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Intelligent Solar Tracking And Load Optimization System with IOT Integration

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Abstract: In a strength to increase system efficiency and exploit the usage of solar energy, the proposal recommends an Internet of Things-enabled smart solar tracking and load controlling system. The technology usages double-axis tracking to dynamically adjust the placing of the solar panels based on real-time light intensity statistics in order to capture the maximum solar irradiation imaginable throughout the day. Simultaneously, the system tracks developments in power usage and allots load as resourcefully as probable to cut down on unused and increase performance. IoT amalgamation makes it promising to control and monitor remotely via cloud-based technologies, allowing users to monitor energy production, load performance, and panel status in real time. The suggested system is appropriate for both residential and commercial solar applications since it places an emphasis on efficiency, sustainability, and intelligent automation. By integrating intelligent load control and solar tracking with IoT, the system's goal is to make renewable energy systems far more user-friendly and energy efficient.

Keywords: Internet of Things, smart solar tracking, load management, dual-axis tracking and intelligent control.

I. Introduction

The usage of renewable energy sources, mainly solar electricity, has improved due to the increasing requirement for energy worldwide and the undesirable environmental effects of fossil fuels. However, because solar energy sources are sporadic, they offer significant management and manipulation issues. In response, Internet of Things (IoT)-enabled smart solar observing and load management schemes have surfaced as viable ways to improve user approachability, system dependability, and energy efficiency. Real-time collection of data, remote surveillance, and smart decision-making are made possible by the integration of IoT technologies with solar energy systems.

To provide exact evaluation of performance and detection of faults, factors like radiation from the sun, voltage panel temperature, and current are tracked by microcontrollers, smart sensors, and platforms that use the cloud [1]. Additionally, IoT-based control of load makes it easier to distribute and use generated energy optimally, which lowers reliance on power from the grid and increases the overall system's reliability [2]. In addition to helping save energy, these solutions support the goals of environmentally conscious urban infrastructure and smart grids as well. With developments in embedded technology, machine learning, and communication via wireless protocols, IoT-enabled solar power solutions are growing increasingly affordable, scalable, and versatile for use in industrial, residential, and commercial environments [3]. Due to their sustainability and long-term financial advantages, solar electricity systems have become more and more important as a result of the global move to renewable energy. However, issues with solar power systems include inconsistent generation, wasteful energy use, and a shortage of real-time monitoring. The Internet of Things' (IoT) incorporation into solar tracking and load control systems has accelerated recently in an effort to overcome these constraints [4-6]. IoT-enabled equipment including microcontrollers, sensors, and gateways is used by smart solar observing systems to collect and send real-time data about the performance of solar panels, temperature, system faults, energy storage levels, and irradiance.

The dependability and effectiveness of solar installations are increased by this data, which makes predictive maintenance, remote surveillance possible, and effective diagnostics [7-8]. Additionally, users can right to use receive notifications, system parameters remotely, and get real-time system data through the integration of cloud-based platforms and mobile applications [9-10]. Another crucial element that guarantees the best possible use of the solar energy produced is load management. Utilizing IoT-based control strategies to prioritize and schedule loads, a system can decrease grid dependability, lower peak loads, and balance consumption [11-12]. Especially in micro-grid environments and smart homes, this kind of intelligent energy supervision helps achieve energy sustainability objectives in addition to cost savings [13-14].

In order to forecast energy production trends and make wise storage decisions or load-shedding, recent advancements have also investigated the application of artificial intelligence and machine learning in Internet of Things-based solar schemes [15-16]. Automated, highly flexible, and user-centric energy arrangements that complement contemporary smart grid contexts have been made possible by these technologies [17-18]. In order to improve energy efficiency, offer real-time visibility, and facilitate smarter energy usage, this study suggests developing a smart solar monitor and load management framework that is integrated with the Internet of Things. The suggested model seeks to provide affordable, scalable solutions that can be used in both commercial and residential applications, all the while promoting sustainable enlargement and lowering carbon emissions.

For this study secondary data has been collected. From the website of KSE the monthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2014. And from the website of SBP the data for the macroeconomic variables are collected for the period of five years. The time series monthly data is collected on stock prices for sample firms and relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.

II. PROPOSED SYSTEM

The primary aim of this suggested work is to monitor the system's power using the Arduino's measured voltage and current values. The energy consumption and power are displayed on the solar energy structure's monitor. This system aids in the smart grid's implementation for effective use. The concept describes a novel Internet of Things-based solar energy monitoring device. The Internet of Things is necessary for this solar energy monitoring system because of a radiation range of sunlight. The current yield of solar panels is not fixed and can change based on time, environmental conditions, and location. Due to their constant exposure to the sun, they need to be examined frequently. IoT technology allows you to keep an eye on the solar panels (Figure. 1). This method uses solar cells, which are mounted in solar panels and convert sunlight towards energy. We have a fleet of Arduinos. Voltage and Current parameters are tracked by sensors. Both the voltage and the current are equal. This displays all of the information that is visible on the LCD display. A parameter's display on an IoT device is continuously accessible through the sensors that is connected to, allowing the user to monitor its value in any network location. Our main objective in this study is to obtain the best power production possible while the solar panels accumulate dust.

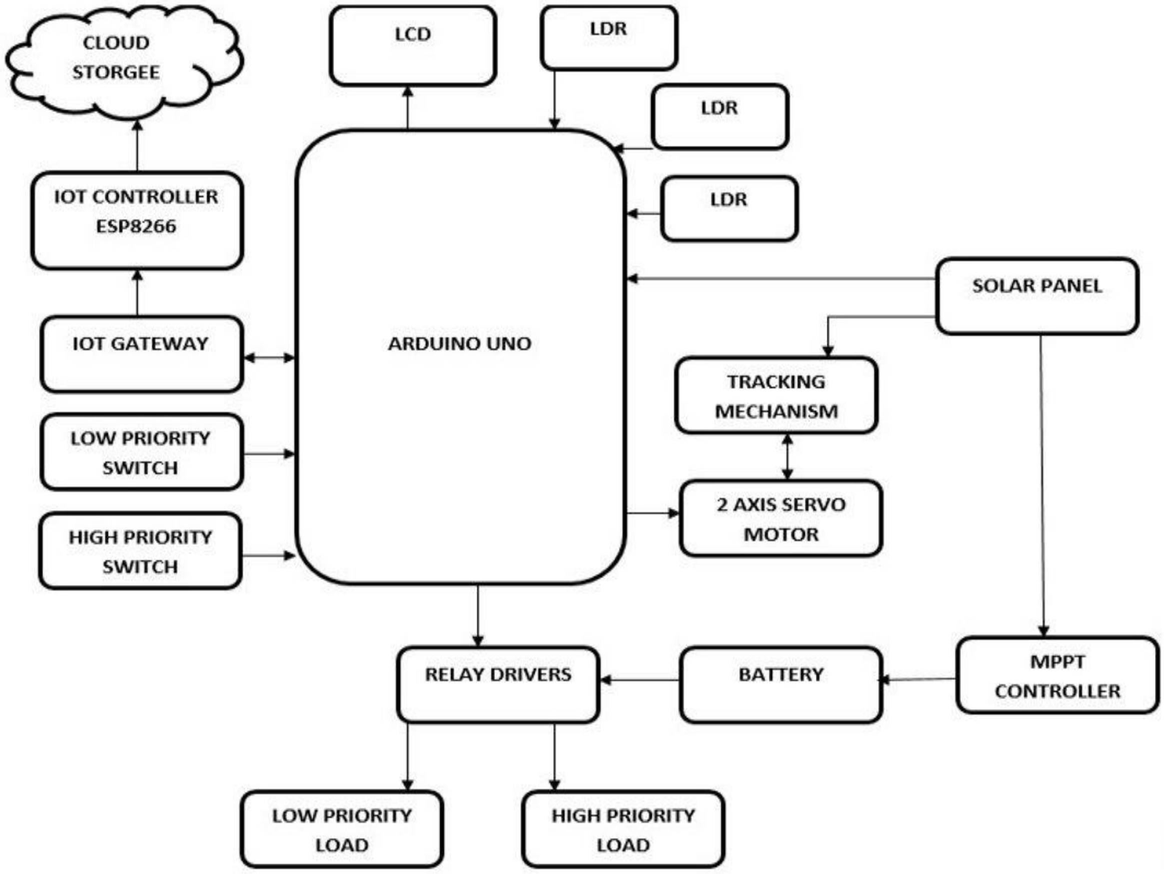


Figure 1: Block Diagram of Proposed System

It's also important to remember that the system is going to fail if you discover an issue in the solar panels. According to the information we have, the loads might be connected to the electrical grid via a battery or solar system. Finds and acknowledges ensures that when a drop below predetermined threshold is recognized, after alerting the administrator or user, the system shows the alert on the graphical user interface. It keeps an eye on the sun all the time. This video uses IoT technologies to display a variety of variables, including temperature, voltage, and current, on the LCD.

III. EXPERIMENTAL SETUP

The suggested approach's hardware arrangement is shown in Figure 2. Batteries are used to store the electricity produced by solar panels. Arduino measures voltage and current via analog pins. These figures are utilized via Arduino programming for calculating energy and power.

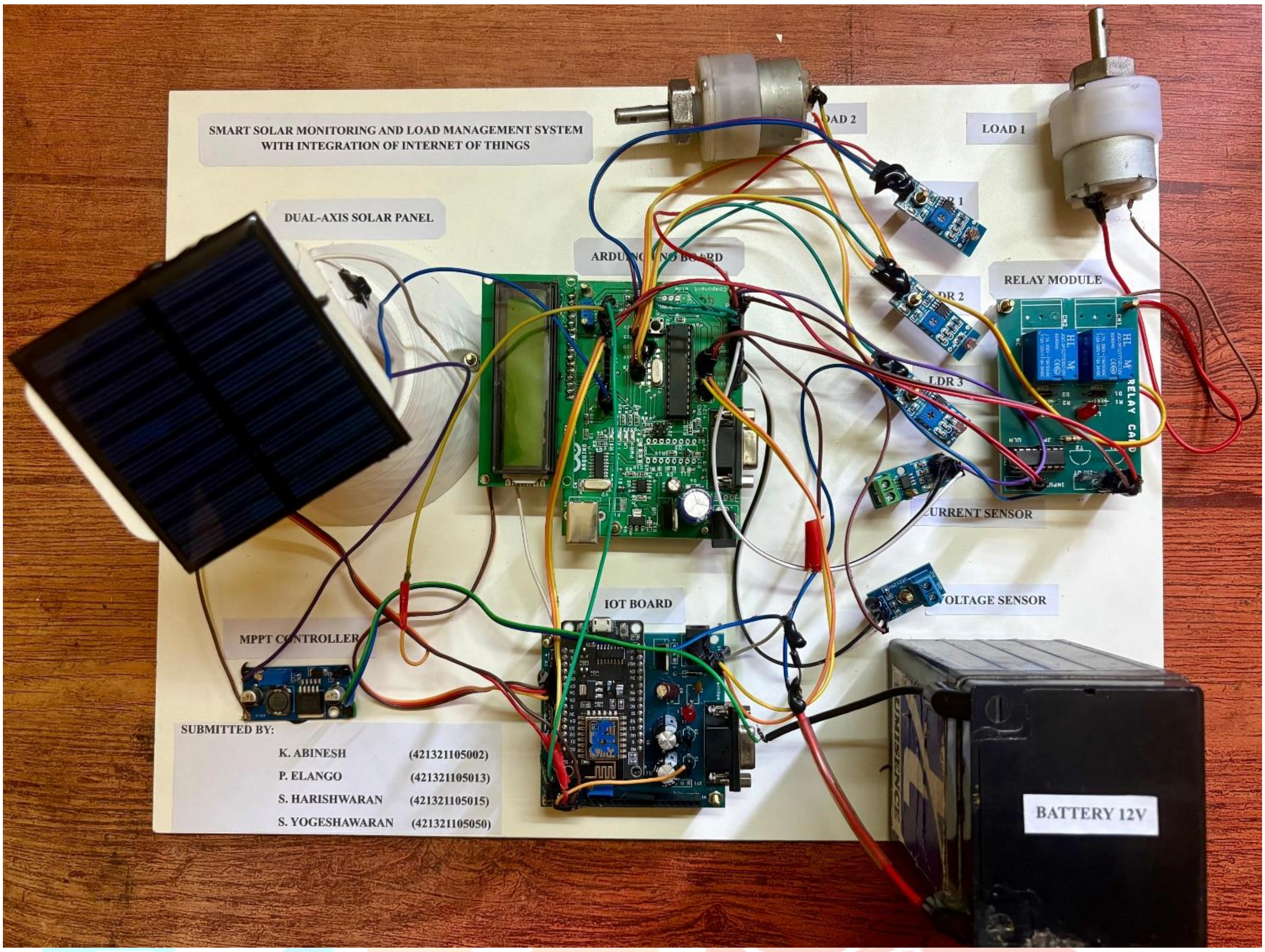


Figure 2: Hardware Arrangement

The term "dual-axis" refers to the automatic system's ability to watch and follow the sun in two directions at once: altitude angle (up-down) and azimuth angle (left-right). The DC motor, shaft coupling, limit switches, worm-gear, and rotating encoder comprised the mechanism for altering the azimuth and altitude angles.

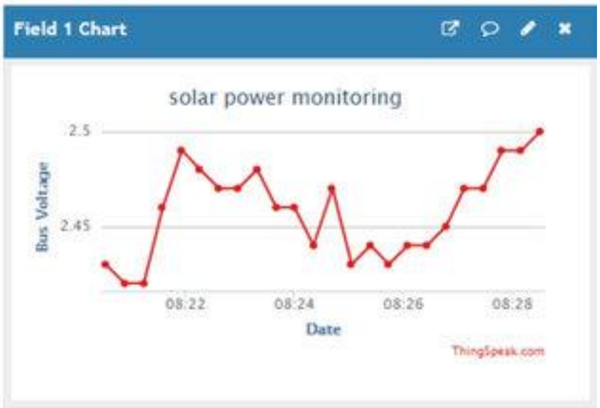
IV. EXPERIMENTAL RESULTS AND DELIBERATIONS

The EMC is a user-friendly graphical user interface for recording current and voltage data in utilities and solar installations. In addition to solar power systems, it features power meters voltmeters, and ammeters for utility measurement and indication. These meters provide power, current, and voltage information. Readings are collected from this system throughout the course of a day at a particular field location.

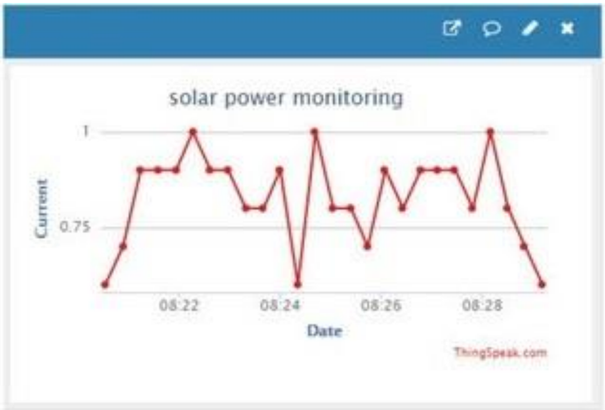
The morning time, afternoon time, and late-evening time readings that were obtained are displayed graphically below.

Case (i) Morning Time (8.20 a.m to 8.30 a.m)

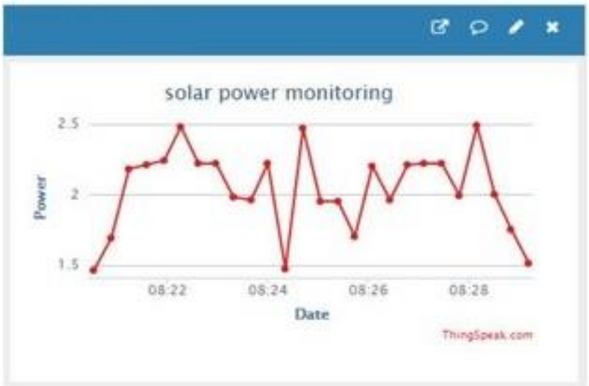
Figure 3 shows the measurements of temperature, light intensity, voltage, power, and current taken at a specific hour in the early hours of the day. The voltage that solar energy systems may generate ranges from 2.4 V to 2.5 V is show in figure 3 (a). The minimum and highest current levels for a period are approximately 0.51 mA and 1 mA, accordingly is shown in figure 3 (b). At this point, the maximum power was 02.5 mW, while the minimum was approximately 01.5 mW is shown in figure 3 (c). At that moment, the maximum light intensity was over 839 cd, while the minimum was nearly 801cd is shown in figure 3 (d). Using the sensor, we took a reading of the temperature on the surface of solar panels at a specific time of day and hour. The temperature during that specific event varies between 22.51 °C and 22.91 °C is shown in figure 3 (e).



(a) Voltage vs date/Time

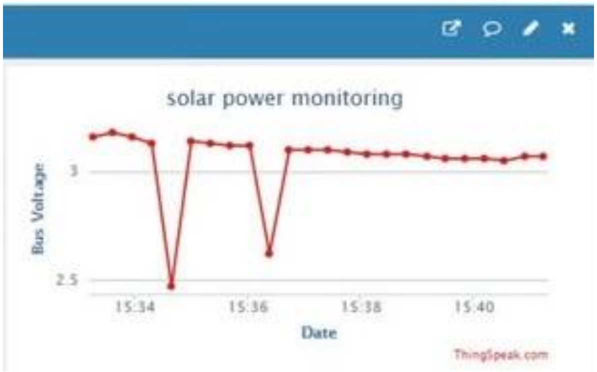


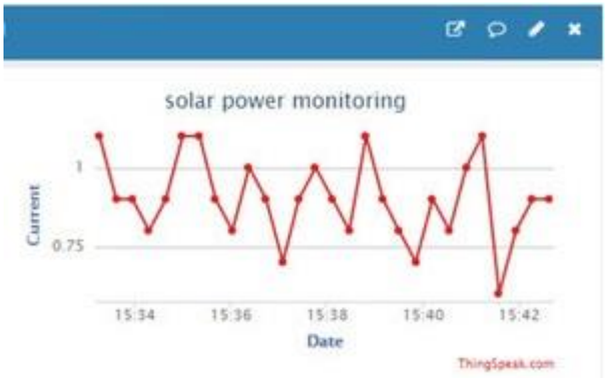
(b) Current vs date/Time



(c) Power vs date/Time

(d) Light intensity vs date/Time



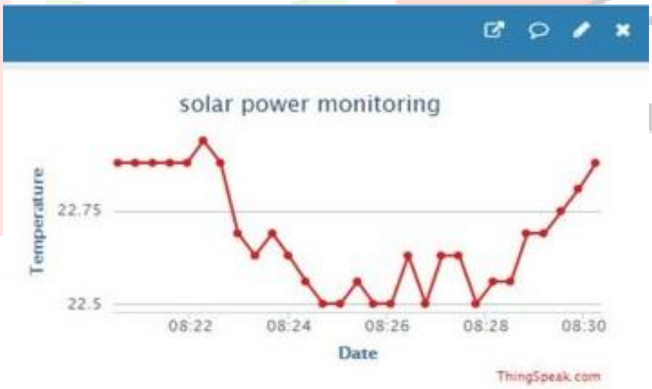


(e) Temperature vs date/Time

Figure 3. The fluctuation of various solar parameters

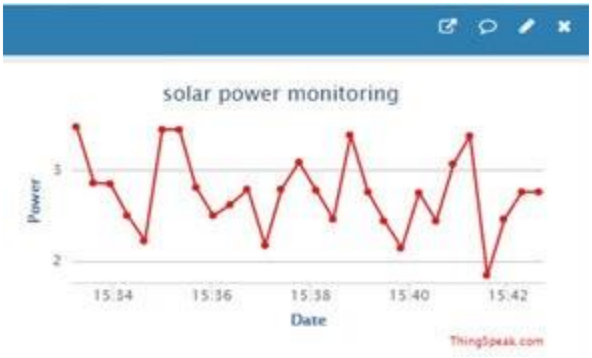
Case (ii) Afternoon Time (3.30 p.m to 3.45 p.m)

Figure 4 shows the measurements of temperature, light intensity, voltage, power, and current taken at a specific hour in the afternoon session of the day. Since the solar panel receives the greatest light in the morning, the highest possible voltage that we could produce is approximately 3.2 V, which is higher than the value in the morning is shown in figure 4 (a). During that period, the smallest current was approximately 0.5 mA, while the maximum current was approximately 1.12 mA is shown figure 4 (b). 3.5 mW per workday was greater than the figure recorded in the morning for that specific daylight. The curve indicates that the light intensity is consistently at its maximum value of 1024 cd. 31.21 °C was the highest recorded temperature, and 29.01 °C was the lowest.

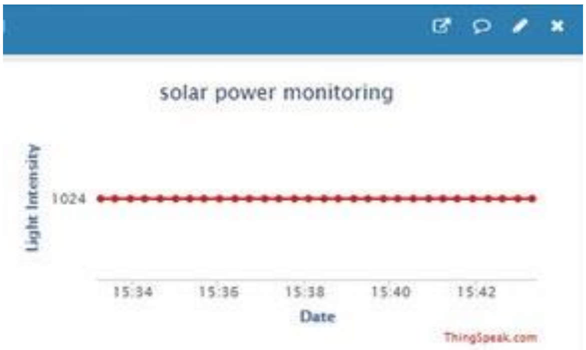


(a) Voltage vs date/Time

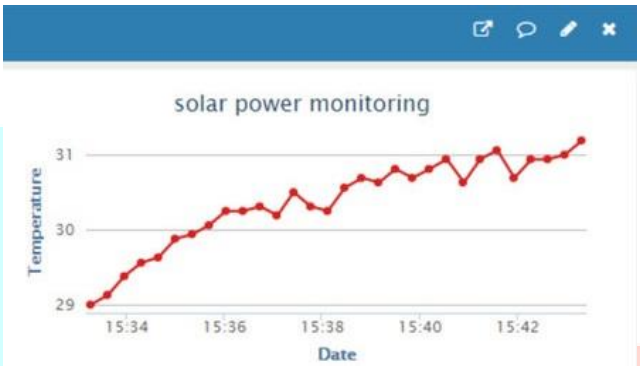
(b) Current vs date/Time



(c) Power vs date/Time



(d) Light intensity vs date/Time

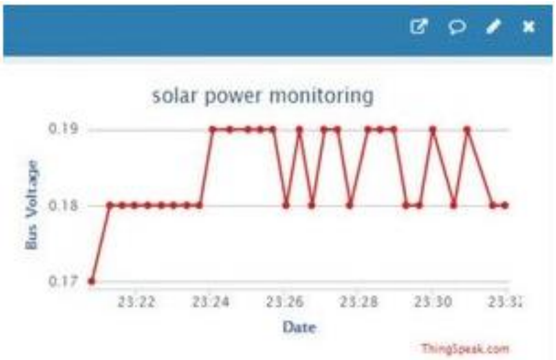


(e)Temperature vs date/Time

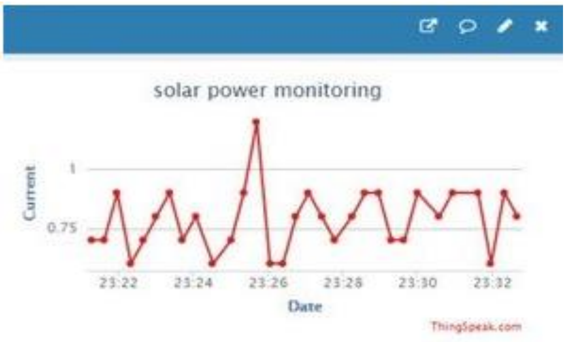
Figure 4. The fluctuation of various solar parameters

Case (iii) Evening Time (11.20 p.m to 11.30 p.m)

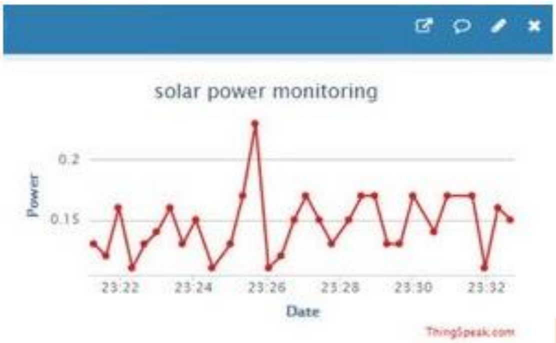
Figure 5 shows the measurements of temperature, light intensity, voltage, power, and current taken at a specific hour in the evening session of the day. The smallest generated voltage within this period was 0.17 V because of a low level of nighttime light and while the maximum generated voltage is approximately 0.19 V is shown in fig 5 (a). In this case, the current detector may identify a produced current of a minimum 0.6 mA and the maximum produced current of about 1.2 mA is shown in figure 5 (b). The highest solar panel creation was 0.23 mW, and this was remarkably low when compared with the afternoon and morning is shown in figure 5 (c). This is due to the fact that solar panels receive the least amount of light during night. The least amount of electricity produced is approximately 0.1mW. At this time, the highest and lowest values light intensities are 329 cd and 324 cd, correspondingly is shown in figure 5 (d). When comparison with the afternoon and morning, evening light intensity changes are minimal. The temperature of the surface of solar panels on a particular day between 11.20 p.m. and 11.30 p.m. The temperature clearly fluctuates from 24.0 °C to 25.0 °C over that time is shown in figure 5 (e).



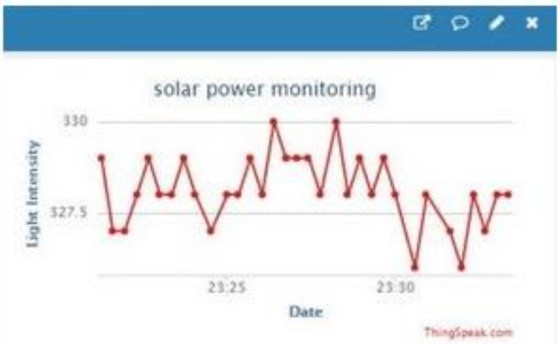
(a) Voltage vs date/Time



(b) Current vs date/Time



(c) Power vs date/Time



(d) Light intensity vs date/Time

(e)Temperature vs date/Time

Figure 5. The fluctuation of various solar parameters

V. CONCLUSIONS

A Smart solar monitoring and load management system with integration of Internet of Things model has fruitfully measured temperature, current, voltage, and light output of solar panels using a graphical user interface (GUI) and gather real-time data from places far from its control center in this work. Among other environmental parameters, the system was able to continually monitor the system data. As long as the equipment is linked with the Internet, the IOT idea enables users to monitor at any time and any location. The created system can let users or connected parties forecast and assess the solar system's performance. By installing a dual axis tracking method, we can control the solar PV panel to maximize the amount of solar radiation and achieve the utmost output. This work uses a Thing speak-based surveillance system that not only displays data interactively but also offers an open-source at low prices. The goal is to reduce dependency on license-based software, costly commercial software, and additional cloud services. Based on the test outcomes, the system used in this research can be expanded into a bigger system for more straightforward, real-time parameter monitoring and open-source software platform.

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