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 ijirset@gmail.com

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Intelligent Solar Water Pump

Aadesh Pawar, Abhijeet Raut, Anmol Pagare, Prasanna Pothi,

TCOER Student, Department of Electrical Engineering, TCOER Engineering College, Pune, India

Assistant Professor, Department of Electrical Engineering, TCOER Engineering College, Pune, India

ABSTRACT: This project presents the development of an intelligent solar water pump system with dual power sources, integrating a moisture sensor-based control mechanism and manual switch operation. The system utilizes both solar and mains supply (MSCB) to power the water pump, providing reliability and flexibility in operation. Key components include a microcontroller unit (MCU) for system control, a moisture sensor for automated pump activation based on soil moisture levels, and a manual switch for user intervention. Additionally, the system incorporates IoT capabilities by transmitting real-time voltage data from both the solar and MSCB power sources to the ThingSpeak website for remote monitoring and analysis. The implementation of this system offers an efficient and user-friendly solution for water management, allowing for automatic pump operation based on soil moisture conditions while providing manual control options for user convenience. By leveraging IoT technology, users can remotely monitor the performance and power status of the system, enabling timely intervention and optimization for enhanced water conservation and energy efficiency.

KEYWORDS: solar water pump ,IoT integration , solar power supply , sensor based control , remote monitoring , water management.

I. INTRODUCTION

In response to the growing need for efficient and sustainable water management in agriculture and remote areas, an innovative intelligent solar water pump system has been developed. This system integrates cutting-edge technologies including solar power, advanced sensors, microcontroller-based control, and IoT connectivity to optimize water usage while enabling remote monitoring and control. At its core, the system utilizes solar panels to harness renewable energy, providing a green and cost-effective power source for irrigation. The ESP32 microcontroller serves as the central control unit, orchestrating the operation of sensor-driven pumps that respond to real-time environmental data. These pumps, controlled by moisture and water level sensors, ensure precise irrigation only when needed, thus conserving water and enhancing crop health. The system's ability to automatically switch between solar and mains electricity (MSCB) based on ambient light levels, monitored by an LDR sensor, further enhances efficiency and reliability. Leveraging IoT technology, sensor data such as soil moisture levels, water levels, solar voltage, and ambient light conditions are transmitted to an online platform for comprehensive remote monitoring and analysis. This capability empowers users, including farmers and remote operators, to manage and optimize water resources effectively, regardless of geographic location. By combining renewable energy utilization, smart sensor-driven control, and real-time data analytics, the intelligent solar water pump system represents a transformative solution that promotes sustainability, efficiency, and productivity in agricultural and remote water supply applications.

II. OBJECTIVE

The objective of the "Intelligent Solar Water Pump with Dual Power Source and Sensor-Based Control" project is to develop a system that optimizes water management by utilizing soil moisture and water level sensors to regulate the operation of a water pump. Integrating solar power as the primary energy source, the system aims to reduce dependency on conventional electricity and promote sustainability. By implementing a dual power source system with relays to switch between solar and mains electricity based on ambient light levels sensed by an LDR sensor, the project ensures uninterrupted pump operation under varying weather conditions. The inclusion of sensor-based automation enables the system to autonomously activate or deactivate the pump, maintaining optimal soil moisture levels for plant growth while minimizing water wastage. Additionally, the ESP32 microcontroller's Wi-Fi capabilities allow for remote monitoring and control, empowering users to access real-time data and adjust settings for efficient water management from anywhere with internet connectivity. Overall, the project aims to create an intelligent, sustainable, and reliable water pumping solution for agricultural applications.

III. LITERATURE REVIEW

- **“Solar Powered Water Pumping System”** By Sonal S. Patil Prof. Mr. Ranjit M. Zende Zeal College of Engineering and Research, Narhe :

In this paper, the authors propose an affordable and efficient solar-powered water pumping system that can be used in areas with no access to electrical power. The system stands out by excluding the need for batteries, reducing maintenance costs, and increasing its overall lifespan. Instead of using traditional DC motors, the system opts for single-phase induction motors, known for their efficiency and lower cost. The heart of the system lies in a clever electronic setup connecting the induction motor to a solar panel. This setup includes a boost converter that increases the panel's voltage and a special inverter using Sinusoidal Pulse Width Modulation (SPWM) control. The authors emphasize the economic and practical benefits of this design. Simulation results, conducted using MATLAB/Simulink, confirm the system's effectiveness. The study explores the potential of using solar cells to power water pumps efficiently, showcasing a promising and cost-effective solution for sustainable water supply in areas without regular access to electricity.

- **An Intelligent Solar water pump monitoring system using IOT technology** by Nidhi Sharma¹, Yogesh Shejwal :

The research introduces a smart system for monitoring solar water pumps using IoT technology. Given the importance of agriculture in India and the shift towards solar energy for irrigation, the study focuses on making water pump systems more efficient. The system includes sensors in solar panels, controllers, and pumps, all connected to a central unit. This unit communicates with the administrator's phone through a GSM module, providing real-time updates on pump status. If an issue arises, the system identifies the faulty part, allowing for remote troubleshooting. The paper highlights the system's potential for larger-scale applications. The literature review emphasizes the relevance of monitoring systems in solar water pumping and differentiates pump types based on their efficiency and suitability for various water sources. Overall, the study contributes to improving solar water pump management in agriculture through advanced monitoring and communication technologies.

IV. BLOCK DIAGRAM

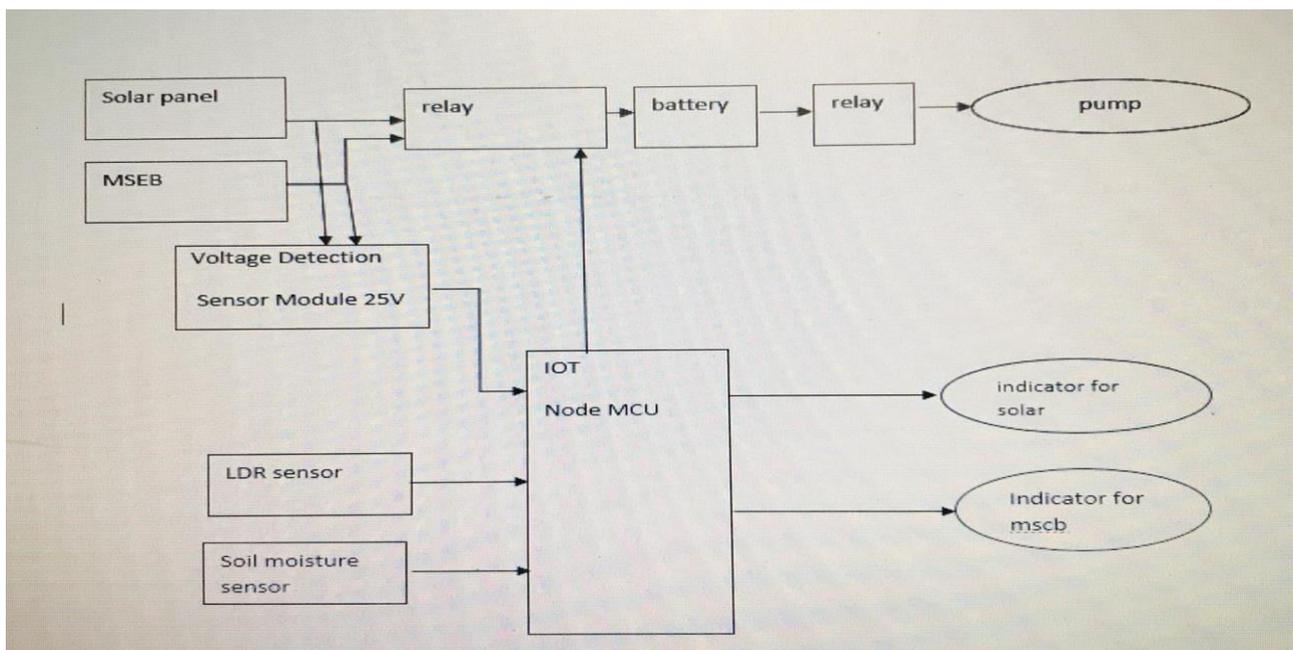


Figure 1. block diagram of intelligent solar water pump

CIRCUIT DIAGRAM

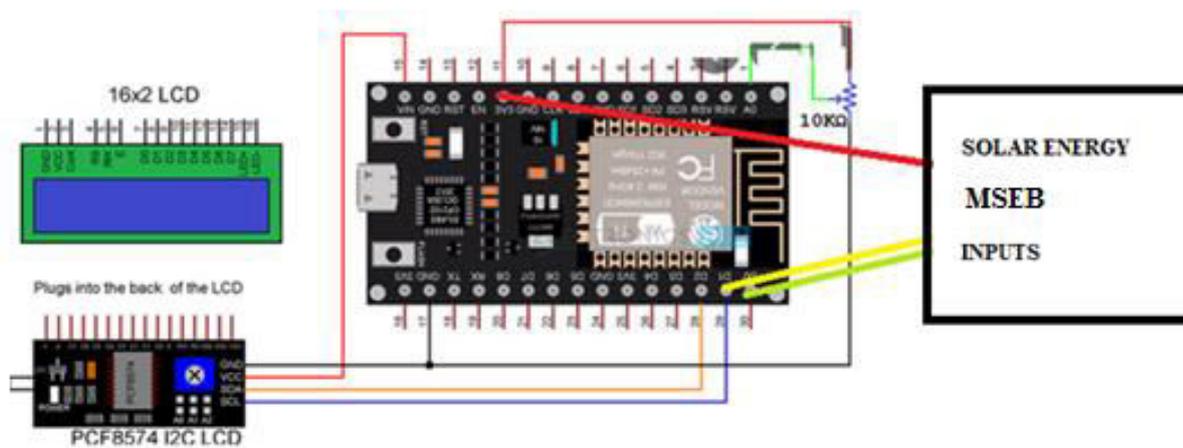


Figure 2. circuit diagram of intelligent solar water pump

V. WORKING

The "Intelligent Solar Water Pump with Dual Power Source and Sensor-Based Control" system comprises several interconnected components working harmoniously to optimize water management and ensure efficient operation. At its core lies the solar panel, which harnesses solar energy and converts it into electrical power. This power is regulated and stabilized by a step-down buck converter, ensuring compatibility with the system's voltage requirements. The ESP32 microcontroller serves as the brain of the system, orchestrating data acquisition, decision-making, and control processes. It communicates with various sensors, including the moisture sensor for Sensor-Operated Pump 1 and the water level sensor for Sensor-Operated Pump 2. When soil moisture levels drop below a predefined threshold, Pump 1 is activated to irrigate the soil, maintaining optimal moisture levels. Similarly, Pump 2 is triggered by low water levels in the reservoir, ensuring a continuous water supply. The system's adaptability to varying environmental conditions is facilitated by an LDR sensor, which measures ambient light levels. Based on these readings, the ESP32 dynamically switches between solar and mains electricity, prioritizing solar power when sunlight is sufficient and switching to mains electricity during low light conditions. Relay control is managed by the ESP32, with Relay 1 governing Pump 1 and Relay 2 governing Pump 2. These relays are activated or deactivated as per the ESP32's instructions, regulating pump operation accordingly. Optionally, a battery storage system can be incorporated for backup power, allowing the system to operate during nighttime or periods of low sunlight. The integration of IoT technology enables real-time monitoring of sensor data and system performance via platforms like ThingSpeak, providing users with remote access and control capabilities through web or mobile interfaces. Together, these components form a sophisticated yet efficient system for intelligent water pumping and management, leveraging renewable energy sources and advanced sensor-based controls to enhance agricultural productivity and sustainability.

VI. METHODOLOGY

The methodology for implementing the "Intelligent Solar Water Pump with Dual Power Source and Sensor-Based Control" project involves several key steps. First, the system design and planning phase defines project requirements and selects appropriate hardware components. Next, hardware setup involves assembling the system, connecting the solar panel, sensors, and ESP32 microcontroller, ensuring proper wiring and communication. Software development includes writing firmware for the ESP32 to read sensor data, control pump and relay operations, and manage power sources dynamically based on predefined logic and thresholds. Testing and calibration ensure accurate sensor readings and system reliability under various conditions. Integration and optimization fine-tune interactions between hardware and software modules, optimizing power management and ensuring seamless operation. Field deployment and validation involve installing the system in the target environment, monitoring performance, and gathering feedback for improvement. Documentation and maintenance ensure proper documentation, user guidelines, and a maintenance plan.

for long-term functionality and reliability. By following this methodology, the project can successfully deliver an intelligent solar water pump system, promoting sustainable water management in agriculture.

VII. COMPONENTS

1. Solar Panel and Step-Down Buck Converter:

- The solar panel harnesses solar energy and converts it into electrical power.
- The step-down buck converter regulates and stabilizes the voltage output from the solar panel to a level suitable for powering the system components.

2. ESP32 Microcontroller:

- The ESP32 microcontroller serves as the central processing unit of the system, responsible for data acquisition, decision-making, and control.
- It reads input signals from various sensors and controls the operation of the pumps and relays based on predefined logic and thresholds.

3. Moisture Sensor (Sensor-Operated Pump 1):

- The moisture sensor measures soil moisture levels.
- When the soil moisture drops below a specified threshold, the ESP32 activates the corresponding relay to turn on Pump 1.
- Pump 1 draws water from a water source (like a well or tank) and irrigates the soil to maintain optimal moisture levels.

4. Water Level Sensor (Sensor-Operated Pump 2):

- The water level sensor monitors the water level in a reservoir or tank.
- If the water level is below a set threshold, indicating the need for refilling, the ESP32 activates the relay controlling Pump 2.
- Pump 2 is responsible for filling the reservoir from another water source (such as a well or storage tank) to ensure a continuous water supply.

5. LDR (Light Dependent Resistor) Sensor:

- The LDR sensor measures ambient light levels.
- Based on the LDR reading, the ESP32 determines the availability of solar energy:
- If sufficient sunlight is detected (high LDR reading), the ESP32 prioritizes using solar power.
- If sunlight is insufficient (low LDR reading), the system switches to mains electricity (MSCB) supply.

6. Relay Control:

- The ESP32 controls two relays:
- Relay 1: Controls the operation of Pump 1 based on moisture sensor readings.
- Relay 2: Controls the operation of Pump 2 based on water level sensor readings.
- The relays are activated or deactivated by the ESP32 to turn the pumps on or off as needed.

7. Battery Storage (Optional for Backup):

- A battery may be used to store excess solar energy for nighttime operation or during periods of low sunlight.
- The ESP32 can manage battery charging and discharge to ensure continuous operation of critical components.

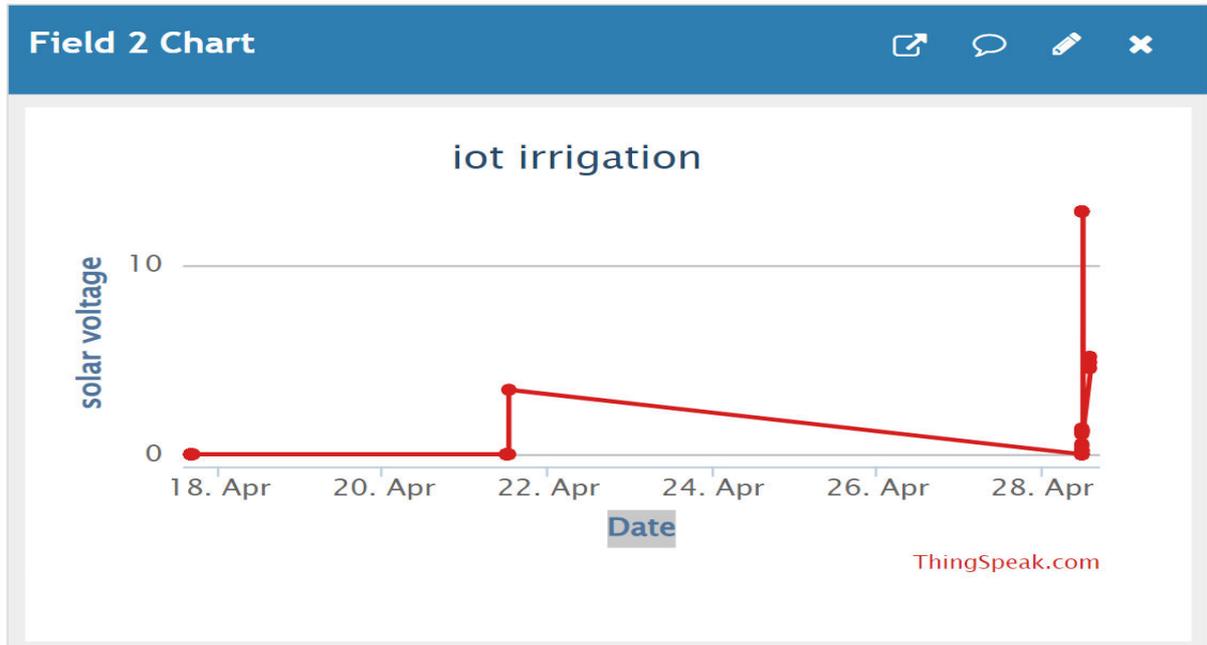
8. IoT Integration (ThingSpeak or Similar Platform):

- Sensor data (moisture level, water level, LDR reading, power supply status) is transmitted to an IoT platform (e.g., ThingSpeak) using the ESP32's Wi-Fi capabilities.
- Users can remotely monitor the system's performance and environmental conditions in real-time through a web or mobile interface.

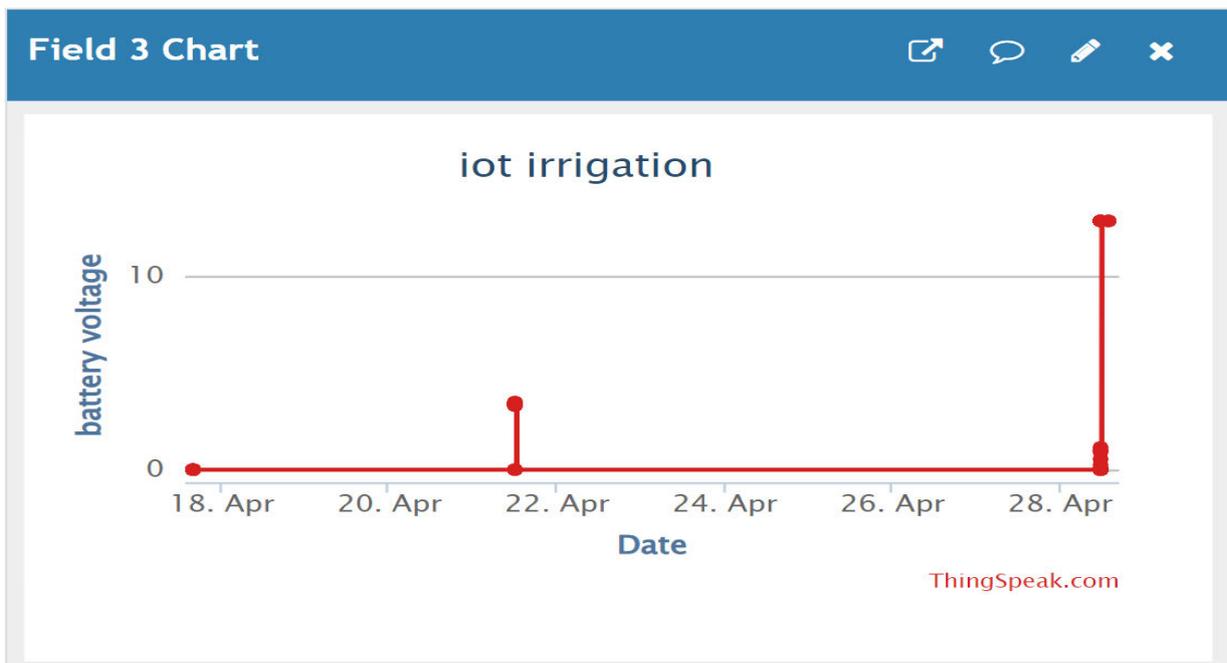


VIII. EXPERIMENTAL RESULTS

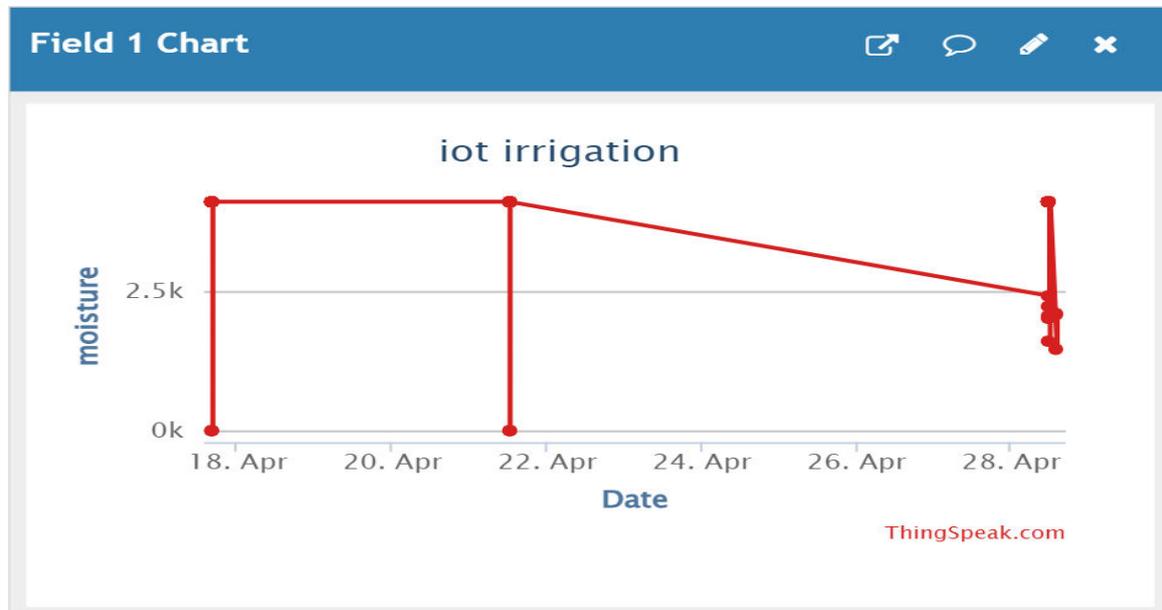
- Solar voltage:



- Battery voltage:



- Moisture sensor:



ADVANTAGES

1. **Efficient Water Management:** By utilizing soil moisture and water level sensors, the system ensures precise irrigation tailored to the needs of the plants, minimizing water wastage and optimizing water usage efficiency.
2. **Renewable Energy Integration:** Incorporating solar power as the primary energy source reduces reliance on fossil fuels, promoting sustainability and reducing carbon emissions associated with conventional electricity generation.
3. **Cost Savings:** Solar energy is a free and abundant resource, leading to significant cost savings in the long run compared to traditional electricity sources. Additionally, the system's intelligent control algorithms optimize energy usage, further reducing operational costs.
4. **Reliability and Redundancy:** The dual power source system, coupled with battery storage for backup, enhances system reliability by ensuring continuous operation even during adverse weather conditions or power outages.
5. **Remote Monitoring and Control:** IoT integration enables remote monitoring of system performance and environmental conditions, allowing users to adjust settings and troubleshoot issues remotely, thereby saving time and resources.
6. **Customization and Scalability:** The system can be tailored to specific agricultural needs and easily scaled to accommodate larger farming operations or diverse crop types, making it adaptable to various agricultural environments and requirements.
7. **Environmental Benefits:** By promoting sustainable water management practices and reducing reliance on non-renewable energy sources, the project contributes to environmental conservation and mitigates the impact of agriculture on natural resources.

IX. CONCLUSION

In conclusion, the development of an intelligent solar water pump system represents a significant advancement in sustainable agriculture and remote water supply management. By integrating cutting-edge technologies such as solar power utilization, advanced sensor-driven control, microcontroller automation, and IoT connectivity, this system offers

a comprehensive solution to optimize water usage, enhance crop health, and promote energy efficiency. The utilization of solar panels as the primary power source not only reduces reliance on conventional electricity but also contributes to a cleaner and more environmentally friendly irrigation process. The system's ability to automatically switch between solar and mains electricity based on ambient light levels, monitored by the LDR sensor, ensures continuous operation even under varying environmental conditions. Sensor-driven pumps controlled by moisture and water level sensors enable precise and targeted irrigation, preventing overwatering and conserving water resources. The ESP32 microcontroller serves as the central hub, processing sensor data and making intelligent decisions to activate the pumps and manage the power supply efficiently. Furthermore, the integration of IoT technology allows for real-time remote monitoring and control of the system. Users can access vital information such as soil moisture levels, water reservoir status, solar energy availability, and system operation status from anywhere with internet access. This capability empowers farmers and operators to make informed decisions, optimize irrigation schedules, and respond promptly to changing environmental conditions. The inclusion of a step-down buck converter ensures stable and regulated voltage supply, enhancing the reliability and performance of the system components. Additionally, the optional use of battery storage provides backup power, ensuring uninterrupted operation during periods of low solar energy availability or power outages.

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