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IOT Based Monitoring of Solar plant through Lab VIEW

[1]Rajiv Nagorao Kumbhrgave, [2]Pravin Arjun channekar, [3]Ankush Ramnaresh Sengar, [4]Mrs. R.L.Nale

[123]Student, [4]Guide

[1,2,3,4] Electrical Engineering,

[1,2,3,4] Shree Ramchandra College of engineering, Pune, India

Abstract: The rapid depletion of non-renewable energy sources has increased the need for reliable and sustainable alternatives, among which solar energy is one of the most effective options. However, many solar power plants are still operated manually, where an operator must be physically present at the site to monitor system parameters and manage switching operations. This manual process often leads to reading errors, delayed maintenance, and safety risks for the operator. To overcome these problems, this project proposes an IoT-based Solar Power Plant Monitoring and Control System using Arduino and NI LabVIEW.

The system is designed to monitor important parameters such as light intensity, temperature, voltage, and current in real time using appropriate sensors. An Arduino controller collects the sensor data and communicates with NI LabVIEW software installed on a PC for monitoring, visualization, and control. The system also supports data logging to Excel, which helps in maintaining historical records for performance analysis and faster maintenance. A relay unit is used for automatic solar and battery switching, while LED and buzzer indications provide alert and status notifications.

This proposed system is smart, cost-effective, and reduces human effort significantly. It improves accuracy in parameter monitoring, enhances operator safety, reduces maintenance time, and supports better decision-making through continuous data logging and real-time IoT-based supervision. Thus, the project offers an efficient automation solution for modern solar plant management.

Index Terms **-** Solar Power Plant, IoT Monitoring, Arduino, NI LabVIEW, Data Logging, Automation, Voltage Sensor, Current Sensor, Temperature Sensor, Light Intensity Sensor, Relay Control, Battery Switching.

I. INTRODUCTION

Energy is one of the most important requirements for modern life, industry, agriculture, and communication systems. For many years, the world has depended heavily on non-renewable energy sources such as coal, petroleum, and natural gas. But these resources are limited, costly, and harmful to the environment. Their continuous use increases pollution, global warming, and long-term energy insecurity. Because of this, the demand for clean, renewable, and sustainable energy sources has increased rapidly. Among all renewable sources, solar energy is one of the most promising because it is freely available, eco-friendly, and suitable for both small-scale and large-scale power generation.

Solar power plants convert sunlight into electrical energy using photovoltaic panels. These systems are being adopted widely in homes, industries, institutions, and utility-scale installations. Even though solar energy offers many benefits, efficient operation and maintenance of solar plants is still a major challenge. In many cases, solar plants are monitored manually by operators who must remain physically present at the site to check parameters such as panel voltage, current, temperature, battery status, and light intensity. This traditional method is time-consuming, less efficient, and prone to human error. Wrong readings, delayed fault detection, and lack of proper record keeping can reduce the performance of the plant and increase maintenance cost. Manual monitoring can also expose operators to electrical risks and unsafe working conditions.

To improve the performance and safety of solar systems, automation and smart monitoring techniques are becoming essential. Technologies such as IoT, embedded systems, and data logging can make solar plant operation more reliable and intelligent. By using sensors and controllers, important parameters can be measured continuously and displayed in real time. These values can also be stored for future analysis, making fault diagnosis and maintenance easier. Automation also helps reduce human effort and improves the overall efficiency of the system.

This project focuses on the design and development of an IoT-based Solar Power Plant Monitoring and Control System using Arduino and NI LabVIEW software. The proposed system uses sensors such as a light intensity sensor, temperature sensor, voltage sensor, and current sensor to collect real-time data from the solar setup. Arduino acts as the main controller for reading sensor values and sending them to the PC. NI LabVIEW is used to create a graphical monitoring dashboard where the user can observe all parameters easily. The system also provides data logging to Excel, which helps maintain proper records of plant operation. In addition, relay control is used for solar and battery switching, while LED and buzzer units provide indication and alert functions.

The main aim of this project is to build a smart, cost-effective, and user-friendly system that reduces manual effort and improves the monitoring and control of solar power plants. The project is useful for improving accuracy, enhancing operator safety, reducing maintenance time, and supporting better energy management. It demonstrates how automation and IoT technologies can be applied in renewable energy systems to make them more efficient, reliable, and practical for modern applications

II. Literature Review

Ayasha Siddiqua, Afsana Anjum, Sunanda Kondapalli, and Chamandeep Kaur, in the paper “Regulating and Monitoring IoT Controlled Solar Power Plant by ML,” presented at the 2023 IEEE International Conference on Computer Communication and Informatics (ICCCI), pushed the literature beyond simple sensing by linking solar plant monitoring with machine-learning-based regulation. The core value of this work is that it treats the solar plant as a system that must not only be observed but also intelligently managed. For your review, this paper is important because it shows that modern solar monitoring research is increasingly combining sensor data with decision-making logic instead of stopping at display-only dashboards.

L. M. Merlin Livingston, Elangovan Guruva Reddy, K. S. Rajesh, M. Muthulekshmi, and E. N. Ganesh, in “Fuzzy Logic Controlled Photovoltaic System with IoT Technology,” published in the 2023 Second International Conference on Smart Technologies for Smart Nation (SmartTechCon), focused on the integration of fuzzy logic control, IoT-based monitoring, and MPPT-oriented photovoltaic operation. The available abstract information indicates that the system improved energy efficiency and stability compared with conventional PV setups, while also supporting remote administration, real-time monitoring, and early fault/error detection. This is directly useful to your project because it proves that intelligent control layered on top of real-time monitoring can improve overall plant performance, not just visibility.

Shakil Hossain Sajjad, Md. Erfanul Haque Sajib, Md. Nasim Hasan, and Md. Abdur Razzak, in “Design and Implementation of an IoT Based Solar Power Monitoring System,” presented at the 2023 IEEE World AI IoT Congress (AIIoT), proposed a dedicated IoT-based architecture for remote supervision and evaluation of PV performance. The paper is significant because it reflects the strong 2023 trend toward building low-cost connected solar monitoring platforms that support continuous observation from remote locations. For your literature review, this work supports the argument that solar plants benefit greatly when key parameters such as current, voltage, and operating status are transmitted continuously instead of being checked manually at site level.

Adam Barbosa, Hamza Mubarak, Fazel Mohammadi, Mohammad J. Sanjari, and Mehrdad Saif, in "A Real-Time IoT-Based Data Acquisition and Monitoring System for Photovoltaic Applications," presented at the 2024 3rd International Conference on Power Systems and Electrical Technology (PSET), addressed a major gap in PV monitoring: achieving a cost-effective and reliable real-time acquisition framework that can also serve as a foundation for future predictive modeling. This paper is especially relevant because it treats data acquisition itself as a serious engineering problem, not just a coding task. Its contribution strengthens the case for your project's use of continuous sensing, centralized visualization, and logged records, since those are exactly the building blocks required before any predictive or advanced maintenance layer can be added later.

Ganesh Asaram Bhatane, Vitthal Janardhan Gond, Sachin Vasant Chaudhari, and P. William, in "Real Time Performance Monitoring of Solar PV Panel IoT System for Energy Optimization," presented in the 2024 4th International Conference on Innovative Practices in Technology and Management (ICIPTM), emphasized real-time panel-level monitoring specifically for energy optimization. Even from the title and conference listing alone, the direction is clear: current IEEE work is not satisfied with raw measurement; it is trying to use live PV data to improve output efficiency. This paper fits your project closely because your proposed system also monitors voltage, current, temperature, and light intensity so that performance loss, abnormal operation, and maintenance needs can be identified early.

Parvathy Babu, Mudit Sharma, Mohd Talha Khan, and Sanjay Kumar Sahu, in "Solar Panel Maintenance Using IoT," presented at the 2024 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI), moved the discussion from monitoring toward maintenance-centered IoT usage. That is a strong development in the literature, because one of the biggest real-world issues in solar plants is not just reading parameters but using those readings to reduce downtime, detect degradation, and trigger timely service. This paper supports your project justification very well: once data is logged continuously, maintenance becomes faster, more objective, and less dependent on operator guesswork.

Marwah Qasim Al-Obaidi, Nabil Derbel, Wssan Adnan Hashim, and Hussein Alsheakh, in "Real Time PV Solar System Fault Detection for Serbasti Water Pumping System," presented at the 2024 21st International Multi-Conference on Systems, Signals & Devices (SSD), took a more advanced route by combining IoT data and deep-learning-based fault detection for photovoltaic systems. The abstract states that the method compares simulated PV behavior with real-time sensed data and successfully performs fault detection, characterization, and classification. This is a serious step up from ordinary monitoring systems. In your literature review, this paper is important because it proves that once a plant begins collecting structured real-time electrical data, the same data can later support intelligent fault analysis and faster troubleshooting.

Diganta Baruah, Ritocheta Roy, Raunak Ahmed, Senthilmurugan Subbiah, Sonali Chouhan, and Kumaresan Angappan, in "Contextual Approaches to Data-Driven Fault Detection in Solar Photovoltaic System," presented at the 2024 IEEE International Conference on Evolving and Adaptive Intelligent Systems (EAIS), highlighted a more refined idea: PV fault detection improves when machine-learning models use contextual information rather than relying only on raw electrical values. The surrounding literature visible on the paper page notes that this contextual direction improved generalization and classifier robustness. This matters because solar systems do not operate in fixed laboratory conditions; they change with irradiance, temperature, time, and environment. So this paper shows that future solar monitoring systems will increasingly need context-aware intelligence, not only raw signal capture.

Another notable 2024 IEEE direction appears in the paper by Raluca Nelega, Gergo Kovacs, Alexandru Oprea, Romulus Valeriu Flaviu Turcu, and Emanuel Puschita, titled "Real-Time Monitoring System of Photovoltaic Power Plant Using UAV Thermal Images," presented at IEEE SmartGridComm 2024. This work expands solar monitoring beyond electrical sensors and introduces UAV-based thermal inspection for plant-level supervision. It shows that current research is broadening from conventional current-voltage sensing to image-based health assessment of large PV installations. Even though your project is simpler and based on Arduino, sensors, relay control, and LabVIEW, this paper helps you show that the field is evolving toward richer monitoring layers, while your proposed model remains a low-cost foundational approach suitable for smaller plants and educational deployments..

III. METHODOLOGY

The methodology of this project is based on designing a smart system that can monitor, control, and log the important parameters of a solar power plant using Arduino and NI LabVIEW software. The system is developed to reduce manual effort, improve reading accuracy, and provide safe and efficient plant operation. It works by collecting real-time data from different sensors, processing it through the Arduino controller, and displaying the data on a LabVIEW-based monitoring dashboard. At the same time, the system stores the measured values for future analysis and uses relay control for switching operations.

In the first stage, the required hardware components are selected and connected properly. These include the light intensity sensor, temperature sensor, voltage sensor, current sensor, 12V battery, relay module, LED/Buzzer, Arduino board, and PC with NI LabVIEW software. Each sensor is used to measure a specific parameter of the solar system. The light intensity sensor detects the amount of sunlight falling on the panel, the temperature sensor measures operating temperature, the voltage sensor checks output voltage, and the current sensor measures load or charging current. These parameters are necessary to understand the performance and health of the solar setup.

In the second stage, the Arduino acts as the main controller of the system. It continuously reads sensor values through its input pins, converts the analog signals into digital values, and prepares the data for monitoring. Arduino also controls the relay unit for switching between solar supply and battery supply whenever required. The LED and buzzer are used as status indicators and alert devices, especially when any parameter crosses the normal range or abnormal conditions occur.

In the third stage, the Arduino is interfaced with NI LabVIEW software installed on a PC. LabVIEW is used to create a graphical user interface dashboard where the user can see all important parameters in real time. This dashboard helps the operator monitor the plant easily without manually checking each value from the hardware setup. The system can display values such as voltage, current, temperature, and light intensity in a simple and understandable format. This improves operational convenience and reduces human errors during observation.

In the fourth stage, the system performs data logging. The measured sensor values are stored continuously in an Excel file through LabVIEW. This recorded data is useful for performance analysis, fault tracking, maintenance planning, and comparison of system behavior over time. Data logging also makes it easier to identify any unusual variation in the solar plant and supports better decision-making for maintenance activities.

In the final stage, the complete system is tested under different conditions to verify its operation. The readings from all sensors are checked, the relay switching is observed, and the dashboard output is validated. The alert functions using LED and buzzer are also tested. Based on the test results, the system confirms whether the proposed model is suitable for real-time solar plant monitoring and control.

Overall, the methodology follows a practical flow of sensing, processing, monitoring, control, and data logging. This approach makes the system smart, economical, and effective for solar power plant automation.

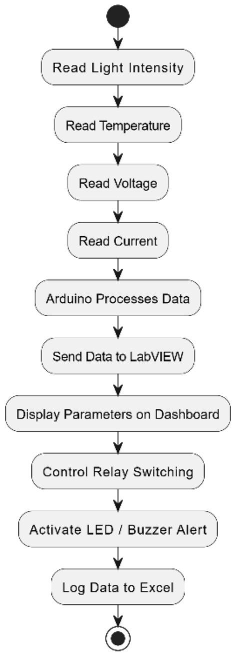

Fig 1 : Flow Diagram

IV. Result & Discussion

The developed IoT-based Solar Power Plant Monitoring and Control System using Arduino and NI LabVIEW was tested successfully for real-time monitoring, parameter display, relay-based control, and data logging. The system was able to sense and display the important solar plant parameters such as light intensity, temperature, voltage, and current continuously on the LabVIEW dashboard. The measured values were updated in real time, which helped in observing the system condition without the need for manual checking at the site.

During testing, the light intensity sensor responded properly to changes in surrounding light conditions and provided useful information about solar input availability. The temperature sensor measured the operating temperature of the setup and helped indicate thermal variation in the system. The voltage and current sensors successfully monitored electrical output conditions, which are essential for checking plant performance and battery charging status. These values were displayed clearly on the LabVIEW interface, making the system easy to understand and operate.

The relay module performed switching operations correctly based on system conditions, showing that the proposed setup can support automation in solar applications. The LED and buzzer indications also worked properly during alert and status conditions, which improves system safety and gives quick warning to the operator. Another important outcome was the data logging feature, where all major readings were recorded in Excel format through LabVIEW. This makes the system useful not only for real-time observation but also for future analysis, maintenance planning, and performance tracking.

The overall result shows that the proposed system reduces dependency on manual observation and improves monitoring accuracy. It also reduces the possibility of human error in reading and recording plant parameters. Since all major values are available in one dashboard and stored automatically, the maintenance process becomes easier and faster. The project therefore proves that a low-cost combination of Arduino, sensors, relay control, and LabVIEW can provide an effective monitoring and control solution for small and medium solar power setups.

At the same time, the system has some practical limitations. The project is mainly suitable for prototype-level or small-scale implementation. Its accuracy depends on the quality and calibration of sensors. Also, the system is dependent on continuous hardware functioning and PC connectivity for LabVIEW monitoring. Even with these limits, the project achieves its main objective well and demonstrates a strong base for future smart solar automation systems.

Sr. No.	Parameter / Function	Expected Result	Observed Result	Status
1	Light Intensity Monitoring	Real-time sunlight detection	Light values changed correctly with light variation	Successful
2	Temperature Monitoring	Continuous temperature measurement	Temperature shown properly on dashboard	Successful
3	Voltage Monitoring	Accurate voltage display	Voltage values displayed in real time	Successful
4	Current Monitoring	Continuous current measurement	Current values monitored properly	Successful
5	LabVIEW Dashboard	Live display of all parameters	Dashboard showed all sensor values clearly	Successful
6	Relay Control	Automatic switching operation	Relay responded correctly during testing	Successful
7	LED/Buzzer Alert	Warning/status indication	Alert indication worked properly	Successful
8	Data Logging	Store readings in Excel file	Sensor data logged successfully	Successful

Table 1 : Result Table

Discussion

The discussion of the project results indicates that automation can significantly improve the operation of solar power systems. In the conventional method, an operator must remain present to monitor readings and manage switching manually. In the proposed model, these tasks are simplified through sensors, controller-based processing, and software monitoring. This reduces human workload and improves the speed of observation and decision-making.

The project also shows the importance of combining hardware monitoring with software visualization. Arduino alone can collect sensor values, but when integrated with LabVIEW, the system becomes much more practical and user-friendly. The dashboard allows users to interpret plant conditions quickly, while the logging feature creates a useful operational record. This is especially important for maintenance and performance evaluation.

V. CONCLUSION

The proposed IoT-based Solar Power Plant Monitoring and Control System using Arduino and NI LabVIEW achieves the main objective of improving solar plant monitoring through automation, real-time sensing, and data logging. The system is able to measure key parameters such as light intensity, temperature, voltage, and current, and display them continuously on a monitoring interface. It also supports relay-based control and alert indication, which reduces manual effort and improves operational safety.

From the implementation and study of recent literature, it is clear that modern solar monitoring systems are moving toward real-time IoT monitoring, low-cost sensing, remote supervision, predictive maintenance, and fault detection. Recent papers after 2022 also show strong research interest in PV monitoring, data-driven fault diagnosis, and smart maintenance, which supports the relevance of this project.

This project is especially suitable for small-scale solar installations, academic demonstration, and prototype-level automation systems where affordability, simplicity, and usability are important. Although it is not as advanced as full industrial SCADA or AI-heavy smart-grid solutions, it provides a strong practical foundation

In short, the project is successful, meaningful, and technically justified. It reduces human dependency, improves observation accuracy, supports maintenance through logged records, and demonstrates how IoT and automation can strengthen renewable energy systems.

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