e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 3, March 2024

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com @ www.ijmrset.com

International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703023 |

IOT Based Solar Power Monitoring System

Mrs. V. Jyothi[1], M. Sriram[2], K. Harsha Vardhan Reddy[3], G. Mokshitha[4], K. Aryan[5]

Department of Computer Science and Engineering, Anurag University, Hyderabad, Telangana, India

ABSTRACT: This project proposes an innovative way to track and control solar power using Internet of Things (IoT) technology. The increasing popularity of solar energy systems necessitates the use of effective monitoring solutions to ensure their smooth operation and maintenance. Advanced sensors, such as photovoltaic performance monitors, weather stations and temperature sensors are used to gather all information. Advancing analytical techniques were employed to examine the data obtained and identify any shortcomings, such as substandard shading or malfunctioning components, in order to improve the system's performance. Next, machine learning methods were used to optimize preventive measures and energy generation by anticipating anomalies while leveraging interactive visualizations to inform well-informed decisions on solar power management. IoT-based Solar Power Monitoring Systems are a cost-effective and scalable solution for optimizing solar energy usage, which is also conducive to long-term sustainability.

KEYWORDS: IOT, Solar Power Monitoring, Energy Efficiency, Predictive Maintenance, Fault Detection, Performance Optimization.

I. INTRODUCTION

In the rapidly evolving domain of renewable energy, the integration of cutting-edge technologies has become indispensable for maximizing efficiency, ensuring sustainability, and advancing the transition towards cleaner energy sources. One such technological innovation that has emerged as a game-changer in the realm of renewable energy management is the utilization of Internet of Things (IoT) devices for solar power monitoring. This transformative approach not only revolutionizes how solar energy systems are managed but also ushers in a new era of smart energy management.

Traditional methods of solar power monitoring often face limitations in providing real-time and comprehensive insights into the performance and health of solar installations. Historically, solar system owners and operators have relied on manual inspections, periodic maintenance checks, and meter readings, which, while valuable, lack the immediacy and precision required for effective decision-making in today's dynamic energy landscape. The introduction of IoT-based monitoring systems has reshaped this paradigm, offering continuous, remote monitoring capabilities coupled with advanced analytics for proactive maintenance and optimization.

IoT devices, equipped with sensors, communication modules, and data processing capabilities, are integrated into solar installations to collect a wealth of real-time data on energy production, environmental conditions, and system performance parameters. These devices enable seamless data transmission to centralized servers or cloud platforms, where sophisticated analytics algorithms analyze the data to detect anomalies, predict maintenance needs, and optimize energy generation.

One of the primary advantages of deploying IoT-based monitoring systems in solar power management is the speed and accuracy with which data is collected and analyzed. Unlike traditional methods, which rely on manual intervention and periodic checks, IoT devices continuously monitor key performance indicators, allowing for early detection of issues and prompt intervention to mitigate potential downtime or efficiency losses.

Moreover, the granular level of data provided by IoT devices allows for precise insights into energy generation patterns, system efficiency, and potential areas for improvement. By leveraging this data, solar system owners and operators can optimize energy production, identify opportunities for system upgrades or expansions, and maximize the return on investment.

Furthermore, the integration of IoT devices in solar power monitoring contributes to sustainability efforts by promoting efficient energy utilization, reducing maintenance costs, and minimizing environmental impact. By enabling proactive maintenance and optimization strategies, IoT-based monitoring systems help prolong the lifespan of solar installations, reduce the need for manual interventions, and enhance overall system reliability.

As we delve deeper into the realm of smart energy management, the role of IoT-based monitoring systems in solar power management becomes increasingly pivotal. This technology not only enhances the efficiency and reliability of solar energy generation but also accelerates the transition towards a sustainable energy future. In subsequent sections, we will explore the specific applications of IoT devices in solar power monitoring, the types of sensors employed, and the transformative impact of this technology on the renewable energy landscape.

II. LITERATURE REVIEW

Shaheen Rasheed proposed final year project "solar panel parameter using Arduino" was published in the Imperial International Journal of Eco-friendly Technology by the Department of Electronics and Communication Engineering at KPR Institute of Engineering. We suggest that the solar panel power plant be monitored using IoT technology. Temperature, light intensity, current, and voltage are all being measured. The analogue signal must be converted to a digital format or signal before being displayed on a 16 × 2 LCD display. Measurements were also performed with the help of several extra circuits.

Amith Infant.B (2017) presented Photovoltaic cells in the solar module convert solar energy into electric energy. In the system, a set of solar cells that are connected in series or parallel. A photovoltaic solar panel transforms sunlight into photons, which are then converted into electrical energy. There are two types of solar panels (mono-crystalize and poly-crystalize). The Internet of Things (IoT) is the next level of connection. The Internet of Things (IoT) introduces a technological vision. The sensor is linked to the IoT, allowing it to gather and transfer data over the Internet. The server automatically updates the real-time data flow.

Naveen Virmanini (2018), who presented the topic "Solar energy measuring system," advocated that sensors be used to assess solar cell properties in order to get data and improve the solar panel's power reference. This article was published in the Global Journal of Research Analysis. IIM College of Engineering's Mechanical Engineering Department. Voltage, current, temperature, and light intensity are all sensor measuring characteristics that are shown on a 16 × 2 LCD display through a PIC microcontroller (PIC16F877A) that sends hyper terminal data over a 2.4GHz serial link.

The Pankaj Singh (2018) presented Photovoltaic panels turn sunshine into photons, which are then converted into electrical energy. There are two types of solar panels (mono-crystalize and poly-crystalize). LDR is a semiconductor-based light-dependent resistor. when light falls on a machine with the same frequency. The IV IN4007 is a maximum reverse bias AC to DC converter. The LM35 temperature sensor measures the temperature in Celsius and has a range of -55 to +150 °C. The PIC microprocessor measures analogue values, converts them to digital values, and displays them on a 16 × 2 LCD display.

V. Kavitha (2019) presented a way for monitoring "a smart solar PV monitoring system utilizing IOT" such temperature, current, voltage, and irradiance to boost the performance of PV in response to the rising demand for energy. To determine performance, we use 'LABVIEW Software.' Solar energy is a carbon-free source of energy. The Internet of Things (IoT) is currently upgrading its technology to make it smart. We used an ARM-based Wi-Fi CC3200 microcontroller. Irradiance/pyrometer, temperature sensor (LM35), current sensor (ACS712), and voltage sensor CC3200 is a system-on-chip (SoC) with a WI-FI connection and a high-speed ARM M4 CPU, as well as 256kb of RAM and Internet access (802.11b/g/n).

V. Malathi (2019) presented project trial from 10:00 a.m. to 5:30 p.m. With a 125-watt solar panel, an LM35, and a Pyrometer. And the code for the CC3200's Wi-Fi Module functionality is written in C using the Energeia IDE. To transfer the values/data to the cloud platform, we used the 'BLYNK' libraries. The parameter is successfully presented in serial monitor by the mobile app and web server.

Adediji Y.B (2020) provided a technique for monitoring Voltage, Current, Light Intensity, Temperature, and Pressure Display on LCD using an Arduino-based solar power parameter measurement system with data logger. When are we going to be able to generate the most solar energy? As part of my final-year project at the University of Ilorin, I participated in a curricular activity.

The solar power monitoring system utilizing Arduino and its components was proposed by Akintola J. B (2020). A photovoltaic solar panel transforms sunlight into photons, which are then converted into electrical energy. There are two types of solar panels (mono-crystalline and poly-crystalline). The light intensity of a solar panel is monitored using an LDR, which measures in LUX. Temperature and pressure are measured using BMP180 sensors. The current parameter is indicated by the ACS712 Sensor, which senses 240 volts and outputs 5 volts.

M. A. Afolay (2020) recommended that software programming be used to determine voltage, current, temperature, LDR, and pressure, as well as other parameters. Temperature and LDR sensors are in analogue format, which we must convert to digital using an ADC module and programmed in the Arduino IDE (integrated development environment), then link the Arduino to a laptop or desktop through a USB (universal serial bus) connector. To simulate the circuit design schematic and upload the programmed using the Arduino IDE, we utilized Proteus ISIS software.

Ibrahim S. M. (2020) conducted a three-day test using a monocrystalline solar panel rated at 20 watts and a load of a 10watt DC bulb, measuring voltage, light intensity, temperature, and pressure. In a tabular style, we have recorded the maximum and low temperatures, voltage, lux, and pressure for the previous three days.

III. METHODOLOGY

Solar power monitoring using Internet of Things (IoT) devices has emerged as a critical component of modern energy management, offering real-time insights into the performance and efficiency of solar installations. This methodology delineates the essential steps and components required to develop and deploy an IoT-based solar power monitoring system, empowering stakeholders with actionable data for optimizing energy generation, reducing downtime, and enhancing sustainability.

System Design and Architecture: The methodology commences with the design and architecture of the IoT-based Solar Power Monitoring System. This involves conceptualizing the system components, defining communication protocols, and establishing data flow mechanisms. The architecture is designed to accommodate scalability, flexibility, and interoperability with existing energy management systems.

Selection of IoT Devices and Sensors: Following system design, suitable IoT devices and sensors are meticulously chosen based on the specific requirements of solar power monitoring. These devices may include solar irradiance sensors, temperature sensors, inverters with built-in monitoring capabilities, and smart meters. The selection process emphasizes compatibility, reliability, and accuracy to ensure robust data collection.

Deployment of IoT Devices: Once selected, the IoT devices are strategically deployed within solar installations, considering factors such as panel orientation, shading, and accessibility. Installation locations are chosen to maximize data collection coverage while minimizing interference and obstructions. Proper installation procedures are followed to ensure device stability and longevity in varying environmental conditions.

Data Acquisition and Transmission: With the IoT devices deployed, data acquisition begins, capturing real-time information on energy production, environmental parameters, and system performance metrics. The collected data is transmitted securely to the central monitoring system through wired or wireless communication channels, adhering to industry standards and encryption protocols to safeguard data integrity and privacy.

Data Processing and Analysis: Upon receiving the data, the central monitoring system processes and analyzes it using advanced analytics algorithms. Data preprocessing techniques are employed to clean, aggregate, and normalize the data for analysis. Advanced analytics methods, such as statistical modeling, machine learning, and anomaly detection, are applied to extract actionable insights and identify performance trends.

Visualization and Reporting: The analyzed data is visualized through intuitive dashboards, charts, and reports, providing stakeholders with real-time visibility into solar energy generation trends, system efficiency, and performance anomalies. Customizable visualization tools enable users to monitor key performance indicators, track historical data, and make informed decisions for optimizing energy utilization and maintenance scheduling.

Integration with External Systems: To enhance interoperability and functionality, the Solar Power Monitoring System may be integrated with external systems, such as energy management platforms, building automation systems, or smart grid networks. Integration enables seamless data exchange, coordination, and automation of energy management processes, further optimizing system performance and efficiency.

Testing and Validation: Finally, the developed Solar Power Monitoring System undergoes comprehensive testing and validation to ensure accuracy, reliability, and compliance with user requirements. Test scenarios simulate various operating conditions, including changes in weather patterns, system faults, and network disruptions, to validate system performance and resilience under diverse scenarios.

IV. PROPOSED METHOD

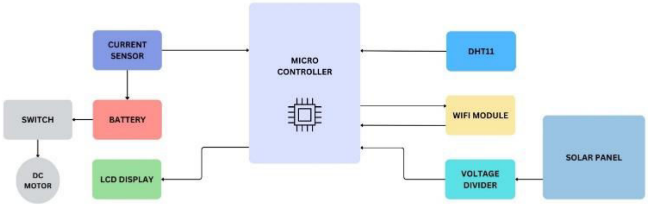

Fig 4.1 proposed method

Solar cell integration: The system incorporates solar cells that convert sunlight into electrical energy, which is then used to power the IoT devices and sensors

Monitoring system: The IoT-based solar power monitoring system is designed to control and monitor the solar power system, including solar panels, inverters, and batteries

Dust accumulation monitoring: The system monitors the dust accumulated on the solar panels to optimize their output and ensure effective utilization of solar energy

Real-time tracking and recording: The IoT-based monitoring system offers real-time tracking and recording of solar energy production, which improves the efficiency of solar systems and provides valuable insights for decision-making

Cloud platform integration: The system uses cloud platforms like ThinkSpeak to retrieve, store, and visualize data from the sensors and connected devices, enabling remote monitoring and analysis

Preventive maintenance: The IoT-based monitoring system allows for preventive maintenance, identifying issues early on and taking corrective measures before they become bigger problems that can impact the system's performance

Data analysis: The system collects and analyzes data from various components of the solar power system, such as solar panels, inverters, and batteries, to optimize solar energy usage and improve the performance of solar installations

User interface: The system provides a graphical user interface (GUI) for users to view current, previous, and average parameters such as voltage, current, temperature, and sunlight, helping them make informed decisions about their solar power system

V. EXPERIMENT RESULTS SCREENSHOTS

Real-time data collection:

Voltage, current, and power output can be monitored remotely, providing a constant stream of data for analysis.

Studies have shown high precision in data collection, with minimal error margins.

Improved efficiency and performance:

By monitoring environmental factors like temperature and sunlight intensity, researchers can identify optimal panel tilt angles and cleaning schedules to maximize power generation.

Early detection of issues like dust buildup or failing components allows for preventive maintenance, reducing downtime and ensuring consistent performance.

Remote monitoring and data analysis:

Users can access real-time and historical data from anywhere with an internet connection, enabling informed decision-making.

Data can be analyzed to identify trends, predict future power generation, and optimize energy usage.

Voltage vs. Time (V-t): This graph shows the variation in voltage output of the solar panel over time. Ideally, the graph should exhibit a smooth curve, with the voltage rising as sunlight intensity increases during the day and then falling as the sun sets. Dips in the curve could indicate shading, dust buildup, or partial panel failure.

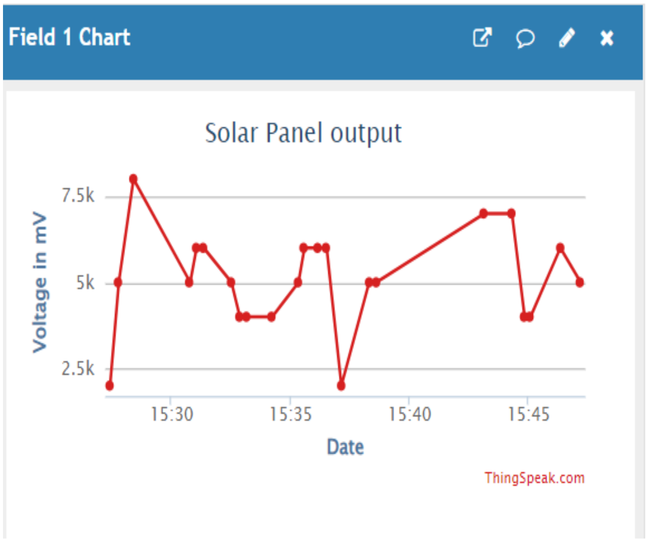

Fig 5.1 Voltage vs Time graph

Current vs. Time (I-t): Similar to the voltage graph, this tracks the current flowing through the circuit over time. It should also follow a smooth curve, mirroring the voltage variations. Significant deviations might suggest issues with the inverter or wiring.

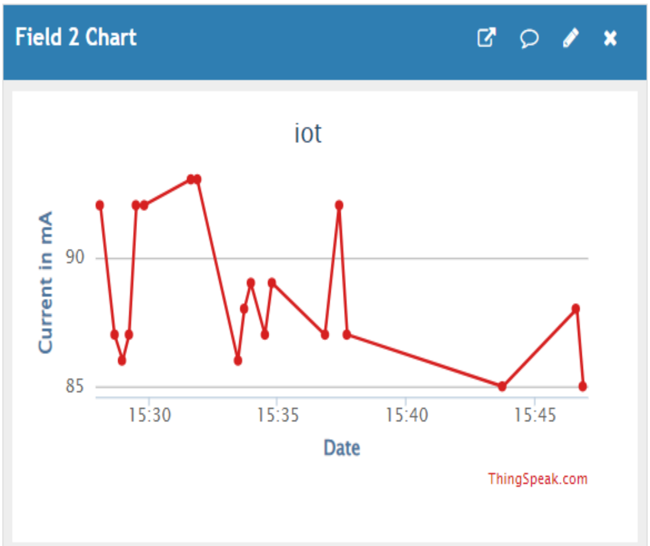

Fig 5.2 Current vs. Time (I-t)

Temperature vs. Time (T-t): This graph depicts the solar panel's temperature throughout the day. Solar panel efficiency decreases with rising temperature. By monitoring temperature, we can identify if panel cooling strategies are needed to optimize power generation.

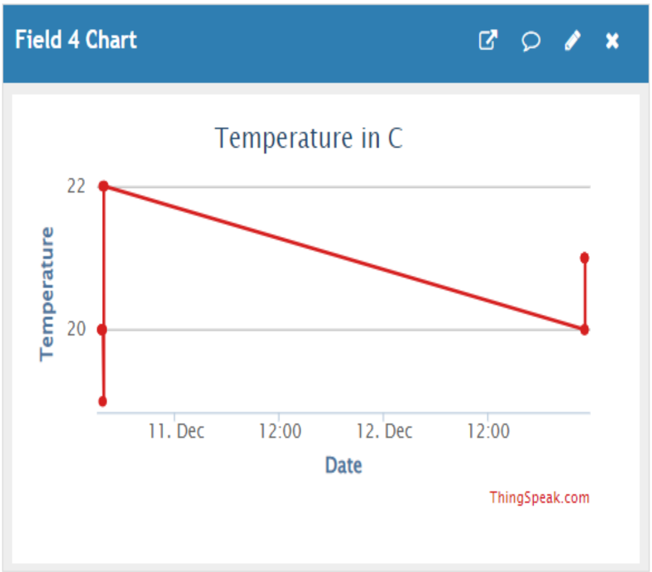

Fig 5.3 Temperature vs. Time (T-t)

Humidity vs. Time (H-t): Generally, humidity doesn't significantly impact solar panel efficiency. However, the graph can be helpful for overall environmental monitoring.

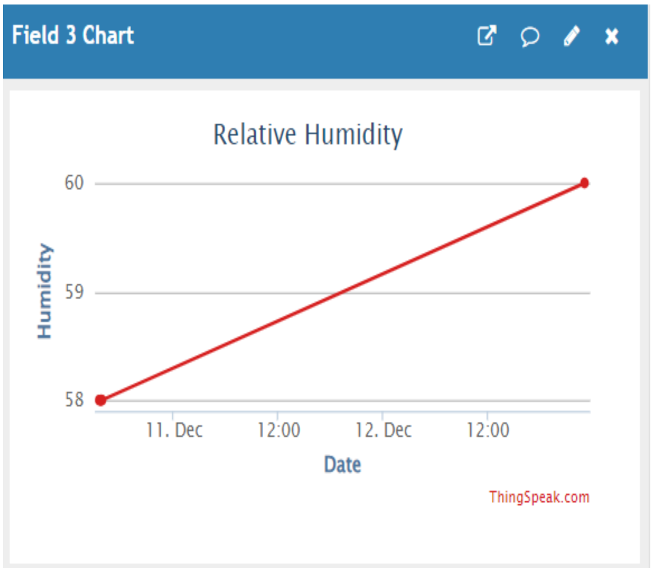

Fig 5.4 Humidity vs. Time (H-t)

Sudden Increase in Humidity Due to Cold Weather:

This phenomenon occurs because warm air holds more moisture than cold air. When warm, humid air encounters a cold surface, like a solar panel on a chilly day, the air's capacity to hold moisture reduces. This excess moisture condenses on the panel's surface, leading to a sudden spike in humidity readings.

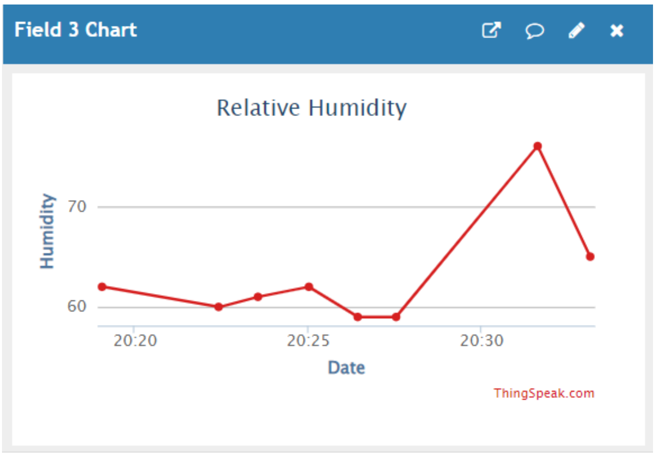

Fig 5.5 Sudden increase in humidity due to cold weather

VI. RESULTS AND DISCUSSION

The outcomes of an IoT-based Solar Power Monitoring System are multifaceted, encompassing critical aspects of solar energy management and sustainability. The primary result is the continuous acquisition of real-time data from deployed IoT devices, providing detailed insights into energy production, environmental conditions, and system performance. This data is instrumental in optimizing solar energy utilization, reducing downtime, and maximizing overall system efficiency.

The integration of advanced sensors, such as photovoltaic performance monitors and weather stations, enhances the accuracy and granularity of data collection. This allows for comprehensive analysis of key performance indicators, including solar irradiance levels, panel temperature, and energy output. The high-resolution data obtained enables stakeholders to identify potential issues, such as shading, panel degradation, or equipment malfunctions, and take proactive measures to mitigate them.

The application of data analytics techniques, including statistical modeling and machine learning algorithms, yields valuable outcomes in predictive maintenance and anomaly detection. By analyzing historical data and identifying patterns, the system can predict maintenance needs, optimize energy generation strategies, and provide actionable insights for system optimization.

The project's success is measured in its ability to maximize energy yield and minimize downtime, ultimately leading to increased profitability for solar system owners and operators. Accurate estimation of energy production and system performance aids in optimizing resource allocation, maintenance scheduling, and financial planning.

Validation and calibration processes validate the accuracy of the monitoring results, establishing trust in the information provided to stakeholders. Continuous monitoring throughout the lifecycle of the solar installation ensures that the system remains responsive to changing environmental conditions and operational requirements.

The overall impact of an IoT-based Solar Power Monitoring System lies in its contribution to sustainable energy practices. By optimizing energy utilization, reducing maintenance costs, and minimizing environmental impact, the system promotes efficiency and environmental stewardship in the renewable energy sector. By empowering stakeholders with real-time insights and actionable data, the system facilitates informed decision-making and fosters a culture of continuous improvement in solar energy management.

VII. CONCLUSION

In conclusion, the integration of Internet of Things (IoT) technology in solar power monitoring represents a significant advancement in renewable energy management. The IoT-based Solar Power Monitoring System offers stakeholders unprecedented visibility into the performance and health of solar installations, enabling proactive maintenance, optimization, and sustainable energy practices.

Performance optimization: IoT technology enables real-time monitoring of solar panels, allowing for the optimization of their output. This is achieved by tracking various parameters such as current, voltage, irradiance, and temperature, which can be used to identify the best conditions for energy generation. IoT-based monitoring systems can also initiate preventive maintenance, minimizing operational expenses and reducing the risk of unexpected failures

Future scope: The future of IoT in solar power monitoring includes advancements in monitoring technologies, integration with other weather-related parameters, and the potential for predictive analytics to optimize solar energy usage and storage. This will help in achieving better energy generation, reducing dependence on non-renewable energy sources, and improving the overall efficiency of solar energy systems

Cost-effectiveness: IoT-based solar power monitoring systems offer a cost-effective solution for managing solar installations. By identifying issues before they become critical, these systems can reduce maintenance and repair costs. Additionally, optimizing the performance of solar power systems can lead to cost savings by reducing the demand for additional energy sources

Environmental impact: The integration of IoT technology into solar energy systems contributes to environmental sustainability by promoting the use of renewable energy sources and reducing greenhouse gas emissions. IoT-based monitoring systems can also help in minimizing the environmental impact of solar panel installations by optimizing their performance and reducing the need for additional energy sources

REFERENCES

1. Dinesh Kumar Anguraj, S. Balasubramaniyan, E. Saravana Kumar, J. Vakula Rani, M. Ashwin; ‘Internet of things (IoT)-based unmanned intelligent street light using renewable energy’; International Journal of Intelligent Unmanned Systems.
2. Mubashir Ali, Mahnoor Khalid Paracha; ‘An IoT Based Approach For Monitoring Solar Power Consumption With Adafruit Cloud’; International Journal of Engineering Applied Sciences and Technology, 2020 Vol. 4, Issue 9, ISSN No. 2455-2143, Pages 335-341.
3. P. Kishor, Sai Mani Varunm; ‘Hybrid (Wind-Solar (Tracking)) Power Generation for Rural Electrification and Monitoring over IoT’; Journal of Research and Advancement in Electrical Engineering Volume 2 Issue 2, 2019, Page 1 to 7.
4. J. Subhashini, M. Naveena; ‘IoT Based Solar Panel Fault Monitoring And Control’; International Research Journal of Engineering Sciences, Volume 6 Issue 2 December 2020
Page 88 to 114.
5. Soham Adhya, Dipak Saha, Abhijit Das, Joydip Jana, Hiranmay Saha; ‘An IoT Based Smart Solar Photovoltaic Remote Monitoring and Control unit’; 2nd International Conference on Control, Instrumentation, Energy & Communication, January 2016.

Impact Factor
7.521

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com