IOT Based Smart Solar Inverter And Irrigation System

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ABSTRACT

The IoT-Based Solar Power Inverter and Irrigation System is a cutting-edge design that connects renewable energy generation with smart agricultural automation to boost efficiency, reliability, and sustainability. The solar power produced by a solar panel is the main source of energy for this system and a battery to store it as well as sensors like those for monitoring voltage, current, temperature, soil moisture, humidity, and day/night detection based on LDRs is used to monitor the whole process. The inverter manages the power from the solar panel to supply AC loads, and at the same time, it supports the DC-powered irrigation components. An IoT module like ESP8266 or ESP32 collects real-time parameters continuously and uploads them to a cloud platform for data logging, visualization, and remote access.

The irrigation subsystem makes use of soil moisture data to control water pumps automatically, which in turn leads to optimal usage of water and prevents over-irrigation and under-irrigation at the same time. The system is capable of switching between solar and battery power without any interruption in operation. Farmers will have the power generation, environmental conditions, and irrigation status monitored in real-time through a web dashboard or mobile app. This integrated approach improves agricultural productivity while at the same time reducing manual labor, energy costs, and environmental impact. In conclusion, the system is a scalable and energy-efficient smart farming solution for rural and remote areas.

Keywords: IoT, Solar Inverter, Smart irrigation, Renewable Energy, ESP8266, Soil Moisture, Smart Farming .

1. INTRODUCTION

The demand for sustainable energy and efficient agricultural practices has been on the rise, hence the development of smart technology-driven solutions has been the most influential factor. Agriculture is one of the most resource-demanding sectors that need a reliable power supply and efficient water management to produce crops. In addition to that, the use of traditional irrigation methods usually results in water wastage, which is a major problem that is further compounded by the constant power outages in rural areas. The use of renewable energy along with smart automation has become quite a necessity in solving these problems.

The IoT-Based Solar Power Inverter and Irrigation System harnesses the power of solar energy, combined with real-time monitoring and control via IoT. Solar energy is a green, cheap, and constant energy source for irrigation pumps and other farm facilities. The inverter converts solar in the form of DC into AC and then distributes it very efficiently to different loads. The sensors used for monitoring soil moisture, temperature and humidity, and the voltage/current of the solar system provide continuous data for IoT technology. This data is sent to cloud platforms, and farmers can then monitor both system performance and the environment conditions from a distance.

2. SYSTEM ARCHITECTURE

The system architecture of this project consists of sensors, a controller, output devices, and an IoT cloud platform. Sensors such as LDR, soil moisture sensor, rain sensor, and DHT11 continuously monitor environmental conditions like sunlight, soil moisture, rainfall, temperature, and humidity. These sensor signals are given to the ESP8266 NodeMCU, which acts as the main controller and processes the data according to the programmed logic. Based on the sensor conditions, the controller automatically controls the relay to switch the solar inverter or irrigation pump ON or OFF and activates the buzzer for alerts. All important parameters are displayed locally on a 16×2 I2C LCD. At the same time, the ESP8266 sends real-time data to the Firebase cloud using Wi-Fi, enabling remote monitoring through a mobile or web application.

3. PROBLEM IDENTIFICATION

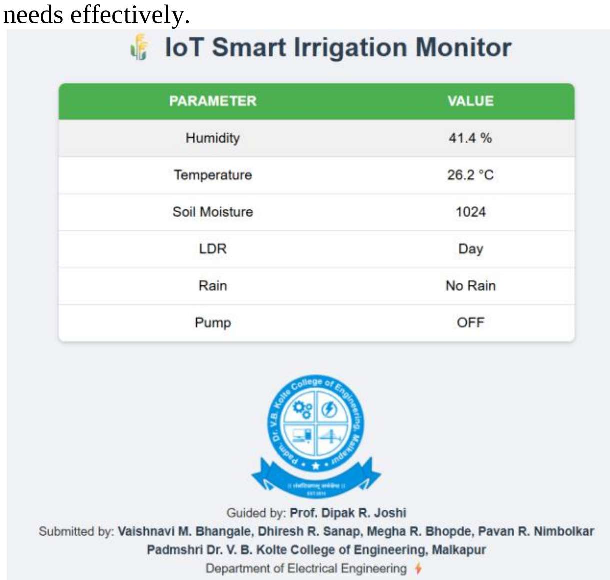
Agricultural productivity in many rural and semi-rural regions is heavily affected by unreliable power supply, inefficient water usage, and lack of real-time monitoring of environmental conditions. Traditional irrigation methods often rely on manual operation, leading to excessive water wastage, delayed irrigation, and increased labor requirements. Additionally, farmers face challenges in monitoring solar power output, battery status, and inverter performance, which are critical for operating irrigation pumps in areas with limited grid access.

Existing systems lack integration between renewable energy sources and intelligent monitoring platforms, resulting in poor energy management and limited automation capabilities. The absence of remote monitoring also prevents farmers from making timely decisions during critical crop growth stages. Moreover, conventional irrigation setups cannot adapt automatically to changing soil moisture levels, temperature variations, or day–night conditions, leading to inconsistent water supply and reduced crop health.

4. RESULTS

The IoT-Based Solar Power Inverter and Irrigation System developed have successfully combined the use of solar energy generation, environmental monitoring, and automated irrigation into one single smart platform. The system defines accurately the key parameters like solar voltage, current, battery status, temperature, humidity, soil moisture, and day/night detection. All these parameters are uploaded to the IoT cloud continuously, which allows monitoring in real-time from any remote location through a web or mobile interface.

The user interface presented the live data and the historical logs in such a way that they were easy to comprehend and thus, aided decision-making and system diagnostics. The data logging functions enabled the carrying out of daily and monthly performance evaluations which included the total solar power generated. The system has, thus, shown to be energy-efficient, reduced labor requirements, provided accuracy in crop hydration, and utilized renewable energy for agricultural needs effectively.


IoT Smart Irrigation Monitor

PARAMETER	VALUE
Humidity	41.4 %
Temperature	26.2 °C
Soil Moisture	1024
LDR	Day
Rain	No Rain
Pump	OFF

5. CONCLUSION

The IoT-Based Solar Power Inverter and Irrigation System is a modern-day agricultural solution that is secured efficient, sustainable, and automatically operated. The system designed by combining solar energy with intelligent sensor-based monitoring and IoT connectivity, solves the problem of unreliable power supplies, excessive water usage, and lack of real-time environment awareness. The automated irrigation controlled by soil moisture readings ensures that water is used optimally while IoT monitoring allows the farmers to know the solar power generation, inverter performance, and field conditions from any place. With this system, the farmer's work is significantly reduced, and their productivity increases besides being eco-friendly. In short, the integration of renewable energy and IoT technology has proven to be a way forward in terms of reliability, efficiency, and sustainability in agriculture.

6. FUTURE SCOPE

- Foreseeing irrigation requirements and maximizing water use according to crop species and climate variations by merging AI/ML algorithms.
- Use of solar charge controllers based on MPPT for solar energy harnessing more effectively.
- Moving into the complete Smart Farm automation area consisting of fertilizer, pest, and greenhouse controls.
- Creating a mobile app with better UI/UX, the ability for data access even when offline, and multilingual support.
- Implementing LoRaWAN or 5G communication technology for better connectivity in extensive farming lands.
- Use of weather forecasting APIs for predictive irrigation and power management.
- Monitoring battery health to provide solar-powered irrigation systems with greater reliability.
- Making it possible for community farming in which several farms share energy and data through a centralized IoT gateway.
- Implementation of fault detection mechanism for inverter, pump, and sensor problems using smart diagnostics.
- Collaboration with government agricultural data platforms for support schemes, crop advisory, and automation insights.

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