



## **DESIGN AND ASSEMBLY OF 1.5KVA STAND-ALONE SOLAR POWER SYSTEM**

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**FEBRUARY 2025**

**APPROVAL**  
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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF BENIN, BENIN-CITY.**

**IN PARTIAL FUFILMENT OF THE REQUIREMENT FO THE AWARD OF BACHELOR IN ENGINEERING (B.ENG) IN ELECTRICAL AND ELECTRONICS ENGINEERING.**

**FEBRUARY 2025**

## CERTIFICATION

This is to certify that this project was carried out by

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## **DEDICATION**

To God Almighty, the fountain of knowledge, from whom all wisdom and understanding flow. You have been our source of inspiration, strength, and guidance throughout this journey. We acknowledge Your divine hand in every step of this work, and with hearts full of gratitude, we return all glory and honor to You.

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## LISTS OF ABBREVIATIONS

ABBREVIATION	MEANING
A	Ampere
Ac	Alternating Current
AH	Ampere Hour
Dc	Direct Current
DOA	Days of Autonomy
DOD	Depth of Discharge
ELD	Effective Load Demand
Ioc	Open Circuit Current
ImP	Maximum System current
Isc	Short Circuit Current
KVA	Kilo-volts Ampere
PSH	Peak Sun Hour
PWM	Pulse Width Modulation
Vmp	Maximum Power Voltage
Voc	Open Circuit Voltage
W	Wattage
WH	Watt-Hour

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## **ABSTRACT**

The growing need for sustainable and renewable energy solutions has driven interest in solar power systems as an alternative to conventional electricity sources. This project, titled "**Design and Assembly of a 1.5KVA Stand-Alone Solar Power System,**" aims to equip students with the essential knowledge required to build an efficient solar power system. It focuses on fundamental aspects such as **load analysis, proper material sizing, and system integration** to ensure optimal performance.

The project outlines the step-by-step procedures involved in selecting and assembling key components, including **solar panels, charge controllers, inverters, and batteries**. A detailed approach to load analysis ensures that energy demands are accurately assessed, allowing for appropriate system design. The study also explores construction techniques, testing procedures, and performance evaluations to verify the system's efficiency and reliability.

By providing hands-on experience and theoretical insights, this project serves as a valuable educational tool for students, fostering a deeper understanding of solar energy applications and promoting sustainable energy solutions.

## CHAPTER ONE

### INTRODUCTION:

#### 1.1 Background of the Project

The dual imperatives of maintaining energy security and reducing climate change have caused a dramatic transition in the global energy landscape during the past few decades. The search for alternate, renewable energy sources has become necessary due to the quick depletion of fossil fuels and the harm they do to the environment. Because of its availability, sustainability, and falling costs, solar energy has become one of the most promising of these.

The increasing demand for dependable, decentralized energy solutions led to the design and construction of a 1.5KVA standalone solar power plant. In areas where the electrical grid is either nonexistent or extremely unstable, this technology is especially pertinent. Rural and isolated areas in many developing nations frequently experience insufficient power supplies, which impedes economic growth and has a detrimental effect on people's quality of life.

The goal of this project is to develop a solar power system that can supply small businesses or households with the energy they require. The initiative intends to offer a sustainable and affordable substitute for conventional energy sources by utilizing solar technology. Off-grid applications benefit greatly from the system's ability to function independently of the grid due to its stand-alone nature.

#### 1.2 Statement of Problem

Lack of access to dependable energy is one of the main issues that populations in rural or isolated places face. The power grid is either unstable or does not reach rural areas in many parts of the world, particularly in developing nations, which results in frequent power outages. The environmental impact of using fossil fuels to generate electricity and the high cost of extending the grid to these areas make matters worse. Without dependable electricity, economic development is hampered, healthcare and education services are impacted, and the standard of living for locals is diminished. For instance, it is difficult for businesses to run effectively, for schools to offer sufficient lighting for evening classes, and for healthcare facilities to provide necessary services.

By planning and putting together a 1.5KVA standalone solar power system that can supply a

reliable and sustainable source of electricity, this project aims to address these problems. In addition to providing off-grid populations with an immediate energy solution, the project's use of solar energy advances the larger objective of lowering carbon emissions and addressing climate change.

### **1.3 Aim and Objectives of the Project**

The primary aim of this project is to develop a 1.5KVA stand-alone solar power system that can deliver reliable and sustainable electricity to an office with the loads: three (3) energy bulbs of 10W each, a printer of 500W, a fan of 80W, a television of 250W, and a laptop of 80W.

Reduce Reliance on the Grid Power: to decrease the dependence on the national grid and promote the use of renewable resources.

Select and assemble the necessary components, including the charge controller, inverter, Panels, Circuit breakers, cables, and batteries.

Gain practical experience in designing and assembling solar power systems: To develop hands-on skills and knowledge in solar power system design, assembly, and installation.

To create a solar power system that minimizes energy conversion efficiency while minimizing energy losses. This involves selecting high efficiency solar panels, optimizing the placement and orientation of panels, and ensuring efficient energy storage and distribution.

### **1.4 Relevance of the Project**

In light of international initiatives to promote sustainable development and lessen the effects of climate change, this project is extremely pertinent. Economic and social development are greatly aided by having access to clean, dependable electricity. Decentralized solutions, such as standalone solar power systems, can supply the energy required to spur growth and raise living standards in areas without or with an unstable electrical grid.

Additionally, the initiative supports global objectives like the Sustainable Development Goal 7 of the UN, which is to guarantee that everyone has access to modern, affordable, dependable, and sustainable energy by 2030 (UNDP, 2019). This project addresses the pressing issue of climate change and advances the global shift to renewable energy by showcasing the viability and advantages of solar power.

## **1.5 Scope of the Project**

This project's scope encompasses a number of important tasks, beginning with a thorough examination of the target consumers' energy requirements. The design of the solar power system, including the choice of parts like solar panels, batteries, charge controllers, and inverters, will be influenced by this research. The project will also entail the system's actual installation and assembly, followed by testing to make sure it performs as expected. The project will incorporate an economic analysis to assess the system's cost-effectiveness in addition to its technological components. Both the necessary initial expenditure and the long-term savings from lower energy prices will be taken into account in this analysis. The system's potential to lower greenhouse gas emissions and encourage sustainable energy use will be the main focus of the evaluation of its environmental impact.

## **1.6 Limitations of the Project**

Although solar energy has many advantages, this initiative has a number of drawbacks. The unpredictability of solar energy, which depends on location and weather, is one of the primary obstacles. The system's operation may be hampered in places with little sunshine or during extended cloud cover, requiring the usage of backup power sources or more battery storage.

The system's initial cost is another drawback. Even while solar technology has gotten cheaper over time, some consumers may still find the initial outlay for buying and setting up a standalone system to be a major deterrent. This is especially true in areas with low incomes, where funding for renewable energy projects may be harder to come by.

Technical assistance and maintenance are also important factors. The system's long-term sustainability and dependability may be impacted in remote locations by the lack of availability to qualified personnel and replacement parts. This emphasizes how crucial it is to teach local staff how to carry out simple maintenance and troubleshooting duties.

## CHAPTER 2

### LITERATURE REVIEW:

#### 2.1 Overview of Standalone Power Systems

This chapter examines the fundamental elements of a stand-alone power system, exploring its design considerations, operating principles, and applicability to modern power system technology. The integration of solar energy and energy storage systems is given special attention, with a focus on the usage of a 220AH battery in a 1.5kVA independent system. We also examine previous studies and pinpoint any holes that our effort aims to fill.

Standalone power systems are becoming more and more popular as workable options for distant areas, particularly those that use renewable energy. These systems frequently incorporate conventional generators, energy storage, and renewable energy sources like solar or wind (Barley & Winn, 1997). Beginning with wind-diesel combinations, the concept of hybrid power systems was first proposed in the late 1970s, and numerous pilot projects demonstrated their technical viability (Barley & Winn, 1997). Off-grid solar power systems are a particular kind of standalone setup that uses the sun to generate electricity to power household devices (Sadanandam & Srinivas, 2018). These systems must balance fluctuating energy inputs and changing power demands, so effective control is crucial (Groumpos et al., 1984). The world's first village freestanding solar system at Schuchuli, Arizona, serves as an illustration of this, effectively showcasing the potential for power load management (Groumpos et al., 1984). Energy storage is a crucial element in guaranteeing the dependability of wind-powered freestanding hybrid systems, which have also grown in popularity (Kaldellis, 2010).

#### Principle Of Operation

Three essential procedures comprise the fundamental functioning of a stand-alone power system:

1. Energy Generation: Direct current (DC) power is produced by solar photovoltaic (PV) panels using sunlight. Although solar PV is the main energy source for this project, wind turbines or diesel generators could be added.
2. Energy Storage: Batteries are used to store extra energy produced during times of strong sunshine. Here, a 200AH battery is chosen to supply backup power at night or in overcast

weather when solar generation is minimal.

3. **Energy Conversion and Distribution:** Since the majority of home appliances require alternating current (AC) power, the DC power stored in the batteries needs to be transformed into AC using an inverter. The converted AC power is reliable and appropriate for the loads connected to the system thanks to the inverter.

Because standalone systems can be upgraded to power bigger commercial and industrial setups, they can be adapted for small-scale domestic applications.

## **2.2 Solar Photovoltaic (PV) Power Generation**

The majority of contemporary standalone power systems rely heavily on solar PV technology. Through the photovoltaic effect, solar cells—which are usually composed of semiconductor materials like silicon—directly transform sunlight into electrical energy. This energy source is clean, renewable, and easily scalable to meet the system's energy needs.

### **Principle of operation**

When sunlight strikes a semiconductor, such a silicon-based solar cell, electrons are driven loose from their atoms, resulting in the photovoltaic effect. As the electrons go through the substance, this produces an electrical current. Modules of solar cells are assembled and joined to create solar panels.

A number of variables affect a solar PV system's efficiency:

1. **Solar Irradiance:** The energy output of photovoltaic panels is influenced by the amount of sunshine that strikes them. Geographical location, seasonal variations, and meteorological variables all affect solar irradiation.

2. **Panel Orientation and Tilt:** In order to generate the most energy, solar panels need to be slanted at an angle that corresponds to the latitude and orientated to capture the most sunlight. Typically, this means facing either north or true south in the southern hemisphere.

3. **Temperature:** In hotter climates, cooling systems or air circulation may be necessary to maximize performance because solar panel efficiency declines with rising temperatures.

Because of its endurance (usually more than 25 years), low running costs, and adaptability, solar PV systems are especially beneficial for off-grid applications. A standard 400W solar panel array is appropriate for a 1.5kVA system because it can produce enough electricity to support modest residential demands.

## **2.3 Energy Storage Systems: Batteries**

Since solar energy is sporadic and only available during the day, energy storage is essential to guaranteeing a steady power supply in standalone systems. When needed, like at night or on overcast days, batteries store the extra energy generated by solar panels throughout the day.

### **Principle of operation:**

When power is required, electrochemical reactions in batteries release the chemically stored electrical energy. Deep-cycle batteries, like the 200AH battery used in this project, are perfect for standalone systems since they can be repeatedly discharged and recharged without experiencing a noticeable loss of capacity.

**Battery Capacity:** The battery's capacity, expressed in ampere-hours (AH), shows how much energy it can hold. Depending on the load, a 200AH battery can provide 200 amps for an hour, 20 amps for ten hours, or 1 amp for 200 hours. When figuring out how long the system can function without solar power, this capacity is essential.

The percentage of the battery's capacity that is utilized is known as the Depth of Discharge, or DoD. A 50% DoD, for instance, indicates that half of the battery's capacity has been utilized. Although deep-cycle batteries are made to function well at high DoD, a greater DoD will shorten the battery's lifespan. A DoD of 50% is employed in this project to strike a compromise between energy availability and longevity.

**Battery Efficiency:** A battery's round-trip efficiency indicates how much energy may be extracted from it in relation to how much was added. Lithium-ion batteries, despite being more costly, can have efficiencies of 95%, while lead-acid batteries, which are frequently used in standalone systems, have efficiencies of about 80%.

In order for the standalone system to function around-the-clock, even in the absence of solar generation, batteries are essential. When there is no sunlight, the 200AH battery makes sure that there is sufficient energy stored to suit the system's needs.

## **2.4 Power Inverters**

The direct current (DC) produced by solar panels and stored in batteries must be converted into alternating current (AC), the standard for electronic devices and home appliances, via power inverters, which are crucial parts of standalone systems.

### **Principle of operation:**

Inverters create an alternating voltage waveform that resembles AC power by quickly turning

DC electricity on and off using electrical circuits. A modified sine wave or a pure sine wave may be the resultant waveform:

1. Pure Sine Wave Inverters: These inverters generate a high-quality, smooth AC waveform that resembles the grid's power. Since they reduce harmonic distortion, they are perfect for delicate electronics and motor-driven appliances like fans and refrigerators.
2. Modified Sine Wave Inverters: These generate a less complex AC waveform but are less costly. They work well for less delicate loads, but they could interfere with devices that need power from pure sine waves.

A 1.5kVA pure sine wave inverter has been chosen for this project. It is appropriate for small domestic appliances and electronics because it can manage loads of up to 1,500 watts. In order to reduce energy losses during conversion, the system design also takes into account the inverter's efficiency, which is normally between 85 and 95 percent.

## **2.5 Charge Controllers**

One essential part that controls the voltage and current entering the battery from the solar panels is the charge controller. It guarantees effective battery charging and guards against overcharging, which shortens the battery's life.

### **Operational Principle**

To avoid overcharging, a charge controller modifies the energy flow from the solar panels based on the battery's state of charge (SoC). Additionally, it guards against deep discharge, which might harm the battery. In standalone systems, charge controllers come in two primary varieties:

1. PWM: As the battery gets closer to full charge, PWM controllers progressively lower the power delivered to it. Although this technology is easy to use and reasonably priced, it is not as successful in converting the solar panels' maximum output.
2. Maximum Power Point Tracking (MPPT): More advanced MPPT controllers are able to modify the solar array's operating point in order to capture the most power possible. They are perfect for systems where optimizing energy generation is crucial because they are usually 20–30% more efficient than PWM controls.

An MPPT charge controller was chosen for this project in order to prolong the life of the 200AH battery and provide the best possible energy harvesting from the solar panels.

## **2.6 Energy Management Systems (EMS)**

The standalone power system's "brain" is the Energy Management System (EMS). It tracks the movement of energy between the load (appliances), storage (battery), and generating source (solar panels). To guarantee the system runs effectively and dependably, the EMS assists in balancing the power supply and demand.

### **Operational Principle**

The EMS gathers information from a number of sensors throughout the system, including load demand, solar irradiance, and battery voltage. The EMS can make decisions in real time based on this data, including:

deciding which loads should be powered first when energy is scarce.

Controlling the battery's cycles of charging and draining can help it last longer.

If the battery is too low, non-essential loads will be automatically turned off.

In order to improve overall system resilience and reliability, an advanced EMS can also include predictive analytics, which enables the system to adapt based on weather forecasts or projected energy consumption.

## **2.7 Existing Research on Standalone Power Systems**

In recent years, there has been a notable increase in research into small-scale standalone systems, including solar PV-battery combos. According to studies, combining energy storage with renewable energy can lessen reliance on fossil fuels, cut greenhouse gas emissions, and offer dependable electricity in isolated locations. A study on a 1.5kVA standalone system with a 200AH battery, for instance, showed that it could supply enough energy for rural households' communication devices, small appliances, and illumination. Research is still being done to find a solution to the problem of maximizing battery life while preserving energy availability.

The economics of independent systems is another important field of research.

Because solar panels, inverters, and batteries must be purchased upfront, standalone systems are frequently regarded as costly. However, a number of studies have shown that these initial expenses might be outweighed by the long-term operational savings, especially when compared to fuel-based generators. A case study on small standalone systems in East Africa, for instance, showed that although the initial setup cost was higher than with diesel generators, the payback period was little over three years because of the fuel and maintenance

savings. Additionally, government subsidies and the declining costs of solar technology and batteries made solar-powered systems more economically feasible.

## **2.8 Key Components and Their Importance in Standalone Power Systems**

### **Solar Photovoltaic (PV) Panels**

As previously mentioned, the main source of power for this project is solar PV panels. They directly transform sunlight into electrical energy that can be stored in batteries for later use or used right away. It is impossible to overestimate the significance of PV panels in the system since they offer a clean and renewable energy source that significantly reduces dependency on fossil fuels and guarantees that off-grid or isolated locations have access to electricity.

Wattage (power production), durability, and efficiency are frequently taken into consideration while choosing PV panels. This system's 400W panels are made to provide enough electricity during the hottest parts of the day to charge the battery and supply the system's daily energy needs. For this project, polycrystalline panels were selected because they provide a reasonable balance between cost-effectiveness and efficiency.

### **220Ah battery**

The 220AH battery acts as the system's energy storage device, storing extra power produced by the solar panels during the day for usage at night. The battery is an essential part of any independent system since it guarantees that the system can supply power around-the-clock.

Because of its affordability and longevity, a deep-cycle lead-acid battery is utilized in this project. Lead-acid batteries are still a common option for small-scale standalone systems because to their lower cost, even though they have a lower energy density and efficiency than lithium-ion equivalents. To increase the battery's lifespan, its charge and discharge cycles must be properly managed. To extend battery life, it is generally advised to maintain the depth of discharge (DoD) below 50%.

### **The Inverter**

The majority of household appliances require AC power, which is converted from DC power stored in the battery by the 1.5kVA pure sine wave inverter chosen for this system. The system's power requirements must be properly taken into account while sizing the inverter. For instance, a 1.5kVA inverter is suitable if the system must power devices that use up to 1,500 watts at once.

The kind of inverter is also important. For delicate devices like PCs, TVs, and some home appliances, pure sine wave inverters are crucial because they generate cleaner, more consistent electricity than modified sine wave inverters. The associated loads will operate more smoothly and with less distortion thanks to this inverter selection.

### **MPPT Charge Controller**

A key component in maximizing the energy generated by the solar panels is the MPPT charge controller. With the help of MPPT technology, the charge controller may modify the panels' electrical operating point so that, even in the face of fluctuating sunlight, they always produce their maximum amount of electricity. Compared to basic PWM charge controllers, this leads to energy harvesting that is up to 30% more efficient.

The MPPT controller also prevents the battery from being overcharged, which could harm it permanently, by controlling the power flow from the solar panels to the battery. It guarantees effective charging of the battery and keeps it in a healthy condition of charge.

### **System for Energy Management (EMS)**

The EMS keeps an eye on and regulates the energy flows in the system to make sure that the battery lasts as long as possible and that the available power is used effectively. For instance, the EMS may disconnect non-critical devices and prioritize vital loads, like lighting, if the battery charge falls below a predetermined threshold. In order to identify days with low solar energy production and modify energy use appropriately, an EMS can also incorporate weather forecasts.

## **2.9 Gaps in Existing Research**

Even though the design and implementation of standalone power systems have advanced significantly, there are still a number of unanswered questions. The long-term longevity and performance of batteries in off-grid systems is one important factor. It is unclear how high temperatures, different discharge depths, and irregular charging patterns affect battery life, especially in harsh environmental circumstances.

Further research is also needed in the area of integrating more sophisticated energy management systems (EMS) with predictive algorithms, such as those that take into account weather forecasts, load usage trends, and grid interactions (in hybrid systems). Future studies should concentrate on enhancing EMS intelligence to better optimize energy use and prolong

system component operating life, especially in distant locations where maintenance is challenging.

Furthermore, although the economics of standalone systems are improving, little is known about financing schemes and regional government incentives. Research might examine the most effective means of facilitating the adoption of stand-alone systems through creative financing options like microloans or pay-as-you-go solar.

In conclusion, research indicates that independent power systems are becoming more and more practical for supplying off-grid communities with dependable, sustainable electricity. A viable strategy for reaching energy independence is the combination of solar photovoltaics and energy storage devices, such as 200AH batteries. But there are still issues that need to be resolved, especially when it comes to improving system efficiency and battery performance through sophisticated control and management strategies. By assessing a 1.5kVA standalone power system's performance in actual use, this study seeks to advance knowledge of these systems.

## CHAPTER THREE

### METHODOLOGY:

#### 3.1 Component Selection:

The design and construction of a 1.5KVA standalone solar power system are the main topics of this chapter, which also outlines the essential parts and how they work together. This project is to use solar energy to provide a dependable power source appropriate for off-grid applications, especially in rural locations without access to conventional electricity, in response to the growing demand for sustainable energy solutions. In order to make sure the system is suitably sized to satisfy these demands, the chapter will start by outlining the precise power requirements of the expected loads.

The choice of vital parts, such as solar panels, batteries, inverters, and charge controllers, will then be supported by evidence of their effectiveness, capacity, and fit for the system's intended purpose. Every element will be analyzed in light of its function within the system, with a focus on how energy storage and renewable energy sources are integrated.

Additionally, this chapter will offer thorough, detailed instructions for putting the system together, including how to mount solar panels and connect the inverter and batteries. Throughout the building process, safety measures will be emphasized to guarantee that all work is done securely and to reduce the hazards related to electrical components. This chapter lays the foundation for creating a working solar power system that not only satisfies current energy demands but also helps create a more sustainable future by methodically addressing these factors. Before a solar power system is referred to as such, various components are put together to ensure that the goal is met, and they are as follows:

- i. The inverter
- ii. The batteries
- iii. The solar panels
- iv. The charge controller
- v. The cabling and connectors
- vi. The mounting structures

## **3.2 The Inverter**

### **Components of the Inverter :**

The key part of a solar power system that transforms the direct current (DC) generated by solar panels into the alternating current (AC) required by the majority of home appliances is an inverter. For an inverter to function properly, it requires a number of components. These consist of the following.

- i. Input Section
- ii. Output Section
- iii. Transformer:
- iv. Control circuits
- v. Cooling System
- vi. Monitoring System:
- vii. Switching circuit
- viii. Regulators

### **Input Section:**

The vital entry point for direct current (DC) electricity produced by solar panels is the input part of a solar inverter. In order to ensure maximum performance and safety, this part is made to effectively manage and convert the incoming energy. It consists of a number of parts that cooperate to manage several solar panel strings, control voltage, and guard against overcurrent. Furthermore, a lot of inverters have Maximum Power Point Tracking (MPPT) technology, which continuously adapts to shifting solar circumstances to optimize energy extraction. All things considered, the input section is crucial to the efficient and safe operation of the solar inverter, which converts solar energy into usable power.

## **Output Section:**

Delivering converted alternating current (AC) electricity to the grid or domestic systems is a critical function of a solar inverter's output portion. In addition to an output filter that smoothes the waveform to lower harmonics and guarantee steady voltage and frequency, this component also contains the AC output terminals where the electricity leaves the inverter. This part modifies the output voltage of inverters with transformers to satisfy grid or appliance specifications. In order to ensure compatibility, synchronization circuits are also essential since they match the inverter's output with the grid frequency. Furthermore, real-time performance data is provided by monitoring and communication interfaces, and protective devices such as circuit breakers and fuses guard against overloads and short circuits. When combined, these components guarantee the output section's safe and effective operation, enabling the dependable integration of solar energy into electrical systems.

### **Transformers:**

To raise the voltage to the necessary level for household or grid use, a transformer is frequently utilized. In order to reduce weight and increase efficiency, some inverters are transformerless. These inverters use sophisticated power electronic components, such as MOSFETs or IGBTs (Insulated Gate Bipolar Transistors), to convert DC to AC. To produce the AC waveform, these parts quickly turn on and off. The transformer that transforms the 24V battery power into 240V is center-tapped. The transformer is a step-up transformer with a primary winding of 24 volts and a secondary winding of 240 volts.

### **Control circuits:**

A solar inverter's control unit is the brain that coordinates everything, guaranteeing dependable and effective solar energy conversion. It controls the input and output procedures, modifying settings to maximize efficiency in a range of scenarios. The Maximum Power Point Tracking (MPPT) algorithms included in this unit enable the inverter to continuously adjust to variations in sunshine and sustain the maximum amount of energy extracted from solar panels. The control unit also keeps an eye on system performance, identifies malfunctions, and puts preventative measures in place to guard against possible problems like overloads or short circuits. The control unit ensures smooth operation and integration with the electrical grid while improving the solar power system's overall lifetime and efficiency by

coordinating various tasks.

### **Colling System:**

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### **Monitoring System:**

The monitoring system of a solar inverter is crucial for ensuring optimal performance and facilitating maintenance. This system tracks various parameters, such as voltage, current, power output, and efficiency, providing real-time data on the inverter's operation. Many modern inverters come equipped with built-in displays or connectivity options that allow users to monitor performance remotely via smartphone apps or web interfaces. This feature enables users to check energy production, identify potential issues, and assess the overall health of the solar power system. Additionally, the monitoring system can send alerts or notifications in case of faults or performance drops, allowing for timely troubleshooting and repairs. By providing valuable insights and enhancing visibility into system performance, the monitoring system plays a key role in maximizing energy production and ensuring the reliability of the solar power installation.

### **The Switching Circuit:**

A solar inverter's monitoring system is essential for guaranteeing peak performance and making maintenance easier. This system provides real-time data on the inverter's operation by monitoring a number of parameters, including voltage, current, power production, and efficiency. Many contemporary inverters have integrated screens or connectivity features that let consumers check performance from a distance using online interfaces or smartphone apps. Users can verify energy production, spot possible problems, and evaluate the general condition of the solar power system with this tool. To enable prompt troubleshooting and

repairs, the monitoring system can also provide warnings or notifications in the event of malfunctions or performance declines. The monitoring system is essential to optimizing energy output and guaranteeing the dependability of the solar power installation since it offers insightful information and improves visibility into system performance.

### **Regulators:**

One essential part of a solar inverter that transforms direct current (DC) from solar panels into alternating current (AC) is the switching circuit. Typically, this circuit makes use of semiconductor devices that quickly turn the DC input on and off, such as IGBTs (Insulated Gate Bipolar Transistors) or MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors). This causes the circuit to produce a pulsating DC waveform, which is subsequently processed further to produce a clean AC waveform. Since quick switching reduces power losses and improves the inverter's overall performance, the switching circuit is built for maximum efficiency and speed. To maximize energy conversion and preserve the intended output frequency and voltage, the control unit also manages the switching process. All things considered, the switching circuit is essential to guaranteeing that the inverter effectively converts solar energy into usable electricity while preserving excellent performance and dependability.

These self-destructive devices protect the circuit from excessive current flow. 3.1.6 LINKS Reset and on/off switches are two common switches that inverters employ. The reset switch can be used to turn the power on and off.

### **Regulators:**

The regulator is a part that uses an internal standard voltage to continuously check the supply's actual output. It then employs electrical control to modify the circuit's resistance as necessary. Since many electronic circuits have different loads on their power supplies and many circuits will malfunction if the supply voltage fluctuates, the regulator is essential. Both internal short circuit current restriction and thermal overload protection are provided by the regulator IC. Output, ground, and input are its three terminals. The last two digits of the IC part number represent the voltage. This inverter uses the IC 7812 regulator, which provides 12Vdc.

## Choosing the Inverter:

Your solar power system's dependability and efficiency depend on the solar inverter you choose. When choosing an inverter, keep the following important considerations in mind:

A vital phase in the design of a solar power system is load calculation, which establishes the energy needs of the house or business the system will provide. Here's how to successfully do a load calculation:

### Load Calculation:

- a. **Identify Electrical Appliances:** Make a comprehensive list of all electrical appliances and devices that will be powered by the solar system. Include everything from lighting and kitchen appliances to heating and cooling systems.
- b. **Determine Power Ratings:** Check the power ratings of each appliance, typically found on their labels or in user manuals. Power is usually measured in watts (W). If the rating is given in amps (A), you can calculate watts using the formula:

$$\text{Watts} = \text{Volts} \times \text{Amps} \dots \dots \dots \text{Equation 1}$$

For example, a device that operates at 120 volts and draws 10 amps uses:

$$120\text{V} \times 10\text{A} = 1200\text{W}$$

- c. **Estimate Usage Hours:** Estimate how many hours each appliance will be used daily. This information is essential for calculating daily energy consumption.
- d. **Calculate Daily Energy Consumption:** Multiply the power rating of each appliance by the number of hours it is used to find the daily energy consumption in watt-hours (Wh)

$$\text{Daily Consumption} = \text{Power Rating (W)} \times \text{Usage Hours} \dots \dots \dots \text{Equation 2}$$

Sum the daily consumption for all appliances to get the total daily energy requirement.

- e. **Consider Peak Load:** Identify the peak load, which is the maximum amount of power required at any given time. This is important for ensuring that the inverter can handle the load during peak usage.
- f. **Account for Efficiency Losses:** Include a safety margin to account for efficiency losses in the system, typically around 10-20%. This helps ensure that the system can handle variations in performance and unexpected increases in load.
- g. **Calculate Total Load:** Finally, add together the daily energy requirements and the safety margin to determine the total load that the solar system needs to support.

Example Calculation

having the following appliances:

- LED Light Bulbs: 3 bulbs at 10W each, used for 12hrs
- Printer: 500W, used for 3hrs
- Fan: 80W, used for 6hrs
- Television: 250W for 6hrs
- Laptop: 80W for 6hrs

Total Energy demand =  $\Sigma(L_i)$ ..... **Equation 3**

Where  $L_i$  is = Individual Load Demand and TED = Total Energy Demand

$$TED = 30W + 500W + 80W + 250W + 80W = 940W$$

Adding a safe factor of 30%

$$TED = 282W + 940W = 1222W \text{ or } 1.222KW$$

Converting to KW to KVA

$$KW \times 1.2$$

$$1.222 \times 1.2 = 1.4664KVA \text{ approximately } 1.5KVA$$

So therefore, we would choose an **Inverter of 1.5KVA, 12V**

**Inverter Capacity:** Never choose the inverter's Volt-Ampere (VA) rating. Power Factor x Watts equals VA. The range of the power factor value is 0.6 to 0.8. Keep in mind that an inverter rated at 600VA (power factor of 0.8) can only deliver about 480 Watts!

**Inverter Type:** Inverters with square, quasi-sine, and pure sine waves are now accessible. Generally speaking, all electrical devices, including computers and televisions, are meant to operate on a sine wave.

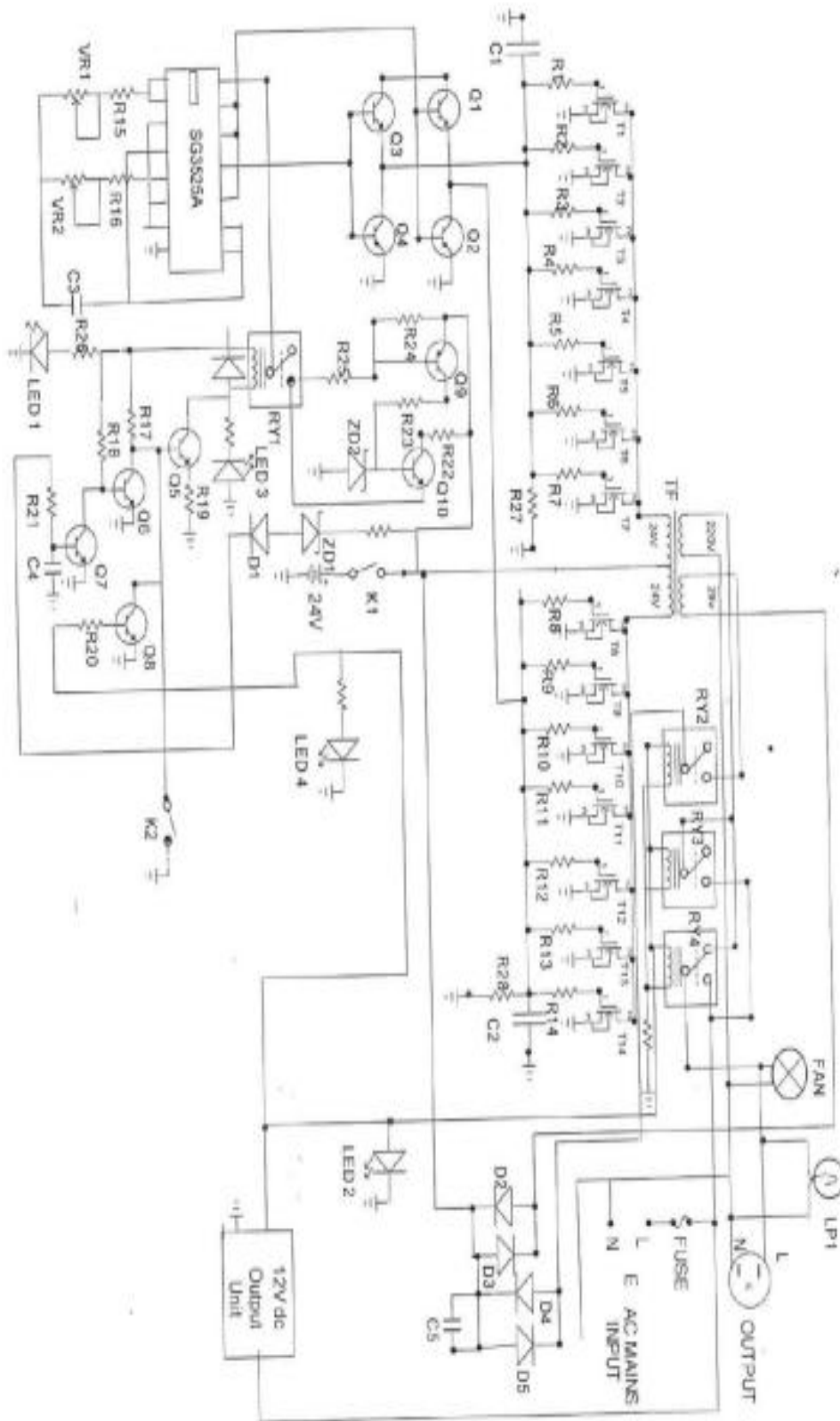


Fig 3.1 Circuit Diagram Of The Inverter

### 3.3 Battery

**Capacity and Type:** The system utilizes a 200AH deep-cycle lead-acid battery. This type is chosen for its durability and cost-effectiveness, making it suitable for repeated discharge and recharge cycles.

**Depth of Discharge (DoD):** A recommended DoD of 50% is implemented to balance performance and longevity, ensuring that the battery can be cycled effectively without significantly reducing its lifespan.

**Charging and Discharging Cycles:** The battery will store excess energy generated during sunny periods and release it during low sunlight or nighttime. Proper management of charging cycles is crucial; the MPPT charge controller will optimize charging, preventing overcharging and deep discharge to protect the battery's health.

#### **Efficiency and Performance:**

The efficiency of a battery, often referred to as round-trip efficiency, indicates how much energy can be retrieved compared to how much was put in. For lead-acid batteries, this efficiency is typically around 80%. This means that 80% of the energy used to charge the battery can be retrieved during discharge. Understanding this efficiency is essential for calculating the overall energy availability of the system.

#### **Maintenance and Care:**

While lead-acid batteries are robust and relatively affordable, they do require some maintenance to ensure optimal performance. Regular checks on the electrolyte levels (for flooded lead-acid batteries) and keeping terminals clean can help maintain efficiency. Additionally, temperature management is important, as high temperatures can accelerate degradation.

#### **Battery Selection**

The battery is a fundamental component of the standalone solar power system, serving as the energy reservoir that ensures reliable power supply. For this system, a 12V, 200AH deep-cycle lead-acid battery has been selected. This type of battery is ideal for household inverters due to its ability to deliver prolonged backup power during periods of low solar generation.

Deep-cycle lead-acid batteries, especially tubular-type storage batteries, are recommended for their extended backup duration and high capacity-to-size ratio. Backup time refers to the number of hours the inverter can supply electricity to the output load in the event of a power outage, and this is primarily determined by the battery's Ampere-Hour (AH) rating. The 200AH capacity allows for significant energy storage, ensuring that essential loads can be powered even during extended periods without sunlight.

Additionally, tubular batteries are designed to provide enhanced power and efficiency, making them capable of being recharged more rapidly compared to traditional battery types.

This characteristic is particularly beneficial in a solar power system where energy input can vary significantly based on weather conditions.

Managing the Depth of Discharge (DoD) is critical for maximizing the lifespan of the battery. For this project, a DoD of 50% is maintained, which helps prolong the battery's operational life by preventing excessive discharge. Overall, the selected battery plays a vital role in ensuring that the standalone system remains functional and efficient, capable of meeting energy demands throughout the day and night.

### **Steps for Battery Selection:**

1. Determine the total daily energy consumption

#### **Using Equation 2:**

- LED Lights:  $3 \times 10W \times 12\text{hours} = 360\text{Wh}$
- Printer :  $500W \times 3 \text{ hours} = 1500\text{Wh}$
- Fan :  $80W \times 6\text{hours} = 480\text{Wh}$
- Television:  $250W \times 6\text{hrs} = 1500\text{Wh}$
- Laptop:  $80W \times 6\text{hrs} = 480\text{Wh}$

#### **Total Daily Consumption:**

##### **Using Equation 2**

$$360\text{Wh} + 1500\text{Wh} + 480\text{Wh} + 1500\text{Wh} + 480\text{Wh} = 4320\text{Wh}$$

2. Divide the total daily energy consumption by the inverter efficiency

$$4320\text{Wh} / 0.9 = 4800\text{Wh}$$

3. Multiply by days of autonomy

In our design, we are using one day (1) of autonomy

$$1 \times 4800 = 4800\text{Wh}$$

4. Divide by the temperature compensation factor of 0.9

$$4800 / 0.9 = 5333.33\text{Wh}$$

5. Divide by the battery depth of discharge, which is 50% (Lead Acid battery)

$$5333.33 / 0.5 = 10666.67\text{Wh}$$

6. Divide by the system nominal voltage

$$10666.67 / 24 = 444.45\text{Ah}$$

Choosing a battery of 220Ah 12V, we would have the following number of battery to use in our system.

$$444.45\text{Ah} / 220\text{Ah} = 2.0\text{Ah}$$

We will need a two (2) number of 220Ah 12V battery in our design.

Battery capacity in Wh:

$220\text{Ah} \times 24 = 5280\text{Wh}$  and we have use two (2) number of this battery

$$5280 \times 2 = 10560\text{Wh}$$

**Total backup time** = battery capacity / real power

$$10560\text{Wh} / 1222\text{W} = 8.64\text{hrs}$$

## SERIES AND PARALLEL CONNECTION OF BATTERIES

### SERIES CONNECTION

The positive terminal of one battery is connected to the negative terminal of the subsequent battery when batteries are connected end-to-end in series. Two 12-volt batteries connected in series would result in a total voltage of 24 volts since the voltage of the batteries is added together. The current is still the same as with a single battery, though.

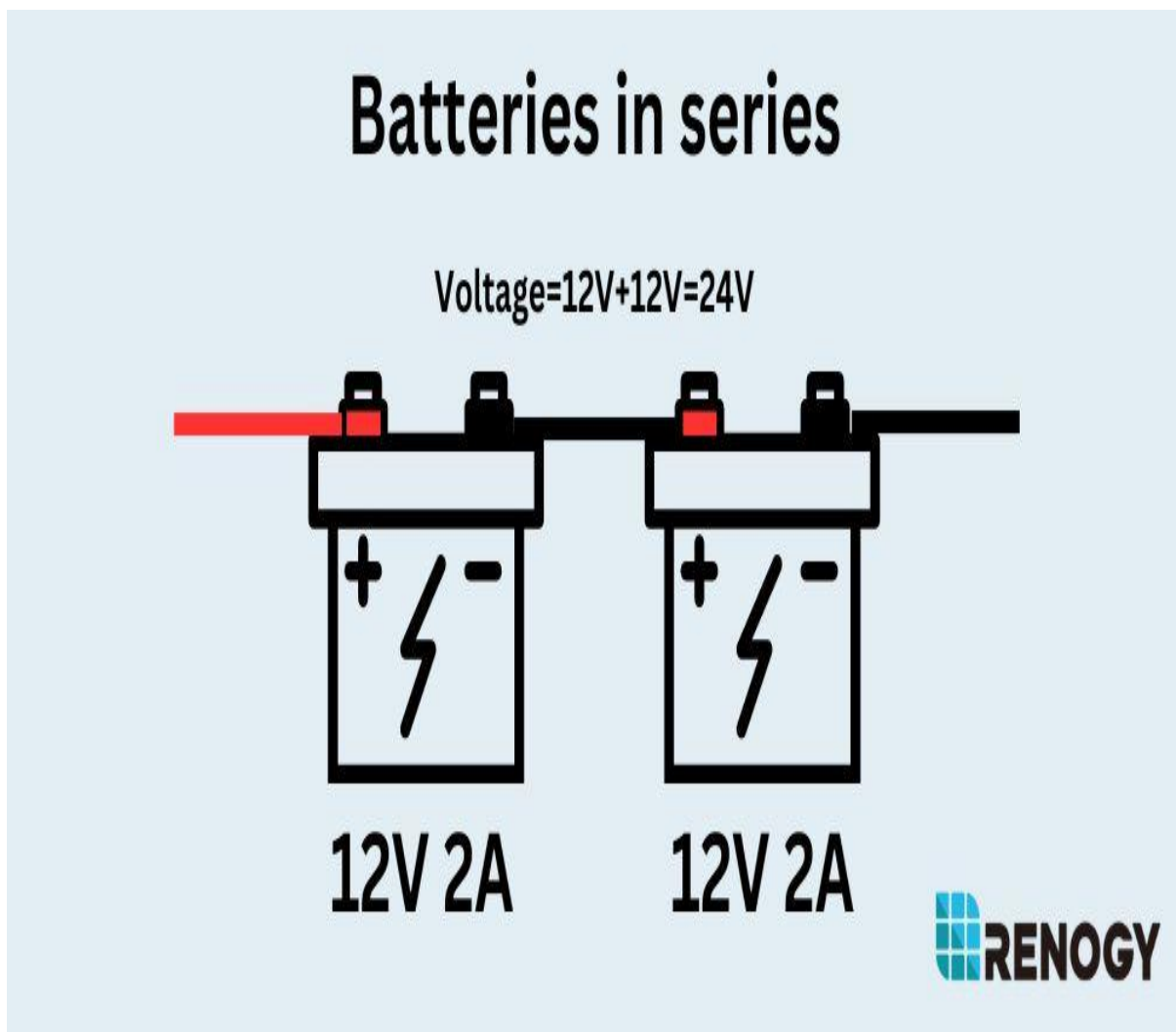


Fig 3.2 Batteries Connected In Series

The connection is completed in solar energy systems until every battery is connected. The positive and negative output terminals are then the battery string's remaining positive and negative terminals.

## PARALLEL CONNECTION

All of the positive terminals of the batteries are connected together when they are connected in parallel, and all of the negative terminals are connected together as well. The batteries' overall voltage is constant, but their combined current is increased. Therefore, the total current capacity would be 4 amps if the two batteries with a 2 amp capacity were linked in parallel.

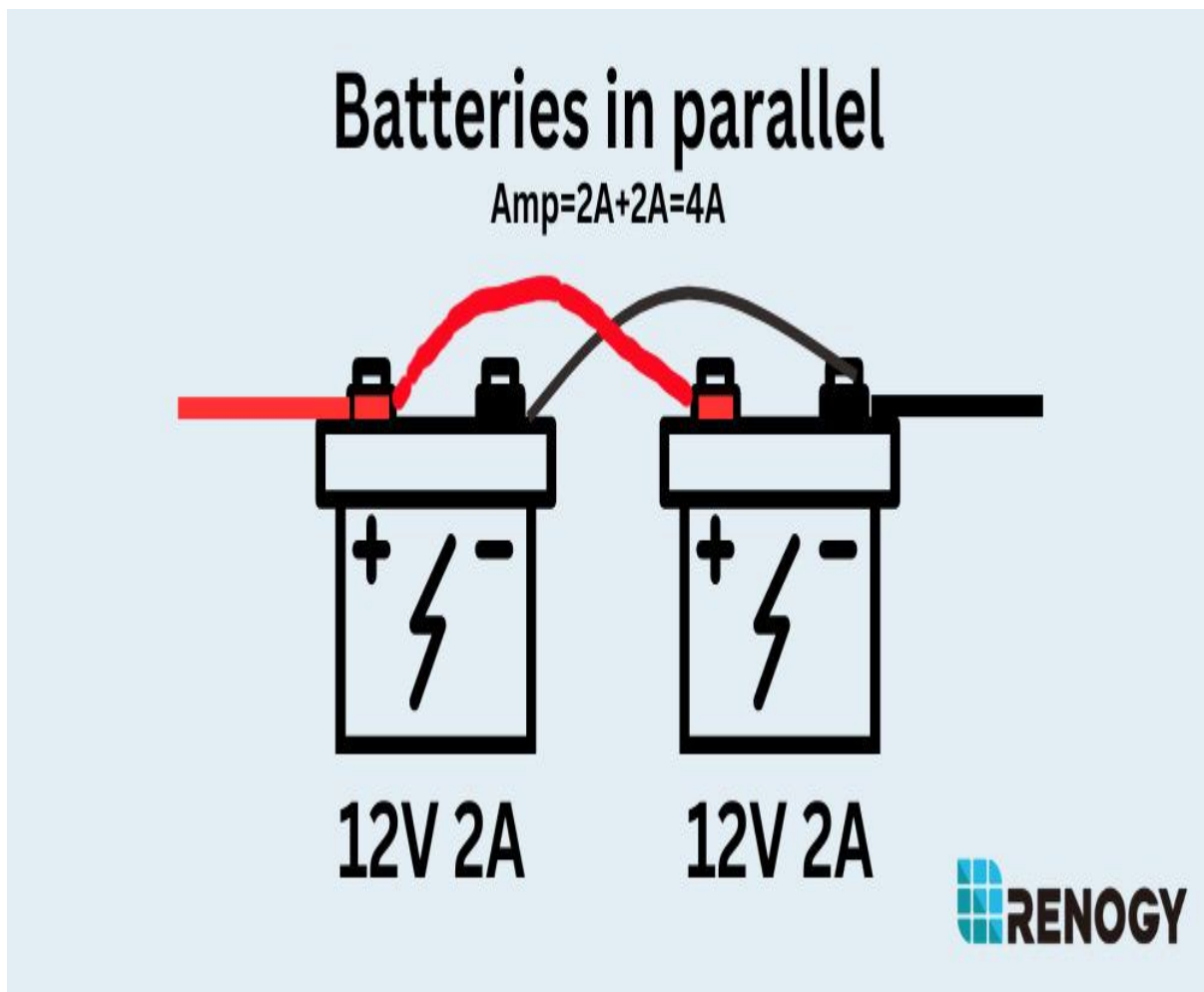


Fig 3.3 Batteries Connected In Parallel

When connecting batteries in parallel in solar energy systems, all of the batteries' positive and negative terminals must be connected together. The battery bank's remaining terminals are then used to extract the positive and negative output terminals.

### **3.4 Solar Panels**

The standalone solar power system's main energy-generating component, solar panels, transform sunlight into electrical power for home appliances. A solar panel array made up of 400W high-efficiency polycrystalline panels has been chosen for this endeavour.

#### **Type and Efficiency**

Polycrystalline solar panels are chosen for their balance of cost and efficiency. These panels consist of multiple silicon crystals, which allow for good performance in various weather conditions while being more affordable than their monocrystalline counterparts. The overall efficiency of these panels typically ranges from 15% to 20%, making them suitable for maximizing energy production within limited space.

#### **Installation Considerations**

To optimize energy generation, the solar panels must be strategically installed. Key factors include:

- **Orientation:** In the northern hemisphere, panels should ideally face true south to capture maximum sunlight throughout the day. In the southern hemisphere, they should face true north.
- **Tilt Angle:** The panels should be tilted at an angle that corresponds to the latitude of the installation location to enhance solar exposure, especially during winter months when the sun is lower in the sky.
- **Shading:** It's crucial to install the panels in a location free from shading caused by trees, buildings, or other obstructions, as even partial shading can significantly reduce energy output.

#### **Performance and Characteristics**

The performance of solar panels is affected by several factors, including solar irradiance (the amount of sunlight hitting the panels), temperature, and the angle of incidence. Monitoring these conditions is essential to ensure optimal energy production.

#### **Solar Energy calculation Production:**

To ensure that the solar panel array can meet the daily energy consumption, it's essential to calculate the total energy production from the panels. Using the previous example of daily energy consumption (4320Wh), we can assess whether the solar panels can adequately supply this amount.

With the following steps, we can determine the total wattage of solar panel we would need to charge our battery bank comfortably.

1. Divide the daily energy consumption by the inverter efficiency

$$4320 / 0.9 = 4800\text{Wh}$$

2. Divide by the solar panel performance ratio

$$4800 / 0.9 = 5333.33 \text{ Wh}$$

Divide by the peak sun hour

$$5333.33\text{Wh} / 5\text{h} = 1066.67\text{W}$$

With an individual solar panel with the rating 400W,  $V_{mp} = 30.9\text{V}$ ,  $I_{mp} = 12.9\text{Amps}$ , we will need

$1066.67\text{W} / 400\text{W} = 2.67$  approximate 3W solar panels. I.e 3 three (3) number of 400W solar panels to charge our battery bank.



Fig 3.4 Solar Panel Illustration

## SOLAR PANELS IN SERIES AND PARALLEL

Two popular ways to raise the voltage and current of a solar panel array are to connect the panels in parallel and series.

### Series Connection

The positive (+) terminal of one solar panel is connected to the negative (-) terminal of another when solar panels are connected in series. While the array's current will be equal to that of a single solar panel, its overall voltage will be the sum of the voltages of each individual solar panel.

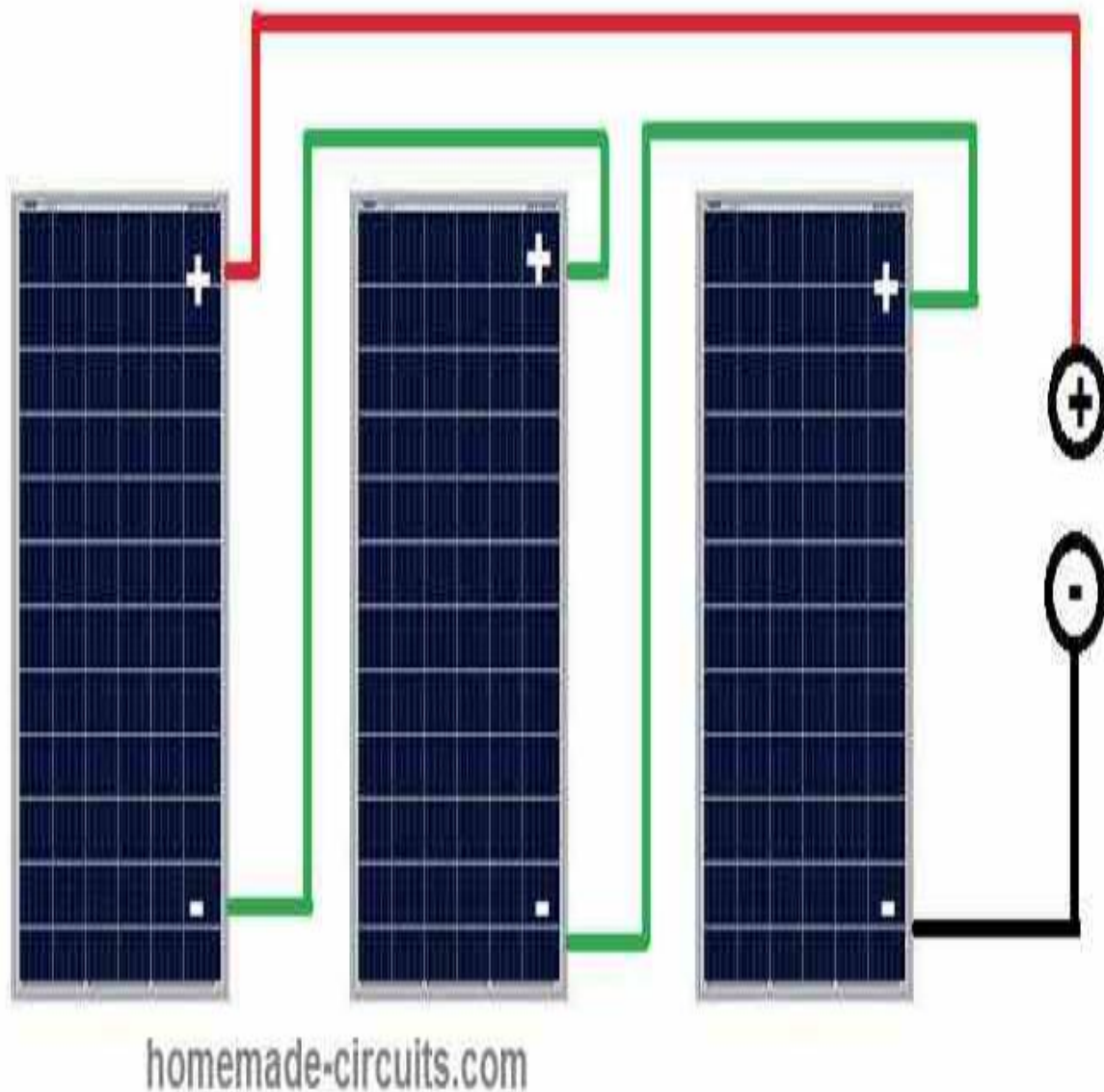


Fig 3.5 SOLAR PANELS CONNECTED IN SERIES

### Parallel Connection

In parallel solar panel connections, all of the solar panels' positive (+) and negative (-) terminals are connected together. The array's overall voltage will be equal to that of a single solar panel, and its current will be the sum of the currents from all of the individual solar panels.

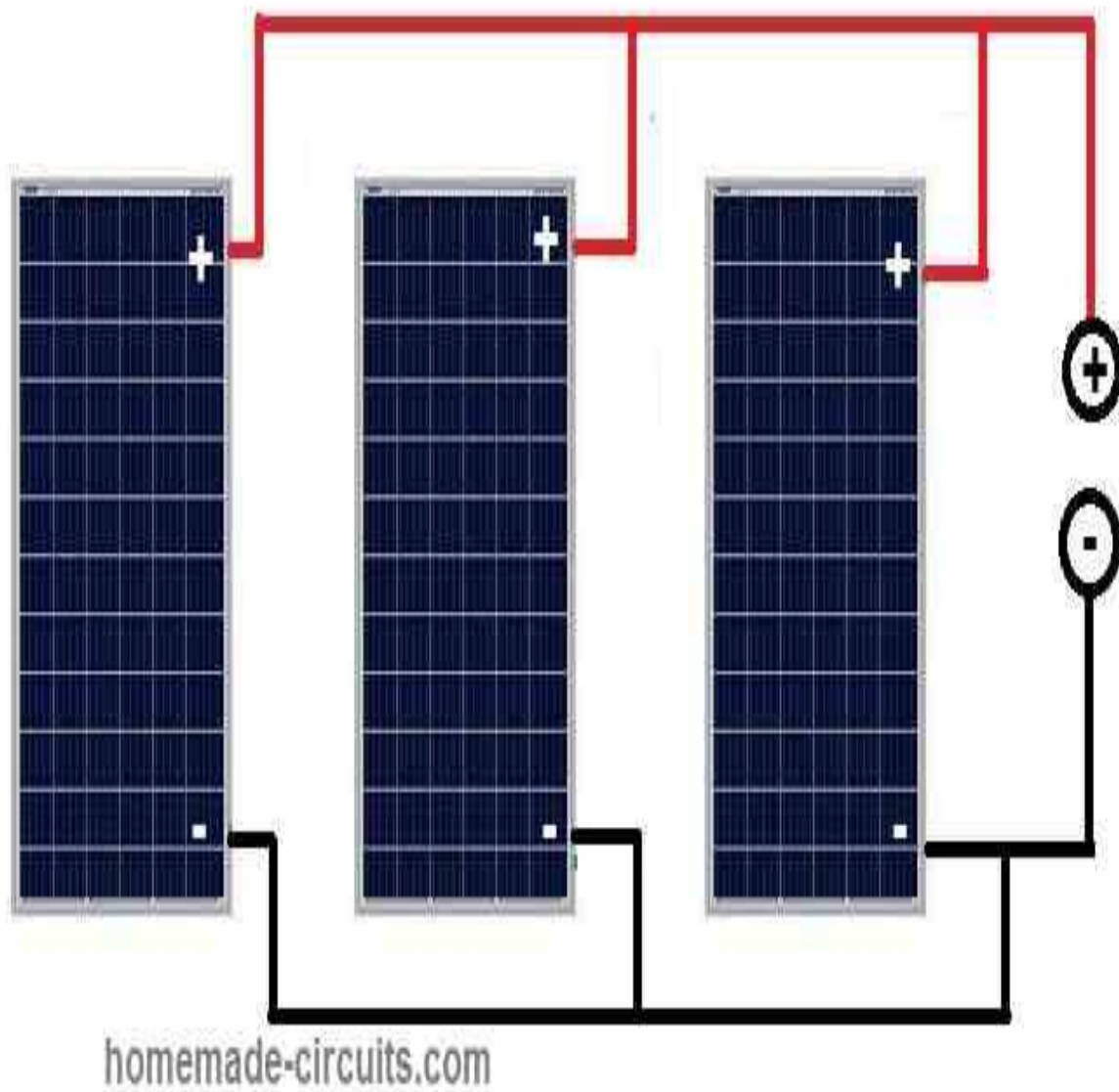


Fig 3.6 Solar Panels Connected In Parallel

### Series-Parallel Connection of Batteries

We have discussed the two main configuration for solar panels which are series and parallel configuration. With a close observation, it is observed that each configuration has it's unique advantages and disadvantages. We can combine those configuration to achieve those advantages which are increase in voltage and current simultaneously.

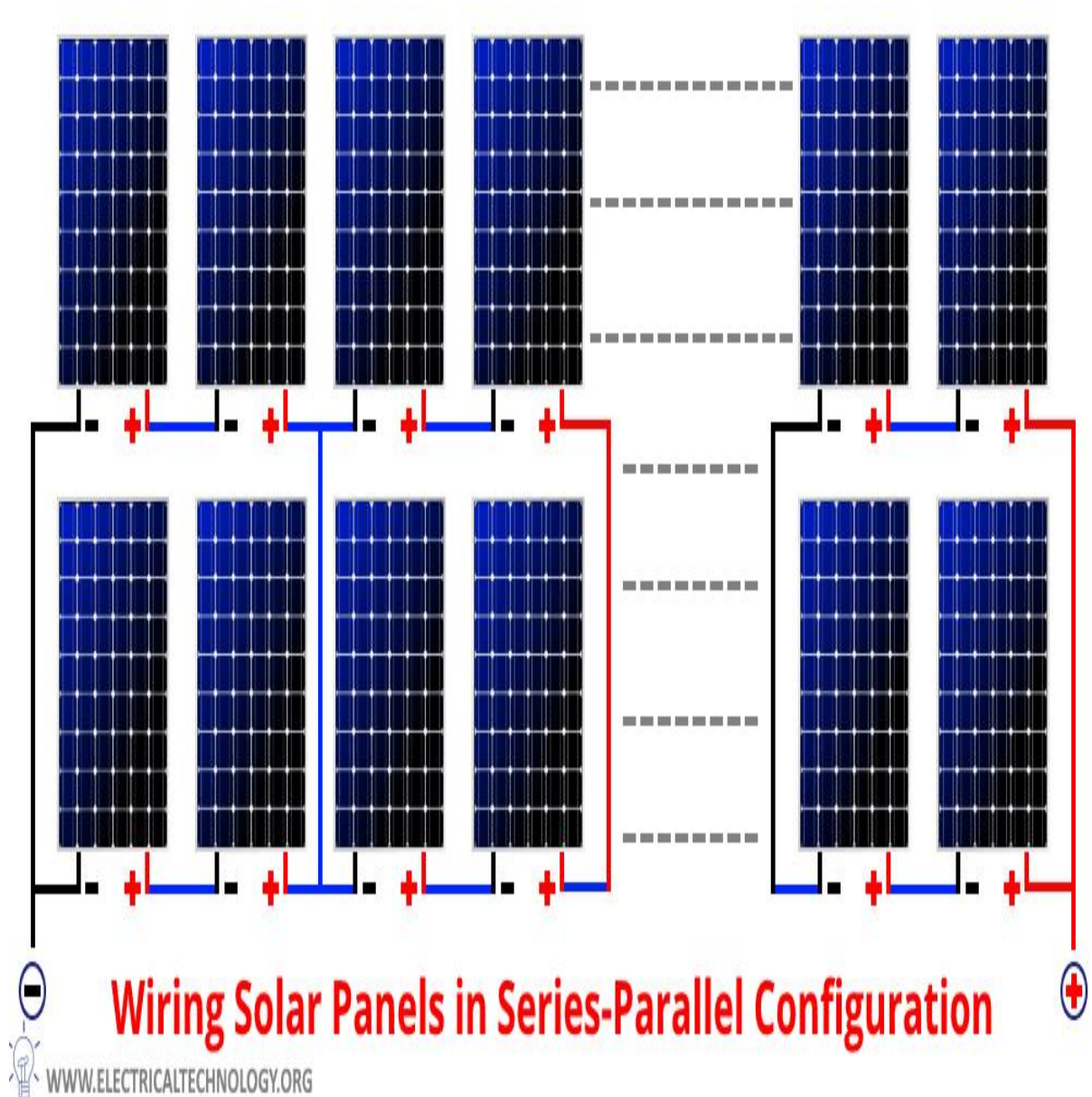


Fig 3.7 Series-Parallel Connection of Solar Panels

### **3.5 The Charge Controller:**

An essential part of a stand-alone solar power system is the charge controller, which controls the electricity flow between the battery and the solar panels. Its main duties include keeping an eye on the solar panels' voltage and current, making sure that charging is done effectively, and avoiding overcharging, which shortens the battery's lifespan and damages it. In order to preserve the battery's longevity and health, the charge controller also guards against deep discharge by cutting the load when the battery voltage falls below a predetermined level. By ensuring that the 200AH battery is charged to its ideal level, this control improves the system's overall efficiency and offers a dependable power source for domestic requirements. Because of its sophisticated features, an MPPT (Maximum Power Point Tracking) charge controller has been selected for this project. The MPPT controller dynamically modifies the electrical operating point of the solar panels to maximize energy production, in contrast to conventional PWM (Pulse Width Modulation) controllers, which progressively lower power as the battery gets closer to full charge. This results in a significant boost in energy harvesting, maybe by as much as 30%, which is particularly advantageous in situations with fluctuating sunshine. Additionally, the MPPT controller offers more design freedom by enabling the incorporation of higher voltage solar panels. Through the use of an MPPT charge controller, this project seeks to optimize energy conversion efficiency and guarantee optimal system performance, ultimately bolstering the sustainability and dependability of the independent solar power system.

#### **Selection of Charge Controller:**

Selecting the appropriate charge controller involves several calculations to ensure it matches the system's specifications and requirements. Here are some key calculations to consider:

##### **1. Solar Panel Voltage and Current**

- Determine the total voltage and current output of the solar panels. This helps in selecting a charge controller that can handle the maximum input from the panels.
- For example, if you have multiple panels connected in series, sum their voltages; if they are in parallel, sum their currents.

##### **2. Battery Voltage**

- Ensure the charge controller matches the voltage of the battery system (e.g., 12V, 24V). The controller should be designed to work with this voltage.

##### **3. Maximum Charge Current**

- Calculate the total current from the solar panels to ensure the charge controller can handle it. This is particularly important for MPPT controllers, which can handle higher currents due to their efficiency.
- For instance, if your solar panel array has a total output of 400W and operates at 12V, the maximum current can be calculated as:

$$\text{Current(I)} = \text{Voltage(V)} / \text{Power(P)}$$

$$1200\text{W} / 12\text{V} = 100\text{Amp}$$

Therefore, we will choose a charge controller of 36V 100Amp

#### 4. Battery Capacity and Charge Rate

Calculate the recommended charge current for the battery to optimize its lifespan. A common rule is to charge the battery at a rate of 10-20% of its capacity. For a 200AH battery, this means:

$$\text{Charge Current} = 200\text{AH} \times 0.1 = 20\text{A} \text{ to } 200\text{AH} \times 0.2 = 40\text{A}$$

This helps determine if the chosen controller can provide sufficient charge without overloading.

#### 5. System Safety Margin

- Consider a safety margin when selecting the controller to ensure it can handle unexpected surges in current or variations in solar output. A common practice is to choose a controller rated for at least 25% more than the maximum current you calculated.

##### **Sizing the charge controller:**

In sizing the charge controller, it is ideal to use the formulae

Size of charge controller = maximum power of the solar panel / Maximum power voltage

$$\text{Size of charge controller} = 1066.67 / 30.9 = 34.52\text{A}$$

We will use a 2040A MPPT charge controller in our design.

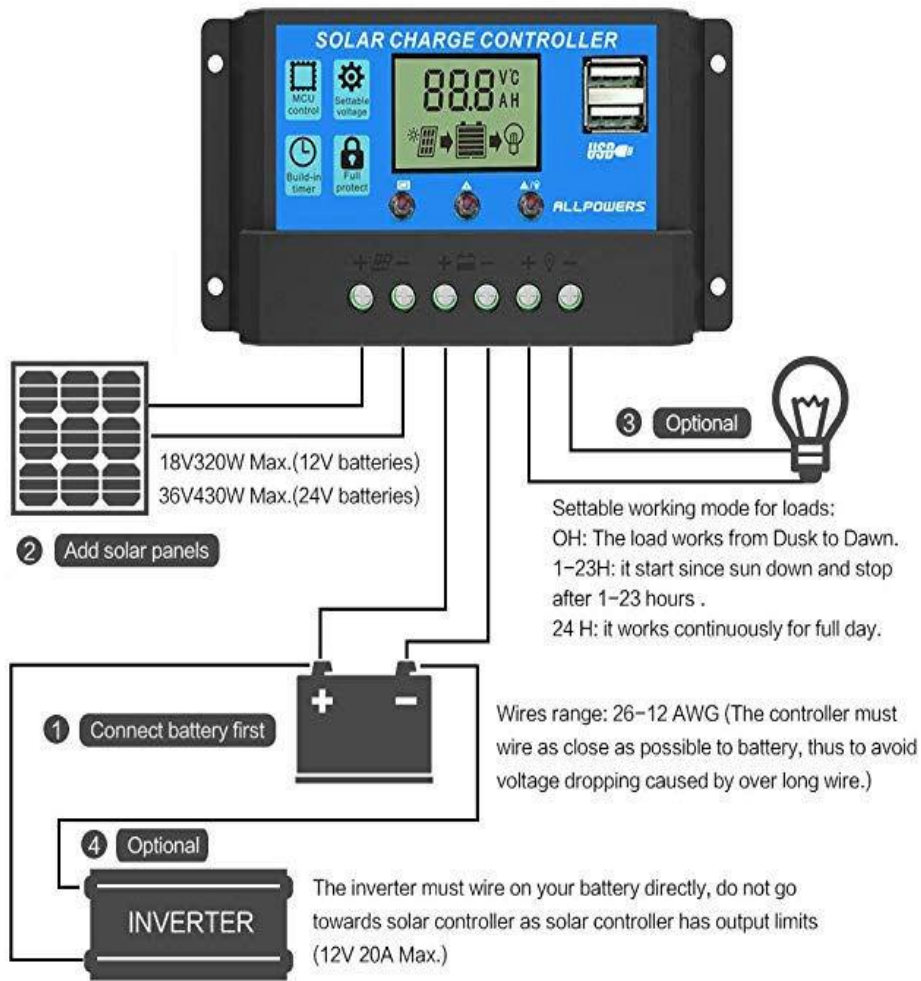


Fig 3.8 Assembly the Solar Components

### **3.6 Cabling and Connectors:**

A solar power system's cables need to have the right size to manage the current without becoming too hot. DC-rated cables, which are made to endure the particular climatic conditions of outdoor installations, are typically used in solar systems. The maximum current load and component distance are used to calculate the wire gauge. While excessively thick cables can be needlessly expensive and unwieldy, using too thin cables can result in voltage drop, which lowers system efficiency.

Since they serve as the contact between solar panels, batteries, and inverters, connectors are equally crucial. To endure outdoor circumstances, they need to be strong and resistant to weather. MC4 connectors are a common type of connector used in solar systems. They are made to provide simple and safe connections between solar panels and other parts. Connections that are securely fastened and sealed reduce the chance of electrical problems and energy losses.

To safeguard the system against over-current situations, it's also critical to think about installing the proper fuses or circuit breakers. By preventing component damage, these safety mechanisms lower the chance of a fire.

### **Protection Devices:**

Fuse integration in this project improves system safety and dependability by stopping excessive current from passing through the solar panels, batteries, and inverters, among other components.

Typically, fuses are placed at strategic areas of a solar power system, such as between the charge controller and the battery and between the solar panels and the charge controller. This configuration guarantees that the fuse will blow in the case of a problem, such as an overload or short circuit, stopping the current flow and halting additional system damage.

It's important to choose the right fuse rating; to prevent annoying blowing during regular operation, the fuse should be rated just over the maximum anticipated current. For example, a fuse with a 35A or 40A rating would be suitable if the system's maximum current is determined to be 30A. It's crucial to strike a balance between this and protection requirements, though, as an excessively high rating could prevent it from blowing in a fault scenario.

Fast-acting fuses can also offer instant protection in circumstances when damage prevention requires rapid interrupts. Using strategically positioned fuses in the system devised for this project guarantees that all parts may function securely and efficiently, increasing the system's lifespan and giving consumers peace of mind.

### 3.7 Mounting Structures

Mounting structures are a vital component of a standalone solar power system, as they secure the solar panels in place and ensure optimal positioning for maximum sunlight exposure. The choice of mounting structure can significantly influence the system's energy production and overall efficiency.

There are several types of mounting structures commonly used in solar installations:

**Fixed Mounts:** These are the simplest and most cost-effective option, holding solar panels at a fixed angle. Fixed mounts are typically set at an angle that maximizes solar exposure based on the geographic location. While they do not allow for adjustment throughout the year, they are reliable and require minimal maintenance.

**Adjustable Mounts:** These structures allow users to manually change the angle of the solar panels to optimize their position based on seasonal changes in the sun's path. This adjustability can improve energy capture compared to fixed mounts, but they require periodic adjustments and may be more complex to install.

**Tracking Systems:** These advanced mounting solutions automatically adjust the orientation of solar panels throughout the day to follow the sun's movement. Single-axis trackers move the panels from east to west, while dual-axis trackers can tilt and swivel, providing the highest energy output. However, these systems are more expensive and require more maintenance.

**Rooftop Mounts:** In residential applications, solar panels are often installed on rooftops. These mounts are designed to secure panels at a suitable angle and may use specialized brackets to minimize roof penetration and potential leaks.

**Ground Mounts:** For installations with ample land space, ground-mounted systems can be used. These structures provide flexibility in positioning and can often be installed at optimal angles for solar capture.

In the context of this project, selecting an appropriate mounting structure is essential for maximizing the efficiency of the solar panels. Factors to consider include the location's climate, the available space, and the desired balance between cost and energy output. Proper installation of the mounting structure is crucial, as it must be robust enough to withstand wind and weather conditions while ensuring that the solar panels remain securely in place over time. Ultimately, the right mounting solution can significantly enhance the performance and longevity of the solar power system.

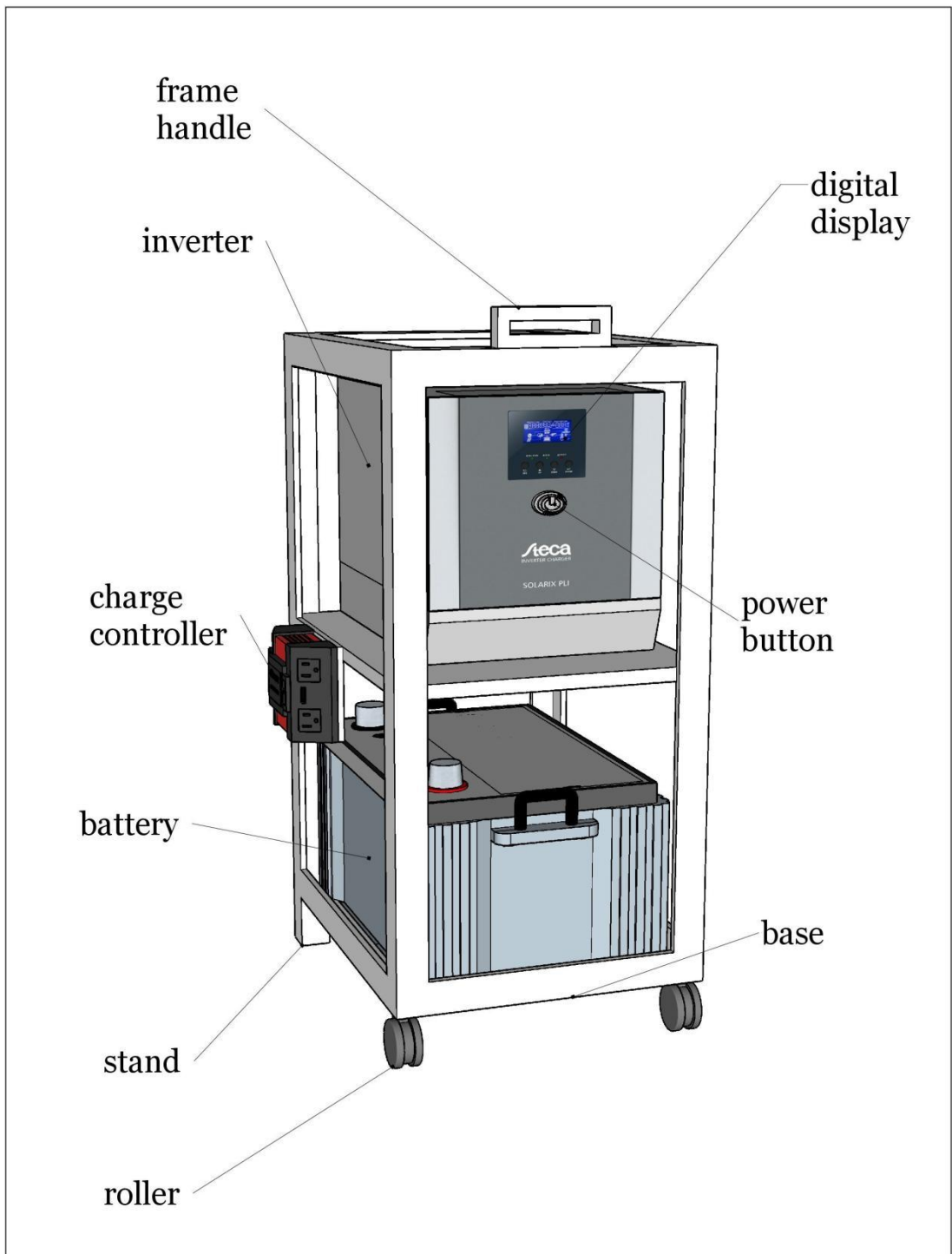


Fig 3.9 AN OVERVIEW OF THE SYSTEM COMPONENTS

### 3.8 System Integration and Functionality

This determine how effectively the individual components work together to deliver reliable energy. The integration of components ensures that the system can capture solar energy, store it efficiently, and provide power as needed.

At the core of the integration is the energy flow pathway:

**Energy Generation:** Solar panels capture sunlight and convert it into direct current (DC) electricity. The number of panels and their orientation play a significant role in determining the overall energy output, as they must be aligned to maximize exposure to sunlight throughout the day.

**Energy Storage:** The generated DC electricity is then directed to the battery storage system. A charge controller regulates this flow, ensuring that the batteries are charged efficiently while preventing overcharging and deep discharging. This regulation is crucial for extending the lifespan of the batteries and maintaining optimal performance.

**Energy Conversion:** When electricity is needed for household appliances, the stored DC power is converted to alternating current (AC) by the inverter. This conversion is essential since most household devices operate on AC power. The inverter must be properly sized to handle the expected load, ensuring that it can supply enough power without overloading.

**Power Distribution:** Once converted to AC, the electricity is distributed to various appliances and devices within the home. Proper wiring and connectors ensure that energy flows safely and efficiently, minimizing losses along the way.

**Monitoring and Control:** An energy management system (EMS) plays a vital role in optimizing the operation of the entire system. It monitors energy production, storage levels, and consumption patterns, allowing for real-time adjustments. This ensures that critical loads are prioritized during periods of low energy availability, helping to extend battery life and improve overall system reliability.

**Safety Features:** Integration also involves incorporating safety mechanisms, such as fuses and circuit breakers, to protect against over-current and potential electrical hazards. Proper installation of these components is essential for ensuring user safety and system durability.

Overall, effective system integration allows the standalone solar power system to operate autonomously, providing a continuous supply of clean energy. The seamless interaction between components maximizes efficiency, ensuring that energy generated during the day can be used at any time, even when sunlight is not available. This holistic approach not only enhances the system's performance but also underscores the viability of solar energy as a sustainable solution for energy needs, particularly in remote or off-grid locations.

### 3.9 Installation and Assembly Process:

The installation and assembly process of a standalone solar power system is crucial for ensuring its efficiency and reliability. This process involves several key steps, each requiring careful planning and execution to maximize the system's performance. Here's a detailed overview:

1. **Site Assessment:** Before installation, a thorough assessment of the site is essential. This includes evaluating the location for optimal sunlight exposure, taking into account shading from trees or buildings, and ensuring sufficient space for all components. Understanding local regulations and permits required for installation is also crucial.

2. **Component Preparation:** Gather all necessary components, including solar panels, battery storage, inverter, charge controller, mounting structures, cabling, and connectors. Each component should be checked for quality and compatibility with the overall system design.

3. **Mounting Structure Installation:** Begin by installing the mounting structures for the solar panels. This step involves securing the structures to the ground or roof, ensuring they are level and stable. If using ground mounts, it may be necessary to dig holes for posts or use concrete to anchor the mounts securely.

4. **Solar Panel Installation:** Once the mounting structure is in place, the solar panels can be attached. Panels should be oriented and tilted at an angle that optimizes solar exposure based on geographic location. It's important to securely fasten the panels to prevent movement due to wind or weather conditions.

5. **Electrical Wiring:** After the panels are mounted, the electrical connections can be made. This includes connecting the solar panels to the charge controller and ensuring proper wiring to the battery and inverter. Use appropriately rated cables to minimize energy loss and ensure safety. Proper connectors and junction boxes should be used to protect against moisture and corrosion.

6. **Charge Controller and Inverter Setup:** Install the charge controller in a location that allows easy access for monitoring. Connect it to the battery and solar panels according to the manufacturer's instructions. The inverter should also be mounted securely and connected to the battery and electrical system, ensuring proper ventilation to prevent overheating.

7. **Battery Installation:** Position the battery in a cool, dry place, away from direct sunlight and moisture. Proper ventilation is essential to prevent gas accumulation, especially if using lead-acid batteries. Connect the battery to the charge controller and inverter, ensuring that all connections are tight and secure.

8. **Safety Measures:** Implement safety features such as fuses and circuit breakers to protect against over-current and short circuits. Ensure all components are properly grounded to prevent electrical shock and damage.

**9. System Testing:** Once everything is connected, conduct a thorough testing of the system. Check the functionality of the charge controller, inverter, and battery charging process. Verify that the solar panels are generating power and that the system is delivering electricity to the designated loads.

**10. Monitoring and Maintenance:** After installation, establish a routine for monitoring system performance. This includes checking battery levels, monitoring energy production, and inspecting for any signs of wear or damage. Regular maintenance, such as cleaning solar panels and checking connections, will help ensure long-term efficiency.

In conclusion, a well-planned and executed installation process is vital for the successful operation of a standalone solar power system. Attention to detail in each step, from site assessment to final testing, will contribute to the system's reliability, efficiency, and overall performance.

### **3.10 Fabrication Process:**

Bill of engineering materials and evaluation, welding operation, material selection, and bench fitting operation.

**1. Bench Fitting Operation:** The process of manually assembling and polishing metal components with a variety of tools and methods is called bench fitting operation. Producing components that demand a high degree of accuracy and precision is standard procedure in engineering workplaces. The following are a few instruments and methods utilized in bench fitting operations:

- **Holding tools:** These are the tools that are used to hold the workpiece in place while carrying out the various fabrication procedures needed to create a 2.5 KVA solar power generator. A few instances of holding tools are pliers, clamps, and vices.
- **Striking tools:** These are the tools that are used to hit or provide pressure to other tools or the workpiece. A few instances of hitting instruments are punches, hammers, and mallets.
- **Cutting tools:** These are the tools that are used to cut, saw, file, chisel, and other operations to remove extra or undesirable material from the workpiece. Cutting tools include things like drills, chisels, files, hacksaws, and so forth.
- **Marking, measuring, and testing tools:** These are instruments for marking, measuring, and testing the workpiece's size, form, and quality. A few instances of instruments used for marking, measuring, and testing are dividers, calipers, rulers, gauges, scribes, and so on.

**2. Welding Operation:** Melting and fusing two or more metal components together is the process of welding. In solar power generator construction, welding is used to join the frames for solar panel mounting, frames also for batteries racks. Several techniques, including arc, gas, resistance, and others, can be used to do welding. Depending on the kind, gauge, and form of the metal components, each technique offers benefits and drawbacks.

**3. Material Selection:** The following materials are used in the fabrication processes: rollers, angle bars, and mild steel.

I. Mild Steel: Mild steel is a kind of steel with a low carbon content—typically less than 0.25 percent. Since it is inexpensive, simple to produce, and strong enough for a variety of uses, it is one of the most popular and extensively utilized types of steel. Low-carbon or plain-carbon steel are other names for mild steel.

Mild steel is appropriate for a variety of uses due to its diverse qualities. Several of these attributes include:

- Density: Mild steel is comparatively heavy when compared to other metals, with a density of roughly 7850 kg/m<sup>3</sup>.
- Strength: Mild steel has a moderate tensile strength that varies based on grade and composition, from 400 to 550 MPa. It also possesses a good yield strength, or the tension at which permanent deformation starts.
- Hardness: According to the Brinell scale, mild steel has a low hardness of roughly 120 BHN. It is therefore soft and simple to drill, file, or cut.
- Melting point: Mild steel can tolerate high temperatures without losing its shape or qualities since it has a high melting point of roughly 1450 °C.
- Weld-ability: Mild steel can be fused and melted along with other metal components because of its exceptional weldability. One popular technique for creating things made of mild steel is welding.
- Machinability: Mild steel is very machinable, meaning it can be finished and shaped with a variety of instruments and methods, including grinding, milling, and turning. Another popular technique for creating things out of mild steel is machining.
- Ductility: Since mild steel is highly ductile, it can be bent or stretched without splitting or breaking. For mild steel products to be formed and shaped, ductility is a crucial attribute.

- **Magnetic:** Mild steel's high iron content gives it good magnetic characteristics. Electric currents have the ability to magnetize or attract it. Certain applications, such as transformers, generators, and motors, benefit from magnetic characteristics.

II. **Angle Bar:** A common material in engineering, fabrication, and building is angle bar. It is sometimes referred to as steel angle, angle iron, or L-bracket. This is a metal bar with two perpendicular sides and an L-shaped cross section. Various metals, including brass, stainless steel, aluminum, and carbon steel, can be used to make angle bars. Depending on its intended usage and construction, angle bars can have equal or unequal legs.

Angle bar is useful for a variety of applications due to its many qualities and benefits. Among them are:

- **Strength:** The angle bar has a moderate tensile strength and yield strength, which means it can resist stretching and bending forces without breaking or deforming. Angle bars can also support heavy loads and withstand high temperatures.
- **Durability:** Angle bars are highly resistant to rust and corrosion, particularly when coated in protective coatings or galvanized. Angle bars are also resistant to deterioration and deformation over an extended period of use. Angle bars are highly resistant to rust and corrosion, particularly when coated in protective coatings or galvanized. Angle bars are also resistant to deterioration and deformation over an extended period of use.
- **Versatility:** Angle bars can be shaped and sized to meet a variety of requirements and specifications by drilling, cutting, welding, or bending. Angle bars can also be fastened to other metal components using a variety of methods, including welding, bolting, and riveting.
- **Cost-effectiveness:** Compared to other metal materials, angle bar is readily produced and reasonably priced. Because they need less labor and time to make, angle bars can help lower the cost of building and manufacturing.

### **3.11 Bill of Engineering Measurement and Evaluation (BEME)**

The BEME, often known as the bill, is a measuring and evaluation instrument used to value and assess the cost of construction projects and works. It includes labor, materials, equipment, and any other resource required for the project's proper completion.

S/N	Materials	Quantity	Unit Cost
1	1.2Kw/1.5KVA Inverter	1	350,000
2	40A/24V Charge Controller	1	120,000
3	220Ah Battery	2	265,000
4	6mm wire	Lots	14,000
5	Angle Bar	4	15,000
6	PV	3	125,000
7	Total	Total	889,000

## CHAPTER 4

### RESULT ANALYSIS, CONSTRUCTION PROCEDURES AND TESTING

#### 4.1 Construction Process:

The construction of the 1.5KVA standalone solar power system involved several key stages to ensure accuracy, efficiency, and safety. The process was carried out in a structured manner to achieve a robust and functional system. The following procedures were followed:

##### 4.1.1 System Assembly

**Mounting Structure Installation:** The mounting structure was assembled using mild steel and angle bars to provide a stable foundation for the solar panels. The structure was positioned at an optimal tilt angle to maximize sunlight exposure.

**Solar Panel Installation:** The solar panels were securely fixed onto the mounting structure. MC4 connectors were used to establish secure electrical connections between the panels.

**Charge Controller Setup:** The charge controller was installed at a convenient and accessible location. It was connected to the solar panels and batteries using appropriately sized DC cables to regulate the flow of electricity.

**Battery Installation:** The battery bank was set up in a well-ventilated area, ensuring proper spacing to prevent overheating. The batteries were connected to the charge controller using insulated copper cables.

**Inverter Connection:** The inverter was installed and connected to the battery bank and output distribution system. Care was taken to ensure correct polarity and secure wiring to avoid power loss.

**Wiring and Circuit Protection:** Appropriately sized cables were used to connect all components. Fuses and circuit breakers were installed at strategic points to protect the system from over-current conditions.

#### 4.2 TESTING PROCEDURES

Testing was conducted to verify the performance and functionality of the system. The tests were carried out in a stepwise manner to ensure that each component operated as expected.

### 4.2.1 System Initialization

Before powering the system, a comprehensive check of all connections was performed to ensure there were no loose or faulty connections. A multi-meter was used to confirm voltage levels at key points.

### 4.2.2 Performance Testing

**Solar Panel Output Verification:** The voltage and current output of the solar panels were measured under different sunlight conditions to confirm that they met the expected values.

**Charge Controller Functionality:** The charge controller was tested to ensure proper regulation of power flow to the batteries. The LED indicators and digital readings were checked for accuracy.

**Battery Charge and Discharge Test:** The battery bank was monitored during charging to verify that it stored energy efficiently. Load tests were conducted to assess battery discharge behavior.

**Inverter Output Test:** The inverter output voltage was measured to confirm it supplied stable AC power. Various household loads were connected to evaluate performance.

**Load Testing:** The system was tested under different load conditions to ensure it could handle the expected power demands without fluctuations.

## 4.3 RESULT ANALYSIS

After testing, the system's performance was analyzed to determine its efficiency and reliability. The key findings were as follows:

**Solar Panel Efficiency:** The measured solar panel output was consistent with the manufacturer's specifications, with minor variations due to weather conditions.

**Battery Performance:** The battery bank demonstrated efficient charge and discharge cycles, with minimal energy loss observed during testing.

**Charge Controller Regulation:** The charge controller effectively managed power flow, preventing overcharging and deep discharging of the batteries.

**Inverter Performance:** The inverter provided stable AC power output within acceptable voltage limits, ensuring compatibility with standard appliances.

**System Stability:** The overall system operated reliably, maintaining steady power output with no significant fluctuations.

#### 4.4 CHALLENGES AND SOLUTIONS

During the construction and testing phase, several challenges were encountered, and corresponding solutions were implemented:

Challenge	Solution Implemented
Voltage drops in wiring	Used thicker cables to reduce resistance and improve efficiency.
Overheating of battery terminals	Ensured proper tightening of connections and improved ventilation.
Inverter fluctuations under heavy load	Upgraded cable connections and ensured sufficient battery charge before testing.
Weather variations affecting solar input	Adjusted panel angles for optimal sunlight capture.
Intermittent connectivity issues	Used high-quality connectors and secured all connections properly.

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATIO:

#### 5.1 Design Problem:

In the design project, the follow problems were observed:

1. Uneven power distribution leading to overloaded circuits.
2. Inefficient use of power resources.
3. Overheating of components due to high power dissipation.
4. Thermal stress leading to reduced lifespan or failure.
5. Voltage regulation issues under varying load conditions.
6. Damages from short circuits, over-current or over-voltage.

#### 5.2 Recomendation:

Hybrid inverters are crucial for providing reliable backup power to homes, businesses, and medical devices, making them ideal for industrial use. They integrate grid power, solar energy, and battery storage, ensuring uninterrupted electricity, especially in areas with unstable grids. Promoting their use can enhance energy resilience and support critical operations during outages.

In remote or off-grid areas, hybrid inverters paired with solar energy offer a sustainable solution, replacing costly and polluting alternatives like diesel generators. This can improve quality of life, support development, and reduce environmental impact.

Future designs should focus on improvements such as enhanced over-current and overload protection, faster switching components, and more efficient charging circuits. These advancements will make hybrid inverters safer, more reliable, and adaptable to diverse needs.

Investing in these innovations ensures dependable, sustainable energy access, empowering communities and supporting global efforts toward energy security and environmental sustainability.

### **5.3 Conclusion:**

It is with great pleasure that we introduce a groundbreaking project designed to provide reliable and efficient power solutions. Imagine having uninterrupted power supply whenever you need it. No more frustrating outages or stressful moments when your devices run out of juice. That's exactly what this project aims to achieve.

At the heart of this innovation is a powerful 1.5KVA inverter. It's designed to keep your lights on, your devices running, and your life uninterrupted - even when the grid fails.

For families, small businesses, and anyone relying on essential appliances, this means peace of mind. No more worrying about power outages or scrambling to find alternative solutions.

But that's not all. This inverter also tackles power spikes that can damage your electronics and cause costly headaches. By smoothing out these surges, it protects your valuable devices and saves you money and stress in the long run.

What's more, this inverter is energy-efficient, ensuring that every bit of power is used wisely. This helps cut down on electricity bills, providing welcome relief for anyone on a budget.

One of the biggest benefits of this project is reducing the need for noisy, expensive generators. For people living in small apartments or studios, generators are often impractical - they take up space, require constant maintenance, and can be a hassle to refuel.

In contrast, this inverter is quiet, low-maintenance, and environmentally friendly. It's a smarter, cleaner way to keep the power flowing without the drawbacks of traditional generators.

This project is about more than just technology - it's about making life easier and more sustainable. By providing a reliable, efficient, and eco-friendly power solution, it's helping people navigate the challenges of unreliable electricity in a practical and affordable way.

For anyone tired of dealing with outages, power spikes, or the noise and cost of generators, this inverter is a game-changer. It's a small but powerful step toward a future where energy is more accessible, dependable, and kind to both people and the planet.

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