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BUILDING ELECTRICIAN SOLAR PV SYSTEM TECHNICIAN

Learner Guide

National Vocational Certificate Level 4

Version 1 - January 2020

NAVTTC

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Contents

Introduction

Welcome to your Learner's Guide for the *Solar PV Technician Level 4* Program. It will help you to complete the program and to go on to complete further study or go straight into employment.

The *Solar PV Technician Level 4* program is to engage young people with a program of development that will provide them with the knowledge, skills and understanding to start this career in Pakistan. The program has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding the needs and expectations of their customers.

The main elements of your learner's guide are:

- **Introduction:**
  - This includes a brief description of your guide and guidelines for you to use it effectively
- **Modules:**
  - The modules form the sections in your learner's guide
- **Learning Units:**
  - Learning Units are the main sections within each module
- **Learning outcomes**:
  - Learning outcomes of each learning units are taken from the curriculum document
- **Learning Elements:**
  - This is the main content of your learner's guide with detail of the knowledge and skills (practical activities, projects, assignments, practices etc.) you will require to achieve learning outcomes stated in the curriculum
  - This section will include examples, photographs and illustrations relating to each learning outcome
- **Summary of modules**:
  - This contains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  - These have been added to provide further explanation and clarity on some of the difficult concepts and areas. This further helps you in preparing for your assessment.
- **Multiple choice questions for self-test**:
  - These are provided as an exercise at the end of your learner's guide to help you in preparing for your assessment.

Overview of the program

Course: *Solar PV Technician Level 4*	**Total Course Duration:** 700 Hours
Course Overview:	

Solar energy has been making headlines across the world for the last few years. The global installed capacity of solar photovoltaic (PV), also termed solar cells, has grown from 5GW to more than 400GW. This phenomenal success owes to wide ranging factors; most importantly, conducive policies, technological advancements and economy of scale. Solar PV system is now becoming financially competitive with conventional forms of power generation. Dubai, for example, is currently developing an 800MW through solar PV project with a power purchase agreement signed at less than three US cents per kW hour.

Solar radiation, or level of sunshine, is the resource or fuel for solar energy systems. Accurate measurement and analysis of this resource are fundamental to achieve the anticipated performance. However, there are other important parameters that also need to be taken into account to predict and evaluate a system's performance and this is often where mistakes are made.

The solar industry of Pakistan has nearly doubled in size every year for the past five years, and this trend is expected to continue in future, so there are opportunities for how to become a Solar PV Technician.

Solar PV System Technician determines the design of the array and performs the installations. The process to become a Solar PV System Technician mostly depends on where an individual want to install residential solar systems. Internationally becoming a solar energy professional sometimes requires a license specific to solar PV instalment. Pakistan regulates its own solar installation and safety processes, it might be different from other world rules and regulations, hence required no license but a certificate in this qualification can provide ample of employment opportunities.

The qualification of Building Electrician – Solar PV System Technician is developed based on solar energy sector's demand on the pattern of competency based training under national vocational qualification framework (NVQF). It carries a learning volume of 1000 hours i.e. 6 hours per day and five days a week means 33.4 weeks which is almost 8 months and four months is recommended as internship.

Solar PV System Technician plays a vital role in the installation and maintenance of Solar PV System and Electrical appliances. The increased use of solar energy has maximized the demand of Solar PV Technician having the skills to install and maintain solar photovoltaic systems, thus, meeting the ever-growing demand of industry. This course has been design and developed to achieve its objectives of providing appropriate skills. The pass out of this course would be able to:

- Work in small & big construction units as Solar PV Technician.
- Work as building electrician in an electrical outfit / company / organization.
- Work as building electrician with construction contractor.
- Be self employed by having own electrical / wiring workshop.

Module Title and Aim	Learning Units	Theory hours	Workplace hours	Timeframe of Modules
Module 1: **Conduct site assessment for Solar PV system installation**	LU-1: Carryout load assessment. LU-2: Perform shadow analysis. LU-3: Estimate wiring requirements. LU-4: Identify the south direction for mounting structure.	18	32	**50**
Module 2: **Develop basic Solar PV system design**	LU-1: Calculate load for solar PV system design. LU-2: Assess working schedule of load. LU-3: Select Panels. LU-4: Determine backup time. LU-5: Draw basic design of solar PV System.	20	70	**90**
Module 3: **Interpret job document**	LU-1: Prepare checklist for job. LU-2: Interpret schematic diagram. LU-3: Record the data. LU-4: Prepare log sheet for general maintenance.	18	32	**50**
Module 4: **Install Solar PV System**	LU-1: Arrange required tools and equipment. LU-2: Perform PV test. LU-3: Erect the mounting structure. LU-4: Fix PV modules as per circuit design. LU-5: Install Battery Bank. LU-6: Install inverter/charge controller / variable frequency drive (VFD). LU-7: Install Solar PV Pumps. LU-8: Connect the PV modules as per circuit design.	28	72	**100**
Module 5: **Perform Solar PV System Wiring**	LU-1: Interpret wiring diagram. LU-2: Connect the PV modules as per circuit diagram. LU-3: Lay Cables. LU-4: Perform wiring test. LU-5: Carry out battery test. LU-6: Interconnect the PV system. LU-7: Configure the inverter / charge controller	20	60	**80**
Module 6: **Troubleshoot Solar PV System**	LU-1: Diagnose the fault. LU-2: Identify solution of the faults. LU-3: Rectify the faults.	16	54	**70**

	LU-4: Carryout post rectification function test. LU-5: Perform wiring tests.			
Module 7: **Maintain Solar PV system**	LU-1: Prepare check list for maintenance. LU-2: Follow routine maintenance log sheet. LU-3: Maintain Solar PV modules. LU-4: Maintain inverter/Charge. controller/Protection circuits. LU-5: Maintain battery bank. LU-6: Perform post verification function of the system.	13	87	**100**
Module 8: **Adopt Safety Precautions**	LU-1: Ensure Personal safety. LU-2: Ensure workplace safety. LU-3: Ensure safety of tools and equipment.	06	54	**60**
Module 9: **Develop basic Entrepreneurial skills**	LU-1: Develop basic computer operating skills. LU-2: Develop basic communication skills. LU-3: Develop basic marketing skills. LU-4: Identify needs of the market. LU-5: Follow Environmental, Health and Safety standards.	22	78	**100**
	TOTAL	**161**	**539**	**700**

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Module-1

Module - 1: Conduct Site Assessment for Solar PV System Installation

Objective: This module covers the skills and knowledge required to Carry out load assessment, perform shadow analysis, estimate wiring requirements and Identify the south direction for mounting structure.

Duration:	**50 hours**	**Theory:**	**18 hours**	**Practical:**	**32 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Carryout load assessment	**Trainee will be able to:** • Determine nature of load • Identify rating of load • Measure running load • Calculate the load	• Types of Load. • Specification of various Loads. • Types of measuring instruments. • Working principle of measuring instruments. • Measuring techniques and parameters of various loads.	**50Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Perform shadow analysis	**Trainee will be able to:** • Conduct physical visit of the site • Identify path of the shadow • Use shadow detector • Enquire about future developmental prospects	• Interpret site maps. • Use of different path identification tools. • Techniques for site maps preparation.			**Class room** **Theory** **Lab** **Practical**
LU-3: Estimate wiring requirements	**Trainee will be able to:** • Observe existing condition of wiring (If needed) • Workout length of the wire • Select appropriate size of the wire • Select appropriate type of the wire • Figure out required safety and control devices.	• Types of wiring. • Interpretation of wiring diagrams. • Wiring specifications (Size and types of cable). • Types of Safety and control devices. • Functions of different safety and control devices. • Optimization techniques for wiring essential.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-4: Identify the south direction for mounting structure	**Trainee will be able to:** • Observe the location • Point out south direction by using compass	• Use of Compass and GPS. • Direction description Methods			**Class room** **Theory** **Lab** **Practical**

Carryout Load Assessment

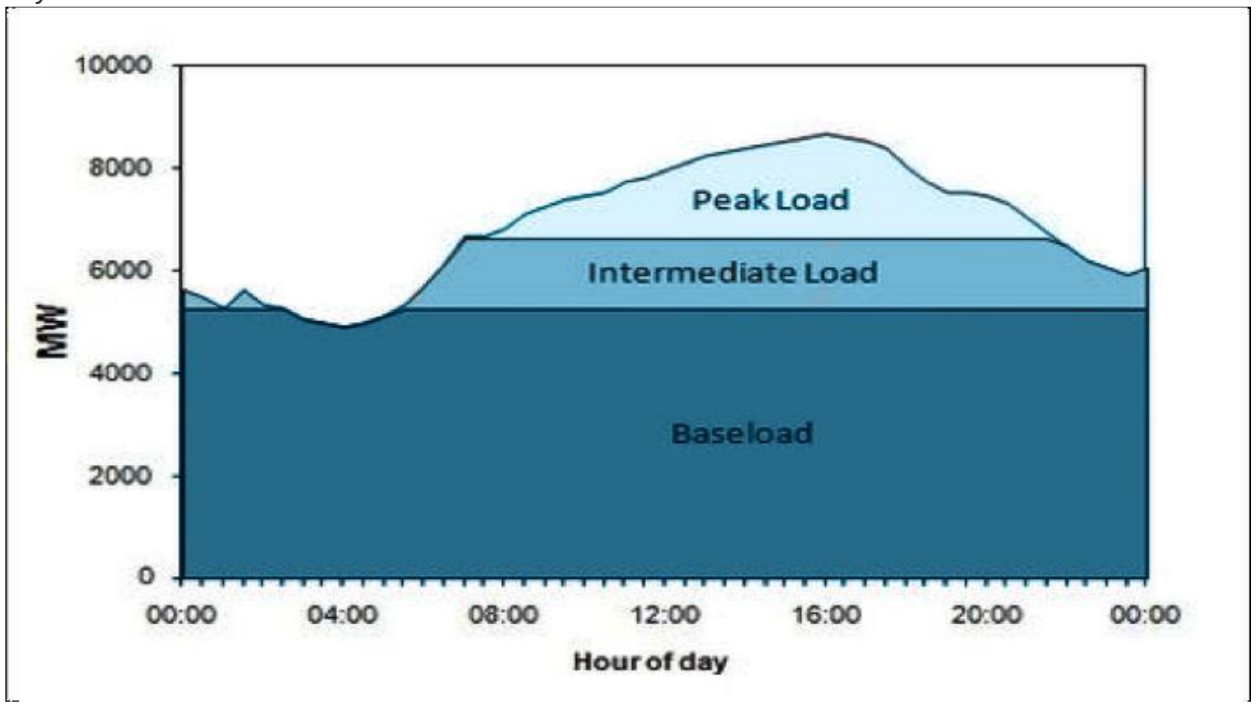
Load in electrical engineering, is the amount of current being drawn by all the components (appliances, motors, machines, etc.). Load is further categorized as base load and peak load depending upon the nature of the electrical components connected. All electrical appliances do not run at all times, e.g.:

- A toaster or microwave oven may be used for a few minutes,
- A television or computer may be used for a few hours
- Lighting in the house is only required during the evening and so on.

There are several appliances which keep running at all the times, no matter what. The refrigerator, for example, has to be plugged in at all the times. Another such example is the heating, ventilation and cooling systems in the house (**HVAC system**).

Peak Load

The term peak load power is defined by the electricity exchange as power, between 8 am and 8 pm. Wind and solar power does not congest the lines. The increasing production of solar power during the course of the day follows the rising demand for power. Photovoltaic systems provide electricity precisely when it is needed.



Peak Load and Base Load defined Base load is the minimum level of electricity demand required over a period of 24 hours. It is needed to provide power to components that keep running at all times (also referred as continuous load).

Peak load is the time of high demand. These peaking demands are often for only shorter durations. In mathematical terms, peak demand could be understood as the difference between the base demand and the highest demand. Now going back to the examples of household loads like microwave oven, toaster and television are examples of peak demand, whereas refrigerator and HVAC systems are examples of base demand.

Load Factor

The load factor percentage is derived by dividing the total kilowatt- Hours (kWh) consumed in a designated period by the product of the maximum demand in kilowatts (kW) and the number of hours in the period. In the example below, the monthly kWh consumption is 36,000 and the peak demand is 100 kW. There were 30 days in the billing period. To determine the load factor, you can use the following formula is used:

***Example*:**

This load factor indicates the monthly energy consumption of 36,000 kWh used by the customer was 50% of the total energy available (72,000 kWh) for use at the 80 kW level.

To determine the load factor, you can use the following formula:

Total kWh for the billing period x 100

(Peak Demand x # of Days x 24 Hours)

$$\frac{36{,}000 \text{ kWh} \times 100}{57{,}600 \text{ kWh}}$$

= 0.625 x 100

= 62.5% load factor

Another Example:

Total kWh = 18,000 kWh

Demand = 50 kW

The number of Days = 30

Energy consumption detail

Hours per Day = 24

$$\frac{18{,}000 \text{ kWh} \times 100}{(50 \text{ kW} \times 30 \text{ Days} \times 24 \text{ Hours})}$$

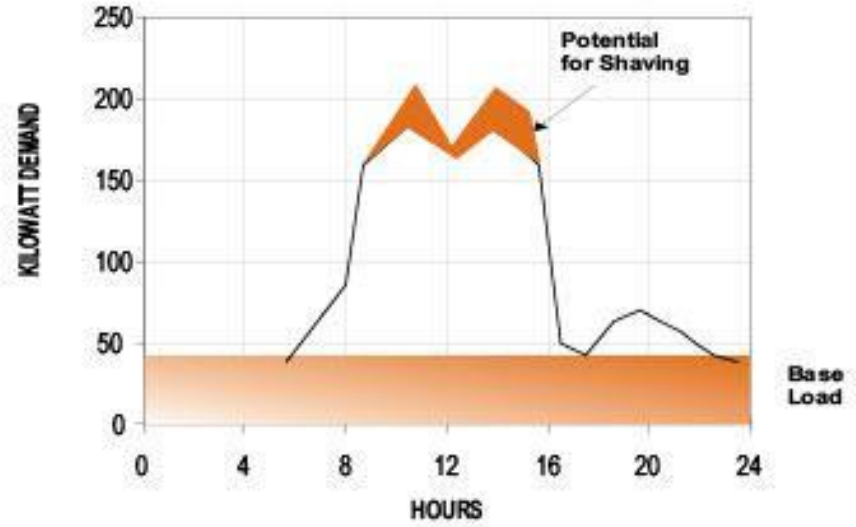
18,000 kWh x 100

36,000 kWh

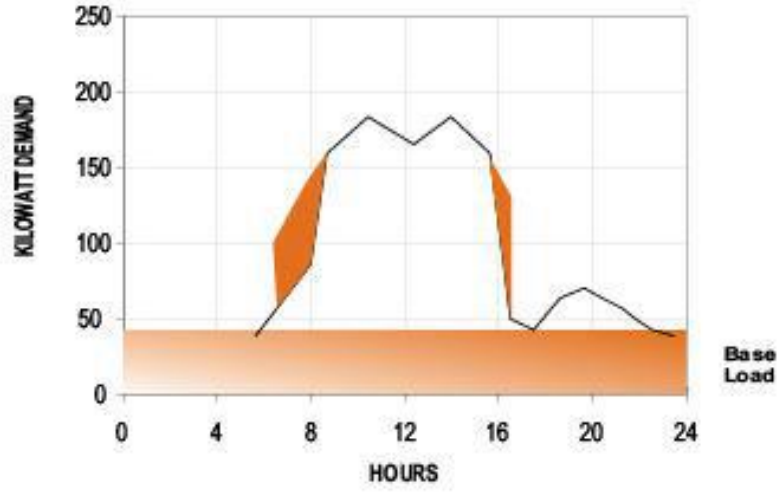
= 0.50 x 100= 50%

In this example, the Load Factor is 50% showing that, on average, the peak demand was fully used for 12 hours a day for 30 days. One of the simplest ways of improving load factor is to shave the peaks. Shaving means having a portion of the electrical load operating at peak times of the day shifted to non-peak times. For example, instead of operating ten machines at 11:00 a.m., it would be advantageous to have three operating at 9:00 a.m., five at 10:00 a.m. and two at 11:30 p.m. All machines are still operating but not at the same time.

The diagram below indicated in red, where savings would be possible;



The diagram below shows, the daily load profile **after** the peaks have been shaved. The dark shaded peak area above has been shaved and relocated in the illustration below.



Daily Power Consumption

Energy consumption refers to the amount of energy consumed by an individual or organization, or to the process or system of such consumption**.** Nearly every modern convenience increases the amount of energy consumed.

Or

The amount of energy consumed depends on the activity or object. Home illumination is one of the most common forms of energy consumption. To illuminate a room, a light bulb must be powered by electricity, any use of which contributes to energy consumption. Computers and mobile phones also contribute to daily energy consumption. The very production of a computer causes energy to be consumed by factories, workers, distribution systems and the stores that sell the end product.

A daily cup of coffee is a product of energy consumption. Every part of the process to create coffee consumes energy. The beans used for the coffee must be picked, transported, cleaned and roasted before arriving at a store to be sold. The machinery used to grind and brew the coffee also uses electricity. Air conditioners use large amounts of electricity to cool an area, and cars use fuel. Even a bed costs energy to create. Its materials are refined, and then assembled, and at each step along the way, energy is consumed.

Perform Shadow Analysis

Shading Analysis

Shadow analysis is one of the most essential steps in phase of solar energy system design or analysis. In photovoltaics it is important to analyse Shadow caused by surrounding objects and/or vegetation. In special cases like analysis or design of BIPV systems, exact analysis of shadow-voltaic systems (overhangs, vertical Shadow fins, awnings etc.) is also very important. Similar analysis is also part of passive house or solar house design - overhangs must also be planned very carefully in such case. Basic calculations can be done by some simple equations - formulas for some typical simple cases you may find below. Some graphical tools like solar path calculator (pilkington) are also available. For analysis of complex objects several computer tools are available. Some of them offer even 3D simulation. Shadow is especially important in photovoltaics. It should be eliminated as much as possible. Even small obstacles like chimneys, telephone poles etc. shouldn't be neglected. To minimise influence of photovoltaic array Shadow (if shadow can not be avoided) different system optimisation techniques can be used.

Shadow devices, general

For different simple cases it is in general not difficult to calculate shadows for particular day and time. Below you will find some formulae's end equations which may help you to calculate shadows for most common particular cases in engineering practice.

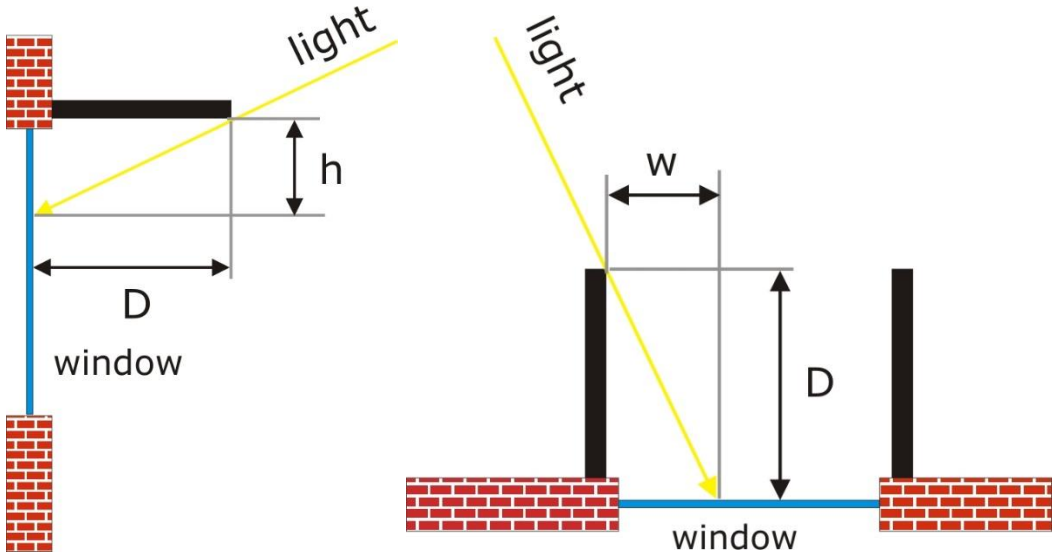


Figure: Horizontal shading device, overhang, side view (left) vertical shading device, vertical fin, top view (right)

[Equ 1] shading geometry

$$h = \frac{D \cdot \tan \alpha}{\cos(\Phi - \Psi)}$$

h, D - geometry of horizontal shading device (see Figure 1, left)

α - sun height, Φ - solar azimuth, Ψ - plane azimuth

[Equ 2] shading geometry

$$w = D \cdot \tan(\Phi - \Psi)$$

w, D - geometry of vertical shading device (see Figure 1, right)

Φ - solar azimuth, Ψ - plane azimuth

[Equ 3] shading geometry

$$\gamma = \arctan\left(\frac{\tan \alpha}{\cos(\Phi - \Psi)}\right)$$

γ = vertical shadow angle (VSA)

w, D - geometry of vertical shading device

Φ - solar azimuth, Ψ - plane azimuth

Optimization of Strings

Shadow losses of photovoltaic systems can not be avoided (if shadow occurs), but at least portion of them can be minimised. Right time to consider this issue is the system plannings phase, later it is usually too late. Shadow of strings - if crystalline modules are mounted on the roof like on the picture below, they should be always mounted horizontaly (like on the picture) and never vertically. Reason is quite simple: each crystalline module usually includes two bypass diodes which are active if shadow occur. When modules are mounted horizontally the module still operates with some amount of power (50 0% or less) if the bottom row is shaded, because only one bypass diod is active. But if modules are mounted vertically and if lower row is shaded partially or completel both bypass diodes are active and amount of output power is close to zero. Strings on the roof, modules oriented horizontaly, souce SSES Preffered orientation of modules in strings on the roof (courtesy SSES). String configuration - modules that are shaded more often than other parts of array should be connected into separate string(s) if possible. This will prevent losses of the whole system because of partial shadow of only one part of array.

Inverter configuration

Inverter configuration - some inverter offer several inputs, for each string its own input - in case of shadow of one string, other inputs will still operate in MPP.

Amorphous modules

Amorphous modules - in cases where shadow can not be avoided use of amorphous modules should be considered. Amorphous modules are far less sensitive on partial shadow (in comparison with crystalline modules) so that even in case of partial shadow they produce significant amount of power.

Array shape

Array shape - In some cases, like example of the church roof on the picture - you can also prevent shadow losse with carefully array design. Array on the picture has shape of trapezoid, because of shadow of church's bell tower.

Optimised array shape, courtesy Pfleiderer Dach Optimised array shape, courtes Pfleiderer Dach Optimisedn array shape, courtesy Pfleiderer Dach

Church's roof covered with photovoltaic roof tiles, optimised array shape

Tools for Shadow Analysis

Solar Pathfinder - The Solar Pathfinder has been the standard in the solar industry for solar site analysis for decades. Its panoramic reflection of the site instantly provides a full year of accurate solar/shade data, making it the instrument of choice.

Estimate Wiring Requirements

Cable Thickness

We generally have electrical appliances working at 220V which is significantly higher compared with the usual PV system DC voltages of 12V, 24V or 48V. For the same wattage much higher currents are involved in the PV systems. This brings into picture resistance losses in the wiring. Let us see how it can be significant. 20 meter is the length of cable between the panel and the charge controller. A typical cable with 1.5 sq mm cross section has resistance of about 0.012 Ohms per meter of wire length. So a 20-meter-long wire will offer resistance of 20 x 0.012 = 0.24 Ohms. If it is a 24V system and a 10 ampere current is flowing through this wire, then from the Ohm's law (V = I x R), we can calculate voltage drop across this wire: 2.4V. It means the voltage at the charge controller end of the cables will be 2.4V less than the voltage produced by the panels if a 10 Amp current is flowing. This 10% voltage drop is clearly unacceptable. What if we use a 6 sq. mm cross section cable which has a resistance of 0.003 Ohms per meter The total resistance for 20-meter-long cable will now be 0.06 Ohms; and the voltage drop, 10×0.06 or 0.6V. It is 2.5% voltage drop for a 24V system which might be acceptable. But what about the increased cost of thicker cable? Likewise, there would be wiring all around and careful attention must be paid to know the impact on overall system efficiency. Thus, cable length and size needs careful attention right at the planning stage. Another way to reduce resistance loss is to raise the system voltage, to say 48V. It will still give the same watt as above (48V x 5A = 240W). Doubling the system voltage reduces the voltage drop by 1/4th.

Wires & Cables

The main difference between AC voltage and low voltage DC photovoltaic system installation is different voltage range at PV systems and much higher currents. The system's careful design should consider proper wire sizing allowing for efficient operation. The most important parameter is the wire section. Inappropriate wire sizing could result in excessive heating and even fire due to large current. Properly connected and sized wiring won't require any maintenance for years. Exterior modules and other PV components connection wires and cables should be used with UV radiation resistible insulation. Standard wire and cable insulation cracks under years of exposure to atmospheric conditions and UV radiation. The temperature range is also important. Exterior cables should allow for temperature range from -45°C to up to +80°C or even more. Application of such cables will enable efficient system operation for the next two decades or longer. Standard, usually stranded wires and cables are used for interior connections. A simple rule to follow in small systems is 1-2mm wire area/1 A current. Its application will prevent wire from

overheating and curb loss within required limits. Some general recommendations that should be followed are:

- The maximum allowed loss between battery and charge regulator is up to 1 %.
- Maximum allowed loses between solar modules and charge regulators are up to 3 %.
- Maximum allowed loses between charge regulator and loads are up to 7 %.

Select and Size Wires

Once the brand and model of modules to be used are selected, then array is sized and configured including the selection of an inverter model, and smaller electrical devices (i.e. combiner or junction box, disconnects, etc.), size wire, over current devices (fuses and breakers), and conduit for the circuit is then finalized. For residential solar electric systems, copper wires are used. Aluminum wire is less expensive but breaks easily and corrodes. It's also less efficient in conducting electricity.

Identify The South Direction for Mounting Structure

Tilt Angle

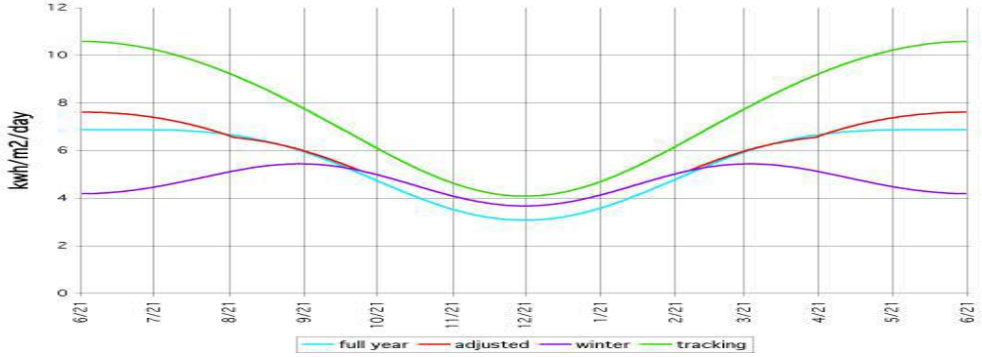
To capture the maximum amount of solar radiation over the course of a year, a solar array should be tilted at an angle approximately equal to a site's latitude, and facing 15 degrees of due south. To optimize winter performance, the solar array can be tilted 15 degrees more than the latitude angle, and to optimize summer performance, 15 degrees less than the latitude angle. At any given instant, an array will output maximum available power when pointed directly at the sun. To compare the energy output of your array to its optimum value, you will need to know the site's latitude, and actual tilt angle of your array- which may be the slope of your roof if your array is flush-mounted. If your solar array tilt is within 15% of the latitude angle, you can expect a reduction of 5% or less in your system's annual energy production. If your solar array tilt is greater than 15 degrees off the latitude angle, the reduction in your system's annual energy production may fall by as much as 15% from its peak available value. During the winter months at higher latitude, the reduction will be greater.

Example of Various Tilt angle

It is simplest to mount your solar panels at a fixed tilt and just leave them there. But because the sun is higher in the summer and lower in the winter, you can capture more energy during the whole year by adjusting the tilt of the panels according to the season. The following table shows the effect of adjusting the angle, using a system at 40° latitude as an example. (The comparison would be a little different for different latitudes.) Each option is compared with the energy received by the best possible tracker that always keeps the panel pointed directly at the sun.

% optimization	Fixed	Adjust 2 seasons	Adjust 4 seasons	2 Axis Tracker
	71.1%	75.2%	75.7%	100%

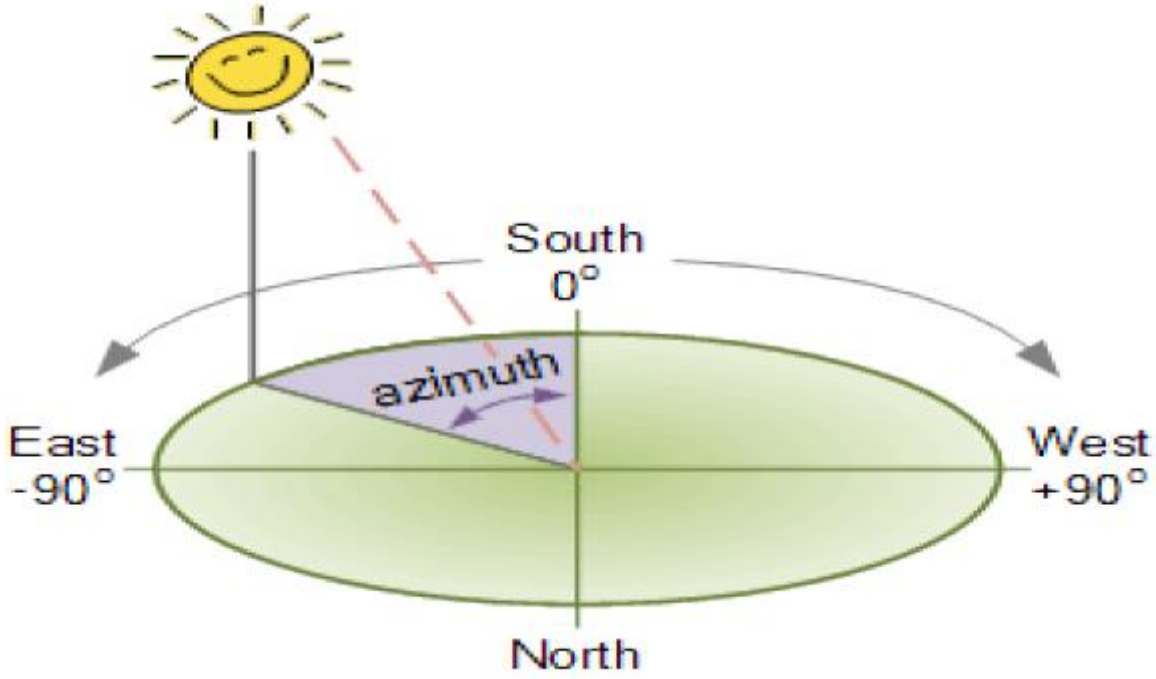
In short, adjusting the tilt twice a year gives you a meaningful boost in energy. Adjusting four times a year produces only a little more, but could be important if optimized production in spring and fall is needed. The graph below shows the effect of adjusting the tilt. The turquoise line shows the amount of solar energy obtained each day if the panel is fixed at the full year angle. The red line shows how much solar energy would be obtained by adjusting the tilt four times a year as described below. For comparison, the green line shows the energy generated from two-axis tracking, which always points the panel directly at the sun. (The violet line is the solar energy per day if the panel is fixed at the winter angle, discussed below.) These figures are calculated for 40° latitudes.



If the solar panels have a fixed tilt angle, and maximum amount of energy is obtained over the whole year. A fixed angle is convenient but note that there are some disadvantages; Less power is obtained if the angle is adjusted. Also, if you live where there is snow, adjusting the panels to a steeper angle in winter makes it more likely that they will shed snow. A panel covered in snow produces little or no power.

Azimuth Angle and Magnetic Declination

If a south-facing roof is unavailable, an east or west-facing surface is the next best option. (Solar Edge and Micro Inverter Solar Power Grid tied systems allows for your solar panels to be facing more than one direction, while centralized grid-tied inverter systems allows for only one orientation.) Solar power output decreases proportionally with a horizontal angle or "azimuth," greater than 15 degrees from due south. The decrease in annual power output from a latitude-tilted east or west facing array may be as much as 15% or more in the lower latitudes or as much as 25% or more in the higher latitudes. Avoid directing tilted solar panels northwest, north or northeast, as it will get little power output. Magnetic declination, the angle difference between magnetic south and true solar south, must also be taken into account when determining proper solar array orientation. If a magnetic compass alone is used to determine where to point the array, you may not capture the maximum declination field lines.



KNOWLEDGE ASSESSMENT TEST

Conduct site assessment for solar PV system

Module:1 Time Allowed: 45 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple-choice questions.

1) The following is indirect method of Solar energy utilization?

a. Wind energy
b. Biomass energy
c. Wave energy
d. None of above

2) What is a load?

a. It is resistance of a circuit
b. It is capacitance of a circuit
c. It is impedance of a circuit
d. None of above

3) The value of Solar Constant is

a. 1347 W/m^2
b. 1357 W/m^2
c. 1367 W/m^2
d. 1500 W/m^2

4) Theoretical efficiency of monocrystalline PV cell is

a. 1%
b. 20%

c. 50%
d. 100%

5) lux meter is use to check the

a. Power
b. Resistance
c. Luminous intensity
d. Current

Instructions to Candidates: You must write short answers to all questions.

Q1. How solar energy is converted into electrical energy?

Answer:

Q2. What is electrical current?

Answer:

Q3. What is meant by electrical voltage?

Answer:

Q4: What are the different type of loads?

Answer:

Q5. What should be the direction of solar PV panels?

Answer:

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Module-2

Module – 2: Develop basic Solar PV system design

Objective: This module covers the skills and knowledge required to calculate load, select panels, determine backup time, assess working schedule of load and workout of capacity of devices.

Duration:	**90 hours**	**Theory:**	**20 hours**	**Practical:**	**70 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Calculate load for solar PV system design	**Trainee will be able to:** • Enlist the No. of appliances • Measure the PV system load • Calculate the PV system load • Record the PV system load.	• Types of appliances and their respective load. • Sizing and compatibility of inverter. • Load Calculation.	**90Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Assess working schedule of load	**Trainee will be able to:** • Inquire the load duty hours from customer • Determine the peak load hours • Observe peak sun hours.	• Base load hours. • Peak sun hours. • Peak load hours. • Irradiance intensity estimation. • Using instruments and/or empirical formula.			**Class room** **Theory** **Lab** **Practical**
LU-3: Select Panels	**Trainee will be able to:** • Select the type of PV panel • Determine the capacity of PV solar panel • Select number of PV solar panel	• Types of PV Module. • Specification of PV Module. • Size of PV Module • Capacity of PV Module.			**Class room** **Theory** **Lab** **Practical**
LU-4: Determine backup time	**Trainee will be able to:** • Estimate the required backup time of load • Estimate the capacity of battery bank • Select the types of batteries for backup	• Battery duty hours/back up hours. • Types of batteries and Specification. • Battery Sizing. • Inter-connection Techniques of Cells and Batteries			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-5: Draw basic design of solar PV System	**Trainee will be able to:** • Workout capacities of devices • Sketch a diagram as per requirements • Get the design approve by the client	Understanding of basic design components of Solar PV system. • Workout capacities of devices. • Understanding of the single line diagram. • Sizing and compatibility of the inverter.			**Class room** **Theory** **Lab** **Practical**

Learning Unit: 1

Calculate Load for Solar PV System Design

Load Analysis

A fundamental part of energy management, and the first step in improving a health facility energy system, is an electrical load inventory. An electrical load inventory is a listing of all electricity consuming equipment in a facility, everything from light bulbs to expensive lab equipment to cell phone chargers. These electrical loads drive energy consumption and costs, but also facilitate the critical health services that take place in such facilities; understanding the best way to support, protect and expand those services start with an analysis of those loads.

A basic electric load assessment involves creating a table showing power ratings, or loads (in Watts), of all electrical devices in the facility along with an estimate of the number of hours each device will operate on a daily basis. This results in an estimate of facility consumption, the number of Watt-hours used by the facility per day, and the total facility electrical load, the sum of all inventoried loads. These two basic metrics, load and consumption, form the basis for the design of energy supply and distribution systems, like PV panels, battery banks, inverters, generators, electrical circuits and UPS systems. They are also used to track increases or reductions in energy usage, a key energy management activity.

When properly executed, a load analysis can yield valuable insights into facilitating energy usage that can be used to save on energy costs, increase productivity and protect critical assets.

Load Analysis				
S No.	Name	Quantity(No.)	Load(W)	Total Load(W)
1	LED lights	10	12	120
2	Fans	3	80	240
3	Fridge	1	250	250
4	Washing machine	1	800	800
5	LED TV	1	200	200
6	Computer	1	350	350
7	AC	2	2000	4000
	Grand Total			5960

Assess working schedule of load

There are no standards governing load schedules and therefore this calculation is based on generally accepted industry practice. The following methodology assumes that the load schedule is being created for the first time and is also biased towards industrial plants. The basic steps for creating a load schedule are:

- Step 1: Collect a list of the expected electrical loads in the facility
- Step 2: For each load, collect the electrical parameters, e.g. nominal / absorbed ratings, power factor, efficiency, etc
- Step 3: Classify each of the loads in terms of switchboard location, load duty and load criticality
- Step 4: For each load, calculate the expected consumed load
- Step 5: For each switchboard and the overall system, calculate operating, peak and design load

Example Load Analysis

Item	Qty.	×	Watts	×	Hrs. / Day	×	Days / Wk.	÷ 7 =	Avg. Daily Wh
Refrigerator	1		507		3.0		7		1,521
Fans	2		100		7.5		5		1,071
Computers	2		80		8.0		5		914
Lights	8		25		6.0		5		857
Wireless router	1		15		24.0		7		360
Printer	1		200		2.0		5		286
Clothes washer	1		320		1.0		2		91
Total									5,101

Learning Unit: 3

Select Panels

PV Cell Types

Cells can be manufactured from different type of materials. There are main two types of PV cells which are commercially available:

1. Crystalline silicon wafers
   - Mono crystalline PV cell
   - Multi/Poly crystalline PV cell
2. Thin film

Monocrystalline PV Cell

Mono crystalline or Single-crystal silicon is grown from highly pure molten silicon. The single crystal cylindrical ingot is cut into thin slices (200---300 μm). The edges are cut off to give a hexagonal shape in order to make optimum use of available module surface most efficient type of cell with 14-18% efficiency.

Polycrystalline PV cell

Polysilicon is a hyper pure form of silicon and is the earth's second most abundant element. Due to its semiconductor-like material properties, **polysilicon** is used as feedstock material in most solar energy applications. Polysilicon is an initial building block for the process of manufacturing silicon based Solar PV. Multi crystalline or polycrystalline silicon is heated to high temperature and cooled under controlled conditions in a mold (casting process). As the molten silicon sets, an irregular poly-or multi-crystal is formed. This is visible in the shimmering fish-scale like appearance of the wafers. The square silicon block is then cut into thin slice (300μm) and the blue color is due to the application of an anti-reflection layer cells (efficiency 10-15%).

Polycrystalline solar panels are less efficient than those made from a single crystal. However, they are much simpler to produce and cost far less to manufacture. Which in turn is passed onto consumers, meaning they are also much cheaper to buy at market The durability and longevity are however indifferent, and unaffected by difference in crystal formation. Polycrystalline could put solar panels into the hands of consumers that cannot afford the Mono crystalline alternatives.

Thin Film

There are three primary types of thin film solar cells: amorphous silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium selenide (CIS/CIGS). They are deposited as gas on a glass, layer aluminum or plastic surface. Layer of (thin film) semiconductor material is only 0.5-2.0μm thick and less semiconductor raw material is used in thin film silicon. Less sensitive to the effects of shade and high temperatures and suitable for location with large share of diffuse irradiation (e.g. in areas with high air pollution) thin film production cost today similar to silicon wafers. Thin film efficiency is lower than silicon wafers (6-8%).

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (Wp) produced depends on size of the PV module and climate of site location. We have to consider panel generation factor which is different in each site location. To determine the sizing of PV modules, calculate as follows:

Calculate the total Watt-peak rating needed for PV modules

Divide the total Watt-hours per day needed from the PV modules by panel generation factor to get the total Watt-peak rating needed for the PV panels needed to operate the appliances.

Calculate the number of PV panels for the system

Divide the answer obtained in item 2.1 by the rated output Watt-peak of the PV modules available to you. Increase any fractional part of result to the next highest full number and that will be the number of PV modules required.

Result of the calculation is the minimum number of PV panels. If more PV modules are installed, the system will perform better and battery life will be improved. If fewer PV modules are used, the system may not work at all during cloudy periods and battery life will be shortened.

For Example:

The total load in watts are 1000 watt. 1.3 should be multiplied with the total load because of the losses in solar PV, that is

Total watts required= 1000x1.3= 1300watts

Let's select the panel watts= 325

Total number of panels required= 1300/325= 4

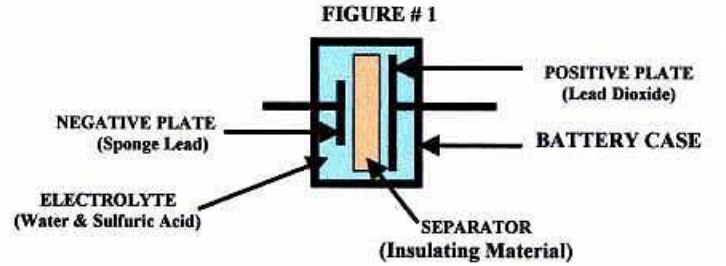
So the required panels will be 4.

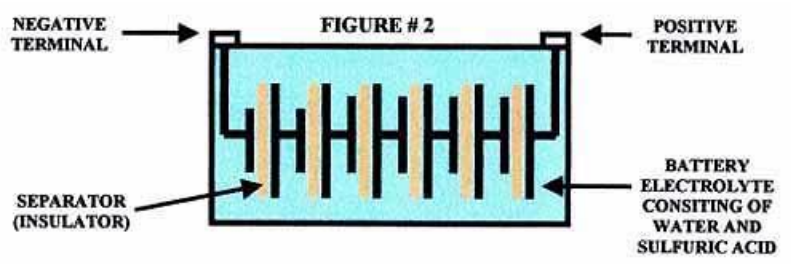
Determine Backup Time

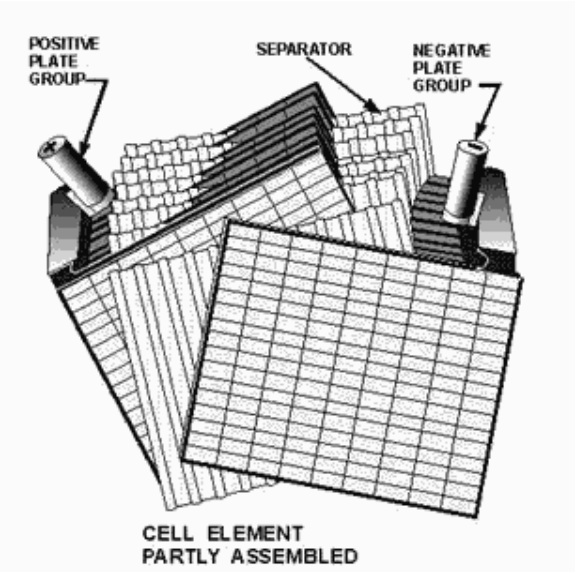
Battery is a source of electrical power that is used to store electrical power. This power can be recovered from the battery when we need it. A **charge controller** is an essential part of nearly all power systems which control the battery charging system, whether the power source is PV, wind, hydro, fuel, or utility grid. **Light** plays very important role in our daily life. **Inverter** is a circuit which converts DC voltage into AC voltage. **UPS** stands for Uninterrupted Power Supply. It is the type of electronic device that protects other electrical or electronic equipment from power uncertainties.

Battery Construction

Lead acid batteries used in the RV and marine industries usually consist of two 6-volt batteries in series, or a single 12-volt battery. These batteries are constructed of several single cells connected in series. Each cell produces approximately 2.1 volts. A six-volt battery has three single cells, which when fully charged produce an output voltage of 6.3 volts. A twelve-volt battery has six single cells in series producing a fully charged output voltage of 12.6 volt.







In figure 1, pair of positive and negative plates that are separated by a separator are shown while in figure 2, complete cell is shown consisting of six pairs of positive and negative plates. These pairs are connected in series to form a complete cell.

Type of Lead-Acid Batteries

Automotive or Starting Batteries:

Automotive (also called Starting) batteries are shallow discharge lead acid batteries used mainly to start automotive engines. Because of their thin plates, they are damaged even when moderately discharged on a regular basis. Only 20 per cent of their capacity is removed per cycle. Therefore, they are not suitable energy storage for PV systems.

Improved Automotive Batteries:

With capacities between 70 and 200 amp-hours, these batteries have thicker plates, larger acid wells and, often, a handle for carrying. Improved automotive lead-antimony batteries are often used in small solar home systems. Although not the best choice for solar home systems, they are certainly better than standard automotive batteries.

Traction Lead-Acid Batteries:

These types of batteries, developed for use in fork-lifts or golf-carts, are good for off-grid PV systems as they can tolerate deep discharges much better than automotive batteries and hence have a good cycle life. They have much thicker lead plates with a higher lead density than automotive batteries (which have „spongy" lead). They are available in 2V, 6V or 12V sizes. However, because of their antimony content, they require frequent refilling from loss of electrolyte due to gassing.

Stand-by Batteries:

These batteries are used to power vital equipment (such as telephone exchanges) in the event of grid or generator failure. They have thick pure lead plates (without antimony addition) and are very heavy. They are not ordinarily designed for deep discharge and they are usually kept in a high state of charge because they are constantly on float charge. They do not have as long a cycle life as traction batteries.

Maintenance-free Batteries (Lead Calcium):

These batteries are enclosed (but not completely sealed) and are sometimes sold for PV applications. Originally designed for automotive applications, their advantage is that they do not require electrolyte refill because of calcium added to their plates. However, the spongy calcium plates do not tolerate deep discharge well and can be damaged if left in a partial state of charge. Unless the system has enough power to maintain a very high state of charge, lead-calcium batteries are to be avoided.

Valve-regulated Lead-Acid Batteries (VRLA):

If a battery is called „maintenance-free" and is sealed (with no openings for adding acid) it is probably a valve-regulated battery. This means that, ordinarily, when gas is given off during charging, it is recombined into the battery as electrolyte (water). If the battery is overcharged, there is a safety valve that vents electrolyte and prevents dangerous build-up of gas pressure inside the battery. Note that VRLA batteries usually require special settings on charge controllers. VRLA batteries are much more expensive than ordinary lead-acid batteries and, because many use calcium in their plates to reduce gassing, they may be less tolerant of deep discharge.

Gel Batteries (Captive Electrolyte):

Gel batteries use sulphuric acid that has been turned into a gel form. Sealed at the factory, they do not leak or spill, so they are easily transported and require no maintenance. Some types can withstand deep discharges and have a good cycle life. They have low self-discharge rates. Note that many gel cell batteries are not made for deep discharging – always check the label/datasheet/manual. Captive electrolyte batteries have poor performance characteristics at high temperatures, so they should not be used in hot sites. Also, they should not be charged at high voltages or be heavily overcharged as this will cause a loss of electrolyte and may cause damage (or in the worst case, an explosion).

AGM (Absorbed Glass Mat) Lead-Acid Batteries:

With AGM batteries, liquid sulphuric acid electrolyte is absorbed into glass fiber mats so they do not leak, even if cracked. Many AGM batteries are designed for stand-by "float" applications, not deep discharging. AGM are often a good choice of batteries for off-grid solar PV systems, but,

like gel batteries, they are also quite expensive. Some types are able to recombine gases, so they can tolerate overcharging and do not require special charge controller settings. Furthermore, they are extremely rugged and can withstand vibrations. AGM batteries tend to have a shorter cycle life than gel cell batteries, especially when deep discharged regularly.

Tubular Plate Batteries (OPzS – wet or OPzV – gel cells):

Tubular plate batteries, also called OPzS (liquid electrolyte) or OPzV (gel) batteries, are made especially for off-grid and solar electric applications and have excellent deep discharge characteristics. The positive plates in tubular cells are made of rods protected in a 'tubular" sleeve – not a flat plate – which gives them an exceptionally long cycle life. They often come in transparent cases that allow easy viewing of the electrolyte level and are sold in 2–6 volt sizes. They are among the most expensive batteries for off-grid installations and are ordinarily used for large installations. Tubular cells are susceptible to stratification and sulphation.

Discharge Rate

Discharge rate in conjunction with the battery capacity is a fundamental parameter in the design of a battery bank for a PV system, as the energy which can be extracted from the battery is found by multiplying the battery capacity by the depth of discharge. Batteries are rated either as deep-cycle or shallow-cycle batteries. A deep-cycle battery will have depth of discharge greater than 50%, and may go as high as 80%. To achieve the same useable capacity, a shallow-cycle battery bank must have a larger capacity than a deep cycle battery bank.

In addition to the depth of discharge and rated battery capacity, the instantaneous or available battery capacity is strongly affected by the discharge rate of the battery and the operating temperature of the battery. Battery capacity falls by about 1% per degree below about 20°C. However, high temperatures are not ideal for batteries either as these accelerate aging, self-discharge and electrolyte usage.

Finding out battery backup time:

To find out the battery timing we have to multiply battery ampere hour with its voltage into the number of batteries into depth of discharge divided by the total load in it.

For example:

Backup Time = Battery AH x Battery V x N x DoD / Load in Watts
Battery AH= battery in Ampere hour

Battery V= battery voltage

N=number of batteries

DoD= depth of discharge (means how much a battery can be discharged before damaging the battery)

Draw Basic Design of Solar PV System

For designing a solar PV system, we should know how to select inverter, panels, wires and batteries according to desired load which has been previously discussed. To design we should strictly follow the ratings mentioned on the inverter. After noting the ratings on the inverter we should connect the solar PV modules accordingly.

PV Connection Series and Parallel

Parallel circuits have multiple paths for the current to move along. If an item in the circuit is broken, current will continue to move along the other paths, while ignoring the broken one. This type of circuit is used for most household electrical wiring. For example: when you turn off your TV, it doesn't also turn off your lights.

When wiring solar panels in parallel, the amperage (current) is additive, but the voltage remains the same. e.g. If you had 4 solar panels in parallel and each was rated at 5 volts and 5 amps, the entire array would be 5 volts and 20 amps.

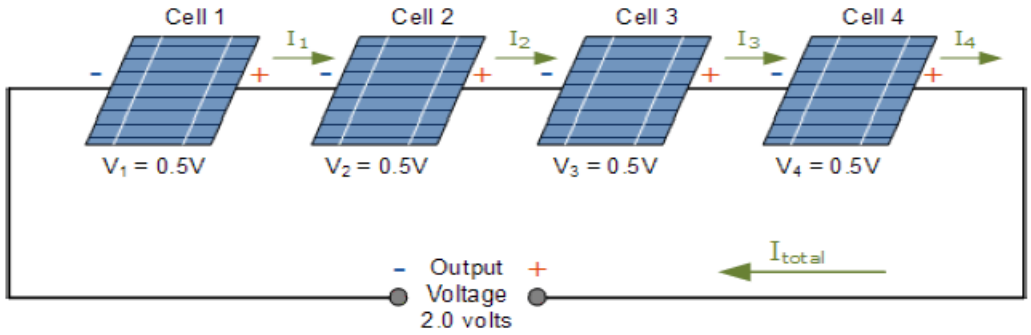
Series circuits have only one path for current to travel along. Therefore, all the current in the circuit must flow through all the loads. A series circuit is a continuous, closed loop - breaking the circuit at any point stops the entire series from operating. An example of a series circuit is a string of old wedding lights - if one bulb breaks, the whole string turns off.

When wiring solar panels in a series, the voltage is additive, but the amperage remains the same. e.g. If you had 4 solar panels in a series and each was rated at 5 volts and 5 amps, the entire array would be 20 volts and 5 amps.

Remember: just like batteries, solar panels have a negative terminal (-) and a positive terminal (+). Current flows from the negative terminal through a load (current consumed by a piece of equipment) to the positive terminal.

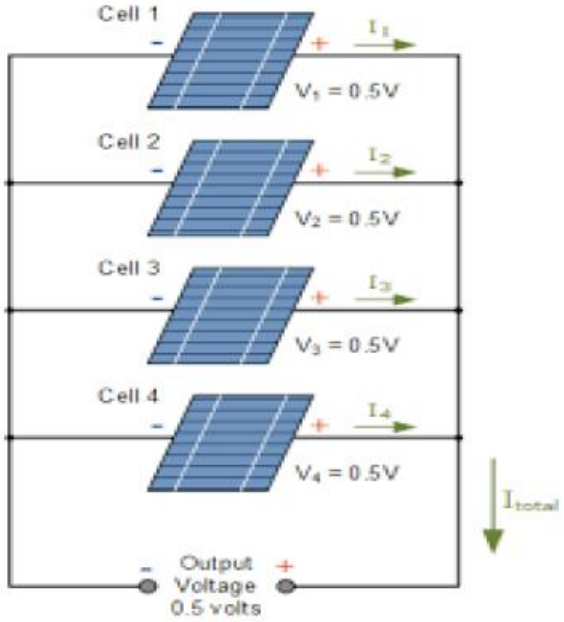
Wiring Solar Panels in a Series Circuit

Connect the positive terminal of the first solar panel to the negative terminal of the next one. e.g. If you had 4 solar panels in a series and each was rated at 5 volts and 5 amps, the entire array would be 20 volts at 5 amps.



Wiring Solar Panels in a Parallel Circuit

Connect all the positive terminals of all the solar panels together, and all the negative terminals of all the panels together. e.g. If you had 4 solar panels in parallel and each was rated at 12 volts and 5 amps, the entire array would be 5 volts at 20 amps.



NOWLEDGE ASSESSMENT TEST

Module:2 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) Load is

a. Only Resistive
b. Only Capacitive
c. Only Inductive
d. None of above

2) What percentage loses are in solar panels?

a. 20%
b. 30%
c. 50%
d. None of above

3) DOD stands for

a. Depth of demand
b. Depth of Discharge
c. Demand of Discharge
d. Demand

4) Theoretical efficiency of monocrystalline PV cell is

a. 1%
b. 20%
c. 50%
d. 100%

5) Volt meter is use to check the

a. Power
b. Resistance
c. Voltage
d. Current

Instructions to Candidates: You must write short answers to all questions.

Q1. How are Peak sun hours calculated?

Answer:

Q2. What are different types of solar PV module?

Answer:

Q3. How to calculate battery backup?

Answer:

Q4: Draw the basic design of 2 solar PV modules connection with PV system.

Answer:

Q5. Which Batteries are best for Solar PV system?

Answer:

BUILDING ELECTRICIAN SOLAR PV SYSTEM TECHNICIAN

Learner Guide

National Vocational Certificate Level 4

Version 1 - January 2020

Module-3

Module - 3: Interpret job document

Objective: This module covers the skills and knowledge required to prepare checklist for the job, interpret schematic diagram, record the data and prepare log sheet for general maintenance.

Duration:	**50 hours**	**Theory:**	**18 hours**	**Practical:**	**32 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Prepare checklist for job	**Trainee will be able to:** • Prepare list of material required • Prepare list of tools required • Prepare list of equipment required	• Identification and understanding of the required materials, tools and equipment.	**50Hrs**		**Class room Theory Lab Practical**
LU-2: Interpret schematic diagram	**Trainee will be able to:** • Read schematic diagram of wiring • Read schematic diagram of civil work • Read schematic diagram of mechanical work	• Understanding of schematic diagram for solar PV system • Understanding maps civil and mechanical work.			**Class room Theory Lab Practical**
LU-3: Record the data	**Trainee will be able to:** • Collect the data • Enlist the data • Prepare report	• Techniques for preparing bill of quantities (BOQ). • Reporting formats.			**Class room Theory Lab Practical**
LU-4: Prepare log sheet for general maintenance	**Trainee will be able to:** • Prepare schedule of routine maintenance • Identify the activities for conducting routine maintenance • Prepare list of tools for routine maintenance	• Scheduling techniques. • Understanding of routine maintenance. • Types of maintenance (Corrective maintenance and Preventive maintenance). • Tools and techniques for maintenance.			**Class room Theory Lab Practical**

Learning Unit: 1

Prepare checklist for job

A checklist is a type of job aid used to reduce failure by compensating for potential limits of human memory and attention. It helps to ensure consistency and completeness in carrying out a task. A basic example is the "to do list". A more advanced checklist would be a schedule, which lays out tasks to be done according to time of day or other factors. A primary task in checklist is documentation of the task and auditing against the documentation.

Step 1: Do a “brain dump”

Step 2: Organize and prioritize tasks

Step 3: Put them on your to-do list

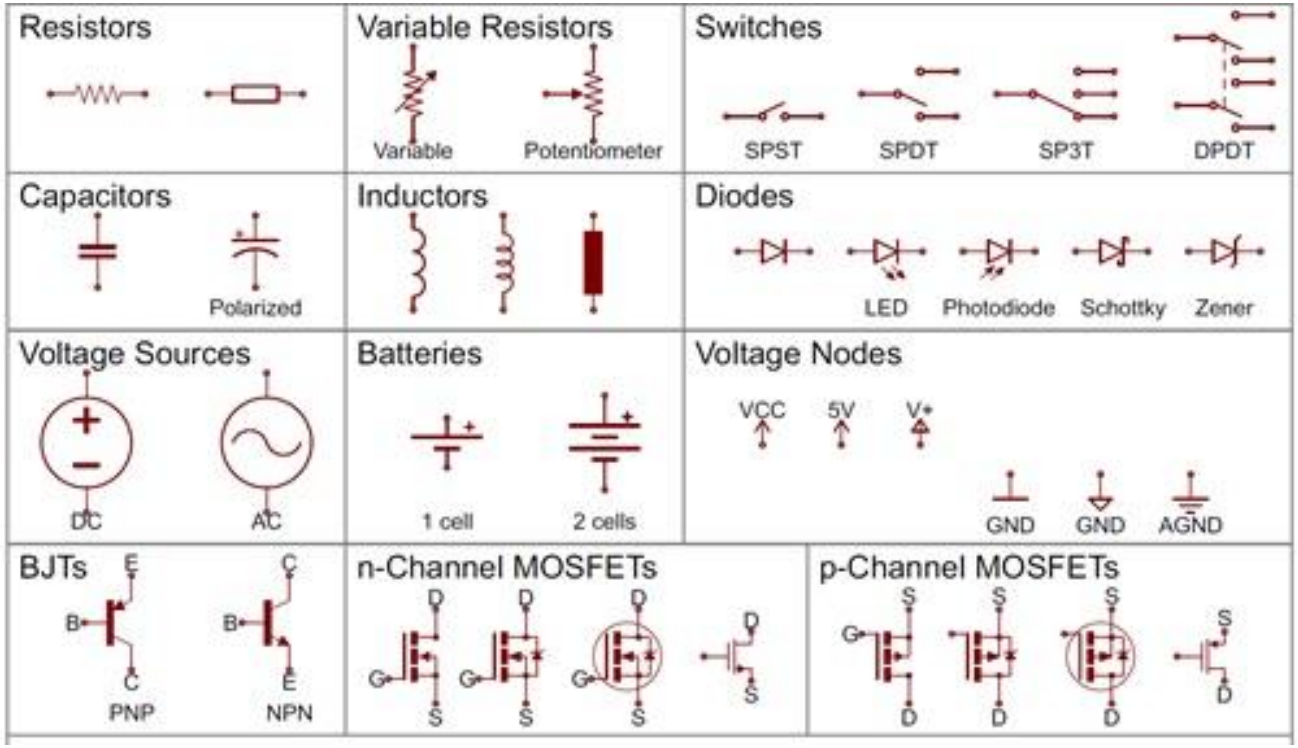
Step 4: Check off each item as you complete it

Step 5: Continue adding items as they come up

Interpret schematic diagram

Schematics are our map to designing, building, and troubleshooting circuits. Understanding how to read and follow schematics is an important skill for any electrical or electronics job.

This tutorial should turn you into a fully literate schematic reader. We'll go over all of the fundamental schematic symbols:



Learning Unit: 3

Record The Data

Something that is important is called data. To record information, we have to follow certain steps in order to retrieve it when needed:

- Collect the data
- Enlist the data
- Prepare report

Collect the data:

It is the process of gathering and measuring information on targeted variables in an established system, which then enables one to answer relevant questions and evaluations. Data collection is a component of research in all fields of study including physical and social sciences, humanities and business. While methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same. The goal for all data collection is to capture quality evidence that allows analysis to lead to the formulation of convincing and credible answers to the questions that have been posed.

Enlist the data

The data which was previously collected, needs to be written in such a form which can be accessed when desired. This is very important in the process of recording the data.

Preparing Report

After data collection and enlisting it, then comes the process of making a report. In academia there is some overlap between reports and essays, and the two words are sometimes used interchangeably, but reports are more likely to be needed for business, scientific and technical subjects, and in the workplace.

The structure of a report is very important to lead the reader through your thinking to a course of action and/or decision. It's worth taking a bit of time to plan it out beforehand.

Step 1: Know your brief Step 2: Keep your brief in mind at all times

The Structure of a Report

Like the precise content, requirements for structure vary, so do check what's set out in any guidance.

However, as a rough guide, you should plan to include at the very least an executive summary, introduction, the main body of your report, and a section containing your conclusions and any recommendations.

1. Executive Summary
2. Introduction
3. Report Main Body
4. Conclusions and Recommendations

KNOWLEDGE ASSESSMENT TEST

Module:3 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) Before going how to know which tool is missing?

a. Checklist
b. Toolbox
c. Ask a colleague
d. None of above

2) In a schematic diagram, there are

a. Symbols
b. Generic diagram
c. Real picture of a component
d. None of above

3) How can the data be recorded?

a. Collect data
b. Enlist data
c. Report data
d. All of the above

4) Routine checkup is a form of

a. Corrective maintenance
b. Preventive maintenance
c. Both a and b
d. None of above

5) What is the symbol for wire.

a. Looped line

b. Dotted line
c. Dashed line
d. Continuous line

Instructions to Candidates: You must write short answers to all questions.

Q1. How to make a simple checklist?

Answer:

Q2. Draw a diagram of 2 bulbs and fan controlled by 3 switches and a dimmer.

Answer:

Q3. Make a list of items used in solar PV system?

Answer:

Q4: what are the general maintenance of solar panels?

Answer:

Q5. Make a list of general maintenance of Solar PV system?

Answer:

BUILDING ELECTRICIAN SOLAR PV SYSTEM TECHNICIAN

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Module-4

Module – 4: Install Solar PV System

Objective: This module covers the skills and knowledge required to arrange required tools and equipment, perform PV test, erect the mounting structure, fix PV modules and connect the PV modules as per circuit diagram.

Duration:	**100 hours**	**Theory:**	**28 hours**	**Practical:**	**72 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Arrange required tools and equipment	**Trainee will be able to:** • Collect the required tools and equipment • Check physical status of tools and equipment • Perform transportation of tools and equipment • Manage safe storing of tools and equipment	• Identification and use of the required tools and equipment. • Inspection techniques of tools and equipment. • Calibration techniques of tools and equipment. • Safety requirements for storing tools, equipment and materials. • Safety tools, equipment (PPE) and techniques at the site. • Transportation safety requirements.	**100Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Perform PV test	**Trainee will be able to:** • Conduct short circuit current test • Conduct open circuit voltage test	• Identification and use of testing equipment. • Testing parameters and conditions. • Procedure for Short-circuit current test. • Procedure for Open-circuit voltage test.			**Class room** **Theory** **Lab** **Practical**
LU-3: Erect the mounting structure	**Trainee will be able to:** • Assemble the structure parts • Fix mounting structure • Adjust angles of the mounting structure	• Types of mounting structures. • Fixing techniques. • Types of angles. • Adjustment techniques/ orientation of the mounting structure.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-4: Fix PV modules as per circuit design	**Trainee will be able to:** • Install PV module on the mounting structure • Verify angle of the PV module with the help of angle finder/ meter • Ensure shadow overlapping.	• Installation techniques of PV module on the mounting structure. • Verification of the angle of PV module. • Measuring techniques to avoid Shadow. • Use of Angle-finder.			**Class room** **Theory** **Lab** **Practical**
LU-5: Install Battery Bank	**Trainee will be able to:** • Arrange batteries with accessories as per requirements • Fix battery bank in the racks • Make parallel series strings for batteries, as per circuit design	• Understanding of batteries and required accessories. • Installation techniques of batteries as per required circuit diagram. • Battery fixing and safety techniques.	**100 Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-6: Install inverter / charge controller / variable frequency drive (VFD)	**Trainee will be able to:** • Arrange inverter and charge controller in variable frequency drive (VFD) • Fix inverter and charge controller in variable frequency drive (VFD) • Ensure fixation as per circuit design	• Types of inverter and charge controller. • Specification of inverter and charge controller. • Installation of inverter and charge controller. • Setting parameters of inverter and charge controller.			**Class room** **Theory** **Lab** **Practical**
LU-7: Install Solar PV Pumps	**Trainee will be able to:** • Arrange Solar pumps as per desired capacity • Fix Solar pumps • Ensure fixation of Solar pumps as per circuit design	• Types of solar pumps. • Specification of solar pumps. • Selection criteria of solar pumps and accessories. • Installation techniques of solar water pump. • Testing techniques of solar water pump.			**Class room** **Theory** **Lab** **Practical**
LU-8: Connect the PV modules as per circuit design	**Trainee will be able to:** • Make strings as per circuit design • Make arrays as per circuit diagrams	• Preparation of strings and arrays as per circuit diagram. • Standard operating procedure for PV Module inter-connection.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
	• Connect arrays with junction boxes				

Arrange Required Tools and Equipment

Tools are the most important thing while considering the installation of system. Tools required for Solar PV installation are:

Tool Belt

This belt has a roller style buckle with 2 clips. It is padded around the waist which makes this very comfortable to wear. The suspenders are great way to remove some of the weight off your back and onto your shoulders.

Pliers

This is the most versatile tool to use. It is a must for twisting wires together for tight connections. They can also be used to tighten Red B-Caps and pull.

Diagonal Side Cutting Pliers

We primarily use these to cut my wires to specific lengths when I am terminating on devices.

Needle Nose Pliers

We use these for multiple tasks. They are great for reaching dropped screws or to hold a screw for drilling.

Strippers

These are the most comfortable strippers we have ever used. They form to your hand well and the spring is not too tight allowing for easy usage. These also have the 10-32 and 6-32 hole slots so you can cut them down and not damage the thread.

Screwdriver

This is a must have for any electrician. This tool has so many features rolled into one. It has both screwdrivers and nut drivers built in. This

is super convenient because it reduces the amount of tools you need to carry on your tool belt. NEVER use this in a live electrical panel. Sometimes the detachable pieces become loose and fall. This could cause a short or arch between the live buss and the panel enclosure. If it must be used in a live panel, always use fully insulated screw drivers.

Screwdriver Set

This set comes with everything one needs e.g. flat head screwdrivers, Phillips #2, and a trim screwdriver.

SOG Kilowatt Folding Knife.

This is a great addition to everyone tool set. It comes with 3 separate wire stripping accessories.

Electrician Level.

This particular level is used as it utilizes the rare earth magnets. It is useful when installing EMT conduit and installing electrical cabinets. Rare Earth Magnet Tape Measure. This is an essential tap measure for solar technician because it has an inbuilt compass for detecting direction.

Voltage Detector

This is used to quickly determine if a circuit is on or off.

Magnetic Nut Driver Set

This is used when we need to install breakers in an electrical panel. The magnetic tip is helpful because it helps us to pick the dropped screws and nuts.

Clamp Meter

This comes with testing leads. It also has a nice magnet on the back that allows you to place it on a metal cabinet. It allows for larger wire amp

readings.

LED Head Lamp

There are going to be times in service when you are working in dark spaces. Head lamps are a great way to keep ones hands free and they provide the light in the exact place you are looking.

Safety Goggles

These are an important part of being safe on the job. Full shielded safety goggles protect from dust, or when you are cutting conduit or hammer drilling and setting concrete anchors.

Cut Resistant Gloves

These gloves help protect you by removing the hazard of cuts. They are great to use when cutting conduit with a saw-zaw or when using a band saw. Also they are great to use when pulling wire.

Learning Unit: 2

Perform PV Test

Solar Installation Tester

Such type is the only all-in-one PV tester that can complete simple, fast and comprehensive PV testing in less than one minute. Test open circuit voltage, short circuit current and insulation resistance simultaneously and store the results internally, at the touch of a button.

Irradiance Meter

The solar survey series of irradiance meters are the perfect tools for solar photovoltaic and solar thermal installers to conduct comprehensive solar site surveys. With a solar reference cell to measure true irradiance, the solar survey provides greater accuracy of measurement data compared to meters which use a photo diode detector.

Solmetric

The solmetric PV analyzer is complete electrical test solution for verifying photovoltaic array performance. For each string, the analyzer measures current and power as a function of voltage. Measured results are compare to the performance predicted by advanced built- in models.

Thermal Cameras & Imaging

Originally developed in building construction and industrial thermal analysis, thermal cameras are nowadays very useful tool for detailed thermal inspections of solar arrays. With periodical inspections array problems (module hot spots) can be detected in advance so that large malfunctions and yield (money) loss can be prevented right on time.

Clamp Meter

In electrical and electronic engineering, a current clamp or current probe is an electrical device having two jaws which open to allow clamping around an electrical conductor. This allows properties of the electric current in the conductor to be measured, without having to make physical contact with it, or to disconnect it for insertion through the probe. Current clamps are usually used to read the magnitude of a sinusoidal current (as invariably used in alternating current (AC) power distribution systems), but in conjunction with more advanced instrumentation the phase and waveform are available. Very high alternating currents (1000 A and more) are easily read with an appropriate meter; direct currents, and very low AC currents (milli-amperes) are more difficult to measure.


400A
40A
Hz
Ω
V
CLAMP
MULTIMETER OFF
SELECT
REL Δ
HOLD
000.0
UNI-T
UT204
TRUE RMS
CAT III 300V
CAT II 600V
COM
CE

Learning Unit: 3

Erect the Mounting Structure

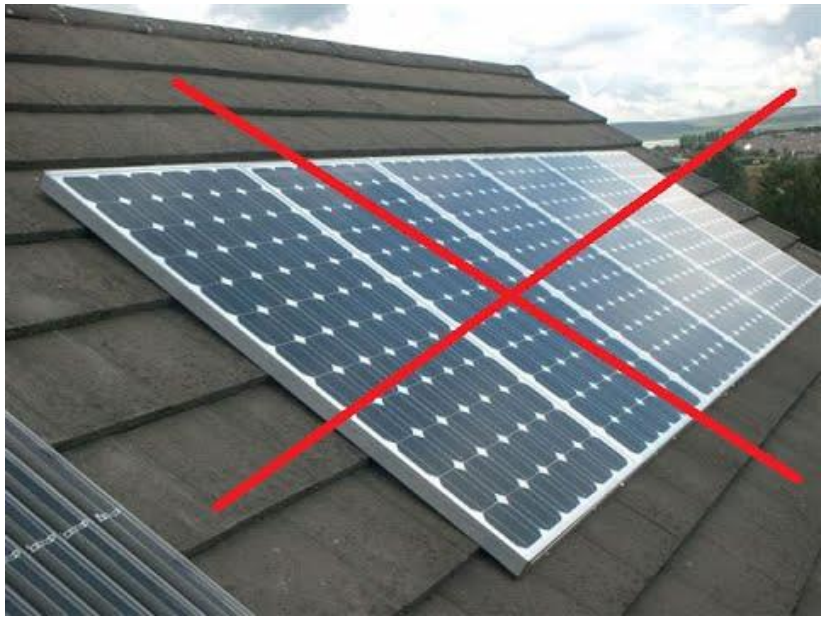
There are several ways to install a PV array at a residence. Most PV systems produce 5-to-10 Watts per square foot of array area. This is based on a variety of different technologies and the varying efficiency of different PV products. A typical 2 KW PV system will need 200-400 square feet of unobstructed area to site the system. Consideration should also be given for access to the system. This access space can add up to 20% of needed area to the mounting area required.

Roof mount

Often the most convenient and appropriate place to put the PV array is on the roof of the building. The PV array may be mounted above and parallel to the roof surface with a standoff of several inches for cooling purposes. Sometimes, such as with flat roofs, a separate structure with a more optimal tilt angle is mounted on the roof.

Proper roof mounting can be labor intensive. Particular attention must be paid to the roof structure and the weather sealing of roof penetrations. It is typical to have one support bracket for every 100 Watts of PV modules. For new construction, support brackets are usually mounted after the roof decking is applied and before the roofing materials is installed. The crew in charge of laying out the array mounting system normally installs the brackets. The roofing contractor can then flash around the brackets as they install the roof. A simple installation detail and a sample of the support bracket is often all that is needed for a roofing contractor to estimate the flashing cost.

Masonry roofs are often structurally designed near the limit of their weight bearing capacity. In this case, the roof structure must either be enhanced to handle the additional weight of the PV system or the masonry roof transitioned to composition shingles in the area where the PV array is to be mounted. By transitioning to a lighter roofing product, there is no need to reinforce the roof structure since the combined weight of composite shingles and PV array is usually less than the displaced masonry product.



Roof Mounted Solar Panel Installations on Houses:

- The solar PV array must not protrude more than 200mm above the roof line;
- The solar PV array must not be higher than the highest part of the roof excluding chimneys;
- The solar PV array must not face onto or be visible from the highway if located within a conservation area;
- As far as practicable the array should be sited to minimize the effect on the external appearance of the building.

Ground Mounted Installations:

The installation of small ground mounted solar PV systems comes under 'permitted development' when:

- The solar PV array must be no more than 4m high;
- The solar PV array must be installed more than 5m from the property boundary;
- The size of the solar PV array must not exceed $9m^2$ (4-5 large solar panels);
- The solar PV array must not face onto or be visible from the road if located within a short distance.

Solar PV Canopies & Solar PV Carport Installations:

Carport and canopies should be open on at least two sides;

- The carport or canopy should not extend further than the front of the house;
- The carport or canopy should have a coverage of under 30m;
- The carport or canopy should be under 4m high (highest point);
- The carport or canopy should be no wider than half the width of the original house;
- The carport or canopy should only be used for residential purposes i.e. not used for conducting business;
- The carport or canopy should not take up more than 50% of the available outside space.

Commercial Roof Space Solar Panel Installations:

- Pitched roofs: The solar PV array must not protrude more than 200mm above the roof line;
- Flat Roofs: The highest part of the solar PV array must be less than 1m higher than the highest part of the roof (excluding any chimney);
- The PV array must be sited more than 1m away from the external edges of the roof;
- As far as practicable the PV array should be sited to minimize the effect on the external appearance of the building.

Ground Mounted Installations on Commercial, Agricultural or Industrial Land:

The installation of commercial ground mounted solar PV systems only comes under 'permitted development' when:

- The solar PV array is no more than 4m high;
- The solar PV array is installed more than 5m from the property boundary;
- The size of the solar PV array does not exceed $9m^2$ (4-5 large panels);
- The solar PV array does not face onto or be visible from the road if located near road.

Shade Structure:

An alternative to roof mounting is to mount the system as a shade structure. A shade structure may be a patio cover or deck shade trellis where the PV array becomes the shade. These shade systems can support small to large PV systems.

The construction cost with a PV system is a little different than for a standard patio cover, especially if the PV array acts as part of the entire shade roof. If the PV array is mounted at a steeper angle than a typical shade structure, additional structural enhancements may be necessary to handle the additional wind loads. The weight of the PV array is 2-to-4 kg/ft^2, which is well within structural limits of most shade support structures. The avoided cost of installing roof brackets and the associated labor could be counted toward the cost of a fully constructed patio cover.

The overall cost of this option will likely be higher than roof mounting, but the value of the shade often offsets the additional costs. Other issues to consider include;

- Simplified array access for maintenance;
- Module wiring, if visible from underneath, must be carefully concealed to keep the installation aesthetically pleasing;
- Cannot grow vegetation, or must be diligent about keeping it trimmed back from modules and wiring.

Building-Integrated PV Array (BIPV):

Another type of system displaces some of the conventional roofing product with building integrated PV modules. Commercially available products currently include roof slates and standing seam metal roofing products. Special attention must be paid to ensure that these products are installed properly and carry the necessary fire ratings. Dimensional tolerances are critical and installation requirements must be followed precisely to avoid roof leaks.

Learning Unit: 4

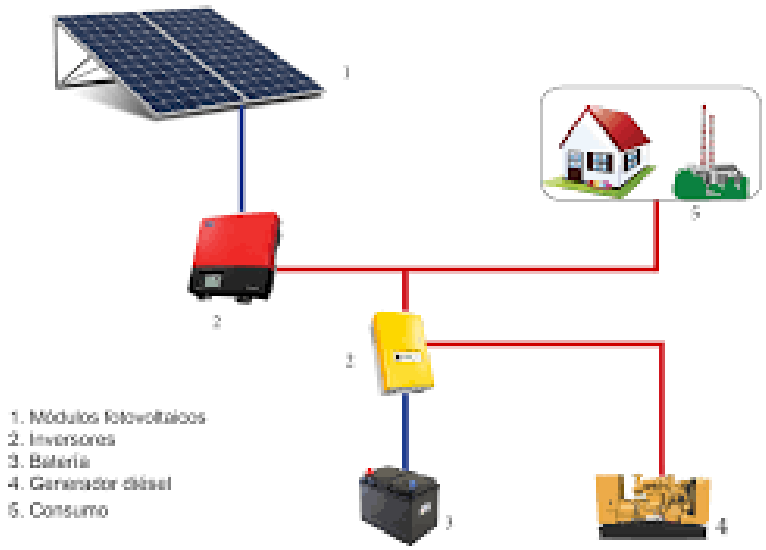
Fix PV Modules as Per Circuit Design

After selecting the equipment and the mounting structure, now is the phase to fix the PV modules according to the plan.

Solar Hybrid Power Systems

Hybrid systems combine a number of electricity production and storage pieces to meet the energy demand of a given facility or community. In addition to PV, engine generators, wind generators, small hydro plants, and any other source of electrical energy can be added as needed to meet energy demands and fit the local geographical and temporal characteristics. These systems are ideal for remote applications such as communications stations, military installations, and rural villages.

Essential to developing a hybrid electric system is knowing the energy demand to be met and the resources available. Energy planners therefore, must study the solar energy, wind, and other potential resources at a certain location, in addition to the planned energy use. This will allow them to design a hybrid system that best meets the demands of the facility or community.



Hybrid Advantages:

Advantages of Hybrid Power System

- Stores & saves solar or cheaper off-peak energy.
- Allows use of solar energy during peak times (self-use or load-shifting)
- Power available during a grid outage or blackout –UPS
- Enables advanced energy management (i.e. peak shaving)
- Enables energy independence
- Reduces power consumption

Disadvantages: of Hybrid Power System

Higher cost than on-grid solar. Mainly due to the high cost of batteries.

- Larger more complex installation requires more room and higher installs cost.
- Battery life of 6-15 years.
- Can limit how many appliances can run at the same time (depending on the type of hybrid inverter and its capability).

SOLAR HOME SYSTEM (SHS)

Solar Home Systems (SHS) are stand-alone photovoltaic systems that offer a cost-effective mode of supplying amenity power for lighting and appliances to remote off-grid households. In rural areas, that are not connected to the grid, SHS can be used to meet a household's energy demand fulfilling basic electric needs. Globally SHS provide power to hundreds of thousands of households in remote locations where electrification by the grid is not feasible. SHS usually operates at a rated voltage of 12 V direct current (DC) and provides power for low power DC appliances such as lights, radios and small TVs for about three to five hours a day. Furthermore, they use appliances such as cables,

switches, mounts, and structural parts and power conditioners / inverters, which change 12/ 24 V power to 240VAC power. For larger appliances, SHS are best used with efficient appliances so as to limit the size of the array.
A SHS typically includes one or more PV modules consisting of solar cells, a charge controller which distributes power and protects the batteries and appliances from damage and at least one battery to store energy for use when the sun is not shining.

STAND-ALONE SMALL SOLAR ELECTRIC SYSTEMS

A stand-alone home solar electric or PV system operates "off-grid" – it isn't connected to an electricity distribution grid operated by a utility.
A stand-alone PV system makes sense if any of the following apply:

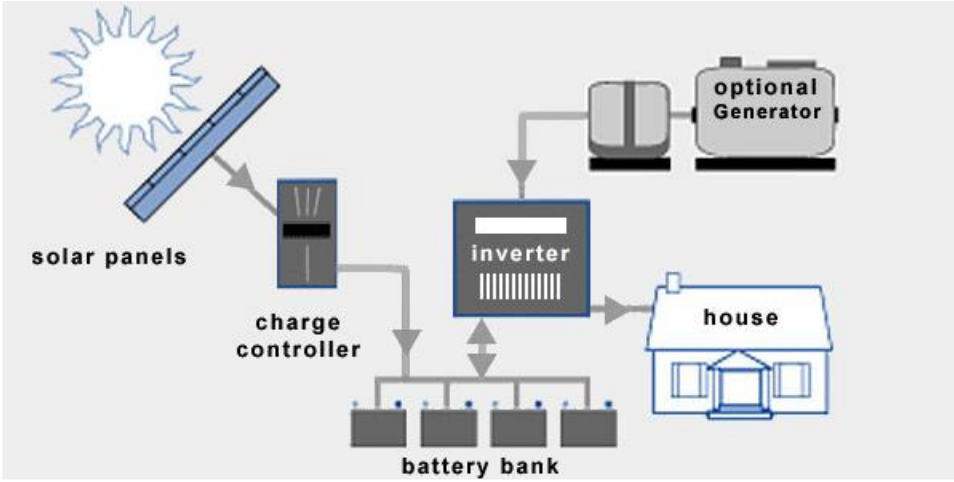
- You live in a remote location where the system would be more cost effective than extending a power line to a grid.
- You're considering a hybrid electric system -- one that uses both a PV system and a small wind electric system.
- You need minimal amounts of power; e.g., irrigation control equipment and remote sensors.

GRID-CONNECTED SMALL SOLAR ELECTRIC SYSTEMS

A grid-connected home solar electric or PV system receives back-up power from a utility's grid when the PV system is not producing enough power. When the system produces excess power, the utility is required to purchase the power through a metering and rate arrangement. Net metering is the best arrangement, as the power provider essentially pays retail price for the electricity that is fed back into the grid.

Off- Grid Solar System and Its Components

The generator of the solar power system (or the engine is an array of solar panels) has no moving parts and it is silent. Solar panels convert sun light radiation directly to DC electrical power, making advantage of the photoelectric effect.
Since electricity is needed around the clock and the sun (which delivers power to the panels) is available only during daylight, some way to store electricity during the day to be used overnight is a necessity. The most ubiquitous electricity storage is the battery. The off-grid inverter, inverts the DC electricity from the battery into more useful AC electricity (230V, 50 Hz). Another necessary element is the charge controller that protects the array of batteries from overcharge.



The Components of Off-Grid Solar Systems

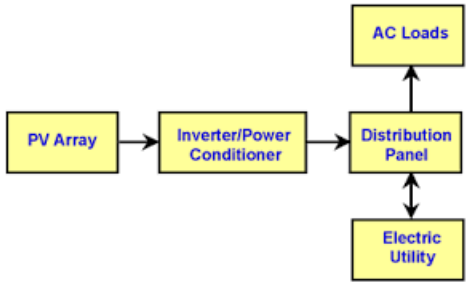
These are the components of the off grid solar power generator:

- Solar panels sized to fit the home consumption.

- Batteries: Deep cycle batteries (not car batteries), can be charged and discharged many times, as many as required. Install the batteries in a ventilated space and not in a living area, not exposed to extreme hot/cold temperature and with good maintenance access. The life expectancy is 5-15 years (much shorter than the other elements' life expectancy).
- Charge Controller.
- A pure sine wave inverter.
- Grounding, surge protector, circuit breakers and other safety and protection devices.
- Optional and highly desired: a good smart display to see the performance and status of the different parts.
- Shortest and a higher gauge DC lines to reduce losses on the lines.

On- Grid Solar System and Its Components

A grid-connected system allows power for home or small business with renewable energy during those periods (daily as well as seasonally) when the sun is shining, the water is running, or the wind is blowing. Any excess electricity produced is fed back into the grid. When renewable resources are unavailable, electricity from the grid supplies the needs, eliminating the expense of electricity storage devices like batteries.



In addition, power providers (i.e., electric utilities) in most countries allow net metering, an arrangement where the excess electricity generated by grid-connected renewable energy systems "turns back" electricity meter as it is fed back into the grid. If more electricity is used, then the system feeds into the grid during a given month; power provider is paid only for the difference between what has been used and what has been produced. Some of the things you need to know when thinking about connecting home energy system to the electric grid include:

- Equipment required to connect the system to the grid.
- Grid-connection requirements from power provider.
- Federal, provincial and community codes and requirements.

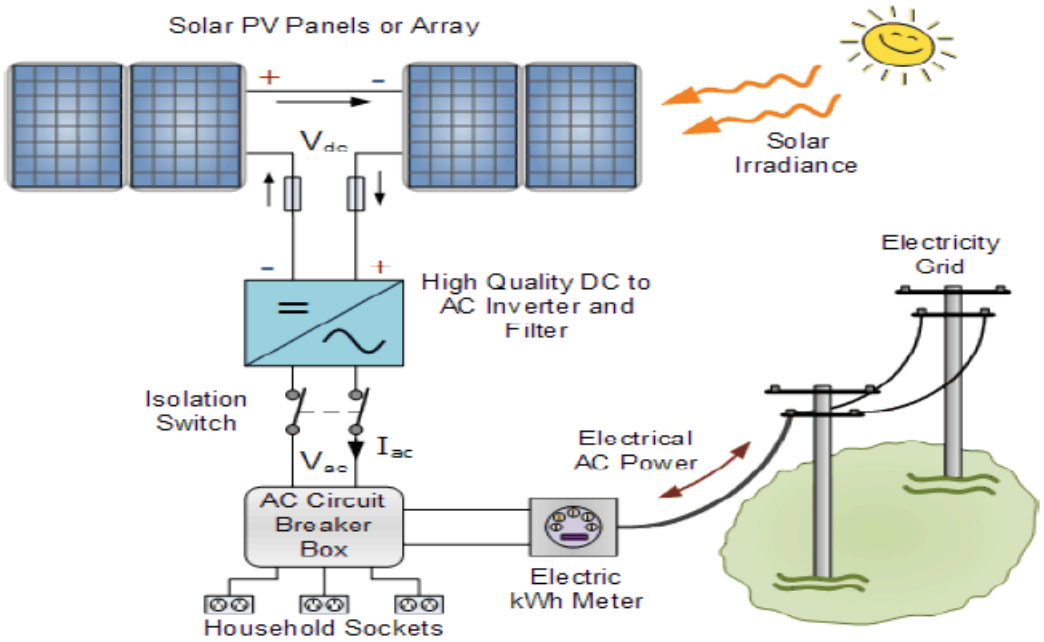
EQUIPMENT REQUIRED FOR GRID-CONNECTED SYSTEMS

Aside from the major small renewable energy system components, additional equipment (called "balance-of-system") is required in order to safely transmit electricity and comply with power provider's grid connection requirements. The following items may be needed:

- Power conditioning equipment.
- Safety equipment.
- Meters and instrumentation.

Because grid-connection requirements vary, supplier/installer should contact power provider to learn about its specific grid-connection requirements before purchasing any part of your renewable energy system.

Simplified Grid Connected PV System



Grid connected PV systems always have a connection to the public electricity grid via a suitable inverter because a photovoltaic panel or array (multiple PV panels) only deliver DC power. As well as the solar panels, the additional components that make up a grid connected PV system compared to a standalone PV system are:

Inverter: The inverter is the most important part of any grid connected system. The inverter extracts as much DC (direct current) electricity as possible from the PV array and converts it into clean mains AC (Alternating Current).

- Electricity at the right voltage and frequency for feeding into the grid or for supplying domestic loads. It is important to choose the best quality inverter possible for the budget allowed as the main considerations in grid connected inverter choice are: *Power* – Maximum high and low voltage power the inverter can handle and *Efficiency* – How efficiently does the inverter convert solar power to AC power.
- ***Electricity Meter****:* The electricity meter also called a Kilowatt hour (kWh) meter is used to record the flow of electricity to and from the grid. Twin kWh meters can be used, one to indicate the electrical energy being consumed and the other to record the solar electricity being sent to the grid. A single bidirectional kWh meter can also be used to indicate the net amount of electricity taken from the grid. A grid connected PV system will slow down or halt the aluminum disc in the electric meter and may cause it to spin backwards. This is generally referred to as *net metering*.
- ***AC Breaker Panel and Fuses:*** The breaker panel or fuse box is the normal type of fuse box provided with a domestic electricity supply and installation with the exception of additional breakers for inverter and/or filter connections.
- ***Safety Switches and Cabling*****:** A photovoltaic array will always produce a voltage output in sunlight so it must be possible to disconnect it from the inverter for maintenance or testing. Isolator switches rated for the maximum DC voltage and current of the array

and inverter safety switches must be provided separately with easy access to disconnect the system. Other safety features demanded by the electrical company may include earthing and fuses. The electrical cables used to connect the various components must also be correctly rated and sized.

- ***The Electricity Grid****:* Finally, the electricity grid itself to connect too, because without the utility grid it is not a Grid Connected PV System**.**

A grid connected system without batteries is the simplest and cheapest solar power setup available, and by not having to charge and maintain batteries they are also more efficient. It is important to note that a grid connected solar power system is not an independent power source unlike a standalone system. Should the mains supply from the electrical grid be interrupted, the lights may go out, even if the sun is shining. One way to overcome this is to have some form of short term energy storage built into the design.

Install Battery Bank

Connecting in Series:

When connecting your batteries in Series you are doubling the voltage while maintaining the same capacity rating (amp hours). This might be used in a scooter, power wheels' vehicle, or other applications.

In order to connect batteries in series, following steps are taken:

1. Use a jumper wire between the negative of the first battery and the positive of the second battery.
2. Run negative wire off of the open connector from the first battery and positive off of the open connector on the second battery.

Connecting in Parallel:

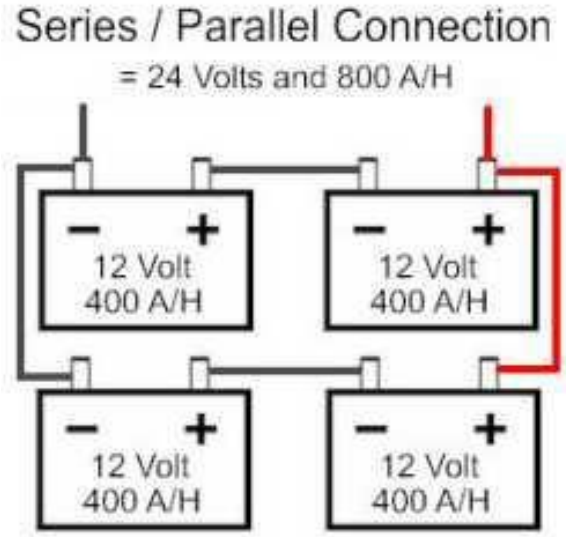
When connecting in Parallel, you are doubling the capacity (amp hours) of the battery while maintaining the voltage of one of the individual batteries. This would be used in applications such as laptop batteries, some scooters, some UPS backups, etc.

Following steps are taken when connecting batteries in parallel:

(1) Use a jumper wire between the positives of both batteries and another jumper wire between the negatives of both batteries.

(2) Connect positive and negative wires to the same battery to run to your application.

Series and parallel 12V battery connections increase voltage to 24V and also increase the amperage.



Learning Unit: 6

Install Inverter/Charge Controller/Variable Frequency Drive (VFD)

Introduction to Inverters

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage, frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

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 battery 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.

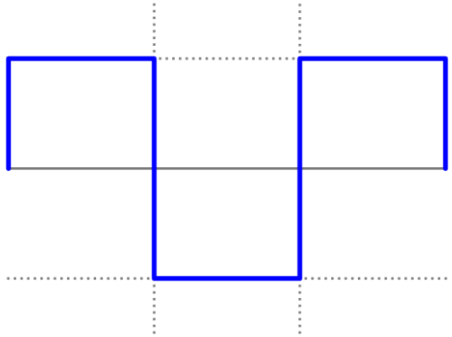
TYPES OF INVERTERS

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. The two dominant commercialized waveform types of inverters as of the recent time are modified sine wave and sine wave.

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.

Square Wave:

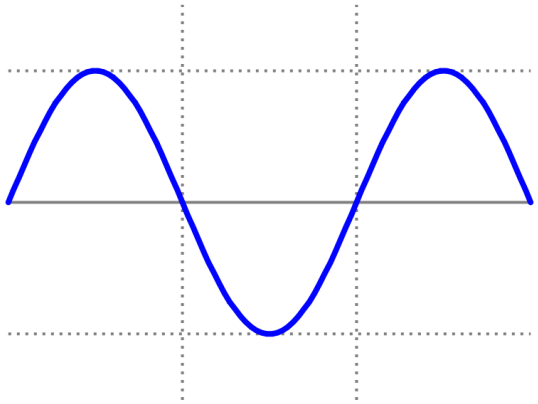
This is one of the simplest waveforms an inverter design can produce and is best suited to low-sensitivity applications such as lighting and heating. Square wave output can produce "humming" when connected to audio equipment and is generally unsuitable for sensitive electronics.



Sine Wave:

A power inverter device which produces a multiple step sinusoidal AC waveform is referred to as a *sine wave inverter*. To more clearly distinguish the inverters with outputs of much less distortion than the *modified sine wave* (three step) inverter designs, the manufacturers often use the phrase *pure sine wave inverter*. Almost all consumer grade inverters that are sold as a "pure sine wave inverter" do not produce a smooth sine wave output at all, just a less choppy output than the square wave and modified sine wave inverters. However, this is not critical for most electronics as they deal with the output quite well.

Where power inverter devices substitute for standard line power, a sine wave output is desirable because many electrical products are engineered to work best with a sine wave AC power source. The standard electric utility provides a sine wave, typically with minor imperfections but sometimes with significant distortion. Sine wave inverters are more complex and have significantly higher cost than a modified sine wave. Switch-mode power supply (SMPS) devices, such as personal computers or DVD players, function on quality modified sine wave power. AC motors directly operated on non-sinusoidal power may produce extra heat, may have different speed-torque characteristics, or may produce more audible noise than when running on sinusoidal power.



Modified Sine Wave:

The modified sine wave output of such an inverter is the sum of two square waves one of which is phase shifted 90 degrees relative to the other. The result is three level waveform with equal intervals of zero volts; peak positive volts; zero volts; peak negative volts and then zero volts. This sequence is repeated. The resultant wave very roughly resembles the shape of a sine wave. Most inexpensive consumer power inverters produce a modified sine wave rather than a pure sine wave.

Other Waveforms

By definition there is no restriction on the type of AC waveform an inverter might produce that would find use in a specific or special application.

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 240VAC 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.

SOLAR INVERTER

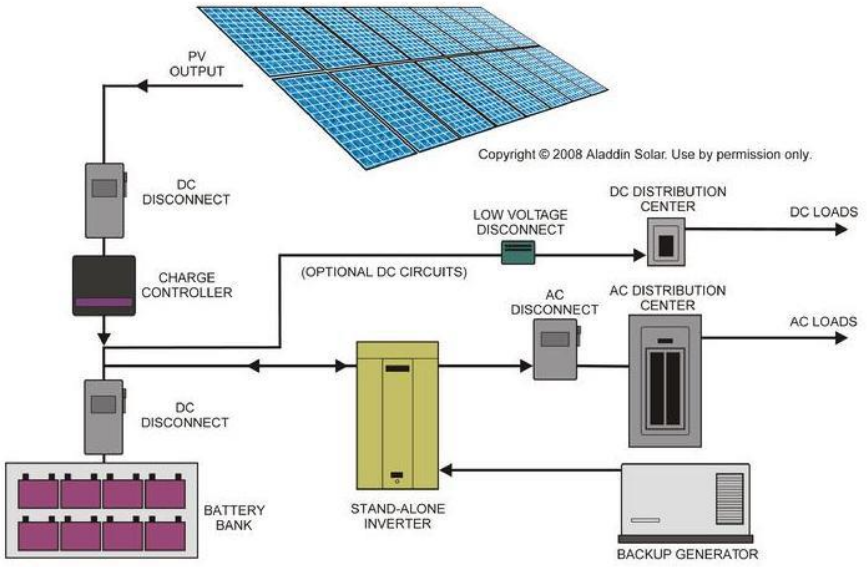
A solar inverter, or converter or PV inverter, converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, offgrid electrical network. It is a critical balance of system (BOS)– component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

Classification

Solar inverters may be classified into three broad types:

1. ***Stand-alone inverters***, used in isolated systems where the inverter draws its DC energy from batteries charged by photovoltaic arrays. Many stand-alone inverters also incorporate integral battery chargers to replenish the battery from an AC source, when available. Normally these do not interface in any way with the utility grid, and as such, are not required to have anti-islanding protection.

TYPICAL PV STAND-ALONE SYSTEM



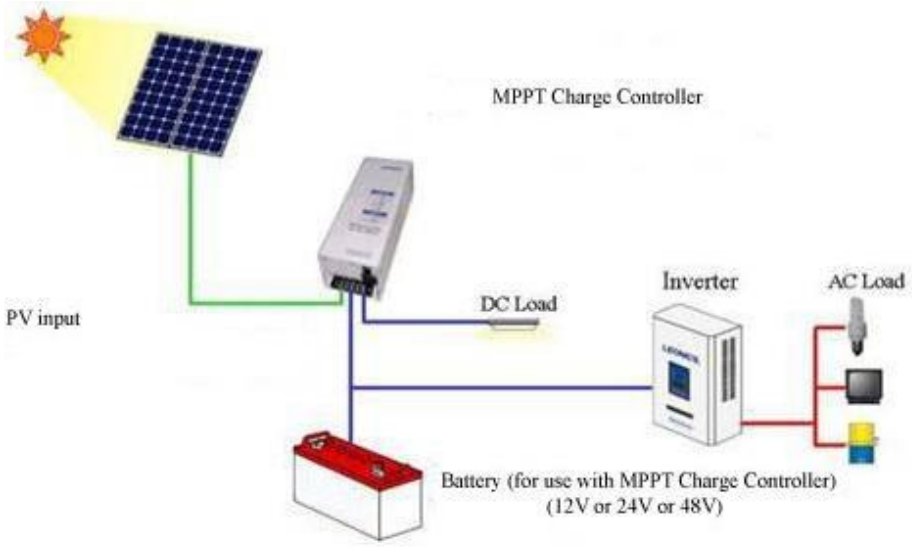
2. ***Grid-tie inverters***, which match phase with a utility supplied sine wave. Grid-tie inverters are designed to shut down automatically upon loss of utility supply, for safety reasons. They do not provide backup power during utility outages.

3. ***Battery backup Inverters*** are special inverters which are designed to draw energy from a battery, manage the battery charge via an onboard charger, and export excess energy to the utility grid. These inverters are capable of supplying AC energy to selected loads during a utility outage, and are required to have anti-islanding protection.

MAXIMUM POWER POINT TRACKING

Solar inverters use Maximum Power Point Tracking (MPPT) to get the maximum possible power from the PV array. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency known as the *I-V curve*. It is the purpose of the MPPT system to sample the output of the cells and determine a resistance (load) to obtain maximum power for any given environmental conditions.

The fill factor, more commonly known by its abbreviation *FF*, is a parameter which, in conjunction with the open circuit voltage (Voc) and short circuit current (Isc) of the panel, determines the maximum power from a solar cell. Fill factor is defined as the ratio of the maximum power from the solar cell to the product of Voc and Isc.



SOLAR MICRO INVERTER

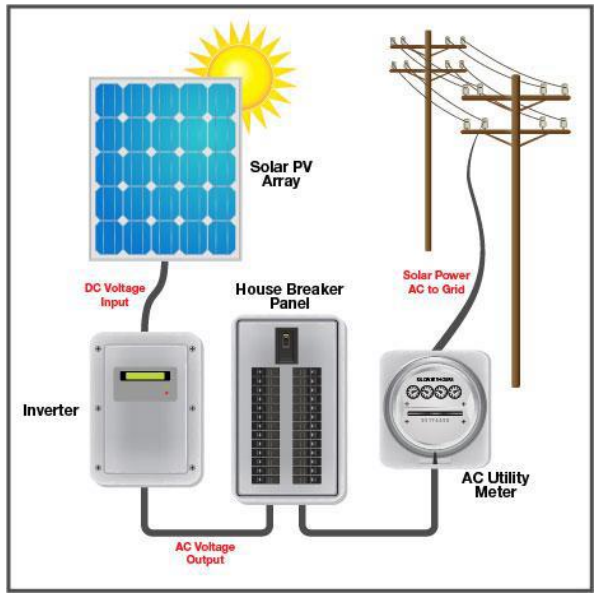
Solar micro-inverter is an inverter designed to operate with a single PV module. The micro-inverter converts the direct current output from each panel into alternating current. Its design allows parallel connection of multiple, independent units in a modular way.

Micro-inverter advantages include single panel power optimization, independent operation of each panel, plug-and play installation, improved installation and fire safety, minimized costs with system design and stock minimization.

GRID TIED SOLAR INVERTERS

Solar grid-tie inverters are designed to quickly disconnect from the grid if the utility grid goes down. In the event of a blackout, the grid tie inverter will shut down to prevent the energy it produces from harming any line workers who are sent to fix the power grid.

Grid-tie inverters that are available in the market today use a number of different technologies. The inverters may use the newer high-frequency transformers, conventional low-frequency transformers, or no transformer. Instead of converting direct current directly to 120 or 240 volts AC, high-frequency transformers employ a computerized multi-step process that involves converting the power to high-frequency AC and then back to DC and then to the final AC output voltage.



SOLAR PUMPING INVERTERS

Advanced solar pumping inverters convert DC voltage from the solar array into AC voltage to drive submersible pumps directly without the need for batteries or other energy storage devices. By utilizing MPPT (maximum power point tracking), solar pumping inverters regulate output frequency to control the speed of the pumps in order to save the pump motor from damage.

Solar pumping inverters usually have multiple ports to allow the input of DC current generated by PV arrays, one port to allow the output of AC voltage, and a further port for input from a water-level sensor.

INSTALLATION OF HYBRID SOLAR INVERTER

Two main categories of hybrid inverters are Grid-Tie Solar Inverter and Off-Grid Solar Inverter. We are discussing about the Off-Grid solar inverter because they are simple and a wide variety of them are available in local market. They are sub-categorized into modified sine wave inverter (low cost) and pure sine wave inverter (their cost is high). If you need to run motor load such as Water Pump, AC, Fridge or other types of appliances which contains compressor / motor then Pure-Sine-Wave inverters are recommended. For Fans, Air Coolers, Fluorescent Lamps (Energy Savers), Bulbs and Tube Lights Modified-Sine-Wave will also work.

Working and design of Hybrid Inverters are same as normal Inverter / UPS, the only difference is that their input supports is more than one source such as Battery, Main (WAPDA), Generator or Wind Turbine. In the settings or menu, you can configure the priority of input source: such as Solar First, WAPDA First or Solar and WAPDA Source. The setting of charging source for battery:

Charge battery from Solar only, Charge battery from WAPDA only or the combination of both. The installation work includes following:

(1) Solar sizing;
(2) Load calculation;
(3) Battery sizing;
(4) Backup time;
(5) Protectors, circuit breakers;
(6) Wiring (AC & DC);

(7) Earthing.

As Solar system designing and load calculation has the key role in energy as well as cost saving, also Hybrid Inverter involves high electric voltages and currents.

HYBRID INVERTER SETTINGS

Hybrid Solar Inverter provides the options to configure the device according to the requirement. The typical setting options that almost all Hybrid Inverters provide are:

Source Priority

This is the most important step in configuring any Hybrid Solar Inverter. Solar, WAPDA and battery are the three types of available sources:

For Output Load

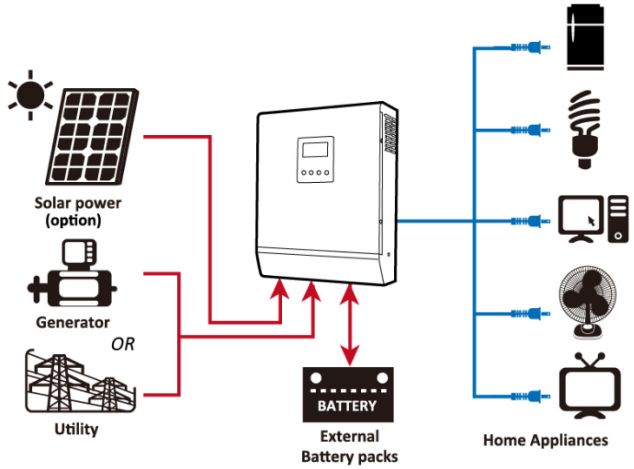
1. Power load (Solar)
2. Power load main (WAPDA)
3. Power load (Both)

For Charging Battery

1. Charge battery from Solar only
2. Charge battery from Main (WAPDA) only
3. Charging battery from both

The other options include

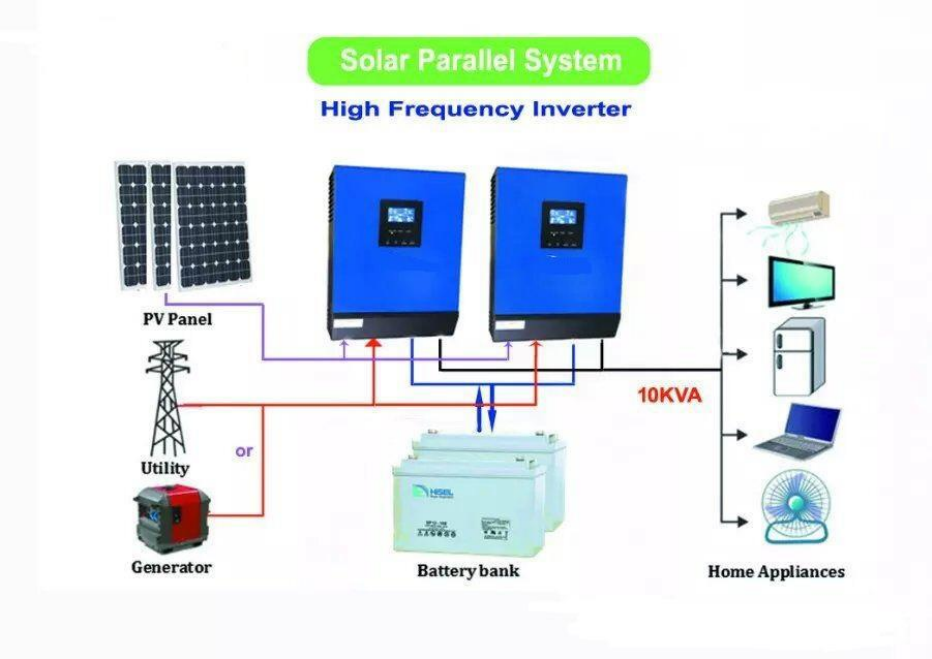
- Low battery Cut-Off Voltage
- Battery Type: (Lead-Acid Battery) Flooded, GEL, AGM
- Float Charging Voltage
- Charger Cut-Off Voltage



PARALLEL OPERATION OF HYBRID INVERTER

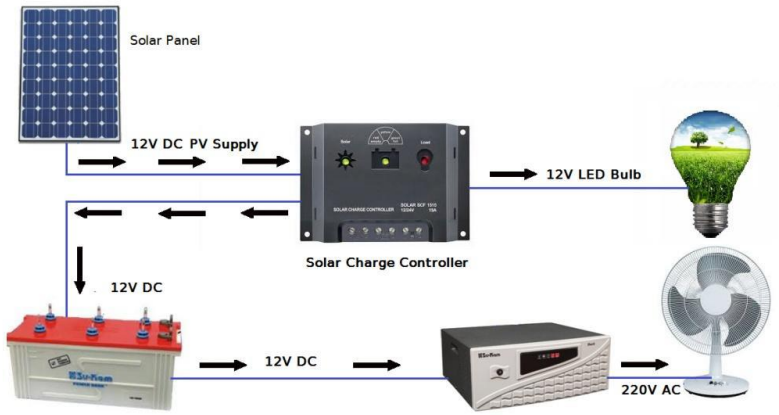
Between PV plants that supply stand-alone systems and those that feed into the public grid come with installations that generate power in parallel to the grid (grid-compatible parallel operation).

Grid-parallel operation is necessary anywhere where a public grid exists but the power supply is unreliable. Moreover, such systems are also practical in situations where a large power consumer (such as a factory) is connected to a weak grid spur and the power demand regularly exceeds the capacity of the grid connection. In both cases, photovoltaics' assists in stabilizing the power grid and bridging bottlenecks in supply.



Functions of Charge Controller

A charge controller is an essential part of nearly all power systems that charge batteries, whether the power source is PV, wind, hydro, fuel, or utility grid. Its purpose is to keep your batteries properly fed and safe for the long term.



The basic functions of a controller are quite simple. Charge controllers block reverse current and prevent battery overcharge. Some controllers also prevent battery over discharge, protect from electrical overload, and/or display battery status and the flow of power. Let's examine each function individually.

Blocking Reverse Current:

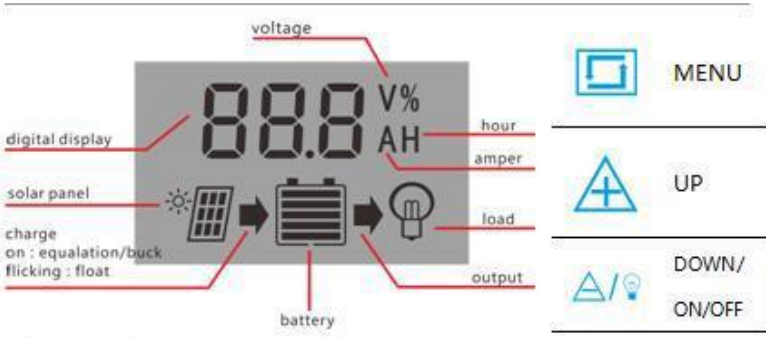
Photovoltaic panels work by pumping current through the battery in one direction. At night, the panels may pass a bit of current in the reverse direction, causing a slight discharge from the battery. The potential loss is minor, but it is easy to prevent. Some types of wind and hydro generators also draw reverse current when they stop. In most controllers, charge current passes through a semiconductor (a transistor) which acts like a valve to control the current. It is called a "semiconductor" because it passes current only in one direction. It prevents reverse current without any extra effort or cost. In some controllers, an electromagnetic coil opens and closes a mechanical switch. This is called a relay. The relay switches off at night, to block reverse current. If a PV array is being used only to trickle-charge a battery (a very small array relative to the size of the battery), then a charge controller may not be needed. This is a rare application. An example is a tiny maintenance module that prevents battery discharge in a parked vehicle but will not support significant loads. One can install a simple diode in that case, to block reverse current. A diode used for this purpose is called a "blocking diode".

Preventing Overcharge:

When a battery reaches full charge, it can no longer store incoming energy. If energy continues to be applied at the full rate, the battery voltage gets too high. Water separates into hydrogen and oxygen and bubbles out rapidly. There is excessive loss of water, and a chance that the gasses can ignite and cause a small explosion. The battery will also degrade rapidly and may possibly overheat. Excessive voltage can also stress loads (lights, appliances, etc.) or cause the inverter to shut off.

Preventing overcharge is simply a matter of reducing the flow of energy to the battery when the battery reaches a specific voltage. When the voltage drops due to lower sun intensity or an increase in electrical usage, the controller again allows the maximum possible charge. This is called "voltage regulating." It is the most essential function of all charge controllers. The controller "looks at" the voltage, and regulates the battery charging in response. Some controllers regulate the flow of energy to the battery by switching the current fully on or fully off. This is called "on/off control." Others reduce the current gradually. This is called "pulse width modulation" (PWM). Both methods work well when set

properly for any type of battery. A PWM controller holds the voltage more constant. If it has two-stage regulation, it will first hold the voltage to a safe maximum for the battery to reach full charge. Then, it will drop the voltage lower, to sustain a "finish" or "trickle" charge. Two stage regulating is important for a system that may experience many days or weeks of excess energy (or little use of energy). It maintains a full charge but minimizes water loss and stress. The voltages at which the controller changes the charge rate are called set points. When determining the ideal set points, there is some compromise between charging quickly before the sun goes down, and mildly overcharging the battery. The determination of set points depends on the anticipated patterns of usage, the type of battery, and to some extent, the experience and philosophy of the system designer or operator. Some controllers have adjustable set points, while others do not.



Overload Protection:

A circuit is overloaded when the current flowing in it is higher than it can safely handle. This can cause overheating and can even be a fire hazard. Overload can be caused by a fault (short circuit) in the wiring, or by a faulty appliance (like a frozen water pump). Some charge controllers have overload protection built in, usually with a push-button reset.

Built-in overload protection can be useful, but most systems require additional protection in the form of fuses or circuit breakers. If a circuit with a wire size for which the safe carrying capacity (ampacity) is less than the overload limit of the controller, then that circuit must be protected with a fuse or breaker of a suitably lower amp rating. In any case, follow the manufacturer's requirements for any external fuse or circuit breaker requirements.

Low Voltage Disconnect (LVD):

The deep-cycle batteries used in renewable energy systems are designed to be discharged by about 80 percent. If they are discharged 100 percent, they are immediately damaged. Imagine a pot of water boiling on kitchen stove. The moment it runs dry, the pot overheats.

If you wait until the steaming stops, it is already too late! Similarly, if you wait until your lights look dim, some battery damage will have already occurred. Every time this happens, both the capacity and the life of the battery will be reduced by a small amount. If the battery sits in this over discharged state for days or weeks at a time, it can be ruined quickly. The only way to prevent over discharge when all else fails, is to disconnect loads (appliances, lights, etc.), and then to reconnect them only when the voltage has recovered due to some substantial charging. When over discharge is approaching, a 12-volt battery drops below 11 volts (a 24 V battery drops below 22 V). A low voltage disconnect circuit will disconnect loads at that set point. It will reconnect the loads only when the battery voltage has substantially recovered due to the accumulation of some charge. A typical LVD reset point is 13 volts (26 V on a 24 V system). All modern DC power inverters have LVD built in, even cheap pocket-sized ones. The inverter will turn off to protect itself and the loads as well as the battery. Normally, an inverter is connected directly to the batteries, not through the charge controller, because its current draw can be very high, and because it does not require external LVD. If there are DC loads, then a LVD is required. If a charge controller has built-in LVD, it must have enough capacity to handle DC loads. For example, let's say a charge controller handles less than 10 amps of charge current, but there is a DC water pressurizing pump that draws 20-amps (for short periods) plus a 6-amp DC lighting load. A charge controller with a 30 amp LVD would be appropriate. Therefore, a 10-amp charge controller that has only a 10 or 15-amps load capacity will not work!

TYPES OF CHARGE CONTROLLERS

The charge controller is a key component of a solar power system and specifying the best one for the system requires some analysis. Below is a quick overview:

The two types of charge controllers most commonly used in today’s solar power systems are *Pulse Width Modulation* (PWM) and *Maximum Power Point Tracking* (MPPT). Both adjust charging rates depending on the battery's charge level to allow charging closer to the battery’s maximum capacity as well as monitor battery temperature to prevent overheating.

Pulse Width Modulation(PWM) Charge Controller:

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs.

Charging a battery with a solar system is a unique and difficult challenge. In the “old days,” simple on-off regulators were used to limit battery out gassing when a solar panel produced excess energy. However, as solar systems matured it became clear how much these simple devices interfered with the charging process. The history for on-off regulators has been early battery failures, increasing load disconnects, and growing user dissatisfaction. PWM has recently surfaced as the first significant advance in solar battery charging. PWM solar chargers use technology similar to other modern high quality battery chargers. When a battery voltage reaches the regulation set point, the PWM algorithm slowly reduces the charging current to avoid heating and gassing of the battery, yet the charging continues to return the maximum amount of energy to the battery in the shortest time. The result is a higher charging efficiency and rapid recharging.

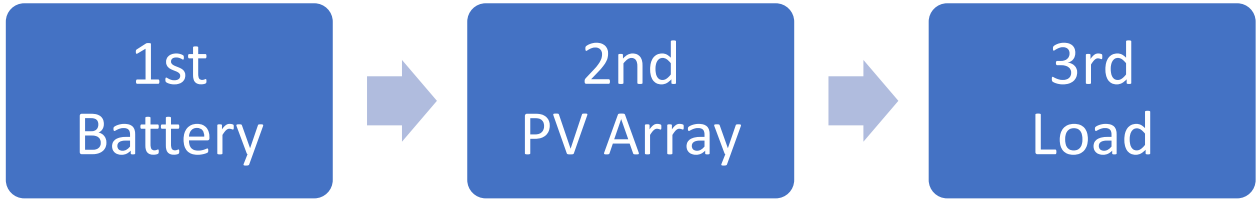
Maximum Power Point Tracking (MPPT) Charge Controller:

A Maximum Power Point Tracker (MPPT) is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries these are sometimes called "power point trackers" for short - not to be confused with PANEL trackers, which are a solar panel mount that follows, or tracks, the sun).

There is some confusion about the term "tracking": Panel tracking - this is where the panels are on a mount that follows the sun. The most common are the Zone works and Watt sun. These optimize output by following the sun across the sky for maximum sunlight. These typically give about a 15% increase in winter and up to a 35% increase in summer. This is just the opposite of the seasonal variation for MPPT controllers. Since panel temperatures are much lower in winter, they put out more power. Maximum Power Point Tracking is electronic tracking – usually digital. The charge controller looks at the output of the panels, and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. Most modern MPPT's are around 93-97% efficient in the conversion. Typically, a 20 to 45% power gain in winter and 10-15% in summer is achieved. Actual gain can vary widely depending weather, temperature, battery state of charge, and other factors. Grid tie systems are becoming more popular as the price of solar drops and electric rates go up. There are several brands of grid-tie only (that is, no battery) inverters available. All of these have built in MPPT. Efficiency is around 94% to 97% for the MPPT conversion on those.

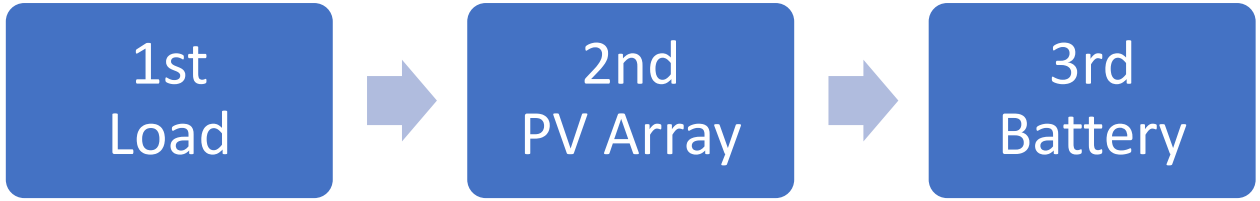
CONNECTION SEQUENCE OF CHARGE CONTROLLERS

For connecting sequence of charge controller, the rule of thumb is “first battery then load”. This means that in connecting the charge controller in a PV system, the battery is connected first with charge controller then followed by PV array and then load. If PV array is connected first with charge controller, the high voltage of PV array could be damage the charge controller.



DISCONNECTING OF SEQUENCE OF CHARGE CONTROLLER

When the charge controller needs to be disconnected from the PV system, first disconnect the load from the charge controller followed by the PV array then the battery.



Learning Unit: 7

Install Solar PV Pumps

It is a fact that all of us are dependent on water for survival and the best way to get unlimited supply at home is through a water pump. But a solar water pump is a better idea as it makes use of sunlight and not electricity to draw water for you. If you are someone who is interested in

installing a small scaled or a large scaled solar water pump at home or office, then this article will prove useful. It will help you learn the steps or procedure to follow for installing solar water pump.

STEP 1: Set up the solar panel stand

STEP 2: I-Beam placement and foundation for installation of solar panels

STEP 3: Add lower C Channel for holding of solar panel in the center of the frame

STEP 4: Add other beams and channels if necessary

STEP 5: Adding solar panels on the frames

STEP 6: Make the electrical connections of PV panels with solar pump and inverter

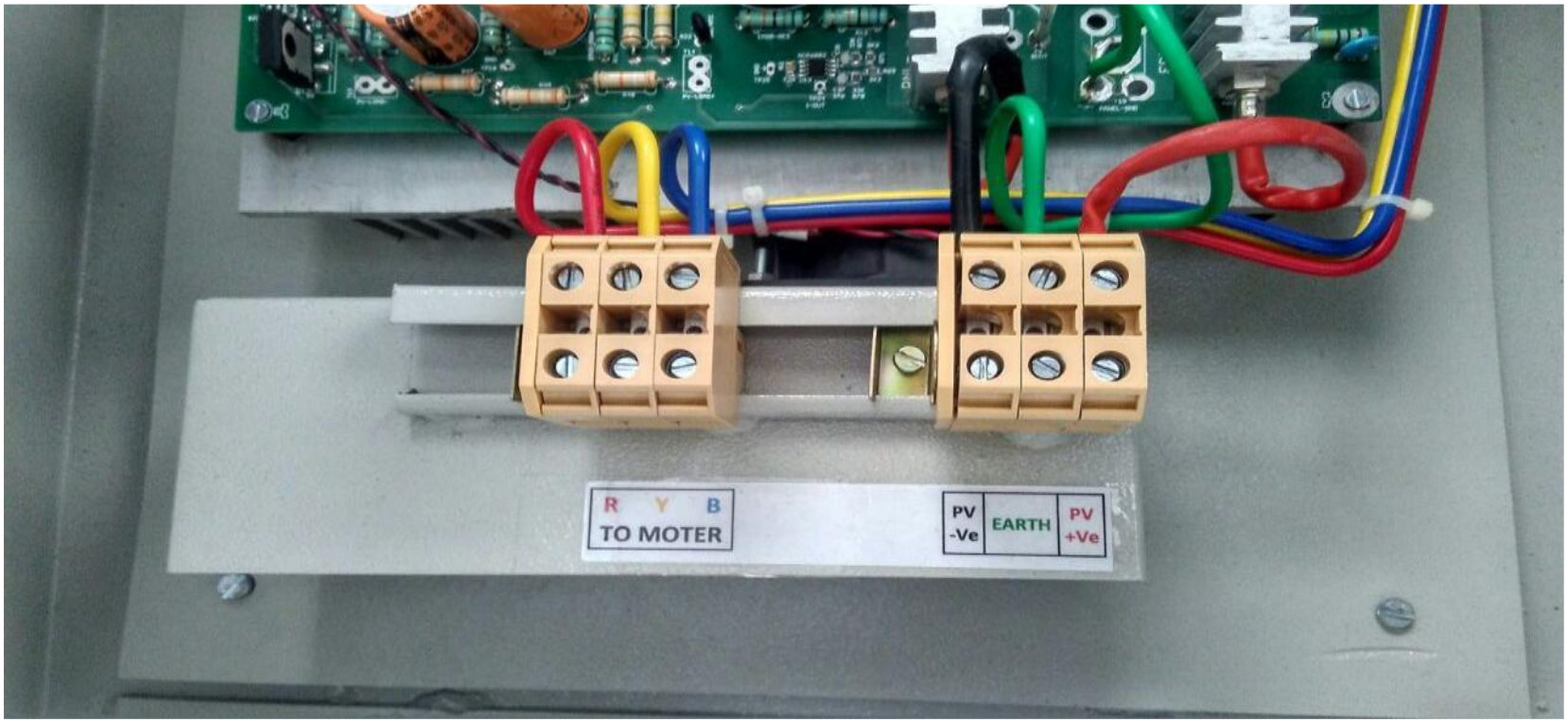
STEP 7: If it's a submersible pump lower the pump in the hole with pipe and cable firmly jointed as mentioned in the picture.

Learning Unit: 8

Connect the PV modules as per circuit design

Visual Inspection: Before commissioning system should be visually inspected for physical damages and proper connections. Commissioning:

1. Connect the PV input "+VE & –VE" to the Solar pump controller terminal marked "PV –VE" & "PV +VE" respectively.
2. Connect the output to motor terminal marked output "RYB" terminals respectively.
3. Appropriate chemical earthing shall be done for Solar Panels and Controller.


R Y B
TO MOTER
PV
-Ve
EARTH
PV
+Ve

4. Lighting arrestor shall be provided along with panels.

Pre-Operating Precautions:

1. All electrical external connection is properly done.
2. Be sure that the ground connection is made and connected earth to ground.

KNOWLEDGE ASSESSMENT TEST

Module:4 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) While doing a job in the field, it is necessary to

a. Ware tool belt
b. Have toolbox
c. Ware PPEs
d. All of the above

2) Which angle is to be taken care of while panels face south direction

a. Azimuthal angle
b. Panel angle
c. Latitude angle
d. Longitude angle

3) Short circuit test is used for

a. Maximum voltage
b. Maximum current
c. Luminous intensity
d. Maximum Power

4) Open circuit test is used for

a. Maximum voltage
b. Maximum current
c. Luminous intensity
d. Maximum Power

5) In submersible pump which is the best option.

a. VFD
b. Inverter
c. Charge controller
d. None of the above

Instructions to Candidates: You must write short answers to all questions.

Q1. What are the tools used for general maintenance?

Answer:

Q2. What is short circuit and open circuit test?

Answer:

Q3. How much current flows when short circuit and open circuit show with equation?

Answer:

Q4: Discuss any 3 types of mounts for Solar panels?

Answer:

Q5. How can we increase the voltage and current of the given batteries?

Answer:

BUILDING ELECTRICIAN SOLAR PV SYSTEM TECHNICIAN

Learner Guide

National Vocational Certificate Level 4

Version 1 - January 2020

Module-5

Module – 5: Perform Wiring of Solar PV System

Objective: This module covers the skills and knowledge required to interpret wiring diagram, lay cables, perform wiring test, carryout battery test, connect PV system with battery and inverter, configure inverter and verify proper working of the system through load execution test.

Duration:	**80 hours**	**Theory:**	**20 hours**	**Practical:**	**60 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Interpret wiring diagram	**Trainee will be able to:** • Collect the wiring diagram and layout from job documents • Identify paths and marking for wiring	• Interpretation of wiring diagram. • Layout techniques as per wiring diagram.	**60Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Connect the PV modules as per circuit diagram	**Trainee will be able to:** • Interconnect the strings to make arrays • Insulate all the arrays as per standard • Combine all the arrays through combiner box	• Interconnection techniques for PV Module, strings and arrays. • Insolation materials and techniques. • Installation and connection of Junction box			**Class room** **Theory** **Lab** **Practical**
LU-3: Lay Cables	**Trainee will be able to:** • Install conduits for cables • Lay cables through the conduits • Connect the cables to the control and safety boxes	• Types of conduits. • Cables laying techniques. • Types of wiring joints. • Cable color coding.			**Class room** **Theory** **Lab** **Practical**
LU-4: Perform wiring test	**Trainee will be able to:** • Perform continuity test • Perform polarity test • Perform earth test	• Proper Earthing procedure and testing. • Understanding and use of testing equipment/instruments.			**Class room** **Theory** **Lab** **Practical**
LU-5: Carry out battery test	**Trainee will be able to:** • Perform specific gravity test • Perform internal short circuit test • Perform terminal voltage test • Check terminal for carbon contents	• Identification of battery testing instruments. • The use of battery tester. • Understanding standard operation condition of battery. • Battery maintenance techniques.			**Class room** **Theory** **Lab** **Practical**

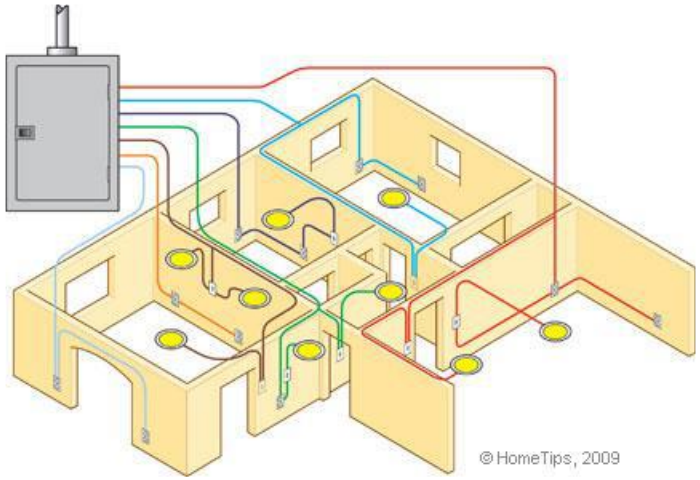
Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
	• Perform battery bank polarity test				
LU-6: Interconnect the PV system	**Trainee will be able to:** • Connect the battery bank to the inverter/charge controller through safety circuits • Connect the PV modules to the inverters/controllers through safety circuits • Connect the inverter with the input A.C source • Connect the load to the inverter through safety circuit	• Types of safety circuits. o Connection of arrays via fuses to inverter o Use of DC circuit breaker on DC side. o Use of SPDs. o Use of AC breaker on AC side. • Interconnection techniques of the PV solar system.			**Class room** **Theory** **Lab** **Practical**
LU-7: Configure the inverter / charge controller	**Trainee will be able to:** • Interpret the inverter manual • Inquire the customers'/site requirements • Set the parameters as per requirement	• Interpretation of inverter manual. • Setting parameters of charge controller/inverter as per requirements. • No-load testing techniques.			**Class room** **Theory** **Lab** **Practical**

Interpret Wiring Diagram

A wiring diagram is a simplified conventional pictorial representation of an electrical circuit. It shows the components of the circuit as simplified shapes, and the power and signal connections between the devices.

A wiring diagram usually gives information about the relative position and arrangement of devices and terminals on the devices, to help in building or servicing the device. This is unlike a schematic diagram, where the arrangement of the components' interconnections on the diagram usually does not correspond to the components' physical locations in the finished device. A pictorial diagram would show more detail of the physical appearance, whereas a wiring diagram uses a more symbolic notation to emphasize interconnections over physical appearance.

A wiring diagram is often used to troubleshoot problems and to make sure that all the connections have been made and that everything is present.



Electrical installations are generally the result of original installations combined with a number of changes and upgrades made over the years to accommodate site expansions or new business requirements. Subsequently, electrical wiring is very often not optimized or logical and more importantly poorly documented. A number of checks should be made to provide you with the most up-to-date information.

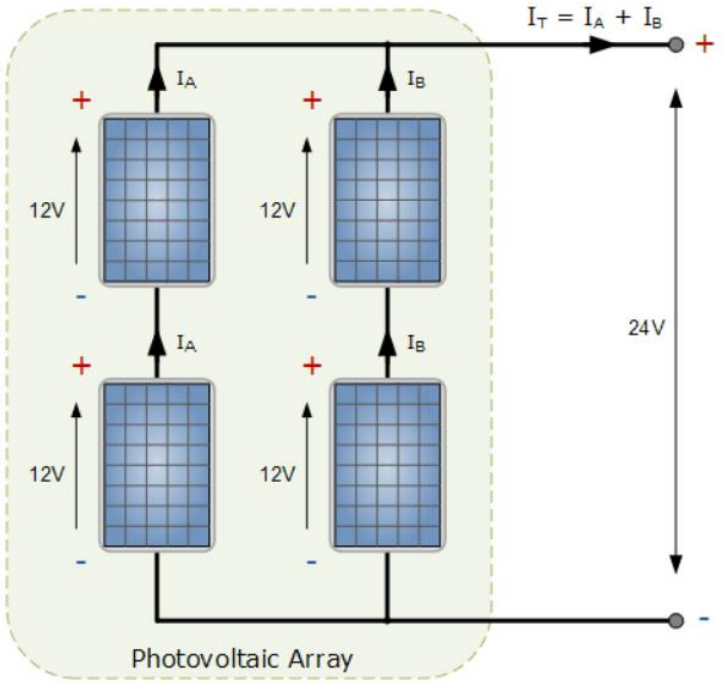
Connect The PV Modules as per Circuit Diagram

The amount of solar radiation received and the daily energy demand are the two controlling factors in the design of the photovoltaic array and solar power systems. The photovoltaic array must be sized to meet the load demand and account for any system losses while the shading of any part of the solar array will significantly reduce the output of the entire system.

If the solar panels are electrically connected together in series, the current will be the same in each panel and if panels are partially shaded, they cannot produce the same amount of current. Also shaded PV panels will dissipate power and waste as heat rather than generate it and the use of bypass diodes will help prevent such problems by providing an alternative current path.

Blocking diodes are not required in a fully series connected system but should be used to prevent a reverse current flow from the batteries back to the array during the night or when the solar irradiance is low. Other climatic conditions apart from sunlight must be considered in any design.

Since the output voltage of silicon solar cell is a temperature related parameter, the designer must be aware of the prevailing daily temperatures, both extremes (high and low) and seasonal variations. In addition, rain and snowfall must be considered in the design of the mounting structure. Wind loading is especially important in mountain top installations.



Now we will look at how we can use semiconductor photovoltaic arrays and solar panels as part of a Stand Alone PV System to generate power for off-grid applications. 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.

To gather the necessary information about the proposed system, utilities usually require that an interconnection application is submitted to their interconnection department. The application may be submitted by the account holder or, when properly designated, by the contractor that designs and installs the PV system. The interconnection application usually includes professional technical drawings, such as a site plans and an electrical diagram.

In the parallel permitting process, the AHJ will complete the inspection and, when passed, will issue a signed final permit.

Once the utility has received the approved final permit, it will schedule an inspection of the installed system. During the site visit, performed by qualified utility personnel, the solar system will be tested, and, if necessary, revenue meters installed and/or replaced. When the system is approved, the utility will notify the account holder and the installer, which will then be able to turn on the system and export power to the utility grid.

Lay Cables

One common factor for most of the photovoltaic power systems is outdoor use, characterized by high temperatures and high UV radiation. Single-core cables with a maximum permissible DC voltage of 1.8 kV Umax. The phase to ground DC voltage rating must be Uo1.5kVDC and a temperature range from -40 °C to +90 °C ambient, 120 °C on the conductor for 25-year service life against thermal ageing. Ambient temperature and conductor temperature is derived from the Arrhenius law for ageing of polymers - ageing of polymers doubles for every 10 °C rise.

DC string cables must be class II double insulated to protect against short circuits and ground faults.

Following is the table for guidance of the wire gauge.

S no.	Cable cross section size (AC)	Millimeter(mm)	Amperes(A)
1	1/.044	1	11
2	3/.029	1.5	13
3	3/.036	1.5	13
4	7/.029	2.5	18
5	7/.036	4	24
6	7/.044	6	31
7	7/.052	10	42
8	7/.064	16	56
9	19/.052	25	62
10	19/.064	35	73
11	19/.072	50	90
12	19/.083	70	145
13	37/.072	95	185
14	37/.083	120	230
15	37/.093	150	260
16	37/.103	185	355
17	61/.093	240	405
18	61/.103	300	480
19	91/.093	400	560
20	91/.103	500	617
21	127/.103	630	694

S no.	Cable cross section size(DC)	Millimeter(mm)	Amperes(A)

1	14/.0076	.5	3
2	23/.0076	.75	6
3	40/.0076	1	10
4	70/.0076	1.5	15
5	110/.0076	2.5	20
6	162/.0076	4	25

Insulation:

The cable's insulation must be able to withstand thermal and mechanical loads. As a consequence, plastics which have been cross-linked are increasingly used today. The insulation and jacket materials are extremely resistant to weathering, UV-radiation and abrasion. Additionally, it is salt water resistant and resistant to acids and alkaline solutions. It is suitable for fixed installation as well as for moving applications without tensile load. It is especially designed for outdoor use, which means direct sun radiation and air humidity, but due to the halogen free flame retardant cross-linked jacket material the cable can also be installed in dry and humid conditions indoors.

Different Types of Electrical Wiring Systems

The types of internal wiring usually used are:

- Cleat wiring.

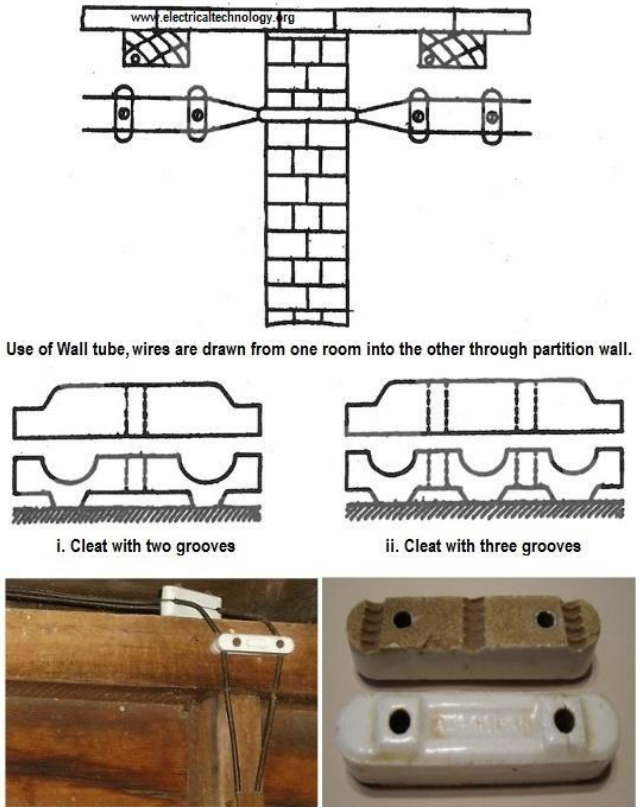
- Wooden casing and capping wiring.
- CTS or TRS or PVC sheath wiring.
- Lead sheathed or metal sheathed wiring.
- Conduit wiring.

There are additional types of conduit wiring according to pipes installation (where steel and PVC pipes are used for wiring connection and installation).

- Surface or open conduit type
- Recessed or concealed or underground type conduit

1. Cleat Wiring

This system of wiring comprises of ordinary VIR or PVC insulated wires (occasionally, sheathed and weather proof cable) braided and compounded held on walls or ceilings by means of porcelain cleats, plastic or wood. Cleat wiring system is a temporary wiring system therefore it is not suitable for domestic premises. The use of cleat wiring system is over nowadays.



Use of Wall tube, wires are drawn from one room into the other through partition wall.

i. Cleat with two grooves

ii. Cleat with three grooves

Advantages of Cleat Wiring:

- It is simple and cheap wiring system.
- Most suitable for temporary use i.e. under construction building.
- As the cables and wires of cleat wiring system is in open air, therefore fault in cables can be seen and repaired easily.

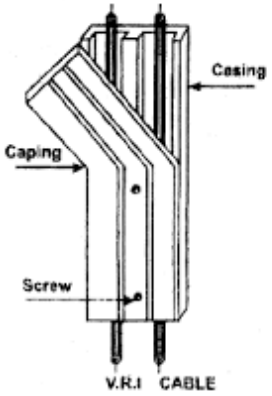
- Cleat wiring system installation is easy and simple.
- Customization can be easily done in this wiring system e.g. alteration and addition.
- Inspection is easy and simple.

Disadvantages of Cleat Wiring:

- Appearance is not so good.
- Cleat wiring can't be used for permanent use because sag may occur after sometime of the usage.
- In this wiring system, the cables and wiring is in open air, therefore, oil, steam, humidity, smoke, rain, chemical and acidic effect may damage the cables and wires.
- It is not lasting wire system because of the weather effect, risk of fire and wear & tear.
- It can be only used on 250/440 volts on low temperature.
- It can't be used in important and sensitive location and places.
- It is not lasting, reliable and sustainable wiring system.

Casing and Capping Wiring

Casing and capping wiring system was famous wiring system in the past but, it is considered obsolete this days because of conduit and sheathed wiring system. The cables used in this kind of wiring were either VIR or PVC or any other approved insulated cables. The cables were carried through the wooden casing enclosures. The casing was made up of a strip of wood with parallel grooves cut length wise so as to accommodate VIR cables. The grooves were made to separate opposite polarity, the capping (also made of wood) used to cover the wires and cables installed and fitted in the casing.



Wooden Casing & Capping Wiring System

Advantages of Casing Capping Wiring:

- It is cheap wiring system as compared to sheathed and conduit wiring systems.
- It is strong and long-lasting wiring system.
- Customization can be easily done in this wiring system.
- If phase and neutral wire is installed in separate slots, then repairing is easy.
- Stay for long time in the field due to strong insulation of capping and casing.
- It stays safe from oil, steam, smoke and rain.

- No risk of electric shock due to covered wires and cables in casing & capping.

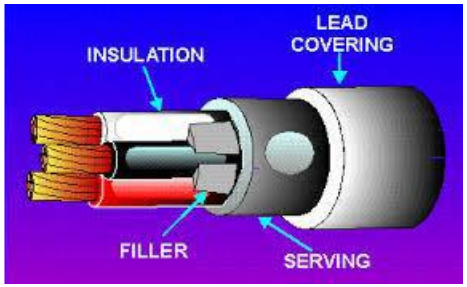
Disadvantages Casing Capping Wiring:

- There is a high risk of fire in casing & capping wiring system.
- Not suitable in the acidic, alkalies and humidity conditions
- Costly repairing and need more material.
- Material can't be found easily in the contemporary
- White ants may damage the casing & capping of wood.

Lead Sheathed Wiring

The type of wiring employs conductors that are insulated with VIR and covered with an outer sheath of lead aluminum alloy containing about 95% of lead. The metal sheath given protection to cables from mechanical damage, moisture and atmospheric corrosion.

The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against electrolytic action due to leaking current and to provide safety in case the sheath becomes alive. The cables are run on wooden batten and fixed by means of link clips just as in TRS wiring.



Conduit Wiring

There are two additional types of conduit wiring according to pipe installation

- Surface Conduit Wiring.
- Concealed Conduit Wiring.

Surface Conduit Wiring

Concealed Conduit wiring

Surface Conduit Wiring

If conduits installed on roof or wall, it is known as surface conduit wiring. In this wiring method, holes are made on the surface of wall on equal distances and conduit is installed then with the help of rawal plugs.

Concealed Conduit Wiring

If the conduits are hidden inside the wall slots with the help of plastering, it is called concealed conduit wiring. In other words, the electrical wiring system installed inside the walls, roofs or floors with the help of plastic or metallic piping is called concealed conduit wiring. It is the most popular, beautiful, stronger and common electrical wiring system nowadays.

PVC PIPE OR PVC CONDUIT

An electrical conduit is a tube used to protect and route electrical wiring in a building or non-building structure. Electrical conduits may be made of metal, plastic, fiber, or fired clay. Conduit is generally installed by electricians at the site of installation of electrical equipment. Its use, form, and installation details are often specified by wiring regulations.

Electrical conduit provides very good protection to enclosed conductors from impact, moisture, and chemical vapors. Varying numbers, sizes, and types of conductors can be pulled into a conduit, which simplifies design and construction compared to multiple runs of cables or the expense of customized composite cable. Wiring systems in buildings may be subject to frequent alterations. Frequent wiring changes are made simpler and safer through the use of electrical conduit, as existing conductors can be withdrawn and new conductors installed, with little disruption along the path of the conduit.

Types of Conduit

Following conduits are used in the conduit wiring systems (both concealed and surface conduit wiring) which are shown in the below image:

- Metallic Conduit
- Non-metallic conduit

Metallic Conduit:

Metallic conduits are made of steel which are very strong but costly as well. There are two types of metallic conduits.

- Class A Conduit: Low gauge conduit (Thin layer steel sheet conduit)
- Class B Conduit: High gauge conduit (Thick sheet of steel conduit)

Non-metallic Conduit:

A solid PVC conduit is used as non-metallic conduit now-a-days, which is flexible and easy to bend.

Size of Conduit:

The common conduit pipes are available in different sizes generally ranging from, 13, 16.2, 18.75, 20, 25, 37, 50, and 63 mm (diameter) or 1/2, 5/8, 3/4, 1, 1.25, 1.5, and 2 inches in diameter.

Advantages of Conduit Wiring Systems

- It is the safest wiring system (concealed conduit wring).
- Appearance is very beautiful (in case of concealed conduit wiring).
- No risk of mechanical wear & tear and fire in case of metallic pipes.
- Customization can be easily done according to the future needs.
- Repairing and maintenance is easy.
- There is no risk of damage the cables insulation.
- It is safe from corrosion (in case of PVC conduit) and risk of fire.
- It can be used even in humidity, chemical effect and smoky areas.
- No risk of electric shock (in case of proper earthing and grounding of metallic pipes).
- It is reliable and popular wiring system.
- It is sustainable and long-lasting wiring system.

Disadvantages of Conduit Wiring Systems

- It is expensive wiring system (due to PVC and metallic pipes, additional earthling for metallic pipes Tee(s) and elbows etc.
- It is very hard to find the defects in the wiring.
- Installation is not easy and simple.
- Risk of electric shock (in case of metallic pipes without proper earthling system).
- It is very complicated to manage additional connection in the future.

Comparison between different Wiring Systems

Below is the table which shows the comparison between all the above mentioned wiring systems:

S.No	Particulars	Cleat Wiring	Casing Capping Wiring	Batten Wiring	Conduit Wiring
1	Life	Short	Fairly long	Long	Very long
2	Cost	Low	Medium	Medium	Highest
3	Mechanical Protection	None	Fair	None	Very good
4	Possibility of fire	Nil	Good	Good	Nil
5	Protection from dampness	None	Slight / a little	None	Good
6	Type of labor required	Semi-Skilled	Highly Skilled	Semi-skilled	Highly Skilled
7	Installation	Very Easy	Difficult	Easy	Difficult
8	Inspection	Easy	Easy	Easy	Difficult
9	Repair	Easy	Little bit difficult	Easy	Difficult
10	Popularity	Nil	Fair	Nil	Very High

Comparison of Different Wiring Systems

Perform Wiring Test

Dimensional and Constructional Testing

The tests for Diameter, thickness, ovality and marking are being performed by the manufacturer of the cable or wire. Following are some of the names of the test given bellow:

Mechanical

Mechanical characteristics before and after ageing, hot set test, cold impact, cold bend, elongation at low temperature, pressure test at high temperature, dynamic penetration test

Electrical

Resistance of conductor, voltage test, insulation resistance, long-term resistance of insulation to DC, surface resistance of sheath

Thermal

Compatibility test, damp heat test, thermal endurance

Chemical

Resistance against acid and alkaline

Environmental

Resistance to ozone, weathering/UV resistance

Analytical

Assessment/absence/determination of halogen

Flammability

Vertical flame propagation, smoke emission of cable

S. no	Kind of test	Test conditions
1	Conductor Resistance	Measuring of conductor resistance.
2	High voltage test at complete cable	Dielectric test in water at complete cable with 6,5 kV AC or 15 kV DC
3	Absence of faults	Dielectric test at complete cable with 10 kV AC (100% during production)
4	Measurement of insulation resistance	
5	Insulation resistance at 20°C	Minimum insulation resistance
6	Insulation resistance at 90°C	
7	Surface resistance of sheath	Minimum resistance : $10^9\,\Omega$

S. no	Kind of test	Test conditions
1	Tensile test before ageing	Minimum tensile strength for insulation and sheath:8,0 N/mm² Minimum elongation at break for insulation and sheath: 125%
2	Tensile test after ageing in oven at 150°C	Measuring of tensile strength at insulation and sheath (variation max. -30%) and elongation at break (variation max.-30%).
3	Hot set test at 250°C	elongation under load, max. 100% permanent elongation after cooling, max. 25%
4	Thermal endurance properties for 20.000h	Complete cable, tests acc. to EN 60216-2 for thermal index 120(20.000h) 4 test sequences (last sequence min. 5000h).
5	Cold elongation test.	Tensile test at low temperature (only for cables with diameters > 12,5mm), elongation at break min. 30%
6	Sheath resistance against acid and alkaline solution	Tensile and elongation test after storing in N-Oxal-acid and N-sodium hydroxide solution. Variation of tensile strength max. ± 30%, elongation at break min. 100%.
7	Compatibility test	Tensile and elongation test after storing in a heating cabinet (135°C – 7days) Variation of tensile strength and elongation at break: max. ± 30% for insulation, max. -30% for sheath
8	Cold impact test	No cracks
9	Cold bending test	Cable diameter ≤ 12,5 mm
10	Ozone resistance test on complete cable	Method A according to EN 60811-403 or Method B No cracks
11	Weathering test	Test acc. to method A of ISO 4892-2: 500 h at 60W/m², 300-400nm, 65°C, 50%RH, cycles: 18 min spraying, 102min drying with Xenon-lamp
12	Dynamic penetration test	No penetration before minimum value according to following formula is reached: $F = 150 \cdot \sqrt{D_n}$

13	Damp heat test: Tensile test after ageing climatic chamber	Tensile test after storing for 1000h at 90°C and 85%rH max. variation of tensile strength and elongation at break: max. -30%.
14	Shrinkage test	Maximum shrinkage is 2 % after storing for 1h at 120°C
15	Test for vertical flame propagation at complete cable	Distance between lowest end of upper fixation and starting point of charring shall be minimum 50mm. Additionally the spread of charring below lowest end of upper fixation shall be less than 540mm
16	Smoke emission of complete cable	Result to be obtained : light ransmittance, min. 60%
17	Absence of halogen	min. pH-value: 4,3 max. conductivity: 10□S/mm Chlorine and Bromine content, expressed in HC: max. 0,5% Flouride content: max. 0,1%

Learning Unit: 5

Carry Out Battery Test

A battery resembles a living organism that cannot be measured, only estimated to a varied degree of accuracy based on available symptoms. This simulates a doctor examining a patient by taking multiple tests and applying the law of elimination. Rapid-test methods for batteries have been lagging behind other technologies; complexity and uncertain results when testing outliers are the reasons for the delay.

Cadex realizes the importance of battery diagnostics and has made notable advancements in rapid-test technologies. These developments form the building blocks for Diagnostic Battery Management (DBM), a new direction innovative companies are pursuing in the care and maintenance of batteries. Rather than inventing another new super battery, DBM is vital to assure reliability of current battery systems by monitoring capacity, the leading health indicator, along with other parameters.

Capacity represents energy storage, internal resistance relates to current delivery, and self-discharge reflects mechanical integrity. All three properties must be met to qualify a battery. In addition to these static characteristics, a battery has different of state-of-charge (SoC), dynamic characteristics that effect battery performance and complicate rapid-testing.

Well-developed battery test technologies must recognize all battery conditions and provide reliable results, even if the charge is low. This is a demanding request as a good battery that is only partially charged behaves in a similar way to a faded pack that is fully charged.

Test methods range from taking a voltage reading, to measuring the internal resistance by a pulse or AC impedance method, to coulomb counting, and to taking a snapshot of the chemical battery with Electrochemical Impedance Spectroscopy (EIS). Capacity estimations by deciphering the chemical battery are more complex than digital monitoring by coulomb counting. Digging into the chemical battery involves proprietary algorithms and matrices that function as lookup tables similar to letter or face recognition.

Voltage and internal resistance do not correlate with capacity and fail to predict the end of battery life effectively, especially with Li-ion and lead acid systems. The truth lies in the chemical battery. A digital measurement alone is subject to failure because the chemical symptoms are not represented.

Here are the most common battery test methods:

Voltage: Battery voltage reflects state-of-charge in an open circuit condition when rested. Voltage alone cannot estimate battery state-of-health (SoH).

Ohmic test: Measuring internal resistance identifies corrosion and mechanical defects when high. Although these anomalies indicate the end of battery life, they often do not correlate with low capacity. The ohmic test is also known as impedance test.

Full cycle: A full cycle consists of charge/discharge/charge to read the capacity of the chemical battery. This provides the most accurate readings and calibrates the smart battery to correct tracking errors, but the service is time consuming and causes stress.

Rapid-test: Common test methods include time domain by activating the battery with pulses to observe ion-flow in Li-ion, and frequency domain by scanning a battery with multiple frequencies. Advanced rapid-test technologies require complex software with battery-specific parameters and matrices serving as lookup tables.

BMS: Most Battery Management Systems estimate SoC by monitoring voltage, current and temperature. BMS for Li-ion also counts coulombs.

Coulomb counting: The Full Charge Capacity (FCC) of a smart battery provides coulomb count that relates to SoH. FCC readout is instant but the data gets inaccurate with use and the battery requires calibration with a full cycle.

Read-and-Charge: A charger featuring RAC technology reads battery SoC with a proprietary filtering algorithm and then counts the coulombs to fill the battery. RAC requires a onetime calibration for each battery model; cycling a good pack provides this parameter that is stored in the battery adapters. RAC technology is a Cadex development.

SOLI: The State-of-Life-Indicator estimates battery life by counting the total coulombs a battery can deliver in its life. A new battery starts at 100%; delivered coulombs decrease the number until the allotment is spent and a battery replacement is imminent. The full scale is set by calculating the coulomb count of 1 cycle based on the manufacturer's specifications (V, Ah) and then by multiplying the number with the given cycle count. Developed by Cadex, SOLI can be used in wheelchairs, medical devices, traction and UPS, installed when new or added as retrofit. Wireless connectivity provides fleet management.

Reliable results are only possible when robust symptoms are present. This is not always possible, especially with unformatted lead acid batteries or packs that had been in storage. A good battery pulled form service generally provides solid symptoms with good accuracy; readings from a weak battery can be muddled with inconsistent results. Reliable measurements are impossible if the symptoms are vague or not present, which is the case if the battery has turned into a potato. This fools the system and the battery becomes an outlier. Well-developed rapid-test methods should correctly predict 9 batteries out of 10. EIS has the potential to advance further and surpass other technologies.

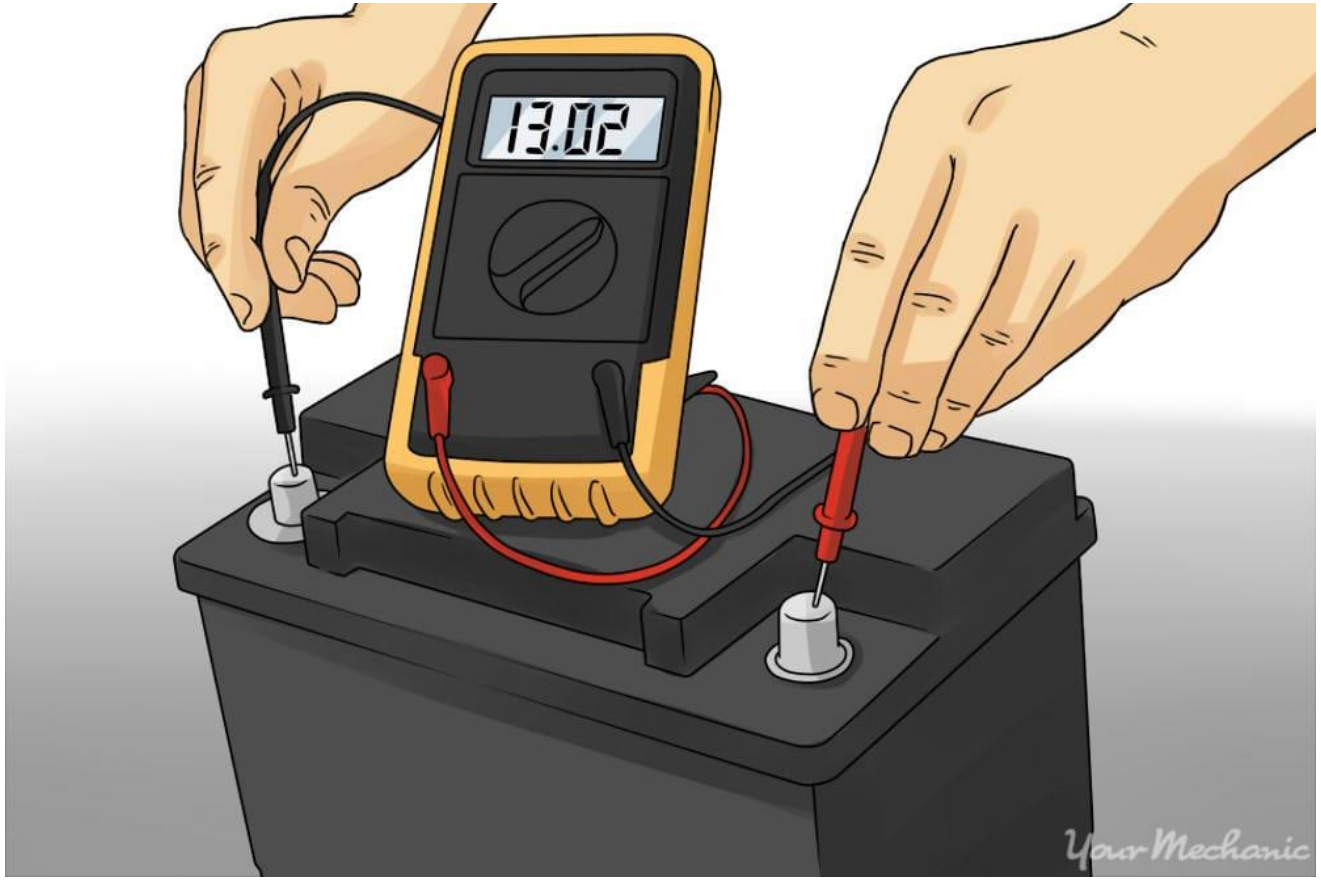


Table 1 summarizes test procedures with the most common battery systems. Lead acid and Li-ion share communalities in keeping low resistance under normal condition. Exceptions are heat fail and mechanical faults that raise the internal resistance and a battery replacement ahead of time. Nickel-cadmium and nickel-metal-hydride, and in part also the primary battery, reveal the end-of-life.

Test Method		Lead acid	Nickel-based	Li-ion	Primary battery
ANALOG	**Voltage**	Estimates SoC in open circuit condition. Temperature and active materials within a battery system may cause slight voltage variations. Performance evaluation is not possible.			
	Ohmic test	Identifies heat fail and other defects; cannot do capacity estimation	Correlation exists between resistance and capacity	Low capacity may not affect resistance	Resistance relates to SoC; unique for each battery type
	Full Cycle	Use sparingly on large batteries	Recommended for small batteries		N/A
	Rapid-test	*Time domain* checks resistance, ion flow; *Frequency domain* reads capacity	Internal resistance correlates in part with SoH.	High efficiency enables time and frequency domain	Resistance check with lookup table for diverse batteries possible
	BMS	Voltage, current and temperature sense to monitor battery	Not practical due to inefficiencies	High efficiency enables coulomb counting	SoC by voltage
DIGITAL	**Coulomb counting**	Low charge and discharge efficiency makes this impractical	Not suitable due to low efficiency and high self-discharge	Good for most Li-ion. LiFePO has high self-discharge	Used for critical applications with good results
	Read-and-charge (RAC)	Not practical because of low charge and discharge efficiency, high self-discharge		Enabled by high efficiency	N/A
	SOLI (State-of-life-indicator)	Estimates battery life based on delivered energy. A new battery starts at 100%. Drawing energy consumes the coulomb allotment, prompting battery replacement when zero. Can be applied to all batteries.			

Battery test methods for common battery chemistries

Table 1: Battery test methods for common battery chemistries. Lead acid and Li-ion share communalities by keeping low resistance under normal condition; nickel-based and primary batteries reveal end-of-life by elevated internal resistance.

At a charge efficiency of 99 percent, Li-ion is best suited for digital battery estimation. This helps in BMS design by enabling capacity estimation with coulomb counting. While the readings are instant, occasional calibration is needed to correct the tracking error that occurs with random battery usage. In comparison, nickel-based batteries have low charge efficiency and high self-discharge, deficiencies that would skew digital tracking. Under the right conditions and moderate temperature, lead acid batteries are reasonably efficient but not quite good enough to use coulomb counting effectively.

Cold temperature reduces the efficiency of all batteries and affects rapid-testing. Although a battery may function below freezing, charge acceptance is reduced and charge times must be prolonged by lowering the current. Some chargers do this automatically; if not certain, do not charge Li-ion batteries below freezing.

Summary

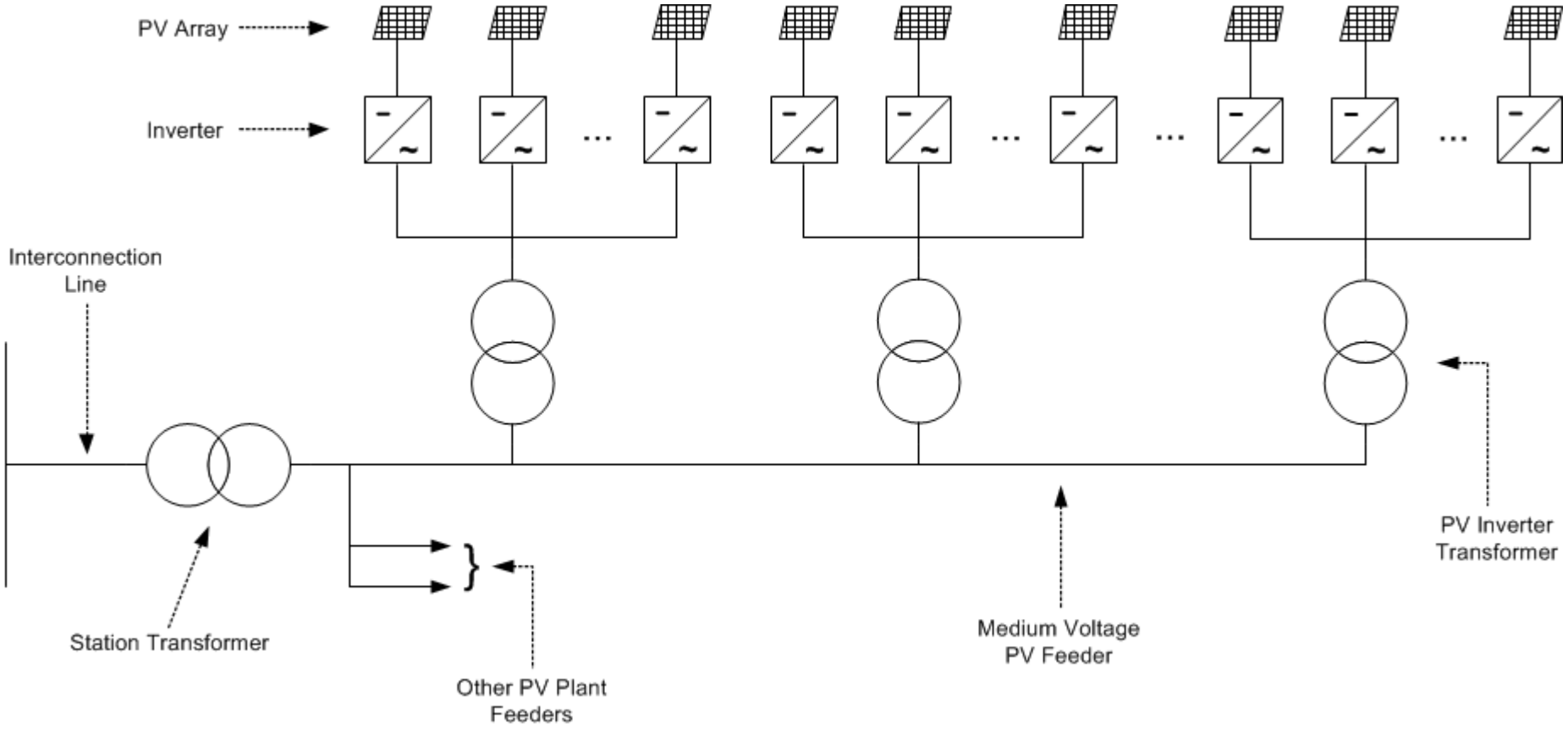
Mark Twain said: “I didn't have time to write a short letter, so I wrote a long one instead.” Efforts to make something “short” also apply in the development of Diagnostic Battery Management. Adding features is easy, but also keeping the price affordable is a challenge. Switching to new microcontrollers with added intelligence and simplifying assembly enables new product features that were unthinkable a few years ago. But as Mark Twain hinted, making something economical takes time.

The objective is to advance the battery into a reliable, safe, cost efficient and environmentally sustainable power source. This requires systems that operate in the background with minimal overhead and little extra cost. The goal is to fully utilize each battery and make state-of-health transparent to the user and fleet supervisor. This can make unexpected battery failures a thing of the past.

Interconnect the PV System

The point of connection is the location at which the DG source including a PV system can be interconnected with the electric utility grid. Since adding power at that point is beyond the initial intended design of the existing electric system at the point of connection, all service equipment, such as main power distribution panel disconnects and conductors, must be sized and rated to allow this addition.

The output of the inverter to be connected to either load side (customer side) or supply side (utility side) service points depending on the size of the PV system and marginal power available at that point. In large a PV system, the available service might not have enough capacity to handle the added power and, in this case, a separate service may need to be installed. A backfeed circuit breaker is a circuit breaker that allows current flow in either direction. The backfeed circuit breaker provides overcurrent protection of the branch circuits from the inverter, and the panel's main service circuit breaker provides protection of the entire PV and load system from the utility. Regardless of the interconnection type, Utility Authorities requires that a permanent directory be placed at each service location showing all power sources for a building.



Load-side interconnection:

Common in small PV systems, the main service disconnect at the customer facility has enough margin to handle the extra capacity added by the PV system, and that allowed an interconnection at the load side.

The type of interconnection providing the following conditions (we will only mention the technical-related issues):

In case multiple power sources are to be interconnected, each added power source (inverter in PV case) must have a dedicated circuit breaker or fused disconnect unless their outputs are first combined at a sub-panel.

Fulfillment of the 120% rule that states that the sum of the rating of the OCPD in all circuits supplying power to a busbar or conductor must not exceed 120% of the rating of the busbar or conductor to prevent overloading conditions. This only applies to breakers that supply the load center with power including the main utility fed circuit breakers and any back-fed circuit breakers from PV sources (load circuit breakers are not considered)

“Bus or Conductor Rating. The sum of the ampere ratings of overcurrent devices in circuits supplying power to a busbar or conductor shall not exceed 120% of the rating of the busbar or conductor.”

In the 2014 code, this straightforward sentence has been revised to include several paragraphs with different scenarios. The meaning might look the same, however, and once you understand the philosophy you will be able to understand Utility Authorities more sophisticated version. It really is the designer’s knowledge to correctly interpret the code since Utility Authorities provide more flexibility to allow more PV capacity for the same circuit size.

The sum of 125 percent of the inverter(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the ampacity of the busbar.

Where two sources, one a utility and the other an inverter, are located at the opposite ends of a busbar that contains loads, the sun of 125 percent of the inverter(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Utility Authorities.

The sum of the ampere rating of all overcurrent devices on panelboards, both load and supply devices, excluding the rating of the overcurrent device protecting the busbar, shall not exceed the ampacity if the busbar. The rating of the overcurrent device protecting the busbar shall not exceed the rating of the busbar.

Interconnection point to be on the supply side of all ground fault protection equipment.

A back-fed circuit breaker in the panel board shall be positioned at the opposite end from the main circuit breaker and marked with a warning label at the back-fed breaker from the PV system.

Learning Unit: 7

Configure the Inverter / Charge Controller

Program	Description	Selectable option		
00	Exit setting mode	Escape		
01	Output source priority: To configure load power source priority	Solar first	Solar energy provides power to the loads as first priority. If solar energy is not sufficient to power all connected loads, battery energy will supply power the loads at the same time. Utility provides power to the loads only when anyone condition happens: -Solar energy is not available -Battery voltage drops to low-level warning voltage or the setting point in program 12.	
		Utility first (default)	Utility will provide power to the loads as first priority. Solar and battery energy will provide power to the loads only when utility power is not available.	
		SBU priority	Solar energy provides power to the loads as first priority. If solar energy is not sufficient to power all connected loads, battery energy will supply power to the loads at the same time. Utility provides power to the loads only when battery voltage drops to either low-level warning voltage or the setting pointing program 12.	
02	Maximum charging current: To configure total charging current for solar and utility chargers. (Max. charging current = utility charging current + solar charging current)	Available options in 1KW/2KWmodel:		
		10A	20A	
		30A	40A	
		50A (default)		
	Maximum charging current: To configure total charging current for solar and utility chargers. (Max. charging current = utility charging current + solar charging current)	Available options in 3KWmodel:		
		10A	20A	
		30A	40A	
		50A (default for PWM model)	60A	
		70A (only for PWM model)		
	Maximum charging current: To configure total charging	Available options in 3KWmodel:		

	current for solar and utility chargers. (Max. charging current = utility charging current + solar charging current)	10A	20A
		30A	40A
		50A (default for PWM model)	60A (default for MPPT model)
		70A (only for PWM model)	80A
		90A	100A
		110A	120A (only for MPPT Models)
03	AC input voltage range	Appliances(default)	If selected, acceptable AC input voltage range will be within 90-280VAC.
		UPS	If selected, acceptable AC input voltage range will be within 170-280VAC.
05	Battery type	AGM(default)	Flooded
		User-Defined	If “User-Defined” is selected, battery charge voltage and low DC cut-off voltage can be set up in program 26, 27 and 29.
06	Auto restart when overload occurs	Restart disable(default)	Restart enable
07	Auto restart when over temperature occurs	Restart disable(default)	Restart enable
09	Output frequency	50Hz(default)	60Hz
11	Maximum utility charging current Note: If setting value in program 02 is smaller than that in program in 11, the inverter will apply charging current from program 02 for utility charger.	Available options in 1KW/2KWmodel:	
		10A	20A(default)
		Available options in 3KWmodel:	
		15A	25A(default)
		Available options in 3KWPlus/5KWmodel:	
		2A	10A
		20A	30A(default)
		40A	50A
		60A	
12	Setting voltage point back to utility source when selecting “SBU priority” or “Solar first” in program 01.	Available options in 1KWmodel:	
		11.0V	11.3V
		11.5V(default)	11.8V
		12.0V	12.3V
		12.5V	12.8V

12	Setting voltage point back to utility source when selecting “SBU priority” or “Solar first “in program 01.	Available options in 2KW/3KW/3KWPlusmodel:	
		22.0V	22.5V
		23.0V(default)	23.5V
		24.0V	24.5V
		25.0V	25.5V
		Available options in 5KWmodel:	
		44V	45V
		46V(default)	47V
		48V	49V
		50V	51V
13	Setting voltage point back to battery mode when selecting “SBU priority” or “Solar first” in program 01.	Available options in 1KWmodel:	
		Battery fully charged	12.0V
		12.3V	12.5V
		12.8V	13.0V
		13.3V	13.5V (default)
		13.8V	14.0V
		14.3V	14.5V
		Available options in 2KW/3KW/3KWPlusmodel:	
		Battery fully charged	24V
		24.5V	25V
		25.5V	26V
		26.5V	27V (default)
		27.5V	28V
		Available options in 5KWmodel:	
		Battery fully charged	48V
		49V	50V
		51V	52V
		53V	54V (default)
		55V	56V
		57V	58V
16	Charger source priority: To configure charger source priority	If this inverter/charger is working in Line, Standby or Fault mode, charger source can be programmed as below:	
		Solar first	Solar energy will charge battery as first priority. Utility will charge battery only when solar energy is not available.
		Utility first	Utility will charge battery as first priority. Solar energy will charge battery only when utility power is not available.

		Solar and Utility(default)	Solar energy and utility will charge battery at the same time.
		Only Solar	Solar energy will be the only charger source no matter utility is available or not.
		If this inverter/charger is working in Battery mode or Power saving mode, only solar energy can charge battery. Solar energy will charge battery if it's available and sufficient.	
18	Alarm control	Alarm on(default)	Alarm off
19	Auto return to default display screen	Return to default display screen(default)	If selected, no matter how users switch display screen, it will automatically return to default display screen (Input voltage /output voltage) after no button is pressed for 1 minute.
		Stay at latest screen	If selected, the display screen will stay at latest screen user finally switches.
20	Backlight control	Backlight on(default)	Backlight off
22	Beeps while primary source is interrupted	Alarm on(default)	Alarm off
23	Overload bypass: When enabled, the unit will transfer to line mode if overload occurs in battery mode.	Bypass disable(default)	Bypass enable
25	Record Fault code	Record enable (default)	Record disable
26	Bulk charging voltage (C.V voltage)	5KWdefault setting: 56.4V	
		If self-defined is selected in program 5,this program can be set up. Setting range is from 12.5V to 15.0V for 1K model,25.0V to 31.5V for 2KW/3KW/3KWPlusmodeland48.0V to61.0Vfor 5KWmodel.Increment of each click is 0.1V.	
27	Floating charging voltage	1KWdefaultsetting:13.5V	
		2KW/3KW/3KWPlusdefaultsetting:27.0V	
		5KWdefault setting:54.0V	
		If self-defined is selected in program 5, this program can be set up. Setting range is from 12.5V to 15.0V for 1K model, 25.0V to 31.5V for 2KW/3KW/3KWPlusmodeland48.0V to 61.0Vfor 5KWmodel. Increment of each click is 0.1V.	
29	Low DC cut-off voltage	1KWdefaultsetting: 10.5V	
		2KW/3KW/3KWPlusdefaultsetting:21.0V	

		5KWdefault setting:42.0V	
		If self-defined is selected in program 5, this program can be set up. Setting range is from 10.5V to 12.0V for 1K model, 21.0V to 24.0V for 2KW/3KW/3KWPlusmodeland 42.0V to 48.0Vfor 5KWmodel. Increment of each click is 0.1V.Low DC cut-off voltage will be fixed to setting valueno matter what percentage of load is connected.	
30	Battery equalization	Battery equalization	Battery equalization disable(default)
		If “Flooded “or “User-Defined” is selected in program 05, this program can be set up.	
31	Battery equalization voltage	1KWdefault setting: 14.6V	
		2KW/3KW/3KWPlusdefault setting: 29.2V	
		5KWdefault setting: 58.4V	
33	Battery equalized time	60min (default)	Setting range is from 5min to 900min.Increment of each click is 5min.
34	Battery equalized timeout	120min (default)	Setting range is from 5min to 900min.Increment of each click is 5min.
35	Equalization interval	30days (default)	Setting range is from 0 to 90days.Increment of each click is 1day
36	Equalization activated immediately	Enable	Disable
		If equalization function is enabled in program 30, this program can be set up. If “Enable” is selected in this program, it’s to activate battery equalization immediately and LCD main page will show “If “Disable” is selected, it will cancel equalization function until next activated equalization time arrives based on program 35 setting. At this time, “” will not be shown in LCD main page.	

KNOWLEDGE ASSESSMENT TEST

(Perform Solar PV system Wiring)

Module:5 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) In series connection current

a. Increases
b. Decreases
c. Remains same
d. None of above

2) Which test can confirm that wire is broken in the middle?

a. Continuity test
b. Polarity test
c. Earthing test
d. None of above

3) Which test can confirm that the battery cell voltage is low

a. Polarity test
b. Gravity test
c. Continuity test
d. Battery test

4) In a charge controller what should be the first component to be connected?

a. Solar panels

b. Stands
c. Earthing plate
d. Battery

5) In case of open circuit, the current flowing in the circuit is

a. Zero
b. Very low
c. Normal
d. Infinite

Instructions to Candidates: You must write short answers to all questions.

Q1. What are the types of Electrical Wiring?

Answer:

Q2. How to connect 50 panels in such a way to get 100V from 20V?

Answer:

Q3. How to cover the cables from environmental damage?

Answer:

Q4: Briefly write wiring tests.

Answer:

Q5. Please explain five different configurations of hybrid inverter?

Answer:

BUILDING ELECTRICIAN SOLAR PV SYSTEM TECHNICIAN

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Module-6

Module – 6: Troubleshoot Solar PV System

Objective: This module covers the skills and knowledge required to Diagnose the fault, identify solution of the faults, rectify the faults, carryout post rectification function test and finally perform wiring test.

Duration:	**70 hours**	**Theory:**	**16 hours**	**Practical:**	**54 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Diagnose the fault	**Trainee will be able to:** • Check inverter for fault code • Verify safety circuits • Check status of wiring • Verify status of battery • Check status of PV Panels • Identify nature of the fault (Hardware or software) • Diagnose the cause of fault • Document the fault	• Consult the respective manuals • Types of fault code. • Required tools/equipment. • Safety procedure for fault diagnoses. • Method for testing of wiring. • Method for testing batteries. • Method for testing of PV panel • Common fault in Hardware • Common fault in software. • Standard report format.	**70Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Identify solution of the faults	**Trainee will be able to:** • Trace out solution of fault code with the help of manual • Estimate cost of rectification • Report the fault to the concerned persons	• Standard fault code correction procedure. • Bill of quantity (BOQ) & or estimated cost. • Reporting format.			**Class room** **Theory** **Lab** **Practical**
LU-3: Rectify the faults	**Trainee will be able to:** • Reset the software for rectification • Arrange the required tools and equipment • Arrange the required material and components • Repair faulty component / equipment	• Rectification procedure. • Tools and equipment. • Materials/components • Repair or replace procedure.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
	• Replace faulty component / equipment • Refer irreparable / un-replaceable faults to the concerned lab				
LU-4: Carryout post rectification function test	**Trainee will be able to:** • Re connect the system with the load • Verify function of the system on full load • Document the services as per instructions • Clean and pack the store as per sop	• No load test • Full load test • Standard operating procedure (SOP). • Reporting format. • Preventive Maintenance. • Standard Housekeeping procedure.			**Class room** **Theory** **Lab** **Practical**
LU-5: Perform wiring tests	**Trainee will be able to:** • Perform continuity test • Perform polarity test • Perform earth test • Rectify the problem	• Method of: ○ Continuity test ○ Polarity test ○ Earth test • Rectify the problem as per sop.			**Class room** **Theory** **Lab** **Practical**

Diagnose the Fault

When a fault occurs in an inverter, the icon ⚠ will flash as a reminder. See below for fault codes for reference.
Note: When the fault occurs, it will be recorded in the flash, Max 9 faults can be saved. You can use Solar Power to read the fault data log. The detail information please refer to Solar Power Manual.

Fault Code	Fault Event	Icon on
01	Fan is locked when inverter is off.	
02	Over temperature	
03	Battery voltage is too high	
04	Battery voltage is too low	
05	Output short circuited or over temperature is detected by internal converter components.	
06	Output voltage is abnormal. (For 3KWmodel) Output voltage is too high. (For 3KWPlus/5KWmodel)	
07	Overload timeout	
08	Bus voltage is too high	
09	Bus soft start failed	
51	Over current or surge	
52	Bus voltage is too low	

53	Inverter soft start failed	
55	Over DC voltage in AC output	
56	Battery connection is open	
57	Current sensor failed	
58	Output voltage is too low	

When there is no information displayed in the LCD, please check if PV module connection is correctly connected.

Warning Situation

There are 4 situations defined as warnings. When a warning situation occurs, icon will flash and the fault code area will display “WR” wordings. No PV module is connected	flash failure
Inverter initial failure	Fan failure (Only for 5KW)

Possible Battery Problems

Physical Damage

If the battery is stored, handled or fitted incorrectly, if the connectors leads are hammered onto terminals, leads are not correctly fastened, the battery will have damage to casing and/ or terminals. This is not a manufacturing fault.

Sulphation

If a battery is allowed to stand in a discharged state either on or off a vehicle for a period of time, a chemical reaction takes place which will permanently impair the performance and life of the battery, this process is called “sulphation”. Sulphation can be seen as a fine white/grey coating on the positive plate and a non-metallic lustre on the negative plate. In most cases this signifies the battery as not serviceable. Attempts to recharge batteries left in a discharged state, even at very low charge rates will lead to damage to the grid and active material interfaces and also sulphate deposits can be formed within the separators. The damage can occur in storage or if the battery is installed on the vehicle (or equipment) that is not used for a period of time. This is because there is a permanent drain on the battery from items such as the alarm, clock, lights, etc. left on which drag the battery down to its lowest possible state of charge. The longer the period left, the greater the sulphation builds up on the plates. The sulphation hinders the efficiency of the electrochemical reactions within the battery between the active material of the plates and the acid.

Wear

As the battery is cycled, i.e. charged and discharged, the active materials within the battery plates are in motion in order to release the electricity stored by the battery. Every time the battery is charged and discharged a small amount of active material is permanently lost from the plates. As the ultimate battery life is determined by many factors, such as temperature, battery operating state of charge, etc it is impossible to stipulate a minimum/maximum life expectancy in the field. This process of normal ageing will eventually cause the battery to lose capacity and it will come to the point where the battery can no longer start the vehicle or equipment.

Deep Cycling

As above, every time a battery is charge and discharge cycled a small amount of material is lost. If a battery is subjected to deep discharging (greater than 35%) and rapid charging the process is accelerated. Additionally, if the recharge does not recover the discharge cycle in full, the battery will exhibit loss of performance and concentration of the acid can occur between plates which can lead to corrosion and loss of performance. Even after recharging, the voltage will be low (under 12.4V).

Overcharging

If the alternator regulator is not set properly, or alternator voltage control circuit fails, then the battery can be subjected to an excessive charge. If left unchecked the battery will overheat and will start to evaporate the electrolyte. The overcharging will accelerate the breakup of the active material and grids and the battery will lose performance. Examination of the battery will typically show low acid level and usually a black coating on filler plugs and a strong smell. It is recommended that the alternator charging voltage is checked by a mechanic. This is not a manufacturing fault.

Incorrect Application

The batteries recommended within this VeGa application list are equal to or above the original equipment specification. Fitting a smaller or less powerful battery will result in a shorter service life and earlier failure. The failure will normally be seen as deep cycling/premature wear and tear.

Undercharging

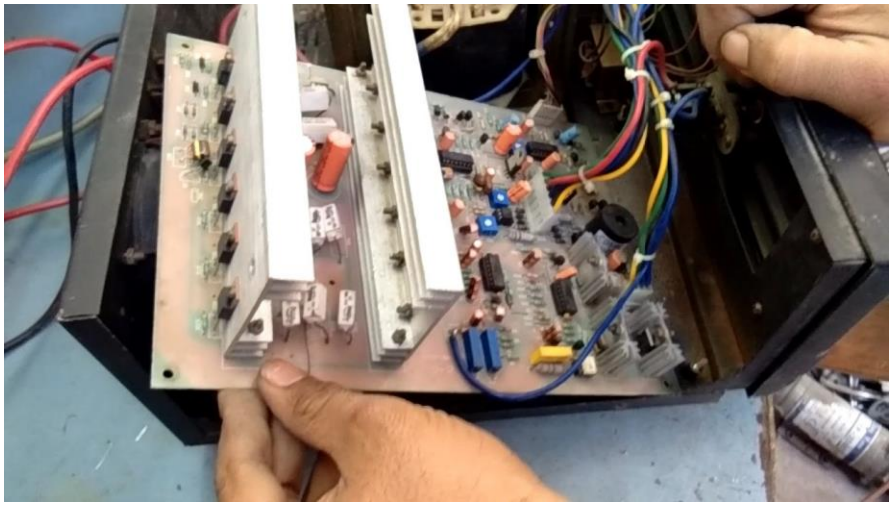
Undercharging occurs if the battery is not receiving enough charge to return it to a full state of charge, this will slowly cause sulphation. This fault can occur if the car is being used only occasionally for short journeys, or for stop-start urban motoring. Undercharging will occur if alternator voltage is low (13.6-13.8volts).

Identify Solution of the Faults

After diagnosing the fault, the solution of the desired fault should be traced. The fault can mainly be in the following equipment:

- Inverter
- Charge controller
- Batteries
- Wiring and cable
- Panels

After the identification of the fault(s) in the solar PV system, the report of the total parts replacement and repairs should be generated. After report generation then should be provided to the owner of the system. For making the business successful it is necessary to provide the accurate details of repair and also the best(lowest) cost that is available should be given.



Rectify the faults

Fault	Solution
Over voltage on Bus Under voltage on Bus Time out for Bus soft start Time out for Inverter soft start Inverter over current Relay or inverter voltage detector fault Output current sensor failure Power failure DC input over current Inverter DC current over GFCI sensor failure	1. Disconnect AC circuit breaker first. Then, disconnect DC circuit breaker. 2. Until LCD screen completely shuts down, turn on DC breaker first. It will show “No Utility” in LCD screen. Then, turn on AC breaker. After 60 seconds, the system will automatically connect to the grid. 3. If the error message still remains, please contact your installer.
Over temperature	1. The internal temperature is higher than specified temperature. 2. Leave inverter to be cooled to room temperature. 3. If the error message still remains, please contact your installer.
High voltage on PV module	1. Check if the open circuit voltage of PV modules is higher than 500VDC. 2. If PV open circuit voltage is less than 500VDC and the error message remains, please contact your installer.
GFCI failure	1. The ground voltage is too high. 2. Please disconnect AC breaker first and then DC breaker. Check if grounding is connected properly after LCD screen completely shuts down. 3. If grounding is correctly connected, turn on DC breaker. After it displays “No Utility” in LCD screen, turn on AC breaker. After 60 seconds, the system will automatically connect to the grid. 4. If the error message still remains, please contact your installer.
PV insulation failure	1. Check if the impedance between positive and negative poles to the ground is greater than 1MΩ. 2. If the impedance is lower than 1MΩ, please contact your installer.
Line value consistent fail between MCU & DSP	1. Please disconnect AC breaker first and then disconnect DC breaker. 2. After LCD screen is completely off, turn on DC breaker. Until it shows “No Utility” in LCD display, turn on AC breaker. After 60 seconds, the system will automatically connect to the grid.

Connection failure between MCU & DSP	3. If error message remains, please contact your installer.
Communication failure between MCU & DSP	
Ground loss	1. Check if the inverter is connected to the ground. 2. If ground is properly connected and the error message remains, please contact your installer.
Grid voltage loss	1. Grid loss is detected or grid input is not within acceptable range. 2. If grid is ok but the error still remains, please contact your installer.
Grid frequency loss	
Islanding is detected.	Grid is abnormal. Please wait for grid to return.
No display in LCD screen.	1. Check input voltage of PV modules. 2. If input voltage is higher than 150VDC, please contact your installer.
Time display in LCD screen changes quickly or slowly.	1. Please calibrate the timer via software. 2. If the problem remains after calibration, please contact your installer.
Inverter is turned on and turned off in turns.	1. It’s normal situation due to insufficient radiation in the short-term time.

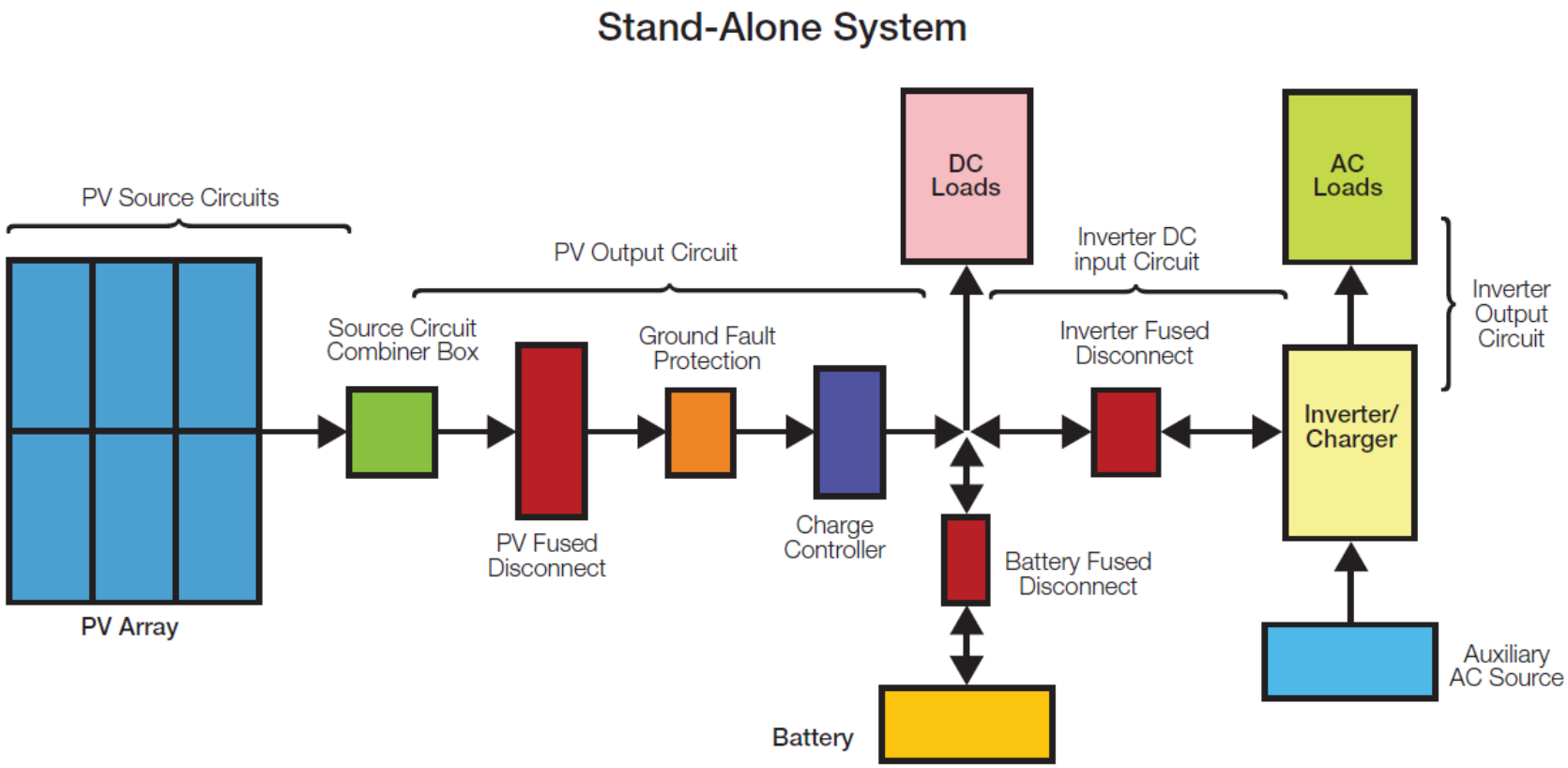
Carryout Post Rectification Function Test

After careful repairs made as per solution described in the manual, it is now time to check if the system works. Make all the connections stepwise and ensure there is no lose connection left behind. If there is any lose connection left, it will ultimately make the connection heated and power loses will occur. This will result in getting low power generation then the desired amount. It can also cause sparks and disconnections are well. Damage can also be made to the wire if the screws are not tightened properly.

These are the following step to be followed before handing over the system to the customer.

- Completing visual inspections.
- Verifying compliance with local rules, regulations and other requirements.
- Conducting electrical verification tests.
- V_{oc}, I_{sc}, insulation resistance, polarity.
- Verifying system functionality including start-up, operations, shut-down and emergency procedures.
- Verifying system power output and energy production meet performance expectations.
- Completing system documentation, including changes for as-built drawings.
- Conducting user orientation and training on system operations and safety.
- Verifying that all structural and electrical components are properly installed and secured.
- Verifying that all components are installed in a neat and workmanlike manner, including wire management practices.
- Verifying proper connections and terminations, including terminal torque specifications.
- Verifying that all required system and equipment labels, marking and placards are correct and in the proper locations.
- Verify that any calibrations or adjustments for inverters, charge controllers or other equipment are properly set or programmed.
- Verifying that all disconnects are open, fuses are removed and lockout/tagout procedures are in place.
- Identifying and completing any unresolved items.

- Completing site clean-up and restoring site to original conditions.



Perform Wiring Tests

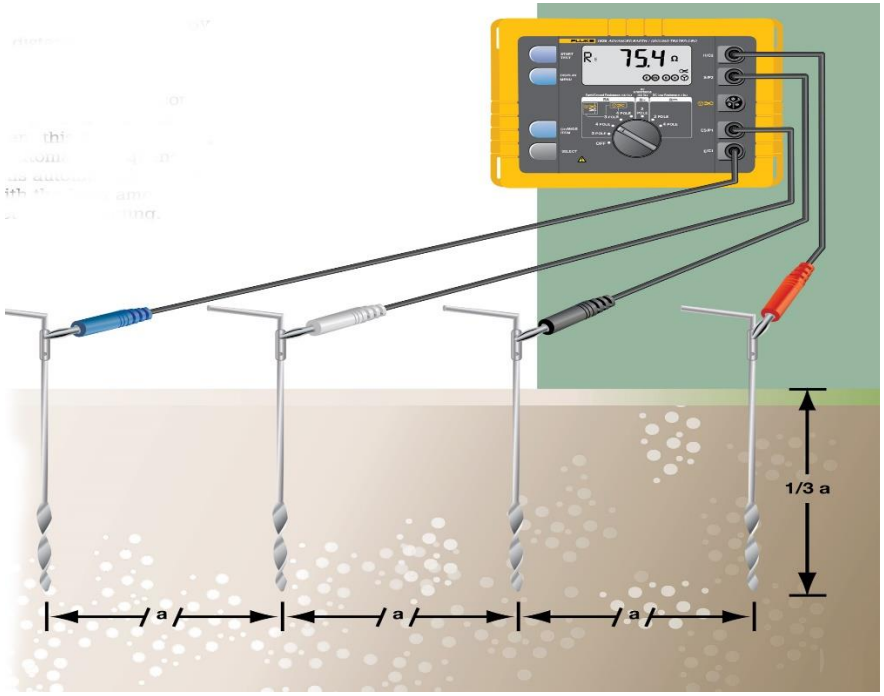
In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path.

Then comes the polarity test 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.
Effective earthing is essential for the safe operation of every electrical system and the only way to ensure that earthing installations are effective and that they remain so, is to test them rigorously and regularly.

Type of soil	Soil resistivity R_E	Earthing resistance					
		Ground electrode depth (meter)			Earthing strip (meter)		
	ΩM	3	6	10	5	10	20
Very moist soil, swamplike	30	10	5	3	12	6	3
Farming soil loamy and clay soils	100	33	17	10	40	20	10
Sandy clay soil	150	50	25	15	60	30	15
Moist sandy soil	300	66	33	20	80	40	20
Concrete 1:5	400	–	–	–	160	80	40
Moist gravel	500	160	80	48	200	100	50
Dry sandy soil	1000	330	165	100	400	200	100

Dry gravel	1000	330	165	100	400	200	100
Stoney soil	30 000	1000	500	300	1200	600	300
Rock	107	–	–	–	–	–	–

The vast majority of power distribution systems are designed so that, if an insulation failure or similar fault occurs, the resulting fault current is diverted to earth. This prevents exposed conductive parts from rising to a dangerous potential, while allowing the fault current to flow for long enough and at a high enough level for protective devices to operate and isolate the fault. It is clear from this description that a reliable, effective earth connection is essential for safe operation of the systems, and that if the earthing system fails or becomes inefficient, at best safety will be compromised and at worst there may well be a significant risk to life and property.



If found such problems, we should try to solve it with care and then start the system accordingly.

KNOWLEDGE ASSESSMENT TEST

Module:6 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) If there is black mark on the connection, it is because of_____.

a. Short circuit
b. Open circuit
c. Perfect circuit
d. Lose connection

2) Inverter is continuously beeping after 2-5seconds mean _____

a. Battery full
b. Battery low
c. Short circuit
d. Open circuit

3) What is the possible fault if panel is not passing any current

a. By-pass diode is burnt
b. Cell is damaged in the panel
c. Panel is broken
d. Dummy cell in a panel

4) Battery gives low voltage, when connected to the load means

a. Battery is new
b. Inverter configuration is wrong
c. Battery cell is short circuited
d. Battery is fully charged

5) Circuit Breaker is turning off automatically after turning on the inverter

a. The circuit breaker is of high ampere
b. The circuit breaker is working properly
c. The circuit breaker is of low ampere
d. None of the above

Instructions to Candidates: You must write short answers to all questions.

Q1. What are different faults regarding solar PV system?

Answer:

Q2. How to check whether resistor is faulty?

Answer:

Q3. What is troubleshooting?

Answer:

Q4: How to perform earthing test?

Answer:

Q5. What is post verification test?

Answer:

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Module-7

Module – 7: Maintain Solar PV system

Objective: This module covers the skills and knowledge required to prepare check list for maintenance, follow routine maintenance log sheet, maintain Solar PV modules and perform post verification function of the system.

Duration:	**100 hours**	**Theory:**	**13 hours**	**Practical:**	**87 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Prepare check list for maintenance	**Trainee will be able to:** • Prepare list of tools and instruments for maintenance • Prepare list of materials for maintenance • Prepare list of activities for maintenance	• Check list for instruments • Check list for tools & equipment • Check list for material as per scope of course. • Maintenance activity check list.	**100Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Follow routine maintenance log sheet	**Trainee will be able to:** • Collect maintenance log sheet • Arrange required tools / instruments for maintenance • Perform activities as per schedule • Place equipment after maintenance as per SOP	• Tools and material required in routine maintenance. • Log sheet • Understand the procedure and techniques of routine maintenance.(5S)			**Class room** **Theory** **Lab** **Practical**
LU-3: Maintain Solar PV modules	**Trainee will be able to:** • Arrange cleaning materials • Wash the panels as per instructions (Avoid washing during peak sun hours). • Check connections and joints of solar PV modules • Check the physical and mechanical health of modules as per standard • Adjust the seasonal tilt angle	• Cleaning material for PV Panels. • Cleaning procedure and techniques. • Safety requirement of PV Panels. • Checking procedure of PV Panels • Till angle.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-4: Maintain inverter /Charge controller/ Protection circuits	**Trainee will be able to:** • Arrange servicing equipment • Check the status of cooling fans • Check input output terminals of inverter s • Perform servicing with electrical blower • Maintain connection status as per standards.	• Types of servicing equipment and materials • Methods of checking of cooling fans. • Inverter input output terminal checking procedure as per standard.			**Class room** **Theory** **Lab** **Practical**
LU-5: Maintain battery bank	**Trainee will be able to:** • Clean terminals of battery with sand paper • Maintain level of electrolytes • Maintain gravity of electrolytes • Maintain battery connections • Apply grease to terminal to avoid corrosion / sulphation • Verify the operations of battery bank	• Tools & equipment for maintenance. • Material for maintenance. • Battery terminal cleanness. • Battery electrolytes. • Battery connections. • Testing procedure.			**Class room** **Theory** **Lab** **Practical**
LU-6: Perform post verification function of the system	**Trainee will be able to:** • Switch on the system • Observe display reading of inverter /charge controller • Perform full load test • Prepare the report of maintenance activities performed	• Post verification of the system. • Inventor display parameter. • Post maintenance record.			**Class room** **Theory** **Lab** **Practical**

Prepare Check List for Maintenance

Maintenance is defined as regularly scheduled inspections, tests, servicing, replacements, repairs and other tasks intended to help reduce the impact and frequency of equipment failures. This includes scheduled preventive maintenance, predictive maintenance and inspection activities.

The objectives of a maintenance program are to help:

Identify maintenance actions on important equipment and incorporate that into the maintenance program activities that result in the greatest benefit within the available budget.

Minimize corrective and breakdown maintenance, maintain satisfactory equipment conditions and improve plant reliability

A preventive maintenance program should be well defined, periodically reviewed and adjusted as necessary. To help ensure proper implementation, procedures should be written in sufficient detail for each piece of equipment in the program.1

Why is maintenance important? The purpose of preventive maintenance is to try to maintain the equipment in optimum working condition and to help prevent any unplanned downtime due to breakdowns. Because components start to wear over time, replacing items prior to failure can cost you far less than the potential consequences of failure while in service. Some people see maintenance as an expense and it can often be one of the first departments to suffer from cuts during difficult times, however, this is very much false. Preventing problems from occurring will almost always be far less than the costs you will incur due to actual failures.2

Maintenance Checklist

Use the list below as a guide to help ensure you are doing everything you can to maintain an efficient facility.

LIGHTING

Inspect at regular intervals, with group replacing lamps when lamps begin to fail.

Any luminaires that have transformers, control gear or accessories, such as spread lenses, glare baffles or color filters, should be routinely checked.

Check exterior lights to make sure cables aren’t torn; all screws and hardware should be in place and working. Gaskets can be replaced to help provide a better watertight seal.

Replace any burned-out lamps and consider group replacing lamps (to create your replacing lamps schedule, calculate lamp life and how often lamps are used).

Ensure that each lamp has the same color temperature.

Re-aim adjustable lighting if necessary.

Dust lamps and clean lens surfaces to enhance lighting performance.

Check all exit lighting for proper installation and function.

Check all interior lighting for proper installation and function.

Check all exterior lighting for proper installation and function.

ELECTRICAL

Change batteries in smoke and carbon monoxide detectors, flashlights and test instruments.

Confirm that timers and photocells are functioning correctly.

Inspect cover plates for cracks and proper tightness.

Inspect and clean all exhaust fans.

SAFETY

Check inventory and restock all first aid kits.

Check eyewash bottles and stations.

Ensure safety signs and equipment labels are in good condition.

Inspect and clean respirators.

Inspect fall protection harnesses and kits.

INVERTER	
PV array isolator mounted adjacent to the inverter ☐ (Rating:……Vdc, ……Adc)	Isolator is mounted on output of the inverter (where required) ☐
Lockable AC circuit breaker mounted within the switchboard to act as the inverter main switch for the PV/inverter system (Rating …… A) ☐	Inverter is installed as per manufacturer's specification ☐
Inverter ceases supplying power within two seconds of a loss of AC mains ☐	Inverter does not resume supplying power until mains have been present for more than 60 seconds. ☐

CONTINUITY CHECK	
Circuit checked (record a description of the circuit checked in this column)	
Continuity of all string, sub-array and array cables	
Continuity of all earth connections (including module frame)	

SYSTEM CHECK

WARNING:

- IF A STRING IS REVERSED AND CONNECTED TO OTHERS, FIRE MAY RESULT.
- IF POLARITY IS REVERSED AT THE INVERTER DAMAGE MAY OCCUR TO THE INVERTER.

	Polarity	Voltage	Short Circuit	Operating Current
String 1		V	A	A
String 2		V	A	A
String 3		V	A	A
String 4		V	A	A
Sub-arrays where required		V	A	A
PV array at PV array switch-disconnector		V	A	A
Irradiance at time of recording the current			W/m2	W/m2

INSULATION RESISTANCE MEASUREMENTS (see table 12.3.1 for minimum values of insulation resistance)	
Array positive to earth	MΩ
Array negative to earth	MΩ

INSTALLER INFORMATION		
CEC Accredited installer's name:		
CEC Accreditation number:		
I verify that the above system has been installed to all relevant standards		
Signed:		Date:
CEC Accredited Designer's name:		
Licensed electrician's name: (where applicable, e.g. LV work)		
Electrician's licence number:		
Signed:		Date:

Follow Routine Maintenance Log Sheet

After creating the checklist of maintenance, now is the time to create a log sheet for it. There are numerous types of maintenances in which electrical and mechanical section are very important for smooth and proper running of the Solar PV system. Create each sections separate checklist, then combine it in one log sheet. Log sheet should have daily weekly and monthly check boxes, which should be check regularly by the maintenance department.

The Excel spreadsheet format is ideal for creating log books. File size is almost unlimited, so there are no restraints on how much information you need to track. Use the first row as a header, and a column for each type of information you are tracking.

Create a log sheet in Excel.

Step1

Open a new Excel file and place the cursor in the A1 cell, in the uppermost left corner of the spreadsheet.

Step2

Type the item you will be tracking, for instance, if you are logging names for registration, type "Name" in the A1 cell.

Step3

Cursor across to the left to the next cell, B1, and type another type of information you are tracking, such as date.

Step4

Continue across the top row, inserting the title of each piece if information you are tracking in the log.

Step5

Format the spreadsheet by adding color or borders to make the information easier to see. Either click and drag the cursor over an area, or click on the letter at the top of the column to highlight the entire column. Next, click on the area of the "Borders and Shading" area of the formatting palette to see your options. (If you don't see the formatting palette on screen, click on "Toolbox" at the top of the Excel window.) One click on the color palette, for example, applies that color to the highlighted area.

Equipment Maintenance Log

Name of Equipment		Supplier's contact details:	
Label:		Date of purchase:	6/28/2017
Serial number:		Person responsible for equipment:	
Manufacturer:		Date put into service:	10/23/2016

Date:	Type of Maintenance	Maintenance performed by:	Date of validation before put into service:	Validation performed by:	Next maintenance planned on (date):	Remarks:

Maintain Solar PV Modules

Tips for Maintenance of Solar Panels

Keep solar panels out of shade as energy production becomes inefficient when they are kept from absorbing any sunlight.

Keep an eye on the solar panels and make sure the inverters are flashing green lights. If they are not flashing, you are losing money by no longer compensating for your electricity use.

Document the day-to-day performance to improve solar panel maintenance. It is important to write down how much energy has been produced at a consistent time every day and make special note of dates where it is very cloudy. Some of the results will be inconsistent. (Your manufacturer would be able to provide you with the best monitoring system for your solar panels.)

Monitoring systems help you see how much you are benefiting the environment and how much CO2 you are emitting into the atmosphere. They can also help you know how much you could benefit from the feed-in tariff scheme.

You can also see information about your solar panels servicing on a wall-mounted display when you are at home.

If you have no time in cleaning solar panels, you can install automated cleaners that work like sprinkler systems or even schedule appointments with solar panel cleaning companies.

Luckily, because solar panels have no moving parts that could be affected by rust or break down, solar power maintenance may not be needed.

 e

Cleaning Tips for Solar Panel Cleaning

Solar panel cleaning kits come in very handy for cleaning solar panels. Inside the kit, you will find a biodegradable soap, a wiper, and a small brush or brush with a longer handle. Mix the soap in the bucket with water. Instructions are provided on the bottle. Dip the brush in the bucket and begin gently wiping the solar panels. You can use plain water or a soft brush to remove any grime or dirt that has built up on the panels.

How to clean solar panels has never gotten easier! Clean solar panels when they are moist or wet so any dirt so residue that is stuck on them can be wiped off easily.

Never use an abrasive sponge or soap for your solar panel cleaning as you may scratch the glass. The best way to clean solar panels by using a soft rag or biodegradable soap.

It is important not to use harsh materials when cleaning solar panels as they could cause damage, and solar panels are costly to repair.

If you clean often, you might be able to just run a hose along the panels to remove any dirt. Fewer calls on solar panel maintenance.

For your safety and the safety of others around you, use a long handled wiper to clean the panels while you are standing on the ground.

If you must get on the roof, take proper care as once you begin cleaning, the roof becomes slippery and you could slide off when you get down, so use safety ropes or a harness for support.

Always watch out for dirt on the solar panels to make sure it doesn't build up since they can absorb sunlight better when they are free of dirt.

Learning Unit: 4

Maintain Inverter /Charge Controller/ Protection Circuits

Solar inverters convert the electricity from your solar panels into power that can be used by the plugs in your house for your TV and other wired products. Panels can't create AC power by themselves; they need the helping hand of a solar inverter.

1. Please check whether the inverter meets damages in operation or not before installing it.

2. Please make sure it will never be disturbed by any electric or electronic equipment that has been installed in the vicinity.

3. Before each electrical connection, please cover each solar panel with opaque materials or switch off the DC side breaker. If solar arrays are exposed in the sun, they will generate dangerous voltages.

4. All the installation and operation must only be finished by professionals.

5. All the wires and cables inside a solar PV system must be tightly connected, making sure no electricity will leak. Their specifications must be appropriate.

6. All the electric appliances' installations must meet the local or national standards.

7. If you want to connect your inverter to the national grid, you must get the permission of the local power bureau and ask professionals to finish the connection.

8. If your inverter needs repairing, you must switch off the electrical connection between the inverter and the national grid, and then switch off the DC side electricity connection.

9. Please wait at least 5 minutes until the inner components have all released power, and then repair.

10. Any trouble that affects the inverter's safety functions must be completely solved before you reboot the inverter.

11. Avoid unnecessary circuit touches.

12. Adhere to static electricity protection standards, and wear static electricity-proof protectors.

13. Please take notice and adhere to the warning on the product.

14. You had better keep a proof checking of the device and make sure it is not damaged or in danger before you operate it.

15. Please make sure your inverter is not too hot, dusty or moist.

Learning Unit: 5

Maintain Battery Bank

Program your voltage set points so that the battery bank charges at the proper voltage.

Refill flooded lead-acid batteries with distilled water every 2-4 weeks as needed.

Regularly check battery state of charge. Apply an equalization charge to flooded batteries every 90 days. (Do not equalize sealed lead-acid or lithium batteries.)

Clean terminal connections and cables to prevent corrosion.

Solar batteries are the costliest component of any off-grid solar system. It's important to program them properly and stick to a regular battery maintenance schedule to keep them running efficiently for years. Neglecting the proper setup and maintenance routine can shorten the lifespan of your batteries and void the product warranty.

Some battery types, like Lithium-ion, require little to no maintenance after the initial setup. Other battery types (especially flooded lead-acid) need regular upkeep to stay in good condition.

No matter what type of batteries you own, this article will help you program your battery bank and give some battery maintenance tips to keep your system running smoothly.

Initial Programming

The first time you bring your system online, you'll need to program your battery chargers to the proper charging settings for your battery bank. These settings dictate parameters like charging voltage and current.

This is where you program voltage set points, the charging voltages applied to the battery during each stage of the charging cycle. Batteries typically charge in 3 phases—bulk, absorb, and float, which can be summarized as follows:

Bulk: High current to replenish charge and bring voltage up as quickly as possible (below 80%)

Absorb: Charge rate slows as batteries approach full state of charge (~80-100%)

Float: Batteries receive a trickle charge at 100% to stay fully charged

Each stage requires the charger to be set at a specific voltage, which is based on the requirements of your battery.

Programming the voltage set points accurately is critical to ensuring the long-term health of your batteries. Setting the wrong charge parameters will make your batteries charge improperly, shortening their lifespan.

There are other values to set during the initial programming phase as well:

Absorb time: The amount of time the charger spends in the absorb phase.

AC input amps: Maximum input current from grid or generator, to ensure the combined current from the battery charger and loads doesn't exceed the rating of the generator. Depends on generator size or grid input breaker. See manual for details.

Max charge rate or charge current limit: Maximum charging current, either expressed as a percentage of the charger output or total maximum charging amps. This setting is used to limit charger output, to make sure your batteries are not overcharged with too much current.

Temperature compensation: Adjusts the battery charger for operation in various temperature ranges. Most chargers include a battery temperature sensor.

These settings are different for every battery and charger. Check the spec sheets or installation manuals for your batteries and chargers to find the specific values for each of the above settings.

Programming your equipment according to the settings recommended in the manual is the first step toward ensuring the long-term health of your battery bank.

Flooded Lead-Acid Battery Maintenance Tips

Flooded lead-acid batteries require regular maintenance to function properly. We recommend checks every 2-4 weeks to keep the battery bank tuned up.

Note: always follow proper safety procedures when working around batteries. Wear eye protection and gloves, remove any jewelry, and secure loose clothing and long hair.

Add distilled water every 2-4 weeks

Flooded lead-acid batteries lose water during the charge cycle. They must be refilled regularly with distilled water to function properly and stay healthy.

Note that you should only use distilled water. Non-distilled water (like tap water) will introduce small particles and contaminants, which weakens the battery chemistry.

Check water levels every 15-30 days and refill as necessary. Your watering schedule depends on your local climate, charge settings and specific application. It may be useful to keep a log to track how often your batteries need to be refilled.

Check water level when batteries are fully charged.

Open the vent well to check the water level.

Add water to just below the maximum water level line. DO NOT overfill past this line. The battery installation manual should indicate where to find the maximum water level line.

Check battery state of charge (SoC):

Use a refractometer (or a hydrometer) to keep an eye on how charged your batteries are. The refractometer measures the specific gravity of your batteries. This video explains how to use a refractometer:

Consult the charts published by your battery manufacturer to find your battery state of charge based on their specific gravity reading. An example chart is shown below.

If your batteries are not holding charge even after a full charge cycle and equalization, they are likely defective, damaged, or have reached the end of their lifespan and are starting to lose some capacity.

Some inverters use a battery monitor to measure state of charge. These battery monitors typically rely on a shunt for measuring the total current coming in and out of the battery bank.

% of Charge	Specific Gravity Corrected To 80° F	Open-Circuit Voltage					
		6v	8v	12v	24v	36v	48v
100	1.277	6.37	8.49	12.73	25.46	38.20	50.93
90	1.258	6.31	8.41	12.62	25.24	37.85	50.47
80	1.238	6.25	8.33	12.50	25.00	37.49	49.99
70	1.217	6.19	8.25	12.37	24.74	37.12	49.49
60	1.195	6.12	8.16	12.27	24.48	36.72	48.96
50	1.172	6.02	8.07	12.10	24.20	36.31	48.41
40	1.148	5.98	7.97	11.89	23.92	35.87	47.83
30	1.124	5.91	7.88	11.81	23.63	35.44	47.26
20	1.098	5.83	7.77	11.66	23.32	34.97	46.63
10	1.073	5.75	7.67	11.51	23.02	34.52	46.03

Battery monitors are a useful tool for daily monitoring, but they require proper setup. If they aren’t installed or programmed correctly, they can provide false readings.

Even if you have a battery monitor, we still recommend checking the specific gravity with a refractometer on a regular basis. It helps verify the battery monitor is accurate and ensures your batteries reach a full charge.

Use a refractometer to check the specific gravity of your flooded lead-acid batteries.

Equalization Charges

Batteries should be equalized occasionally to make sure each cell is equally charged. Apply a controlled overcharge once every 30-90 days, or whenever individual batteries are imbalanced (reading a different voltage or specific gravity).

Check water level before initiating an equalize charge.

Turn off any loads.

Set your charger at the Equalize voltage specified in your battery manual.

Start the Equalize charge. Gassing and bubbling is normal during this process.

Stop charging and take specific gravity readings every hour. The EQ process is complete when the specific gravity stops rising.

Other Routine Flooded Lead-Acid Battery Maintenance

Tighten the battery cable connections as needed. Wear gloves/eye protection and use insulated tools.

Clean terminal connections & cables to prevent corrosion. Mix baking soda and distilled water into a paste and apply with a wire brush. Rinse cleaning residue and dry with a cloth or paper towel.

Keep the top of the batteries clean from dust and debris to avoid creating a current pathway or electrical leakage across the top of the battery.

Sealed Lead-Acid Battery Maintenance

Sealed lead-acid batteries do not need to be filled with water or equalized. They require very little maintenance other than the occasional check-up on the battery's state of charge.

Check Battery State of Charge (SoC):

Use a multimeter to keep an eye on how charged your sealed lead-acid batteries are based on the voltage. A multimeter is equipped with positive and negative probes which allows the meter to get a DC voltage reading from the battery.

Your battery manual should contain a chart that estimates the battery's state of charge based on these voltage readings (like the one in the previous section).

To get the most accurate reading, your batteries should be tested in a resting state. Let your batteries rest for at least 2 hours (no charging/discharging) before taking the voltage reading. Attempting to use the multimeter when batteries are being charged or discharged is going to result in a higher or lower voltage, depending on the load.

If your batteries fail to approach 100% SoC even after a full charge cycle, they are likely defective, damaged, or have reached the end of their lifespan.

Equalization Charges

DO NOT equalize sealed batteries! This applies to flooded lead-acid batteries only.

Other Maintenance

Tighten the battery cable connections as needed. Wear gloves/eye protection and use insulated tools.

Keep the top of the batteries clean to prevent them from getting dusty and grimy.

Lithium-Ion Battery Maintenance

Fortunately, lithium batteries require little to no maintenance (one of the main appeals when comparing lithium vs. lead-acid batteries). Once they are set up properly, they don't need any checks aside from the occasional state-of-charge reading to ensure they are holding a charge.

Lithium battery manufacturers sell a tool to gauge the battery's state of charge (SoC). The tool typically communicates with the built-in Battery Management System (BMS) to get an accurate SoC reading. Simply hook the monitoring tool up to the battery and read the SoC value from the display screen.

Discover Battery makes their own monitoring tool called a Battery Discharge Indicator, while Simpliphi recommends Victron battery monitors for their batteries.

Other Maintenance

Tighten the battery cable connections as needed. Wear gloves/eye protection and use insulated tools.

Keep the top of the batteries clean to prevent them from getting dusty and grimy.

Learning Unit: 6

Perform Post Verification Function of the System

1. Compliance with IEC 62446

IEC 62446 recommends that periodic verification of an existing installation shall be performed. The standard defines the minimum requirements for system documentation, commissioning tests and inspection for PV systems. As such, this standard not only specifies the minimum electrical testing and inspection requirements but equally importantly how the inspection and test results are documented and supplied to the consumer after installation.

Where appropriate, the results and recommendations of previous periodic verifications shall be taken into account. A periodic verification report shall be provided and include a list of any faults and recommendations for repairs or improvements (such as upgrading a system to meet current standards).

2. Avoiding fire risks

As the number of rooftop solar installation systems have grown over the years, so have the number of reported incidents of fires. Household fires started by electrical faults in rooftop solar PV systems have been reported in the UK, Australia, the USA and France – among others. The periodic testing of the electrical cabling and components associated with solar PV systems will ensure the safe operation of the system and reduce the potential fire risk associated with any electrical faults.

3. Effective grounding

As with all electrical equipment, solar panels and their racking systems must be grounded to mitigate potential electric shocks and fire hazards. If the grounding system degrades over time, anyone who comes into contact with a metal piece of the system may receive a shock. While the likelihood of shock is low, should one occur, the chance of substantial injury is great, because of the high voltage arrays, and the added danger of falling from roof mounted systems.

4. Ground faults

PV systems, in particular large scale systems, have many metres of cabling, much of which is buried underground. Poor levels of insulation will allow energy generated by the PV system to leak to earth. This can be particularly problematic during damp or wet conditions where the insulation monitoring or residual current monitoring function within an inverter prevents the inverter from starting up which in turn can significantly reduce the operational efficiency of the PV installation.

5. Environmental degradation

PV systems by their very nature are exposed to the elements. Damage or corrosion to cabling and connectors caused by moisture ingress can result in degradation in performance or increased risk of fire. Regular electrical testing will enable system performance to be monitored and any necessary repairs or remedial actions to be taken.

We have created an infographic to illustrate these 10 reasons which you are free to share and include on your website.

6. Surface contamination and physical damage

PV modules can become dirty or contaminated over time and this can reduce the operational efficiency and system performance. Similarly, exposure to the elements can result in physical damage to the component parts of a PV installation. Objects dropped by birds can result in physical damage to PV modules which may result in reduced output performance. Periodic electrical testing as part of regular maintenance will enable any problems to be identified and diagnosed.

7. Damage to wiring

The most obvious example of bad wiring is when wires hang below the panels and touch the roof or underlying vegetation. Eventually the wire coating will wear or be damaged by rodent attach and potentially expose the copper wires, presenting a shock hazard. Any deterioration of cable connections and wiring can be identified by applying regular electrical testing to identify potential faults.

8. Verification of system performance

The installation of solar PV systems is only undertaken after careful consideration of the costs involved and the potential return on investment provided by lower energy bills and FIT payments.

As a result, the verification of system performance and energy output from the panels is particularly important. In many cases simple electrical faults or wiring failures can cause a serious inefficiency in the ability of the panel to produce power. Although proper metering will give an indication of system performance, periodic electrical testing is vital to verify ongoing functional performance over extended periods.

9. Warranty fulfilment

Periodic electrical testing of solar PV systems to identify and confirm continued safe operation and maximum energy output performance can be required as part of product warranties and PV system component guarantees.

10. Customer documentation

All solar PV installations require the provision of various documentation and forms to the customer. System documentation usually includes system data, installer details, electrical diagrams, operation and maintenance instructions and other information that may be required by certain standards or regulatory bodies.

Copies of all test and commissioning data should also be provided and as a minimum this should include the results from the electrical safety and verification tests undertaken as part of the system installation procedures.

KNOWLEDGE ASSESSMENT TEST

Module:7 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) Preventive Maintenance contains

a. Repair
b. Regular checkup
c. Personal Protective Equipment (PPEs)
d. None of above

2) Maintenance checklist include

a. Electrical section
b. Mechanical section
c. Safety section
d. All of the above

3) Solar panels should be washed

a. When panels are hot
b. When panels are cold
c. When panels are dusty
d. When panels are dry

4) Inverter/ charge controller should be repaired

a. Immediately after disconnecting it
b. After 5 minutes
c. After 10 minutes
d. None of above

5) Specific gravity of battery tells

a. Life of the cell
b. Voltage of the cell
c. Shorting of the cell
d. Number of plates in the cell

Instructions to Candidates: You must write short answers to all questions.

Q1. What are tools and instruments for maintenance?

Answer:

Q2. What is routine maintenance log?

Answer:

Q3. How to maintain the solar panels?

Answer:

Q4: What is the maintenance procedure for inverters/Charge controller?

Answer:

Q5. What is the maintenance procedure for battery banks?

Answer:

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Module-8

Module – 8: Adopt Safety Precautions

Objective: This module covers the skills and knowledge required to protect from all security threats by ensuring personal safety, workplace safety prepare and safety of all tools and equipment.

Duration:	**60 hours**	**Theory:**	**06 hours**	**Practical:**	**54 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Ensure Personal safety	**Trainee will be able to:** • Arrange PPEs as per requirements • Wear proper PPE as per nature of job • Store PPEs at appropriate place after use • Ensure availability of first aid box	• Electrical risk and basic electrical safety. • Relevant PPEs in PV system installation • Use of PPEs • Storage precaution for PPEs. • Common emergency and first Aid procedures.	**60Hrs**		**Class room** **Theory** **Lab** **Practical**
LU-2: Ensure workplace safety	**Trainee will be able to:** • Ensure cleaning of workplace properly • Avoid hazardous (electric / chemical) by adopting safety precautions • Ensure availability of emergency exit • Ensure lighting and ventilation • Ensure availability of Firefighting equipment • Report to the concerned immediately in case of emergency • Ensure safe access to the system	• Workplace safety. • Workplace safety requirements • Work place cleaning procedure. • Workplace Lighting and ventilation requirements • Types of hazards. • Reporting of hazards and emergency. • Emergency handling techniques. • Firefighting equipment and its use.			**Class room** **Theory** **Lab** **Practical**
LU-3: Ensure safety of tools and equipment	**Trainee will be able to:** • Ensure insulation of tools and equipment • Store safely tools and equipment • Clean tools on a regular basis as per schedule	• Safety of tools and equipment. • Requirement of tools and equipment safety. • Storage precaution of tools and equipment.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
		• Maintenance of tools and equipment.			

Ensure Personal Safety

Electrical Risk

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

Personal Protective Equipment (PPE)

Personal Protective Equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to a variety of hazards. Examples of PPE include such items as gloves, foot and eye protection, protective hearing devices (earplugs, muffs) hard hats, respirators and full body suits.

Selecting PPE

All PPE clothing and equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion.

A technician requires PPE to meet the following standards:

- ***Eye and Face Protection***: Many occupational eye injuries occur because workers are not wearing any eye protection while others result from wearing improper or poorly fitting eye protection. Trainers must be sure that their trainees wear appropriate eye and face protection and that the selected form of protection is appropriate to the work being performed and properly fits each worker exposed to the hazard.
- ***Head Protection*****:** Wearing a safety helmet or hard hat is one of the easiest ways to protect a head from injury. Hard hats can protect from impact and penetration hazards as well as from electrical shock and burn hazards.
- ***Hand and Foot Protection:*** Workers who face possible hand, foot or leg injuries from falling or rolling should wear protective gloves or footwear. Also, employees whose work involves exposure to hot substances or corrosive or poisonous materials must have protective gear to cover exposed body parts, including hand legs and feet. If an employee's hand or feet may be exposed to electrical hazards; non-conductive gloves or footwear should be worn. On the other hand, workplace exposure to static electricity may necessitate the use of conductive footwear.

Ensure workplace safety

It's vitally important to take safety precautions when working with electricity. Safety must not be compromised and some ground rules need to be followed first. The basic guidelines regarding safe handling of electricity documented below will help you while working with electricity:

1. Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of electric current.

2. Never use equipment with damaged insulation or broken plugs.

3. If you are working on any receptacle at your home then always turn off the mains. It is also a good idea to put up a sign on the service panel so that nobody turns the main switch ON by accident.

4. Always use insulated tools while working.

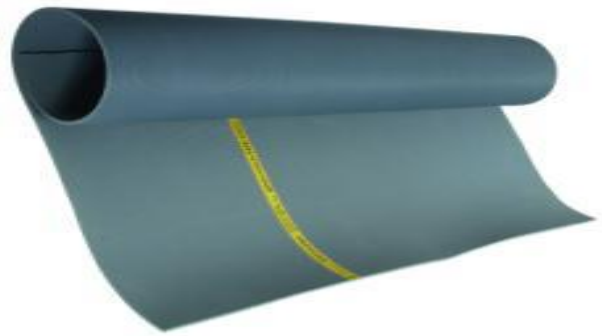
5. Electrical hazards include exposed energized parts and unguarded electrical equipment which may become energized unexpectedly. Such equipment always carries warning signs like "Shock Risk". Always be observant of such signs and follow the safety rules.

6. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.

7. Never try repairing energized equipment. Always check that it is DE energized first by using a tester. When an electric tester touches a live or hot wire, the bulb inside the tester lights up showing that an electrical current is flowing through the respective wire. Check all the wires, the outer metallic covering of the service panel and any other hanging wires with an electrical tester before proceeding with your work.

8. Never use an aluminum or steel ladder if you are working on any receptacle at height in your home. An electrical surge will ground you and the whole electric current will pass through your body. Use a bamboo, wooden or a fiberglass ladder instead.

9. Know the wire code.



10. Always check all your Ground Fault Circuit Interrupters (GFCIs) and Residual Current Device (RCD). They have become very common in modern homes, especially damp areas like the bathroom and kitchen, as they help avoid electrical shock hazards. It is designed to disconnect quickly enough to avoid any injury caused by over current or short circuit faults.

11. Always use a circuit breaker or fuse with the appropriate current rating. Circuit breakers and fuses are protection devices that automatically disconnect the live wire when a condition of short circuit or over current occurs. The selection of the appropriate fuse or circuit breaker is essential. Normally for protection against short circuits a fuse rated of 150% of the normal circuit current is selected. In the case of a circuit with 10 amperes of current, a 15 ampere fuse will protect against direct short circuits whereas a 9.5 amperes fuse will blow out.

12. Working outside with underground cabling can be dangerous. The damp soil around the cable is a good conductor of electricity and ground faults are quite common in the case of underground cabling. Using a spade to dig at the cable can damage the wiring easily so it is better to dig at the cable by hand while wearing insulated gloves.
13. Always put a cap on the hot/live wire while working on an electric board or service panel as you could end up short circuiting the bare ends of the live wire with the neutral. The cap insulates the copper ends of the cable thus preventing any kind of shock even if touched mistakenly.
14. Take care while removing a capacitor from a circuit. A capacitor stores energy and if it's not properly discharged when removed it can easily cause an electric shock. An easy way to discharge low voltage capacitor is that after removal from the circuit is to put the tip of two insulated screw drivers on the capacitor terminals. This will discharge it. For high voltage ones a 12 Volts light bulb can be used. Connecting the bulb with the capacitor will light up the bulb using up the last of the stored energy.
15. Always take care while soldering your circuit boards. Wear goggles and keep yourself away from the fumes. Keep the solder iron in its stand when not in use; it can get extremely hot and can easily cause burns.

Learning Unit: 3

Ensure safety of tools and equipment

Electrical Safety Equipment

The workers are the most important asset of any organization; make sure that they stay safe when doing any type of electrical testing, repair work, installation or maintenance. Some of the safety equipment is given bellow:

Life Saving Kits: Life Saving Kit is essential in every high voltage environment. Composed of various safety components including first aid kit, rescue rod, stretcher, set of fire resistant blankets, insulated matting and more it is a complete solution for every emergency at high voltage environments.

Insulated Gloves: Electrical insulating gloves are a critical lifesaving piece of personal protective equipment, and should be worn on or near exposure electrical parts.

Insulated Matting: Electrical insulating mats save lives of workers' in case, accidental leakage of current while handling or maintaining live high voltage electric equipment.

Earthing & Short Circuiting: Earthing & short circuiting kits are standard portable earth kits that are designed and tested for the high voltage work.

Insulated Ladder: Insulated ladders are used when working on power lines to carry out installation efforts, as these ladders do not conduct.

Appropriate personal protective equipment such as safety goggles, helmet and gloves must be worn to protect against hazards that may be encountered while using hand tools. Workplace floors should be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated. To prevent hazards associated with the use of power tools, workers should observe the following general precautions:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Keep all people not involved with the work at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Maintain tools with care; keep them sharp and clean for best performance.
- Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."

KNOWLEDGE ASSESSMENT TEST

Module:8 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) PPE stands for?

a. Protect personnel Equipment
b. Personal Protective Equipment
c. Personal Precaution Equipment
d. None of above

2) What does a risk assessment tell you?

a. How to report accidents
b. The working hours of the organization
c. Where the first aid box is and the first aiders
d. What risks are associated with the job

3) For which actions is the risk of accident the highest?

a. Fashioning steel with an angle grinder
b. Fashioning steel with a file
c. Fashioning steel with a hammer
d. None of above

4) The safety regulations require an employer to provide which of the following?

a. Toilet Facility
b. Hand tools
c. Lunch
d. Personal protective equipment

5) Industrial safety management is that branch of management which is concerned with hazards from the industries.

a. Reducing
b. Controlling
c. Eliminating
d. All of the above

Instructions to Candidates: You must write short answers to all questions.

Q1. What is first Aid Treatment?

Answer:

Q2. What is the safe procedure of separating the victim from electricity shock?

Answer:

Q3. Types of electrical hazards

Answer:

Q4: What is PPEs?

Answer:

Q5. Enlist the Safety precaution during Work?

Answer:

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Module-9

Module – 9: Develop basic professional skills

Objective: This module covers the skills and knowledge required to develop basic computer operating skills, develop basic communication skills, and develop basic marketing skills.

Duration:	**100 hours**	**Theory:**	**22 hours**	**Practical:**	**78 hours**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-1: Develop basic computer operating skills	**Trainee will be able to:** • Perform Microsoft basic commands in MS word ○ Open File ○ Format a file ▪ Font (Type/size/bold/Italic) ▪ Header Footer ▪ Page number ▪ Insert pics / table/hyperlink • Save a File • Save a folder • Perform basic commands in Microsoft MS Excel ○ Open a worksheet ○ Sum functions ○ If functions ○ Basic calculations ○ Table and graphs ○ Save a worksheet/folder • Prepare Microsoft power point presentation by using basic commands ○ Make a power point file ○ Insert pics/table/hyperlink ○ Design a theme for slides ○ Save a power point file • Perform browsing on the internet as per needs	• Basics of operating system. • MS Word. • MS Excel. • MS Power point. • Internet browsers.	**100Hrs**		**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
	• Perform research online on new trends in the market with the help of internet				
LU-2: Develop basic communication skills.	**Trainee will be able to:** • Negotiate with a client to understand the demand • Plan product supply as per client's requirements • Set price(s) according to client's requirements • Communicate the plan to the client • Take feedback from client on understanding of the exact job with timeline and cost	• Basic communication skills. • Clients' requirements analysis techniques. • Supply order management. • Agreement with clients.			**Class room** **Theory** **Lab** **Practical**
LU-3: Develop basic marketing skills	**Trainee will be able to:** • Present a design to the client as per requirement • Finalize the business deal • Purchase the equipment/tools and consumables as per agreed design • Adopt correct means of transportation • Select promotional means, according to target needs of clients	• Presentation skills. • Business development techniques. • Procurement procedures. • Appropriate Transportation. • Feedback analysis • Promotional channels.			**Class room** **Theory** **Lab** **Practical**
LU-4: Identify needs of the market.	**Trainee will be able to:** • Analyze upcoming market trends. • Develop Professional network. • Demonstrate behavioral skills. • Develop sound interpersonal skills • Develop new designs.	• Market need analysis. • Marketing skills. • Interpersonal skills. • Market exploration / Market Mapping. • Design of marketing strategies.			**Class room** **Theory** **Lab** **Practical**

Learning Unit	Learning Outcomes	Learning Elements	Duration	Materials Required	Learning Place
LU-5: Follow Environmental, Health and Safety standards	**Trainee will be able to:** • Follow Health and Safety Rules • Ensure environmental safety • Ensure compliance of net metering policy • Ensure workplace safety by following safety standards • Ensure safety while operating wires and electricity. • Store all tools and equipment properly in a safe area.	• Environmental and health safety standards. • Net metering policy. • Workshop safety. • Material storage safety.			**Class room** **Theory** **Lab** **Practical**

Learning Unit: 1

Develop Basic Computer Operating Skills

Knowing your way around word processing software is a crucial foundation for all kinds of documents that students will use in their future careers. The sooner they can learn these skills; the sooner they'll be able to draft up documents worthy of attention.

1. Creating, Naming, and Saving a Document

These three basics are the trifecta of getting started with word processing. Make sure to teach students the difference between "Save" (which will save your document under the current name) and "Save As" (which allows you to rename a document).

2. Formatting (bold, italics, font sizes, aligning text)

The toolbar at the top of your page is your friend when it comes to all things formatting. Let students play around with changing font sizes and colors to learn, but then always set clear expectations about the required formatting for an assignment.

3. Creating lists (bullet vs. numbered)

With the click of a button from the toolbar, students can create numbered or bulleted lists. Teach students the different times when this is appropriate (say for an outline or brainstorming).

4. Line spacing

Also on their main toolbar student have the option of how they want to space their lines. Most academic papers use 1.5 or double spaced.

5. Creating columns

Creating columns is especially useful for writing articles, pamphlets, or other specialized pieces. From the "Formatting" drop-down menu students can choose two or three columns, or customize their own number.

6. Inserting a bookmark

Just as you use a bookmark to save your place in a book, you can use one in Word to save your place in a document. From the "Insert" menu, students can place and name a bookmark so they remember to come back to that part later.

7. Inserting an image

If students are writing articles or poetry, they may want to insert an image. Also accessed from the “Insert” menu, make sure students have the image they want saved on their computer so that they can upload it.

8. Hyperlinking

This is a great skill to know for informal papers or blog posts where students want to link their own work to where they accessed the information. Highlight the text you want to hyperlink, right click and choose “hyperlink” and then paste the URL of your destination.

9. Find & Replace

Realize you’ve spelled someone’s name wrong throughout your paper? From the “Edit” menu students can find all of the incorrect spellings and ask Word to automatically replace them with the correct spelling. Problem solved!

10. Grammar & Spell Check

Most up to date word processing programs will automatically check spelling and grammar for students by displaying this squiggly red and green lines. Teach students not to ignore those lines! If they can’t figure out the mistake on their own, right click to find the suggested correction.

11. Inserting a page break

Writing a play with multiple acts and want each one to start on a new page? Insert a page break from the “Insert” menu to ensure that each act will always start at the top of a new page.

12. Using word count

Minimum and maximum word requirements are a fact of life. From college to the workplace students will need to write within a word count range. Use the “Tools” menu to find out how to check your word total so far. This number is also displayed as a running total at the bottom of the screen in Microsoft Word.

13. Inserting Tables

Whether writing a biology lab report or a business proposal, you may want to insert a table in your writing. To do so click the “Table” button on the toolbar and select how many rows and columns you’re going to need.

14. Inserting Rows/Columns

Need more rows or columns than you initially anticipated? Just right click within your table and choose to add a row above or below or a column to the right or left. Repeat as needed!

15. Cell shading

Add visual appeal to your table by shading specific rows or columns to draw attention to headings. Highlight the cells you want to shade and from the “Table Design” menu choose shading and the color of your choice.

16. Changing column/row width

While a table will automatically generate with rows and columns of uniform size, there are plenty of instances when one needs to customize the layout. The easiest way to do so is by dragging the gridlines between rows and columns to suit your needs.

17. Text alignment in tables

When it comes to tables, attention to detail matters. Customize the alignment of text within a cell by right clicking in the cell (or highlighting multiple cells and right clicking) to choose how you would like your text to be displayed.

18. Changing text direction

Complicated tables or formats may require you to change the direction of your text to better fit the space or increase readability. Click within a designated cell and from the “Layout” tab click the text direction button to toggle between horizontal and vertical text.

19. Merging cells

For more specialized tables you might want to merge some cells together within certain columns or rows. Just highlight the cells in mind and right click to select “Merge”. Voila!

20. Inserting a header

A header is useful in that it appears on every page of your document. This might be your name, a logo, a title, or a page number. Whatever you want your header to include, choose “Header” from the “Insert” menu to add text. Or, double click at the very top of a page to manually insert your header.

21. Inserting a footer

Same idea as above, just at the bottom of the page. Remember, whatever you write here will show up on every page!

22. Footnotes

Common in academic writing, footnotes allow an author to make a note about an idea in the text. Make sure your cursor is after the sentence or word you want to make a note about and then click “Footnote” from the “Insert” menu to add your comment.

23. Page numbers

Research papers and longer pieces of writing often have page numbers to help the reader reference points in the text. From the “Insert” menu choose page number and select where on the page you would like numbers to show.

24. Inserting the date

Want to include the date and time on written work? Put your cursor on your document where you’d like the date to go and select “Date and Time” from the “Insert” menu.

25. Printing

All done? It’s time to print! Either select the printer icon on the toolbar or click “Print” from the “File” dropdown menu. Make sure students pay attention to how many copies they’re printing, if they want double sided, and what printer they are printing to.

26. Page orientation

Most written work is done in portrait orientation (meaning your paper goes up and down), but there are plenty of times that we would like to have more space from left to right. Select “Page Setup” from the “File” dropdown menu and choose “Landscape”.

27. Custom margins

Whether you’re adding a block quote or leaving room for annotations, you might want to change the margins for all or part of your text. This can either be done from the “Formatting” tab, or using the ruler at the top of your page. Just make sure you’ve highlighted the text you want your new margins to apply to before you get started.

28. Save and Save As

You can save a Microsoft Word document by going into the File menu and clicking "Save". If you have specific publication or printing requirements, you can also use the "Save As" feature to save your document as a file type other than MS Word (e.g., PDF). Saving your work when you complete it is mandatory if you want Word to retain your progress.

Learning Unit: 2

Develop Basic Communication Skills.

Here are the 9 Tips for Improving Your Communication Skills:

1. **Make communication a priority.** Take classes, read books, magazine articles or learn from successful communicators around you. Seek a mentor or coach.
2. **Simplify and stay on message.** Use simple, straightforward language. Remember that Lincoln's Gettysburg Address was 286 words, about two minutes long.
3. **Engage your listeners or readers.** Draw your listeners and readers into the conversation. Ask questions and invite opinions. Solicit their feedback.

4. **Take time to respond.** After you've listened (and understood) take time to "draft" in your head what you want to say.
5. **Make sure you are understood.** Don't blame the other person for not understanding. Instead, look for ways to clarify or rephrase what you are trying to say so it can be understood.
6. **Develop your listening skills, too.** The best communicators are almost always the best listeners. Listen without judgment and don't be distracted by thinking about what you want to say next. Then, respond, not react.
7. **Body language is important.** Studies show that 65% of all communication is non-verbal. Watch for visual signs that your listener understands, agrees or disagrees with your message. And be aware that your body is sending signals, too.
8. **Maintain eye contact.** Whether speaking to a crowd or one-on-one, maintaining eye contact builds credibility and demonstrates you care about your listeners.
9. **Respect your audience.** Recognize your message is not just about you or what you want. You should sincerely care about the needs and the unique perspectives of those to whom you are communicating. One of the best ways to show your respect is simply by paying attention to what they say.

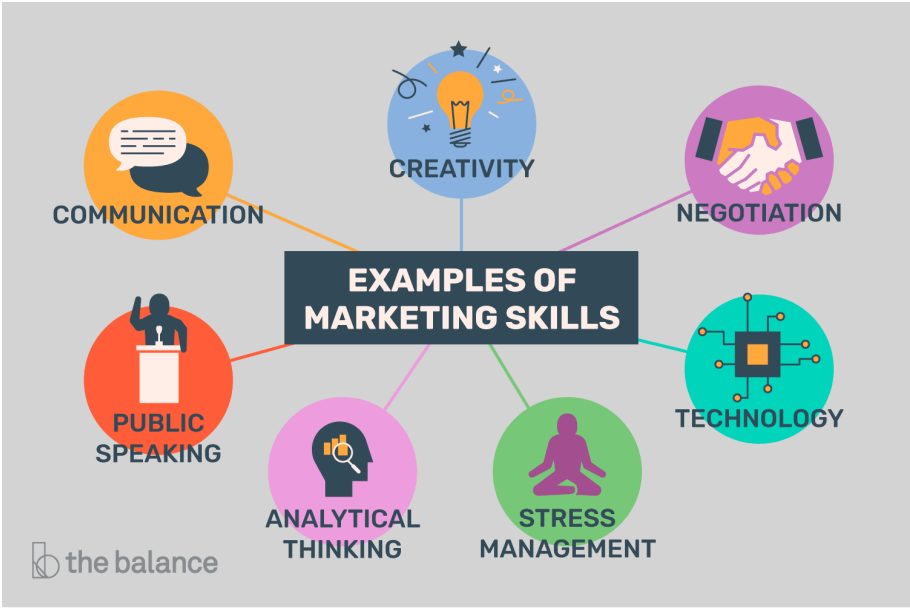
Now how to get feedback from the customer? It's no secret that collecting and analyzing customer feedback can be highly valuable for improving your product or service. However, obtaining that feedback can often prove to be a tricky challenge for many businesses. This is because customers are motivated by their own goals and deadlines, so it's not their responsibility to provide your company with feedback.

- Send follow up email.
- Initiate SMS surveys.
- Add feedback surveys into your WiFi network.
- Create paper feedback cards.
- Send surveys via a mobile beacon.
- Review live chat transcripts.
- Conduct customer interviews.
- Analyze recorded sales calls.
- Record website visitor session replays.
- Monitor social media channels.
- Offer incentives for feedback.
- Adopt Net Promoter Score.
- Include post-purchase feedback.
- Delay asking for feedback.
- Use feedback monitoring sites.

Learning Unit: 3

Develop Basic Marketing Skills

Over the last few years, we've spent tens of thousands of hours working with hundreds of different marketers. When you spend this much time with people in a certain role, one of the more interesting things you can do is try to determine the skills that make someone successful in that role.



In general, today's highly successful marketers:

1. Are revenue-driven marketers
2. Know their customers and markets
3. Create remarkable customer experiences
4. Are great storytellers
5. Test everything and assume nothing
6. Never stop acquiring new marketing tricks
7. Use data to make decisions
8. Enjoy working with technology
9. Manage their work according to a schedule
10. Write very, very well
11. Deliver specific, identifiable results

Identify Needs of the Market

We tend to think that today is certain and tomorrow is uncertain, but that logic needs to be flipped. Certainty, the present implies there is nothing we can do today to alter an outcome, and yet we can make changes for the better today. Uncertainty implies we can have a different and hopefully better future. The better we deal with our current problems, the higher our chances are of creating a better future. If we don't act now, tomorrow will not improve.

While a professional network can, of course, help you find leads when you are job searching, there is a multitude of other ways a solid one can help advance your career. Here are just a few of them:

Learn about a career: When you are choosing a career, it is essential to gather information about the occupations you are considering. While there are resources to explore your options, one of the best ways to learn about a career is by conducting an informational interview with someone who is currently working in it. You can look to your network for help in getting people to interview.

Find prospective job candidates: If you are responsible for hiring, your contacts can help put you in touch with prospective job candidates. You can also learn about applicants that did not come through your network.

Get advice about a project: Are you worried about tackling a work project with which you have no experience? A member of your network who has done a similar one may be able to offer advice or put you in touch with someone who can. One note of caution: don't share confidential information.

Learn about a prospective employer: Always prepare for job interviews by researching prospective employers. You can learn a lot by talking to members of your network and their contacts.

Prepare to make pitches to clients: Do you need to learn about a prospective client? One of your contacts may be able to help, but again be cautious about sharing confidential information outside your organization.

Here are seven behavioral or interpersonal skills that you should zero in on when establishing the culture in your company:

- Communication.
- Conflict Resolution.
- Organization and Being Able to Balance Work and Life.
- Time Management.
- Self-improvement.
- Stress Management/Resilience.
- Patience.

Good interpersonal skills 'oil the wheels' of these interactions, making them smoother and pleasanter for all those involved. Follow these nine tips to improve your interpersonal skills in the workplace:

- Cultivate a positive outlook.
- Control your emotions.

- Acknowledge others' expertise.
- Show a real interest in your colleagues.
- Find one good trait in every co-worker.
- Practice active listening.
- Be assertive.
- Practice empathy.

Learning Unit: 5

Follow Environmental, Health and Safety Standard

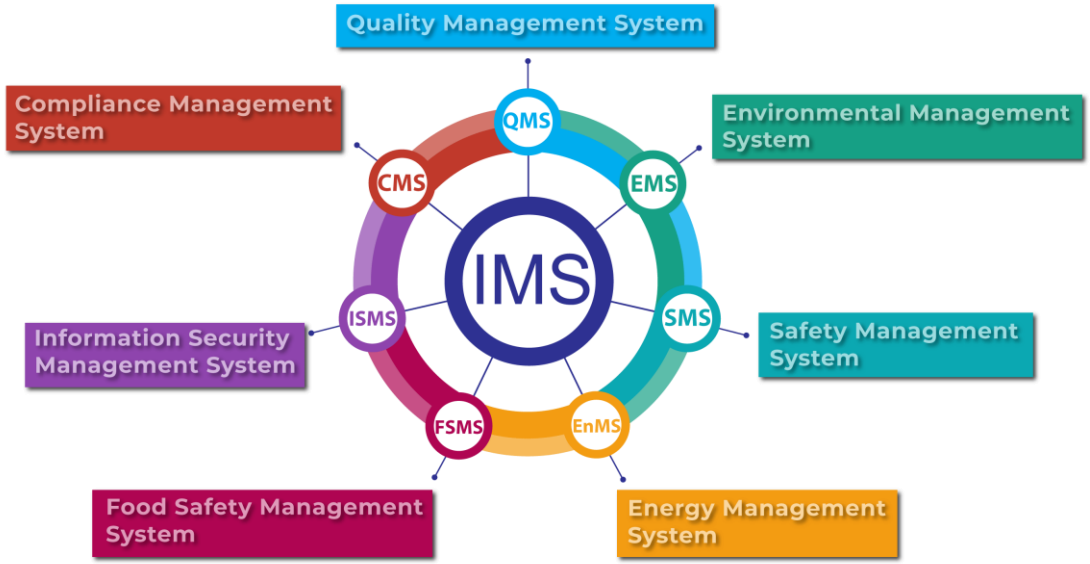
Environment (E), health (H) and safety (S) (together EHS) is a discipline and specialty that studies and implements practical aspects of environmental protection and safety at work. In simple terms it is what organizations must do to make sure that their activities do not cause harm to anyone. Commonly, quality - quality assurance & quality control - is adjoined to form the company division known as HSQE.

From a safety standpoint, it involves creating organized efforts and procedures for identifying workplace hazards and reducing accidents and exposure to harmful situations and substances. It also includes training of personnel in accident prevention, accident response, emergency preparedness, and use of protective clothing and equipment.

Better health at its heart, should have the development of safe, high quality, and environmentally friendly processes, working practices and systemic activities that prevent or reduce the risk of harm to people in general, operators, or patients.

From an environmental standpoint, it involves creating a systematic approach to complying with environmental regulations, such as managing waste or air emissions all the way to helping site's reduce the company's carbon footprint.

Regulatory requirements play an important role in EHS discipline and EHS managers must identify and understand relevant EHS regulations, the implications of which must be communicated to executive management so the company can implement suitable measures. Organizations based in the United States are subject to EHS regulations in the Code of Federal Regulations, particularly CFR 29, 40, and 49. Still, EHS management is not limited to legal compliance and companies should be encouraged to do more than is required by law, if appropriate.



Tool Storage Ideas and Tips

By taking proper care of your tools, you'll ensure that they'll remain in good working order and will be ready for use when you need them. No matter what kind of tools currently in your possession, it's important to take some time organizing your collection so you're protecting your investment. You'll want them in good condition when it's time to start that next DIY project!

If you're running out of room in your home's storage spaces, consider renting a self-storage unit from Self-Storage Specialists. Putting tools, especially larger tools like power saws, in self-storage will keep them safe and away from children. Self-storage is commonly used by contractors, too, because it allows them a place to store their equipment while keeping overhead costs low.

Regardless of where you choose to store your tools, there are a few basic tool storage ideas and tips to keep in mind before you put them away.

Follow the instructions. Some manufacturers will have specific instructions for how to store tools, so consult your manual first and foremost. It's important to follow these instructions, especially for larger power tools like saws or drills, so they remain in good working condition.

Clean them off. Tools should be cleaned each time you use them. Wipe them down with a damp rag or towel to get rid of any dirt, dust, grease or debris. Make sure garden tools are free of mud and grime. Everything should be completely dry before placing it in storage to avoid rust developing.

Use original cases. Power tools usually come in hard, plastic cases, and it's recommended to keep these cases for storage whenever possible. These cases will keep your power tools in storage safe from extreme conditions, plus all the parts can be stored right alongside them in the case. No more lost power cords or chargers!

Invest in sturdy storage containers. If you don’t have the original container, or you’re storing smaller hand tools, invest in some sturdy containers. This will not only keep your tools organized, but also allows them to be easily transportable to your next project area.

Store in a safe, dry place. Along with having the right containers, another way to protect your tools is to ensure that area you’re storing them in is safe and dry. Water or humidity can cause damage to tools, especially power tools.

Go vertical. Tools should never be stored on the ground. Invest in some shelving for smaller tools, or hang pegboard along your workbench or on a wall in your garage. You’ll be able to hang things like wrenches, hammers, box cutters, garden equipment and many other tools so they’ll be easy to access at any time.

KNOWLEDGE ASSESSMENT TEST

Module:9 Time Allowed: 30 minutes

Candidate Name: _____ Father Name: _____

Instructions to Candidates: You must answer all multiple choice questions.

1) Essential for communication skills are?

a. Listening
b. Confidence
c. Friendliness
d. all of the above

2) Checklist can be made in _____.

a. Excel
b. Word
c. PowerPoint
d. None of above

3) _____ are the form of human needs take as shaped by culture & individual personality.

a. Wants
b. Demands
c. Needs
d. Social needs

4) Communication is a non-stop_____.

a. Plan
b. Process
c. Paper
d. None of above

5) Alt+Ctrl+Del is used for.

a. Task manager
b. Explorer
c. Internet explorer
d. New file

Instructions to Candidates: You must write short answers to all questions.

Q1. What are the shortcut keys for copy, paste, cut, redo and undo?

Answer:

Q2. How to do research online on new trends in the market with the help of internet?

Answer:

Q3. How to negotiate with a client to understand the demand?

Answer:

Q4: What are the basic solar packages for domestic solar PV system?

Answer:

Q5. How to ensure environmental safety?

Answer:

FREQUENTLY ASKED QUESTIONS:

1. What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?	Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.
2. What is the passing criterion for CBT certificate?	You shall be required to be declared “Competent” in the summative assessment to attain the certificate.
3. What are the entry requirements for this course?	The entry requirement for this course is 8th Grade or equivalent.
4. How can I progress in my educational career after attaining this certificate?	You shall be eligible to take admission in the National Vocational Certificate Level-3 in Leather Products Development Technician (Pattern Maker). You shall be able to progress further to National Vocational Certificate Level-4 in Heavy Construction Machinery Operator Course; and take admission in a level-5, DAE or equivalent course (if applicable). In certain case, you may be required to attain an equivalence certificate from The Inter Board Committee of Chairmen (IBCC).
5. If I have the experience and skills mentioned in the competency standards, do I still need to attend the course to attain this certificate?	You can opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.
6. What is the entry requirement for Recognition of Prior Learning program (RPL)?	There is no general entry requirement. The institute shall assess you, identify your competence gaps and offer you courses to cover the gaps; after which you can take up the final assessment.
7. Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?	There are no age restrictions to enter this course or take up the Recognition of Prior Learning program

8. What is the duration of this course?	The duration of the course work is 1,510 hrs. (11 months)
9. What are the class timings?	The classes are normally offered 25 days a month from 08:00am to 01:30pm. These may vary according to the practices of certain institutes.
10. What is equivalence of this certificate with other qualifications?	As per the national vocational qualifications framework, the level-4 certificate is equivalent to Matriculation. The equivalence certificate can be obtained from The Inter Board Committee of Chairmen (IBCC).
11. What is the importance of this certificate in National and International job market?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC website.
12. Which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?	You shall be able to take up jobs in the local or overseas construction companies in heavy machinery operator job profile.
13. What are possible career progressions in industry after attaining this certificate?	You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid your career advancement to even higher levels.
14. Is this certificate recognized by any competent authority in Pakistan?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). The official certificates shall be awarded by the relevant certificate awarding body.
15. Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?	On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add your chances to get a job afterwards.
16. How much salary can I get on job after attaining this certificate?	The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount. The heavy Machinery Operator normally earns 20,000 to 25,000 in the start.
17. Are there any alternative certificates which I can take up?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
18. What is the teaching language of this course?	The leaching language of this course is Urdu and English.

19. Is it possible to switch to other certificate programs during the course?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
20. What is the examination / assessment system in this program?	Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparedness of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared “Competent” in the summative assessment to attain the certificate.
21. Does this certificate enable me to work as freelancer?	You can start your small business by purchasing your own heavy construction machine and can start earning 50,000 per month. You may need additional skills on entrepreneurship to support your initiative.

National Vocational and Technical Training Commission (NAVTTC)

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