software for FPGA (Field Programmable Gate Array).
- System solutions for FPGA and debugging (when working with suitable development boards, such as Altium NanoBoard).
- Designing built-in systems.
- Simulation tools for digital and analog circuits.
- Signal quality analyses.
- Management of PCB production processes.

Altium includes editors and program interfaces for all steps of electronic device design. Writing and editing of program code together with translating is done inside Altium Designer environment. In our case, we will pay more attention to drawing and designing of the printed circuit board for an electronic device. Content is designed in a way that offers an overview of different PCB design phases. The first design phase includes an outline of the electrical scheme. The second phase includes translation of the scheme into printed circuit. In this phase, we determine printed matter dimensions, element arrangement, and connections. In the third phase, we will show how to present the printed matter in a 3D environment and the possibilities for using it in other CAD

programs. For this case, we will take a look at current generator circuit, seen in figure 2.61.

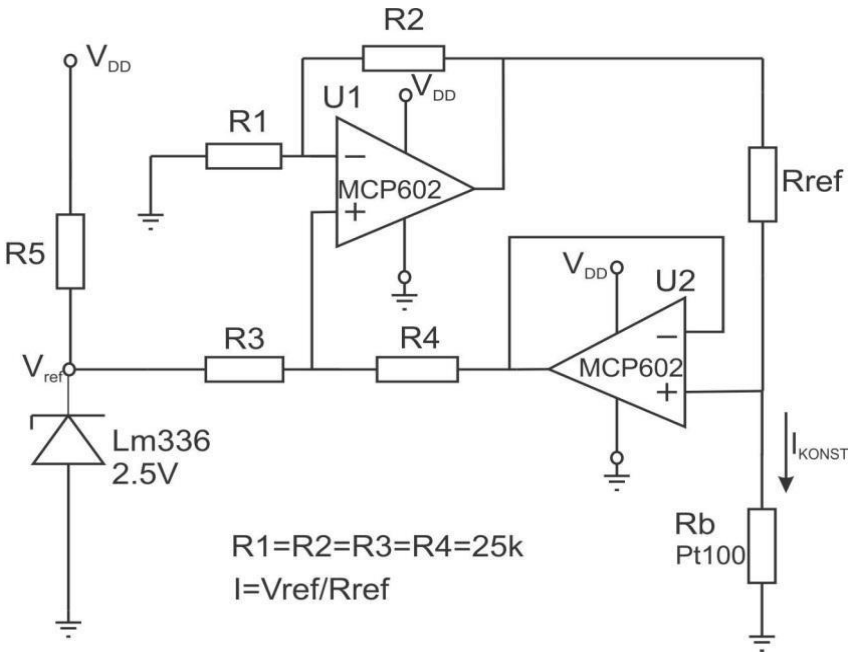
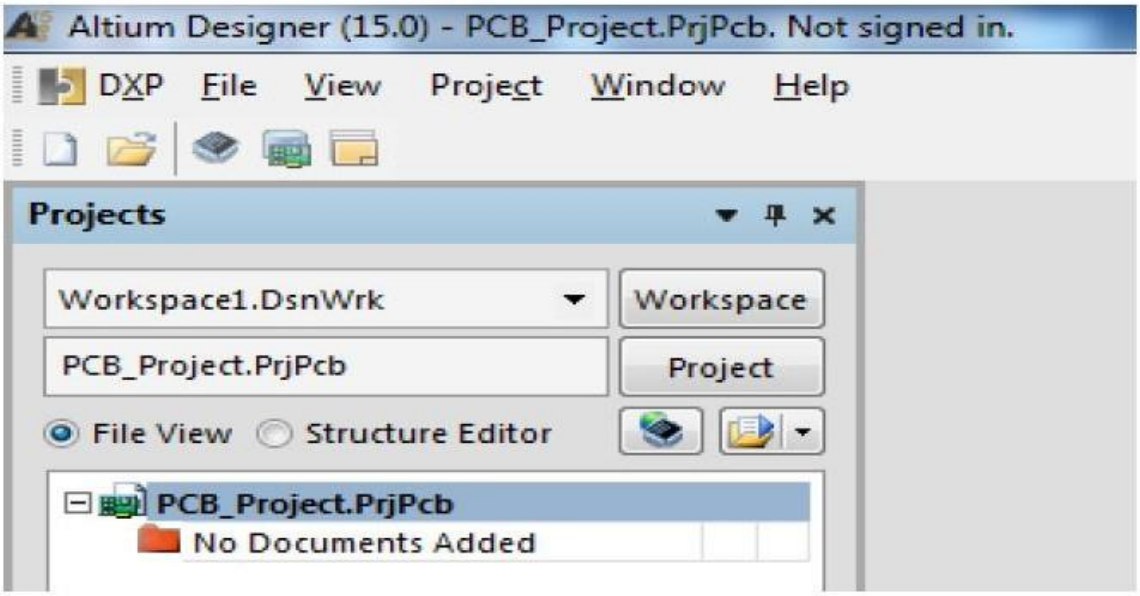


Figure 2.61: Current generator scheme

Creating a new project

For each new printed matter, it is recommended to create a new project because in a project we have saved all document and settings that are related to the design process. Project file xxx.PrjPCB is ASCII file in which are written all output documents and settings, such as printing settings and CAM. Documents that are not related to the project are called free documents. We also add links to electrical schemes, PCB, FPGA, built-in VHDL (Verilog hardware description language) and libraries. When the project is completed, all designs are synchronized inside the documents in the project. The project is created with the following set of commands:

- Choose **File ❼ New ❼ Project ❼ PCB Project,** figure 2.62.



- We can see window Projects, where project **PCB_Projects.PrjPcb** is listed without attached documents.

Rename the project, in our case to **Current_ generator.PrjPcb**, so it can be saved on disc location of our choice with the next command. **File ⟶ save Project As ⟶ Current_generator.PrjPcb.**

Then create a new file for designing electrical scheme 'schematic'. Create new scheme. Choose **File ⟶ New ⟶ Schematic**. We can see file **Sheet1.SchDoc** that is added to the previously created project automatically, seen in image 14.

Rename scheme to **Current_generator.SchDoc**. Save the scheme, **File ⟶** Save As ⟶ Current_generator.SchDoc**.**

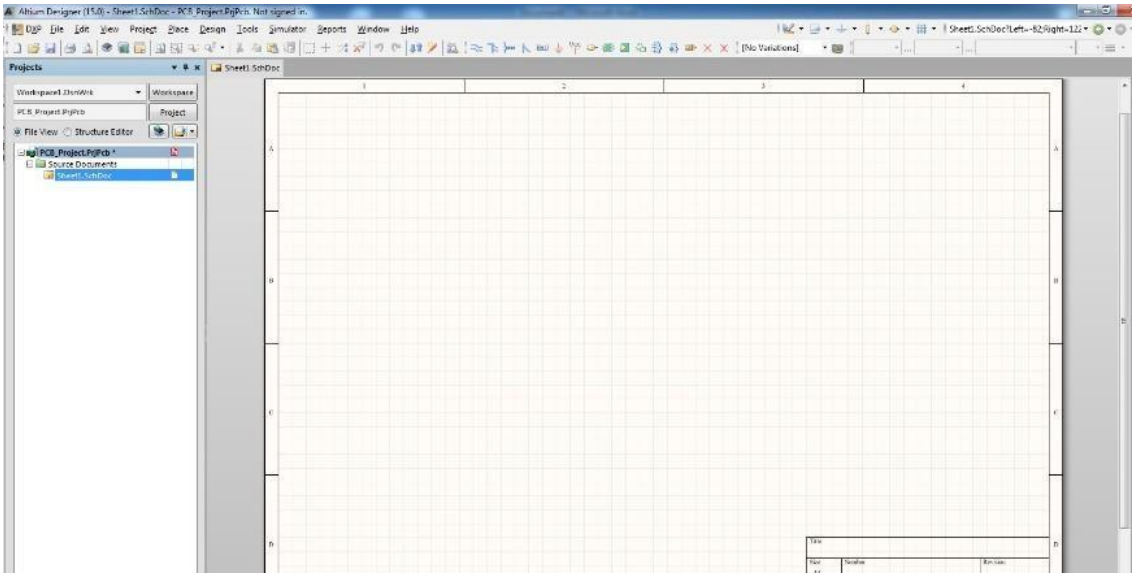


Figure 2.62: Create Circuit Scheme

When an empty scheme is opened, we can see a completely changed view with different keys, menus, etc. Now we are in the editor for electrical schemes. If we want to add already outlined scheme of another project to the created scheme, then choose **Add Existing to Project**.

Before we start designing electrical scheme, we need to set the following:

- Setting format for worksheet: **Design** ⟶ **Document**, Option – choose format A4.
- The worksheet can be enlarged with a combination of CTRL key + scroll wheel; view can also be fit to full screen with command **View** ⟶ **Fit Document** [shortcut: V, D].
- There are many settings that can be accessed from the menu **Tools** ⟶ Schematic **Preferences** [shortcut: T, P], where the settings will influence all schemes in the working project.
- Click on the scheme and select **Default Primitives** and enable option **Permanent**, which offers basic preset values when we select an electrical element from the library and not the settings that we set in the previous step.

Scheme design begins with choosing an element, seen in figure 2.61. In the library of elements, we search for all elements, starting with operational amplifier MCP602. Altium has very strong support for libraries of electrical components, such as schemes, sockets and 3D models.

To search for correct amplifier MCP602, click **Libraries** and then **Search** (or click

Tools ⟶ Find Components) and then opens dialogue window **Libraries Search**.

We need to be careful that we have all components selected and that we search in mode **Libraries on path** where we have to have written the correct path for installed libraries. For the higher possibility of results when searching do not enter all signs, but only the main ones because different manufacturers have different prefixes and suffixes. To do this, enter the search string between two asterisks (in our case: *602*). If we choose a component from the list that is not yet installed, then we get the option to confirm that we can install it immediately which can later be executed. For MCP602 we need to previously install library by manufacturer Microchip (Microchip Linear Devices.IntLib), and then MCP602 is available, so we can select it as seen in figure 2.63.

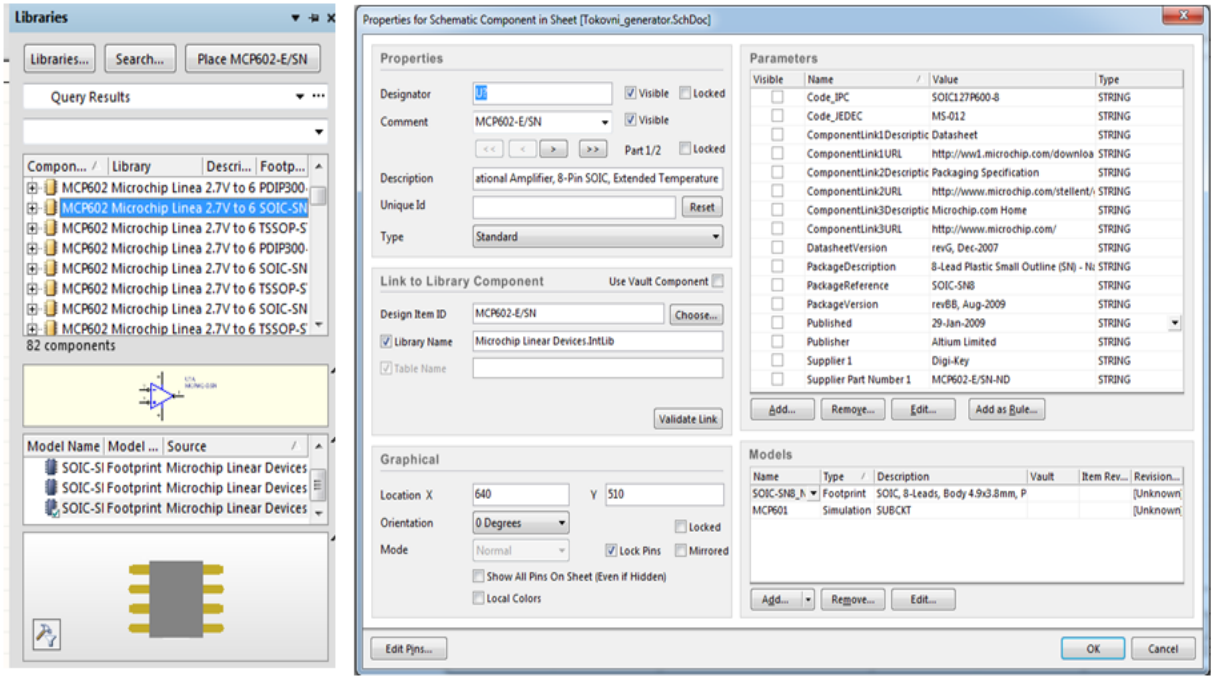


Figure 2.63: Choosing mcp602 from the library

To insert, double-click the component which enables moving of the element into the working area with the cursor. Before we move it to a certain place, we can edit labels and properties which can be enabled by pressing the tab key. Then in the field Designator enter a component label that we will see in the scheme (in our case: U1A). At the model check, if the component has a correct socket (in our case: SMD SOIC – 8 connectors).

When we have set everything needed, we can start with inserting components into the scheme. The component can be set to the wanted position by clicking or pressing ENTER. Then move the cursor and see that with the next click we can insert another OPA from which the label U1A is automatically increased to U1B, and other preset properties remain unchanged. Altium environment enables multiple insertions of components of the same type which is revoked by key ESC.

In the next step, we will insert 7 resistors. For inserting, we will use a basic library that is installed in Altium environment under name **Miscellaneous Devices.IntLib**. Type ***Res*** in the search engine and then select resistor with socket SMD type 2010 that is labeled as **Res3**. Select value 25k that is the most common value and can be later changed at certain resistors. Reset Designator to the lowest value R1 and start with entering values, as seen in the previous example. Then rename two resistors to Rref and Rb by clicking on each one separately and change the name in field Designator, as seen in figure 2.64.

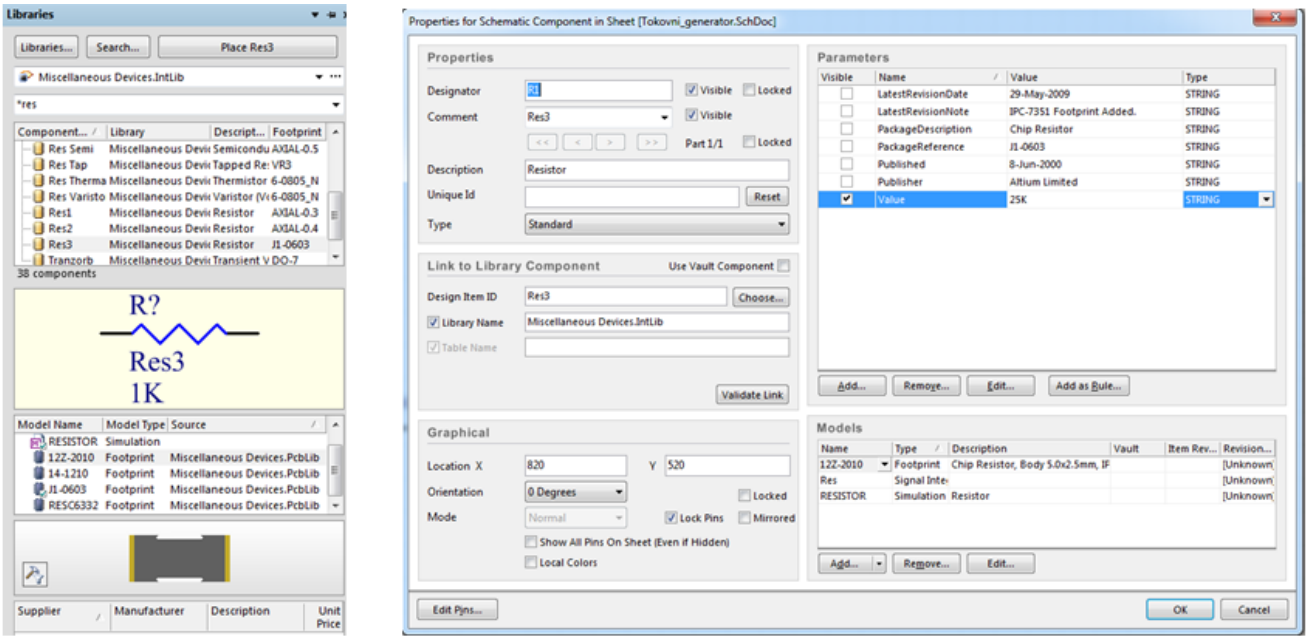


Figure 2.64: Choosing Resistor from the Library

Do the same with elements voltage stabilizer LM336 (2.5V, housing TO92) from library ST-Electronics '**Power Mgt Voltage Reference.IntLib**', capacitors (search string ***Cap***) and connector terminals (search string ***Header***) that can be found in library **Miscellaneous Devices.IntLib**, seen in figure 2.65.

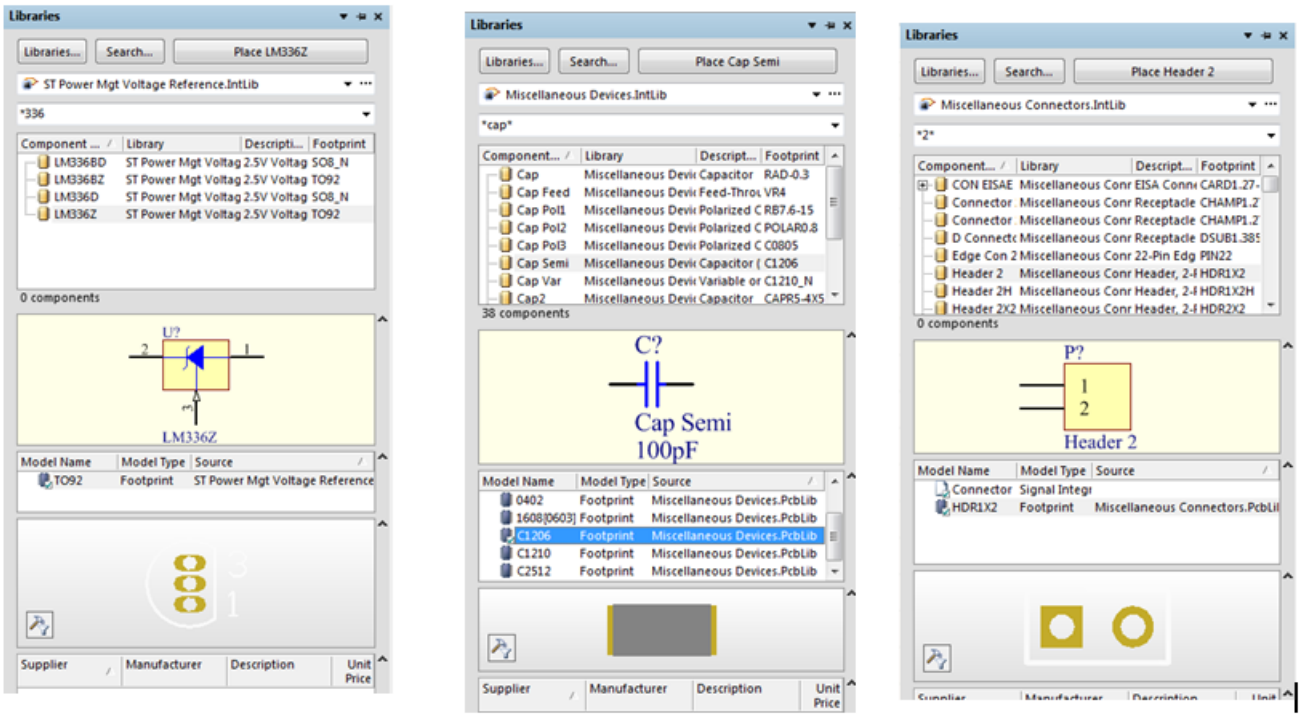


Figure 2.65: Choosing lm336, capacitor and connection terminals

Next, arrange the components correctly in the scheme while considering the rule inputs on the left and outputs on the right site. We need to be careful that there is enough space between the components for connections because if we connect electrical connection over connection pins, then the program will automatically connect it with the crossed connector, figure 2.66.

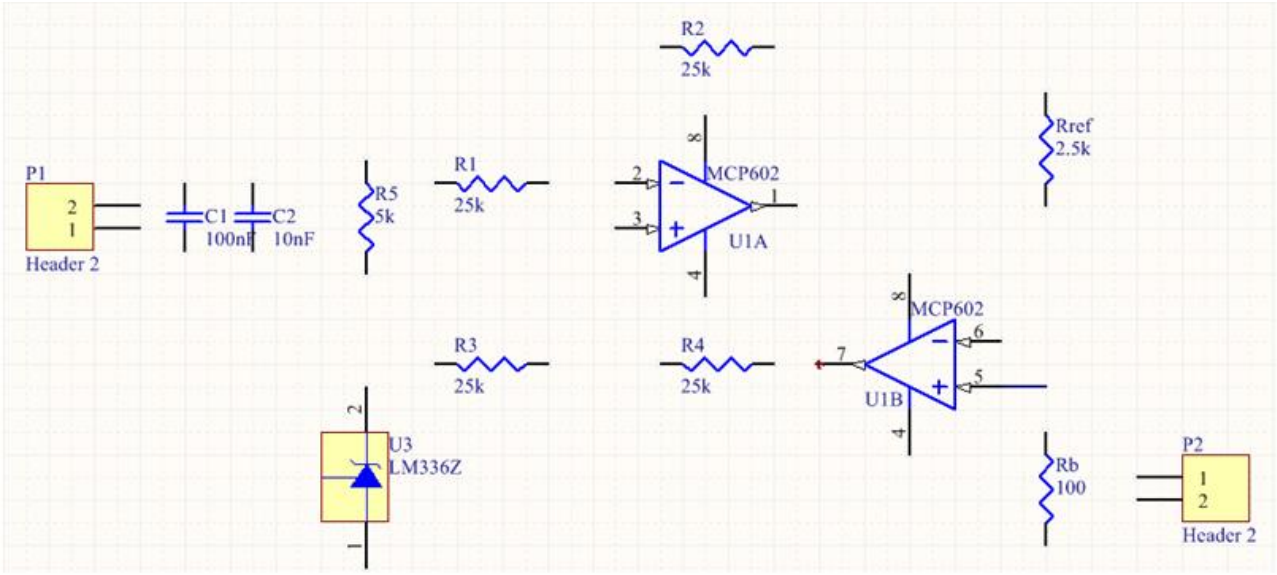


Figure 2.66: Element Arrangement

To the existing components, we also need to add voltage potentials, such as zero-grounding and power supply.

For test purposes, we will insert GND and power supply Vdd (insert them at several places to retain better scheme visibility). When connecting components, we need to consider the following rules:

- We need to have a good overview of the complete scheme
- Draw connections with the tool **Place Wire** [shortcut: P, W]. Pay attention to interconnections to prevent short circuits.
- If we want to move components after we have connected them, we need to delete current connections, move the components and then reconnect them again. We can also use combination CTRL + moves with the mouse, which enables moving of components together with previously made connections.

The finished wiring diagram can be seen in figure 2.67

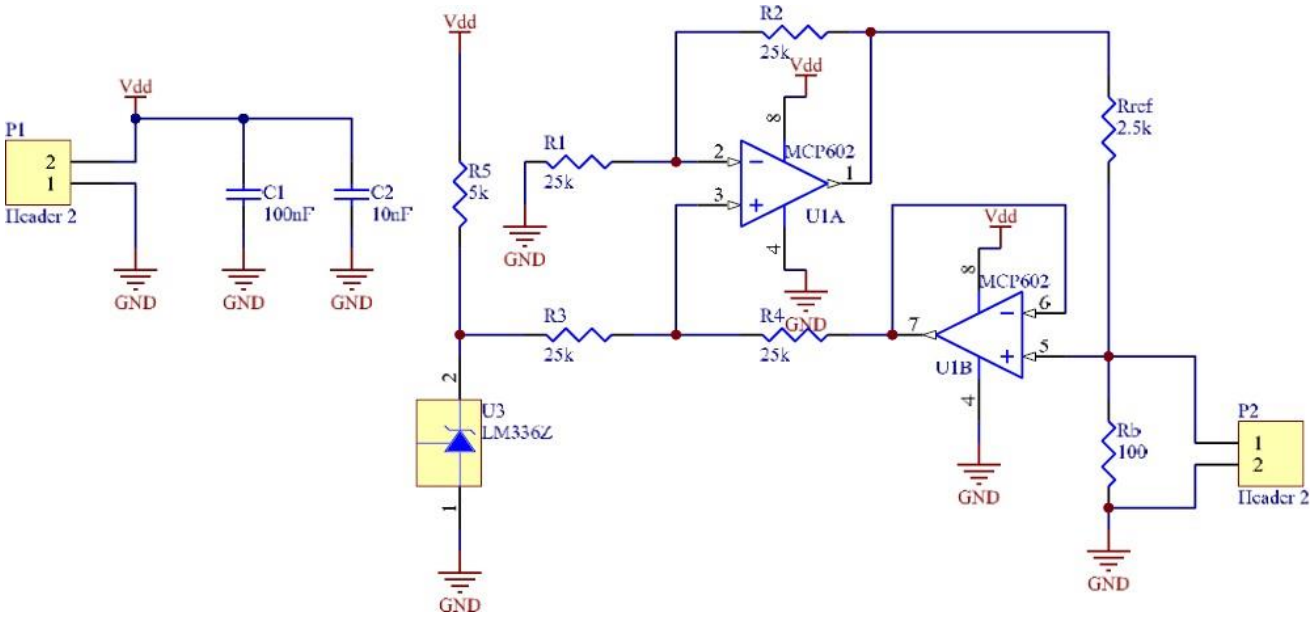


Figure 2.67: Current Generator Scheme

We also need to add to the scheme names of individual connections (nets and net labels) that can be later used in printed matter. Connection names are not essential for circuit functioning but serve as notes or references when reviewing finalized circuit or for later repairs. Component connectors are connected with nets. Some connections with higher importance and potentials in the electrical scheme can be named with the name of our choice. By using symbols for GND and Vdd we have automatically set two names.

When choosing Menu ⟶ Place ⟶ Net label [shortcut: P, N] we get the option to set name to any connection. By pressing TAB, we can change settings, such as color, arrangement and font type for net label before we define to which connection we will set the new name, as seen in figure 2.68.

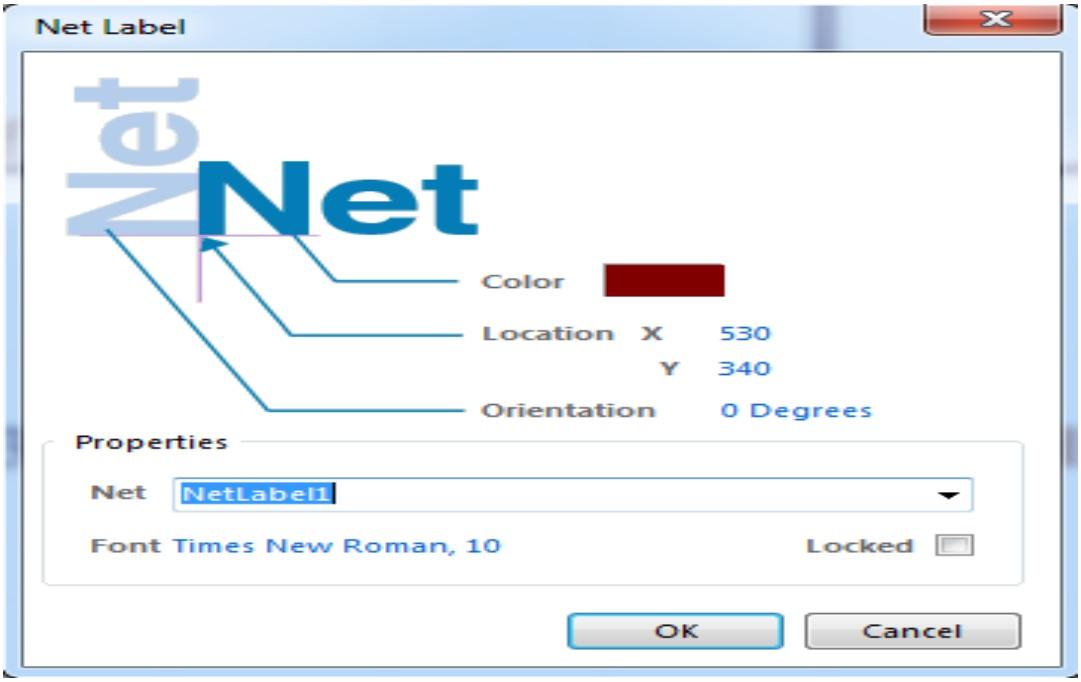


Figure 2.68: Window for setting connection name, font type, color, size

In our circuit, we will use connection name for reference voltage Vref shown in figure 2.69.

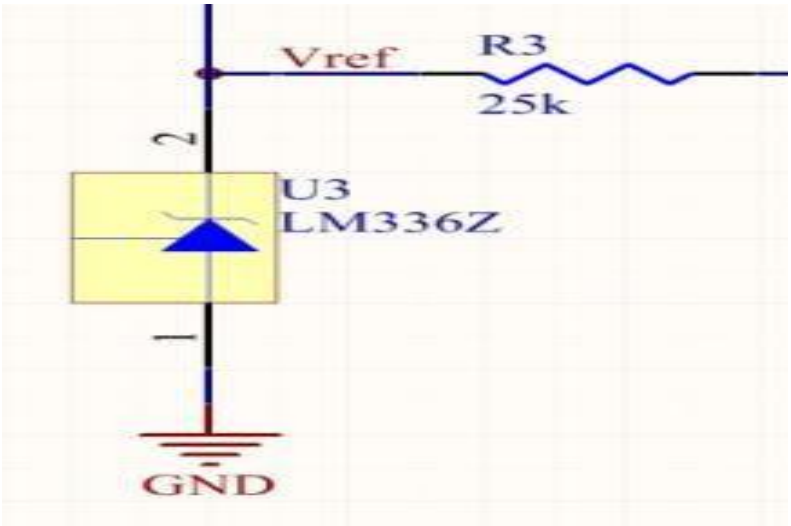


Figure 2.69: Defined name for connection vref

With this, we have finished drawing and designing electrical scheme, which is the basis for moving onto designing the printed circuit board. Before we start translating the scheme into printed matter, it is recommended to configure project settings. This includes settings for detecting errors, connection matrix, class generator, settings for the comparator, generating warning messages, settings for printing, etc. Altium uses all these settings when translating a project. When the project is translated, the complete design and electrical rules that were set are checked. After all errors are solved, the scheme is again translated and uploaded into the target project with for example PCB document. Project comparator enables searching for differences between the source and target files that we see and can be confirmed or rejected (synchronized) from both directions. All settings are available under menu **Project** ⟶ **Project options**.

Determining printed matter

After wiring diagram is finished and the settings are correct, we can start translating wiring scheme into printed matter. In the transaction phase, all electronic scheme design rules are checked with possible error tracking and the repair option. To translate given project **Current_generator.PrjPcb** we need to choose **Project** ⟶ **Compile PCB project**. When translation is finished, the translator message is visible in the message window. To access this window, we need to go to **View** ⟶ **Workspace Panels** ⟶ **System** ⟶ **Messages**. Translated documents will be recorded in window View ⟶ **Workspace Panels** ⟶ **Design Compiler** ⟶ **Navigator**, where we can monitor document structure, list of components and connection types (when clicking the connection we can also see it with marked lines in the scheme). In case of errors and unsuccessful translation, these events are recorded in window **Error Messages**. If the translation is successful, we can move to a new document in which we can design printed matter with the given electrical scheme. First, we create empty PCB. The easiest way is by using interface **PCB Board Wizard** with which we can choose between standardized industrial formats or own dimensions. Later these settings can be changed. **PCB Board Wizard** can be found under menu **Files**, which needs to be enabled in order to be visible, as seen in figure 2.70. If file choosing is not enabled, then we have a row of shortcuts to certain function at the right bottom of the scheme, and under tab **System,** we can tick **Files**.

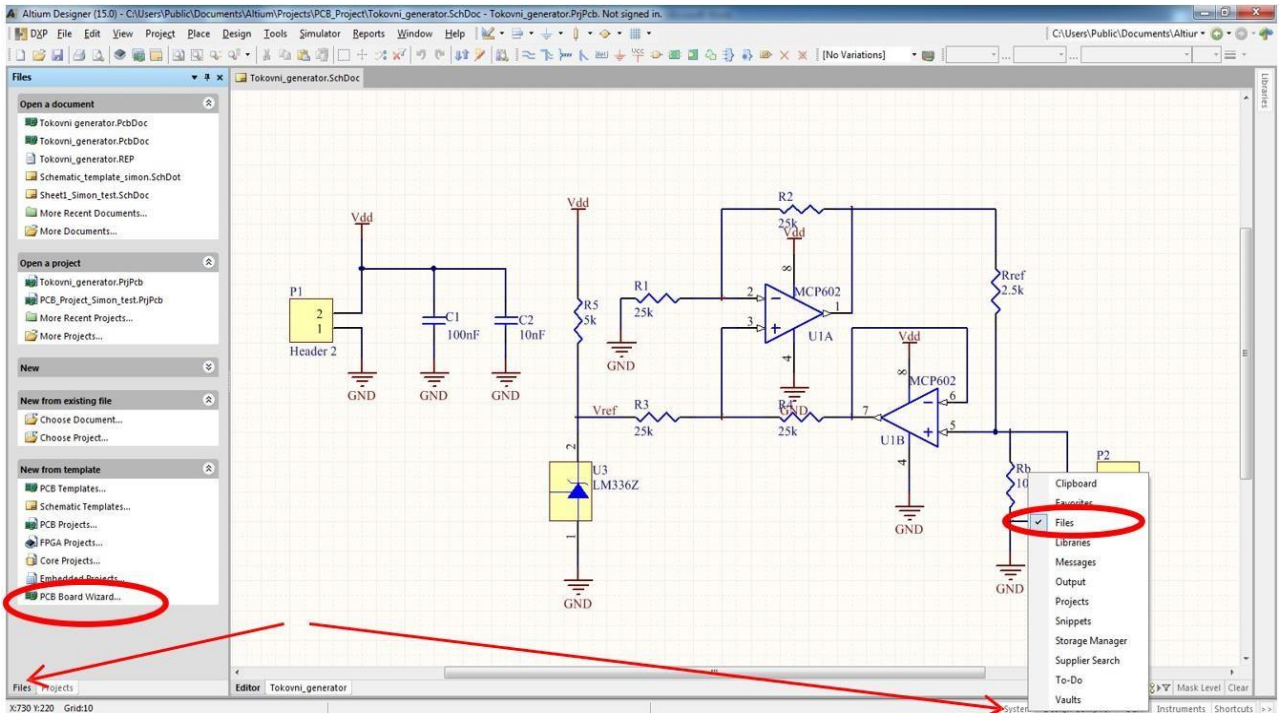


Figure 2.70: Choosing shortcut to files

Document preparation follows these steps:

- First click **PCB Board Wizard** and in the second windows select metric units **Metric**, figure 2.71.

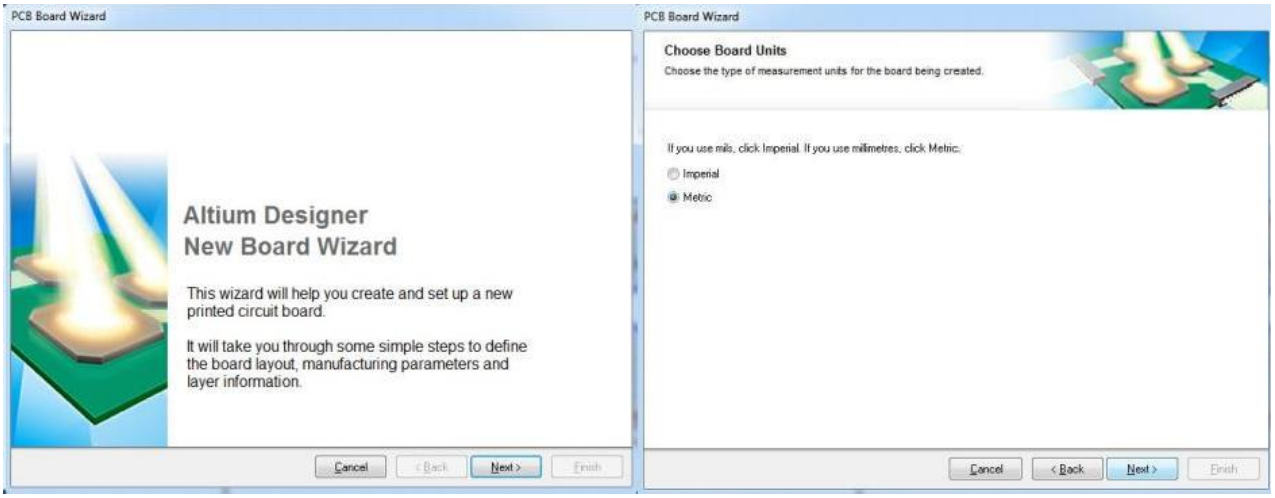


Figure 2.71: Wizard for creating PCB

- In the third window choose between PCB formats. We can choose **Custom** and then enter dimensions W=40 mm, H=30 mm. For designation of PCB edge, select line type **Mechanical Layer1.**
- In the next two windows choose a number of layers and type of VIAs that go through the whole PCB thickness.

- Then select which component type we will mostly install on PCB (SMD, PDIP, etc., depending on the socket) and on how many sides. Most components are surface-mount and are installed only on one side.
- In the following window select recommended settings for connections and VIAs:

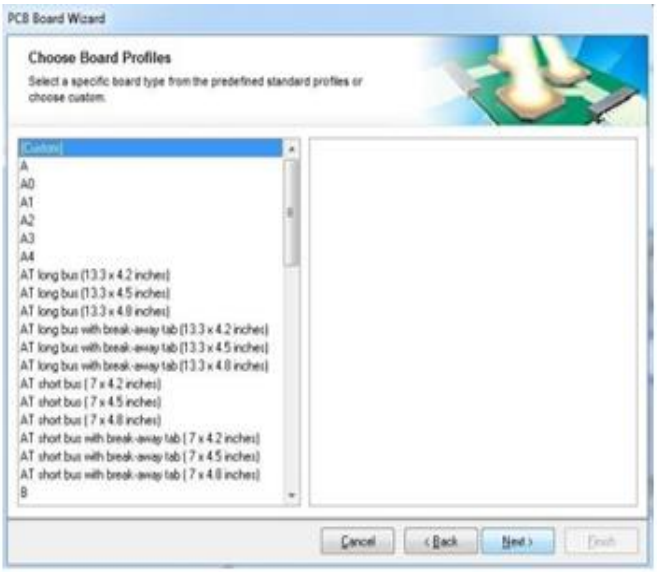
✓ The smallest connection thickness = 0,25 mm

✓ The smallest VIA width = 1 mm

✓ The smallest VIA diameter = 0,6 mm

✓ The smallest distance between connections = 0,25 mm

Figure 2.72 presents two wizard windows for printed matter settings



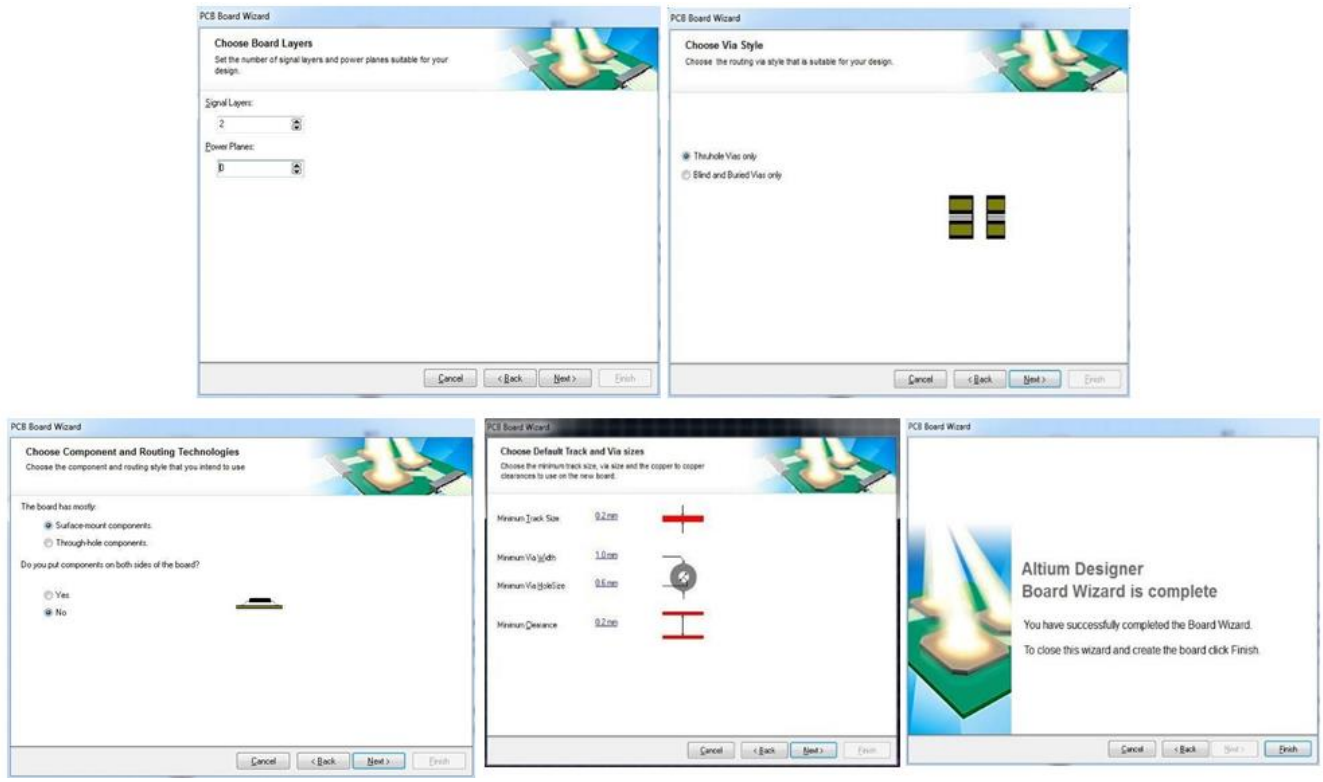
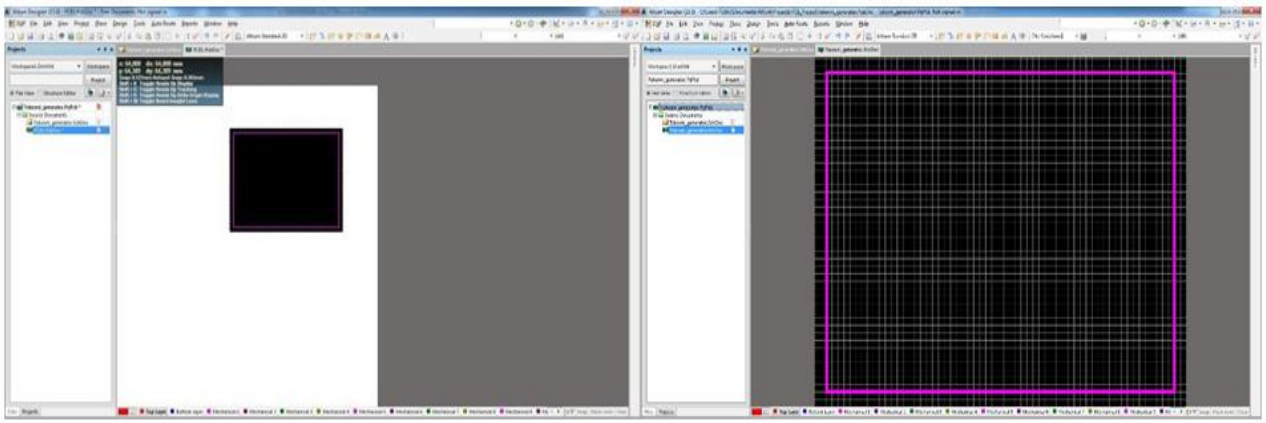


Figure 2.72: Steps in printed matter settings from 2 to 5

After successful creation of printed matter, we see a window with selected dimensions. In order not to have white page background, remove it in settings by clicking **Design** ⟶ **Board options** ⟶ **Display sheet**. PCB view can be adjusted with **command View** ⟶ **Fit** board or shortcut [V, F], seen in figure 2.73.



a) b)

Figure 2.73: Adjusted view of printed matter a) with background, b) without background

PCB dimensions can be later changed. The easiest way is to draw desired frame shape which can be used for determining PCB borders. This can be done by clicking all lines that define PCB edges with mouse and then select the function from menu **Design** ⟶ **Board Shape** ⟶ **Define from selected objects**, to trim PCB to the desired shape, figure 2.74.

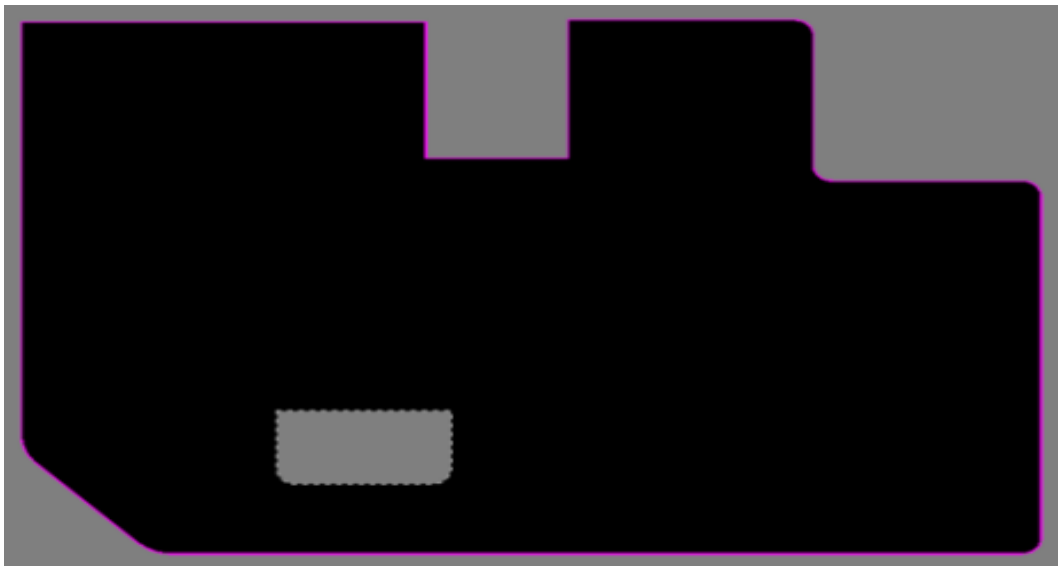


Figure 2.75: custom PCB shape

Project translation - Compiling

First go into electrical scheme environment and translate **Design** ⟶ **Update PCB**. Click **Validate Changes**, where error probability is checked. If everything is correct, there will be confirmation checkmarks under status. If the changes are not correct, we need to return back, check error messages and solve the errors. When the error check is successful, click **Execute Changes**, which transfers components and connections to PCB in the project, figure 2.76.

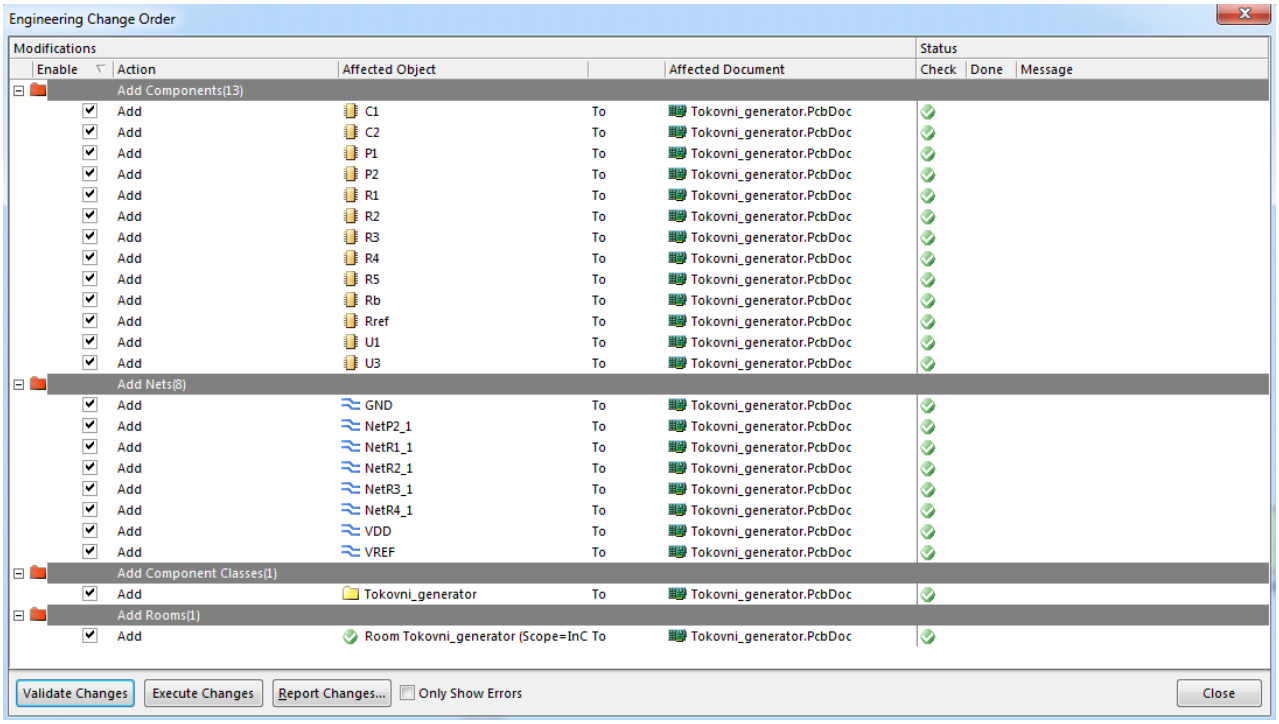


Figure 2.76: Checking scheme during compiling

Transfer of components to PCB printed matter, figure 2.77.

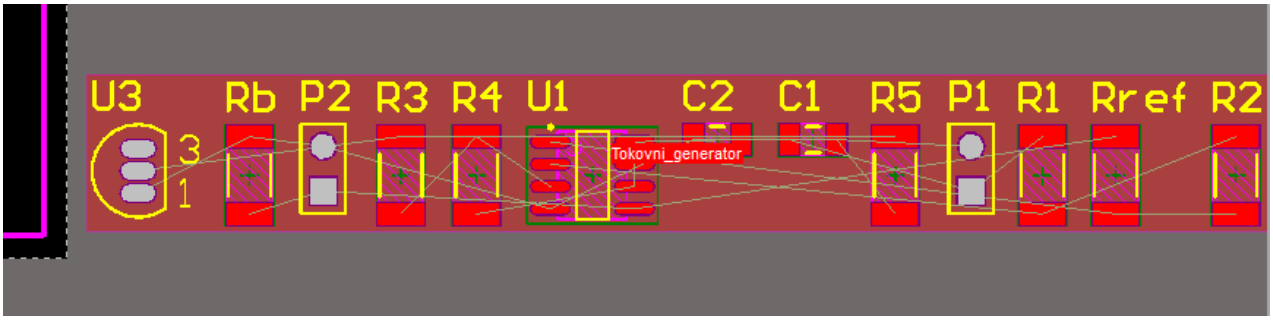


Figure 2.77: Shape of elements for printed matter

From figure 2.77 we can see that arrangement of elements to printed matter is up to the designer. In this case, it is sensible to consider guidelines and instructions of good printed matter design. In the next step follows the arrangement of components to printed matter. Components are arranged by clicking on the component and moving it to the correct position (clicks with the left button and press it while moving the component). Stay within PCB limits. With spacebar we can rotate the component while transferring it. Text that is connected to the components can also be moved the same way as

components.

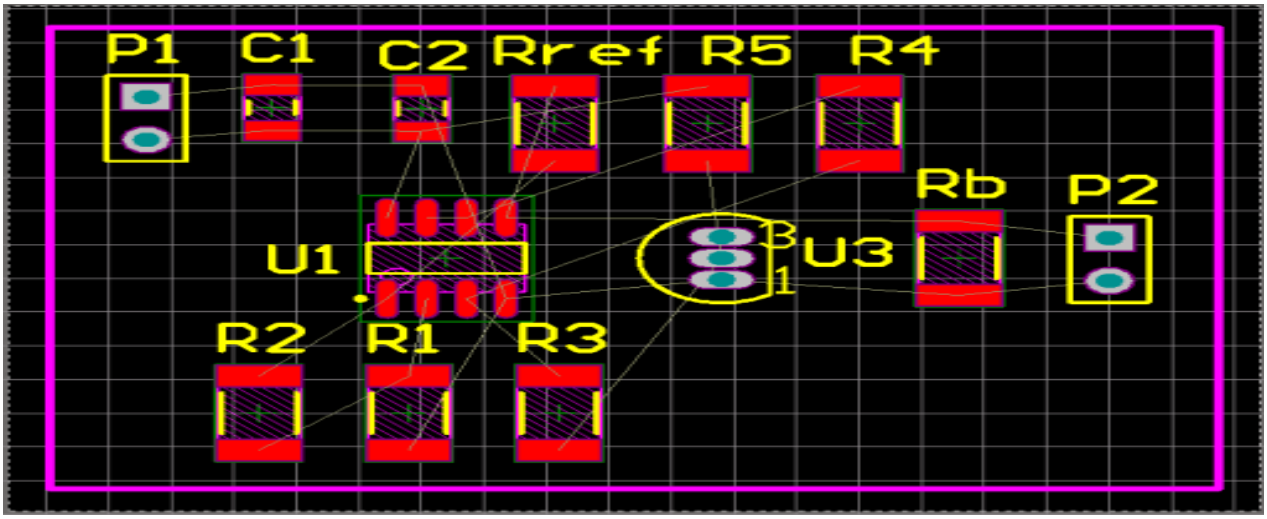


Figure 2.78: Arranged components on printed matter

Altium environment has function support for the easier component arrangement. Several components can be aligned horizontally, vertically, by different edges or center line. They can also be aligned with uniform spacing. These functions can be accessed if we select component group, where we use key SHIFT or round around the components we want to select. Then click with right mouse button and choose **Align** ⟶ **Align** [shortcut: A, A] and mark wanted functions on X and Y axle. Also, when we select one or multiple components, we can move them with mouse or use key combination: CTRL + SHIFT and arrow keys. This means a combination of an arrow key and CTRL causes smaller move (snap grid x 1) in wanted direction than when we press both keys CTRL + SHIFT, which causes the components to be moved for larger distance (snap grid x 10).

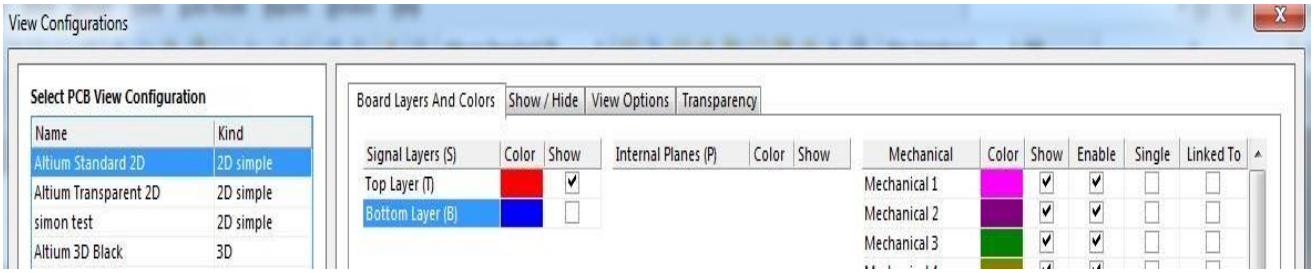
The connection of arranged elements can be made manually or automatically. In manual connection, we have a better overview of connections and the work takes longer to be done. Manual connecting is most often used in larger printed matters. Automatically connecting is generally more useful in less complex circuits.

Manual connecting of PCB printed matter

Manual PCB connecting means establishment of connections and VIAs on printed matter in order to connect all components as presented by the electric scheme. In manual mode, we usually design more complex printed matters, where many design aspects are important, such as EMI influence, RF circuit design, combined analog and digital circuits, combined power electronics, and digital/analog circuits, etc. Many times the designer has to decide and take compromises between certain design parts.

In our case, we will do manual connecting, although the circuit is simple. We will try to draw signal connection on the top layer, for lower layer we will use GND mass, which we will access through VIAs and in certain cases with connection pads (connectors P1 and P2 and reference U3). The connections consist of sequential segments. At each change starts a new connection segment. Generally, Altium enables arrangement of connections in vertical, horizontal arrangement and at 45° angle (at advanced settings we can also use curves) to get a final professional result.

We will use standard settings. First, we will choose view **Top layer**. Use shortcut L to get to the menu **View configuration**, where we remove the checkmark at Bottom layer and confirm the change, seen in figure 2.79.



2.79: Choosing printed matter top layer

Connecting start with . We can only connect those components or connectors that are interconnected electrically in the scheme, which is in PCB environment presented by thin straight lines between connection pads. By pressing key CTRL and clicking certain connection pad, we can easily check which pads are interconnected. When we create a connection between two connectors, we can finish it with automatic function **Auto-complete**. This can be done by clicking the first connector and then the second one and during that press CTRL and arrow key >. The connection will be created in the shortest way between both connectors. This function is successful if the path is fairly simple without major obstacles between both points. The second way is by using key ENTER when connections are finished gradually, with which we decrease the number of segments in one connection. Altium enables other ways of manual connecting where we can press SHIFT + R during moving and select between different methods:

Push – In this mode, the connection will try to break through to the other point by moving already established connections and VIAs within the rules.

Walk around – Path to the second point is trying to find by drawing the connection around obstacles without moving existing connections and VIAs.

Hug & Push – This way is a combination of previous ones.

Ignore – This method allows establishment of connections anywhere without breaking the rules. We need to be also aware of the components that we set on the top surface, where also signal connections and those that have connection pads are routed though PCB to the other side. Such components are soldered below, so we need to connect them with signal connections on the top side with VIAs. VIAs can be found with key Place via . Because we will use the bottom layer for mass, VIAs will be installed at connectors P1, P2, and the reference.

Apart from components and VIAs, it is also good to predict how PCB will be attached to the housing because we usually need screw holes. Those can be created by selecting **Place Pad** . Do not connect it to any electrical connection. Mark option Plated, so there will be no error messages later on when checking PCB.

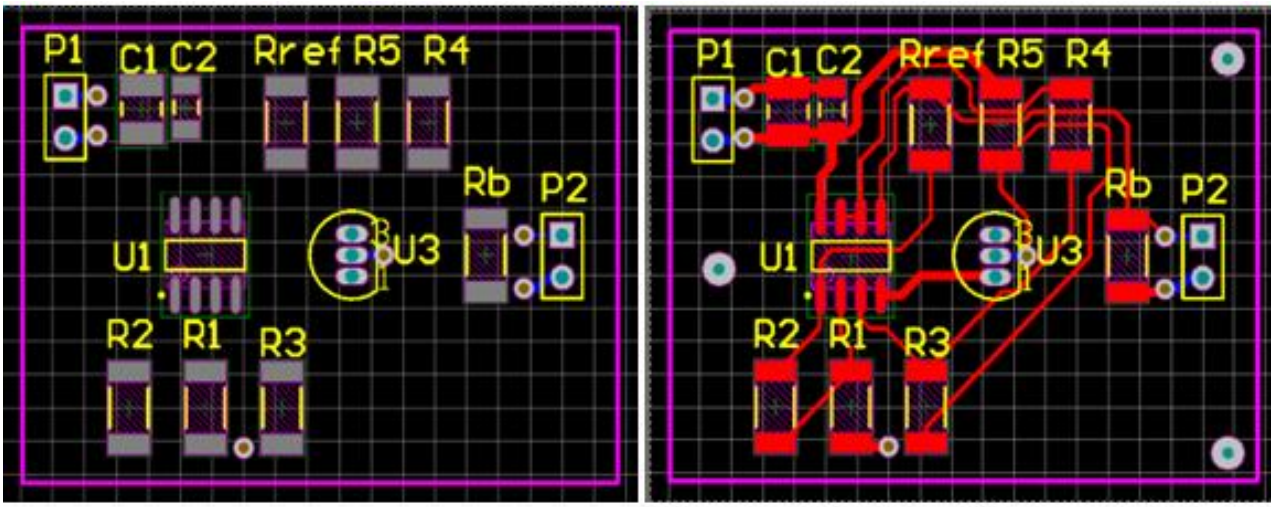


Figure 2.80: Connected printed matter

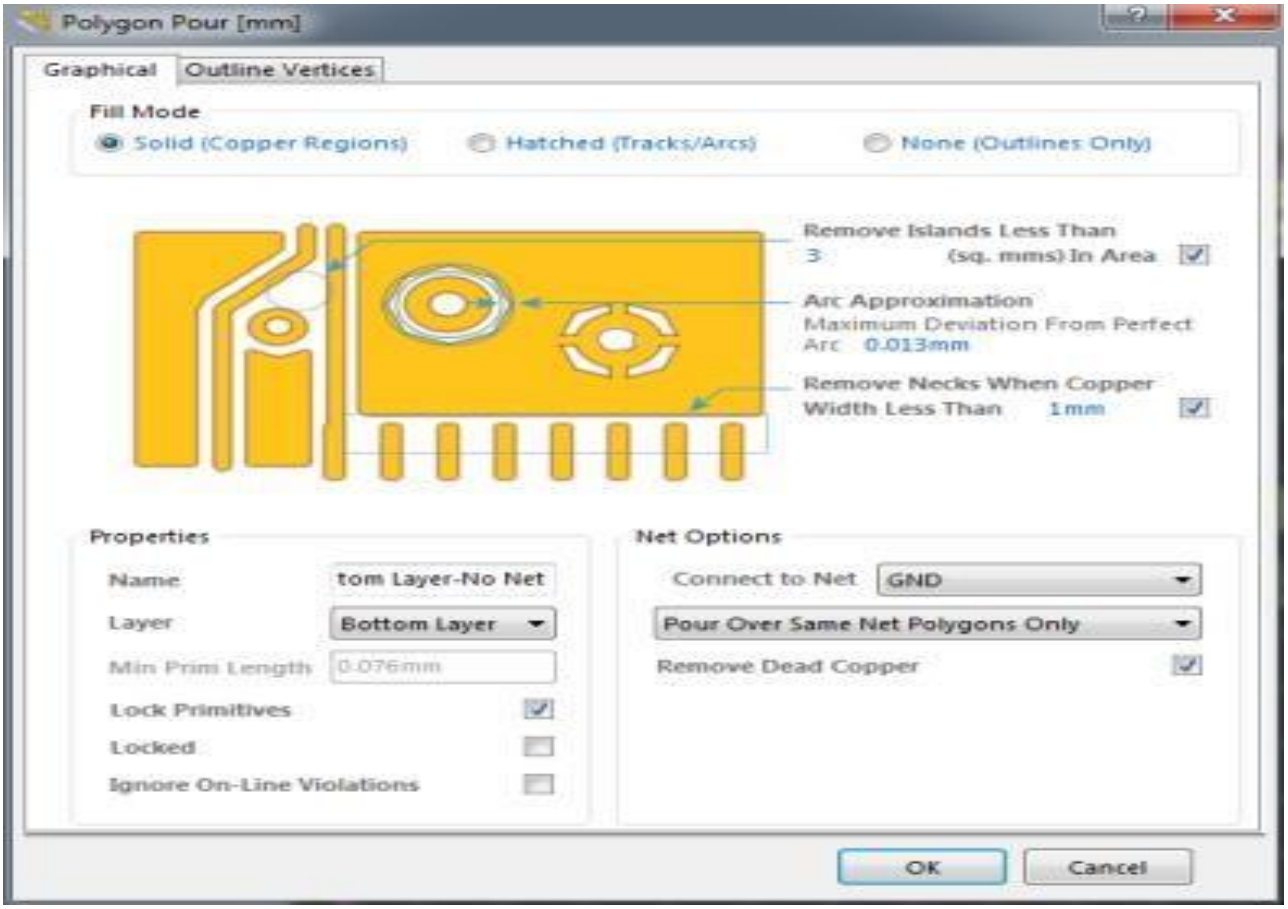


Figure 2.81: Determining polygon for mass on the bottom printed matter side

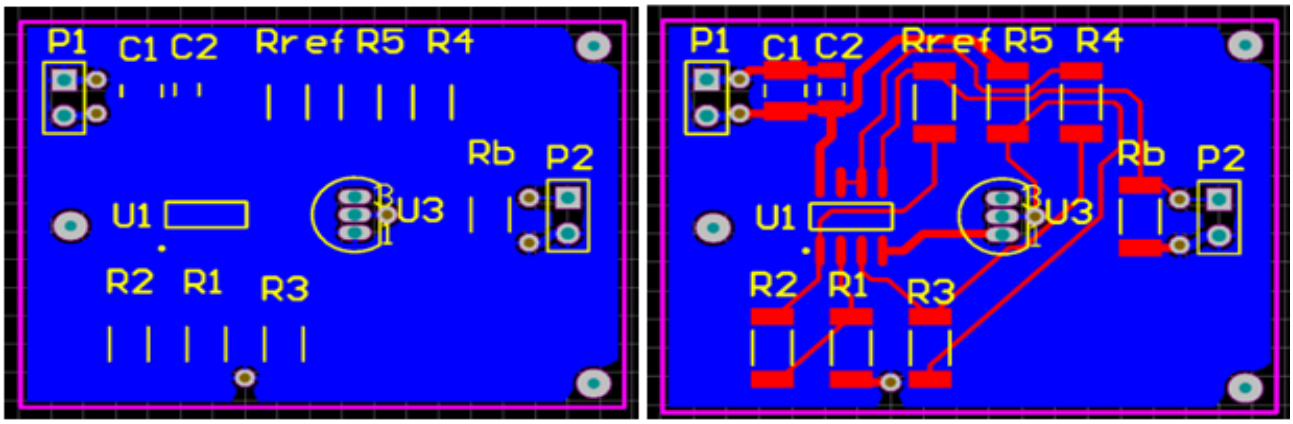


Figure 2.82: Printed matter WIT added mass GND on the bottom side

Automatic routing

Simpler and less complex PCBs can be connected with an automated regime where all rules are strictly met. In our case, we want a signal line on the bottom side and the bottom side of PCB to be reserved for GND polygon. For this, we need to adjust the settings, so connections will be only on the top side. This can be done in rules. **Design**

⟶ **Rules** and under **Routing Layers** we enable only **Top Layer**, image 34. Then select from the menu **Auto Route** ⟶ **All** and click **Route All**.

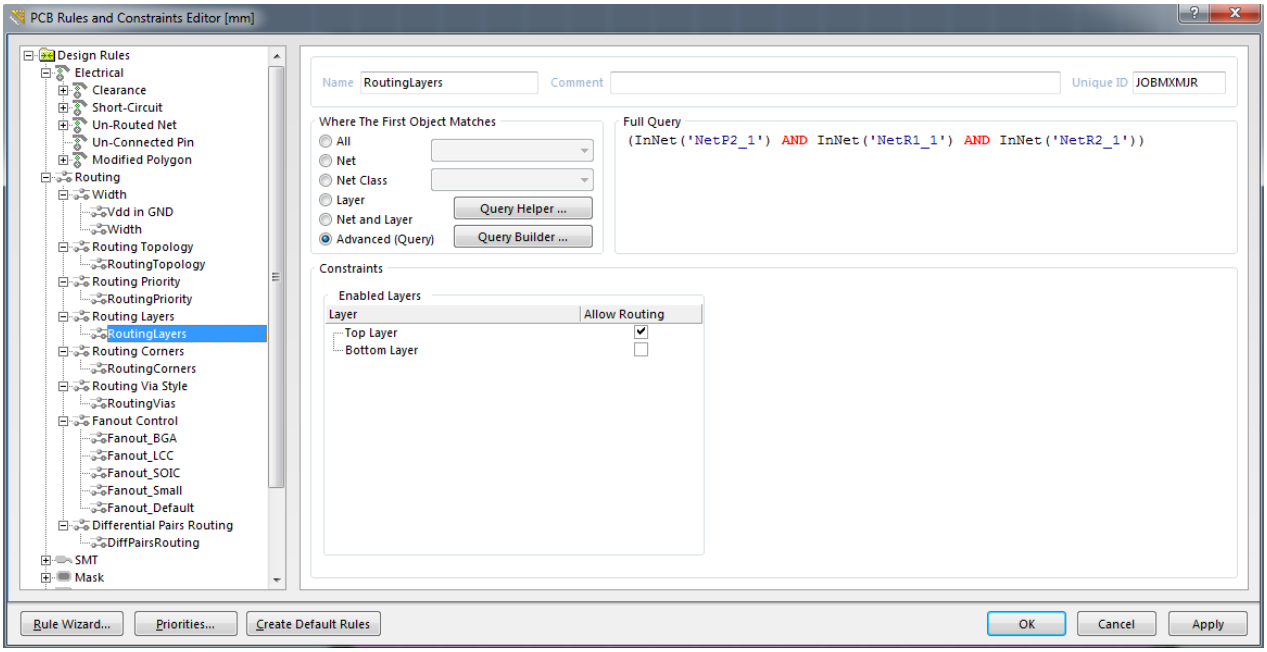


Figure 2.83: Choosing Upper Layer for Automatic Connection between Components

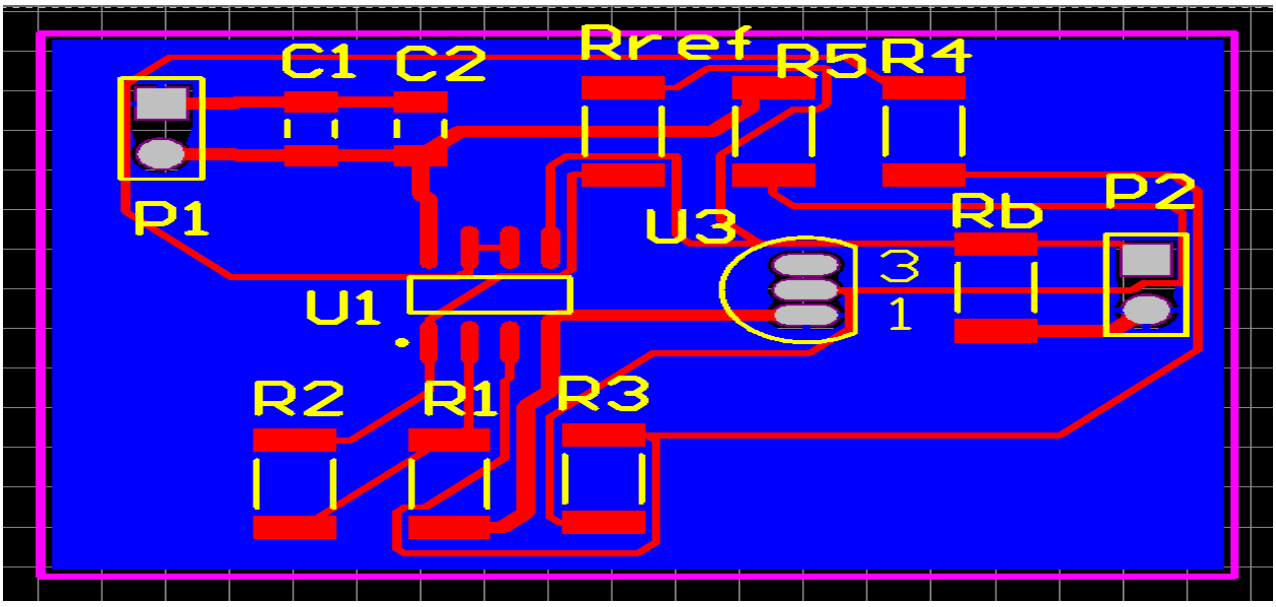


Figure 2.84: Result of automatic connecting

At first glance, the result is similar, but the detail that we manually entered makes a difference. There are quite a few mistakes that we can overlook in printed matter. It is also not considered that the components that are soldered on the bottom side the

electrical contact only on the bottom side, so they need to be connected with connections with VIAs on the top side. VIAs are welcome at GND connections because we can make them shorter. If we connect automatically, it is sensible to use connection group's **Net classes**. These can be set through user interface **Design** ⟶ **Classes**. Here we can add groups by going to the tab Net classes and by right click choose **Add class**. We can see a window where all available electrical connections are written in the column **Non-members** and on the right is space where we can add wanted/marked connection with a click on arrow.

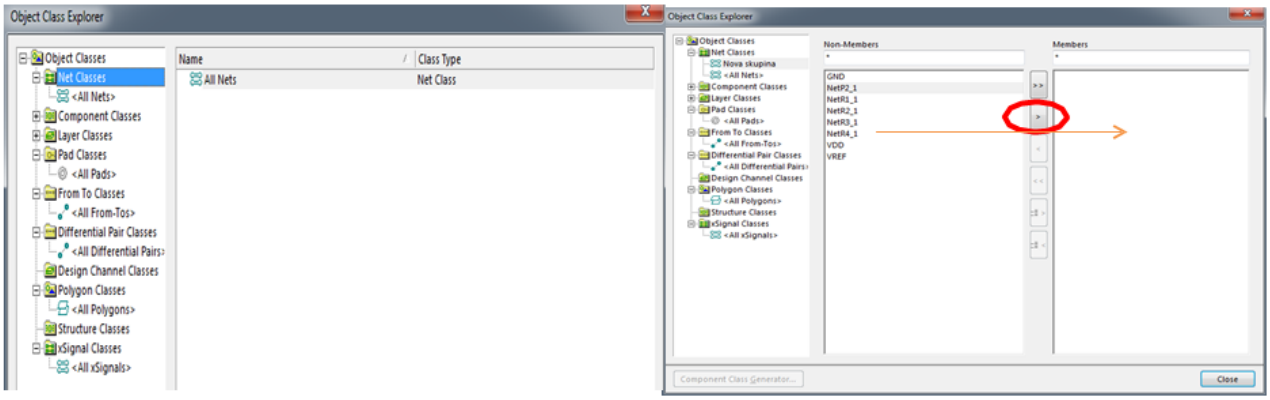


Figure 2.85: Adding Connection Groups

3D view

3D view enables that we can see PCB in space from all perspectives. We can switch between views 1, 2 and 3. Number 3 is a shortcut for the 3D view, seen in figure 2.86.

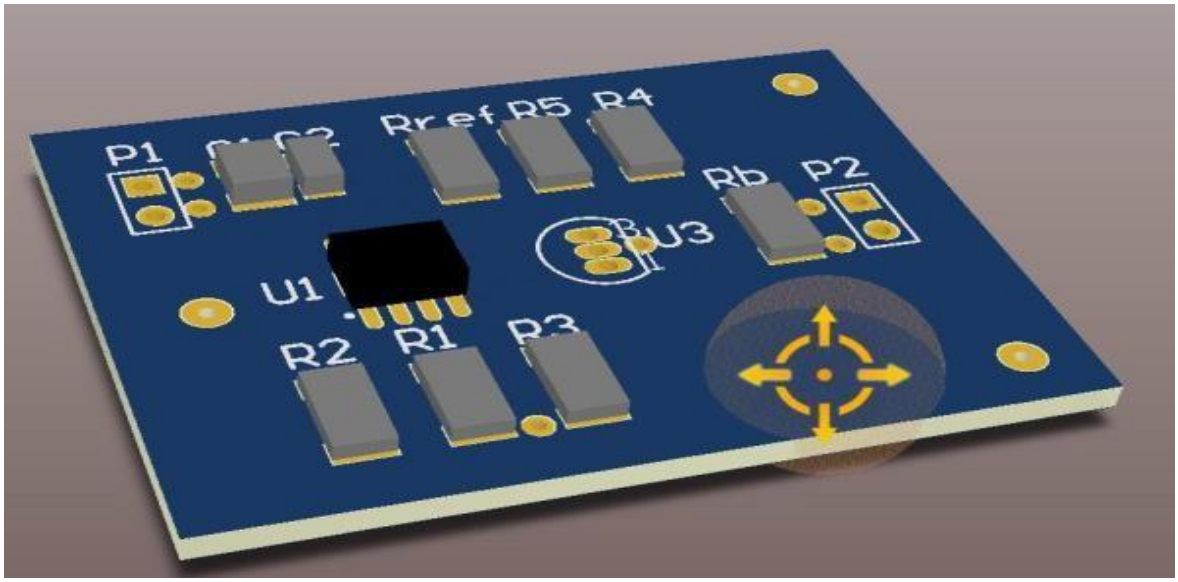


Figure 2.86: 3D view of printed matter

In the 3D view we can use the following shortcuts:

- Zooming in: CTRL + mouse scroll
- Moving up/down: mouse wheel, moving left/right: SHIFT + mouse scroll
- Rotation: SHIFT + right key on mouse and drag in the wanted direction that can be selected on sphere with arrows.

Altium enables import of 3D objects from different CAD tools in *.step* format. It is also possible to export in formats, such as: step, dwg/dxf. Exported objects can be used in other CAD programs that support mentioned formats.

Self Check 2	Written Test

Review Questions

1. Depletion layer is caused by
   A. Doping
   B. Recombination
   C. Barrier potential
   D. Ions
2. The reverse current in a diode is usually
   A. Very small
   B. Very large
   C. Zero
   D. In the breakdown region
3. Avalanche in Diode occurs at
   A. Barrier potential
   B. Depletion layer
   C. Knee voltage
   D. Breakdown voltage
4. The potential barrier of a silicon diode is
   A. 0.3 V
   B. 0.7 V
   C. 1 V
   D. 5V
5. A Diode is an
   A. Bilateral Device
   B. Nonlinear Device
   C. Linear Device
   D. Unipolar Device
6. The diode current is large for which condition
   A. Forward Bias
   B. Inverse Bias

C. Poor Bias

D. Reverse Bias

7. The output voltage signal of a bridge rectifier is

A. Half-wave

B. Full-wave

C. Bridge-rectified signal

D. Sine wave

8. If the maximum DC current rating of diodes in Bridge Rectifier is 1A, what is the maximum DC load current?

A. 1A

B. 2A

C. 4A

D. 8A

9. Voltage multipliers produce

A. Low voltage and low current

B. Low voltage and high current

C. High voltage and low current

D. High voltage and high current

10. Zener diode can be described as

A. A rectifier diode.

B. A device with constant – voltage.

C. A device with constant – current.

D. A device that works in the forward region.

11. If the Zener Diode is connected in wrong polarity, the voltage across the **load is**

A. 0.7 V

B. 10 V

C. 14 V

D. 18 V

12. Number of PN Junctions in a Transistor

A. One

B. Two

C. Three

D. Four

13. The doping concentration of Base in NPN Transistor is

A. Lightly Doped

B. Moderately Doped

C. Heavily Doped

D. Not Doped

14. The Base – Emitter Diode (Base – Emitter Junction) in an NPN Transistor is

A. Doesn't conduct

B. Forward Biased

C. Reverse Biased

D. Operates in breakdown region

15. The size comparison between Base, Emitter and Collector is

A. Base > Collector > Emitter

B. Emitter > Collector > Base

C. Collector > Emitter > Base

D. All are equal

Note: - Satisfactory rating: 19 and above, Unsatisfactory Rating: below 19

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 3	Considering alternative arrangements for the design

2.1. Developing outlines of alternative designs

Design is a process of drawing up of the description that is necessary for creation of non-existing object in the specified conditions. On the basis of the initial description of the object and (or) algorithm of its functioning in the designing process, there is a transformation (in some cases numerous) of the initial description, optimization of the set characteristics of the object, elimination of an incorrectness of the initial description and consecutive representation of descriptions (if necessary) in various languages.

The result of design is the description of the object that will be used for its manufacture.

Development of designing methods:

- Traditional designing methods (evolution of domestic industries – gradual adjustment of products);
- A drawing way of designing (this method appeared at the stage of a mechanical production). The basic feature of drawing methods – only one concept of the whole is considered.
- Modern ways of designing. These ways allow considering the set of concepts of the whole due to expansion of decisions space in which the search for new structures is conducted. New methods of designing are formal schemas, allowing dividing a designing problem into parts and specifying connections between them. The volume of the information necessary for decision-making at each level can be provided only on the basis of modern information technologies.

General features of modern designing methods

Designing strategy includes three basic stages:

- Analysis: gathering a set of alternative decisions and preparation of models for research.
- Synthesis: simulation and rejection of unnecessary models.
- Estimation: elimination of internal contradictions and definition of one sample solution that satisfies all criteria.

The designing strategy can be linear: when each subsequent action depends on an outcome of previous action, but does not depend on an outcome of the subsequent action. Otherwise the strategy becomes cyclic or ramified.

To formalize the process of generation of the variety of model structures the following methods can be used:

- Brainstorming – method of initiation of collective creativity. Processes of ideas generation and their critical estimation are separated in time.
- Synectics – active application of analogies.
- Liquidation of impasses.
- Morphological cards (usually made up as tables).

The purpose of application of a morphological card is the solution of a design problem.

The plan of action:

- To define basic parameters or functions of the product.
- To list a wide spectrum of possible solution, i.e. alternative means of realization of each function.
- To choose solution for each function.

The designing process should cover all stages of product life cycle:

- The formation of requirements to the system and development of the requirement description.
- Designing.
- Manufacturing, test and operational development of pre-production models.
- Serial production.
- Operation and target application.
- Recycling.

The system approach to designing of electronic devices

The system approach to designing of electronic devices includes:

- The establishment of the projected system borders as a whole, i.e. its allocation from the environment.
- The definition of the purposes of the system, criteria of quality of its functioning and methods of their calculation.
- Decomposition of the system on components or subsystems.
- Studying the system in all required aspects.

The classical approach is based on the idea that properties of the whole are determined by the properties of its parts. The system approach is also based on that the parts are

determined by the whole within that they function. Moreover, the system has properties which are not presented by its parts.

There are five principles of the system approach in designing of power electronic devices:

- The electronic device is considered not in itself, but in aggregate with the power supply on an input and loading on an output.
- The necessary set of criteria of quality and functioning of the electronic device is determined, and existing techniques of its calculation are examined.
- Decomposition of the device is made for simplification of its analysis and calculation.

For example, any converting device should realize the following functions:

- ✓ Transformation of the current type (circuit).
- ✓ Regulation of parameters of the transformed energy (pulse modulation, physical effects in linear and nonlinear circuits).
- ✓ Matching of voltages levels of the power supply and a load.
- ✓ Galvanic decoupling.
- ✓ Electromagnetic compatibility.
- ✓ Conditioning input and output parameters (filtration).

First two operations are performed by means of semiconductor switches, the following two – with the help of transformers, and the last two with the help of filters.

Two levels of decomposition:

- ✓ The top level - the system is divided into elementary basic cells.
- ✓ The bottom level - elementary basic cells are considered as the set of elements.
- At the analysis of electromagnetic processes in electronic devices the following classes of assumptions are accepted:
- ✓ All elements of the circuit are ideal; sources provide unlimited power; load is idealized.
- ✓ Real parameters of elements of the circuit are taken into account; loading remains idealized.
- ✓ All elements of the circuit are replaced by real models with real parameters.
- During designing the account of interrelations between designs procedures (the strategy is not always linear) is carried out.

The description of the automated designing process

The automated designing is determined as the process at which separate transformations of the description of the object, and also representation of the description in various languages, is carried out by interaction of the person with a computer. The person in such a system is the person that makes decisions. Block hierarchical approach is a basic in automated design process. It is based on decomposition of a developing system in accordance to systems complexity levels (see Figure 3.1).

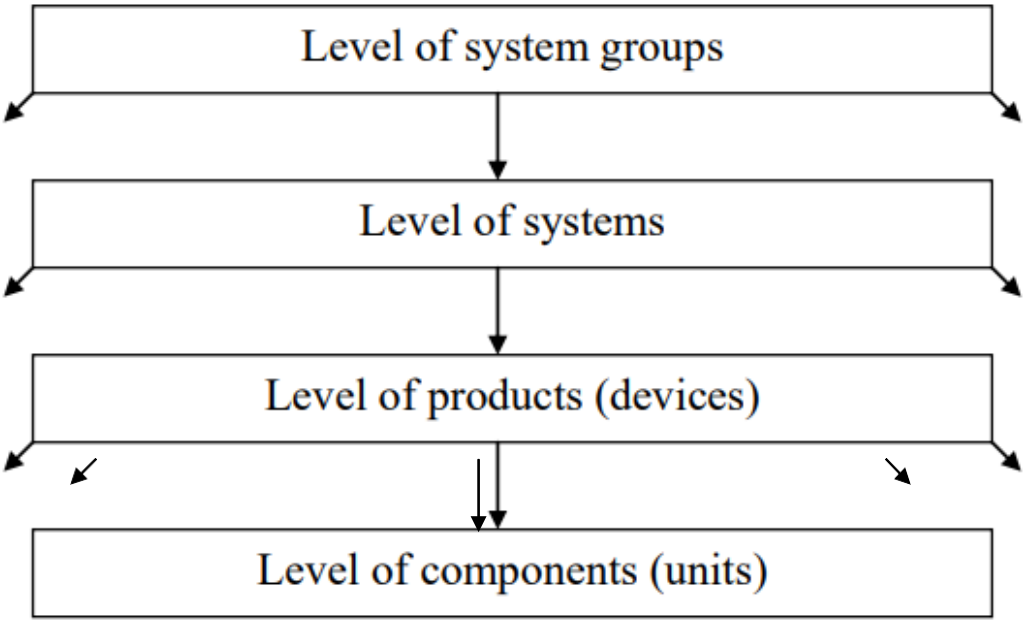


Figure 3.1: Systems complexity levels

The hierarchical approach at each system level includes:

- Structural-parametric designing during which conceptual structural and constructive problems are determined, as well system (external) connections of the designing object.
- Functional-constructive designing during which key parameters and characteristics for each structural variant are determined. For the further consideration perspective variants are selected.
- Constructive-technological designing at which several fully detailed solutions is considered and the final variant is selected.

The designing process consists of stages, design procedures, design operations.

Design stages (sequence of design stages is determined by the contract)

- Development and endorsement of requirements specification.
- **Development and endorsement of electrical circuit.**
- Manufacturing a prototype and carrying out of laboratory tests.
- Development of reliability program.
- Development of the test circuit and test equipment.
- Development of the technical conditions.
- Development of working drawings.
- Development of the operational documentation.
- Development of the technological documentation.
- Development of adjustment instructions.
- Development of pre-test program.
- Manufacture of pre-production models for pre-tests.
- Carrying out preliminary tests.
- Release of the pre-tests report and updating of the design documentation.
- Assignment of the letter of readiness for manufacture to design documentation.
- Manufacturing, acceptance tests and serial production.

One of the main stages of the designing process is a design procedure - formalized set of resulting in design solution. Procedure includes design operations that are invariable for this procedure.

Design procedures of stage 2

- Specification and selection of elements of electrical circuit. It is finalized by the release of the bill of materials.
- Specification and selection of electric connections between elements. It is finalized by the model, prototype, drawing.
- Description of the electrical circuit in standard forms.

The design solution is the intermediate or final description of the designing object which is necessary and sufficient for consideration and definition of the further direction in designing. Design document is a document prepared under the given form and including some design solution.

Self Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

_____is refers to the flow of the electric charge carried by electrons as they jump from atom to atom. (7 points)

a. Super Communication.
b. Conflict Resolution
c. *Electric current*
d. Electric bulb

2._____is flows more easily in some types of atoms than in others (4Points)

a. Electric current
b. managing a team
c. Communication
d. work

3. _____ is a closed loop made of conductors and other electrical elements through which electric current can flow (1 point)

a. Electric current
b. electric circuit
c. Communication
d. work

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 4	Incorporating safety, functional and budget considerations

4.1. Developing the design within the safety and functional requirements and budget limitations

When creating a new electronic device it's important to map out the steps of your design. Having a fully functional prototype ready for demonstration is always impressive. Here's how to design the electrical components that will get your device up and running.

Product concept

During the first stage of our electronic design services, ideas begin to shape a product that is likely to be commercially successful. To analyze the competitiveness of a product being designed, we use a comparison table called Technical Level Map (TLM). This table helps us to define a unique combination of technical and functional characteristics of a future product. Then, our specialists choose a business model to maximize the selling effectiveness of electronic device being designed.

Next, Prom wad technical experts and industry specialists create a detailed specification of the new product and its concept design. The specification includes a full list of all requirements to the product while the concept design contains a full description of its functional features and benefits.

At the same time, business analysts make up a business plan on the basis of the selected business model and expert reviews. This stage can also include a variety of product research done, such as marketing or investment research.

The result of this stage is a complete package of documentation that describes the product concept.

Proof of concept

The second stage implies the creation of a preliminary (draft) project, development of the requirements/specifications, and analysis of a variety of possible uses of a potential product. Next thing that we do is we specify the prices with the company's manufacturing the required components. After we select the manufacturers, we sign a nondisclosure agreement (NDA) and receive, as necessary, additional technical data. Then, we choose base components and calculate preliminary self-cost of a product (so-called Bill of Materials or BOM). When making preliminary calculations, we take into account the cost of manufacturing batches of different volume.

The device implementation then has to be verified by our specialists. By the end of this stage of our electronics design services, a device prototype is assembled and tested. To develop and assemble it, we purchase an evaluation kit for the chosen target platform. Our engineers evaluate the selected hardware and software technical solutions. They also assess potential weaknesses in the context of technical feasibility, the platform's performance and other essential characteristics.

As the result of this stage, we can understand whether we chose the right platform and best engineering solutions. Also, in many cases, we develop a limited functionality, 'desk-type' prototype of the device.

Electronics product development

The aim of the third stage is to create a package of design and project documentation for the new device. During this stage, we specify a list of required components and then design a PCB (print circuit board). We also make a Bill of Materials (a list of all components) and acquire accurate prices from the suppliers.

Then, our engineers design HMI (human-machine interface) and determine control and information display units. At the same time, engineers design the interface, create concepts of controls, and build the functions tree.

Simultaneously with the schematic development, a device case design is developed. We create a solid model and mechanical design of the case on the basis of a previously developed sketch and the HMI, and then carry out PCB layout in the required form-factor. After defining the software architecture at the previous stage, we implement it and then adapt and elaborate the software. Our specialists develop and perform all types of testing needed for verifying the software operation and its correctness. They also develop program tests allowing checking both hardware and software operations.

The result of the electronic product development stage is a full package of the device's design documentation and final preparation for the manufacturing a pilot batch.

Pilot batch

The aim of the fourth stage is the manufacturing of a pilot batch that is used to verify the operability of the device. At this stage, any errors that could be made during the design stage are eliminated. Our customers also use samples of the pilot batch for further promotion of their products to potential buyers or investors, as well as for certification tests of the device.

What happens during this stage is that Prom wad specialists buy and assemble the components, PCBs are put into production, and ease of assembly is verified. Then, we place orders for the device enclosure (cases) that look alike the final version. After PCBs are assembled, the first launch (so-called 'bring-up') is performed. Next, the operating system and the boot loader are ported, high-level software, system, and drivers are elaborated. Finally, Prom wad specialists assemble the device components together and perform thorough integration testing.

When testing results are achieved and test operation is performed, we can elaborate the product's functional requirements and change if needed the design documentation package. Any software changes can be dealt with during other stages, because most of them do not require changes at the hardware level.

Some of our clients ask for repeating of one or several iterations of electronic development. Such iterations can result in changes of construction, schematics, PCBs, etc. In cases when stage ('Product Concept') or ('Proof-of-Concept') were skipped, this scenario is much more likely.

As the result, by the end of this stage a functional pilot batch ready for integration testing is created. When testing is completed, design documentation can be amended when needed.

Certification tests

As we can tell from our experience, if you choose not to perform any preliminary certification tests, the risk of material losses in the future is considerably higher. During this stage, the device class, as well as the need for running preliminary certification trials, is defined, and the schedule of such testing is developed. When the test results are ready, our specialists document the results of performed measurements and amend the design documentation as needed. By the end of the fifth stage of our electronic product design services, the achieved result is the decision of a corresponding organization whether preliminary certification tests for the device are going to be run, and their results.

Preparation for production and launch of pilot batch

The aim of the pilot batch launch is to get the product ready for full-scale manufacture and test the real device production process. During this stage, defects that cannot be

detected in a small number of products can be found and minor changes in PCB, case design or schematics can be made.

Then, Prom wad specialists perform the final optimization of the Bill of Materials, prepare the package of final documentation and together with our engineering technologists develop assembly charts for the particular products. At this point, detailed logistics plans are also made, and bottlenecks, risks and possible weaknesses of large-scale production are being examined.

After the test coverage for the JTAG analyzer is developed and verified by our team, this technology is introduced into production. At the same time, tools for the POST testing and post-production tests are developed, if the test coverage needs to be increased.

The result of the sixth stage includes a manufactured pilot batch and developed documentation for the launch of full-scale manufacture of the future device.

Full-scale production

The aim of this final stage is the full-scale industrial manufacturing of the product, ready for sale to the end users.

During this stage, the mass production can be supported by our engineers in the following ways:

- ✓ technological process control
- ✓ product quality control
- ✓ Quick reaction to components replacements (for example if any component is not available, etc.)
- ✓ determination of causes for defects that occur during production (violation of technological processes, low quality of initial components)
- ✓ increasing the test coverage and improvement of test procedures for detected bottlenecks
- ✓ optimizing the production process in order to save money on costs

The result of the experts' work during this stage is quality assurance of the production process and a batch of the manufactured products delivered to our customer.

Project Title: Rain detection and water level controller

Scenario:

The main theme of this project is to save water, in addition to water level controlling in the tank, that will open the cap of the tank if we detect the rain water and not only these, we have added another feature to our device by adding buzzer (alarm), so that it gives alarm when rain falls which help to bring back the items (clothes, eatables) that we have kept in sunlight for drying.

This project can be understood well by dividing it into three parts:

- Water level controller
- Rainfall detection
- Adding alarm

In first part will help us in controlling the water motor by sensing the water level in a tank. This system monitors the water level of the tank and automatically switches ON the motor whenever the tank is empty and switched OFF when the tank is full. In second part we detect rain water and in the third part we let the alarm to make sound if we detect rainfall.

Introduction:

The project is water level sensing in water tanks, controlling water level automatically and detection of rain and giving alarm if rain is detected. This approach would help in reducing water wastage as we can even use the rain water by allowing it into the water tank and the alarm will help the household men/women in bringing the items that were kept in sun for drying. Furthermore, we fix a LCD for indicating the level of water in the tank and this LCD also indicates the rainfall. Water is most commonly used resource for daily consumption, agriculture, industry. So, efficient use of water by monitoring the tank level of water is a potential constraint for home/office. Automatically controlling the motor by detecting the level of water would save lot of water. Water, one of the great natural resources should be utilized in proper form. But a huge amount of water is being wasted during daily life due to lack of control. Our proposed system guarantees to accumulate a good amount of usable water every day.

Water Level Detection

For water level detection, many have used direct sensors that are available in market and in later stages many have prepared their own sensing circuits using transistors.

Water level indication

After detection of level of water in the tank, one has to show the level of water in the tank by using LEDs or display devices like LCD screens.

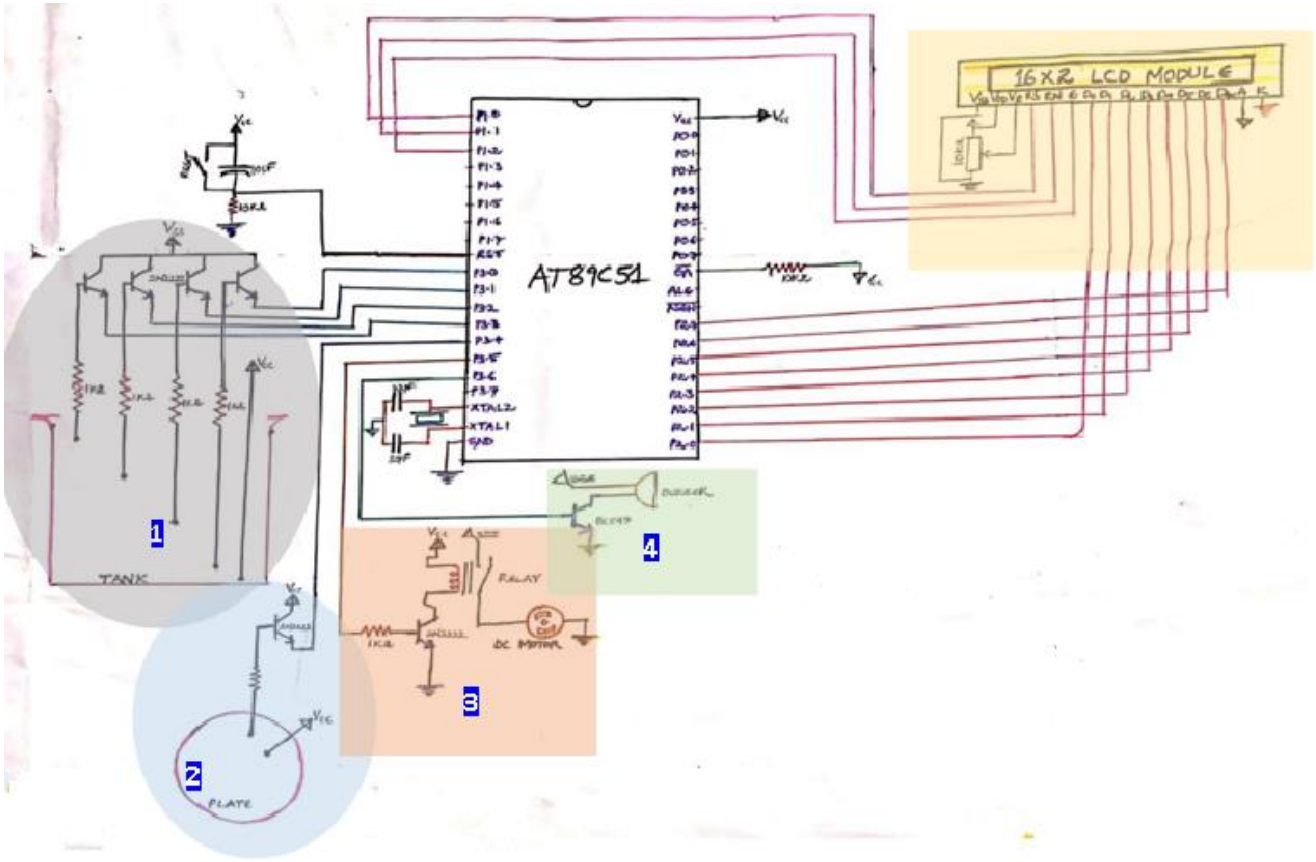


Figure 4.1: Circuit diagram of Rain detection and water level controlling, water level sensing (Section.1), rain detection (Section.2), automatic switching (Section.3), an alarm (Section.4) and LCD (Section.5)

Automatic Level controller

For switching ON/OFF the motor automatically, one has many switching devices like Bipolar Junction Transistor (BJT), Relay, Solid State Relay (SSR), Metal Oxide Semiconductor Field Effect Transistor (MOSFET)/ IGBT, Darlington Transistor. Most people used Relay (Electro Mechanical Relay) as switching device due to its outstanding properties.

Rain Detection

For rain detection, there are direct rain detection sensors available in the market and we can even make our own rain sensing circuit using the transistors.

Interfacing Buzzer with Microcontroller

We have interfaced Buzzer with microcontroller for alarm by giving instruction to the micro- controller.

Circuit & Design Principle:

In this section we explain about our rain water & water level controlling circuit diagram shown in figure 1. This project design principle is based on “Water conducts electricity” and we are detecting water level in tank and rain detection using this principle.

This section is subdivided into four sections as shown in the figure 4.1.

Level sensing

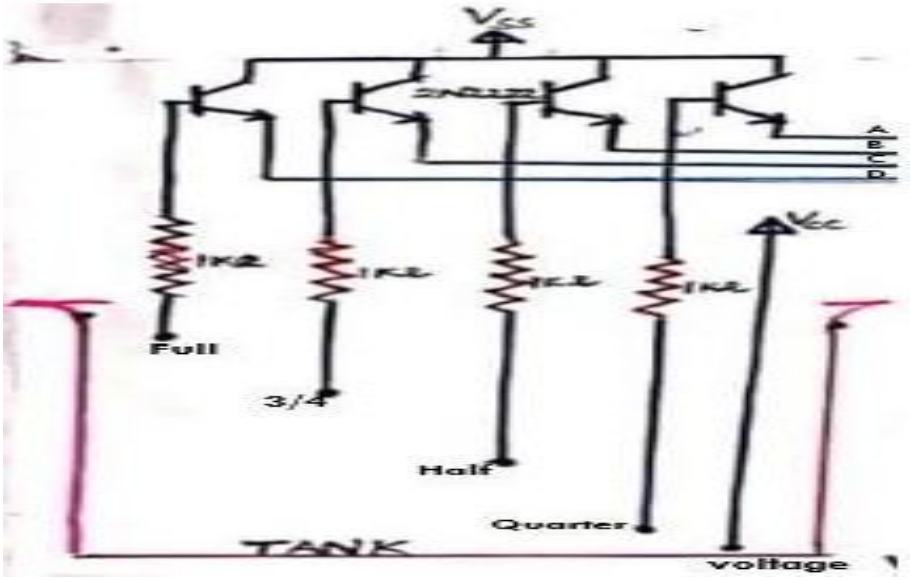


Figure 4.2: Water level sensing and inputting A, B, C, and D to Microcontroller

Here the emitter end of the transistors (A, B, C, D) are connected to microcontroller, supply voltage of 12V is given to bottom of the tank. Whenever the water touches the “Quarter” levels, as the Vcc is in bottom of water, conduction takes place at “Quarter”(base terminal of transistor) due to Vcc. This base current flows to emitter and the transistor gets active, as transistor is active the collector current also flows to emitter. In short we can say that if transistor gets active then it indicates that the transistor has sensed the particular level in the tank. This emitter current is given as input to the microcontroller, based on the input that gets; microcontroller gives the output as per our code. Similarly the transistor gets active whenever the water reaches “Half”, “3/4” and “Full” levels. The emitter currents of the transistors are given as input to the microcontroller. If water level won’t touch “Half” then the transistors will be inactive and there won’t be any emitter current.

Rain Detection

Here the emitter of the transistor (E) is connected to the microcontroller, a supply voltage (Vcc) of 12V is given to the bottom of the plate, whenever the rain falls, there will be conduction between the “Bottom” and “Base” terminal of BJT. When there will be conduction then transistor gets active and emitter current flows and when there is no conduction then emitter current won’t flow to microcontroller as input signal.

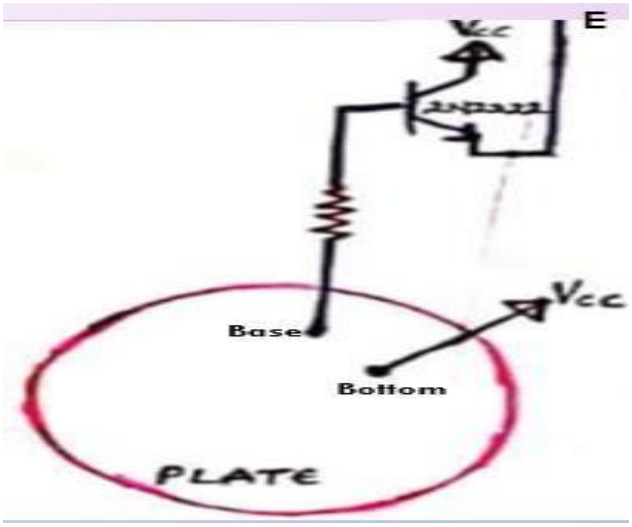


Figure 4.3: Rainfall detection and inputting E to Microcontroller

Automatic Switching

There are different switching devices available, Relay is one of them and the relay that we are using here is an electro mechanical relay, a 5 pin relay.

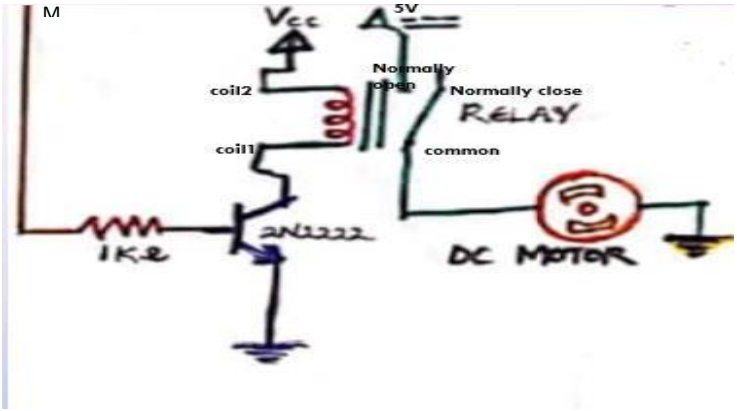


Figure 4.4.Automatic motor switching using Relay

Whenever the transistor will be active, the coil will be magnetized and attracts the switch, as the switching taken place, motor gets ON. Whenever the transistor will be inactive, the coil won’t be magnetized, so the switch will be in ‘Normally close’ position, motor will be OFF condition. Placing a PN junction diode in parallel to the coil will be

good because when the transistor gets inactive suddenly then the magnetic energy stored in the coil will be changed to voltage and because of this voltage heavy currents might flow through transistor, because of which the transistor might burn. So, placing diode across the coil will decrease the flow of heavy currents through transistor.

Alarm

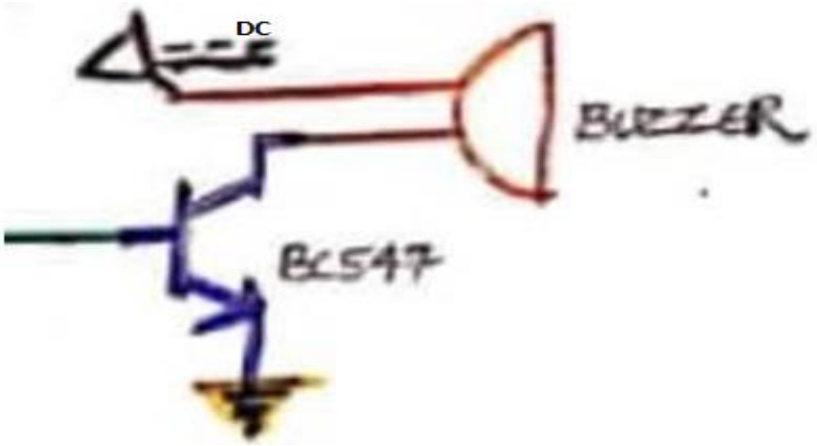


Figure 4.5: Circuit for Alarm when rainfalls

The end 'BUZ' is connected to microcontroller, From 4.2, we can detect rainfall, if we detect rain fall then we make BUZ high, if no rainfall then we make BUZ low. Whenever the pin of the microcontroller is high then the transistor will be in active state, the buzzer produces sound. If the pin is low then the transistor will be inactive, so the buzzer won't produce any sound.

Liquid Crystal Display

8 data pins (D0, D1, D2, D3, D4, D5, D6, and D7) of LCD are connected to any PORT of microcontroller (We connected to PORT2 as shown in Figure 4.1).

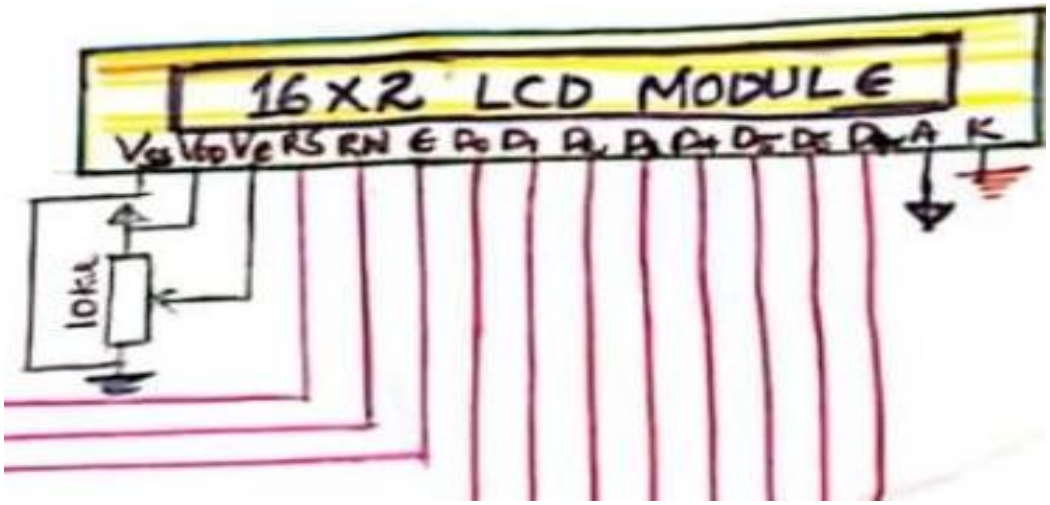


Figure 4.6: Liquid Crystal Display

Register select (RS), Read/Write (RW) and High/ Low (E)of LCD is connected to three pins of micro-controller(we connected to PORT1 first three pins).Vss, Vdd, Ve is connected to potentiometer for contrast adjusting. Anode (A), cathode (K)is connected with positive, negative terminal of battery.

Budget

Table 4.1: Financial (Budget) Requirements of the Proposed Research Project

Financial (Budget) Requirements of the Proposed Research Project					
Item	**Quantity**	**Activity date**	**Unit cost**	**Amount in Birr**	**Remark**
Personal:				**-**	
Design approval				8000.00	
Local travel:				**-**	
Contractual vehicle (Adama to Addis)	3	10	3000	30,000.00	
Field subsistence:				**0**	
Field Visit and Data Collection	3	30	206	18,540.00	
Testing and Validations	3	20	206	12,360.00	
Services:				**-**	
Equipment & materials:				**-**	
Atmega2560 with Arduino bootloader	2		4572	9144.00	
GSM shield module SIM900	2		1245	2490.00	
16×2 LCD Module for Arduino	2		700	1400.00	
TSD 10 turbidity	1		3567	3567.00	
Atlas Scientific ORP probe	1		3125	3125.00	
Power Adaptor	1		450	450.00	
HC-SR04 ultrasonic Sensor	1		1500	1500.00	
A buzzer.	1		150	150.00	
DS3231 RTC Module	1		1125	1125.00	

SD card module LC studio	1		1250	1250.00	
Micro SD card 32GB	1		450	450.00	
Light emitting diode (Red, Green, Blue)	4 pieces for each		20	240.00	
54 pin IC base for Atmega2560	2		750	1500.00	
AH44E (Hall effect sensor)	2		1367	2734.00	
1k resistor (Quantity - 2) 10k resistor	3		20	60.00	
IN4007 diode	1		20	20.00	
PIC 16F877A	2		450.00	900.00	
Relay 12V	3		155.00	465.00	
40pin DIP socket	1		150	150	
16 MHz Crystal oscillator	2		120	240.00	
7805 voltage regulator	4		50	200.00	
3.7 V 6 AH rechargeable polymer lithium ion battery	1		550	550.00	
1x470uf capacitor 1x10uf capacitor 2x22pf paper capacitor 1x100nf capacitor	5		40	200.00	
Consumable:					
Stationery, Materials	10 Pack for each		150.00	1500.00	
Total				102,310	
Contingency (10%)				**10,231**	
Grand Total				**112,541**	

Self Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1._____ **is** representing your charity's total operations. (7 points)

a. Super Communication.
b. Budget calculation
c. Supervisors
d. Organizational budgets

2. Financial expense includes (2oints)

a. Fixed expense
b. Fixed cost.
c. Communication
d. work

3. Fixed costs include _____. (1 points)

a. bill of material
b. managing a team
c. Rents
d. sales material

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 5	Constructing and testing prototype hardware systems

5.1. Constructing and testing prototype hardware

Early efforts at launching new electronic hardware products were long and complicated. However, with recent advances in microcontrollers and manufacturing techniques, such as 3D printing and injection molding, engineers and designers can now take products to market faster than ever.

Developing a prototype is a critical aspect of electronics hardware design, and one whose phases need to be followed closely, step by step. Accordingly, the following defines what a prototype is, before going on to discuss the stages involved in developing one. It is a preliminary model of a product from which newer models are developed. For electronic products, a prototype is the first version that is introduced to a small number of people for testing. Note, however, that prototypes may or may not be designed with the same materials, or on the same scale, as the final products.

Benefits of Developing Electronic Hardware Prototypes

Time and resources are some of the most essential metrics in industrial production.

Below are some of the key benefits of prototyping to the overall production process:

- The early detection and mitigation of design errors and product defects
- The provision of continuous, real-time feedback in the interest of optimizing product design
- General assistance in determining the machinery requirements for production
- The procurement of a proof of concept to obtain funding from investors and other project stakeholders
- Minimization of resource wastages particularly by determining material and labor requirements for full-scale production

Electronic hardware prototypes can also be of several types.

These include:

Proof of Concept Prototypes

A proof of concept prototype demonstrates to all parties involved in a project that a new product design will work as intended. Before human and capital resources are committed, designers and electrical engineers will usually demonstrate a working model

(on a pilot scale) to project managers and investors. This is to show that the target product is both technically and economically viable.

While a proof of concept prototype usually lacks the full functionality of a final product, it facilitates the changes that will need to be made before large-scale manufacturing is underway. And again, this leads to a reduction in production costs.

Functional Prototypes

Unlike proof of concept prototypes, functional prototypes have the same appearance and contain all the features and capabilities of the final products (although they may be built with cheaper materials).

To further reduce production costs before they reach the end users, moreover, functional prototypes are produced on a small scale. Then, only after the prototypes have been tested extensively, will the project stakeholders decide whether to pursue full-scale production or otherwise.

Virtual Prototypes

As the name suggests, virtual prototypes show the finished product in a visual form. Engineers may use computer-aided design/manufacturing (aka CAD/CAM) tools, circuit modeling or 3D modeling software to design, simulate, and of course test the system-level design of a product. The prototype is then revealed to project stakeholders and manufacturers, alongside further product designers who may suggest ways to improve the design.

Steps of Electronic Hardware Prototyping

Below are some essential steps involved in electronics hardware prototyping:

- **Schematic Design**

The first stage of building a prototype is in creating the schematic circuit diagram. The schematic is a system-level representation of the product that shows how the components will be interconnected in the final product. Schematics can be created using electronics design software such as PCB Web or KiCad EDA. After the design is finished, it is taken to a manufacturer to produce the bare PCB into which the vital components will be integrated. (Note: while producing such a board in-house may be viable for large companies, it is often expensive for startups, engineers, and hobbyists.)

- **Component Placement and Routing**

After obtaining the bare PCB, the next step is to determine the precise location of every component on the board. Component placement is a technical and highly-sensitive process that must satisfy both electrical and physical dimension rules. Using PCB design software for component placement saves time, minimizes design errors, and prevents costly production runs of defective products.

It's immediately following such placement that engineers need to create a layout with conductive tracings. These are used to link the various circuit components (resistors, capacitors, MOSFETs, etc.) that are embedded in the board.

- **Testing and Verification**

Having by now correctly placed and routed the circuit components, engineers are left to verify the final design against the original schematic for congruency. PCB design software can test for physical dimensions (e.g., wire widths, spacing are between conductive tracings, etc.), as well as electrical design rules (e.g., creep age and clearance). Additionally, engineers may perform quality checks, such as those needed to ensure that signal and power traces are kept separate, there is adequate grounding, and so on).

- ✓ **Debugging**

Debugging is a quality assurance (or QA) technique for finding and eliminating errors or defects in the prototype that the PCB manufacturer may have missed during the hardware part production.

- ✓ **Programming**

This stage involves programming a microcontroller, which is integrated into the board to add functionality and control to the product. Typically, this is achieved using a low-level language, such as C.

Industrial Design

During the final stage of production, the finished electronics are built into a suitable enclosure, such as one made of metal or thermoplastic. Modern products use advanced manufacturing techniques such as 3D printing (for low-volume production) or injection molding (for high-volume production). Electrical engineers will partner with industrial or materials engineers for this phase of the project.

Visual Prototype Designed

Software simulation and output is shown in Figure 5.1. For simulation we have used switch Buttons instead of BJT and water in a tank. In figure 7 the buttons of 'Quarter', 'Half', '3/4' are closed so the output on LCD is showing "3/4" full. Based on alarm we can open the cap of the tank.

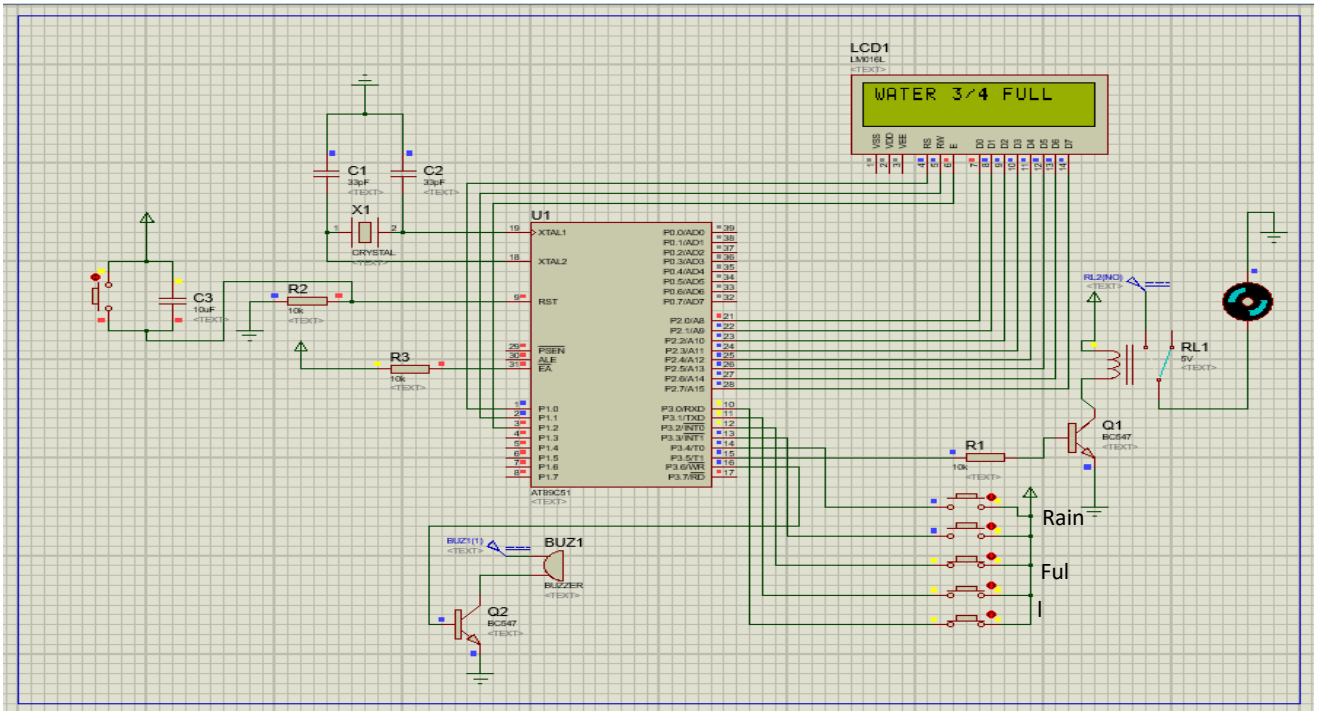


Figure 5.1: Circuit simulation output on Proteus software

Table 5.1: Tabular result for the above Proteus simulation in Figure 5.1

Seq. No.	Switch button (Quarter)	Switch Button (Half)	Switch button (3/4)	Switch button (Full)	Switch button (Rain)	Tank level	Motor	Alarm
1	0	0	0	0	1	Empty	ON	ON
2	1	0	0	0	0	Quarter	ON	OFF
3	1	1	0	0	1	Half	ON	ON
4	1	1	1	0	1	¾	ON	OFF
5	1	1	1	1	0	Full	OFF	ON

Expected outcome and benefits

Automatic water level controller helps in swimming pools, overhead water tanks and in industries and rain detection with alarm will be helpful for household Women/Men in getting the items like clothes that are kept in sunlight for drying and one can even open the cap of the overhead tank while raining and by this we can even utilize rain water.

The future scope of this project would be adding a mechanical device that can open and close the water tank cap automatically, while in times of rain, this can save lot more water and we can make these all in one device available to user for low cost.

Self Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1._____ is an early sample, model, or release of a product built to test a concept or process. (7 points)

a. Super Communication.

b. Prototype

c. Photo type

d. visors

2. _____is a test or preliminary model of an idea, design, process, interface, technology, product, service or creative work (2points)

a. Drawing

b. Product.

c. Prototype

d. work

3._____ is an early sample, model or release of a product created to test a concept or process (1 point)

a. Supervisors

b. Management

c. Product

d. prototype

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Information sheet 6	Rectifying and retesting malfunctions

6.1. Rectifying and Retesting Malfunctions Electronics Design

The cost and income plan created for a particular process or department operating within a business. For example, a functional budget for the manufacture of a product line might include estimated costs of production, marketing, sales, labor, equipment and materials, as well as projected sales income

Depending on the feasibility of these estimates, Budgets are of three types -- balanced budget, surplus budget and deficit budget. Depending on the feasibility of these estimates, budgets are of three types' balanced budget, surplus budget and deficit budget.

In-Circuit Test:

- Here, checking for shorts, opens, resistance, capacitance, and other basic quantities which will show whether the assembly was correctly fabricated.
- It may be performed with a bed of nails type test fixture and specialist test equipment.
- Based on the design of the circuit and complexity.
- it takes around five to fifteen minutes to undergo this process

Board Functional Test:

- Functional test (FCT) is used as a final manufacturing step providing a pass/fail determination on finished PCBs before they are shipped
- To validate that product hardware is free of defects that could, otherwise, adversely affect the product's correct functioning in a system application
- Requirements of a functional test, its development, and procedures vary widely from PCB to PCB and system to system
- The most common form of functional test, known as "hot mock-up" simply verifies that the PCB is functioning properly
- Generally time taken to undergo functional test is between fifteen and forty minutes

Self Check 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1._____ is the cost and income plan created for a particular process or department operating within a business. (7 points)

a. Super Communication.
b. Project budget
c. functional budget
d. Customer

2. Types of budget includes_____. (2points)

a. cost budget
b. Balanced budget
c. Communication
d. sales budget

Note: Satisfactory rating: 4.5 and above - Unsatisfactory Rating: below 4.5

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 7	Providing Solutions to unplanned events

7.1. Providing Solutions to unplanned events

Electrical utility is always hard at work making sure that their electrical production matches demand and that the electrical grid is in good working order. But despite those efforts, certain uncontrollable events like severe weather or sudden spikes in demand can cause an interruption in service. This can also happen as a result of overdue maintenance or damage to parts of the delivery system.

Brownout:

A brownout is different than a blackout. While a blackout causes total power loss for an extended period of time, a brownout is a bit different. In order to better protect your home, it's important for you to know why these happen and what you can do to make it through with as little damage as possible. Blackouts typically occur as a result of a weather-related or mechanical power failure. They result in total power loss until power is restored. A brownout, while sometimes caused by severe weather, is generally related to high electricity demands during peak times, and the resulting drop in voltage experienced across the electrical grid. In order to handle the surge in power, electric operators will reduce the power output so that they prevent serious damage or a full blackout. As a result, homes still have power during a brownout. They will simply be operating on a lot less power than what they normally have. Some bulbs might not work, outlets could be finicky, and you may or may not be able to get power to certain appliances and electronics, depending on how much the power was cut.

What to Look For

Typically, a brownout is exactly how it sounds. You'll notice first, usually, that your lights go dim or start to flicker, creating a brownish, dim glow. You may also see your appliances and electronics switching on and off, or notice that your Internet keeps getting interrupted because it can't maintain a solid power connection. Usually, the electric provider has done this intentionally and you won't need to notify them.

However, if it lasts for more than a few hours, you should probably give them a call to make sure that there isn't a bigger problem.

The constant surges and drops in power that come from a brownout can cause a lot of damage to computers and other electronics if they are plugged in during the incident.

The best thing that you can do is to unplug as many items as you can and turn off all lights and other power-drawing items that you don't absolutely need. If you have a home alarm system or electronic locks, you'll need to have a backup option in place to keep your home secure. You should also install surge protectors on every outlet to protect all of your devices. If possible, install a whole-home surge protection system at the circuit box so that your entire home is protected at its core.

To propose designs and choose between alternative solutions, plan for implementation, evaluate the solution and its consequences, and communicate the problem, process, and solution. Evaluations are an important means of generating recommendations to guide future work. Problems Evaluations can help prevent problems and provide an independent perspective on existing problems. When selecting an outcome for evaluation, look for those with problems or where complications are likely to arise because the outcome is within a sensitive area with a number of partners.

The same criteria for selecting outcomes should be applied to selecting project evaluations. Some partnership protocols require their related projects to be evaluated.

Self Check 7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1._____ is an important means of generating recommendations to guide future work. (7 points)

a. Implementation.
b. Report
c. Supervisors
d. Evaluations

2._____ Evaluations can help prevent Problems (2points)

a. Problems
b. Report
c. Communication
d. Solution

3. The same criteria for selecting outcomes should be applied to select_____. (1 points)

a. Supervisors
b. project evaluations
c. Communication
d. Leader

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Information sheet 8	Documenting Project design.

8.1. Documenting Project design.

The project design document (PDD) is the key document involved in the validation and registration of a CDM project activity. The PDD is reviewed by the DOE during the validation process to ensure that a project meets the requirements for validation.

The detailed design document- formally records the design of the content that is, the lessons or modules and all the deliverables necessary. The detailed design document records the design of content.

A design specification is a detailed document providing a list of points regarding a product or process. For example, the design specification could include required dimensions, environmental factors, ergonomic factors, aesthetic factors, maintenance that will be needed,

The Design is a short paragraph describing the problem to be solved, establishing the need for the product, and then setting out the specifications within which the product is to be developed. The Technical design document should focus to include information about product details, software development process product purpose and complete project information. So, this would remain as a form of a communication channel between stakeholders and developers.

During this stage, most of the design data are collected, analyzed, and used in evaluating alternative concepts for meeting project requirements. Data collectors and the client should frequently interact with the Design Team members as concepts are revised or rejected and additional design data needs or resources are identified.

Self Check 8	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided

1._____) is the key document involved in the validation and registration of a CDM project activity. (7 points)

a. Super Communication.
b. Conflict Resolution
c. **project design document**
d. visors

2. _____is a detailed document providing a list of points regarding a product or process.. (2points)

a. Report
b. managing a team
c. Communication
d. design specification

3. _____is a short paragraph describing the problem to be solved, establishing the need for the product (1 points)

a. Supervisors
b. Design
c. Communication
d. Design specification

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

LG #21	LO #4- Obtain approval for the design

Instruction sheet

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

- Presenting and explaining the design to the client
- Negotiating for modifications to the design with relevant person
- Obtaining Document and approval design from the appropriate person
- Monitoring quality of work

This guide will also assist you to attain the learning outcome stated. Specifically, upon completion of this Learning Guide, you will be able to:

- Present and explaining the design to the client
- Negotiate for modifications to the design with relevant person
- Obtain Document and approval design from the appropriate person
- Monitor quality of work

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information's
4. Accomplish the "Self-checks

Information sheet 1	Presenting and explaining the design to the client

1.1. Presenting and explaining the design to the client

This is the person responsible for managing the project on behalf of the client. This may be an individual from within the client's organization or may be a consultant, such as an architect, surveyor, engineer or project manage

A creative project proposal explains what you want to accomplish as it breaks down the things you need to achieve your main goal. This makes sure that both you and your client understand the objective and the outcome of the project with only clear expectations.

Prototyping of embedded hardware/software systems is important, because it shortens the path from specification to the final product. Special attention is given to prototyping in the industry to support the design and testing of multimodal and multifunctional embedded systems.

Self Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided.

1._____ is explains what you want to accomplish. (7 points)

a. abstract
b. Research
c. Supervisors
d. project **proposal**

2. _____explains what you want to accomplish as it breaks down the things you need to achieve your main goal (2points)

a. goals
b. managing a team
c. project **proposal**
d. work

3. The project **client's** organization or may be a consultant includes

a. Architect
b. managing a team
c. Communication
d. work

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Information sheet 2	Negotiating for modifications to the design with relevant person

2.1. Modifying design for the relevant person(s)

This section should describe any major changes in scope or implementation arrangements approved by subsequent to appraisal and whether the project design was flexible enough to accommodate necessary changes.

Critical Terminology As with any engineering discipline, electrical engineering is full of its own special words and lingo that can make electrical engineering speak sound like a foreign tongue. Buffer, bias, and couple are three such words that can often trip-up new comers. Buffer is one of those words that seem to have a different meaning in every discipline of science and engineering.

Buffer has two meanings in electrical engineering depending if the context is analog or digital electronics. In analog electronics, to buffer means to preserve the content of a low power signal and convert it to a higher power signal via a buffer amplifier.

This is a frequent operation in analog electronics since low power signals can be more easily interfered with than high power signals, but often only low power signals are available from electronic sensors. If signals are represented by voltage in a circuit, the power of the signal is proportional to the amount of current drawn by the circuit. Since current draw is dependent on the impedance of the circuit, a high impedance circuit has less power, while a low impedance circuit has more power. The function of a buffer amplifier in this case is to convert a high impedance circuit to a low impedance circuit.

This buffering scenario is represented by an equivalent circuit shown in where a voltage output electronic sensor has relatively high output impedance If the sensor output is used to drive a load impedance directly, much of the voltage signal may be lost to attenuation. In order to remedy this problem, a buffer amplifier is inserted between the sensor outputs. The input of the buffer amplifier measures this voltage signal with high input impedance and replicates the signal VIN with output impedance. Since is smaller than, the sensor signal can be used to drive without suffering significant attenuation.

Self Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided.

1._____ preserve the content of a low power signal and convert it to a higher power signal via a buffer amplifier. (7 points)

a. Super Communication.

b. electrical engineering

c. Buffer

d. visors

2. _____is full of own special words and lingo that can make electrical engineering speak sound like a foreign tongue. (2points)

a. Buffer

b. electrical engineering

c. Communication

d. work

3. What is the function of a buffer amplifier (1points?)

a. high impedance circuit

b. electrical engineering

c. Communication

d. Buffer

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Information sheet 3	Obtaining Document and approval design from the appropriate person

3.1. Final designing and document approval

Definition of required resources, and establishes design requirements and other major activities to develop the final designs.

The initial design schedule and estimated design cost or when possible, through should be presented by team members and reclamation managers for approval. Agreement with the scope of work and schedule signifies that the design activity plan milestone has been reached.

Periodic submittal dates must be incorporated into the design schedule. Field staff and the Design Team should establish priorities of design data requirements so the investigations focus on collection of the data that would most influence the concept selection.

The design team will define initial design data requirements, including the geotechnical design data, and establish the data submittal schedule. The selected conceptual design is refined and the designs completed to the point that specifications preparation can be initiated. Design data collection, testing, and analysis should be completed during the design stage. in special circumstances, however, interactive design data activities needed to provide more definitive information (especially sampling and testing) may be scheduled for completion after design if impacts on design time and design cost are understood and acceptable to reclamation managers. When it is agreed that the data can be used after design the design team should obtain concurrence by a decision memorandum.

Self Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided.

1._____ is the initial design data requirements. (7 points)

a. Communication
b. Electrical
c. Supervisors
d. design team

2. Initial design data requirements is including? (2points)

a. geotechnical data
b. design team
c. Communication
d. Electrical

3. _____ is refined the designs completed to the point that specifications preparation can be initiated. (1 points)

a. Supervisors
b. managing a team
c. conceptual design
d. design team

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Information sheet 4	Monitoring quality of work

4.1. Working Quality

Work quality is the value of work delivered by an individual, team or organization. This can include the quality of task completion, interactions and deliverables. Quality of work life (QWL) can be defined as the total quality of an employee's work life at an organization. Not only quality work of employees is tied to happier employees but also better business results. When the quality of work-life is stable, productivity is bound to increase.

Work quality is a common consideration in managing the performance of programs, projects, vendors and individuals.

Employee satisfaction and quality of work life directly affect company's ability to serve its customers. Efforts towards QWL measurement help in efficient and effective allocation of resources to enhance productivity and stability of the workforce.

Self Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Choose the best answer in the following question. Write the letter on a separate provided.

1._____ is the value of work delivered by an individual, team. (7 points)

a. Work quality.
b. Resolution
c. Supervisors
d. Work safety

2. Work quality includes _____. (2points)

a. Work safety
b. task completion
c. Communication
d. work report

3. _____is directly affect company's ability to serve customers (1 point)

a. Supervisors
b. management of work
c. Quality of work
d. Communication

Note: - Satisfactory rating: 6 and above - Unsatisfactory Rating: below 6

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

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AKNOWLEDGEMENT

We wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this TTLM.

We would like also to express our appreciation to the TVET instructors and respective industry experts of Oromia Regional TVET Bureaus, TVET College and Federal Technical and Vocational Education and Training Agency (FTVET) who made the development of this curriculum with required standards and quality possible.

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