IOT-BASED SOLAR POWER AND ENVIRONMENTAL CONDITIONS MONITORING USING RASPBERRY PI

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Abstract

The integration of Internet of Things (IoT) technology in renewable energy systems has opened new possibilities for real-time monitoring and efficient energy management. This paper presents the design and implementation of an IoT-based system for monitoring solar power generation and environmental conditions using a Raspberry Pi. The system incorporates various sensors to measure solar panel voltage, current, temperature, humidity, and ambient light intensity. Data collected from the sensors is processed and transmitted by the Raspberry Pi to a cloud platform for real-time visualization and analysis. The proposed system enables remote access to solar performance metrics and environmental parameters, thereby facilitating preventive maintenance, energy efficiency, and informed decision-making. The compact and cost-effective architecture makes it suitable for deployment in rural or off-grid locations. Experimental results demonstrate the effectiveness of the system in monitoring environmental changes and optimizing solar energy utilization.

Keywords: IoT Based, Raspberry pi, DHT11 Sensor, Thingspeak,

1. INTRODUCTION

Solar power systems have relied on manual data logging or isolated embedded systems to monitor key parameters such as voltage, current, and temperature. These methods, while functional, are often limited in scope, lack remote accessibility, and provide insufficient data for proactive maintenance and performance optimization. Moreover, environmental factors such as temperature, humidity, and solar irradiance significantly influence the efficiency of PV panels, making real-time environmental monitoring a critical component of solar power system management.The emergence of the Internet of Things (IoT) has revolutionized the way data is collected, transmitted, and analyzed. IoT enables interconnected smart devices to sense and share data over the internet, allowing users to monitor and control systems remotely. In the context of renewable energy, IoT integration facilitates real-time diagnostics, predictive maintenance, and efficient energy management by providing a constant stream of data and insights. This not only improves energy yield but also extends the lifespan of solar infrastructure and reduces operational costs. Raspberry Pi, a compact and low-cost single-board computer, presents a powerful platform for developing IoT-based monitoring systems. With built-in connectivity features, compatibility with a wide range of sensors, and support for Linux-based operating systems, Raspberry Pi enables developers to build customizable and scalable solutions for real-time data acquisition, processing, and transmission.The collected data is processed locally and sent to a cloud platform, where it is visualized through an intuitive web-based dashboard. This enables users—whether engineers, researchers, or energy consumers—to remotely monitor system performance, detect faults, and make informed decisions in real-time.

2. PROBLEM STATEMENT

The effective operation and maintenance of solar photovoltaic (PV) systems are critically dependent on real-time monitoring of both electrical output and environmental conditions. However, existing monitoring solutions are often costly, proprietary, and lack flexibility, making them unsuitable for deployment in remote, rural, or small-scale solar installations. Moreover, many systems fail to provide integrated monitoring of environmental parameters—such as temperature, humidity, and solar irradiance—which directly affect the efficiency and longevity of solar panel.

3. LITERATURE REVIEW

Solar energy systems are widely recognized as sustainable and eco-friendly alternatives to fossil fuels. Efficient monitoring of these systems is critical to maximizing their energy output and lifespan. Recent advances in the Internet of Things (IoT) technology provide innovative ways to monitor solar power systems and environmental conditions in real-time. Raspberry Pi, a low-cost and flexible computing platform, has become popular in implementing such IoT-based monitoring IoT-based monitoring systems using Raspberry Pi have become effective tools for managing solar power installations by continuously tracking both electrical performance and environmental conditions such as temperature and humidity. These environmental factors play a crucial role in solar panel efficiency—high temperatures can decrease power output, and excessive humidity can impact the system's durability. By integrating sensors that measure voltage, current, temperature, and humidity, Raspberry Pi enables real-time data collection and remote monitoring, which helps in early fault detection and optimizing maintenance schedules. This approach improves overall system reliability and energy production. However, challenges such as minimizing the power consumption of monitoring devices and securing transmitted data remain important areas for further improvement.

4. EXISTING SYSTEM

This setup collects solar panel output along with environmental data, then transmits the information to a cloud platform for visualization and analysis. Such systems allow users to monitor solar panel performance remotely, detect faults early, and adjust maintenance plans based on environmental conditions.

5. PROPOSED SYSTEM

The Raspberry Pi will collect and process this data in real-time, sending it to a cloud-based platform for remote monitoring and analysis. By leveraging this integrated approach, the system will enable early fault detection, predictive maintenance, and optimization of energy output based on changing environmental conditions. Additionally, the design will prioritize energy-efficient operation and implement security protocols to safeguard data transmission, addressing limitations found in existing systems.

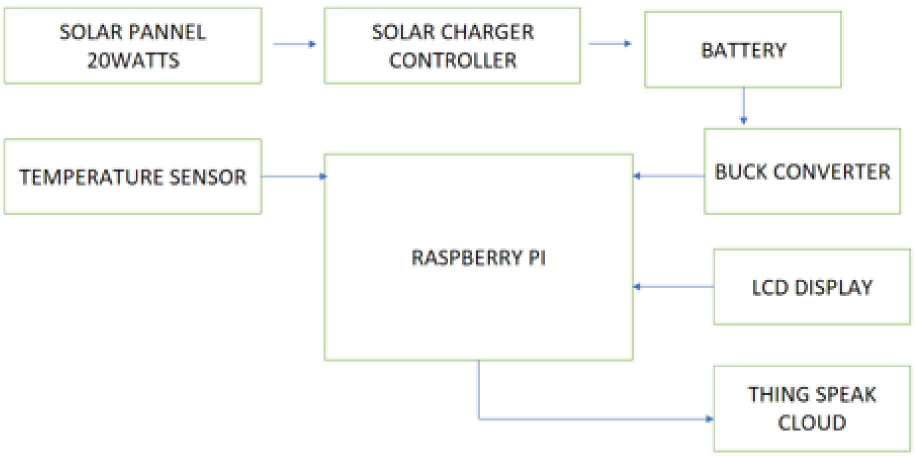

Figure 5.1 Block diagram of proposed system

6. HARDWARE AND SOFTWARE IMPLEMENTATION

The proposed system utilizes a Raspberry Pi as the central controller to collect, process, and display data from various sensors while managing power from a solar-based energy source. A 16x2 LCD display, connected via an I2C interface, is used to present real-time information such as temperature, humidity, and voltage levels. The environmental sensing is achieved using a DHT11 sensor for measuring temperature and humidity, and an MQ gas sensor to detect the presence of harmful gases like carbon monoxide or methane. These sensors are directly interfaced with the GPIO pins of the Raspberry Pi. To monitor energy parameters, an INA219 voltage and current sensor module is used, which provides data on power generated by the solar panel and the energy consumed by the system. The power supply comprises a solar panel connected to a charge controller, which in turn charges a 12V battery. A DC-DC boost converter is employed to regulate the voltage from the battery, ensuring a stable power supply to the Raspberry Pi and other modules. The system also includes a 7-segment display integrated with the boost converter to show output voltage in real-time.

7. OPERATIONAL SCENARIOS FOR THIS PROJECT

The designed system operates effectively across various scenarios, demonstrating its practical utility in both indoor and outdoor environments. In a typical operational scenario, the system is deployed in a remote or off-grid location where it continuously monitors ambient temperature, humidity, and gas concentration using the DHT11 and MQ sensors. The solar panel charges the battery during daylight hours, and the charge controller ensures safe charging and discharging cycles. The Raspberry Pi, powered via the regulated output from the boost converter, continuously collects sensor data and displays real-time values on the 16x2 LCD screen. This setup is particularly useful in agricultural fields, where monitoring environmental conditions is critical for crop health, or in small industrial environments where gas leak detection is essential for safety.

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8. CIRCUIT DIAGRAM

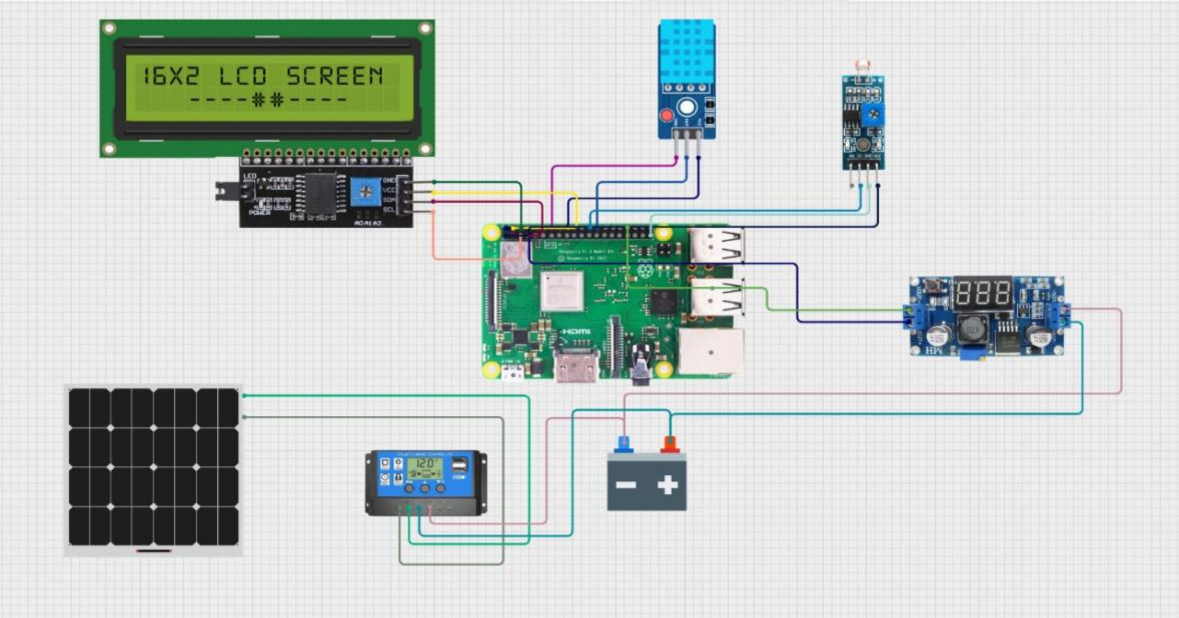

Figure 7.1 : Circuit diagram

9. RESULT & DISCUSSION

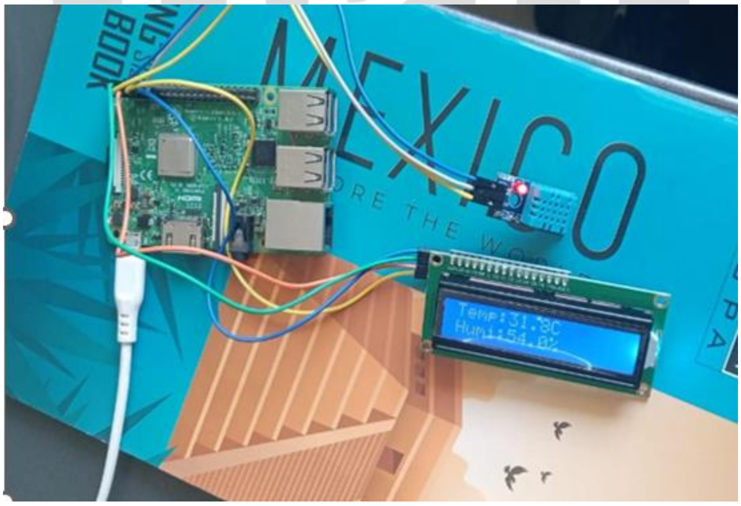

Figure 9.1 Hardware setup

10. CONCLUSION

The implementation of an IoT-based solar power and environmental monitoring system using Raspberry Pi offers an efficient, low-cost, and scalable solution for real-time data collection and system optimization. By integrating sensors to measure critical parameters such as temperature, humidity, voltage, and current, the system provides valuable insights into both environmental conditions and solar panel performance. The use of Raspberry Pi enables reliable data processing, local display, and remote monitoring capabilities, making the system suitable for smart energy management in both rural and urban settings. This approach not only enhances the efficiency and maintenance of solar power systems but also supports the broader goal of promoting sustainable energy through intelligent technology integration.

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