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IoT Based Solar Power Monitoring System

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Abstract: *Energy is a key aspect for every family, company and other setting, including agriculture. Carefully controlling energy use and wisely conserving it for appliances are essential. Energy consumption is directly impacted by coal, oil and gas in terms of power generation. The approach outlined here involves labeling the energy used by solar power as renewable energy on the internet. An ESP32 and the Thingspeak.com platform is used to monitor this location. Daily monitoring of the consumption of renewable energy is done through smart monitoring. The user is knowing how much energy they are using. Consumption of renewable energy and power issues are both impacted by analysis. Microgrid, Solar Street Lights, Smart Villages and Solar Cities are only a few Examples.*

Keywords: Solar Power.

I. INTRODUCTION

One of the most fundamental demands in everyone's life in the modern world is access to electricity. All home appliances, public transportation, lighting, refrigeration and warmth depend on electricity. Even though daily energy consumption is rapidly increasing, energy resources are also depleting at the same time. Solar energy is become very popular. The photovoltaic effect, commonly referred to as solar energy, transforms light energy into electrical energy in this technology. Keeping an eye on this system is quite helpful since we can monitor its condition and receive notifications when a problem occurs. An IoT based system for monitoring solar power is the one that is being proposed. Solar cells, a component of this system solar panels, are what ultimately transform light into electricity.

The operation and output of a solar power system are monitored using a solar power monitoring system. The amount of energy generated by the solar panels, the amount of energy used by the system, and the system's overall efficiency are all tracked and analyzed. This system typically consists of sensors and software that measure many quantities, including temperature, sun radiation, and energy output. Users may track the operation of their solar power system and see any problems that might be compromising its efficiency thanks to real-time analysis and display of the data acquired by these sensors.

A solar power monitoring system can assist users reduce their energy use by offering useful insights into energy usage trends in addition to monitoring the performance of a solar power system. As a result, there may be an improvement in energy efficiency, cheaper energy expenses, and a smaller carbon impact.All things considered, a solar power monitoring system is a crucial device for anyone wishing to increase the output and effectiveness of their solar power system. Users may make informed choices about their energy use and improve the efficiency of their solar power system with the help of the real-time data and insights provided by this technology. Sensors are used to measure the voltage and temperature parameters. The results are shown on the LCD panel.

The paper is structured as follows. A detailed discussion on Methodology approach is given in section 2. Photovoltaic cell is explained insection3.Internet of things is explained in section 4. Things speak is explained insection5. Analysis and Modulation given in section 6. Result is explained insection7.Conclusionisgiveninsection 8.

II. METHODOLOGY

The main objective of the proposed project is to increase the power production of the solar panel. IoT technology is utilized to monitor and display properties like voltage and temperature using sensors, and any problems with the solar panels' performance will also be disclosed. Solar radiation is used to show how sunlight from the sun is captured by solar panel, which then transform the sunshine into usable energy forms like heat and electricity. Sensors are employed to measure the electrical energy, such as a voltage sensor that uses the voltage divider principle to measure the voltage generated by solar panel. Mathematical calculations are then used to determine the current. Figure 1 depicts the suggested monitoring systems intended structure. The introduced system's experimental setup includes solar panel, a regulated power supply, an ESP32 Wi-Fi module, voltage and Temperature sensor, an I2C LCD (liquid crystal display) and Node MCU. Embedded C is used to develop programming codes using Arduino IDE.

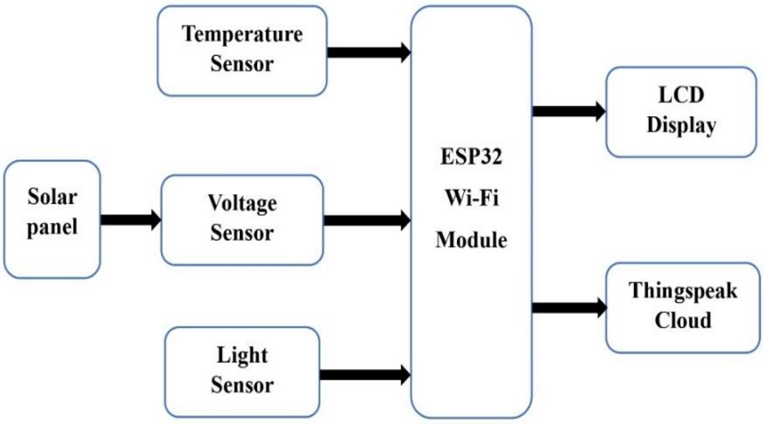

Fig1: Block Diagram

2.1 Used Hardware Components

A. LCD Display

The actual value of this I2C Serial LCD module lies in its ability to streamline firmware creation using the widely used Arduino library, save some I/O pins on the Arduino board, and simplify circuit connectivity. This 16x2 LCD display module has an I2C interface and is a premium 2-line, 16-character LCD with internal control adjustment, backlight and I2C communication interface.

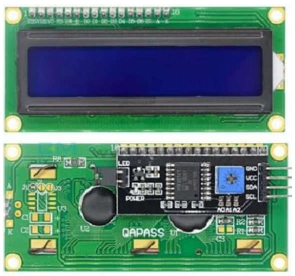

Fig 2: LCD Display

B. Voltage Sensor

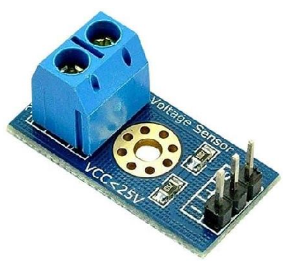

Fig 3:Voltage Sensor Module

A potential divider is used by the straightforward but extremely helpful Voltage Sensor module to lower the input voltage by a factor of 5 volts. The 0-25V Voltage Sensor Module makes it feasible to monitor voltage that are significantly higher than what a microcontroller is capable of sensing via its analog input. This is a great option for measuring voltage using an open source platform such an Arduino, ESP32 or Raspberry Pi. Engineers directly deal with measurements in many electrical projects with a few fundamental needs.

C. LDR

Electronic circuit designs typically contain light dependent resistors, also known as LDRs or photo resistors, when it is necessary to detect the presence or level of light. The common resistors found in other electronic systems, such as the metal film resistor and carbon film resistor are extremely dissimilar from LDRs. They were specifically designed to adapt to the change in resistance brought on by their light sensitivity.

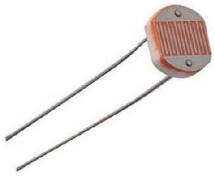

Fig 4: Light Dependent Resistor

D. LM35 Sensor

Precision integrated circuit temperature sensor from the LM35 series have an output voltage that is linearly proportional to the temperature in degree Celsius. It has an advantage over linear temperature sensor calibrated in kelvin because the output can be easily scaled to Centigrade without requiring the user to deduct a constant voltage from the output.

Lower costs are guaranteed via trimming and calibrating at the wafer level. The LM35 device is exceptionally easy to interface with reading or control circuit due to its low output impedance, linear output, and flawless Intrinsic calibration. The device can be powered by plus and minus supplies or a single supply. The LM35 device draws only 65 A from the supply, which results in a very low self heating of less than 0.11°C in still air.

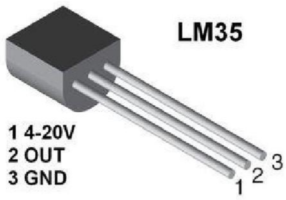

Fig 5: LM35TemperatureSensor

E. NodeMCU:

The Node MCU board includes serial communication protocols, analogue pins, and digital and digital pins. We may create programmes with the aid of the Arduino IDE and transmit them to the Node MCU for a variety of tasks. This makes learning a new language for the Arduino board simple for developers. Node MCU will be utilized in the project to convey energy-related information, such as the energy usage and the appliances linked to the consumer/organization, as well as to receive end-user input. Many IoT platforms enable integration with Node MCU and communication with the board using tools like Thing Speak. We can manage the board and adjust how the appliances are turned on and off by connecting the relay to the board.

Fig 6: NodeMCU(ESP32Wi-Fimodule)

Pin Description of NODEMCU

- **Power Pins:** The power pins consist of four pins there are Micro-USB, 3.3V, GND and Vin. Each pin is explained in below configuration.
- **Micro-USB:** The NODE MCU board can be powered through this USB port.
- **GND:** The NODE MCU board is grounded using this pin on the circuit board.
- **12 Vin:** This is the Arduino board input voltage pin, which is used to supply input power from a source.
- **Control Pins:** The control pins consist of two pins there are EN, RST pins. Those pins are explained in below configuration:
- **EN:** The EN pin stands for enable pin. This pin is used for the input supply of the system.
- **RST:** The RST pin stands for the reset pin. This pin of the board is used to reset the microcontroller. It is used to Resets the microcontroller.
- **Analog Pin:** This pin is an analogue input and operates between 0 and 3.3 volts. On this board, the analogue pin can function as a digital input or output pin.
- **GPIO Pins:** The NODE MCU board has 34 general purpose input output pins. These pins are used for the input and output pins in this board.
- **SPI Pins:** This board has four serial peripheral interface pins named as SD1, CMD, SD0, CLK. These pins are used for the SPI (Serial Peripheral Interface) communication.

F. Resistor

An electronic component known as a resistor is used to limit the passage of electric current in a circuit. It is a passive component, which means it runs without a power supply. A resistor is constructed out of a substance like metal or carbon that has a high resistance to the flow of electricity. A resistor's resistance is expressed in ohms (Ω), and it depends on the resistor's material, length, and cross-sectional area. The resistance increases as the resistor gets longer and thinner. Through-hole resistors, surface-mount resistors, and variable resistors (sometimes called potentiometers) are some of the different sizes and types of resistors.

Fig 7: Resistor

III. PV CELL (PHOTOVOLTAIC CELL)

An electronic device that transforms light energy into electrical energy is a photovoltaic cell, commonly referred to as a solar cell. It is built to absorb light photons and release electrons, and it is comprised of semiconductor materials like silicon. The photovoltaic cell is excited by light energy, which causes the semiconductor material's electrons to become liberated from their atoms and flow across a circuit, producing an electrical current. Electronic devices can be powered by this current, or it can be stored in batteries for later use. Photovoltaic cells come in a variety of forms, such as monocrystalline, polycrystalline, and thin-film cells.

When the semiconductor material is exposed to the light, a portion of the photons are absorbed by the semiconductor crystal, leaving a significant number of the free electrons in crystal. This is the main driving force behind the generation of power by photovoltaics. A photovoltaic cell is the primary component of a system that harnesses the photovoltaic effect to produce the electricity from light energy. Silicon is the semiconductor material that is most frequently utilized to make solar cells. The silicon atom has five valence electrons. In order to create covalent bonds, each silicon atom in a solid crystal trades one of its five valence electrons with the silicon atom that is closest to it.

The most effective silicon cells are monocrystalline cells, which are created from a single crystal; polycrystalline cells, which are created from many crystals, are marginally less effective. Thin-film cells are the least efficient but are flexible and lightweight, making them useful in some applications. They are created by depositing a thin layer of photovoltaic material onto a substrate. Solar panels for generating power, portable electronics, and even some cars and aeroplanes all use photovoltaic cells in some capacity. They playa significant role in the expanding field of renewable energy and assist in lowering our reliance on fossil fuels.

Fig.2. Photovoltaic cell

IV. INTERNET OF THINGS

Human-to-human, human-to-environment and human-to-machine interactions have all been linked to IoT as a catalyst. We are now able to connect conventional everyday devices to the internet thanks to the idea of Internet of Things (IoT).The Internet of Things concept enables remote device analysis. The concept of the Internet of Things (IoT) offers the required framework and possibility of fusing the real and virtual worlds. Systems run on computers and the rest of the world. The notion is becoming more popular. It has been more crucial since there are more and more wireless gadgets. Devices with a market share that is soaring quickly.

The network of physical objects or devices known as the Internet of Things (IoT) is outfitted with sensors, software and other technologies that allow them to communicate exchange data with other objects and system over the internet. The objects in the IoT can range from simple everyday products such as smart appliances, wearables and home automation systems, to more complicated industrial machines and infrastructure such as smart cities, transportation systems, and healthcare equipment.

The insights and analytics that may be produced from the data supplied by these connected devices can help people and organizations make better decisions and increase effectiveness, productivity, and overall quality of life. With the internet, hardware units speak to one another. The system can connect to the internet thanks to the ESP32 Wi-Fi module that is used in it. Electricity is being used for a variety of purposes, including agriculture, industry, residential use, hospitals and other places where there is a continual increase in population. As a result, it is getting harder to manage electrical maintenance and demand. As a result, it is vital to practice energy conservation to the fullest extent possible.

V. THINKSPEAK

Think speak is utilized as an open source cloud platform application. which transfers data from the local network to the cloud using the hypertext transfer protocol from devices linked to systems via the internet. It refreshes all of the sensor data logs, location tracking applications, and status applications that users give to and get from users. To use this, the user must first register an account with several channels for tracking various system parameters or tracking parameters on a remote device.

The administrator or user of this cloud can view the data as a graphical representation. With the internet based monitoring, information about energy output is sent to a router and made accessible via an online interface. The main benefit of these systems is that you can easily access information about your solar panel output from anywhere you have an internet connection.

An open source IoT application called Thingspeak. And utilizes API to store and retrieve the data via the Local Area Network or Internet using the HTTP protocol. Thing speak is useful to develop social networks of objects with status updates, location tracking applications, and sensor recording applications. The Ruby language is used to create

Thingspeak. With Thingspeak, you can gather sensor data for cloud storage, analyze and visualize your data, and take action by setting off a reaction. It can transfer data to and from Arduino, Raspberry Pi, and other devices.

VI. ANALYSIS AND MODELING

In order to calculate the solar voltage and Temperature to the position of the sun, the method employed in solar monitoring using IoT has multiple steps, as shown in the following flowchart (figure 3). It reads sensor values like voltage and Temperature. The value is shown on the LCD.In this project, we'll use an ESP32 Wi-Fi module to create an IoT-based solar power monitoring system. The ESP32 joins a Wi-Fi network and uploads solar sensing data to a Thingspeak server, including solar panel voltage, temperature, and light intensity. Optimal power generation from solar power facilities requires monitoring.

The energy sector's future lies in solar energy. The focus of nations all around the world is on clean, renewable energy sources. The most plentiful resource that is always and everywhere is sunlight. The sun's energy can be used to create clean electricity. To increase the effectiveness of solar cells, lower the cost of making solar panels, and enhance electricity distribution to solar plants, research and innovation are ongoing. This initiative also aims to innovate in order to increase solar panels' effectiveness.

The project permits the monitoring of a solar panel's power production, incident light intensity, and operating temperature using an ESP32 Wi-Fi Microcontroller. The solar panel and the sensors are precisely connected to the ESP32 controller, which controls the panels and loads. Users from all over the world can access the website to view the voltage, temperature, and sunshine intensity. Numerous possible uses for this technology exist, including Solar cities, Smart villages, Microgrid and Solar Street lights.

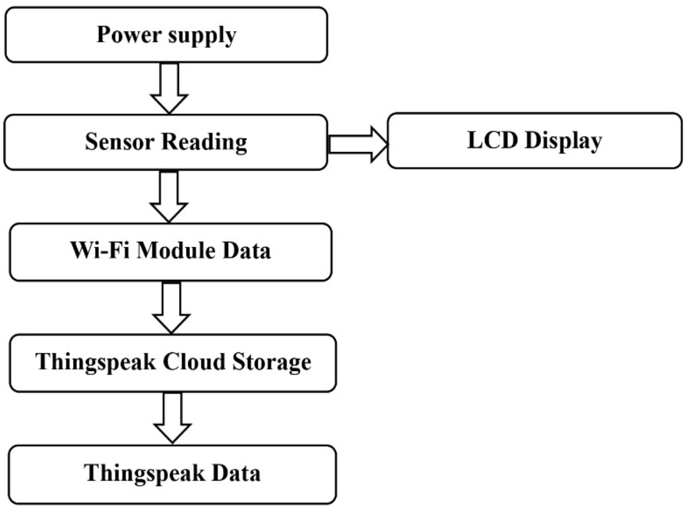

Fig.3 Flow chart

- **Power supply:** Solar panels serve as the power source. The normal terminal voltage for a 12 Volt solar panel is 15.0 Volts. In order to support IOT-based components, the voltage is lowered to 5–10 Volts using a regulator.
- **Sensor Report:** Through a solar panel, it determines the values of voltage and Temperature sensors. A voltage sensor can detect either AC or DC voltage levels, while a Temperature sensor senses temperature.
- **Thingspeak Cloud Storage:** Thingspeak is an opensource IoT platform and that uses protocols to store data and retrieve from microcontroller over the internet or through LAN. It allows us to create IoT apps and gather and store the sensor data in cloud. It offers apps that analyze, visualize. Thingspeak, is a web-based platform for gathering data from numerous sensors.

- **Wi-Fi Module:** Its wireless transceiver offers internet connectivity for embedded applications, and it is capable of hosting IoT apps or offloading entire Wi-Fi networking activities from another application processor. It performs a variety of tasks, including networking, data processingand web server.
- **LCD Display:** The parameters of the solar panel, the voltage, temperature and the power are shown on the LCD in real time.

VII. RESULTS

As a result of the project, the LCD can show the voltage and Temperature parameters of solar panel in real time. Thinkspeak IoT platform is used to display and store the solar panel parameters in an application or web page. To enable remote monitoring of the solar panel. The output on the webpage is shown as a table with the parameters and their units along with the date and time. To analyze the data, each parameter is shown in a graph on the web server with references to time and date.

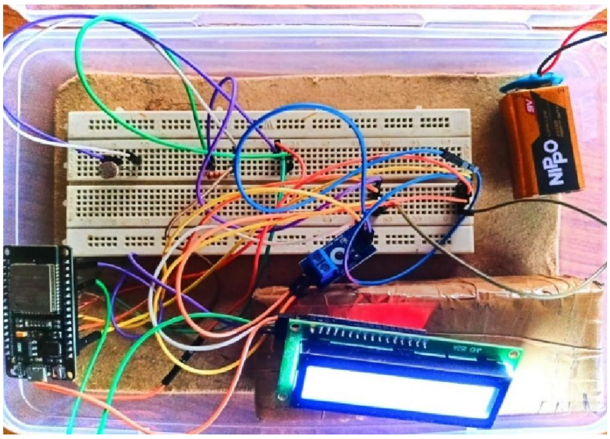

Fig.3 Connection diagram

Thinkspeak is utilized as an opensource cloud platform application. Which transfers data from the local network to the cloud from sensors or other devices connected to systems via the internet. It refreshes all of the sensor data logs, location tracking applications, and status applications that users give to and get from users. The user must first register an account with several channels for monitoring various system parameters in order to use this. The main benefit of these systems is that you can easily access information about your solar panel output from any location with an internet connection. The voltage and Temperature values of the solar panels from their working site to Thingspeak cloud are shown in figure 4.

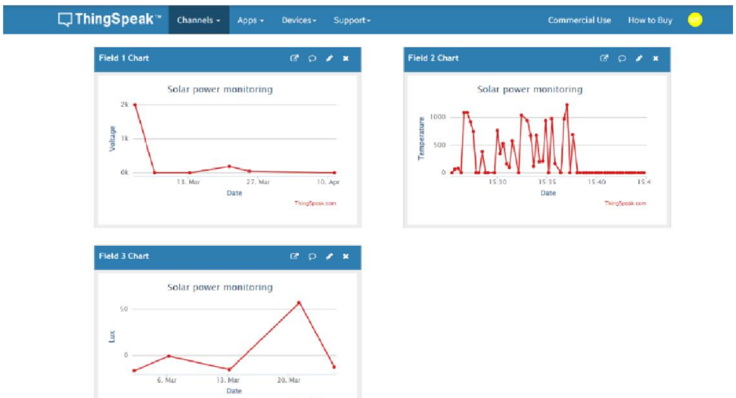

Fig.4 Output data in Thingspeak

7.1 Advantages

- Monitor the amount of electricity consumed.
- Solar monitoring systems are climatically resistant.

- Assist in improving the solar system's efficiency.
- Value of money.

7.2 Disadvantages

- Solar power is utilized to charge batteries so solar powered gadgets can be used at night.
- Solar panels can be pricey.

VIII. CONCLUSION

The Internet of Things (IoT) is used to construct a virtual solar power monitoring system. The Thingspeak application, which is cloudbased uses mobile to display the measured solar parameter in realtime. Through the remote access the suggested work aids in predict the solar PV module's performance. This can expand to include large-scale solar plants so that they can take preventative action by routinely evaluating their performance. The suggested approach continuously updates the voltage and current parameters by storing the most recent data. Continuously monitoring the solar photovoltaic system makes it simple and straightforward to perform a daily or monthly analysis. If there is any uncertainty in the generated data, it is also possible to find any flaws in the system by monitoring the solar panels that are operated at the maximum capability.

The suggested approach continuously updates the voltage and Temperature parameters by storing the most recent data. It is easy and simple to do a daily or monthly study when the solar photovoltaic system is continuously monitored. If the generated data is ambiguous, it is also feasible to find any flaws in the system by keeping an eye on the solar panels that are working to their full potential.

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