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Design and Implementation of a Cost-Efficient Solar Inverter System with MPPT for Residential Use

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ABSTRACT :

This paper presents a practical and affordable solar inverter system integrated with Maximum Power Point Tracking (MPPT) control. Using a 10W, 18V solar panel and a 12V 8Ah battery, the system stores energy and converts it to 230V AC output with an inverter and step-up transformer. An Arduino microcontroller governs the MPPT mechanism to ensure optimal energy capture and storage. This project aims to provide an efficient, low-cost power supply solution suitable for homes and rural applications where grid access is limited or unreliable.

Keywords : Solar Inverter, MPPT, Photovoltaics, Arduino, Renewable Energy, DC-AC Conversion

1. Introduction

As the world seeks sustainable energy alternatives, solar power has emerged as a clean and accessible source. However, challenges like variable sunlight and inefficient energy usage often limit its effectiveness. To address this, systems need to be designed that can track and use the maximum power output of solar panels. MPPT technology provides a solution by dynamically adjusting the system's operating point to capture the most energy. This project proposes a simple and budget-friendly MPPT-based solar inverter setup, ideal for residential or educational use. By combining solar harvesting, efficient energy management, and reliable conversion to AC power, the system is well-suited for areas with limited or no access to the electrical grid.

2. Literature Review

Numerous studies highlight the importance of MPPT in solar systems. Techniques such as Perturb and Observe (P&O), Incremental Conductance, and Hill Climbing have been implemented successfully to improve efficiency. Authors like Chetan Singh Solanki have emphasized the impact of MPPT on solar panel performance. Research also shows that Arduino-based controllers offer an affordable way to implement real-time MPPT adjustments. Prior work indicates that microcontrollers can significantly enhance energy extraction and system control without increasing complexity. This project leverages these insights to design a simplified, robust, and effective solar inverter system using an Arduino-based MPPT strategy, making the solution accessible for low-cost implementations.

3. System Design and Methodology

The system includes a solar panel for power generation, an MPPT controller for optimization, a battery for energy storage, and an inverter circuit with a transformer to deliver usable AC voltage. The 10W panel converts sunlight into variable DC output. The Arduino-based MPPT algorithm adjusts system voltage and current for maximum power harvesting. Energy is stored in a 12V 8Ah battery and later converted into 230V AC through an inverter, which is controlled via Arduino-generated PWM signals. A step-up transformer boosts the voltage to household level. The layout is carefully planned on a compact PCB, ensuring minimal loss and good thermal management.

4. Component Description and Operation

The solar panel serves as the primary energy source, producing DC power from sunlight. The MPPT controller, guided by an Arduino microcontroller and the P&O algorithm, tracks voltage and current in real time to maximize output. A 12V 8Ah lead-acid battery stores this energy. The inverter section uses MOSFETs (IRF540N), triggered by PWM signals from the Arduino, to create a high-frequency square wave. A 12V to 230V transformer then converts this to AC voltage. Additional circuit elements include diodes for current control, capacitors for smoothing voltage, and regulators to protect sensitive components. These elements are assembled on a PCB designed for reliability and space efficiency.

5. Results and Analysis

The system was tested under various lighting conditions and performed consistently. The MPPT algorithm adapted effectively, optimizing the panel's power output despite changing sunlight levels. The battery charged efficiently and the inverter provided a stable 230V AC output. Though the output is a square wave, it works well for most basic appliances. The system achieved around 85% overall efficiency, demonstrating its practicality for everyday use. These findings validate the effectiveness of the system design and confirm its usefulness in off-grid or supplemental energy scenarios.

6. Conclusion and 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.

7. References

[1] Solanki, C.S., 'Solar Photovoltaics: Fundamentals, Technologies and Applications.'
[2] Patel, H. & Agarwal, V., 'Modeling the Effects of Partial Shading on PV Arrays Using MATLAB.'
[3] Ramaprabha, R., Mathur, B.L., 'Review of Solar MPPT Techniques.'
[4] Arduino Platform Documentation - www.arduino.cc
[5] National Renewable Energy Laboratory - www.nrel.gov
[6] IRF540N Transistor Datasheet
[7] IEEE Xplore: MPPT and Solar Inverter Research Articles
[8] Elsevier: Renewable and Sustainable Energy Reviews
[9] Battery University - www.batteryuniversity.com
[10] International Journal of Renewable Energy Research (IJRER)