SOLAR PV SYSTEM INSTALLATION AND MAINTENANCE

Level-II

Learning Guide-54

Unit of Competence	Perform Wiring of Solar PV System
Module Title	Performing wiring of Solar PV System
LG Code	EIS PIM2 M10 LO-1 LG-54
TTLM Code	EIS PIM2**TTLM0819V1**

LO 1:- Prepare to lay wiring

Instruction Sheet	Learning Guide: 45

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

- Collecting the wiring diagram and layout
- Identifying paths and marking for wiring drawing or plan
- Obtaining tools, equipment and testing devices needed and check for correct operation and safety

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 –**

- Collect the wiring diagram and layout is from job documents
- Identify paths and marking for wiring from working drawing or plan
- Obtain and check tools, equipment, and testing devices needed to carry out the work for correct operation and safety.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below 3 to 6.
- Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, sheet 5, sheet 6, sheet 7, and sheet 8 in page 3, 6, 9, 12, 16, 20, 23, & 26 respectively.
- Accomplish the Self-check 1, Self-check 2, Self-check 3 ,Self-check 4, self -check 5, self -check 6, self-check 7 & self- check 8 in page 5, 8, 11, 15, 19, 22, 25 & 29 respectively

1.1 Concept: - An electrical wiring diagram helps eliminate mistakes and speed up the residential installation*.* Solar Wire Aluminum or Copper, Solid or Stranded are used for Solar PV Installations.

Residential electrical wiring systems start with the utility's power lines and equipment that provide power to the home, known collectively as the service entrance. The power is run through an electric meter, which records how much energy is used in the home and is the basis for the monthly electric bill. In general, the utility company's jurisdiction stops with the meter. After that point, all of the electrical equipment is the homeowner's responsibility.

✓ **Service Entrance**

The service entrance is the equipment that brings electrical power to the home. Most residential service includes three wires: two cables carrying 120 volts each (for a total of 240 volts) and one grounded neutral wire. If the cables are hung overhead, they are collectively called a service drop. If they are routed underground, they are known as a service lateral. A service drop connects to the home at a service head, or weather head, on the roof or exterior wall of the house.

✓ **Electric Meter**

Once the power reaches the house via the service drop or service lateral cables, it **passes through the electric meter,** which may be mounted on an exterior wall or may be located inside the home's breaker box. The meter records all electricity used by the home, measured in kilowatt-hours, or kWh. A 100-watt light bulb burning for 10 hours uses 1 kWh of electricity. Meters may be analog or digital type, although most new meters are digital and can be read remotely by the utility company.

✓ **Main Service Panel**

The main service panel, commonly known as the breaker box or circuit breaker panel, distributes power to all circuits throughout the building. Each circuit has a breaker that can shut itself off in the event of a short circuit or overload to cut power to the circuit. Old homes may have fuses instead of breakers. Fuses are just as effective as breakers, but most new panels today use breakers instead of fuses.

It is important to note that power coming from the service lines to the electric meter, and then to the main service panel, is always live. Before working on these areas the power company must shut off the power. The power going out of the panel to the household circuits can be shut off by the main breaker in the service panel, but the power coming into the panel is not affected by the main breaker.

- ✓ **Electrical Boxes**

An electrical box is a plastic or metal box used to connect wires and install devices such as switches, receptacles (outlets), and fixtures. An electrical box is almost always required for mounting devices and for housing wiring splices. Boxes come in many different sizes and several different shapes. A box must be sized appropriately for the number and size of wires entering the box. Metal electrical boxes must be grounded to the home's grounding system; plastic boxes do not need grounding because they are nonconductive.

- ✓ **Hot and Neutral Wires**

Each electrical circuit contains at least one "hot" wire that carries the electrical current from the service panel to the circuit devices and a neutral wire that carries current back to the service panel. Hot wires typically are black or red but can be other colors. Neutral wires typically are white. In some circuits, the neutral wire is used as a hot wire and the circuit has no dedicated neutral.

- ✓ **Ground**

An electrical ground is a safety system that provides a safe path for electricity to follow in the event of a short circuit, electrical surge, or other safety or fire hazard. In modern home wiring systems, each circuit has its own ground wire that leads back to the service panel. After the panel, the ground system terminates at a ground rod driven into soil or to another ground conductor where electricity is safely dissipated into the earth. Older homes may have ground systems that rely on metal electrical boxes, metal conduit (which houses wiring), and metal water pipes.

1.2 Steps for solar system installation

1.2.1 **Site visit**: the first step to getting your solar system installed

- The service provider evaluates the electrical status of home and ensures everything is compatible with new energy system.
- Evaluate the condition of roof to ensure that it’s structurally sound.
- Evaluates the property to consider system size, roof type, angle of roof, shading, etc

1.2.2 Documentation: the logistical paperwork required for your solar panel installation

- Installing solar panels involves an approved paperwork.
- The time frame for this step is mainly dependent on how long it takes your installer to get it all finished and submitted

1.2.3 Ordering equipment: Choosing the panels and inverters and getting your solar panel installation scheduled

- Select of solar panels and inverters.
- Ordering and shipment stage of the solar panel installation process.
- Durability, efficiency and aesthetics are the primary factors are considered

1.2.4 Solar panel installation : the big day

- Solar installer will start by preparing the roof and making sure the shingles or tiles are properly attached.
- Put in electrical wiring that will connect to your electrical panel and general power system.
- After the electrical wiring is complete, they will install racking to support panels (this is the only piece of equipment that will actually be attached to the roof). the panels are placed onto the racking.
- Finally, inverter(s) are connected to the panels to convert direct current (DC) energy into the alternating current (AC) energy used in homes

1.2.5 Approval and interconnection

- Commencing to generate power from your rooftop.
- Verify that the electrical wiring was done correctly
- The mounting was safely and sturdily attached
- The overall install meets standard electrical and roof setback codes.

Self-Check -1	Written Test

Directions: chose the best answer for the following questions.

1. _______________ wire is used for solar installation (3 points)

A. Copper C. Stranded

B. Aluminum D. Solid E. All

2. At what step verification of electrical connection is done? (3 points)

A. Approval and interconnection C. Documentation

B. site visit D. Ordering equipment

3. Which comes first to of solar system installation (3 points?)

A. Site visit B. Documentation

C. Ordering equipment D.Solar panel installation

E. Approval and interconnection

Give short answer

a. What are the steps for solar home system installation?

Note: **Satisfactory rating – 4.5 points Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

2.1 Common electrical diagrams

A. schematic

A schematic, or schematic diagram, is a representation of the elements of a system using abstract, graphic symbols rather than realistic pictures. A schematic usually omits all details that are not relevant to the information the schematic is intended to convey, and may add unrealistic elements that aid comprehension.

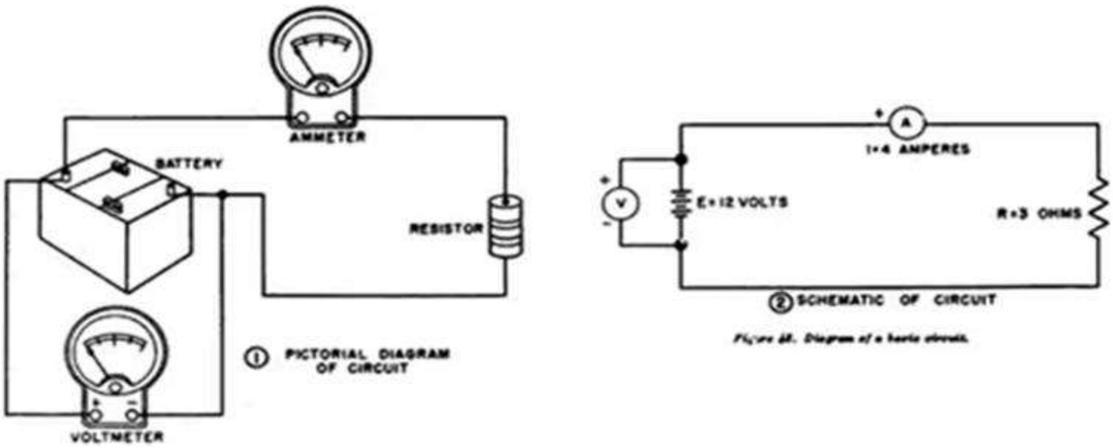


Figure 11: schematic diagram

B. Block diagram

A block diagram is used primarily to present a general description of a system and its functions. This type of diagram is generally used in conjunction with text material. A block diagram shows the major components of a system and the interconnections of these components. All components are shown in block form, and each block is labeled for identification purposes.

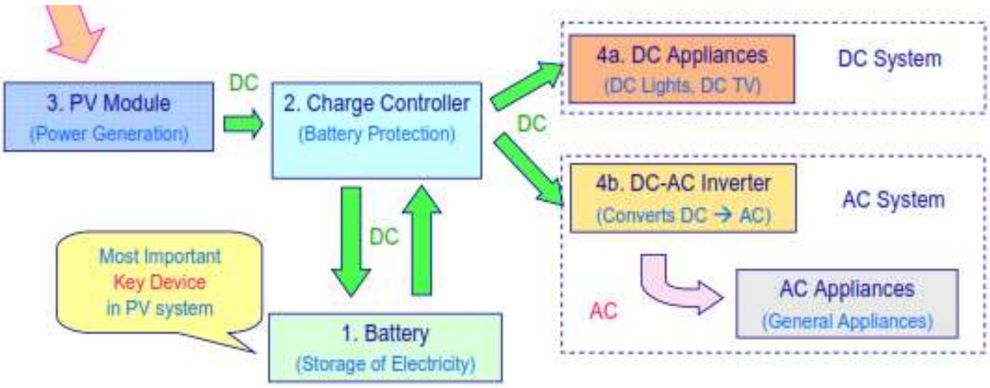


Figure 22: Block diagram

C. Wiring diagram

It is a detailed diagram of each circuit installation showing all of the wiring, connectors, terminal boards, and electrical or electronic components of the circuit. It also identifies the wires by wire numbers or color coding. Wiring diagrams are necessary to troubleshoot and repair electrical or electronic circuits.

You should use the schematic diagram previously discussed to determine where the trouble might be in the circuit when a malfunction occurs. The schematic diagram does not show the terminals, connector points, and so forth, of the circuit. Therefore, you must go to the circuit wiring diagram to determine where to make the voltage or resistance checks in the circuit when troubleshooting.

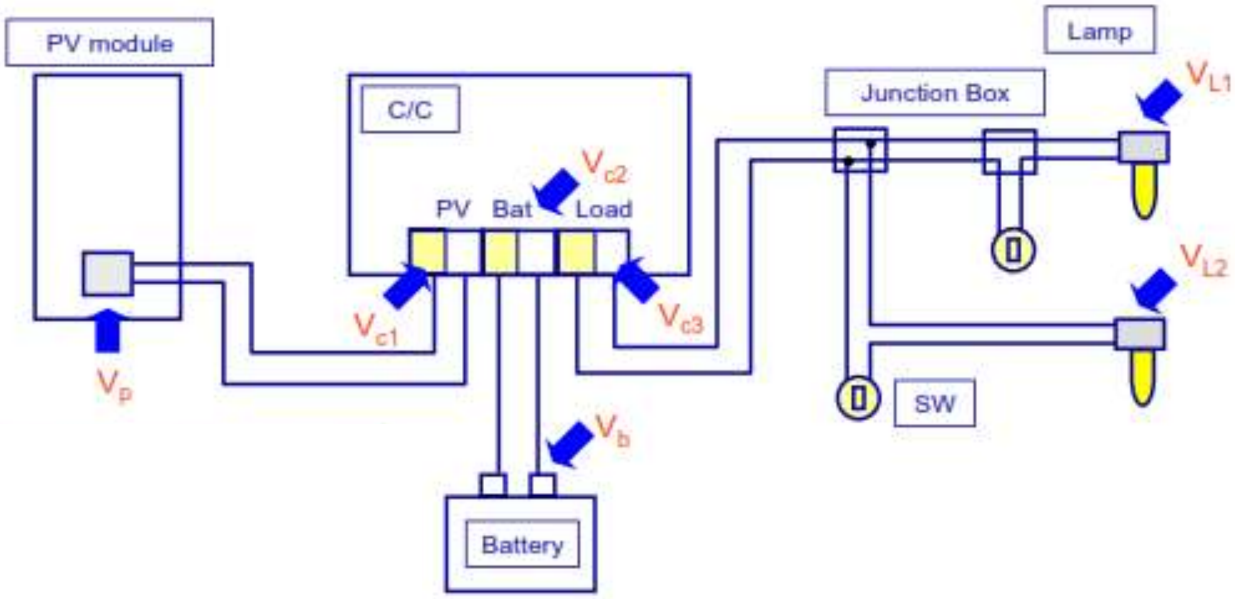
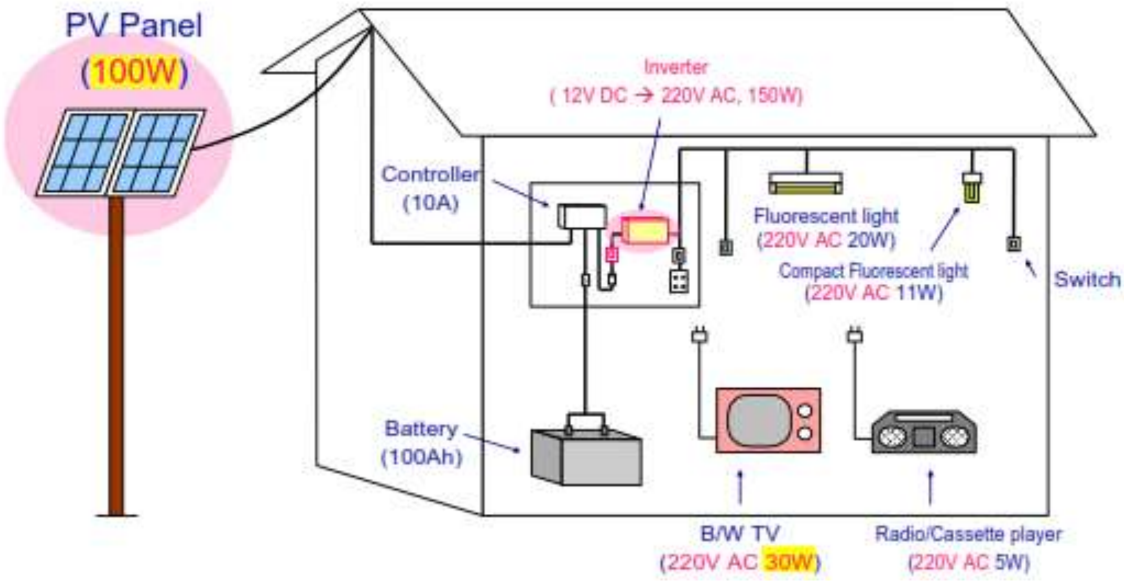


Figure 33: Block diagram

D. Single-line diagram

The single-line diagram is used basically for the same purpose as the block diagram. When used with text material, it gives you a basic understanding of the functions of the components of a system.

There are two major differences between the single-line diagram and the block diagram. The first difference is that the single-line diagram uses symbols, rather than labeled blocks, to represent components. Second, the single-line diagram shows all components in a single line. There are no interconnections shown for selected components as were shown on the block diagram (for example, alternator to voltage regulator and back to the battery). The single-line diagram is very simplified and should be used primarily to learn (in very broad terms) the function of each of the various components as a part of the total system



2.2 Collecting wiring diagram and layout

The wiring and layout diagrams should be first collected and analyzed so that the solar PV system installation meets the requirement of the customer. Being familiar with these diagrams helps to perform an installation in more standard and safe manner

Self-Check -2	Written Test

Directions: chose the best answer for the following questions .

Choose the best answer

1. ________________ is a simple visual representation of the physical connections and physical layout of an electrical system or circuit. (3 points)

   A. A wiring diagram   C. A schematic diagram

   B. A pictorial diagram   D. All

2. which often use photos with labels or highly-detailed drawings of the physical components is (3 points)

   A. A wiring diagram   C. A schematic diagram

   B. A pictorial diagram   D. All

3. ………is a diagram used primarily to present a general description of a system and its functions. (3 points)

   i. A block diagram   B. Single-line diagram

   ii. Wiring diagram   D. ALL are correct answers .

Name: ___________________________   Date: ________________

Short Answer Questions

Give short answer

4. What is the difference between a wiring diagram and a schematic diagram? (3 points)

Note: **Satisfactory rating 4.5 points   Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ____________

Rating: _____________

3.1 Rough-In Electrical Wiring

Electrical rough-in involves the installation of the Electrical rough-in is typically the last rough-in trade on-site because it's easier to run wires around ductwork and pipes than vice versa.

Electrical Rough-In Steps

1. **Layout the Plan & Devices -** Layout and mark locations of all switches, lights and outlets on studs
2. **Nail Up Junction Boxes -** Once devices are laid out, junction boxes and can lights are mounted.
3. **Pull Wiring -** Once junction boxes are mounted, the Electrician will drill holes in the studs and install the wiring from box-to-box.
4. **Electrical Service Panel -** Finally, mount and build the electrical panel, meter box, grounding and overhead service wire.

During the electrical rough-in phase all wires are left bare and are generally not connected to any switches, outlets or devices

3.2 Marking wiring

Wire marking is one of the easiest and most affordable ways to improve a facility, especially when it is done right when the wires are initially installed. Coming up with a good wire marking strategy will allow your facility to benefit from this process for many years to come. Take a moment to learn how to mark wires so that you can implement a good standard in your facility right away.

Decide What Goes on the Markings

The first thing to do is to determine what information will go on the markings. Each facility will require a different type of information, but in general it will include things like what equipment the wire is going to, and where it is coming from. In addition, adding details about the voltage of electrical wires, the type of data wires, and other things will be helpful.

Creating Wire Labels

Once you know what you want to go on the wire labels you will need to have them created. In most cases the easiest way to do this is to use an industrial label printer with good quality label stock. This will allow you to print off custom labels as they are needed so there is no delay involved with ordering them from a third-party printer. Markings for wiring can be made using heat shrink stock that wraps around the label, or tag style labels that are attached right to the label.

Installing the Wire Markings

Once the labels are ready, it is time to install them on the wires themselves. Ideally this will be done during the installation process of the wires so that you don't have to re-trace the wires that are already in production. Securely attaching the wire markings to the wires will allow them to be seen for years to come. At the very least, these markings should be put on each end of the label. If the label is going across a long distance, or through obstructions, then labels should also be placed at key points along the way.

Self-Check -3	Written Test

Directions: chose the best answer for the following questions .

1. Among the following the one is basic steps Rough-In Electrical Wiring Steps (3 points)

C. Layout the Plan & Devices
C. Pull Wiring
D. Nail Up Junction Boxes
D. Electrical Service Panel
E. All are basic steps.

2……………is one of the easiest and most affordable ways to improve a facility +(3 points).

A. Wire marking
C. pull wiring
B. Creating Wire Labels
D. No answer

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

Answer Sheet

Score = ____________

Rating: _____________

4.1 Basic Tools and test devices needed for correct operation and safety

Fortunately, most of the tools needed for a PV install are commonly used and easily found. There are very few highly specialized tools. Below are several lists that describe many of the tools needed for an installation.

Site Assessment Tools

- 50-100 ft. tape measure
- Solar Pathfinder (evaluates the solar energy potential at a site)
- Compass (not needed if you’re using a Solar Pathfinder)
- Maps (reference for location latitude and magnetic declination)
- Digital camera

Basic Tools Needed for Installation

- Angle finder
- Torpedo level
- Fish tape
- Chalk line
- Cordless drill (14.4V or greater), multiple batteries
- Uni-bit and multiple drill bits (wood, metal, masonry)
- Hole saw
- Hole punch
- Torque wrench with deep sockets
- Nut drivers (most common PV sizes are 7/16”, ½”, 9/16”)
- Wire strippers
- Crimpers
- Needle-nose pliers
- Lineman's pliers
- Slip-joint pliers
- Small cable cutters
- Large cable cutters
- AC/DC multimeter
- Hacksaw
- Tape measure
- Blanket, cardboard or black plastic to keep modules from going “live” during installation
- Heavy duty extension cords
- Caulking gun
- Fuse Pullers

Additional Tools to Consider (especially for multiple installations)

- DC clamp-on ammeter
- Reciprocating saw / Jig saw
- Right angle drill
- Conduit bender
- Large crimpers
- Magnetic wristband for holding bits and parts
- C-clamps
- Stud finder
- Pry bar

Tools for Battery Systems

- Hydrometer or Refractometer
- Small flashlight (to view electrolyte level)
- Rubber apron
- Rubber gloves
- Safety goggles
- Baking Soda (to neutralizer any acid spills)
- Turkey Baster
- Funnel
- Distilled Water
- Voltmeter

Solar PV testers are focused on troubleshooting and fault finding – this is what makes them different! Solar system testing is straight forward, but when unexpected test result occur in the field, the difficult work usually begins. With everything from solar irradiance and shading meters to solar installation testers, you'll be sure to find whatever you need to successfully install and maintain a PV panel installation.

4.2 Checking Tools, equipment and testing devices

All tools, testing equipment and PPE should be visually inspected before each use for signs of damage. Testing equipment should be checked for damage to insulated leads and probes and needs to be confirmed as working before use.

Testing equipment should be tested regularly to ensure it provides the level of protection required. Testing intervals will depend on several factors including:

- the frequency of use
- the environment in which it is being
- Manufacturer's advice.

For example, a multimeter used in a workshop environment may be subject to less damage that a multimeter carried in the back of a work van.

In absence of manufacturer's advice PCBUs should refer to a competent person with the knowledge and skills required for testing the particular type of equipment.

Items that have been misused or damaged should not be used until they have been re-retested and confirmed as functioning correctly.

Test equipment used for measurements such as earth continuity and insulation resistance should be regularly tested to confirm they are working correctly.

Some equipment such as multimeters may be able to be tested in-house, by using a calibrated resistor test block. Other equipment such as fault loop impedance testers or RCD testers may require specialist testing.

Tools and equipment must undergo thorough inspection to minimize or eliminate potential hazards. It is recommended that this audit is conducted daily or monthly but more often for tools that are heavily used. Start by providing a description of work and list down the tools for the operation. Do a site walkthrough to check if area is safe and free from hazards. Evaluate if the workers are competent, wearing appropriate PPE and are not under the influence of alcohol and drugs. Inspect if the hand and power tools pass quality standards and are free from damage like cracked blades, fraying cords, worn out handles and loose parts. Complete the audit by taking photos of tools that need repair or replacement and include other recommendations and reminders.

Self-Check -4	Written Test

Directions: chose the best answer for the following equations

1. Which of the following is a tool for battery system? (3 points)

   A. Hydrometer C. fish tape

   B. rubber gloves D. voltmeter

2. ______________________ are focused on trouble shooting and fault finding (3 points)

   A. Solar pv testers C. pliers

   B. Cutters D. Strippers

Name: __________________________ Date: ________________

Short Answer Questions

Give short answer

3. What is needed for correct operation and safety of solar pv system? (3 points)

   Ans. Tools ,equipments and testing devices

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

Answer Sheet

Score = ___________

Rating: ____________

Operation Sheet 1	Techniques of collecting the wiring diagram and layout

1.1. **Methods of doing layout diagrams**

Step-1 Collect the main components of PV system layout diagram

Step-2 Convert to schematic diagram and

Step-3 complete the wiring.

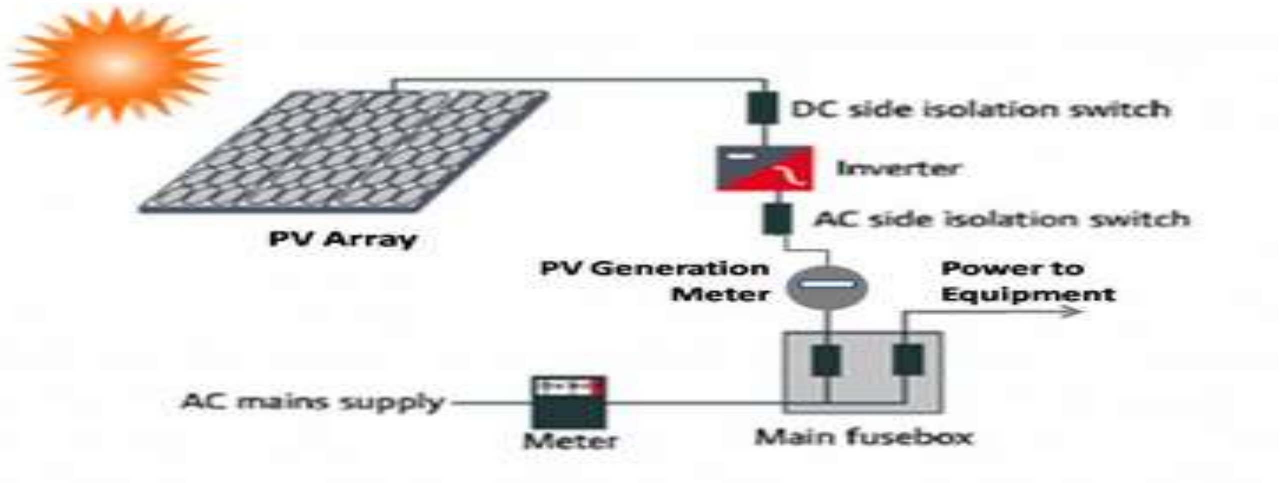


Figure 1.1: - Solar wiring system layout diagram

Operation Sheet 3	Techniques of Obtaining tools, equipment and testing devices needed and check for correct operation and safety

3.1 Perform collection of appropriate tools, equipments and testing devices

Step 1. Prepare a tool kit

Step 2. Prepare equipments and testing devices

Step 3. Check for correct operation and safety

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 Collect wiring diagram and layout

Task-2 Identify paths and marking for wiring drawing or plan

Task-3 Obtain tools, equipment and testing devices needed and check for correct operation and safety

List of Reference Materials

1- BOOKS

1. Stand-Alone Solar Electric Systems, Mark Hankins,Earthscan,2010,1st ed
2. Level 2 Technician Training manual, International Solar Energy Society/German Section,DGS e.V. 2009,2nd ed.
3. Solar Electric System Design, Operation and Installation; Washington State University Extension Energy Program, October 2009
4. Solar PV Standardized Training Manual, Developed by SNV for the Rural Solar Market Development

2- WEB ADDRESSES (PUTTING LINKS)

SOLAR PV SYSTEM INSTALLATION AND MAINTENANCE

Level-II

Learning Guide-55

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TTLM Code	EIS PIM2**TTLM0819V1**

LO 2: Connect the PV modules as per circuit diagram

Instruction Sheet	Connect the PV modules as per circuit diagram

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

- Interconnecting **the** strings are to make arrays
- Insulating all the arrays as per standard
- Combining all the arrays through combiner box

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 –**

- The strings are interconnected to make arrays
- All the arrays are insulated as per standard
- All the arrays are combined through combiner box

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, sheet 7, and sheet 8 in page 3, 6, 9, 12, 16, 20, 23, & 26 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3 ,Self-check 4, self -check 5, self -check 6, self-check 7 & self- check 8 in page 5, 8, 11, 15, 19, 22, 25 & 29 respectively

Information Sheet-1	Photovoltaic installations

1.1. Definition

Photovoltaic is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry. A photovoltaic system employs solar modules, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted, wall mounted, or floating. The mount may be fixed or use a solar tracker to follow the sun across the sky.

Solar PV has specific advantages as an energy source: once installed, its operation generates no pollution and no greenhouse gas emissions, it shows simple scalability in respect of power needs, and silicon has large availability in the Earth's crust.

1.2. **Photovoltaic installations**

Photovoltaic installations are becoming an increasingly important player in the global renewable energy production market. The biggest disadvantage of photovoltaic installations is their high price, and relatively low efficiency. Photovoltaic cells achieve a theoretical efficiency of 30%, but in real conditions this efficiency is much lower at roughly 15%. Photovoltaic installations are particularly recommended in locations where the amount of solar radiation is high and where photovoltaic installations will be able to work at full capacity for most of the year.

To set up a photovoltaic installation the first step is to assess the solar resource in the location chosen. Following the assessment, the installation is designed, installed, and put into operation.

Solar resource assessment:

- ✓ Compile data of atmospheric conditions (irradiation, temperature, wind and other conditions that have a direct influence on energy production by photovoltaic means) for the exact location where the installation is going to be carried out.
- ✓ Obtain "standard year" based on at least 3 national and international databases (with 10 years' history at least).
- ✓ Calculate the performance ratio of the installation**:** Based on the photovoltaic components chosen and other considerations due to the integration or estimation of the expected energy production at the location.

Photovoltaic installation design

Design and simulate the different installation configurations possible using computer applications according to the peculiarities of the location chosen.

After the financing has been accepted and during execution:

- ✓ Monitor the installation
- ✓ Start-up
- ✓ Operation and diagnosis conditions after the first year's activity. The normal stages are:
    - o Assess production data, availability, faults, and incidents.
    - o Study the evolution of the plant components in time, in order to assess their degradation conditions.
    - o Analyze the wave quality injected into the grid
    - o Prepare report and diagnosis.

This methodology can be applied to any photovoltaic installation connected to the grid, regardless of its power.

In general, a building-mounted PV installation comprises the following:

- The PV panels, affixed to the roof of the building or integral with the roof or facade.
- DC cables, connectors and junction boxes which take the power produced to an inverter. Sometimes junction boxes can also contain fuses, diodes, and surge-arrestors.
- One or more inverters which convert the DC power to AC. These are often termed 'string inverters' or 'central inverters'. The majority of installations in the UK use string inverters.
- 'Micro-inverters' involve an inverter, usually mounted on the roof under each panel, or small group of panels, which reduces the length of DC cabling and avoids high DC voltages, which are a potential source of electrical arcs. The remaining cabling on the roof and down to the distribution board can then be standard AC cable (exterior grade on the roof). The use of micro-inverters is becoming more popular as more systems come onto the market.
- One or more DC isolation switches provided to isolate the PV array from the inverter. Note: DC isolation switches are not interchangeable with AC isolation switches.
- AC cables which take the AC output from the inverter to the building's main electrical supply. There will be a meter to record the energy generated and an AC isolation switch on this line.
- A connection to the main AC supply via suitable protection devices, such as circuit breakers and residual current detectors (MCBs and RCDs)..
- Alternatively, for off-grid premises or installations, the DC power may be stored in batteries and/or converted to a local AC supply.

1.3 Standards and Codes

PV installations should be installed in accordance with national guidance and any specific guidance issued by manufacturers. There are a number of standards that PV products should comply with which include (amongst other factors) requirements that address fire hazards.

Where the system owner wishes to register to receive the government's feed-in tariff incentive, PV installations of less than 50kWp must comply with the MCS (micro-generation certification scheme) installation standard MIS 3002. To comply with MIS 3002, installers must use MCS or equivalent certificated PV modules. MCS certification of PV modules requires testing of products to international standards and assessment of manufacturing processes, materials, procedures, and staff training. It therefore provides building owners with a measure of confidence in the installers and products used. Furthermore, PV systems that form part of the roof structure should satisfy a fire exposure test, e.g. DD CEN/TS 1187 test 4 or BS 476 Part 3. This test seeks to ensure that fire will not spread between buildings via the roofs. From April 2014, all systems mounted on pitched roofs must also comply with MCS 012 in order to be accepted under the MCS. MCS 012 includes wind uplift and weather tightness testing of pitched roof installation kits and, for roof integrated products, the fire exposure tests described above.

Self-Check -1	Written Test

Directions: chose the best answer for the following equations

1. ……is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect (3 points)

   A. Hydrometer C. fish tape

   B. Photovoltaic D. voltmeter

2. If you are technician of solar PV, you will install PV in all except the one (3 points)

   A. Ground-mounted

   B. rooftop mounted

   C. wall mounted

   D. . floating

   E. no answer

2.1 Definition

In a larger PV array, individual PV modules are connected in both series and parallel. A series-connected set of solar cells or modules is called a "string". The combination of series and parallel connections may lead to several problems in PV arrays. One potential problem arises from an open-circuit in one of the series strings. The current from the parallel connected string (often called a "block") will then have a lower current than the remaining blocks in the module. This is electrically identical to the case of one shaded solar cell in series with several good cells, and the power from the entire block of solar cells is lost. The figure below shows this effect.

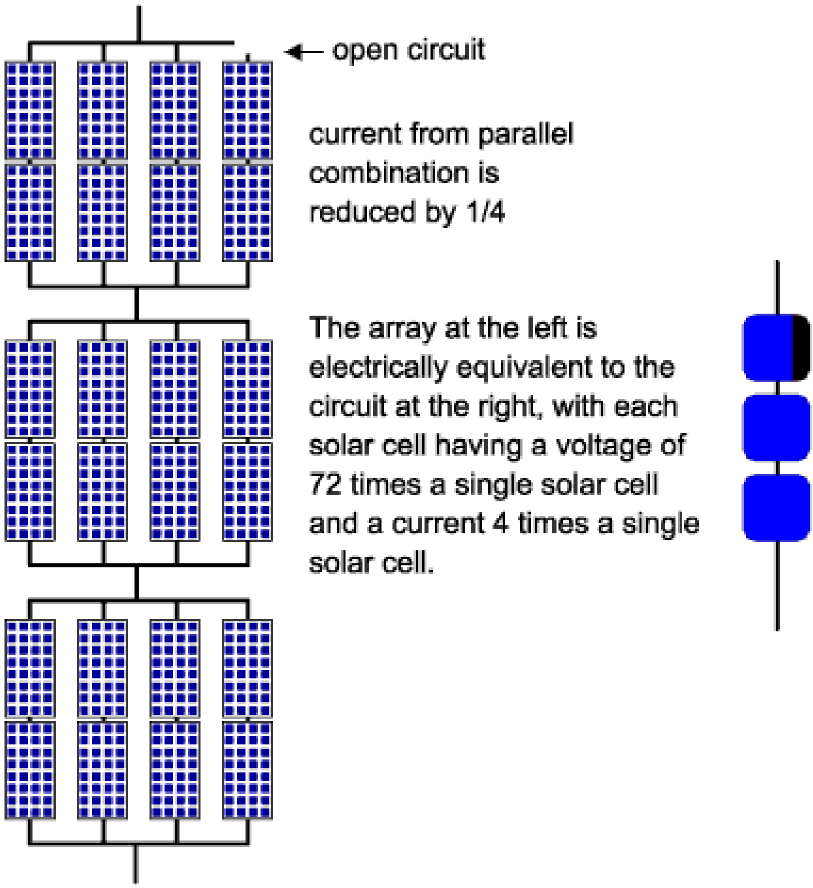
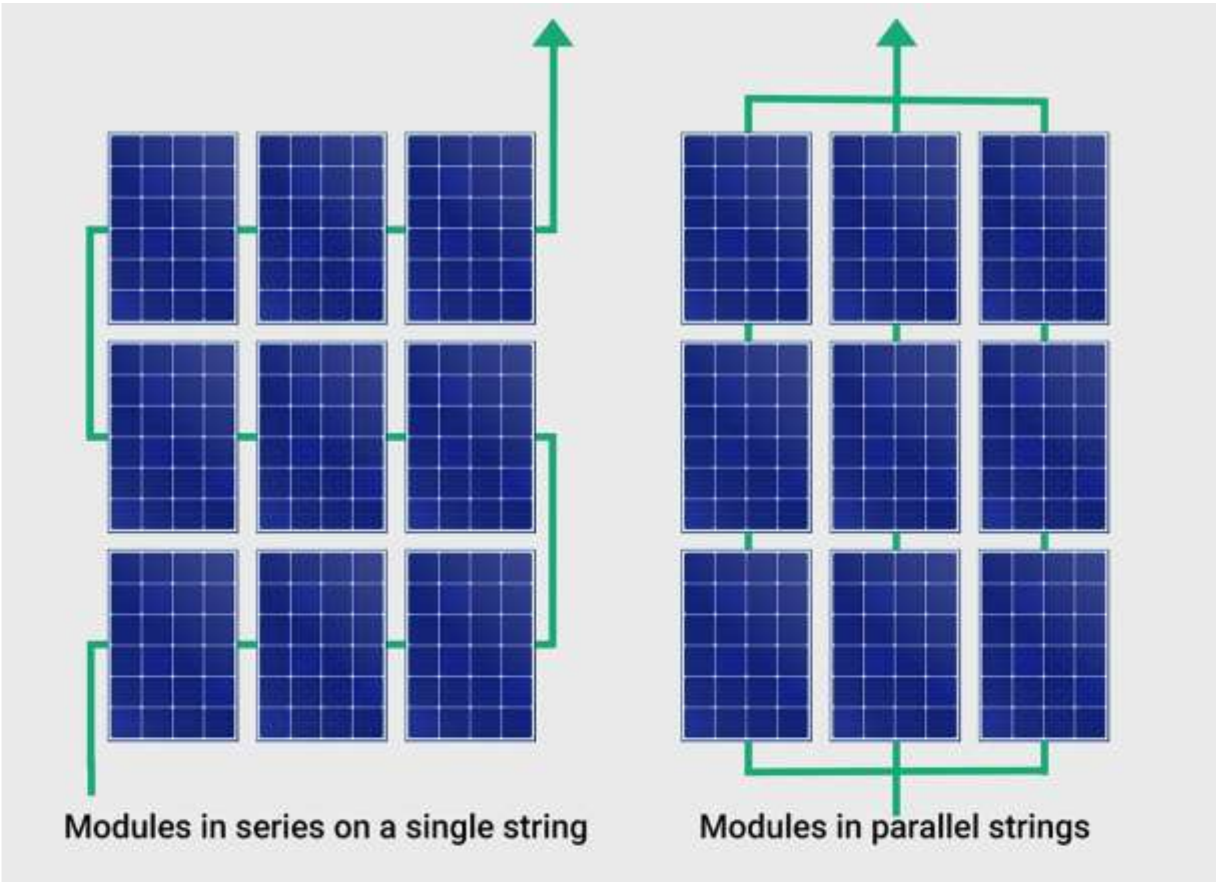


Figure 1. An array

There are multiple ways to approach solar panel wiring. One of the key differences to understand is stringing solar panels in series versus stringing solar panels in parallel. These different stringing configurations have different effects on the electrical current and voltage in the circuit.



2.2 Connecting Solar Panels in Series

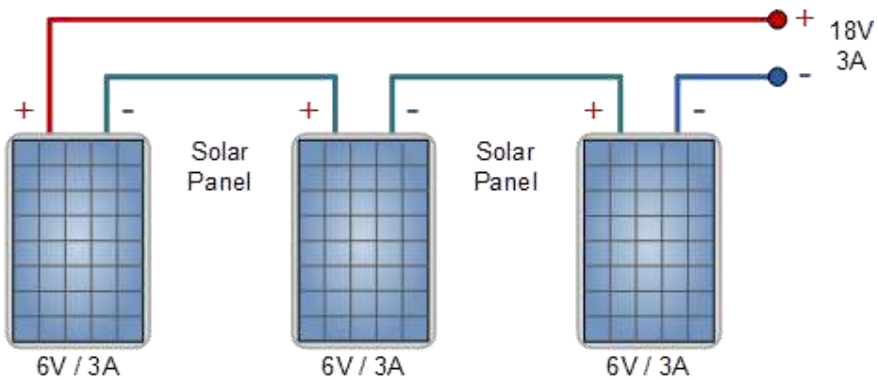
Stringing solar panels in series involves connecting each panel to the next in a line (as illustrated in the left side of the diagram above).

Just like a typical battery you may be familiar with, solar panels have positive and negative terminals. When stringing in series, the wire from the positive terminal of one solar panel is connected to the negative terminal of the next panel and so on.

When stringing panels in series, each panel additional adds to the total voltage (V) of the string but the current (I) in the string remains the same.

One drawback to stringing in series is that a shaded panel can reduce the current through the entire string. Because the current remains the same through the entire string, the current is reduced to that of the panel with the lowest current.

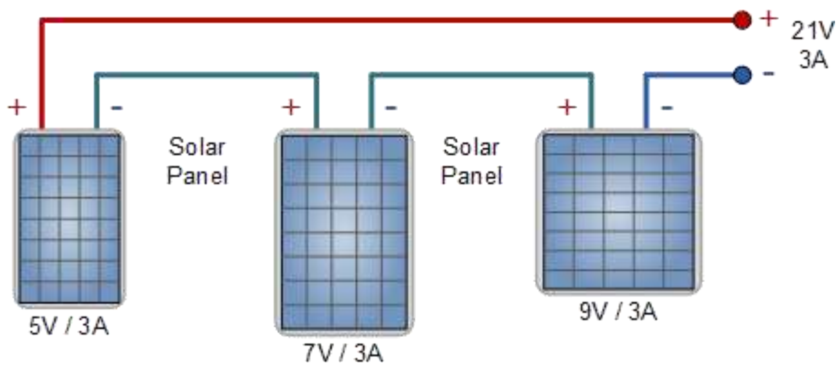
2.2.1 Solar Panels in Series of Same Characteristics



In this method ALL the solar panels are of the same type and power rating. The total voltage output becomes the sum of the voltage output of each panel. Using the same three 6 volt, 3.0 amp panels as above, we can see that when they are connected together in series, the array produces 18 volts (6 + 6 + 6) at 3.0 amps, or 54 watts (volts x amps).

Now let's look at connecting solar panels in series with different nominal voltages but with identical current ratings.

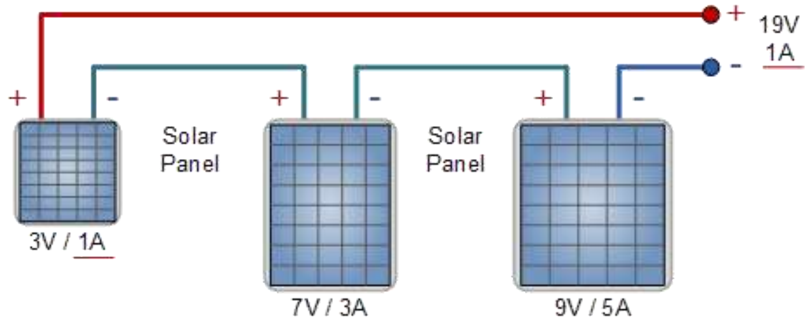
2.2.2 Solar Panels in Series of Different Voltages



In this method all the solar panels are of different types and power rating but have a common current rating. When they are connected together in series, the array produces 21 volts at 3.0 amps, or 63 watts. Again the amperage remains the same at 3.0 amps but the voltage output jumps to 21 volts (5 + 7 + 9).

Finally, let's look at connecting solar panels in series with completely different nominal voltages and different current ratings.

2.2.3 Solar Panels in Series of Different Currents



In this method all the solar panels are of different types and power rating. The individual panel voltages will add together as before, but this time the amperage will be limited to the value of the lowest panel in the series string, in this case 1 amp. Then the array will produce 19 volts (3 + 7 + 9) at 1.0 amp only or only 19 watts out of a possible 69 watts available reducing the arrays efficiency.

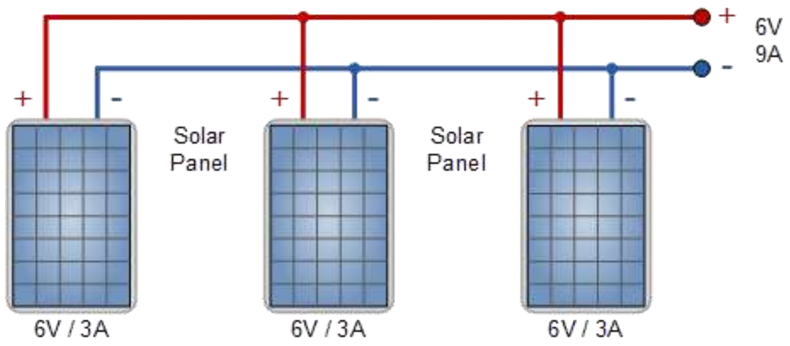
We can see that the solar panel rated at 9 volts, 5 amps, will only use one fifth or 20% of its maximum current potential reducing its efficiency and wasting money on the purchase of this solar panel. Connecting solar panels in series with different current ratings should only be used provisionally, as the solar panel with the lowest rated current determines the current output of the whole array.

2.3 Connecting Solar Panels in Parallel

Stringing solar panels in parallel (shown in the right side of the diagram above) is a bit more complicated. Rather than connecting the positive terminal of one panel to the negative terminal of the next, when stringing in parallel, the positive terminals of all the panels on the string are connected to one wire and the negative terminals are all connected to another wire.

When stringing panels in parallel, each additional panel increases the current (amperage) of the circuit; however, the voltage of the circuit remains the same (equivalent to the voltage of each panel). Because of this, a benefit of stringing in series is that if one panel is heavily shaded, the rest of the panels can operate normally, and the current of the entire string will not be reduced.

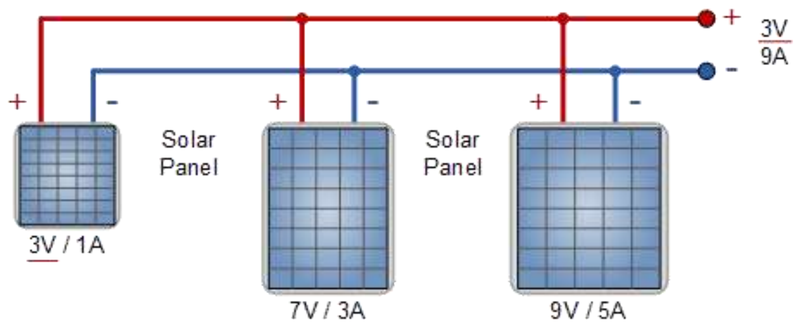
2.3.1 Solar Panels in Parallel of Same Characteristics



In this method ALL the solar panels are of the same type and power rating. Using the same three 6 volt, 3.0 amp panels as above, the total output of the panels, when connected together in parallel, the voltage output would remain the same at 6 volts, but the amperage would increase to 9.0 amps (3 + 3 + 3), or 54 watts.

But what if our newly acquired solar panels are non-identical, how will this affect the other panels. We have seen that the currents add together, so no real problem there, just as long as the panel voltages are the same and the output voltage remains constant. Lets look at connecting solar panels in parallel with different nominal voltages and different current ratings.

2.3.2 Solar Panels in Parallel with Different Voltages and Currents



Here the parallel currents add up as before but the voltage adjusts to the lowest value, in this case 3 volts. Solar panels must have the same output voltage to be useful in parallel. If one panel has a higher voltage it will supply the load current to the degree that its output voltage drops to that of the lower voltage panel.

We can see that the solar panel rated at 9 volts, 5 amps, will only operate at a maximum voltage of 3 volts as its operation is being influenced by the smaller panel, reducing its efficiency and wasting money on the purchase of this higher power solar panel. Connecting solar panels in parallel with different voltage ratings is not recommended as the solar panel with the lowest rated voltage determines the voltage output of the whole array.

Then when connecting solar panels together in parallel it is important that they ALL have the same nominal voltage value, but it is not necessary that they have the same ampere value.

Connecting solar panels together to form bigger arrays is not all that complicated. How many series or parallel strings of panels you make up per array depends on what amount of voltage and current you are aiming for. If you are designing a 12 volt battery charging system than parallel wiring is perfect. If you are looking at a higher voltage grid connected system, than you're probably going to want to go with a series or series-parallel combination depending on the number of solar panels you have.

But for a simple reference in regards to how to connect solar panels together in either parallel or series wiring configurations, just remember that parallel wiring = more amperes, and series wiring = more voltage, and with the right type and combination of solar panels you can power just about any electrical device you may have in your home.

Self-Check -2	Written Test

Directions: chose the best answer the flowing questions.

1. An array is a group of solar panels connected in (3 points)
   A. Parallel B. Series and Parallel
   C. Series D. All
2. Which of the following is true about Solar Panel(3 points)
   A. Parallel with Different Voltages and Currents
   B. Parallel of Same Characteristics
   C. Connecting Solar Panels in Parallel
   D. solar panels in series of different currents
   E. All

<u>Give short answer</u>

1. What is a string?

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

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Information Sheet-3	**Insulating arrays as per standard**

3.1 Insulating arrays: - An **insulator** on the other hand is a material which does not allow an electric current to flow. Rubber and most plastics are insulators.

Wires and cables (conductors) are insulated and protected by a variety of materials (insulators) each one having its own particular properties. The type of material used will be determined by the designer who will take into account the environment in which a control panel or installation is expected to operate as well as the application of individual wires within the panel. As part of the insulating function, a material may have to withstand without failing.

Just as with other electric power generation, PV systems present the risk of shock and electrocution when current takes an unintended path through a human body. Current as low as 75 milliamps (mA) across the heart is lethal. The human body has a resistance of about 600 ohms. Per Ohm's law, voltage (V) equals current (I) times resistance (R), so V = IR.

To calculate the amount of current that would course through a person's body if exposed to 120 V, simply divide 120 V by 600 ohms (I = V/R), which totals 0.2 amps or 200 mA. That's more than 2.5 times the lethal limit of 75 mA, so protecting yourself and your workers against such an event is critical.

Electrical shocks are typically caused by a short circuit resulting from corroded cables and connections, loose wiring, and improper grounding. Key places to look for these conditions in a PV system include the combiner box, PV source and output circuit conductors, and the equipment grounding conductor. The grounding conductor bonds all metallic components together—and eventually to ground—through the grounding electrode conductor and grounding electrode.

3.2 Insulation failure faults

Individual insulation failures are often difficult to detect in monitoring. And when insulation problems are suspected in the system, it is an additional challenge to pinpoint them precisely..

The monitoring system reports: the ease with which insulation faults can be detected in monitoring depends, among other things, on the type of inverter used. Some inverters provide direct insulation values; others simply switch off when the value falls below a certain limit. The system described here uses inverters that do not measure insulation values. The result is that the monitoring first indicates reduced performance in the affected inverter when compared with the other inverters.

A closer look at the monitoring data shows: In the yield curves of the affected strings, isolated failures of entire inverters and all of the connected strings can be seen. This is especially the case in the early morning hours, but sometimes occurs at other times of day as well. This effect occurred relatively infrequently in summer but now that fall has arrived it is happening more often.

The hypothesis: The time at which the inverters fail may indicate one or more insulation faults. This is indicated on the one hand by the delayed start of the system in the morning hours when dew and moisture cover the modules, cables, and connectors, and on the other hand when rain reaches the affected area with the insulation problem. In order to determine the latter, the yield curves of the individual strings and inverters have to be compared with corresponding weather data.

Identifying the fault and the affected modules: Because insulation faults cause a reduction in yield and pose a potential safety risk (in extreme cases due to arcing), the operator decides to address the problem. A technician has to go to the plant. If the faults cannot be detected with the naked eye, it becomes complicated. After all, the insulation faults only occur at certain times, such as in wet and humid weather, and they can only be measured then. This means that the technician has to measure the individual strings and modules at the times when problems were detected during monitoring; in the early morning hours, for instance. Because the technician is in the plant at the right time, the detective work can begin. First, they can set to work on all of the strings of the affected inverters individually and measure the insulation of the string at the inverter. Each time, they have to unplug the connector and insert the insulation measuring device. A single reading takes about two minutes to record. Added to this is the time spent on the roof walking between the various inverters.

Self-Check -3	Written Test

Directions: **say true if the statement is correct and false if the statement is inorecrct.**

1) Insulator is a material which allows an electric current to flow (2 points)
2) Wires and cables (conductors) insulated and protected by a variety of materials (insulators) (2points)
3) Rubbers and plastics are a good examples of insulator materials (2points)
4) Electrical shocks are typically caused by a short circuit resulting from corroded cables and connections, loose wiring, and improper grounding(2points).

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

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet-4	Combining arrays through combiner box

4.1 Solar Array Combiners

An **array combiner** is pretty much what it says **-** it takes the wires from several arrays and/or solar panels and combines them into one main bus or feed. Fuses (and fuse holders) or breakers are not usually included with combiner boxes, as each setup will be different. Those must be purchased separately.

An "array" may be one panel or many in series and may range from a single panel 12-volt up to multi-panel high voltage arrays for grid-tie systems. Grid tie systems can go as high as 600 volts DC, while nearly all battery systems are 12, 24, or 48 volt. Higher voltage systems over 48 volts have different NEC code requirements than those for low voltage battery systems, and the two types are NOT interchangeable.

There are also two types of wiring for combiners. Most common is the standard one that has been around for years where each pair of wires from the panel junction box is connected to terminal blocks. One problem is that nearly all new panels come with MC connectors, not junction boxes. That often requires that an **MC extender cable** be purchased and cut in half to transition from the solar panel wiring to the array combiner junctions.

Becoming more available, but still uncommon, are combiner boxes using MC connectors that simply plug in. They have simplified wiring in many cases, and the cables are available in a wide range of sizes. Unfortunately, the availability of combiner boxes specifically designed for use with MC cables is a bit sparse right now, and the chassis mount MC connectors are often difficult to find and rather expensive.

Low Voltage Combiners (battery systems):- Most lower voltage battery based systems up to 48 volts can use DC breakers.

High Voltage Combiners (grid-tie):- High voltage combiners may have voltages of up to 600 volts DC, and to meet electrical and safety codes, nearly always require fuses be used instead of breakers.

4.2 When solar array combiner is required

The role of the combiner box is to bring the output of several solar strings together. Daniel Sherwood, director of product management at Solar BOS, explained that each string conductor lands on a fuse terminal and the output of the fused inputs are combined onto a single conductor that connects the box to the inverter. “This is a combiner box at its most basic, but once you have one in your solar project, there are additional features typically integrated into the box,” he said. Disconnect switches, monitoring equipment and remote rapid shutdown devices are examples of additional equipment.

Solar combiner boxes also consolidate incoming power into one main feed that distributes to a solar inverter, added Patrick Kane, product manager at Eaton. This saves labor and material costs through wire reductions. “Solar combiner boxes are engineered to provide overcurrent and overvoltage protection to enhance inverter protection and reliability,” he said.

As a general rule for battery systems, an array combiner is not really needed for 1 or 2 panels, and may not be needed for 3 to 4 panel systems. If you have more than 4 panels or strings of panels to combine, we definitely recommend a combiner box.

“If a project only has two or three strings, like a typical home, a combiner box isn’t required. Rather, you’ll attach the string directly to an inverter,” Sherwood said. “It is only for larger projects, anywhere from four to 4,000 strings that combiner boxes become necessary.” However, combiner boxes can have advantages in projects of all sizes. In residential applications, combiner boxes can bring a small number of strings to a central location for easy installation, disconnect and maintenance. In commercial applications, differently sized combiner boxes are often used to capture power from unorthodox layouts of varying building types. For utility-scale projects, combiner boxes allow site designers to maximize power and reduce material and labor costs by distributing the combined connections.

The combiner box should reside between the solar modules and inverter. When optimally positioned in the array, it can limit power loss. Position can also be important to price. “Location is highly important because a combiner in a non-optimal location may potentially increase DC BOS costs from losses in voltage and power,” Kane explained. “It only constitutes a few cents per watt, but it’s important to get right,” Sherwood agreed.

Little maintenance is required for combiner boxes. “The environment and frequency of use should determine the levels of maintenance,” Kane explained. “It is a good idea to inspect them periodically for leaks or loose connections, but if a combiner box is installed properly it should continue to function for the lifetime of the solar project,” Sherwood added.

4.3 Quality of the combiner box

The quality of the combiner box is the most important consideration when selecting one, especially since it’s the first piece of equipment connected to the output of the solar modules. “Combiner boxes are not expensive compared to other equipment in a solar project, but a faulty combiner box can fail in a dramatic way, involving shooting flames and smoke,” Sherwood warned. “All should be third-party certified to conform to UL1741, the relevant standard for this type of equipment,” Sherwood said. Also be sure to pick a combiner box that meets the technical requirements for your project.

A new trend is the incorporation of a whip: a length of wire with a solar connector on the end. “Rather than a contractor drilling holes in the combiner box and installing fittings in the field, we install whips at the factory that allow the installer to simply connect the output conductors to the box using a mating solar connector,” Sherwood explained. “It’s as easy as plugging in a toaster.”

This year arc-fault protection and remote rapid shutdown devices are more popular than ever, due to recent changes in the National Electrical Code that require them in many solar applications. “New technologies and components are driven by the NEC changes, as well as the desire for enhanced energy efficiency and reduction of labor costs,” Kane said. Some of these new components include: higher voltage components, integral mounting hardware and custom grounding options.

Self-Check -4	Written Test

Directions: say true if the statement is correct and false if the statement is incorrect.

1. An array combiner takes the wires from several arrays and/or solar panels and combines them into one main bus or feed (2 points)

2. Low Voltage Combiners (battery systems)is the most lower voltage battery based systems up to 600 volts that can used DC breakers (2points)
3. High voltage combiners may have voltages of up to 48 volts DC, and to meet electrical and safety codes(2points)
4. The quality of the combiner box is the most important consideration when selecting the first piece of equipment connected to the output of the solar modules. (2points).

Note: **Satisfactory rating - 4points** **Unsatisfactory - below 4 points**

Answer Sheet

Score = ___________
Rating: ____________

SOLAR PV SYSTEM INSTALLATION AND MAINTENANCE

Level-II

Learning Guide-56

Unit of Competence	Perform Wiring of Solar PV System
Module Title	Performing wiring of Solar PV System
LG Code	EIS PIM2 M10 LO-3 LG-56
TTLM Code	EIS PIM2**TTLM0819V1**

LO 3:- Lay Cables

Instruction Sheet	Learning Guide: 45

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

- Installing Conduits as per standard
- Lading Cables through the conduits
- Connecting cables to control and safety boxes
- Installing Wiring and accessories
- Terminating Cables and conductor accessories
- Installing Cables for future service
- Following procedures for referring non-routine events
- Caring out Cable installation and termination efficiently
- Checking Circuits/machines/plant with OHS requirements
- Installing wiring and accessories to comply standards

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 –**

- Install Conduits as per standard
- Lad Cables through the conduits
- Connect cables to control and safety boxes
- Install Wiring and accessories
- Terminate Cables and conductor accessories
- Install Cables for future service
- Follow procedures for referring non-routine events
- Caring out Cable installation and termination efficiently
- Check Circuits/machines/plant with OHS requirements
- Install wiring and accessories to comply standards

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below 3 to 6.

- Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, sheet 5, sheet 6, sheet 7, and sheet 8 in page 3, 6, 9, 12, 16, 20, 23, & 26 respectively.
- Accomplish the Self-check 1, Self-check 2, Self-check 3 ,Self-check 4, self -check 5, self -check 6, self-check 7 & self- check 8 in page 5, 8, 11, 15, 19, 22, 25 & 29 respectively

1.1. **Concepts of tools and equipment's**

Definition: - An *electrical conduit* is a tube used to protect and route *electrical* wiring in a building or structure. *Electrical conduit* may be made of metal, plastic, fiber, or fired clay. Most *conduits* is rigid, but flexible *conduit* is used for some purposes.

The term "electrical conduit" refers to durable tubing or other types of enclosure used to protect and provide a route for individual electrical wiring conductors. Conduit is typically required where wiring is exposed or where it might be subject to damage. A conduit can be made of metal or plastic and may be rigid or flexible. All conduits are installed with compatible fittings (couplings, elbows, connectors) and electrical boxes, usually made of the same or similar material. Conduit must be installed in accordance with the National Electrical Code (NEC) and all applicable local code rules.

Conduit wiring is a system where the cables are enclosed in metal or plastic tubes. The conductors have insulation which is rated at the voltage required but gives no mechanical protection.

1.2 Types of conduit

Type 1 - Rigid Non-Metallic Conduit (PVC)

Type 2 - Rigid Metal Conduit (RMC) / Rigid Steel Conduit (RSC)

Type 3 - Intermediate Metal Conduit (IMC)

Type 4 - Galvanized Rigid Conduit (GRC)

Type 5 - Electrical Metal Tubing (EMT)

Type 6 - Flexible Metal Conduit (FMC)

1.3 Conduit Accessories and Fittings

From the various accessories required for conduit wiring the most common ones are the following:

D. **Conduit Boxes:** - are of different designs. These are removable covers, provide platy of space for drawing cables and housing cables and give better appearance. The purposes of conduit boxes are:

- For providing connections to light, fan, and other points. The conduit boxes serving the purpose are known as outlet boxes because conduits terminate at the boxes. These boxes may have entry either from side or from back or from sides.
- For pulling of cables in to the conduits. The boxes serving this purpose are known as inspection boxes (for checking of conduits and cables). These are provided after every 30 meter length of straight run.
- For housing junction of cables. The conduit boxes serving this purpose are known as junction boxes. I.e. for housing of connection points.

A four way conduit box is employed where sub-circuit wires come together bunched in one conduit and then are taken off in different directions. Three way boxes are employed for bridging out the conduit going down to the switches. Two way boxes with two outlets in one line are used in straight run.

E. **Conduit coupler:** - conduit is available in lengths from 3m to 5 m and for straight runs of greater length; couplers are used to join two lengths of conduit. The lengths of the screwed conduit are always threaded at both ends on the outer side. The threads on conduits are usually tapered. If shorter lengths are required then they must be cut off with a hack saw, all roughness removed from the end and then threaded with a die. One coupler is supplied free of costs with each length of conduit by manufacturer. The couplers are threaded on its inner surface.

Another method of coupling of light gauge conduit is by means of grip coupler. This method is economical in view of its minor cost of fitting as no extra labor is required for making threads. The ends of conduits are placed in the grip coupler and screws tighten. All conduits joined by this method must be perfectly clean so that electrical continuity is not disturbed. This method can also used for flexible conduits.

For coupling a flexible conduit to the rigid conduit a combined coupling is used. The coupler used for this purpose has threaded hole on one side to receive threaded end of the conduit and has a large hole to receive the flexible conduit on the other side.

F. **Conduit bushings**: - these are used when the rigid conduit enters the conduit box or a hole which is not threaded. These are used to prevent cable from being cut by the edges. These are of two types male and female, male bushes are provided with threads on their outer surface and female bushes are provided with threads on their inner surface. Conduits can be directly screwed in to the female bushes; male bushes are used with couplers.

G. **Conduit Reducers: -** are used when size of conduit changes. Conduit reducers have both male and female threads. The conduit reducer is fitted in to the couplers or conduit box and in to it the conduit of smaller size is screwed.

1.3 Fixing of conduit: - method of fixing a conduit is an important matter. In sunk work the conduit has to be held securely and the plaster does the rest, but in surface work it requires great attention so that the work is neat as well as secure and the minimum of damage is done to the walls.

Clips: - are used for fixing conduit. The advantage of clip conduit fixing is that only one line of fixing holes is required.

Saddles: - are used for fixing the conduit when clips cannot give a firm enough hold or a single screw cannot be depended for fixing. Multiple saddles are used if two or more lengths of conduit run together. All these are made of the correct size for the various diameters of conduit.

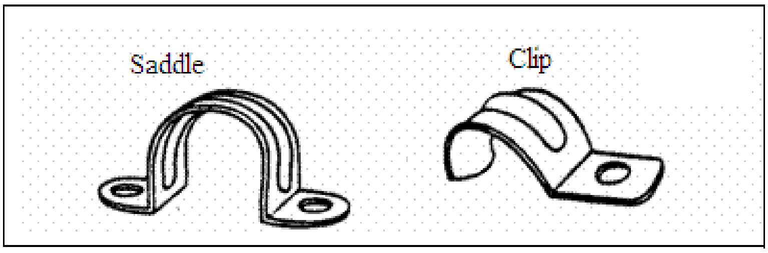


Figure 1-4. Conduit supports

Clips are usually fastened with nails. Normal nails are used of the clips are to be fastened onto a wooden surface, but hardened steel nails are required on masonry surfaces,

Saddles are fastened with wood screws and a wall plug is fastened to a masonry surface and with screw only if fastened to a wooden surface. For better support of the cable, position the clips of horizontal runs of cables in such a way that their nails are places underneath the.

The number of supports needed depends on the type of conduit being used. Holes in framing members may serve as supports. EMT requires supports within 3 feet of each outlet box, junction box, and cabinet. Rigid-steel conduit must also be supported within 3 feet of a box. The distance between supports may be increased to 20 feet on direct vertical runs of rigid-steel conduit from machine tools and other equipment if threaded couplings are used and the riser is supported at each end. After all conduits has been installed, supported, and connected to the boxes, you are ready to install the conductors.

Bends and elbows: - in general conduit fittings include bends and elbows. All these can be either of the inspection type (provided with the detachable lid) or solid. Solid elbows should be used only at the end of the conduit run (e.g. close behind the light fitting). The detachable lid provided in inspection type elbows facilitate pulling of cables. Elbows which are of shorter radius, are only where sudden right turn is required or on a surface work where neatness is required. Bends are usually used for changing the direction of conduit. These should never be sharp. The minimum allowable radius of curvature is 2.5 times the outside diameter of the conduit.

1.3 Installing conduits

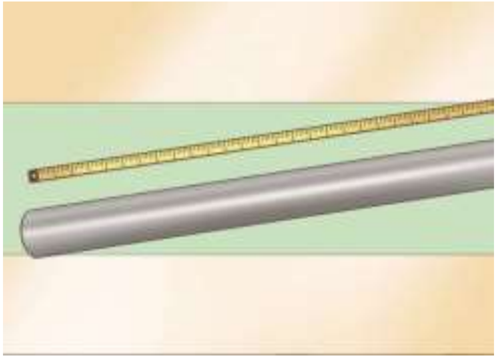
Electrical conduit fittings form the outer covering for most electrical wiring from one point to the next. They shield the wires from the external environment so as to make the wire last longer and also to keep humans and pets safe from electric shocks or other such vulnerabilities. Electrical conduits are predominantly made of insulating and sturdy material for optimum functionality. Although it is best suited for a professional electrician to accomplish most electrical conduit fittings, there are some minor ones that you can easily do on your own.

STEP 1:- Choose the right material for installing electrical conduit fittings: The most preferred material is known as EMT (Electrical Metallic Tubing). EMT is very easy to install as you can effortlessly bend it and assemble it as per your needs. Also, you can conveniently take it off in case your wiring goes wrong somewhere. If you do not have it in your house, you can buy EMT from any of the electrical surplus stores for pretty cheap.

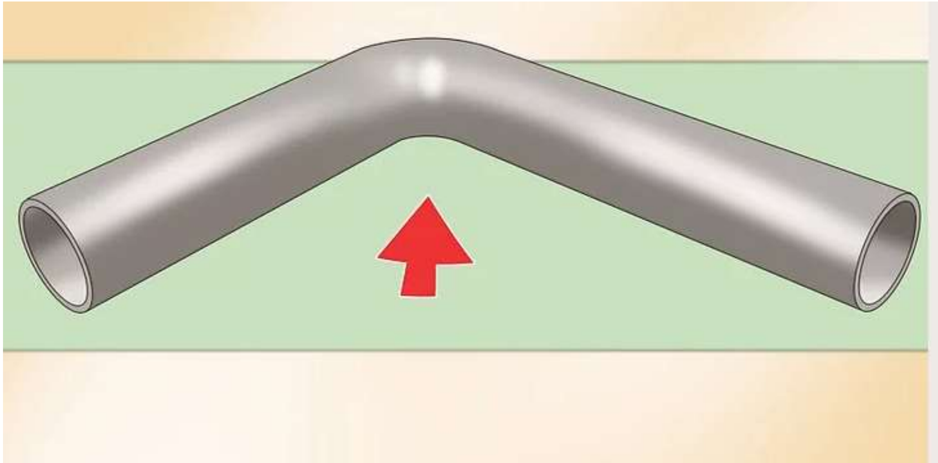
STEP 2:- Chalk out a wiring plan: Find out the location of the electrical boxes on your wall to trace the route of the conduit. Draw the path from the main power source to the electrical box

STEP 3:- Measure the amount of conduit that you would need: Make appropriate marks in pencil wherever you think the bends should be, and measure the total length of the conduit that would be needed to finish the entire electrical conduit fittings. Now

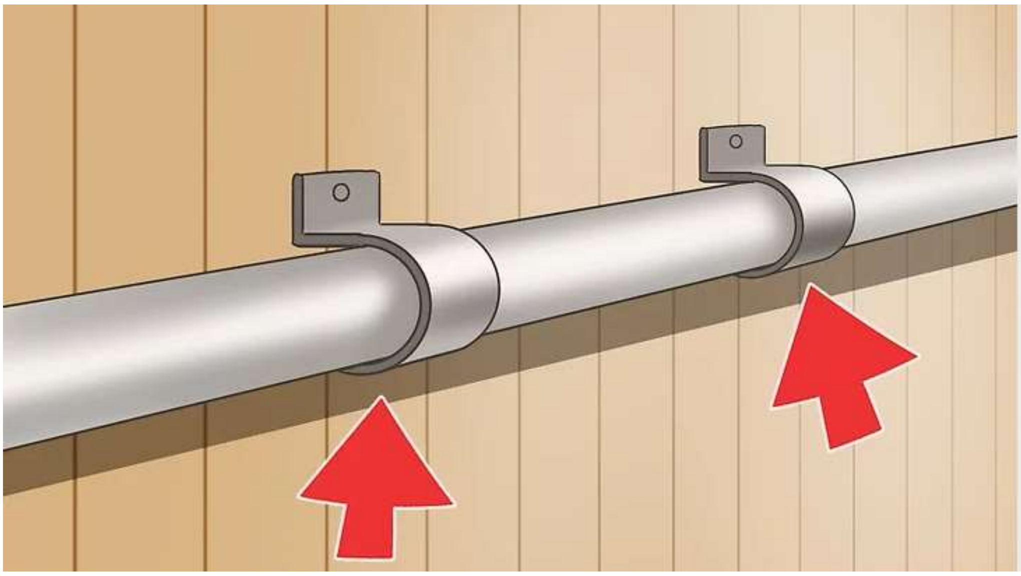
cut the length that you just measured with a tool called hacksaw. The cut ends are likely to have burrs which can be removed using a debarring tool or with pliers.



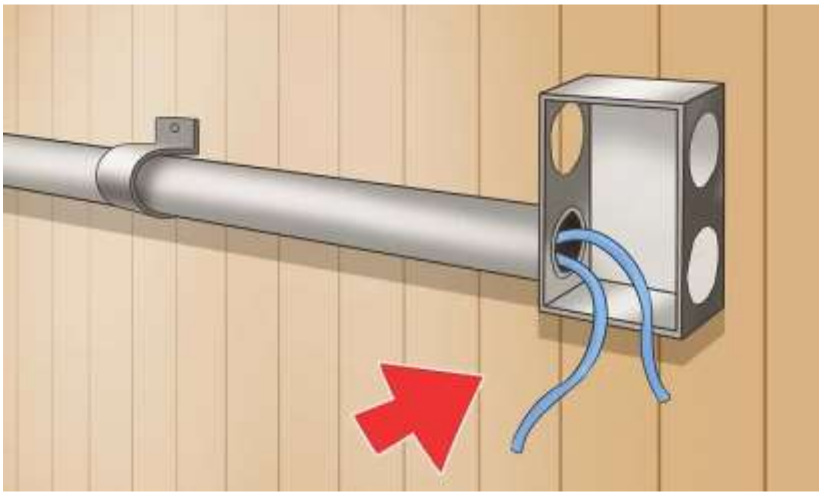
STEP 4:- Make the necessary bends: It is now time to make bends that you had marked on the pipe in the previous step. Owing to the easy flexibility of EMT, this should not be very difficult. Conduit benders come in handy for doing this bending.



STEP 5:- Attach fittings to the wall: You can use screws and straps with either single or double holes, available at electrical surplus shops, to attach electrical conduit fittings to the wall.



STEP 5:- Tape the ends and put the wires in place: Use a widely available fish tape and run it through the entire route of the conduit fittings you just installed. Fix together the ends along with the electrical wires with the same fish tape. Give a finishing touch by pulling all the wire in the pipe in their right place.



Self-Check -1	Written Test

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

Choose the best answer

1. Which of the following is grouped under the types of conduits?(3 points)

   A. Rigid PVC Conduit C. Electrical Non-Metallic Tubing
   B. Electrical Metallic Tubing D. Flexible Metal Conduit E. All

2. Which of the following the necessary step to installing conduit(3 points).
   A. Choose the right material for installing electrical conduit fittings
   B. Chalk out a wiring plan
   C. Measure the amount of conduit that you would need:
   D. Make the necessary bends
   E. Attach fittings to the wall
   F. .All

Give short answer

A. What is the purpose of an electrical Conduit ?

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

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet-2	Lading Cables through the conduits

2.1. Meaning of Lading cables

Lading cables means lading cables through the conduit: How to pull wires through electric conduit, How to pull wire through long conduit, how to pull wire through flexible conduit, How Pull wire through a wall conduit

2.2. How to lad cables

When you feed the wires into conduits, you need to push all wires smoothly from their spools. Meanwhile, make the wires unrolled when you are feeding them. Make the wire smooth by lubricate and push them into the tube, the other hand pull wires off of spools. When the tapes appear at the other end of the conduit, another person is needed to attach wires to the fish tape end. Then you can pull the wires through the conduit. Follow the following steps to

Pulling wires can be difficult enough through straight runs of conduit, but throwing a few bends and turns in the run increases friction, making pulling much more difficult. That's when you use a lubricant. Wire-pulling compound is a non-conductive lubricant in either a gel or a slimy, soapy form that makes both the conduit and wires slick by coating the wiring, allowing it to slide through the conduit with relative ease.

Apply the compound directly to the wires before pulling them into the conduit. Use the lubricant more heavily at the beginning of the pull and less so toward the end of the pull, as the interior of the conduit will become coated along its length as you pull. Follow the manufacturer's instructions for proper application.

- **Pulling Wire with a Mouse**

A conduit mouse, also called a conduit piston, is a small cylinder of foam that is slightly smaller than the interior diameter of the conduit. You use it with a shop vacuum.

1. Tie a strong string, called a pull string, to the loop on the wire running through the mouse.
2. Insert the mouse into the conduit on the end that is opposite to the end you will pull from. The mouse goes in first, followed by the string.
3. Fit the hose of a shop vac over the other end of the conduit, and turn on the vacuum until the mouse is sucked all the way to that end, then turn off the vacuum.
4. Pull the mouse out of the conduit and untie the string from the wire loop.
5. Secure the string to the wires, and lubricate the wires, as needed.
6. Feed the wires into the conduit while your partner pulls them from the other end, using the string.

- **Pulling Wire with a Fish Tape**

The most commonly used tool for pulling wire through conduit is fish tape, an electrician's tool with a long, flat metal wire wound inside a wheel-shaped spool. Fish tapes are widely available in a range of lengths starting at 25 feet. There are also nylon tapes that don't include a spool; these may be the most economical option for when you need a fish tape only for small jobs.

1. Feed the end of the tape, which has a hook on it, into the same end of the conduit that you will pull from.
2. Push the tape through the conduit, unwinding from the spool as you go. Stop feeding when the hook end emerges from the opposite end of the conduit.
3. Strip insulation from the end of each wire, using wire strippers. Strip each wire a different amount. For example, if there are three wires, strip one about six inches, one about four inches, and one about two inches.
4. Hold the three wires together so their insulation is aligned. Grab all three with linesman's pliers and twist their bare ends together.
5. Bend the longest wire into a hook and loop it through the hook of the fish tape, then wrap the loop closed.
6. Wrap the fish tape hook and the bare wire ends with electrical tape.
7. Apply lubricant to the tape, if desired. Feed the wires into the conduit while your partner pulls them through from the other end by pulling on the fish tape.

Self-Check -2	Written Test

Directions: chose the best answer for the following questions.

1. Which one is true about lading cables into conduits?(3 points)

A. Pull wires through electric conduit C. Pull wire through flexible conduit
B. Pull wire through long conduit D. Pull wire through a wall conduit E. All

2. ………conduit piston which is small cylinder of foam that slightly smaller than the interior diameter of the conduit (3 points)

A. Pulling Wire with a Mouse B. Pulling Wire with a Fish Tape

C. Only A is correct answer D. no answer

<u>Give short answer</u>

A. What is the purpose of lading electrical cables into a Conduit ?(3 points)

Note: Satisfactory rating – 4.5points **Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-3	connecting cables to control and safety boxes

1.1 Definition of an electrical cable

An *electrical cable* is an assembly of one or more *wires* running side by side or bundled, which is used to carry *electric* current. A *cable* assembly is the composition of one or more *electrical cables* and their corresponding connectors.

1.2 Connecting cables

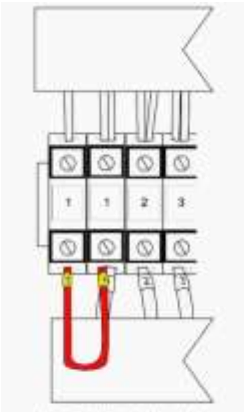
Electrical cables are used to connect two or more devices, enabling the transfer of electrical signals or power from one device to the other. Cables are used for a wide range of purposes, and each must be tailored for that purpose. Cables are used extensively in electronic devices for power and signal circuits. When you're installing wires and cables, secure them with a clamp to prevent damage and strained connections. Clamp selection depends on the type of electrical box you use: Built-in cable clamps are not required for single plastic boxes, but cables must be stapled.

H. Connections should be secured against accidental loosening. Correctly tighten terminal screws and where a connecting plug is fitted, use the clamps or screws provided to secure it to its mating socket.

I. Particular attention in this respect should be taken with the protective bonding circuit, for example by using star washers and a lock nut where necessary

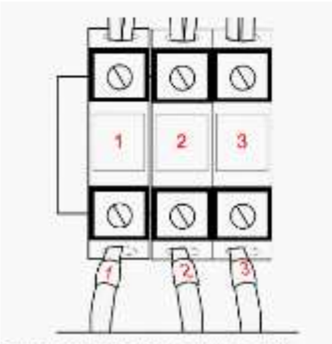
J. Two or more conductors may only be connected to a terminal that is designed for the purpose. The majority of connecting blocks will only take one or two conductors. Don't force in any more.

K. Add an additional terminal and connect it to the other by a link laid in the cable trucking to gain an extra connection point.



L. Soldered connections should be made only to terminals suitable for that purpose. Transformers may be fitted with turret tags suitable for soldering and printed circuit board assemblies may have solder pins.

M. Terminals and terminal blocks should be clearly marked and identified to correspond to the markings in the drawings.



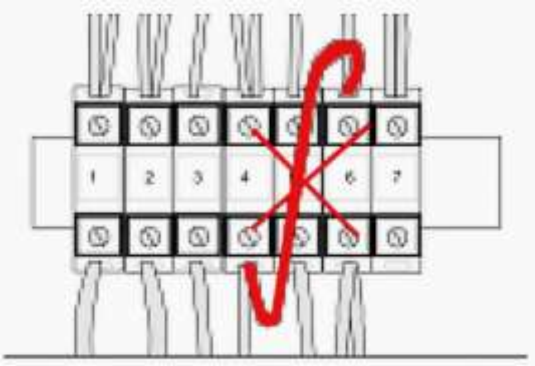
Terminals and terminal blocks should be clearly marked and identified to correspond to the markings in the drawings

N. Ensure that identification tags and cable markers are legible, marked with a permanent ink, and suitable for the environment where the panel is to be used.

They should also correspond with those shown in the machine drawings and instruction or service documentation

O. A means of retaining conductor strands should be provided where terminals are not equipped with this facility, for example by crimping on bootlace ferrules. Do not use solder.

P. Terminal blocks should be mounted and wired so that the internal and external wiring does not cross over the terminals



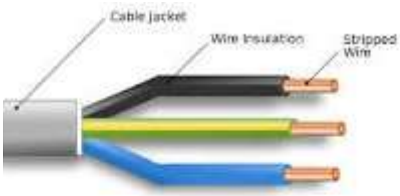
Terminal blocks should be mounted and wired so that the internal and external wiring does not cross over the terminals

Q. Flexible conduits and cables should be installed in such a way that liquids can drain away from fittings and terminations.

1.3 Control safety boxes

Electricians usually minimize the number of junction boxes needed for wiring. They plan the circuitry so that they can make connections for branch circuits inside a switch or receptacle box, using a box big enough to accommodate all the wires.

Here are some personal safety precautions to keep in mind: Always keep your work area dry. Don't wear flapping or loose clothing when working. Don't work with metallic jewelry on your hands like watches, rings and bracelets.



Self-Check -3	Written Test

Directions: Choose the best answer for the following questions.

1. Which is true about an electrical cable(3 points).

   A. an assembly of one or more *wires*   *C.* bundled

   B. running side by side   D. all

2. A control box is used(3 points)

   A. For safety purpose   *C.* to connect different cables

   C. For distribution   D. all

Give short answer

B. What are the uses of a control box (3 pionts)?

Note: **Satisfactory rating – 4.5points** **Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-4	Installing Wiring and accessories

1.1. What is an electrical wiring?

Electrical wiring is an electrical installation of cabling and associated devices such as switches, distribution boards, sockets, and light fittings in a structure. Wiring is subject to safety standards for design and installation. Wiring shall consist of PVC insulated, copper conductor wires installed in heavy gauge steel galvanized conduits.

1.2. Methods of wiring

1. Once the wall has been fully finished, the installation of the wiring accessories shall be positioned in the designated location following the approved shop drawing.

2. There is a specific and fixed height when to come to the installation of the wiring accessories, it can be seen on the specifications as well as in the approved shop drawing.

3. A proper alignment of all the accessories to the verticals and horizontal edges, plumbs, and mounted following the specific standard height stipulated below should be followed. More so, the Engineer shall be giving his/her approval about this matter.

4. The flush accessories are supposed to be covered with fitted plates onto any surface (wall, ceiling, etc.). If it so happened that an accessory does not adhere to the proper alignment, it shall be removed for fixing purposes.

5. A flush mounting type of connection units shall be used whenever installing in control rooms, offices, and public places.

6. A surface or a panel mounting type of connection shall be used whichever is suited whenever installing in plant room, staff room, switch room, and workshop areas.

7. A weatherproof type of switches with a specific IP rating shall be used in installing in wet areas as well as external locations. This will be based on the suitable level and provided specification of each project.

8. There shall be a provision of clearances in two wiring accessories as stipulated in the approved shop drawing.

9. The four edges of a finished wall with a continuous contract shall be installed with necessary plates.

10. There should be a 1.5mm alignment tolerance with the installation of the plates.

11. The use of spirit level is essential in fixing the alignment of the accessories.

12. The sealing of both the accessories and the wall shall be done with utmost correctness.

13. There shall be a mounting of the screws and the sealing caps shall be used if needed by the specification or if recommended by the manufacturer.

14. The wiring accessories shall be used and installed in perfect condition (no visible damages, cut marks, or scratches).

15. The box shall be cleaned well before the termination of the wire on both the sockets and switches.

16. There should be an earthing terminal directly connected to the earth continuity conductor of the final subcircuit in all the switch socket areas.

17. The switches shall be directly wired to the live side of the circuit that they are in control of.

18. The ratings of the switches as well as the sockets are in adherence to the approved shop drawing, and the stipulated specifications and submittals of materials.

19. The Polarity shall be considered in terminating.

20. The finishing plate shall be in adherence to the approved drawings and submittals of materials.

21. There should be a protection provided for all the wiring devices or accessories right after the installation.

22. There shall be a supervision of the control Engineer and the supervisor to make sure that all the materials are properly installed in adherence to the drawing approved by the shop, specification stipulated on the contract, and approved submittals.

23. When the installation is completed, the Work Inspection Report (WIR) shall be submitted to the consultant

Self-Check -4	Written Test

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

Choose the best answer

1. Which one of the following is major type of wiring system ?

   A. Lead Sheathed Wiring
   B. Surface Conduit Wiring
   C. Concealed Conduit
   D. All

2. Which of the following an electrical installation of cabling and associated devices(3 points)

   A. switches
   B. distribution boards
   C. sockets
   D. light fittings in a structure
   E. all

Give short answer

D. What is the purpose of Installing, wiring and accessories?

Note: **Satisfactory rating – 4.5points** **Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet-5	Terminating Cables and conductor accessories

2.1. Definition of termination

Electrical termination is a term used to describe the specific point at which a conductive device, such as wire or cable, ends or starts. The conductive device may or may not pass the carried electricity or signal onto another conductive device at this point

1.2 **Cable Termination**

There is a variety of termination methods for cable. The termination method utilized depends basically on the system installed, type of cable used and type of connector; Using the proper termination method allows for good mechanical and electrical integrity. No matter what type of termination you will be performing, the most important thing is to use the proper tools and materials for the type of termination. For example, a crimp using pliers will work, but using a crimp tool and the proper die designed for your type of cable and connector is better. Using the proper solder type and the right temperature for solder type connections will ensure a lasting connection. We will review four basic termination techniques. This is just to provide some general guidelines. The termination method may vary somewhat based on system requirements and connector manufacture design methods.

1.3 **Termination Types**

- **Solder Type**

A solder type connection allows for a strong, solid mechanical and electrical connection. Clean the connection well. For electrical circuits you must use a rosin type flux to clean all connections. Do not use acid flux that is commonly used for plumbing installation. The acid based flux will cause corrosion and inherently cause intermittent problems with the electrical signal. The choice of solder is also important. Using a solder standard60/40 formula will meet the majority of your soldering needs. However, lead-free and high-grade silver solder is available for special applications. Also, use a soldering iron of the proper wattage. If the soldering iron is not hot enough, you may not be able heat the connection enough to get a good solder joint. This may cause what is known as a "cold" solder joint and can cause intermittent problems like opens to occur. However, if the soldering iron is too hot, you can cause damage to the components of the system near the connection. This can also cause the insulation to possibly melt causing the bare primaries to make contact with each other resulting in a short.

- **Crimp Type**

A crimp type connection allows for quick and simple installation while still maintaining a mechanical and electrical connection fairly close to a solder type termination. Solid or stranded wire can be used in this type of termination. Some of the key points to remember for a good clean connection are as follows:

1. Make sure you use the proper size connector for the type of cable you are using.
2. Make sure all of your cuts and stripping are clean.
3. Avoid nicks as much as possible.
4. Use the proper crimp tool; don’t try to improvise with pliers, etc.

The most common crimp method involves two crimps, one on the insulation for a stronger mechanical connection, and one on the conductor or shield for a good electrical connection. A crimp tool is designed specifically for this type of termination for the type of connector you are using. This allows for good connections both mechanical and electrical.

Self-Check -5	Written Test

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

Choose the best answer

1. At what point will an electric wire terminate?
   A. Connector C. terminal point
   B. switch D. All
2. Which one of the following is a method used to terminate electrical equipment
   A. Welding Wires C. Crimping
   B. Soldering D. All

Give short answer

3. What is the terminating cable and its use ?

Note: **Satisfactory rating – 4.5points** **Unsatisfactory - below 4.5 points**

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-6	Installing Cables for future service

1.1. Types of installing cables

Wire types vary in conductor material and insulation. The two common conductor materials used in residential and commercial solar installations are copper and aluminum. Copper has a greater conductivity than aluminum, thus it carries more current than aluminum at the same size.

Aluminum may be weakened during installation especially during bending; however it is less expensive than copper wires. It is not used (not permitted) for interior home wiring, as they are used in larger gauges for underground or overhead service entrances and for commercial operations. Combination of insulated individual wire into one unit is called cable. It is common for house wiring to use cable of two separate conductors. The cables with three conductors or more are also available. The outside insulation holds the several wires together and the inside insulation is a layer around each individual wire. For house wiring installation, two conductor cable is more convenient to install than two single conductor wires.

1.2. Conductor's Choice

Even in the design of a simple single insulated wire many factors must be considered: temperature, voltage, DC resistance of the conductor, insulation, O.D., required flexibility, physical properties of the conductor (tensile strength, voltage drop, conductivity, weight) and when necessary, specific electrical.

1.3. Parameters for choosing the wire

There are three parameters affecting correct chose of the wire

1) The amount of electricity which flows in the wire;

2) The wire size (in mm2)

3) The wire length (in meters)

The installed cables will be connected to different loads based on the power required and the voltage need.

Self-Check -6	Written Test

Directions: chose the best answer for the following questions.

1. The size of the cable that will be connected to the load depends on.(3 points)
   A. length B. diameter C. amount of electricity D. all
2. The common conductor materials used in residential and commercial solar installations are(2 points)
   A. copper B. Aluminum C. bronze D. A & B

Give short answer

1. What are the factors that considered in designing conducting wires (3 points) ?

Note: **Satisfactory rating – 2.5points** **Unsatisfactory - below 2.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet- 7	Following procedures for referring non-routine events

1.1. Following procedures

The safety procedures that should be followed in non-routine events like designing the solar PV system based on the requirement, installing solar panel, installing cables and wires, troubleshooting during hazards and firefighting and OHS precautions considered are very important to maintain the longevity of the system.

1.2. Non- routine events

Non-routine work are jobs and tasks that are performed irregularly or being performed for the first time. Since these tasks and jobs are not performed regularly, it can be difficult to understand all of the hazards associated with the job.

The Potential hazards for fire fighters working near PV systems

- Potential hazard Description
- Electrical shock
- Electrical shock or burn injury
- Slips and falls Space limitations reduce access
- Collapse PV adds to the “dead load” on a roof;
- Arc or ground fault Fire may be started by arcs
- Combustion As with other building materials and materials in the PV system

Self-Check -7	Written Test

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

Choose the best answer

1. Which one of the following is a non-routine activity?
   A. Cleaning solar panel C. installing solar panel
   B. testing battery D. All

Give short answer

2. List procedures of non-routine events in solar PV system?

Note: **Satisfactory rating – 2.5points Unsatisfactory - below 2.5 points**

Answer Sheet

Score = ____________
Rating: _____________

Information Sheet-8	Carrying out Cable installation and termination efficiently

1.1 Carrying out cable installation

The final choice of a wiring system must rest with those designing the installation and those ordering the work, but whatever system is employed, good workmanship by competent persons and the use of proper materials is essential for compliance with the IEE Regulation 134.1.1. The necessary skills can be acquired by an electrical trainee who has the correct attitude and dedication to his craft.

PVC insulated and sheathed wiring systems are used extensively for lighting and socket installations in domestic dwellings. Mechanical damage to the cable caused by impact, abrasion, penetration, compression, or tension must be minimized during installation (Regulation 522.6.1). The cables are generally fixed using plastic clips incorporating a masonry nail, which means the cables can be fixed to wood, plaster or brick with almost equal ease.

Cables should be run horizontally or vertically, not diagonally, down a wall. All kinks should be removed so that the cable is run straight and neatly between clips fixed at equal distances providing adequate support for the cable so that it does not become damaged by its own weight (Regulation 522.8.4). Where cables are bent, the radius of the bend should not cause the conductors to be damaged (Regulation 522.8.3). Terminations or joints in the cable may be made in ceiling roses, junction boxes, or behind sockets or switches, provided that they are enclosed in a non-ignitable material, are properly insulated and are mechanically and electrically secure (IEE Regulation 526). All joints must be accessible for inspection testing and maintenance when the installation is completed (IEE Regulation 526.3).

Purpose designed “PV cables” are readily available and it is expected that all installations would use such cables. An IEC PV cable standard is under development and it is expected cables in compliance with this standard will be required once it is issued. Cables routed behind a PV array must be rated for a temperature range of at least of -15°C to 80°C. Cables must be selected and installed so as to minimize the risk of earth faults and short-circuits. This can be achieved by reinforcing the protection of the wiring either through :a) Single conductor “double insulated” cable b) Single conductor cable suitably mechanically protected conduit/ trunking.

External cables should be UV stable and water resistant. Where cables are likely to be subjected external movement, i.e. those mounted immediately behind the array, it is recommended that they be flexible (multi-stranded) to allow for thermal/wind movement of arrays/modules.

Because PV array cables almost exclusively rely on double or reinforced insulation as their means of shock protection they should not be buried in walls or otherwise hidden in the building structure as mechanical damage would be very difficult to detect and may lead to increase instances of shock and fire risk.

1.2 Efficient termination

Efficient termination means selection of appropriate cable and connect the appropriate voltage to match the load .Conductors should be suitably protected from mechanical damage; suitable methods may include the use of metallic trunking or conduit or the use of steel wire armored cable. Exterior cable colour coding is not required for PV systems. Consideration must be given to the UV resistance of all cables installed outside or in a location that may be subject to UV exposure, PV cables are therefore commonly black in color to assist in UV resistance.

Crimping is the most commonly used method of wire termination, and is most efficient for high-volume wire termination. The terminations are fast, clean and mechanically strong. For low volume or fieldwork, loose terminals are applied with a plethora of handheld and bench top crimping devices.

Self-Check -8	Written Test

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

Choose the best answer

1. The external cable should be __________________ and ______________ resistant.

A. Water B. Ultra violet light C. Light D. A and B

Note: **Satisfactory rating – 2.5points** **Unsatisfactory - below 2.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet-9	Checking Circuits/machines/plant with OHS requirements

1.1 Checking Circuits

Ground faults and arc faults are the two most common reasons for fires in photovoltaic (PV) arrays; methods are available that can mitigate the hazards. Field procedures for testing PV arrays for ground faults, and for implementing high-resolution ground fault and arc fault detectors in existing and new PV system designs. Some PV system ground faults go undetected, which can lead to fires in PV arrays. These undetected faults (*blind spots)* can be effectively eliminated by detection systems . Arc fault detectors are now available that can detect and remove series arc faults as required.

1.2 OHS requirements

- Mechanical ventilation provided throughout the fabrication area at a sufficient rate
- Personal protective equipment (PPE) provided, used
- Safe maintenance and cleaning of manufacturing installations where exposure to chemicals and dust could occur
- Ensure that only workers who are specifically trained on electrical risks, the characteristics of solar energy systems and on how to perform this work actually conduct the work.
- Evaluate the hazards of the connection to the power supply system and have the contact details of the power company at hand until the work is completely finished.

Self-Check -9	Written Test

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

Choose the best answer

1. What causes fire hazards of PV arrays?
   A. Ground faults B. Arc faults C. both

Give short answer

2. Which detector are now easily for detection and removal of arc faults ?

Note: **Satisfactory rating – 2.5points** **Unsatisfactory - below 2.5 points**

Answer Sheet

Score = ___________

Rating: ____________

Information Sheet-10	Installing wiring and accessories to comply standards

1.1. Installing wiring

Choosing the right wire sizes in your PV system is important for both performance and safety reasons. If the wires are undersized, there will be a significant voltage drop in the wires resulting in excess power loss. In addition, if the wires are undersized, there is a risk that the wires may heat up to the point in which a fire may result.

An electrical wire carries **current** much like a water hose carries **water**. The larger the diameter of the water hose, the less resistance there is to water flow. Moreover, even with a large diameter hose, shorter hoses have better flow than longer hoses. Longer hoses have more resistance than shorter ones of the same diameter. Electrical wires behave the same manner. If your electrical wires (the copper gauge) are not large enough or if the cable is longer than needed, then the resistance is higher resulting in less watts going to either your battery bank or the grid.

Copper wires are sized using the gauge scale: American Wire Gauge (AWG). The lower the gauge number, the less resistance the wire has, and therefore the higher current it can handle safely.

The chart below shows the capacity of various wire gauge sizes and their typical amp rating and application for both residential and solar applications.

1.2. Accessories that comply standard

Connect the positive terminal of the first **solar panel** to the negative terminal of the next one. The important difference between wiring panels in series or in parallel is that electrically it affects the voltage and amperage of the resultant circuit. In a series circuit you sum the voltage of each panel to get the overall voltage of the array. eg. If you had 4 **solar panels** in a series and each was rated at 12 volts and 5 amps, the entire **array** would be 48 volts at 5 amps.

Self-Check – 10	Written Test

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

Choose the best answer

3. What will happen If the wires are undersized ?
   A. Voltage drop
   B. Power loss
   C. the wires heated
   D. All

Give short answer

4. What is the purpose of Installing wiring and accessories ?

1. **How to pull wires through electric conduit**

Step 1 - Check your conduit

Step 2 - Use an existing pull wire or string

Step 3 – Pull the wire through the conduit

Step 4 – Use Wire Lubricant

Step 5 – Using fish tape

2. **How to pull wire through long conduit**

Step 1: Use first fish tape, to expose one end of the fish tape. Make a few rings with 12 ropes. Then bundle coils and wrapped around the end of the fish tape.

Step 2: Take second fish tape and open it, then make a hook at the end of it. The fish tape should can bend freely.

Step 3: Ask two workers to stand at two ends of conduit. One takes hooked end fish tape, the other take the looped end fish tape, then begin pushing them from two ends of the conduit.

Step 4: Spin the hooked end to make it easier to grab one of the loops. Once finished, pulling one end of the fish tape, then the other end is pulling through the conduit.

List of Reference Materials

3- BOOKS

5. Stand-Alone Solar Electric Systems, Mark Hankins,Earthscan,2010,1st ed
6. Level 2 Technician Training manual, International Solar Energy Society/German Section,DGS e.V. 2009,2nd ed.
7. Solar Electric System Design, Operation and Installation; Washington State University Extension Energy Program, October 2009
8. Solar PV Standardized Training Manual, Developed by SNV for the Rural Solar Market Development

4- WEB ADDRESSES (PUTTING LINKS)

SOLAR PV SYSTEM INSTALLATION AND MAINTENANCE

Level-II

Learning Guide-57

Unit of Competence	Perform Wiring of Solar PV System
Module Title	Performing wiring of Solar PV System
LG Code	EIS PIM2 M10 LO-4 LG-57
TTLM Code	EIS PIM2**TTLM0819V1**

LO 4:- Perform wiring test

Instruction Sheet	Learning Guide: 48

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

- Observing work completion and OHS hazards
- Performing continuity tests
- Performing Polarity test using appropriate tools
- Performing Earth test operating procedures

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 –**

- Observe work completion and OHS hazards
- Perform continuity tests
- Perform Polarity test using appropriate tools
- Perform Earth test operating procedures

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below 3 to 6.
- Read the information written in the information Sheet 1, Sheet 2, Sheet 3 & Sheet 4, in page , & 26 respectively.
- Accomplish the Self-check 1, Self-check 2, Self-check 3 ,Self-check 4 in page & 29 respectively

1.1. Concepts ofObserving work completion and OHS hazard

The most important concept to remember is that you are responsible for your own safety and the safety of others. Most safety practices are common sense. Unfortunately, they can be forgotten or overlooked unless you make safe practices a habit or an instinct.

- **A safety observation report** :is a tool used by safety officers to document hazards as well as safety commendations in the workplace. It is a comprehensive report that includes photo evidence and detailed descriptions of key safety observations. Performing and documenting regular safety observations can ensure a safe workplace as well as share best practices with other teams. Observe common working areas, equipment and procedures which can affect employee health and safety. Different workplace industries require different key areas of focus when it comes to safety. However, here are the important categories to inspect when performing a safety observation report for any given workplace:

- **Common Working Areas**
  These are areas where workers spend most of their time either working or passing through. A safe and tidy working area can minimize the risk of employee injury, health hazards and productivity loss.What to check: lighting, accessibility, temperature, humidity, dry floor/ even pavement, no sharp edges of work tables or chairs, appropriate work tools and ergonomics.
- **Personal Protective Equipment (PPE)**
  PPE is used to protect employees from physical harm. Not wearing or wearing damaged equipment may lead to serious injury.What to check: availability, condition and appropriateness of PPEs, damage, ratio of employees vs available PPE and training.

1.3 Fire Safety Equipment and Procedures

Safety equipment and procedures must be available and accessible at all times to employees in case of fire-related emergencies. What to check: fire extinguishers, evacuation posters, fire drills, first aid kits, emergency lighting, sprinklers, fire alarms and emergency exits.

1.4 Electrical Hazards

Faulty and messy wiring can cause trip hazards, fire, electrocution and property damage.

What to check: wiring, outlet locations, extension cords and electric equipment.

1.5 Proper Storage

Proper storage of documents, materials and equipment can minimize trip hazards and injuries from manual handling.

What to check: tidiness, appropriate signage, proper location storage and ergonomic manual handling.

1.6 Importance of OHS

- Reflects your Commitment to Safety.
- Spread the Message Quickly and Efficiently.
- Reduces your Responsibility as an Employer.
- Boosts Safety Consciousness among Employees.
- Decrease in number of accident claims.

2 Types of personal protective equipment

Name of quipment	Importance	Picture
1.Foot protection	It protection our foot from injuries	
2.Eye protection	It protects an eye	
3.Hand protection	Prevent our hand from damaging	

Fig personal protective equipment’s

Self-Check -1	Written Test

I. **Say true or false**

1. Reflect your Commitment to Safety is part of individual activities.

Note: **Satisfactory rating - 1 and 5 points Unsatisfactory - below 1 and 5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet-2	Performing continuity tests

2.1. **Concepts ofperforming continuity tests**

- A continuity test is a technique to check and verify the current flow in the electric circuit between two paths. A continuity test is important for identifying any breaks or issues in the flow of current an electrical circuit.
- A continuity test is an important test in determining the damaged components or broken conductors in a circuit. It can also help in determining if the soldering is good, if the resistance is too high for flow of current or if the electrical wire is broken between two points. A continuity test can also help in verifying or reverse-engineering an electrical circuit or connection.
- Continuity testing can be used to detect cold solder connections and problems with wire and cable products. In field applications, handheld multimeters with dual probes are used. In addition, this form of electrical testing can be used to check connections between the pads and traces on printed circuit boards (PCBs).

2.2 What is Done During Continuity Testing?

The most common and basic way of performing a continuity test is with the help of a resistance tester (any simple Multi meter with this function will do). This is because the resistance of conductors between the two ends is usually very small (less than 100 ohm).

Continuity tester has two leads connected to a small battery, and when you touch the leads together to complete the circuit, the meter should register 0 resistance or if you have a dedicated continuity tester, the light should come on. If you're using a digital multimeter, the device may also beep.

Continuity of protective conductors including main and supplementary equipotential bonding. Every protective conductor, including circuit protective conductors, the earthing conductor, main and supplementary bonding conductors should be tested to verify that all bonding conductors are connected to the supply earth. Tests are made between the main earthing terminal (this may be the earth bar in the consumer unit where there is no distribution board present) and the ends of each bonding conductor.

2.3 How to do Continuity Testing?

Measuring Continuity in an Electrical Device:

This method is used for testing continuity is an easy and reliable way to determine whether a switch or outlet has internal damage. If you're using a multi meter, set it to the "Continuity" function, or select a midrange resistance setting, in ohms.

- **Step 1: Turn Off the Breaker That Controls the Circuit**
  The power needs to be off when testing continuity. Verify that no electricity is flowing by using a noncontact circuit tester.
- **Step 2: Check the Tester**
  Check the tester by putting the leads together and ensuring that the device lights up, beeps or registers 0 ohms of resistance.
- **Step 3: Touch Lead to Terminal**
  Touch one lead on one of the hot terminals of the device, identified by a brass screw.
- **Step 4: Touch Other Lead to Terminal**
  Place the other lead on any other terminal except the green ground terminal. If the tester lights up, beeps or shows 0 resistances, it means that electricity can flow freely between those terminals, and in most cases, that means that the device is good. If the device is a switch, the tester should go off and on when you flip the switch.
  You can use this technique to check appliance switches, thermostats and fuses. Be sure the power is off, and then touch the leads to the terminals of the device in question.

2.4 Continuity of Circuit Protective Conductors (CPC)

The test is carried out as follows:

- Temporarily link the line conductor to the CPC in the Consumer Unit.
  - Test between the line and the CPC at each accessory point e.g. a ceiling rose, switch or socket outlet. The reading obtained at each accessory point should be a low resistance value. The resistance measured at the extremity of the circuit is the sum of the resistances of the line conductor and protective conductor (R1 + R2).

When we talk about Continuity Testing within the Inspection and Testing Procedure then we apply the same principle, but with a bit more detail.

Step 1: Select the circuit to be tested in the distribution board and remove the Line conductor from the MCB

Step 2: Connect the Line conductor to the Earth conductor (for simplicity, connect it to one of the spare terminals on the Earth bar). This way you will form a circuit which is half made up of the Line conductor and half made of the Earth conductor (provided that the terminations within the electrical accessories such as wall sockets are correct).

Step 3: Select the correct test function on the test equipment, which is the low reading ohm meter function

Step 4:. Do not forget to null the test instrument if required (you can do this by connecting the two test leads together and pressing the TEST button until the measured value on the display becomes zero ohm`s)

Step 5: Measure between Line and Earth terminals at each outlet in the circuit. The highest reading should be recorded on the Schedule of Test Results as the value of (R1+R2).

Step 6:.Return the Line conductor back in to the MCB

2.5 Continuity Testing Overview

- Continuity is the presence of a complete path for current flow. A circuit is complete when its switch is closed.
- A digital multi meter's Continuity Test mode can be used to test switches, fuses, electrical connections, conductors and other components. A good fuse, for example, should have continuity.
- A DMM emits an audible response (a beep) when it detects a complete path.
- The beep, an audible indicator, permits technicians to focus on testing procedures without looking at the multi meter display.
- When testing for continuity, a multi meter beeps based on the resistance of the component being tested. That resistance is determined by the range setting of the multimeter. Examples:
- If the range is set to 400.0 Ω, a multi meter typically beeps if the component has a resistance of 40 Ω or less.
- If the range is set 4.000 kΩ, a multi meter typically beeps if the component has a resistance of 200 Ω or less.
- The lowest range setting should be used when testing circuit components that should have low-resistance value such as electrical connections or switch contacts.

Benefits of Continuity Testing

- Return of that investment is a long-term one and it will also save time.
- Tests can be done 24/7.
- Fewer human resources are required.
- Reusability: The scripts are reusable. You don't need new scripts all the time.
- Reliability: It is more reliable and quicker way when running boring repetitive standardized tests which cannot be skipped.
- It not only checks for continuity but also for shorts.

2.6 Importance of continuity tests

The main important of continuity test is to check the relationship between the wires.

Fig 4.2 continuity testing

Self-Check -2	Written Test

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

I. Say true or false

1. The main important of continuity test is to check the relationship between the wires.

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

Answer Sheet

Score = ____________

Rating: ______________

Name: ______________________ Date: _____________

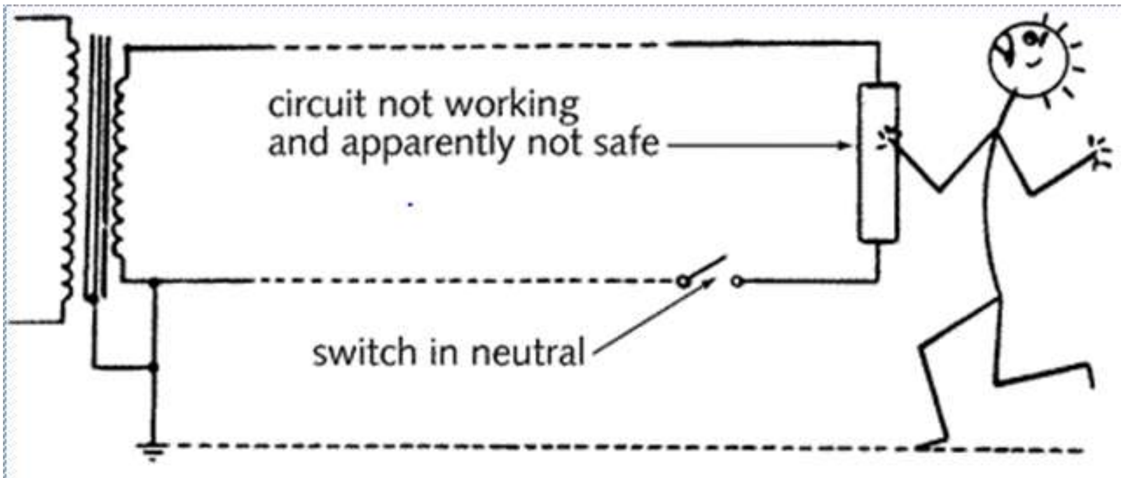
Short Answer Questions

3.1. What is polarity testing?

Polarity testing is one of the tests that are required for initial testing of the installation under IEC 60364 standards.

Polarity means the direction of the induced voltages in the primary and the secondary winding of the transformer. If the two transformers are connected in parallel, then the polarity should be known for the proper connection of the transformer. Electrical polarity is a term used throughout industries and fields that involve electricity..

This test will verify that all the switches installed in the system are connected in current carrying conductor and not in neutral. For example, if you isolate or switch the neutral of a circuit via a single-pole circuit breaker or switch, it would appear that the circuit is dead where in fact it is still live.



If polarity is not correctly determined there may be a risk of electric shock during maintenance procedures.

Electrical polarity is a term used throughout industries and fields that involve electricity. There are two types of poles: positive and negative. This represents the electrical potential at the ends of a circuit. A battery has a positive terminal and a negative terminal. Interconnections of electrical device nearly always require correct polarity to be maintained. Correct polarity is essential for the operation of vacuum tube and semiconductor devices, many electric motors, electrochemical cells

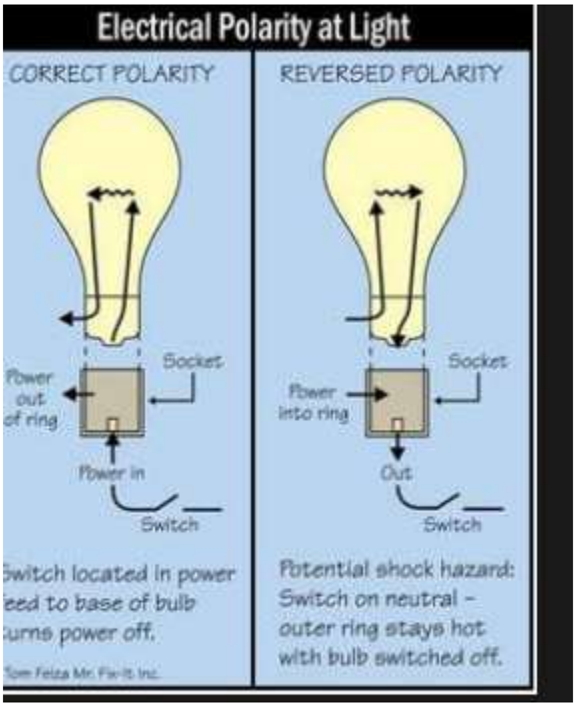


Fig 3.1 Electrical light

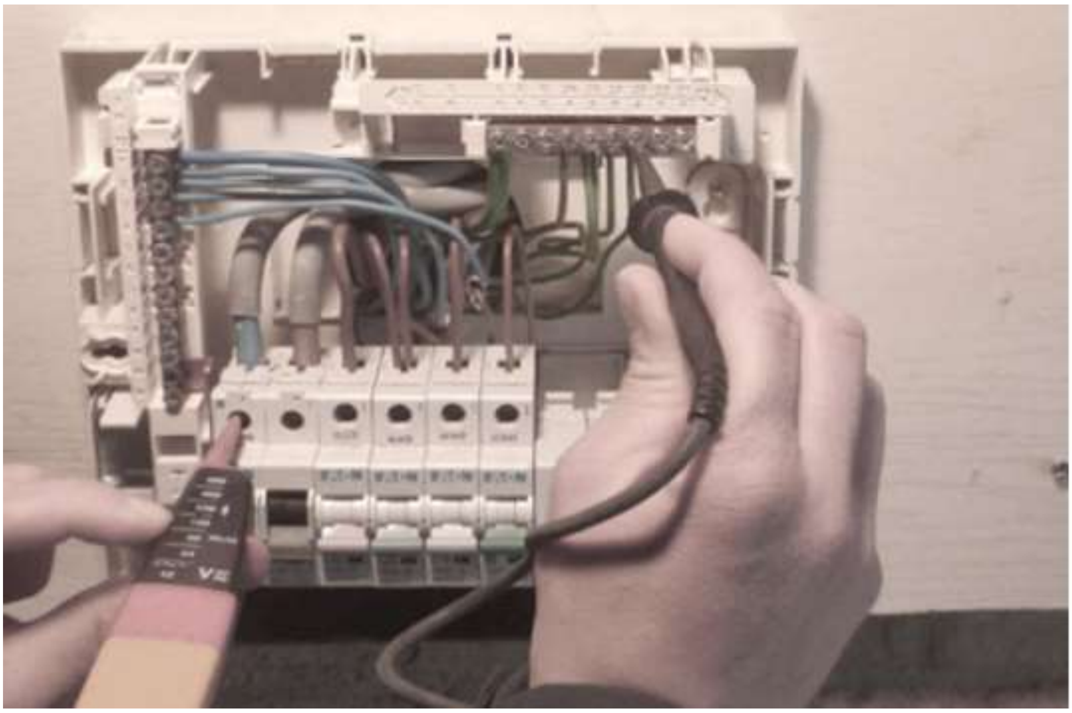


fig3.1 polarity testing

Self-Check -3	Written Test

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

I. Choose the best answer for the following questions

1. The line between positive and negative is

A. Positive B. polarity C. electronics D. Negative

2. Electrical polarity is a term used throughout industries and fields that involve electricity.

B. True B. false

Note: **Satisfactory rating - 2 points Unsatisfactory - below 2 points**

Name: _________________________ Date: _______________

Short Answer Questions

Answer Sheet

Score = ___________
Rating: ____________

Information Sheet-4	Performing Earth test operating procedures

4.1 Concepts of Performing Earth test operation procedures

PV systems are treated as a part of LV electrical installations. The earthling resistance test with two clamps is a suitable method for measuring

- Earth grounding is an intentional connection from a circuit conductor.
- It could be used to test the earth resistance.

4.2 components

- Earth electrode: The prime function of an earth electrode is the protection of Persons
- **Main earthling terminals**: it is intended for the connection of main bonding
- and circuit protection conductors with disconnect able test link.
- Earthling conductors: it is commonly called the earthling lead. It joins the installation
- Earthling terminal to the earth electrode.
- Protective conductors: The circuit protective conductor increasingly called the system of conductors.

4.3 Checking the PV System for Ground Faults

Danger to life due to electric shock when touching live system components in case of a ground fault

If a ground fault occurs, parts of the system may still be live. Touching live parts and cables results in death or lethal injuries due to electric shock.

- Disconnect the product from voltage sources and make sure it cannot be reconnected before working on the device.
- Touch the cables of the PV array on the insulation only.
- Do not touch any parts of the substructure or frame of the PV array.
- Do not connect PV strings with ground faults to the inverter.
- Ensure that no voltage is present and wait five minutes before touching any parts of the PV system or the product.

4.4 Test by Measuring the Voltage

- Measure the voltages:
- Measure the voltage between the positive terminal and the ground potential (PE).
- Measure the voltage between the negative terminal and the ground potential (PE).
- Measure the voltage between the positive and negative terminals.
  If the following results are present at the same time, there is a ground fault in the PV system:

  - ✓ All measured voltages are stable.
  - ✓ The sum of the two voltages to ground potential is approximately equal to the voltage between the positive and negative terminals.

- If a ground fault is present, determine the location of the ground fault via the ratio of the two measured voltages and eliminate the ground fault.
- If a definite ground fault cannot be measured and the message is still displayed, measure the insulation resistance.
- Reconnect the strings without ground faults to the inverter and re-commission the inverter (see inverter installation inverter)

4.5 Ground system design

Simple grounding systems consist of a single ground electrode driven into the ground. The use of a single ground electrode is the most common form of grounding. Complex grounding systems consist of multiple ground rods, connected, mesh or grid networks, ground plates, and ground loops.
These systems are typically installed at power generating substations, central offices, and cellphone tower sites. Complex networks dramatically increase the amount of contact with the surrounding earth and lower ground resistances.

4.6 Soil resistivity measurement

Soil resistivity is necessary when determining the design of the grounding system for new installations (green field applications) to meet your ground resistance requirements. Ideally, you would find a location with the lowest possible resistance. Poor soil conditions can be overcome with more elaborate grounding systems. The soil composition, moisture content and temperature all impact soil resistivity. Soil is rarely homogenous and its resistivity will vary geographically and at different depths. Moisture content changes seasonally, varies according to the nature of the sublayers of earth and the depth of the permanent water table. It is recommended that the ground rods be placed as deep as possible into the earth as soil and water are generally more stable at deeper strata.
Calculating soil resistivity
The measuring procedure described here uses the Wenner method and uses the formula:

$\rho = 2\pi A R$

where:

ρ = the average soil resistivity to depth A in: ohm-cm.

π = 3,1416.

A = the distance between the electrodes in cm.

R = the measured resistance value in ohm from the test instrument.

Measuring soil resistance

To test soil resistivity, connect the ground tester as shown in Fig. 1. Four earth ground stakes are positioned in the soil in a straight line, equidistant from one another. The distance between earth ground stakes should be at least three times greater than the stake depth. The Fluke1625 earth ground tester generates a known current through the two outer ground stakes and the drop in voltage potential is measured between the two inner ground stakes. The tester automatically calculates the soil resistance using Ohm's Law ($V=IR$).

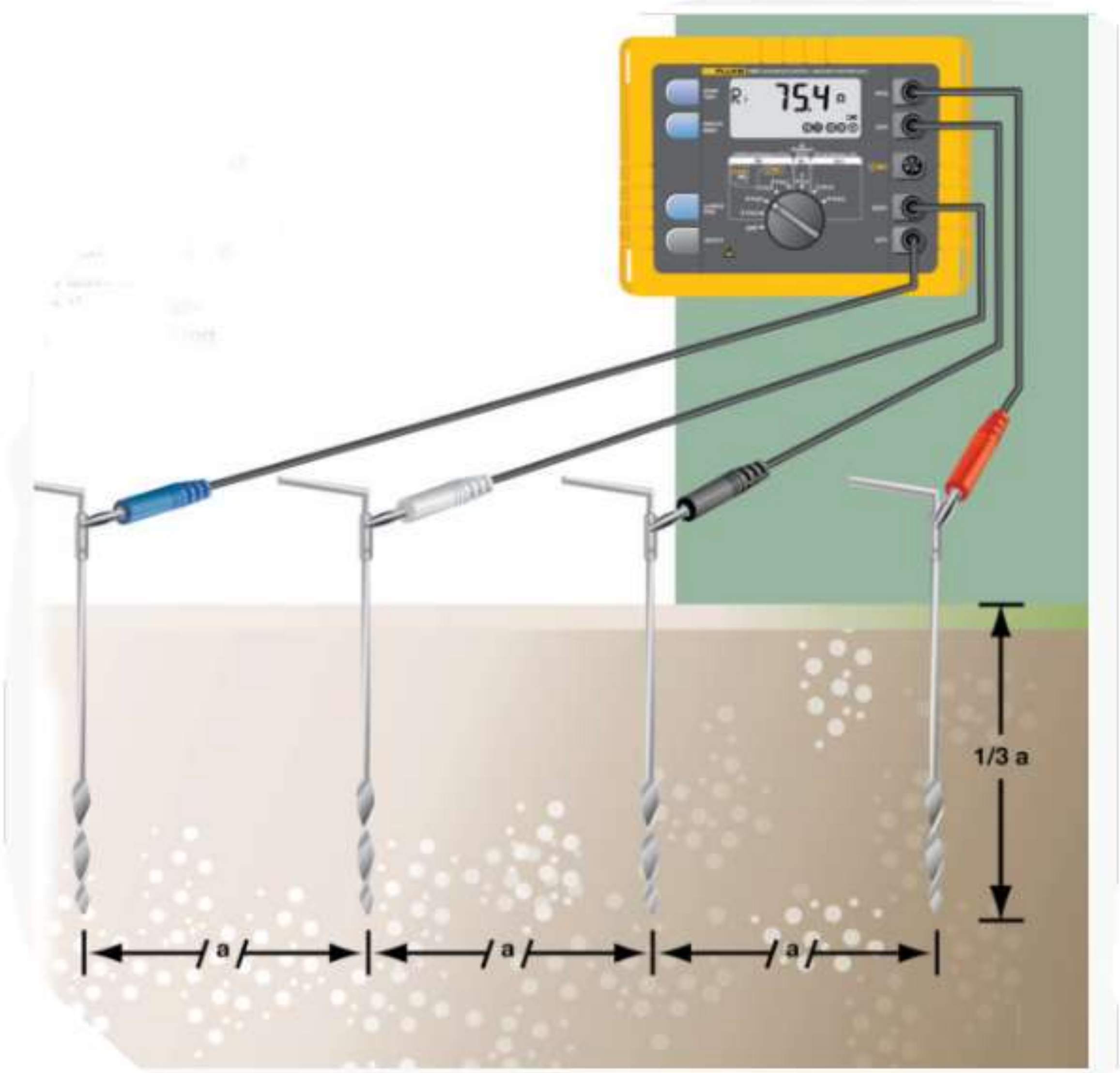


Fig. 1: Test current paths in the stakeless method.

Self-Check -4	Written Test

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

I. Say true or false

1. Earth grounding is a national connection from a circuit conductor.
2. The prime function of an earth electrode is the protection to persons.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Operation Sheet 2	Techniques of performing continuity test

2.1. **Procedures of continuity test**

Step-1 Wear appropriate PPE

Step-2 Clean the continuity tester

Step-3 identify the problems of the wire

Step-4 Measure the wire

Operation Sheet 3	Techniques performing Polarity test using appropriate tools

3.1 Steps of polarity testing

Step-1Switch off the circuit breaker supplying the circuit.

Step-2Connects the link from the specific circuit, and put a temporary link that

will the line conductor

Step- 3 Test continuity by placing the test leads across the line conductor

Step-4 If the instrument shows zero reading (with continuity sound) then the

Switch is connected properly to the line conductor.

Step-5 If the instrument shows some significant ohmic value then the switch is not connected to the line conductor. Interchange the connections to fix the problem

Operation Sheet 4	Performing Polarity test using appropriate tools

Steps of Performing Polarity test

Step-1 Prepare for the work

Step-2 Earth grid continuity test

Step-3 Resistivity test or resistance test

LAP Test	Practical Demonstration

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

Name: ____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Task-1Perform wiring test

Task-2Perform continuity test

Task-3 perform polarity test

Task-4 Performing Earth test operation

Reference

1. Mark Hankins Earthscan,2010,1st ed : Stand-Alone Solar Electric Systems
2. DGS e.V. 2009,2nd ed.: Level 2 Technician Training manual International Solar Energy Society/German Section
3. Washington State University Extension Energy Program,October 2009: Solar Electric System Design, Operation and Installation
4. Developed by SNV for the Rural Solar Market Development: Solar PV Standardized Training Manual
5. Antonio C. Jimenez ,National Renewable Energy Laboratory ,USA 2000: Renewable Energy for Rural Schools
6. George Eccleston , Solar & 12 Volt Power for beginners: Off grid power for everyone by Kindle Edition
7. Lacho Pop, Dimi Avram :The ultimate Solar Power Design, Lachezar Popov and Publishing Ltd

Website: https://hit-es.com/pv-performance-testing/
Video : https://www.youtube.com/watch?v=Hey1QZkYFSQ

SOLAR PV SYSTEM INSTALLATION AND MAINTENANCE

Level-II

Learning Guide-58

Unit of Competence	Perform Wiring of Solar PV System
Module Title	Performing wiring of Solar PV System
LG Code	EIS PIM2 M10 LO-5 LG-58
TTLM Code	EIS PIM2**TTLM0819V1**

LO 5:- Perform wiring test

Instruction Sheet	Learning Guide: 49

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

- Conducting Specific gravity test
- Conducting Internal short circuit test
- Performing Terminal voltage test
- Checking terminal for carbon contents
- Carrying out battery bank polarity test

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 –**

- Conduct Specific gravity test
- Conduct Internal short circuit test
- Perform Terminal voltage test
- Check terminal for carbon contents
- Carrying out battery bank polarity test

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below 3 to 6.
- Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, sheet 5, in page, & 26 respectively.
- Accomplish the Self-check 1, Self-check 2, Self-check 3 ,Self-check 4, self -check 5, in page & 29 respectively

Information Sheet-1	Conducting Specific gravity test

4.1 Concepts ofSpecific gravity test

- **What Is Specific Gravity?**

The specific gravity is the ratio between the density of an object, and a reference substance.

The term "Specific Gravity" (SG) is used to define the weight or density of a liquid as
Compared to the density of an equal volume of water at a specified temperature.
The specific gravity can tell us, based on its value, if the object will sink or float in our reference substance. Usually our reference substance is water which always has a density of 1 gram per milliliter or 1 gram per cubic centimeter.

- **What is Density?**

So, what is density, anyway? An object's density is a measure of how compact or heavy it is, in a given volume. We measure density in mass per unit volume which is written using measures like grams per milliliter (g/mL), grams per cubic centimeter (g/cm^3), or kilograms per liter (kg/L).

Here are two objects with different densities. On the left is an object highly packed with particles. That means it has a high density. On the right is an object with a low density. You can see that the particles are not packed tightly but that there are fewer particles occupying the same volume. To find the density of an object, we divide its mass by its volume.

For example, take an object with a volume of four liters and a mass of one kilogram. We plug these numbers into the density formula and discover that its density is 0.25 kg/L.

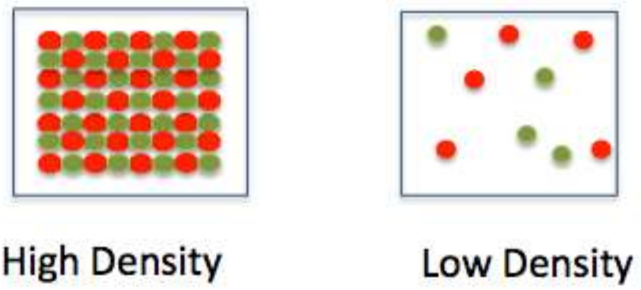
- **The Formula for Specific Gravity**

The formula for specific gravity, given that the reference substance is water, is the density of the object divided by the density of the water. Here, we use the Greek symbol Rho to indicate density.

$$Specific\ Gravity = \frac{density\ of\ the\ object}{density\ of\ water} = \frac{\rho_{object}}{\rho_{H_2O}}$$

The specific gravity has *no unit* because the units of the numerator and the denominator are the same, so they just cancel each other out. Let's look at an example. Here, the density of the object is 19 g/mL and the density of water is 1 g/mL. We cancel the unit g/mL because this unit is present in both the numerator and the denominator:

$$Specific\ Gravity = \frac{density\ of\ the\ object}{density\ of\ water} = \frac{19\ \cancel{\frac{g}{mL}}}{1\ \cancel{\frac{g}{mL}}}$$



$$density = \frac{mass}{volume} = \frac{m}{v}$$

The density is directly related to the mass of the object (unit: usually in grams but can be measured in kilograms or pounds), so the specific gravity can also be determined by dividing the mass of the object by the mass of the water.

$$Specific\ Gravity = \frac{mass\ of\ the\ object}{mass\ of\ water} = \frac{m_{object}}{m_{H_2O}}$$

The mass itself is directly related to the weight of an object, measured in units called Newtons. So, the specific gravity can also be solved by dividing the weights of the object and the water.

$$Specific\ Gravity = \frac{weight\ of\ the\ object}{weight\ of\ water} = \frac{W_{object}}{W_{H_2O}}$$

Note that in all of these the units are the same so the result will have no units as they'll cancel each other out.

When we throw pennies in water fountains to make a wish, the pennies sink to the bottom. That's because the pennies are denser than water. If we plug the pennies into the specific gravity formula as our object, we'd find that the specific gravity would be greater than one. When the **specific gravity** is greater than one, the object will sink, and when the specific gravity is less than one, then the object will float.

4.2 **Importance ofConducting Specific gravity test**

When it comes to configuring a mixer, knowing the specific gravity of the fluids being blended is important because it will influence the torque & horsepower that is required to properly mix your fluid.

The specific gravity of a liquid can be expressed as:

$$SG = \rho / \rho H_2O$$

SG = specific gravity
ρ = density of fluid or substance (kg/m^3)
ρH_2O = density of water (kg/m^3)

Two commonly used methods for determining the specific gravity of liquid

Hydrometer: Usually a cylindrical glass stem with a scale inside, and a bulb at one end weighted with mercury or lead. When lowered into a container of liquid, the calibrated glass stem will float freely in the fluid. Using the point where the fluid surface touches the stem, a reading of the specific gravity can be taken directly from the scale.

- **Specific-Gravity Bottle**: A flask made to hold a known volume of liquid at a specified temperature (usually 20°C). The bottle is weighed, filled with the liquid whose specific gravity is to be found, and weighed again. The difference in weights is divided by the weight of an equal volume of water to give the specific gravity of the liquid.

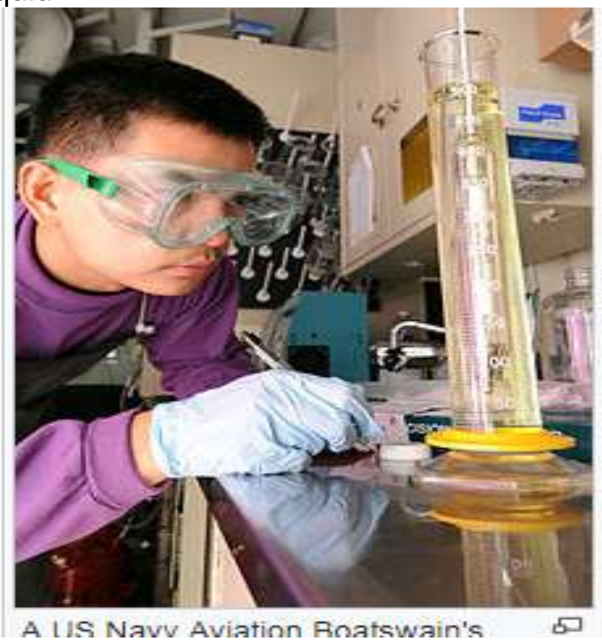


Fig 1.1 measuring specific gravity

Self-Check -1	Written Test

II. Choose the best answer

1. The term “Specific Gravity” refers to;
   A. Density of liquid to density of water
   B. density of any liquid to density of water
   C. Density of oil to density of water
   D. all
2. The specific gravity is measured by_______
   A. Hydro meter
   B. pick load tester
   C. multi meter
   D. Compression test

3. A flask made to hold a known volume of liquid at a specified Temperature is called________

   A. Specific-Gravity Bottle
   B. glass tester
   C. hydrometer
   D. Multi meter

Note: **Satisfactory rating – 2.5 and above points Unsatisfactory - below 3 and 5 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Information Sheet-2	Conducting Internal short circuit test

2.1 Concepts ofConducting internal short circuit test

In fact, **solar cells** are rated by their **short circuit** current. No - you will not damage a **solar panel** by shorting it. While it is conceivable that a **solar panel** may be damaged while running under **short circuit**, if it is then it is faulty and would also have been damaged by operating it at its design full power point

The purpose of a **short-circuit test** is to determine the series branch parameters of the equivalent circuit of a real battery.
The internal conductance of the photovoltaic generator in any mode satisfies to perform a short-circuit test to estimate this resistance.

The systems more realistically by representing PV generation in dynamic hardware bench test conducted by Southern California Edison's ... transformed to a higher voltage internally or externally to the.

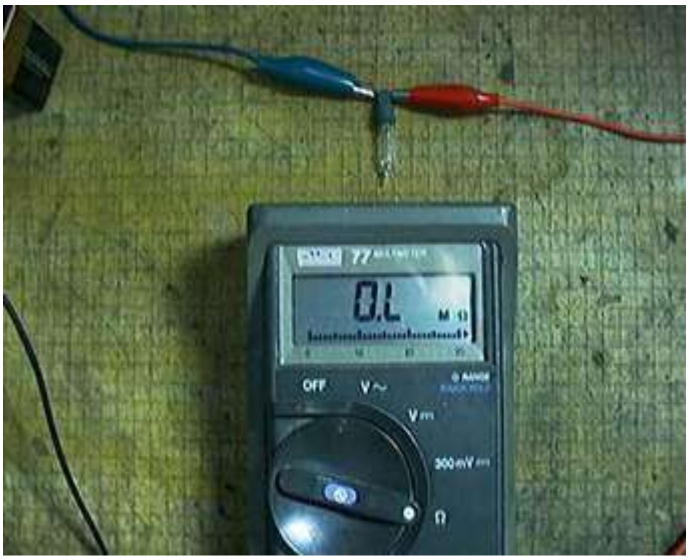


Fig 2.1 short testing device

Self-Check -2	Written Test

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

I. Say true or false

2. Short circuit is happen when excessive voltage is created in the system.

Note: **Satisfactory rating -1 points** **Unsatisfactory -1 below points**

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Information Sheet-3	Performing Terminal voltage test

3.1 **Concepts of Performing Terminal voltage test**

Voltage is a quantitative expression of the potential difference in charge between two points in an electrical field. Since voltage is pressure then it needs checking using digital multi meter.

The internal resistance of a voltage source affects the output voltage when current flows. The voltage output of a device is called its terminal voltage and is given by where is the electric current and is positive when flowing away from the positive terminal of the voltage source.

Digital multimeter

The nominal voltage of a lead-acid battery is 2,0V per cell. Conventionally, 12V batteries with six cells and 24V batteries with 12 cells in series are available. OPzS and OPzV batteries are generally offered as single cells. In Operation, the voltage at the electrodes fluctuates according to the operating state. During charging, the upper charge voltage marks the upper limit and for discharging, the lower discharge voltage is permissible lower limit. Another parameter is the gassing voltage, above which a battery starts gassing significantly in the charging process.

The open-circuit or no-load voltage of a battery is termed the *resting voltage* and cannot be measured immediately after charging or discharging, as thermodynamic equilibrium has to be set in first. Besides, the resting voltage is dependent on the electrolyte concentration. In practice, for example, it is somewhere between 12 and 12,7V for a 12V battery.

How do you test a solar panel with a multimeter?

- Testing Open Circuit Voltage (VOC)
- Connect the positive lead of the multi meter to the positive wire (or terminal) of the solar panel, and the negative lead of the multi meter to the negative wire (or terminal) of the solar panel. The multi meter will now show the Open Circuit Voltage of the solar panel.

What is open circuit voltage in solar panel?

- The **open-circuit voltage**, V_{OC}, is the maximum **voltage** available from a **solar cell**, and this occurs at zero current.
- The **open-circuit voltage** corresponds to the amount of forward bias on the **solar cell** due to the bias of the **solar cell** junction with the light-generated current.

Battery Open Circuit Voltage and Terminal Voltage

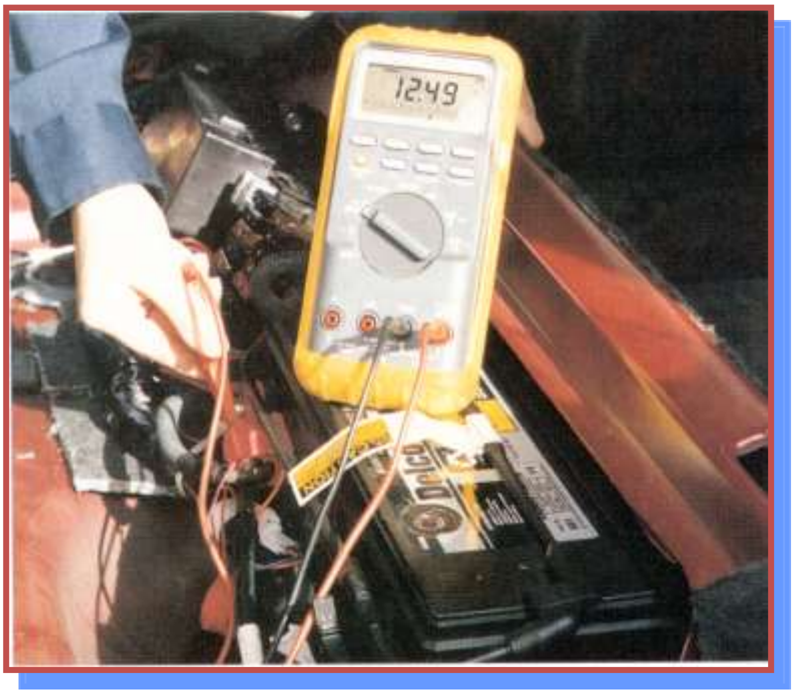
The terminal voltage of a battery is maximum when it is fully charged and when no current is flowing. The condition of no current flow is equivalent to open circuit. Therefore, the maximum terminal voltage of a battery is also referred to open circuit voltage of a battery (V_o)

When current flows through a battery, its terminal voltage is lower than the open circuit voltage. This happens because of the internal resistance of the battery. Due to its own resistance, some voltage drop occurs inside the battery. This voltage drop is equal to the current flowing through the battery multiplied by the internal resistance of the battery.

3.2 Battery Voltage Test

- Used on maintenance-free batteries
- Connect a voltmeter across the battery terminals
- Turn on headlights for a light load
- Read the meter
- A fully charged battery under a 5 amp load should have a voltage of 12.5 volt

- Open circuit cell voltage is 2.1 volts
- Cells are connected in series
- Battery voltage depends on the number of cells
- A 12-volt battery has 6 cells and an open circuit voltage 12.6 volts
- A 6-volt battery has 3 cells and an open circuit voltage 6.3 volts



This battery is about 100% charged with a 5 amp load

Battery Voltage versus Specific Gravity

Battery Voltage

Load on battery (Amps)	Specific Gravity (Percent charge)				
	1.265 (100%)	1.250 (95%)	1.230 (75%)	1.200 (50%)	1.175 (25%)
0	12.7	12.6	12.5	12.4	12.2
5	12.5	12.4	12.3	12.1	11.8
15	12.3	12.2	12.0	11.7	11.3
25	12.1	11.9	11.6	11.2	10.7

This is the range in which most vehicle batteries normally operate in customer service.

At 1.180 and below, starting will be unreliable and function of other circuits may be erratic.

3.3 Cell Voltage Test

- Insert special cadmium (acid resistant) tips of a low voltage meter into each cell
- Test all cells
- Maximum variation between cells should not be more than 0.2 volts

Efficiency of Batteries

Efficiency of Batteries	Testing
Energy Efficiency = $\frac{\text{Discharge Energy [Wh]}}{\text{Charge Energy [Wh]}}$ Resistance and chemical reactions reduce efficiency. High current, (fast charge / fast discharge), reduces efficiency. Typical for lead acid battery C10.	• Test charge: Check open circuit voltage • Test function: Check voltage under C-rated current, voltage drop must not be >1V. • Test capacity: Discharge battery with C-rating, record current, voltage and time. **Maintenance** • Flooded batteries: Check level of electrolyte periodically, refill **distilled water** if needed. • VRLA: Cannot easily be checked for electrolyte or refilled after overheating or overcharging. • Keep terminals clean, greased for corrosion protection and tightly fastened • Dispose broken batteries properly at local battery dealers, recycling / toxic waste collection facilities.

- More energy is needed for charging a battery than is recovered during discharging Reasons: Internal resistance and chemical processes producing heat
- Charging occurs at a higher voltage than discharging for the same current.
- At the same current, charging takes longer than discharging for one cycle.
- Over-voltages during charging and voltage drop during discharging depend on the respective current hence the efficiency is higher for lower currents with longer charge/discharge times.
- A reasonable estimate for the efficiency is 90%.

Self-Check -3	Written Test

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

I. **Say true or false**

1. The internal resistance of a voltage source affects the output voltage when a current flows.

Note: **Satisfactory rating - 1 points** **Unsatisfactory - below 1_points**

Name: ___________________________ Date: ________________

Short Answer Questions

Answer Sheet

Score = ____________
Rating: _____________

4.3 Concepts of checking terminal for carbon contents

Battery corrosion is caused by hydrogen gas being released from the sulfuric acid Inside the battery.

- Causes of Battery Terminal Corrosion

There are a few different reasons why you may notice corrosion on your battery terminals. Here are the most common reasons:

- **Hydrogen gas leakage**

The battery turns acid into electric current. There moments the hydrogen gas in the battery leaks and finds its way to the atmosphere. It reacts with other substances, and you have battery terminal corrosion.

Depending on which side it forms, you can diagnose various battery problems – if it is on the negative terminal, this is a sign of undercharging while if it is on the positive terminal, it is due to overcharging. Most batteries suffer from undercharging, and this is the reason you see it more on the negative side.

- **Electrolyte leakage**

This problem is synonymous with lead-acid batteries. Due to age or damage, the electrolyte in the battery can leak and accumulate on the battery terminals. The probability of the electrolyte leaking is increased if you overfill the battery water.

- **Corrosion in the copper clamps**

Copper is a good conductor and does not corrode easily. However, when electric currents pass through the copper terminals, there is the production of copper sulfate, which leads to battery terminal corrosion. a bluish precipitate on the copper terminals can identify copper sulfate. Copper sulfate does not conduct electricity well, and that is why you will start experiencing trouble starting your car.

- **Overcharging and overfilling battery**

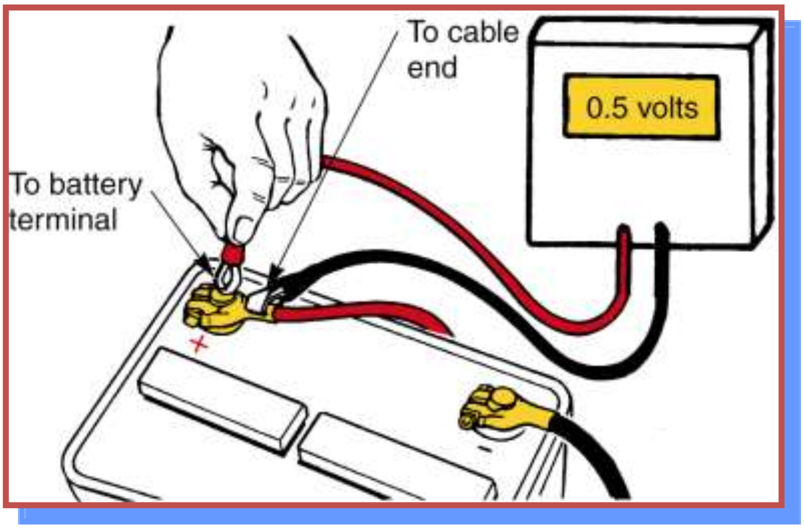
If you overfill your battery with water, it can cause the electrolyte to leak through the vents and corrode the terminals. Ensure that you put the right amount of battery water.

If you overcharge your battery something similar happens – the electrolyte gets charged upon kinetic energy and overflow to the terminals causing corrosion.

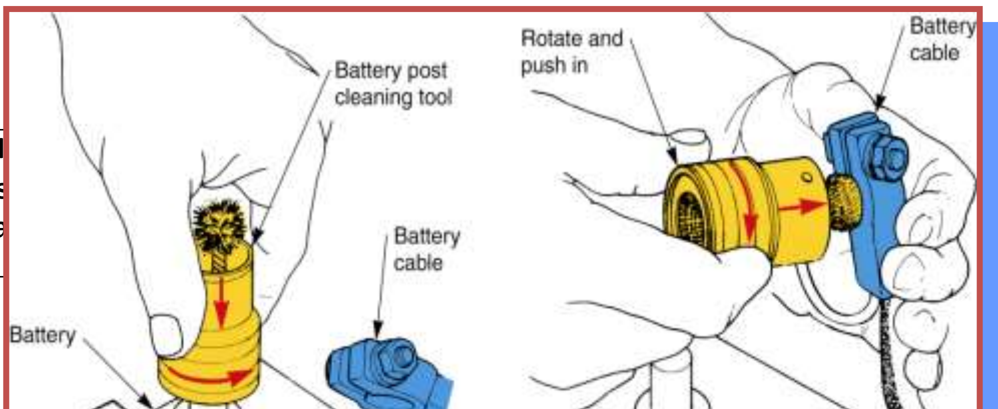
Fig corroded battery terminals

4.2. Battery Terminal Test

- Check for poor connections between the battery cables and terminals
- Connect the negative voltmeter lead to the cable end
- Connect the positive lead to the battery terminal
- Disable the injection or ignition
- Crank the engine while watching the voltmeter readings
- Clean the connections if the voltage is above 0.5 volts



- ✓ Cleaning Battery Posts and Cable Ends
- ✓ Rotate female end of brush on post and Use male end of brush on cable end



Self-Check -4	Written Test

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

I. Choose the best answer

1. Which of the following is not causes of battery terminal corrosion?
   A. Corrosion in the copper clamps
   B. Overcharging and overfilling battery
   C. Electrolyte leakage
   D. D. all
2. Copper is a good conductor and does not corrode easily.
   A. True B. false

Note: **Satisfactory rating - 2 points Unsatisfactory - below 2 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Information Sheet-5	Carrying out battery bank polarity test

5.1 **Concepts of Carrying out battery bank polarity test**
A battery bank is group of batteries connected together using series or Parallel wiring. This allows more power to be stored than using a single .

Polarity is defined as, the condition of a body or system in which it has testing with a multi meter usually involves touching positive and negative

Reverse polarity protection sounds dull, but it provides the perfect excuse to blow things up

Batteries are fully charged, during solar panel use and in situations where reverse polarity may occur. The controller features a switch allowing for us the battery storage in a PV system should be properly controlled to avoid catastrophic operating. Storage batteries account for most PV system failures and contribute significantly to both the initial and the ... Reverse polarity protection: 14 V.

5.2**Importance ofConducting Specific gravity test**

knowing the specific gravity of the fluids being blended is important because it will
influence the torque & horsepower that is required to properly mix your fluid.
with higher specific gravity, more torque would be required to produce the desired result.

Self-Check -5	Written Test

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

I. Say true or false

1. A battery bank is group of batteries connected together with series only.

A. True B. false

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

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Operation Sheet 1	Techniques of Conducting Specific gravity test

1.1Techniques of Conducting Specific gravity test

Step-**1**Wear appropriate PPE
Step-2Check that your liquid is the correct temperature
Step-3Place the hydrometer in the liquid.
.Step-4 Insert the hydrometer into the liquid.
Step-5.Spin the hydrometer gently

Operation Sheet 2	Techniques Conducting Internal short circuit test

2.1. Procedures of Conducting Internal short circuit test

Step-1 Wear appropriate PPE

Step-2 Disconnect the solar panel completely from the battery and regulator

Step-3 Angle the solar panel towards the sun

Step-4 Ensure that the multi meter is set at 10A, at least to start with. You can change the setting later if required.

Step-5 Measure the operating current by connecting the +ve from the multi meter to the positive cable from the regulator, and the -ve from the volt meter to the positive battery terminal

Operation Sheet 3	Techniques of Performing Terminal voltage test

3.1 Techniques of Performing Terminal voltage test(Test Sequence)

Step-1 Wear appropriate PPE
Step-2 Documentation Inspection
Step- 3 Preliminary System Inspection
Step- 4 System Installation & Instrumentation
Step- 5 System Functional Test

Operation Sheet 4	cleaning terminal for carbon contents procedures

Steps of Performing Polarity test

Step 1: Mix up your homemade battery cleaner
Step 2: Undo the cables from the battery and inspect it.
Step 3: Dip a toothbrush in your cleaner and start scrubbing*!*
Step 4: Rinse off the residue with water and dry
Step 5: Rub petroleum jelly onto the terminals and reattach the cables*.*

LAP Test	Practical Demonstration

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

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Task-1 Conduct specific gravity test

Task-2 Conduct Internal short circuit test

Task-3 Perform Terminal voltage test

Task-4 check terminal for carbon contents

Task-5 Carry out battery bank polarity

Reference

1. John Platts and John St. Aubyn (eds). Peter Peregrinus, 1992. Uninterruptible Power Supplies
2. Nick Stockton. Wired, August 11, 2014.What It Will Take to Win Google's Million-Dollar Electric Power Prize
3. Rajendra Singh and Krishna Shenai. IEEE Spectrum, February 6, 2014:DC Microgrids and the Virtues of Local Electricity by Inverters waste energy converting DC power to AC,
4. Video : https://www.youtube.com/watch?v=hOjcaKmR4lE ; https://www.youtube.com/watch?v=dWu8SOBVFE8

Solar PV System Installation and Maintenance

NTQF Level - II

Learning Guide -59

Unit of Competence	**Perform wiring of Solar PV System**
Module Title	**Performing wiring of Solar PV System**
LG Code	**EIS PIM2 M10 LO-6 LG-59**
TTLM Code	**EIS PIM2 0819v1**

LO6: Interconnect the PV system

Instruction Sheet	Learning 47

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

- Connecting battery bank to the inverter / charge controller
- Connecting PV modules to the inverters / controllers
- Connecting investor with the input D.C source
- Connecting load to the inverter

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:**

- Connect the battery bank to the inverter / charge controller through safety circuits as per plan specification
- Connect the PV modules to the inverters / controllers through safety circuits
- Connect the inverter with the input D.C source
- Connect the load to the inverter through safety circuit

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-check 1" **in page -.**
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

.

Information sheet-1	Connecting battery bank to the inverter / charge controller

1.1. Definition of connecting battery connecting

A photovoltaic system will be given permission to interact with the power grid only after a formal approval has been issued by the utility company. The process through which a utility verifies a solar system's compliance to its technical and administrative requirements is commonly referred to as interconnection process.

The interconnection process runs in parallel with the permitting process. During this process the local Authority Having Jurisdiction (AHJ) verifies the system's compliance to the National Electrical code, fire code and other local standards. While the AHJ and the utility company will generally not interact during the process, they will require and recognize each other's approval documents.

During the interconnection process, utilities certify that a PV system meets the following general requirements:

- The power exported to the grid is measurable and compliant with the grid's standards in terms of voltage, frequency; power quality that the equipment used is certified.
- The AC side of the PV system (between the inverter and the utility meter) meets the utility's safety requirements (labelling, location of equipment, connection to electric panel).
- The power and energy generated meet the net metering program requirements.

Interconnection standards define how a distributed generation system, such as solar photovoltaic (PVs), can connect to the grid. In some areas of the United States, the interconnection process lacks consistent parameters and procedures for connecting to the grid or is unnecessarily complex. This drives up costs and causes delays, which can be significant barriers to project development. The ability to interconnect to the grid in a cost-effective and timely manner may determine whether a project moves forward or not. The continued growth of the distributed solar market has prompted electric utilities, regulators, and others to consider improvements to the interconnection processes. Below are resources to help you understand the interconnection policy landscape and how it may impact your project develop

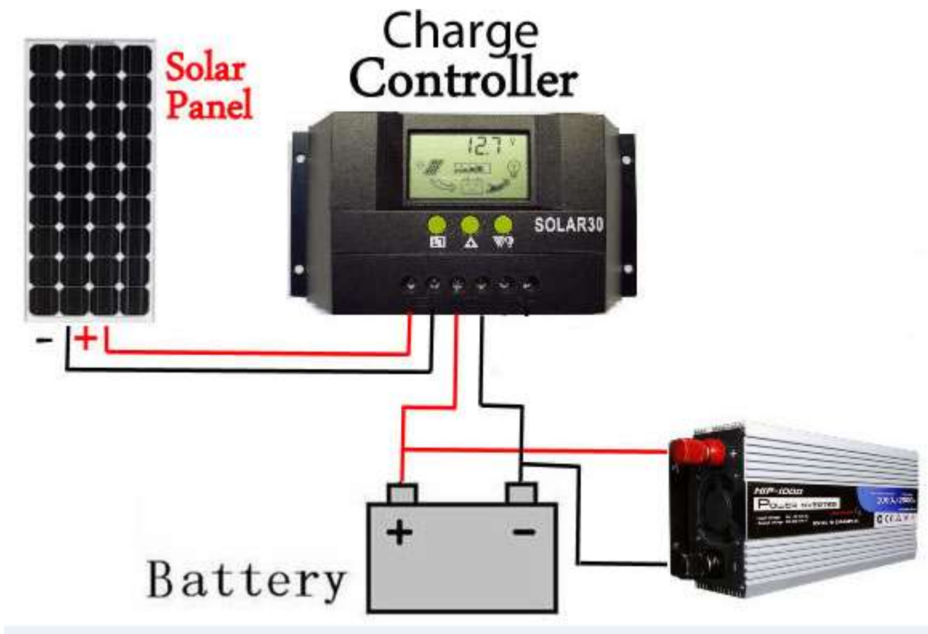
1.2. The following links exit the site

- **Connecting to the Grid Guide, 6th Edition**
  Interconnection policies are an essential piece of a supportive state-level regulatory policy framework addressing how project developers will interconnect distributed generation systems to the grid. This guide, produced by the

Interstate Renewable Energy Council, Inc. (IREC), introduces the issues surrounding policy and technical considerations of grid-integrated renewable energy.

- **Database of State Incentives for Renewables & Efficiency (DSIRE)**
  DSIRE, operated by the N.C. Clean Energy Technology Centre, is the most comprehensive source of information on incentives and policies that support renewable energy and energy efficiency programs in the United States. It includes information on state-level interconnection policies only, so be sure to check with your local electricity provider about its specific interconnection process and timeline.
- **Model Interconnection Procedures**
  As costs of renewable energy continue to fall, and more systems connect to the grid, interconnection procedures developed over the last decade are under strain. IREC's *Model Interconnection Procedures* summarize a number of best practices for the safe and reliable connection of renewable energy systems to the utility grid.
- **A State-Level Comparison of Processes and Timelines for Distributed Photovoltaic Interconnection in the United States (PDF)**
  This report, produced by the National Renewable Energy Lab (NREL), presents results from an analysis of distributed solar interconnection and deployment processes in the United States. In the report, NREL assesses the range in project completion timelines nationally and in five states with active solar markets (Arizona, California, New Jersey, New York, and Colorado). The report also assesses the portion of projects that required one month or more for either the utility interconnection application review and approval or permission-to-operate process, as this may indicate a project or process delay.
- **Photovoltaic Systems Interconnected onto Secondary Network Distribution Systems – Success Stories (PDF)**

  While the number of PV systems interconnected to the grid has increased significantly over the last decade, only recently have PV systems been installed in major metropolitan areas and tied to electric distribution secondary network systems (networks). Utilities use networks to distribute electricity to customers in areas where there are large concentrations of load and where reliability greater than that of a radial system is needed. This report, prepared by NREL, examines six case studies of PV systems that were successfully integrated into secondary network systems.
- **Distributed Solar Interconnection Challenges and Best Practices (PDF)**
  A survey and interviews conducted by Solar Electric Power Association have uncovered utility initiatives to lower the administrative costs of interconnection, making the process of connecting to the grid simpler and more transparent for project developers.



1.3. 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).

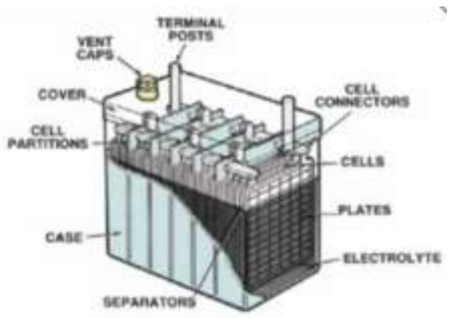
- **The primary functions of a storage battery in a PV system are:**
  - ✓ Energy Storage Capacity and Autonomy: to store electrical energy when it is produced by the PV array and to supply energy to electrical loads as needed by the system or on demand.
  - ✓ Voltage and Current Stabilization: to supply 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.
- **Types of Solar Batteries**

Solar systems require use of deep cycle batteries. These differ from standard car batteries in that deep cycle batteries have been developed for frequent discharge and slow recharge. Car batteries are therefore not suitable for use in solar systems.

- ✓ **Flooded Type**

This is a lead acid type battery.

- ❖ While these are good batteries, this type needs to be stored outside of your home or in an area with lots of air as they emit gas and can be dangerous in your home if not handled carefully.
- ❖ This type of battery is economical and will last for years if maintained properly.
- ❖ The most popular brands of this type of battery are Trojan, Surrette and Deka.
- ❖ Make sure to ventilate this type of battery if in an enclosure.



- ✓ **Gel Type**
  - ❖ This type of battery does not have vents and will not emit gas so it is safe to use indoors.
  - ❖ Being able to use it where the temperature is constant is definitely a plus because it helps the battery to perform better and last longer.
  - ❖ Although this is a good battery for solar applications, it takes a low charge to recharge which may cost you more.

- ✓ **Absorbed Glass Mat (AGM) Type**

- This type of battery has a woven glass mat in between cells to help sustain charging longer.
- This type is considered by most solar users to be the best as it holds charges for longer and the battery lasts longer.
- They are leak proof, spill proof and do not emit gas, making them the safest and most easy to maintain.
- Even though this type is more expensive it is worth it.
- These types of batteries are used in airplanes, hospitals and remote communication centers.
- The most sought after brand of this type are the Sun Extender and the Concorde.

Self-Check -1	Written Test

Choose the best answer from the given alternative

1. The term PWM refers:

   A. Maximum Power Point Tracking
   B. personal window materials
   C. people window materials
   D. Minimum Power Point Tracking

2. The power going into the battery bank from the solar array is called

   A. Electrical control unit
   B. charger controller
   C. unit controller
   D. all

Note: **Satisfactory rating 1.5 and above points Unsatisfactory - below 1 points**

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

Answer Sheet

Score = ____________
Rating: _____________

Name: ___________________________ Date: ________________

Short Answer Questions

Operation Sheet -1	Connecting battery bank to the inverter

I. Technics of connecting battery bank to the inverter / charge controller

Step-1 Wear appropriate PPE
Step-2 identify batteries type
Step-3 identify number of batteries
Step-4 Charging the batteries and keeping them fully charged at all times.

2.1. Concepts of solar **PV module**

A unit comprised of several PV cells, and the principal unit of a PV array; it is intended to generate direct current power under un-concentrated sunlight

Photovoltaic solar panels absorb sunlight as a source of energy to generate direct current electricity. A photovoltaic (PV) module is a packaged, connected assembly of photovoltaic solar cells available in different voltages and wattages. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. The most common application of solar energy collection outside agriculture is solar water heating systems.

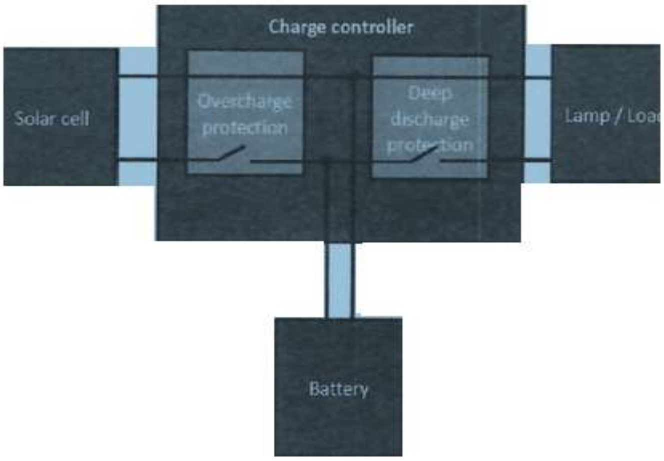
Regarding photovoltaic or solar panels with crystalline cells, the photoactive layer consists of serial and/or parallel interconnected solar cells which are embedded into two plastic films. A front glass protects the interior for mechanical damage. Regarding thin-film solar modules the photoactive layer is applied directly onto the glass which then is laser-cut into strips and interconnected serial.

When your solar panels collect sunlight and turn it into energy, it gets sent to the inverter, which takes the DC energy and turns it into AC energy. At that point, your solar electricity can power your appliances and electronics or, if you're producing more electricity than you need, it can feed back into the grid

- How many PV modules are in a string?
  Diagram of a single series string of four modules connected to an inverter. For home PV systems with no battery backup, the most common array configurations use 2 to 4 strings of 7 to 12 modules each.

2.2. Importance o the inverters / controllers

- Can be an energy efficient way of changing voltage.
- Can step voltage up or down.
- Can provide electrical isolation between input and output.
- Can provide an AC voltage from a DC source.
- Can smooth out random variations in input voltage.
- Can be used to produce 50 Hz from a 60 Hz supply or vice versa


Charge controller
Solar cell
Overcharge protection
Deep discharge protection
Lamp / Loa
Battery

2.3. Module and efficiency

A typical 150 watt PV module is about a square meter in size. Such a module may be expected to produce 0.75 kilowatt-hour (kWh) every day, on average, after taking into account the weather and the latitude, for an insolation of 5 sun hours/day. In the last 10 years, the efficiency of average commercial wafer-based crystalline silicon modules increased from about 12% to 16% and CdTe module efficiency increased from 9% to 13% during same period. Module output and life degraded by increased temperature. Allowing ambient air to flow over, and if possible behind, PV modules reduces this problem. Effective module lives are typically 25 years or more. The payback period for an investment in a PV solar installation varies greatly and is typically less useful than a calculation of return on investment. While it is typically calculated to be between 10 and 20 years, the financial payback period can be far shorter with incentives

Self-Check -2	Written Test

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

I. **Say if the statement is write say true if the statement is wrong say false**

1. An inverter is advice that converts the AC voltage to an DC voltage
2. An inverter can be used to produce 50 Hz from a 60 Hz supply or vice versa.
3. Important of the inverter is can be an energy efficient way of changing voltage.

Note: **Satisfactory rating –1.5 & above points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: _______________

Short Answer Questions

Operation Sheet 2	Technic’s of Connecting PV modules to the inverters / controllers

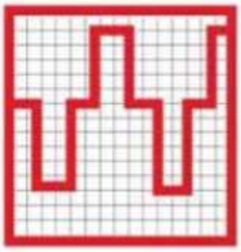
II. Procedures of Connecting PV modules to the inverters / controllers

Step-1. Wear appropriate PPE
Step-2. Connect 500 watts solar panels (Poly crystalline PV Modules)
Step-3. Luminous 1.5 KVA sine wave (double battery)
Step-4. Connect invertor Plus Batteries to the system

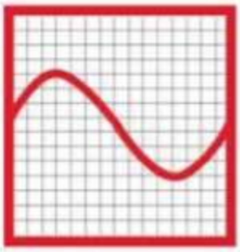
3.1. Define Inverter

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 Sine Wave



Pure Sine Wave

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

Each of these inverters has a specific purpose where it can be used.

Systems designed to deliver alternating current (AC), such as grid-connected applications need an inverter to convert the direct current (DC) from the solar modules to AC. Grid connected inverters must supply AC electricity in sinusoidal form, synchronized to the grid frequency, limit feed in voltage to no higher than the grid voltage and disconnect from the grid if the grid voltage is turned off. Islanding inverters need only produce regulated voltages and frequencies in a sinusoidal wave shape as no synchronisation or co-ordination with grid supplies is required.

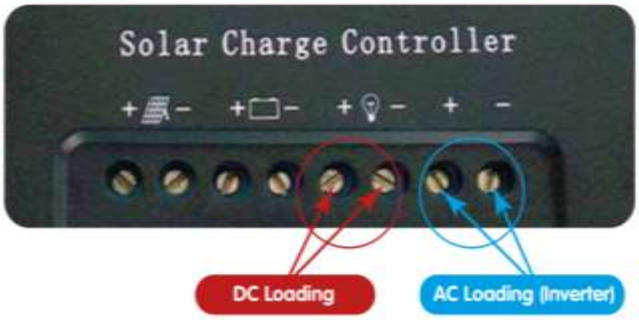
A solar inverter may connect to a string of solar panels. In some installations a solar micro-inverter is connected at each solar panel. For safety reasons a circuit breaker is provided both on the AC and DC side to enable maintenance. AC output may be connected through an electricity meter into the public grid. The number of modules in the system determines the total DC watts capable of being generated by the solar array; however, the inverter ultimately governs the amount of AC watts that can be distributed for consumption. For example, a PV system comprising 11 kilowatts DC (kW_{DC}) worth of PV modules, paired with one 10-kilowatt AC (kW_{AC}) inverter, will be limited to the inverter's output of 10 kW. As of 2014, conversion efficiency for state-of-the-art converters reached more than 98%. While string inverters are used in residential to medium-sized commercial PV systems, central inverters cover the large commercial and utility-scale market. Market-share for central and string inverters are about 50% and 48%, respectively, with less than 2% for micro-inverter

- ✓ Maximum power point tracking (MPPT) is a technique that grid connected inverters use to get the maximum possible power from the photovoltaic array. In order to do so, the inverter's MPPT system digitally samples the solar arrays ever changing power output and applies the proper resistance to find the optimal *maximum power point*.
- ✓ Anti-islanding is a protection mechanism to immediately shut down the inverter, preventing it from generating AC power when the connection to the load no longer exists. This happens, for example, in the case of a blackout. Without this protection, the supply line would become an "island" with power surrounded by a "sea" of unpowered lines, as the solar array continues to deliver DC power during the power outage. Islanding is a hazard to utility workers, who may not realize that an AC circuit is still powered, and it may prevent automatic re-connection of devices.

Inverter/Converter

Type	Power	Efficiency[a]	Market Share[b]	Remarks
String inverter	up to 100 kW_p[c]	98%	50%	Cost[b] €0.15 per watt-peak. Easy to replace.
Central inverter	above 100 kW_p	98.5%	48%	€0.10 per watt-peak. High reliability. Often sold along with a service contract.
Micro-inverter	module power range	90%–95%	1.5%	€0.40 per watt-peak. Ease of replacement concerns.
DC/DC converter Power optimizer	module power range	98.8%	n.a.	€0.40 per watt-peak. Ease of replacement concerns. Inverter is still needed. About 0.75 GW_P installed in 2013.

- **Connecting the Inverter**
  - ✓ The inverter is connected to the charge controller at the terminals indicated in the image below (+) and (-).
  - ✓ The terminals are loosened and the cable from the inverter is fitted with the same polarity:

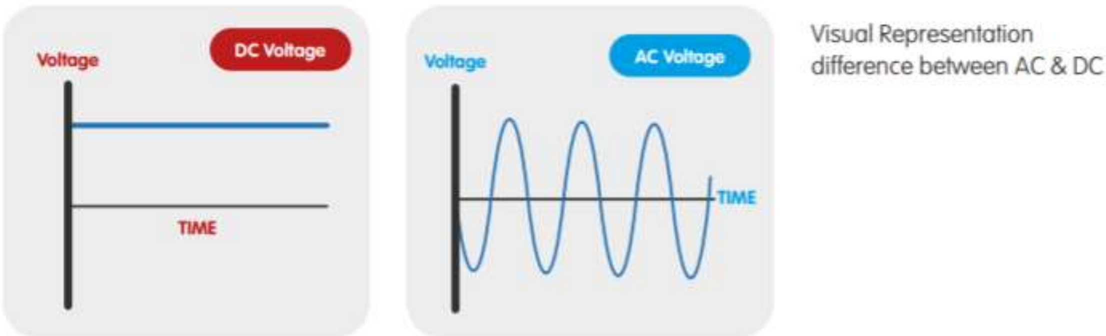


3.2. Comparison of AC & DC

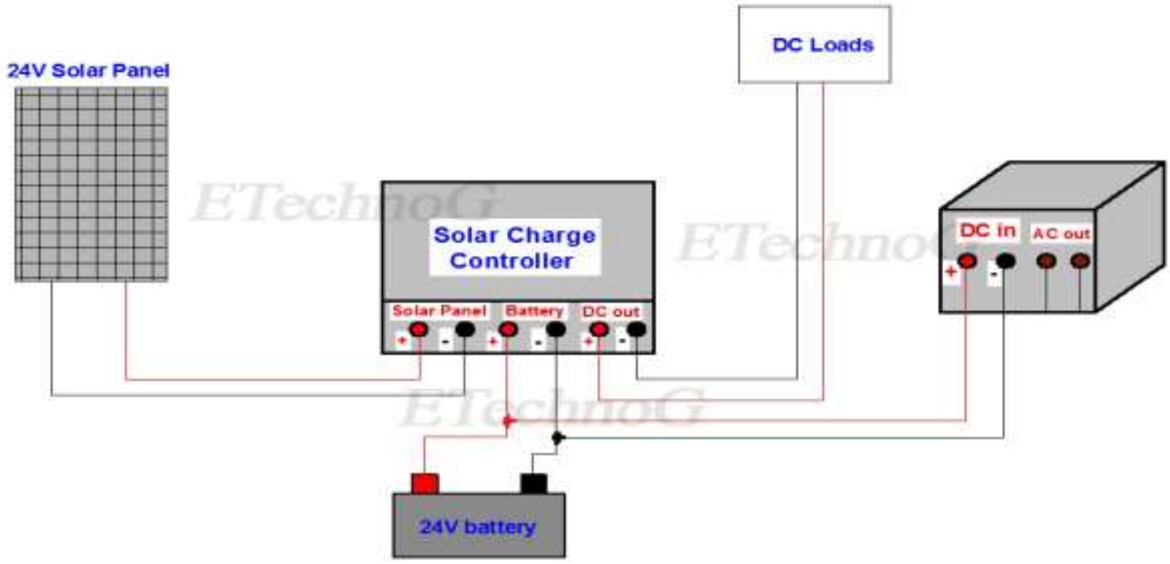
In electricity generation there are two distinct types of electricity which are direct current electricity (DC) and alternating current electricity (AC). Direct Current (DC) is used mostly in houses that are not connected to the grid, and are running with batteries. Alternating Current electricity (AC) is the type of current most commonly used in households that are connected to the grid to power electrical appliances (for example TVs, refrigerators, radios, lighting and many others). Loading or the Load

This is where the electrical energy is to be used.

- Solar energy can power both DC and AC appliances or gadgets.
- DC loads include:
  - ✓ Radios
  - ✓ Light bulbs
- AC Loads include:
  - ✓ Refrigerators
  - ✓ Televisions
  - ✓ Computers



On some electrical devices DC and AC Voltage are represented by signs as follows (these are the signs that are used on most millimetres to indicate the two voltages)


24V Solar Panel
DC Loads
Solar Charge Controller
Solar Panel
Battery
DC out
DC in
AC out
24V battery
ETechnoG

Self-Check -3	Written Test

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

I. **Say if the statement is write say true if the statement is wrong say false**

1. An inverter provides an
   Ac voltage from dc power **s**ources and is useful in grids.
2. An AC Loads are include refrigerators, televisions, computers
3. Same examples of DC loads include,radios,light bulbs
4. Electricity generation there are two distinct types of electricity which are direct current electricity (DC) and alternating voltage (AV)

Note: **Satisfactory rating - 3 points Unsatisfactory - below 2points**

Answer Sheet

Score =

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Operation Sheet 3	Ways of connecting inverter with the input D.C source

III. Ways of connecting inverter with the input D.C source

Step-1 Wear appropriate PPE

Step-2. Switching out the PV array

Step-3 adjusting the voltage with in an Mpp charge controller

Step-4 Short circuiting the PV array with an shunt controller

Information sheet-4	**Connecting load to the inverter**

4.1. Definition of loads

A photovoltaic system, also **PV system** or **solar power system** is a power system designed to supply usable solar power by means of photovoltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the output from direct to alternating current, as well as mounting, cabling, and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline. Strictly speaking, a **solar array** only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware, often summarized as balance of system (BOS). As PV systems convert light directly into electricity, they are not to be confused with other solar technologies, such as concentrated solar power or solar thermal, used for heating and cooling.

PV systems range from small, rooftop-mounted or building-integrated systems with capacities from a few to several tens of kilowatts, to large utility-scale power stations of hundreds of megawatts. Nowadays, most PV systems are grid-connected, while off-grid or stand-alone systems account for a small portion of the market.

Operating silently and without any moving parts or environmental emissions, PV systems have developed from being niche market applications into a mature technology used for mainstream electricity generation. A rooftop system recoups the invested energy for its manufacturing and installation within 0.7 to 2 years and produces about 95% net clean renewable energy over a 30-year service lifetime

Figure 4: schematic of stand-alone PV system with battery storage powering DC and AC loads

4.2. Input and output

- **Input voltage**

A typical power inverter device or circuit requires a relatively stable **DC power source** capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. Examples include:

- ✓ 12 V DC, for smaller consumer and commercial inverters that typically run from a rechargeable 12 V lead acid batteries or automotive electrical outlet.
- ✓ 24, 36 and 48 V DC, which are common standards for home energy systems.
- ✓ 200 to 400 V DC, when power is from photovoltaic solar panels.
- ✓ 300 to 450 V DC, when power is from electric vehicle battery packs in vehicle-to-grid systems.
- ✓ Hundreds of thousands of volts, where the inverter is part of a high-voltage direct current power transmission system.

- **Output waveform**

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design. Common types of inverters produce square waves or quasi-square waves. One measure of the purity of a sine wave is the total harmonic distortion (THD). A 50% duty cycle square wave is equivalent to a sine wave with 48% THD Technical standards for commercial power distribution grids require less than 3% THD in the wave shape at the customer's point of connection. IEEE Standard 519 recommends less than 5% THD for systems connecting to a power grid.

There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage.

- **Output frequency**

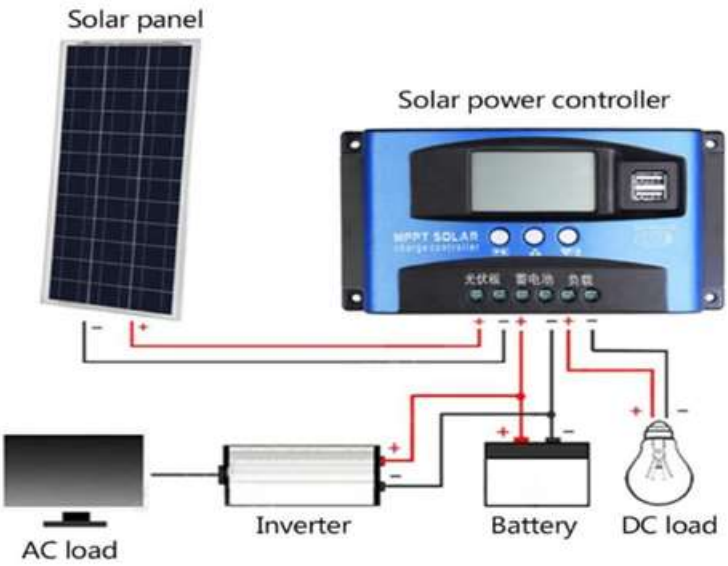
The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 hertz. If the output of the device or circuit is to be further conditioned (for example stepped up) then the frequency may be much higher for good transformer efficiency.

- Output voltage

The AC output voltage of a power inverter is often regulated to be the same as the grid line voltage, typically 120 or 240 VAC at the distribution level, even when there are changes in the load that the inverter is driving. This allows the inverter to power numerous devices designed for standard line power. Some inverters also allow selectable or continuously variable output voltages.

- Output power

A power inverter will often have an overall power rating expressed in watts or kilowatts. This describes the power that will be available to the device the inverter is driving and, indirectly, the power that will be needed from the DC source. Smaller popular consumer and commercial devices designed to mimic line power typically range from 150 to 3000 watts. Not all inverter applications are solely or primarily concerned with power delivery; in some cases the frequency and or waveform properties are used by the follow-on circuit or device.



Connection Schematics Diagram

Self-Check -4	Written Test

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

I. Say if the statement is write say True if the statement is wrong say False

1. The primary source of the photovoltaic system is charger controller.
2. A power inverter will often have an overall power rating expressed in watts or kilowatts
3. The AC output voltage of a power inverter is often regulated to be the same as the grid line voltage, typically 50 or 380 VAC

Note: **Satisfactory rating - 1 points Unsatisfactory - below 1points**

Answer Sheet

Score =
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Operation Sheet 4	Techniques of connecting load to the inverter

IV. **Steps to Connecting load to the inverter**

Step-1 Wear appropriate PPE
Step-2 select proper voltage load
Step-3 select proper wire that connects to load and inverter
Step-4 Determine the sizing of the cables cross sectional area

LAP Test	Practical Demonstration

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

Name: ______________________________Date: ________________

Time started: ______________________Time finished: ________________

Task-1.Wear appropriate PPE

Task-2 Connect battery bank to the inverter / charge controller

Task-3 Connect PV modules to the inverters / controllers

Task-4 Connect inverter with the input D.C source

Task-5.Connect load to the inverter

Reference

1. http://www1.eere.energy.gov/solar/solar_glossary.html#photovoltaic_panel
2. http://rredc.nrel.gov/solar/glossary/gloss_p.html
3. http://www1.eere.energy.gov/solar/solar_glossary.html#I
4. Qing-Chang Zhong and Tomas Hornik. Wiley-Blackwell, 2013:Control of Power Inverters for Distributed Generation and Renewable Energy
5. Keng Wu. Lulu, 2008: Power Rectifiers, Inverters, and Converters
6. William Shepherd and Li Zhang. CRC Press, 2004: Power Converter Circuits .
7. John Platts and John St. Aubyn (eds). Peter Peregrinus, 1992: Uninterruptible Power Supplies

Solar PV System Installation and Maintenance

NTQF Level - II

Learning Guide -60

Unit of Competence: -	**Perform wiring of Solar PV System**
Module Title: -	**Performing wiring of Solar PV System**
LG Code:	**EIS PIM2 M10 LO-7 LG-60**
TTLM Code:	**EIS PIM2 0819v1**

LO 7: Configure the inverter /charge controller

Instruction Sheet	Configure the inverter /charge controller

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

- Interpreting The inverter manual is accessed and interpreted
- Collecting customers / site requirement inquiries through appropriate data collection procedures
- Setting parameters for the work as per requirement

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 –**

- Interpret he inverter manual is accessed and interpreted
- Customers / site requirements inquires are collected through appropriate data collection procedures
- Parameters for the work are set as per requirement

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number
3. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-check 1" **in page**
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

a. Solar Inverter

The Solar Inverter is an essential device in any solar power system. Its basic function of the inverter is to change the variable Direct Current output of the solar panels into Alternating Current. The various electrical and electronic components connected in the circuit help in the conversion.

The converted Alternating Current power is used for running your appliances like the TV, Refrigerator, Microwave, etc. For some particular applications, we can directly use the Direct Current power from the solar panel such as LED night lights, a cell phone charger. Generally, the power of a home solar power system is used for power AC loads.

b. Types of Solar Inverters

There are a lot of common Solar Inverters all over the world. But there are a few types of solar inverters available in the market which includes the following.

i. Off Grid Inverters

Off grid inverters are used in remote systems wherein the solar inverter is fed DC power from a battery panel. This battery panel is charged by solar panels.Several such inverters have integrated with basic battery chargers which can be used to boost the battery from an AC power source.

ii. Grid Tie Inverters

An inverter which is associated with the grid can be said to be a grid tie inverter. These inverter feed power in the electricity grid by corresponding phase and frequency. And, the frequency ranges 50Hz in India and 60Hz in North America of the o/p AC power with the effectiveness supplied AC power. These inverters are designed to automatically shut down once sensing a loss of supply from the utility.

Figure 5: Grid Tie Inverters

iii. Battery backup Inverters

These special types of inverters are particularly designed to draw energy from a battery. The charge of the battery is preserved by using an on-board charger and an additional energy is transferred to the grid. Such inverters have the ability to provide AC power to particular loads during power outages. They also have the anti-islanding function.

Figure 6: Battery backup Inverter

iv. Micro Inverters

Micro inverters are modern in the solar industry. They are small, compact size and portable with a lot of performance. They include all the features of any central inverters.

Figure 7: Micro inverters

c. Advantages of Solar Inverter

After knowing in detail what is a solar inverter and how it is a suitable making appliance work at residential & industrial levels we must discuss about the several advantages of the solar inverter.

- Solar energy has constantly helped in decreasing the greenhouse effect and global warming.
- By using of solar based devices will help in saving money and also energy. Because many people have started using these devices.
- A solar inverter helps in changing the DC into batteries or AC. This supports people who use a partial amount of electricity.

- The synchronous solar inverter that helps small homeowners and also power companies as they are huge in size.
- The multifunction solar inverter is the finest among all and works powerfully. It converts the DC to AC very carefully which is suitable for commercial establishments.
- This inverter is cost effective, i.e. low cost than generators.
- Apart from these there are additional devices too, that make use of solar energy such as, solar heater, cooker.

d. Disadvantages of Solar Inverter

- Primarily, we need to shell out a lot of money for purchasing a solar inverter
- It will work efficiently and produce DC only when the daylight is strong.
- The solar panels are used to attract the sunshine needs lots of space
- Solar Inverters can work when there is no Sunshine but the battery which is available in that is charged fully with the help of Sunshine.

Self-Check -7	Written Test

Direction I: Multiple choice questions

Instruction: Choice the best answer from the given alternative and write your answer on the answer sheet provided in the next page (2 point each)

1. Direct Current output of the solar panels is Converts into Alternating Current by:

   C. Rectifier
   D. Inverter
   E. Transformer
   F. All of the above

2. Which inverters are used in remote systems?

   A. Off grid inverters
   B. Grid tie inverter
   C. Battery backup Inverters
   D. Micro Inverters

3. Which inverters are used to draw energy from a battery?

   A. Off grid inverters
   B. Grid tie inverter
   C. Battery backup Inverters
   D. Micro Inverters

4. Which inverters are associated with the grid system?

   A. Off grid inverters
   B. Grid tie inverter
   C. Battery backup Inverters
   D. Micro Inverters

Note: **Satisfactory rating - 2 points and above Unsatisfactory - below 2 points**

Answer Key

1. B
2. A
3. C
4. B

Information Sheet-2	Collecting customers / site requirement

a. Data acquisition

Data acquisition systems are the collection of information that can be processed or stored by a computer to document or analyze some phenomenon. Measurement systems are used in the data acquisition.

Data acquisition systems come in many different PC technology forms to offer flexibility when choosing a measurement system. The organization of information flow in the system is an important problem in designing and operating the measurement. Two aspects are essential for this organization: the kind of transmission in the system and the mode of information exchange between system devices.

b. Customers numbers versus the amount of energy need

The customer's power need is considered and data are collected in order to determine the required solar panel size, battery wattage, charge controller, inverter and other components.

Self-Check -2	Written Test

Instruction: Write TRUE if the statement is correct or False if it is incorrect (2 point each)

1. Data acquisition systems is the collection of information.
2. Data acquisition systems come in PC technology.
3. The customer's power need is not considered for PV installation.

Note: **Satisfactory rating – 2 and above points, Unsatisfactory - below 2 points**

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

Answer Key

1. True
2. True
3. F

Answer Sheet-1

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Setting parameters work

Setting the parameters is essential prior to solar installation. It helps to ensure the exact requirements of the solar PV system and install based on this data. There will not be shortage of power for the appliances.

The parameters that are needed for installing a solar PV are temperature of the PV module; solar irradiation and power dissipation; the measuring gage is in the shade or soiled; PV module in the shade or soiled; recording period; efficiency factor of the PV modules; efficiency factor of the inverter; differences in solar cell technologies .

Instruction: Write TRUE if the statement is correct or False if it is incorrect (2 point each)

1. Setting the parameters is essential prior to solar installation.
2. Temperature of the PV module; solar irradiation and power dissipation do not affect PV installation

***Note:* Satisfactory rating – 1 and above points, Unsatisfactory - below 1 points**

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

Answer Key

Answer Sheet-1

Score = ___________

Rating: _____________

Name: ___________________________ Date: ________________

Operation Sheet 1	Interpreting the inverter manual

1.1 Configuration of an inverter

The steps in configuring an inverter to the solar PV system are

1. Introducing the solar edge optimizer power harvesting system (The SolarEdge power optimizer is a DC/DC converter which is connected by installers to each solar module turning them into smart modules.)
2. Installing the power optimizer
3. Installing the inverter
4. Connecting the AC and the string to the inverter

Operation Sheet 2	Collecting customers / site appropriate data

Perform the site assessment ,customer need based on the data collected for solar PV home system installation and determine the number of solar panels ,the size of the battery, and other components.

1.1 Site requirement :-

- Structural and mechanical stability,
- Fire safety,
- Environment requirements,
- Safety in use,
- Noise levels and protection against noise,
- Energy economy and heat retention,
- Sustainable use of natural resources

1.2 Amount of sunlight reached

Check the actual amount of available sunlight , both direct and scattered, reached at the site and approve it is more than 5 W/m^2. It is easy to determine the number of PV panels needed for the customer.

Operation Sheet 3	Setting parameters work

Perform the analysis using the following parameters and determine the solar PV system installation of the customer

1. Temperature of the PV module;
2. Solar irradiation and power dissipation;
3. The measuring gage is in the shade or soiled;
4. PV module in the shade or soiled; recording period;
5. Efficiency factor of the PV modules;
6. Efficiency factor of the inverter;
7. Differences in solar cell technologies .

LAP Test	Configure the inverter /charge controller

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 Interpret and access the invertor manual

Task-2 Collect customers / site requirement inquiries through appropriate data collection procedures

Task-3 Set parameters for the work as per requirement

List of Reference Materials

BOOKS

1. Mark Hankins Earthscan,2010,1st ed : Stand-Alone Solar Electric Systems
2. DGS e.V. 2009,2nd ed.: Level 2 Technician Training manualInternational Solar Energy Society/German Section
3. Washington State University Extension Energy Program,October 2009: Solar Electric System Design, Operation and Installation
4. Developed by SNV for the Rural Solar Market Development: Solar PV Standardized Training Manual
5. George Eccleston , Solar & 12 Volt Power for beginners: Off grid power for everyone by Kindle Edition
6. Micah Toll, DIY Solar Power: How To Power Everything From The Sun Kindle Edition
7. Lacho Pop, Dimi Avram :The ultimate Solar Power Design, Lachezar Popov and Publishing Ltd

Website : https://www.researchgate.net/figure/Configuration-of-the-Stand-Alone-PV-System_fig3_233953637

Solar PV System Installation and Maintenance

NTQF Level - II

Learning Guide -61

Unit of Competence	**Perform wiring of Solar PV System**
Module Title	**Performing wiring of Solar PV System**
LG Code	**EIS PIM2 M10 LO-8 LG-61**
TTLM Cod	**EIS PIM2 0819v1**

LO 8: Complete work

Instruction Sheet	Complete work.

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

- Observing and following work set-up and completion OHS risk control measures and procedures
- Following routine procedures are to set up and adjust apparatus ready for use.
- Cleaning and making work site safe in accordance with established procedures
- Notifying the completion of the installation work and apparatus and forwarding documentation to appropriate persons in accordance with established routines

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 –**

- Work set-up and completion OHS risk control measures and procedures are observed and followed
- Routine procedures are followed to set up and adjust apparatus ready for use.
- Work site is cleaned and made safe in accordance with established procedures
- Work accomplishment is notified of the completion of the installation work and apparatus documentation is forwarded to appropriate persons in accordance with established routine

Learning Instructions:

8. Read the specific objectives of this Learning Guide.
9. Follow the instructions described in number
10. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
11. Accomplish the "Self-check 1" **in page**
12. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
13. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
14. Submit your accomplished Self-check. This will form part of your training portfolio.

1.1 Concepts

To set up a stable and flexible solar power system, you need solar panels, a charge controller, a battery and a power inverter. The installation of a complete solar home PV system can be done after getting all the components of solar system separately, wiring everything and assemble it. The work set up consists the following steps.

1. **Determine power consumption demands**
   - ✓ **Calculate total Watt-hours per day for each appliance used**
   - ✓ **Calculate total Watt-hours per day needed from the PV modules.**
2. **Size the PV modules**
   - ✓ **Calculate the total Watt-peak rating needed for PV module**
   - **Calculate the number of PV panels for the system**
3. **Inverter sizing**
4. **Battery sizing**
5. **Solar charge controller sizing**

With the stationary component of some office jobs, properly setting up your workstation is important to help reduce your risk of injuring yourself. Musculoskeletal Disorders (MSD) include a range of inflammatory and degenerative conditions known as Repetitive Strain Injuries (RSI) or Cumulative Trauma Disorders (CTD). In an office setting, the risk is primarily associated with fixed and/or awkward postures alone or in combination with repetitive motions.

MSD generally start off mildly and progress to more frequent and intense symptoms. Symptoms include:

- Muscle fatigue
- Aches or pain
- Loss of strength
- Redness or swelling of area
- Numbness or tingling sensations
- Joint stiffness

You may experience symptoms in your low back, neck/shoulders, arms/hands, or head/eyes.

In order to appropriately set yourself up to your workstation, the University of California – Davis has provided a detailed online office workstation setup video (posted below) that you may use to aid in your workstation set up. Or, if you would like, you can scroll a little farther down and see in text our recommended steps.

1.2. STEPS TO AVOID OFFICE MSD

- **DESIGN WORKSPACE FOR YOUR NEEDS**

  - ✓ Place items used most often closest to you and then expand out accordingly
  - ✓ Position workstation items to minimize reaching and stretching
  - ✓ Vary tasks/postures throughout the day

- **ADJUST YOUR WORKSTATION**

During this process it is important to be aware of the items that can't be changed in your office, such as the table height, and set your workstation up accordingly. Start with adjusting your chair and then move onto your workstation.

- **Step One: Chair Set Up**

  Use your chair's features to help position you appropriately.

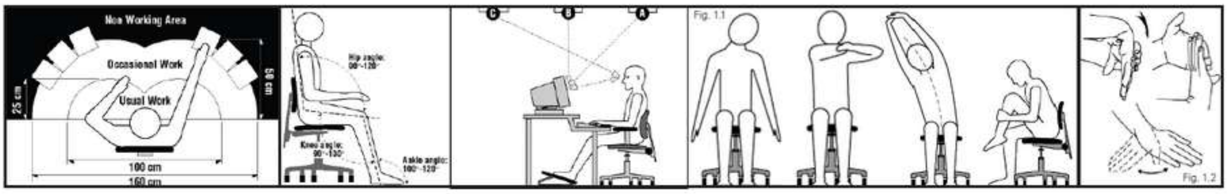
  - **Seat Height:** Your feet should be flat on the ground and thighs parallel to the floor
  - **Seat Depth:** There should be a space between the back of your knees and the seat pan
  - **Seat Angle:** Adjust the seat pan angle to comfort, usually around 90-95 degrees.
  - **Backrest Support:** Place the lumbar support at the small of your back
  - **Backrest Angle:** Adjust the inclination of the backrest angle to comfort, 95-105 degrees is optimal. If you have a 'free float' function in your chair, try it out and use it.
  - **Armrest Height:** Adjust the arm rests to allow your elbows to 'fall' onto the arm rests (i.e., keeping your shoulders down)

- **Step Two: Workstation Set Up**

  - ✓ Step One: Chair Set Up.
  - ✓ Seat Height: Your feet should be flat on the ground and thighs parallel to the floor.
  - ✓ Seat Depth: There should be a space between the back of your knees and the seat pan.
  - ✓ Seat Angle: Adjust the seat pan angle to comfort, usually around 90-95 degrees.

- **STRETCH AT YOUR WORKSTATION**

  One final and important step is to ensure that you stretch periodically (about every hour) to help minimize pain and strain while working. Hold these stretches for 3-5 seconds and repeat 3 times. See the figures below for stretching examples for your neck, shoulders, and back



Tension relief stretches have also been provided by the Canadian Centre for Occupational Health and Safety (CCOHS) and they may also be used.

If you desire further information about office ergonomics, the CCOHS has some valuable information within their Office Ergonomics section that will provide a bit more information than what is provided on this page. You will also find office set up examples and do’s and don’ts that may be of value to you. Just scroll through the desired links on the sidebar.

If you have any questions regarding setting yourself up to your workstation after you have gone through the 3 steps, please feel free to contact EHS for further assistance.

Self-Check -1	Written Test

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

Choose the best answer

1. What are the first step in sizing solar PV installation

B. Battery sizing
C. B. Module sizing
D. C. Inverter sizing
E. D. Demand calculation
F.

2. Tension relief stretches have also been provided by the Canadian Centre for Occupational Health and Safety (CCOHS) and they may also be used.
   A. True
   B. False
3. One final and important step is to ensure that you stretch periodically (about every hour) to help minimize pain and strain while working.
   A. True
   B. False

1.1 Adjust routine procedures

The solar PV home system installation is done correctly using the procedures. Sometimes the need for power may increase. There should be an adjustment on the size of the different components of the PV system. Increasing or decreasing the watts your system can produce and store is accomplished by adding more solar panels and batteries to your PV system. Add more panels to make more power. Add more batteries to store more power.

These routines help you maintain order and also help the kids stay calm. If there is a set activity for every part of the day, you will be able to focus more on your teaching and less on giving instructions and generally controlling the class. This is just one of many reasons routines are important for teachers.

Classroom procedures help students know what to do when the bell rings, when their pencil breaks, when they finish their work early, or when the need to use the restroom. A smooth running classroom is the result of a teacher's ability to effectively teach procedures for just about everything in their classroom.

- **The procedures that will be followed can be stated as follows.**
  - ✓ Calculate the energy demand considering all electrical appliances
  - ✓ Determine the number of solar panels
  - ✓ Calculate the size of battery and charge controller

- ✓ Sizing the inverter
- ✓ Determine the size of cables

1.2 Set-up apparatus

Based on the adjustment required, the apparatus that will be connected to the system should have an appropriate voltage and current for well-functioning. Therefore the battery and charge controller size, the inverter size should fit the size of the panels.

Self-Check -2	Written Test

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

Choose the best answer

1. Which of the following will be changed when we increase the output by three times based on the demand
   A. panel size
   B. battery storage
   C. Inverter size.
   D. All
2. The battery and charge controller size, the inverter size should fit the size of the panels.
   A. True
   B. False

Give short answer

4. What is the reason for increasing the size of the solar panel?

3.1. Cleaning worksite:-

- The following steps before cleaning are important

  - ✓ Turn Off the PV System
  - ✓ Use a Soft Brush Or a Sponge
  - ✓ Avoid Using Water with High Mineral Content
  - ✓ Do Not Use High Pressure
  - ✓ Use Water with a Similar Temperature
  - ✓ Never Use an Abrasive Material to Clean the Solar Panels
  - ✓ Read Your Solar Panel Manufacturer Instructions
  - ✓ Do Not Ever Walk over the Modules

- Using the precautions listed above look at a review of the steps you need to follow:
  - ✓ Get up early in the morning (6-7 am).
  - ✓ Disconnect your PV array from the inverter by pushing the rapid shutdown button or
  - ✓ Pulling down the DC disconnect switch in your combiner box.
  - ✓ Gather some distilled water and mix it with a little dish soap (just a little).
  - ✓ Look for a soft brush and start cleaning your modules with the water mix.
  - ✓ After all modules are soaped, remove the soap with a low-pressure hose.
  - ✓ Leave the modules to dry over 30-45 minutes and turn back on the DC disconnect switch

Figure: Cleaning Standard

Self-Check -3	Written Test

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

Choose the best answer

What are the main factors affecting the sola PV to work appropriately?

A. Solar irradiation
B. B. temperature
C. C. Efficiency of the module
D. D. efficiency of inverter
E. E. All

Give short answer

5. What are the site requirement parameters for a solar home system PV installation ?

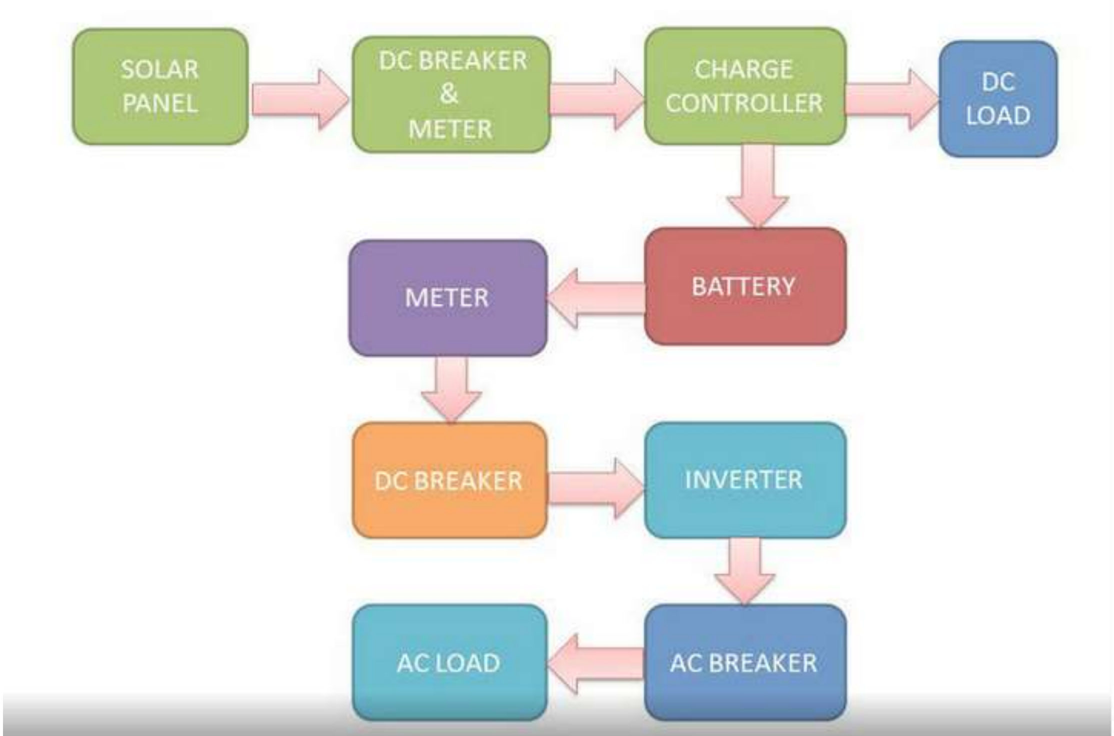
Operation Sheet- 1	Techniques of Following work set-up and completion OHS risk

Perform the inspection of solar PV sytem sizing

Step 1: Collect OHS and design requirements

Step 2: Checkup the work set-up is according to the design

Step3: Ensure OHS requirements are kept



How the solar system fits together

Operation Sheet 2-3	Cleaning work site with established procedures

a. Perform the cleaning of the solar PV using the following :

Step 1. Use solutions mainly designed for roof-mounted systems are the solar panel cleaning products like Poly water.

Step 2. Use specially designed chemicals for module cleaning that allow you to perform the maintenance from a safe distance on the ground or using stairs.

Step 3. Check these products are designed with a specific water pressure that does not harm the surface of the glass.

Step 4. Poly water also uses a hose attachment bottle with the mix of water and soap with the option to rinse (using the mix) or to wash (only using water).

As you can see it is a simple process that, when carried out with a routine schedule, can maximize your solar energy outputs over the year. Never forget maintenance procedure is a two person job and that also involves checking your wires, possible signs of degradations, delamination, damages, or burns behind the solar panels (if possible).

Solar panel manufacturers never recommend to go up to the roof to clean your modules without special protection (harnesses), but with these tips, you can do it yourself while being on the ground or using movable stairs.

Information Sheet-4	Notifying Complete installation Work

4.1. Define notification of Work

- Scope of Work will be checked during completion of the installation of the solar PV
  - ✓ Contractor shall provide all labor, materials, tools, equipment's, transportation; hoisting, rigging, insurance, etc. for all work herein specified and or required to complete the project
  - ✓ All work shall be in accordance with Uniform Building Code,
  - ✓ All work under this contract shall be guaranteed for a fixed period
  - ✓ The contractor shall submit shop drawings for the technical officer review and record drawings for all work provided under this contract for use.
  - ✓ Finally, the technical supervisor approves the installation is done according to the agreement and the design of solar PV system.

- Under the Health and Safety at Work Act 2015 (HSWA) you must notify us when certain work-related events occur. A modifiable event is when any of the following occurs as a result of work: a death a modifiable incident.

- What is a notifiable incident? An incident is notifiable if it arises out of the conduct of a business or undertaking, and results in: the death of a person. the serious injury or serious illness of a person

- Under OHS laws, employers are required to notify Work Safe about fatalities, serious injuries or health and safety incidents that happen in a work place. The duties of workplaces under OHS laws, including what is a notifiable incident, when to notify Work Safe and how to preserve a worksite after an incident.

- Under the new act a notifiable event is when any of the above occurs as result of work. The underlining of the word 'work' is important. A death, injury or illness that is unrelated to work is not a notifiable event, for example a diabetic worker slipping into a coma at work is not a notifiable event.

- An incident in the workplace is an unplanned event that doesn't result in injury, but does cause damage to property, or has enough significant risk to merit recording.

- A simple reporting procedure will help you obtain important information about health and safety issues in the work place identify problems when they arise, and address them. Safety reporting procedures make it simpler for you and your workers to manage safety issues and prevent recurrences of incidents and injuries.

- "serious injury or illness of a person" means an injury or illness requiring the person to have: (a) immediate treatment as an in-patient in a hospital, or (b) immediate treatment for:
    - ✓ the amputation of any part of his or her body
    - ✓ a serious head injury
    - ✓ a serious eye injury
    - ✓ a serious burn
- **serious injury or illness of a person"** means an injury or illness requiring the person to have:
    - ❖ immediate treatment as an in-patient in a hospital, or
    - ❖ immediate treatment for:
    - ✓ the amputation of any part of his or her body, or
    - ✓ a serious head injury, or
    - ✓ a serious eye injury, or
    - ✓ a serious burn, or
    - ✓ the separation of his or her skin from an underlying tissue (such as degloving or scalping), or
    - ✓ a spinal injury, or
    - ✓ the loss of a bodily function, or
    - ✓ serious lacerations, or
    - ❖ medical treatment within 48 hours of exposure to a substance,
    - ✓ and includes any other injury or illness prescribed by the regulations but does not include an illness or injury of a prescribed kind.

4.2. What the most common types are of work related accidents?

But to be forewarned is to be forearmed, so here are ten of the most common accidents and injuries in the workplace;

- Slips, trips and falls
- Muscle strains

- Being hit by falling objects
- Repetitive strain injury
- Crashes and collisions
- Cuts and lacerations
- Inhaling toxic fumes
- Exposure to loud noise

In order to control workplace hazards and eliminate or reduce the risk, you should take the following steps:

- identify the hazard by carrying out a workplace risk assessment;
- determine how employees might be at risk;
- evaluate the risks;
- Record and review hazards at least annually, or earlier if something changes.

Self-Check -4	Written Test

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

Choose the best answer

1. Who notifies the completion of solar PV installation?
   A. The contractor
   B. B. the customer
   C. C. the importer
   D. D. the technical supervisor
   E. E. All
2. A simple reporting procedure will help you obtain important information about health and safety
   A. True
   B. false
3. Under the new act a notifiable event is when any of the above occurs as result of work.
   A. True
   B. false

Give short answer

1. What are the procedures to follow during the completion of work?

Operation Sheet-4	Notifying Complete installation Work

Perform checking the basic principles that were agreed with the contractor's design fits a quality PV system

1. Ensure the roof area or other installation site is capable of handling the desired system size.
2. Specify sunlight and weather resistant materials for all outdoor equipment.
3. Locate the array to minimize shading from foliage, vent pipes, and adjacent structures.
4. Design the system in compliance with all applicable building and electrical codes.
5. Design the system with a minimum of electrical losses due to wiring, fuses, switches, and inverters.
6. Ensure the design meets local utility interconnection requirements.

LAP Test	Complete work

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

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

Task-1 Observe and following work set-up and completion OHS risk control measures and procedures

Task-2 Follow routine procedures are to set up and adjust apparatus ready for use

Task-3 Clean and making work site safe in accordance with established procedures

Task-4 Notify the completion of the installation work and apparatus and forwarding documentation to appropriate persons in accordance with established routines

1. Australian Guidelines for the Prevention and Control of Infection in Healthcare, 2010. NHMRC Commonwealth of Australia. Available online at: http://www.safetyandquality.gov.au/our-work/healthcare-associated-infection/national-infection-control-guidelines/
2. Australian/New Zealand Standard AS/NZS 4146:2000. Laundry practice.
3. Best practices for Environmental Cleaning for Prevention and Control of Infections. 2009. Provincial Infectious Diseases Advisory Committee, Ontario Canada.
4. Cleaning Standards for Victorian health facilities, 2011. Government of Victoria. Available online at: http://www.health.vic.gov.au/cleaningstandards/
5. Environmental Cleaning Policy, 2012. NSW Health. Available online at: http://www1.health.nsw.gov.au/PDS/pages/doc.aspx?dn=PD2012_061
6. Environmental Cleaning Standard Operating Procedures, 2012. NSW Health. Available online at: http://www.cec.health.nsw.gov.au/patient-safety-programs/assurance-governance/healthcare- associated-infections/environment-cleaning
7. Guidelines for Environmental Infection Control in Health-care Facilities, 2003. Centre for Disease Control and Prevention (CDC). Available online at: https://www.cdc.gov/infectioncontrol/guidelines/environmental/index.htm