IOT- Based Solar Power Monitoring

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Abstract—Rooftop solar panels are becoming more popular these days, but in order to know how effectively the solar photovoltaic system is working and for performance evaluation, there should be some monitoring system. As the world is moving towards renewable energy and nations like ICELAND have achieved 100% renewable energy status and India has also started to lean towards renewable energy, a growing number of people are using renewable energy sources. Some solar photovoltaic systems are inaccessible , making it impossible to monitor them, and the solar panels are not use to their full effectiveness towards the day. To achieve this, the solar panel was to observe the most sunlight possible at all times. Microcontroller and internet of things technologies are used in the system to monitor the solar photovoltaic system. The world now is turning towards renewable energy sources and countries like ICELAND have obtained 100% renewable energy status of india has also started to lean towards renewable energy.

Keywords: **Liquid Crystal Display [LCD], IOT[Internet of things], Solar**

1. INTRODUCTION:

One of the most fundamental demands in everyone's life in the modern world is access to electricity. Electricity is required for all household appliances, transit systems, lighting, refrigeration, and warmth. Daily energy use is rising quickly, but energy resources are also declining at the same time. Due to its availability and lower cost in terms of conversion technology, solar energy has become quite fashionable. In this technology, the photovoltaic effect—also known as solar energy—converts light energy into electrical energy.[1]

We can keep trac of this system's state and get alerts when an issue arises by keeping an eye on it, which is quite beneficial. An IoT-based solar power monitoring system is described in the suggested system. In this arrangement, solar cells found in solar panels transform sunlight into electricity. Sensors are used to measure the current and voltage parameters, and the results are shown on the LCD screen. With the use of the cloud server network and the internet of things, an object might be sensed, tracked, and managed remotely. With the aid of this technology, machines may talk to one another and be managed without the need of people. An IOT-based system for solar power monitoring keeps track of things like for maximum power generation, solar power plants need to be closely watched. This aids in obtaining power from power plants in an effective manner while keeping an eye out for damaged solar panels, loose connections, dust accumulation on panels reducing output, and other similar problems impacting solar performance. The automated solar power monitoring solution that we suggest here is based on the Internet of Things and enables automatic solar power monitoring from anywhere over the internet. To track the parameters of solar panels, we employ an ATmega controller-based system. Our technology continuously checks the solar panel's output and sends data through the internet to an IOT system.[4]

For maximum power generation, solar power plant need to be closely watched. This assists in recovering effective power output from power plants while checking for damaged solar panels, connections, and dust buildup on panels that could affect their efficiency. Output and other such issues affecting solar performance. Dark outside, when solar production is zero.

To develop a solar power monitoring system with use of sensors. By using humidity and temperature sensor monitor the weather condition.

[1]. The Bluetooth interface of an Android tablet or mobile phone serves as a communication channel for this method's digital hardware and the power conditioning unit's digital hardware to exchange data.The monitoring software's programmed visual interface may organise the saved data to assess the daily, weekly, and monthly values of each measurement independently.

[2]. Introduction to the infrastructure for real-time monitoring of a wind turbine-based renewable energy production system based on measurements of each source's current and voltage. After processing, the parameters are sent via USB to a personal computer (PC) so they can be kept in a database and used to immediately monitor the system. The monitoring software's coded visual interface can organise the saved data and manage the analysis of the daily, weekly, and monthly values of each measurement independently.

[3] According to yashihro Goto,an integrated system that maintainance and remotely monitors telecom power plant has been constructed and put into use. The system's features include better user interfaces that make use of information and communication technologies as well as the integration of management and remote

monitoring tasks into a single system.

[4]. In order to improve performance and maintenance, the authors in this paper monitor the health of solar PV systems. The knowledge of when performance is likely to fail is provided in advance through remote monitoring capabilities. After studying delayed delay behaviour, system recognition technique is applied to describe the dynamics of the internet delay.

[5]. The system proposed in this study centres on the DG agents, grid agents, and Mu agents. Distributed energy resources (DERs), load, storage, and grid agents are examples of DG agents. The Mu agent serves as the communication link between the lower-level DG agents and the control agent and other higher-level agents.

[6]. As part of the project, Abhishek Parikh et al. (2015) provided continuous condition monitoring and defect detection to guarantee the stable power delivery of solar panels in remote areas.Engineering professionals involved in the maintenance of solar panels have identified this research challenge. The Voltage Sensor, Current Sensor are presented as the proposed solution to this wireless sensor node.

[7]. According to K.G. Srinivasan et al. (2016), the Internet of Things is a concept that envisions the real world as an extension of the internet, complete with ordinary objects. A pure integration of the physical world into computer-based systems is made possible by the Internet of Things (IoT), which also reduces the need for human intervention while improving efficiency, accuracy, and economic benefit. Numerous uses for this technology exist, including solar cities, smart villages, microgrids, solar street lights, and others.

[8] R.Vignesh et al. (2016) shown that IoT advances the work faster and more intelligently while implementing sophisticated growth technologies. Every solar photovoltaic cell in a solar panel needs to be monitored in order to know its current condition. This monitoring is also necessary for identifying any solar cell defects and putting correction measures into place so that the solar panel may continue to function properly.

[9]] According to Mayuri Ejgar et al. (2017), the installation of solar plants has been rapidly rising over the past few years all over the world. Strings of solar panels, inverters, and transformers, as well as the overall efficiency and performance of solar plants, depend on the efficient and prompt maintenance of various components.

[10] Using the Internet of Things, Manish Katyarmal et al. (2018) provided a presentation. Technology for monitoring solar energy production has the potential to significantly improve the plant's operation, monitoring, and maintenance. The global cost of renewable energy equipment is decreasing due to technological improvement, which encourages the construction of massive solar power plants.

[11]. A method for remote monitoring and analysis of photovoltaic panels utilising the Internet of Things was put forth by Dr. Lavanya Dhanesh et al. in 2019. A device that transforms light energy into electricity is a photovoltaic panel. The suggested solution uses current and voltage measurements for remote monitoring. The Internet of Things is used to transmit data between servers and photovoltaic panels. The micro controller unit processes the current and voltage data. The measured data are wirelessly transmitted to the hosting server. The light energy from the photovoltaic cell is first transformed into electrical power. then using a sensor, measuring the voltage and current. Real-time monitoring systems in photovoltaic power generation are crucial and necessary in specific circumstances.

[12]. Shailesh Sarswat et al.'s system architecture for real-time monitoring of Solar Photovoltaic System (SPV) parameters with Internet of Things (IoT) technology was presented in 2019. For this, a comprehensive mobile application for real-time monitoring of the PV panel output Voltage, Current, and Power is developed on the Android platform.

[13].To address the shortcomings of earlier solar systems, Vishal S. Patil et al. (2019) suggested a solar power monitoring system that uses the Internet of Things. An Internet of Things (IoT) is a network of linked gadgets that communicates use information. The Arduino Uno is employed in this solar power monitoring system. The ATmega328p was utilised on the Arduino Uno microcontroller board. Another microcontroller chip created by Atmel is the ATmega328p.

[14]. In order to improve the operation, monitoring, performance, and maintenance of solar power plants, Vidyalakshmi et al. (2020) advocated using the internet of things. The approach for the remedy must keep an eye on the amount of dust on the solar panels to determine their maximum output. The solar panel's output power is always based on the radiation that the solar cell detects. It uses IoT technology to monitor the load on the panels, sending data from the appliances and panels to the cloud over the internet for analysis.

[15] The renewable energy sources that V. Kavitha et al. (2019) suggested have been shown to be trustworthy and are widely regarded as the greatest option for meeting our rising energy needs. Additionally, a PV system's operational reliability is increased while maintaining a low system cost by using a wireless monitoring system.

Adavantages:

Solar monitoring systems may resist changing weather.

Stable power quality that is poor.

Hardware and software customization.

Makes renewable energy use more efficient possible.

Disadvantages:

The cost of solar panels is a drawback.

Due to the fact that solar-powered equipment can be utilised at night, solar electricity is used to charge batteries, which are enormous in size.

The batteries need to be changed now and then.

In a short time, solar energy can be captured.

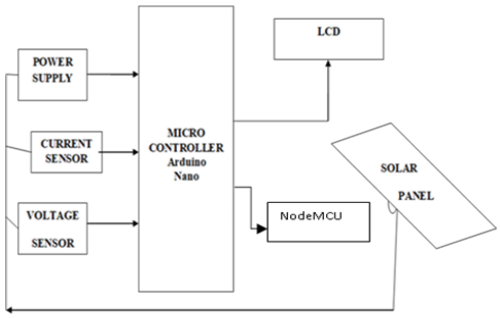
Applications:

Universities and Colleges

Commercial uses

2. METHODOLOGY:

Following that, the electrical by applying the voltage divider principle, sensors like voltage sensors can measure the voltage produced by solar panels, and current may be calculated using mathematical formulas. Figure 1 depicts the suggested monitoring system's intended structure. The described system's experimental setup comprises of solar panels, a regulator power supply, an ESP8266 Wi-Fi module, voltage and current sensors, a liquid crystal display, and an Arduino Nano microcontroller. Embedded C is used to develop programming codes using the Arduino IDE.



Block Diagram in Fig

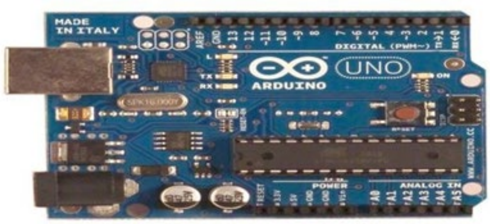
The Internet of Things gathers information from various solar panels and distributes it to meet specific needs. IOT platforms, like cloud platforms, may take the information that is useful and discard the rest. By using this data, it is possible to identify errors and mitigate problems before they arise. It is possible to make correct decisions based on real-time information using data from connected sensors like voltage and current sensors, which saves time and money. Our solar system's inverters are how solar monitoring systems function. Solar inverters with setup for property monitoring software are offered by businesses. Solar inverters are used in home appliances to convert DC current into AC current; data regarding power level and production is captured and sent tosystems for monitoring in the cloud and the apps that go with them. The value of the voltage and current measured in the solar panel is displayed on an LCD. Through associated smart home devices and mobile apps, the user can access the information in a variety of ways.

As a result, the system's efficiency will rise and maintenance costs will drop. The fundamental component of this system is a network of ESP32 embedded systems. The host network and embedded system form the IOT system's core in the proposed system. In this network, we connected solar panels to the Internet using cloud computing by using an ESP32 module. The proposed system makes use of IoT to monitor solar energy. To read the sensor information, a microcontroller called Arduino is used. voltage sensor The Arduino is coupled with and a voltage divider. Through a USB cable, Arduino is linked to the ESP32 module. The ESP32 server module is in operation. Through ESP32, the data from the Arduino is shown on the website. This also includes the processing of data obtained from the sensors using microcontrollers. Monitoring solar power plants will improve future grid integration and decision-making for large-scale solar power facilities. The online control system employing IOT will be constructed once the system has been properly created and simulated on the software.

3. Hardware Components

a. Uno Arduino

High functionality combined with comfort and simplicity is what the Arduino UNO is designed to do. The Arduino UNO serves as a connection point for the Internet of Things (IoT) and solar panels. It operates on a 5 volt direct current supply.



b. Wifi Module ESP8266

Express if System created the ESP8266, a system on chip (SoC) module with Wi-Fi capabilities. It is mostly utilised for the creation of embedded IoT applications. It is utilised to interface the cloud server with the microcontroller. The ESP32 module is a line of inexpensive, low-power system on a chip microcontroller with built-in dual-mode Bluetooth and Wi-Fi. It is comprehensive.

c. LCD

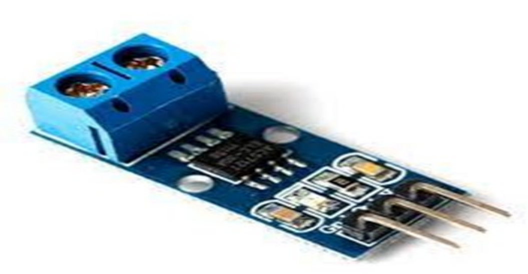
Many different products, such as LCD televisions, computer monitors, instrument panels, cockpit displays for aeroplanes, and interior and outdoor signs, utilise LCD technology. Portable consumer electronics like digital cameras, watches, calculators, and mobile phones, especially smartphones, often have small LCD screens. This is also true with LCD projectors.

d. Power Supply Unit

A step down transformer (230/15V), a rectifier, a filter, and a voltage regulator make up the device.The rectifier turns the AC into DC after the transformer lowers down the voltage from 230V to 15V. The filter circuit, which includes a bypass capacitor, removes the undesired ripples in the DC voltage. Finally, a voltage regulator is employed to keep the voltage supplied to the Arduino within the range of +12 to -12.

e. Sensor for Current

current ACS 712 The current is measured using a sensor with a 20A range. Infineon's current sensors are used to detect both AC and/or DC currents, and they offer precise and reliable current measurement up to 120 A or 31 mT, respectively. One or both of the integrated current rails in our magnetic current sensors arewhen the current is low, or the magnetic field of an external current rail when the current is medium to high. Products including traction inverters, industrial drives, solar inverters, and EV charging systems are intended for usage in 48 V as well as high voltage and/or broad bandgap applications.



f. Power Sensor

The voltage supply is monitored, computed, and determined using this sensor. The AC or DC voltage level can be determined by this sensor. This sensor's input can take the form of voltage, while its output can take the form of switches, analogue voltage signals, current signals, audio signals, etc. Other sensors can produce outputs like AM (Amplitude Modulation), PWM (Pulse Width Modulation), or FM (Frequency). Some sensors produce sine waveforms or pulse waveforms as their outputs. The voltage divider may affect how these sensors measure.

g. PV solar panel

A solar panel is a device that uses photovoltaic (PV) cells to transform sunlight into electricity. Materials used to create PV cells produce electrons when exposed to light. Direct current (DC) electricity is created when electrons go through a circuit; this electricity can be used to power a variety of devices or stored in batteries. PV modules, solar electric panels, and solar cell panels are further names for solar panels.

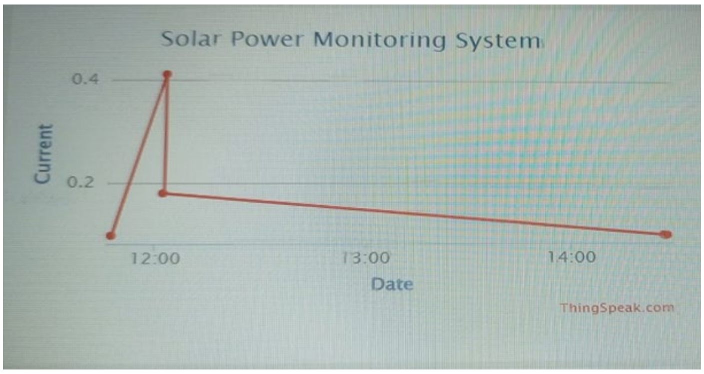
4. Results and Discussion

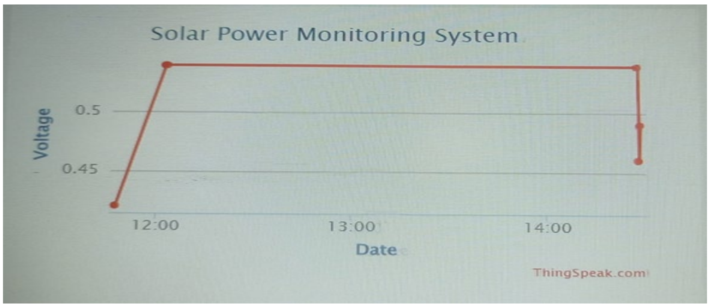
The parameters of the solar panel, as well as the voltage, current, and power, are displayed in real time using the LCD. In this project, a solar power monitoring system based on the Internet of Things is created to get the solar panels' maximum output power. With the aid of IoT technology, the received voltage and current are displayed on the LCD screen. We can examine the readings on our mobile device by connecting to the WiFi Network because the sensors are wired with a Wi-Fi module.

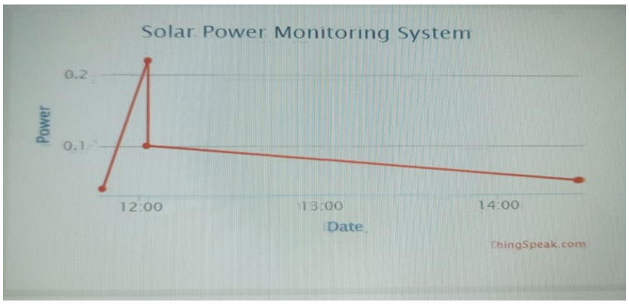
The outcome is presented as a table that includes the details, including the units, date, and time.

SL.NO	DATA	UNIT
1	VOLTAGE	14.7 Volts
2	CURRENT	0.46 Amperes
3	POWER	6.74 Watts

Graph of Current, Voltage and Power







5. Conclusion

In conclusion, the use of IoT in monitoring solar power is an effective way to improve the efficiency and reliability of solar energy systems. By integrating various sensors and devices with cloud-based platforms, it is possible to collect and analyze real-time data on solar panel performance, power consumption, and other key metrics. This data can then be used to optimize the energy output of solar panels, predict potential failures or malfunctions, and reduce maintenance costs.

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