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Design of a Smart PV Monitoring System Using Internet of Things (IoT)

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ABSTRACT

Renewable energy systems monitoring has become an integral part of system designing in determining the appraisal of PV systems installation. With huge investments in several installations by individuals, organizations, and the government, it is important to monitor and evaluate the performance of these projects to predict possible failures and take necessary actions. This research work presented a smart approach to monitoring these installations remotely while providing a real-time evaluation of the performance for prompt decision-making and further research work in deep learning algorithm.

Keywords: Deployment, Smart PV, Monitoring Systems, Internet of Things (IoT), Installations, Organizations

1. INTRODUCTION

Electricity availability is one of the performance indicators of industrious and advanced countries (Abatan *et al.,* 2019). For a country to develop and also sustain its industries, such must have minimum access to electricity. Efforts has been made by government, companies, and individuals to explore renewable energy system as an alternative power supply for their various energy demands. However, as valuable as this knowledge about solar panels may appear, several factors have an impact on their efficiency and overall effectiveness. The disadvantages of solar panels are due to a variety of environmental conditions such as dust, shadow, temperature, dreary weather, quality of batteries, and, so on. All of these aspects play a vital effect in the ultimate output quality. To solve varieties of associated issues with PV systems, measures must be taken on its monitoring. PV systems installers are to carry out system assessment and maintenance of their installations remotely to forestall the chances of failures of these installations. The old way of doing these has been through physical inspections which is not economical and require a substantial investment of time. This paper examined the conventional approach of PV system monitoring, its limitations and presented a smart approach to solve these problems.

2. REVIEW OF RELATED WORK

Manual way of monitoring was used in the past for monitoring. In these case, the technical expert travels down to the installation for face-to-face assessment. As a result of technological advancement, Wireless Sensor Network (WNS) was introduced. These consist of radio frequency (RF), transceivers, microcontrollers, sensors and power sources. About two to three technologies were deployed using (WSN). These were ZigBee and Bluetooth which operates on a frequency of 2.4GHz. in these case, installations can only be monitored within the frequency range thus posing a high degree of limitations to remote monitoring. Related works of different researchers weare re discussed below.

Table 1: Related Works

Author	Year	Title	Method Used	Findings	Knowledge Gap
Subarna Shakya	2021	A self-Monitoring and Analyzing System for Solar Power Station using IoT and Data Mining Algorithms	PV Performance datas are collected through IoT sensors and sent to the cloud for further analysis using neural network architecture monitored on the web, computers and mobile devices.	PV installed is connected with IoT hardware board which transfers observed signals to the cloud for data mining. Variations in the generated power is compared the previous one while findings are sent for maintenance.	This is a recent way of monitoring the performance of PV systems
Kavitha et al	2019	A Smart Solar PV Monitoring System Using IoT	Fabrication of microcontroller based PV monitoring system based on three layer architecture of Internet of Things (IoT)	Temperature, voltage, current and irradiance sensors were installed for real-time measurement. Blynk libraries communicated the sensed values to the cloud platform. These were displayed over a mobile phone.	This is a recent way of monitoring the performance of PV systems

Author	Year	Title	Method Used	Findings	Knowledge Gap
Ragupathi et al	2018	Development and Performance Analysis of IoT Based Real Time Solar PV Monitoring System	Internet of Things (IoT) was adapted for real-time monitoring, fault detection is done using MATLAB. It also have the hardware part of it connected to the attached to the PV installation.	Sensors measure the voltage, temperature etc and send to microcontroller which processes then send to the cloud storage in Thingspeak. Real-time data analysis of the system is graphically presented in Thingspeak.	This design provided a web-based monitoring for the PV system. A CSV file is available for analysis and download. Fault detection carried out using MATLAB. This is one of the most recent approach to monitoring installations.
Odigwe et al	2013	Development of a software solution for a Solar PV power systems sizing and monitoring	Design of a hardware attached to the PV installation and development of a software monitoring system for data collection and processing using worst month method.	The method makes the best PV system size estimates using the month in the year with least average solar insolation.	The design stores data on SD card which is uploaded on the computer. Data's cannot be assessed anywhere at any time in the world.

3. METHODOLOGY

A Solar PV Installation Monitoring System was designed to keep track of the Battery and Photo-Voltaic (PV) performance using the Internet of Things (IoT). The design of the Smart Solar PV Monitoring System was divided into two. These are the hardware and the software parts. The hardware part was deployed at the installation site of the PV System. The software that monitors the performance was installed on a mobile phone. It keeps logs of the performance of the battery and the solar panel. The performance of these two components of the Solar PV system can be checked anywhere in the world as long as there are internet services.

3.1 Description of Components used

The hardware design used some electronic components and a microcontroller as the basic building block for the monitoring system. These components were listed below.

1. Atmega328p
2. GSM/GPRS module
3. LEDs
4. Resistors – to form a voltage divider to read solar volt and battery volt
5. Relay – to Switch off appliances
6. Voltage Regulator

3.2 Thingspeak IoT Platform

Thingspeak is an open-source platform that allows you to collect and store sensor data in the cloud. It provides you with the app to analyze and visualize your data in Matlab. The microcontroller with other related components was used to send sensor data. A separate channel was used to store data.
Features of Thingspeak are collecting data in private channels, applications integration, event scheduling, MATLAB analytics, and visualization.

3.3 ATMEGA328P Architecture

The microcontroller used is Arduino (ATMEGA328P). The ATMEGA328P is a low-power CMOS 8-bit microcontroller with enhanced RISC (reduced instruction set computer) architecture. In Order to maximize performance and parallelism, the AVR uses Harvard architecture with separate memories and buses for program and data. Instructions in the program memory are executed with a single level of pipelining. The clock is controlled by an external 16MHz Crystal Oscillator.

3.4 Design Circuit, Block, and Fabrication Diagram

The block diagram and the design circuit diagram are shown below.

The block diagram

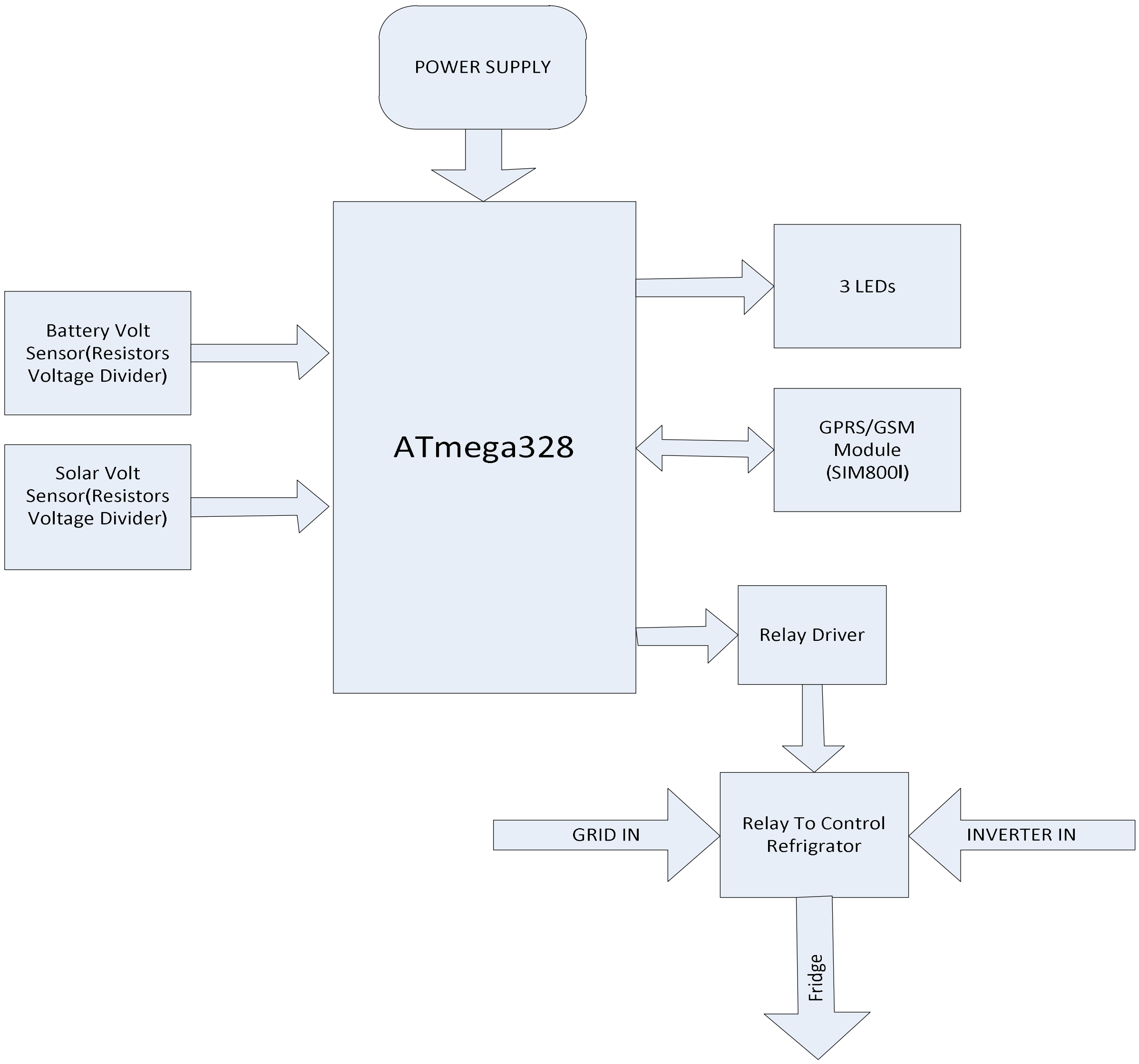

Figure 1: Block diagram for the hardware part of the Solar PV Monitoring System (Using ATMEGA328)

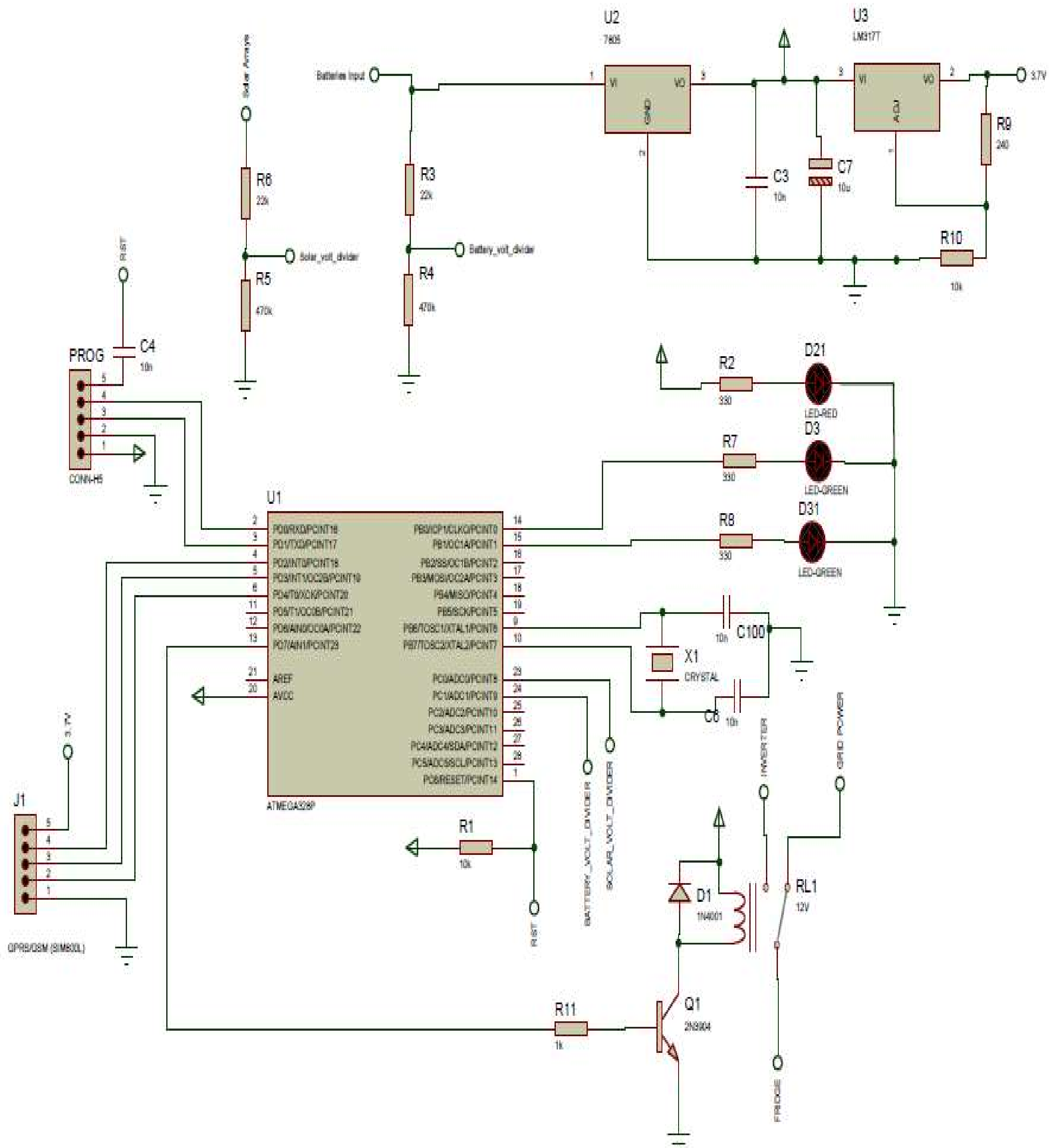

Figure 2: Circuit diagram for hardware part of Solar PV Monitoring System (Using ATMEGA328)

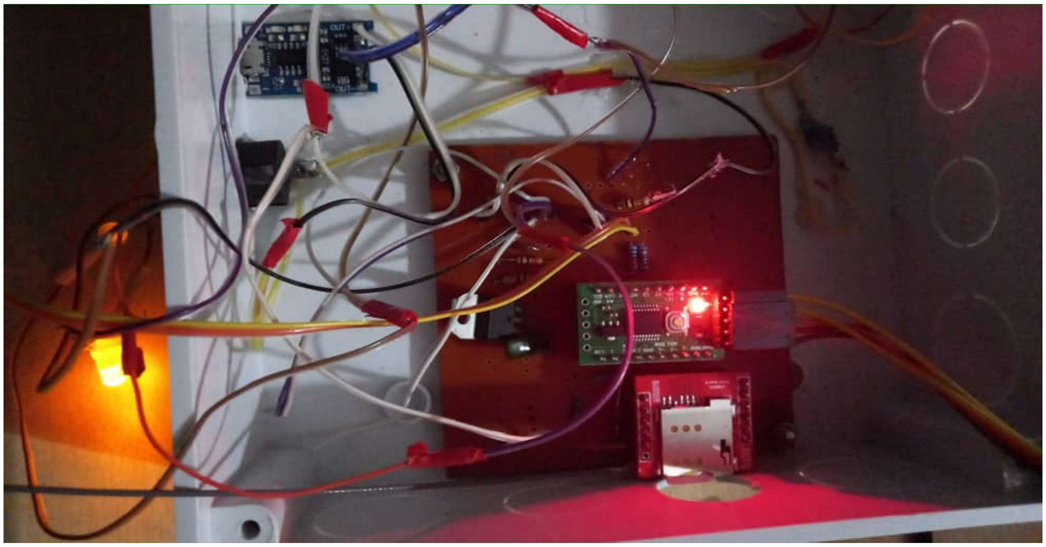

Figure 3: Design Fabrication Diagram (Internal View1)

Figure 4: Design fabrication diagram (View2)

Figure 5: Monitoring System Application

4. RESULTS AND FINDINGS

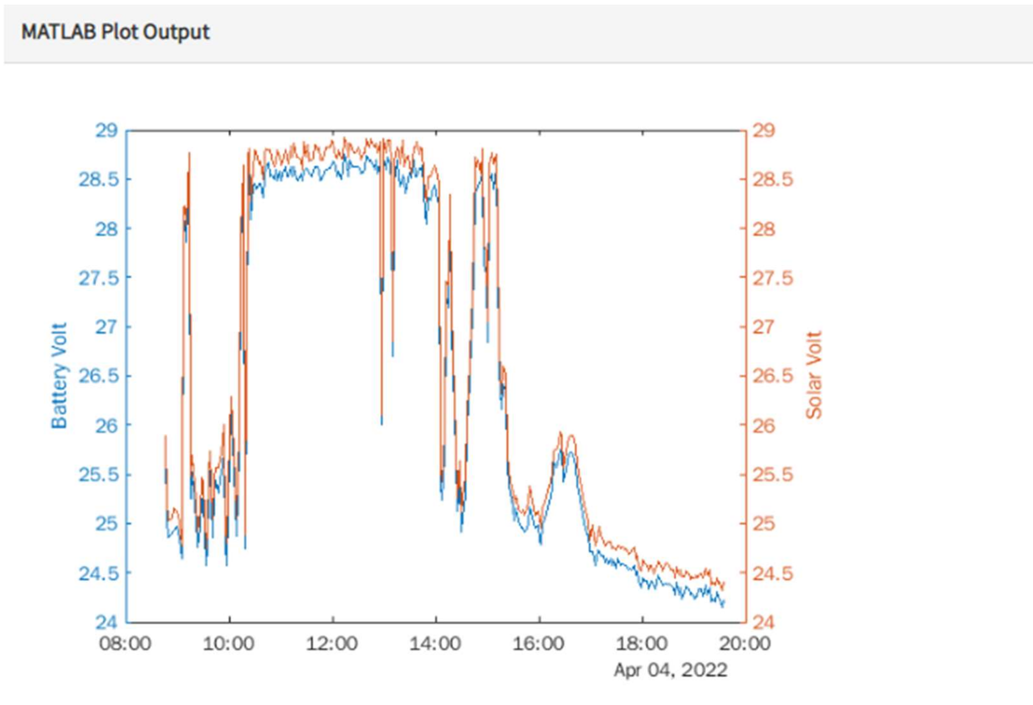

Figure 6: MATLAB output plot for battery voltage and solar voltage

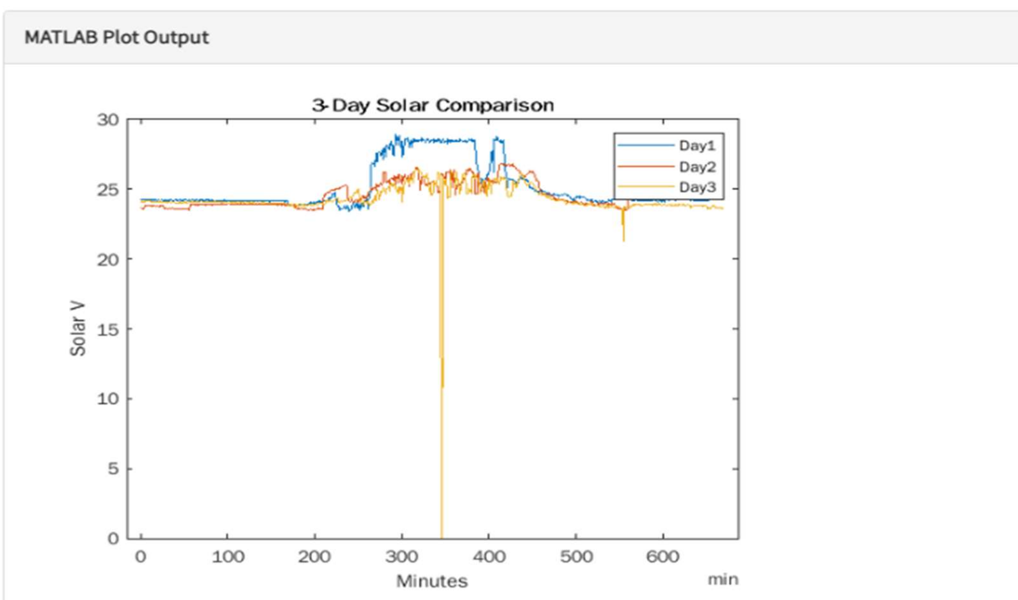

Figure 7: MATLAB Output Plot for 3 Days Comparison Analysis of Solar PV System Performance

Figure 6 showed the MATLAB output plot graph for battery voltage and solar panel voltage. This was conducted between 08:00 to 20:00 i.e. 8am to 8pm (12 hours). Data was collected once every three minutes. It was observed that the variation between the battery's voltage and the solar panel's voltage was not more than 0.5V. This is almost insignificant in the graph. The output thus showed that whenever the solar system is charging, the battery's voltage and the solar panel are the same throughout the charging cycle. At 14:00 hour, there was an abrupt change in the rate of charging, and this significantly affected the battery's voltage as well. Further findings were implemented using three (3) days of Comparison Analysis of the PV System's performance. From the graph in figure 7, days 1 and 2 showed similar performance while day 3 showed an abrupt variation from other days. This was a result of an unusual weather change in less than two minutes on the third day.

5. CONCLUSION

Increase in temperature reduced the voltage generated by the PV system and an increase in the irradiance increases the overall output power. All these parameters and the battery performance are adequately monitored in real-time through the mobile application installed on the mobile phone as demonstrated in fig. 5. Thingspeak IoT platform displayed a real-time analysis of the conditions of the parameters measure which serves as a guide for further assessment of the PV installation. This will prevent sudden break-down of the installation and increase the life span of the PV system usage.

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