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IoT Based Solar Panel Monitoring and Control

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Abstract

IoT technologies are used to track solar power in this study. In the Internet of Things (IoT), data can be collected and sent wirelessly without human involvement. In remote areas where there is abundant solar energy, this IoT-based technology is best suited. As it stands, regular access to the areas is still a challenge and expensive. Solar panels, NODE-MCU (ESP8266), Voltage Sensor, Current Sensor, Temperature Sensor, Servo motor, LDR, etc. comprise these IoT-based technologies.

Keywords –Solar panel Tracking, maximum power point tracking, Sensors, IoT System

1) Introduction

As the non-renewable energy resources are dwindling, the utilization of renewable resources for producing power is increasing. Solar panels are getting increasing popularly. A solar panel gathers solar energy, then converts it to electrical energy, and stores it in a battery. This energy can be used as needed or as a straight replacement for grid power. The Sun's position with respect to the solar panel changes due to the rotation of the Earth. For solar panels to be most efficient, they need to be continuously oriented toward the Sun. Continuous orientation is the only way to maximize solar energy production. Therefore, the solar panel should always face the direction of the Sun. To get the most out of a solar power plant, it is critical to keep an eye on it. In order to keep an eye on the output of these power plants, Solar panel defects, such as dust and other contaminants, can reduce the solar panel's output. Using an IoT-based solar power monitoring system, the cloud-based system provides solar monitoring and checks if there is a problem in solar panel connection by lowering output. NODE-MCU ESP8266 is the controller that monitors all the solar panel parameters. Monitor the solar panel and transmit the data to the Internet of Things (IoT). As soon as an output falls below a predetermined threshold, an alert is issued to notify users of an issue with solar panel connections or dust on the panel. This makes it possible to monitor the solar panel and ensure that it is producing the best amount of electricity possible.

2) Literature review

a) Bluetooth smartphone interface is used for real-time tracking and system control development. It serves as a link for exchanging data with the power conversion unit's hardware, and the microcontroller processes the renewable source's current and voltage measurements using sensing circuits. The parameters are sent to the computer via USB, where they are immediately detected by the system Daily, weekly, and monthly made on the system.

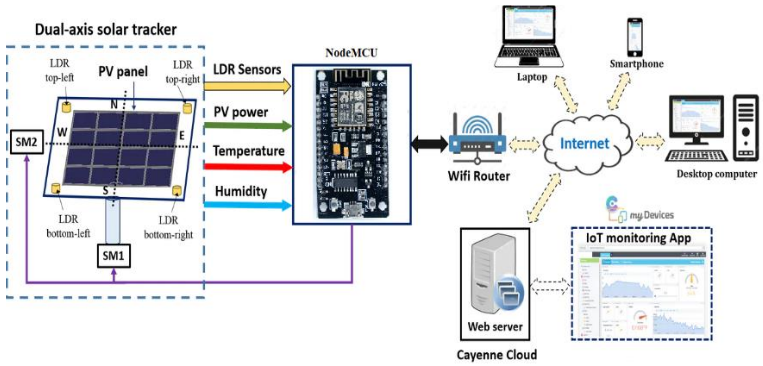
b) Goto and Yoshihiro, has evidence that the integrated system for monitoring and managing has been established and is in use. The feature system's data can be used to enhance the user interface by using communication technologies. Over 200,000 telecom power plants, including inverters, rectifiers, and air conditioning plants, can be operated and maintained by the system. Control and remote monitoring are all integrated into one system that has been installed in over 8,000 buildings worldwide. Propose a plan of action.

3) Propose System

The proposed work's design and implementation can be divided into two sections. The solar photovoltaic monitor system's architecture can be separated into three levels: data acquisition, data processing, and data display and storage. The data acquisition stage collects data from various sensors like the voltage, current, temperature, humidity, and irradiance then sends it to the next step via wired or wireless communication. The data are briefly kept in auxiliary devices such as data loggers, analyzed, and then delivered to the final stage for presentation. At the last level, data is received by the workstation, and the system then takes the necessary measures to configure the system appropriately. These data are accessible via the internet from any location at any time.

a) Monitoring System

Data processing modules and transmission protocols for solar PV monitoring systems have been thoroughly reviewed. With the data transmission modules, connected devices and networks can be gathered, controlled, and managed in a real-time environment. They also serve as a sort of cloud computing middleware, connecting various devices via the cloud. With the help of an IoT-based monitoring system, you can gather data such as panel voltage, current, temperature, humidity (on a small scale), etc. using sensors (electrical and environmental) and transmit it via a network layer using various transmission protocols Via Wi-Fi. The data processing layer uses multiple data processing modules such as a NoduMCU to process the necessary data. The functionality of various layers, such as sensor, transmission, data processing, and application layers, was also investigated. The execution of different layers depends on whether they are used for small-scale or large-scale monitoring or powered by software or the cloud. A comparison of large- and small-scale solar photovoltaic (PV) systems for various electrical and environmental parameters.ESP8266 and ESP 32 examined their data transmission protocols, parameters, software, monitoring platform, and related results.. To ensure data security while being transmitted between devices, the monitoring system utilizes a variety of network protocols. Concerns about a monitoring system's communication protocol's low range, computational speed, storage memory, and other limitations motivate the need for it . Solar PV system monitoring can be accomplished with wireless communication protocols using ESP8266 Wi-Fi module (NodeMCU).



b)Tracking Control

Types of Trackers

The following is a list of the different types of trackers,

i) Active solar tracker

Active solar trackers employ sensors and a controller to follow the sun's course and capture as much radiation as possible. Single-axis solar trackers follow a single cardinal axis; dual-axis solar trackers follow two cardinal axes (tracks along two orthogonal cardinal axes).

ii) Passive solar tracker

Trackers powered by the sun's heat, such as passive solar ones, can move because of their ability to compress fluid quickly. There are also chronological solar trackers, which use the earth's rotation and different geographical areas to determine when the sun will rise and set each day.

iii) single-axis and dual-axis types

Trackers can be divided into single-axis and dual-axis types based on the axis of rotation. In order to design an Arduino based dual axis solar tracker, several projects have been carried out. For a more efficient tracking system, a fuzzy based pi controller is used.

4) Compound Used

a) **Solar Panel**

Solar panels are devices that collect energy from the sun's rays and use it to power a gadget or generate heat. For the most part of solar panels are simply a collection of solar cells, which may be used to create energy through a process known as solar cell photovoltaic effect.

b) NodeMCU (ESP8266)

Chip-based NodeMCU boards are designed to meet the needs of a new connected world. A separate application processor could handle all Wi-Fi networking tasks for you, or you could host the application on your own processor.

GPIOs on the NodeMCU allow it to be integrated with sensors and other application-specific devices with minimal development up-front and minimal loading during runtime because of its powerful on-board processing and storage capabilities Allowing for minimal external circuitry, the entire solution is designed to fit on a small PCB, including the front-end module.

Plug-and-play WiFi projects are possible with the NodeMCU development board. NodeMCU firmware is pre-installed on the module, requiring only the installation of the USB driver (below). In one breadboard-friendly package, the Nodemcu WIFI Dev Board Internet of Things board integrates a complete WiFi module with all of the GPIO separated from the USB-serial interface.

NodeMCU, a Lua-based firmware for the NodeMCU, is pre-flashed on this board, making it easy to control via a scripting language called Lua. So, in a matter of minutes, you'll be good to go. Internet of Things (IoT) projects benefit greatly from the ease of use and all-in-one functionality provided by the ESP-12 Lua NodeMCU WIFI Dev Board.The WiFi Module chip is at the heart of this board's design. This WiFi development board includes all of the components needed to programme and upload code right on the board. 3.3V regulator, logic level converter, and USB to serial chip upload codes are all built-in, so you can get started right away.

c) Voltage and Current Sensor

A voltage can be calculated and monitored with the help of a voltage sensor. Voltage sensors can detect whether the voltage is AC or DC. This sensor's input is voltage, and its outputs include switches, analogue voltage signals, current signals, and an audio signal.

A current sensor measures and converts current flowing through a measured path into a measurable output voltage. There are numerous current sensor types, and each sensor is optimized for a certain current range and ambient condition.

d) Temperature Sensor

Temperature sensors measure the temperature of their environment and convert the input data into electronic data for monitoring or signaling changes in temperature. Temperature sensors come in many standard. Here you can get a variety of Temperature & Humidity sensors, including a Digital Microcomputer Thermostat Switch, a Humidity Controller Module, a high-temperature resistance Probe, Moisture Sensor, and many more modules.

e) LDR: (Light Dependent Resistors)

LDRs are also known as photo resistors or CdS cells because they are light-dependent. A photoconductor is another name for it. Photoconductivity is the underlying principle of this device. An LED's resistance decreases as light intensity goes down, so the passive component is essentially a resistor in this case. Optoelectronic devices such as this are used most commonly in sensors that vary with light level or light/dark activated switching circuits.

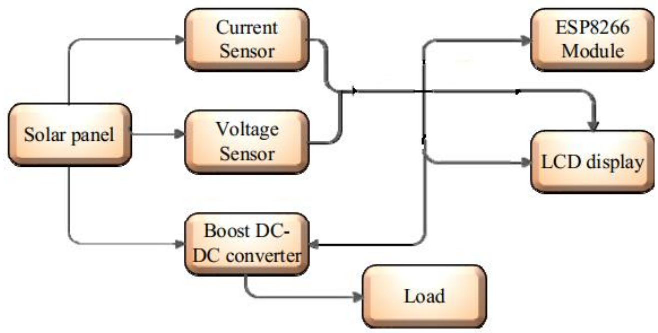
How does it works in this system (ESP8266)

Wireless local area networks (WLANs) are based on the 802.11 family of standards. Wireless monitoring relies on an ESP8266-based Wi-Fi module to transmit data. An error reading of 2.5 percent in the ammeter is possible with this tool, as are voltages up to 30 V with an error of 0.073 percent in the voltmeter. The Wi-Fi range is up to 100 meters, and its data rate ranges from 11 megabits per second to 54 megabits per second. However, compared to other data transmission modules, the Wi-Fi module uses more power to transmit data.

A solar PV system that uses low-power communication can be monitored and protected using an ESP 8266 Wi-Fi module. In addition to three nodes with a 12 V DC motor, LED lights, and LED lamps, there were three nodes that had an average error of 2.4% for the current sensor and 0.073% for voltage. To reduce the data transmission time and increase the efficiency of the proposed work, further improvements are needed. Various electrical parameters can be tracked using an ESP32 module to monitor solar panels and batteries. An ESP32 Wi-Fi module and an SD card reader were used in the system design. A total of 12 solar modules rated at 130 watts each were put through their paces in the lab. The work was focused on developing low-power applications that could scale up to handle higher power requirements, like 1 kW.In future research, environmental parameters, such as panel conditions, should be considered in addition to the methodology mentioned above. Furthermore, the technology on display shows that it is unable to support any intelligent decisions or alerts. Created a low-cost solar PV plant MPPT tracking system with the help of the ESP8266 Wi-Fi module. A data acquisition sensing board and a DC-DC boost converter were part of the system. Another feature of the system is that the monitored data is displayed in real-time on a website. Integrating a failure system to send information about sensor failure could implement additional fault detection and remote sensing improvements.

To monitor parameters of solar panels such as voltage, current, and temperature using a Wi-Fi module-based monitoring system. Real-time parameter monitoring was carried out. Voltage and current errors were found to be 0.96 percent and 5.6 percent, respectively, on average. The methodology used is straightforward and could be further refined for various purposes, including fault detection, efficiency measurement, and panel condition monitoring. An efficient monitoring and control system can be developed using SCADA's architecture. Sensors, an ESP32 Thing Micro-Controller (RTU), a Thinger.IO local server IoT platform, and a Raspberry Pi were all used to build the final structure.

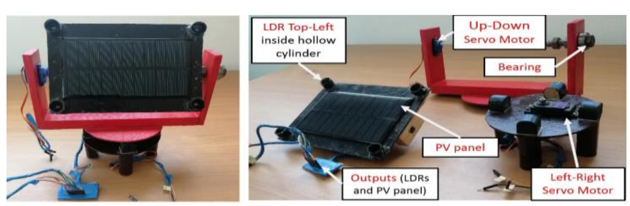
A Micro-Controller and a Wi-Fi Router for the home network are required. The ESP38266 Thing Micro-Controller (RTU) collects electrical data from various sensors and sends it to the Thinger for data storage, remote control, and real-time monitoring. IoT platform over a Wi-Fi network Solar PV System to remotely monitor voltage, current, power, and energy consumption.

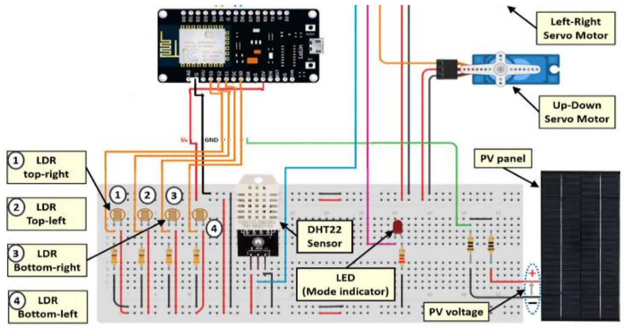


Schematic diagram of the monitoring scheme using an ESP8266 module.

In this System we use Dual-axis types

An IoT application's dashboard can be used to automatically or manually track the position of the sun using LDR sensors. LDR sensors provide data to the controller, which determines where the sun is (and as a result, the intensity of its light). A second servomotor (SM1) and a second servomotor (SM2) transform the data into commands to rotate the PV panel in the direction of the sun. In addition, the NodeMCU receives information about temperature, humidity, voltage, and current generated by the PV. Data taken by microcontrollers is sent to the cloud (web server) using an Ethernet shield attached to a NodeMCU. Solar tracking information from the IoT monitoring app can also be viewed in real-time via pre-created widgets. This IoT monitoring app was built in Blynk. The user can view all the solar tracker data on the dashboard of the IoT app when the smartphone or computer is connected to the internet. In this way, PV panels can be monitored for their performance and environmental conditions. When the dashboard widgets that they correspond to are in manual mode, the servo motors will also follow their directions. So the user can optimize the system so that maximum energy is extracted from the PV panel by finding optimal environmental conditions. An IoT application also allows for the sending of notifications (via SMS or Email) when a threshold value is reached by a sensor





6) Software Used

a) Arduino IDE

Depending on the needs of the system, there are different types of Arduino boards. One commonality among all Arduino boards is that they can all be programmed with the Arduino IDE. Inputs and outputs of an electronic system such as speed, voltage, and size can differ widely. You may have to purchase a programming interface if the board is designed as an embedded solution. Some devices can run directly on 3.7V batteries, while others require a 5V source. A fundamental component of Arduino software and hardware is the Arduino board.

Arduino IDE - a ready-made software used to upload the computer code to the board and program the circuit board - consists of a physical board and a board that can be programmed.
The key features of Arduino IDE are,

i) Analog or digital input signals can be read by Arduino boards and turned into outputs which can be connected to the cloud or be used in many other ways.

ii) Your board can be controlled by sending instructions via the Internet to its microcontroller through Arduino IDE.

iii) With Arduino, a USB cable is all that is necessary to load a new program onto the board, unlike with the earlier programmable circuit boards.

iv) A simplified version of C++ is used in the Arduino IDE, which facilitates the learning process.

v) Furthermore, Arduino provides a standard form factor for breaking the functions of the microcontroller into an easier to use package.

b) **Blynk APP**

Blynk is an Internet of Things platform. In addition to controlling hardware remotely, it displays sensor data, stores data, visualizes it, and does many other cool things.

There are three major components in the platform:

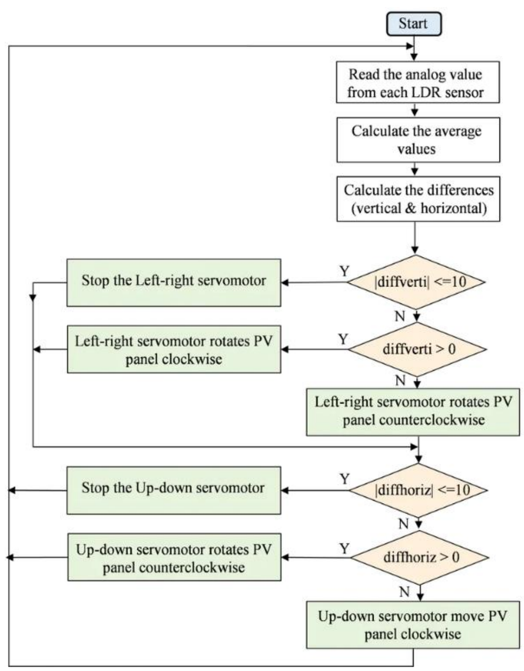
Blynk App – With it, you are able to interface with projects by using a variety of widgets. Blynk App's main goal is to create an interface between humans and machines.

Blynk Server – Communication between the smartphone and hardware is handled by this component. Blynk Cloud and Blynk servers can both be used. A nodeMCU can even be launched on it due to its open-source nature and ability to handle thousands of devices.

Blynk Libraries - Communication with the server allows for the execution of inbound and outbound commands from your Blynk hardware and app.

Each time you press a Button, your Blynk automatically finds its way to its hardware. As a result, everything happens in a blink of an eye in the opposite direction as well.

The microcontroller operation flowchart is shown Below.



7) Conclusion

For the purposes of testing, a dual-axis active solar tracking laboratory prototype is described in this paper.The controller is an ESP8266 module. Solar panels with high power ratings can be used in this prototype system as an alternative power generation source. A 5-watt solar panel is used in this project.

In different weather conditions, such as on a sunny day or a gloomy day, different datasets have been recorded with the implemented tracker. Depending on the maximum light intensity, the solar tracker will move around the axis to ensure that the solar panel receives the maximum amount of solar energy possible. As a result, depending on the application, the system can be monitored from a remote location.

These techniques have weekly, monthly, and daily tracking of solar energy. The analysis was simplified, made more convenient, and was more cost effective as a result. Non-conventional energy that processes can consume indefinitely. Our planned system's ability to observe and control the voltage it generates gives us a chance to overcome the disadvantages of an earlier proposed system. The solar array voltage generation. This technique has a low operating cost and can be used in remote locations, and it also reduces the amount of manpower required

8) Future Scope

This project could be made even more innovative and capable of forecasting climate conditions as well as human behavior if we add artificial intelligence to our current technology. Since suggestions will be provided by the system, this intelligent system will also assist in understanding and repairing any defects. The current system is Wi-Fi compatible, but the GSM module allows for further customization. The GSM module necessitates the use of a sim card in order to communicate with the cloud. This method would be simple to understand and used by the entire town.

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