Solar PV System Installation and Maintenance

Level-II

Learning Guide-62

Unit of competence:-	**Solve Basic DC & AC Circuit Problems in Photovoltaic Energy System**
Module Title:-	**Solving Basic DC & AC Circuit Problems in photovoltaic Energy System**
LG Code:	**EIS PIM2 M11 LO1-LG-62**
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LO 1: Prepare to work on DC and AC electrical circuits

Instruction Sheet	Learning Guide 53

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

- Identifying OHS procedures
- Following OHS risk control work preparation measurements
- Obtaining the nature of the circuit problem from documentation
- Coordinating advice sought from the work supervisor
- Identifying sources of materials.
- Inspecting tools, equipment and testing devices

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

- Identify, obtain and understand OHS procedures for a given work area.
- Follow OHS risk control work preparation measures and procedures
- Obtain the nature of the circuit problem is from documentation or undertake from work supervisor to establish the scope of work.
- Seek advice from the work supervisor to ensure the work is coordinated effectively with others.
- Identify and access sources of materials that may be required for the work in accordance with established procedures.
- Obtain and check Tools, equipment and testing devices needed to carry out the work are for correct operation and safety

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 "Sheet1, Sheet 2, Sheet 3 , Sheet 4 , Sheet 5 and Sheet 6" in page 4,12,14,18,20 & 23
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3 Self-check 4 Self-check 5 and Self-check6" **in page 11, 13 ,17, 19 ,22 and 25** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, "Operation Sheet2 and "Operation Sheet3 **in page -2628 & 29**
6. Do the "LAP test" **in page – 32**

Information Sheet-1	Identifying OHS procedures

1.1General Introduction

OSH and state safety laws have helped to provide safe working areas for electricians. Individuals can work safely on electrical equipment with today's safeguards and recommended work practices. In addition, an understanding of the principles of electricity is gained. Ask supervisors when in doubt about a procedure. Report any unsafe conditions, equipment, or work practices as soon as possible.

OHS includes the laws, standards, and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

- **Safety Procedures in a Workplace**

  Having the knowledge, skills and attitudes to carry out tasks safely is critical in any workplace. What skills will you need? Working safely is like driving safely. In order to work safely you need to know about:

  - ✓ OHS roles in the workplace
  - ✓ OHS training and inductions
  - ✓ Where to find OHS information
  - ✓ Relevant signs
  - ✓ Rules and procedures
  - ✓ keeping up-to-date
  - ✓ Reporting problems, accidents and incidents.

1.2. Personal protective equipment (PPE)

As PV systems get larger and direct current (dc) operating voltages up to 1,000 Volts (V) become increasingly common; arc flash requirements are a growing Concern and it is more common to see arc flash warning labels on combiner boxes and disconnects. Unfortunately for maintenance personnel, many existing PV systems have been installed without labels warning of arc flash hazard. Service personnel need to be able to perform on-site evaluations to determine when a higher category of PPE is required to perform the work. Tasks such as performing thermal imaging on operating inverters with opened coverings or doors or verifying voltages in switchgear commonly require arc flash rated PPE.

Figure 1-1. Clothing should fit comfortably to avoid danger of becoming entangled in moving machinery or creating a tripping or stumbling hazard.

- **Follow the signs**

Workplaces are signed to draw attention to hazards or requirements of different areas. Different types of signs in the workplace will be different colors and mean different things.

✓ **Mandatory signs**

Mandatory signs are ***blue*** and ***white.*** They tell you things that you must do in a work area. They are often used to tell people to wear safety equipment or stick to the walkways.

✓ **Caution signs**

Caution signs are ***yellow*** and ***black***. They indicate workplace hazards such as forklifts, noise, radiation areas or overhead cranes.

✓ **Danger signs**

Danger signs are always ***red***, ***black*** and ***white***. They indicate where no-go areas exist, such as high voltage areas or chemical storage areas.

Fig. 1.2 Safety signs showing type of PPE to worn

Fig .1.3 Breathing protection signs

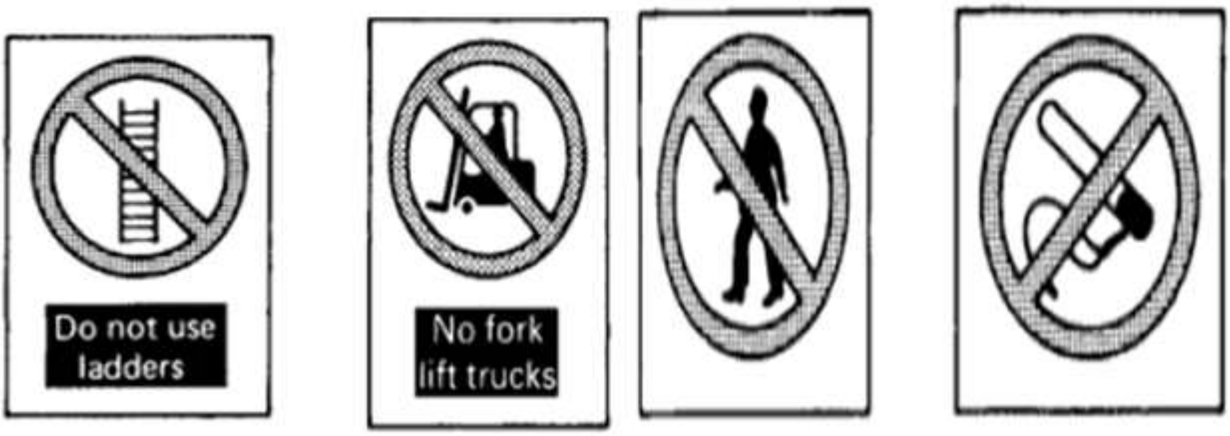


Fig.1.4 Prohibition signs

Fig. 1.5 Warning signs

1.3. Fuse Removal

A *fuse* is an electrical safety device that operates to provide over current protection of an electrical circuit.

- **Different Types of Fuses**

Fuses are invented first by "Thomas Alva Edison" but nowadays many **types of fuses** are available in the market. Generally, there are two types of fuses:-

✓ **DC Fuses:** DC fuses have larger in size. DC supply has constant value above 0V so it is hard to neglect and turn off the circuit and there is a chance of an electric arc between melted wires. To overcome this, electrodes placed at larger distances and because of this the size of DC fuses get increased.

✓ **AC Fuses**: AC fuses are smaller in size. They oscillated 50-60 times in every second from minimum to maximum. So there is no chance of Arc between the melted wires. Hence they can be packed in small size.AC fuses are further categorized into two parts, i.e.,

- **Low voltage fuses**

Example of low Voltage fuses:- Cartridge Type Fuses

Cartridge Type Fuses: It is the type of fuses in which they have totally closed containers & has the contact i.e., metal besides.

Fig 1.6 Cartridge Type Fuses

- **High voltage fuses**

Examples of High voltage fuses:- Cartridge Type HRC Fuse

Cartridge Type HRC(High rupturing capacity)Fuses:- are used for high current applications.

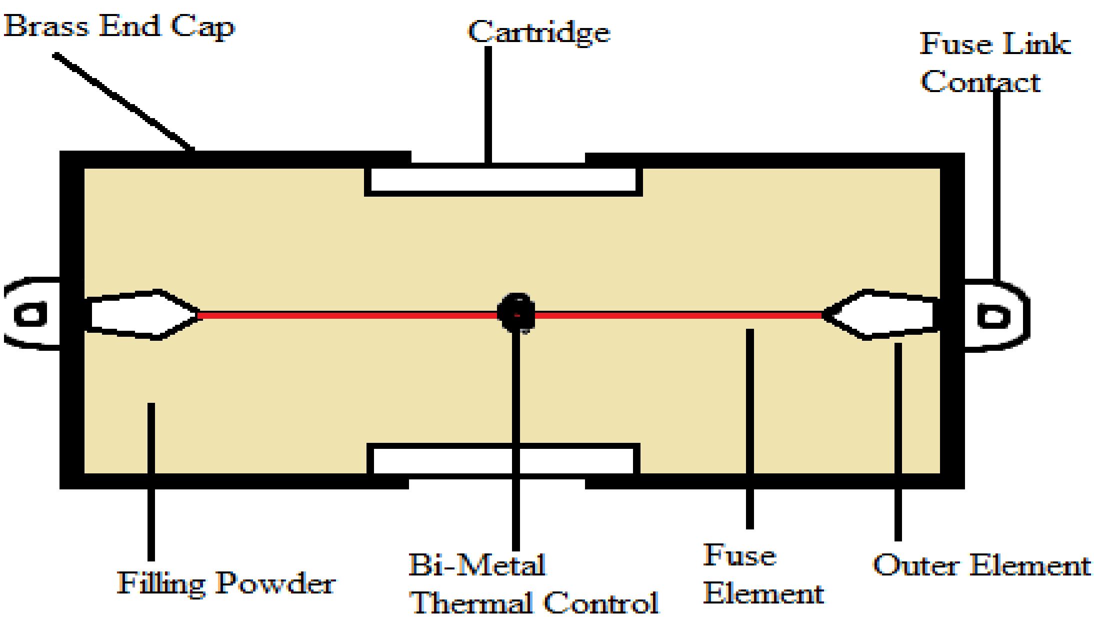


Fig.1.7 Cartridge Type HRC Fuses

- **Fuse replacement**

Fuses blow for a reason. Whenever a blown fuse is found, investigate why the fuse blew. When replacing fuses, it is essential to source the appropriate size, type, and rating. Do not assume that the fuse being replaced was the correct size, type, and rating, because an incorrect rating or size could be the reason the fuse blew. It may be necessary to consult the product manual to ensure the correct fuse is sourced. It is common to come across operating systems with incorrect fuses in place.

✓ Tools included when replacing fuses:
  - ohmmeter
  - PPE(gloves, goggle, safety shoe, helmet, apron)
  - screwdriver or combiner box key, if applicable;
  - fuse puller, if applicable; and
  - recording device (pen and paper, laptop or tablet preferred).

✓ **Safety considerations**
  - Fuses should never be replaced or tested while the circuit is energized. Shut the system down prior to servicing fuses.
  - Wear proper PPE for electrical voltage testing, at least until no voltage has been verified and the source has been locked out, if applicable.

1.4. Ground fault circuit interrupter (GFCI):

A ground fault circuit interrupter (GFCI) is an electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit. A potentially dangerous ground fault is any amount of current above the level that may deliver a dangerous shock. Any current over 8 mA is considered potentially dangerous depending on the path the current takes, the amount of time exposed to the shock, and the physical condition of the person receiving the shock.

Therefore, GFCIs are required in such places as dwellings, hotels, motels, construction sites, marinas, receptacles near swimming pools and hot tubs, underwater lighting, fountains, and other areas in which a person may experience a ground fault.

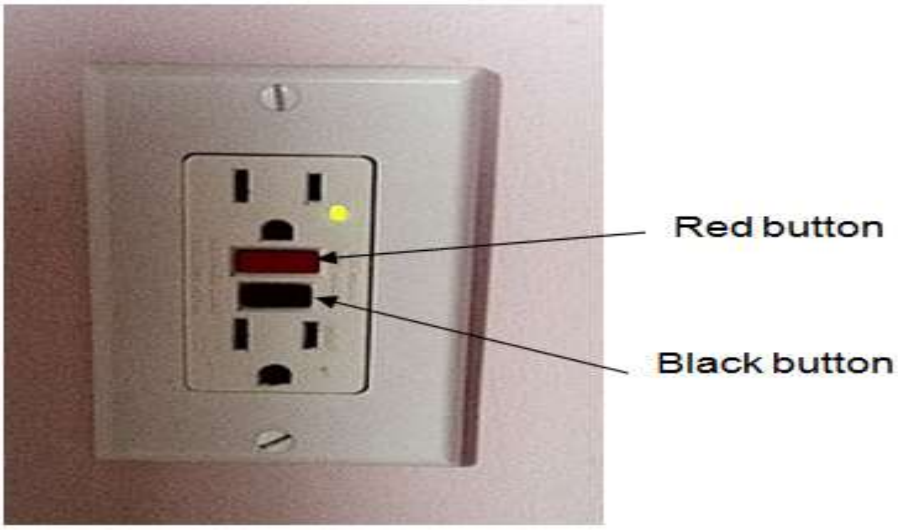


Fig.1.8 GFCI receptacle with red button for Test and black button for Reset

A GFCI compares the amount of current in the ungrounded (hot) conductor with the amount of current in the neutral conductor. If the current in the neutral conductor becomes less than the current in the hot conductor, a ground fault condition exists. he amount of current that is missing is returned to the source by some path other than the intended path (fault current). A fault current as low as 4 mA to 6 mA activates the GFCI and interrupts the circuit.

1.5. Electrical Shock

Strange as it may seem, most fatal electrical shocks happen to people who should know better. It's not the voltage but the current that kills. People have been killed by 100 volts AC in the home and with as little as 42 volts DC. The real measure of a shock's intensity lies in the amount of current (in milliamperes) forced through the body. Any electrical device used on a house wiring circuit can, under certain conditions, transmit a fatal amount of current. Currents between 100 and 200 milliamperes (0.1 ampere and 0.2 ampere) are fatal. Anything in the neighborhood of 10 milliamperes (0.01) is capable of producing painful to severe shock

1.6. FIRST AID FOR ELECTRIC SHOCK:

Shock is a common occupational hazard associated with working with electricity. A person who has stopped breathing is not necessarily dead but is in immediate danger. Life is dependent on oxygen, which is breathed into the lungs and then carried by the blood to everybody cell. Since body cells cannot store oxygen and since the blood can hold only a limited amount (and only for a short time), death will surely result from continued lack of breathing.

However, the heart may continue to beat for some time after breathing has stopped, and the blood may still be circulated to the body cells. Since the blood will, for a short time, contain a small supply of oxygen, the body cells will not die immediately. For a very few minutes, there is some chance that the person's life may be saved. The process by which a person who has stopped breathing can be saved is called artificial ventilation (respiration). The purpose of artificial respiration is to force air out of the lungs and into the lungs, in rhythmic alternation, until natural breathing is reestablished. Records show that seven out of ten victims of electric shock were revived when artificial respiration was started in less than three minutes. After three minutes, the chances of revival decrease rapidly.

Artificial ventilation should be given only when the breathing has stopped**.** Do not give artificial ventilation to any person who is breathing naturally. You should not assume that an individual who is unconscious due to electrical shock has stopped breathing. To tell if someone suffering from an electrical shock is breathing, place your hands on the person's sides at the level of the lowest ribs. If the victim is breathing, you will usually be able to feel movement.

Once it has been determined that breathing has stopped, the person nearest the victim should start the artificial ventilation without delay and send others for assistance and medical aid. The only logical, permissible delay is that required to free the victim from

contact with the electricity in the quickest, safest way. This step, while it must be taken quickly, must be done with great care; otherwise, there may be two victims instead of one.
In the case of portable electric tools, lights, appliances, equipment, or portable outlet extensions, the victim should be freed from contact with the electricity by turning off the supply switch or by removing the plug from its receptacle. If the switch or receptacle cannot be quickly located, the suspected electrical device may be pulled free of the victim. Other persons arriving on the scene must be clearly warned not to touch the suspected equipment until it is reenergized.

The injured person should be pulled free of contact with stationary equipment (such as a bus bar) if the equipment cannot be quickly reenergized or if the survival of others relies on the electricity and prevents immediate shutdown of the circuits.
Once the victim has been removed from the electrical source, it should be determined whether the person is breathing. If the person is not breathing, a method of artificial respiration is used.

Self-Check -1	Written Test

Directions: - For the following statements, write TRUE if it is correct or write FALSE if it is incorrect on another answer sheet..

1. OHS includes the laws, standards, and programs.
2. Mandatory signs are indicated by yellow and black colors.
3. AC fuses are larger than DC fuses in size.
4. A fault current as low as 4 mA to 6 mA activates the GFCI and interrupts the circuit.
5. Most fatal electrical shocks are the result of current rather than voltage

***Note:* Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Information Sheet-2	Following OHS risk control work preparation measurements

2.1 Safety requirements

Safety begins with adequate planning and preparation. Effective safety policies must be in place and employees and contractors must be familiar with—and committed to following—safety procedures in order to prevent accident or injury. Major safety requirements during PV servicing include the proper use of lockout/ tagout procedures, the use of personal protective equipment (PPE), procedures for safely disconnecting live circuits, and appropriate observation of and compliance with all PV-specific system signage and warnings.

- **Lockout/Tagout**

Lockout/tagout (LOTO) procedures are designed to ensure safe working practices and must be strictly followed whenever systems are de-energized prior to servicing. LOTO is required when energized equipment is serviced or maintained, safety guards are removed or bypassed, a worker has to place any part of his or her body in the equipment's point of operation, or hazardous energy sources are present. In most cases, a LOTO procedure involves two pieces of equipment:

✓ A lock that will be secured to the power source & prevent it from being switched on

✓ A tag attached to the locked device that cautions others not to attempt to use it

✓ **Proper LOTO labeling includes**:

- name of the person placing the LOTO and the date placed,
- details regarding the shutdown procedure for specific equipment,
- a list of all of the energy sources and isolating devices, and
- labels indicating the nature and magnitude of stored potential or residual energy within the equipment.

✓ **A lockout/tagout is used when:**

- Servicing electrical equipment that does not require power to be ON to perform the service
- Removing or bypassing a machine guard or other safety device
- The possibility exists of being injured or caught in moving machinery
- Clearing jammed equipment
- The danger exists of being injured if equipment power is turned ON

Self-Check 2	Written Test

Directions: - For the following statements, write **TRUE** if it is correct or write **FALSE** if it is incorrect on another answer sheet.

1. Safety begins with adequate planning and preparation
2. LOTO is required when de- energized equipment is serviced or maintained.
3. When LOTO is required, lock and tag all energy isolating devices,
4. LOTO is not required when removing or bypassing a machine guard or other safety device.
5. Major safety requirements during PV servicing are lockout/tagout.

Name: ________________________________ Date: _______________

3.1 Introduction to nature of the problem on DC and AC in PV System

Low power PV installation technicians need effective strategies for identifying and correcting problems quickly. System operators or owners may become aware of a PV installation's underperformance through one of the following means:

- a predefined Data acquisition system (DAS) alert, which may be weather-related, a result of comparison with other systems in the portfolio, or a result of comparison with other monitored parts of the system at a site with multiple inverters;
- a manual review of the DAS data through online portal that indicates performance irregularities;
- a comparison of present performance with performance test results from previous maintenance visits; and
- customer or external entity reports of a potential problem, often because of an unexpected increase in a monthly bill.

3.2 Managing Energy Flow in Off-Grid PV Systems

When off-grid solar electric systems fail, the most common cause is poor system management or poor design and installation. Too often off-grid PV system owners do not understand how much energy their system is collecting and how much energy their appliances are using. Consequently, they manage energy poorly and their batteries are continually in a low state of charge. Continually discharged batteries are a major cause of battery – and system – failure. The section below is intended to help you gain an understanding of energy management in PV systems.

- **Collecting and storing more energy**
  - ✓ Keep modules clean
  - ✓ Keep batteries well-charged.
  - ✓ Keep batteries clean.
  - ✓ .Ensure proper connections and cable choice.

3.3 Active Management of Collected Solar Energy

Load management is the practice of making sure that energy demand balances the harvest of electrical energy from the sun. This means that use of electrical energy must be carefully monitored and controlled, especially during cloudy periods. Properly functioning off-grid PV systems are actively managed by their owners: when there is excess solar, this is utilized, and when available energy is constrained, energy use is reduced.

- **Understand systems' energy collection and use limitations**
  Use the information in the system-planning section to understand energy flows in systems. System owners need to be aware which months have the lowest energy availability and take actions to reduce consumption during those periods.

- **Use loads according to the system design and turn off appliances not in use.**
  Systems are designed to produce a given amount of electricity. Appliances should be used according to the plan for their use. If a TV is supposed to be used for four hours, then eight hours of daily use will inevitably drain the battery

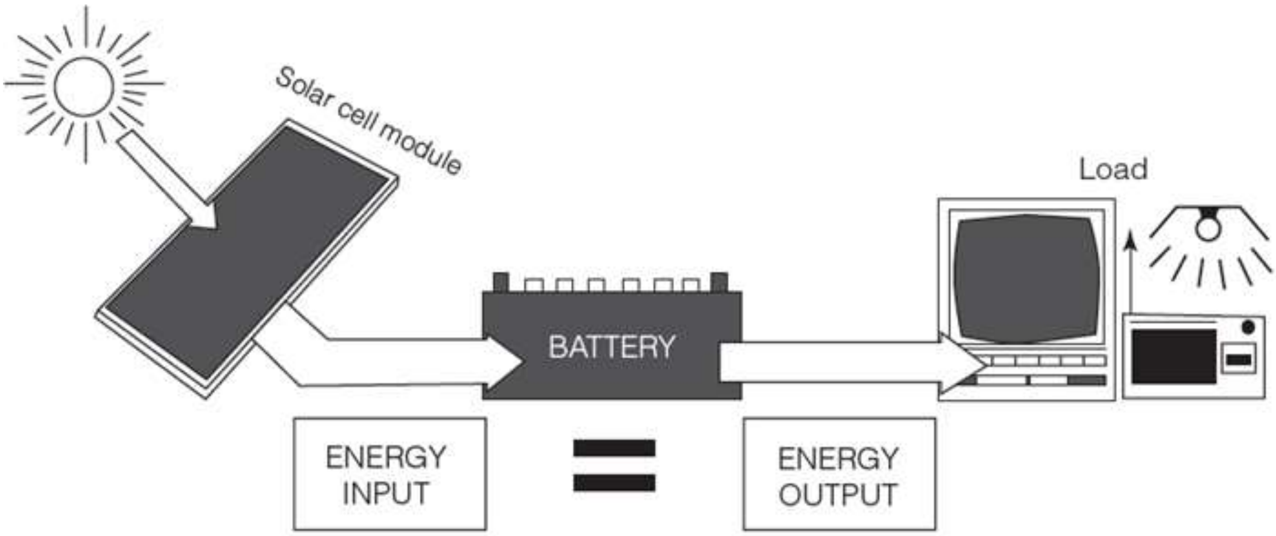


Figure 3.1 *The energy output to the loads must be balanced by the energy input from the array*

- **Reduce power use during cloudy weather**
  During cloudy months the array output is likely to be reduced by one-third or more. The load may therefore have to be reduced to protect the batteries.

- **Monitor and control load-demand increases**
  A common problem with off-grid PV systems is that there is a 'creeping' increase in load demand. Often, after a period of well-managed use, energy demand creeps upwards. People add appliances to the system without thinking and start to use them for longer periods. System managers must be watchful to prevent or plan for this.
  - ✓ Keep records of daily battery voltage and any other parameters that your system metering allows. Do this in a log book .
  - ✓ Plan for additions of appliances and loads .If you add appliances, increase the size of the solar array and battery bank according to the increase in the load.
  - ✓ Talk to all energy users to make sure they understand the limitations of the system. Encourage them to understand how the system works.

3.4. Technical Solutions to Reduce Energy Use

- **Use efficient appliances and lamps**
  Fluorescent tube and LED lamps are always preferable to incandescent lamps. When buying appliances such as radios, televisions, computers, refrigerators or sewing machines, choose types that use less power but still meet your requirements.

- **Use timer switches on lamps and loads**
  Timer switches turn lights and appliances on and off automatically so that energy is not inadvertently wasted. There are two types of timer switches:
  - ✓ **Controller-based timers**. Located in the control system, this type of timer turns major circuits on and off at times set by the system manager.

- ✓ **Appliance-based timers**. This type of timer is simply a switch with a timing device inside it that automatically turns the light off after a preset amount of time (e.g. five minutes).

- **Put reflectors on lamps and paint walls with a light color**

In situations (such as schools, clinics or workshops) where solar power is primarily used for lighting, place reflectors on lamps used in work area.

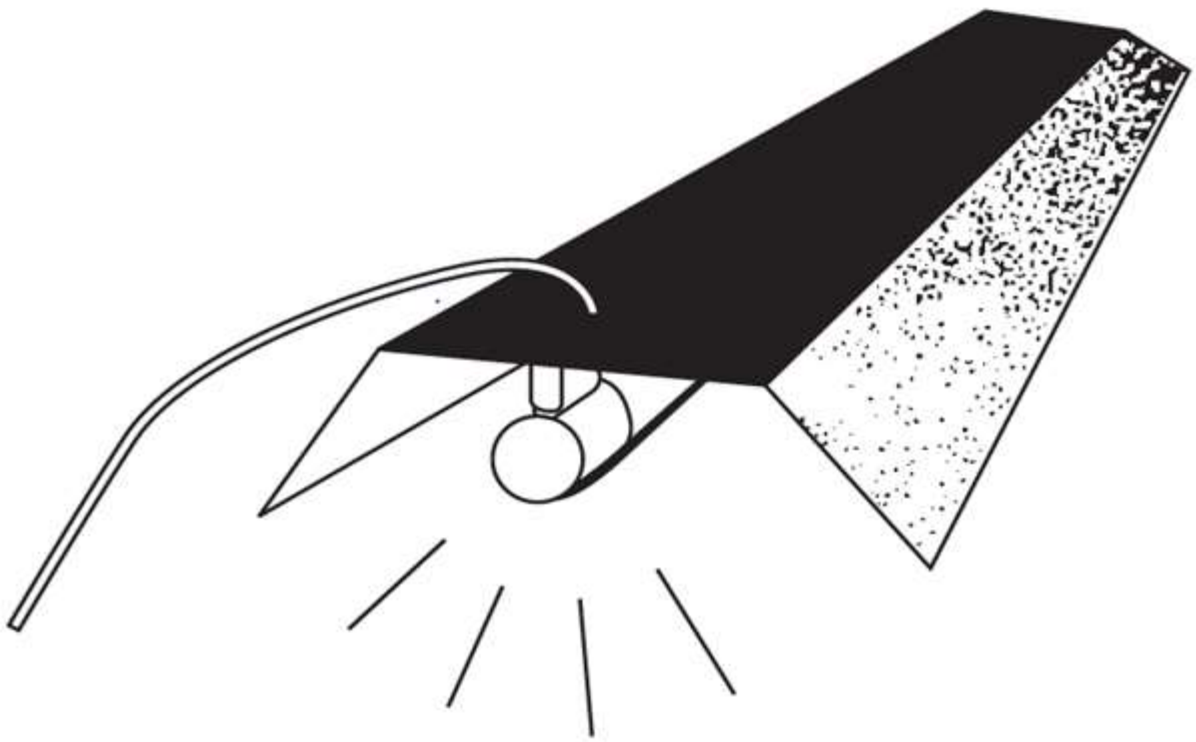


Figure 3.2 ***Reflector fitting***

Self-Check -3	Written Test

Directions: - For the following questions, choose the correct answer from the given alternatives and write the **letter** of your choice in **uppercase** on the answer sheet.

1. Low power PV installation technicians need effective strategies for:
   A. Correcting problems quickly
   B. Identifying problems
   C. Buying new solar cells
   D. A and B are correct
   E. A and B are incorrect
2. One of the followings is **NOT** correct about collecting and storing more energy in PV system:
   A. Keep batteries discharged.
   B. Keep batteries clean.
   C. Keep modules clean.
   D. Ensure proper connections and cable choice.
   E. None of the above
3. One of the followings is **NOT** correct about active management of collected solar energy:
   A. Understand systems' energy collection and use limitations
   B. Use loads according to the system design and turn off appliances not in use
   C. Reduce power use during cloudy weather
   D. Monitor and control load-demand increases
   E. None of the above
4. Which one of the following is **TRUE** about reducing energy use in PV system:
   A. Use efficient appliances and lamps
   B. Use timer switches on lamps and loads
   C. Put reflectors on lamps and paint walls with a light color
   D. All of the above
   E. None of the above
5. Appliance-based timers turn major circuits on and off at times set by the system manager.
   A. True
   B. False

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Name: ___________________________ Date: ________________

Information Sheet-4	Coordinating advice sought from the work supervisor

4.1 Introduction

Asking for advice is a nice implicit way of complementing a more senior colleague — you wouldn't be asking unless you respected that person's skills and judgment — but it doesn't require you to say or do anything obsequious. It demonstrates humility, but in a way it also demonstrates competence since it will seem awfully clever of you to have had the good sense to ask *your supervisor* for advice since he will naturally think he's experienced person to the wok.

- **Advice-seekers are seen as warm and humble**

People really like people who ask them for advice, perceiving advice-seekers to be warmer, more humble, and more cooperative than non-seekers.

- **Advice-seekers are more likely to be promoted**

But this isn't just a question of getting the supervisor to say nice things about you. In job performance reviews, advice-seekers were significantly more likely to be recommended for promotion than non-seekers.
Getting and giving good quality advice means that we have an accurate idea of how we are going at work. We all need to hear:

- ✓ what we do well; and
- ✓ What improvements we can make.

4.2 Why do we constantly seek advice?

There are many reasons. Most common is that we are not expert in a particular area and we have somebody around with better knowledge. He/she is a good person and kind enough to listen to your request for advice.

4.3 How do you ask your supervisor for more support?

Find your supervisor's potential to be a multiplier by using the following ideas:

- ✓ Be realistic.
- ✓ Don't be afraid to ask for support- but do so at critical junction points. ...
- ✓ Ask if there's more help you can give.
- ✓ Demand feedback.
- ✓ Know your supervisor's preferences.

Self-Check 4	Written Test

Directions: - For the following statements, write **TRUE** if it is correct or write **FALSE** if it is incorrect on another answer sheet.

1. Every person is expert in a particular area.
2. Asking for advice is a nice understood way of complement.
3. Be realistic has no any impact on asking advice.

Information Sheet-5	Identifying sources of materials.

5.1 Tools required for operation and maintenance

Solar micro-grid systems are generally installed in remote locations. Therefore, it is important that all essential tools, spares and consumables are kept in the site ready for use. A list of such tools and materials are listed below.

Fig.5.1 Tools and accessories for O&M and troubleshooting of micro-grid system

5.2 Safety Equipment

Following (5.2.1) is a list of recommended safety equipment that you should have available. Check these items against a site safety plan and check to make sure all equipment is in working order before beginning a job.

5.2.1. Personal Safety Resources

- A work partner (never work alone!)
- An understanding of safety practices, equipment, and emergency procedures
  Safety checklists
- Safety helmets & eye protection

- Battery safety accessories
- Appropriate safety harnesses, if working on elevated sites
- Proper measuring equipment: electrical and dimensional
- Tape and use wire nuts or cable connectors on end of cables

5.2.2. Site Safety Resources

- First-aid kit
- Fire extinguisher
- Appropriate ladders
- Appropriate lifting equipment
- Safety goggles, apron, gloves

Self-Check 5	Written Test

Directions: - For the following statements, write **TRUE** if it is correct or write **FALSE** if it is incorrect on another answer sheet.

1. First-aid kit is a site safety resources
2. Solar micro-grid systems are generally installed near locations.
3. Before beginning a job, all equipment must check and arranged in working order.
4. Working alone is better than working with partner.

Information Sheet-6	Inspecting tools, equipment and testing devices

6.1. Introduction

The purpose of an inspection is to identify whether work equipment, tools and testing devices can be operated, adjusted and maintained safely. With any deterioration detected and remedied before it results in a health and safety risk. Not all work equipment needs formal inspection to ensure safety and, in many cases, a quick visual check before use will be sufficient. However, inspection is necessary for any equipment where significant risks to health and safety may arise from incorrect installation, reinstallation, deterioration or any other circumstances.

6.2. What you must do?

You should inspect work equipment, tools and testing devices if your risk assessment identifies any significant risk (for example, of major injury) to operators and others from the equipment's installation or use. The result of the inspection should be recorded and this record should be kept at least until the next inspection of that equipment. Records do not have to be made in writing but, if kept in another form (e.g. on a computer), these should be held securely and made available upon request by any enforcing authority.

Work equipment that requires inspection should not be used, unless you know the inspection has taken place. Where it leaves your undertaking, or is obtained from another (e.g. a hire company) it should be accompanied by physical evidence of the last inspection, such as an inspection report or, for smaller items of equipment, some form of tagging, color coding or labeling system.

6.3. What you should know?

Specifies the circumstances where inspection is required to ensure healthy and safe conditions are maintained:

- where the safety of work equipment depends on the installation conditions, it should be inspected after installation and before first use, and after reassembly at any new site / location
- at suitable intervals, where work equipment is exposed to conditions causing deterioration liable to result in dangerous situations
- each time exceptional circumstances (e.g. major modifications, known or suspected serious damage, substantial change in the nature of use) are liable to have exposed the safety of the work equipment

6.4. What should the inspection cover?

This will depend on type of work equipment, its use and the conditions to which it is exposed. An inspection should concentrate on those safety-related parts which are necessary for the safe operation of work equipment and, in some cases; this may require testing or dismantling. However, not all safety-critical features on a particular item of work equipment may require inspection at the same intervals.

An inspection can vary in its extent, as the following demonstrate:

- quick checks before use (e.g. electric cable condition on hand-held power tools, functional testing of brakes, lights on mobile machinery)
- more extensive examinations, undertaken every few months or longer (e.g. general condition of a ladder, close examination of a safety harness, portable appliance testing)

6.5. When should work equipment, tools and testing devices that needs inspection be re-inspected?

Work equipment which is exposed to conditions causing deterioration that could result in a dangerous situation should be inspected at suitable intervals, and after every event liable to jeopardize its safety. The frequency of inspection may vary; depending on environmental conditions (e.g. equipment subject to harsh outdoor conditions is likely to need more frequent inspections than if used in an indoor environment).

The frequency of inspection should be determined through risk assessment, taking account of the manufacturer's recommendations, industry advice and your own experience. It may be appropriate to review the frequency of inspection in the light of your experience. Intervals between inspections can be increased if the inspection history shows negligible deterioration, or shortened where experience shows this is necessary to prevent danger.

6.6. Who should carry out the inspection of work equipment?

Equipment can be inspected by anyone who has sufficient knowledge and experience of it to enable them to know:

- what to look at
- what to look for
- what to do if they find a problem

The necessary level of competence will vary for inspections, according to the type of equipment and how / where it is used. The nature of these inspections does not have to be determined by the same person who undertakes them, provided the person determining them is competent. This can often be done in-house by experienced staff, taking account of:

- the manufacturer's recommendations
- industry advice
- their own experience of the equipment, its use, the particular factors of the workplace and the people using the work equipment

Self-Check 6	Written Test

Directions: - For the following questions, choose the correct answer from the given alternatives and write the **letter** of your choice in **uppercase** on the answer sheet.

1. The purpose of an inspection is:
   A. To identify whether work equipment, tools and testing devices can be operated safely
   B. To identify whether work equipment, tools and testing devices can be adjusted safely
   C. To identify whether work equipment, tools and testing devices can be maintained safely.
   D. All of the above
2. Equipment can be inspected by anyone who has sufficient knowledge and experience to:
   A. Enable what to look at
   B. Enable what to look for Enable
   C. Enable what to do if they find a problem
   D. .All of the above
   E. None of the above
3. One of the followings is NOT correct statement about inspection:
   A. Work equipment that requires inspection should not be used
   B. Inspection is done when at intervals, where work equipment is exposed to conditions causing
   C. The frequency of inspection should be determined as the result of risk assessment.
   D. .All of the above
   E. None of the above

Operation Sheet 1	CONTENT- Identifying OHS procedures

Implementation of - First Aid for an individual when he/she victims with electricity.

Assuming that an individual is exposed to electric shock:

Therefore, to free the victim from contact with the electricity in the quickest, safest way, exercise or do the following activities.

Step 1. Furnish yourself with appropriate PPE
Step 2. Unplugs the appliance or turn off the power at the control panel.
Step 3. Protect yourself with dry insulating material.
Step 4 Do NOT touch the victim until the source of electricity has been removed
Step 5. Use nonconductive material to free the victim from electrical contact.
Step 6- Determined whether the person is breathing
Step 7. Place your hands on the person's sides at the level of the lowest ribs
Step 8. use a method of artificial respiration if the person is not breathing
Step 9 . Apply mouth-to-mouth resuscitation if the victim is not breathing
Step 10. Do not give artificial ventilation to any person who is breathing naturally.

Fig 1. 1First Aid for Electric Shock Victims

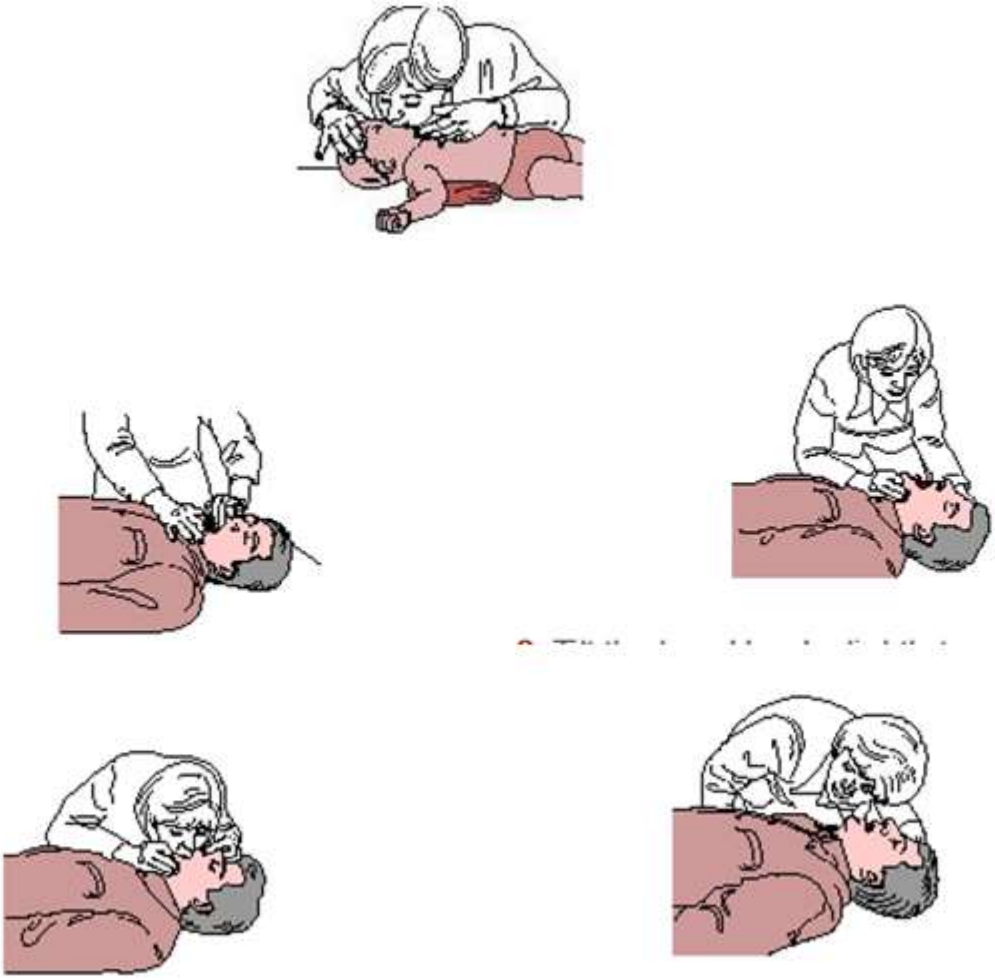


Fig 1 .2 Emergencies and First Aid - Mouth-to-Mouth Resuscitation

Operation Sheet -2	Following OHS risk control work preparation measurements(2)

Objective: Servicing or maintaining energized equipment or machines.

Activity: Before the maintenance or service work, Lockout/tagout the electrical energy distribution board by apply the following steps..

Step 1. Furnish yourself with appropriate PPE

Step 2. Notify others that the equipment will be shut down

Step 3. Perform a controlled shutdown to power down the equipment,

Step 4 open all of the energy isolating devices identified on the equipment's specific LOTO procedure,

Step 5. Lock and tag all energy isolating devices,

Step 6- dissipate or restrain stored or residual energy

Step 7. Verify that the equipment is completely de-energized by testing for voltage with a voltmeter ,

.

Operation Sheet -3	Inspecting tools, equipment and testing devices(6)

Objective: **Inspection of Equipment and testing devices**

Before the inspection or service work; furnish yourself with appropriate PPE and perform the following tests appropriately using the following steps.

Task I. Inspection and maintenance of Earthing and Lightening Protection

1. Check the continuity of the entire grounding system using an ohmmeter
2. Perform ground test for Earthing and Lightening Protections.
   N.B. Make sure that all module frames, metal conduit and connectors, junction boxes, and electrical components chassis are earth grounded.

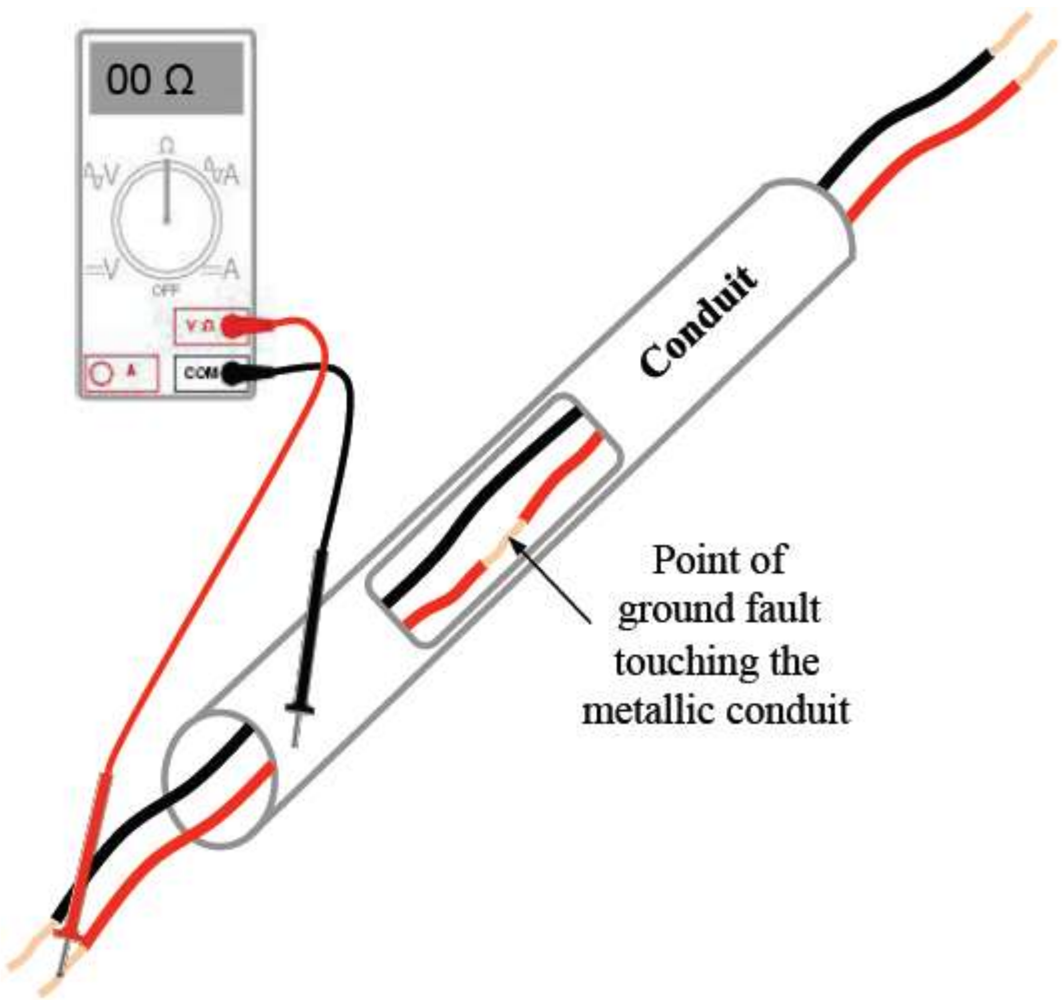


Fig.3.1 finding a ground fault

Task II. Inspection and maintenance of System Wiring

1. Check visually all conduit and wire insulation for damage.
2. Check for loose, broken, corroded, or burnt wiring connections.
3. Check if all equipments are connected with proper wire and conduit
4. Check all terminals and wires for loose, broken, corroded, or burnt connections or components.
5. Make sure all wiring is secured, by gently but firmly pulling on all connections.

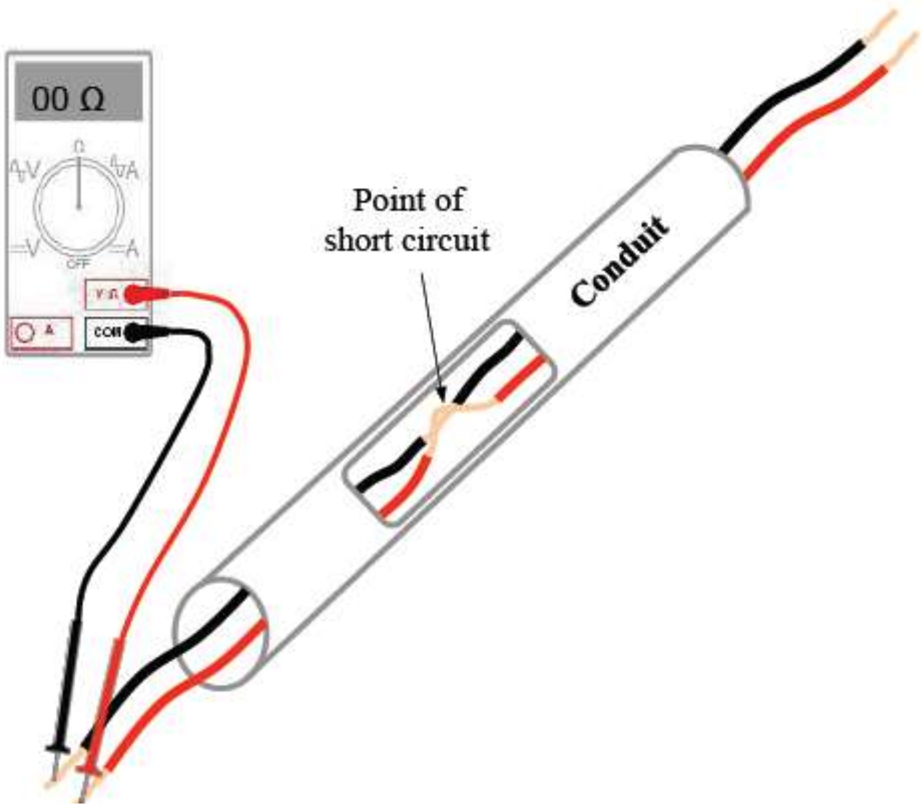


Fig.3.2 finding a short circuit

Task III. Inspection and maintenance of Batteries

For the following *Battery load test:* an accurate DC voltmeter is required.

1. Operate the system loads from the batteries for five minutes.
   This will remove any minor "surface charge" the battery plates may have. Turn off the loads and disconnect the batteries from the rest of the system.
2. Measure the voltage across the terminals of every battery, as shown in Figure 3.4 below. If external cell connectors are used, measure the voltage across each cell, as shown in Figure.

N.B Do not attempt to measure individual cell voltages unless the connectors are external. *Measuring.*

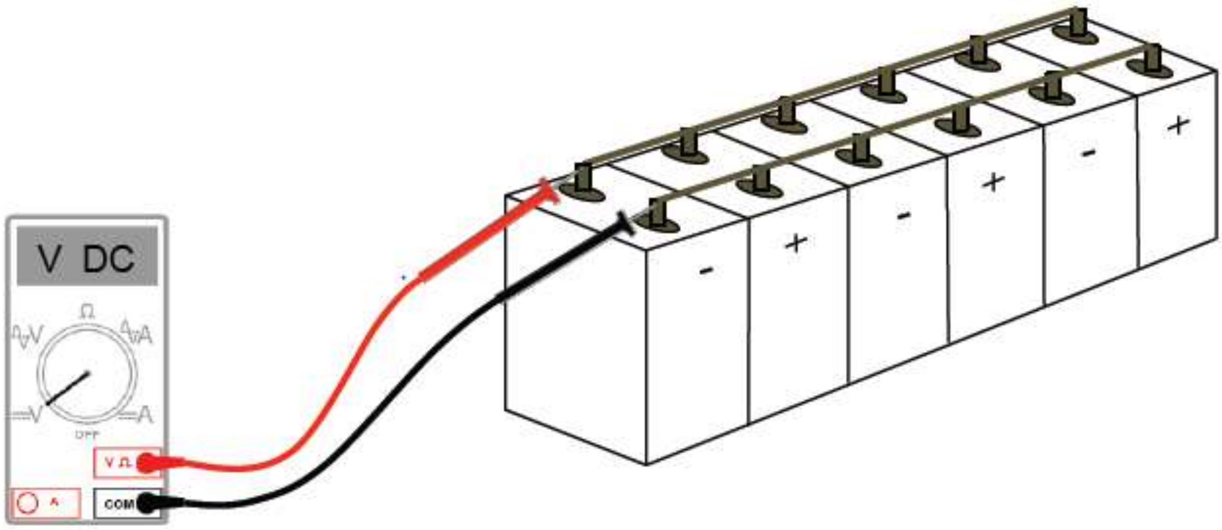


Fig.3.3 Measuring the Open Circuit Voltage of Cells with External Connections

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Select the necessary hand tools and voltmeter, and then perform the following tasks within **30**minutes.

Task 1: Perform *Battery load test*.

NB. Turn off the loads and disconnect the batteries from the rest of the system.

Task 2. Replace a blown fuse using appropriate hand tools and necessary PPE

List of Reference Materials

1. https://greenliving.lovetoknow.com/Why_Is_Solar_Energy_Important
2. Installation, Operation & Maintenance of Solar PV Microgrid Systems
   First Edition
   GSES India Sustainable Energy Pvt. Ltd.
   for Clean Energy Access Network (CLEAN)
3. Stand-Alone Solar Electric Systems,The Earthscan Expert Handbook for Planning, Design and Installation,
   Mark Hankins
   series editor:
   frank Jackson

4. https://www.safeworkaustralia.gov.au/doc Model Work Health and Safety Regulations

Solar PV System Installation and Maintenance

Level II

Learning Guide-63

Unit of competency	**Solve basic DC,AC circuit problem**
Module title	**Solving basic DC,AC circuit problem**
LG code:	**EIS PIM2 M11 LO2-LG-63**
TTLM code:	**EIS PIM2 TTLM 0919v1**

LO2: Solving DC and AC circuit problems

Instruction Sheet	Learning Guide #54

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

- Following OHS risk controls
- Determining the need of live test/ measure
- Checking circuits.
- Methods of DC and AC circuits fault finding and maintenance
- Photo voltaic power system
- Dealing Unexpected situations with safely
- Solving problems without damage

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

- Follow OHS risk control work measures and procedures are.
- Determine the need to test or measure live is in strict accordance with OHS requirements and when necessary conducted within established safety procedures.
- Check Circuits as being isolated where necessary in strict accordance OHS requirements and procedures.
- Use Established methodological techniques to solve DC and AC circuits fault finding and maintenance problems from measure and calculated values as they apply to electrical circuit.
- Deal Unexpected situations are with safely and with the approval of an authorized person.
- solve Problems without damage to apparatus, circuits, the surrounding environment or services and using sustainable energy practices

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 "Sheet 1,Sheet 2, Sheet 3,Sheet 4 Sheet 5, Sheet 6 and Sheet 7" in 36,41,48,52,64,70 and 74 respectively.
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3, Self-check 4, Self-check 5, Self-check 6 and Self-check 7" in page 40,47,51,63,69,73 and 77 respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 " in page 78,79 and 80.
6. Do the "LAP test" in page 81

Information Sheet-1	Following OHS risk controls

1.1 Introduction to Following OHS risk controls

Control measures which have been put in place must be reviewed periodically to check that they actually fix the problem, without creating another one. OHS health and safety risk management should be an ongoing and continuously improving process. To ensure effectiveness in eliminating or minimizing risk control measures. OHS risk management process are below.

1.1.1 Hazard identification A worker who identifies a hazard must:

- notify others in the vicinity
- take action to eliminate the hazard immediately – so far as is reasonably practicable and where it is safe to do so
- if it is not reasonably practicable to eliminate the hazard, take action to prevent injury or damage
- report the hazard to an immediate line supervisor as soon as possible for further action and implementation of controls

1.1.2 Recording and reporting

Upon receipt of a hazard report, the line supervisor must ensure the hazard is managed. Upon the receipt of a hazard report, the Incident and Security Team shall complete an assessment of the situation in accordance with the Bulk Authority Emergency Response Plan. If the situation is assessed as a Level 1 event then the report will be recorded in the incident & emergency management system and managed and communicated in accordance with the requirements of this plan

1.1.3 Reporting electrical accidents and incidents

Incidents, injuries, hazards and near misses is a legal requirement of employees under the Occupational Safety and Health. The reporting of electrical accidents is also a requirement of the Electricity which defines electrical accidents as an accident:-

- That results from a sudden discharge of electricity or that otherwise has, or is likely to have, an electrical origin; and
- That causes, or is likely to cause, danger to life, a shock or injury to a person or loss of or damage to property. The regulations also state that if employees

report an incident of this type to their employer, then the obligation to report it to Energy Safety passes to the employer

2. Risk assessment:

Risk assessment is a term used to describe the overall process or method where you: Identify hazards and **risk** factors that have the potential to cause harm (**hazard** identification). Analyze and evaluate the **risk** associated with that **hazard** (**risk** analysis, and **risk evaluation**)

The following actions are to be undertaken to complete OHS risk

- Identify the consequence
- Identify the likelihood
- Rate the inherent risk

Table 1.1 Risk matrix table

Likelihood		Very Likely	Likely	Unlikely	Highly Unlikely
Consequences	Fatality	High	High	High	Medium
	Major Injuries	High	High	Medium	Medium
	Minor Injuries	High	Medium	Medium	Low
	Negligible Injuries	Medium	Medium	Low	Low

Risk matrix

1.1.4 ELECTRICAL SAFETY RISK ASSESSMENT

The intent of this procedure is to perform a risk assessment, which includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk. A risk assessment should be performed before work is started.

1.1.5 Electrical Risk Assessment

- Identify the electrical hazards associated with the task and the electrical system, or electrical process involved (example: shock hazard risk; arc flash hazard risk).
- Identify the electrical work to be performed within the electrical system or process.

- Define the possible failure modes that result in exposure to electrical hazards and the potential resultant harm.
- Assess the severity of the potential injury from the electrical hazards.
- Determine the likelihood of the occurrence for each hazard.
- Define the level of risk for the associated hazard.
- If the level of risk is not acceptable, identify the additional measures or corrective actions to be taken. Example: wear appropriate PPE and if the risk too great, do not perform the task. The risk related to an identified hazard may be thought of as being composed of the severity of the injury and the likelihood of occurrence of that injury

1.2 risks Control hierarchy

- Identify the risk controls and responsibilities by identifying controls in the following specific order:
- Eliminate the hazard. If elimination of the hazard is not reasonably practicable, minimize the risk so far as reasonably practicable by:
- Substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk
- Isolating the hazard from any person exposed to it
- Implementing engineering controls.
- If a risk then remains, then minimize the remaining risk, so far as is reasonably practicable, by implementing administrative controls. If a risk then remains, then minimize the remaining risk, so far as is reasonably practicable, by ensuring the provision and use of suitable Personal Protective Equipment (PPE).

2. Importance of following OHS risk control

Following OHS risk control measures are health and safety risk management should be an ongoing and continuously improving process developmental work/activities since it;

- Conducting safe work completion risk management
- Improving productivity and quality products
- Perfuming AC &DC circuit problem solving safely.
- Use for improvements
- Create Environmental friend work place
- Eliminate hazards and injuries from work place
- Involve workers, who often have the best understanding of the conditions that create hazards and insights into how they can be controlled.
- Identify and evaluate options for controlling hazards, using a "hierarchy of controls."
- Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.
- Develop plans with measures to protect workers during emergencies and non routine activities.

- Evaluate the effectiveness of existing controls to determine whether they continue to provide protection, or whether different controls may be more effective. Review new technologies for their potential to be more protective, more reliable, or less costly.
- Select controls
- Develop and update a hazard control plan
- Select controls to protect workers during no routine operations and emergencies
- Implement selected controls in the workplace
- Follow up to confirm that controls are effective

Self-Check -1	Written test

Directions chose the correct answer for the following questions and write on the black space

1) ________________ A worker who identifies a hazard must:

A. notify others in the vicinity

B. take action to eliminate the hazard immediately – so far as is reasonably practicable and where it is safe to do so

C. If it is not reasonably practicable to eliminate the hazard, take action to prevent injury or damage.

D. All

2) _____________ Incidents, injuries, hazards and near misses is a legal requirement of employees under the Occupational Safety and Health Act 1984

A. Reporting electrical accidents and incidents

B. notify others in the vicinity

C. Risk assessment

D. all

3) To effectively control and prevent hazards, employers should

A. Involve workers, who often have the best understanding of the conditions that create hazards

B. Identify and evaluate options for controlling hazards, using a "hierarchy of controls."

C. Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.

D. Develop plans with measures to protect workers during emergencies and non-routine activities

E. all

Information Sheet- 2	Determining the need of live test/ measure

2.1 Introduction Determining the need of live test/ measure

Live Testing or Live working shall be defined as the practice of working on parts of the electrical system while the part in question is still live. This may or may not include the removal of covers or protective devices without isolating the means of supply during such an operation. The safest way to conduct electrical work is to shut off electric power and work on de-energized equipment. However, there may arise extraordinary circumstances that necessitate work on energized equipment.

Live testing helps ensure all electrical apparatuses within the circuit are set within their respective recommended electrical polarities for continuous flow of electrical energy.

2.2 What is done during Live Testing?

Live testing applies to all electrical conductors and equipment operating at 50 volts nominal, or greater. This procedure also applies to live parts operating at less than 50 volts nominal, if there is an increased risk of exposure to electrical burns or to explosion due to electrical arcs.

- **Live working may not be undertaken unless the following applies:**
  - ✓ It is unreasonable in all circumstances for it to be dead.
  - ✓ It is reasonable in all circumstances for him to be at work on or near it while it is live.
  - ✓ Suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury.
  - ✓ The use of all insulated tools & matting and protective equipment in use
  - ✓ Situations where working “live” is acceptable.
- **Live circuit test working may be undertaken**

When adequate precautions are taken to prevent danger or injury to all persons

- ✓ Persons carrying out work on live equipment shall be competent to do so safely.
- ✓ Live exposed parts shall not be left unattended at any time.
- ✓ Live work will only be carried out where there exists no risk of water ingress to live exposed parts.
- ✓ Live work may only be carried out where it is impracticable to isolate the supply.
- ✓ Signs shall be fitted in all cases on circuits under test stating “Warning, circuit under test “Do Not Operate”.
- ✓ The following situations are not appropriate to be worked on live:

- ✓ Motor terminal covers must not be removed live.
- ✓ Panel covers must not be removed if adequate knowledge of that panel is not known.
- ✓ Covers shall not be removed in wet environments.
- ✓ Live work must not be undertaken where by “risk assessment” danger or injury may occur to the engineer or others.
- ✓ Signs shall be fitted in all cases on circuits under test stating “Warning, circuit under test “Do Not Operate”.

2.3. Procedures to be implemented when working “live”:

- All suitable precautions shall be taken to prevent “danger” arising.
- All personnel not directly involved with the task in hand will be kept clear of the
- area at all times.
- Suitable barriers and warning signs shall be erected as and when appropriate.
- If any doubts regarding safety arise then work must be halted and the
- circuit made dead prior to any further progress being made.
- Precautions shall be taken to ensure that no nearby dead circuits become unexpectedly live.”
- The appointed site representative shall be kept fully informed of areas where live work is being undertaken.
- Signs shall be fitted in all cases on circuits under test stating “Warning, circuit
- under test “Do Not Operate”.

2.4 Make sure you have the proper PPE

For the task at hand inspect your Personal Protective Equipment (PPE) before performing the task. Is it rated for the voltage and energy under test? Are you protecting each body zone, such as head, eyes, ears, trunk, arms, fingers, and legs? Is your PPE in good condition? Are you using it correctly? Do you have sufficient PPE to prevent injury? Ask “what if” questions, and determine what PPE you need to protect yourself — maybe safety glasses, gloves, face shield, insulating blankets, or even a flash suit. Each situation is different, even on similar equipment.

2.5 How to Conduct Live Testing?

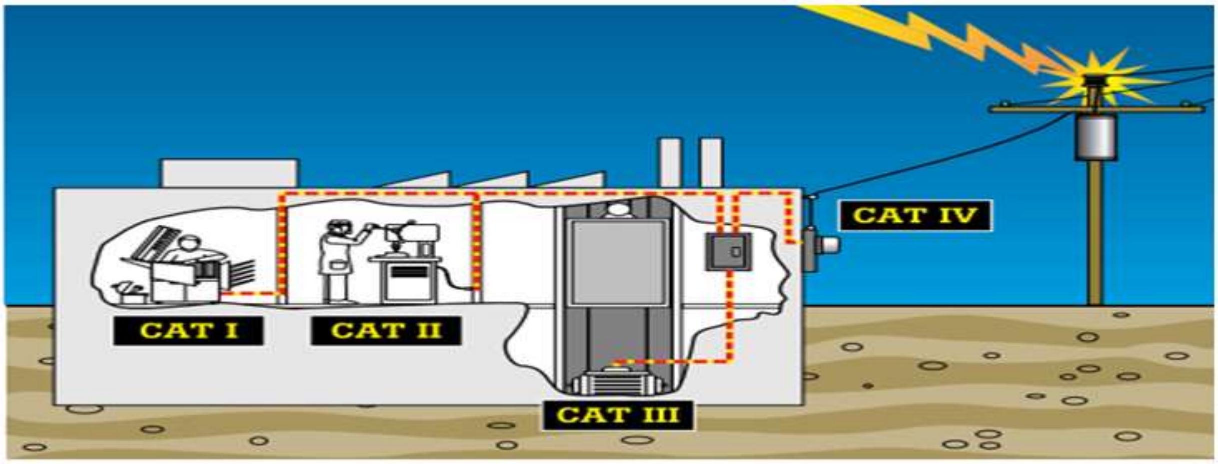


Figure.2.1 Live testing

- **Following are the tests that we carry out during live testing:**

Conducting a live-dead-live testing is easier with a Proving Unit on hand. A Proving Unit generates a known voltage source, so that you can verify the functionality of your test tools before connecting to the panel**.**

- ✓ Live-dead "three-point testing" or "LDL") are the process of Testing the functionality of electrical testing equipment prior to beginning work.
- ✓ Testing the circuit to verify de-energized state.
- ✓ Re-testing the electrical test equipment to re-confirm functionality.

2.6 How to Measure Current

A multimeter provides one of the easiest ways to measure alternating and direct current (AC & DC). We provide some of the key guidelines . . .
It is often necessary to know how to measure current using a multimeter. Current measurements are easy to make, but they are done in a slightly different way to the way in which voltage and other measurements are made. However current measurements often need to be made to find out whether a circuit is operating correctly, or to discover other facts associated with its current consumption.

Current is one of the basic electrical / electronic parameters, and therefore it is often necessary to measure the current flowing in the circuit to check its operation.
Both digital and analogue multimeters are able to measure current very easily....
When using a multimeter to measure current, the only way that can be used to detect the level of current flowing is to break into the circuit so that the current passes through the meter. Although this can be difficult at times, it is the best option.

A typical current measurement can be made as shown below. From this it can be seen that the circuit in which the current is flowing has to be broken and the multimeter inserted into the circuit. In some circuits where current may often need to be measured, terminals with a shorting link may be added to facilitate the current measurement.

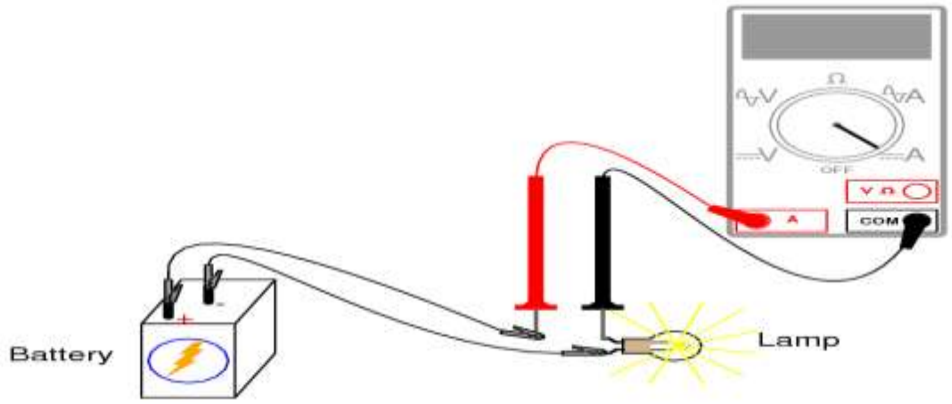


Figure2.2 how to measure current using multimeter

2.7 How to Measure Voltage

Voltage is a measurement of potential electric energy between two points. You can measure the voltage of household circuitry or batteries using a digital multimeter, an analog multimeter, or a voltmeter. Most electricians and novices prefer a digital multimeter, but you can also use an analog multimeter. A voltmeter only measures voltage, so use this if you don't plan to take other measurements.

2.8 How to test polarity

We require a polarity test to ensure that all single pole devices (fuses, switches and circuit breakers) are connected in the PHASE conductor only. We cannot simply trust that the electrician(s) have connected things up the right way; everyone makes mistakes, even if it's your own work. "Basically it is a test that creates a circuit using the phase conductor and the single pole device in question, breaking the circuit when operating the device, means that the reading on the instrument will change, and thus confirming that that device must be connected in the phase conductor.

It ensures apparatus connected to the circuit is connected correctly, and does not become damaged. Plug in tester, and ensure the polarity is correct according to the charts on the test instrument. (Varies from tester to tester)

2.9 Why do a Polarity Test?

The purpose of a polarity test to ensure that all single pole devices (fuses, switches and circuit breakers) are connected in the phase conductor only.

We cannot simply trust that the electricians have connected things up the right way; everyone makes mistakes, even if it's your own work. Since ac installations consist of a Live and a Neutral conductor, it is extremely important that these conductors are connected the right way around, within all electrical accessories such as wall sockets or plugs.

To ensure this, polarity test is done at each relevant point. This simple test is just as important as all the others, and many serious injuries and electrocutions could have been prevented if only polarity checks had been carried out.

- **The requirements for polarity test are:**
  - **All fuses and single pole switches are in the phase conductor.**
  - **The Centre contact of equipment like lamp holder is connected to the phase conductor.**
  - **All socket outlets and similar accessories are correctly wired.**

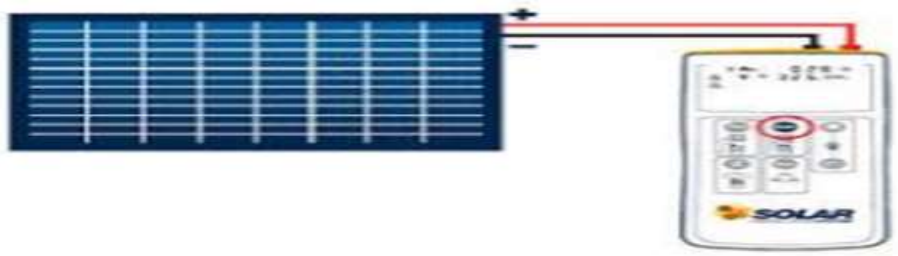


Figure 2.1Testing polarity pic

Figure 2.2Testing polarity pic

Self-Check -2	Written Test

Directions: chose the correct answer for the following questions and write on the black space

Use the Answer sheet provided in the next page:

1. Testing on parts of the electrical system while the part is still live.
   A. Live test
   B. Inspection test
   C. Impedance test
   D. All
2. The following Procedures to be implemented when working "live":
   A. All suitable precautions shall be taken to prevent "danger" arising.
   B. Precautions shall be taken to ensure that no nearby dead circuits become unexpectedly live."
   C. Signs shall be fitted in all cases on circuits under test condition
   D. All
3. A test that Fuses, switches and circuit breakers are connected in the PHASE conductor only
   A. Polarity test C. continuity test
   B. Earth loop impedance test D. all
4. ____________ is to make sure that the circuit is disconnected fast enough to prevent overheating and possibly a fire.
   A. continuity test C. Earth loop impedance test
   B. Earth loop impedance test D. all
5. The highest electric current which can exist in a particular electrical system under short circuit conditions.
   A. Prospective short circuit current (PSCC)
   B. Loop impedance
   C. Over load
   D. All

Information Sheet-3	Checking circuits

.1 Introduction: Circuit testing

The first step in almost any electrical project is to check for power to make sure the circuit or device is safe to work on. You can do this with a variety of inexpensive testers or even a multimeter**.** There are several types of electrical tests conducted on PV systems. Many of these tests can be conducted with common electrical test equipment, while some measurements require special meters and instruments. In many cases, system performance information is measured, recorded and displayed by PV system inverters or charge controllers, and can be used to verify system functions and proper operation.

.2 Spotting Electrical Problems before They Cause Damage

By identifying electrical wiring hazards before problems appear, you can make your home safer and possibly prevent a fire or a dangerous electrical shock.

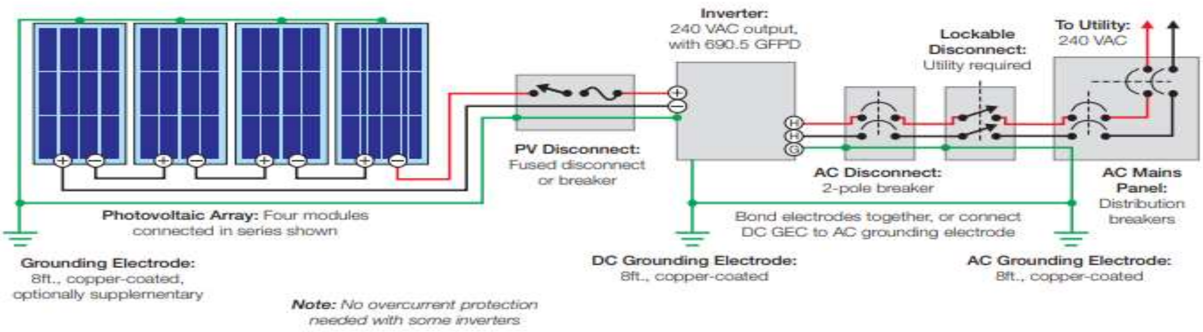
Even the humble electrical outlet or light switch can have numerous things that can go wrong, most of them resulting from faulty installation.

Here, then, is a list of wiring problems you might encounter by simply peering into an outlet or switch box with a flashlight. Many of these are easy to fix, but if you find a lot of them, you might want to call in an electrician for an expert inspection of your entire electrical system.

.3 The following are common types of testing

- Continuity Testing

Continuity testing is commonly used to verify grounding and bonding connections in electrical systems. These tests also verify the proper operation of disconnecting means and the function of overcurrent protection devices like fuses and circuit breakers. Measurements of resistance can also be used for estimating voltage drop in conductors, terminations and other connections and for evaluating windings in motors and transformers.



- **Polarity Testing**

As for any dc circuits, the polarity of array wiring and dc equipment is a critical concern for PV installations. The polarity of every source circuit and the entire PV power source must be verified prior to connecting to any dc utilization equipment, such as batteries, charge controllers, inverters or electrical loads. Without required PV array source and output circuit overcurrent protection reversing the polarity of an array connection to a battery can lead to disastrous results and damage PV modules or source circuit wiring. A reversed polarity array can also act as a load, and discharge current from a battery without some form of reverse current protection like a blocking diode.

Figure 3.2 polarity test

- **Open-Circuit test**

Open-Circuit Voltage Testing Prior to closing the PV array dc disconnects, the open-circuit voltage (Voc) for each PV array source circuit should be tested and compared with expectations. This test can also be used to verify proper polarity. These tests simply verify correct installation, and are not intended to verify performance. Open-circuit voltage tests require a suitable voltmeter capable of reading AC and DC voltages of 600 V to 1000 V.

- **Short-Circuit Current Testing**

Short-circuit current tests are conducted on PV string source circuits to verify proper readings and that the circuits are clear from major faults. Similar to the open-circuit voltage tests, these tests are only intended to verify proper system operation, not performance. Suitable test equipment, capable of safely short-circuiting high-voltage dc circuits is required. Most digital multi-meters can measure dc current up to 10 A, but require a suitable shorting device to safely measure the current. Clamp-on ammeters are also available for dc current measurements, and require and external shorting device as well

- **Earth Fault Loop Impedance Test**

Every circuit must be tested to make sure that the actual loop impedance does not exceed that specified for the protective device concerned. Because of the severity of coming into contact with an electrical fault, having your electrical installations and power points tested for earth fault loop impedance is crucial.

Your systems are valuable and circuitry needs to be maintained for the durability and functionality of your business. In most homes, basic shock protection is done by organizing an earthing circuit with automatic switches in the indoor wiring circuits.

This quickly cuts off supply to an earthing circuit where a fault occurs and touch voltage exceeds an acceptable limit.

According to the current national safety standards, you are required to conduct loop impedance test on your premises to ensure the safety of all guests and employees.

Self-Check -3	Written Test

Directions: say true or falls for the following question

1. The first step in any electrical project is to check for power to make sure the circuit or device is safe to work on.
2. Continuity testing is commonly used to verify grounding and bonding connections in electrical systems.
3. As for any dc circuits, the polarity of array wiring and dc equipment is a critical concern for PV installations.
4. Short circuit test that the circuits are clear from major faults.

Information Sheet-4	DC and AC circuits fault finding and maintenance

4.1 introduction

Power generation based on PV sources has gradually increases during the last few decades. This development has been matched with research into more efficient solar panels. The efficiency of solar panels naturally ranges throughout the system, since any losses will disturb the final efficiency of the whole system.

Recently, the area PV inverters have progressed to distributed systems of inverters, where a small inverter module is connected to every panel. This is favorable since each panel can be enhanced locally, thereby improving the energy harvest. Besides increased efficiency, this also allows individual measurements of solar panels. These new capabilities make new possibilities in monitoring of the health of solar panels that is technically termed as fault detection. The output power degradation not only depends on the PV panels. The occurrences of faults in any other components such as Maximum Power Point Tracking (MPPT), inverter, Voltage Source Converter **(VSC).**

4.2 Classifications of faults in photovoltaic system (PV) system

Faults in PV system can be identified in two side of the system: DC side and AC side, the interface between this to part is DC/AC inverter that connected to load. The classification of faults is shown in Figure 1

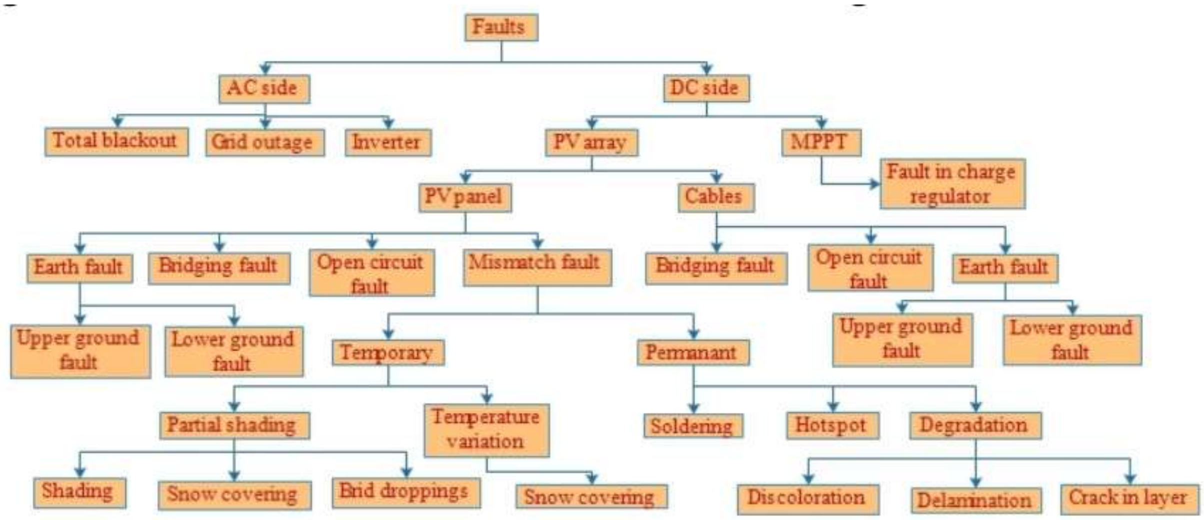


Fig.4.1. Classification of faults

4.2.1 Faults in DC side

The faults occur in DC side of the PV system are classified into two major types:

- **Faults in PV Array:** Faults involve two main groups, PV panel fault and cabling. The most common types of fault in PV Panel/Module are Earth Fault, Bridge Fault, Open Circuit Fault and Mismatch Fault.

Fig.4.2. Faults in PV Array

- ✓ **Earth Fault Earth fault** -occurs when the circuit develops an unintentional path to ground. Two types of grounding shall be provided for PV system such as system grounding and equipment grounding. In system grounding, the negative conductor is grounded through the Earth fault protection device (GFPD) in the PV inverter. The exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures should be grounded in equipment grounding. Two types of Earth faults namely Lower Earth fault and Upper Earth fault can occur. In Lower Earth fault, the potential fault point is upper than half of the maximum voltage power point. And the Upper Earth fault will create large backed current and very high Earth-fault current. Without any sensor, these faults are identified, when the sign of the monitored primary current of the solar inverter is changed. When the primary current becomes negative, the solar inverters initiate a controlled internal short circuit.

- ✓ **Bridging fault** when low- resistance connection recognized between two points of different potential in string of module or cabling, the bridging fault will occur. Insulation failure of cables such as an animal chewing through cable insulation, mechanical damage, water ingress or corrosion cause these faults.
- ✓ **Open Circuit Fault** an open circuit fault occurs, when one of the current-carrying paths in series with the load is broken or opened. The poor connections between

cells, plugging and unplugging connectors at junction boxes, or breaks in wires cause these fault.

- ✓ **Mismatch Fault** When the electrical parameters of one or group of cell are changed from other, the mismatches in PV modules will occur. These fault results in irreversible damage on PV modules and large power loss. These faults can be classified into permanent and temporary mismatches. Temporary mismatches occurs when a part of the panels array are shaded by shade from the building itself, light posts, chimneys, trees, clouds, dirt, snow and other light- blocking obstacles. Non- uniform temperature can identified due to snow covering. Permanent mismatch occurs due to faults in hotspot, soldering and degradation. Hot spot heating happens when the operating current exceeds the reduced short circuit current of a shadowed or faulty cell or group of cells within the module. Soldering fault can be identified in resistive solder bond between cell and contacted ribbons. Discoloration, delamination and transparent layer crack result in degradation fault.
- ✓ **Fault in cables** Bridging Fault, Open-Circuit fault and Earth Fault are occur in power line carrier and cabling system. An aged connection box at the back side of a solar panel or in the corner and bend aria of cable cause bridging fault. Upper earth and lower earth faults occur between panels and ground. It results in dropped output voltage and power, and can be dangerous if the leakage currents are running through a person.

Fig.4.3. Fault in cables

- **Fault in MPPT** (maximum power point tracker) increases the power fed to the inverter from PV array. The performance of MPPT degrades when the failure occurs in the charge regulators. The output voltage and the output power reduces when fault occur in MPPT.

✓ **Faults in AC side**

In AC side two types of faults can be identified: total black out which measured as exterior fault for system, lighting and unbalanced voltage or grid outage for AC part defect such as weaker switch, over current or over voltage and etc. Meanwhile most PV inverters having transformers that could give good galvanic isolation between PV arrays and utility grids and perfect electrical protection

The AC output power will become low and DC output power remains the same, when there is a fault in the inverter. This details confirms that there is no possibility that a wire modules/strings and inverter was broken or a breakdown occurs in strings and/or modules. So, fault in the inverter is the reason for power loss.

4.3 Preventive maintenance

One of the most valuable techniques for identifying existing problems and preventing future problems is to walk the site and conduct a thorough visual and hands-on inspection of the PV system components. These inspections should be conducted at regular intervals, and personnel should use checklists developed for these periodic maintenance activities to ensure that the inspections are thorough and complete.

- **Routine Maintenance Tasks**

A properly installed solar electric system requires relatively little maintenance. In fact, the work involved in maintaining a solar electric system is much less than that needed to maintain a diesel- or petrol-powered generator. The best maintenance practice is to make regular inspections of the equipment (especially batteries and modules), to make sure things are kept clean and to make sure all electrical contacts are tight. The following section describes most of the tasks that need to be done when maintaining a system. If the suggested procedures below are followed, a system should work well. Perform an annual system check to look for problems not covered below, such as tree-growth or birds' nests shading the modules, insects in junction boxes, garden plots above buried wires and other unexpected problems.

- **Analysis of system records**

During the routine maintenance and servicing of any system, look through the operation records of the system (if they are kept). System managers should check the following on a monthly basis:

- ✓ Daily battery state-of-charge log. This will indicate whether the battery has been in a low or full state of charge, and whether this continued for a long time.

- ✓ Records of any recent repairs or problems with the system.
- ✓ Some charge regulators and amp-hour meters store detailed records of battery state of charge, daily energy use and solar charge (a few of these enable the information to be downloaded on to memory sticks or laptops). Always review this data to see how the system has been performing, and how much energy has been collected and utilized.

- **Battery maintenance**

Batteries are the heart of any off-grid PV system. They should be kept in a high state of charge (above 70 percent at the very least). For long life, they should be allowed to reach full charge at least once a week. After deep-discharges, they should be allowed to fully recover their charge. They should be kept clean. Flooded batteries should have their electrolyte level checked regularly.

Fig.4.3. Battery maintenance

- **Check battery state of charge (at least twice a month or as required by the system log)**

For information on checking battery state of charge see Chapter 4. If the battery is in a low state of charge reduce use of the load and allow the battery to be fully charged by the array (or have it charged by alternative means). Check battery state of charge at the same time every day. A good time to do this is when the sun is low in the sky, and when no loads are in use. For large systems (e.g. institutions), keep records of battery state of charge and performance in a log book. This allows users to judge more easily whether a battery needs replacement or whether it is failing. Flooded batteries require more intensive maintenance than AGM or gel batteries, but all batteries require regular maintenance. Clean batteries (check once a month to see if cleaning is required) If you are cleaning a single battery, carry it outside to avoid spilling acid. Keep plenty of water nearby to rinse spills. If you are cleaning a bank of batteries, make sure the battery enclosure is clean and dry, in addition to the batteries. Use a clean rag and sandpaper for battery cleaning tasks.

- ✓ First, switch off or disconnect the solar charge.
- ✓ Remove the battery fuse and disconnect the battery from the leads, and remove the battery terminals from the posts.
- ✓ Clean the top and outside of the battery with a cloth and water (do not allow water to enter the cells).
- ✓ With sandpaper, clean battery terminals and posts until they are shiny. If the terminals are corroded (i.e. if they are covered with white powder), clean them carefully using sandpaper and a solution of baking soda and water. If the terminal has been badly corroded replace it.
- ✓ Put back the clean terminals and tighten the bolts. Apply petroleum jelly or grease to protect the outside of connected terminals. And don't forget to wash your hands afterwards.

4.4 Module maintenance

Since modules have no moving parts, they require minimum maintenance. Keeping the glass surface clean is the most important task. Also, be aware of shade from plants or trees that grow up around the array. Check occasionally for loose nuts and corrosion in the mounting hardware.

- **Clean dirt and dust build-ups on modules (once a month)**
  - ✓ Solar modules must be kept clean to produce maximum power. Dust collecting on top of the module can greatly reduce electric output. During the dry seasons, inspect the module every two weeks for collected dust by running a finger along the top. Also, look for bird-droppings, leaves, streaks or signs of damage.
- ✓ Clean modules with water and, if necessary, a mild soap (solvents should never be used). Wipe the glass with your hands, a sponge or a soft cloth (rough cloths or brushes will scratch the glass – do not use). Make sure all surfaces of the array are fully rinsed and streak-free

Fig.4.4. Clean dirt and dust build-ups on modules

- **Check array output and module/array connections (once a year)**

✓ Check the output of the array at noon on a sunny day. Measure the open circuit voltage (Voc) and the short-circuit current (Isc). Compare these with previous figures, and note any change.

✓ Inspect the junction box on the back of each module to make sure that the wiring is tight. Make sure that wires have not been chewed or pulled out. Ensure that no insects or lizards are living in the junction boxes. Remove plant growth, spider webs and debris from the back of the array.

✓ Wiring and charge controller If wiring is installed properly, there should be no wiring problems for the life of the system. However, it is useful to check the wiring of a system at least once a year, especially in places where it might be chewed, tampered with or accidentally pulled.

4.5. Wiring and charge controller

If wiring is installed properly, there should be no wiring problems for the life of the system. However, it is useful to check the wiring of a system at least once a year, especially in places where it might be chewed, tampered with or accidentally pulled.

- **Inspect wiring, fuses, indicator lamps and switches (once a year)**

✓ Inspect system wire runs for breaks, cracks in the insulation or places where it has been chewed. This is especially important for old or exposed wire.

✓ Inspect junction boxes to make sure they have not become homes for insects. Make sure they are still watertight.

✓ Check switches to make sure they are operating properly

✓ Check fuses to find if any have blown. If so, find the cause and repair. Replace a blown fuse with a new one of the same size.

- ✓ Check the indicator lamps on the charge controller. The solar charge indicator should come on when the sun is up. If it is not on, check to see if the batteries are being charged. Check whether the other LED indicator lamps are working.
- ✓ Check the tightness of connections in the terminal and connector strips. Make sure no bare wires are visible.
- ✓ Check earthing cables and rods to make sure they are still intact

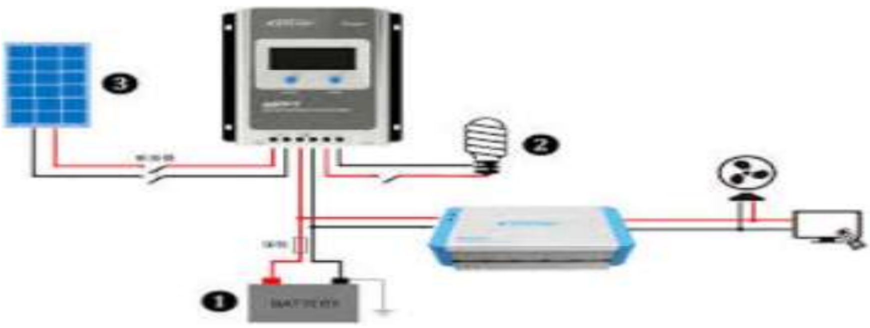


Fig.4.5. Wiring and charge controller

4.6. Lamps and loads

On a daily basis, operate the loads as efficiently as possible. Maintenance of loads includes turning lights and appliances off when not in use. As needed, do the following:

- Clean lamps, reflectors and fixtures once every few months. Dust and dirt make lamps seem less bright.
- Check for blackening tubes in fluorescent fixtures. If tubes blacken at one end it is an indication that they are approaching the end of their lives and that their output is reduced. Replace blackened or blinking tubes.

4.7 Detailed Visual Inspection

The installation should be inspected regularly for issues that impact the physical integrity or performance of the PV system. A visual inspection should include the following actions:

- Inspect the inverter/electrical pad to make sure it does not show excessive cracking or signs of wear. The inverter should be bolted to the pad at all mounting points per the manufacturer installation requirements. Depending on the size, location, and accessibility of the system to unqualified personnel, the inverters, combiner boxes, and disconnect switches should require tools or have locks to prevent unauthorized access to the equipment.

- Look for warning placards including arc flash or PPE requirements for accessing equipment. Be sure to comply with all warning placards. If no placards are present, or if some placards are missing, make a note of it and install the missing placards during the maintenance visit. Consult the NEC and Underwriters Laboratories (UL) standards as well as the site host to determine signage requirements.
- Inspect PV modules for defects that can appear in the form of burn marks, discoloration, delamination, or broken glass.
- Check modules for excessive soiling from dirt buildup or animal droppings. (See Array Washing Procedure for proper procedures for cleaning an array.)
- Ensure that the module wiring is secure and not resting on the roof, hanging loose and exposed to potential damage, bent to an unapproved radius, or stretched across sharp or abrasive surfaces.
- Inspect racking system for defects including rust, corrosion, sagging, and missing or broken clips or bolts.
- If sprinklers are used to spray the array, check that the water is free of minerals (demineralized) as these minerals can cause gradual performance degradation.
- Inspect conduits for proper support, bushings, and expansion joints, where needed.
- In roof-mounted systems, check the integrity of the penetrations.
- In ground-mounted systems, look for signs of corrosion near the supports.
- Open combiner boxes and check for torque marks on the connections. Torque marks are made when lugs have been tightened to the proper torque value. Ideally they are applied during initial installation, but if not, the technician can mark the lug after torqueing during a maintenance visit. A proper torque mark is made with a specialized torque marking pen. The mark is a straight line through the lug and the housing. Over time, if the line separates between the lug and the housing, it shows that the lug has moved and needs to be re-torqued. Look for debris inside the boxes and any evidence of damaging water intrusion. Look for discoloration on the terminals, boards, and fuse holders.
- Check to make sure the cabinet penetrations are properly sealed and there is no evidence of water ingress. Check for torque marks on the terminals.

- Perform a visual inspection of the interior and exterior of the inverter. Look for signs of water, rodent, or dust intrusion into the inverter. Check for torque marks on the field terminations.
- If a weather station is present, ensure that the sensors are in the correct location and at the correct tilt and azimuth. A global horizontal irradiance sensor should be flat, and a plane of array irradiance sensor should be installed to the same pitch and orientation as the array. Irradiance sensors should be cleaned to remove dirt and bird droppings.

4.8 Corrective Maintenance

Corrective Maintenance covers the activities performed by the Maintenance team in order to restore a PV plant system, equipment or component to a status where it can perform the required function. The Corrective Maintenance takes place after a failure detection either by remote monitoring and supervision or during regular inspections and specific measurement activities (see Annex d). Corrective Maintenance includes three activities:

- Fault Diagnosis also called troubleshooting to identify fault cause and localization;
- Temporary Repair, to restore the required function of a faulty item for a limited time, until a Repair is carried out;
- Repair, to restore the required function permanently. In cases where the PV plant or segments need to be taken offline, the execution of scheduled Corrective Maintenance during night or low irradiation hours would be considered best practice as the overall power generation is not affected.

4.9 Predictive Maintenance

Predictive Maintenance is a special service provided by Contractors who follow best practices principles. It is defined as a condition-based maintenance carried out following a forecast derived from the analysis and evaluation of the significant parameters of the degradation of the item. A prerequisite for a good Predictive Maintenance is that the devices on site can provide information about their state, in such a way that the contractor can evaluate trends or events that signal deteriorations of the device.

As a best practice, the device manufacturer should provide the complete list of status and error codes produced by the device together with the detailed description of their meaning and possible impact on the function of the device. Additionally, a standardization of status and error codes through inverters and data loggers within a same brand should be followed and, in the future, this standardization should be common to all manufacturers.

- **Inspect wiring, fuses, indicator lamps and switches (once a year)**
  - ✓ Inspect system wire runs for breaks, cracks in the insulation or places where it has been chewed. This is especially important for old or exposed wire.
  - ✓ Inspect junction boxes to make sure they have not become homes for insects. Make sure they are still watertight.
  - ✓ Check switches to make sure they are operating properly
  - ✓ Check fuses to find if any have blown. If so, find the cause and repair. Replace a blown fuse with a new one of the same size.
  - ✓ Check the indicator lamps on the charge controller. The solar charge indicator should come on when the sun is up. If it is not on, check to see if the batteries are being charged. Check whether the other LED indicator lamps are working.
  - ✓ Check the tightness of connections in the terminal and connector strips. Make sure no bare wires are visible.
  - ✓ Check earthing cables and rods to make sure they are still intact

Self-Check-4	Methods of DC and AC circuits fault finding and maintenance

Directions: Answer all the questions if the answer is write say true if the answer is wrong say false

1. Faults in PV system can be identified in two side of the system.
2. Faults in PV Array Faults in PV arrays involve two main groups, PV panel fault and cabling.
3. An open circuit fault occurs, when one of the current-carrying paths in series with the load is broken
4. **MPPT** (maximum power point tracker) increases the power fed to the inverter from PV array.
5. Corrective Maintenance covers the activities performed by the Maintenance team in order to restore a PV plant system,

Information Sheet-5	Photo voltaic power system

5.1 Introduction Photo voltaic power system

Solar electricity is electric power generated from sunlight using devices called solar cell modules. Solar electricity can replace, cost-effectively, small applications of petroleum-fueled generators, grid power and even dry cell batteries. The technology has spread rapidly throughout the world for both on-grid and off grid application. Millions of rural off-grid homes are using solar photovoltaic (PV) systems throughout the developed and developing world. Small off-grid solar electric systems differ from grid or generator electricity in a number of ways:

- Small off-grid PV systems are based on extra-low-voltage direct current electricity, not low-voltage 230 or 110 volts (V) alternating current (see the Glossary for a definition of 'extra-low' and 'low' voltage).
- Off-grid PV systems usually store energy in batteries.
- Electricity is generated on-site by photovoltaic modules.
- For systems to be economical, all electricity produced must be used efficiently.

5.1.1 Solar Energy Conversion

Solar Energy is harnessed and converted to heat or electricity using various technologies. Below is a description of the basic technologies

5.1.2 Solar Energy to Electricity

The term photovoltaic means electricity from the sun. Photovoltaic technology is used to convert light energy into electrical energy. This technology has been developed on the basis that some semiconductor materials such as silicon generate voltage and current when exposed to light. A thin wafer consisting of an ultra-thin layer of N-type silicon on top of a thicker layer of P-type silicon (where N – Negative and P – Positive) will have an electrical field where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of the wafer, it causes the electrical field to provide momentum and direction to light-stimulated electrons, resulting in a flow of electrical current to any electrical load connected. Figure A below illustrates this principle.

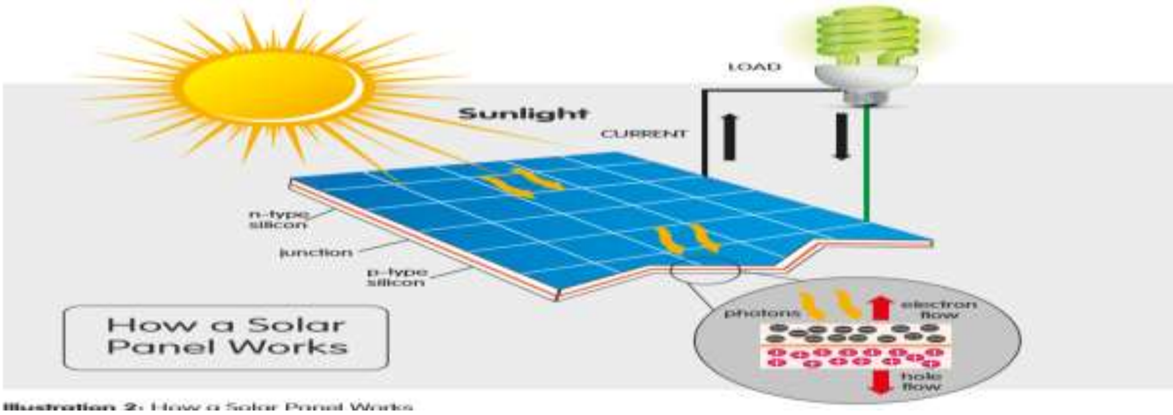


Fig.5.1 how a solar panel work

5.1.3 Solar Energy to Thermal Energy

Solar thermal systems operate when radiation/heat from the sun is directed to a device which captures and concentrates the heat to a carrying media (air or water). The fluid gains heat from the pipes/fins installed within the system and delivers it through an outlet either as warm or hot. Figure B below illustrates the concept using water as the medium.

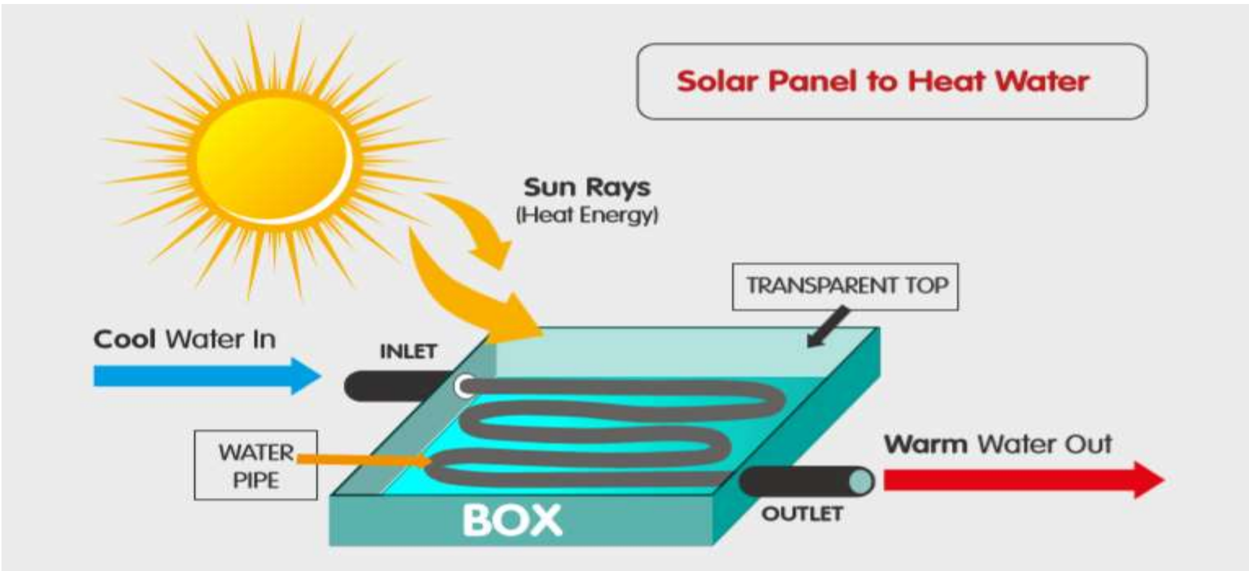


Fig.5.2 solar panel to heat water

5..1.4 PV System Components

- Photovoltaic systems consist of some or all of the following components:
  - ✓ PV Panel
  - ✓ Load
  - ✓ Wiring
  - ✓ Inverter
  - ✓ Charge controller
  - ✓ Battery

Whether a system has some or all of these components is dependent on factors such as the size, the type of load powered, required current (AC or DC or both) and how it is used (all day or a few hours a day).

- **PV Panel**

Photo voltaic (PV) or solar cells are the building blocks of solar panels. They are made of semiconductor materials. They convert sunlight into direct current (DC) electricity. In practice a typical silicon PV cell produces voltage of 0.5 – 0.6 DC under open-circuit, no-load conditions. The current (and power) output of a PV cell depends on its efficiency and size (surface area), and is proportional to the intensity of sunlight striking the surface of the cell.

Groups of PV cells are electrically configured into modules/panels which can be connected into arrays to achieve desired power and voltage outputs. Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate, while panels include one or more PV modules assembled as a pre-wired, field-installable unit. A photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels.

Figure 5.3 Solar cell, module, array and solar generator

5.1.5. Charge Controller / Charge Regulator

The solar charge regulator/ charge controller is basically a voltage and/or current regulator which is connected between the solar panel and the battery and load. Its main function is to manage the charge and discharge of the battery and keep the battery pack in good condition.

The charge controller regulates the voltage and current flowing from the solar panel(s) to the battery since most solar panels can produce more than the rated voltage (for example a solar panel rated 12 volts can produce up to 20 volts).
Without the regulation the battery will be damaged due to overcharging. This is so because maximum voltage for most batteries is between 14 and 15 volts.

The figure below shows a typical solar charge controller. However, they come in various forms and designs depending on the application and manufacturer. They vary in terms of their working voltage or system voltage and the current that they are supposed to handle during operation.

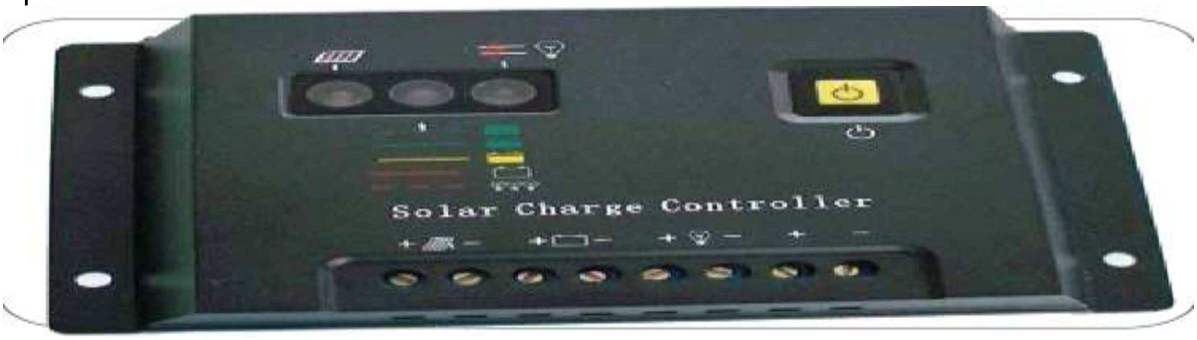


Figure 5.4 charge controller

- **Advantages of Using a Charge Controller**
  - ✓ It monitors the battery voltage, stops charge when the battery is fully charged
  - ✓ Extends battery life
  - ✓ Regulates power from the solar panels, protecting the battery from overcharging
  - ✓ The charge controller ALSO protects our gadgets

- **Disadvantages of NOT Using a Charge Controller**
  - ✓ Damage of batteries since there is no regulation of power
  - ✓ Damage of Electrical gadgets
  - ✓ Damage of the solar panel due to reverse flow of voltage

- **Solar Batteries**

Solar batteries are available in various forms and designs depending on the use and also on the manufacturer. Basically, a solar battery must be able to withstand constant and frequent charging whilst it delivers the required power/voltage output. A solar battery is not expected to fail in a short space of time (when it is properly used).

- **The primary functions of a storage battery in a PV system are**:
  - ✓ Energy Storage Capacity and Autonomy: to store electrical energy when it is produced by the PV array and to supply energy to electrical loads as needed by the system or on demand.
  - ✓ Voltage and Current Stabilization: to supply power to electrical loads at stable voltages and currents, by suppressing or 'smoothing out' transients that may occur in PV systems.
  - ✓ Supply Surge Currents: to supply surge or high peak operating currents to electrical loads or appliances.

- **Inverter**

This is a device that converts DC electricity into AC electricity, allowing the PV system to be used for appliances that require AC current. Inverters come in various forms and designs, there are however 3 basic types of inverters which are:

- ✓ Square wave
- ✓ Modified (quasi) square wave
- ✓ Sine wave
- ✓ Each of these inverters has a specific purpose where it can be used.

Image 4: Pure Sine Wave Inverter

Self-Check -5	Methods of DC and AC circuits fault finding and maintenance

Directions: Answer all the questions if the answer is write say true if the answer is wrong say false

1. Solar electricity is electric power generated from sunlight using devices called solar cell modules
2. The term photovoltaic means electricity from the sun.
3. Using of Charge Controller It monitors the battery voltage, stops charge when the battery is fully charged
4. Inverter is a device that converts DC electricity into AC electricity
5. there are however 3 basic types of inverters which are:-Square wave, Modified (quasi) square wave and Sine wave

Information Sheet-6	Dealing Unexpected situations with safely

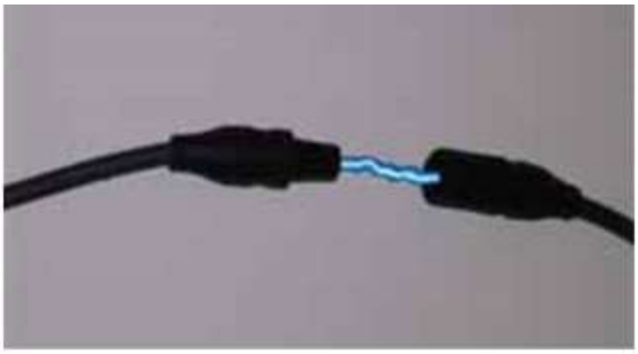
6.1 Introduction Dealing Unexpected situations with safely

Electricians are familiar with electricity coming from the utility side of the meter. With solar electric systems there are 2 sources of electricity: the utility and the solar electric system.

Turning off the main breaker doesn't stop a solar electric system from having the capacity to produce power. Electricians are used to isolating the 'load' from the power source (usually with a breaker or other disconnect switch) and then they proceed to work on that 'safed zero energy load'. With a solar electric system you work on the power source itself (the PV panels or associated wiring) – this is fundamentally different than working on a 'safed load' and you must keep this in mind. Even low light conditions can create a voltage potential that can lead to a shock or arc-flash. A surprise shock delivered at the wrong time could cause a fall from a roof or ladder.

- Note that PV inverters may have significant capacitors that could hold a charge after the power source is removed – always follow manufacturer's directions and check the equipment you are working on for specific operation and safety information.
- The only method of 'turning off' a solar array is removing the 'fuel' source – the sun. If needed, cover the array with an opaque cover that blocks sunlight to prevent a solar panel from generating electricity.
- Small amounts of sunlight can produce a voltage potential and shock or arc-flash hazard
  - ✓ Voltages can be present even in very low light conditions. While these voltages may not be enough to operate the inverter, the potential voltages are enough to produce a shock to an unsuspecting installer. Surprise shocks can cause injuries directly or cause a fall from a roof or ladder.
  - ✓ Prior to working on a string of solar PV panels, if you're going to be connecting or disconnecting circuits, you should disrupt the current path by disconnecting the DC Disconnect switch. Tag and lock out the circuit using standard procedures discussed in the previous section.
- Grid tied solar systems have 2 energy sources to consider
  - ✓ Shutting off the main circuit breaker does not affect the potential output of a solar PV array – even if the inverter shuts off.
    It's important to remember that opening (turning off) the main breaker does not shut off the power source from the solar array. Wires from the PV side of the circuit can still have a voltage potential that can deliver significant current even in low light conditions.
  - ✓ Disconnect switches can isolate the solar PV array but they do not shut the power off. Remember that if you open the DC disconnect switch, the line from the solar PV array can still have voltage potential on it. This is similar to the voltage potential present on the utility side of the line after the main breaker is opened. Treat the wiring coming from the solar PV array with the same caution you treat the utility power line. A residential PV array can have up to 600 VDC potential.

- An electric arc-flash hazard exists while adding or removing a series of solar PV panels
  - ✓ NEVER disconnect PV module connectors or other associated PV wiring under load!
  - ✓ While adding or removing a series of solar PV panels, if a path for current is completed or the string was under load, an electrical arc can occur across the wire junction. The energy from the bright arc-flash can cause severe burns. Another hazard is the surprise arc blast causing you to lose balance and fall off a roof or ladder.



  - ✓ Always open the DC Disconnect Switch prior to working on a solar PV system.

  - ✓ Use a current clamp to check for hazardous energy prior to working on a PV array.

6.2 Working with electrical circuits

Preventing electric shock by working on de-energized circuits is a key to electric safety. Following are some items to consider when working on electric circuits.

- Always de-energize circuits before beginning work on them.

- You can't get shocked by a de-energized circuit. Unfortunately, many electric accidents have been caused by assumed 'dead' circuits. Working safely on circuits includes testing them for hazardous energy prior to working on them.
- Use a meter or circuit test device such as a current clamp to ensure the circuit is dead prior to working on it.

6.3 Working with batteries

Working with battery back-up systems can be the most dangerous part of solar electric installations and maintenance. Batteries can be dangerous! Make sure all employees working with batteries understand the dangers and safety codes relevant to battery systems.

- Refer to NEC and manufacturing guidelines for issues pertaining to proper handling, installation, and disposal of batteries.
- Typical batteries are lead acid. Both lead and acid are harmful chemicals. Lead is known to cause reproductive harm and acid can cause severe burns.
- Care should always be taken to prevent arcing at or near battery terminals. Always open the Main DC disconnect switch between the batteries and the inverter prior to servicing or working on the battery bank.
- Battery banks can store voltages with very high current potential. These higher potentials can create electrical arc hazards. Metal tools and personal jewelry can create arcing on batteries that lead to severe burns or battery explosions. Remove personal jewelry and use only appropriate tools when working on batteries.
- When working on batteries it is recommended that eye protection be worn.
- Dead batteries are considered hazardous and must be recycled properly

Directions: Answer all the questions if the answer is write say true if the answer is wrong say false

1. PV inverters may have significant capacitors that could hold a charge after the power source is removed.
2. The only method of 'turning off' a solar array is removing the 'fuel' source.
3. Small amounts of sunlight can produce a voltage potential and shock or arc-flash hazard
4. The energy from the bright arc-flash can cause severe burns.
5. Using a current clamp to check for hazardous energy is prior to working on a PV array.

Information Sheet-7	Solving problems without damage

7.1 Introduction: Solving problems without damage

Solving problems /Troubleshooting/ means fixing problems as they occur. Although the equipment in properly installed systems is unlikely to fail, problems sometimes occur. This section explains how to tackle problems in solar electric systems when they do occur.

First, don't panic. Most problems have very simple causes and can be discovered simply by checking in a few key places. The battery is a likely source of problems in small solar electric systems and it is likely to give you clues on the cause of the problem. Always carry a multimeter when solving */troubleshooting/*, as you can use it to quickly measure the battery's state of charge, check for broken wires and shorts, check the output of the module and measure voltage drops. Fuses can be easily checked with a multimeter: an intact fuse has a low resistance, less than 1 ohm – a blown fuse has a high resistance (mega ohms). Learn where to buy fuses and electrical equipment. The section below provides basic questions you should first ask about the system to identify the source of the problem. This is followed by a detailed table that should help you identify specific problems.

7.2 Types of basic problems to Check first!

- What was the weather like for the weeks before the problem? Has the weather been cloudy? Is it likely that the load has been using more energy than the solar modules produce? If this is the case then the problem may be a management issue and not a failure of any part of the system.
- Is the system new? Do the owners know how to use and maintain it properly? If the system is only a few weeks old or less, then the problem may be due to the failure of one of the parts (due to faults in the components) or improper installation. On the other hand, if the owners do not know how to use the system, you should question them carefully about how they manage the system.
- What is the type, condition and age of the battery? Can it still hold a charge? If the battery is corroded and looks like it has not been cleaned in months, then it may be the source of the problem. Similarly, if the system uses a five-year-old battery, there is reason to suspect that it has reached the end of its life. If, however, the battery is new, clean and well-charged, then you may have to look elsewhere.
- Are all the fuses and circuit breakers okay? Locate all the fuses in the system and see if any have blown. Check to see what caused the fuse to blow (e.g. overload, short circuit) before replacing it. Are all the wires connected securely? Are any corroded? Is there any place where a wire is likely to have broken?
- Are the modules dusty? Are they shaded? Is one missing or broken?
- Is the charge controller functioning? Is it delivering solar charge to the battery? Are all the indicator LEDs or meters working?

7.2.1 Detailed Solving problems /*troubleshooting*/ guide

- If you cannot find the problem with your system after using the above basic check, then you may have to do a bit more exploring to find what is wrong. The following troubleshooting guide outlines other possible causes of system failure.

Table7.1trouble shooting guide

Problem	Cause	How to Fix
1. Battery State of Charge is Low "Battery low" indicator LED on, low voltage disconnect turns OFF load, or battery state of charge is constantly below 11.5 volts	• There is no sola charge	See # no solar charge below
	• Battery acid low	Add distilled water to cells
	• Bad connection to control terminal	Check for broken wires or loose connection
	• Defective (bad) battery or cell	Check state of charge of each cell. If there is a significant difference between cells, replace or repair
	• Loose or corroded battery terminal	Clean and tighten battery terminals
2. No Solar charge Solar charge indicator does not light up during the day. There is no current in wires from array.	• Defective controller	Check operation of controller with dealer. Replace or repair if necessary.
	• Inverter draining battery	Run system without inverter. Reduce AC load use.
	• Short circuit along wires to modules	Locate and repair short circuit
	• Loose connection in wires connecting battery to the control	Locate and repair loose connection
	• Blown "solar" fuse	See #5 (Blown fuse) below
	• Thick coating of soot or dust on module	Clean module with water and soft cloth
	• Broken module	Check for broken cells, broken glass, or poor connection inside module. Replace solar cell module.
3. Lamps do not work one or more lamps fail to come ON when connected. (Check for blown fuse first)	• Bad tube or globe	Replace with new tube or globe
	• Broken ballast inverter (fluorescent lamp).	Replace ballast inverter with new one
	• Bad connection	Locate broken or loose wire and repair
	• Switch is "OFF"	Turn switch "ON"

	• Tubes or globes have very short lifetimes	Check voltage of system: too low or too high? (Voltage is always lower when load is ON)
4. Appliances do not work One or more appliances fails to come ON when connected or operates poorly. (Check for blown fuse first)	• Bad connection	Locate broken or loose wire and repair
	• Switch is "OFF"	Turn switch "ON"
	• Defective/broken socket	Check socket. If defective or broken, replace. Check fuse in socket
	• Broken appliance	Try appliance where there is a good power supply. Replace or repair
	• Inverter not working (For AC Appliances)	Turn inverter "ON" Repair/replace inverter
	• Poor operation of appliance	Check for low voltage (DC) Check for output of inverter (AC)
5. Blown fuse The fuse is removed, fuse wire is melted.	• Short circuit along wire to solar cell module battery or load	Locate cause of short circuit, repair – then replace fuse.
	• Fuse sized too small	Use fuse 20% larger than combined power of loads
	• Lightning strike or power surge	Replace fuse

Self-Check -7	Solving problems without damage

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

1. Battery State of Charge is Low "Battery low" indicator LED on
   A. There is no sola charge
   B. Battery acid low
   C. Bad connection to control terminal
   D. Defective (bad) battery or cell
   E. All
2. No Solar charge solar charge indicator does not light up during the day.
   A. Defective controller
   B. Inverter draining battery
   C. Short circuit along wires to modules
   D. Loose connection in wires connecting battery to the control
3. Lamps do not work One or more lamps fails to come ON when connected
   A. Bad tube or globe
   B. Broken ballast inverter (fluorescent lamp).
   C. Bad connection
   D. Switch is "OFF"
   E. All
4. Appliances do not work one or more appliances fails to come ON when connected or operates poorly.
   A. Bad connection
   B. Switch is "OFF"
   C. Defective/broken socket
   D. All
5. Blown fuse The fuse is removed,
   A. Short circuit along wire to solar cell module battery or load
   B. Fuse sized too small
   C. Lightning strike or power surge
   D. All

Operation Sheet-1	Determining the need of live test/ measure

1.1 perform live testing for voltage measurement

Procedure:-

Step 1 put the red lead into the V slot and the black lead into the COM slot.
Step 2 Select the mode for DC or AC voltage with the center selection dial.
Step 3 Choose the range of the voltage you plan to test.
Step 4 Test the multimeter on a battery before anything else.
Step 5 Read the display to find the voltage measurement, and make adjustments if needed.

Operation Sheet-2	Determining the need of live test/ measure

1. **perform live testing current**

Procedure:-

1. Break the circuit (or a branch)
2. Insert an ammeter
3. The current through the ammeter is measured by the needle deflection angle.
4. The current through the resistor or any circuit component X is the same as that through the ammeter.
5. Electronic instruments are used to display or transmit the results

Operation Sheet-3	Determining the need of live test/ measure

Clean Solar PV module Panels

Procedure:-

1. A a rule, stay on the ground. ...
2. Turn off your system before start you cleaning. ...
3. As a rule, avoid using hard, or mineral rich, water. ...
4. Use soft brushes and squeegees. ...
5. Clean early in the morning or in the evening when the panels are cool.

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 3 hour.

Task 1. Determine the live test/ measure for voltage

Task 2. Determine the live test/ measure for current

Task 3. Clean Solar Panels

List of Reference Materials

Reference

1. How to Manage Work Health and Safety Risks Code of Practice 2011 (Qld)
   http://www.deir.qld.gov.au/workplace/law/codes

2. **Australian Business Consulting & Solutions**
   http://www.australianbusiness.com.au/whs/resources/managing-ohs-risk-in-your-workpla

3. https://www.osha.gov/ occupational safety &health administration

4. **Learn What is Polarity Test & Why to Conduct Polarity Test |**
   https://carelabz.com › what-polarity-test-why-conduct-polarity-test

5. Prospective Fault Current Test - The Illustrated Guide | Sparky
   http://www.sparkyfacts.co.uk/Inspection-and-Testing-Prospective-Fault-Current-Test.php

6. Planning and Installing Photovoltaic Systems(DGS)Web: www.earthscan.co.uk

Solar PV System Installation and Maintenance

Level-II

Learning Guide -64

Unit of Competence	Solve Basic DC & AC Circuit Problems in Photovoltaic Energy System
Module Title:	Solving Basic DC & AC Circuit Problems in Photovoltaic Energy System
LG Code:	EIS PIM2 M11 LO3-LG-64
TTLM Code:	EIS PIM2 TTLM 0919v1

LO3: Complete work and document Problem solving activities

Instruction Sheet	Learning Guide #55

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

- Following OHS work completion risk control measures
- Cleaning work site with safe condition
- Documenting justification solutions to solve circuit problems
- Documenting work completion

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

- Follow OHS work completion risk control measures and procedures
- Clean Work site in accordance with established procedures.
- Document Justification for solutions used to solve circuit problems.
- Notify Work completion is documented and appropriate person(s) in accordance with established procedures

Learning Instructions:

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below 3 to 6.
9. Read the information written in the information "Sheet1, Sheet 2, Sheet 3 and Sheet 4"in page 85,90,92and 95 respectively.
10. Accomplish the "Self-check 1, Self-check t 2, Self-check 3 and Self-check 4" **in page 89,91,94and 97** respectively.
11. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, **in page 98.**
12. Do the "LAP test" **in page 99** (if you are ready).

Information Sheet-1	Following OHS work completion risk control measures

1.1 Concepts of OHS work completion risk control measures

The term OHS work completion risk control measures are reasonably practicable means of work completion. That is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters .assets in a community that help meet certain needs for those around them.

1.2 Types OHS work completion risk control measures

The type of risk control measures OHS health and safety risk management should be an ongoing and continuously improving process. To ensure effectiveness in eliminating or minimizing risk of work completion control measures. So that the common types of risk control measures are follow.

Table 1. Hierarchy of control measures

HIERARCHY OF CONTROL MEASURES	
Eliminate	**First option – most effective**: can the hazard be removed altogether by elimination of process or substance?
Substituting	Involves replacing the hazard with one that presents a lower risk.
Isolating	Separate yourself from the hazard or separate the hazard from you.
Engineering	Change the design of equipment, the workplace or the process ……. do it differently.
Administrative controls	Reduce or eliminate the exposure to a hazard by adherence to procedures, instructions, signage or training. Administrative controls are dependent on human behaviour for success.
Personal Protective Equipment (PPE)	**Last option – least effective**: provides a barrier between a person and the hazard. This is dependent on PPE being chosen correctly as well as fitted and work at all times where required.

- **Elimination**

Elimination should always be the first control measure you consider can this risk be removed entirely from this activity?

Examples of elimination:

- ✓ Use extendable tools to eliminate work at height
- ✓ Materials delivered cut to size to remove the use of blades
- ✓ Cordless equipment to get rid of trailing cables

- **Substitution**

Substitution is the second best control measure you could use.

Maybe the risk cannot be removed entirely, but could it be reduced by replacing the material, substance or process with something less dangerous?

Examples of substitution:

- ✓ Replacing ladders with tower scaffolds
- ✓ Substituting a hazardous chemical with a safer alternative
- ✓ Changing high-level vibrating equipment with newer equipment with less vibration exposure

- **Engineering controls**

Third on our list, are engineering controls? These are usually fixed temporary or permanent controls. Engineering controls could be collective (protecting all workers e.g. edge protection for work at height) or individual (protecting a single user e.g. anchor points for connecting via lanyard). Give priority to measures which protect collectively over individual measures. Examples of engineering controls:

- ✓ Extraction machines to remove hazardous dust or fumes from the air
- ✓ Enclosing dangerous items of machinery or moving parts
- ✓ Installing guard rails to fall hazards

- **Administrative controls**

At number four, we have administrative controls. While this type of control is lower down on the list it will often be an essential part of your control measures.

These are rules and systems to carry out the work. What are the procedures you need to work safely? Examples of administrative controls:

- ✓ Limiting use of vibrating equipment below exposure action values
- ✓ Banning work at height and lifting operations in bad weather
- ✓ Enforcing a one-way traffic system on site

- **Personal protective clothes and equipment**

Last, but not least on our list, is personal protective clothing and equipment (PPE). PPE is the last line of defense against a hazard, so while it shouldn't be your first choice when controlling risks, it can give added protection for any remaining level of risk, or should other controls fail. Examples of PPE:

- ✓ Use of ear defenders when using noisy equipment

Finger 1.2 complete personal safety equipment

- ✓ Harnesses and lanyards where the risk of falls cannot be eliminated completely
- ✓ Hard hats where there may be falls of tools or materials overhead
- ✓ Using proper electrical tools e.g. (insulated handle screw driver and tester)

1.3 Importance of OHS work completion risk control measures

Using OHS risk control measures are health and safety risk management should be an ongoing and continuously improving process developmental work/activities since it;

- Conducting safe work completion risk management
- Improving productivity and quality products
- Perfuming AC &DC circuit problem solving safely.
- Use for improvements
- Create Environmental friend work place
- **Eliminate** hazards and injuries from work place

1.4 Monitoring the workplace for new hazards and ineffective controls

Once a planned and systematic system is in place to manage the full range of local hazards and associated risks, continuous monitoring is required to detect new hazards and highlight any ineffective controls. If an issue is found, corrective action should be taken to fix the problem. If the action will take more than a few weeks the action should be recorded and progress monitored through to completion using the Local Action Plan. Periodic and systematic monitoring to be undertaken by local areas encompasses:

- reporting and investigation of hazards and incidents through the Hazard & Incident Reporting & Investigation System, and regular analysis of reports generated from the system
- Regular, scheduled workplace inspections (six monthly for low risk and quarterly for high risk environments
- Ongoing maintenance, measurement and testing of plant and equipment and associated risk controls (e.g. testing of interlocks, electrical testing of equipment)
- Workplace monitoring, where necessary, for levels of hazardous agents such as noise or airborne chemical concentrations
- Undertaking corrective actions identified from internal and external safety evaluations
- When someone wants to strengthen existing relationships and build new ones that will promote successful work completion risk measures in the future.

Self-Check -1	Written Test

Directions: 1 chose the correct answer for the following questions and write on the black space.

1. The term ____________________are reasonably practicable means of work completion
   A. OHS work completion risk control measures B. PPE
   C. Regulation D. Police
2. Periodic and systematic monitoring to be undertaken by local areas encompasses____
   A. Reporting and investigation of hazards and incidents through the Hazard & Incident
   B. Local assessment
   C. OHS police
   D. Services

Directions: 2 Say True or False

1. The importance of OHS work completion risk control measures Conducting safe work completion risk management
2. Hard hats/ helmet where there may be falls of tools or materials overhead is PPE risk control measure.

Note: **Satisfactory rating - 3 and 5 points** **Unsatisfactory - below 3 and 5 points**

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

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet- 2	Cleaning work site with safe condition

2.1 Introduction to Cleaning work site with safe condition

Cleaning work site and maintain work area according to OHS and safe condition and return tools to maintaining order and store them according to manufacturers' specifications and enterprise requirements. Report malfunctions, faults, wear or damage to tools to the supervisor.

2.2 Types of Cleaning work site with safe condition

- **Clean with hand tools**

  keep your hand tools in good, clean condition with two sets of rags. One rag should be lint-free to clean or handle precision instruments or components.

  The other should be oily to prevent rust and corrosion.
- **Clean electrical power tools**

  Keep power tools clean by brushing off any dust and wiping off excess oil or grease with a clean rag.
- Inspect any electrical cables from dirt, water, sharp metals and for any chafing or exposed wires.
- **Clean hoisting machinery**

  locate the checklist or maintenance record for each hoist or other major piece of equipment before carrying out cleaning activities.

  You should clean operating mechanisms and attachments of excess oil or

2.3 Importance of Cleaning site with safe condition

A clean shop or work site can also reduce the costs of organization in the prevention of lost or damaged of quality of works, tools and equipment.

- A clean shop or site keeps your costs down.
- A clean shop/site at the end of each period is not optional!
- Stripe wires must never be thrown on the floor of site area.
- Shop order can lead to many usefully safe conditions.
- Quality and clean work areas are confidential for workers.

Self-Check -2	Written Test

Directions: chose the correct answer for the following questions and write on the black space.

1.____________is a process according to OHS and safe condition.

A. Environmental
B. Maintenance
C. Cleaning work site and maintain work area
D. Assessments

2. One of the following is not type of cleaning method

A. Clean with hand tools
B. Clean electrical power tools
C. Clean hoisting machinery
D. Maintenance

3. The Importance of cleaning site with Safe condition is_____________

A. Inspect any electrical cables
B. PV model maintenance
C. reduce the costs of organization in the prevention of lost or damaged
D. Tools

***Note:* Satisfactory rating - 6points** **Unsatisfactory - below 5 points**

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

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Documenting Justification solutions to solve circuit problems

3.1 Justification of solution documentation

A process of documentation of problem solving in the workplace justification is the activities of document outlines the steps necessary to complete a task or process. It is an internal, ongoing documentation of the process while it is occurring—documentation cares more about the "how" of implementation of DC & AC PV problem solving than the "what" of process impact. Problem solving is essentially a group of interrelated processes, and if these processes aren't in writing, breakdowns can occur. Thus process documentation serves as a crucial guide for trainees and employees to reference.

Documentation of work completion problem solving solutions are a roadmap for your work it helps you identify the current state of a process to know how you can improve it. Any task that is done more than once or completed by multiple people needs to be documented. Doing so provides consistency for your organization and allows you to monitor and revise processes as you go along.

3.2 How to make a document

- Determine the scope of the document and identify your type of document. Will it cover one task in a chain of operations or the entire procedure?
- Consider the audience for whom you are writing. What do they already know about the subject? Where and how are they using the product? What are their demographics?
- Write a title and introduction describing what the process is, why or when users need to do it and how it fits into the big picture of the organization. Provide context as to why the process is important.
- Describe the individuals who will be involved in the task and define their roles. Be sure to use job titles rather than individual names.
- .Identify the task boundaries, or start and end points.
- Determine the outputs of the task, or what is being produced.

3.3 Important of Justification of solution documentation

While it may be time-consuming, justifying documentation provides numerous benefits to your task that make it well worth the effort.

- Allows for continual and timely changes in solving problems to increase efficacy
- Prevents procedures from going unused due to lack of understanding

- Preserves knowledge even when those involved in the work has been left.
- Helps to determine if the work is efficient.
- Assists all members of an organization in understanding processes and knowing who to contact with problems
- Improves security
- Makes it easier to maintain DC &AC PV Circuit standards and consistency.
- Serves as on-hand teaching tools for new technicians
- Allows for outsourcing because you can easily transfer knowledge

Self-Check -3	Written Test

Directions: 1 chose the correct answer for the following questions and write on the black space.

1. A process of_________________ is the activities of document outlines the steps necessary to complete a task or work.
   A. Documentation of problem solving in the workplace justification
   B. Filing documents
   C. justification of documents
   D. task documentation process
2. Documentation of work completion problem solving solutions are _____________.
   A. Roadmap for your works.
   B. instruction
   C. information sheet
   D. data
3. The Importance of Justifying document is to solve problem easily and to assists all members of an organization in understanding processes and knowing who to contact with problems
   A. True
   B. False

Note: **Satisfactory rating – 3 and 4 points** **Unsatisfactory - below 3 and 4 points**

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

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Information Sheet-4	documenting work completion

4.1 Concept of documenting work completion

hat is a “documenting”? - Definitions and references are the following some of the main objectives of an organization’s documentation, independent of whether or not it has implemented a formal Quality management System (QMS).

- Communication of Information - as a tool for information transmission and communication. The type and extent of the documentation will depend on the nature of the organization’s products and processes or work processed the degree of formality of communication systems and the level of communication skills within the organization, and the organizational culture.
- Evidence of conformity - provision of evidence that what was planned, has actually been done.
- Knowledge sharing - to disseminate and preserve the organization’s experiences.

A typical example would be a technical specification or drawing and installation and maintenance manual, which can be used as a base for solar PV installation system.

Many industry associations publish their own lists of particular document control standards that are used in their particular field. Following is a list of some of the relevant documents. The information available and should be kept are;

- Equipment Manuals
- Design Drawings
- Technical specification
- Maintenance quick-reference guides
- Additional photos
- Work safety procedures

4.2 Important of documenting work completion

Documents stored in a document management system such as procedures, work instructions, and policy statements provide evidence of documents under control. Failing to comply could cause the loss of business, or damage to a business's reputation. The following are important aspects of document control:

- Ensuring that relevant versions of applicable documents are available at their “points of use”
- Ensuring that documents remain legible and identifiable

- Ensuring that external documents like customer supplied documents or supplier manuals are identified, controlled made easy to access
- Preventing "unintended" use of obsolete documents (document replaced by newer)
- All data and operation & maintenance history are to be documented and to stay accessible for potential, later preventive maintenance and failure repair.
- Necessary documents are important that the specification and drawing help product identify the product by its serial number and part number meets all requirements of the specification and is free of workmanship and material failures.
- All equipment having undergone major repairs have to be accompanied by maintenance records, confirmed by supervisor conformed.

4.3 Documenting and Evaluating Performance

Solar PV installation and maintenance work report should consist the amount of work done and the locations of work solar PV installation /machinery as well as the resources used. Normally, these are completed at the end of each day, or at the end of each job if more than one activity is performed during the day.

The daily work reports should be reviewed by the supervisors promptly to ensure that they were completed properly and to determine if the performance standards were substantially followed. Significant variations should be followed up promptly to determine the cause and, if necessary, take corrective action.

The daily work reports are summarized on a monthly basis to produce performance evaluation reports. These are used to evaluate performance and monitor progress toward accomplishing the work program. Again, significant deviations from the planned work program and budget should be investigated and appropriate follow-up action taken.

The importance of this step cannot be over emphasized. Without evaluation and control to ensure that the plan is followed, the entire maintenance management effort will be useless.

The trainees might have apply their skill and knowledge/understanding of the works or/ task/activity reporting and documenting important to observe and the task being performed the preferred way to ensure safest method of documented.

Self-Check -4	Written Test

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

1. Documents stored in a document management system such as_____________
   A. Procedures, work instructions, and policy statements provide evidence of documents under control.
   B. The process of reviewing or checking
   C. The collected information that interpretation.
   D. Documentation and work completion

2. Importance of documenting work completion activates are________
   A. Analyzing information
   B. Interpreting information
   C. Renewing and updating information
   D. Ensuring that relevant versions of applicable documents are available at their "points of use"

3. ____________________should consist the amount of work done and the locations of work area as well as the resources used.
   A. Solar PV installation and maintenance work report
   B. Generator operation
   C. Pump operation & maintenance
   D. Welding perfume

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 and 4 points**

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

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 1	Procedures of cleaning work site with safe condition

1.1 **Procedures of cleaning work site with safe condition**

Figure 1.1 clean PV array module

Step 1.wear appropriate personal protective equipment

Step 2 Sort in order materials

Step 3 Set in order in designated locations

Step 4 Clean up PV model or work area

Step 5. Put all waste and trash in the appropriate containers

Step 6 Return all unused spare parts and components on appropriate rack

Step 7 Check all cleanup jobs are for completed

Step 8 Return cleaning tools and equipment's to their proper places

Step 9 make sure all of the tools and equipment have been returned

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary tools and materials you are required to perform the following tasks within **1 hour.**

Task 1: Perform cleaning of work site with safe condition

List of Reference Materials

5. https://www.heathandsaftyhandbook.
6. https www.worksafe.vic.gov.au
7. https://www.safeworkaustralia.gov.au/doc Model Work Health and Safety Regulations