

## A Feature Extraction of Photovoltaic Solar Panel monitoring system based on Internet of Things (IoT)

J. Saranya<sup>1,\*</sup>, and V. Divya<sup>2</sup>

<sup>1</sup>Department of Computer Science, School of Computing Science, VISTAS, & Department of Computer Applications, C.T.T.E College for Women, Chennai, India

<sup>2</sup>Department of Information Technology, School of Computing Science, VISTAS, Chennai, India

### Abstract

**INTRODUCTION:** The Internet of Things (IoT) is a modern technology that improves user experience and gives items more intelligence. A large number of applications have already embraced the IoT. Our lives were made significantly easier and more accessible by the development of the IoT. In this research a photovoltaic solar panel system has been monitored using IoT.

**OBJECTIVES:** The feature extraction of a photovoltaic solar panel monitoring system based on the IoT working process is provided in this work. The implementation of maximum power point tracking (MPPT) algorithm also covered, along with a brief description of the pre-processing method, datasets and the PV system features are extracted.

**METHODS:** The model develops a thorough grasp to increase the voltage and current efficiency, a maximum power point tracking technique (MPPT) is implemented in this research study.

**RESULTS:** A safer solar panel monitoring system displays the result in LCD display screen it shows various readings, including the IP address, voltage and current rating, light intensity, temperature, and fault occur on the system receive warning message.

**CONCLUSION:** The proposed solar panel monitoring system demonstrates high level voltage and current accuracy when compared to the existing method.

**Keywords:** Internet of Things, Liquid Crystal Display, Photovoltaic solar panel, Maximum Power Point Tracking

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\*Corresponding author. Email: [saran.vel1987@gmail.com](mailto:saran.vel1987@gmail.com)

### 1. Introduction

"IoT" technology has the potential to significantly improve the management, monitoring, and upkeep of solar photovoltaic power facilities. The cost of renewable energy technology is falling due to technological breakthroughs on a global scale. This promotes the development of substantial Solar photovoltaic installations. The majority of solar PV systems are placed in remote locations, making remote monitoring hard. Improved strategies for remotely automated Plant monitoring using web-based interfaces are required. This article explains how to remotely assess the operation of a solar photovoltaic system utilizing the latest IoT technology.

This will make real-time monitoring, problem detection, facility history analysis, and preventative maintenance much easier. Solar energy is among the most alluring renewable energy sources for electrification. PV systems must be installed in order to transform solar energy's light energy into usable direct power. Anywhere there is enough energy potential, PV systems can be placed.

The biggest problem with PV systems is determining their performance because it changes based on several aspects and the operation of system components. In order to evaluate its performance, it needs a real-time surveillance system. This study provides an overview of IoT applications for real-time surveillance and management of PV system performance [1]. For maximum force yield, the sun-based force plants should be examined. In addition to checking for broken sunlight-

based boards, connections, and residue built up on boards that limit yield and other issues hurting sun-oriented execution, this restores enough force yield from power plants.

Therefore, in that research, we present a computerized Internet of Things-based solar force checking framework that takes robotic solar force observation from anywhere on the internet into account. The properties of the sun-oriented board are filtered using an ATmega controller-based design. Our system continuously tracks the sun-facing board and uses the internet to send the force yield to the IoT system [2].

The IoT makes it possible to remotely sense and manage objects using current network infrastructure [3]. While minimizing human involvement, this pure incorporation of the real world into computer-based systems promotes efficiency, accuracy and economic gain. A few users for this technology include solar streetlights, smart villages, micro grids and solar cities.

## 2. Literature Survey

In [4], the authors designed A low-cost monitoring system for solar panels that is being created for online visualization and performance enhancement. This helps track the location of defects and facilitates preventive maintenance. A suggested and constructed IoT-based cloud monitoring solution for remote PV facilities uses the Raspberry Pi. Using the LABVIEW tool for real-time surveillance, the fundamental characteristics of a PV system are examined in order to study problem identification in PV plants.

In [5], the authors monitored the generation of power and current/voltage from renewable energy sources. Solar panel monitoring is feasible. To be able to improve the effectiveness of the solar panel, this paper also covers changing the pitch angle. A network system that consists of an Arduino, an Atmega328 IC, and a Node MCU monitors solar modules. By performing the suggested work at a PV power plant, you could set up a solar tracking system. Simpler. Keeping track of power production can also help PV systems function more efficiently overall.

In [6], the authors described an IoT solution for measuring solar energy in real-time. It seeks an open-source Internet of Things solution that can collect data in real-time and continuously track the efficiency of solar panels and the surroundings in which they are placed. The Solar Power Monitoring System's main goal is to provide a data collection system that seems to produce remote energy yields with data.

In [7], the authors designed to use solar trackers more effectively, a smart monitoring system built on a microcontroller and Lab view is developed.

In [8], the authors designed The A cheap solar panel monitoring system is being made using IoT. With enhanced performance and web-based visualization. Maintenance and fault-finding are aided by this centred on the implementation

of creative, commercially viable Internet of Things-based technologies for remotely monitoring the operation of a solar PV facility. As a result, real-time monitoring, defect identification, historical plant analysis, and preventive maintenance will all be made simpler.

In [9] the authors demonstrate an affordable smart multi-sensor architecture featuring voltage, current, irradiance, temperature, and inertial sensors for keeping track of panel-level conditions PV systems to find the causes of efficiency loss. Each PV panel is connected to a sensor node because Wireless sensor networks are the system's foundation.

In [10] the authors implemented A decentralized PV plant is being continuously monitored in the cloud using the cutting-edge data collection and transmission technology known as System for Monitoring natural Energy We launched a series of system projects as technology developed to reach this most recent design.

In [11] the authors focused on efficient, precise, reliable, complicated, and effective ways for controlling dirt formation on solar panels. Overall, the solar panel's output power was enhanced by using integrated smart systems, real-time monitoring, and cleaning. Customers can use it to remotely manage operations and keep an eye on the solar panels' health in real time. An important constraint of In order to enable for future broadening of theoretical conclusions, this research is the incomplete empirical examination of modern smart systems.

In [12] the authors described a method for monitoring and controlling solar power consumption that is IoT-based and gives users control over their EV batteries and power supply. Due to the fact that solar farms are frequently situated in difficult-to-access regions, this technique enables users to virtually manage their systems from a distance.

According to the literature review mentioned above, solar systems are currently the most sought-after products in India for both homes and businesses. You might be shocked to find that utilizing the sun to create power is not a novel idea. People have been fascinated about this kind of energy since scientists discovered materials that can create electrical current just by being exposed to light. With the summary provided in this research, get ready to explore the fascinating and ever- changing world of solar power. These early PV pioneers paved the way for the present PV industry. Outside of space programs, the initial generation of PV cells was in efficient and unpopular. In this research, an attempt has been made to extract the features of PV panel pertaining to measure voltage, current, temperature and time.

## 3. Data set

In many cases, the essential dataset is assessed using an IoT based solar panel monitoring system. The analysis of

explanatory data usually uses this statistical technique. It is clear that the values of several factors are distorted, which defies conventional wisdom. We used a novel method for data pre-processing; the dataset was first renamed to include the MPPT method.

This is because modern solar panels are among the most profitable and effective sources of renewable energy today. In order to represent real-time voltage and current monitoring, the dataset is renamed. In order to harness solar energy, three main technologies are used: PV, which directly transform light into electricity; solar heating and cooling systems, which gather thermal energy and utilize it to heat or cool water and the environment; both indirect solar power and direct solar power, which employ solar thermal energy to power substantial electric turbines. The performance and monitoring of solar energy plants can be greatly improved by the deployment of IoT.

It is a method for keeping track of how much dust has gathered on solar panels so that the maximum useful amount of electricity can be produced. The amount of radiation that strikes the solar cell determines how much power is produced by solar panels. The central controller, which keeps an eye on the panels and loads and is connected to them, has all of the sensors neatly plugged into it. Now, the user can see the voltage, current, and sunlight.

Solar Power Generation dataset were collected

- Monitoring panel (Date & Time)
- User Details (User login id)
- Device Details (Device id)
- Device status (Active/Inactive)]
- Device output (Device voltage, Device current)
- Irradiation (Irradiation level)
- Ambient Temp (Temperature level)
- Weather Generation

The My SQL database, which the website uses to store data, is another interesting element. The four tables are the Users table, the Raspberry Pi table, the PV Station table, and the PV Array table. The user1\_id, pvarray1\_id, and device1\_uid are used as foreign keys, with station1\_id serving as the PV Station table's main key. GPS coordinates are also included in the table. All signals from a PV array, including current, voltage, power, temperature, and other data, are stored using the primary key, pvarray1\_id. For the Raspberry Pi, the table's primary key is Device1\_uid. The Raspberry Pi 3's IP address, CPU temperature, available disc space, and other information are all tracked by this programme. In the Users database, the user's apii\_key, avatar, phone number, username, iss\_active, email address, and roles are all listed. The table's primary key is user1\_id. The certification markings apii\_key and apii\_token are used to upload data, and the iss\_active status indicator indicates whether a system is active or inactive in order to demonstrate its status.

## 4. Pre-processing techniques

As dust builds up on the solar panel, the key objective is to improve its power output. Additionally, it tells if the battery or solar panel is linked to the load and displays the solar panel's last defect. If the required conditions are satisfied, the system detects a user or administrator, alerts them, and presents them in the GUI. To track the sun, solar panels are used. Voltage, current, and temperature are just a few of the metrics that IoT technologies are employed to present here on the LCD. This guide provides instructions on how to construct a Node MCU-based, low-cost solar panel monitoring system. This technique can be used to figure out the voltage and light output of PV arrays. Solar module monitoring was carried out. The block diagram for the monitoring system for photovoltaic solar panels is shown in Figure 1. The system, which consisted of a microcontroller, sensors, and software, was used to get these results. Operating the code that uses the present sensor is much easier.

The IP address, voltage rating, light intensity, and fault occurring on the system get warning message may all be found on the LCD display screen where we can view our data.

- Data Cleaning (E.g. missing data, Noisy data, duplicate data)
- Data Integration (the joining of several databases and files)
- Data transformation (aggregation and normalization)
- Data reduction (e.g., data compression, dimension reduction).

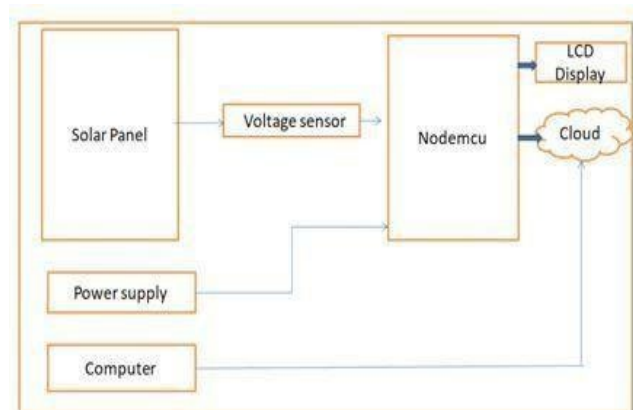


Figure 1. Photovoltaic solar panel monitoring system

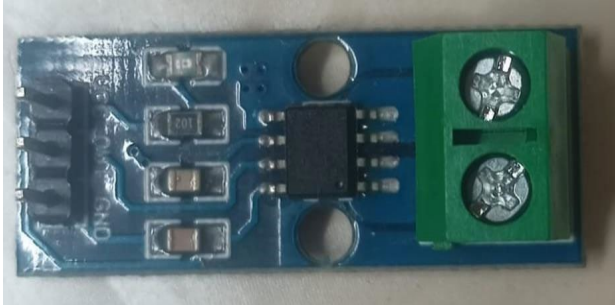
## 5. Feature Extraction

Many features are designed to be implemented in the feature extraction section, which produce power, voltage, current, temperature, time, device specification, device status, and user details. All data is kept in the cloud as well as in the SQL database.

### 5.1 PV Power

PV devices, often known as solar panels, are used in the process of converting solar light energy into power (or current). Solar panels are constructed from a variety of solar

cells, which are layers of silicon, phosphorous, and boron. These solar cells gather photons from the sun, mix them with nearby electrons, and create energy that may be used for a variety of purposes. PV Power varies depending on the option. Figure.2 demonstrates the current sensor circuit.



**Figure 2.** Current Sensor Circuit

### 5.2 PV Voltage

To measure voltage, use a PV Voltage Sensor. Different electrical or optical signals may be recognized or categorized by a device known as a voltage sensor. Using this sensor, the quantity of voltage that is obtained in an object is calculated and measured. Figure.3 shown below the voltage sensor circuit, its major applications involve detecting and measuring AC or DC voltage levels. Switches, analogue voltage signals, current signals, and other output options are available for this sensor, which takes voltage as an input.



**Figure 3.** Voltage sensor Circuit

### 5.3 PV Time

PV The number of compounding or discounting periods is represented by the number of times the present value at the start of the time period was represented by time. It could stand in for a certain number of years, months, days, or other predefined time periods.

### 5.4 PV Temperature

The temperature sensors are used to forecast and monitor PV (solar energy) storage. The energy storage modifies itself

according to the temperature value. Show a gauge that depicts the website's temperature information.

### 5.5 Device Specification

Using a My SQL database, the system displays all data in the form of a table that includes information about date and time.

- The current in amps
- volts of voltage
- Temperature
- Time

### 5.6 Device Status

The working concept of this system is uncomplicated and easy to implement because all of the components are connected to the controller, allowing us to display or trigger an alarm to verify if the system is active or inactive. If not in use, we can determine what is causing the issue and fix it right away.

### 5.7 User Details

Time to time user login details has been collected with the below specified details.

- username
- mail ID
- phone number
- Login Time
- Logout Time

## 6. Implementation of maximum power point tracking

This phrase describes the MPPT strategy applied by PV inverters. MPPT is a PV inverter algorithm that keeps under a range of conditions, such as fluctuating solar irradiation, temperature, and load, the PV system should operate at or near the peak power point of the PV panel. To increase the amount of electricity generated by PV systems, solar inverter manufacturers use MPPT algorithms. The power voltage curve is depicted here to demonstrate how the system should function at its "maximum power point" (or peak voltage). Voltage control is the responsibility of the algorithms. When designing PV system controllers, MPPT algorithms are frequently used. The algorithms ensure that the PV system consistently produces the most electricity possible by taking into account changing irradiance (sunlight) and temperature. Figure.4 demonstrates the PV module with MPPT current and voltage from minimum to maximum levels. It's shown in the below Figure. 4.

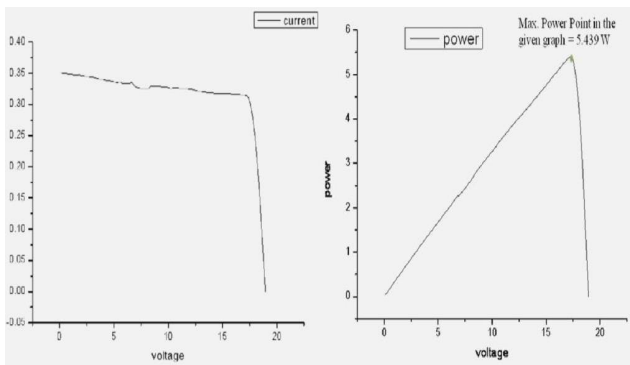


Figure 4. PV module with MPPT

### 6.1 Perturbation and observation (P & O)

To maximize power output, this algorithm modifies the operational voltage. Although, there are other better and more advanced alternatives to this surgery. Since a solar panel's MPP fluctuates with temperature and irradiance, MPPT algorithms are essential in PV applications. A solar arrays output must be increased as a result. The two most popular algorithms are P & O and Inc. Con because they are straightforward to design. The P-V curve often has a single maximum point; therefore, this is not particularly significant. In contrast, when the PV array is partially shaded, these curves show a lot of maxima. Figure.5 illustrated the perturbation and observation level.

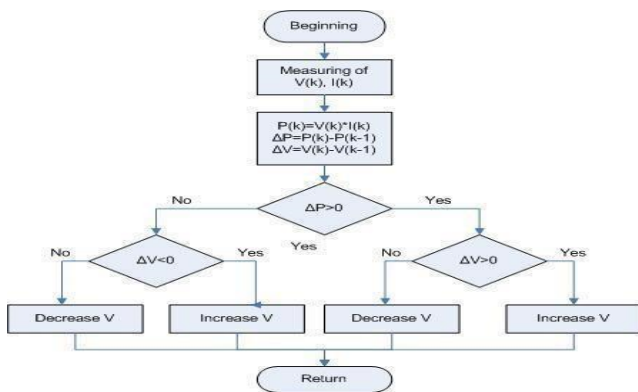


Figure 5. Basic P & O MPPT flow chart

### 7. Result Analysis

Two of the sensors that receive the output from the solar panel are voltage sensors and light intensity sensors. These sensors receive a digital or analogue signal from the solar panel and transmit it to the microcontroller or CPU. We may easily obtain digital signals from our microcontroller in our digital devices with the help of the integrated Our microcontroller contains a Wi-Fi module. We can also view the data or parameters on our LCD monitor, Smartphone, or PC. This

article explains how to use a Node MCU to create a cheap, real-time tracking system for solar panels. The output (voltage and light intensity) of a PV array can be calculated using this system. The monitoring of solar modules was done. The system, which consisted of a microcontroller, sensors, and software, was used to get these results. The code that makes use of the current sensor is much simpler to operate. The LCD display screen shows our readings, including the IP address, voltage rating, light intensity, temperature, solar irradiance, and fault occur on the system receive warning message.

### 8. Conclusion

The usage of IoT for solar power plant monitoring and control is a crucial step as energy derived from natural sources are gradually included into utility systems. Therefore, as a result of automation and intellectualization of solar power plant management, decision-making for the construction of large-scale solar power projects and the grid integration of those facilities will be improved in the future. By leveraging current, low- power wireless modules, IoT-based remote monitoring that improved the system's energy efficiency.

Using the internet to remotely regulate solar panels would reduce the need for human interaction with these kinds of systems and enable comfortable plant monitoring. Additionally, solar tracking was improved the plant's energy effectiveness.

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