

# IoT BASED SOLAR PERFORMANCE MONITORING SYSTEM

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**Abstract** --This paper aims to develop an IoT-based solar energy measurement system using multiple sensors to measure solar cell parameters like voltage, current, and temperature. The data, along with time and date, will be uploaded to the Thingspeak website. Solar energy is captured and stored in a rechargeable battery, which powers LEDs. Current and temperature sensors measure solar panel current and voltage, respectively. A microcontroller, Arduino Nano, controls the system, which inputs these parameters and uploads them to the Thingspeak webpage. The microcontroller loads an embedded "C" language program. Thingspeak is an open-source IoT application and API that uses HTTP protocol to store and retrieve data from objects over a local network or the Internet. The device monitors and updates data on an IoT platform, utilizing cutting-edge technology to expand monitoring methods and detect solar energy efficiency. This project aims to provide effective solar systems services by detecting solar energy efficiency.

**Keywords**— Internet of Things (IoT), solar energy, Photovoltaic (PV) Monitoring, Real-time data, Wireless Communication, Sensors, ThingSpeak.

## I.INTRODUCTION

Modern life depends on access to electricity, which is used for home appliances, transportation systems, lighting, refrigeration, and heating. Photovoltaic effect, sometimes known as solar energy, turns light energy into electrical energy. Proposed is an IoT-based solar power monitoring system whereby solar cells in solar panels transform sunlight into electricity. Sensors track voltage and current parameters; their outputs show on an LCD screen. The Internet of Things and cloud server network let

objects be sensed, tracked, and controlled far away.

This system detects problems including damaged panels, loose connections, and dust accumulation, so ensuring efficient power generation and monitoring solar power plants for maximum power generating. Built on the Internet of Things, the automated solar power monitoring system allows for automatic monitoring from anywhere over the internet. Solar panel parameters are tracked using an ATmega controller-based system, which constantly monitors output and feeds data to an IoT device.

Solar power plants must be closely watched for damaged panels, connections, and dust accumulation that might compromise efficiency in order to maximize power generating. The system monitors weather using humidity and temperature sensors as well. This technology lessens the need for human involvement in solar power system management and guarantees best solar power generation.

[1]The digital hardware used in this method and the digital hardware of the power conditioning unit communicate with each other via the Bluetooth interface of an Android tablet or smart phone. The stored data may be arranged by the monitoring software's built-in visual interface to evaluate the daily, weekly, and monthly values of each measurement separately.

[2] A study by Verma, Kumar, and Chotlani suggests that IoT-based solar monitoring systems can remotely regulate and maintain photovoltaic systems. Data is transferred via a Wi-Fi module to a server, and the solar panel rotates to maximize energy production. Real-time data from voltage, LDR, and temperature sensors is used to control the system, with an Arduino Mega spinning the panel. The system

measures temperature and rotates with the LDR to maintain optimal performance.

[3] Neelanshi S. Palkar and Ashish Janwe2 studied a 20 W solar panel with multiple sensors, microcontroller, wi-fi module, OLED display, and memory card for data retrieval.

[4] Ankit Kekre and Suresh K. Gawre developed a solar monitoring system using a solar plant, voltage, current, and temperature sensors. The system uses MATLAB programming codes and a website for data visualization. It transmits data over mobile networks for logging and user inspection, and sends SMS alerts if readings deviate from typical ranges. The data is stored on a computer system for future reference.

[5] The authors of this paper keep an eye on the condition of solar PV systems to enhance performance and maintenance. Through remote monitoring capabilities, it is possible to predict when performance is likely to fail. Following an analysis of delayed delay behavior, the dynamics of the internet delay are described using a system recognition technique.

[6] The Internet of Things is a concept that imagines the physical world as an extension of the internet, complete with commonplace objects, according to K.G. Srinivasan et al. (2016). The Internet of Things (IoT) enables a seamless integration of the real world into computer-based systems, lowering the need for human involvement while increasing productivity, accuracy, and financial gain. There are several applications for this technology, such as microgrids, solar street lighting, smart villages, and solar cities, among others.

[6] The number of solar plants installed worldwide has increased dramatically in recent years, according to Mayuri Ejgar et al. (2017). The effective and timely maintenance of several components is essential to the overall performance and efficiency of solar plants, as well as to strings of solar panels, inverters, and transformers.

[7] Vishal S. Patil et al. (2019) proposed an Internet of Things-based solar power monitoring

system to alleviate the drawbacks of previous solar systems. A network of connected devices that exchange data is known as the Internet of Things (IoT). This solar power monitoring device makes use of an Arduino Uno. The Arduino Uno microcontroller board made use of the ATmega328p. The ATmega328p is another Atmel microcontroller chip.

[8] In 2019, Dr. Lavanya Dhanesh et al. proposed a way to use the Internet of Things for remote monitoring and analysis of photovoltaic panels. A photovoltaic panel is a device that converts light energy into electrical power. The recommended method for remote monitoring makes use of voltage and current data. Data is transferred between servers and solar panels via the Internet of Things. The voltage and current data are processed by the micro controller unit. The hosting server receives the measured data via wireless transmission. After converting the photovoltaic cell's light energy into electrical power, the voltage and current are measured by a sensor. In certain situations, real-time monitoring systems for photovoltaic power generation are essential and required.

#### Advantages:

**Real-time data acquisition:** Constantly monitors ambient conditions, panel efficiency, and energy output for quick insights.

**Remote monitoring:** Eliminate the requirement for on-site inspections by using web or mobile platforms to access system performance from any location.

**Automated reporting and alerts:** Provides immediate notifications of defects or performance dips, facilitating prompt action.

**Improved energy efficiency:** Utilizes data analytics to optimize power distribution, cleaning schedules, and panel orientations.

**Scalability:** Fits well with utility-scale, commercial, and residential solar arrays.

**Impact on the environment:** Optimizes the use of solar energy, resulting in a more sustainable and greener energy footprint.

#### Disadvantages:

One disadvantage of solar panels is their price. Large batteries are charged using solar electricity since solar-powered devices can be used at night.

Periodically, the batteries must be replaced.

Solar energy can be captured quickly.

### Applications of the project:

Residential Solar Systems

Solar Farms

Commercial Buildings

Agricultural Applications

Remote Locations

Educational Institutions

Government Buildings

## II. METHODOLOGY

After that, sensors such as voltage sensors can measure the voltage generated by solar panels using the voltage divider principle, and mathematical formulas can be used to calculate current. The intended structure of the proposed monitoring system is shown in Figure 1. Solar panels, a regulator power supply, an ESP8266 Wi-Fi module, voltage and current sensors, a liquid crystal display, and an Arduino Nano microcontroller make up the experimental setup for the system described. The Arduino IDE is used to create programming codes in embedded C.

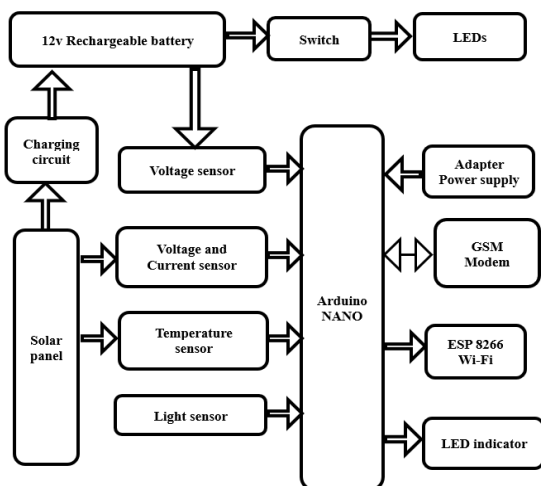


Fig 1: Block Diagram

To fulfill particular requirements, the Internet of Things collects data from multiple solar panels and disseminates it. Similar to cloud platforms,

IOT platforms might take the information that is helpful and discard the rest. This information can be used to spot mistakes and address issues before they become serious. Time and money can be saved by using data from connected sensors, such as voltage and current sensors, to make informed decisions in real time. Solar monitoring systems are powered by the inverters in our solar system. Businesses offer solar inverters with software setup for property monitoring. Home appliances use solar inverters to change DC current into AC current; Data about production and power level is recorded and transmitted to cloud-based monitoring systems and the accompanying apps. An LCD shows the measured voltage and current in the solar panel. The user has multiple ways to access the information through related mobile apps and smart home devices.

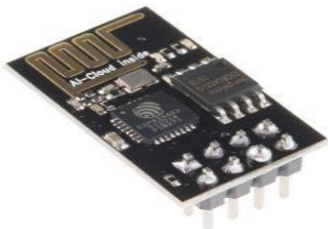
Consequently, maintenance expenses will decrease and the system's efficiency will increase. A network of ESP32 embedded systems forms the core of this system. The core of the IOT system in the suggested system is made up of the host network and embedded system. Using an ESP32 module and cloud computing, we linked solar panels to the Internet in this network. The suggested system uses the Internet of Things to track solar energy. An Arduino microcontroller is used to read the sensor data. A voltage detector A voltage divider is connected to the Arduino. The Arduino and ESP32 module are connected via a USB cable. The server module for the ESP32 is operational. The website displays the data from the Arduino via ESP32. This also covers the use of microcontrollers to process sensor data. Future grid integration and large-scale solar power facility decision-making will be enhanced by monitoring solar power plants. After the system has been accurately designed and simulated on the software, the online control system using IOT will be built.

## III. HARDWARE COMPONENTS

### (a) Arduino pro mini:

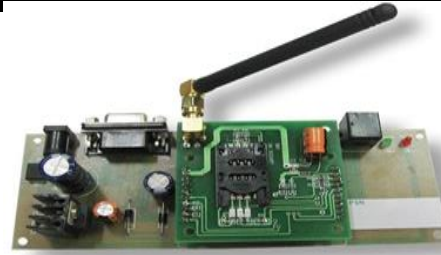
This is a 3.3V Arduino running the 8MHz bootloader. Arduino Pro Mini does not come with connectors populated so that you can solder in any connector or wire with any orientation you need. We recommend first time Arduino users start with the Uno R3. It's a great board that will get you up and running quickly. The Arduino Pro series is meant for users that understand the limitations of system voltage (3.3V), lack of connectors, and USB off board. This board connects directly to the FTDI Basic Breakout board and supports auto-reset. The Arduino Pro Mini also works with the FTDI cable but the FTDI cable does not bring out the DTR pin so the auto-reset feature will not work. There is a voltage regulator on board so it can accept voltage up to 12VDC. If you're supplying unregulated power to the board, be sure to connect to the "RAW" pin on not VCC.

#### (b) Wifi Module ESP8266



The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

#### (c) Global System for Mobile Communication (GSM):



A small and multipurpose communication tool, the SIM300 GSM module is made for wireless applications that need GSM connectivity. It was created by SIMCom and can send SMS, make voice calls, and establish GPRS data connections worldwide because it supports tri-band GSM/GPRS frequencies (900/1800/1900 MHz). It is perfect for embedded systems and Internet of Things projects because it uses AT commands to communicate with microcontrollers via a UART interface. The SIM300 is a popular component in home automation, security, and remote monitoring systems because of its low power consumption, support for SIM cards, and ability to work with external antennas.

#### (d) LCD:



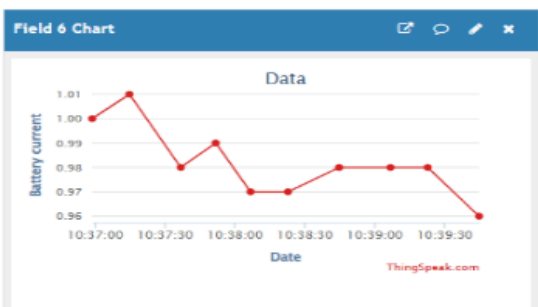
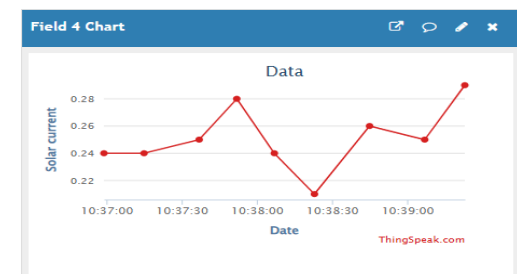
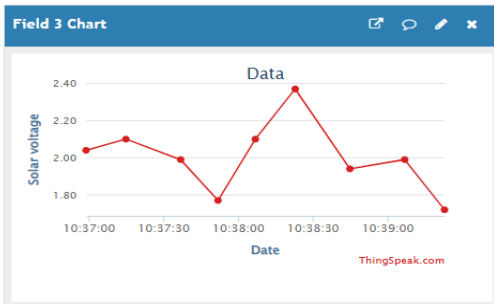
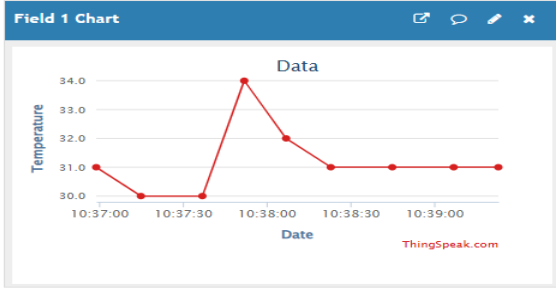
LCD technology is used in a wide range of products, including computer monitors, instrument panels, LCD televisions, airplane cockpit displays, and outdoor and interior signage. Small LCD screens are frequently found in portable consumer electronics such as digital cameras, watches, calculators, and cell phones, particularly smartphones. This also applies to LCD projectors.

#### (e) Voltage Sensor:

A voltage sensor is an electronic device that detects and measures voltage levels in electrical circuits. It helps monitor overvoltage and under voltage conditions, ensuring system stability and safety. Voltage sensors are commonly used in power systems, industrial automation, and



Graph of Current, Voltage and Temperature



### V. CONCLUSION

In conclusion, one practical method to raise the effectiveness and dependability of solar energy

systems is to employ IoT for solar power monitoring. Real-time data on solar panel performance, power consumption, and other important metrics can be gathered and analyzed by integrating different sensors and devices with cloud-based platforms. With this information, solar panel energy output can be maximized, possible malfunctions or failures can be anticipated, and maintenance expenses can be decreased.

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