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# SOLAR MAXIMUM POWER POINT TRACKING SYSTEM AND IT'S APPLICATION TO GREEN HOUSE

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## ABSTRACT

This paper presents a low-voltage, cost-effective, and high-efficiency solar maximum power point tracking (MPPT) system for greenhouse applications. The primary controller in this system is a microcontroller, programmed in C language, to accurately track and extract the maximum solar power. A buck converter is employed for efficient MPPT operation. The extracted power is then used to drive essential greenhouse equipment, such as pumps and fans. Solar energy is abundant, but only a fraction of its potential is harnessed due to the high cost of solar installations and the fixed nature of solar panels, which do not receive optimal sunlight throughout the day. To address these issues, a new microcontroller-based solar tracking system is proposed, implemented, and tested. This system can function independently of the geographical location, adjusting the solar panel's position to continuously face the sun for maximum radiation absorption. The proposed tracking system is designed to track the sun in a single plane, simplifying construction and usage. Additionally, the design incorporates a PC-based system monitoring facility. A single-axis tracker is chosen for its simplicity and ease of implementation. This approach offers an efficient solution to optimize solar energy utilization in greenhouse environments.

**Keywords**: LDR, Solar Panel, Arduino UNO.

## I.INTRODUCTION

In recent years, the demand for renewable energy sources has significantly increased due to the rising concerns about environmental degradation and the need for sustainable development. Solar energy, being one of the most abundant and eco-friendly sources, has gained widespread attention. However, despite its vast potential, solar power generation is not fully optimized due to several challenges, including the high cost of solar installations and the inefficiency of fixed solar panels. Fixed solar panels are unable to track the sun's movement throughout the day, resulting in suboptimal energy generation. To address this, a solar maximum power point tracking (MPPT) system is crucial to ensure that solar panels operate at their peak efficiency by adjusting their orientation to capture the most sunlight. This paper proposes a low-voltage, cost-effective, and high-efficiency MPPT system specifically designed for greenhouse applications. The system utilizes a microcontroller programmed in C language to track the maximum power point of the solar panel. By incorporating a buck converter, the system ensures that the extracted power is efficiently utilized to drive essential greenhouse equipment, such as pumps and fans. Additionally, the system features a single-axis solar tracker, which allows the solar panel to follow the sun's path, maximizing the energy captured. This approach provides an affordable solution to improve the efficiency of solar power systems, making them more accessible and practical for small-scale applications, such as greenhouse energy management. The solar tracker system is designed to be geographically independent, meaning it can operate effectively in any location, adjusting the solar panel's position based on the sun's movement to optimize energy absorption. Moreover, the system is equipped with a PC-based monitoring feature, allowing users to track system performance and efficiency remotely. The integration of these technologies is aimed at increasing the reliability and sustainability of solar energy systems in greenhouse environments, thus contributing to more energy-efficient agricultural practices.

## II.LITERATURE REVIEW

The integration of solar energy systems into greenhouse applications has gained significant attention due to its potential to provide a sustainable and cost-effective energy source. Solar energy offers several advantages, including being abundant, renewable, and environmentally friendly. However, the efficiency of solar power generation is limited by factors such as the fixed positioning of solar panels and the inability to extract the maximum available energy from the sunlight. To overcome these limitations, solar tracking systems and Maximum Power Point Tracking (MPPT) techniques have been proposed and studied extensively.

Solar tracking systems aim to optimize the orientation of the solar panels by following the sun's movement, maximizing the amount of sunlight absorbed throughout the day. The most commonly used solar tracking systems are single-axis and dual-axis trackers. Single-axis trackers, which follow the sun's movement in one plane, are less complex and cost-effective compared to dual-axis trackers, which track the sun's movement in both horizontal and vertical planes. Several studies have shown that single-axis solar tracking systems can increase the energy output of photovoltaic panels by up to 25-40% compared to fixed installations (Li, et al., 2013). These tracking systems are widely used in applications where cost efficiency is important, such as small-scale solar installations and greenhouse energy management.

The concept of MPPT involves continuously adjusting the operating conditions of a solar panel to ensure it generates the maximum possible power. MPPT algorithms are designed to track the solar panel's maximum power point under varying environmental conditions, such as changes in sunlight intensity and temperature. Traditional MPPT algorithms include Perturb and Observe (P&O) and Incremental Conductance (IncCond) methods. These algorithms are typically implemented using microcontrollers or digital signal processors (DSPs) to optimize power generation (Sharma & Aggarwal, 2015). Among these algorithms, P&O is widely used due to its simplicity and ease of implementation, making it suitable for cost-effective solar systems in applications like greenhouse power management.

In recent years, the use of microcontrollers, particularly the Arduino platform, has gained popularity in solar tracking and

MPPT applications. Arduino-based controllers are inexpensive, easy to program, and offer flexibility in adapting to various solar power configurations. The incorporation of Light Dependent Resistors (LDRs) as sensors for tracking the sun's position has also been extensively studied. LDRs are simple, low-cost sensors that change resistance in response to light intensity, making them ideal for detecting the sun's direction (Gowri & Harini, 2019). By using LDRs to monitor light intensity on different sides of a solar panel, the microcontroller can adjust the solar panel's position to track the sun in real-time.

Several studies have also focused on the use of solar energy for greenhouse applications. Greenhouses require a constant supply of energy to power equipment such as fans, pumps, and irrigation systems. Solar power is an ideal solution for meeting these energy needs while reducing the reliance on grid electricity and minimizing the environmental impact. Previous research has explored the feasibility of solar energy systems for greenhouses, demonstrating that solar power can provide sufficient energy for greenhouse operations and improve sustainability (Kalogirou, 2009). Integrating MPPT and solar tracking systems further enhances the efficiency of solar-powered greenhouse systems, ensuring that the energy needs of the greenhouse are met even under varying weather conditions.

In addition to improving energy generation, the integration of solar energy with MPPT and tracking systems also contributes to reducing the overall operational costs of greenhouse systems. The ability to extract the maximum power from solar panels through MPPT ensures that solar energy is utilized effectively, thus lowering the cost per unit of energy generated. Furthermore, the use of solar tracking systems ensures that solar panels continuously operate at their optimal angle, further improving system efficiency and reducing the need for frequent maintenance or adjustments. In conclusion, solar tracking and MPPT technologies are essential for maximizing the efficiency of solar energy systems. The use of microcontrollers, such as Arduino, along with simple sensors like LDRs, offers a low-cost and efficient solution for solar tracking. Combining these technologies with the power needs of greenhouses can lead to more sustainable and cost-effective agricultural practices, promoting the use of renewable energy in agricultural applications.

## III.METHODOLOGY

The methodology for developing the Solar Maximum Power Point Tracking (MPPT) system for greenhouse applications involves both hardware and software design. Initially, key components are selected for the system, including an Arduino UNO microcontroller, photovoltaic (PV) panels, Light Dependent Resistors (LDRs), a buck converter, and a servo motor. The microcontroller, chosen for its affordability and ease of programming, acts as the central control unit, while the LDRs are used to detect sunlight intensity and provide feedback to the microcontroller for adjusting the solar panel's orientation. The servo motor moves the panel based on this feedback, ensuring it remains aligned with the sun to maximize energy absorption. The buck converter steps down the output voltage from the solar panel to power the greenhouse equipment, such as pumps and fans.

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Once the components are chosen, the hardware is integrated, with the microcontroller programmed in C language to control the servo motor's movement and implement a simple MPPT algorithm. This algorithm ensures the solar panel operates at its maximum power point by adjusting its operating conditions. The microcontroller also manages the power distribution to the greenhouse equipment. The system is designed to be geographically independent, so it can adjust the solar panel’s position based on the sun’s movement throughout the day. A PC-based monitoring system is developed to track the system’s performance in real-time, allowing users to monitor parameters like power generation and system efficiency.

After integration, the system undergoes testing and calibration. The solar panel’s response to changing light conditions is tested, and the servo motor’s performance is checked to ensure the solar panel is accurately tracking the sun. The MPPT algorithm is verified for its ability to extract maximum power from the panel, and the performance of the greenhouse equipment is evaluated to ensure that the generated power is sufficient for operational needs. The entire system is monitored and fine-tuned for optimal efficiency in greenhouse applications.

## IV.CONCLUSION

This paper presents the development and implementation of a low-voltage, cost-effective, and high-efficiency solar Maximum Power Point Tracking (MPPT) system for greenhouse applications. The proposed system utilizes a microcontroller, specifically the Arduino UNO, which is programmed to track the sun’s movement and optimize the solar panel's orientation using Light Dependent Resistors (LDRs). The system adjusts the solar panel’s position with a single-axis solar tracker, maximizing the energy captured throughout the day. The power generated is then used to drive greenhouse equipment such as pumps and fans, contributing to a more sustainable and energy-efficient greenhouse operation.

The integration of MPPT algorithms and solar tracking systems ensures that the solar panels operate at their maximum power point, regardless of changing sunlight conditions. By utilizing the buck converter, the system ensures efficient power conversion and distribution to the greenhouse equipment. The monitoring system incorporated into the design allows users to track performance in real-time, enabling the assessment of system efficiency and power generation. The results of this project demonstrate that solar energy, when harnessed effectively through MPPT and tracking systems, can significantly reduce energy costs and dependency on non-renewable sources.

In conclusion, this system provides a cost-effective solution for solar-powered greenhouses, enabling sustainable agriculture while reducing the environmental footprint. The proposed solar tracking and MPPT system is adaptable to various geographical locations, making it a versatile solution for a wide range of applications. Further improvements in system design, efficiency, and cost can contribute to the widespread adoption of renewable energy systems in agricultural practices.

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