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Solar Power Harvesting Using MPPT and Inverter

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Abstract: *This project focuses on efficient solar power harvesting using Maximum Power Point Tracking (MPPT) techniques and a DC-AC inverter. Solar energy, being a clean and renewable source, is increasingly used to meet growing energy demands. However, the efficiency of panels is influenced by environmental factors such as sunlight intensity and temperature. To maximize energy extraction, MPPT algorithms are employed to dynamically solar adjust the operating point of the solar panel to ensure it consistently operates at its maximum power point. The harvested DC power is then converted to AC using a high-efficiency inverter to make it suitable for household or grid applications. This system enhances the overall energy conversion efficiency and provides a reliable power source with reduced dependence on conventional energy systems*.

Keywords: MPPT, Inverter, Solar Energy, Battery

I. INTRODUCTION

The extensive use of fossil fuel has resulted in the global problem of greenhouse emissions. Thus solar power generation is becoming very useful since it pollution less and scarcity of fossil fuel energy is rising, while the cost of solar arrays is decreasing. Solar energy may be widely used in residential application in nature. Since solar energy is not available at night, storing its energy is an important issue in order to have continuous energy availability.

An inverter is necessary to convert the dc power to ac power. since output voltage of a solar cell array is low,a dc-dc power converter is used in a small-capacity solar power generation system. The active devices and passives in the inverter produce a power loss. The power loss due to active devices include both conduction losses and switching losses. The switching losses is proportional to the voltage and the current

These days, the global energy crisis and pollution management are the main issues. The majority of electricity is produced using non-renewable resources, and as the demand for electricity is growing daily, these sources will eventually run out of supply. One of the renewable energy sources is Photovoltaic (PV) modules that are coupled to the grid are a viable substitute for autonomous and sustainable energy source. By continuously modifying the electrical functioning point of the modules or arrays, Maximum/Peak Power Point Tracking (MPPT) is a technology used in photovoltaic modules to maximize the power production from solar energy panels.

This technique ensures that the solar energy panels function at their maximum power point (MPP), where they can produce the highest possible power under varying environmental conditions. Power electronic technology, which is widely used and developing quickly, is crucial to distributed generation and the inclusion of non exhaustible energy sources into the electrical grid.

Due to a number of benefits, including better spectral performance with a lower switching frequency than traditional inverters, which in turn reduces switching losses, multilevel voltagesource converters have become one of the finest options for medium-voltage, high power applications. Because of its modular circuit construction, the CHB converter is one of the top well-liked multilevel inverter topologies.

Recently the use of renewable energy resources has been increased to save the environment and remaining fossil fuel and the requirement of storing the energy is also increased

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II. LITERATURE SURVEY

Solar energy harvesting using photovoltaic (PV) systems is a rapidly growing field, particularly due to its environmentally friendly nature and the ongoing demand for renewable energy sources. The efficiency of solar power systems is influenced by the ability to harvest the maximum amount of energy from the solar panels, which is made possible through techniques such as Maximum Power Point Tracking (MPPT) and the use of efficient inverters. This literature survey aims to summarize the key findings and advancements in the field of solar power harvesting, focusing on the role of MPPT algorithms and inverter technologies.

This paper reviews various MPPT techniques used in photovoltaic systems with DC-DC converters. It discusses artificial intelligence-based methods like fuzzy logic control and neural networks for optimizing power extraction. You can check it out here.

MPPT Schemes for Standalone and Grid-Connected Systems – This survey explores different MPPT techniques for both standalone and grid-connected solar systems, highlighting their advantages and challenges. Find more details here.

SystematicReview of MPPT Techniques–Thispaper provides a comprehensive review of MPPT methods, including recent advances in artificial intelligence for solar energy optimization.

Inverters are essential components in any solar power system. They convert the DC electricity generated by solar panels into AC electricity, which can be used by household appliances or fed into the electrical grid. Modern inverters can also integrate MPPT to optimize the power conversion process.

Microinverters: Microinverters are small inverters attached to individual solar panels. Each panel operates independently, allowing for greater flexibility and minimizing losses due to shading or differing panel orientations.

III. MPPT

Maximum Power Point Tracking (MPPT) is a technique used in photovoltaic (PV) systems to ensure that the solar panels operate at their maximum power output under varying environmental conditions. The amount of power a solar panel produces depends on several factors, such as the angle of sunlight, temperature, and shading. These factors affect the voltage and current characteristics of the solar panel, meaning that the maximum powerpoint (MPP) shifts dynamically throughout the day.

MPPT is crucial because the power produced by a solar panel is not constant — it changes based on external conditions. By using MPPT, a solar system can continuously adjust its operating point to track the MPP, ensuring that the system generates the highest possible amount of power at any given time.

MPPT involves monitoring the outputvoltage and current from the solar panels, and dynamically adjusting the operating point to find the maximum power. This is typically achieved by varying the load on the solar panel to maintain the point where power output is maximized.

The operating voltage and current are typically controlled by adjusting the duty cycle of a DC-DC converter (in the case of isolated systems) or a grid-tied inverter. Several algorithms have been developed to optimize the tracking of this maximum power point.

IV. PROPOSED SYSTEM

In this proposed system, we aim to efficiently harvest solar energy using Maximum Power Point Tracking (MPPT) and an inverter to convert the DC power generated by the solar panels into AC power for household or industrial use. Here's a breakdown of the system's components and working

The input voltage of the solar panel is dc and it takes the dc input from the solar panel. The dc-dc boost converter boost up the input voltage and gives to the multilevel inverter.

1. Solar Panel Array

The system begins with an array of solar photovoltaic (PV) panels that convert sunlight into DC electricity. The efficiency of these panels can vary depending on sunlight intensity, temperature, and other environmental factors.The voltage and current produced by the solar panels will fluctuate based on these environmental conditions.

2. MPPT (Maximum Power Point Tracking) Controller

The output from the solar panels isn't constant due to the varying intensity of sunlight throughout the day. To maximize the energy harvested, the MPPT controller is used.

The MPPT algorithm continuously adjusts the operating point of the solar array to extract the maximum possible power**.**

The MPPT system tracks the Maximum Power Point (MPP), which is the combination of voltage and current at which the solar panel operates most efficiently**.**

3. Monitoring and Control System

A monitoring system may be incorporated to track the performance of the entire solar power system. This system can provide real-time data on energy production, consumption**,** and system health.The monitoring system can also allow remote control, adjustment, and alerts for any system faults or malfunctions.

4. DC-DC Converter

After the MPPT controller adjusts the solar panel output to the maximum power point, the DC power is sent to a DC-DC converter. This componentRegulates the DC voltage to a level suitable for further processing or direct usage.
Allows for voltage step-up or step-down as required for specific applications or for feeding into the inverter.

BLOCK DIAGRAM:

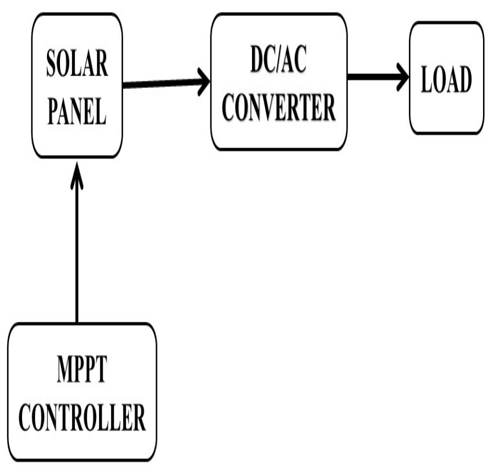

FIG: BLOCK DIAGRAM

The existing system block diagram shown in figure .The input voltage of the solar panel is dc and it takes the dc input from the solar panel.

V. RESULTS AND DISCUSSION

Enhanced Energy Harvesting: MPPT maximizes the energy produced by the solar panels, while the inverter ensures that as much of that energy as possible is converted to usable AC power.Improved Overall System Efficiency: When

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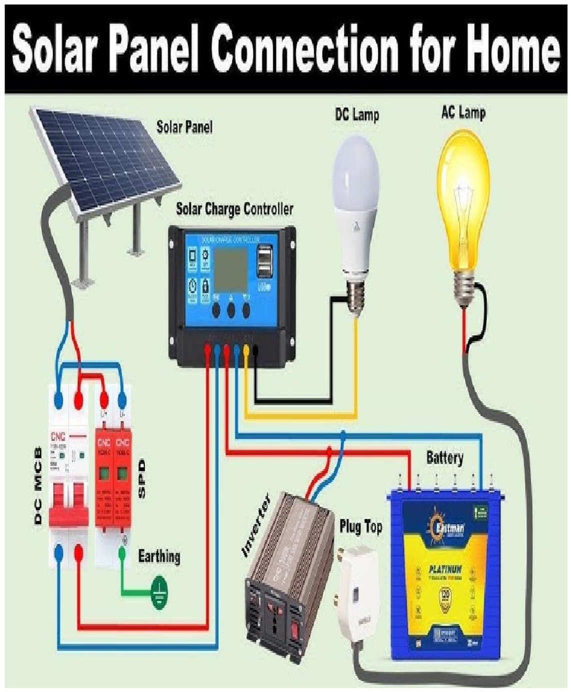
MPPT and inverters work together, system efficiency can increase by up to 30-40% compared to systems that do not utilize MPPT or have less efficient inverters.

The integration of MPPT technology and high-efficiency inverters significantly improves the return on investment (ROI) for solar power systems. This can be especially important in areas with inconsistent sunlight, where the ability to extract maximum power under varying conditions can lead to a higher energy yield.



Schematic Diagram

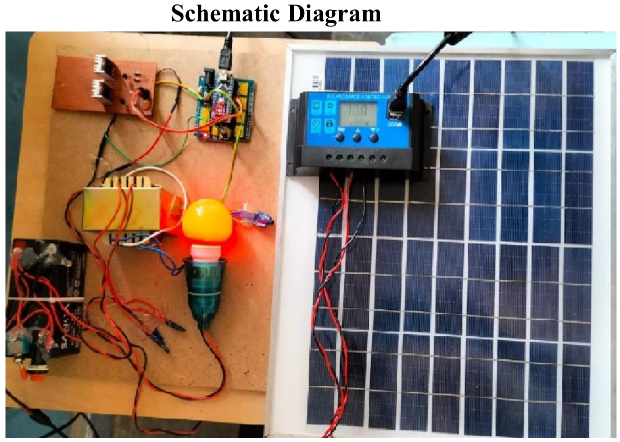


Fig: Prototype

VII. CONCLUSION

This project successfully demonstrates a functional and efficient solar inverter system using MPPT control. The integration of low-cost components like Arduino and compact circuitry makes it ideal for rural and small residential setups. It not only promotes sustainable energy use but also educates users about renewable technologies. In the future, the system can be upgraded to produce sine wave output, integrated with IoT for remote monitoring, and scaled for larger loads. These developments would expand its application scope and enhance its efficiency and user-friendliness.

The integration of Maximum Power Point Tracking (MPPT) and inverters plays a crucial role in optimizing the efficiency of solar power harvesting systems. MPPT is a key technology used to ensure that a solar panel operates at its optimal power output by continuously adjusting its operating point in response to varying sunlight and temperature conditions. By tracking the maximum power point, MPPT helps to maximize energy production.

Inverters, on the other hand, are essential for converting the direct current (DC) electricity generated by solar panels into alternating current (AC), which is required for most energy is effectively converted and fed into the grid or utilized by the end-users.

VIII. FUTURE SCOPE

This project successfully demonstrates a functional and efficient solar inverter system using MPPT control. The integration of low-cost components like Arduino and compact circuitry makes it ideal for rural and small residential setups. It not only promotes sustainable energy use but also educates users about renewable technologies. In the future, the system can be upgraded to produce sine wave output, integrated with IoT for remote monitoring, and scaled for larger loads. These developments would expand its application scope and enhance its efficiency and user-friendliness.

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