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SOLAR POWER MONITORING SYSTEMS: EXPLORING THE INTERNET OF THINGS (IOT)

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Abstract: Using renewable energy sources is an efficient way to address the commercial sector's persistent electricity supply imbalance. When compared to other renewable energy sources, which have a limited global spread, solar power is often recognized as the most advantageous option. To allow the widespread deployment of solar systems, cutting-edge frameworks that permit remote monitoring of plants via a web interface must be used. Because of the abundance of remote and inaccessible areas, centralized monitoring of these sites is impossible. The Internet of Things (IoT) permits the identification and remote control of things via network architecture, allowing the physical world to be seamlessly integrated with computer systems. The Internet of Things (IoT) has shown to be an efficient management and monitoring tool for renewable energy generation. To keep track of crucial solar panel data, the IoT application employs an Arduino-based monitoring and recording device. The device continuously monitors the solar panel and provides data about the panel's power production to an IoT network. The present system makes use of a simplified user interface to emphasize the multiple characteristics of the solar panels. If the achieved result falls below the user-specified threshold, the user will be promptly notified. Remote monitoring of solar power facilities is now available thanks to this technology.

Keywords: Internet of Things (IOT), Power Output, Renewable Energy, Solar Energy, Solar Panel

1. INTRODUCTION

In today's world, having access to electricity is considered a need. The graph of energy consumption has shown a rising tendency throughout time, while the graph of energy sources has shown a comparable negative trend. To compensate for the lack of electrical supply, a diverse range of resources are used to generate energy. Conventional and alternative energy are the two most common types of energy that can be utilized to generate electricity. Energy can be obtained from a variety of sources, including nuclear and fossil fuels. Nonetheless, because of their scarcity, these sources are recognized as unusual. Solar energy has far-reaching consequences for our energy infrastructure's future, and it is an essential component of any sustainable energy system. The sun's rays are essential as a key source of electricity generation and in the conversion of solar energy into electricity. The most common approach is known as solar thermal energy.

Despite the availability of various renewable energy sources including wind, tides, geothermal, and rain, solar power has a number of advantages.

Because of its wide availability and low environmental impact, solar photovoltaic energy is generally recognized as the most favorable renewable energy source. This is especially true when compared to alternatives that are geographically limited. The sun hits the Earth at a rate of 430 quintillion joules per hour, enough to power the entire world for an entire year. However, it is difficult to put so much energy to good use. Despite the fact that solar panels are ubiquitous in modern culture, their operational state is rarely frequently evaluated. As a result, the specific amount of energy produced by these things is uncertain, and they can only run at peak efficiency for about two hours. However, by controlling and monitoring solar panels, Internet of Things (IoT) adoption may be able to

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successfully address these difficulties. Constant monitoring of solar power plants is essential to maximize energy output efficiency. This configuration makes it easier to monitor for issues such as damaged panels, faulty connections, dust accumulation on panels resulting in lower output, and other factors that can impair solar performance.

Remote detection, monitoring, and control of an object is now possible thanks to improvements in Cloud Server Network and IoT technology. Machines can now communicate with one another thanks to improvements in IoT technology, rendering human involvement redundant.

A web server with internet connectivity can be used to monitor a number of panel metrics, including voltage, current, and power, thanks to the IoT-based solar power monitoring framework. The solar panel employs a Light Dependent Resistor (LDR) to locate and position itself in areas with the greatest sun irradiation, hence boosting its daily operational efficiency and the amount of solar energy produced.

2. HARDWARE REQUIREMENTS

Arduino Uno

The open-source microcontroller board Arduino Uno is built around the ATmega328 microprocessor (datasheet). A 16MHz crystal oscillator, a reset button, 14 digital I/O ports, a power jack, a USB port, an ICSP header, and a USB port are all included in the Arduino Uno. Everything needed to get the microcontroller up and running is included in the system, including a choice of power sources (battery, AC-to-DC adapter, and USB connection to a computer). A 5-volt DC power source is required to operate the device. The Arduino UNO is simple to use and packed with useful capabilities. It is a data transmission medium that connects the solar panel to the Internet of Things.

Fig.1 Arduino Uno

Wi-Fi Module ESP8266

The Espressif Systems ESP8266 is a Wi-Fi microcontroller with a full Micro Controller Unit (MCU) and TCP/IP protocol stack. We believe the cost is reasonable. The most common application of this technique is embedded IoT application development. The ESP8266 bridges the gap between the microcontroller and the cloud server. Before being uploaded to an IoT or Cloud server, data gathered by an Arduino device must be processed by an ESP8266 module.

Fig.2 Wi-Fi Module ESP8266

Liquid Crystal Display (LCD)

A popular and versatile type of flat-panel electronic display is the liquid crystal display (LCD) screen. A 16x2 LCD display may show up to 32 characters across two lines. Green letters on a black backdrop will be displayed on the 16x2 LCD panel. A liquid crystal display (LCD) graphically depicts various sensor-collected parameters. This comprises measurements of the solar grid's voltage, current, and power. For a variety of reasons, LCD modules are superior to multi-segment LEDs. LCDs are originally less expensive and more efficient. Second, they are more user-friendly than rival LED technologies. LCDs have an additional advantage over seven-segment LEDs in that they can display bespoke characters. Furthermore, LCDs may display extra characters, broadening their range of uses.

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Fig.3 Liquid Crystal Display (LCD)

DC Motor

Motors are machines that transform electrical signals into mechanical rotation; they typically consist of a stator and a rotor with a permanent magnetic field. It is feasible to keep the magnetic field going by using electromagnetic windings or permanent magnets. Brushless, servo, and gear motors are among the many capacities and configurations of DC motors. These motors are typically used in applications that require a wide range of speed and torque. A control motor, namely a DC servomotor with a rotational speed of 10 rpm, is used in the application. The motor runs on the Pulse Width Modulation (PWM) principle, which states that the rotational angle of the motor is controlled by the duration of pulses transmitted to a specific control pin. A resistor connects all of the necessary components between the motor and the gearing, allowing the solar panel to revolve.

Fig.4 DC Motor

Power Supply Unit

Among other things, the apparatus in question includes a voltage regulator, a filter, a rectifier, and a step-down transformer with a voltage ratio of 230/15V. A rectifier converts an AC current to a DC current in this case, and the DC voltage is filtered by a bypass capacitor to eliminate ripples. When connected to an alternating current power supply, the transformer converts the 230V input voltage to a safer and more controllable 15V output voltage. The Arduino power supply is set to stay between +12 and -12 volts.

Relay

A relay is a device that may be controlled electrically and is used to regulate equipment. At this point, the controller sends only the largest digital signal to the relay. Initially, the controller produced three digital signals based on data from the three Light Dependent Resistors (LDRs) attached to the Arduino. After converting the relay into a DC motor driver circuit, the circuit can be configured to direct the DC motor in the direction of the brightest area.

Fig.5 Relay

Light Dependent Resistor (LDR)

A relay is a device that may be controlled electrically and is used to regulate equipment. At this point, the controller sends only the largest digital signal to the relay. Initially, the controller produced three digital signals based on data from the three Light Dependent Resistors (LDRs) attached to the Arduino. After converting the relay into a DC motor driver circuit, the circuit can be configured to direct the DC motor in the direction of the brightest area.

The value of a photoresistor or light-dependent resistor (LDR) varies in reaction to lighting. A Light Dependent Resistor's (LDR) operation is mostly dependent on photoconductivity. The resistance of the photoresistor varies in response to changes in illumination, making it a variable resistor. We can measure the solar power plant's light exposure by connecting the Light Dependent Resistor (LDR) to a constant voltage source via the Arduino ports.

Fig.6 Light Dependent Resistor (LDR)

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Solar Panel

The solar panel, also known as a photovoltaic module, is a device that converts solar energy into electrical energy by gathering sunlight. An array is made up of many solar panels, each of which contains a number of individual cells. The more solar panels that can be put, the more solar energy that can be harvested. Photovoltaic solar panels, or PV panels, are made of a semiconductor material that is chemically and electrically comparable to silicon. Photovoltaic panels provide direct current (DC).

Fig.7 Solar Panel

3. SOFTWARE REQUIREMENTS

Things Speak Cloud Setup

Things Speak is an open-source IoT infrastructure that offers a number of services for IoT application development. The disclosed system is an Application Programming Interface (API) that uses HTTP to ease data transmission between a local network and a cloud-based storage system. Data from sensors and other system-related components can be saved and retrieved via the internet using this API. Clients (users) can connect with one another via the Things Speak cloud platform application, tracking and location applications, and status applications, which all update the data records created by the sensors. Before beginning to use the Things Speak app, the user must first register an account, which allows access to the app and its capabilities. These lines allow for the display of a wide range of framework and remote device parameters. The data can be viewed visually by those who control or use this cloud computing system. Energy generation data is sent to a router with online monitoring capabilities, where it may be accessed via an easy-to-use web interface. Users can access information on the energy produced by their solar panels from any location with an internet connection using these technologies.

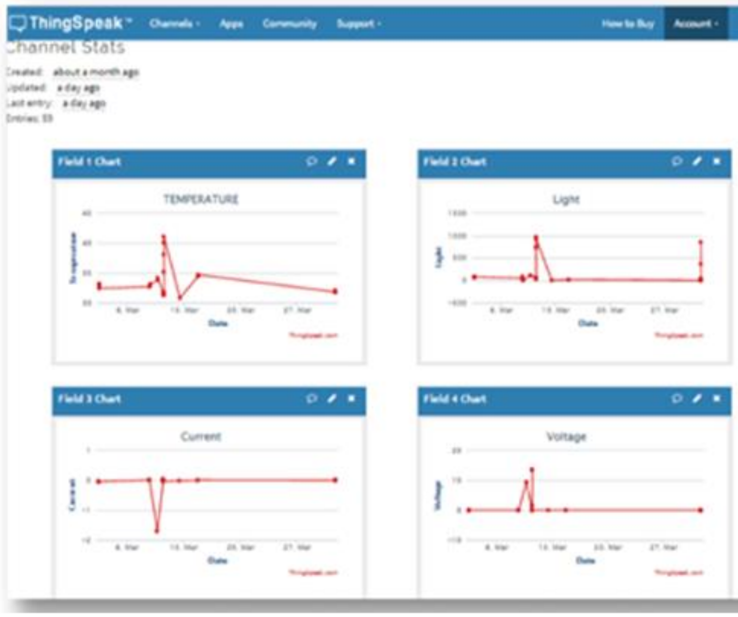

Fig.8 ThingsSpeak Cloud Setup

Arduino Integrated Development Environment (IDE)

The open-source Arduino IDE development environment's principal capabilities are to change, build, and upload code to the Arduino board on a variety of systems, including Linux (both 32-bit and 64-bit variants), Windows, and Mac OS X. This configuration is also compatible with the C and C++ programming languages. The installation procedure is simple. It is straightforward to include libraries that work with the hardware module. Furthermore, it is possible that regular software upgrades will be made available.

4. WORKING PROCESS

Sensors are used to determine the present state of the solar panel; a current sensor, for example, measures the current. A DC servo motor and a light-dependent resistor (LDR) work together to rotate the solar panel throughout the day so that it receives the most direct sunlight possible. The relay serves as the actuator's controller. The relay and the light-dependent resistor (LDR) sensor are

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linked to the controller. The sensor signal is utilized to compute the power and voltage of the LDR and solar panel, both of which serve as controller inputs. The values for these parameters are then displayed to the user on the LCD. The controller receives analog signals from the sensor and LDR, and the controller's output signal activates the relay.

The Wi-Fi module mediates communication between the controller and the remote server by providing a uniform interface. It permits the communication of panel parameters to the server, such as voltage, current, and generated power. The present state of the panel can also be determined remotely. The panel's parameters are captured and saved on the server every hour and day so that they may be compared and evaluated later.

Analytics are utilized to efficiently present the most critical information after combining data from various solar panels into the Internet of Things platform. Applications created to meet specific criteria use the data.

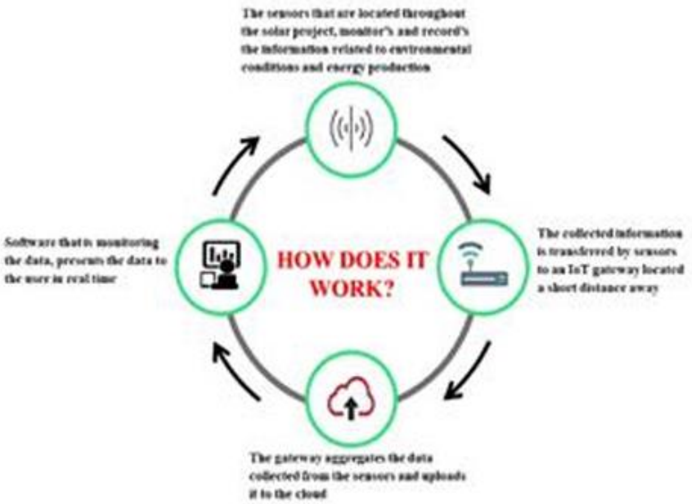

Fig.9 How to use the Internet of Things to keep track of your solar panels

Internet of Things (IoT) platforms that have strong data classification capabilities, such as Things Speak, Microsoft Azure, and Google Cloud Platform, allow for the accurate identification of useful data while ignoring irrelevant data. We may use this data to better reliably diagnose problems, predict consequences, and suggest areas for improvement. We can create more exact judgments based on real-time information by collecting data through networked sensors while preserving precious resources.

5. CONCLUSION

The goal of this project is to create a system that uses IoT to maximize solar panel manufacturing. The LCD displays the voltage, current, and temperature of the solar array using IoT technology. The daily, weekly, and monthly study of the solar power plant's performance gets more streamlined and efficient as monitoring continues. When applied to power plant data, this approach reveals anomalies that would otherwise go undiscovered. Solar tracking is a mechanism that moves a solar panel to follow the path of the sun throughout the day, enhancing the panel's efficiency.

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